Cranfield University

Dujuan Brandéz Sevillian

Flight deck engineering: Impact of flight deck crew alerting and information systems on English as a second language flight crewmembers performance in airline flight operations

School of Engineering

Department of Air Transport Systems and Human Factors
Cranfield Safety and Accident Investigation Centre

PhD

Cranfield University

School of Engineering

PhD

January 2017

Dujuan B. Sevillian

Flight deck engineering: Impact of flight deck crew alerting and information systems on English as a second language flight crewmembers performance in airline flight operations

Supervisors:

Dr. Steve Jarvis
Dr. Graham Braithwaite
Dr. Wen Chen Li

Academic Year 2016-2017

This thesis is submitted in partial fulfillment of the requirements for the degree of PhD

ABSTRACT

There are many pieces of flight deck research on general use of written English language technical information and problem solving using technical documentation. Contributory causes of aircraft accidents have been due to misunderstandings of crew alerts and procedural divergence by English as-a-second language flight crewmembers (ESL). Research was conducted to understand impact of written English language technical information on ESL flight crewmembers' performance. Two types of systems were evaluated, technical documentation and crew alerting systems that contain technical information, with respect to their impact on ESL flight crewmember performance. Preliminary analysis results indicated written English language technical information can be confusing, difficult to read and interpret, and leads to misunderstandings by ESL flight crewmembers during aircraft non-normal conditions. English as-a-second language flight crewmembers indicated they often experience problems executing written English language technical procedures after outset of crew alerts.

Conversely, experimental trials revealed ESL flight crewmembers did not experience many cognitive performance issues with use of crew alerting systems and technical information designed with an English language emphasis. English as-a second language flight crewmembers' English language proficiency, background knowledge, and use of use of metacognitive strategies to read and comprehend written English language on crew alerting and information systems, indicated they utilized written English technical information with ease. Particularly, ESL flight crewmembers' workload was low, they had fast response times to system faults, and they experienced minimal procedural deviations. On the contrary, when ESL flight crewmembers utilized written English language technical procedures translated into their native language during non-normal conditions, they experienced several cognitive performance challenges. English as-a second language flight crewmembers' background knowledge of written English language technical information translated into their native language, use of metacognitive strategies to read and comprehend written English language translated into their native language, indicated they experienced difficulties with reading and comprehending translated technical information on information systems. Particularly, ESL flight crewmembers were challenged cognitively when they responded to crew alerts through execution of decision-making processes. They indicated translation of written English language technical information into their native language was a pre-cursor to procedural deviation, long response times to system issues, as well as high workload during experimental trials.

It is recommended that further research focus on design and use of written English language technical documentation by ESL flight crewmembers during non-normal conditions. It is also recommended that if deemed practical by the aviation industry, further research should focus on design, integration, and utilization of technical documentation in a language(s) other than English, and measurement of ESL flight crewmembers performance on the flight deck.

Keywords: Human Factors, flight deck engineering, procedures, ESL, aviation safety, lexicon, crew alerting systems, vocabulary, crew station, aircraft accident investigation

ACKNOWLEDGEMENTS

First, I would like to thank Cranfield University-U.K for the opportunity to pursue my PhD in the U.K. Undertaking a PhD is not an easy task and takes a commitment for many years. It is a challenging task, but a rewarding opportunity to give back to the aviation and aerospace industry. I look forward to visiting the campus, professors, and conducting postdoctoral research regarding ESL flight crewmembers performance on the flight deck. I would like to personally thank Dr. Steve Jarvis, Dr. Graham Braithwaite, Dr. Phil John, Dr. David Mba, and the flight deck engineering systems staff at Cranfield University for their support in the completion of this degree.

Thanks to various regulatory agencies, airline flight safety/training departments, ESL flight crewmembers, and airline pilots associations for their support with helping me gather data for my thesis. I look forward to keeping in touch with all of you, and conducting postdoctoral research with your support.

Thank you Department of Defense (DOD) officials for continued support in my career endeavors as well as conversations that helped shape and support my research studies. Thank you engineering experts at NASA for our candid conversations on this research. Thank you FAA and local government officials for their continued support in my career. Thanks to the Boeing Company for generous support and laudable conversations.

I would also like to personally thank Dr. David Graeber (Boeing flight deck engineering subject matter expert) for his continued support in my career, reading all of my papers that were submitted to journals and editing them. I would also like to thank him for his continued support as a subject matter expert in the field of aviation human factors engineering.

I would like to thank all of the peer reviewed journal and book publishers for supporting my efforts in publishing my work to be viewed by the industry. I look forward to working with many of you in the future!

As there were many authors cited in the my literature review, it would be great to have the opportunity to meet them, learn more about their research, while sharing research conducted for this thesis. This would provide an opportunity to link research endeavors and hopefully foster new research ideas.

Thank you to my wife for her support throughout this whole process and having faith in me. Thank you East Atlanta, GA for making it happen and all those who aspire to improve aviation safety everyday.

Table of Contents

RESEARCHER'S PROPRIETARY STATEMENT

The researcher currently works for The Boeing Company within the field of systems engineering, crew station design, human factors engineering, and aviation safety. No proprietary data from The Boeing Company was utilized for the PhD, nor was there proprietary data utilized from any other companies to facilitate this research. All required information that was presented at conferences, and submitted to book/journals was cleared through the Boeing Company's release of information to the public process requirement. This process was needed in order to ensure that no Boeing proprietary information would be released without The Boeing Company knowledge. There were no

Export Administration Regulations (EAR) and no International Traffic in Arms Regulations (ITAR) protected data associated with the research conducted by the researcher in this document. All data was protected throughout all studies conducted by the researcher and proprietary agreements were established prior to the start of the studies. The researcher also followed the appropriate ethics guidelines established through Cranfield University and The Boeing Company to conduct the research activities. All subjects that were utilized for each of the studies filled out agreements required by the Human Subjects Review Board committee (HSRB) at Cranfield University.

SCIENTIFIC RESEARCH PAPERS, ABSTRACTS, AND CONFERENCE PRESENTATIONS PUBLISHED

The following research papers, conference presentations, and abstracts were published in the aerospace industry. These papers are related to researcher's dissertation theme (Flight Deck Engineering: Impact of Flight Deck Crew Alerting and Information Systems on ESL fight crewmembers performance in Airline Operations). Last, the researcher received an award from the aerospace industry medical field because of the PhD research conducted at Cranfield University.

<u>Technical Papers</u>

Sevillian D, Jarvis S. (2013). *Human mental models within flight deck crew alerting systems*. In Badiru A B (Ed) *Handbook of Industrial and Systems Engineering (2nd Edition)* Taylor & Francis, Chapter 26, p.487. Nov 2013.

<u>Conference Presentations</u>

Sevillian, Jarvis S. & Graeber D. (2015). Impact of flight deck crew alerting and information systems on ESL flight crew performance in airline operations Parts 1 and 2. *The 86th Annual Aerospace Medical and Human Performance Annual Meeting. Orlando, FL.*

<u>Abstracts</u>

Sevillian, Jarvis S. & Graeber D. (2015). Impact of flight deck crew alerting and information systems on ESL flight crew performance in airline operations Parts 1 and 2. *The 86th Annual Aerospace Medical and Human Performance Annual Meeting. Orlando, FL.*

<u>Awards</u>

2015 Space Medicine Association Dr. Jeffrey Myers Young Investigator Award
2009 ISASI Rudolf Kapustin Scholar Award

THESIS STRUCTURE

The researcher's thesis is comprised of nine chapters. Chapter one provides an introduction to the problem regarding impact of written English language on ESL flight crewmembers performance on the flight deck. It also introduces flight deck engineering and system design principles. Chapters two and three describe fundamentals of written English language design, ESL adult proficiency, background knowledge, metacognitive strategies, and reading comprehension performance challenges. Chapter four provides a review of ESL adult interface with the GUI. Chapter five reviews a potential opportunity to address written English language challenges on ESL adults by means of translation processes. Chapter six is a synthesis of the literature reviewed. Chapter seven and eight are the researcher's studies. Chapter nine is the researcher's thesis synthesis, which include recommendations and conclusions.

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AC-Advisory Circular
A/C-Aircraft
AIA-Aerospace Industries Association
ANOVA-Analysis of Variance
AQP-Advanced Qualification Program
ARR-Agreement Rater Reliability
ASRS-Aviation Safety Reporting System
ATA-Air Transportation Association
ATP-Air Transport Pilot
ATSB-Australian Transport Safety Bureau
AWL-Academic Word List
B-Blue
CA-Crew Alert
CAST-Commercial Aviation Safety Team
CAWDS-Crew Advisory Warning and Display System
CENIPA-Center for Investigation and Prevention of Accidents
CFR-Code of Federal Regulations
CHIRP-Confidential Hazardous Incident Reporting Program
CONFIG-Configuration
CVR-Cockpit Voice Recorder
DC-Direct Current
DFDR-Digital Flight Data Recorder

DOT-Department of Transportation
EAAI-European Association of Aerospace Industries
EAR-Export Administration Regulations
EASA-European Aviation Safety Administration
ECAM-Electronic Centralized Aircraft Monitor
ECFR-Electronic Code of Federal Regulations
EICAS-Engine Indicating and Crew Alerting System
ELEC-Electrical
ELPRs-English language Proficiency Requirements
EMER-Emergency
ERJ-Embraer Regional Jet
ESL-English as a Second Language
ESP-English for Specific Purposes
FAA-Federal Aviation Administration
FBI-Federal Bureau of Investigation
FCOM-Flight Crew Operations Manual
FCTM-Flight Crew Training Manual
FDD- Flight Deck Displays
FOQA-Flight Operations Quality Assurance
GBE-Global Basic English
GPWS-Ground Proximity Warning System
GSLEW-General Service List of English Words
GUI-Graphical User Interface
HYD-Hydraulic
H-Level-High Level
H-L-High Level
HSRB-Human Subjects Review Board
ICAO-International Civil Aviation Organization
IAC-Interstate Aviation Committee
IFALPA-International Federation Airline Pilots Association
IM-Interval Management
ITAR-International Traffic in Arms Regulations
I-Intermediate
LF-Low Frequency
L-I-Low to Intermediate
LO-Low
MAIB-Maritime Accident Investigation Board
M-Level-Medium Level
NASA-National Aeronautics and Space Administration
NRS-National Reporting System
NTSB-National Transportation Safety Board
PNF-Pilot Not Flying
RCL-Reading Comprehension Level
QRH-Quick Reference Handbook
SAT-Scholastic Aptitude Test
SMS-Safety Management Systems

SLT-Source Language Text
SPLRS-Spoilers
SPSS-Statistical Package for Social Science
ST-Sub-technical
SYS-System
TABE CLAS-E- Tests of Adult Basic Education Complete Language Assessment System—English
TBD-To Be Determined
TCAS-Terrain Collision Avoidance System
TIRP-Technical Information Reading Protocol
TLT-Target Language Text
TLX-Task Loading Index
TOEFL-Test of English as a foreign language
TVLSs-Technical Vocabulary Learning Strategies
Y-Yellow
U.S.A.-United States of America
U.K.-United Kingdom

Chapter 1: Introduction

1.1 Background of the Problem and Motivation: A preview of written English language challenges experienced by ESL crewmembers in the transportation industry

This chapter introduces the background of written English language problems in the transportation industry, followed by impact on ESL flight crewmembers in the airline industry. The following paradigm (Figure 1) provides an overview of the aspects covered in this chapter. Three circles in the middle of Figure 1 indicate common challenges that crewmembers/flight crewmembers experience while using written English language. Particularly, reading comprehension of written English language is reviewed, with respect to crewmembers/flight crewmember performance. Top circle with rectangle highlights general challenges ESL crewmembers experience reading and comprehending written English language. Second circle to the left with rectangle highlights fundamental issues that native (English speaking as first language) flight crewmembers experience with reading written English language. Intent of this circle is to provide the reader with an understanding of inherent issues in written English language that challenge flight crewmembers speaking English as their native language. Third circle with three rectangles on the right highlights challenges the ESL flight crewmembers experience when they utilize written English language. This includes ESL flight crewmembers English language proficiency, reading comprehension abilities, and the effect of design/integration of written English language on crew alerting systems and QRH checklists. Discussion of aircraft accidents, government and industry research, are reviewed so that the reader has a clear picture of factors impacting crewmembers performance on the flight deck. Note: Term 'flight crewmembers' and 'pilots' are utilized frequently throughout the thesis. These terms are operationally defined as flight crew other than flight attendants. In particular, the term flight crewmembers or pilots correspond to first officer and captain flight deck positions.

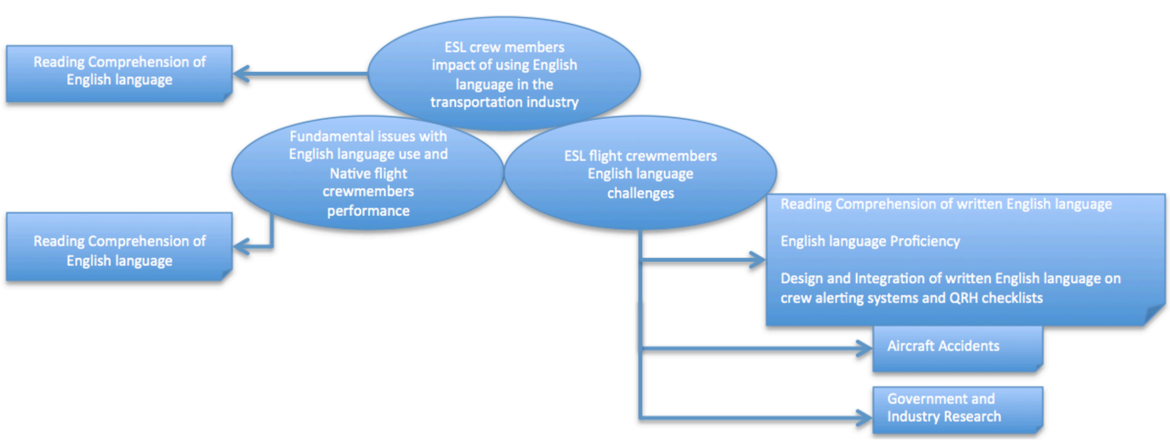


Figure 1 Chapter 1: Visualization Roadmap

In today's multimodal transportation system, use of written English language technical documentation by adults that speak ESL has been deemed challenging. Particularly, factors that influence their ability to perform while using technical documentation are related to their English language proficiency and ability to read and comprehend written English language. For example, in the maritime industry, the Confidential Hazardous Incident Reporting Program (CHIRP) reported that misunderstandings with written English language on technical documents by ESL seafarers, have led to accidents. Furthermore, ESL seafarers' ability to read and comprehend written English language has been noted as a challenge that negatively impacts their performance (Rashed and Kamal, 2010). On September 1, 2004, a ship crashed in Scotland. One of the factors that contributed to the crash was the crewmembers inability to read and understand written English language. Particularly, the ESL crewmembers did not understand written English technical information in the safety manual. Even though the crewmembers had some level of English language reading comprehension proficiency, the investigative report did not indicate how well each of the crewmembers read and interpreted technical information designed with an English language emphasis (MAIB, 2005). The report also does not inquire on how well crewmembers understood written English language vocabulary words or sentences. These types of pre-cursors to misunderstandings of written English language should have been reviewed, as they have the potential to impact crewmembers performance.

The aviation industry has also indicated that use of technical documentation by people that speak English as-a-second language is challenging, particularly in their use of the technical documentation in the operational environment. Specifically, in the airline industry, ESL maintenance operations personnel have indicated they were challenged with reading safety related information on written English language technical documentation. They indicated that it was difficult to understand information in the manuals (Drury and Ma, 2003). Aforementioned perspectives are indications that use of technical information by ESL individuals is challenging, and has the potential to impact their ability to read and comprehend technical information. But, how do these types of challenges impact ESL flight crewmembers on the flight deck? More importantly, do these challenges impact the ability of ESL flight crewmembers to perform using flight deck crew alerting and information systems? What are the effects of written English language design on ESL flight crewmembers performance? A forthcoming preliminary review of the aforementioned questions is provided in the next paragraph.

Typical crew composition on the flight deck consists of a captain and first officer. On the flight deck, flight crewmembers use Western-built crew alerting and information systems designed with a written English language emphasis. Flight crewmembers communicate with each other regarding system malfunctions/failures using crew alerting and information systems. Flight crewmembers often need to solve aircraft system issues either unilaterally or bilaterally. Regardless of how they communicate with each other, flight crewmembers should be competent with use of written English language on crew alerting and information systems. Written English language has been proclaimed as the language often utilized on the flight deck for written procedures Hutchins et al (2006); therefore, it would seem practical that flight crewmembers have an adequate grasp of the language. However, design and integration of written English language on crew alerting and information systems has the potential to impact flight crewmembers ability to read and interpret written English language. Moreover, flight crewmembers level of English language proficiency is an indicator of how well they read and interpret written English language. Subsequently, their proficiency is likely to impact how effectively and efficiently they read and understand written English language on technical information and crew alerting systems.

Chapter one aim is to discuss issues with written English language, and the effect it has on flight crewmembers (English as their native language) performance. The reader will understand inherent issues in written English language that impact flight crewmembers reading and comprehension, considering English as their first language. Understanding fundamental issues with written English language will help probe how these issues have potential to impact ESL flight crewmembers performance on the flight deck. As the main focus of this thesis will be how written English language has an impact on ESL flight crewmembers ability to read and comprehend written English language, the researcher will profile challenges that they experience while using crew alerting and information systems. Essentially, this chapter provides an overview of the purpose and use of flight deck crew alerting and information systems. Industry concerns on compatibility of ESL flight crew members interface with use of Western built flight deck crew alerting and information systems is also discussed. Last, a review of aircraft accidents that resulted in fatalities is reviewed. These accidents also highlight ESL flight crewmember misunderstandings on use of flight deck crew alerting and information systems.

1.2 Significance of written English language challenges on the flight deck: What is the real problem with written English language and flight crewmembers performance?

The aviation industry is well known for naming its information utilized by flight crewmembers on the flight deck as ‘technical information’. The word ‘technical’ has been touted by aviation professionals as terminology used to describe the characteristics of a system and its features. It may also describe the aviation domain and its specific characteristics. The word ‘information’ is generic to many industries. It is operationally defined in this thesis as text utilized to convey a message, which may be in the form of documentation and/or illustrated on the Graphical User Interface (GUI) of a computer screen (e.g. crew alerting system). Written English language technical information has the potential to contain many different sorts of vocabulary words, text type, layouts, styles, and structures. Technical information can be found on flight crew alerting systems, typically operated on Western-built Flight Deck Displays (FDD). Crew alerting systems enable flight crewmembers ability to operate aircraft safely and communicate effectively throughout the typical phases of flight (e.g. taxi, takeoff, cruise, and landing) (Sevillian & Jarvis 2013). Information systems (e.g. Quick Reference Handbook (QRH)), which are often designed in paper format and referred to as technical documentation, aid flight crewmembers with processing information from crew alerts, and executing decisions on the flight deck. Design philosophy of Western built flight deck crew alerting and information systems (e.g. crew alert systems/QRH checklist) is to provide flight crew members with alert style and feedback mechanisms such as warnings, cautions, and advisories (Abbott, 2000). These types of alerts may describe a system or flight path situation. Corresponding QRH checklist procedure tasks enable flight crewmembers to respond to a system failure(s)/malfunction(s) and guide them through the decision-making process (Degani and Wiener, 1994). Flight deck crew alerting and information systems should provide flight crewmembers with written English language that is readable and understandable, with respect to displayed text on crew alerting systems and in QRH checklist paper/visual presentation methods.

Adamski and Stahl (1997) and the National Transportation Safety Board (NTSB) reiterated that information on checklists and displays should be designed so that the reader may comprehend the intent of the message. However, they also indicated that design of technical messages have the potential to be misunderstood by flight crewmembers on the flight deck. These recommendations by Adamski and Stahl (1997) and the NTSB are initial indicators that the language of written English language technical information has the potential to impact flight crewmember performance. Before understanding characteristics of written English language technical information, it is important to grasp the philosophy of written English language. Written English language is a form of communication that can be utilized to convey messages to one or more individuals. Written English language has the potential to be complex in words and sentences, and can take longer to process from a cognitive perspective (Zhang, 2013). On the flight deck, use of written English language can be found on technical documentation (e.g. QRH checklist). Use of written English language technical documentation by native (English as-first language) English speaking flight crewmembers has been noted to impact their abilities to read and comprehend the language, especially during abnormal/emergency conditions.

What are inherent factors of written English language that cause native English speaking flight crewmembers to be challenged with technical information they read on checklists? In 2006, a Q400 aircraft crashed due to an over speed propeller issue. One of the factors that influenced the crash was native English speaking flight crewmembers use of the QRH emergency checklist to solve a failure on the flight deck. After the accident, investigators interviewed flight crewmembers on the aircraft. Flight crewmembers indicated they were challenged when using the QRH checklist (emergency conditions section) because the information was unclear, which led to their misunderstanding and negatively impacted their response to the emergency condition. Furthermore, flight crewmembers noted that information on caution indicators conflict with information written on the QRH checklist. This led flight crewmembers to misinterpret the system fault regarding the over speed propeller (SAIB, 2007). This accident provides an indication that written English language on QRH checklists have impact flight crewmembers' ability to solve problems related to system failures on the flight deck. Since alerts and checklists are utilized together to solve a problem, it would seem prudent that English language is written adequately. In this case, misunderstandings occurred as a result of unclear terminology on the checklist. This study provides evidence that written English language is challenging to native English language speakers.

There have been other issues noted by native English speaking flight crewmembers on their use of written English language on the flight deck. DeBrito (1998) conducted a subjective simulator study with airline pilots. There were approximately 30 simulator sessions utilized for the study. The study investigated flight crewmembers ability to execute written English language procedures on the flight deck, particularly within the context of 'to do lists' (e.g. QRH checklists), theoretically known as procedure text. There were several themes that emerged from the study. Two of the themes from the study were the following: design of checklists and flight crewmembers reading comprehension of checklists. With respect to design of checklists, flight crewmembers indicated they often experience difficulties accessing information related to abnormal and emergency situations. This was likely due to the organization of the checklist procedures. Design of abbreviations on the Electronic Centralized Aircraft Monitor (ECAM) and QRH checklist were noted to cause interpretation issues with flight crewmembers. It was indicated that abbreviated text utilized often on the ECAM and QRH may have been due to limited space on the display and checklist. The second theme described many of the reading comprehension issues flight crewmembers experienced. Flight crewmembers reading comprehension abilities were negatively impacted while using written English QRH checklist procedures. An abundance of words on the QRH checklist and conditional statements (e.g. if…then) negatively impacted flight crewmembers interpretation of information. Another finding from Debrito's (1998) study was flight crewmembers inability to understand words on the QRH checklist, which led to them omitting QRH checklist procedures. Another factor that influenced flight crewmembers inability to understand the QRH checklist was the context of the abnormal/emergency condition to understand the meaning of the situation. If flight crewmembers do not understand information on the checklist, they annotate their thoughts on the checklist, which affords a better understanding of the situation. Finally, flight crewmembers noted that they access other reference materials because the checklist does not always provide clear information to execute a decision.

1.2.1 Section Summary

This section underscored characteristic features of written English language that impact native English language speakers when they read technical information on the flight deck. The Q400 accident study emphasized that native English speakers are challenged by use of written English language, with respect to reading comprehension. The SAIB (2007) and DeBrito's (1998) studies shed light on design of the QRH checklist and flight crewmembers ability to read and comprehend written English language technical information. However, the studies do not provide much explanation on each of these themes. There was no discussion as to why flight crewmembers were negatively impacted with use of written English language procedures. The authors describe many issues that flight crewmembers experience, such as design and reading comprehension problems with QRH checklist and ECAM procedures. However, there is not an adequate representation of these issues, and if these issues are the result of flight crewmembers English language proficiency. Does the design of QRH checklists and ECAM procedures negatively impact flight crewmembers reading comprehension? With respect to displayed ECAM procedures, are their types of vocabulary words and text type that are more difficult to understand than others? Is there a relationship between vocabulary word type and flight crewmembers English language proficiency? These types of questions should have been answered within the context of the SAIB (2007) and Debrito's (1998) studies. Nevertheless, this study reveals that native English speakers are challenged with reading comprehension of written English language.

1.3 Written English language factors influencing ESL flight crewmembers

As Debrito's (1998) and the SAIB (2007) studies highlight factors that influence readability and understandability of written English language technical information by native English speaking flight crewmembers, what is the impact on flight crewmembers that read and comprehend English as-a-second language? Evidently, factors illustrated in Debrito's (1998) and the SAIB (2007) studies may be relevant in other studies regarding English as-a-second language flight crewmembers. The next study reviews impact of the QRH checklist on the ability of ESL flight crewmembers to read and understand written English language in the airline industry.

Drury et al (2003) conducted a survey study with 113 flight crewmembers. Primary focus of the study was to examine the effects of design and operational use of the QRH checklist, and the impact on flight crewmembers' ability to read and understand written English language. The study also examined the impact on ESL flight crewmember use of the QRH checklist, with respect to the factors previously discussed. Regarding ESL flight crewmembers, the study included various regions where flight crewmembers likely speak English-as-a-second language (e.g. Asia). Of the 113 flight crewmembers, 30 of them from Asia region responded to the survey. These flight crewmembers indicated that reading and interpreting the QRH checklist was difficult. Approximately 25 percent of flight crewmembers from the Asia region indicated design of the QRH checklist, was a factor that influenced their ability to read and understand the QRH checklist. Even though a higher percentage of flight crewmembers indicated that operational aspects (e.g. physical location of the QRH checklist) were a primary factor that impacted their use of the checklist, flight crewmembers from Asia region found difficulties with reading and comprehending information on the QRH checklist. Difficulties that flight crewmembers from the Asia region experienced should not be considered trivial, rather they should be an indication that written English language on the QRH checklist should be further investigated.

Drury's et al (2003) survey study on QRH checklist provides an indication that ESL flight crewmembers are challenged by the design of QRH checklists, and corroborates certain aspects brought up by Debrito's (1998) study. However, Drury et al's (2003) study does not cover several certain aspects on design and use of QRH checklists. Firstly, there is no indication as to English language proficiency level of the 113 flight crewmembers, nor was there an indication of ESL flight crewmember English language proficiency level. English language proficiency levels for Asian flight crewmembers should have been reviewed, as these could be factors that influenced their ability to read and understand written English language on the QRH checklist. The study should have also provided input on ESL flight crewmember background knowledge of written English language. These types of demographics help understand fundamental factors that influence their ability to read and understand written English language. Secondly, the study fails to link the QRH checklist to a typical flight deck situation. In other words, there was no link between ESL flight crewmembers use of the checklist in a non-normal condition. The results may have been different if non-normal conditions were examined. For example, if the survey had examined the interface between the QRH checklist and crew alerting systems (as these are utilized concurrently on the flight deck), the results may have been different. Furthermore, the study identifies several QRH checklist issues (e.g. difficulty with written English language conditional statements and omission of checklist steps) but does not link any of them to flight crewmembers that speak English as-a-second language in a non-normal aircraft condition. Quick reference handbook checklist issues could be considered strategies used by ESL flight crewmembers to read and understand the checklist, and they could also be factors that impact their performance. Regardless, if the QRH checklist issues had been connected to English language proficiency level of ESL flight crewmembers, the results could have been different. Last, regarding design of the QRH checklist, the survey does not include types of vocabulary words (e.g. academic, technical words) nor does it include a review of the type of text (e.g. informational/instructional text). English language proficiency level and strategy use could be an indicator of how well ESL flight crewmembers read and understand vocabulary words and text type. Therefore, these factors should be linked to understand the impact on ESL flight crewmembers. Overall, Drurys et al's (2003) study provides more input on the challenges that ESL flight crewmembers' experience while using the QRH checklist, but more research is needed to understand other factors, such as the effect of Western built flight deck crew alerting and information systems on ESL flight crewmembers.

1.3.1 Section Summary

This section highlighted that ESL flight crewmembers are negatively impacted by use of written English language. Drury et al's (2003) study should have emphasized more on factors that influence the ability of ESL flight crewmembers to read and interpret written English language. English language proficiency is a factor that has the potential to influence ESL flight crewmembers ability to read and understand written English language technical information in non-normal aircraft situations. English as-a-second language flight crewmembers English language proficiency should be adequate when using flight deck crew alerting and information systems. Their proficiency level should enable effective and efficient reading and interpretation of various presentation methods of flight crew alerts and information systems. However, there is variability in flight crewmembers English language proficiency using these devices Holder (2003) and many ESL flight crewmembers operate Western culture designed flight deck crew alerting and information systems (Amalberti, 1998).

In order to ensure flight crewmember system interfaces are adequate, written English language technical documentation should be consistent with human expectations and designed logically (Degani & Wiener, 1993 and Holder, 2003). But, there have been other noted airline industry challenges with respect to understanding factors that influence ESL flight crewmember performance, while they read and interpret written English language technical information. These challenges have led to unfortunate outcomes on the flight deck, as a result of ESL flight crewmembers misunderstanding written English language technical documentation. As ESL flight crewmembers experience written English language technical information (flight deck crew alerting and information systems) reading comprehension challenges during non-normal aircraft conditions, what is the impact on their performance? Next section highlights more details on factors influencing ESL flight crewmember performance on the flight deck.

1.4 Unfortunate Impact on ESL flight crewmembers performance and Industry concerns

Utilization of written English language on the flight deck can impact flight crew performance (Ornato and Peberdy, 2014). It can also impact the ability of ESL flight crewmembers to respond adequately to an alert and corresponding technical documentation (EASA, 2012). Adequacy of alert response is especially important when responding to non-normal conditions on the flight deck (Burian et al, 2005). There have been noted challenges that negatively impact ESL flight crewmembers performance while they use written English language technical documentation.

In December 2014, the investigation committee of Indonesia investigated a crash involving an Airbus A-320 aircraft operated by Air Asia (KNKT, 2015). One of the factors that may have influenced the crash was the inability of ESL flight crewmembers to read and understand written English language information on the QRH checklist. Particularly, the report suggests that ESL flight crewmembers were challenged by their interpretation of information regarding execution of a computer-reset function described on the QRH checklist. The investigation revealed that ambiguous statements on the checklist may have confused ESL flight crewmembers. Furthermore, the QRH checklist did not allow for one clear interpretation of the non-normal system condition, but instead afforded many possibilities. These factors impacted the flight crewmembers ability to follow the QRH checklist and solve the problem. Although this accident revealed factors that influenced ESL flight crewmembers' ability to read and comprehend written English language technical information, it fails to highlight other relevant circumstances. The report does not provide any indication of specific factors that impacted ESL reading comprehension; rather the report provides scant details regarding ESL flight crewmembers' interpretation issues. As reading comprehension of the QRH checklist was a factor that influenced their decision-making processes, the report should have included information regarding challenges they experienced using written English language technical information (e.g. vocabulary word types, text genre). The report also suggests that reading procedures aloud on the flight deck is an effective strategy to use while reading the ECAM and QRH checklist. But, the report does not provide any indication that reading aloud ECAM and QRH checklist procedures impacted the Pilot Not Flying (PNF) ability to execute procedures. In other words, when the PNF read procedures aloud, did the PNF provide any indication of issues utilizing ECAM and QRH checklist procedures? Reading procedures aloud may reveal difficulties with the ability of ESL flight crewmembers to read and interpret written English language. Or, reading aloud procedures could be a strategy that aids ESL flight crewmembers with ability to understand information they read. There are two gaps in the Air Asia crash investigation report that should have been addressed. The gaps in the investigative report are as follows: 1) lack of detail regarding effect of ESL flight crewmembers use of reading aloud strategy while executing ECAM and QRH checklist procedures, 2) lack of information regarding ESL English language reading comprehension challenges while using QRH checklists. Nevertheless, these types of gaps will be further researched, with respect to impact on ESL flight crewmembers performance. The researcher's intent is to provide more evidence that can help explain these issues in the literature review and the researcher's studies. The next aircraft accident reveals more information on the impact of written English language technical information on ESL flight crewmembers performance on the flight deck.

On June 1, 2009 an Airbus A-330 aircraft crashed while en route from Rio de Janeiro, Brazil to Paris, France. One of the factors discussed in the accident report was use of written English language technical documentation by ESL flight crewmembers. In particular, the report indicated that the ability of ESL flight crewmembers to interpret procedures written in English language was an issue. Detailed instructions could have negatively impacted ESL flight crewmembers performance. Although this accident provides details on English language challenges experienced by ESL flight crewmembers, it lacks precise details as to why ESL flight crewmembers had difficulties reading and understanding procedures written in English. English-as-a-second language flight crewmembers English language proficiency was not reviewed with respect to their ability to recognize vocabulary words, process vocabulary words, read and understand text genres, reading sentences that are complex, and acronyms/abbreviations on operational documentation. As these factors are considered documentation design related variables that could have impacted ESL flight crewmembers English language proficiency, and ability to read and comprehend procedures, these issues should have been investigated by the investigative agency. Conceivably, the ability of ESL flight crewmembers to read and understand operational procedures could have impacted their workload and time to respond to the airspeed issue they experienced during the flight. Therefore, the aforementioned factors that have the potential to impact ESL flight crewmembers reading comprehension of operational procedures should have been investigated (BEA, 2012).

On the topic of operational procedures, another accident occurred in 2011 that highlighted the impact of ESL flight crewmembers use of written English language technical documentation. On July 13, 2011, Noar Linhas airlines flight 4896 crashed killing 16 people. The Center for Investigation and Prevention of Accidents (CENIPA) of Brazil indicated that a contributory cause of the crash was related to utilization of written English language by ESL flight crewmembers to solve an emergency engine failure on takeoff. In addition, ESL flight crew members were challenged by use of the QRH checklist because of inaccuracies in written English language, and reading comprehension issues regarding use of technical documentation while executing and responding to the engine failure (CENIPA, 2013). Although the accident report describes challenges with use of written English language technical documentation, the report fails to provide sufficient evidence on how the ESL flight crewmembers responded to the engine failure alert. In other words, there was not a clear understanding how the QRH checklist was utilized to respond to the text displayed on the crew alerting system. The level of ESL flight crewmembers English language proficiency was not addressed in the report, with respect to their reading comprehension of written English language text on the crew alerting system. Regarding engine failure alert response by ESL flight crewmembers, the accident report did not provide an understanding of the reasons why written English language inaccuracies were in the QRH checklist. There was also no indication as to how the misunderstandings negatively impacted ESL flight crewmembers performance. Understanding types of inaccuracies on the QRH checklist (e.g. vocabulary word and sentence structure) may have provided a better understanding of the impact on ESL flight crewmembers.

On July 24, 2014 a MD-83 crashed in Mali killing all passengers and crewmembers (MCI, 2016). One of the causal factors of the crash was related to ESL flight crewmembers inadequate response time and awareness to airspeed and engine crew alerting information. Investigation revealed engine pressure ratio information from a sensing mechanism was erroneous, and FCOM procedure text naming convention used by the manufacturer was inadequate, with respect to an aircraft icing condition. It was recommended that the manufacturer clearly define procedure text related to anti-icing systems activation, and refrain from ambiguous wording in the procedure and provide clear interpretation of ice detection by the flight crew. This accident reveals that there is a need to understand types of procedure text and vocabulary word types that appear in aircraft operating procedures. Even though the investigation revealed a need to examine procedure text designed by the manufacturer, an examination into flight crewmember English language proficiency and background knowledge should have also been evaluated. The researcher's forthcoming studies will reveal importance of ESL flight crewmembers' English language proficiency, background knowledge, and impact on crew alerting response time and cognitive workload.

In a study conducted by the Aerospace Industries Association (AIA) and European Association of Aerospace Industries (EAAI), they focused on precursors to misunderstandings and inappropriate crew responses when managing propulsion system malfunctions/failures. One goal of the study was to provide awareness on factors that influence ESL flight crewmembers response to propulsion system malfunctions/failures. One factor that was included in the study was system design, and understanding the importance of providing adequate system diagnostics and procedures on flight decks that have an English language emphasis. The associations determined that almost 15 percent of events investigated by the NTSB were related to ESL pilot cross-culture adaptation with respect to propulsion system malfunction/failures (Sallee and Gibbons, 1998). In other words, how other linguistic backgrounds adapt to use of written English language on propulsion system malfunctions/failures. Although the associations discussed potential improvement areas needed for propulsion system diagnostics, they did not focus on how written English language technical documentation (e.g. propulsion system malfunction/failures documentation) should be designed and utilized considering ESL flight crewmembers interaction with flight deck crew alerting systems. There was no discussion on ESL flight crewmembers English language proficiency factors (e.g. reading comprehension abilities) that may influence system design. Also, there was no indication if background knowledge of words and sentences on technical documentation negatively impact ESL flight crewmembers reading comprehension. An investigation into ESL flight crewmembers English language proficiency factors, and background knowledge, may provide a better understanding of potential areas that could be improved within the propulsion system diagnostics design.

The Federal Aviation Administration (FAA) Commercial Aviation Safety Team (CAST) indicated that incorporating human factors design-engineering considerations for ESL flight crew members is imperative, to reduce the rate of potential errors primarily in the use of technical documentation (e.g. technical checklists, procedures, and placards) on the flight deck. It was also noted that incorporating design considerations for use of technical documentation on flight deck should reduce ESL flight crewmember training (FAA, 2013). According to the FAA, flight deck procedures and messages need to be clearly designed so the meaning is understandable by ESL flight crewmembers. Even though these observations were made by the FAA, their guidance to manufacturers via Advisory Circular (AC) 25.1322.1 and 14 Code of Federal Regulations (CFR) 25.13222, do not explicitly reference a need to ensure focus on ESL flight crewmembers interface with flight deck crew alerting and information systems (DOT FAA, 2010 and ECFR, 2015). In particular, no information exists on crew alerting systems and procedures compatibility with respect to ESL flight crewmembers. There are no indications as to how the FAA intends to ensure the manufacturers design systems that enhance the ability of ESL flight crewmembers to read and comprehend written English language. It would seem practical to include reference to ESL flight crewmembers and their interface with crew alerting and information systems, since FAA has indicated that the design of these systems need to be improved. Government and industry agencies have indicated that there are cases noted where ESL flight crewmembers have been negatively impacted by use of crew alerts, and associated technical documentation with an English language culture emphasis. According to Smith-Jackson and Wogalter (2000), design of English language signal words has attempted to account for linguistic differences. However, Wogalter et al (1997) indicated, safety information related to warnings was inadequately comprehended by ESL individuals (native Spanish speaking people) in socio-technical environments. Wogalter's et al (1997) research does not include a review of pre-cursors to English language interpretation issues by Spanish speaking people. Subsequent research should address how design and use of English written signal words impact an ESL individual's performance. For example, are signal words designed so that they may be read and comprehended by individuals that speak English as-a-second language? A study conducted by FAA (1996), stated the following:

> "concerns are raised that misunderstandings may occur when non-native English speakers must use English [on the flight deck]. English-language-based flight decks [are] operated by flight crewmembers whose native language is not English. This is exacerbated by abbreviations and cryptic messages on caution and warning systems, flight mode annunciators control display units, etc." (FAA, 1996). [It was also indicated that QRH and FCOM manuals and crew alerts should be simplified with a keen focus on non-native English speakers].

The FAA (1996) did not provide a detailed analysis of concerns regarding crew alerting systems and linguistic challenges on ESL flight crewmembers. Specifically, it would appear pertinent to address fundamental causes of misunderstandings of flight crew alerts by ESL flight crewmembers and measure their performance on the flight deck. For example, the FAA should have provided detailed information on the effects of crew alerting systems design on ESL flight crewmember reading comprehension. It would also seem paramount to review typical ESL flight crew performance case studies that focus on their workload, response time, and errors while using crew-alerting systems on the flight deck. On the other hand, the FAA should have addressed challenges that ESL flight crewmembers experience with use of checklists (e.g. QRH). A review by the FAA on specific challenges that may impact ESL flight crewmembers performance while utilizing English written technical information design features on the QRH should have been discussed. Misunderstandings with use of written English language technical information may be the result of ESL flight crewmember English language proficiency. In particular, reading and comprehension of written English language (e.g. vocabulary word types, and text types) may be a factor influencing misunderstandings, but more research is needed to address this claim.

Despite efforts made by the FAA in 1996 to address concerns on crew alerting system design and ESL flight crewmembers interface, these factors continued to be an industry challenge. In 2013, the FAA conducted a study on flight deck safety and generated four recommendations to industry that were related to cultural and language differences. One of those recommendations was that the FAA should ensure that procedures and checklists be designed using simplified technical English. The FAA (2013) re-iterated crew alerting indications (e.g. symbols and text) should afford ability to be understood by international flight crew populations that speak English-as-a-second language. But, does ESL flight crewmember English language proficiency and background knowledge of written English language on crew alerting systems, enable them to read and understand technical information on these systems? The FAA (2013) also provided a recommendation regarding simplified technical English. However, they did not discuss factors within checklist design that may have an effect on the ability of ESL flight crewmembers to read and understand text. One of these factors may be related to sentence length (long text versus short text). Sentence length may be a factor that has the potential to impact ESL flight crewmember reading comprehension. Furthermore, does simplified text or long length (elaborate) text impact ESL flight crewmember reading comprehension, and thus their performance? These factors should have been addressed in the FAA report.

In yet another accident related to written English language technical information challenges on ESL flight crewmembers, Laird (2006) revealed challenges on their ability to respond to a crew alert. Language barriers have the potential to confuse, delay receptiveness, or cause a flight crewmember to make an undesirable decision in the operational environment. In 1993, Chinese flight crewmembers crashed a MD-80 aircraft. A factor that may have contributed to the cause of the crash of China Northern flight 6901 was the flight crewmember's misunderstanding of the aural warning from the Ground Proximity Warning System (GPWS). According to the report, the pilot did not understand the meaning of 'Pull Up' (Laird, 2006). Although the China Northern flight

6901 accident report describes misunderstandings in the interpretation of written English language by ESL flight crewmembers, it does not provide detailed information as to why ESL flight crewmembers were challenged with the alert warning and phrase ‘pull up’. The ability of ESL flight crewmembers to understand and utilize English written technical documentation (e.g. GPWS alert configuration warnings in the QRH/Flight Crew Operations Manual (FCOM)) on the flight deck is also essential, especially when responding to crew alerts. However, there was no discussion on the relationship between ESL flight crewmember use of the GPWS with respect to their English language proficiency and background knowledge of the text (e.g. vocabulary words, text genre). Furthermore, there was no discussion on factors that may have negatively impacted ESL flight crewmember understanding of written English language FCOM/QRH technical procedures. As these types of procedures can be utilized in conjunction when responding to a displayed alert, there should have been a discussion on ESL flight crewmembers’ understanding regarding each of these systems. In particular, factors such as vocabulary word type, text genre, and abbreviated text on the GPWS and QRH/FCOM technical procedures may have influenced ESL flight crewmembers ability to respond adequately to the alert. But, these factors are not discussed in the accident report.

Another noteworthy accident occurred on September 13, 2008, when a Boeing 737 crashed on the approach phase of flight. The Interstate Aviation Committee (IAC) of the Aircraft Accident Investigation Commission concluded that the co-pilot had “learned technical English at a non-certified training center and the teachers who conducted the training did not have any aviation, linguistic or pedagogical education. It was also noted that the co-pilot’s level of English language proficiency did not allow him to make proper use of technical documentation on the flight deck” (IAC, 2009, pg. 131). The report suggested that English language proficiency requirements should be developed for personnel that use technical documentation written in English on the flight deck. It was recommended that warnings such as the ‘Bank Angle’ roll authority phrase, which is spoken in English by an artificial voice, should be designed to include written English language directional considerations. Design of directional considerations should aid ESL flight crewmembers ability to understand written English language technical information such as aircraft right or left. Lastly, it was noted that flight crews’ training (background knowledge) was on a Russian built aircraft and they were transitioning to a Western built flight deck (IAC, 2009). Although the IAC discussed contributory causes of the accident related to ESL flight crewmembers English language proficiency, and challenges they faced during the approach phase, there is not enough information to conclude if ESL flight crewmembers’ English language proficiency impacted their reading comprehension of written English language procedures. The report fails to provide a detailed examination of the factors that influenced the ESL flight crewmembers performance on the flight deck. This may be important regarding use of flight deck crew alerting and information systems. Certain aspects such as ESL flight crewmembers demographics with respect to background/residency were not discussed in the accident report, and should have been included. Particularly, there was no indication if ESL flight crewmembers had any experience with English language in different western regions of the globe. This may have contributed to their level of English language proficiency. Also, the report provided recommendations on designing directional information that may enhance ESL flight crewmembers understanding of technical information. But, there was no dialogue on how directional information should be designed to afford adequate use by ESL flight crewmembers. Particularly, there was no discussion as to how vocabulary type and text type may influence ESL flight crewmembers understanding of the design of directional information. Furthermore, does design of directional control information on a warning display account for ESL flight crewmembers ability to read and understand written English language technical information on QRH/FCOM procedures? In other words, are there written English language design and integration features that enable ESL flight crewmembers with different English language proficiency levels, the ability to adequately read and comprehend written English language? These types of questions will be answered in the researcher's literature review and studies.

On July 6, 2013, a Boeing 777-200 crashed during the landing phase. In a technical report issued by Boeing to the NTSB, there was an indication that ESL flight crewmembers utilized the Engine Indicating and Crew Alerting System (EICAS) during the landing phase. It was determined that ESL flight crewmembers may be challenged more often speaking English language than comprehension of written English language (Boeing, 2014). However, the Boeing report fails to describe the challenges with comprehension of written English language on the flight deck, and the associated gaps that may exist between ESL flight crewmembers and their understanding of written English language technical documentation. According to the NTSB, there were inadequacies in written English technical documentation, specifically information related to the auto-throttle logic, and how it was interpreted by ESL flight crewmembers (NTSB, 2014).

Other noted concerns have been found on ESL adult use of aeronautical technical written English language and their proficiency challenges. The Civil Aviation University of China indicated that approximately 80 percent of their ESL adults have determined that English language and vocabulary use is considered a challenge and barrier with respect to reading comprehension (Wang, 2011a). Language challenges with respect to ESL flight crewmembers use of safety related technical documentation on the flight deck, has been noted as a contributor to ESL flight crewmembers misunderstandings.

According to Ho (1996), approximately 30 percent of ESL flight crewmembers experienced barriers interpreting written English language flight safety technical documentation. The ESL flight crewmembers experienced problems with understanding the operational procedures manual. Although Ho (1996) documented information on ESL flight crewmember misunderstandings of safety related data, it was also stated that ESL flight crewmembers should use English on the flight deck but not during non-normal conditions. Furthermore, it was noted that there is a need to provide manuals that are designed in a different language, perhaps the native language of the ESL flight crewmember. But, Ho (1996) does not provide an indication of the consequences that may result from translating written English language manuals into another language. According to aforementioned research, emergency conditions can create performance challenges for ESL flight crewmembers using written English language technical documentation, according to findings from several aircraft accidents. Utilization of written English language technical documentation appears to be difficult to read and interpret by ESL flight crewmembers. However, does translation of written English language documentation into another language remedy reading comprehension challenges for ESL flight crewmembers? According to Ogilvie (1984), since many pieces of technical information on the flight deck are considered technical English language terminology, translation of English language into another language has the potential to impact word meaning and thus leads to misinterpretation by flight crewmembers. Impact of translating written English language into another language, and the impact on ESL adults/flight crewmember performance, will be further investigated throughout the context of the thesis.

1.4.1 Section Summary

This section provided information on the factors that influence ESL flight crewmembers ability to read and understand technical information. Details from FAA studies and accident investigations revealed concerns about the ability of ESL flight crewmembers to read and interpret vocabulary words, but do not scrutinize these issues thoroughly. English as-a-second language English language proficiency and background knowledge was not thoroughly investigated, with respect to their ability to read written English language technical information. Research studies indicated translation of written English language could remedy reading comprehension of written English language technical information issues ESL flight crewmembers experience on the flight deck. But, it was also indicated that translation of written English language technical information into ESL flight crewmembers native language could impact word meaning. The next section provides information on English language proficiency and factors that could influence ESL flight crewmembers use of written English language.

1.5 Industry review of English language Proficiency and Industry Concerns

Another factor that may influence ESL flight crewmembers' ability to read and understand written English language technical information, is their written English language proficiency. English as-a-second language flight crewmembers are required to meet various English language proficiency requirements before they become rated as an airline pilot. One of the requirements for flight crewmembers (ESL and native flight crewmembers) is their ability read English language per 14 CFR 61.153 subpart B. Conceivably, this requirement should include an ESL adult's ability to read and comprehend written English language technical information on the flight deck (i.e. crew alerting information and QRH checklists). Since ESL flight crewmembers utilize these systems on the flight deck, they should have an adequate grasp of reading and interpreting English language. But, the FAA regulations do not highlight the need for ESL flight crewmembers to be proficient with reading and interpreting English language technical information. It appears as if ESL flight crewmembers ability to read technical information is assumed by the regulator, and therefore governed by the 14 CFR 61.153 subpart B statute. But, the FAA cannot assume that each ESL flight crewmember that reads information on the flight deck is proficient with their use of technical information. As the ability for ESL flight crewmembers to read and comprehend English language are factors that have the potential to impact their performance, these factors are not discussed in 14 CFR 61.153. Regarding certification of airline pilots, ability to read English language is often a pre-requisite to becoming an airline pilot. Ability to read English language is often documented as a minimum requirement established by federal agencies, (i.e. FAA and European Aviation Safety Administration (EASA)) before ESL flight crewmembers may obtain an Airline Transport Pilot (ATP) certification. The ATP is a common certification for airline pilots in the U.S.A., and it is also the standard rating for ESL pilots (ECFR, 2016).

Other requirements levied on ESL flight crewmembers are related to other features of English language, like the International Civil Aviation Organization (ICAO) English Language Proficiency Requirements (ELPRs). Their requirements do not focus on ESL flight crewmembers ability to read English language; instead ICAO incorporates requirements related to English language proficiency (i.e. listening comprehension and speaking skills). The ICAO has noted that ELPRs are important to evaluate pilot and air traffic controller listening and speaking skills, with respect to radiotelephony communication (ICAO, 2004). In 2004, the ICAO study on ELPRs indicated by 2008 all ESL flight crewmembers must meet the minimum English language proficiency level, which was level four (adequate use of English language) regarding flight deck communications with ATC. This requirement is currently be levied by the ICAO (ICAO, 2010). The ICAO regulatory statute of minimum English language proficiency level 4 is an indication that ICAO has considered homogeneity of ESL flight crewmembers with respect to their English proficiency. The ICAO has also indicated levels 5 and 6 English language proficiency levels (excellent levels of English language proficiency) is also their perspective on having heterogeneity among ESL flight crewmembers. In other words, advanced levels (level 5 and 6) English language proficiency creates diversity among ESL flight crewmembers giving them the opportunity to excel beyond level 4 (operational). Nevertheless, ICAO provides no indication of any requirements that stipulate homogeneity amongst all ESL flight crewmembers, with respect to their ability to read and comprehend English written language on crew alerting and information systems. Therefore, ESL English language proficiency requirements with respect to reading comprehension should be standardized.

The ICAO's lack of reading comprehension levels levied on ESL flight crewmembers, and lack of a standard level of proficiency, could be an indicator that new methods need to be established. This may also be an indicator to investigate reading comprehension problems that ESL flight crewmembers may experience using technical information on the flight deck. Even though ability to read, speak, listen, and comprehend English language are interrelated cognitive themes, there is a gap between FAA and ICAO philosophical approaches on English written language. The ICAO has often stated "there are three distinct roles of language as a factor in aviation accidents and incidents [they are:] use of phraseologies, proficiency in plain language, and the use of more than one language" (ICAO, 2004, p.xii). The ICAO noted that in "accidents investigated by the NTSB, insufficient language proficiency on part of the flight crew or controller had played a contributing role in the chain of events leading to the accident" (ICAO, 2004, p.1-1). Although the ICAO's previously stated claims on English language proficiency appear to be leading indicators that negatively impact ESL flight crewmember performance, there is a lack of investigation into factors that influence ESL flight crewmember English language proficiency with respect to their ability to read and comprehend technical information on the flight deck. Regardless of ESL flight crewmembers ability to speak, listen, and comprehend English language on the flight deck during radiotelephony operations, there could be other factors that impact their performance. The following questions need further scrutiny and will be explored in the thesis:

What other fundamental issues impact ESL flight crewmembers English language reading/comprehension proficiency on the flight deck? Are ESL flight crewmembers ATP ratings an effective method to assess their English language reading abilities? Does their English language proficiency level impact their ability to read and understand the design of written English language technical information on the flight deck? Does technical aviation written English procedures (e.g. phrases, words, acronyms, and abbreviations) negatively impact ESL flight crew performance, with respect to responding to flight deck crew alerting? These questions will aid the researcher in understanding ESL flight crewmembers English language demographics. English as-a-second language flight crewmembers English language experience demographics may facilitate understanding of leading indicators, which may impact the ability of ESL flight crewmembers to read and understand English language.

1.5.1 Section Summary

Government standards provide an indication that reading, comprehending, and speaking English language may have an influence on their ability to use English language on the flight deck. Lack of standardization and evaluation of ESL flight crewmembers ability to read and understand written English language on the flight deck was revealed. It was noted that there is a need to standardize ESL proficiency levels with respect to written English language on the flight deck. This is needed to ensure that ESL flight crewmembers are proficient with reading and comprehending written English language. The next section provides more details on the impact of ESL English language proficiency on the flight deck.

1.6 English language Proficiency Indicators, aircraft accident factors, and future directions

Causal factors from previously discussed aircraft accident investigations highlight negative impacts related to ESL flight crewmembers' performance with respect to English language proficiency. However, aircraft accident investigation reports do not elaborate on ESL flight crewmember English language proficiency deficiencies on the flight deck. This may be the result of no standards that assess impact of ESL flight crewmember English language reading comprehension proficiency on their performance. Since there are no standards that assess impact of ESL adults reading comprehension of written English language on crew alerting and information systems, assessing their performance on the flight deck may be difficult. Previously stated, ICAO ELPRs only focus on ESL adult ability to listen, speak and comprehend radiotelephony operations. The ICAO ELPRs have been utilized as a means of describing ESL flight crewmembers

English language proficiency on the flight deck. According to IAC (2013), obtaining an adequate level of ICAO English language proficiency does not provide evidence that ESL flight crewmembers have the ability to adequately read, understand, and use written English language operational procedures documentation on the flight deck. The Russian Federation IAC (2013) revealed that complexity of sentence structure and vocabulary words in technical manuals has the potential to negatively impact ESL flight crewmembers' competency using written English language. The Russian Federation did not disclose vocabulary word types that may have caused difficulties with interpreting the technical manuals. There is also a gap in the report written by the Russian Federation regarding vocabulary text type. There was no indication that the type of written English language (vocabulary words) challenged ESL flight crewmembers' reading comprehension. The Russian Federation also indicated that ESL flight crewmembers' English language proficiency needs to be addressed, and performance measures developed to further understand the issue of ESL flight crewmembers use of operational procedures documentation written in English language. Even though these recommendations were provided by the agency, a more focused approach on factors that influence ESL flight crewmembers reading comprehension and their proficiency on vocabulary types, and text types needs further scrutiny. Therefore, several questions emerge from details of the Russian Federation's investigation. In particular, are there different types of written English language vocabulary words that impact ESL flight crewmembers proficiency and performance on the flight deck? Are there written English language text types that impact their proficiency and performance? Does more than one type of vocabulary word appear on written English language technical information, and does the combination of vocabulary word types on written English language technical information, impact ESL flight crewmembers performance? The aforementioned ESL flight crewmembers English language proficiency insights were the result of an ATR-72-201 fatal airplane crash in 2012 investigated by IAC. The previous questions identified should be further investigated with respect to how the factors identified impact ESL flight crewmember performance. These types of questions will be answered in the literature review and researcher's studies. Collectively, perspectives discussed previously have the potential to impact ESL flight crewmembers on the flight deck. Written English language design, ESL flight crewmembers English language proficiency are interactive factors that have the potential to impact ESL adults reading comprehension of written English language on the flight deck.

1.6.1 Section Summary

This section revealed that ESL flight crewmember English language proficiency is a factor that influences performance on the flight deck, and was a contributory cause in the ATR-72-201 investigative report. It was noted that more research is needed regarding ESL flight crewmembers' proficiency and use of written English language technical information on the flight deck. Next section provides an overview of flight deck engineering and system design principles. It also discusses impact of crew alerting systems and QRH checklists design on ESL flight crewmember performance.

1.7 Introduction to Flight Deck Engineering: crew alerting and information systems design challenges on ESL flight crewmembers

Previous discussion on factors that influence ESL flight crewmembers English language proficiency and procedural divergence warranted a more in-depth review of pre-cursors that impact ESL flight crewmember performance using flight deck crew alerting and information systems on the flight deck. Purpose of this section is to provide an overview of flight deck engineering design features used in Western designed crew alerting and information systems. Overview of written English language design challenges on crew alerting and information systems is also provided. Lastly, a preview of ESL flight crewmember performance challenges attributed to design of written English language technical information on crew alerting and information systems is discussed.

Figure 2 provides the reader with a visualization of the concepts covered throughout this section. Top circle and two sub-circles in the figure represent design philosophy for crew alerting and information systems. Intent of reviewing design philosophy is that it could drive ability of ESL flight crewmembers to read and understand written English language on crew alerting systems and QRH checklists. Boxes on the left and right indicate fundamental factors that impact ESL flight crewmembers ability to read and comprehend written English language (ESL flight crewmembers English language proficiency and reading comprehension). Two boxes at the bottom of the paradigm represent examples of written English language characteristics on crew alerting systems and QRH checklists.

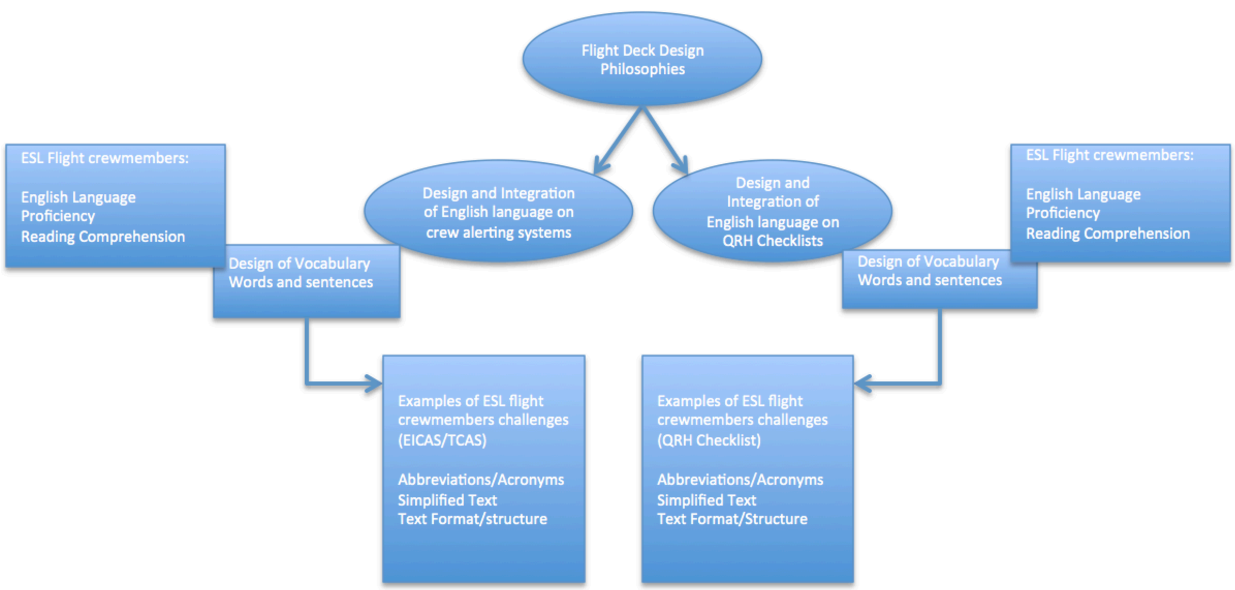


Figure 2: Visualization Roadmap

1.7.1 Design of Crew Alerting Systems and ESL flight crewmembers challenge

Modern flight decks are designed with an English language emphasis. Systems are provided on the flight deck and include an array of crew alerting information systems (e.g. EICAS and QRH procedure checklists). Written English language procedures are designed considering complexity of tasks as well as corresponding crew alerting information (e.g. low hydraulic fluid) (Degani, 1992, Degani and Wiener, 1998). Written English language characteristics on crew alerting and information systems are critical regarding design philosophy of systems, and should be considered when integrating the human system interface. Furthermore, compatibility of written English language is important when considering use of crew alerting and information systems by ESL flight crewmembers (Hutchins et al, 2006). Understanding different linguistic characteristics helps define the user requirements for the design of systems (Smith-Jackson and Wogalter, 2000b), which is a function of the systems engineering process. Human factors engineering considerations with respect to clarity and consistency in the layout, logic, and application of written English language characteristics on crew alerting and information systems are paramount. Design of crew alerting and information systems should preclude the possibilities of ambiguous and non-essential written English language technical information. Usability of these systems by ESL flight crewmembers should not hinder their ability to interpret written English language technical information. Western designed crew alerting and information systems should allow crewmembers to respond adequately with information that is understandable to ESL flight crewmembers.

Often, there are tasks on the flight deck that require ESL flight crewmembers to be proficient in written English language. Their ability to use background knowledge of written English language technical information adequately while responding to crew alerts, and executing procedures becomes essential to the task. Alerts such as warnings, cautions, and advisories are displayed on crew alerting systems in the form of English written text. According to Laughery and Paige-Smith (2006), a warning should contain written language appropriate for all individuals who may read, and comprehend using a different language. There are many written English language technical information characteristics (e.g. abbreviations and phrases) on crew alerting and information systems. To convey relevant aspects of written English language technical information on crew alerting and information systems, the researcher will provide two examples of crew alerting (Crew Advisory and Warning Display System (CAWDS) and Traffic Collision Avoidance System (TCAS)) and an information system. Researcher will review these systems and its features. Details of these systems features and their significance on ESL adults/flight crewmember reading comprehension of English written language will be discussed in forthcoming chapters. These types of system features are representative of the design and integration of written English language, and describe the details that the researcher intends to cover throughout the thesis. These features will allow the researcher to provide the reader with an understanding of potential challenges ESL flight crewmembers may encounter while using these types of systems.

Figure 3 is a pictorial example of a type of alert system commonly utilized in the airline industry to alert flight crewmembers of system health. Another system commonly utilized for alert information is TCAS (air traffic situation awareness related alerting). Previously stated, CAWDS and TCAS are utilized by ESL flight crewmembers to understand various system health and flight path management aspects. Alert system synoptic(s) and corresponding technical English language written text conveys system health status. This information assists ESL flight crewmembers with understanding adequacy of system functionality, including non-normal conditions such as malfunctions/failures. Flight path management written English language text on the TCAS display provides avoidance criteria, warnings and cautions to alert ESL flight crewmembers about issues that may require their situation awareness. On the CAWDS display, information is designed to follow a linear, direct and focused reading, a common practice utilized on alert displays that are designed with a Western culture emphasis (Ulijn and Strother, 2012). Information on the CAWDS (Figure 3) is designed to follow a logical flow, which conveys information related to system health status. Written English language technical information on CAWDS is designed with consideration of appropriate hazard level identification such as warning and caution with corresponding hues. Abbreviations/acronyms, phrases, and sentences are utilized to describe alert situations. There are several different types of vocabulary words, abbreviations, and phrases that are mixed within the structure of the alert indicators. Vocabulary words on the alert indicators appear to be simplified. On the CAWDS, some areas on the indicator system show text related to fuel pressure. The TCAS contains written English language text that emphasizes hazard level identification (e.g. warning and caution) with corresponding hues to identify situation severity. The TCAS also conveys combined word and numbering schemes, which provide appropriate level of detail on terrain and traffic locations. Like the CAWDS, there are an abundance of abbreviations/acronyms, and phrases on the TCAS. There are no sentences that describe the alert situation on the display. Perhaps, the reason no sentences exist may be due to an inability to provide sentences on this type of alert display due to space limitations. Or, some vocabulary words on the TCAS may be adequate for ESL flight crewmembers reading comprehension of the situation, thereby making it impractical to have sentences on the alert display. However, more research will be conducted to understand these possible challenges on ESL flight crewmembers reading comprehension.

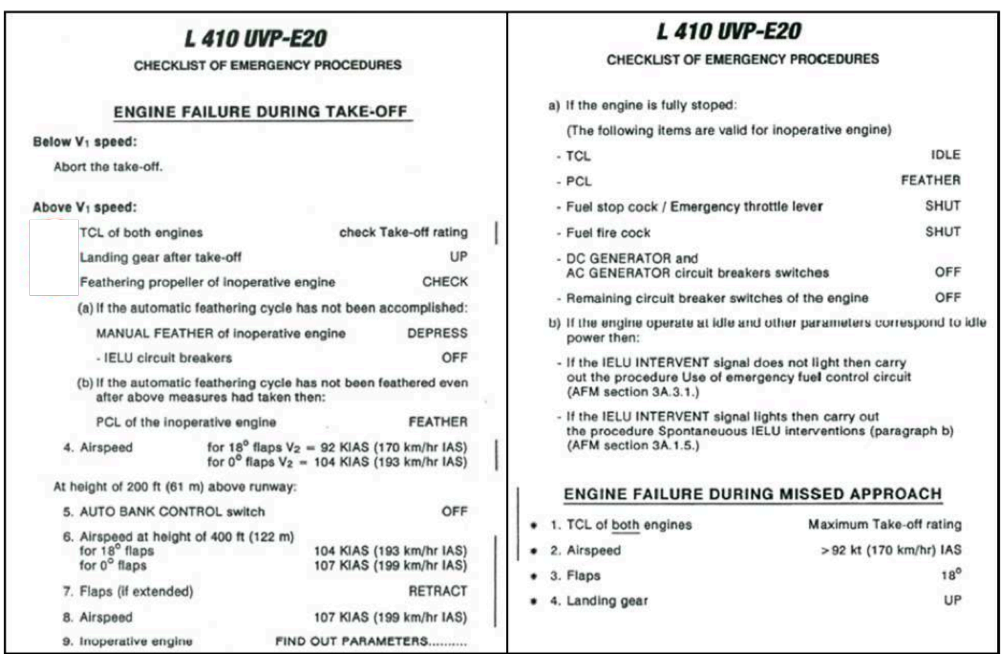
From NTSB (2011)

Figure 3 CAWDS

1.7.2 Design of Information Systems and ESL Flight Crew Members Challenge

Corresponding technical documentation (e.g. FCOM and QRH checklist) provide ESL flight crewmembers with information to resolve various system issues on the flight deck, including crew alert messages. Such alerts require ESL flight crewmembers background knowledge of system health, failure modes, and require ESL flight crewmembers keen understanding of how to effectively solve problems related to crew alerts. Problem solving on the flight deck requires ESL flight crewmembers ability to read, comprehend, and execute various tasks using technical documentation with an English language emphasis. Tasks are designed to ensure that information on flight deck crew alerting systems and corresponding technical procedures meet crewmember mental model expectations, so that they have adequate information to maintain safe flight. Problem solving is especially important when responding to aircraft non-normal/emergency conditions that require use of Western built information systems. For example, a QRH checklist may be utilized to diagnose an engine failure or electrical system failure. The QRH checklist is a common type of checklist, developed by manufacturers of an airplane and contain technical information that generally coincides with information displayed on the alert system (i.e. warning, cautions, advisories).

Figure 4 is an example of written English language technical information utilized by ESL flight crewmembers in response to an engine failure on takeoff. Key aspects shown in Figure 4 are examples of written English language design style features. The QRH checklist follows a left to right reading style, typical of written English language cultural characteristics (Ulijn and Strother, 2012). The QRH paper checklist includes different types of acronyms/abbreviations, phrases, sentences, and emergency conditions wording that are mixed within the structure of the QRH checklist. Sentence structure is different in many areas on the QRH checklist, including some sentences that do not contain all of the elements that make-up a sentence, and thus appear to be simplified. The format is also different in each section of the QRH checklist.


L 410 UVP-E20

CHECKLIST OF EMERGENCY PROCEDURES

ENGINE FAILURE DURING TAKE-OFF

Below V_1 speed:

Abort the take-off.

Above V_1 speed:

TCL of both engines — check Take-off rating
Landing gear after take-off — UP
Feathering propeller of inoperative engine — CHECK

(a) If the automatic feathering cycle has not been accomplished:
MANUAL FEATHER of inoperative engine — DEPRESS
- IELU circuit breakers — OFF

(b) If the automatic feathering cycle has not been feathered even after above measures had taken then:
PCL of the inoperative engine — FEATHER

4. Airspeed — for 18° flaps V_2 = 92 KIAS (170 km/hr IAS); for 0° flaps V_2 = 104 KIAS (193 km/hr IAS)

At height of 200 ft (61 m) above runway:

5. AUTO BANK CONTROL switch — OFF
6. Airspeed at height of 400 ft (122 m) — for 18° flaps 104 KIAS (193 km/hr IAS); for 0° flaps 107 KIAS (199 km/hr IAS)
7. Flaps (if extended) — RETRACT
8. Airspeed — 107 KIAS (199 km/hr IAS)
9. Inoperative engine — FIND OUT PARAMETERS..........

L 410 UVP-E20

CHECKLIST OF EMERGENCY PROCEDURES

a) If the engine is fully stoped:
(The following items are valid for inoperative engine)
- TCL — IDLE
- PCL — FEATHER
- Fuel stop cock / Emergency throttle lever — SHUT
- Fuel fire cock — SHUT
- DC GENERATOR and AC GENERATOR circuit breakers switches — OFF
- Remaining circuit breaker switches of the engine — OFF

b) If the engine operate at idle and other parameters correspond to idle power then:
- If the IELU INTERVENT signal does not light then carry out the procedure Use of emergency fuel control circuit (AFM section 3A.3.1.)
- If the IELU INTERVENT signal lights then carry out the procedure Spontaneuous IELU interventions (paragraph b) (AFM section 3A.1.5.)

ENGINE FAILURE DURING MISSED APPROACH

- 1. TCL of both engines — Maximum Take-off rating
- 2. Airspeed — >92 kt (170 km/hr) IAS
- 3. Flaps — 18°
- 4. Landing gear — UP

Figure 4 L410 UVP-E20 Aircraft QRH Checklist: From IAC (2013)

Crew alerting systems and QRH checklist previously discussed represent how written

English language technical information was designed so that ESL flight crewmembers may use the information in response to crew alerts. Arrangement of information, style, and logic flow of information is noted on both displayed crew alerts and the QRH checklist. Even though the design of information is considered an important aspect of crew alerting and information systems, design has the potential to impact ESL flight crew usability and thus performance. Understanding ESL flight crewmembers differences in their cognitive processing of written English language information is paramount, especially factors that may influence operator performance (Smith-Jackson, 2006; Riley et al, 2006). Cognitive factors that may influence ESL flight crewmember reading comprehension of technical information include English language literacy and proficiency. According to Burian (2006) ESL flight crewmembers have the potential to experience cognitive difficulty with interpretation of information on checklists.

Written English language interpretation difficulties on checklists can be related to design ambiguities such as phrases, abbreviations, and acronyms. It may be easy to read literature when the language is familiar to the individual reading written English language (native English language individuals), but, if the reader is accustomed to understanding a different language (ESL individuals), they may not understand the abbreviations or acronyms adequately (Hartley, 1994). Abbreviations and acronyms should be designed adequately so that technical information on checklists may be followed by ESL flight crewmembers, and thus allowing them to respond effectively to the alert. According to Dyson (2004), configuration of data may impact reading comprehension of information on paper. Configuration of data can also impact ESL flight crewmembers information processing on displayed crew alerts. Mangen et al (2013) stated that with respect to linear text on paper, adequate spatial integration of technical information and layout has the potential to support memory and recall of information. However, design inconsistencies with use of English language on checklists have the potential to cause misunderstandings and even disregard for checklist procedures (Degani and Wiener, 1998). According to Flight Safety Foundation (2015), the International Federation of Airline Pilots Association (IFALPA) indicated a large number of ESL flight crewmembers use written English language QRH checklists on the flight deck. Therefore, checklists should be written clearly and refrain from ambiguous language in text corpora. Spelling out abbreviated text is important wherever possible on checklists to afford understanding by ESL flight crewmembers. For example, V_{NE} is abbreviated for a reference speed 'not exceed', related to aircraft airspeed based on aircraft condition during typical phase of flight (e.g. takeoff/landing).

With respect to design of checklists, ESL flight crewmembers should not have to translate written English language technical information back in to their native language to solve problems on the flight deck. Written English language technical documentation should be written in a format that is compatible with ESL flight crewmember expectations. However, ESL flight crewmember reading comprehension can be impacted by design of English language (e.g. sentence length, simplified text). According to Hutchins et al (2006, p.5), with respect to checklists, "strings of characters that name the procedure cannot be translated because translation would destroy the correspondence between the form of the message and the form of the procedure name." In other words, string of characters such as 'FUEL SHUTOFF' may not be translated. On the other hand, Drury and Ma (2005), indicated that certain pieces of aviation technical written information may be translated and still retain its understanding even if it were fully translated. They also indicated that certain written English language technical terms should not be translated because its translation may be very difficult to understand by the non-native English individual. Such technical terms like rudder and empennage are universally accepted technical terms and are understood by many cultures. Deleting or adding information as a result of a translated language by ESL individuals can be the result of misunderstandings with syntactic sentence structure. Words and sentences that are unfamiliar to an ESL individual can be attributed to errors of omission and commission (Dordick, 1996). Design of English language can lead to misunderstandings of English language. Misunderstandings of written English language by ESL individuals can lead to translation of written English language technical information into ESL adult native language. This behavior has the potential to impact ESL adults understanding of information, if the word or sentence is not the same word or sentence translation with the same meaning in ESL adults native language. This can cause ESL adults to revert back to English language. According to Kobayashi and Rinnert (1992), reverting back to English language can occur because an ESL adult lacks understanding of translated syntax meaning. This behavior by ESL individuals can result in inappropriate translation of technical information back into their native language.

Displayed crew alerts should follow many of the aforementioned written English language design criteria, and design goals to preclude misunderstandings of English language by ESL flight crewmembers. Visual ergonomics (English text design) associated with locating information on a display can impact information access as well as reading and comprehension (Holzinger et al, 2011). Since display space is limited for the amount of crew alerting information that is allocated on a screen, does the design of sentences, phrases, abbreviations and acronyms have the potential to impact ESL flight crewmembers cognitive processing of information? Indeed, abbreviations do appear on alert systems (e.g. ECAM and EICAS) often, and space is limited, but there is still a need to investigate the effects of written English language abbreviations on ESL reading comprehension (DeBrito, 1998). According to Hutchins et al (2006), written English language text on displays appears in different formats such as abbreviations and acronyms. Careful considerations regarding design of phrases and other pieces of technical information on displays has the potential to impact performance. Amount of written English language technical information on displays would seem critical to ESL flight crewmembers ability to understand written English language. The FAA (1996) indicated that displayed safety related warning information has the potential to impact ESL understanding of written English language, especially abbreviated text. As Wogalter et al (1997) indicated there is a disparity in research on factors that influence how effectively ESL individuals read and understand written English language safety related alerts (e.g. warnings). What is the degree of ESL flight crewmembers reading ability and understandability of safety related alerts on crew alerting systems? Does their English language proficiency of written English language improve or exacerbate misunderstandings of safety alert information in different formats? Do ESL flight crewmembers have adequate background knowledge of written English language on crew alerting and information systems? These questions will be answered within the context of the thesis.

1.7.3 Chapter Summary

In the beginning of this chapter, the researcher provided a brief overview of written English linguistic challenges on ESL crewmembers in different sectors of the transportation industry, including aviation maintenance. There were noted gaps in the MAIB investigative report regarding written English language challenges on ESL crewmembers. It was noted that challenges that ESL crewmembers experienced in the MAIB investigated ship accident, are indeed relevant to difficulties that ESL flight crewmembers experience while using written English language on the flight deck.

This chapter also provided an introduction to the problem of written English language issues in the airline industry. Particularly, use of written English language by ESL flight crewmembers on the flight deck was explored. The researcher discussed many airline aircraft accidents. Aircraft accidents discussed revealed that a multitude of cognitive variables (e.g. vocabulary reading comprehension, text types, and word meaning) impact ESL flight crewmembers' ability to read and understand written English language technical information. Overall, aircraft accidents indicated that ESL flight crewmembers' reading comprehension abilities were linked to written English language misunderstandings on the flight deck. As there were noted gaps in the investigation reports related to written English language impact on ESL flight crewmembers performance, the researcher provided an indication that more research will be conducted to fill these types of gaps throughout the literature review and studies.

Government agencies provided inputs on factors that influence written English language barriers on the flight deck, with respect to flight deck crew alerting and information systems. General overview of written English language technical documentation use by ESL flight crewmembers, and flight deck crew alerting and information systems was discussed. Overview of AIA, EAAI, ICAO and FAA research on language challenges regarding ESL flight crewmembers was also discussed. Both ICAO and FAA determined there is a need to research impact of ESL flight crew performance with respect to their use of written English language technical documentation and response to crew alerts. It was also noted that FAA regulations indicate the need for ESL flight crewmembers to have the ability to read English language. But, their regulations do not elaborate on ESL flight crewmember reading comprehension or context of English language use on the flight deck. The ICAO provided details on the scope of ELPRs, but it was noted that their regulations do not cover ESL adult ability to read English language.

Collectively, it was determined that there is a gap between the two agencies regarding ESL flight crewmembers ability to read and understand English language. Therefore, more research is needed to understand the impact of ESL flight crewmembers ability to read and comprehend English language on the flight deck. The AIA and EAAI determined that more research on ESL flight crewmembers is needed, with respect to their use of system diagnostics with an English language emphasis. Since English-language-based flight decks are operated by ESL flight crewmembers, there is a need to research impact of written English language on ESL flight crewmember performance. Particularly, design and integration factors such as vocabulary type, text genre, and sentence length need to be investigated, as these factors could impact ESL flight crewmember reading comprehension.

English as-a-second language strategy utilized to read and understand written English language technical information, could also impact how well they read and comprehend written English language. English as-a-second language flight crewmembers level of English language proficiency and background knowledge of written English language technical information are demographic factors that could contribute to how well ESL flight crewmembers understand written English language. These are some of the factors that need to be further investigated, with respect to design of written English language on crew alerting and information systems, and the effects these factors have on ESL flight crewmembers performance.

Introduction to flight deck engineering provided an overview of how inconsistent use of written English language in the design of crew alerting systems, has the potential to cause misunderstandings and negatively impact human performance. Aforementioned design factors should be considered as part of the human factors engineering design of crew alerting and information systems. Critical design questions that address the impact of written English language technical information design on flight deck crew alerting and information systems, should be proposed to designers of information on displays and corresponding procedures. These design questions should be highlighted in the preliminary design and critical design review phases of product development. Moreover, these questions should address the impacts on ESL flight crewmember performance, and how to effectively design crew alerting and information systems to accommodate ESL flight crewmembers on the flight deck. After all, design of written English language technical information on crew alerting and information systems has the potential to impact ESL flight crewmember interaction with these systems. Written English language design could impact their reading comprehension abilities, and strategy utilized to read and understand written English language.

English as-a-second language background knowledge of written English language technical information could also impact their ability to read and understand text. English as-a-second language ability to read written English language technical information has the potential to impact ESL flight crewmembers performance. Structure and layout of written English language technical information on crew alerting and information systems, have the potential to confuse or lead to misunderstandings by ESL flight crewmembers on the flight deck. Translation of written English language technical information into an ESL flight crewmember native language has the potential to impact their reading comprehension.

Although design of written English language appears to be a critical component in the development and design of crew alerting and information systems, there are many other factors that can impact ESL flight crew performance and their use of written English language technical information. Fundamentally, chapter three provides in-depth reviews of English language literacy and proficiency challenges with respect to ESL adult use of written English language. These factors need to be discussed so that there is a clear understanding regarding the underpinnings of written English language challenges on ESL adults. Finally, the researcher will address the extent to which written English language has the potential to impact design of crew alerting and information systems. This will be accomplished by exploring written English language challenges on ESL adults.

From an industry standpoint, there has not been an adequate alignment between the causes and effects that negatively impact ESL flight crewmembers English language proficiency and their reading comprehension abilities, when using written English language on technical information. Additionally, there has not been an adequate alignment between ESL flight crewmembers background knowledge of vocabulary words/text genre, and their ability to read and understand written English language technical information. Earlier reported challenges on ESL flight crewmembers performance while using written English language technical information should be adequately investigated with respect to design and use of Western built crew alerting and information systems by ESL flight crewmembers. There has not been an adequate global execution plan to harmonize English language gaps that exist between ESL flight crewmember ability to read and comprehend written English language, and use of written English language on flight deck crew alerting and information systems. Therefore, an investigation into precursors that negatively impact ESL flight crewmember performance managing crew alerting and information systems on the flight deck is necessary.

The goal of the researcher's investigation into these issues is to support many of the current and past initiatives that government and industry have mentioned, while providing new evidence to substantiate their claims. Following table highlight aforementioned aircraft accident factors that influenced native and ESL flight crewmembers' performance. The table provides a general scope of operational issues discovered in each aircraft accident, so that there is a clearer picture of factors influencing ESL flight crewmembers' performance on the flight deck. Finally, possible crew workload impacts contributing to the accidents are highlighted, so that the reader has an understanding of various types of cognitive factors discussed in the literature review and researcher's studies. Crew workload impacts have the potential to negatively impact flight crewmember performance, and therefore need to be highlighted as potential performance impacts on the flight deck. Overview of these factors will help facilitate an understanding of the type of issues that the researcher will further investigate in various studies.

Table 1 Aircraft Accident Factors

Aircraft Accident Identification	ESL/Native flight crewmembers	Contributory Factors to Aircraft Accident	Operational Impact on Flight Deck	Possible Crew Workload Impact Factor
Q400 Aircraft Accident	Native flight crewmembers	Unclear written English language terminology on QRH checklist	Misinterpretation of crew alerting information (system fault data)	Temporal Demand, Performance
Air Asia Aircraft Accident	ESL flight crewmembers	Challenged by interpretation of a computer-reset function on the QRH checklist. Ambiguous statements confused ESL flight crewmembers	Negatively impacted ESL flight crewmembers ability to solve system problem	Temporal Demand and Mental Demand
A330 Aircraft Accident	ESL flight crewmembers	ESL flight crewmembers were challenged with interpretation of technical documentation on the flight deck. Lengthy procedure caused ESL adults to experience reading comprehension issues with documentation.	ESL flight crewmembers misunderstandings in technical documentation and ESL flight crewmembers inability to execute procedures adequately impacted their performance	Mental Demand, Performance
Noar Linhas Airlines Aircraft Accident	ESL flight crewmembers	QRH checklist written English language inaccuracies and ESL flight crewmembers reading comprehension challenges	Failure to solve an emergency engine failure on takeoff	Performance
China Northern Aircraft Accident	ESL flight crewmembers	ESL flight crewmembers did not understand meaning of Ground Proximity warning system misunderstanding of words 'pull-up'	Failure to respond to Ground Proximity warning system in a timely manner led to limited window of response time	Temporal Demand
Boeing 737 Aircraft Accident	ESL flight crewmembers	ESL flight crewmembers learning of written English language and their English language proficiency	ESL flight crewmembers English language proficiency did not allow them to properly utilize technical documentation on the flight deck	Mental Demand, Performance
Boeing 777 Aircraft Accident	ESL flight crewmembers	Misunderstandings of automated systems and written English language technical information on landing phase. Particularly, the 777 FCOM procedures contained dissimilar wording that was needed to be integrated to solve an issue	May have led to limited window of opportunity to recover aircraft from a low airspeed (aircraft was in a low energy state)	Performance, Temporal Demand
ATR-72 Aircraft Accident	ESL flight crewmembers	Written English language complex sentence structure and vocabulary words on flight deck technical documentation, and English language proficiency	Negatively impacted ESL flight crewmembers ability to read and understand written English language technical documentation on the flight deck	Effort, Frustration, Mental Demand
MD-83 Aircraft Accident	ESL flight crewmembers	Written English language in FCOM is ambiguous regarding flight crew response to aircraft icing conditions and Engine Pressure Ratio issues.	Negatively impacted their response time and ability to read and understand text associated with non-normal conditions	Mental Demand, Temporal Demand

1.7.4 Thesis Objective:

This thesis will explore impacts on ESL flight crewmembers' ability to read and comprehend written English language on the flight deck. Evidence will be provided on factors that effect ESL flight crewmember English language proficiency, background knowledge, and strategy, while they use standardized written English language on flight deck crew alerting and information systems. The researcher will also explore impact of standardized written English language on flight crewmember performance. On the other hand, the researcher will investigate impact of translating written English language into ESL flight crewmember native language to understand impact on their performance. The researcher has proposed the following general hypothesis below for the thesis:

There will be a statistically significant difference and interaction between ESL flight crewmember reading comprehension proficiency and performance when they read and comprehend written English language on QRH checklists and ECAM system, and written

English language on QRH checklists translated into ESL flight crewmembers' native language. Note: Researcher provided specific hypotheses that were tested in the experimental study chapter. Hypotheses contain conditions that were tested, as well as alternative hypotheses.

Overall, chapter one provided the reader with an overview of written English language technical information effect on flight crewmembers. Specific challenges that ESL flight crewmembers experience while using flight deck crew alerting and information systems was discussed. There is a need to explore fundamental challenges of reading and interpreting written English language, and the effects on ESL flight crewmembers. Chapter two provides a discussion on more factors that have the potential to influence ESL flight crewmember performance with respect to design and integration of written English language. Last, summarized compilations of the researcher's literature reviews are provided in Appendix D in the form of several tables. These tables describe each chapter section and main concepts. Tables will also provide limitations (shortcomings) in the studies discussed, and the researcher's approach to fill the gaps of the studies (if there are any), by means of covering the issues in the researcher's preliminary studies and/or experimental study. If there are no shortcomings identified by the researcher, then the tables will contain words 'none identified'.

Chapter 2: Fundamentals of English language literacy and proficiency challenges—the ESL Adult Part I

This chapter focuses on the fundamental challenges that written English language has on literacy and proficiency of ESL adults. Descriptions and discussions of literacy and proficiency factors that may influence ESL adults ability to read, perceive, and understand written English language are discussed. Theories on different types of literacy and proficiency strategies, and ESL adult performance challenges using written English language will be reviewed. The researcher may utilize terms such as ESL 'adult', 'participant', and 'individual' interchangeably throughout the chapter. Operationally defined within the context of the chapter, ESL adults, participants, and individuals are referred to as anyone other than children in the various studies discussed. The researcher chose to analyze research on ESL adults for two reasons: a.) broad differences exist between ESL adults and ESL children English language reading comprehension abilities and proficiency levels b.) English as-a-second language adults occupy captain and first officer positions on the flight deck. Utilizing adults provide a better representation of the type of individual that may experience reading comprehension challenges while using written English language. Finally, there are several instances in the thesis where the term 'written English language' is utilized. For reader clarity purposes, written English language should not be confused with physically handwriting English words; rather the term is used to describe use of written English language in the form of documentation and/or user visual interfaces. Physical handwriting of English words has its own implications on ESL adult readability and understandability in text. Therefore, the researcher's literature review and studies account for written English language on documentation and on the graphical user interface, and thus do not focus on physical handwriting. The following figure provides the reader with a visualization of the concepts covered throughout this chapter and chapter four.

Four circles in the middle of the paradigm Figure 5 illustrate fundamental factors that impact ESL adult ability to read written English language, while the three boxes illustrate supplemental factors that impact ESL adult reading comprehension. That is, ESL adult English language proficiency, background knowledge of English language (i.e. vocabulary words, sentences, and text genre), experiences with using English language (e.g. speaking, reading comprehension), and use of metacognitive strategies all impact the ESL adult ability to read and comprehend written English language. Two circles at the bottom of the paradigm indicate design and integration of crew alerting systems and QRH checklists. English as-a-second language flight crewmembers have the potential to be impacted by use of these systems, based on information in the aforementioned circles and boxes. All of these factors will be discussed through a series of studies that help the reader understand impact of written English language on ESL adult performance. It will also prepare the reader with an understanding of the type of data the researcher intends to capture in various studies on ESL flight crewmember performance.

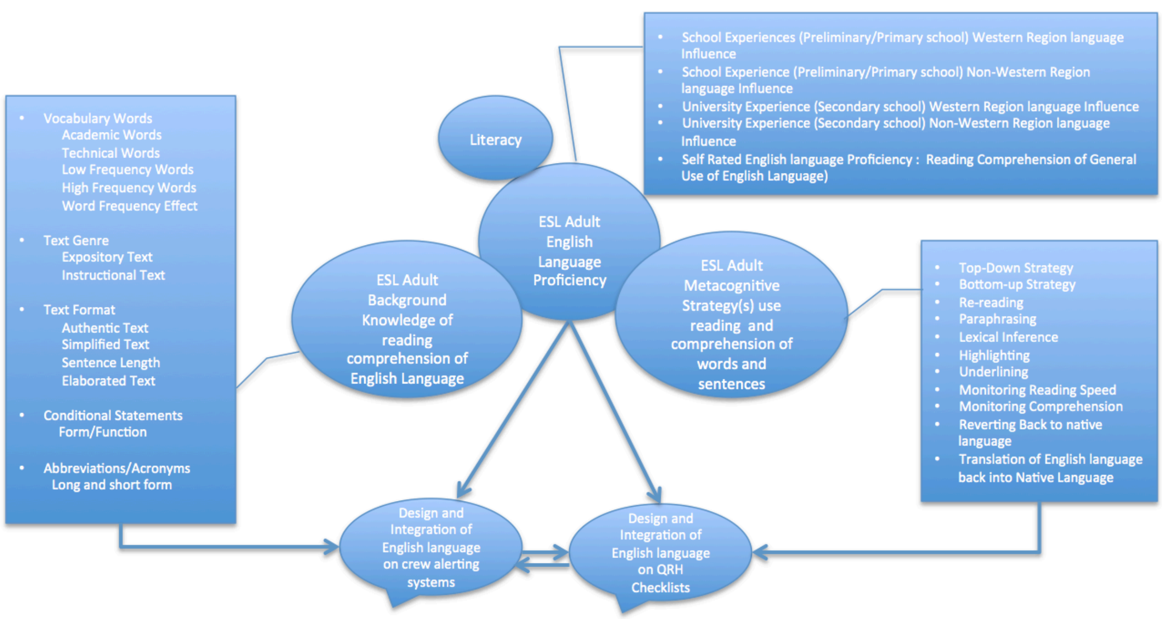


Figure 5 Chapters 2 and 3: Visualization Roadmap

2.1 ESL Adults written English Language Strategies Utilization: Fundamental Elements of literacy and proficiency

Literacy, the ability to read, write and comprehend information is important regarding understanding and use of English language. Proficiency is defined as how well an individual may perform using English language within the context of their environment. In other words, proficiency is the degree of knowledge, skills, and abilities that one may possess in the context of their environment, and has the potential to impact their abilities (adequately or inadequately) to use English language. Essentially, there are three types of literacy: print, text, and functional. Print literacy is the ability to read, write, and interpret English language based on background knowledge. Text literacy is the ability to interpret text in different forms. Functional literacy is ability to perform a task while using English language (Nielsen-Bohlman and Institute of Medicine, 2004). Written English language can be very difficult to read for ESL adults. To address English language literacy issues, the education industry has developed protocols to address ESL adult English language literacy concerns. One protocol is Tests of Adult Basic Education Complete Language Assessment System—English (TABE CLAS-E) form 9 and 10. This is an established curriculum that addresses reading and comprehension of English language amongst other factors that influence ESL English language literacy and proficiency. The ESL adult taking the test is evaluated using the National Reporting System (NRS) protocol, which provides an evaluation of literacy levels (e.g. beginner, low, high, and advanced literacy levels) (McGraw, 2014). Although tests on English language literacy and proficiency are intended address ESL abilities to read and comprehend written English language, there are still challenges on ability to read and interpret written English language.

Condelli and Wrigley (2006) conducted a study on factors that influence English language literacy and language abilities on ESL adults. Their results indicated that ESL adults experience difficulties decoding and comprehending written English language. Difficulties with cognitive processing of written information and complexity of syntax meaning can be difficult considering English-as-a second language individuals (Yildiz-Genc, 2009). According to Anderson (2004), individuals that are literate in a language other than English experience many challenges with their reading abilities more often reading English language, than with use of their native language. What are the challenges that ESL individuals experience while reading written English language? What are the challenges that impact ESL adults reading comprehension? With respect to cognitive challenges on the ESL adult, what are the processes/strategies by which they read and interpret English language? Fundamentally, it is important to understand the definitions of reading, comprehension, comprehension monitoring, cognition, and metacognition, as these are all aspects critical to understanding written English language. Reading is the process by which an individual takes lexical knowledge and skills and applies it to a body of text to process and understand information (Rashidi and Piran, 2011). Comprehension is the ability to understand written text and apply vocabulary knowledge and strategies to understand syntax (Hancock, 1998). Comprehension monitoring is utilized to consistently evaluate intentions while reading text, and regulate flow of understanding text (Baker & Brown, 1984). Cognition is a process utilized by an individual to perceive and understand information in his/her contextual environment. Metacognition is often referred to as how someone may understand their thinking processes to organize their ideas to assess a situation (Anderson, 2002 and Flavell, 1976). Particularly, metacognition processes can aid ESL individuals with ability to use certain reading strategies to read and understand English language and can lead to adequate to high levels of English language proficiency (Keshavarz and Assar, 2009). According to Karbalaei (2010), the degree of success in reading and understanding English written language is deeply rooted in the efficiency of strategy utilized by ESL adults. Preparing and planning on adequacy of reading, decision-making processes on when to use certain reading schemes, monitoring strategy use, and use of strategy and evaluation of strategy on reading text are four central components used in reading information written in English. All of these components should be collectively utilized as English language reading strategies and not isolated.

Anderson (2004) stated that mental models have been constructed to understand how ESL adults read written English language. In particular, strategies such as bottom-up, top-down, and interactive models are considered three dimensions of reading models utilized by ESL adults. Depending on the reading activity, ESL adults systematically utilize these models so that they understand meaning of written English language text (Hsiao and Oxford, 2002). But, are these models beneficial to an ESL adult's ability to read and comprehend written English language? Firstly, a review of model types utilized by ESL adults to read and understand written English language is needed. Essentially, bottom-up model is related to how an ESL adult may comprehend information considering the flow of information (linear text flow). In this model, the preliminary steps are decoding the syntax (letters, words, and phrases). Then, the individual decodes the sentence and makes meaning of the information they read. English-as-a-second language adults make inferences on words to facilitate understanding of written English language text when they use bottom-up models. Use of this model is highly dependent on ESL adult English language proficiency, with respect to their vocabulary knowledge (Liu, 2014). Top-down model consists of the reader using previous knowledge of information they read to understand syntax. English-as-a second language adults may activate their content schema, or background knowledge of the topic to help facilitate an understanding of the subject (Lin and Chern, 2014). Paribarht, and Wesche (1999) indicated that background knowledge has the potential to influence model/strategy use by ESL adults. Interactive model is the combination of top-down and bottom-up model use by ESL adults, which enables their ability to instantaneously decode text and use background knowledge to read and understand text.

Although bottom-up, top-down, and interactive models provide an understanding of fundamental reading strategies utilized by ESL adults, there are studies that describe the effect of using these models/strategies, on ESL adult reading comprehension. A study conducted by Parry (1991) discussed the effects of ESL adult English language proficiency on their ability to read written English language, while using bottom-up model strategy. A small population of ESL adults was utilized for Parry's (1991) study, which included four adults from different countries. Each of the four adults' English language reading proficiency was evaluated and determined to be low or intermediate levels. Text chosen for the study was Anthropology (linguistics focus), which was considered to have challenging vocabulary words. Parry's (1991) study goal was to determine if ESL adults could identify challenging words in the text, and if they were successful using bottom up strategy to understand word meaning. Furthermore, if vocabulary words in the text were challenging, factors influencing their misunderstanding of the vocabulary words were identified. Results indicated that use of the bottom-up model led to ESL adults skipping words in text due to difficulties with understanding them. It was also noted that ESL adults translated English written words back in to their native language. Furthermore, ESL adults indicated that more time was needed to understand words in the text that were unfamiliar to them. Finally, since ESL adults had low to intermediate levels of vocabulary knowledge, it was determined they may have guessed more words due to their inability to understand the meaning of the words. This could also be the result of ESL adult low or intermediate English language proficiency levels when they read written English language. In summary, Parry's (1991) study provides an indication that use of bottom-up model strategy by ESL adults with low to intermediate English language proficiency led to word translation back into their native language. Use of this strategy by ESL adults with low to intermediate English language proficiency also indicated that they adults skipped words while they were reading them in text. Finally, ESL adults with low to intermediate English language proficiency utilizing this strategy have the potential to negatively impact their written English language reading comprehension. The next study aims to provide an overview of the impact that top down model strategy use by ESL adults has on their reading comprehension abilities, and compares it to their use of bottom up strategy.

A study was conducted on the types of strategies utilized by ESL adults to read English language. Yildiz-Genc (2009) utilized 15 ESL adults with an intermediate level of English language reading proficiency. Participants read written English language text without a time constraint, followed by an interview on what they had read. The study revealed that the two strategies utilized by adults were bottom-up and top-down strategies. Top-down strategy was utilized the most often, likely due to participant English language proficiency. Use of top-down and bottom-up strategies have often been coined strategic reading according to Anderson (2003). With respect to bottom-up strategies, participants indicated they were challenged with word meaning and there was a constant focus on root word. They also indicated using certain written English language sentences to interpret and connect their ideas on previous sentences. Participants also noted they translated English words, sentences, and phrases into their native language. Regarding complex sentences, participants indicated they split each of them in order to understand sentence meaning. They also re-read information in order to understand the meaning of the sentences. Finally, participants utilized their background knowledge of the text they read in order to understand the meaning. Use of top-down processing of written English language by participants indicated that they predicted information in sentences prior to reading the whole sentence, and either confirmed or rejected their predictions. Yildiz-Genc (2009) concluded that participants used their background knowledge of the situation so that they could understand the text, metacognitive reading strategies to read and comprehend text, and they utilized their knowledge of English language to read and interpret written English language. Regarding top-down strategy use by adults, Hammadou (1991) also indicated that individuals utilize top-down processing of information often when reading written English language text. Use of background knowledge to interpret unfamiliar written English language text by an ESL individual has also been referred to as lexical inferring, a cognitive process that is utilized by the reader to understand meaning of a word (Paribarht, and Wesche, 1999). Lexical inferring strategy will be discussed in further detail later in this chapter. The next study explores interactive model strategy use by ESL adults and the effects on their reading comprehension.

Interactive model is most widely utilized and consists of ESL adults instantaneously decoding syntax (Barnett, 1989). Interactive models combine use of bottom-up and top-down models to read written English language (Lally, 1998). A study conducted by Fatemi et al (2014) discussed interactive model strategy use by ESL adults and its effect on their reading comprehension. Fatemi et al (2014) also wanted to understand the effects of ESL adult style of thinking. English as-a-second language participants were categorized as field independent or field dependent type strategy participants. Field dependent cognitive style participants use external cues to understand written English language text (rely on general perspectives on the meaning of text), while field independent type strategy participants use internal cues to understand written English language text (critically analyzes information in text to understand it). Fatemi et al (2014) utilized each of the cognitive styles in the study to understand its impact on ESL adults reading strategy (bottom-up/top-down). The study consisted of 80 ESL participants; their reading comprehension abilities were evaluated prior to the start of the test to understand if each of the participants were proficient using written English language. Results indicated they were highly proficient with utilizing written English language. Participants were divided into two groups each with 40 ESL participants. Two tests were performed (pre-test and post-test) that were related to reading comprehension. The pre-test was performed to ensure heterogeneity between each of the groups. Results from the pre-test suggested that scores from ESL participants in group one and two that used top down strategy and bottom up strategy (field dependent and field independent cognitive styles of reading), indicated no statistically significant difference between the two groups. This was most likely the result of ESL participants (group one and two) equivalent general knowledge of the subject they read during the study. The posttest conducted revealed different results with respect to each group. Results indicated that scores from participants that utilized top-down strategy (field dependent and field independent cognitive style) and field dependent cognitive style performed better than those whom utilized field independent cognitive style while reading written English language. Regarding bottom-up strategy use by participants, they performed better when using field independent compared to field dependent cognitive style while reading written English language. The reason for these results could be that participants that used top down model and field dependent cognitive style generally viewed the text they read by using their knowledge of the subject, which is a feature of top down strategy. On the other hand, participants that utilized top down strategy and field dependent did not have background knowledge of the subject, and thus did not comprehend the text in the same manner as the ESL participants that utilized field dependent cognitive style. Regarding bottom up strategy use by participants, they scored high regarding field independent cognitive style use, compared to field dependent cognitive style use. The reason for these results could be that participants were more accustomed to use of field independent technique when reading text that required them to critically analyze the text rather than use their general knowledge of the text. In summary, the results from each group in the posttest indicate that use of bottom up and top-down strategy has an impact on participant ability to read and comprehend written English language. Given participants used both models to understand the text, these can be considered interactive use of the models (interactive model). Based on results, interactive model strategy use by participants can be considered useful, depending on the text and cognitive style utilized by participants to read and comprehend English written language.

Each of the studies previously discussed reveal important details about model use and

ESL adult English language proficiency. Parry's (1991) study indicated that ESL adults with low to intermediate levels of written English language proficiency use bottom-up model and related strategies to read and comprehend written English language. In Yildiz-Genc (2009) study, ESL adults with intermediate English language proficiency used top-down and bottom-up model and related strategies, while they read and comprehended written English language. Overall, Fatemi et al's (2014) study provides evidence that participants with high English language proficiency use interactive model and other related strategies to read written English language. One topic that was not covered in each of the studies, and could have an effect on the results of this study, was participant use of vocabulary word type, and text genre in text corpora. As vocabulary word type and text genre have the potential to impact on ESL adult ability to read and comprehend written English language, these factors will be covered in a forthcoming chapter.

2.1.1 Section Summary

This section provided the reader with an understanding of mental models utilized by ESL adults to read written English language. Studies in this section indicate that the type of strategy utilized by ESL adults to read and understand written English language has the potential to impact their ability to read and comprehend English written language. In particular, bottom-up strategy model appears to help the ESL adult with decoding syntax and other related written English language (e.g. phrases). Top-down strategy model helps the ESL adult reader with using their background knowledge of the reading material to help facilitate reading comprehension processes. Both strategies (top-down and bottom-up) are important, however participants in aforementioned studies and in the researcher's studies will not be able to judge their use of these, as they would have to possess remarkable metacognitive skill. Nevertheless, metacognition is the theoretical process and will be utilized in the researcher's data collection processes. English as-a-second language adults utilize interactive model frequently when they read written English language. Strategy use by ESL adults has the potential to aid in their ability to organize ideas and process written English language according to Hsiao and Oxford (2002) and Barnett (1989). The aforementioned models utilized by ESL adults to read written English language could be applicable on the flight deck. Since ESL flight crewmembers read written English language on QRH checklists and crew alerting systems on the flight deck, use of these models by ESL flight crewmembers could be beneficial. On the other hand, if these models are utilized on the flight deck, ESL flight crewmember English language proficiency should be noted, as this could be an indicator of which model is utilized to facilitate their understanding of written English language text on the flight deck. Figure 6 is a paradigm illustrating connections between ESL adults' use of bottom-up strategy, top-down strategy, interactive strategy, and ESL adults' written English language proficiency.

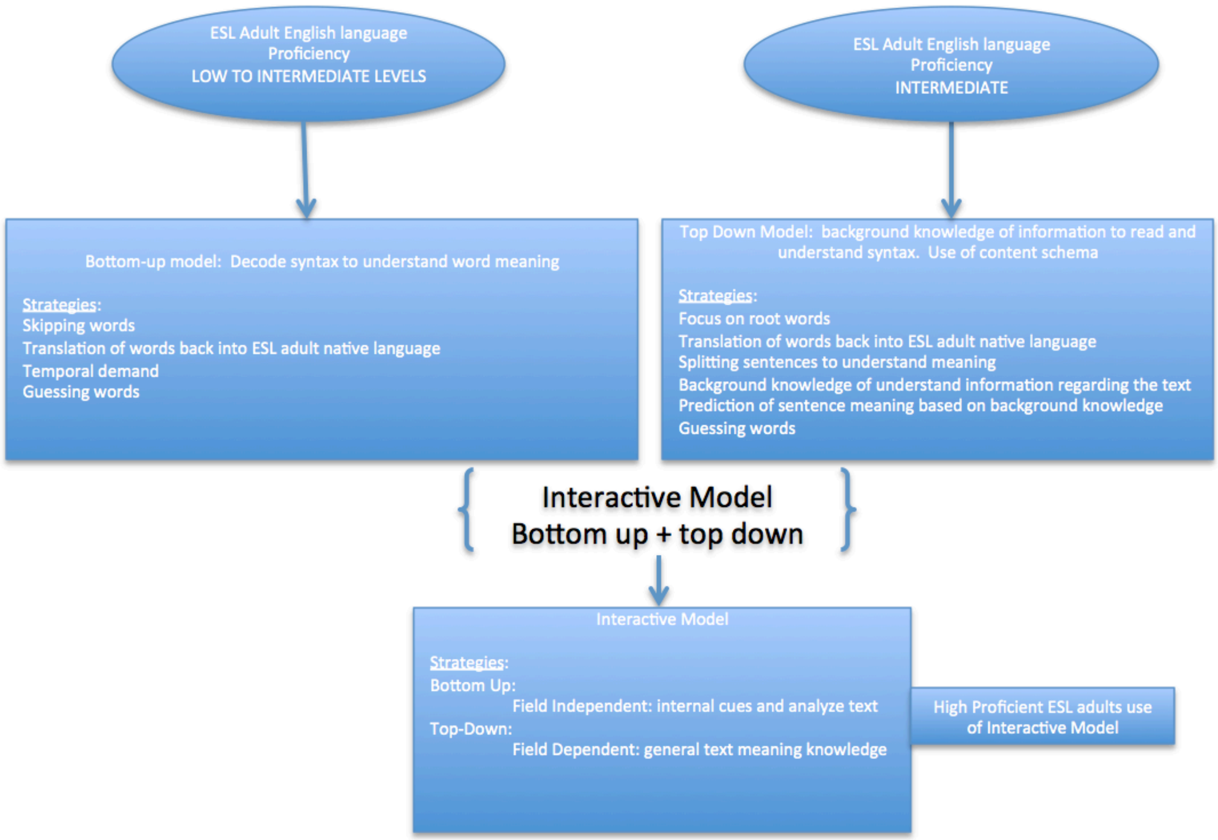


Figure 6 Influence of Model Use by ESL adults

Next section describes another strategy utilized by ESL adults to read and comprehend written English language.

2.2 ESL Adults Cognitive Processing of Words in Sentences and use of Lexical Inferencing

Research studies previously discussed indicated ESL adult ability to read and comprehend English language has an impact on their mental model and strategies utilized to read and comprehend written English language. But, what other factors influence ESL adult ability to read and comprehend English language? Ability to read and comprehend words is a factor that influences ESL adult English language proficiency and their ability to understand written English language sentences. Aim of this section is to provide the reader with an understanding of impacts on ESL adult ability to read and comprehend words in sentences. The section also provides a review of ESL adult background knowledge of written English language and English language proficiency level while using a strategy to read and comprehend written English language.

Words that appear in a sentence can be described as tokens, or the overall count of words in text corpora. Often, there are different types of words in text corpora that make up a sentence. Vocabulary word types in text have the potential to impact the way in which ESL individuals process information. Vocabulary word types have characteristics that should be noted, and help ESL adults facilitate an understanding of their meaning. For example, "the verb 'entertain' includes a family of words related to entertain, such as 'entertains', 'entertained', and 'entertaining', but not 'entertainment', Word family is a description of different words with various parts of speech" (Moghadam et al, 2012 pg. 556). Essentially, cognitive processing of vocabulary words like 'entertain' found in sentences aid ESL adults with reading and understanding strings of characters in a sentence. Understanding word family assists ESL adults with making educated guesses of words in sentences, if they are familiar with the word and its family. In other words, ESL adults make inferences on words in sentences by associating words with their word family, to understand word meaning. Reading and comprehending words in sentences also includes ability to understanding syntax and grammar.

One common strategy utilized to understand words in sentences is called lexical inferencing. English-as-a-second language adults utilize lexical inferencing often, so they can read and comprehend written English language. Inferencing is a process that requires making an educated guess on word meaning and combines it with understanding of general knowledge of their contextual environment (Haastrup, 1991; Brown & Yule, 1983). According to Alderson (2000), ESL adults that use word-guessing strategies as a heuristic to understand word meaning are at a disadvantage and may not overcome reading comprehension challenges. Regardless of this claim, studies have provided an explanation on using lexical inferencing strategy, and the effect on ESL adult reading comprehension. Paribakht and Wesche (1999) investigated factors that influence reading comprehension with respect to ESL adult understanding of unfamiliar words and their meaning. Their study revealed that ESL adults use lexical inferencing strategy more than other strategies. Recall, in previous studies that discussed top-down model and bottom-up model strategies, word guessing was a strategy used to read and understand written English language.

A study conducted by Wang (2011b) investigated use of lexical inferencing strategies by ESL adults. Their study also focused on learning vocabulary as a result of utilization of inferencing strategies. Thirty-four ESL advanced English language proficiency level adults participated in the study. They had background knowledge of English language in academic and technical English genres at a university. Participants read an article that contained 240 words. Results indicated that ESL participants utilized lexical inferencing strategies such as word association and collocation knowledge. Word association is described as the association of text that comes to the readers mind first and then connecting the word to the given word. "Collocation means that certain words often co-occur and they are often in a syntactic relation such as verb-object ('take care'), and in a lexical relation such as antonym, synonym and superordinate (such as furniture and table, chair, sofa, etc.) (Wang, 2011b p. 305; Waring & Nation, 2004)". With respect to Wang's (2011b) study, there were many participants that guessed words that were unknown to them because they did not know the meaning. Many participants were challenged with interpretation of unknown words and thus did not recognize new words in the text, some participants made incorrect inferences of the unknown words. Lastly, use of lexical inferencing by ESL participants and words they learned incidentally was compared. Results indicated that ESL participant vocabulary increased as a result of learning unknown words. This finding is consistent with Dycus (1997) and Nassaji, (2004) studies, which indicated that increased understanding and a vast knowledge of vocabulary could lead to inferential success. On the other hand, less proficient ESL readers have the potential to make incorrect inferences on words in text, which is attributable to less utilization of certain type of inferencing strategies. Such strategies (e.g. re-reading information, evaluation of text) can impact ESL reading comprehension performance.

A study conducted by Dwaik and Shehadeh (2013) investigated effect of lexical inferencing on 60 ESL adults' reading comprehension abilities. Primary focus was to determine if proficiency levels and lexical inferencing strategy had an effect on ESL adults' ability to guess vocabulary words from text corpora. Each participant was considered high or low proficient English language readers. Results indicated that participants with high proficiency of written English language performed better (guessed more words correctly) with lexical inferencing strategy than low proficient readers of English language. English as-a-second language low proficient written English language readers guessed more vocabulary words incorrectly. With respect to reading comprehension, participants utilized context clues within a sentence to read and understand words in text. It was also noted that participants with low level of English language reading proficiency performed well regarding their use of context clues while reading text, but did not perform well using their background knowledge to understand the text. This could be the result of insufficient background knowledge of the text they were reading. In summary, Dwaik and Shehadeh (2013) provide an indication that participant written English language proficiency has an impact on their ability to guess words and the use of strategies to read and comprehend written English language. However, there are some gaps in the authors study regarding participants' English language proficiency levels and their ability to comprehend written English language. Firstly, there was no indication if each of the participants had background knowledge in the text they were reading. As previously stated by Yildiz-Genc (2009), utilization of background knowledge can help ESL adults with understanding words in sentences. Therefore, ability to predict word meaning with use of lexical inferencing strategy can be advantageous. But, as Dwaik and Shehadeh (2013) have indicated, ESL adult English language proficiency is a factor that influences their ability to use lexical inferencing strategy effectively (guessing correct meaning of words). Secondly, there is no indication of the types of vocabulary words in the text, and if types of vocabulary words impacted ESL participants reading comprehension. On the other hand, if ESL participants' English language proficiency is adequate do they understand vocabulary types in text? Could text genre (e.g. instructional, expository text) have an impact on how much text they understand? These questions will be answered in a forthcoming section. Overall, Dwaik and Shehadeh's (2013) study does provide adequate details on the factors influencing ESL adult ability to read and comprehend written English language while using lexical inferencing strategy. The study also provides the reader with an understanding of the impact ESL adult proficiency has on their ability to read and comprehend written English language, while using lexical inferencing strategy. Next study provides more information on the impact of lexical inferencing strategy on ESL adult reading comprehension. In particular, the study focuses on vocabulary depth and lexical inferencing strategy use by ESL adults.

Nylander (2014) utilized 20 ESL adults for their study and conducted a test on their vocabulary depth, while another task focused on use lexical inferencing strategy use. The reading passage provided to participants was related to a topic they were familiar with and had adequate background knowledge to understand the text. However, it was noted that the text included a combination of known and unknown words. Demographics collected prior to the study revealed differences among participants regarding their English language proficiency levels. These differences were related to their background knowledge reading English language. In particular, each of the participants was taking different English language courses at a university in a non-western region. Although there were noted differences in participant English language proficiency, each of the participants was presumed highly proficient regarding their ability to read written English language. Results indicated a positive correlation between lexical inferencing strategy use by participants and their vocabulary depth. Participants that scored high on the vocabulary depth test performed better with lexical inferencing strategy use than ESL adults that had a lower vocabulary depth. In summary, Nylander's (2014) study provided details that help the reader understand the effects of vocabulary depth on ESL adults' ability to read and comprehend written English language. However, there are some limitations to the study. Firstly, it is unclear on genre of text (e.g. instructional or academic text) chosen for the study, which may have an impact on how well ESL adults utilize strategies such as lexical inferencing to read and comprehend written English language text. Secondly, the author utilized vocabulary words frequently found in written English language from a reliable source, which may be an indication that certain vocabulary words may be more comprehensible than others in text.

2.2.1 Summary

This section provided more detail on factors that influence ESL adult ability to read and comprehend written English language. Lexical inferencing appears to impact how ESL adults associate words in text. Wang's (2011b) study illustrated the difficulties that ESL adults encounter when utilizing lexical inferencing strategies. Incorrect inferences on unknown words caused a high percentage of ESL adults to be challenged with reading and comprehension of text. Lexical inferencing strategies can be useful to ESL adults, but the risk of incorrectly identifying meaning of unknown words can lead to difficulties reading, processing, and comprehending information. Paribakht and Wesche (1999) reported that use of lexical inferencing has the potential to impact ability of ESL adults to identify and interpret unknown words in text. According to Wang's (2011b) study, knowledge of vocabulary has the potential to impact ESL adults' ability to make correct inferences on words in text. Does vocabulary word types impact ESL reading and comprehension? It was highlighted in Dycus (1997) and Nassaji, (2004) studies that an increased understanding of vocabulary words could lead to increased levels of reading and comprehension. Particularly, in Nassaji's (2004) study, vocabulary depth was an indicator of frequency of strategy use by ESL adults. Evidently, ESL adults strong vocabulary knowledge led to their utilization of different types of lexical inferencing strategies, while ESL adults that did not have a vast knowledge of vocabulary, were not as successful with lexical inferencing strategy use. Finally, Dwaik and Shehadeh (2013) and Nylander's (2014) studies provide two important details. There could be variability in lexical inferencing strategy use by ESL adults considering their different English language proficiency levels. Also, lexical inferencing strategy use can be beneficial, but text genre and vocabulary word type may have an impact on ESL adults' vocabulary knowledge and thus impact their reading comprehension performance. In a forthcoming section the researcher will discuss effects of vocabulary word type and text genre on ESL adult ability to read and comprehend written English language.

Many of the factors discussed in this section are applicable on the flight deck. Particularly, lexical inferencing strategy has the potential to impact how often ESL flight crewmembers make correct or incorrect inferences on word meaning. Obviously, incorrect inferences on word meaning have the potential to impact ESL flight crewmembers response to a crew alert. Whether using a QRH checklist or displayed crew alert information to solve a problem on the flight deck, reading and comprehension of English language by ESL flight crewmembers has the potential to be effected with use of lexical inferencing. As Wang's (2011b) study indicated, preview of text by ESL adults could lead to guessing words that are unfamiliar to them. This could be disadvantageous to ESL flight crewmembers, as their time may be limited to respond to a system malfunction/failure. For example, if ESL flight crewmembers are processing information on a hydraulic pump failure, and there are words on the crew alerting system and QRH checklist that are difficult to understand, use of lexical inferencing could impact their performance. In particular, an educated guess of a vocabulary word located on the QRH checklist, or on the crew alerting system could potentially lead to correct or incorrect word inferences regarding the hydraulic pump failure. But, does the adequacy of ESL flight crewmembers depth and breadth of written English language contribute to their ability to respond to an alert and thus use a QRH checklist to solve a hydraulic pump failure?

In the previous studies, it was indicated that ESL adults with high English language proficiency levels that used lexical inferencing strategy to read and comprehend English written language, led them to make more correct inferences on word meaning than ESL adults with low proficiency of English written language. Considering these results, if ESL flight crewmembers have high levels of proficiency, and they utilize lexical inferencing strategy, this may be an indicator of how many correct word inferences ESL flight crewmembers make while reading the QRH checklist or on displayed crew alerts. On the other hand, if ESL flight crewmembers have low levels of English language proficiency, this could be an indicator of how often they make incorrect word inferences while reading the QRH checklist and displayed crew alerts. Nevertheless, English language proficiency and use of lexical inferencing strategy has the potential to impact ESL flight crewmember performance while using QRH checklists and crew alerting systems.

Another factor that may influence ESL flight crewmembers' ability to respond adequately to a crew alert and use of a QRH checklist are omission and commission of words. Omission and commission of words on crew alerting or information systems may be beneficial to ESL adults, thus providing them ability to skip over words they don't know or add in words familiar to them. However, this could lead to ESL adults incorrectly interpreting word meaning and has the potential to cause errors. Moreover, errors in word interpretation could impact ESL flight crewmembers understanding of the context of the word in a sentence or on an alert display. Furthermore, incorrect word inferencing could lead to misunderstandings, missed steps, and inclusion of words/phrases not in the original design of the crew alerting system or QRH checklist. After all, utilization of lexical inferencing strategy by ESL adults could be linked to their English language proficiency level. In other words, ESL adult level of proficiency has been linked to how often he/she uses lexical inferencing strategy to understand word meaning. The previous types of questions in this section will be answered in the researcher's studies. The next section provides more detail on ESL adult reading ability and interpretation of words in sentences with respect to sentence length and simplified text.

2.3 Sentence length and simplified text impact on ESL adults reading comprehension

Sentence length and simplified text are important factors to consider when reading text corpora (long and short lengths of text). It is especially important to adhere to sentence length and simplified text considering potential effects on ESL adult reading comprehension. In the previous sections, the researcher emphasized that text contains many types of vocabulary words. Although words in sentences may be comprehensible to the reader, the reader may not understand the sentence or organization of text (Alderson, 2000). The organization of sentences in text corpora (e.g. a reading passage) may be grouped into two categories: long or short. These types of sentences may be complex or simple for an ESL adult reader to process. What should be the practical length of sentences in a body of text comprehensible to ESL adults? Are shorter sentences more difficult to read and comprehend than longer sentences or vice versa? Does simplification of sentences remedy ESL adult reading comprehension challenges? English as-a-second language adult ability to obtain context clues from shorter or longer sentences and use them as building blocks to interpret sentence meaning has the potential to impact their ability to accomplish reading tasks. Hashemi and Bagheri (2014) indicated that longer text is more inclined to give ESL adults the appearance that it is more difficult to read than shorter text. Crossley et al (2007) indicated that the process of shortening text reduces complexity and organizes the text in a manner to support ESL reader vocabulary (lexis) knowledge. Nevertheless, these assertions need to be substantiated with evidence. Scientists have indicated different viewpoints on the impact of sentence length on ESL adult reading comprehension.

Mehrpour and Riazi (2004) developed a study on written English language sentence length impact on ESL adult reading comprehension performance. They hypothesized that sentence length may have an impact on ESL adults reading comprehension. They utilized 100 ESL participants to conduct their study. Some participants majored in English language while others did not. Half of group one participants (did study/major in English language) received the long sentence length version test and the other half a shorter length portion of the test. Half of group two participants (did not study/major in English language) received the shorter length version of the test and the other half of group two received the longer version of the test. Two tests were administered to assess reading comprehension. Each test contained three corpuses of text, each shortened from the original version with several multiple-choice questions. The reason for shortening text corpora from their long versions was to reduce the amount of insignificant and grammar related redundancies in the text. The first corpus of text had a length of approximately 240 words, while the second contained almost 240 words, and the last corpus of text more than 260 words. Topics covered in the corpus of text could be considered technical and academic text (e.g. medicine, sociology). No statistically significant differences were reported in the results. The researchers provided two possible reasons for this finding. As they indicated in their preliminary review of the ESL participants' English language background, all of them were considered proficient and had less than five years of experience with use of English language. Another reason for the statistically insignificant results could be due to text length alterations. It was found that shorter text length was more difficult to read in general than the longer length text, considering two of the corpuses of text read by ESL adults. Mehrpour and Riazi (2004) raise important issues on the factors influencing ESL adult abilities to read short and long lengths of text. But, there are some parts of the study that could have covered more detail. For instance, the authors claim that the text chosen for the study was technical and academic. But, they do not indicate if participants had background knowledge of these two types of text. In other words, background experience/knowledge of the text could be indicators of how well ESL adults perform when they read short and long sentences in a corpus of text. Regarding previously mentioned studies on strategy use by ESL adults; Barnett (1989) indicated that top-down processing is the use of previous knowledge of the information to understand syntax. Top-down processing model should have been assessed in the study to further understand if participant background knowledge of written English language was factor that may have influenced the first group's ability to understand short sentences. On the other hand, since group two did not study/major in English language, did they have any background knowledge with use of academic and technical text? If ESL adults did not have background knowledge with these types of text, it is plausible that they could have utilized bottom up model and lexical inferencing to understand the shortened text. Perhaps, ESL adult background knowledge of text corpora could influence how well they perform when text length is either shortened or elaborated. A couple concepts emerge from Mehrpour and Riazi's (2004) study. The first concept was that short text and long text have an impact on ESL adults' reading comprehension. Second concept was simplification of text may be beneficial, but has the potential to negatively impact reading comprehension of written English language. The next study provides an overview of how simplification of text can impact ESL adult reading comprehension of English written language.

A study conducted by Gardner and Hansen (2007) focused on lexical simplification of text and the impact on ESL adult perceived reading comprehension. Simplification of text includes reducing vocabulary complexity in a sentence (Oh, 2001). They utilized Global Basic English (GBE) to simplify text and reduce the occurrence of complex vocabulary words in text (e.g. words like 'temporal demand' changed to 'time'). Their study consisted of 135 ESL adults with experience in three university English language programs. Authors utilized tests to understand participant level of English language proficiency that focused on reading and grammar. Each of the ESL participants was categorized into four different English language proficiency levels: beginning, low intermediate, high intermediate, and advanced. There were 12 paragraphs related to horticulture and these authentic texts were modified using the GBE lexical simplification process. Differences in spelling of vocabulary words did not change word meanings. Texts contained various types of vocabulary words (e.g. high frequency words). The researchers created two text corpora identified as text A and text B. Text A contained six paragraphs in their original format and six paragraphs simplified. Text B included six paragraphs in their simplified format and six paragraphs that were original format. Each of the texts was supplemented with a comprehension rating scale with various indicators of participant perceived rating regarding their comprehension of each paragraph. Results indicated that ESL participants' perceived comprehension of the simplified texts were higher than the original text format. Considering participants' proficiency levels previously discussed, their use of the simplified text indicated less highlighted unknown words than the original text. This is another finding indicating that simplified text has the potential to be advantageous to ESL adults. Gardner and Hansen (2007) provided good details on the impact of sentence simplification on ESL adult reading comprehension. Changing vocabulary words in text should be done carefully with consideration that the alteration may lead to misunderstandings with word meaning. A change in word meaning has the potential to increase the likelihood of ESL adults misunderstanding word meaning or omitting words unknown to them. The next section describes effects of text type and text simplification has on ESL adults' ability to read and comprehend written English language.

Hashemi and Bagheri's (2014) study hypothesized that written English language reading task completion time pressures and text length have the potential to impact ESL adult performance. According to Perfetti (1985), time pressures have a potential impact on reading ability, due in part to the effects of cognitive processing of sentences and sentence structure deficits. Hashemi and Bagheri's (2014) study utilized approximately 200 ESL adults. Each of the participants was intermediate to high level of English language proficiency. Two tests were utilized to understand effect of time pressures on ESL adult reading comprehension abilities of written English language. The first test was a Test of English as a Foreign Language (TOEFL), which contained five corpuses of text and multiple-choice questions. Genre of text utilized for the study included a blend of academic and technical content. The additional test was the TOEFL test truncated. Text length was reduced by removing grammatical redundancies and words in sentences that did not contribute to the overall efficacy of reader comprehension. At the same time, proper consideration was given to not lose the overall meaning of the sentence. Each of the five corpuses of text was reduced from approximately 360 words in text to 270 words in text. Group A received the original TOEFL test and Group B received the simplified version of the TOEFL, both groups had a 60-minute time limit. Group C utilized the original TOEFL and Group D utilized the simplified text version, neither had a time limit. The other half of participants (Groups E, F, G, H) followed the same experimental design as Groups A, B, C and D. Results indicated that the length of text and time limit were considered statistically significant. Participants' performance was different based on the situation (time and text length and the interaction between both). It was also indicated that ESL participants' performed better when using a simplified version of text. Regarding time limit and text length, results found a significant difference between participant performance that had a time limit and those that did not have time limit. Essentially, no time limit resulted in better comprehension of texts, whereas introducing a time limit within the task resulted in a negative impact to ESL participant reading comprehension performance. In summary, Hashemi and Bagheri's (2014) study discussed many details on the impact of time limit on ESL adult reading comprehension performance using text that was simplified. Regarding temporal demand pressures, McDonough (1999) indicated previously that ESL adult reading rate (fast/slow) has the potential to be impacted by the type of strategy utilized to read text. Since a time limit was indicated as a factor that negatively impacted participant reading comprehension in Hashemi and Bagheri's (2014) study, the authors should have provided an explanation of strategy use by participants, since use of this strategy can be utilized to mitigate time pressures in simplified text. On the other hand since groups C and D had no time limit to complete the task, participants may have taken more time to review the text and comprehend the meaning of the text, consequently they did not rush through it. A final aspect that was discussed in Hashemi and Bagheri's (2014) study was the effect of word efficacy on ESL participant reading comprehension. It was noted that reducing text length and simplification of text improved ESL adult performance. These results are consistent with Gardner and Hansen's (2007) study.

A final study conducted by Eslami (2014) focused effect of sentence length on 260 ESL adult reading comprehension abilities. Proficiency levels were utilized in the study as an indicator of ESL adult experiences with written English language. Goal of the study was to understand the impact of text complexity on ESL adult performance. Comparable to Gardner and Hansen's (2007) and Hashemi and Bagheri's (2014) studies, TOEFL test was used to understand proficiency levels and assess a baseline for the first of two tests conducted. The second test was considered an often-utilized measure of ESL adult comprehension abilities, while the third test was developed to measure different lexical characteristics. Each of the tests was constructed based on the ESL adult proficiency level (e.g. high, intermediate, low proficiency). As previous scientists in this section indicated in their research, reduction in certain clauses, sentence length, and sentence complexity were considered attributes necessary to develop the amended text in the tests. It was mentioned that syntax was reduced but not vocabulary words in the corpus of text, a noticeably different perspective on sentence length reduction than Gardner and Hansen's (2007) and Hashemi and Bagheri's (2014) portrayed in their studies. This activity was needed to ensure the text was readable and comprehensible for study participants. Results indicated that highly proficient ESL adults did not perform much differently with use of each of the texts (three versions). On the other hand, participants representing middle and lower level proficiency ranges performed significantly different using two of the three texts. Simplified text and original text version were deemed more adequate for participants in the middle and lower level reading comprehension proficiency ranges than the third version. Finally, it was indicated that shorter sentences and reducing complexity of sentence readability contributed to ease of understanding texts. In summary, several perspectives emerge from Eslami's (2014) study. This study design accounted for participants' proficiency level in design of the tests for evaluating performance. Determining levels of proficiency by utilizing self-ratings could have impacted how the tests were simplified. Finally, Eslami (2014) stated that syntax (arrangement of words) was truncated in the sentences of the corpus of texts, but vocabulary words remained consistent through the text. Even though participants stated that simplification of text was deemed adequate for reading comprehension, it is essential to evaluate types of vocabulary that were reduced throughout the corpus of texts to provide a clear understanding of the impact on ESL adults reading comprehension. Vocabulary types and their impact on ESL adults reading comprehension will be reviewed in the forthcoming section.

2.3.1 Summary

All of the aforementioned factors have the potential to impact ESL flight crewmember performance. Earlier in chapter one, one of the recommendations from the FAA (2013) study was that procedures and checklists should be designed using simplified technical English. All of these factors are paramount when considering altering/not altering the design of written English language text. Regarding crew alerting systems, they often have time-to-respond protocol embedded within the architecture of the system. It becomes more important to design a system that affords ease of understanding regarding written English displayed language. For example, if a time critical warning is displayed with associated text, ESL flight crewmembers should be able to understand the meaning of the text. As previously discussed, the text length has the potential to impact ESL adults understanding of text. If they choose to utilize a strategy to read and comprehend text, it could potentially impact how fast/slow ESL flight crewmembers may respond to a crew alert. Simplification of text appeared to be a factor that was beneficial in the studies previously discussed. But, the simplification of text should not change the meaning of vocabulary words, nor should it impact their meaning. If the meanings of vocabulary words are changed on a QRH checklist, it could potentially impact ability of ESL flight crewmembers to respond adequately to a crew alert. With respect to ESL flight crewmember English language proficiency, critical considerations on the type of text and vocabulary in the text should be considered when designing QRH checklists. Since ESL flight crewmember levels of English language proficiency has the potential to be variable, altering text (sentence length and simplification of text) could impact their performance using the QRH checklist.

Regarding displayed crew alerts, if ESL flight crewmembers are challenged with the design of alert text, their time to respond may also be negatively impacted. In particular, if long (elaborated) text is utilized on an alert display, this could impact ESL flight crewmembers abilities to decipher vocabulary words in sentences on a display. It should be noted that the design of a displayed alert and corresponding QRH checklist should consider adequate mapping between the alert text design and QRH checklist text design. Thus, the design of the text should afford adequate use by ESL flight crewmembers. In other words, the alert and corresponding documentation must be readable and comprehensible by ESL flight crewmembers when the outset of an alert occurs on the flight deck. As these systems are utilized to solve problems on the flight deck, the adequacy of the design has the potential to impact ESL flight crewmember performance. Another factor that should be considered when designing crew alerting and information systems for ESL flight crewmembers is whether or not the text is authentic/unaltered from its original version (designed with no text alterations). As many of the previous studies highlighted, text that is not simplified or reduced in sentence length can impact ESL adults reading comprehension. But, does alert and information systems text not simplified or reduced in length, have an impact on ESL flight crewmember performance? This question will be answered in the researcher's studies. On another note, as the FAA (2013) previously stated, language barriers have the potential to confuse and delay receptiveness on the flight deck.

Regarding information systems (e.g. QRH checklist), if vocabulary words in sentences are misunderstood by ESL flight crewmembers or unrecognized by them, this has the potential to delay response to the crew alert. For example, if there is an electrical bus malfunction on an avionics system, misunderstandings of written English language vocabulary words on the QRH checklist by ESL flight crewmembers has the potential to delay response to the alert. Delays in responses to crew alerts has the potential to impact flight safety. Although this section provides the reader with details on sentence length and simplification, what is the effect of vocabulary words and ESL reading comprehension? The next chapter provides details on the impact of vocabulary comprehension on ESL adults reading performance. In particular, vocabulary word types are discussed and the effects on ESL adult reading and comprehension abilities.

2.3.2 Chapter Summary

All theories discussed previously in this chapter are inherent factors of written English language, which have the potential to impact ESL flight crewmembers ability to read and comprehend written English language. Notable theories on mental models, frequency of vocabulary word types (e.g. academic, scientific, high frequency, and low frequency words). English as-a-second language adults literacy and proficiency of written English language may impact their strategy use, when they read information on crew alerting and information systems. In particular, strategy use by ESL flight crewmembers has the potential to impact their ability to read and interpret written English language information on crew alerting (e.g. EICAS) and information systems (e.g. QRH checklists). Use of self-rated ESL flight crewmember English language proficiency levels may also provide evidence of their degree of English language proficiency. Use of lexical inferencing by ESL flight crewmembers to decode meaning of words may be tactful, but could lead to misunderstandings on word meaning. If ESL flight crewmembers are not proficient with written English language or not aware of strategy use, their performance using crew alerting and information systems may be impacted. Since the meaning of words on QRH checklists are common to featured words on crew alerting systems, ESL adults must make the correct inferences on the words they read. If they do not make correct inferences on word meaning, the risk that they will interpret information incorrectly can increase. Therefore, understanding ESL flight crewmembers English language proficiency and strategy use (i.e. bottom up, top down, and interactive) is a key component to understanding how well they understand word meaning.

Sentence length and text simplification could have an impact on ESL flight crewmember reading time and reading comprehension of text corpora. If ESL flight crewmembers spend a long time reading QRH checklists due to the length of sentences, it could impact their ability to respond to crew alerts in sufficient time. Therefore, careful consideration on the length of sentences should be adhered to so that the impact on ESL flight crewmembers reading comprehension is not impacted. Regarding text simplification, if the text is too simple it may reduce the ability for ESL flight crewmembers to read and comprehend text efficiently. Simplifying text from its authentic version should be carefully evaluated, as these are potential drivers of misunderstandings and long reading times. These factors may impact understanding of checklists and flight deck crew alerts.

Chapter 3: Fundamentals of English language literacy and proficiency challenges—the ESL Adult Part II

This chapter builds upon chapter two, providing additional literature review on vocabulary words and their features in written English language, and challenges that ESL adults experience when they utilize written English language. Vocabulary size and depth will be discussed as well as vocabulary word types in text genres, and how these factors impact ESL adult reading comprehension performance. Finally, discussion on abbreviations/acronyms and conditional statements will be discussed, and the impact on ESL adults reading comprehension performance.

3.1 Vocabulary word types and Text Genres Part I: Impact on ESL adult Reading Comprehension

Ability of ESL adults to understand written English language may be predicated by vocabulary word types, vocabulary size (breadth), and depth of vocabulary knowledge. Vocabulary size is an indicator of how ESL adults understand word meaning. Vocabulary depth can also be impactful to ESL adult ability to understand various word families and additional information about a word(s) (Nadarajan, 2008). Word families are typically a vocabulary word with other instances of the word in different forms. For example the word submit has other words in its family such as 'submission' and 'submitting'. Research studies have indicated that use of vocabulary by ESL adults can be difficult and has the potential to impact reading comprehension (Levine and Reves, 1990). Several scientists have argued that vocabulary word types in written English language text and size of vocabulary can impact understanding of word meaning by ESL adults. Nation (2001) indicated that frequency of words in text could attribute to how well ESL adults understand written English language. Firstly, it is paramount to understand the fundamentals of vocabulary types. Nation (2001) indicated that there are four types of written English language vocabulary words that can be found in written English text: high frequency, academic and sub-technical, technical, and low frequency words. High frequency words appear in written English language text often (e.g. to, from, the) and are listed in West's (1953) General Service List of English Words (GSLEW). Utilization of High frequency words in text requires the ESL adult to know at least 2,000 words. The

GSLEW list was created to assist English as-a-second language learners. Table 2 highlights examples of high frequency words in written English language text.

Table 2 High Frequency Words: From West (1953)

1. a	45. agency	89. anyone
2. ability	46. agent	90. anything
3. able	47. ago	91. anyway
4. about	48. agree	92. anywhere
5. above	49. agriculture	93. apart
6. abroad	50. ahead	94. apology
7. absence	51. aim	95. appear
8. absent	52. air	96. appearance
9. absolute	53. airplane	97. applaud
10. accept	54. alike	98. applause

Academic words are common in education (e.g. science and law disciplines) and have been grouped into the Academic Word List (AWL), which were developed to catalog most frequently occurring words in academic text and assist learners of English-a-second language Coxhead (1998). Academic words are related to high frequency words found in text, but they are specific to academic context (e.g. linguistics) and can be found in newspapers. Academic words can also be found on the AWL, which holds approximately 500 academic words. Academic words such as affect, alter, and approach, are examples of words that can be visualized in written English language text. A subset of academic words is referred to as sub-technical words. Sub-technical words may be generic to any technical field not just aviation for instance (e.g. engine, door, seat) (Alemi and Ebadi, 2010). Sub-technical words may be considered more difficult for ESL adult reading comprehension due to their commonality across many disciplines. Sub-technical words have the potential to be complex and effect ESL adult understanding of word meaning. An excerpt from Coxhead (1998) academic word list is located in Table 3. This table highlights examples of academic words (headwords) located in the left column and their word families (right column) that appear in written English language text.

Table 3 Academic Words: From Coxhead (1998)

submit	submission, submissions, submits, *submitted,* submitting
subordinate	subordinates, subordination
subsequent	subsequently
subsidy	*subsidiary,* subsidies, subsidize, subsidized, subsidizes, subsidizing
substitute	substituted, substitutes, substituting, *substitution*
successor	succession, successions, *successive,* successively, successors
sufficient	sufficiency, insufficient, insufficiently, sufficiently
sum	summation, summed, summing, sums
summary	summaries, summarize, summarized, summarizes, summarizing, summarization, summarizations
supplement	*supplementary,* supplemented, supplementing, supplements

Technical words are common in a specific subject area and are different based on scientific discipline (e.g. aviation, maritime, and chemical industries). Since there are many different technical fields of study, agreement on threshold of words that should be known by a reader has not been verified. Many technical words may be familiar to ESL adults depending on frequency of their occurrence in text and ESL adult familiarity of the text. Technical words are required to be known by ESL adults based on their training and background knowledge of the technical field (Coady and Huckin, 1997). Chung and Nation (2004) indicated that technical vocabulary has the potential to cause difficulties with ESL adult interpretation when reading text that is considered technical. It is important to consider this possible issue when ESL adults try to determine if the word is technical or if it is not technical, which is sometimes based on the function of the word in a sentence. Technical words may also be easier to read and understand since they have the potential to be comparable in ESL adult native language. On the other hand, it has been argued that technical words are difficult to read and comprehend by ESL adults. This may be because technical words are generally extended versions of sub-technical words, and they require long processing times based on the type of text (e.g. medical and aviation scientific text). However, it has been noted that this could also be related to the degree of ESL adult English language proficiency (Li Siu-leung and Pemberton, 1994). A review and discussion of these perspectives will be covered in this section. Furthermore, Table 4 provides examples of some technical words in written English language text.

Table 4 Technical Words: Example From Wang (2011)

1. Propeller	2. Landing Gear	3. Wing Strut
4. Wing	5. Right Wing Aileron	6. Right Wing Flap
7. Fuselage	8. Horizontal Stabilizer	9. Fin and Dorsal
10. Rudder	11. Elevator	12. Left Wing Flap
13. Left Wing Aileron	14. Door	15. Seat
16. Windshield	17. Engine Cowl	18. Spinne
19. Wheel Cover	20. Landing Light	21. Wing Tip Light

The final type of vocabulary words is low frequency. Low frequency words are a larger group of vocabulary words (e.g. proper nouns and Scholastic Aptitude Test (SAT) words) and do not occur often in reading academic written English language text. There are an abundance of low frequency words in written English language. The meaning behind low frequency words is the association with the context/logic of the message. Hence, low frequency words do not need to be learned by the reader prior to reading text as they aid in the flow/progression of words and understanding of text. Comparable to technical vocabulary words, low frequency words do not have a threshold of words that should be known by a reader.

Flight deck crew alerting systems and QRH checklists contain high frequency words, academic words, low frequency words, and technical/scientific words. Regarding technical/scientific words, many of them are found on the crew alerting systems and QRH checklists, and are in the form of abbreviations and acronyms. As these types of words have a technical/scientific emphasis, these words are related to field of aerospace, specifically flight deck crew systems. Figure 7 and Figure 8 are examples of a crew alerting system and QRH checklist containing some of the aforementioned types of words. The EICAS system contains three words in a yellow hue and in brackets. The words indicate caution on the crew alerting system. The first word is an acronym named 'IM' which stands for interval management. Interval and Management are part of the GSLEW list, and they are considered high frequency words. The word 'Error' and 'Excess' are high frequency words on the GSLEW. On the Battery Bus QRH checklist there are many words, the researcher has identified some of them (each word highlighted with an arrow), to convey words on the academic list, GSLEW list, and technical/scientific words. The word 'appropriate' is found on the academic word list and is considered an academic word, while the word 'attempt' is found on the GSLEW list and is considered a high frequency word. The acronym QRH long word form is named 'quick reference hand book'. Each of these words is also on the GSLEW. The technical/scientific acronym 'DC' long word form is named 'direct current' followed by words 'metering panel', which is common to EICAS systems in the aerospace industry. The word 'gauges' is considered a low frequency word, and acronym DC is a low frequency word on the QRH checklist. The word 'DC' and 'gauges' are common words in other industries.

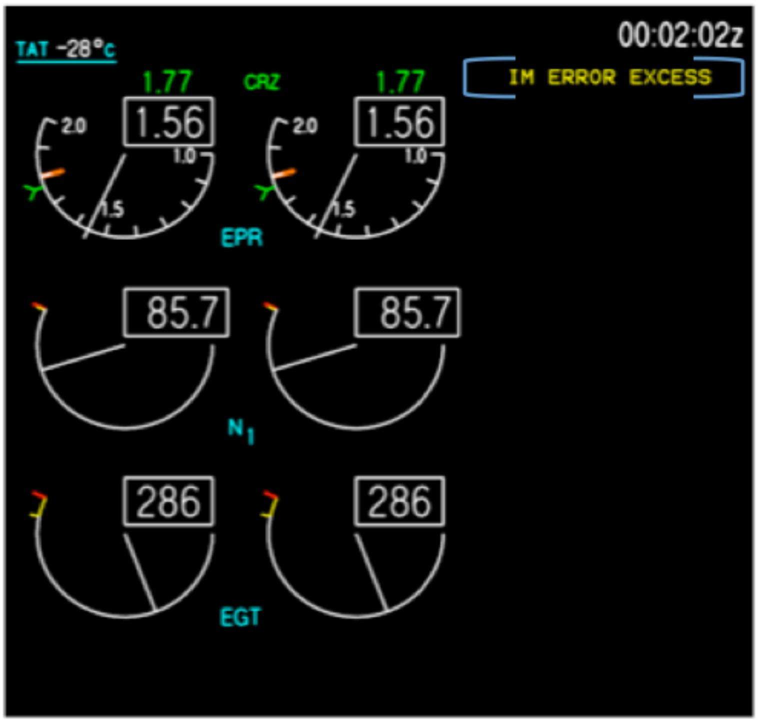


Figure 7 EICAS System

From NASA (2013)

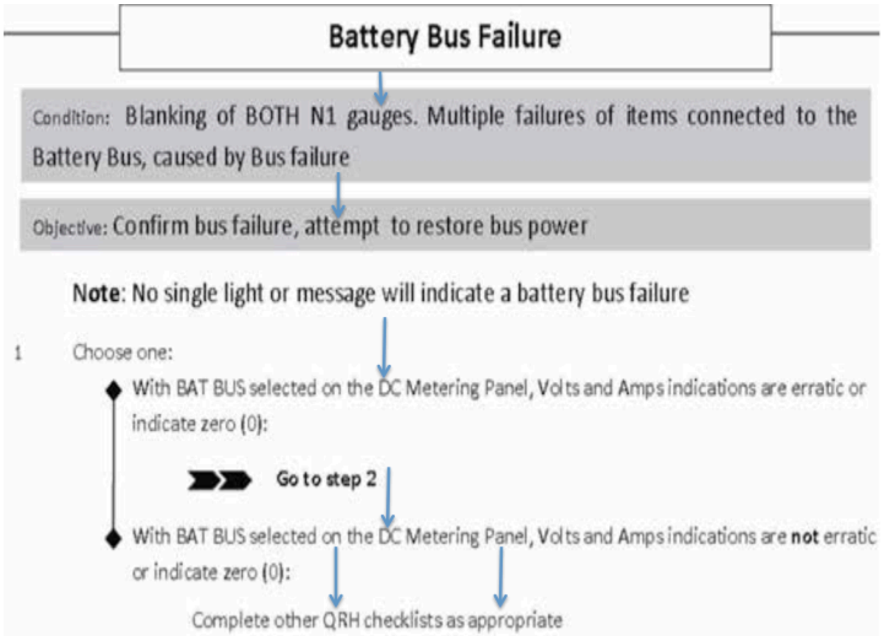


Figure 8 Battery Bus Failure QRH Checklist

From AAIB (2015) Bulletin

In the researcher's experimental study, vocabulary word types, like many discussed previously, will be analyzed to show how ESL flight crewmember written English language proficiency, background knowledge, and metacognitive strategies impact their performance. Vocabulary word types on crew alerting systems and QRH checklists could cognitively challenge ESL flight crewmembers ability to read and comprehend vocabulary words in text corpora. But, what influences ESL adult ability to understand vocabulary word types and text genre? Does ESL adult level of proficiency provide an adequate measure of their ability to read and understand types of vocabulary words? Moreover, are there strategies utilized by ESL adults to read and understand vocabulary words and text genre? There have been studies on ESL adult use of high frequency words, low frequency words, technical words, academic and sub-technical words, and the impact on their reading comprehension.

3.1.1 Academic—Sub-technical vocabulary words in technical text

Ashrafzadeh et al's (2015) study of sixty ESL participants (thirty studying medicine, thirty studying English language) investigated factors influencing participants' reading comprehension of academic words with sub-technical terminology in technical text. Both groups had their English language proficiency evaluated and were assessed as intermediate. Two texts, one related to general medicine included sub-technical terms that was short text (approximately 300 words), and the other related to technical medical text that was long (almost 400 words), which was by far considered extremely technical. Comprehension questions were provided to each participant after reading each text. Results showed high mean (average) comprehension scores for participants studying medicine that read academic text with sub-technical words and highly technical text. Medical academic sub-technical words and highly complex medical text was deemed more difficult to comprehend by ESL participants studying English language than participants with a medical background. Thus, participants with adequate background knowledge of medicine comprehended sub-technical and technical written English language better than participants with less background knowledge. Ashrafzadeh's et al (2015) study provides new information regarding effects of sub-technical and technical terms on ESL adult reading comprehension. Ashrafzadeh's et al (2015) study indicated that ESL adults had intermediate levels of written English language. If ESL adults had low levels or high levels of English language proficiency, the results may have been different. Ashrafzadeh et al (2015) introduce another factor that could negatively impact ESL adults' ability to read and understand technical text, the effect of longer versus shorter text. As Mehrpour and Riazi (2004) indicated previously, text length has the potential to impact an ESL adult's ability to read and understand written English language. Next topic aims to provide more emphasis on technical vocabulary and the impact on ESL adult reading comprehension.

3.1.2 Technical/Scientific Vocabulary words in Technical Text

Mohammed and Swales (1984) indicated that written English language technical vocabulary is perceived as difficult for ESL adults. In particular, use of technical documents and procedures by ESL adults in many socio-technical environments (e.g. military and medical fields) has been deemed challenging. Other factors that may influence understanding of technical vocabulary are related to ESL adult English language proficiency, background knowledge of the technical subject (e.g. medicine, aviation), and strategy they utilize to interpret written English language. The next study discusses the impact of technical vocabulary impact on ESL adult reading comprehension.

Wanpen et al (2013) investigated effect of ESL adult technical vocabulary proficiency, background knowledge of a technical discipline, and strategy use to read and comprehend technical vocabulary. Approximately fifty participants that were taking an English language-engineering course were selected for the study, 28 had general education background and 22 participants had a vocational background. Three instruments were utilized to complete the study. The first instrument was a technical vocabulary assessment with several parts. The assessment included levels of proficiency including high, medium, and low. The first part of the assessment was a matching exercise (e.g. electronic equipment and functionality matching) followed by a fill in the blank exercise to identify technical words, and finally multiple-choice questions related to technical vocabulary. The second instrument was a strategy questionnaire with many questions and several categories. The questionnaire included the following categories coined by the author as Technical Vocabulary Learning Strategies (TVLSs): strategy determination (strategy used to explore new word meanings), strategies utilized in the social context (interaction with social media to understand English language), remembering strategies (decoding of words based on previous knowledge), cognitive (similar to remembering strategies), and metacognitive strategies (evaluation of an individual's understanding of word meaning). A rating scale with six levels was utilized to provide insight on strategy utilized. Last, interviews were conducted that were semi-structured. Results indicated that participants with vocational backgrounds were rated high regarding technical vocabulary proficiency. Participants with general education rated low regarding technical vocabulary proficiency. This result could be related to the vast amount of English language for Specific Purposes (ESP) curriculum that participants with vocational background were accustomed to in the engineering context. Their experience with technical vocabulary words likely enabled them to score higher on proficiency test than the participants with academic background. General perspective of ESP is to provide participants with specific courses related to technical disciplines such as engineering and science. Regarding strategy use by participants to understand technical vocabulary, individuals with an academic background used metacognitive strategies more often than those with a vocational background. This result could be because participants with a vocational background had adequate knowledge of technical vocabulary and were able to use their background to assimilate word meaning. However, both groups utilized metacognitive strategies frequently. In particular, some of the aspects of strategy use by participants to understand technical vocabulary were the following: evading unfamiliar words, reviewing words and their meanings often, and using existing English language information in the media to help them understand technical words. Use of metacognitive strategies was likely due to participants' desire to develop their technical vocabulary. On the other hand, participants with an academic background used social cues, determination, memory, and cognitive strategies less than ESL participants with a vocational background. The participants with a vocational background utilized the aforementioned strategies more often during the study. Finally, the author concluded that technical vocabulary words competence was higher with participants whose background was vocational than with participants that had an academic background. The next study reveals more important details on the effect of scientific technical text on ESL adult ability to read and comprehend written English language.

Abdul-Hamid and Samuel (2012) focused on written English language scientific text and the impact on ESL adult reading comprehension. Their qualitative study consisted of 10 ESL adults that read two types of scientific texts. It was noted that participants' range of English language proficiency was either proficient or less than proficient. The goal of the study was to compare/contrast ESL adult reading difficulty of two texts. Each of the participants had background knowledge of the texts in their native language. The first text contained 592 words and the latter text was 744 words. Participants had background knowledge of more than 50 percent of the first text, and participants knew (familiarity) approximately 20-30 percent of the second text. Each text contained several academic vocabulary words mixed with scientific words. Regarding scientific text, results indicated participants' highlighted text they were unfamiliar with or deemed difficult. They also translated written English language words in to their native lexis and utilized lexical inferencing to understand words that they did not know the meaning. Omission of words that participants did not understand was also noted during the study. Interviews revealed reading and understanding issues with complex scientific words. It was indicated by participants that long complex sentences were very difficult to understand and resulted in them re-reading sentences. Results regarding reading of scientific text by ESL participants indicated that their level of English language proficiency could have contributed to their difficulties understanding scientific text. Academic vocabulary was difficult to interpret within the scientific text. Although there were difficulties reading the scientific text, academic vocabulary words embedded within the structure of the scientific text were more difficult to understand. The reason for these difficulties could be the participants' English language proficiency level and their familiarity with academic vocabulary words in the scientific text. Regarding number of words in the texts, these could also be important determinants of ESL adult English language proficiency levels. As Mehrpour and Riazi (2004) indicated, if text is simplified, long, original, or sentence length altered, these factors could be contributors that effect ESL adult reading comprehension. Wanpen's et al (2013) study corroborated Abdul-Hamid and Samuel's (2012) study regarding technical vocabulary and its potential to impact ESL adults' reading comprehension. Interestingly, in Abdul-Hamid and Samuel's (2012) study, ESL adults translated words that were unfamiliar to them into the native language. This strategy appears to help facilitate ESL adults understanding of written English language scientific text. As ESL participants had background knowledge in the text in their native language, (certain percentage from each of the texts), it is peculiar as to why they did not understand some of the words in the text. Next study reveals important details on the impact of low frequency words on ESL adults reading comprehension.

3.1.3 Low frequency and high frequency vocabulary words in technical text genre

Low-frequency words occur less frequent in written English language text and have the potential to be technical. They are associated with a specific field and can be found in expository or technical reading. The difference between low frequency and technical words are that low frequency words do not have a comprehensive utility (Nisbet, 2010). For example, the word 'rudder' is used in aviation to describe movement of an aircraft left or right. Rudder may also be utilized in the maritime industry as left and right movement of a boat; hence the meaning of the word is equivalent in both industries. General use of the term rudder can be utilized in academic/sub-technical and technical vocabularies. On the contrary, words like 'deoxyribonucleic acid' or 'ribonucleic acid' are terms used in genetics. These types of words are closely related to the medical field and are normally not confused with other scientific fields like aviation or maritime. The next study discusses the impact of low frequency words on ESL adult reading comprehension.

Kweon and Kim (2008) investigated effect of low-frequency words on 12 ESL participants taking classes related to reading written English language. Two of their focus areas in the study pertained to ESL adults' reading comprehension of un-simplified text: frequency of word occurrence in a corpus of text and participants' learning rates, and vocabulary types and participant learning rates. Participants had an academic scientific background or engineering background according to university records. The TOEFL test scores revealed that participants were proficient with reading written English language. Participants read three un-simplified authentic texts; the first contained 260 pages, second 190 pages, and third 200 pages. The first text was a family/friendship book, the second an adventure book, and the third a science fiction book. Regarding word frequency and vocabulary types and the effect on ESL participants' learning rates, results indicated that retention rate for high frequency words were faster than low frequency words. This result indicates that high frequency words were also easier to learn than low frequency words. On the contrary, low frequency words were easier to learn than high frequency words when ESL participants needed to understand the meaning of low frequency words. It was also noted that reading comprehension of nouns in un-simplified text was easy to understand by ESL adults. The authors conclude that this could be due to nouns potentially being simple in text, thereby making it easier to understand by ESL adults. On the contrary, ESL adults did not easily understand utilization of verbs and adjectives in the un-simplified text. This result indicated that these types of words are cognitively difficult to process by ESL adults due to the sophisticated encoding structure. Finally, background knowledge in a scientific field may help ESL adults understand low frequency words in text. Moreover, this result by Kweon and Kim's (2008) study corroborates Abdul-Hamid and Samuel's (2012) study, which indicated background knowledge of the text, is a key component in ESL adults' reading comprehension. Regarding ESL adult English language proficiency levels, Kweon and Kim's (2008) study revealed that adequate written English language reading abilities help facilitate understanding of low frequency words. It should also be noted that the participants were taking classes in English language, this could also be a factor that influenced their ability to read and understand the language. These findings support Wanpen's et al's (2013) study, which indicated that taking courses in an English language curriculum helps facilitate reading comprehension of written English language. Kweon and Kim's (2008) study also noted, when ESL adults needed to understand the meaning of low frequency words, they were successful.

3.1.4 Summary

All of the aforementioned studies reveal important details on types of written English language vocabulary words and impacts on ESL adult reading comprehension. The factors discussed in these studies can be applied to the design and integration of vocabulary words on flight deck crew alerting and information systems. Regarding crew alerting systems, they contain different types of vocabulary words. For instance, Figure 7 and Figure 8 contain technical vocabulary and academic vocabulary words. These types of vocabulary words are designed on crew alerting systems and QRH checklists. Vocabulary words should not be designed or integrated on the GUI or QRH checklists without understanding ESL flight crewmembers English language proficiency, and background knowledge of vocabulary words in text. As each of the types of vocabulary words has the potential to impact ESL flight crewmember reading comprehension, design of vocabulary words on a GUI has the potential to impact their reading comprehension performance.

English as-a-second language adult ability to understand vocabulary words is needed, so that they are able to read and understand text on each of the systems. In chapter one, there was a large body of information that covered effect of technical documentation on ESL flight crewmembers performance. Most of the authors in chapter one refer to crew alerting systems, QRH checklists/FCOMs as a body of texts containing technical words, and they indicated these types of vocabulary words are challenging to ESL flight crew members. But, it appears that there are many different types of vocabulary words on crew alerting and information systems, not just technical words. Differences in vocabulary word types on crew alerting systems or QRH checklists has the potential to impact ESL flight crewmembers performance when the read written English language.

Regarding time allocated to read vocabulary words, the previous studies indicate that time is a factor that has the potential to influence ESL adults' abilities to read vocabulary words. Therefore, time factors could likely impact ESL flight crewmember ability to respond to crew alerts, if they are not proficient with the type of vocabulary word (s). Metacognitive strategies may be utilized by ESL flight crewmembers to understand vocabulary words, but they should have an adequate knowledge of the text, to facilitate ease of reading comprehension. The next studies provide an overview of specific text genres utilized by ESL adults that have the potential to impact their ability to read and understand written English language.

3.2 Vocabulary word types and Text Genres Part II: Impact on ESL adult reading Comprehension

Another factor that may influence ESL adult reading comprehension is the structure of informational and instructional text, two genres of text that have the potential to contain technical vocabulary. First, it is important to understand the difference between informational (expository) and instructional text with respect to technical vocabulary. According to Iwai (2007) and Meyer (1982), expository text contains several elements that make-up the structure of the text. Expository text is often related to text in the academic environment. The structural make-up of expository text include the following: description of the situation, cause and effect, analysis of the situation (indicating similar and dissimilar viewpoints), series of questions that provide answers to address a problem, arrangement of factual information, and sequential timeline of the situation). Instructional text describes how something should be conducted. For example, a checklist/procedure for operating an avionics system may describe how to input information into the system to that it may operate.

Features of instructional text include the following: auxiliary verbs (e.g. may or must) and a list of items that need to be accomplished, including annotations (e.g. bulleted list or numbered items). An illustration of the task may be included with instructional text to help foster understanding of the written text. Instructional text has the potential to be short or long in text structure. For example, consider the following instructional texts: the first represents short text and the latter long text: 'WARNING: Do not open the flight deck door'. 'WARNING: Do not open the flight deck door during flight. If opening the flight deck door, turn the knob, release the lever and pull to open'. The previously mentioned instructional types are examples of how instructional texts may be represented in written English language. These types of instructional texts may be lengthy, or contain complex wording, which has the potential to effect ESL adults reading comprehension (Bielsa-Murcia, 1999). Furthermore, instructional text may aim to provide an indication to ESL adults on how to complete a task, such as a 'to do list'/take action instructions (e.g. recover the failed electrical bus system). Or, instructional text may aim to 'check status' which merely provides instructions on how to check the condition of a situation (e.g. check health status of the fuel system). Instructional texts have the potential to impact ESL adult reading comprehension and strategy use. There are ESL adults that utilize expository and instructional texts to complete reading tasks. So, what are the effects of these types of texts on ESL adult reading comprehension? Are there specific strategies that enable ESL adults to understand expository and instructional types of texts? Although there are two forms of instructional texts, the researcher will discuss one of them ('to do lists') as these types of instructional texts have been noted in chapter one as challenging to an ESL adult.

Carrell (2001) developed a study that focused on effect of instructional text on ESL adult reading comprehension. Thirty-three advanced and intermediate level participants had background knowledge of English language at a university in the U.S.A. Procedure text was designed with an emphasis on text that was not familiar to participants. Procedure text utilized in the study was related to computer word processing steps, and it was designed to provide instruction ('to do') to the participants. It was formatted with high-level procedures followed by sub-level procedures. Results indicated participants' read procedure text with ease, likely due to format of the instructions. On the other hand, Carrell (2001) indicated that these results could be due to English language proficiency levels of each participant. This could have influenced their ability to read and comprehend the procedure text. It was also noted that using participants with different proficiency levels could have impacted the results. Regarding metacognitive strategy use by participants, they were noted using lexical inferencing to read and understand procedure text. Finally, it was noted that one procedure text was utilized in the study, and if different texts were utilized, formatted differently, results may have been different. Collectively, this study provides adequate information on impact of procedure text design, use, and its effect on ESL adult reading comprehension. It also indicates that ESL adults with advanced and intermediate English language proficiency levels use lexical inferencing strategy to read procedure text. Their ability to understand procedure text formatted with high level and sub-level text, are factors that indicate positive impact their reading comprehension.

Park (2010) developed a study that primarily focused on use of expository text by 115 ESL adults. Park's (2010) experiment compared/contrasted ESL adult reading comprehension of expository text with a technical emphasis and narrative (novel) text by participants, and measured their reading comprehension. Many adults were studying English language for academic credit while some focused on engineering and science fields of study for academic credit. Participants that studied English language as their major had almost 10 years of experience with the language. There were 40 ESL participants that had experiences using English language in various regions of the globe where English was the population's primary language (e.g. U.S.A., and United Kingdom (U.K.)). Regarding English language proficiency, a high percentage (80 percent) of participants rated themselves either fairly good or not adequate regarding use of English language. Fifteen percent of participants rated themselves as adequate with using English language, while one participant that did not rate his/her proficiency level. Participants also rated their English language reading proficiency, 80 percent noted they were fairly good or not adequate, while 20 percent indicated high English language proficiency.

Regarding the passages that ESL participants read during the study, they read two dissimilar pieces of text (expository with a technical emphasis and novel texts). Results indicated that metacognitive strategies were utilized frequently, including highlighting, re-reading for interpretation purposes, and referencing other sources. Less utilized strategies included note taking and paraphrasing text. Overall, ESL participants that had a high self-rated proficiency utilized more strategies. Use of reading strategies by highly English language proficient ESL participants was likely utilized due to their knowledge of the strategies. Participants' reading comprehension of expository text with a technical emphasis and novel text indicated more difficulties with respect to reading comprehension complexity than novel texts. One reason that expository text was more difficult than novel text was likely due to expository text low cohesion factor (explanations are less perceptible in the structure of the text). This negatively impacted their reading comprehension of written English language. Text cohesion factor requires the reader to use their background knowledge to decipher through the text. Regarding metacognitive strategy use by participants it was noted by Rouhi et al (2015) and Storch (2001) that highlighting information in expository text is an indication that the ESL reader understands the structure (cause and effect). They also indicated that background knowledge in the subject is paramount when reading expository text. Background knowledge was highlighted as important when ESL adults read written English language.

3.2.1 Summary

All of the factors discussed previously are indicators that expository text with a technical emphasis can be difficult for ESL adults to read and comprehend. Text genres have an impact on ESL adults reading comprehension and instructional and expository text has the potential to be used on crew alerting systems and QRH checklists. In other words, expository text is considered cause and effect/problem solving text, crew-alerting and information systems may feature this type of text. Likewise, instructional text that feature 'to do list' type text can be found on crew alerting systems and QRH checklists. Earlier in chapter one, the researcher indicated that crew alerting systems and QRH checklists are utilized to solve problems. Since crew alerting systems indicate system failures (e.g. hydraulic, electrical), it is important that ESL flight crewmembers understand written English language text displayed on the screen. Likewise, information on QRH checklist information should be comprehensible to ESL flight crewmembers. Another factor to consider regarding crew alerting systems and expository text are ESL flight crewmembers English language proficiency levels and background knowledge of the text. Based on the previous ESL adult studies, ESL flight crewmembers can benefit from having technical vocabulary word knowledge and text genre knowledge. If ESL flight crewmembers have background knowledge of the text, and they have experience from a western region culture (i.e. U.S.A.), they are more likely to understand the format of the text. Having this knowledge of text helps them read and comprehend the text efficiently. What are other types of written English language factors that impact ESL adult reading comprehension? Mohammed and Swales (1984) indicated that certain features of technical documentation need more scrutiny, including text format, conditional statements (e.g. if/then) in text, abbreviations in text, informational and instructional text. The next section provides studies that address impact of conditional statements, abbreviations, and acronyms on ESL adult reading comprehension.

3.3 Conditional Statements: Complex or Easy to read and understand? The ESL adult impact

Another factor that may influence ESL adult reading comprehension is the utilization of conditional statements in technical documentation. In chapter one it was noted in DeBrito's (1998) study that conditional statements in sentences such as 'if/then', negatively impact flight crewmembers ability to understand written English language technical information. However, DeBrito's (1998) study did not elaborate on conditional statements impact on flight crewmembers reading and interpretation of written English language text in technical information. Furthermore, the study did not address English language proficiency factors that may have influenced flight crewmembers ability to understand written English language text. Therefore, more information must be gathered to substantiate this claim. It is paramount to understand fundamentals of conditional statements in written English language sentences, before understanding how they may impact ESL adult reading comprehension of written English language in technical information. The following questions need to be answered regarding conditional statements: What variables do ESL adults need to consider when they read conditional statements in sentences (e.g. design of the statement or enhanced text)? What types of conditional statements are common in written English language? What impact does written English language conditionals in technical documentation have on ESL adult reading comprehension?

The if-conditional statement is normally comprised of conditional and general clauses. The conditional clause starts with the conjunction 'if' followed by the condition (general clause) (Phoocharoensil, 2014). Regarding 'then' conditional clause, it describes the outcome of the situation. Accordingly, conditional statements in written English language sentences describe cause and effect. Conditional sentences have been considered difficult to read and understand by ESL adults (Ramirez, 2005). The primary challenge that an ESL adult experiences when reading if/then conditional statements in sentences, is the structure of the sentence. The structure of conditional statements has the potential to confuse ESL adults due to clauses (if/then), which are essentially the form and tense pattern (function) (e.g. present, future, past) (Jacobsen, 2012). The following example Figure 9 illustrates how ESL flight crewmembers could be confused, or misunderstand written English language conditional statements in text corpora. Figure 9 is from a QRH checklist on the emergency conditions section named 'smoke in the cabin' which is also a crew alert on the flight deck. The conditional statement on QRH checklist does not contain the required form of presenting a conditional statement. It only contains 'if' clause but no corresponding conditional clause. The statement should have included 'then', which would have represented proper form of the conditional statement. This conditional statement has the potential to impact ESL flight crewmembers ability to recognize, understand tense, or time related factors associated with the conditional statement.

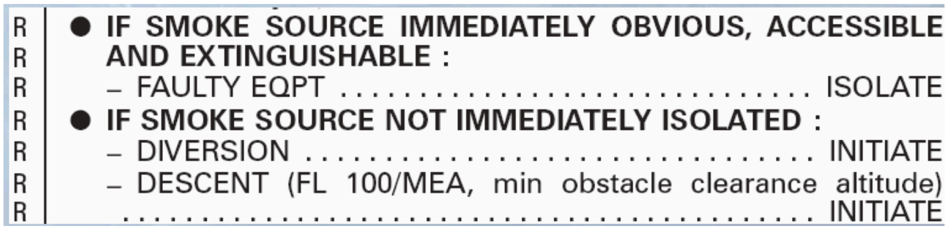

R ● IF SMOKE SOURCE IMMEDIATELY OBVIOUS, ACCESSIBLE
R AND EXTINGUISHABLE :
R – FAULTY EQPT .... ISOLATE
R ● IF SMOKE SOURCE NOT IMMEDIATELY ISOLATED :
R – DIVERSION .... INITIATE
R – DESCENT (FL 100/MEA, min obstacle clearance altitude)
R .... INITIATE

Figure 9 QRH checklist conditional statement From Villain & Pfeiffer (2006)

According to Lai-chun (2005), written English language conditional statements are grouped into four distinct categories: present factual, future predictive, present counterfactual, and past counterfactual. Present factual describes a situation that does not change, and is often found often in technical documentation. For example, 'if you turn on the aircraft bleed system, air flows through the cabin'. Future predictive describes a situation that has the potential to change considering future possibilities. For example, 'if the air bleed system turns off it may be an indication that the system has failed'. In this sentence, the word 'may' introduces a contingency regarding the condition of the system. In other words, the word 'may' indicates that the system could have failed or it may be something else that caused the system failure. Future predictive conditionals are utilized most often in English written language. Present counterfactuals are related to a current situation that is false or could not occur logically. For example, 'if William Boeing were alive, he would design a 787 aircraft'. Past counterfactuals are related to a situation in the past that is false or could not occur logically. For example, if William Boeing knew about composite technology in the early 1900s, he would have designed a lighter aircraft. These types of variables in conditional sentences are important to understand, as they have the potential to be found in technical information. The next studies describe the impact of written English language conditionals on ESL adult reading comprehension.

A study conducted by Yeh and Gentner (2005) investigated ESL adult reading comprehension of present factual and present counterfactual conditional statements in written English language texts. Yeh and Gentner (2005) compared ESL adults and English speaking adults with respect to reading comprehension and reaction time. The authors measured ESL adults and English-speaking adults performance while they read four texts that contained the two types of counterfactuals. The authors also wanted to determine if the present factual conditional was easier to detect (form and function) in text than the present counterfactual. To evaluate the degree of detectability, the authors utilized a rule of thumb method. The rule of thumb method consisted of participants using the following strategy to read the texts: a.) their background knowledge of the texts b.) searching for context clues within the texts. Both of strategies were used to evaluate ESL and English-speaking adult accuracy of reading the correct conditional statement in texts. The authors hypothesized that ESL participants would take longer to complete the task of reading each of the texts than English speaking participants. A time limitation was not levied on the participants. There were 84 ESL participants that had more than a decade of English language training. Each of the ESL participants provided self-ratings of their English language proficiency levels. The rating levels for each of the ESL participants provided indicated they had low levels of English language proficiency. Thirty English-speaking participants participated in the study and their English language proficiency self-ratings were not completed. Results indicated that English-speaking participants' reading comprehension performance was better than ESL participants, when they read counterfactual conditional statements in the texts. Background knowledge (rule of thumb strategy) use by ESL and English speaking adults to read texts, conveyed small percentage differences in strategy use. Reading comprehension percentages were equal between ESL adults and English speaking adults that read factual conditionals in texts. Percentages were also equal for ESL adults and English speaking adults when they used background knowledge and searching context clues in the texts. Regarding accuracy of detecting counterfactual statements in texts using searching context clues strategy, ESL participants' performance was unsatisfactory. On the other hand, English-speaking participants' performance was satisfactory with accuracy of detecting counterfactuals using searching context clues strategy. Regarding each of the conditional statements read by ESL adults and English speaking participants, and their strategy use while reading the texts, their mean reaction times indicated they were not significantly different.

In summary, Yeh and Gentner (2005) provide details on use of written English language conditionals by ESL adults. The results suggest that ESL adults with low English language proficiency levels are not efficient with reading comprehension of counterfactual statements. On the contrary, they appear to be efficient with reading comprehension of factual conditionals. English as-a-second language adults' ability to detect conditionals accurately in texts is an indicator of how well they perform reading conditionals in texts. With respect to ESL adult detection of counterfactual conditional statements in text, their performance was unsatisfactory when they utilized searching context clues strategy to read and understand counterfactuals in text. This result could be that their reading abilities of written English language were not sufficient to read the texts. Their ability to detect the counterfactuals in text could have been negatively impacted. On the other hand, their use of background knowledge strategy to read factual conditionals was adequate. This could be the result of ESL participants possessing some English language background. As indicated by Lin and Chern (2014), ESL adults may activate content schema/background knowledge to understand written English language texts. This strategy may have helped ESL adults detect the factual conditional more efficiently than counterfactual conditionals. It is obvious that ESL adult ability to detect counterfactual conditionals in text is important when they read written English language texts. Finally, Yeh and Gentner (2005) indicated that ESL adults' ability to detect a counterfactual(s) has the potential to impact their mental processing of the counterfactual in text. In other words, if ESL adults are not accurate with detecting a counterfactual(s) they may use more strategies to understand the counterfactual. Therefore, risk of ESL adults re-reading the counterfactual(s) in text, or previous sentences to understand the counterfactual is likely to occur. Although present factual and present counterfactual statements impact ESL adults' reading comprehension performance, how do future predictive and past counterfactual statements impact ESL adults reading comprehension performance? However, what is the effect of enhancing text (e.g. bold or underlined text design) and the impact on ESL adults' ability to read and comprehend future predictive counterfactual statements? The final counterfactual of this section that will be discussed is the past counterfactual conditional and future predictive counterfactual.

A study conducted by Saeidi et al (2013) examined impact of enhancing conditionals in text on ESL adults noticing them compared to unenhanced text. It is important to understand that the ability for ESL adults to notice text can impact their ability to read and comprehend text adequately (Schmidt, 1990 and 1993 and Song and Suh 2008). Saeidi et al's (2013) study contained 60 ESL participants; each had a background in English language learned from a university. Participants had an intermediate English language proficiency level. Each of the participants read a passage and a pretest and posttest administered by the researcher. The passage contained several conditionals including past counterfactual conditional and future counterfactual conditional. The results indicated that overall scores (pretest and posttest) did not change participants' reading performance. That is, enhancements to past and future counterfactual conditional statements did not create a significant impact to participants' performance, compared to unenhanced text. These results could mean that ESL adults' knowledge of conditionals in the form they read was based on syntactic structures of conditionals that were unenhanced. Therefore, they were used to seeing the unenhanced version of the future counterfactual conditional statement. Collectively, this study provides adequate details on the effect of enhancing past and future counterfactual conditional statements. They describe the effect of enhancing text and that enhancing text does not always increase reading comprehension of the text. As ESL adults had knowledge of the future counterfactual through a pretest, it may indicate that exposing ESL adults to text prior to their official use (e.g. during a task) may be beneficial. Since there was not a significant increase in comprehension between both forms of text, it may be an indicator that time exposed to the text may impact ESL adult reading comprehension.

3.3 Summary

In summary, all of the studies mentioned in this section indicate reading conditional statements impacts ESL adult reading comprehension performance. Several types of conditionals were discussed. Each of the researchers indicated that ESL adult English language proficiency and background knowledge of English language conditionals are factors that influence ESL adults ability to recognize the form and function of the conditional statement in text corpora. Specifically, Yeh and Gentner (2005) agreed with Saeidi et al (2013) regarding low and intermediate English language proficiency impact ESL adult ability to read and comprehend conditional statements in text. In these studies, future counterfactual, present factual, and present counterfactual conditionals impacted ESL adults' reading comprehension. In Yeh and Gentner's (2005) study, ESL adults' reaction time for detecting conditionals indicated no impact to ESL adults' reading comprehension. Unlike Yeh and Gentner's (2005) study, Saeidi et al (2013) provided an indication that input enhancement to conditionals do not necessarily increase reading comprehension. But, Saeidi et al (2013) do indicate that even though statistically the results are not statistically significant, input enhancements to conditional statements can help with detecting and noticing conditionals in text. In Yeh and Gentner's (2005) and Saeidi et al's (2013) studies, structure of text did not appear to impact ESL adults' performance reading conditionals in text. Conditional statements are found on QRH checklists. English as-a-second language flight crewmembers background knowledge of text on checklists may help facilitate their understanding of conditionals in text. English as-a-second language flight crewmembers use of metacognitive strategies may not be the only method to read and understand written English language conditional statements. English as-a-second language flight crewmembers English language proficiency and background knowledge of the text they read, may be indicators of how well they will detect conditional statements (correctly/incorrectly) and recognize them in texts on QRH checklists.

3.4 Abbreviations and Acronyms: A tale of two unique written English language factors

Written English language phrases in text corpora have the potential to impact ESL adult reading comprehension (Ha Cohen-Kerner et al, 2013). Phrases can be utilized to shorten longer forms of a word. They are operationally defined as clipped forms (e.g. math versus mathematics) and have the potential to impact ESL adults reading and understanding of written English language. Common phrases utilized in written English language are abbreviations. Acronyms are a form of abbreviations that are also found in written English language text (e.g. National Aeronautics and Space Administration (NASA). Acronyms are developed from terminology or phrases that may be considered lengthy and therefore shortened by using key components (letters) to convey its meaning. Generally speaking, abbreviations/acronyms are considered ambiguous words due to their presentation in text. They contain small number of letters, which can be difficult to understand regarding the word meaning. As abbreviations contain short forms and long forms of a word (e.g. cklst versus checklist, or feds versus Federal) and acronyms contain a small amount of letters (e.g. NASA-National Aeronautics and Space Administration, or FBI-Federal Bureau of Investigation), connecting the meaning of the longer version of the word to the shorter version of the word has the potential to be challenging (McInnes , 2011). Regarding ESL adults, it may be difficult for them to understand the meaning of written English language abbreviations/acronyms if they do not have an adequate contextual knowledge of the word meaning. Moreover, abbreviations/acronyms may be perplexing to ESL adults if they do not have adequate background knowledge of the written English language text (e.g. scientific/academic). English as-a-second language adults with inadequate background knowledge of reading written English language abbreviations/acronyms, have the potential to be negatively impacted, when they translate the information back into their native language. That is, written English language abbreviations/acronyms could potentially have different meanings in a different language, or different meanings based on the text type (Kuzmina et al, 2015). Both abbreviations/acronyms in text corpora have been noted as challenging to read and comprehend by ESL adults. In chapter one the FAA (1996) stated that written English language acronym use on crew alerting systems and QRH checklists are cryptic, and have been noted as difficult to read and understand by ESL flight crewmembers. Scientists also indicated that acronyms have the potential to be challenging to individuals that speak English as a second language, when they read acronyms in text. But, what are the fundamental factors that influence readability and understandability of acronyms by adults that speak English as a second language? Does ESL adult English language proficiency impact their ability to understand written English language acronyms?

A study conducted by Kim (2006) examined the effects of abbreviations/acronyms on ESL adults. Less than 10 participants were utilized for the study each with background knowledge in the text chosen for them to read. Participants had experience living in the U.S.A. and using written English language. Their experience ranged from less than one year to three years and English language proficiency levels ranged from low to high. It was noted that translating English language into their native language was a common metacognitive strategy utilized to understand abbreviations/acronyms, but led them to misinterpret the words. Participants used lexical inferencing strategy when they read abbreviations/acronyms in text. However, while using this strategy, many of them misinterpreted the words because they had a different meaning in their native language. Results indicated that acronyms were difficult to read and understand, and they were comprehended differently with respect to each of the ESL adults' English language proficiency level. Moreover, it was indicated that adults were challenged when they connected the acronym to the word meaning. In Kim's (2006) study, genre of text (e.g. academic, technical) was not provided. As previously discussed by Ashrafzadeh et al (2015), if ESL adults have background knowledge of the genre of text that they read and background knowledge on the subject, it has the potential to impact their reading comprehension performance. Moreover, background knowledge of text genre and background knowledge on the subject are adequate measures of ESL adult proficiency levels. Next study provides more information on the impact of abbreviations/acronyms on ESL adult reading comprehension abilities.

A study conducted by Larsen and Hansen (2010) examined the impact of written English language text (with technical terminology) on 10 ESL adults. One of the goals of the study was to determine if abbreviations in scientific texts impacted participants' ability to read and comprehend written English language. Two authentic written English language texts that were scientific genre were chosen for the study, and were modified into simplified versions, creating two additional texts. The first authentic text was considered complex due to its specialization. The first text contained an abundance of abbreviations. The other authentic text was less challenging due to its familiarity to the participants. Each of the texts contained approximately 600 tokens (number of words) and contained simplified versions (e.g. edited verbs/clauses), but simplification did not change the meaning of words in the texts. The researchers did not make changes to scientific terminology in the text. The texts also contained other vocabulary words (e.g. high frequency words).

According to demographics collected by Larsen and Hansen (2010), each of the participants had experience with scientific text like the texts chosen for the study. Most of the participants rated their English language proficiency as very well. Results indicated that when participants that read abbreviations in a previous sentence (text one and text three), they were challenged by their ability to process abbreviations, and understand the next sentence. In other words, ability for adults to transfer context clues from abbreviations in the previous sentence to the next sentence was hindered, and negatively impacted their reading comprehension. It was indicated that text one and three (original/authentic) took longer for participants to process than for texts two and four (simplified texts). Participants also re-read the abbreviations in texts one and three to understand them. Participants' reading comprehension times (regarding abbreviations) were less when reading texts one and three than with reading complex text versions two and four. Interestingly, the study revealed that participants re-read previous sentences in the complex text that contained an abundance of abbreviations to understand the next sentence, which led to longer processing times. As previously discussed by McDonough (1999), processing times (longer/shorter) is regulated by strategy use by adults. Additionally, as each of the participants had background knowledge of the texts, this helped them understand the texts. However, when adults read the more complex texts they indicated they were challenged. Coady & Huckin (1997) indicated ESL adults possessing good understanding of technical vocabulary words is needed if they are required to have background knowledge of the text. The next study provides information on the impact of acronyms on adult reading comprehension.

Park et al (2014) developed a study that investigated the effects of written English language abbreviations on ESL adults. In particular, they wanted to understand how adults decode the meaning of acronyms. Their study consisted of seven participants from different countries. Each of the ESL participants' level of English language proficiency was very good, per reading comprehension scores from TOEFL reading comprehension test. Two of the participants had a technical background, while the other participants had a background in either academics or business field of study. Each of the participants had experience with English language in the U.S.A. and had background in the text chosen for the study. Text chosen for the study was related to computer technology and contained reading comprehension questions. Each of the participants read the texts without a time limitation. Results indicated that texts with acronyms were difficult to read, and background knowledge was utilized to understand the meaning of acronyms. Participants with academic or business background knowledge completed the task quicker than participants that did not have a background in the text. Participants' utilized dictionary sources to understand the meaning of acronyms in text, and decided if it was more practicable to find the their native language equivalent (e.g. Chinese) or English language meaning of the acronyms. Adults utilized metacognitive strategies such as predicting word meaning in text and monitoring reading comprehension, when they read acronyms. Overall, Park's et al (2014) study reveals important themes that are worth noting. Firstly, their study provides supporting evidence that a high level of English language proficiency is required to interpret acronyms. Secondly, background knowledge in text that is technical is important, but ability to decode acronyms using metacognitive strategies is more important. Thirdly, experience in a western culture may also afford understanding of written English language. Similar to Larsen and Hansen's (2010) study, Park's et al (2014) study revealed that background knowledge and use of metacognitive strategies to read and understand text is important. As Kim's (2006) study indicated, prior background in a western culture helps facilitate an ESL adult's ability to read and understand written English language text.

3.4.1 Summary

In summary, all of the aforementioned studies in this section that addressed the impact of acronyms/abbreviations on ESL adults reading comprehension provide an understanding of the challenges ESL adults may encounter while reading acronyms/abbreviations in text. All of the factors discussed from each of the studies apply to the flight deck operational environment. With respect to the crew alerting system interface, ESL flight crewmembers may be impacted by the ambiguous nature of acronyms/abbreviations. For example, crew alerting systems feature acronyms/abbreviations on their graphical user interface (GUI). Since acronyms/abbreviations have the potential to contain small amounts of letters, ESL flight crewmember reading comprehension performance could potentially be impacted. If ESL flight crewmembers have low English language proficiency and limited background knowledge of acronyms in text, it could negatively impact their reading comprehension. Limited background knowledge could negatively impact how they process the acronym/abbreviation and thereby impact their ability to decode the meaning of the words. If there are many acronyms/abbreviations on the GUI, it could also impact ESL flight crewmembers ability to decode them in text. English as-a-second language flight crewmembers timely decoding of acronyms/abbreviations may be important, especially if the aircraft condition (e.g. system malfunction/failure) requires a timely response. On the other hand, if ESL flight crewmembers have a high level of English language proficiency and a vast amount of background experience with acronyms/abbreviations in text, their reading comprehension may not be negatively impacted. With respect to the design of the crew alerting system and layout area, it is also important to realize that space could be limited on the GUI of crew alerting systems. Accordingly, it is important to understand the impact of acronyms on ESL flight crewmembers reading comprehension. Furthermore, if space is limited on a crew alerting display, does the use of acronyms impact ESL flight crewmembers ability to read and understand them in a timely manner? The aforementioned question will be answered in the researcher's forthcoming studies. Park's et al (2014) study revealed that temporal demand on ESL adults while they read the texts was not regulated. However, it was noted that less time was utilized to read and comprehend acronyms, if ESL adults had a sufficient amount of background knowledge of the acronyms in text. Previously stated, if longer response times are needed, so that ESL flight crewmembers understand acronyms/abbreviations on the display, it could impact their ability to solve time critical system/aircraft problems.

Regarding acronyms/abbreviations on the QRH checklist, ESL flight crewmembers background knowledge, English language proficiency, and their ability to use metacognitive strategies (e.g. decode acronyms/abbreviations in text) could impact their ability to respond adequately to non-normal aircraft/system conditions. As paper checklists typically have more space on them, and have the potential to contain vast amounts of sentence types, ESL flight crewmembers reading comprehension on use of acronyms/abbreviations in text could be impacted. Simplified or elaborated text and/or long or short sentences with acronyms/abbreviations could impact ESL flight crewmembers reading comprehension. As acronyms/abbreviations have the potential to be ambiguous in QRH checklists, sentence length and text length could exacerbate ESL flight crewmembers reading comprehension of acronyms/abbreviations due to their shortened forms of the longer word in text.

3.4.2 Chapter Summary

This chapter provided evidence on how vocabulary size and depth are factors that influence ESL adult ability to read and comprehend English written language. Text genre, conditional sentences, and abbreviations/acronyms all have an impact on ESL adult ability to read and comprehend written English language text. Vocabulary size may be an indicator as to how well ESL flight crewmembers read and comprehend written English language. As Smith-Jackson (2006) and Riley et al (2006) revealed in chapter two, cognitive processing of information by ESL flight crewmembers has the potential to impact their language literacy thus impact reading and comprehension. English as-a-second language flight crewmembers adequacy of understanding of word meaning can potentially impact their ability to interpret words on crew alerting and information systems.

Regarding acronyms and abbreviations on checklists and on crew alerting systems, these types of words have the potential to impact ESL flight crewmembers ability to read and understand text. More importantly, if ESL adults do not have a good understanding of the long form of the abbreviation/acronym or they misinterpret the short form, they may misinterpret information on the checklist or crew alerting system. If abbreviations or acronyms are in text that ESL flight crewmembers do not understand, their reading comprehension may be negatively impacted. Regarding ESL flight crewmembers ability to read written English language conditional statements, ESL adults have the potential to be negatively impacted if they do not recognize the form or function of the conditional statement. Often, there are conditional statements in text on QRH checklists, especially in the notes section of QRH checklists. Overall, adequacy of ESL flight crewmembers English language proficiency, and background knowledge are two driving factors that could impact their ability to read and comprehend written English language conditional statements.

Chapter 4: Written English language on the GUI: Impact on ESL adults reading comprehension

This chapter introduces written English language on the GUI (e.g. computer screen interface) and its effect on ESL adult ability to read and understand written English language. This chapter will investigate ESL adult ability to read and understand vocabulary types, text type etc. on computer screens. Next studies provide an overview of the impact GUI design has on ESL adult ability to read and comprehend written English language. Towards the end of the chapter the researcher will convey the relationship between the GUI and ESL flight crewmember reading comprehension abilities of technical information. Below is a paradigm Figure 10 describing each of the elements that will be discussed in this chapter. Top circle is the focus of the chapter, graphical user interface, followed by crew alerting systems design features. These features are with respect to vocabulary word design specifics (i.e. abbreviations and acronyms). Vocabulary word design specifics such as text format and text genre will be explored (left box). English as-a-second language adult background knowledge, English language proficiency will be reviewed, as well as their ability to use metacognitive strategies to read and comprehend written English language on the GUI (four bottom boxes).

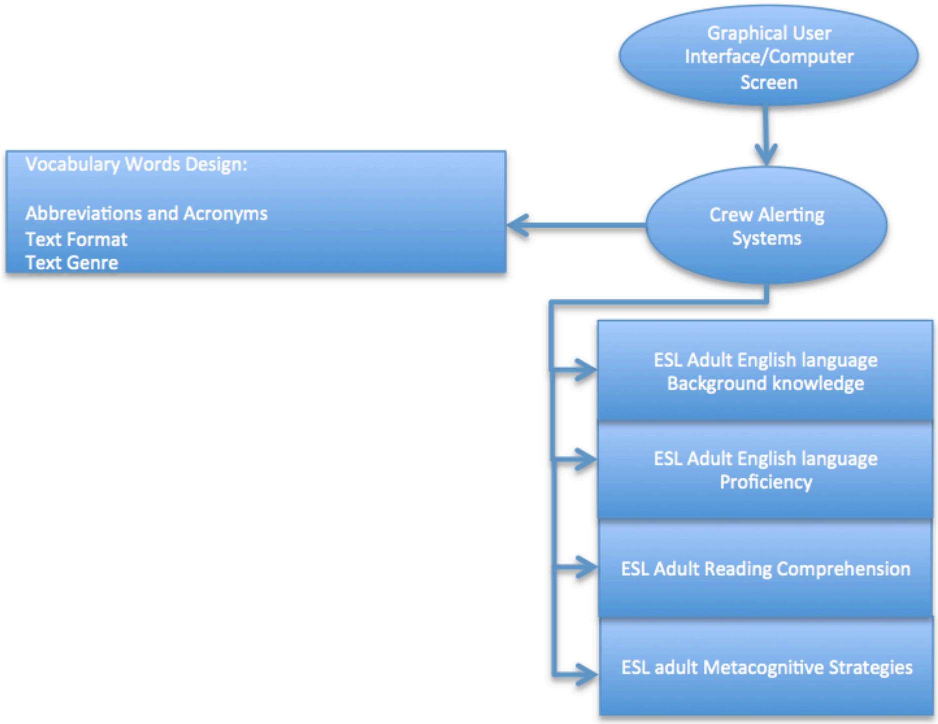


Figure 10 Chapter 4 Visualization Roadmap

Recall, in chapter one that it was indicated by several researchers that ESL adults are challenged with reading English language on computer screens. Particularly, Sallee and Gibbons (1998) and FAA (1996) indicated displays that feature system diagnostics and alert criteria often present a challenge to ESL flight crewmembers reading and comprehension. Particularly, these challenges are related to written English language design on computer screens. You (2009) indicated that ESL adults that read written English language on computer screens have the potential to be challenged due to their ability to retrieve text from screen. In particular, text is presented differently on the computer screen compared to text on paper format. English as-a-second language adults mental model of written English language text on computer screens is different from paper checklists on the following basis: a.) perception of presentation format regarding vocabulary words b.) metacognitive reading comprehension strategies. Each of the aforementioned mental models could have an impact on ESL adult performance.

You (2009) developed a study that investigated the impact of ESL adult ability to read and comprehend written English language on computer screens and paper format. One hundred and twenty ESL adults participated in the study, possessing some background knowledge of English language through instruction at a local university. Two texts unfamiliar and familiar to the participants were utilized for the experiment. The first two participant groups indicated they were familiar with two texts, while the other group was not familiar with them. Participants' proficiency levels were determined to be low, medium, and high, based on a reading comprehension test. On average, text length was approximately 340 words. Text length of the two original texts (i.e. texts familiar and unfamiliar) was cut from approximately 550 words to 340 words by removing passage complexities and nebulous words in sentences. Each of these text alterations impacted the layout of text on paper and computer screen. The computer screen space allowed for almost 30 lines of text, which was visible to participants. The paper text allowed more space for lines of text than on the computer screen. Each of the readings was expository text type. Results indicated that participants' reading comprehension performance reading from paper format and a computer screen was satisfactory. Regarding participants text background knowledge, participants performed significantly better when they read written English language text from paper, than when they read from a computer screen. Considering each format (e.g. computer screen and paper), participants performed significantly better when they read text that was familiar to them, rather than reading unfamiliar texts. Participants utilized metacognitive strategies like re-reading and highlighting text when they read the texts in different formats (GUI and paper). It was noted that ESL adults utilized more strategies when they read English language on paper format than on computer screen. This result was because ESL adults were more accustomed to using metacognitive strategies to read written English language in paper format than from a computer screen. Participants indicated they were comfortable using their background knowledge of the text to read and understand text on a computer screen. Low proficiency adults did not perform as well reading texts unfamiliar to them in paper and computer screen format, whereas medium and high proficiency participants performed better reading texts in the same format. Texts that were familiar to ESL adults across each level of proficiency performed well reading the texts, regardless of format. These results may have been due to participants' background knowledge of the texts they read in the experiment. The next study highlights the effect of ESL adult ability to read text on a computer screen.

A study conducted by Anderson (2003a) investigated ability of ESL adults to read and comprehend written English language from a computer screen. It was hypothesized that ESL adults utilize certain reading strategies often due to complexity of reading English language on a computer screen. The study consisted of approximately 250 ESL adults, each with a background in English language. Half of the participants had a background using English language in the U.S.A., whereas the latter half had experience using English language in South America. Each of the participants had either intermediate or high English language proficiency levels. The text they read on the computer screen was related to the academic discipline they studied at a university. Results indicated that there were several strategies that ESL adults utilized to read and comprehend written English language on a computer screen. Adjusting rate of reading, lexical inferencing, and re-reading text, were three of the strategies often utilized by adults to read written English language on a computer screen. Strategies utilized the least by participants to read on a computer screen were the following: translating information back into native language and highlighting text. It was noted that adults utilized strategies because they were challenged with reading words on the computer screen. Therefore, using these strategies likely helped them understand written English language on the computer screen, and thereby improved the reading comprehension ability. In summary, Anderson's (2003a) study provides important details on the impact of metacognitive strategy use by ESL adults to read written English language on a computer screen. It was noted that participant English language proficiency is a factor that influences their ability to read and comprehend written English language on a computer screen. Evidently, possessing intermediate to high levels of English language proficiency can lead to use of metacognitive strategies. Interestingly, these types of metacognitive strategies utilized in Anderson's (2003a) study are factors that influence ESL adults' ability to read written English language on paper. This is an indication that some of the same strategies may be utilized to read from a computer screen. You's (2009) corroborated Anderson's (2003a) study, indicating that metacognitive strategies use can be used to read written English language on a computer screen.

4.1 Chapter Summary

Studies discussed in this chapter reveal important details on ESL adult use of written English language on computer screens. Each author provided evidence that there are impacts on ESL adult ability to read and comprehend written English language. All of the factors discussed in this chapter are applicable on the flight deck. Regarding temporal demand on ESL flight crewmembers, if there are time constraints regarding response to system malfunctions or failures, ESL flight crewmembers must be able to respond effectively to them, and correct the flight situation. Depending on the type of metacognitive strategies used to read English written language on a crew alerting system, it may impact their ability to respond adequately to the system malfunction or failure. For instance, if ESL flight crewmembers re-read text on a crew alerting system due to misunderstandings of the text, it could take them longer to fix the system malfunction, or assess the failure. This could lead to longer reaction times to the crew alert and thus lead to a flight safety issue. On the other hand, some strategies may not impact ESL flight crewmember response time to system failures, but hinder their success with perception and interpretation of written English language on crew alerting systems.

English language proficiency is also a factor that has the potential to impact ESL flight crewmembers' ability to respond effectively to crew alerting systems. Evidently, intermediate and high levels of English language proficiency are indicators of how well ESL flight crewmembers will read and understand information on computer screens. If ESL English language proficiency levels are low, it could mean that they may not use as many strategies, or only certain strategies. This could have the potential to impact their response to crew alerts. Many of the metacognitive strategies used by ESL adults in previous studies in this section, have the potential to impact ESL flight crewmembers workload. If they use an abundance of metacognitive strategies or certain types of metacognitive strategies, will this impact their workload responding to crew alerts? This question will be answered through various studies the researcher will provide in forthcoming chapters.

Chapter 5: Translation of written English language into ESL adult native language: Opportunity or Issue?

The researcher has highlighted various strategies throughout the literature review that ESL adults can utilize to help them read and understand written English language. Use of strategies by ESL adults has the potential to impact their workload and other cognitive related issues. In chapter one, Ho (1996) and Ogilvie (1984) argued that due to written English language complexity, it may/may not be feasible to translate written English language into ESL adult native language. Ho's (1996) conjecture was that translation of written English language into ESL adult native language may help them with reading and understanding text. On the other hand, in chapter two Hutchins et al (2006) and Drury & Ma (2005) indicated that translation of written English language has the potential to impact ESL adults reading comprehension. Each of these perspectives do not provide any evidence that translation of written English language into ESL adult native language is a factor that positively or negatively impacts their performance. Therefore, there must be evidence to support each of these claims to provide clarity on this issue. The aim of this chapter is to understand the impact of translating written English language into another language. This chapter will also highlight theoretical processes on how to translate written English language into ESL adult native language. Finally, the researcher will show the relevance of translating written English language information into ESL flight crewmembers native language, and impacts on their reading comprehension. Does translating written English language into another language impact ESL adult reading comprehension? The next studies reveal the impact of translating written English language into ESL adult native language. First, paradigm Figure 11 below describes the elements that will be discussed in this chapter.

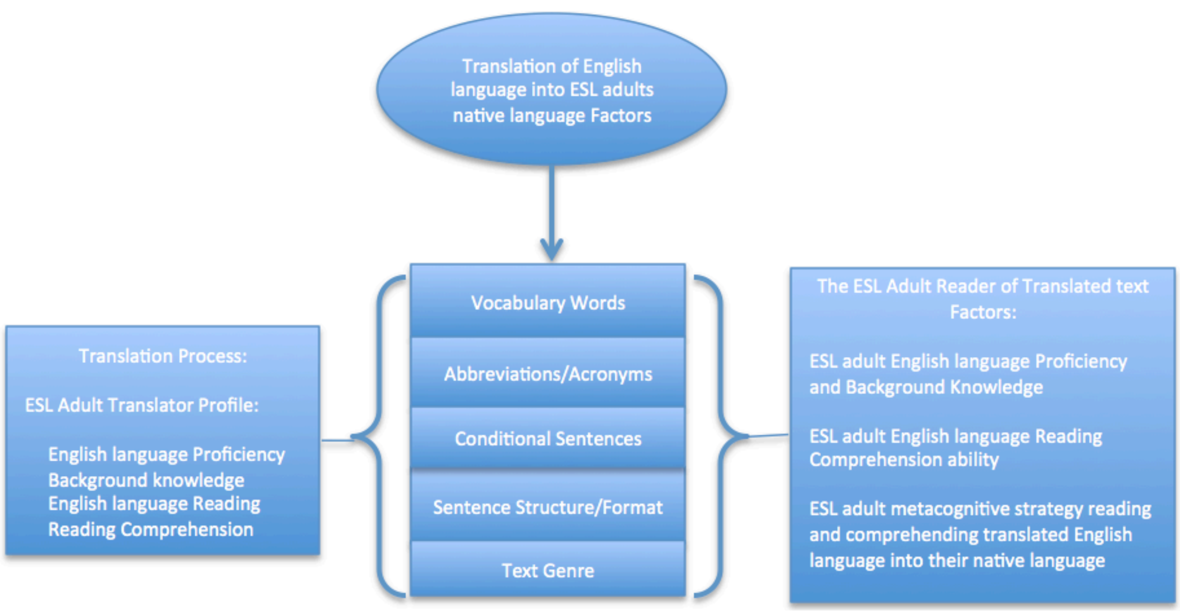


Figure 11 Chapter 5 Visualization Roadmap

Translation of lexis theory allows the translator to utilize methodology to ensure adequate translation of written language. Translators utilize direct or oblique type translation (Vinay and Darbelnet, 2000). Direct translation requires translation of each vocabulary word and sentence appearing in text corpora, from source language to target language. Ability to directly translate vocabulary words and sentences from source language to target language could be due to both languages have similar metalinguistic features. Oblique translation may require a more intricate analysis of the syntax in text corpora, due to inability to translate all information in text corpora from source to target language. Translators may use specific procedures to translated vocabulary words and sentences from source language into target language. Next seven procedures are utilized in translation of lexis. Borrowing procedure requires adapting the source language to target language. This requires the translator to find words with similar culturally unique effects in the source language prior to translating to the target language. In other words, the translator locates similar terminology that the reader may recognize in the target language. For example, if there is a unique term in written English language (source language) that may be recognized in the target language Flemish, it may be worth borrowing specific terminology from source language so that there is an equivalent understanding in the target language (Flemish lexis). Caique procedure borrows syntax from source language to target language, and then direct translation of text occurs after reviewing structure of vocabulary words/sentences in text corpora. Direct lexis translation procedure occurs when the translator ensures exact translation of vocabulary words/sentences and ability to reverse effect of translation back into the source language. Transposition procedure replaces vocabulary words in the same word family without interrupting word meaning in text. Modulation procedure impacts the message formality and changes perspective of viewpoint. Equivalence procedure requires text to be equivalent with each other (source/target language). In other words, the style and structure of text corpora are equivalent due to their syntagmatic form. Finally, adaptation procedure is utilized when information in the source language is limited or undetermined in the target language. Translators have to focus on creating equivalent terminology to ensure adequacy in word meaning, so that the reader can interpret information in text corpora. Adaptation can be considered a specific type of equivalence. For example, if there is a word in the source language that seems appropriate in the target language, it may not be appropriate to translate it directly (e.g. written English language to Dutch language) (Vinay and Darbelnet, 2000). In the researcher's experiment, it will be determined if aforesaid methods are appropriate for the translation activities. Next studies discuss impact of translation on ESL adult performance.

Zhao (2015) conducted a study with 15 ESL adults that focused on impact of translating written English language into ESL adult native language. Goal of the study was to interview ESL adults to understand impact of translation on their reading comprehension. Results indicated that translation of written English language into ESL adult native language has benefits as well as intricacies. Benefits include translation of written English language considering a group of ESL adults have same native lexis background. In other words, if there are group of Chinese native adults that read and comprehend Chinese, it is more efficient to translate written English language into their native language. This approach is effective due to the Chinese adult having related understanding of their native language with other Chinese adults. Another benefit is learning meaning of a translated word(s) in ESL adult native language facilitates learning, thereby increasing level of understanding. Finally, ESL adults that have good background knowledge of their native lexis read and comprehend a second language adequately. Complexities include inability to translate every vocabulary word in text corpora into ESL adult native language effectively (Dash & Dash, 2007; Larson, 1998). Misinterpretation by ESL adults can occur due to translated vocabulary word meaning (written English language to ESL adult native language). Finally, if an ESL adult translating written English language into ESL adult native language does not have background knowledge in translating written English language vocabulary words into their native language, there could be negative impacts to reading comprehension. As (Gile, 1995) indicated, understanding the Source Language Text (SLT) is important when translating written English language (SLT) into the Target Language Text (TLT) (ESL adult native language). Zhao (2015) provides adequate evidence that translating vocabulary words into an ESL adult native language can impact reading comprehension. This study provides a segue into the researcher's next studies, which focus on other elements of translating written English lexis and impact on ESL adult reading comprehension.

In chapter four the researcher indicated that acronyms/abbreviations were challenging for ESL adults to read and interpret due to their ambiguous form. In addition, acronyms/abbreviations are difficult to translate meaning into another language. Since translation of word meaning is considered a metacognitive strategy that is utilized by ESL adults to facilitate reading comprehension, what is the effect of translating abbreviations and acronyms? In other words, does translation of written English language abbreviations and acronyms into ESL adult native language impact their reading comprehension? According to Ynfiesta et al (2013), translating acronyms into another language (e.g. ESL adult native language) is challenging. Acronyms that are found in written English language may not be the same in another language. Particularly, differences in spelling of an acronym in written English language and the meaning of the long form of the word are two factors that could impact the way in which ESL adults read and interpret acronyms in text. Another factor that has the potential to influence ESL adult reading comprehension of acronyms are the differences in acronym use in ESL adult native language. That is, the acronym meaning could potentially mean something different or have multiple meanings in ESL adult native language. Hence, this factor could impact ESL adult ability to read and comprehend the acronym. Background knowledge of the acronym in text is also a factor that influences ESL adult ability to read and comprehend the acronym.

Ynfiesta et al (2013) developed a study that focused on translation of written English language acronyms into another language. Intent was to determine if there were reading comprehension issues with written English language acronyms used in technical text, translated into a different language. Approximately 20 acronyms were found in text containing technical vocabulary words, which were evaluated by a translator. Results indicated translation of written English language acronyms into another language was difficult. Without background knowledge of the written English language long form of the acronym, it is difficult to process translated written English language acronyms into another language. It was noted that this resulted in misunderstandings of the acronyms that were translated into another language. Another factor that was discovered in the study was that translation of technical text into another language requires expert background knowledge of the text that is being translated. It was noted that use of reference material and experts that are keen to the technical aspects of the text translated is needed, so that the meaning of acronyms are not lost due to the translation of them from written English language into another language. Furthermore, it was found that acronyms used often in written English language technical text had different meanings of the equivalent spelling of the acronym used in another language. This caused the translator to be confused when trying to identify equivalent forms of the acronym in another language. Conceivably, fundamental issues found in translation of acronyms in technical text into another language could also be a factor that influences readability and comprehensibility of English language acronyms in different genres of text (e.g. academic text, scientific text, instructional text). Collectively, this study sets the framework for the next studies regarding translation of written English language into another language. Even though the previous study focused translation of written English language acronyms into another language, what are the impacts on other pieces of written English language? As there are other forms of vocabulary words, sentences, and other English language vocabulary in written English language text, how does translation of written English language into another language impact ESL adult reading comprehension performance?

A study conducted by Barani and Karimnia (2014) investigated impact of written English language translated into Persian lexicon. The authors wanted to understand the impact of translating written English language into Persian, and the effect on ESL adults metacognitive strategy use while reading the text translated. Their study consisted of 32 ESL adults that had either background knowledge in text translation theories or knowledge in reading comprehension. Each of the participants had background knowledge of text translation in Persian form, their native language. Advanced level English language scientific text was utilized for the study. Each of the written English language vocabulary words and sentences were evaluated regarding equivalency of meaning in Persian language during the translation process. This was performed due to the possibility of differences between written English language and Persian language word and sentence meanings. Results indicated several strategies utilized by participants to understand written English language text and subsequently translate into Persian language. Many participants used metacognitive strategies such as re-read sentences and paraphrase words while they read English language text. It was indicated that they utilized these strategies for problem solving purposes, which were related to difficulties understanding word meaning. Barani and Karimnia's (2014) study highlight important details on translation processes and the effect of translating written English language into another language. Three themes emerged from their study that are noteworthy. First theme was background knowledge of text in written English language. It was noted that participants were familiar with the text in English, as they had experience reading the scientific text. This is an initial indication that knowledge of written English text prior to evoking translation processes is important. Second theme was translator experience with process of translating written English language text. It was noted that the translator considered the design of phrases, sentences, and vocabulary words in written English scientific text prior to translating their meanings into Persian language. This process was likely conducted due to the possibilities of misinterpreting word meanings in written English language and translating them into Persian language. In other words, translators of written English text considered the effects on participants' reading comprehension, before they executed the experimental trials. The final theme is metacognitive strategy use by participants to interpret written English language translated into Persian language. Evidently, many of the same strategies utilized to read and understand written English language are equivalent strategies utilized by participants to read Persian language. The next study provides more information on the impact of translating written English language text into another language, and its effect on ESL adult reading comprehension.

Al-Sohbani and Muthanna (2013) developed a study that focused on ESL adults lack of lexicon knowledge while reading written English language translated into their native language. One hundred ESL participants were selected for the study and all participants were considered highly proficient in the English language, each with a decade of experience using English language. Results indicated that each of the ESL participants were challenged reading written English language text translated into their native language. The primary issue was participant lack of vocabulary background knowledge of the text they read. In particular, they indicated they did not have adequate knowledge of written English acronyms and abbreviations, and when acronyms and abbreviations were translated into their native language, they were difficult to read and understand. This is an indication that participant lack of adequate written English language lexicon negatively impacted their reading comprehension abilities when they read English language translated into their native language. Careful consideration should be given to translating terms from English to ESL adult native language. Overall, Al-Sohbani and Muthanna's (2013) study provide more information on the complexities of translating written English language into another language. Particularly, this study highlights the following themes: a.) English language proficiency impacts ESL adult's ability to understand translated text in their native language b.) English language lexicon is difficult to translate into another language. These themes provide an indication that there is a need to consider ESL adult lexical vocabulary knowledge of text, and their ability to understand the meaning of words in text that is translated into their native language. Although Al-Sohbani and Muthanna (2013) provide an indication that ESL adults may be challenged with reading English text translated into their native language, what other factors may influence ESL adult ability to understand translated text? The next study reveals more information on the process of translating written English language text into another language.

Alfadly and AldeibaniFull (2013) discussed the impact of translated written English language into ESL adult native language. Their study consisted of 54 ESL participants with background knowledge in translation theories and had vast knowledge of English language. Several sentences from a piece of text were translated from written English language into Arabic language, participants' native language. Results indicated that translation of written English language into Arabic written language led to verbose text, and multiple meanings of words. Furthermore, ESL adults translated parts of words, which impacted the meaning of the sentence. It was also noted that certain languages like Arabic could not be translated adequately, due to their orthographic nature (the way in which words are formed) in the Arabic culture. Regarding reading comprehension impacts on participants, the researchers indicated the participants were challenged when they tried to decode the meaning of sentences translated from English language to Arabic language. Conditional sentences were considered very difficult to read, when translated from English language to Arabic language. The major issue with conditional statements was use of proper tenses (e.g. if, then statements) when translating the sentence. In particular, future and past conditionals sentences were a few of the challenges that ESL adults encountered when reading translated sentences from written English language to Arabic language. As chapter one and three revealed that written English language conditional sentences are difficult to read and process, ESL adults should be required to have keen knowledge of sentence structure when translating these types of sentences. Overall, Zhao (2015), Alfadly and AldeibaniFull (2013), Al-Sohbani and Muthanna's (2013), Barani and Karimnia (2014), and Ynfiesta et al (2013) studies reveal that translating written English language can be challenging.

5.1 Chapter Summary

Chapter five provided many concepts that revealed important details on the impact of translating written English language into ESL adult native language. Many of the scientists agreed on theories discussed, some disagreed, and new information was revealed on the impact of translating written English language into ESL adult native language. Overall, many of the concepts that were discussed previously have the potential to negatively impact ESL flight crewmembers ability to read written English language translated into their native language. In this chapter it was noted that written English language translation into ESL adult native language is feasible. The ESL translator should adhere to understanding translation processes and consequences for not translating text adequately into ESL adult native language. It was also indicated that English language proficiency, background knowledge, translation experience, and metacognitive strategies are essential components ESL adult translators must consider when translating written English language into their native language.

With respect to information systems (e.g. QRH checklists), if ESL flight crewmembers spend time decoding, re-reading, or paraphrasing text translated into their native language, it could lead to longer response times to crew alerting systems. Long sentences and misinterpreted forms of abbreviations and acronyms could impact ESL flight crewmembers reading comprehension of written English language on the QRH checklist. All of the aforementioned factors have the potential to impact flight crewmembers workload. In particular, ESL adult temporal demand and mental demand could be negatively impacted due to perception and processing of written English language information translated into their native language. Overall, metacognitive strategies utilized by ESL flight crewmembers to understand a translated language have the potential to impact flight safety. Impact on flight safety could be exacerbated if ESL adults are challenged with reading and comprehending English language translated into their native language. Recall from Hutchins et al (2006), Drury & Ma (2005), and Ogilvie (1984) studies, some words may be translated, but careful consideration should be given to words that have multiple meanings or cannot be translated. These results are especially important when translating technical information into ESL adult native language. Overall, this chapter provides another contribution of knowledge regarding impact of written English language on ESL adult reading comprehension. It also provides substantive information on the case of written English language translation processes into ESL adult native language.

Chapter 6: Literature Review Synthesis and Chapter Summary

Chapter six is a compilation of theoretical underpinnings that were discovered in the previous chapters of the literature review. Aforementioned chapters explored an array of factors that contribute to the challenges ESL adults experience when they read and comprehend English as their second language. These chapters examined fundamental issues with ESL adults interpretation of written English language, but they also shaped the researcher's scope on ESL flight crewmembers challenges they may be present on the flight deck. Particularly, factors covered in the previous literature review may also be issues that ESL flight crewmembers experience while using flight deck crew alerting and information systems. This literature review covered many aspects regarding the impact of written English language on ESL adults. As the introduction provided a methodical progression towards the researcher's position on written English language issues in the aviation industry, chapters in the literature review illustrated more evidence of the problem. Based on the literature review, ESL adult background knowledge in English language appears to be a viable factor that facilitates understanding of ESL adult English language proficiency levels. Particularly, there were different types of written English language comprehension tests discussed (e.g. TOEFL) throughout many of the case studies. Many of the tests evaluated the following elements: an ESL adult's ability to a.) speak English language b.) read and comprehend English language c.) write English language. Elements 'a' and 'c' may not seem relative to the overall theme of this thesis. However, based on results from various case studies, these elements appear to shape ESL adults background knowledge of English language and written English language, and these elements should be considered with respect to ESL adult reading comprehension. Element 'b' is the focus of this thesis and will be evaluated throughout the analysis of the researcher's studies. English as-a-second language adults that have background knowledge of the previously mentioned elements in English language, helps pinpoint where they may exhibit low, medium, or high levels of English language proficiency. But, reading comprehension tests are not the only evaluation tools that help facilitate understanding of ESL adult background knowledge of English language. It was noted in several case studies that ESL adults that spend time in a western culture may be more proficient with English language than other ESL adults that do not have that experience. Use of self-rating techniques by ESL adults help explain their English language proficiency and can also provide the researcher with evidence of how well they read and comprehend English language. Furthermore, ESL adults background knowledge of

English language in university level classes or other forms of schooling may provide a clearer picture of their depth and breadth of English language background knowledge.

In the beginning of this research, the researcher provided an indication that technical documentation is utilized often by the airline industry. Although technical documentation has been termed ‘technical’ by the airline industry, vocabulary words in technical documentation have the potential to contain different types of vocabulary words. Debrito (1998) and SAIB (2007) described fundamental issues with flight crewmember use of English written language. Reading comprehension of English language by flight crewmembers was regarded as difficult and can lead to misunderstandings using QRH checklists and crew alerting systems. Remarkably, Drury et al (2003) corroborated many of the factors illustrated in Debrito’s (1998) and SAIB’s (2007) studies. Drury et al (2003) study set the framework on the elements of written English language that have the potential to cause misunderstandings and confusion for ESL flight crewmembers. Vocabulary words were identified as elements of written English language, that have the potential to negatively impact ESL flight crewmembers ability to read and comprehend English written language on the flight deck. Contributory causes of many aircraft accidents were the result of misunderstandings of English written technical information. Aircraft accidents also revealed that further investigation of written English language impacts on ESL flight crewmember reading comprehension performance is required. English as-a-second language flight crewmembers English language proficiency was reviewed, and it was noted that the aviation industry does not have compatible standards on English language proficiency of ESL flight crewmembers. Particularly, focus on ESL flight crewmembers reading comprehension of written English language and its impact on their performance on the flight deck is lacking between agencies like ICAO and FAA. As it was noted in many regulations, ability to speak, listen, and comprehend spoken language appears to be the primary focus on the aforementioned regulators agenda. Although regulations provide details on English language proficiency and ICAO created ELPRs, coverage on ESL flight crewmember ability to read and comprehend written English language on the flight deck is lacking. Nevertheless, the FAA, ICAO and other reputable agencies have attempted to bridge the gap between ESL flight crewmembers and their interface with flight deck crew alerting and information systems. But, as many of the agencies have revealed, the gap still exists with understanding the impact of written English language on ESL flight crewmembers performance.

Various scientists highlighted the importance of designing and integrating written English language into flight deck crew alerting and information systems. Many considerations were provided on designing compatible crew alerting and information systems for ESL flight crewmembers. Graphical representations were provided to describe features of crew alerting displays and a QRH checklist. The following elements of written English language were described on the graphics, so that the reader was provided with an understanding of the challenges that ESL flight crewmembers may experience when using crew alerting and information systems: written English language readability, and written English language understandability by ESL flight crewmembers. Such factors were examined so that it was clear to the reader on the topics that would be reviewed in the forthcoming chapters. Degani (1992), Laughery and Paige-Smith (2006), Ulijin and

Strother (2012) were just some of the scientists that provided noteworthy evidence on potential impacts western built displays and checklist design has on ESL flight crewmembers.

Chapter two and three provided a host of cognitive theories that explain reasons why written English language in different formats, vocabulary types, and text structure have the potential to be challenging to ESL adults. In chapter two many scientists revealed important information on use of metacognitive strategies by ESL adults to read English written language. Bottom up and top down models are effectively utilized to read written English language. But, depending on ESL adult English language proficiency, they may use one model more than the other to understand written English language (Parry, 1991, Hsiao and Oxford, 2002, Anderson, 2004, Liu, 2014). Gathering evidence on ESL adult background (e.g. demographics) appears to be an efficient way to collect data on ESL adult proficiency, and time spent in a western culture learning written English language. Lexical inferencing was described as an effective means of providing an educated guess to an unfamiliar word. Scientists discussed the effects of lexical inferencing strategy on ESL adults. It was indicated that depending on ESL adult English language proficiency levels, some ESL adults could be more efficient than others in guessing words. The researcher highlighted that the metacognitive strategies, lexical inferencing, and English language proficiency are factors that could influence ESL flight crewmembers use of QRH checklists and crew alerting systems. After all, these systems contain written English language and they require ESL adults to have an adequate understanding of their English language features. So, use of metacognitive strategies and lexical inferencing could help facilitate ESL adults understanding of QRH checklists and crew alerting systems, or it could hinder their abilities if they are under time constraints. Regarding ESL adult English language proficiency, low levels of ESL adult English language proficiency lead to certain types metacognitive strategies used more often than others, or abundance use of strategies. On the other hand, even highly proficient ESL adults tend to use an abundance of metacognitive strategies, because they are familiar with using them to read and comprehend written English language. If ESL flight crewmembers utilize these strategies it could help them understand texts, but impact their reading comprehension performance (e.g. alert time response, misunderstandings etc.). Vocabulary knowledge (depth and breadth) were also considered factors that influence ESL adults ability to make educated guesses on words that are unfamiliar to them Dwaik and Shehadeh's, 2013; Nylander, 2014).

Another topic revealed interesting clues on ESL adult reading comprehension. Sentence length and simplified text was described as a factor that impacts ESL adult reading comprehension performance. Sentence length has an impact on ESL adult ability to read and understand English written language. Particularly, depending on the length of the sentence (short/long) ESL adult reading comprehension may be impacted. Short sentences may be difficult to read by ESL adults if their background knowledge of the text is not adequate. Reading text corpora may also be difficult for ESL adults to understand if their vocabulary knowledge is not sufficient. These types of factors are likely to impact ESL adults reading comprehension of sentences that are short. On the other hand, long text has the potential to impact ESL adult temporal demand to read text.

Long texts take longer to read and comprehend than shorter text. On the topic of text simplification, it was noted that careful consideration should be given to simplifying text. Removing vocabulary words could impact the context of the sentence, and thereby impact an ESL adult's ability to read and comprehend the text. It was noted that ESL adult English language proficiency level is important when they read texts that are elaborated or simplified (Gardner and Hansen, 2007; Mehrpour and Riazi, 2004). As vocabulary depth and breadth are factors that have the potential to impact ESL adults understanding of written English language words, these factors could also impact ESL flight crewmembers ability to read and comprehend English language on the flight deck. In chapter one, it was indicated that vocabulary words were misunderstood by ESL flight crewmembers, and could have contributed to aircraft accidents. It is clear that vocabulary types (i.e. high frequency words, scientific words) in text can impact an ESL adult's reading comprehension performance.

On the flight deck, QRH checklist and crew alerting systems design can impact how well ESL flight crewmembers understand vocabulary words. Obviously, ESL flight crewmembers English language proficiency must be reviewed to understand if this factor may influence their ability to read and understand vocabulary words on crew alerting and QRH checklists. Sentence length on text simplification on crew alerting and QRH checklists must be reviewed as well. If sentences are altered from their authentic text design with long or small text lengths, it could impact ESL flight crewmembers reading comprehension performance on the flight deck. For example, if the text is shortened on the QRH checklist or crew alerting system, could the message be lost in reading? That is, if changes are made to text length, it could impact how well ESL flight crewmembers read and understand the text on the QRH checklist. On the other hand, if no text alterations are made, it could be an indicator that ESL adults understand the authentic form.

Next topic that was reviewed in chapter three provided more emphasis on the effects of vocabulary types on ESL adults reading comprehension. Having a keen focus on ESL adult depth and breadth of vocabulary knowledge are essential to understand how they read and understand English written text. It was indicated that ESL adults ability to understand vocabulary words impact their ability to understand word meaning in text. Nation (2001) and West (1953) set the framework for understanding the different types of vocabulary words (e.g. high frequency, academic and sub-technical, technical, and low frequency words) found in written English language text. Vocabulary word types found in texts are arguably features of written English language text corpora that can impact ESL adult ability to read and comprehend text. High frequency, academic, and sub-technical vocabulary words are found often in written English language text. Technical and low frequency vocabulary words do not occur frequently in academic text, however they are prominent in text that is focused in specific disciplines, like aviation and science.

Studies on vocabulary words revealed that high frequency vocabulary words afford ESL adults the ability to recognize them faster than those that do not occur frequently in text. Sub-technical vocabulary appears to be difficult to read and understand depending on format (e.g. reading words out of context versus in context). Depending on the type of text that sub-technical vocabulary words appear in (academic versus technical texts), it has the potential to impact ESL adult ability to read and understand the texts. In particular, it was mentioned that ESL adults ability to understanding word meaning negatively impacted their reading comprehension performance. Regarding sub-technical vocabulary words in technical and academic texts, ESL adults English language proficiency levels or experience learning English language, has the potential to impact ESL adults reading comprehension. It was also noted that background knowledge of sub-technical and technical vocabulary words in technical text helps facilitate ESL adults understanding of the text (Ashrafzadeh et al 2015; Wanpen et al 2013). On the topic of technical vocabulary words, it was noted that ESL adults background knowledge of texts (i.e. academic versus technical) are leading indicators that drive them to use metacognitive strategies while reading technical vocabulary words. If ESL adults have a good understanding of technical vocabulary in text, they are less likely to utilize an abundance of metacognitive strategies. On the other hand, ESL adults that do not have an adequate background in technical vocabulary may use an abundance of metacognitive strategies to read and understand technical vocabulary words. Finally, it was noted that mixing use of academic and technical vocabulary words in text can impact ESL English language proficiency, and can lead to ESL adults translating English words back into their native language. Translation of vocabulary words back into the ESL adults native language is an indicator of metacognitive strategy use to understand English written language, and could also be an indication of ESL adult misunderstanding of technical vocabulary words.

Regarding ESL flight crewmember use of crew alerting and information systems, if there are more frequent words utilized on both types of systems, could this impact their ability to read and comprehend information? It would seem practical to consider reviewing word frequency effect and types of vocabulary words on both systems. Since ESL flight crewmembers English language proficiency has the potential to impact understanding of vocabulary words, their proficiency must be cross-referenced against the types of vocabulary words found on both types of systems. If mixing vocabulary word types on both forms of devices (e.g. crew alerting and QRH checklists) has an impact on ESL flight crewmembers ability to read and understand text corpora on these devices, it could impact their reading comprehension performance. Therefore, a preview and analysis of the text and vocabulary words on text, prior to use by ESL flight crewmembers use may be practical before they use the text to perform a task. Previewing written English language texts prior to having ESL flight crewmembers use them to perform a task is important. This type of activity is needed, so that the likelihood of factors that could drive ESL flight crewmembers workload can be identified, when they use crew alerting systems and QRH checklists.

Use of conditional statements by ESL adults in English written language was also covered in chapter three. Scientists revealed various complexities of their forms in written English language text. Debrito’s (1998) study revealed that conditional statements cause flight crewmembers to misunderstand their forms, when they use them to resolve system malfunction/failure issues on the flight deck. Essentially, Lai-chun (2005) and Yeh and Genter (2005) revealed that there are several types of conditional statements in

English written language. These types (e.g. past counterfactual and present counterfactual) of conditionals have the potential to impact ESL adults reading performance due to how they appear in text based on tense and syntactic structure. It was noted that ESL adults that do not understand syntactic structure and tense forms of conditionals, experience difficulties reading them and comprehending their structures in text. It was also noted that ESL adult English language proficiency is also a factor that influences their ability to read and understand written English language conditional statements. Particularly, accuracy of detecting a conditional can impact how they process the conditional in text. Adequacy in English as-a-second language background knowledge of conditionals in text make them easier to read and understandable.

Conditional statements could be a factor that impacts ESL flight crewmembers ability to read QRH checklists. If they are not familiar with the form of the type of conditional statement, it could drive the ability to read and understand text on the QRH checklist. More importantly, ESL flight crewmembers English language proficiency could also predict how well they many read and understand English written text on QRH checklists. As the syntactic structure of conditional statements could drive ESL flight crewmembers readability of them, these types of statements on QRH checklists must be reviewed in detail. As ESL flight crewmembers ability to read conditional statements could impact their temporal demand and perception of information when they cross reference information on the flight deck, these too must be reviewed to understand the impact on ESL adults reading comprehension. Another topic covered in chapter three was the ambiguous nature of abbreviations and acronyms and the impact they have on ESL adults reading comprehension performance. As the FAA (1996) indicated, abbreviations/acronyms are ambiguous forms of text. Their cryptic forms make it difficult for ESL adults to read and comprehend them in text. Fundamental issues that ESL adults experience when reading abbreviations/acronyms were discussed in Kim's (2006) and Abdul-Hamid and Samuel's (2012) studies. Their studies revealed that ESL adults often use lexical inferencing to read and understand abbreviations/acronyms. But, if ESL adults do not have adequate background knowledge of text, it may be difficult to read abbreviations/acronyms in text. It was noted that background knowledge consists of time spent in a western influenced culture, and experience learning and using English language in formal means (e.g. university level, schooling). English as-a-second language adult inadequate background knowledge exacerbates the issue of reading abbreviations and acronyms in text. It was noted that misunderstandings with abbreviations/acronyms cause ESL adults to revert the abbreviations/acronyms back into their native language. Reversion of English written abbreviations/acronyms back into ESL adults' native language can cause significant interpretation issues with their meanings. Also, ESL adult inadequate background knowledge of the abbreviation/acronym can lead to misunderstandings of their long form.

Translation of written English language abbreviations/acronyms can impact the meaning of the word if ESL adults translate them incorrectly (Larsen and Hansen, 2010). It was noted that abbreviations and acronyms that are found in certain genres of text aid ESL adults with understanding their meaning due to their familiarity with the text. Regarding flight deck crew alerting systems and QRH checklists, it is important to realize the effect of abbreviations/acronyms may have on ESL adult reading comprehension on these devices. If there are abbreviations/acronyms on QRH checklists and crew alerting systems, ESL flight crewmembers must have adequate background knowledge of these types of words, and an adequate English language proficiency level. If they do not have adequate background knowledge and/or do not have an adequate proficiency level reading and comprehending them, it could impact their performance. In other words, ESL flight crewmembers workload may be negatively impacted if they do not have an adequate grasp of the abbreviation/acronym (short form) and the abbreviation/acronym (long form). Understanding each of these forms of words can potential impact ESL flight crewmembers ability to respond adequately to crew alerting systems and use of QRH checklists. If ESL flight crewmembers misunderstand, or guess incorrectly the abbreviations on crew alerting systems and QRH checklists, it could negatively impact their response to a system malfunction or failure on the flight deck.

Chapter four indicated text genre and ESL adults metacognitive strategies, text familiarity, background knowledge, and English language proficiency are factors that impact their ability to read and comprehend information on a GUI. Depending on the length of the sentence on the screen, it could impact ESL adults' ability to read and understand text on the screen. In the case of You's (2009) study, ESL adults' background knowledge of the text helps facilitate understanding when the text appears on a screen format. Adequate background knowledge leads to successful reading comprehension of text on a screen. Regarding ESL adult English language proficiency, low, medium, and high levels of English language proficiency are factors that influence ESL adults' ability to use certain metacognitive strategies. In each of the studies reviewed in chapter four, ESL adults utilized more metacognitive strategies, especially problem solving, when they read information on screens. They indicated that it was easier to use metacognitive strategies when reading paper than from screens. This result was because ESL adults' background knowledge indicated they were familiar with text on paper more than on the screen. Hence, reading text form the computer screen impacted their performance. That is, compared to the time ESL adults spent reading text from the screen versus on paper, they performed better reading and comprehending written English language on paper than on screen format. Regarding ESL flight crewmembers use of crew alerting systems on the flight deck, their use of certain types of metacognitive strategies when they read information on the GUI may impact their reading comprehension performance. Particularly, if they use one type of metacognitive strategy more than the other, it could impact their ability to respond to the crew alert effectively. Time spent decoding words such as abbreviations/acronyms could impact their ability to respond effectively to a crew alert.

Finally, chapter five provided the reader with information on translating written English language into an ESL adult's native language. In chapter one and two, several scientists cautioned and endorsed translating written English language into ESL adult native language. It was indicated that translation of written English language into ESL adult native language should not be performed without understanding translation processes. Furthermore, it is essential to have a translator with experience in English language and their native language. More importantly, the translator should be proficient with written

English language when executing translation processes. Studies indicated that negative impacts to translating written English language into ESL adult native language occur, due to ESL adult's lack of background knowledge of the text translated (Ynfiesta et al, 2013). It was also indicated that certain types of written English language words like abbreviations/acronyms are difficult to translate. Obviously, as the researcher highlighted in chapter four, abbreviations/acronyms are ambiguous forms of written English language words. Potential for ESL adults to misunderstand the translated abbreviation/acronym is greater when they are translated incorrectly, than when they are sustained in their English written form. Another factor that was discovered regarding translating abbreviations/acronyms was ESL adult misunderstandings of the long form of the abbreviation/acronym in their native language. That is, abbreviations/acronyms will be difficult to read and understand by ESL adults if the translator incorrectly translates them. English as-a-second language adult English language proficiency and knowledge of words in ESL adult native language is crucial; in order to have minimal negative impact to ESL adult reading comprehension of translated text. Finally, verbose translation of written English language from English to an ESL adult's native language can cause confusion and misunderstandings.

Regarding QRH checklists, if the translator of written English language into ESL flight crewmember's native language does not have a good grasp of the language in English they could misinterpret the form of the language in their native language. If the type of word or text translated into ESL flight crewmembers native language does not contain an equivalent word or text in their native language, it could impact ESL flight crewmembers reading comprehension when they complete a task. Misinterpretation of words and text in by the translator during word/text translation processes could lead to long response times to alerts, longer times reading text on checklists. Vocabulary words and text that have changed from their authentic text should be evaluated carefully, as the translation process could lead to verbose words, which could impact ESL adult response time. On the other hand, if the translation process is executed adequately, there is a possibility that ESL flight crewmembers may understand equivalent forms and meaning of words in text in their native language.

Based on previous studies discussed in chapters 1-5, the researcher determined that this information warrants several new studies on factors that impact ESL adults' ability to read and comprehend written English language. In the context of socio-technical systems, impact of ESL flight crewmember ability to perform when they read and comprehend written English language on flight deck crew alerting and information systems, needs further scrutiny. The researcher developed four paradigms in table format, which summarize many of the factors previously discussed in the literature review. The paradigm consists of four themes from the literature review. Under each theme are factors/features of English language, that have the potential to impact ESL flight crewmembers reading comprehension of English language.

Following themes are illustrated in next table (ESL flight crewmembers English language proficiency, background knowledge/experience using English language, and metacognitive strategies). These themes have the potential to impact how ESL flight crewmembers perceive, process, and utilize written English language on the flight deck. Remainder contains themes that have the potential to impact how ESL flight crewmembers interact with crew alerting systems design and integration. Themes and corresponding factors in tables will be utilized in the researcher's preliminary studies and experimental study, to understand if these factors influence ESL flight crewmembers English language reading comprehension.

Table 5 Literature Review Themes 1, 2, 3, and 4

Literature Review Theme 1: ESL flight crewmembers English language background knowledge and proficiency
Ability speaking English language
Ability to Read and Comprehend written English language
Preliminary School (Grade School) non-western region experience reading and speaking English language
Preliminary School (Grade School) western region experience reading and speaking English language
Secondary School (University) western region experience reading and speaking English language
Secondary School (University) non-western region experience reading and speaking English language
ICAO ELPR level
ATP certification
Literature Review Theme 2: ESL flight crewmembers background knowledge/experience with using English language vocabulary words and text genres
Knowledge of text genre on crew alerting systems
Knowledge of text genre on QRH checklists
Knowledge of typographical elements on QRH checklists
Experience with conditional statements on QRH checklists
Experience with abbreviations/acronyms short form and long form
Experience with authentic text, elaborated text, and simplified text
Experience with vocabulary word type on crew alerting systems
Experience with vocabulary word type on QRH checklists
Years of Experience with written English language
Literature Review Theme 3: ESL flight crewmembers metacognitive strategies
Re-read text
Paraphrase text
Underline text
Highlight text
Translating English language text into ESL adults native language
Revert back to native language to understand English language
Monitoring Reading Comprehension
Taking Notes
Breaking apart sentences
Predicting Word Meaning from previous sentence information
Top-Down Strategy (prior knowledge of text; activating text schema)
Bottom-Up Strategy (decoding text)
Skipping Words/Omission of Words
Referencing other Resources to clarify information (e.g. dictionary)
Lexical Inferencing
Literature Review Theme 4: Crew Alerting Systems and QRH Checklists Design and Integration
Acronyms/Abbreviations
Vocabulary Word Types
Text Genre
Conditional Statements
Number of Tokens in Text
Authentic Text
Sentence Length (long/short)
Text Simplification

Chapter 7: Preliminary Research Studies

Fundamentals of written English language challenges were reviewed in detail during the literature review process. Literature review suggests there could be a difference in ESL adult performance when they read and comprehend English language on technical information. But, how does written English language challenges impact ESL flight crewmembers performance? Chapter one indicated that pre-cursors to procedural deviation and misunderstandings have occurred on the flight deck, due to ESL flight crewmembers English language reading comprehension difficulties with English language technical information. Given ESL flight crewmembers may experience written English language challenges that could impact their performance and lead to aircraft accidents, what is the effect on ESL flight crewmembers interface with design and integration of English language on crew alerting systems and QRH checklists? Are these factors still prevalent on the flight deck? What types of data can be collected to help the reader understand if these issues are still prevalent? Preliminary studies will provide detailed analyses of factors that influence ESL flight crewmembers ability to understand written English language in technical information. Next preliminary studies were designed to guide the researcher's experimental hypothesis, experimental design, and experiment.

Aims

Researcher's aim of the preliminary studies (parts one and two) was to determine if ESL flight crewmembers performance was negatively impacted by reading and comprehension of written language in technical information. In other words, does design and integration of written English language on crew alerting systems and QRH checklists impact ESL flight crewmembers performance on the flight deck? Particularly, the researcher wanted to determine the degree of impact that design and integration of information on crew alerting systems and QRH checklists had on ESL flight crewmember reading comprehension abilities. As ESL flight crewmember English language proficiency was discussed in chapter one as a contributory cause of many aircraft accidents, and has the potential to impact performance, further research is needed on this issue. Regarding ESL adult English language proficiency, chapters two and three provided a plethora of information that described effect of ESL adult English language proficiency on their ability to read and comprehend written English language. The researcher also wanted to understand types of metacognitive strategies ESL flight crewmembers utilized while reading and comprehending English language on both types of systems (i.e. crew alerting systems and QRH checklists). Recall, ESL adults utilize metacognitive strategies to read and comprehend English language.

Finally, ESL flight crewmembers background knowledge of English language needs to be reviewed to understand if background knowledge is a factor that impacts their ability to read and comprehend English language. Recall from chapters two and three; ESL adult background knowledge of English language tends to be different. In other words, variability in ESL adult knowledge of English language has the potential to impact how well they read and understand English written language on crew alerting systems and

QRH checklists. Collectively, ESL flight crewmembers English language proficiency, metacognitive strategy use, and background knowledge were evaluated in the researcher's preliminary studies to understand the effect these variables have on their performance, when using crew alerting systems and QRH checklists on the flight deck.

Demographics

Preliminary study part one was a qualitative research study with a population of 19 male ESL flight crewmembers (N=19). The term participants will be utilized throughout preliminary study one to describe flight crewmembers that participated in the study. Each participant flew large transport category aircrafts (Airbus A-320, Boeing 737, and Embraer Air 145/170 Regional Jets (ERJ)) for major airlines and they were certified airline transport pilots.

ESL flight crewmembers' background knowledge and English language proficiency

Participants learned English language during formal schooling, from a western culture or in the participant's country of origin. Particularly, participants schooling was either preliminary school (i.e. grade school/pre-school) and/or secondary school, which was typically university education. Participants' experiences with English language were considered background knowledge using English language.

Each participant indicated their ICAO English language proficiency level was between levels four and six. The ICAO ELPRs requirements indicate that level four rating is adequate operational use of English language, while level six indicates excellent use of English language on the flight deck. The ICAO English language proficiency levels data was gathered as a means of understanding participant background knowledge of English language. Recall, chapter three provided several indications that ESL adult experience with English language may be a contributor to them understanding the language. Furthermore, in chapter three several studies indicated that TOEFL and other equivalent evaluations were provided to understand ESL adult experience using English language (e.g. reading comprehension and speaking experiences). Although the ICAO English language proficiency levels focus primarily on participant speaking and listening comprehension abilities, ICAO ELPRs were utilized as a means of collecting participant English language experience data. Therefore, the ICAO ELPR level for each participant was collected.

ESL flight crewmembers' reading comprehension abilities

Participants utilized self-ratings to rate their written English language Reading Comprehension Level (RCL) abilities (proficiency), with respect to their general use of written English language. Participants also self-rated their English language RCL abilities when reading and interpreting written English language on crew alerting systems and QRH checklists. Recall, chapter two and three indicated that self-rated English language proficiency levels help understand an individual's ability to read and understand English language. Participant self-rated RCL proficiency abilities were low-intermediate (L-I level), intermediate (I-level), or High Level (H-level). The researcher operationally defined each of their proficiency levels. The L-I English language proficiency indicated participants had an understanding of English language, but were challenged with vocabulary words and sentence structure. The I-level English language proficiency indicated participants were comfortable with using the language, but needed more background knowledge of certain words that are unfamiliar to them. Finally, H-level English language proficiency indicated participants were comfortable with their reading and comprehension of English language. English as-a-second language written English language proficiency levels were categorized as 'general use of English language' (ability to read and comprehend written English language in a non-socio-technical environment), which was related to the their educational experiences with generic reading comprehension of written English language. Additionally, participants' English language proficiency levels were categorized as written English language proficiency on crew alerting systems and QRH checklists (ability to read and comprehend written English language in a socio-technical environment) (i.e. technical information on the flight deck). Participants indicated that information on crew alerting systems and QRH checklists are generally utilized together, therefore they indicated their proficiency levels as such for reading and comprehending information on crew alerting systems and QRH checklists. English language proficiency levels were categorized as such to clearly define differences between participant general knowledge of English language, and if differences in proficiency level exist with their reading comprehension of technical information on the flight deck. Below are tables that illustrate demographics for each of the participants.

Table 6 Demographics Preliminary Study part 1 (N=19)

DEMOGRAPHICS	Pilot 1	Pilot 2	Pilot 3	Pilot 4	Pilot 5	Pilot 6	Pilot 7	Pilot 8
Country of Origin	Ecuador	Ecuador	Ecuador	Ecuador	Brazil	Brazil	Ecuador	Trinidad
Age	53	32	43	29	34	50	37	51
Airline Years of Experience	15	8	11	4.5	10	6	10	8
Native Language Spoken	Spanish	Spanish	Spanish	Spanish	Portuguese	Portuguese	Spanish	Caribbean Dialect
English language learned/Country	Grade School/Ecuador	Grade School/ Ecuador	Grade School/U.S.	University/U.S.	University/ South America	University /U.S.	University /U.S.	University/Trinidad
ICAO ELPR Level	Level 6	Level 6	Level 6	Level 6	Level 4	Level 4	Level 5	Level 6
Self-rated English language RCL (General Use of English language)	I-Level	I-level	I-Level	I-Level	I-Level	H-Level	H-Level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	I-Level	I-Level	H-Level	L-I Level	L-I Level	H-Level	I-Level	H-Level

Table 7 Demographics Preliminary Study Continued (N=19)

DEMOGRAPHICS	Pilot 9	Pilot 10	Pilot 11	Pilot 12	Pilot 13	Pilot 14	Pilot 15	Pilot 16
Country of Origin	Brazil	Brazil	Brazil	Brazil	Jordan	Jordan	Jordan	Jordan
Age	36	28	45	41	32	25	38	28
Airline Years of Experience	12	6	17	11.5	3	2	13	3
Native Language Spoken	Spanish	Spanish	Spanish	Spanish	Arabic	Arabic	Arabic	Arabic
English language learned/Country	Grade school/Secondary /U.S.	Secondary School/U.S.	Secondary School/ U.S.	Secondary School/ U.S.	Pre-school/Jordan	Pre-school/Jordan	Pre-school/U.S.	Pre-school/Jordan
ICAO ELPR Level	Level 4	Level 4	Level 4	Level 4	Level 5	Level 5	Level 6	Level 6
Self-rated English language RCL (General Use of English language)	I-Level	I-Level	I-Level	H-Level	H-Level	H-Level	H-Level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	L-I level	L-I Level	H-Level	L-I Level	H-Level	H-Level	H-Level	H-Level

Table 8 Demographics Preliminary Study Continued (N=19)

DEMOGRAPHICS	Pilot 17	Pilot 18	Pilot 19
Country of Origin	Colombia	U.S	Bulgaria
Age	22	26	37
Airline Years of Experience	4	1	4
Native Language Spoken	Spanish	Spanish	Bulgarian
English language learned/Country	University/U.S.	Pre-school/U.S.	Pre-school/University as exchange student in U.S.
ICAO ELPR Level	Level 5	Level 5-6	Level 6
Self-rated English language RCL (General Use of English language)	I-Level	I-Level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	I-Level	I-Level	H-Level

Table 9 ESL flight crewmembers general demographics

Demographic	Percentages
Country of Origin	5/19 (~26% Ecuador) 6/19 (~32% Brazil) 4/19 (~21% Jordan) 1/19 (~5% Trinidad) 1/19 (~5% U.S.A) 1/19 (~5% Bulgaria) 1/19 (~5% Colombia)
Age (Average/Minimum/Maximum)	36 years old (average); 22 years old (Minimum); 53 years old (Maximum)
Airline Years of Experience (average)	7.8 years of Airline Experience
Native Language Spoken	11/19 (~58% Spanish) 2/19 (~ 11% Portuguese) 1/19 (~5% Caribbean Dialect) 4/19 (~21% Arabic) 1/19 (~5% Bulgarian)

The researcher's study part one demographics show that the most common participant country of origin was Brazil, second was Ecuador, and third was Jordan. Remainder of participants' country of origin was Trinidad, U.S.A., Bulgaria, and Colombia. Average participant age was 36 years old with a range from 53 to 22 years old. Common native language spoken by participants was Spanish followed by Arabic, Portuguese, Caribbean Dialect, and Bulgarian.

Methodology

To investigate impact of written English language on participants' use of crew alerting systems and QRH checklists, the researcher developed the following methodology to assess the issue. This qualitative study generated common themes. The researcher, by means of face-to-face conversations interviewed four of the 19 participants. These interviews helped the researcher understand primary issues that participants experienced utilizing technical information on crew alerting system and QRH checklists. Information from the interviews was transcribed, coded, and themes were developed from the data.

Secondly, the researcher developed a questionnaire for the remaining 15 participants. A questionnaire was utilized to collect relevant data on participants' performance when they read written English language on crew alerting systems and QRH checklists (see Appendix A). The questionnaire focused was on the following general aspects: degree of participant's ability to read and interpret English language on crew alerting and QRH checklists, English language proficiency levels (i.e. ICAO ELPRs and self-rated English language reading and comprehension proficiency levels), background knowledge of English language and written language on crew alerting systems and QRH checklists, and metacognitive strategies used to read and comprehend English language on crew alerting and QRH checklists.

Thirdly, follow-up conversations were conducted with participants via email and phone communication, if their responses required further clarification. Finally, after collecting the questionnaires, the researcher transcribed the data, created narratives from the questionnaire, coded, and developed themes based on participant responses. More information on the coding method will be discussed in the analysis section.

Limitations

Data collected from surveys were not specific to a particular crew alerting system (e.g. hydraulic or pneumatic systems) or corresponding QRH checklists, rather it was a general perspective on participants use of written English language on the previously mentioned systems (e.g. crew alerting systems and QRH checklists). Furthermore, this study did not measure participants' performance using crew alerting systems and QRH checklists. The researcher did not measure impact of vocabulary words, text genre, workload, etc. on participant performance. Thus, as these types of variables were not investigated it limited the scope of the researcher's preliminary research study, but provided the researcher with an understanding of factors that may need scrutiny in future studies.

Analysis

The researcher analyzed data collected from the interviews and questionnaires. One method of analysis was central tendency. Central tendency (i.e. mean) was utilized to analyze demographic information collected from each of the participants. After the researcher transcribed, coded, and developed thematic data from the interviews and questionnaires, central tendency was used to analyze theme frequency. The coding method utilized was inspired from the researcher's literature review. Theoretically, all of the elements that were reviewed in the literature review have the potential to impact participant reading comprehension of written English language on the flight deck. Participant use of metacognitive strategies to read and understand written English language, English language proficiency, and their background knowledge have the potential to impact their perception and processing of English language on crew alerting systems and QRH checklists. Therefore, the following coding method was developed to create themes (Figure 12).

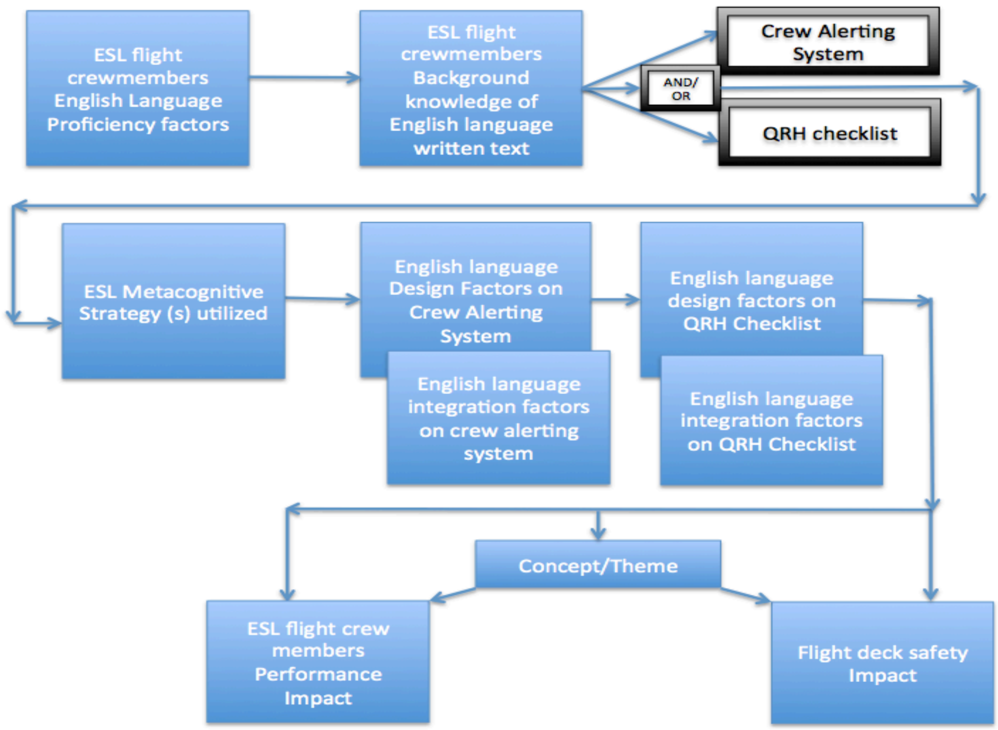


Figure 12 High Level Data Coding Theory Method

The high level data coding theory method is supplemented with a coding transcription template and coding matrix. The coding transcription template example (Table 10) describes factors that influence participants' reading comprehension of written English language on crew alerting systems and QRH checklists.

Coding transcription template overview

The coding transcription template is where the researcher collected data from the interviews and questionnaires. First column is participant number. Second and third columns are demographics impact sub-themes. Demographics impact sub-themes are fundamental factors that impact participants' ability to read and comprehend written English language. Particularly, second column is related to participants' background knowledge of English language, general English language proficiency, and English language proficiency when they read English language on crew alerting systems and QRH checklists. Third column is participants' English language background knowledge vocabulary words/text genre on crew alerting systems and QRH checklists.

Fourth column is the cognitive sub-theme that describes metacognitive strategies used by participants to read and understand English language. Fifth and sixth columns indicate crew alerting (CA) design and integration factors and descriptions of the impact. Seventh and eighth columns indicate QRH checklist English language design/integration factors, and descriptions of the impact. Collectively, these columns are considered CA and QRH design/integration sub-themes. All sub-themes created main themes. Therefore, columns nine and ten are main themes from participant interviews and questionnaires. Main themes represent the overall impact on participant performance and flight safety. Participant performance is related to their reading comprehension of written English language on crew alerting systems, QRH checklists, or a combination of using both systems to solve a problem on the flight deck. Flight safety impacts are a result of reading comprehension negative impacts on participants' ability to solve problems on the flight deck (e.g. ECAM malfunction/failures, EICAS warnings/cautions). Finally, if participants did not indicate written English language on crew alerting systems/QRH checklists negatively impacted their performance (columns 5-10); the researcher annotated the transcription template with words 'no impact identified'.

Coding Keys Overview

Coding keys contain a variety of factors utilized to code each participant's interview and questionnaire data. Factors are intended to be influences on participant performance and flight safety. Intent of coding keys was to categorize each of the factors into a common sub-theme, so they may be utilized to understand the impact on participant performance and flight safety (main themes). Factors found to be relevant in the interviews and questionnaires were utilized in the coding process. Recall, many of these factors listed in each of the coding keys were from the researcher's review of literature. Finally, each of the coding keys titles (i.e. ESL flight crew members English language background knowledge and proficiency factors) contains bold face font, which corresponds to the bold face font on the coding transcription template. There are five key codes, each with a code number and letter. The number corresponds to the key code and the letter corresponds to the factor (i.e. 1D). There may be more than one code utilized on the transcription template to describe factors participants indicated during the interview or on the questionnaire.

Table 10 Coding transcription template

PILOT Number	**#English Language Background knowledge and Proficiency Factors**	**#English language words/text genre Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***

# Denotes ESL flight Crewmembers Demographics Sub-Theme
*Denotes ESL flight crewmembers Cognitive Sub-theme
**Denotes ESL flight Crewmembers crew alerting systems and QRH checklists Design/Integration Impact Sub-theme

Table 11 General Coding Matrix

Key 1 Coding		Key 2 Coding	
ESL flight crew members English language background knowledge and proficiency factors	**CODE**	**ESL flight crew members vocabulary words/text genre background knowledge factors**	**CODE**
English language –ICAO ELPR level 4, 5, or 6	1A	Knowledge of English language text genre on crew alerting systems (e.g. technical text)	2A
Preliminary School (Grade School) non-western region experience reading comprehension and speaking English language	1B	Knowledge of English language text genre on QRH checklists (e.g. technical text)	2B
Preliminary School (Grade School) western region experience reading and speaking English language	1C	Knowledge of English language elements on QRH checklists (e.g. typographical elements)	2C
Secondary School (University) non-western region experience reading and speaking English language	1D	English language experience with conditional statements on QRH checklists (e.g. structure, noticing)	2D
Secondary School (University) western region experience reading and speaking English language	1E	Background knowledge of abbreviations/acronyms (e.g. short form and/or long form)	2E
ATP Certification (ability to read English language)	1F	Background knowledge of text format on crew alerting systems and QRH Checklists (e.g. authentic, elaborated, or short text)	2F
Airline years of experience using crew alerting systems and QRH checklists	1G	ATP certification (knowledge of crew alerting systems /QRH checklists)	2G
Self rated English language proficiency RCL of general use of English language (L-I)	1H	Background knowledge of vocabulary word type on crew alerting systems	2H
Self rated English language proficiency RCL of general use of English language (I)	1I	Background knowledge of vocabulary word type on QRH checklists	2I
Self rated English language proficiency RCL of general use of English language (HL)	1J		
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (L-I)	1K		
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (I)	1L		
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (HL)	1M		

Table 12 General Coding Matrix continued

Key 3 Coding	
ESL flight crewmembers metacognitive strategy factors	**CODE**
Re-Reading Text	3A
Paraphrasing Text	3B
Underlining Text	3C
Referencing other Resources to clarify information (e.g. dictionary)	3D
Highlighting Text	3E
Translating English written language into ESL flight crewmembers native language	3F
Reverting back to native language to read English language	3G
Reading aloud text on flight deck	3H
Monitoring reading comprehension	3I
Taking Notes	3J
Breaking Apart Sentences	3K
Bottom up strategy (Decoding text)	3L
Top down strategy (prior knowledge of text; activating text schema)	3M
Interactive strategy (Combination of Bottom up and Top Down Strategy use)	3N
Monitoring reading speed	3O
Skipping words/omission of words	3P
Key 4 Coding	
Crew alerting systems English language design and integration factors	
Sentence Length (Short)	4A
Acronyms/abbreviations	4B
Text Genre (e.g. technical)	4C
Number of Tokens in Text	4D
Authentic Text	4E
Sentence Length (Long)	4F
Simplification of Text	4G
Vocabulary Words Type	4H
Key 5 Coding	
QRH checklist English language design and integration factors	
Conditional Statements	5A
Number of Tokens in Text	5B
Authentic Text	5C
Sentence Length (Long)	5D
Simplification of Text	5E
Acronyms/Abbreviations	5F
Text Genre (e.g. technical)	5G
Vocabulary Words Type	5H
Sentence Length (Short)	5I

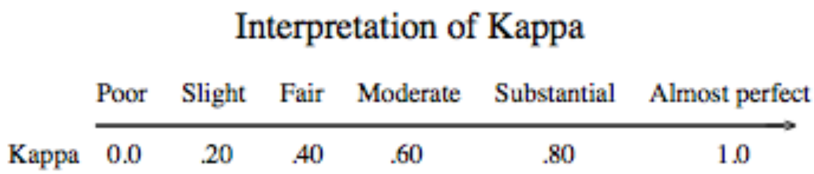
Inter-rater reliability

To ensure the researcher did not have any bias when categorizing participant proficiency levels, key code sub-themes, and main themes from interviews and questionnaires, inter-rater reliability analysis was conducted. The researcher consulted two flight deck engineering experts to review each theme created by the researcher. They had a background in human factors and ESL flight crewmember interface with crew alerting and information systems. The researcher developed an exercise named ‘pin the proficiency level, key code sub-theme and main theme to each participant narrative’.

Each of the experts pinned each key code/sub-theme and main theme to the narrative they thought is represented. After the researcher collected the results from the exercise, the researcher reviewed the results to ensure the key codes, sub themes, and main themes the researcher developed were consistent with each expert results. The researcher utilized Cohen's Kappa coefficient to analyze the each rater results. Results indicated substantial inter-rater reliability with the Cohen's Kappa coefficient of (*k=1*). Table 13 provides the detailed inter-rater reliability analysis conducted. Figure 13 provides reference to Cohen's Kappa coefficient parameters to understand the results. This figure can be utilized as reference for the reader regarding forthcoming inter-rater reliability analyses in the thesis.

Table 13 Cohen's Kappa coefficient inter-rater reliability results Preliminary Study Part I

Artifact	Rater 1	Rater 2	Agreement		
Pilot 1 Narrative	0	0	1		1= agreement between raters
Pilot 2 Narrative	1	1	1		1= agreement between raters
Pilot 3 Narrative	1	1	1		1= agreement between raters
Pilot 4 Narrative	1	1	1		1= agreement between raters
Pilot 5 Narrative	1	1	1		1= agreement between raters
Pilot 6 Narrative	1	1	1		1= agreement between raters
Pilot 7 Narrative	1	1	1		1= agreement between raters
Pilot 8 Narrative	0	0	1		1= agreement between raters
Pilot 9 Narrative	1	1	1		1= agreement between raters
Pilot 10 Narrative	1	1	1		1= agreement between raters
Pilot 11 Narrative	1	1	1		1= agreement between raters
Pilot 12 Narrative	1	1	1		1= agreement between raters
Pilot 13 Narrative	1	1	1		1= agreement between raters
Pilot 14 Narrative	1	1	1		1= agreement between raters
Pilot 15 Narrative	1	1	1		1= agreement between raters
Pilot 16 Narrative	1	1	1		1= agreement between raters
Pilot 17 Narrative	1	1	1		1= agreement between raters
Pilot 18 Narrative	0	0	1		1= agreement between raters
Pilot 19 Narrative	1	1	1		1= agreement between raters
	MATCH	19			
	TOTAL	19			
	ARR Percent	100%			
		Rater 2			
		0	1		
Rater 1	0	3	0	3	16%
	1	0	16	16	84%
		3	16	19	
		16%	84%		
1=Agreement					
0=No Agreement					
k=Probability of agreement observed-Probability of agreement based on chance/1-Probability of agreement based on chance					
k=(Pr((a)-Pr(e))/1(1-Pr(e))					
Pr (a)	1				
Pr (e)	0.734072022				
k=	1				



Kappa	Agreement
< 0	Less than chance agreement
0.01–0.20	Slight agreement
0.21– 0.40	Fair agreement
0.41–0.60	Moderate agreement
0.61–0.80	Substantial agreement
0.81–0.99	Almost perfect agreement

Figure 13 From Viera and Garett (2005) Understanding Inter-observer agreement: The Kappa Statistic

Sample Narratives from Preliminary Study Part I

The following sample narratives are from the researcher's preliminary study part one. Intent of these sample narratives is to provide the reader with the types of information that was collected from the participants during the study.

Sample #1 participant excerpt from narrative

"I normally don't have too many issues with crew alerts on the EICAS system. The EICAS system is primarily easy to use. However, I have had some problems, which have always been when I try to understand certain acronyms and vocabulary words that are written in English. It seems as if the people that write the manuals don't make the connection between the crew alerting systems and the QRH/FCOM procedures. What I'm referring to is when we take the information out of the QRH checklist and follow directions to solve the crew alert. When I use procedures to respond to critical system alerts, it is difficult and often takes too long to understand how some of the words match with a particular fault on the EICAS. Sometimes there are consistency issues with wording and can be difficult to understand. I also have to re-read and omit information on the hydraulic checklist because of the challenging wording. I often feel that the wording is too long as well, and should be revised for clarity purposes, especially because my native language is not English. I personally think my English language proficiency can be better, but I'm still certified on ICAO as level 5. Regarding flight path related safety issues or system issues, there are times were long response times impacts my ability to work other tasks".

Sample #2 participant excerpt from narrative

"I have a lot of experience flying but I even notice that there are many phrases (abbreviations and acronyms) in QRH checklists that do not have references to the real form word. What I mean is that checklist items in the hydraulic checklist (QRH) at my airline that are difficult to interpret. The information is often wordy and I ask my self do the checklists need to be that long to explain the problem on the ECAM. I often notice

that there are other words that could be explained better so that I can use them to answer the malfunction issue. Sometimes it impacts my response time to a malfunction but it does not normally end up in a flight safety issue, more just a workload issue. I have to look at the checklist wording and remember my training knowledge on the system and determine what other tasks need to be handled. So, I monitor how long I spend reading each checklist to do item. Most of the time I feel that my English language proficiency is OK, but with some words, I do question how well I understand the English in the checklist. I think that checklists should be designed for the ESL flight crew too and not just regular English language flight crew. What I mean is that the people that design the checklist need to remember the second language crewmember".

Results

Results indicated that several participants experienced challenges with their reading comprehension of written English language on both types of systems (i.e. crew alerting systems and QRH checklists). Next 13 tables provide detailed information on results from the study. Collectively, participant demographics data and findings from the coding/theme exercise conveyed noteworthy findings regarding design and integration of written English language on crew alerting systems and QRH checklists. Detailed coding analyses are located in Appendix B. Columns that contain 'N/A' indicate participants did not indicate any demographic/design/integration factors/negative performance impacts.

Table 14 is an overview of factors that influenced participants' ability to perform using crew alerting systems and QRH checklists. It also provides a general review of impacts highlighted by participants in their interviews and questionnaires regarding flight safety. Results in Table 14 column one show that almost all participant descriptions of reading comprehension performance impacts indicated their performance on the flight deck was negatively impacted by use of crew alerting systems, QRH checklists, or a combination of utilizing both systems to solve system malfunctions/failures systems. Column two provides the reader with an understanding of metacognitive strategy use by participants to read and interpret English language. It was indicated that high percentage of participants utilized metacognitive strategies to read and interpret written English language on each system (i.e. QRH checklists and crew alerting systems). To understand impact of each system on participant performance, the researcher highlighted systems (i.e. crew alerting systems and QRH checklist) that impacted each flight crewmember. Accordingly, column three indicated that reading and interpreting information on crew alerting systems negatively impacted many participants' reading comprehension performance. Whereas, column four indicated that QRH checklists negatively impacted a high percentage of participants' reading comprehension performance. Column five conveyed that many participants' performance was negatively impacted when they utilize crew alerting systems and QRH checklists together to solve problems (e.g. malfunctions/failures) on the flight deck. Finally, column six conveyed high percentage of participants' flight safety was negatively impacted due to their performance being negatively impacted by reading comprehension of English language on crew alerting systems, QRH checklists, and combination of both systems.

Note: Boxes filled with grey indicate ESL flight crewmembers did not mention negative impact on their performance or flight deck safety, with respect to their use of crew alerting systems, QRH checklists, or a combination of both systems. Boxes with an ('X') indicate ESL flight crewmembers mentioned their performance was negatively impacted by use of crew alerting systems, QRH checklists, or a combination of both systems. Boxes shaded with blue indicate ESL flight crewmembers percentages of using CAs and QRH checklists; shaded blue boxes also provide overall theme.

Table 14 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=19)

ESL flight crewmember description of impact on performance (n=19)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 1: Difficulty understanding abbreviations and acronyms leads to misunderstandings with reading and comprehending them in QRH Checklists and on Crew Alerting Systems	Y	X	X	X	Diagnose improperly system malfunction or failure
PILOT 2: Long reading times due to reading unfamiliar long form acronyms on QRH checklists and crew alerting systems	Y	X	X	X	Long response time to respond to system malfunction
PILOT 3: Omission of certain vocabulary words on Crew alerting systems that are simplified leads to reverting back to my native language and long reading times	Y	X			Reverting back to native language leads to word Omission which leads to longer response time, but still have time to respond in a timely manner
PILOT 4: Misinterpretation of certain vocabulary words in conditional statements on QRH checklists and FCOM procedures impacts reading time	Y		X		Longer response times to crew alert
PILOT 5: Re-reading long text on QRH checklist leads to longer response times	Y		X		Long response time to crew alerts negatively impacts timing for completing tasks (e.g. ATC coordination)
PILOT 6: Re-reading challenging text leads to better understanding of text on the QRH checklist	Y		X		Impacts mental workload and takes time away from other tasks

Table 15 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=19) continued

ESL flight crewmember description of impact on performance (n=19)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 7: Skipping and re-reading abbreviations and acronyms on ECAM system and QRH checklists leads to longer processing of information	Y	X	X	X	Sometimes a missed step/skipped procedure on QRH checklist leads to misinterpretation of abbreviation/acronyms information on EICAS
PILOT 8: Sometimes translation of acronyms and abbreviations into my native language on QRH checklist and ECAM system is effective other times not effective	Y	X	X	X	Incorrect translation leads to more time re-processing information for correct word meaning
PILOT 9: Long sentence processing leads to more time reading for clarity purposes due to sentence length on QRH checklists. Vocabulary words on EICAS system are re-read if they are not understood	Y	X	X	X	Sometimes leads to long response times to crew alerts
PILOT 10: Longer processing time and mental demands when highlighting or underlining vocabulary words on QRH checklists	Y		X		Leads to longer concentration (mental demand) on task, and sometimes difficulty solving ECAM issues
PILOT 11: Challenging vocabulary words on EICAS leads to high workload. If I don't understand the conditional statement on the QRH checklist or recognize the relationship between system malfunction it can lead to higher mental workload	Y	X	X	X	High mental demand and workload leads to other tasks not completed on time

Table 16 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=19) continued

ESL flight crewmember description of impact on performance (n=19)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 12: Very detailed QRH checklists often leads to high mental demand, especially if vocabulary words are unknown	Y		X		If words are unknown they don't usually lead to a flight safety issue, more just a frustration issue
PILOT 13: Lengthy QRH checklists and too detailed procedures often lead to mental demand and high workload	Y		X		High workload due to long reading, which is dependent on the type of system malfunction
PILOT 14: Low mental workload when I translate words back into my native language when I don't know them on the QRH checklist, because I step through each procedure and make sure it is right the first time	Y		X		Takes more time diagnosing the system malfunction
PILOT 15: Decoding Abbreviations on EICAS sometimes lead to high mental workload. Lack of standardization of wording in certain areas on QRH checklist/ FCOM procedures and long sentences lead to longer processing time	Y	X	X	X	Longer processing time reading abbreviations on EICAS and vocabulary words and sentences on QRH checklist/FCOM leads to re-reading sentences. Sometimes translating system issue into my native language incorrectly

Table 17 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=19) continued

ESL flight crewmember description of impact on performance (n=19)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 16: When I pace myself reading QRH procedures and decode text, I have to make sure that I complete the procedure on time, which is sometimes medium to high workload	Y		X		Rarely, but sometimes I do have a time lag where I read a procedure too long (medium to high workload) to understand it, and takes away from other tasks.
PILOT 17: Not much impact when I read text on QRH checklists. I sometimes re-read information that is unfamiliar to me. This sometimes leads to longer processing speed	Y		X		
PILOT 18: Slight challenges with interpreting technical information on the QRH checklist to complex sentences that I have to reread, which leads to longer time processing of information.	Y		X		
PILOT 19: No Description due to no negative impacts noted by ESL flight crewmember	N				
Percentage= 18/19 (~95%) flight crewmembers indicated written English language negatively impacted their performance	Percentage=18/19 (~95%) flight crewmembers indicated use of metacognitive strategies to read and interpret written English language	Percentage =8/19 (~42%) flight crewmembers indicate written English language on crew alerting systems negatively impacted their performance	Percentage =17/19 (~89%) Flight crewmembers indicated written English language on QRH checklists negatively impacted performance	Percentage =7/19 (~36%) Flight crewmembers indicated written English language on crew alerting systems and QRH checklists negatively impacted their performance	Percentage =16/19 (~84%) Flight crewmembers indicated written English language on crew alerting systems and/or QRH checklists negatively impacted flight safety

Next results provide the reader with demographics and an understanding of specific factors and performance indicators that influenced participants ability to read and comprehend written English language on crew alerting systems and QRH checklists.

Table 18 ESL flight crewmembers' English language background knowledge factors ('demographics sub-theme') (N=19)

Code	Description	Flight crewmembers Percentages
1A	English language-ICAO ELPR Level 4, 5, 6	19/19 (100%)
1B	Preliminary School (Grade School) non-western region experience reading and speaking English language	3/19 (~16%)
1C	Preliminary School (Grade School) western region experience reading and speaking English language	7/19 (~37%)
1D	Secondary School (University) non-western region experience reading and speaking English language	0/19 (0%)
1E	Secondary School (University) western region experience reading and speaking English language	9/19 (~47%)
1F	ATP Certification (ability to read English language)	19/19 (100%)
1G	Airline years of experience using crew alerting systems and QRH checklists	19/19 (100%)

First demographics sub-theme indicated that each participant had background knowledge of English language and claimed ICAO English language proficiency levels of four, five, or six. All participants indicated they had an ATP certification and years of experience using crew alerting systems and QRH checklists. Regarding participant English language experiences from educational institutions of learning, results indicated their experience was different with respect to institution type and western/non-western region.

Table 19 ESL flight crewmembers' English language proficiency factors ('demographics sub-theme' continued) (N=19)

Code	Description	Flight crewmembers Percentage
1H	Self rated English language proficiency RCL of general use of English language (L-I)	0/19 (0%)
1I	Self rated English language proficiency RCL of general use of English language (I)	10/19 (~53%)
1J	Self rated English language proficiency RCL of general use of English language (HL)	9/19 (~47%)
1K	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (L-I)	5/19 (~26%)
1L	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (I)	5/19 (~26%)
1M	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (HL)	9/19 (~47%)

Second demographics sub-theme indicated that participants had variety of written English language proficiency levels with respect to their RCL of general English language, crew alerting systems and QRH checklists.

Table 20 ESL flight crewmembers' vocabulary words/text genre background knowledge factors ('demographics sub-theme') (N=19)

Code	Description	Flight crewmembers Percentage
2A	Knowledge of English language text genre on crew alerting systems (e.g. technical text)	19/19 (100%)
2B	Knowledge of English language text genre on QRH checklists (e.g. technical text)	19/19 (100%)
2C	Knowledge of English language elements on QRH checklists (e.g. typographical elements)	19/19 (100%)
2D	English language experience with conditional statements on QRH checklists (e.g. structure, noticing)	19/19 (100%)
2E	Background knowledge of abbreviations/acronyms (e.g. short form and/or long form)	19/19 (100%)
2F	Background knowledge of text format on crew alerting systems and QRH Checklists (e.g. authentic, elaborated, or short text)	19/19 (100%)
2G	ATP certification (knowledge of crew alerting systems /QRH checklists)	19/19 (100%)
2H	Background knowledge of vocabulary word type on crew alerting systems	19/19 (100%)
2I	Background knowledge of vocabulary word type on QRH checklists	19/19 (100%)

Third demographics sub-theme indicated that all participants had experience with vocabulary words and text genre background on crew alerting systems and QRH checklists.

Table 21 ESL flight crewmembers' metacognitive strategies factors to read written English language on crew alerting systems and QRH checklists ('cognitive sub-theme') versus English language proficiency (N=19)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
3A	Re-Reading Text	10/19 (~53%)	~32% I-level; ~21% H-Level	~21% I-level; 21% L-I level; 11% H-Level
3B	Paraphrasing Text	0/19 (0%)	N/A	N/A
3C	Underlining Text	2/19 (~11%)	~11% I-Level	~11% L-I level
3D	Referencing other Resources to clarify information (e.g. dictionary)	1/19 (~5%)	~5% H-Level	~5% H-level
3E	Highlighting Text	1/19 (~5%)	~5% I-level	~5% L-I level
3F	Translating written English language into ESL flight crewmembers native language	4/19 (~21%)	~5% I-level; ~16% H-level	~5% I-level; ~16% H-level
3G	Reverting back to native language to read English language	4/19 (~21%)	~21% I-level	~5% I-level; ~16% H-level
3H	Reading aloud text on flight deck	2/19 (~11%)	~5% I-level; ~5% H-level	~11% H-level

Table 22 ESL flight crewmembers' metacognitive strategies factors to read written English language on crew alerting systems and QRH checklists ('cognitive sub-theme') versus English language proficiency (N=19) continued

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
3I	Monitoring reading comprehension	1/19 (~5%)	~5% H-level	~5% H-level
3J	Taking Notes	2/19 (~11%)	~11% I level	~11% L-I level
3K	Breaking Apart Sentences	3/19 (~16%)	~11% I level; ~5% H-level	~5% L-I level; ~11% H-level
3L	Bottom up strategy (Decoding text)	3/19 (~16%)	~5% I level; ~11% H-level	~5% I-level; 11% H-level
3M	Top down strategy (prior knowledge of text; activating text schema)	5/19 (~26%)	~11% I-level; ~16% H-level	~5% L-I level; ~5% I-level; ~16% H-level
3N	Interactive strategy (Combination of Bottom up and Top Down Strategy use)	4/19 (~21%)	~5% I level; ~16% H-level	~5% I-level; ~16% H-level
3O	Monitoring reading speed	2/19 (~11%)	~5% I-level; ~5% H-level	~5% H-level; ~5% H-level
3P	Skipping words/omission of words	2/19 (~11%)	~11% I-level	~5% H-level; ~5% L-I level

Cognitive sub-theme (metacognitive strategy) indicated participants utilized different metacognitive strategies to read and interpret written English language. Additionally, participant metacognitive strategy use and their English language proficiency levels (general English language, crew alerting systems and QRH checklists) were different when they read and interpret written English language. Relevance of participant metacognitive strategy use and their English language proficiency level will be reviewed in the discussion section of this study.

Table 23 ESL flight crewmembers' crew alerting systems English language design and integration factors (N=19)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
4A	Sentence Length (Short)	0/19 (0%)	N/A	N/A
4B	Acronyms/abbreviations	6/19 (~32%)	~16% I–level; ~16% H-level	~16% I-level; ~16% H-level
4C	Text Genre (e.g. technical)	9/19 (~47%)	~32% I-level; ~16% H-level	~21% I-level; ~21% H-level; ~5% L-I level
4D	Number of Tokens in Text	0/19 (0%)	N/A	N/A

Table 24 ESL flight crewmembers' crew alerting systems English language design and integration factors (N=19) continued

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
4E	Authentic Text	9/19 (47%)	~32% I-level; ~16% H-level	~21% I-level; ~21% H-level; ~5% L-I level
4F	Sentence Length (Long)	1/19 (~5%)	~5% I-level	~5% I-level
4G	Simplification of Text	1/19 (~5%)	~5% I-level	~5% H-level
4H	Vocabulary Words Type	5/19 (~26%)	~26% I-level	~11% I-level; ~11% H-level; ~5% L-I level

Regarding written English language on crew alerting systems, many participants indicated several different written English language design and integration factors that influenced their ability to read and interpret information on crew alerting systems. Participant English language proficiency level (general English language, crew alerting systems and QRH checklists) indicated differences with respect to English language design and integration factors that negatively impacted participant reading comprehension of English language on crew alerting systems. Discussion section of this study will provide a review of the impact design and integration factors have on participant ability to read and comprehend written English language.

Table 25 ESL flight crewmembers' QRH Checklists English language design and integration factors

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
5A	Conditional Statements	3/19 (~16%)	~11% I-level; ~5% H-level	~5% L-I-level; ~5% I-level; ~5% H-level
5B	Number of Tokens in Text	3/19 (~16%)	~11% I-level; ~5% H-level	~11% L-I level; ~5% H-level
5C	Authentic Text	17/19 (~89%)	~47% I-level; ~42% H-level	~26% I-level; ~26% L-I level; ~37% H-level
5D	Sentence Length (Long)	5/19 (~26%)	~16% I-level; ~11% H-level	~11% L-I level; ~11% H-level; ~5% I level
5E	Simplification of Text	1/19 (~5%)	~5% H-level	~5% H-level
5F	Acronyms/Abbreviations	4/19 (~21%)	~11% I-level; ~11% H-level	~16% I-level; ~5% H-level
5G	Text Genre (e.g. technical)	17/19 (~89%)	~47% I-level; ~42% H-level	~26% I-level; ~26% L-I level; ~37% H-level
5H	Vocabulary Words Type	14/19 (~74%)	~42% I-level; ~31%-H-level	~16% I-level; ~26% L-I level; ~31% H-level
5I	Sentence Length (Short)	0/19 (0%)	N/A	N/A

Regarding participants use of QRH checklists, many participants indicated several different written English language design and integration factors that influenced their ability to read and interpret information on QRH checklists. Participant English language proficiency level (general English language, crew alerting systems and QRH checklists) indicated differences with respect to English language design and integration factors that negatively impacted participant reading comprehension of English language on QRH checklists. Discussion section of this study will provide a review of the impact design and integration factors have on participant ability to read and comprehend written English language.

Table 26 Flight safety impact (main theme) on ESL flight crewmembers (N=19)

Main Theme: ESL flight crewmembers flight safety impact	PERCENTAGES	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
Improper System Diagnosis -Difficulty understanding abbreviations and acronyms	1/19= ~5%	~5% I-level	~5% I-level
Long Processing Time of Information -Due to translation of words into native language, highlighting/underlining words on checklists -Due to decoding abbreviations	10/19= ~ 52%	~31% I-level; ~21% H-level	~5% I-level; 21% L-I level; ~26% H-level
Workload Impact -Very detailed QRH checklists -Challenging vocabulary words	5/19= ~26%	~16% H-level; ~11% I-level	~21% H-level; ~5% L-I level
Frustration -Very detailed QRH checklists -Unknown Words	1/19= 5%	~5% H-level	~5% L-I level
Omission and Misinterpretation of Information -Skipping words due to misunderstanding -Reverting back to native language	2/19= ~11%	~5% I-level; ~5% H-level	~5% H-level; ~5% I-level

Table 26 illustrates negative impacts on flight safety as a result of participants' performance on the flight deck. Many different types of performance factors negatively impacted participant flight safety. Regarding participant English language proficiency levels (general English language, crew alerting systems and QRH checklists), each participant indicated different proficiency levels with respect to their performance factors that negatively impacted flight safety.

Discussion

This section provides a discussion of each design and integration factor/performance factors that influenced participants' ability to read and comprehend written English language. Goal of this discussion is to provide the reader with an understanding of how written English language concepts reviewed in the literature review are interrelated with the outcome of the researcher's preliminary study. Towards the end of the discussion, the reader should understand the plan forward to further investigate written English language design and integration factors, and participants' performance challenges on the flight deck.

Figure 14 is a paradigm that describes how the researcher will approach the discussion for study one. Three top boxes describe participants' English language background knowledge factors, while middle box describe participants' English language proficiency and their use of metacognitive strategies to read and comprehend written English language on crew alerting systems and QRH checklists. Finally, participants' performance challenges with respect to their use of crew alerting systems and QRH checklists will be discussed as well as impact on flight safety.

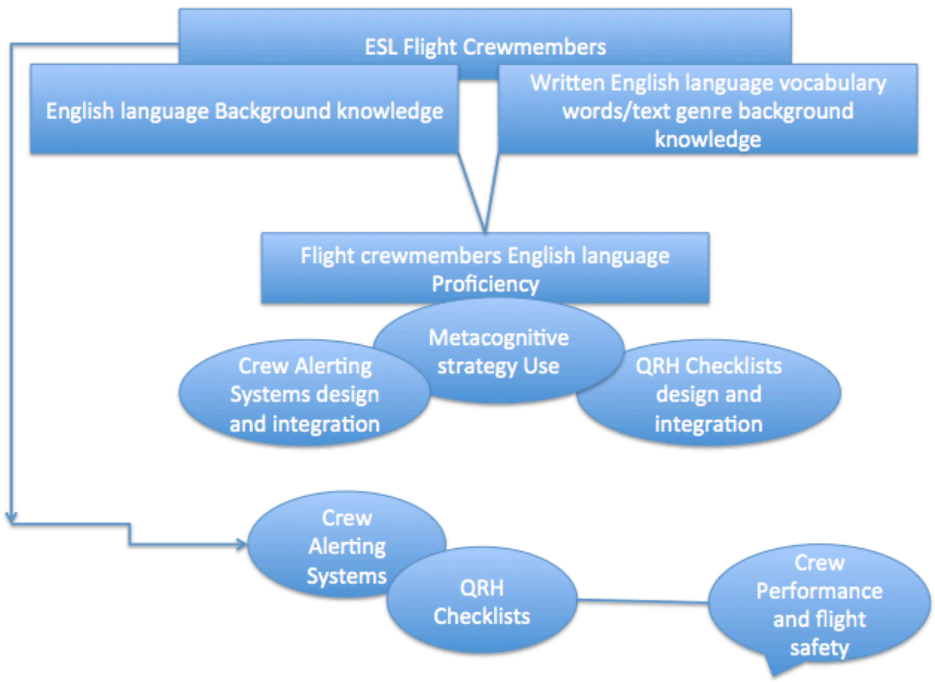


Figure 14 Preliminary study part 1 Paradigm Discussion Points

Previous literature reviewed indicated that ESL adult background knowledge of English language, knowledge of text genre/vocabulary words, and English language proficiency are key components to understand how well adults may read and comprehend written English language. The researcher's preliminary study indicated that all participants had background knowledge of English language. They received English language instruction from a variety of educational institutional learning systems (e.g. university education). Many participants had western region experience with English language (grade school and university) Participants also had airline years of experience using written English language on crew alerting systems and QRH checklists. Therefore, participants had background of vocabulary words/text genre background. Participants' ATP rating was utilized, as it was an indication they were able to read English language on the flight deck. As ECFR (2016) indicated, ATP rating is common for ESL airline flight crewmembers and is an indication that flight crewmembers must be able to read English language.

The ICAO level of English language proficiency data collected indicated that all flight participants met minimum requirements for ELPRs and some exceeded the requirements (ICAO, 2004). Although participants indicated they had ICAO ELPR of level four, five, and six these levels do not provide an indication of how well participants read and comprehend written English language. The IAC (2013) indicated that ESL flight crewmember ICAO ELPRs are not enough to assess how well flight crewmembers read and comprehend written English language. Therefore, self-rated English language proficiency levels were utilized and indicated each participant had different English language proficiency RCL with respect to their general English language reading comprehension. Additionally, participants had dissimilar English language proficiency RCL reading and comprehending written English language on crew alerting systems and QRH checklists. Recall, utilization of ESL adult self-proficiency ratings are important, as they provide indicators of adults metacognitive strategy use, and how well they read and comprehend written English language on technical information, especially expository and instructional texts (Park, 2010, Yeh and Genter, 2005).

Technical information was noted as challenging to many participants regardless of the metacognitive strategy they utilized to read and understand written English language. Their use of metacognitive strategies to read and comprehend written English language on crew alerting systems and QRH checklists were different, and proficiency levels (general English language, crew alerting systems and QRH checklists) varied based on use of either crew alerting systems and/or QRH checklists. Regarding metacognitive strategy use by participants, strategies utilized on QRH checklists (paper format) were different than crew alerting systems (displayed format). As Holder (2003) indicated, flight crewmember English language proficiency has the potential to be different based on their use of each of these systems (i.e. crew alerting systems and QRH checklists).

Collectively, participants' English language proficiency influenced their ability to read and comprehend written English language. Participants had various English language proficiency levels, and each participant proficiency level influenced their ability to read information on crew alerting systems and QRH checklists. Altogether, aforementioned aspects were fundamental requirements needed to assess how well participants read and understand written English language on crew alerting systems and QRH checklists, and challenges they experienced reading technical information. The next sections provide detailed discussions on preliminary study one.

As Smith-Jackson (2006) and Riley et al (2006) indicated, understanding differences in flight crewmembers' cognitive processing of written English language is important, especially factors that may impact their performance. Written English language on crew alerting systems and QRH checklists should be evaluated, with respect to flight crewmembers cognitive ability to read and understand written English language on each of the systems (Burian, 2006 and Holzinger et al, 2011).

With respect to metacognitive strategies use by participants, the researcher's preliminary study indicated differences in type of strategy utilized, number of metacognitive strategies utilized, and most common/least common strategy utilized to read and comprehend written English language. Most participants utilized at least one metacognitive strategy to read and understand written English language, and there were many participants with RCL proficiency H-level (general English language, crew alerting systems and QRH checklists) that utilized many metacognitive strategies to read and understand written English language on crew alerting systems and QRH checklists. As Park (2010) indicated, high self-rated proficiency ESL adults utilize more metacognitive strategies. On the other hand, in the researcher's study participants with RCL proficiency I-level (general English language, crew alerting systems and QRH checklists) also utilized many metacognitive strategies. It was indicated that participants with RCL proficiency I-level were also comfortable with using strategies to read written English language. Participants with RCL proficiency L-I level indicated they utilized strategies to help guide them through the reading comprehension process.

Anderson (2004) indicated that ESL adults read and interpret written English language utilizing mental models. In the researcher's preliminary study, participants (sixteen percent) utilization of bottom up strategy (decoding text) was found. As Liu (2014) indicated, use of this model is dependent on ESL adult English language proficiency. Likewise, participants (eleven percent) with RCL proficiency H-level and five percent with RCL proficiency I-level (general English language) use bottom up strategy (decoding text), while participants (eleven percent) with RCL proficiency H-level and participants (five percent) with RCL proficiency I-level (crew alerting systems, QRH checklists) utilize bottom up strategy (decoding text). It was indicated that participants with RCL proficiency H-level had background knowledge of decoding words on crew alerting systems and QRH checklists. Additionally, participants with RCL of H-level proficiency indicated they were comfortable using this strategy to read and understand written English language on crew alerting systems and QRH checklists.

Use of top down strategy (background knowledge) by twenty-six percent of participants was utilized more than bottom up strategy to activate their background knowledge/content schema of written English language text, on crew alerting systems and QRH checklists. Use of background knowledge by ESL adults to read and interpret English language is typical as indicated by Lin and Chern (2014), Hammadou (1991). In the researcher's study, participants indicated they utilized English language skills they learned from their airline as mechanisms to read and understand written English language on crew alerting systems and QRH checklists. They considered their years of experience as an indicator of background knowledge of English language as well as the different types of checklists containing different layouts of technical information. Comparable to the participants with RCL proficiency H-level that utilized bottom up strategy to read and understand written English language, participants with RCL proficiency H-level also utilize top down strategy more than participants with RCL proficiency I-level and L-I level. Participants (sixteen percent) with RCL proficiency H-level utilize top down strategy, while eleven percent of participants with RCL proficiency I-level (general English language) use top down strategy. On the other hand, participants (sixteen percent) with RCL proficiency H-level, five percent I-level, and five percent L-I level (crew alerting systems, QRH checklists) use top down strategy. Participants with RCL proficiency H-level indicated they were comfortable with written English language on crew alerting systems and QRH checklists because they were able to utilize their background knowledge of the systems. This finding is consistent with Yildiz-Genc's (2009) and You's (2009) study which indicated that background knowledge and familiarity with written English language indicates that ESL adults will read and understand written English language better than text that is unfamiliar to them.

Participants (twenty-one percent) indicated they use interactive strategy. Participants (sixteen percent) were RCL proficiency H-Level and five percent were I-level (general English language), while participants sixteen percent with RCL proficiency H-level and five percent I-level (crew alerting systems, QRH checklists) use interactive strategy. Participants indicated that use of this strategy was due to their ability to decode and use background knowledge on sections of the QRH checklists. This finding is consistent with Fatemi et al's (2014) study. Participants also indicated that familiarity with checklists items helped them recognize certain pieces of text.

Re-reading text on crew alerting systems and QRH checklists was considered a strategy utilized by most participants (fifty-three percent). Participants (thirty-two percent) with RCL proficiency I-level and twenty-one percent of participants with RCL proficiency H-level (general English language) utilized re-reading text strategy. Twenty-one percent of participants that were RCL proficiency L-I level and twenty-one percent that were I-level use re-reading text strategy, while eleven percent of participants with RCL proficiency H-level (crew alerting systems, QRH checklists) use re-reading text strategy. Participants with RCL proficiency H-level indicated they only re-read text, if they didn't understand information on checklists. On the other hand, participants with RCL proficiency level I-level and L-I level indicated they re-read information to have a clearer picture of the system issue. In other words, participants with RCL proficiency I-level and L-I level re-read checklist information as a practice to ensure they understood information, whereas, participants with RCL proficiency H-level, only re-read information if they misinterpreted a word or sentence on a checklist. Participants with RCL proficiency H-level indicated that sometimes very detailed checklists require certain words to be re-evaluated/re-interpreted. As Yildiz-Genc (2009) indicated, intermediate level ESL adults were more inclined to re-read sentences to understand the meaning. In the researcher's preliminary study participants with RCL I-level indicated they re-read information as a common practice, not just to understand word or sentence meaning.

Twenty-one percent of participants translate written English language on QRH checklists into their native language. Sixteen percent of participants had RCL proficiency H-level and five percent I-level (general English language), while sixteen percent of participants with H-level and five percent I-level (crew alerting systems, QRH checklists) translate written English language on QRH checklists back into their native language. As Hutchins et al (2006, p.5) indicated, certain words may not be translated adequately and could destroy word meaning. In the researcher's preliminary study, long processing time of information was due to translation of checklists words and sentences into their native language. As Abdul-Hamid and Samuel (2012) indicated, translation of written English language into their native language led to ESL adults re-reading sentences. This was not the case in the researcher's study, rather participants' reading time was long due to processing translated written English language words into their native language. They indicated they utilize translation strategy because their airline uses the strategy often to understand written English language on crew alerting systems and QRH checklists. Interestingly, ESL adult proficiency levels in Abdul-Hamid and Samuel (2012) study were either proficient or less than proficient. In the researcher's preliminary study, participants RCL proficiency was H-level or I-level, there were no participants that translated written English language text, with RCL proficiency of L-I level. Therefore, the researcher's finding does not support this aspect of Abdul-Hamid and Samuel (2012) study, which indicated that less than proficient adults were negatively impacted by translation process.

Twenty-one percent of participants indicated they use reversion back to their native language strategy to understand written English language on crew alerting systems. Twenty-one percent of participants with RCL proficiency I-level (general English language) indicated they use reversion strategy, while sixteen percent of participants with RCL proficiency H-level and five percent I-level (crew alerting systems and QRH checklists) use reversion strategy. Participants indicated they use this strategy as a common practice at their airline. As Kobayashi and Rinnert (1992) indicated, reverting back to English language can occur because ESL adult lack of understanding translated syntax meaning. This can result in inappropriate translation of technical information back into their native language. In the researcher's preliminary study, participants indicated they utilized this strategy because some aviation abbreviations and words are the same definition and are written fairly the same. Familiarity with words in their native language helps them as they process words on crew alerting systems when they use reversion strategy. As Larsen and Hansen (2010) indicated abbreviations and acronyms that are found in certain genres of text aid ESL adults with understanding their meaning due to their familiarity with the text. Additionally, this strategy did not lead participants to incorrect translation of words into their native language.

Referencing other resources to help clarify information (e.g. dictionary) was a strategy utilized by five percent of participants. A participant with RCL proficiency H-level (general English language, crew alerting systems and QRH checklists) uses referencing other resources strategy to read written English language on crew alerting systems and QRH checklists. Five percent of participants use highlighting text strategy on QRH checklists, the participant had RCL proficiency I-level (general English language) and L-I level (crew alerting systems and QRH checklists). Participants (eleven percent) utilize taking notes strategy. Eleven percent of participants' proficiency levels were RCL proficiency I-level (general English language) and L-I level (crew alerting systems and QRH checklists). According to Park's (2010) study, there were many ESL adults that utilized referencing and highlighting strategies to read and comprehend written English language text. In Park's (2010) study, note taking was the least utilized strategy. Additionally, Park's (2010) study indicated that more ESL adults had fairly good or not adequate English language proficiency, than high English language proficiency level ESL adults (English speaking and reading comprehension abilities). Contrary to Park's (2010) study, the researcher's preliminary study indicated that referencing and highlighting strategies were utilized the least by participants with RCL of H-level, I-level, and L-I level (general English language, crew alerting systems and QRH checklists). Note taking strategy was not utilized the least by participants, it was utilized more than referencing and highlighting text to read and interpret written English language on checklists. They indicated note taking helped them remember words they may see again on QRH checklists. Whereas, referencing and highlighting were indicated as a strategy utilized to access information on the checklists when they had a system malfunction/failure in an aircraft they flew.

Monitoring reading comprehension was utilized by five percent of participants. A participant with RCL H-level (general use of English language, crew alerting systems and QRH checklists) indicated use of monitoring reading comprehension strategy. Whereas, monitoring reading speed was commonly utilized by eleven percent of participants. A participant with RCL proficiency I-level and a participant with H-level (general English language) use monitoring reading speed strategy. Both participants indicated their RCL proficiency levels were H-level (crew alerting systems and QRH checklists). As Park's et al (2014) study revealed, ESL adults with very good English language proficiency utilized monitoring reading comprehension to read and comprehend written English language. Part of Park's et al (2014) study was corroborated in the researcher's preliminary study. One participant with high English language proficiency utilized monitoring reading comprehension to read written English language on QRH checklists. It was indicated that this was a practice the flight crewmember utilized to help set his expectations on the type of information he was about to read. Monitoring reading speed strategy was not indicated in Park's et al (2014) study, but was utilized as a strategy by two participants with high and intermediate level of English language proficiency in the researcher's preliminary study.

Few participants (eleven percent) used skipping/omission of words on crew alerting systems and QRH checklists. Each participant (eleven percent) had RCL proficiency I-level (general English language), while eleven percent of participants each had RCL proficiency H-level and L-I level (crew alerting systems, QRH checklists). Each participant indicated they utilized skipping and omission of words if they did not understand written English language text. As Dordick (1996) indicated omission of words is due to ESL adults misunderstanding words, or unfamiliar words in text. As this was the case in the researcher's preliminary study, this strategy was also utilized by flight crewmembers with different levels of English language proficiency. As Abdul-Hamid and Samuel (2012) study revealed, ESL adults that were proficient with English language and less than proficient utilize skipping/omission strategy to understand written English language.

Participants (sixteen percent) that utilize breaking apart sentences had a variety of RCL proficiency levels. Participants (eleven percent) with RCL proficiency I-level and five percent H-level (general English language) use breaking apart sentences strategy. On the other hand, five percent of participants with RCL proficiency L-I level and eleven percent of participants with RCL proficiency H-level (crew alerting systems, QRH checklists) indicated they utilized breaking apart sentences strategy. It was indicated that they use this strategy if they were unfamiliar with text or text seemed to be longer than expected on QRH checklists. Part of this finding is corroborated in Anderson (2003) study. In Anderson's (2003) study, it was indicated that intermediate level ESL adults utilized breaking apart sentences to understand written English language text. The researcher's preliminary study revealed that participants with RCL proficiency H-level, L-I level, and I-level utilized breaking apart sentences to read and understand text on QRH checklists.

Participants (eleven percent) utilize underlining text on QRH checklists and had RCL proficiency of I-level and L-I level (general English language, crew alerting systems and QRH checklists). Participants indicated they utilized underlining strategy if they were unfamiliar with text, and if time permitted would go back and review the meaning of the word during a period of time that was not congested with other tasks. They also indicated they underlined text if it was unfamiliar to them in their native language. This finding is different from Rouhi et al (2015) and Storch (2001) studies. They suggested highlighting text or providing emphasis to text is an indication that ESL adults were familiar with the structure of text. As participants had background knowledge of text structure on QRH checklists, it is peculiar as to why they underlined text for a different reason than how Rouhi et al (2015) and Storch (2001) studies explained use of this metacognitive strategy.

Finally, few participants (eleven percent) with RCL I-level and H-level (general English language) utilized reading aloud strategy. The participants (eleven percent) also indicated they had an RCL proficiency of H-level (crew alerting systems, QRH checklists). Participants indicated they read aloud QRH checklists procedures and information on crew alerting systems, as this was a common practice at their airline. They also indicated use of this strategy to ensure that understood the QRH checklist procedure. As KNKT (2015) indicated, it is a common practice to read aloud procedures to understand information on crew alerting systems and QRH checklists.

Summary

In summary, metacognitive strategy use by all participants was a common practice. It was also an effective method for them to read and comprehend written English language. English language proficiency is a factor that influences participants' ability to read and comprehend written English language on crew alerting systems and QRH checklists. Although participants' English language proficiency levels varied based on strategy type utilized to read and comprehend written English language, use of metacognitive strategies helped them with processing information on crew alerting systems and QRH checklists. It should also be noted that regardless of participants' English language proficiency (general English language and/or crew alerting systems and QRH checklists), participants utilized different types of metacognitive strategies. Background knowledge of English language and background knowledge of vocabulary words/text genre was important when participants utilized metacognitive strategies to read written English language on crew alerting systems and QRH checklists. More research is needed on types of vocabulary words and text genre on crew alerting systems and QRH checklists. Furthermore, more information is needed to understand how participants' proficiency, English language background knowledge, and background knowledge of vocabulary words/text genre impact their use of metacognitive strategies to read and understand written English language.

As the FAA (1996) indicated, crew-alerting systems need to be evaluated with respect to how ESL flight crewmembers' interface with them. The FAA also indicated that different ESL flight crewmembers with different linguistic backgrounds should be evaluated with respect to their ability to read and comprehend English language. Accordingly, the researcher evaluated factors of crew alerting systems that impact flight crewmember ability to read written English language on crew alerting systems, as well as their English language proficiency.

Participants (thirty-two percent) indicated that use of acronyms and abbreviations on crew alerting systems were factors that negatively impacted their reading comprehension of written English language. Sixteen percent of participants with RCL proficiency I-level and H-level proficiency (general English language, crew alerting systems and QRH checklists) indicated that understanding meaning of long form acronyms and abbreviations was a factor that negatively impacted their reading comprehension. As McInnes (2011) indicated, adequate background knowledge of the long form of abbreviations is paramount. Thus, if ESL adults do not have an adequate understanding of the short form abbreviation, their reading comprehension may be negatively impacted. In the researcher's study, many participants indicated they had background knowledge of written English language text on crew alerting systems. However, participants that were not accustomed to seeing certain malfunctions/failures on crew alerting systems indicated did not recognize the text that was abbreviated. The researcher's preliminary study corroborated part of Park's et al (2014) study. Participants with RCL proficiency H-level had background knowledge of text on crew alerting systems, but still were not familiar with abbreviations and acronyms on crew alerting systems. This finding corroborates Park's et al (2014) study. On the other hand, participants with RCL proficiency I-level were also negatively impacted by abbreviations and acronyms on crew alerting systems.

Regarding text genre (e.g. technical) and authentic text factors, participants (forty-seven percent) indicated that these factors negatively impacted their reading comprehension. Participants (thirty-two percent) with RCL proficiency I-level and sixteen percent H-level (general English language) indicated aforesaid factors negatively impact their reading comprehension. Twenty-one percent of participants with RCL proficiency I-level, twenty-one percent H-level, and five percent L-I level (crew alerting systems, QRH checklists), indicated they experience negative impacts with text genre (e.g. technical) and authentic text. Technical genre text on crew alerting systems was difficult to read and understand. Participants with different proficiency levels indicated that certain words are not easily comprehensible to them. They indicated that familiarity with technical words on crew alerting systems impacted their reading comprehension. They also stated that authentic text tends to focus heavily on English as first language participants and not participants that speak English as a second language. In particular, participants' indicated that western region language is often difficult to understand on technical displays if English is not their first language. They also stated that certain technical words should be written differently to convey meaning, which could make the words easier to understand. Regarding ability to retrieve information from displayed text, read and understand it, participants indicated they were challenged by technical information on displays.

As You (2009) indicated, ESL adults that read written English language on computer screens, have the potential to be challenged due to their ability to retrieve text from screen. Text is presented differently on the computer screen compared to text on paper format can negatively impact reading comprehension. In the researcher's preliminary study, retrieval of technical information on displays was an issue that negatively impacted their reading comprehension. This finding supports You's (2009) study that focused on expository text on computer screens. The researcher's study also indicated that participants' proficiency was different with respect to their ability to read information on crew alerting systems. That is, participants with RCL proficiency I-level, H-level, and L-I level indicated they were negatively impacted by written English language on crew alerting systems. This finding does not support part of You's (2009) study, which indicated that having background knowledge and familiarity with text affords ease of reading comprehension, when adults read text on computer screens, especially adults with high reading comprehension proficiency levels. In the researcher's study, participants had background knowledge and were familiar with text on the GUI, but each participant was negatively impacted, regardless of proficiency level. Therefore, in this case, participant English language proficiency levels negatively impact their ability to read and comprehend information on the GUI.

Vocabulary word types (e.g. technical words) were factors that influenced many participants' ability to read information on crew alerting systems. Twenty-six percent of participants with RCL proficiency I-level (general English language) indicated they are negatively impacted by vocabulary word type (e.g. technical words) on crew alerting systems. On the other hand, participants with RCL I-level (eleven percent), H-level (eleven percent), and L-I level (five percent) proficiency (crew alerting systems and QRH checklists) indicated they are negatively impacted by English language on crew alerting systems.

Regarding text simplification, five percent of participants indicated negative impact to reading text that appeared to be simplified on crew alerting systems. A participant with RCL proficiency I-level (general English language) and H-level (crew alerting systems, and QRH checklists) indicated they were negatively impacted. This finding does not corroborate You's (2009) study, which indicated simplification of expository text on computer screens was beneficial to their reading comprehension. On the other hand, the researcher's study does support You's (2009) study regarding ESL adults text familiarity and background knowledge of text facilitate adequate reading comprehension of written English language text. This was the case in the researcher's study that information on crew alerting systems was familiar to participants and they had background knowledge of the text.

Finally, participants (five percent) indicated that sentence length (long) negatively impacted their ability to read and comprehend information on crew alerting systems. It was noted that sentences on the advisory alert page are sometimes too long and could be shortened for clarity purposes. One participant with RCL proficiency I-level (general English language) and RCL proficiency I-level (crew alerting systems and QRH checklists) indicated sentence length (long) negatively impacted their reading comprehension.

Summary

Collectively, participants' English language background knowledge, background knowledge of text genre/vocabulary words type, and English language proficiency are factors that influence their ability to read and comprehend written English language on crew alerting systems. Text genre (e.g. technical), authentic text, vocabulary words, and abbreviations and acronyms are written English language factors that will be further investigated, as they were critical factors that negatively impacted participants' ability to read and interpret written English language on crew alerting systems.

Acronyms and abbreviations on QRH checklists were indicated as factors that negatively impacted many participants' (twenty-one percent) ability to read and comprehend written English language on QRH checklists. Furthermore, participants (eleven percent) with RCL proficiency I-level and H-level (general English language) indicated challenges with acronyms and abbreviations on QRH checklists. Sixteen percent of participants with RCL proficiency I-level, and five percent H-level (crew alerting systems and QRH checklists) indicated they were challenged by acronyms and abbreviations on QRH checklists. Participants indicated they were negatively impact by acronyms and abbreviations on QRH checklists due to their perception of the word in their language. In other words, when participants read through checklists they indicated constant reversion back to their native language to understand word meaning, and sometimes translate acronyms and abbreviations back to their native language. As Kuzmina et al (2015) indicated, written English language abbreviations/acronyms could potentially have different meanings in a different language, or different meanings based on the text type (Kuzmina et al, 2015), especially if ESL adults translate information back into their native language. As this was the case in the researcher's study, this finding supports Kuzmina et al (2015) study. Furthermore, participants also indicated they experienced negative impacts to their reading comprehension when they read the short form of abbreviations, due to them being unfamiliar with the terminology in the long form. This finding supports McInnes (2011) study, which indicated background knowledge/text familiarity is important when reading written English language acronyms and abbreviations. Finally, Kim (2006) indicated that high and low proficiency level ESL adults are negatively impacted by acronyms and abbreviations in text. Likewise, this finding from Kim's (2006) was supported in the researcher's preliminary study.

As authentic text, text genre (e.g. technical), and vocabulary words on QRH checklists are important aspects of written English language, their format on checklists could negatively impact participants' ability to read and understand written English language. Bielsa-Murcia (1999) indicated that instructional text has the potential to be lengthy, or contain complex wording, which has the potential to effect ESL adult reading comprehension. In the researcher's study, high percentage of participants (eighty-nine percent) indicated text genre (e.g. technical) and authentic text negatively impacted their reading comprehension. Participants (forty-seven percent) with RCL proficiency I-level and forty-two percent H-level (general English language) indicated negative impacts to their reading comprehension. Twenty-six percent of participants with RCL proficiency I-level, twenty-six percent of participants with L-I level, and thirty-seven percent with H-level (crew alerting systems and QRH checklists) were also negatively impacted by written English language on QRH checklists. Participants indicated that written English language text on QRH checklists are difficult to read due to inconsistencies, format of technical information, and complex wording on QRH checklists. This leads to interpretation issues. As Wanpen et al (2013) indicated, low, medium and high proficiency level ESL adults are negatively impacted by written English language technical genre text. As this was the case in the researcher's preliminary study, participants indicated technical text negatively impacted their reading comprehension. Researcher's preliminary study also corroborates Bielsa-Murcia's (1999) finding on complex wording, with respect to its impact on adults that read and comprehend written English language as their second language.

Sentence length (long) was a factor that negatively impacted twenty-six percent of participants. Participants (sixteen percent) with RCL proficiency I-level and eleven percent H-level (general English language) indicated sentence length (long) negatively impacted their reading comprehension on QRH checklists. Participants (eleven percent) with RCL proficiency H-level, eleven percent L-I level, and five percent I-level (crew alerting systems, QRH checklists) indicated sentence length (long) negatively impacted their reading comprehension on QRH checklists. Participants indicated that often sentences are verbose and are too long to read when responding to a crew alert. This finding corroborates Bielsa-Murcia's (1999) finding on instructional text being lengthy.

Sixteen percent of participants indicated conditional statements negatively impacted their reading comprehension of information on QRH checklists. Likewise, sixteen percent of participants indicated number of tokens contributed to negative impacts on their reading comprehension. Participants (eleven percent) with RCL proficiency I-level and five percent H-level (general English language) indicated that conditional statements and number of tokens negatively impacted their reading comprehension of information on QRH checklists. On the other hand, five percent of participants with RCL proficiency L-I level, five percent I-level, and five percent H-level indicated conditional statements negatively impact their reading comprehension on QRH checklists (crew alerting systems, QRH checklists). Eleven percent of participants with RCL proficiency L-I level and five percent H-level indicated number of tokens negatively impact their reading comprehension on QRH checklists. Participants indicated, conditional statements in the notes section of the QRH checklist contain vocabulary words that are unfamiliar to them, and conditional statements are sometimes not recognizable. On the other hand, participants indicated that some checklists contain proper use of conditional statements, while others do not. This factor has a negative impact on participants' reading comprehension.

As Jacobsen (2012) indicated, improper design of written English language conditionals (if/then) clauses can impact ESL an adult's ability to read and comprehend written English language. As this was the case in the researcher's preliminary study, this finding supports Jacobsen (2012) study. Participants' English language proficiency reading conditional statements on the QRH checklist was different in the researcher's preliminary study. This finding does not support Yeh and Gentner's (2005) study, which indicated that low proficiency ESL adults were only negatively impacted by written English language conditional statements. In the researcher's study, conditional statements negatively impacted participants with different levels of proficiency. On the other hand, participants' ability to recognize conditional statements on QRH checklists negatively impacted their ability to read and comprehend written English language. This finding supports Yeh and Gentner's (2005) study, which indicated that ESL adults were negatively impacted by their ability to recognize conditionals on written English text.

Regarding number of tokens in text, participants indicated that certain QRH checklists (e.g. fuel systems) contain too many words, which negatively impacts their reading comprehension of text. As Larsen and Hansen (2010) indicated, reading comprehension of small amounts of words on authentic text that contains technical text, tends on to be easily comprehended by ESL adults, especially those with high English language proficiency and background knowledge of the text they read. In the researcher's study, participants had different levels of English language proficiency. Part of Larsen and Hansen's (2010) study was corroborated by the researcher's preliminary study. Participants had background knowledge of the text the read, but proficiency levels were different, and a highly proficient participant indicated negative impact to reading comprehension, due to number of tokens in text.

Participants (five percent) with RCL proficiency H-level (general English language, crew alerting systems, QRH checklists) indicated that simplification of text is a factor that negatively impacts their reading comprehension. It was noted that some text should be simplified but others not simplified. Simplified text on QRH checklists can impact interpretation of information on crew alerting systems.

Finally, participants (seventy-four percent) indicated vocabulary words type was a factor that negatively impacted their reading comprehension of information on QRH checklists. It was noted that vocabulary words on complex checklists (i.e. electrical and engine) related to non-normal conditions are difficult because they contain words that are in different forms (HYD, hydraulic, H). It was noted that all of the words on QRH checklists are considered to be technical by flight crewmembers in the industry. In the researcher's experimental study, it will be determined if all vocabulary words on QRH checklists are considered technical words. Forty-two percent of participants with RCL proficiency I-level and thirty one percent H-level (general English language) indicated vocabulary word types negatively impact their reading comprehension of information on QRH checklists. On the other hand, participants (sixteen percent) with RCL proficiency I-level, twenty-six percent L-I level, and thirty-one percent H-level (crew alerting systems, QRH checklists) indicated they were negatively impacted by vocabulary words on QRH checklists. According to Levine and Reves (1990), use of vocabulary by ESL adults can be difficult and has the potential to impact reading comprehension. Several scientists have argued that vocabulary word types in written English language text and size of vocabulary can impact understanding of word meaning by ESL adults. It was also noted by Nation (2001) that English language proficiency has an impact on how well ESL adults ability to read English language vocabulary words.

Summary

Overall, written English language on QRH checklists was difficult to read and comprehend by participants. Participants with different levels of English language proficiency indicated negative impacts to their reading comprehension, when they read text on QRH checklists. Text genre (e.g. technical), authentic text, vocabulary words, sentence length (long) and abbreviations/acronyms tend to negatively impact participants' reading comprehension more than conditional statements, sentence length (short), number of tokens, and simplification of text. More research is needed on the aforementioned factors that influence participants' ability to read and comprehend written English language on QRH checklists.

Participants indicated their performance was negatively impacted when they read and comprehended written English language on crew alerting systems and QRH checklists. Participants' English language proficiency levels were different, with respect to each performance impact.

Regarding participant improper systems diagnosis, five percent of participants with RCL proficiency I-level (written English language, crew alerting systems and QRH checklists) indicated flight safety was negatively impacted. The participant indicated that abbreviations and acronyms are difficult to understand which negatively impacted their performance, and flight safety. According to participant, this occurred because of their inability to recognize long form of acronyms/abbreviations, and this led to misdiagnosing the system malfunction/failure.

Five percent of participants indicated frustration negatively impacted their ability to read written English language information. The participant's RCL proficiency level was H-level and L-I level (general English language, crew alerting systems and QRH checklists). Very detailed QRH checklists and unknown words frustrated a participant. It was indicated that trying to manage flight situations and reading checklists is difficult, and trying to understand difficult words makes managing malfunctions/failures challenging. As many of the aforementioned scientists have indicated, long sentences and unknown words can impact reading ESL adult reading comprehension. Their English language proficiency is also an indicator of how well they process written English language information. Recall from chapter one, many contributory factors of aircraft accidents were the result of English language design and integration factors, and flight crewmembers' English language proficiency. This is an indication that aforementioned factors are still prevalent factors that impact flight safety.

Participants (eleven percent) indicated omission and misinterpretation of information on crew alerting systems and QRH checklists negatively impacted flight safety. Five percent of participants with RCL proficiency I-level and five percent with H-level (general English language) indicated flight safety was negatively impacted. Five percent of participants with RCL proficiency H-level and five percent I-level (crew alerting systems and QRH checklists) indicated negative impacts to flight safety. Participants indicated their performance was negatively impacted and led them to skip over words and revert back to their native language to understand English language. They indicated that they miss steps in a procedure due to misunderstanding text. When a step is missed, it exacerbates response to other problems on the flight deck that are interrelated to the previous problem that was not fixed appropriately.

Workload negatively impacted a twenty-six percent of participants' performance when they read written English language on crew alerting systems and QRH checklists. Participants (sixteen percent) with RCL proficiency H-level, eleven percent I-level (general English language), and L-I level (five percent), twenty-one percent H-level (crew alerting systems and QRH checklists) indicated that very detailed checklists and challenging vocabulary words negatively impacted their performance. They indicated that certain words on QRH checklists (e.g. technical) are very difficult because there are several of them, on different types of checklists. Therefore, due to lack of commonality in checklist design it negatively impacts reading comprehension performance. As Degani and Wiener (1998) indicated, design inconsistencies with English language on checklists have the potential to cause misunderstandings and even disregard for checklist procedures.

A high percentage (fifty-two percent) of participants indicated long processing time of information on crew alerting systems and QRH checklists was a factor that negatively impacted flight safety. Participants (twenty-one percent) with RCL proficiency H-level, thirty-one percent I-level (general English language), and five percent I-level, twenty-one percent L-I level, and twenty-six percent H-level (crew alerting systems, QRH checklists) indicated negative impacts to flight safety. This was a result of translating words into their native language, highlighting and underlining words and having to decode abbreviations on crew alerting systems and QRH checklists. They indicated that often the process of reading and understanding written English language on both systems (i.e. crew alerting systems and QRH checklists) can be time consuming, especially when words are unknown, it takes longer to process information and disposition the crew alert. As previously discussed by McDonough (1999), processing times (longer/shorter) is regulated by strategy use by adults. Indeed, participants' indicated they utilized various metacognitive strategies to read and understand written English language on crew alerting systems and QRH checklists, and it led to long response times.

Summary

Collectively, flight safety negative impacts were the result of participants' reading comprehension performance using crew alerting systems and QRH checklists. Design and integration factors led to negative performance impacts on participants. Their English language proficiency was a factor that influenced their ability to read and comprehend written English language. As each participant had background knowledge of English language, different English language proficiency levels, these factors contributed to their ability to read and understand written English language on crew alerting systems and QRH checklists. More research is needed on English language design and integration factors, as well as performance impacts on participants that impact flight safety.

Recommendations

Based on results from the researcher's preliminary study, more research is needed on participant English language background knowledge, background knowledge of text genre and vocabulary words, English language proficiency levels with respect to their metacognitive strategy use, and written English language factors that influence their ability to read, comprehend and perform using English language on crew alerting systems and QRH checklists. Therefore, the researcher's next study will aim at collecting more evidence on the aforementioned factors and performance indicators.

Conclusions

The researcher's aim of the preliminary study was to determine if written English language on crew alerting systems and QRH checklists negatively impacts participants' ability to read and comprehend English language. It can be concluded that written English language factors on each of these systems negatively impact participants' performance. Participants' English language background knowledge, background knowledge of text genre and vocabulary words on crew alerting systems and QRH checklists, are important demographics that help provide an understanding of how familiar participants are with their use of written English language. Participants' English language proficiency is also a factor that influences their ability to read and comprehend English language. Participants' English language proficiency levels are particularly important for understanding their metacognitive strategy use to read written English language. Particularly, type of strategy and number of strategies utilized by participants to read information on crew alerting systems/QRH checklists are paramount, to understand how participants' interface with design/integration factors on crew alerting systems and QRH checklists. It should also be noted that ICAO English language proficiency levels noted by participants did not coincide with their RCL proficiency of general English language or their RCL proficiency on use of crew alerting systems and QRH checklists. This is an indication that English language proficiency levels tend to be different between participants, and ICAO English language proficiency levels may not be the only method to attain English language proficiency levels. Use of participants' self-rated RCL proficiency is an adequate method of collecting information on their abilities to read and comprehend written English language.

PRELIMINARY STUDY PART 2

Aims

Preliminary study one indicated that participants' reading comprehension of written English language on crew alerting systems and QRH checklists was negatively impacted, when using these systems on the flight deck. Participants' English language background knowledge, background knowledge of text genre and vocabulary words were indicated as factors that influence their ability to read and comprehend English language on crew alerting systems and QRH checklists. Use of metacognitive strategies to read written English language on crew alerting systems and QRH checklists was linked to their English language proficiency. Participants' English language proficiency was also linked to their ability to read and comprehend information on crew alerting systems and QRH checklists. As participants' Reading Comprehension Level (RCL) proficiency, background knowledge, and metacognitive strategies were factors that influenced their ability to read and comprehend written English language, design and integration of written English language on crew alerting systems and QRH checklists were factors that negatively impacted their performance and flight safety.

Intent of preliminary study two was to determine if previous factors and performance indicators investigated in study one was still prevalent in study two. In other words, are participants negatively impacted by design and integration of written English language on crew alerting systems? Does their RCL proficiency of English language influence their ability to read and comprehend written English language on the flight deck? Does their background knowledge of English language, text genre and vocabulary words influence their ability to read and comprehend English language on the flight deck? Lastly, does design and integration of written English language on crew alerting systems and QRH checklists negatively impact their performance and flight safety? These questions will be answered in study two.

Demographics

The population for this qualitative research study was 35 male and female ESL flight crewmembers (N=35) from different countries, and different airlines. The term participants will be utilized throughout preliminary study two to describe flight crewmembers that participated in the study. Each participant was a certified airline transport pilot that flew large transport category aircrafts (Airbus A-319/320/330 and Boeing B-747/777) for major airlines.

ESL flight crewmembers' background knowledge and English language proficiency

Participants learned English language during formal schooling, from a western culture or their country of origin. Particularly, participants' schooling was either preliminary school (i.e. grade school, middle school, home school) and/or secondary school, which was typically university education. Participant experiences with English language were considered background knowledge using English language. Each participant indicated their ICAO English language proficiency rating (ELPR) levels were between levels four, five and six. The ICAO ELPRs level data was gathered as a means of understanding participant background knowledge of English language. Recall, the researcher's preliminary study one provided ICAO ELPR levels and they were beneficial to understanding participants' English language proficiency. Although the ICAO English language proficiency levels focus primarily on participants' speaking and listening comprehension abilities, it was utilized as a means of collecting their English language experience data.

ESL flight crewmembers' reading comprehension abilities

Participants rated their written RCL abilities (proficiency) with respect to their general use (reading comprehension) of English written language. Participants also self-rated their English language RCL abilities when reading and interpreting written English language on crew alerting systems and QRH checklists. Recall, participant self-rated English language proficiency levels help understand their ability to read and understand English language. Participant English language proficiency levels were High-level (H-Level), Medium level (M-level), and Low Level (L-level). The researcher operationally defined each of their proficiency levels. Participants with H-level English language proficiency indicated they were exceptional with understanding different forms of written English language. Participants with M-level English language proficiency indicated they experienced challenges with certain vocabulary words in English language, but had a good understanding of the language. Flight crewmembers' with L-level English language proficiency indicated they were challenged by vocabulary words and sentence syntax.

Participant written English language proficiency levels were categorized as 'general use of English language' (ability to read and comprehend written English language in a non-socio-technical environment), which was related to the their educational experiences with generic reading comprehension of written English language. Additionally, participant English language proficiency levels were categorized as their written English language proficiency on crew alerting systems and QRH checklists (ability to read and comprehend written English language in a socio-technical environment) (i.e. technical information on the flight deck). Participants indicated that information on crew alerting systems and QRH checklists are generally utilized together, therefore they indicated their proficiency levels as such for reading and comprehending information on crew alerting systems and QRH checklists. English language proficiency levels were categorized to clearly define differences between participants' general knowledge of English language, and if differences in proficiency level exist with their reading comprehension of technical information on the flight deck.

Table 27 Preliminary Study Part II Demographics (N=35)

DEMOGRAPHICS	Pilot 1	Pilot 2	Pilot 3	Pilot 4	Pilot 5	Pilot 6	Pilot 7	Pilot 8
Country of Origin	Brazil	Malaysia	Belgium	Portugal	Portugal	Ecuador	Portugal	Portugal
Age	49	60	40	59	28	33	35	35
Airline Years of Experience	25	40	15	25	4	5	13	4
Native Language Spoken	Portuguese	Hokkien (Chinese Dialect)	Dutch	Portuguese	Portuguese	Spanish	Portuguese	Portuguese
English language learned/Country	High school (U.S.A)	Pre-school (Malaysia)	Home Schooling (Vienna, Austria)	Air Force University (Portugal)	Home Schooling (Portugal)	Pre-school (Ecuador)	High School (Portugal)	High School (Portugal)
ICAO ELPR Level	Level 6	Level 6	Level 5	Level 5	Level 6	Level 4	Level 6	Level 5
Self-rated English language RCL (General Use of English language)	H-level	H-level	M-level	M-level	L-level	M-level	H-level	M-level
Self-rated RCL: English language on crew alerting systems and QRH checklists	H-level	H-level	H-level	M-level	H-Level	M-level	H-level	H-level

Table 28 Preliminary Study Part II Demographics Continued (N=35)

DEMOGRAPHICS	Pilot 9	Pilot 10	Pilot 11	Pilot 12	Pilot 13	Pilot 14	Pilot 15	Pilot 16
Country of Origin	Portugal	Portugal	Portugal	Portugal	Portugal	Portugal	Germany	Belgium
Age	49	44	32	44	51	44	49	33
Airline Years of Experience	12	13	11	21	23	18	23	8
Native Language Spoken	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	German	Flemish
English language learned/Country	University (Portugal)	Pre-school (Portugal)	High School (Brazil)	Grade School and High School (Portugal)	High School (Portugal)	High School (Portugal)	High School (Germany)	Home Schooling (Belgium)
ICAO ELPR Level	Level 5	Level 4	Level 5	Level 5	Level 5	Level 6	Level 6	Level 5
Self-rated English language RCL (General Use of English language)	M-level	M-level	M-level	H-level	M-level	M-level	H-level	H-level
Self-rated RCL: English language on crew alerting systems and QRH checklists	M-level	H-level	M-level	M-level	M-level	M-level	H-level	M-level

Table 29 Preliminary Study Part II Demographics Continued (N=35)

DEMOGRAPHICS	Pilot 17	Pilot 18	Pilot 19	Pilot 20	Pilot 21	Pilot 22	Pilot 23	Pilot 24
Country of Origin	Japan	Korea	Belgium	Portugal	Japan	Mozambique	Portugal	Japan
Age	50	52	40	54	38	49	41	50
Airline Years of Experience	27	10	15	10	11	25	21	15
Native Language Spoken	Japanese	Korean	Swahili	Portuguese	Japanese	Portuguese	Portuguese	Japanese
English language learned/Country	High School (Japan)	Middle School (Korea)	Middle School (Belgium)	High School and University (Portugal)	Middle School (Japan)	Grade School (Mozambique)	Middle School (Portugal)	High School (Japan)
ICAO ELPR Level	Level 5	Level 4	Level 4	Level 6	Level 4	Level 5	Level 6	Level 4
Self-rated English language RCL (General Use of English language)	M-level	M-level	H-level	H-level	M-level	H-level	H-level	M-level
Self-rated RCL: English language on crew alerting systems and QRH checklists	L-level	M-level	M-level	M-level	M-level	H-level	H-level	L-level

Table 30 Preliminary Study Part II Demographics Continued (N=35)

DEMOGRAPHICS	Pilot 25	Pilot 26	Pilot 27	Pilot 28	Pilot 29	Pilot 30	Pilot 31	Pilot 32
Country of Origin	Portugal	Chile	Chile	Chile	Chile	Chile	Japan	Italy
Age	37	54	32	46	48	37	43	32
Airline Years of Experience	4	14	11	15	15	3	17	8
Native Language Spoken	Portuguese	Spanish	Spanish	Spanish	Spanish	Spanish	Japanese	Italian
English language learned/Country	Portugal (Middle School)	Chile (Middle School)	Chile (Middle School)	Chile (Middle School)	Chile (Middle School)	Ecuador (Middle School)	Japan (Middle School)	Italy (High School)
ICAO ELPR Level	Level 6	Level 5	Level 5	Level 5	Level 5	Level 5	Level 4	Level 4
Self-rated English language RCL (General Use of English language)	H-level	H-level	H-level	H-level	H-level	H-level	H-level	H-level
Self-rated RCL: English language on crew alerting systems and QRH checklists	M-level	M-level	M-level	H-level	H-level	H-level	M-level	H-level

Table 31 Preliminary Study Part II Demographics Continued (N=35)

DEMOGRAPHICS	Pilot 33	Pilot 34	Pilot 35
Country of Origin	Poland	Poland	Poland
Age	36	25	48
Airline Years of Experience	10	5.5	13
Native Language Spoken	Polish (Slavic)	Polish (Slavic)	Polish (Slavic)
English language learned/Country	Poland (High School)	Czech Republic (High School)	Czech Republic (High School)
ICAO ELPR Level	Level 4	Level 4	Level 6
Self-rated English language RCL (General Use of English language)	H-level	H-level	H-level
Self-rated RCL: English language on crew alerting systems and QRH checklists	M-level	H-level	M-level

Table 32 ESL flight crewmembers general demographics

Demographic	Percentages
Country of Origin	13/35 (~37% Portugal) 1/35 (~2.8% Brazil) 1/35 (~2.8% Malaysia) 3/35 (~8.5% Belgium) 1/35 (~2.8% Ecuador) 1/35 (~2.8% Germany) 4/35 (~11.4% Japan) 1/35 (~2.8% Korea) 1/35 (~2.8% Mozambique) 5/35 (~14.2% Chile) 3/35 (~8.5% Poland) 1/35 (~2.8% Italy)
Age (average/minimum/maximum)	~ 42 years old (average); 25 years old (minimum); 60 years old (maximum);
Airline Years of Experience (average)	~14.5 airline years of experience
Native Language Spoken	16/35 (~45.7% Portuguese) 1/35 (~2.8% Hokkien) 1/35 (~2.8% Dutch) 6/35 (~17.4% Spanish) 3/35 (~8.5% Polish) 1/35 (~2.8% Italian) 1/35 (~2.8% Korean) 1/35 (~2.8% Swahili) 3/35 (~8.5% Japanese) 1/35 (~2.8% German) 1/35 (~2.8% Flemish)

General demographics collected from this study indicated that participant most frequent country of origin was Portugal, while Belgium, Japan, Chile, and Poland were predominately flight crewmembers' next frequent country of origin. Brazil, Malaysia, Ecuador, Germany, Korea, Mozambique, and Italy were the least frequent flight crewmembers' country of origin. Participant average age was 42 years, while 60 years was the oldest flight crewmember and 25 years old was the youngest. Participants averaged 14.5 average years of airline experience. Participants' native language spoken was predominately Portuguese, while Spanish, Polish, and Japanese were next frequent languages spoken by participants. Hokkien, Dutch, Italian, Korean, Swahili, German, and Flemish were the least frequent languages spoken by participants.

Methodology

This qualitative research study generated common themes. The researcher developed an interview schedule (see Appendix A) that focused on impact of crew alerting systems and QRH checklists on participants' performance. Particularly, the interview schedule focus was on the following general participant aspects: ability to read and interpret English language on crew alerting systems and QRH checklists, English language proficiency levels (i.e. ICAO ELPRs and self-rated English language reading and comprehension proficiency levels), background knowledge of English language, and written language on crew alerting systems and QRH checklists, and metacognitive strategies utilized to read and comprehend English language on crew alerting and QRH checklists.

Secondly, the researcher asked the 35 participants (N=35) to partake in an online interview discussion. The researcher developed an online discussion forum so that participants could discuss crew alerting and QRH checklists issues face-to-face with the researcher, which created a better method of communicating issues discussed. Discussion was focused on factors that impact participants' ability to read and comprehend written English language on crew alerting systems and QRH checklists, and factors that impact their performance and flight safety. Discussion with participants lasted for approximately one and half hours, followed by an interview debrief. Interview debrief consisted of reviewing questions that interviewees had regarding questions asked by the researcher, clarification of information, and any other relative information on impact of crew alerting systems and QRH checklists on participants' performance.

Thirdly, follow-up conversations were conducted with participants via email and phone communication, if further interview response clarity was needed. Finally, after collecting online interview data, the researcher transcribed it creating narratives and developing/coding themes based on participant answers. More information on the coding method will be discussed in the analysis section.

Limitations

Data collected from surveys were not specific to a particular crew alerting system (e.g. hydraulic or pneumatic systems) or corresponding QRH checklists, rather it was a general perspective on participant use of written English language on the previously mentioned systems. Furthermore, this study did not measure participants' performance using crew alerting systems and QRH checklists. The researcher did not measure impact of vocabulary words, text genre, workload, etc. on participant performance. Thus, as these types of variables were not investigated it limited the scope of the researcher's preliminary research study, but provided the researcher with an understanding of factors that may need scrutiny in future studies.

Analysis

The researcher analyzed data collected from the online discussion forum. One method of analysis was central tendency. Central tendency (i.e. mean) was utilized to analyze demographic information collected from each of the participants. The analysis of demographics was needed to convey similarities or differences within the participant population. After the researcher transcribed, coded, and developed thematic data from the interviews and questionnaires, central tendency was utilized to analyze frequency of themes. The coding method utilized was inspired from the researcher's literature review. Theoretically, all of the elements that were reviewed in the literature review have the potential to impact participants' reading comprehension of written English language on the flight deck. Participants use of metacognitive strategies to read and understand written English language, English language proficiency, and their background knowledge have the potential to impact their perception and processing of English language on crew alerting systems and QRH checklists. Therefore, the following coding method was developed (see Figure 15) which was utilized to create themes.

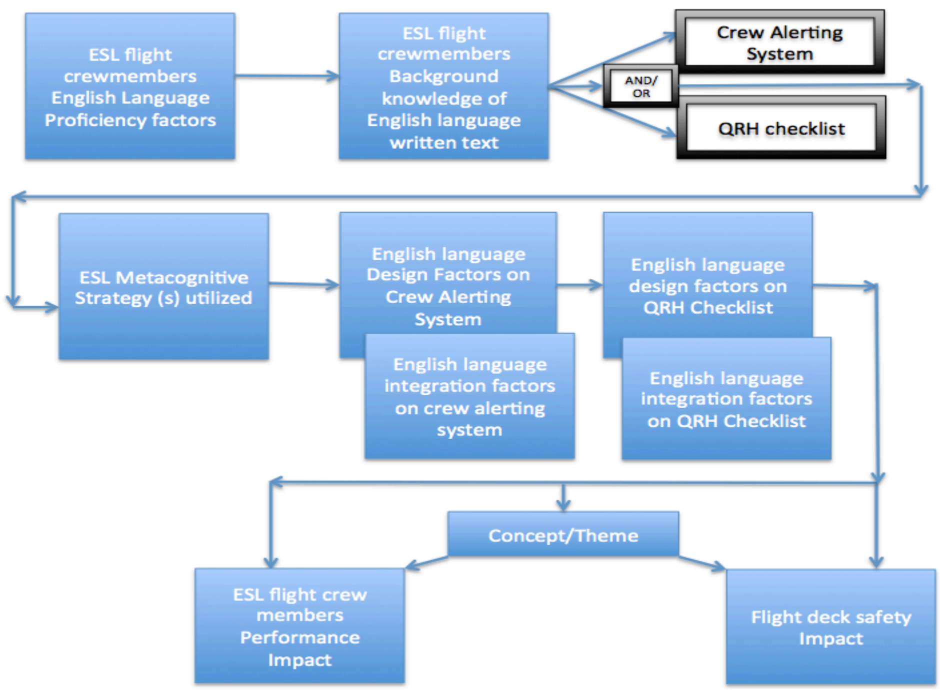


Figure 15 High Level Coding Theory Method

Coding transcription template overview

Comparable to the researcher's preliminary study one, the same coding transcription template was utilized to collect data from participants during the online interview discussion. Table 33 provides an overview of the coding transcription template.

Table 33 Coding transcription template

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language words/text genre Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***

# Denotes ESL flight Crewmembers Demographics Sub-Theme
*Denotes ESL flight crewmembers Cognitive Sub-theme
**Denotes ESL flight Crewmembers crew alerting systems and QRH checklists Design/Integration Impact Sub-theme

Coding Keys Overview

Coding keys contain a variety of factors utilized to code each participant's online discussion data. Factors are intended to be influences on participant performance and flight safety. Intent of coding keys was to categorize each of the factors into a common sub-theme, so they may be utilized to understand the impact on participants' performance and flight safety (main themes). Factors found to be relevant in the online discussion forum were utilized in the coding process. Recall, many of these factors listed in each of the coding keys were from the researcher's review of relevant literature. Finally, each of the coding keys contains bold face font, which corresponds to the bold face font on the coding transcription template. There are five key codes, each with a code number and letter. The number corresponds to the key code and the letter corresponds to the factor (i.e. 1D). There may be more than one key code utilized on the transcription template to describe factors participants indicated during the online interview forum (see next 7 tables).

Table 34 Key 1 and Key 2 General Coding Matrix

Key 1 Coding		Key 2 Coding	
ESL flight crew members English language background knowledge and proficiency factors	**CODE**	**ESL flight crew members vocabulary words/text genre background knowledge factors**	**CODE**
English language –ICAO ELPR level 4, 5, or 6	1A	Knowledge of English language text genre on crew alerting systems (e.g. technical text)	2A
Preliminary School (Grade School/ Middle School/Home School) non-western region experience reading comprehension and speaking English language	1B	Knowledge of English language text genre on QRH checklists (e.g. technical text)	2B
Preliminary School (Grade School/Middle School/Home School) western region experience reading and speaking English language	1C	Knowledge of English language elements on QRH checklists (e.g. typographical elements)	2C
Secondary School (University) non-western region experience reading and speaking English language	1D	English language experience with conditional statements on QRH checklists (e.g. structure, noticing)	2D
Secondary School (University) western region experience reading and speaking English language	1E	Background knowledge of abbreviations/acronyms (e.g. short form and/or long form)	2E

Table 35 Key 1 and Key 2 General Coding Matrix continued

Key 1 Coding		Key 2 Coding	
ESL flight crew members English language background knowledge and proficiency factors	**CODE**	**ESL flight crew members vocabulary words/text genre background knowledge factors**	**CODE**
High School western region experience reading and speaking English language	1F	Background knowledge of text format on crew alerting systems and QRH Checklists (e.g. authentic, elaborated, or short text)	2F
High School non-western experience reading and speaking English language	1G	ATP certification (knowledge of crew alerting systems /QRH checklists)	2G
ATP Certification (ability to read English language)	1H	Background knowledge of vocabulary word type on crew alerting systems	2H
Airline years of experience using crew alerting systems and QRH checklists	1I	Background knowledge of vocabulary word type on QRH checklists	2I
Self rated English language proficiency RCL of general use of English language (H-level)	1J		
Self rated English language proficiency RCL of general use of English language (M-level)	1K		
Self rated English language proficiency RCL of general use of English language (L-level)	1L		
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (H-level)	1M		
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (M-level)	1N		
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (L-level)	1O		

Table 36 Key 3, 4, 5 General Coding Matrix

Key 3 Coding	
ESL flight crewmembers metacognitive strategy factors	**CODE**
Lexical Inferencing (educated guessing of word meaning)	3A
Re-Reading Text	3B
Paraphrasing Text	3C
Underlining Text	3D
Referencing other Resources to clarify information (e.g. dictionary)	3E
Highlighting Text	3F
Translating written English language into ESL flight crewmembers native language	3G
Reverting back to native language to read English language	3H
Reading aloud text on flight deck	3I
Monitoring reading comprehension	3J
Taking Notes	3K
Breaking Apart Sentences	3L
Bottom up strategy (Decoding text)	3M
Top down strategy (prior knowledge of text; activating text schema)	3N
Interactive strategy (Combination of Bottom up and Top Down Strategy use)	3O
Monitoring reading speed	3P
Skipping words/omission of words	3Q
Key 4 Coding	
Crew alerting systems English language design and integration factors	
Sentence Length (Short)	4A
Acronyms/abbreviations	4B
Text Genre (e.g. technical)	4C
Number of Tokens in Text	4D
Authentic Text	4E
Sentence Length (Long)	4F
Simplification of Text	4G
Vocabulary Words Type	4H
Key 5 Coding	
QRH checklist English language design and integration factors	
Conditional Statements	5A
Number of Tokens in Text	5B
Authentic Text	5C
Sentence Length (Long)	5D
Simplification of Text	5E
Acronyms/Abbreviations	5F
Text Genre (e.g. technical)	5G
Vocabulary Words Type	5H
Sentence Length (Short)	5I

Inter-rater reliability

To ensure the researcher did not have any bias when categorizing participants' proficiency levels, key code sub-themes, and main themes from interviews and questionnaires, inter-rater reliability analysis was conducted. The researcher consulted two flight deck engineering experts to review each theme created by the researcher. They had a background in human factors and ESL flight crewmember interface with crew alerting and information systems. The researcher developed an exercise named 'pin the proficiency level, key code sub-theme and main theme to each participant narrative'.

Each of the experts pinned each key code/sub-theme and main theme to the narrative they thought is represented. After the researcher collected the results from the exercise, the researcher reviewed the results to ensure the key codes, sub themes, and main themes the researcher developed were consistent with each of the expert results. The researcher utilized Cohen's Kappa coefficient to analyze the rater results. Results indicated Cohen's Kappa coefficient was *k=.63*, which indicates good inter-rater reliability agreement for study number two. Table 37 is the Cohen's Kappa coefficient analysis for study two. The reason for the coefficient level could have been due to the key codes needing further details to describe the factors; this could have improved the key code selections by the raters. Nevertheless, it can be considered a reliable method to code information from participant narratives.

Table 37 Cohen's Kappa Coefficient inter-rater reliability analysis preliminary study II

Artifact	Rater 1	Rater 2	Agreement	Agreement Scale/Nomenclature
Pilot 1 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 2 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 3 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 4 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 5 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 6 Narrative	1	0	0	0=indicates Non-Agreement between raters
Pilot 7 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 8 Narrative	0	0	1	1= indicates Agreement between raters
Pilot 9 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 10 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 11 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 12 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 13 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 14 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 15 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 16 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 17 Narrative	0	0	1	1= indicates Agreement between raters
Pilot 18 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 19 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 20 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 21 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 22 Narrative	0	1	0	0=indicates Non-Agreement between raters
Pilot 23 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 24 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 25 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 26 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 27 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 28 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 29 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 30 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 31 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 32 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 33 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 34 Narrative	1	1	1	1= indicates Agreement between raters
Pilot 35 Narrative	1	1	1	1= indicates Agreement between raters

	MATCH	33
	TOTAL	35
	AAR PERCENT	94%

		Rater 2			
		0	1		
Rater 1	0	2	1	3	9%
	1	1	31	32	91%
		3	32	35	
		9%	91%		
1= Agreement					
0=No agreement					
Pr (a)	0.94285714				
Pr (e)	0.84326531				
k=	0.63541667				

The following sample narratives are from the researcher's preliminary study part two. Intent of these sample narratives is to provide the reader with the types of information collected from the participants during the study.

Sample Narratives From Preliminary Study Part II

Sample #1 participant excerpt from narrative

"I feel that there are issues with English language on the EICAS. Are you familiar with the design of the EICAS? It may appear by the design that they are simple to read but I have found that it can be difficult because English is not my first language. There are many multiple vocabulary words on EICAS system (related to electrical system failures) is difficult to understand when some vocabulary words are inconsistent when compared to QRH checklist. Multiple vocabulary words on QRH checklist are difficult to understand and impact sentence meaning, due to checklist containing vocabulary words different that do not coincide with electrical system failure. If there are words that I don't understand, sometimes I guess the meaning, but I have background knowledge from training so I that is helpful when guessing. Sometimes I may translate data from certain failures into my own language, other times use my native language during the outset of the alert and then read the checklist. From a flight safety perspective Long response time leads inadequate response time regarding system malfunction response".

Sample #2 participant excerpt from narrative

When I read the ECAM messages there are times when shorter sentences are difficult to understand. I have to really decode the words and then think of what the other parts of the sentence missing are telling me. The manufacturers think that shortening the sentences makes it easier to read, but sometimes feel that the meaning of the sentence may be lost because they omit words (or at least that is what it seems). Short sentences lead to more time clarifying system problem. Simplified text on QRH checklist sometimes takes away from sentence meaning and other sources are needed to clarify situation. Sometimes if I don't understand a word in the electrical section of the checklist I use some of the training references to help me understand. If I have issues with English I find words in my native language and use them. Flight safety impacts related to system malfunctions are really medium workload due to time taken away from other tasks to solve another system issue".

Results

Results indicated that several participants experienced challenges with their reading comprehension of written English language on both types of systems (i.e. crew alerting systems and QRH checklists). Next tables provide detailed information on results from the study. Collectively, participant demographics data and findings from the coding/theme exercise conveyed noteworthy findings regarding design and integration of written English language on crew alerting systems and QRH checklists. Detailed coding analyses are located in Appendix B; columns that contain 'N/A' indicate participants' did not indicate any demographic/design/integration factors/negative performance impacts.

Table 38 is an overview of factors that influenced participants' ability to perform using crew alerting systems and QRH checklists. It also provides a general review of negative impacts participants highlighted in their interviews and questionnaires regarding flight safety. Results on Table 38 column one show that all participants' used metacognitive strategies to read and interpret written English language.

Note: Boxes filled with grey indicate ESL flight crewmembers did not mention negative impacts on their performance or flight deck safety, with respect to their use of crew alerting systems, QRH checklists, or a combination of both systems. Boxes with an ('X') indicate ESL flight crewmembers mentioned their performance was negatively impacted by use of crew alerting systems, QRH checklists, or a combination of both systems. Boxes shaded with blue font indicate ESL flight crewmembers percentages of using CAs and QRH checklists; shaded blue boxes also provide overall theme. All columns with N/A (no issues identified) suggest that flight crewmembers did not indicate negative impacts on their ability to read and comprehend CAs and/or QRH checklists.

Table 38 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35)

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 1: Long Processing time due to written English language information on QRH checklists and crew alerting systems	Y	X	X	X	Difficult phrases on the crew alerting systems and long paragraphs on QRH checklists lead to misinterpretation of safety information
PILOT 2: Long Processing time due to written English language information on QRH checklists and crew alerting systems	Y	X	X	X	Difficult interpretation of abbreviations and acronyms on EICAS system and difficulty understanding vocabulary words on QRH checklists lead to longer response time to system warnings
PILOT 3: Misinterpretation of information on ECAM	Y	X			Misinterpretation of information regarding ECAM warning led to mismanagement of airspeed on landing phase and a go-around maneuver.
PILOT 4: Long Response time and misinterpretation of information on crew alerting systems and QRH checklists	Y	X	X	X	Misinterpretation of Abbreviations and acronyms lead to long and inadequate decision-making processes when responding to flight path warnings and advisories.
PILOT 5: Longer response time and reading speed leads to misinterpretation of information on crew alerting systems and QRH checklists	Y	X	X	X	Misinterpretation of abbreviations acronyms on EICAS and QRH checklists lead to incorrect button pushes on flight deck. Notes section containing conditional statements is not a direct link (logically) to fix system malfunction issue.

Table 39 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35) continued

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 6: Time needed to execute procedures is sometimes longer than expected due to written English language on crew alerting systems and QRH checklists	Y	X	X	X	No Issues identified
PILOT 7: Decision making process is negatively impacted due to written English language information on QRH checklists	Y		X		Inadequate logical flow of information on checklists leads to negatively impacted decision-making process for flight critical or system critical issues when responding to an alert.
PILOT 8: Long response times due to reading and interpreting technical information on QRH checklists and crew alerting systems	Y	X	X	X	Reading and interpreting vocabulary words on crew alerting systems and checklists negatively impacts flight crewmembers decision making process responding to system issues
PILOT 9: Slower than normal time respond regarding crew alerting systems	Y	X			Unfamiliar acronyms on crew alerting system leads to slow response times and other tasks not completed in a timely manner
PILOT 10: Long Response time due to technical information on crew alerting systems	Y	X			Misunderstandings in acronyms and vocabulary words lead to long length of time responding to system failures.
PILOT 11: Late timing to respond to alert due to misunderstandings of challenging vocabulary word on technical manuals	Y		X		Misunderstanding of FCOM procedures lead to confusion, frustration and workload is sometimes high while responding to crew alerts

Table 40 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35) continued

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 12: Vocabulary words are misunderstood and lead to misunderstandings of technical information	Y		X		Decision making processes are impacted which lead to high workload depending on the failure, especially cascading failures
PILOT 13: Unfamiliar terminology leads to long response times and high workload	Y		X		Unfamiliar terms on checklists lead to long response times and high workload, which negatively impact system malfunction response.
PILOT 14: Long response times and task saturation due to written English language on crew alerting systems and QRH checklists	Y	X	X	X	More time troubleshooting system issues due to written English language on crew alerting systems and QRH checklists leads to delayed response, high workload and long response times to air traffic control and other tasks
PILOT 15: Long response times to alert due to information (acronyms) on crew alerting systems and QRH checklists	Y	X	X	X	Time needed to decipher acronyms negatively impacts response to system malfunction/failures
PILOT 16: Long response time to crew alerts due to information (vocabulary words) on crew alerting systems and QRH checklists	Y	X	X	X	Difficulty deciphering vocabulary words on crew alerting systems and QRH checklists due to verbose/non-simplified text leads to long response times regarding system failures and/ fight path related issues.

Table 41 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35) continued

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 17: Long response time due to written English language on QRH checklists	Y		X		Response to engine failures or other non-normal conditions is longer response due to deciphering long sentences and vocabulary words on the QRH checklists
PILOT 18: Long response time due to long sentences and challenging words on crew alerting systems and QRH checklists	Y	X	X	X	Decision-making processes for non-normal conditions are negatively impacted due to processing difficult written English words on QRH checklists Long response times leads to other tasks not completed on time
PILOT 19: Misinterpretation of wording on crew alerting system and QRH checklist	Y	X	X	X	Misinterpretation and difficulties reading and comprehending written English language text on crew alerting systems and QRH checklists leads to issues understanding system malfunction/issue
PILOT 20: Confusion during non-normal conditions due to misunderstandings of written English vocabulary words on QRH checklists leads to longer response time	Y		X		Misunderstandings that lead to longer response times negatively impact decision-making processes regarding system malfunctions
PILOT 21: Vocabulary words on crew alerting systems and QRH checklists negative impact on Decision making processes	Y	X	X	X	System malfunctions or failures are difficult follow (cognitively) due to difficulties understanding vocabulary words.

Table 42 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35) continued

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 22: Vocabulary words on QRH checklists leads to Negatively impacts response time (long response time to system malfunction/ failures	Y		X		Misinterpretation of system malfunction/failure leads to long response time and other tasks not completed in a timely manner.
PILOT 23: Written English language information on crew alerting systems and QRH checklists negatively impact interpretation of information (misinterpretation) and long response times	Y	X	X	X	Misinterpretation of system malfunctions leads to ambiguous inputs on flight deck due to misunderstandings of technical information on crew alerting systems and QRH checklist
PILOT 24: Long response time to crew alert due to misunderstanding of technical information on crew alerting systems and QRH checklists	Y	X	X	X	Misunderstanding of technical information on crew alerting systems and QRH checklists/FCOM procedures leads to long response time on critical system failures and other task not accomplished in a timely manner.

Table 43 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35) continued

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 25: Long response times and Misunderstanding of technical information on crew alerting systems and QRH checklists	Y	X	X	X	Misunderstanding of technical information and misdiagnosis negatively impacts decision—making process when responding to crew alerts (e.g. system failures) using QRH checklist and crew alerting system. Negative impacts with respect to flight crewmembers ability to isolate and locate system failure. High workload and long response time to alerts leads to difficulties executing other related tasks
PILOT 26: Long response time and somewhat higher than normal workload	Y	X	X	X	No issues identified
PILOT 27: Misunderstanding of system malfunction due to abbreviations/acronyms on crew alerting systems and QRH checklists	Y	X	X	X	Misunderstanding of technical information related to system malfunction leads to negative impact to executing necessary steps to resolve system problem, especially during emergency conditions (improper system recovery).
PILOT 28: Misinterpretation of technical information (vocabulary words and acronyms on crew alerting systems and QRH checklists) leads to long response time	Y	X	X	X	Misunderstanding of crew alert and QRH checklist leads to misdiagnosis o system malfunction/failure and re-work of the issue, which leads to long response time.

Table 44 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35) continued

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 29: Short sentences and on crew alerting systems and challenging vocabulary words on QRH checklists lead higher workload and long response time	Y	X	X	X	High Workload and long response time lead to inadequate time to complete other required tasks that are related to cascading failures.
PILOT 30: N/A	Y				No issues identified
PILOT 31: Long time and medium workload due to reading and comprehending written English technical information on crew alerting systems and QRH checklists	Y	X	X	X	Long time responding to system failure leads to other tasks not accomplished on time (e.g. ATC instructions)
PILOT 32: Medium Workload while reading written English language information on crew alerting systems and QRH checklists	Y	X	X	X	No issues identified
PILOT 33: Abbreviations and Acronyms are difficult to understand in their short form, due to limited references of their long form regarding crew alerts and leads to high workload	Y	X	X	X	Difficulties understanding technical abbreviations and acronyms lead to high workload when dealing with multiple system issues

Table 45 CA, QRH checklists, and combination of both (CA and QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=35) continued

ESL flight crewmember description of impact on performance (n=35)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (CA)	ESL flight crewmember performance impact (QRH Checklists)	ESL flight crewmember performance impact (CA and QRH Checklists)	Impact on flight safety
PILOT 34: Difficult vocabulary words and inconsistent terminology on QRH checklist lead to negative impact on responding to crew alerts--Long response times	Y	X	X	X	Long response time leads inadequate response time regarding system malfunction response
PILOT 35: Short sentences and simplified text leads to interpretation issues and medium workload	Y	X	X	X	Medium workload due to time taken away from other tasks to solve another system issue
Percentage= 34/35=97% flight crewmembers indicated written English language negative impact on performance	Percentage = 35/35= 100% flight crewmembers indicated use of metacognitive strategies	Percentage =27/35= ~77% flight crewmembers indicated crew alerting systems negatively impacted their performance	Percentage = 31/35= ~88% of flight crewmembers indicated written English language on QRH checklists negative impact on their performance	Percentage =24/35= ~68% of flight crewmembers indicated written English language on crew alerting systems and QRH checklists negatively impacted their performance	Percentage = 31/35= ~88% of flight crewmembers indicated flight safety was negatively impact when using written English language on crew alerting systems and/or QRH checklists

Next, results provide the reader with an understanding of demographics, specific factors and performance indicators that influenced participants' ability to read and comprehend written English language on crew alerting systems and QRH checklists.

Table 46 ESL flight crewmembers English language background knowledge factors ('demographics sub-theme') (N=35)

Code	Description	Flight crewmembers Percentages
1A	English language-ICAO ELPR Level 4, 5, 6	35/35 (100%)
1B	Preliminary School (Grade School/ Middle School/Home School) non-western region experience reading comprehension and speaking English language	18/35 (~51.4%)
1C	Preliminary School (Grade School/Middle School/Home School) western region experience reading and speaking English language	1/35 (~2.8%)
1D	Secondary School (University) non-western region experience reading and speaking English language	4/35 (~11.4%)
1E	Secondary School (University) western region experience reading and speaking English language	0/35 (0%)

Table 47 ESL flight crewmembers English language background knowledge factors ('demographics sub-theme') (N=35) continued

Code	Description	Flight crewmembers Percentages
1F	High School western region experience reading and speaking English language	2/35 (~5.7%)
1G	High School non-western experience reading and speaking English language	13/35 (~37.4%)
1H	ATP Certification (ability to read English language)	35/35 (100%)
1I	Airline years of experience using crew alerting systems and QRH checklists	35/35 (100%)

First demographics sub-theme indicated that each participant had background knowledge of English language. Each participant claimed ICAO English language proficiency levels of four, five, or six. All participants indicated they had an ATP certification and years of experience using crew alerting systems and QRH checklists. Regarding participant English language experiences from educational institutions of learning, results indicated their experience was different with respect to institution type and western/non-western region.

Table 48 ESL flight crewmembers' English language proficiency factors ('demographics sub-theme' (N=35)

Code	Description	Flight Crewmembers Percentages
1J	Self rated English language proficiency RCL of general use of English language (H-level)	21/35 (60%)
1K	Self rated English language proficiency RCL of general use of English language (M-level)	13/35 (~37.4%)
1L	Self rated English language proficiency RCL of general use of English language (L-level)	1/35 (~2.8%)
1M	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (H-level)	15/35 (42.8%)
1N	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (M-level)	18/35 (51.4%)
1O	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (L-level)	2/35 (~5.7%)

Second demographics sub-theme indicated that participants had variety of written English language proficiency levels with respect to their RCL of general English language, crew alerting systems and QRH checklists.

Table 49 ESL flight crewmembers' vocabulary words/text genre background knowledge factors ('demographics sub-theme') (N=35)

Code	Description	Flight crewmembers Percentage
2A	Knowledge of English language text genre on crew alerting systems (e.g. technical text)	35/35 (100%)
2B	Knowledge of English language text genre on QRH checklists (e.g. technical text)	35/35 (100%)
2C	Knowledge of English language elements on QRH checklists (e.g. typographical elements)	35/35 (100%)
2D	English language experience with conditional statements on QRH checklists (e.g. structure, noticing)	35/35 (100%)

Table 50 ESL flight crewmembers' vocabulary words/text genre background knowledge factors ('demographics sub-theme') (N=35) continued

Code	Description	Flight crewmembers Percentage
2E	Background knowledge of abbreviations/acronyms (e.g. short form and/or long form)	35/35 (100%)
2F	Background knowledge of text format on crew alerting systems and QRH Checklists (e.g. authentic, elaborated, or short text)	35/35 (100%)
2G	ATP certification (knowledge of crew alerting systems /QRH checklists)	35/35 (100%)
2H	Background knowledge of vocabulary word type on crew alerting systems	35/35 (100%)
2I	Background knowledge of vocabulary word type on QRH checklists	35/35 (100%)

Third demographics sub-theme indicated that all participants had experience with vocabulary words and text genre background on crew alerting systems and QRH checklists.

Table 51 ESL flight crewmembers' metacognitive strategies factors to read written English language on crew alerting systems and QRH checklists ('cognitive sub-theme') versus English language proficiency (N=35)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
3A	Lexical Inferencing (educated guessing of word meaning)	12/35 (~34%)	~25% H-level; ~8% M-level	~14% H-level; ~17% M-level; ~2% L-level
3B	Re-Reading Text	12/35 (~34%)	~11% M-level; ~22% H-level	~22% M-level; ~8% H-level; ~2% L-level
3C	Paraphrasing Text	2/35 (~5%)	~2% M-level; ~2% H-level	~2% M-level, ~2% H-level
3D	Underlining Text	1/35 (~2%)	~2% H-level	~2% M-level
3E	Referencing other Resources to clarify information (e.g. dictionary)	7/35 (20%)	20% H-level	~14% H-level; ~5% M-level
3F	Highlighting Text	1/35 (~2%)	~2% H-level	~2% M-level
3G	Translating English written language into ESL flight crewmembers native language	18/35 (~51%)	~28% H-level; ~22% M-level	~25% H-level; ~22% M-level, ~2% L-level
3H	Reverting back to native language to read English language	18/35 (~51%)	~28% H-level; ~22% M-level	~25% H-level; ~22% M-level, ~2% L-level
3I	Reading aloud text on flight deck	3/35 (~8%)	~5% M-level; ~2% H-level	~8% M-level
3J	Monitoring reading comprehension	3/35 (~8%)	~2% H-level; ~2% L-level; ~2% M-level	~5% H-level; ~2% M-level
3K	Taking Notes	9/35 (~25%)	~5% M-level; 20% H-level;	20% M-level; ~5% H-level
3L	Breaking Apart Sentences	4/35 (~11%)	~5% H-level; ~5% M-level	~2% H-level; ~8% M-level

Table 52 ESL flight crewmembers' metacognitive strategies factors to read written English language on crew alerting systems and QRH checklists ('cognitive sub-theme') versus English language proficiency (N=35)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
3M	Bottom up strategy (Decoding text)	6/35 (~17%)	~8% M-level; ~8% H-level	~11% M-level; ~5% L-level
3N	Top down strategy (prior knowledge of text; activating text schema)	8/35 (~22%)	~8% M-level; ~14% H-level	~11% M-level; ~8% H-level; ~2% L-level
3O	Interactive strategy (Combination of Bottom up and Top Down Strategy use)	2/35 (~5%)	~2% M-level; ~2% H-level	~5% M-level
3P	Monitoring reading speed	4/35 (~11%)	~5% H-level; ~2% M-level; ~2% L-level	~8% H-level; ~2% M-level
3Q	Skipping words/omission of words	4/35 (~11%)	~5% M-level; ~5% H-level	~5% M-level; ~2% H-level; ~2% L-level

Cognitive sub-theme (metacognitive strategy) indicated each participant utilized a different metacognitive strategy to read and interpret written English language on crew alerting systems and QRH checklists. Additionally, each participant had different English language proficiency level (written English language, crew alerting systems and QRH checklists) when they read written English language on crew alerting systems and QRH checklists. The importance of participant metacognitive strategy use with respect to their proficiency level will be reviewed in the discussion section of this study.

Table 53 ESL flight crewmembers crew alerting systems English language design and integration factors (N=35)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
4A	Sentence Length (Short)	2/35 (~5%)	~5% H-level; ~5% H-level	~5% M-level; ~5% M-level
4B	Acronyms/abbreviations	17/35 (48%)	~28% H-level; ~17% M-level; ~2% L-level	~22% H-level; ~22% M-level; ~2% L-level
4C	Text Genre (e.g. technical)	24/35 (~68%)	40% H-level; ~25% M-level; ~2% L-level	~28% H-level; ~37% M-level; ~2% L-level
4D	Number of Tokens in Text	1/35 (~2%)	~2% H-level	~2% H-level
4E	Authentic Text	26/35 (~74%)	~42% H-level; ~28% M-level; ~2% L-level	~34% H-level; ~37% M-level; ~2% L-level
4F	Sentence Length (Long)	3/35 (~8%)	~2% M-level; ~5% H-level	~5% H-level; ~2% M-level
4G	Simplification of Text	3/35 (~8%)	~2% M-level; ~2% H-level; 2% L-level	~5% H-level; ~2% M-level
4H	Vocabulary Words Type	19/35 (~54%)	~22% M-level; ~31% H-level	~34% M-level; ~17% H-level; ~2% L-level

Regarding written English language on crew alerting systems, participants indicated they are negatively impacted by many different written English language design and integration factors on crew alerting systems. Additionally, each of the thirty-five participants indicated variability in their English language proficiency levels (general English language, crew alerting systems and QRH checklists). Written English language design and integration factors relevance with respect to participant English language proficiency level will be reviewed in the discussion section of this study.

Table 54 ESL flight crewmembers QRH Checklists English language design and integration factors (N=35)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
5A	Conditional Statements	5/35 (~14%)	~5% M-level; ~2% L-level; ~5% H-level	~8% H-level; ~2% M-level; ~2% L-level
5B	Number of Tokens in Text	1/35 (~2%)	~2% H-level	~2% M-level
5C	Authentic Text	29/35 (~82%)	~51% H-level; ~25% M-level; ~2% L-level	~31% H-level; ~42% M-level; ~5% L-level
5D	Sentence Length (Long)	12/35(~34%)	20% H-level; ~2% L-level; ~11% M-level	~11% H-level; ~17% M-level; ~5% L-level
5E	Simplification of Text	4/35 (~11%)	~11% H-level	~8% M-level; ~2% H-level
5F	Acronyms/Abbreviations	15/35 (~42%)	~11% M-level; ~2% L-level; ~28% H-level	20% M-level; ~17% H-level; ~5% L-level
5G	Text Genre (e.g. technical)	29/35 (~82%)	~51% H-level; ~25% M-level; ~2% L-level	~31% H-level; ~42% M-level; ~5% L-level
5H	Vocabulary Words Type	23/35 (~65%)	~37% H-level; ~2% L-level; ~25% M-level	~25% H-level; ~34% M-level; ~5% L-level
5I	Sentence Length (Short)	1/35 (~2%)	~2% L-level	~2% H-level

Regarding written English language on QRH checklists, participants indicated they are negatively impacted by many different written English language design and integration factors on QRH checklists. Additionally, each of the thirty-five participants indicated variability in their English language proficiency levels (general English language, crew alerting systems and QRH checklists). Written English language design and integration factors on QRH checklists relevance, with respect to participant English language proficiency level will be reviewed in the discussion section of this study.

Table 55 Flight safety impact (main theme) on ESL flight crewmembers (N=35)

Main Theme: ESL flight crewmembers flight safety impact	PERCENTAGES	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
Misinterpretation of information -Phrases -Abbreviations/Acronyms	14/35= 40%	~ 22% H-level; ~14% M-level; 2% L-level	~20% H-level; 17% M-level; ~2% L-level
Long Response Time -Misinterpretation of written English language Information -Interpretation of written English language difficulties -Long Sentences, difficult written English Language vocabulary words	16/35= ~45%	~25% H-level; 20% M-level	20% H-level; 20% M-level; ~5% L-level
Decision-Making Processes -Long Processing time of information written in English language -Logical flow of written English language Information	7/35=20%	~11% M-level; ~8% H-level	~5% H-level; 14% M-level
Logical flow of information written in English language -Written English language information flow on QRH checklist and corresponding flight deck information relationship ambiguity	2/35= ~5%	~2% L-level; ~2% H-level	~5% H-level
Frustration, Confusion, Workload -Misunderstanding of written English language procedures -Decision-making process	8/35= ~22%	~8% M-level; ~14% H-level	20% M-level; ~2% H-level
Improper flight deck inputs -Misunderstanding of information on written English language checklists	1/35= ~2%	~2% H-level	~2% H-level

Table 55 illustrates negative impacts on flight safety as a result of flight crewmembers' reading comprehension performance on the flight deck. Many different types of participant performance factors negatively impact flight safety. Regarding participant English language proficiency levels (general English language, crew alerting systems and QRH checklists), each participant had different proficiency levels. Participant proficiency levels were cross-referenced alongside flight safety negative impacts.

Discussion

This section provides a discussion of each factor/performance factors that influenced flight crewmembers' ability to read and comprehend written English language. Goal of this discussion is to provide the reader with an understanding of how written English language concepts reviewed in the literature review are interrelated with the outcome of the researcher's preliminary study two. Towards the end of the discussion, the reader

should understand the plan forward to further investigate written English language factors and flight crewmembers' performance challenges on the flight deck.
Figure 16 is a paradigm that describes how the researcher will approach the discussion for preliminary study part two. Three top boxes describe flight crewmembers' English language background knowledge factors, while middle box describe flight crewmembers' English language proficiency and their use of metacognitive strategies to read and comprehend written English language on crew alerting systems and QRH checklists. Finally, flight crewmembers' performance challenges with respect to their use of crew alerting systems and QRH checklists will be discussed as well as impact on flight safety.

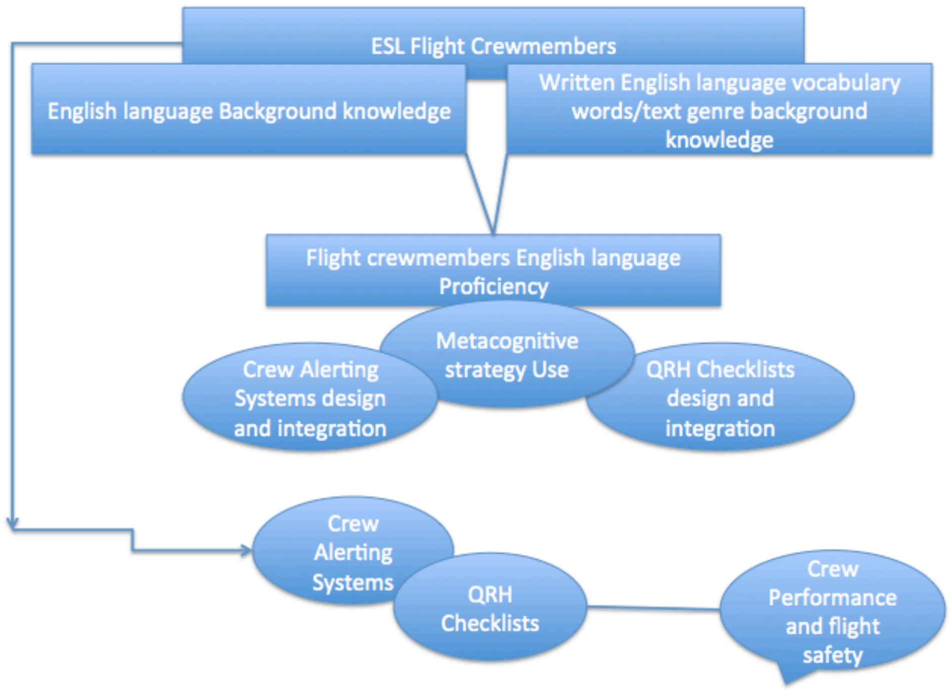


Figure 16 Preliminary study part 2 Paradigm Discussion Points

Previous literature reviewed and results from the researcher's preliminary study indicated that ESL adult/participant background knowledge of English language, knowledge of text genre/vocabulary words, and English language proficiency are key components to understand how well adults/participants read and comprehend written English language. The researcher's preliminary study part two indicated that all participants had background knowledge of English language. Participants had background knowledge of vocabulary words/text genre background. Participant ATP rating was utilized in the study, as it was an indication they were able to read English language on the flight deck. As ECFR (2016) indicated, ATP rating is common for ESL airline flight crewmembers' and is an indication that flight crewmembers must be able to read English language.

The ICAO level of English language proficiency data collected indicated that all flight crewmembers met minimum requirements for ELPRs and some exceeded the requirements (ICAO, 2004). Although participants indicated they had ICAO ELPR of level four, five, and six these levels do not provide an indication of how well flight crewmembers read and comprehend written English language. The IAC (2013) indicated that ESL flight crewmembers' ICAO ELPRs are not enough to assess how well flight crewmembers read and comprehend written English language. Likewise, the researcher's preliminary study indicated the same results. Therefore, self-rated English language proficiency levels were utilized and indicated each flight crewmember had different RCL of English language proficiency with respect to their general English language reading comprehension. Additionally, participants had dissimilar RCL of English language proficiency with respect to written English language on crew alerting systems and QRH checklists. Recall, utilization of self-proficiency ratings are important, as they provide indicators of adult metacognitive strategy use, and how well they read and comprehend written English language on technical information, especially expository and instructional texts (Park, 2010, Yeh and Genter, 2005).

Technical information was noted as challenging to many flight crewmembers regardless of the metacognitive strategy they utilized to read and understand written English language. Their use of metacognitive strategies to read and comprehend written English language on crew alerting systems and QRH checklists were different, and proficiency levels (general English language, crew alerting systems and QRH checklists) varied based on use of either crew alerting systems and/or QRH checklists. Regarding metacognitive strategy use by flight crewmembers, strategies utilized on QRH checklists (paper format) were different than crew alerting systems (displayed format). As Holder (2003) indicated, flight crewmembers' English language proficiency has the potential to be different based on their use of each of these systems (i.e. crew alerting systems and QRH checklists).

Collectively, participant English language proficiency influenced their ability to read and comprehend written English language. Participants had various English language proficiency levels, and each participant proficiency level influenced their ability to read information on crew alerting systems and QRH checklists. Altogether, aforementioned aspects were fundamental requirements needed to assess how well participants' read and understand written English language on crew alerting systems and QRH checklists, and challenges they experienced reading technical information. The next sections provide detailed discussions on preliminary study part two.

Participants utilized metacognitive strategies often to understand the meaning of words on crew alerting systems and QRH checklists. As Alderson (2000) indicated, ESL adults may use word guessing to understand written English language. However, use of lexical inferencing may not help them overcome reading comprehension challenges. In the researcher's study, participants utilized lexical inferencing strategy often. Of the twelve participants indicating use of lexical inferencing strategy, four indicated they have incorrectly guessed words the first time they read them on crew alerting systems and QRH checklists, but when they see the words a second time they remember the word. On the other hand, the remaining eight participants indicated they guess words correctly the first time they read them on crew alerting systems and QRH checklists. Regarding participants' proficiency level there were twenty-five percent of participants with RCL proficiency H-level and eight percent M-level (general English language) that utilize lexical inferencing strategy. There was low percentage of participants with RCL proficiency L-level (two percent), seventeen percent with RCL proficiency M-level, and fourteen percent with RCL proficiency H-level (crew alerting systems and QRH checklists) that utilize lexical inferencing strategy. In Dwaik and Shehadeh (2013) study, their ESL adults' proficiency level was high or low and correctly guessed more words in text corpora. Low proficiency readers guessed more words incorrectly. Part of Dwaik and Shehadeh (2013) study is corroborated in the researcher's study. In the researcher's study, many participants (eight) with RCL proficiency H-level guess more words correctly the first time they read them, while there were M-level and L-level participants (four) that guess words incorrectly the first time they read them on crew alerting systems and QRH checklists. This is an indication that English language proficiency (general English language, crew alerting systems and QRH checklists) tends to be variable across different participants, and lexical inferencing strategy use by participants is linked to different types of proficiency levels. It is also an indication that participants with RCL proficiency H-level were better at guessing words correctly, a finding inconsistent with part of Wang's (2011b) study, which indicated high level proficiency adults were negatively impacted by lexical inferencing strategy use. In the researcher's study review of participant use of lexical inferencing strategy will be reviewed.

Many participants used re-reading text and referencing other sources strategy to read and understand information on crew alerting systems and QRH checklists, while highlighting text on QRH checklists was utilized by one participant. According to Park (2010) ESL adults that rated their proficiency as high level, used more metacognitive strategies to read expository text (technical emphasis). In the researcher's study, of the thirty-five participants, twelve participants (thirty-four percent) utilized re-reading text strategy so they could understand unfamiliar vocabulary words, or to ensure adequate understanding of information on crew alerting systems and QRH checklists. On the contrary, proficiency levels were different and not consistent with Park (2010) study. It was noted in the researcher's study that participants with RCL proficiency H-level (twenty-two percent) and eleven percent of participants with RCL M-level utilized re-reading strategy (general English language). On the other hand, participants (twenty-two percent) with RCL proficiency M-level indicated they used re-reading strategy, while participants with RCL proficiency H-level (eight percent) and two percent of participants with RCL proficiency L-level indicated they use re-reading strategy (crew alerting systems and QRH checklists). Regarding proficiency levels, the researcher's results are an indication that English language proficiency level tends to be variable regardless of RCL proficiency of general use of English language, crew alerting systems and QRH checklists. In the researcher's experimental study, re-reading text will be reviewed to understand if participants use this strategy to read and understand information on crew alerting systems and QRH checklists.

Twenty percent of participants used referencing other sources to read written English language on crew alerting systems and QRH checklists. It was noted that the FCOM and other system/safety and notes section on the QRH checklists is utilized often to understand vocabulary words, abbreviations, acronyms and sentences. As expository text can be found on QRH checklists and crew alerting systems, this finding corroborates Park (2010) study. With respect to participant English language proficiency level, only participants (twenty percent) with RCL H-level (general English language) were found to use referencing other sources to clarify information. On the other hand, participants with RCL proficiency H-level (fourteen percent) use referencing strategy, while participants (five percent) with RCL proficiency M-level use referencing other sources strategy. This finding is consistent with Park's (2010) study, which indicated participants with RCL proficiency H-level use referencing other sources more than other proficiency levels.

One participant (two percent) utilized highlighting strategy to read and understand written English language on crew alerting systems and QRH checklists. The participant proficiency levels were H-level and M-level respectively (general English language, crew alerting systems and QRH checklists). The researcher's finding does not support Park's (2010) perspective that participants with high level proficiency use highlighting text often. In the researcher's experimental study, it will be determined if participants use text highlighting on QRH checklists as a strategy to read and comprehend English language.

Regarding note taking and paraphrasing text strategies, there were more participants (twenty-five percent) that utilized note-taking strategy than paraphrasing text (five percent). Part of the researcher's finding does not corroborate Park's (2010) study, which indicated note-taking strategy was utilized less frequently than other strategies. However, paraphrasing text was utilized less often than other strategies, which corroborates Park's (2010) finding. Proficiency levels were different with respect to participants with RCL proficiency of general English, crew alerting systems and QRH checklists. Firstly, participants (five percent) with RCL proficiency M-level use taking notes strategy, while twenty percent of participants with RCL proficiency H-level (general English language) use taking notes strategy. On the other hand, twenty percent of participants with RCL proficiency M-level used taking notes strategy, while participants with RCL proficiency H-level (crew alerting systems and QRH checklists) used taking notes strategy. Participants indicated that taking notes was utilized if they needed to reference information related to a crew alert later on during the flight. Regarding paraphrasing text, which was utilized infrequently by participants, many of them used this strategy if words were too long to read and they had knowledge of the word in a different form. Of the thirty-five participants two participants (five percent) each indicated use of paraphrasing and their RCL proficiency levels (general English language, crew alerting systems and QRH checklists) were the same (M-level and H-level). In the researcher's experimental study, it will be determined if note-taking strategy was utilized to read information on crew alerting systems and QRH checklists.

Underlining text strategy was used infrequently, but the strategy was utilized to guide a participant (two percent) when reading English language on QRH checklists. It was also indicated that the participant would use a pencil to underline specific text on the checklist specific. The participant had RCL proficiency H-level (general English language) and M-level (crew alerting systems and QRH checklists). In the researcher's experiment, it will be determined if underlining text strategy was utilized to read and comprehend information on QRH checklists.

A high percentage of participants' (fifty-one percent) each utilized translation (cognitively) of written English language back into their native language and reversion back to their native language to read written English language on QRH checklists and crew alerting systems. It was noted that participants' use translation of English language back into their native language because it is easier for them to read and comprehend if the same vocabulary word or phrase exists in their native language. They also indicated that experience with technical information translated into their native language helps with deciphering through English language words. However, it was noted that if there is not an equivalent vocabulary word or phrase in their native language it takes longer to process certain vocabulary words/phrases/abbreviations and acronyms on crew alerting systems and QRH checklists and can sometimes lead to incorrect translation. As Ynfiesta et al (2012) indicated, translation of vocabulary words and acronyms into adult native language can be challenging especially if the translation of the English language acronym is not the same in the adult native language. Differences in the spelling of words can complicate word meaning and the word can mean something different in the adult native language. As this finding was also found in the researcher's study, it can be concluded that translation of vocabulary words and acronyms into participant native language can complicate understanding of word meaning. Regarding participant translation of information on QRH checklists and crew alerting systems into their native language, many of them indicated they did not have a grasp of the long form meaning of the acronym or abbreviation, which led to confusion when they translated information into their native language.

Participants (fifty-one percent) indicated they revert back to their native language due to airline company practices. It was noted that many participants feel they are more comfortable automatically reverting back to their native language because it helps them understand information on crew alerting systems and QRH checklists during non-normal conditions. The researcher's finding corroborates Kobayashi and Rinnert (1992) finding, which indicated adult use of reverting back to English language strategy can occur because an ESL adult lacks understanding of translated syntax meaning. Participants indicated they had issues with sentence syntax and/or word meaning.

Participant RCL proficiency was the same across proficiency categories (general English language, crew alerting systems and QRH checklists) when they use both metacognitive strategies (translation of written English language back into their native language and reversion back to their native language) to read written English language. Participants with RCL proficiency H-level (twenty-eight percent) use each of the aforesaid metacognitive strategies, while twenty-two percent of participants with RCL proficiency M-level (general English language) use each of the aforesaid metacognitive strategies. On the other hand, participants (twenty-five percent) with RCL proficiency H-level use each of the aforesaid metacognitive strategies, while participants (twenty-two percent) with RCL proficiency M-level utilize each of the aforesaid metacognitive strategies. Finally, participants (two percent each) with RCL proficiency L-level utilize each of the aforesaid strategies. Use of strategies like reversion and translation of words back into their native language is an indication that participants have knowledge of metacognitive strategy use and are able to using them to read written English language. It will be determined in the researcher's experimental study if participants' translate and revert back to their native language to read and comprehend text on crew alerting systems and QRH checklists.

Eight percent of participants that utilize reading aloud text on the flight deck indicated they used this strategy to help them through the process of interpreting information on crew alerting systems and QRH checklists. Their proficiency levels were different with respect to their RCL proficiency (general English language, crew alerting systems and QRH checklists). Five percent of participants with RCL proficiency M-level and two percent with RCL proficiency H-level used reading aloud strategy (general English language), while eight percent of participants with RCL proficiency M-level (crew alerting systems, QRH checklists) utilized reading aloud strategy. These proficiency levels indicate that participants with different proficiency levels use reading aloud strategy on the flight deck. It will be determined in the researcher's experimental study if participants read aloud text on the flight deck.

Participants (eight percent) that utilized monitoring reading comprehension strategy indicated they use this strategy to ensure they have not misinterpreted information on QRH checklists. This strategy was utilized to understand challenging abbreviations/acronyms, short text format and long text that are found on QRH checklists. Comprehension monitoring is utilized to consistently evaluate intentions while reading text, and regulate flow of understanding text as indicated by Baker & Brown (1984). As Park et al (2014) indicated, monitoring reading comprehension strategy is utilized by highly proficiency adults to read acronyms/abbreviations. In the researcher's study, each participant was found to have the different RCL proficiency levels (two percent H-level, L-level, M-level), with respect to general English language. Five percent of participants with RCL proficiency H-level used monitoring reading comprehension strategy, while two percent of participants with RCL proficiency M-level (crew alerting systems and QRH checklists) utilized reading comprehension strategy. As the researcher's study provides evidence that participant use of monitoring reading comprehension strategy indicated participants had different proficiency levels, this finding does not corroborate Park et al (2014) study. In Park's study, only high proficiency participants utilized this strategy. It will be determined in the researcher's experimental study if participants use monitoring reading comprehension strategy to read English language.

Eleven percent of participants used breaking apart sentences strategy so they could understand complicated wording on checklists and crew alerting systems, including difficult vocabulary words and sentences. Five percent of participants had RCL proficiency H-level and five percent M-level (general English language) utilized breaking apart sentences strategy. On the other hand, two percent of participants with RCL proficiency H-level used breaking apart sentences strategy and eight percent of participants with RCL proficiency M-level (crew alerting systems and QRH checklists) utilized this strategy. As Yildiz-Genc (2009) indicated, adults utilize breaking apart sentences to understand complex word meaning. On the other hand, the researcher's study does not corroborate Yildiz-Genc (2009) study with respect to intermediate proficiency levels. In the researcher's study proficiency levels were different (H-level and M-level) based on breaking apart sentence strategy utilized by participants. It will be determined in the researcher's experimental study if participants break apart sentences to read written English language.

Participants (seventeen percent) use of bottom-up strategy (decoding text) indicated they used this strategy if they did not understand terminology or standard operating procedures word meaning in QRH checklists or FCOM procedures, and on crew alerting systems. They indicated decoding text and using their background knowledge of information in training helped them understand information on crew alerting systems and QRH checklists. Regarding participant proficiency levels eight percent of participants had RCL proficiency M-level and H-level (general English language), while eleven percent of participants with RCL proficiency M-level utilized bottom up strategy and five percent of participants with RCL proficiency L-level used bottom-up strategy. According to Liu (2014), use of this strategy is highly dependent on adult proficiency levels. The aforementioned proficiency levels explain Liu (2014) perspective that proficiency levels are key components to understand how well adults will understand vocabulary words and text. With respect to participant use of bottom-up model, Parry's (1991) indicated that low and intermediate level participants used this strategy to read written English language. Part of Parry's (1991) study was corroborated in the researcher's study regarding participants with RCL L-level that utilized bottom-up strategy. It will be determined in the researcher's experimental study if participants' decode text to read and comprehend written English language.

Top down strategy was utilized by twenty-two percent of participants. Many participants indicated use of this strategy due to logical flow of information on checklists, vocabulary words, abbreviations and acronyms on crew alerting systems/QRH checklists, and text that appeared too simplified to understand on each of the systems. As all participants had background knowledge of text they read on crew alerting systems and QRH checklists, they did indicate that there were instances when certain malfunctions may occur on a frequent basis and they are able to use their training and previous knowledge of the failure to troubleshoot the issue. As Lin and Chern (2014) indicated, top-down strategy is used often to activate content schema/background knowledge to understand text. It was indicated in Yildiz-Genc (2009) study that adults' predicted information in sentences prior to reading the whole sentence, and either confirmed or rejected their predictions. In the researcher's case, this result was not found; rather top down strategy was utilized to understand text using background knowledge. There were more participants with RCL proficiency H-level (fourteen percent) than participants with M-level (eight percent) with respect to general English language proficiency. On the other hand, participants with RCL proficiency M-level (eleven percent) used top down strategy, while participants with RCL proficiency H-level (eight percent) and two percent of participants with RCL proficiency L-level (crew alerting systems and QRH checklists) utilized top down strategy. As Yildiz-Genc (2009) study indicated, intermediate level adults' used this strategy to understand text. This result was not corroborated in the researcher's study; rather the researcher's study indicated several participants with different proficiency levels use top down strategy. It will be determined in the researcher's experimental study if participants' use top down strategy to read written English language.

Five percent of participants used interactive strategy to read written English language on crew alerting systems and QRH checklists. It was indicated that participants (five percent) used this strategy if there were words or sentences that required them to use their background knowledge and ability to decode text. They indicated that depending on the type of crew alert, they have to use this strategy due to crew alert timing. In other words, certain alerts have integrated timed alerts, which require the participant to act (respond) quickly to the alert. Therefore, use of background knowledge and ability to decode words quickly, facilities quick response and understanding of the issue. Interactive model is most widely utilized and consists of ESL adults instantaneously decoding syntax (Barnett, 1989). Interactive models combine use of bottom-up and top-down models to read written English language (Lally, 1998). Regarding participant proficiency levels, there were two percent of participants with RCL proficiency M-level and two percent of participants with RCL proficiency H-level (general English language), while five percent of participants with RCL proficiency M-level (crew alerting systems and QRH checklists) used interactive strategy. As Fatemi et al (2014) indicated, participants with high English language proficiency use interactive model and other related strategies to read written English language. As this was the case in the researcher's study, it can be concluded that high proficiency level participants utilize interactive strategy. It will be determined in the researcher's experimental study if participants use interactive strategy to read and comprehend information on crew alerting systems and QRH checklists.

Eleven percent of participants indicated they monitor their reading speed when they read written English language on crew alerting systems and QRH checklists. Participants' indicated they monitor reading speed to ensure they have accurately interpreted information and to ensure they have not missed a step in the process. They also stated, depending if the crew alert is a warning or caution, they read text faster than crew alerts than are advisory. Participants (five percent) with RCL proficiency H-level used monitor reading comprehension strategy, while two percent of participants with RCL proficiency M-level and L-level (general English language) monitored their reading speed. On the other hand, eight percent of participants with RCL H-level indicated they monitor their reading speed and two percent of participants with RCL proficiency M-level (crew alerting systems and QRH checklists) monitor their reading speed. As McDonough (1999) indicated, adult reading rate (fast/slow) has the potential to be impacted by the type of strategy utilized to read text. As this was the case with the researcher's study, it can be conclude that monitoring reading speed is a strategy utilized by participants to read and interpret written English language on crew alerting systems and QRH checklists. Additionally, participant proficiency levels are different when they read and interpret information on crew alerting systems and QRH checklists. It will be determined in the researcher's experimental study if participants monitor their reading speed.

Skipping words and omission of words was a strategy utilized by participants (eleven percent) to read and interpret written English language on crew alerting systems and QRH checklists. Participants indicated if they were unfamiliar with a word or did not understand the meaning, they skip or omit the word. This strategy sometimes led to challenges understanding the logic of the information they read. As Dordick (1996) indicated, omission of words in text is due to ESL adults misunderstanding words, or unfamiliar words in text. In the researcher's study five percent of participants, each with RCL proficiency M-level and H-level (general English language) utilized skipping words/omission of words to help them understand information on crew alerting systems and QRH checklists. On the other hand participants (five percent) with RCL proficiency M-level utilized skipping words and omission of words and two percent of participants with RCL proficiency H-level and L-level (crew alerting systems, QRH checklists) utilized skipping words and omission of words to read written English language. It will be determined in the researcher's experimental study if participants skip or omit word on crew alerting systems and QRH checklists.

Summary

Overall, participants indicated that metacognitive strategy use is beneficial to read and understand written English language on crew alerting systems and QRH checklists. Despite challenges they experienced reading and comprehending written English language, they were aware of the strategies and commonly utilized them to understand abbreviations, acronyms, and vocabulary words. It must also be realized that English language proficiency levels are different based on metacognitive strategy use. More research is needed to understand participant metacognitive strategy use with respect to their reading comprehension of vocabulary word types, text genre, acronyms and abbreviations types (long and short form) and how these types of text impact participant performance. As the aforesaid factors are critical to understanding how participants perform on the flight deck, participants' performance will be measured with respect to how they interact (e.g. response time) with written English language on the flight deck.

Participants indicated there were many crew alerting system design and integration written English language factors that negatively impacted their reading comprehension This section provides a discussion of written English language design and integration factors as well as participant proficiency, and how participants were impacted by use of written English language on crew alerting systems.

Sentence length (short) was identified by five percent of participants as a factor that negatively impacts their ability to read and comprehend written English language on crew alerting systems. As Alderson (2000) indicated, sentences that are constructed short can be complex to ESL adults to read and comprehend in text corpora. Participants in the researcher's study (five percent) indicated that there are sometimes texts that appear to be shortened (likely due to spacing restrictions on the display) and negatively impacts the syntax logic. In other words, shorter text on a display screen does not convey the entire system situation effectively, rather there are small chunks of words in sentence format that are written shorter to achieve the overall logic of the sentence. For instance, 'SIDE STICK FAILURE 1 or 2' is a designation of an alert on an ECAM screen. But due to the lack of detailed information it is difficult to decipher the logic of why the stick has failed. In other words, the sentence is incomplete and leads the participant to find other clues about the failure, when the information should be described adequately when the crew alert is enunciated. Due to shorter form words of words in sentences they are more difficult to read and interpret. Regarding participant proficiency, five percent of participants with RCL proficiency H-level (general English language) and RCL proficiency M-level (crew alerting systems and QRH checklists) indicated they were negatively impacted by sentence length (short). This result does not corroborate Eslami's (2014) study on sentence length. Eslami (2014) indicated that adults with reading comprehension proficiency level medium performed better with shorter sentences rather than longer sentences, and reducing complexity of sentence readability contributed to ease of understanding texts. This was not the case in the researcher's study. Participants with RCL proficiency H-level and M-level indicated they were challenged by short text on crew alerting systems. Even though participants had background knowledge of the text on crew alerting systems, they indicated difficulties understanding sentence syntax. As Eslami (2014) study indicated, sentence length was truncated (arrangement of words) but certain vocabulary words were not removed. In the researcher's study, it is peculiar as to why participants indicated issues with short text on crew alerting systems. Nevertheless, the researcher will determine if short text on crew alerting systems is a prevalent issue in the researcher's experimental study.

A high percentage of participants (forty-eight percent) indicated acronyms and abbreviations negatively impact their ability to read and comprehend written English language on crew alerting systems. As Hutchins et al (2006) alluded, written English language text on displays appears in different formats such as abbreviations and acronyms. Careful considerations regarding design of phrases and other pieces of technical information on displays has the potential to impact performance. Participants in the researcher's study identified short forms of abbreviations and lack of long form word reference negatively impacts their ability to read and comprehend written English language on warnings, cautions, and advisories. In that regard, acronyms and abbreviations are written with the assumption that participants know each abbreviation and acronym on crew alerting systems, when in fact certain abbreviations and acronyms displayed on one page has a different meaning on another page. Abbreviations and acronyms are also inconsistent page-to-page on system synoptic (s) (e.g. Conf versus CONFIG). It was noted that the these types of abbreviations/acronyms are not consistent, which leads to misunderstandings regarding meaning of the abbreviation/acronym. As Park et al (2014) alluded to, acronyms were difficult to read, and background knowledge was utilized to understand the meaning of acronyms. In Park et al (2014) study the participants' English language proficiency level was very good. This result does not corroborate results from the researcher's study, since participant proficiency levels were high, low, and medium. In that regard, the researcher's study indicated twenty-eight percent of participants with RCL proficiency H-level were negatively impacted by acronyms/abbreviations, while seventeen percent of participants with RCL M-level and two percent L-level (general English language) were negatively impacted by abbreviations and acronyms. Participants (twenty-two percent), each with RCL H-level and M-level indicated they were negatively impacted by abbreviations/acronyms and two percent with RCL L-level (crew alerting systems and QRH checklists) indicated they were negatively impacted by abbreviations and acronyms. There is still a need to understand the impact of abbreviations and acronyms on participant performance, which will be discussed in the researcher's experiment.

Participants (sixty-eight percent) indicated text genre (e.g. technical) negatively impacted their ability to read and comprehend written English language on crew alerting systems. It was indicated that different forms of technical information on crew alerting systems is difficult to read due to many different types of wording on the alert system. As Nation (2001) indicated that there are four types of written English language vocabulary words that can be found in written English text: high frequency, academic and sub-technical, technical, and low frequency words. Each of the four types of vocabulary words can have an impact on ESL adult reading comprehension. In the researcher's study, participants indicated that wording should be consistent as this negatively impacts participant logic of system alerts. Forty-percent of participants with RCL proficiency H-level indicated they were negatively impacted by text genre (e.g. technical), while twenty five percent of participants with RCL proficiency M-level and two percent L-level (general English language) indicated that text genre (e.g. technical) negatively impacted their reading comprehension. Additionally, thirty-seven percent of participants with RCL proficiency M-level indicated they were negatively impacted by text genre, while twenty-eight percent of participants with RCL proficiency H-level and two percent of participants with RCL proficiency L-level (crew alerting systems and QRH checklists) indicated text genre (e.g. technical) negatively impacted their reading comprehension. In Wanpen's et al (2013) study it was noted that technical vocabulary words competence/proficiency was higher with participants whose background was vocational (related to their job field) than with participants that had an academic background. This result was not corroborated in the researcher's study. In the researcher's study, participants had different levels of English language proficiency, and they had background knowledge of the text. But, they indicated they were challenged by vocabulary words in technical genre text. It is still unclear on the types of vocabulary words in technical genre text that participants identified as difficult to understand. As technical genre text has the potential to contain different vocabulary words, vocabulary word types need to be identified. Therefore, in the researcher's experimental study and overview of vocabulary word types on crew alerting systems will be provided.

Number of tokens in text was identified by two percent of participants as a factor that negatively impacted participant ability to read and comprehend text genre on crew alerting systems. It was indicated that two percent of participants with RCL proficiency H-level (general English language) and RCL proficiency H-level (crew alerting systems and QRH checklists) identified number of tokens in text as a factor that negatively impacted their ability to read and interpret written English language on crew alerting systems. In the researcher's study, it will be determined if number of tokens on crew alerting systems negatively impacts participant reading comprehension.
Participants (seventy-four percent) indicated authentic text was a factor that negatively impacted their ability to read and comprehend text on crew alerting systems. Participants identified technical information (phrases, abbreviations, format, and sentence structure) as factors that negatively impacted their reading comprehension when they use crew-alerting systems. As You (2009) indicated, ESL adults that read written English

language on computer screens have the potential to be challenged due to their ability to retrieve text from screen. It was indicated that manufacturers that present safety information on displays (crew alerts) do not adhere to flight crewmember sensitivities regarding interpretation of written English language. It was noted that design and integration of words on crew alerting systems should be evaluated by ESL flight crewmembers prior to information on displays being designed and integrated on computer screens. As Smith-Jackson and Wogalter (2000) indicated, design of English language signal words has attempted to account for linguistic differences. However, Wogalter et al (1997) indicated, safety information related to warnings was inadequately comprehended by ESL individuals in socio-technical environments. In the researcher's study it was also noted that participant proficiency levels are different regarding their crew alerting systems reading comprehension. If safety information on crew alerting systems are not written clearly and do not provide enough information to complete the task, it may be difficult for participants to read and interpret. Participants (forty-two percent) with RCL proficiency H-level indicated they were negatively impacted by authentic text on crew alerting systems, while twenty-eight percent of participants with RCL proficiency M-level, and two percent of participants with RCL proficiency L-level (general English language) indicated their reading comprehension was negatively impacted by authentic text. Furthermore, participants (thirty-seven percent) with RCL proficiency M-level indicated they were negatively impacted by authentic text, while thirty four percent of participants with RCL proficiency H-level and two percent of participants with RCL proficiency L-level (crew alerting systems and QRH checklists) indicated authentic text negatively impacts their reading comprehension. Aforesaid participant proficiency levels can also be found in You's (2009) study, so it can be concluded that these levels of proficiency are important when evaluating authentic text and participant reading comprehension.

Participants (eight percent) identified simplification of text as a factor that negatively impacted their reading comprehension of written English language on crew alerting systems. Participants' noted that abbreviations, acronyms, phrases, and vocabulary words are often simplified in sentences and leads to misunderstandings of sentence logic. As many of the crew alerting systems contain text that is simplified, it presents a challenge to participants when they interpret information on crew alerting systems. Participant proficiencies were different with respect to their reading comprehension of written English language. As McInnes (2011) indicated, connecting the meaning of the longer version of the word to the shorter version of the word has the potential to be challenging to ESL adults. Eight percent of participants had RCL proficiency M-level, H-level, and L-level (general English language). On the other hand, five percent of participants with RCL proficiency H-level indicated they experienced issues with simplification of text, while participants with RCL proficiency M-level (crew alerting systems and QRH checklists) indicated they experienced issues with simplification of text. In the researcher's study, these findings were not corroborated in Hashemi and Bagheri's (2014) study, which indicated vocabulary words did not negatively impact ESL participants' reading comprehension. It was noted that reducing text length and simplification of text improved ESL adult performance. It was also noted that participant proficiency levels were intermediate to high. In the researcher's experimental study, text and words (abbreviations, acronyms, vocabulary words, and phrases) will be reviewed with respect to altering/not altering authentic text. Furthermore, participant English language proficiency levels will be evaluated with respect to the impact of altering/not altering text.

Participants (eight percent) indicated sentence length (long) negatively impacted their reading comprehension of information on crew alerting systems. Some information contains text too long to read such as advisory information related to synoptic(s) details. It was indicated that certain crew alerting system synoptic pages on the display should be reviewed for sentence length and if all data presented is necessary for the participant to comprehend. The researcher's finding does not corroborate findings in Mehrpour and Riazi (2004) study, which indicated shorter text length was more difficult to read in general than the longer length text, and proficiency levels for participants that had English background were proficient with their reading comprehension of English language. In the researcher's study, participant English language proficiencies were different. Participants (two percent) had RCL proficiency of M-level and five percent H-level (general English language). Each participant indicated long text negatively impacted their reading comprehension on crew alerting systems. Five percent of participants indicated their RCL proficiency was H-level and two percent indicated RCL M-level (crew alerting systems and QRH checklists). They also indicated that long text negatively impacted their reading comprehension on crew alerting systems. Sentence length (long) will be reviewed in the researcher's experiment to understand if participants' highlight this factor as an issue that negatively impacts their reading comprehension of information on crew alerting systems.

Finally, participants (fifty-four percent) indicated that vocabulary word types on crew alerting systems was a factor that negatively impacted their ability to read and comprehend written English language on crew alerting systems. It was indicted that there are different types of vocabulary words on crew alerting systems and they present a challenge to participants when they read information displays. As Levine and Reves (1990) indicated, written English language vocabulary words have the potential to impact ESL adults' reading comprehension. In the researcher's study, it was indicated by participants that their proficiency is a factor that influences their ability to read crew alerting information on displays. Ashrafzadeh's et al (2015) study indicated that participant proficiency level (intermediate), was negatively impacted by different types of vocabulary words in text corpora. In that regard, participant proficiency levels in the researcher's study were different. Thirty-one percent of participants with RCL proficiency H-level indicated they were negatively impacted by vocabulary words, while twenty-two percent of participants with RCL proficiency M-level (general English language) indicated vocabulary words negatively impact their reading comprehension. Thirty-four percent of participants with RCL proficiency M-level indicated they were negatively impacted by vocabulary words in text, while seventeen percent of participants with RCL proficiency H-level and two percent with RCL L-level indicated vocabulary words negatively impact their reading comprehension. In the researcher's experiment, it will be determined if vocabulary words are still a factor that negatively impacts participant performance when they read written English language on crew alerting systems.

Summary

This section provided important details on factors that influence participant ability to read and comprehend information on crew alerting systems. It was noted that design and integration of information on crew alerting systems negatively impacts participant reading comprehension. It should also be noted that acronyms/abbreviations, text genre (e.g. technical), authentic text, and vocabulary types were highly regarded as factors that negatively impact participant ability to read and comprehend information on crew alerting systems. Regardless of participant's indication that they possess background knowledge of crew alerting systems information, they were challenged with information on crew alerting systems. Accordingly, aforesaid factors were evaluated with respect to participant performance in the researcher's experiment.

Participants indicated that written English language on QRH checklists were factors that negatively impacted their ability to read and comprehend information on QRH checklists. The following factors discussed are related to participant English language proficiency and their ability to read technical information on QRH checklists. According to Burian (2006) ESL flight crewmembers have the potential to experience cognitive difficulty with interpretation of information on checklists.

Accordingly, participants (fourteen percent) indicated conditional statements negatively impacted their ability to read and comprehend information on QRH checklists. It was noted that there are inconsistencies in how conditional statements are designed on QRH checklists, which make them difficult to read, and comprehend. It was also noted that conditional statements that are not written properly on QRH checklists make it difficult to understand how to troubleshoot the crew alert on the display screen. As Yeh and Gentner (2009) study alluded, ESL adults' detection of conditional statements (i.e. counterfactual) in text negatively impacted their performance when they utilized searching context clues strategy to read and understand counterfactuals in text. This result could be that their reading abilities of written English language were not sufficient to read the texts. On the other hand, their use of background knowledge strategy to read factual conditionals was adequate. In the researcher's study, participants had background knowledge of reading conditional statements in the notes section of QRH checklists. Therefore, the researcher's finding corroborates Yeh and Gentner's study. On the contrary, proficiency levels were different in the researcher's study. Five percent of participants each with RCL M-level and H-level indicated they were negatively impacted by conditional statements, while two percent of participants with RCL proficiency L-level (general English language) were negatively impacted by conditional statements. On the other hand, participants (eight percent) with RCL proficiency H-level indicated they are negatively impacted by conditional statements, while two percent of participants with RCL proficiency M-level and L-level (crew alerting systems and QRH checklists) indicated conditional statements negatively impacted their reading comprehension. It can be concluded that participant proficiency levels are different and impact their ability to read conditional statements on QRH checklists. More research will be conducted in the researcher's experimental study to determine if conditional statements are still a factor that negatively impacts their performance when they read and comprehend information on QRH checklists.

Two percent of participants' indicated that number of tokens (number of words in a sentence) in text negatively impact their ability to read and comprehend information on QRH checklists. It was indicated that some sections on QRH checklists tend to be wordy and contain extraneous information. The participant proficiency levels were RCL proficiency H-level (general English language) and RCL proficiency M-level (crew alerting systems, QRH checklists). As Larsen and Hansen (2010) alluded to, many tokens in text were difficult for participants to process and understand. In their study, participant proficiency levels were very good. In the researcher's study, proficiency levels were different, which is an indication that participants with different levels of proficiency experience difficulties reading written English language on QRH checklists. It will be determined in the researcher's study if number of tokens in text negatively impact participant reading comprehension of information on QRH checklists.

Participants (eighty-two percent) indicated that authentic text negatively impacted their reading comprehension of information on QRH checklists. Participants' indicated that sentences on QRH checklist are too long and vocabulary words are challenging. Conditional statements (if/then) in the 'notes' section of QRH checklists are inherently difficult to understand when they are related to systems malfunction issues. In particular, they are not formatted adequately for individuals whose first language is not English. Stated in the previous discussion on conditional statements, more attention needs to be given regarding consistency in the way information is written on QRH checklists. In the researcher's study participants with RCL proficiency H-level indicated they were negatively impacted by conditional statements on QRH checklists (e.g. non-normal/emergency conditions), while twenty-five percent of participants with RCL proficiency M-level and two percent of participants with RCL proficiency L-level (general English language) indicated that conditional statements negatively impacted their reading and comprehension abilities. On the other hand, participants (forty-two percent) with RCL proficiency M-level indicated they were impacted more by conditional statements than participants (thirty-one percent) with RCL H-level followed by five percent of participants with RCL proficiency L-level (crew alerting systems, QRH checklists). As Larsen and Hansen (2010) alluded, authentic texts (un-simplified/unaltered from its original version) were difficult for participants to process and understand due to vocabulary words in text. In their study participant proficiency levels were very good. In the researcher's study, proficiency levels were different, which is an indication that participants with different levels of proficiency experience difficulties reading written English language on QRH checklists. In the researcher's experiment, it will be determined if authentic text on QRH checklists negatively impacts participant ability to read and comprehend checklist information.

Thirty-four percent of participants indicated that sentence length (long) was a factor that negatively impacted their reading comprehension of information on QRH checklists. Previously stated, long sentences on checklists are challenging to read and lead to longer reading comprehension, as indicated by participants in the study. Twenty percent of participants with RCL proficiency H-level indicated they were impacted by sentence length, while eleven percent with RCL proficiency M-level, and two percent with RCL proficiency L-level (general English language) indicated long sentences are challenging to read. On the other hand, seventeen percent of participants with RCL proficiency M-level indicated they were negatively impacted by sentence length (long), while eleven percent with RCL proficiency H-level and five percent with RCL proficiency L-level (crew alerting systems and QRH checklists) indicated sentence length are challenging to read. Part of the researcher's study is corroborated in Abdul-Hamid and Samuel (2012) study. In their study, it was indicated by participants that long complex sentences were very difficult to understand. In the researcher's study it was indicated that long sentence lengths negatively impacted participants' reading comprehension of information QRH checklists. As Abdul-Hamid and Samuel (2012) study indicated, participants' proficiency was proficient or less than proficient. It was also indicated that proficiency levels may have impacted their ability to read long sentences in text. In the researcher's study, proficiency levels were different. Participants had H-level, M-level, and L-level English language proficiencies with respect to general English language and crew alerting systems/QRH checklists. In the researcher's experiment, it will be determined if sentence length (long) negatively impacts participant ability to read and comprehend information on QRH checklists.

Eleven percent of participants' indicated that simplification of text was a factor that negatively impacted their ability to read and comprehend information on QRH checklists. Participants' indicated that some text that refers to non-normal conditions is difficult to understand, regarding sentence/word meaning, due to information simplified on the QRH checklist. It was noted that eleven percent of participants with RCL proficiency H-level (general English language) and eight percent of participants with RCL M-level and two percent H-level indicated they are negatively impacted by simplification of text on QRH checklists (crew alerting systems, QRH checklists). As Gardner and Hansen (2007) alluded to, simplification of text did not impact their participants' ability to read and comprehend text. It must be noted that proficiency levels in their study were different (beginning, low intermediate, high intermediate, and advanced). In the researcher's study, participant English language proficiency levels were different, but they indicated they experienced difficulties with simplification of text on QRH checklists. Therefore, it can be concluded that despite different proficiency levels, simplification of text can negatively impact participant reading comprehension of information. The researcher will provide an indication in the experimental study if simplification of text is a factor that negatively impacts participant ability to read and comprehend information on QRH checklists.

Forty-two percent of participants indicated acronyms and abbreviations negatively impacted their ability to read and comprehend information on QRH checklists. In particular, participants indicated that reading and understanding the meaning of acronyms and abbreviations is difficult due to misunderstandings of the long form of the word. Twenty-eight percent of participants with RCL proficiency H-level indicated that acronyms and abbreviations on QRH checklists negatively impact their reading comprehension more than eleven percent of participants with RCL M-level, followed by two percent with RCL proficiency L-level (general English language). On the other hand, twenty percent of participants with RCL M-level indicated they were negatively impacted more by acronyms and abbreviations than seventeen percent of participants with RCL H-level, followed by five percent with RCL L-level (crew alerting systems, QRH checklists). As Kim (2006) alluded, participants in their study experienced issues connecting acronyms to word meaning. As participant proficiency levels were low or high, they indicated that acronym and determining word meaning negatively impacted their reading comprehension of information. Likewise, in the researcher's study participants were negatively impacted when they read and comprehend abbreviations and acronyms on QRH checklists. But, in the researcher's study, participant proficiency levels were different and were more than just high and low levels. Therefore, it can be concluded that proficiency levels are a factor that influence participant ability to read and comprehend abbreviations and acronyms on QRH checklists. In the researcher's study it will be determined if acronyms and abbreviations are still factors that impact participant ability to read and comprehend information on QRH checklists.

Text Genre (e.g. technical) was indicated as a factor that influences participants' (eighty-two percent) ability to read and comprehend information on QRH checklists. It was noted that vocabulary words on technical information (QRH checklists) are difficult to understand due to their inconsistencies of presentation of words on the checklists and cross reference logic of information presented on crew alerting systems. In other words, the information on checklists sometimes does not clearly coincide to the type of failure. A high percentage of participants (fifty-one percent) with RCL proficiency H-level indicated they are negatively impacted by text genre (e.g. technical) Twenty-five percent of participants with RCL proficiency M-level and two percent of participants with RCL proficiency L-level (general English language) indicated they are negatively impacted by text genre (e.g. technical). On the other hand, thirty-four participants with RCL proficiency M-level indicated they are negatively impacted by text genre (e.g. technical). Twenty-five percent of participants with RCL proficiency H-level and five percent of participants with RCL proficiency L-level (crew alerting systems, QRH checklists) indicated they are negatively impacted by text genre (e.g. technical). As Carrell (2001) alluded, proficiency levels may have an impact on participant ability to read and comprehend information on instructional text with technical vocabulary. In Carrell's (2001) study participant proficiency was advanced and intermediate level and they did not indicate any issues with written English language. In the researcher's study participant proficiency levels were different, with some participants claiming low-level proficiency. It can be concluded that even though proficiency levels were different in the researcher's study, they still experienced issues reading and comprehending technical genre text on QRH checklist. In the researcher's experiment, it will be determined if text genre negatively effects their ability to read and comprehend information on QRH checklists.

Participants (sixty-five percent) indicated that vocabulary words type was a factor that negatively impacted their ability to read and comprehend information on QRH checklists. It was indicated that acronyms and abbreviations and related long form vocabulary words are challenging to read due to format (e.g. HYD L versus L HYD 1 FAIL). It was noted that inconsistencies in vocabulary words presentation make it difficult for participants to understand the logic from words on the checklist to information on the flight deck crew alerting system. Thirty-seven percent of participants with RCL proficiency H-level and twenty five percent of participants with RCL proficiency M-level indicated they are negatively impacted by vocabulary words, while two percent of participants with RCL proficiency L-level (general English language) are negatively impacted by vocabulary words. On the other hand, thirty-four percent of participants with RCL proficiency M-level and twenty five percent of participants with RCL proficiency H-level indicated they are negatively impacted by vocabulary words, while five percent of participants with RCL proficiency L-level (crew alerting systems, QRH checklists) indicated they are negatively impacted by vocabulary words on checklists. As Abdul-Hamid and Samuel (2012) indicated, participants' experienced difficulties reading scientific text, but they also experienced difficulties reading and comprehending text when there was a mix of academic vocabulary and scientific words embedded within the structure of the scientific text. Mixing of vocabulary words in text made it more difficult for participants to understand vocabulary word meaning. Recall, difficulties in their study could be the participants' English language proficiency level and their familiarity with academic vocabulary words in the scientific text. In the researcher's study participant English language proficiency levels were different, and they experienced difficulties when there were different types of vocabulary words (inconsistencies) in text on QRH checklists. Therefore, it can be concluded that proficiency is a factor that influences participant ability to read different types of vocabulary words and comprehend information on QRH checklists. More information on the impact of different vocabulary words on QRH checklists will be reviewed in the researcher's forthcoming experimental study.

Sentence length (short) was not highly regarded as a factor that impact participants' (two percent) ability to read and comprehend information on QRH checklists. It was noted that certain sentences on QRH checklists do not contain all of the elements of a sentence, which make it difficult to understand. Two percent of participants with RCL proficiency L-level (general English language) and H-level (crew alerting systems, QRH checklists) indicated they were negatively impacted by sentence length (short). More information will be provided in researcher's experiment regarding impact of sentence length (short) on QRH checklists on participant performance. In Mehrpour and Riazi (2004) study, it was indicated that all participants were proficient with their use of English language and they had background knowledge of English language. They also indicated that sentence length short negatively impacted their ability to read and comprehend written English language. With respect to the researcher's study, participant level of English language proficiency was different. Although they had background knowledge of written English language and text on QRH checklists, they did not indicate that sentence length short was a major impact to their ability to read and comprehend information on QRH checklists. Therefore, it can be concluded that short length text on QRH checklists may not always negatively impact many participants' reading comprehension.

Summary

This section provided a review of written English language design and integration factors that negatively impacted their reading comprehension of information on QRH checklists.

In particular, it was noted that authentic text, sentence length (long), acronyms and abbreviations, text genre, and vocabulary words type were highly regarded as factors that negatively impact their ability to read and comprehend information on QRH checklists. In that regard participant proficiency levels were different, which is an indication that participant ability to understand text on QRH checklists is different with respect to the RCL level proficiency (general English language, crew alerting systems and QRH checklists). As participants had background knowledge of QRH checklists and background knowledge of written English language, these factors will be reviewed in the researcher's experimental study. The next discussion will provide an overview of negative impacts to participant performance, which negatively impacted flight safety.

Many participants indicated their performance and flight safety is negatively impacted due to written English language information on crew alerting systems and QRH checklists.

Participants (forty-percent) indicated that misinterpretation of information (abbreviations and phrases) was a factor that negatively impacted their performance and thus flight safety. Misinterpretation of information often leads to incorrect understanding of information and incorrect inputs on the flight deck when participants respond to crew alerts. As the FAA (1996) indicated, displayed safety related warning information has the potential to impact ESL understanding of written English language, especially abbreviated text. In the researcher's study twenty-two percent of participants with RCL proficiency H-level indicated they were negatively impacted by misinterpretation of information, while fourteen percent of participants with RCL proficiency M-level and two percent of participants with RCL proficiency L-level (general English language) indicated negative impacts. Twenty percent of participants with RCL proficiency H-level, seventeen percent of participants with RCL M-level, and two percent of participants with RCL L-level (crew alerting systems, QRH checklists) indicated flight safety was negatively impacted by misinterpretation of information on crew alerting systems and/or QRH checklists. In the researcher's experiment, it will be determined if abbreviations and phrases on crew alerting systems and/or QRH checklists lead participants to misinterpret information. Furthermore, participant English language proficiency will be reviewed to determine if their level of proficiency contributes to their ability to read and understand written English language on crew alerting systems and/or QRH checklists.

Participants (forty-five percent) indicated that written English language on crew alerting systems and/or QRH checklists negatively impact their performance and thus flight safety. In particular, vocabulary words, long sentences, misinterpretation of information and the process of interpreting (use of metacognitive strategies) written English language leads to long response times and negatively impacts participant performance, and thus flight safety. Part of Parry's (1991) study is corroborated in the researcher's study. As Parry (1991) indicated ESL adults indicated more time was needed to understand words in the text that were unfamiliar to them. In the researcher's study, this finding was evident as a factor that influenced participant performance and flight safety. In Parry's (1991) study it was also indicated that adult proficiency levels were low and intermediate.

This finding is not substantiated in the researcher's study. In the researcher's study, twenty five percent of participants with RCL proficiency H-level and twenty percent of participants with RCL proficiency M-level (general English language) indicated their performance and flight safety was negatively impacted. On the other hand, twenty percent of participants each with RCL proficiency H-level and M-level indicated that their performance and flight safety was negatively impacted, while five percent of participants with RCL L-level (crew alerting systems, QRH checklists) indicated negative impacts to their performance and flight safety. It can be concluded that participant proficiency levels are different with respect to how they interpret information and the impact of misinterpretation of written English language on crew alerting systems and QRH checklists. In the researcher's experiment, it will be determined if vocabulary words, long sentences, misinterpretation of information and the process of interpreting (use of metacognitive strategies) written English language on crew alerting systems and/or QRH checklists leads to long response times, and negative impacts to participant performance, and thus flight safety.

Twenty-percent of participants indicated that their decision-making processes were negatively impacted and led to long response times and negative impacts to their understanding of logical flow of information on crew alerting systems and/or QRH checklists. It was noted that eleven percent of participants with RCL proficiency M-level and eight percent of participants with RCL proficiency H-level (general English language) indicated their performance was impacted and thus flight safety. On the contrary, fourteen percent of participants with RCL proficiency M-level and five percent H-level (crew alerting systems, QRH checklists) indicated their performance and flight safety was negatively impacted by written English language on crew alerting systems and/or QRH checklists. In the researcher's experiment, it will be determined if participant decision making processes are negatively impact by reading information on crew alerting systems and/or QRH checklists.

Low percentage of participants (five percent) indicated that logical flow of information on crew alerting systems and/or QRH checklists negatively impact their performance and thus flight safety. It was noted that vocabulary words are sometimes phrases, and long form of the word. This negatively impacts the logical flow of information. According to Dyson (2004), configuration of data may impact reading comprehension of information on paper. Five percent of participants, each with RCL proficiency levels L-level and H-level (general English language) performance was negatively impacted by written English language on crew alerting systems and/or QRH checklists. On the other hand, five percent of participants with RCL proficiencies H-level (crew alerting systems, QRH checklists) indicated their performance was negatively impacted and thus flight safety. During the researcher's experiment, it will be determined if participants were challenged with logical flow of information on crew alerting systems and QRH checklists. It will also be determined if their proficiency level was an indicator of how well they understood information on QRH checklists and crew alerting systems.

Participants (twenty-two percent) indicated that misunderstandings of written English language procedures negatively impact their workload and participants are frustrated with written English language, and confused with written English language on crew alerting systems and/or QRH checklists. These negative performance indicators are the result of participants' misunderstandings of written English language, which negatively impact their decision-making processes, and thus flight safety. As Drury et al's (2003) study indicated, elements of written English language have the potential to cause misunderstandings and confusion for ESL flight crewmembers. Vocabulary words were identified as elements of written English language that has the potential to cause ESL flight crewmembers to misunderstand information. Fourteen percent of participants with RCL proficiency H-level and eight percent of participants with RCL proficiency M-level (general English language) performance and flight safety is negatively impacted. On the other hand, twenty percent of participants with RCL proficiency M-level and two percent of participants with RCL proficiency H-level (crew alerting systems and QRH checklists) indicated their performance is negatively impacted and thus flight safety, when they read written English language. In the researcher's experimental study, it will be determined if participants performance and flight safety was negatively impacted by use of vocabulary words on crew alerting systems and QRH checklists. It will also be determined if participant English language proficiency was a factor that influenced their ability to read and comprehend English language as well as impact flight safety.

Participants (two percent) indicated that improper inputs on the flight deck are due to misunderstanding of information on QRH checklists. As Sallee and Gibbons (1998) indicated in their studies, improper flight deck inputs by ESL flight crewmembers were a result of how they adapted to written English language related to system diagnostics. In the researcher's experiment, it was indicated that two percent of participants with RCL proficiency H-level (general English language) and RCL proficiency H-level (crew alerting systems, QRH checklists) indicated written English language on QRH checklists negatively impact their performance and thus flight safety. In the researcher's experiment, it will be determined if participants make improper inputs on the flight deck and if they are attributed to negative impacts to their performance and thus flight safety. Furthermore, participant English language proficiency will be reviewed with respect to their ability to perform when they read written English language on crew alerting systems and QRH checklists.

Summary

Written English language factors discussed in this section provide an indication that they negatively impact participant performance. Three of the six 'main themes' (misinterpretation of information, long response times, and decision making processes) have been highly regarded as factors that negatively impact participant performance. There is a direct link between written English language negative impacts on participant performance, and the casual factors (design and integration of written English language) that impact flight safety. It was also noted that participant English language proficiency was different. The researcher's experimental study will provide more with respect to participant background knowledge, participant proficiency level, and if the written English language factors identified still have a negative impact on participant performance and flight safety.

Recommendations

Information discussed in this study provided perspectives on written English language essential to understand factors that negatively impact participant ability to read and comprehend information on crew alerting systems and QRH checklists. It was noted on several occasions that participants use metacognitive strategies to read written English language on each of the systems (crew alerting systems and QRH checklists). It was also noted that certain metacognitive strategies are utilized more often than others to read and comprehend written English language on crew alerting systems and QRH checklists. The researcher will discuss metacognitive strategies utilized by participants to read written English language in the experimental study. As many of the written English language factors discussed previously are factors indicated by participants that negatively impact their performance and flight safety, there is a need to further understand the impact on participant performance. Earlier in this study, it was indicated that there were high percentages of participants that indicated certain aspects of written English language (e.g. vocabulary words) negatively impacted their ability to read and comprehend written English language on crew alerting systems and checklists. But, these problems need to be further investigated with respect to participant performance and if these factors negatively impact participant performance and flight safety on the flight deck.

Conclusions

It can be concluded that written English language on crew alerting systems and QRH checklists have been identified as factors that negatively impact ESL flight crewmembers' performance and flight safety. Flight crewmembers' English language proficiency, background knowledge, and metacognitive strategies are factors that influence their ability to read and comprehend written English language on the aforesaid systems (crew alerting systems/QRH checklists). As written English language design and integration has been deemed a critical component that negatively impacts ability of ESL adults to perform on the flight deck, these issues must be further investigated. Therefore, further analysis is needed regarding ESL flight crewmembers' performance with respect to their use of crew alerting systems and QRH checklists on the flight deck.

Chapter 8: Experimental Research Study

Aims

Preliminary studies one and two provided a plethora of data consistent with information in the literature review identifying issues that negatively impact ESL flight crewmembers' performance when they read and comprehend information on crew alerting systems. While background knowledge of text on crew alerting systems and QRH checklists are essential components when understanding ESL flight crewmembers ability to read and comprehend English language, these are only some of the aspects. Metacognitive strategy used to read written English language, English language proficiency and factors that impact reading comprehension (i.e. written English language on crew alerting systems and QRH checklists) need to be further scrutinized in the form of an experiment. The goal of the researcher's experimental study was to determine if ESL flight crewmember reading comprehension was negatively impacted by the use of written English language on crew alerting systems and QRH checklists. The following questions still need to be answered with respect to their use of crew alerting systems and QRH checklists:

1) Do ESL flight crewmembers utilize metacognitive strategies to read and interpret written English language on crew alerting systems? If so, what are the types of metacognitive strategies utilized?

2) What is the effect of written English language design and integration (i.e. crew alerting systems and QRH checklists) on flight crewmembers' performance?

3) Does flight crewmember English language RCL proficiency (general English language, crew alerting systems and QRH checklists) influence their ability to read and comprehend information on crew alerting systems and QRH checklists?

4) What is the effect of ESL flight crewmembers ICAO ELPRs levels (4, 5, or 6) on their ability to read and comprehend written English language on crew alerting systems and QRH checklists?

5) Does background knowledge (e.g. text genre) influence ESL flight crewmembers' ability to read and comprehend written English language?

6) Does design and integration of written English language on crew alerting systems negatively impact flight crewmember performance and thus flight safety?

In order to further substantiate the results previously discussed in studies one and two, and the researcher's literature review, the researcher designed an experiment to test several hypotheses related to ESL flight crewmembers' ability to read and comprehend written English language information on crew alerting systems and QRH checklists.

General Hypothesis

There will be a statistically significant difference between ESL flight crewmember reading comprehension English language proficiency and performance when they read and comprehend written English language on QRH checklists and ECAM systems, and written English language on QRH checklists translated into ESL flight crewmembers' native language.

Experimental Research Study Variables

Independent Variable

- Language: ECAM/QRH checklists

Dependent Variables

- Participant Response time
- Participant Errors of omission
- Participant NASA TLX workload scores

Criteria for Dependent Variables

Regarding criteria that was utilized for participant response time, errors of omission, and NASA TLX workload scores, the following protocol was utilized:

- Reaction Time: Digital stopwatch was used to collect time data in minutes/seconds. Participant response time data was collected at the outset of the ECAM alert annunciation until participants completed the QRH checklist, then participants were instructed to stop the trial and time data was transcribed.

- Errors of omission: During the experimental trials, the researcher had a copy of each QRH checklist (electrical/hydraulic faults), as did the participants. At the outset of the ECAM alert, the researcher highlighted each procedure omission and transcribed amount of omitted procedures per checklist for each participant during the experimental trials. Additionally, if a procedure was omitted, the researcher put an asterisk next to each line of the checklist where the procedure was omitted. If participants omitted procedures on the ECAM system, they were recorded as well. Determination of ECAM procedure omissions was completed during conversations with the participants during the experimental trial debriefs.

- NASA TLX Workload Scores: After each task was completed, the researcher provided a NASA TLX workload-rating sheet for each participant to fill out with respect to each system fault (electrical/hydraulic).

Experimental Hypotheses

The researcher identified the following five specific hypotheses with conditions of the hypotheses that were tested in Table 56. Testing of these hypotheses can be found in the researcher's experimental results section:

Table 56 Listed and described experimental hypotheses

Hypothesis #1 (H_A)	Condition	Null Hypothesis #1 (H_O)
There will be a significant difference between participant performance with use of ECAM (written English language)/written English language QRH checklists and ECAM (written English language)/Portuguese language QRH checklists, and participant response time to electrical and hydraulic system malfunctions.	Participant response time will be slow with use of ECAM (written English language)/written English language QRH checklists and fast with use of ECAM (written English language)/written QRH checklists Portuguese language when participants respond to electrical and hydraulic system malfunctions.	There will not be a significant difference between participant performance with use of ECAM (written English language)/QRH checklists and ECAM (written English language)/written Portuguese language QRH checklists, and participant response time to electrical and hydraulic system malfunctions.
Hypothesis #2 (H_A)	**Condition**	**Null Hypothesis (H_O)**
There will be a significant difference between participant performance with use of ECAM (written English language)/written English language QRH checklists and their NASA Task Loading Index (TLX) workload scores, and when they use the ECAM (written English language)/written Portuguese language QRH checklists and their NASA TLX workload scores.	Participant NASA TLX workload scores will be high with use of ECAM (written English language)/written English language QRH checklists, and participant NASA TLX workload scores will be low with use of ECAM (written English language)/written Portuguese language QRH checklists, when participants respond to electrical and hydraulic system malfunctions.	There will not be a significant difference between participant performance with use of ECAM (written English language)/written English language QRH checklists and ECAM (written English language)/written Portuguese language QRH checklists and participant NASA TLX workload scores, when they respond to electrical and hydraulic system malfunctions.
Hypothesis #3 (H_A)	**Condition**	**Null Hypothesis (H_O)**
There will be a significant difference between participant performance when they use ECAM (written English language)/written English language QRH checklists, and when they use ECAM (English language)/written Portuguese language QRH checklists with respect to participant errors of omission.	Participant errors of omission will be high with use of ECAM (written English language)/written English language QRH checklists, and errors of omission will be low when they use ECAM (English language)/written Portuguese language QRH checklists, when participants respond to electrical and hydraulic system malfunctions.	There will not be a significant difference between participant performance with use of the ECAM (written English language)/written English language QRH checklists and errors of omission, and the ECAM (written English language)/written Portuguese QRH checklists, when participants respond to electrical and hydraulic system malfunctions.
Hypothesis #4 (H_A)	**Condition**	**Null Hypothesis (H_O)**
There will be a significant positive correlation between participant NASA TLX workload scores (ECAM written English language/written Portuguese language QRH checklists) and participant response time (ECAM written English language/written Portuguese language QRH checklists)	As participants' NASA TLX workload scores decrease while using ECAM written English language/written Portuguese language QRH checklists so will their response time using ECAM written English language/written Portuguese language QRH checklists	There will not be a significant positive correlation between participant NASA TLX workload scores (written English language ECAM)/(written English language/written Portuguese language QRH checklists) and participant response time (ECAM written English language/written Portuguese language QRH checklists)
Hypothesis #5 (H_A)	**Condition**	**Null Hypothesis (H_O)**
There will be a significant positive correlation between participant NASA TLX workload scores and their use of written English language ECAM/written English language QRH checklists, and their written English language ECAM/written English language QRH checklists response times.	As participants' NASA TLX workload scores increase while using ECAM written English language/written English language QRH checklists, so will their response time using written English language ECAM/written English language QRH checklists.	There will not be a significant positive correlation between participant NASA TLX workload scores and their use of written English language ECAM/written English language QRH checklists, and their written English language ECAM/written English language QRH checklists response times.

Demographics

The population for this experimental research study was 30 male ESL flight crewmembers (N=30) from Lisbon, Portugal, that currently work for an airline. The term participants will be utilized throughout the experimental study to describe flight crewmembers that participated in the study. Each participant was a certified airline transport pilot flying large transport category aircraft (Airbus A-319/320/321/330/340). Participants learned English language during formal schooling, (middle school or high school), from a western culture or in their country of origin. Their experience with English language was considered background knowledge.

Participant ICAO English language proficiency levels ranged from level four to six. The ICAO English language proficiency level data was gathered as a means of understanding their English language background knowledge. Recall, the researcher's preliminary study showed that ICAO ELPR levels are beneficial to understanding participants' English language proficiency. Although the ICAO English language proficiency levels focus primarily on individual's speaking and listening comprehension abilities, ICAO ELPRs were utilized as a means of collecting participants' English language experience data. Therefore, the ICAO ELPR level for each participant was collected. Additional participant demographics information regarding ICAO ELPR level is provided in the forthcoming tables.

Participants indicated they had experience with use of Portuguese language and they often unilaterally cognitively translate written English information into their native language Portuguese, during non-normal conditions while flying aircrafts. Cognitive (mental) translation is operationally defined as unilaterally translating information into their native language. Cognitive translation by participants was due to situations where they are confident with terminology in written English language equivalent in written Portuguese lexis, which often have equivalent translation on crew alerting systems and QRH checklists. Participants had different reading comprehension methods of cognitively translating written English language vocabulary words or sentences into their native language Portuguese. Participants indicated their competence reading and comprehending Portuguese language was satisfactory in non-technical and technical situations on the flight deck. On the other hand, participants indicated their airline does not translate QRH checklists/crew alerting systems into their native lexis.

ESL flight crewmembers' reading comprehension abilities

Participants rated their written RCL abilities (proficiency) with respect to their general use (reading comprehension) of English written language. Participants also self-rated their English language RCL abilities when reading and interpreting written English language on crew alerting systems and QRH checklists. Recall, participant self-rated English language proficiency levels help understand their ability to read and understand English language. Participant English language proficiency levels were High-level (H-Level) and Medium level (M-level). The researcher assessed each of their proficiency levels. Participants with H-level English language proficiency indicated they understood written English language. Participants with M-level English language proficiency indicated they experienced some challenges with certain vocabulary words in English language.

Participant written English language proficiency levels were categorized as 'general use of English language' (ability to read and comprehend written English language in a non-socio-technical environment), which was related to the their educational experiences with generic reading comprehension of written English language. Additionally, participants' English language proficiency levels were categorized as written English language proficiency on crew alerting systems and QRH checklists (ability to read and comprehend written English language in a socio-technical environment) (i.e. technical information on the flight deck). Participants indicated that information on crew alerting systems and QRH checklists are generally utilized together, therefore they indicated their proficiency levels as such for reading and comprehending information on crew alerting systems and QRH checklists. English language proficiency levels were categorized as such to clearly define differences between participants' general knowledge of English language, and if differences in proficiency level exist with participants' reading comprehension of technical information on the flight deck. Next tables are demographics that illustrate participants' reading comprehension level.

Table 57 Experimental Study Demographics (N=30)

DEMOGRAPHICS	Pilot 1	Pilot 2	Pilot 3	Pilot 4	Pilot 5	Pilot 6	Pilot 7	Pilot 8
Country of Origin	Portugal	Portugal	Portugal	Portugal	Mozambique	Mozambique	Portugal	Portugal
Age	27	43	43	48	42	46	49	50
Airline Years of Experience	6	17	28	15	26	15	27	26
Native Language Spoken	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese
English language learned/Country	High School (U.S.)	High School (Brazil)	Middle School (Portugal)	High School (France)	High School (Spain)	High School (Portugal)	High School (Portugal)	High School (Brazil)
ICAO ELPR Level	Level 4	Level 6	Level 6	Level 5	Level 6	Level 4	Level 5	Level 5
Self-rated English language RCL (General Use of English language)	H-Level	M-Level	H-Level	H-Level	H-Level	H-Level	H-Level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	H-Level	H-Level	H-Level	M-Level	H-Level	H-Level	H-Level	H-Level

Table 58 Experimental Study Demographics continued (N=30)

DEMOGRAPHICS	Pilot 9	Pilot 10	Pilot 11	Pilot 12	Pilot 13	Pilot 14	Pilot 15	Pilot 16
Country of Origin	Angola	Angola	Mozambique	Brazil	Portugal	Portugal	Portugal	Portugal
Age	49	50	66	51	42	50	49	52
Airline Years of Experience	22	18	37	20	14	20	21	15
Native Language Spoken	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese
English language learned/Country	Middle School (Brazil)	Middle School (Portugal)	High School (Brazil)	High School (Portugal)	High School (Brazil)	High School (Portugal)	High School (Portugal)	High School (Portugal)
ICAO ELPR Level	Level 5	Level 5	Level 5	Level 6	Level 4	Level 5	Level 6	Level 5
Self-rated English language RCL (General Use of English language)	H-Level	H-Level	M-Level	M-Level	H-Level	H-Level	H-Level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	M-Level	H-Level	H-level	H-Level	H-Level	H-Level	H-Level	H-Level

Table 59 Experimental Study Demographics continued (N=30)

DEMOGRAPHICS	Pilot 17	Pilot 18	Pilot 19	Pilot 20	Pilot 21	Pilot 22	Pilot 23	Pilot 24
Country of Origin	Portugal	Portugal	Portugal	Portugal	Portugal	Mozambiq ue	Mozambique	Portugal
Age	52	57	54	52	41	55	37	52
Airline Years of Experience	26	24	43	40	28	26	9	26
Native Language Spoken	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese
English language learned/Country	Middle School (Portugal)	Middle School (Brazil)	Middle School (Brazil)	High School (Spain)	High school (U.S.)	High School (Portugal)	High School (Brazil)	High School (Portugal)
ICAO ELPR Level	Level 6	Level 5	Level 6	Level 6	Level 5	Level 6	Level 6	Level 5
Self-rated English language RCL (General Use of English language)	H-Level	H-Level	H-Level	H-Level	H-Level	H-Level	H-Level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	H-Level	H-Level	H-Level	H-Level	H-Level	H-Level	H-Level	M-Level

Table 60 Experimental Study Demographics Continued (N=30)

DEMOGRAPHICS	Pilot 25	Pilot 26	Pilot 27	Pilot 28	Pilot 29	Pilot 30
Country of Origin	Portugal	Portugal	Portugal	Portugal	Portugal	Portugal
Age	34	47	50	41	53	53
Airline Years of Experience	25	30	34	26	18	40
Native Language Spoken	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese	Portuguese
English language learned/Country	Middle School (Portugal)	Middle School (Portugal)	High School (Portugal)	High School (Brazil)	High School (Brazil)	High School (Brazil)
ICAO ELPR Level	Level 5	Level 5	Level 4	Level 5	Level 6	Level 5
Self-rated English language RCL (General Use of English language)	H-Level	H-Level	H-Level	H-Level	H-level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	H-Level	M-Level	M-Level	H-Level	H-level	H-level

Table 61 ESL flight crewmembers general demographics

Demographic	Percentages
Country of Origin	22/30: ~73.3% Lisbon, Portugal 5/30: ~16.6% Mozambique 2/30: ~ 6.6% Angola 1/30: ~ 3.3% Brazil
Age (average/minimum/maximum)	Average: ~ 47.83 years old Minimum Age= 27 years old Maximum Age= 66 years old
Airline Years of Experience (average)	~24.06 years of airline experience
Native Language Spoken	30/30=100% Portuguese Language

Methodology

The researcher developed a within subjects (repeated measures) experimental design to assess the impact of written English language on crew alerting systems and QRH checklists. Thirty (N=30) male ESL flight crewmembers participated in the study, which was conducted in Lisbon, Portugal, completing a 60-minute experimental session. Most participants' country of origin was Lisbon, Portugal and their first language was Portuguese, while eight participants' country of origin was different (i.e. Angola, Brazil, Mozambique). All participants met the minimum ICAO level 4 operational ELPRs. There were five participants that participated in the study each day, and their participation lasted one hour. Prior to the start of the experimental trials, a thirty-minute overview of the simulated A-320 flight deck equipment/software interfaces was conducted with each participant. The overview was conducted so that participants were familiar with software and hardware functions. Each participant indicated they did not experience any issues with operation of the simulation hardware and software equipment.

Each of the participants piloted the A-320 simulated flight deck for thirty minutes while the researcher injected electrical (ATA 24 Electrical faults) and hydraulic (ATA 29

Hydraulic faults) system faults during the cruise phase of flight. Aforesaid faults were utilized since many participants in the researcher's preliminary studies indicated these were challenging crew alerts/checklists. Furthermore, review of system failure mode data from safety manuals indicated these crew alerts/QRH checklists contained many pieces of written English language. Debriefs were conducted after the experimental trials were completed. Goal of the debriefs was to determine if participants noted any issues regarding their reading comprehension of written English language on crew alerting systems and QRH checklists during the experimental trials, and if their performance was impacted. Analysis of data collected during the experimental trials consisted of parametric tests, which were utilized to test each of the researcher's hypotheses. Analysis was conducted using the Statistical Package for Social Science (SPSS) software.

The following research design was developed for the researcher's experimental study. The experimental design was counterbalanced to ensure there was not a participant practice effect confound in the data. As previously stated, this research study was within subjects (repeated measures) design. Essentially, column one provides participant number, while column two provides the order by which the control/experimental trial was conducted. Column three provides ECAM English language/QRH checklist English language (Control Group), the ECAM was not translated it remained in written English language format. Column four is ECAM English language/QRH checklist Portuguese language. *Note: On the Portuguese language QRH checklists, technical terms (abbreviations, phrases and acronyms) were not translated if they did not have an equivalent meaning in Portuguese language. This is important since the literature review indicated participant reading comprehension would be negatively impacted. Therefore, this factor was taken into consideration to ensure the experimental trials were completed successfully. Particularly, if information on the Portuguese checklists related to flight deck labels, panels, and switches were translated, and they had no equivalent meaning in Portuguese language, it would be difficult for participants' mental model (relationship between Portuguese checklists and English language flight deck nomenclature). On the other hand, abbreviations, acronyms, and phrases on the Portuguese language QRH checklist (i.e. notes section (safety assurance information) were translated if there was an equivalent meaning in Portuguese language. More information on the translated QRH checklists will be reviewed in a forthcoming section.

Table 62 Control and Experimental Groups

	Order	Control Group: (ECAM English language)/QRH checklist English language)	Experimental Group: (ECAM English language)/(QRH checklist Portuguese language; except technical terms*)
Participant number			
1	Do Control First	Hyd	Electrical
2	Do Control First	Electrical	Hyd
3	Do experimental trial first	Hyd	Electrical
4	Do experimental trial first	Electrical	Hyd
5	Do Control First	Hyd	Electrical
6	Do Control First	Electrical	Hyd
7	Do experimental trial first	Hyd	Electrical
8	Do experimental trial first	Electrical	Hyd
9	Do Control First	Hyd	Electrical
10	Do Control First	Electrical	Hyd
11	Do experimental trial first	Hyd	Electrical
12	Do experimental trial first	Electrical	Hyd
13	Do Control First	Hyd	Electrical
14	Do Control First	Electrical	Hyd
15	Do experimental trial first	Hyd	Electrical
16	Do experimental trial first	Electrical	Hyd
17	Do Control First	Hyd	Electrical
18	Do Control First	Electrical	Hyd
19	Do experimental trial first	Hyd	Electrical
20	Do experimental trial first	Electrical	Hyd
21	Do Control First	Hyd	Electrical
22	Do Control First	Electrical	Hyd
23	Do experimental trial first	Hyd	Electrical
24	Do experimental trial first	Electrical	Hyd
25	Do Control First	Hyd	Electrical
26	Do Control First	Electrical	Hyd
27	Do experimental trial first	Hyd	Electrical
28	Do experimental trial first	Electrical	Hyd
29	Do Control First	Hyd	Electrical
30	Do Control First	Electrical	Hyd

See previous paragraph with Note: regarding technical terms

Note: HYD=Hydraulic system Fault

Note: Electrical=Electrical System Fault

English Language text corpora profile method overview and featured crew alerting system #1 and QRH checklist #1

As the literature review indicated, it is important to profile (pre-evaluate) English language to ensure understanding of text genre type and type of vocabulary words in English language text. The researcher developed two paradigms, (Table 63 and Table 64) which provide the reader with information about English language text utilized in the researcher's experimental study. Both paradigms are an overview of ECAM crew alerting system number one QRH checklist number one, and ECAM crew alerting system number two QRH checklist number two. English language found on the electrical system ECAM and QRH electrical system fault checklist was authentic texts (written English language unchanged from its certified original version from the airline). The airline association representative (flight crewmembers union) provided an assessment of the authentic texts utilized fort the experimental study. The assessment included reviewing approved regulatory signatures on airline documentation to ensure texts (i.e. QRH checklists) were certified, as well as reviewing texts to ensure they were utilized on each of the aircraft that participants fly (i.e. A-320/330). Assessment revealed the texts were unchanged from their original version, which was certified by the airline's regulatory agency. In particular, each ECAM system English language text was not simplified, sentence length was not changed, number of tokens was not altered, and English language format on the display screen, and QRH checklists was not changed. As the literature review indicated, if any of the aforesaid processes were utilized prior to the execution of the researcher's experimental study, it could have impacted participant performance. Therefore, the researcher did not change authentic text that was provided by the airline for the experimental study. Regarding the authentic texts (electrical system fault and hydraulic system fault) the text corpora on each QRH checklist and ECAM system vocabulary words were italicized, upper case, lower case, plain text, different fonts, such as underline, size, bold texts, and different forms of vocabulary words that have the same meaning (e.g. CONFIG, configuration, and CONF and GEN, generator). This is an indication that the authentic texts information was designed differently. Finally, each of the QRH checklists contained many conditional statements and their form/function did not follow the prescribed method as indicated in the researcher's literature review. Furthermore, conditional statements contained enhanced text (e.g. italicized text).

English language texts found on the ECAM crew alerting system number one, QRH checklist one, and ECAM crew alerting system number two, QRH checklist number two was technical information (text genre), included nine different vocabulary word types. Text on the ECAM systems and QRH checklists were expository (informational) and instructional text (to do list). Both QRH checklists (electrical and hydraulic systems) contained conditional statements. To understand the types of vocabulary words that participants needed to read and comprehend on each of the systems, Table 63 and Table 64 provide the researcher's transcription template regarding number of vocabulary word types evaluated on each of the systems. Located in Table 63 and Table 64 is the acronym 'to be determined' or 'TBD', which was utilized as a place holder to convey number of words that would be analyzed in the researcher's forthcoming section named 'Analysis Results Part 1 and 2 (English language text corpora preview: crew alerting system #1, QRH checklist #1, crew alerting system #2 QRH checklist #2)'. Refer to this section for number of vocabulary word types on each of the texts.

Finally, the researcher's process for categorizing each vocabulary word was called, 'match the vocabulary word to the crew alerting system and QRH checklist'. This process required a review of the authority reference (i.e. GSLEW, AWL and headwords) to ensure adequate mapping of the of the vocabulary word type on crew alerting systems and QRH checklists to the authority reference. Since the literature review provided the reader with an understanding of the types of authority references utilized to map vocabulary words, vocabulary word types are listed as such to identify the number of words in text corpora on each of the systems (See Table 63 and Table 64). The following authority references were utilized for profiling the English language texts with respect to electrical and hydraulic faults:

- GSLEW (high frequency words)
- AWL (headwords and associated word family)

- Airline A-320 Flight Crew Training Manual (FCTM) and related definitions and operational philosophy sections (long form/short form abbreviations/acronyms)
- A-320 ECAM system (sub-technical/technical/scientific vocabulary words)
- A-320 QRH, A-320 ELEC EMER CONFIG (ECAM/QRH) (sub-technical/technical/scientific vocabulary words)
- A-320 HYD B+Y SYS LO PR (ECAM/QRH) (sub-technical/technical/scientific vocabulary words)

Aforesaid ECAM system and related documentation were utilized to identify sub-technical, technical/scientific words, phrases, abbreviations and acronyms. Regarding phrases, abbreviations, and acronyms (non-technical) found on QRH checklists and ECAM system, the researcher referenced the long form of the word to ensure the aforesaid words were accurate. The researcher utilized the following detailed process to analyze written English language on the ECAM system and QRH checklists:

First, the researcher crossed out numbers and punctuation that appeared on the QRH checklists, and then the researcher omitted punctuation and numbers that appeared on the ECAM screen, since these aspects are not applicable for this analysis. Third, the researcher counted and transcribed total number of words on the ECAM system/QRH checklists. Finally, the researcher used the following highlighter pens to identify vocabulary words types found on the ECAM system/QRH checklists literature when they mapped the vocabulary word type to the authority reference:

- Highlighter Pen Grey=AWL academic words
- Highlighter Pen Orange=GSLEW high frequency words
- Highlighter Pen Light Brown=low frequency words*
- Highlighter Pen Yellow=sub-technical vocabulary words**
- Highlighter Pen Pink=technical/scientific vocabulary words**
- Highlighter Pen Light Blue=technical/scientific acronyms
- Highlighter Pen Light Red=technical/scientific abbreviations/phrases
- Highlighter Pen Light Purple= non-technical vocabulary words (abbreviations/phrases) (GSLEW/AWL)
- Highlighter Pen Light Green=non-technical vocabulary words (acronyms) (GSLEW/AWL)

After the researcher completed the analysis results were reviewed (number of vocabulary words based on highlighting) to ensure the ECAM/QRH checklist vocabulary words match the authority references.

*Researcher counted low frequency words after the aforesaid vocabulary words were counted (e.g. GSLEW, AWL), which left the remainder of less frequently occurring words in text corpora (ECAM and QRH checklist). These vocabulary words were also reviewed and mapped against the authority references (e.g. GSLEW, AWL) to ensure they were not located in any of the authority references.

**Researcher utilized system descriptions information in each of the aforementioned authority references to determine if each word identified on the ECAM/QRH checklist was technical or sub-technical. For example, the word 'hydraulic' is applicable in industries other than aviation/aerospace and therefore was considered a 'sub-technical word'. Regarding technical words, (i.e. 'slats, flaps'), these types of words were considered technical because they can only be found in aviation/aerospace, and are applicable to a specific part, system, or subsystem on the aircraft. Regarding technical/scientific phrases (i.e. aircraft spoilers (A/C SPLRS) or technical/scientific acronyms (i.e. A/C GPWS), these types of words were considered technical because they are found in aviation/aerospace.

Table 63 English Text Profile: flight deck crew alerting and information systems (Electrical System Fault)

ECAM Crew Alerting system #2: ATA 24 Electrical Faults	
Vocabulary Word Type	**Frequency**
GSLEW high frequency vocabulary words	TBD
AWL Academic vocabulary Words (Phrases)	TBD
Low Frequency Vocabulary Words	TBD
Sub-technical Vocabulary Words	TBD
Technical/Scientific Vocabulary Words	TBD
Technical/Scientific Abbreviations/ Phrases	TBD
Technical/Scientific Acronyms	TBD
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	TBD
Non-technical Acronyms (GSLEW/ AWL)	TBD

QRH Checklist #2: ATA 24 Electrical Faults	
Vocabulary Word Type	**Frequency**
GSLEW high frequency vocabulary words	TBD
AWL Academic vocabulary (Words/ Phrases)	TBD
Low Frequency (LF) Vocabulary Words (Words/Phrases/Acronyms)	TBD
Sub-technical (ST) Vocabulary Words (Word/Phrases/Acronyms)	TBD
Technical/Scientific Vocabulary Words	TBD
Technical/Scientific Abbreviations/ Phrases	TBD
Technical/Scientific Acronyms	TBD
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	TBD
Non-technical Acronyms (GSLEW/ AWL)	TBD

English language Text Corpora Profile Method-Crew alerting system #2 and QRH checklist #2

Table 64 English Text Profile: flight deck crew alerting and information systems (Hydraulic System Fault)

ECAM Crew Alerting system #2: ATA 29 Hydraulic Faults	
Vocabulary Word Type	**Frequency**
GSLEW high frequency vocabulary words	TBD
AWL Academic vocabulary Words (Phrases)	TBD
Low Frequency Vocabulary Words	TBD
Sub-technical Vocabulary Words	TBD
Technical/Scientific Vocabulary Words	TBD
Technical/Scientific Abbreviations/Phrases	TBD
Technical/Scientific Acronyms	TBD
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	TBD
Non-technical Acronyms (GSLEW/AWL)	TBD

QRH Checklist #2: ATA 29 Hydraulic Faults	
Vocabulary Word Type	**Frequency**
GSLEW high frequency vocabulary words	TBD
AWL Academic vocabulary Words (Phrases)	TBD
Low Frequency Vocabulary Words	TBD
Sub-technical Vocabulary Words	TBD
Technical/Scientific Vocabulary Words	TBD
Technical/Scientific Abbreviations/Phrases	TBD
Technical/Scientific Acronyms	TBD
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	TBD
Non-technical Acronyms (GSLEW/AWL)	TBD

Analysis Results Part 1 (English language Text Corpora Preview-Crew alerting systems #1 and QRH checklist #1)

Results from the researcher's analysis of ECAM system and QRH checklist (electrical system fault) indicated there were many vocabulary word types on the ECAM system and QRH checklist. The following results are for the ECAM system electrical system fault. There were 117 vocabulary words on the ECAM electrical system fault pages. There were high frequency words, low frequency words, academic words, sub-technical vocabulary words, technical/scientific vocabulary words, and non-technical vocabulary words that were identified by the researcher. Of the 117 vocabulary words 41 were high frequency, 7 academic, 5 low frequency, 10 sub-technical, 5 technical/scientific (words), 7 technical/scientific (abbreviations/phrases), 13 technical/scientific (acronyms), 19 non-technical abbreviations/phrases (high frequency), 4 academic, 4 non-technical acronyms (high frequency) and, 2 academic.

Regarding the QRH checklist (electrical system fault), there were many vocabulary word types, including high frequency, low frequency, academic, sub-technical, and non-technical vocabulary words identified by the researcher. There were 320 words on the electrical fault QRH checklist. Of the 320 vocabulary words 145 were high frequency, 33 academic words, 4 academic word phrases, 58 low frequency words, 18 low frequency phrases, 1 low frequency acronym, 5 sub-technical words, 13 sub-technical phrases, 3 sub-technical acronyms, 6 technical/scientific words, 2 technical/scientific phrases/abbreviations, 24 technical/scientific acronyms, 7 non-technical abbreviations/phrases (high frequency words), 1 academic word. There were no non-technical acronyms (high frequency/academic words).

Below is Table 65, which conveys number of vocabulary word types on the ECAM crew alerting system (hydraulic system fault) and number of vocabulary words types on the QRH checklist (hydraulic system fault).

Table 65 Electrical System Fault Vocabulary Words

ECAM Crew Alerting system #2: ATA 24 Electrical Faults	
Vocabulary Word Type	**Frequency**
GSLEW high frequency vocabulary words	41
AWL Academic vocabulary Words (Phrases)	7
Low Frequency Vocabulary Words	5
Sub-technical Vocabulary Words	10
Technical/Scientific Vocabulary Words	5
Technical/Scientific Abbreviations/ Phrases	7
Technical/Scientific Acronyms	13
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	19 GSLEW/4 AWL
Non-technical Acronyms (GSLEW/ AWL)	4 GSLEW/2 AWL

QRH Checklist #2: ATA 24 Electrical Faults	
Vocabulary Word Type	**Frequency**
GSLEW high frequency vocabulary words	145
AWL Academic vocabulary (Words/ Phrases)	33 AWL Words/4 AWL Phrases
Low Frequency (LF) Vocabulary Words (Words/Phrases/Acronyms)	58 LF Words/18 LF Phrases/ 1 LF Acronym
Sub-technical (ST) Vocabulary Words (Word/Phrases/Acronyms)	5 ST Words/ 13 ST phrases/ 3 ST Acronyms
Technical/Scientific Vocabulary Words	6
Technical/Scientific Abbreviations/ Phrases	2
Technical/Scientific Acronyms	24
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	7 GSLEW/1 AWL
Non-technical Acronyms (GSLEW/ AWL)	0/0

Inter-rater reliability

To ensure the researcher did not have any bias when categorizing vocabulary word types inter-rater reliability analysis was conducted to ensure rater agreement in the data collected. The researcher consulted two ESL flight crewmembers with ATP ratings to review each theme created by the researcher. They had a background in flight crew operations and utilized QRH checklists and ECAM messages on the flight deck daily in their careers. The researcher developed a process named ‘match the vocabulary word to the crew alerting system and QRH checklist’. This process required a review of the authority reference (i.e. GSLEW, AWL) to ensure adequate mapping of the vocabulary word type on crew alerting systems and QRH checklists to the authority reference. Each ESL flight crewmember utilized the following references to map the vocabulary word on the ECAM/QRH electrical system fault checklist to the authority reference:

- GSLEW (high frequency words)
- AWL academic words (headwords and associated word family)
- Low frequency words (no authority reference)*
- Airline A-320 FCTM, QRH checklist
- A-320 ELEC EMER CONFIG (ECAM/QRH) sections applicable to related fault (e.g. schematics)
    - Sub-technical, and technical/scientific vocabulary words including acronyms and abbreviations were counted and cross-referenced to the ECAM/QRH checklist

- A-320 HYD B+Y SYS LO PR (ECAM/QRH) sections applicable to related fault (e.g. schematics)
    - Sub-technical, and technical/scientific vocabulary words including acronyms and abbreviations were counted and cross-referenced to the ECAM/QRH checklist

First, each ESL flight crewmember crossed out numbers and punctuation that appeared on the QRH checklist, and then the flight crewmember omitted numbers and punctuation on the ECAM system, as they were not applicable for this analysis. Second, each flight crewmember counted and transcribed total number of words on the ECAM/QRH checklist. Finally, each flight crewmember used the following highlighter pens to identify vocabulary words types on the ECAM/QRH checklist and then cross-referenced vocabulary word type to the authority reference:

- Highlighter Pen Grey=AWL academic words
- Highlighter Pen Orange=GSLEW high frequency words
- Highlighter Pen Light Brown=low frequency words*
- Highlighter Pen Yellow=sub-technical vocabulary words**
- Highlighter Pen Pink=technical/scientific vocabulary words**
- Highlighter Pen Light Blue=technical/scientific acronyms
- Highlighter Pen Light Red=technical/scientific abbreviations/phrases
- Highlighter Pen Light Purple= non-technical vocabulary words (abbreviations/phrases) (GSLEW/AWL)
- Highlighter Pen Light Green=non-technical vocabulary words (acronyms) (GSLEW/AWL)

After the researcher collected the results from the exercise, the researcher reviewed the results (transcribed numbers/number of vocabulary words based on highlighting) to ensure the ECAM/QRH checklist vocabulary words matched the authority references. The researcher utilized Cohen's Kappa coefficient to analyze the raters' results. Results for the electrical system fault (ECAM) vocabulary words indicated Cohen's Kappa coefficient was $k=0.57$ which indicates moderate-substantial agreement on the Kappa scale. Regarding the electrical system fault (QRH checklist) vocabulary words Cohen's Kappa coefficient was *k=1* indicating excellent inter-rater reliability. Table 66 and Table 67 provide a review of the Cohen Kappa coefficient analysis. The reasons for disagreement among raters could be that vocabulary words that do not have authority references (i.e. low frequency words) and those that relate to FCTM and QRH checklists (i.e. sub-technical words) have a different meaning between raters, with respect to their perspectives on system descriptions and design nomenclature. An established authority reference these types of vocabulary words on crew alerting systems and QRH checklists may help facilitate better agreement between raters. Nevertheless, it can be considered a reliable method to code information with respect to vocabulary words.

*ESL flight crewmembers counted low frequency words after the aforesaid vocabulary words were counted (e.g. GSLEW, AWL), which left the remainder of less frequently occurring words in text corpora (ECAM and QRH checklist). These words were also reviewed and mapped against the authority references (e.g. GSLEW, AWL) to ensure they were not located in any of the authority references.

**ESL flight crewmembers utilized system descriptions information in the each of the aforementioned authority references to determine if each word identified on the ECAM/QRH checklist was technical or sub-technical. For example, the word 'hydraulic' is applicable in industries other than aviation/aerospace and therefore was considered a 'sub-technical word'. Regarding technical words, (i.e. 'slats, flaps'), these types of words were considered technical because they can only be found in aviation/aerospace, and are applicable to a specific part, system, or subsystem on the aircraft. Regarding technical/scientific phrases (i.e. A/C SPLRS) or technical/scientific acronyms (i.e. A/C GPWS), these types of words were considered technical because they are found in aviation/aerospace.

Table 66 Cohen's Kappa coefficient inter-rater reliability analysis ECAM (electrical system fault) vocabulary words analysis

Category: ECAM (Electrical Fault)	Rater 1	Rater 2	Agreement		Agreement Scale/Nomenclature
AWL Words	1	1	1		1=agreement between raters
GSLEW Words	1	1	1		1=agreement between raters
Low Frequency Words	0	0	1		1=agreement between raters
Sub-technical Words	0	0	1		1=agreement between raters
Technical/Scientific Words	1	1	1		1=agreement between raters
Technical/Scientific acronyms	1	1	1		1=agreement between raters
Technical/Scientific abbreviations/phrases	0	0	1		1=agreement between raters
Non-technical Words (abbreviations/phrases GSLEW/AWL)	0	1	0		0=Non-agreement between raters
Non-technical Words (acronyms GSLEW/AWL)	0	1	0		0=Non-Agreement between raters
Authority References: FCTM, QRH, ECAM, AWL, and GSLEW				MATCH	7
				TOTAL	9
				ARR Percent	78%
		Rater 2			
		0	1		
Rater 1	0	3	2	5	56%
	1	0	4	4	44%
		3	6	9	
		33%	67%		
1=Agreement					
0=No Agreement					
REFERENCES					
Cohen's Kappa=					
k=Probability of agreement observed-Probability of agreement based on chance/1-Probability of agreement based on chance					
k=(Pr((a)-Pr(e))/1(1-Pr(e))					
Pr (a)	0.777777778				
Pr (e)		0.481481481			
k=	0.571428571				

Table 67 Cohen's Kappa coefficient inter-rater reliability analysis QRH checklist (electrical system fault) vocabulary words analysis

Category: QRH Checklist (Electrical Fault)	Rater 1	Rater 2	Agreement		Agreement Scale/Nomenclature
AWL Words	1	1	1		1=agreement between raters
GSLEW Words	1	1	1		1=agreement between raters
Low Frequency Words	1	1	1		1=agreement between raters
Sub-technical Words	1	1	1		1=agreement between raters
Technical/Scientific Words	1	1	1		1=agreement between raters
Technical/Scientific acronyms	1	1	1		1=agreement between raters
Technical/Scientific abbreviations/phrases	1	1	1		1=agreement between raters
Non-techncial Words (abbreviations/phrases GSLEW/AWL)	0	0	1		1=agreement between raters
Non-technical Words (acronyms GSLEW/AWL)	0	0	1		1=agreement between raters
Authority References: FCTM, QRH, ECAM, AWL, and GSLEW				MATCH	9
				TOTAL	9
				ARR Percent	100%
		Rater 2			
		0	1		
Rater 1	0	2	0	2	22%
	1	0	7	7	78%
		2	7	9	
		22%	78%		
1=Agreement					
0=No Agreement					
REFERENCES					
Cohen's Kappa=					
k= Probability of agreement observed-Probability of agreement based on chance/1-Probability of agreement based on chance					
k=(Pr(a)-Pr(e))/(1-Pr(e))					
Pr (a)	1				
Pr (e)		0.654320988			
k=			1		

Analysis Results Part 2 (English language Text Corpora Preview-Crew alerting system #2, QRH checklist #2)

Results from the researcher's analysis of ECAM system and QRH checklist (hydraulic system fault) indicated there were many vocabulary word types on the ECAM system and QRH checklist. The following results are for the ECAM system (hydraulic system fault). There were 131 vocabulary words on the ECAM system and reading design style was from left to right. There were high frequency words, low frequency words, academic words, sub-technical vocabulary words, technical/scientific vocabulary words, and non-technical vocabulary words that were identified by the researcher. Of the 131 vocabulary words, 34 were high frequency words, 4 academic vocabulary words, 3 low frequency vocabulary words, 8 sub-technical vocabulary words, 14 technical/scientific vocabulary words, 4 technical/scientific abbreviations/phrases, 17 technical/scientific acronyms, 17 non-technical abbreviations/phrases (high frequency)/7 non-technical abbreviations/phrases (academic), 14 non-technical acronyms (high frequency)/9 non-technical acronyms (academic).

There were 270 vocabulary words on the QRH checklist (hydraulic system fault). There were high frequency words, low frequency words, academic words, sub-technical vocabulary words, technical/scientific words, and non-technical vocabulary words that were identified by the researcher. Of the 270 vocabulary words, 145 were high frequency words, 29 academic words, 40 low frequency words, 13 sub-technical vocabulary words, 17 scientific/technical vocabulary words, 0 technical/scientific phrases/abbreviations, 3 technical/scientific acronyms, 22 high frequency non-technical abbreviations/phrases and 1 academic vocabulary word. Finally, there were 0 non-technical acronyms (high frequency/academic).

Below is Table 68, which conveys number of vocabulary word types on the ECAM crew alerting system (hydraulic system fault) and number of vocabulary words types on the QRH checklist (hydraulic system fault).

Table 68 Hydraulic System Fault Vocabulary Words

ECAM Crew Alerting system #2: ATA 29 Hydraulic Faults	
Vocabulary Word Type	Frequency
GSLEW high frequency vocabulary words	34
AWL Academic vocabulary Words (Phrases)	4
Low Frequency Vocabulary Words	3
Sub-technical Vocabulary Words	8
Technical/Scientific Vocabulary Words	14
Technical/Scientific Abbreviations/Phrases	4
Technical/Scientific Acronyms	17
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	17 GSLEW/7 AWL
Non-technical Acronyms (GSLEW/AWL)	14 GSLEW/9 AWL

QRH Checklist #2: ATA 29 Hydraulic Faults	
Vocabulary Word Type	Frequency
GSLEW high frequency vocabulary words	145
AWL Academic vocabulary Words (Phrases)	29
Low Frequency Vocabulary Words	40
Sub-technical Vocabulary Words	13
Technical/Scientific Vocabulary Words	17
Technical/Scientific Abbreviations/Phrases	0
Technical/Scientific Acronyms	3
Non-technical Abbreviations/ Phrases (GSLEW/AWL)	22 GSLEW/1 AWL
Non-technical Acronyms (GSLEW/AWL)	0

Inter-rater reliability

Previous process/exercise identified by the researcher for inter-rater reliability was also utilized for analysis of English language text corpora on the ECAM/QRH checklist (hydraulic system fault). After the researcher collected the results from the exercise, the researcher reviewed the results (tabulations/number of vocabulary words based on highlighting) to ensure the ECAM/QRH checklist vocabulary words match the authority references. The researcher utilized Cohen's Kappa coefficient to analyze the raters' results. Results indicated Cohen's Kappa coefficient was *k=.55* for ECAM vocabulary words (hydraulic system fault) which indicates moderate agreement between raters and *k=1* for the QRH checklist (hydraulic system fault) which indicates excellent agreement between raters. Next tables provide Cohen's Kappa analyses. The reasons for disagreement among raters could be that vocabulary words that do not have authority references (i.e. low frequency words) and those that relate to FCTM and QRH checklists (i.e. sub-technical words) have a different meaning between raters, with respect to their perspectives on system descriptions and design nomenclature. An established authority reference on crew alerting systems and QRH checklists may help facilitate better agreement between raters. Nevertheless, it can be considered a reliable method to code information with respect to vocabulary words.

Table 69 Cohen's Kappa coefficient inter-rater reliability analysis ECAM (hydraulic system fault) vocabulary words analysis

Category: ECAM (Hydraulic Fault)	Rater 1	Rater 2	Agreement		Agreement Scale/Nomenclature
AWL Words	1	1	1		1=agreement between raters
GSLEW Words	1	1	1		1=agreement between raters
Low Frequency Words	1	0	0		0=non-agreement between raters
Sub-technical Words	0	0	1		1=agreement between raters
Technical/Scientific Words	0	0	1		1=agreement between raters
Technical/Scientific acronyms	1	1	1		1=agreement between raters
Technical/Scientific abbreviations/phrases	1	1	1		1=agreement between raters
Non-technical Words (abbreviations/phrases GSLEW/AWL)	0	1	0		0=non-agreement between raters
Non-technical Words (acronyms GSLEW/AWL)	0	0	1		1=agreement between raters
Authority References: FCTM, QRH, ECAM, AWL, and GSLEW				MATCH	7
				TOTAL	9
				ARR Percent	78%
		Rater 2			
		0	1		
Rater 1	0	3	1	4	44%
	1	1	4	5	56%
		4	5	9	
		44%	56%		
1=Agreement					
0=No Agreement					
REFERENCES					
Cohen's Kappa=					
k=Probability of agreement observed-Probability of agreement based on chance/1-Probability of agreement based on chance					
k=(Pr((a)-Pr(e))/1(1-Pr(e))					
Pr (a)	0.777777778				
Pr (e)	0.50617284				
k=	0.55				

Table 70 Cohen's Kappa coefficient inter-rater reliability analysis QRH checklist (hydraulic system fault) vocabulary words analysis

Category: QRH Checklist (Hydraulic Fault)	Rater 1	Rater 2	Agreement		Agreement Scale/Nomenclature
AWL Words	1	1	1		1=agreement between raters
GSLEW Words	1	1	1		1=agreement between raters
Low Frequency Words	1	1	1		1=agreement between raters
Sub-technical Words	1	1	1		1=agreement between raters
Technical/Scientific Words	1	1	1		1=agreement between raters
Technical/Scientific acronyms	0	0	1		1=agreement between raters
Technical/Scientific abbreviations/phrases	1	1	1		1=agreement between raters
Non-techncial Words (abbreviations/phrases GSLEW/AWL)	1	1	1		1=agreement between raters
Non-technical Words (acronyms GLLEW/AWL)	1	1	1		1=agreement between raters
Authority References: FCTM, QRH, ECAM, AWL, and GSLEW				MATCH	9
				TOTAL	9
				ARR Percent	100%
		Rater 2			
		0	1		
Rater 1	0	1	0	1	11%
	1	0	8	8	89%
		1	8	9	
		11%	89%		
1=Agreement					
0=No Agreement					
REFERENCES					
Cohen's Kappa=					
k= Probability of agreement observed-Probability of agreement based on chance/1-Probability of agreement based on chance					
k=(Pr(a)-Pr(e))/(1-Pr(e))					
Pr (a)	1				
Pr (e)		0.802469136			
k=			1		

Summary

As the literature review suggested, previewing written English language text corpora is essential, especially when English as-a-second language adults read and comprehend English language. As there were many vocabulary words on the crew alerting systems and QRH checklists, and there were different types of vocabulary words, this is an indication that these words could have an impact on participant performance when completing an experimental trial. As indicated in West (1953), the GSLEW (high frequency words) in text requires the ESL adult to know at least 2,000 words. In each of the texts, and the total number of high frequency words in the texts, the number of words was below the threshold of 2,000, as suggested by West (1953). As indicated by Coxhead (1998), academic words and sub-technical words can be found in text (e.g. academic). In the texts chosen by the researcher, they contained many academic words and sub-technical words. This is an indication that these types of words can be found in technical information (crew alerting systems and QRH checklists). As low frequency words occur less frequently in text, this was the case in the researcher's text, when compared to other words in text.

Regarding technical words/acronyms/phrases, there were many of these types of words on each of texts. As Coady and Huckin (1997), Chung and Nation (2004) indicated, technical words are required to be known by ESL adults based on their training and background knowledge of the technical field. Technical vocabulary has the potential to cause difficulties with ESL adult interpretation when reading text that is considered technical. It was also indicated that their proficiency is a key factor that influences their ability to read and interpret technical information. Regarding text layout, ECAM and QRH checklists had different layouts with respect to data presentation. As previously stated, abbreviations, acronyms, and phrases appeared differently in format, with respect to ECAM and QRH checklists. As indicated by Hartley (1994), abbreviations and acronyms should be designed adequately so that technical information on checklists may be followed by ESL flight crewmembers, and thus allowing them to respond effectively to an alert. According to Dyson (2004), configuration of data may impact reading comprehension of information on paper. Configuration of data can also impact ESL flight crewmembers information processing on displayed crew alerts. During the out brief of the experimental trials, a questionnaire will be provided to participants followed by personalized conversations with participants. Conversations between the researcher and participants about their performance using the ECAM and QRH checklists during experimental trials occurred during the debrief session. Information on interview schedule questionnaires determined if written English language negatively impacted their reading comprehension and performance when the read and interpreted information on electrical and hydraulic system fault technical information (crew alerting systems, QRH checklists).

Airline Translator Method

As the literature review suggested, it is paramount that the translator of written English language have background knowledge of the language being translated, technical vocabulary being translated, and have knowledge/expertise in their career (i.e. Airbus aircrafts and associated QRH checklists documentation). Therefore, the researcher selected the airline's pilot association president to participate in the study. The airline's pilot association, herein referred to as association representative, provided their years of experience working for the airline, age, experience translating technical documentation, and background knowledge of text genre, aviation vocabulary words, and technical information on crew alerting systems and QRH checklists. The association representative was also provided support by the most senior airline pilot at the airline to review translated QRH checklists for reading comprehension purposes prior to the experimental trials. Below is a table (Table 71), which provides information regarding aforesaid aspects utilized by the researcher to profile the translator, prior to the translator completing the QRH checklist translation process into Portuguese language.

Table 71 Association Representative and Senior Airline Pilot Profile

Translator Demographics	Association Representative (Translator)	Senior airline pilot (reviewer of the translated QRH checklists)
Country of Origin	Portugal	Portugal
Age	50	57
Airline Years of Experience	26	24
Native Language Spoken	Portuguese	Portuguese
English language learned/Country	High School (Brazil)	Middle School (Brazil)
ICAO ELPR Level	Level 5	Level 5
Self-rated English language RCL (General Use of English language)	H-Level	H-Level
Self-rated RCL: English language on crew alerting systems and QRH checklists	H-Level	H-Level

Airline QRH Checklists Translation (Portuguese Language) Process

As indicated in Chapter 5 it is important to utilize translation theories to translate text corpora. The researcher utilized Equivalence, Adaptation, and Borrowing procedure theories to develop the process of translating the QRH checklists. These theories can be found interrelated within the researcher's 13-step process. Previously discussed, authentic written English language text on QRH checklists were translated from English language to Portuguese language. The ECAM system was not translated, as it remained written English language. Participants did not have experience with authentic text (QRH checklists) translated into their native language Portuguese. This was due to the certified QRH checklists from the manufacturer designed in English language and not translated into Portuguese language. On the other hand, participants indicated they had experience with use of metacognitive strategies such as translation of written English language into Portuguese language, and reverting back to their native language to read and comprehend written English language.

The translation process lasted for seven days and was conducted prior to the researcher executing the experiment. The translation process was conducted using typewritten words on Microsoft Word software application. The association representative (translator) and the senior airline pilot (reviewer of the translated QRH checklists completed the QRH checklist translation process using Microsoft Word software application. Below is the 13-step process that was utilized to translate QRH checklists (electrical and hydraulic system faults) into Portuguese language. Note: Due to airline company copyright policy agreement between the researcher and the airline, QRH checklists were not included in this thesis. Finally, the translation process included use of a Portuguese language dictionary by the translator to ensure proper written Portuguese language was utilized on Portuguese language QRH checklists. This was needed to verify vocabulary words on the written English language QRH checklists had equivalent meaning in Portuguese language.

1.) Determination of translatable and non-translatable technical information items.

2.) Non-translatable technical information- any written English language on the QRH checklist that corresponds to participant inputs on flight deck crew alerting systems or its interfaces (labels/panels/buttons/switches) that are written English language acronyms, abbreviations, or phrases with no equivalent meaning in Portuguese language.

3.) Translatable technical documentation- Information associated with QRH checklist, notes—which included abbreviations, acronyms, and phrases, with equivalent meaning in Portuguese language. Or, non-flight deck input related information such as non-system command inputs by the pilot (i.e. sentences related to safety assurance, or reminders, phrases, notable information, with equivalent meaning in Portuguese language).

4.) Review of aircraft technical illustrations (flight deck overhead panel and other related interfaces).

5.) Matching exercise between QRH checklist technical information and flight deck technical information illustrations, to determine participant best mapping between flight deck crew alerting system interfaces and QRH checklist items.

6.) Review of technical and non-technical items with association representative/senior pilot.

7.) Preliminary review of QRH checklist translation process considered the country's regional pedagogical approaches to teaching Portuguese language in Lisbon, Portugal. This review was needed to understand how participants' read and comprehend Portuguese language when using technical information on the flight deck.

8.) Syntax Exercise and Translation: Arrangement of words, acronyms, abbreviations, phrases, and sentences on checklist. Written English language technical information was not translated into Portuguese language if there was no equivalent word meaning in Portuguese language.

9.) Assurance of font, color, and sentence spacing accuracy was conducted by ensuring written English language checklist font colors and character sizing was the same on the translated checklist.

10.) Review of translation by association representative, senior pilot, and researcher for concurrence.

11.) Printed copies of checklists (A4 paper 1 sided)

12.) Participants executed use of QRH checklists during experimental trials.

13.) Obtained verbal feedback regarding checklist design by participants after the trials.

Limitations

The researcher utilized electrical and hydraulic system ECAM crew alerting system messages for the study. If there were different ECAM systems messages (e.g. pneumatic, engine) participant performance may be different based on written English language design and integration on ECAM system. On the other hand, the researcher utilized electrical and hydraulic malfunction/fault QRH checklists. If other QRH checklists were utilized for the study, participant performance may have been different, with respect to their use of written English language on QRH checklists. Regarding written English language QRH checklists (i.e. electrical and hydraulic) translated into Portuguese language; participant performance may have been different if the researcher translated different QRH checklists into a different language (e.g. Chinese, Japanese language). Last, if there were different participants (e.g. Japanese) with other linguistic backgrounds, results may have been different.

Experimental Research Study Results

Results from the experimental study are noted below. For each hypothesis that was tested, alpha level was (*p=.05)*.

Researcher performed a paired samples correlation to determine if there would be a significant correlation between participant response time, when they utilize written English language ECAM/written English language QRH checklists/written English language ECAM/written Portuguese language QRH checklists. As a correlation test determines strength and direction between two variables this test was utilized to determine a negative or positive correlation and significance. Results indicated that participant mean response times from the written English language ECAM/written English language QRH checklists score was faster (*M=8.75; SD=3.811)* than participant response time on the Portuguese checklists (*M=14.4; SD=4.730)*. The paired samples correlation value indicated a negative correlation *(-.075)*, inverse relationship between participant response times when they utilize written English language ECAM/written English language QRH checklist and written English language ECAM/written Portuguese language QRH checklist. In other words, when participants use written English language ECAM/written Portuguese language QRH checklist to respond to hydraulic and electrical system malfunctions, they tend to have longer response times than with use of written English language ECAM/written English language QRH checklists. Significance value was (*Sig p=.695*). Since $p>.05$, this is an indication of no significant correlation.

Regarding paired samples t-test, a significant difference was found between participant response times when they use written English language ECAM/written English language QRH checklists and written English language ECAM/written Portuguese language QRH checklists. The results indicated $t(29)=-4.947$; *Sig 1-tailed p=0 and Sig 2-tailed p=.000;* $p< .05$, $d= -.132$ (means are insufficient), the researcher accepts the alternative hypothesis (H_A) that there is a significant difference between participant response times when they use written English language ECAM/written English language QRH checklists, and written English language ECAM/written Portuguese language QRH checklists when participants respond to electrical and hydraulic system malfunctions. Participant response times with use of written English language ECAM/written Portuguese language QRH checklists was slow and their response time using written English ECAM/written English language QRH checklists was fast.

Researcher performed a paired samples correlation to determine if there would be a correlation between participants NASA TLX workload scores when they utilize the written English language ECAM/written English language QRH checklists/written English language ECAM/written Portuguese language QRH checklists. Results indicated that mean participant NASA TLX workload score from the written English language ECAM/written English language QRH checklists score was (*M=34; SD=17.777)*, which was lower than participants NASA TLX workload score on the Portuguese checklists (*M=50; SD=23.163)*. The correlation value was *.362*, indicating a positive correlation between the two variables (English language/Portuguese language). This is an indication that when participants utilized written ECAM written English language/written English language QRH checklists their NASA TLX workload scores tend to move in a positive direction, and when participants utilized ECAM written English language/written Portuguese language QRH checklists their NASA TLX workload scores tends to move in the positive direction. The paired samples correlation test indicated a significant correlation between participant NASA TLX workload scores when they use written English language ECAM/written English language QRH checklist and written English language ECAM/written Portuguese language QRH checklist. The significance value for this analysis was $p=.049$, ($p<.05$) and the means are insufficient. This is an indication that there is a significant relationship between the aforesaid variables (English language/Portuguese language).

Regarding the paired samples t-test, the researcher performed a one tailed and two-tailed test and found a significant difference (both tests) between participant NASA TLX workload scores when they use written English language ECAM/written English language QRH checklists, and their NASA TLX workload scores when they use written English language ECAM/written Portuguese language QRH checklists. The values are as follows: $t\ (29)=-3.803$, (*Sig. 1-tailed=.0005; 2-tailed* $p=.001$) ($p<.05$), d= -0.78. Therefore, researcher accepts the alternative hypothesis (H_A) that there is a significant difference between participant written English language workload scores and Portuguese language workload scores, when participants respond to electrical and hydraulic system malfunctions. Participant use of written English language ECAM/written Portuguese language QRH checklists was more difficult than using written English ECAM/written English language QRH checklists.

Researcher performed a paired samples t-test to determine if there will be a significant difference between participant performance when they use ECAM (written English language)/written English language QRH checklists, and when they use ECAM (English language)/written Portuguese language QRH checklists with respect to participant errors of omission. Results indicated that the mean ECAM (written English language) written

English language QRH checklists number of omission was (*M=.3000; SD=.702)*, while the mean ECAM (written English language) and written Portuguese QRH checklists was (*M=.3333; SD=.546)*. This is an indication that participants committed more procedural errors of omission when they utilized ECAM written English language/written Portuguese QRH checklists, than when they use ECAM written English language/written English language QRH checklists, when they respond to electrical and hydraulic system faults. The correlation value was .269 and the significance of the correlation was *.150 (p>.05)*. This is an indication that there was minimal positive correlation between the variables and there was no significant correlation with respect to errors of omission between participant use of ECAM (written English language)/written English language QRH checklists, and when they use ECAM (English language)/written Portuguese language QRH checklists. In other words, participants errors of omission were high with use of ECAM (English language)/written Portuguese language QRH checklists, and low errors of omission when using ECAM (written English language)/written English language QRH checklists.

Regarding the paired samples t-test, results indicated *t (29)=-.239;* sig *(1-tailed=.406; sig 2-tailed=.813; p>.05), d=* -0.05. These results indicated there was no statistically significant difference between observed participant errors of omission when they use ECAM written English language/written English language QRH checklists, and when they use ECAM English language/written Portuguese language QRH checklists when they respond to electrical and hydraulic system faults. The researcher accepts the null hypothesis (H_O), there is not a significant difference between participant errors of omission when they use ECAM written English language/written English language QRH checklists, and when they use ECAM English language/written Portuguese language QRH checklists to respond to electrical and hydraulic system faults.

Researcher performed a Pearson product moment (Pearson's *r*) correlation test to determine if a significant positive correlation exists between participant NASA TLX workload scores (ECAM written English language/written Portuguese language QRH checklists) and participant response time (ECAM written English language/written Portuguese language QRH checklists). Both variables are continuous scale variables, normal distribution, and had a linear relationship. Recall, participant NASA TLX workload scores were (*M=50; SD=23.163)* and response time was (*M=14; SD*=4.730) (higher workload scores and response times were observed when participants utilized ECAM written English language/Portuguese language QRH checklists, compared to their use of ECAM written English language/English language QRH checklists.

Pearson correlation value was *r=.158* which indicates a minimal positive correlation. This result indicates as participant NASA TLX workload scores increase so does their response time to hydraulic and electrical system malfunctions. The significance value was *p=.404 (p>.05), d=*2.15. These results indicated no significant correlation between participant NASA TLX workload scores (ECAM written English language/written Portuguese language QRH checklists) and participant response time (ECAM written English language/written Portuguese language QRH checklists). The evidence suggests that the correlation observed is not generalizable to the population of ESL flight crewmembers. The researcher accepts the null hypothesis (H_O) that no significant positive correlation exists between participant NASA TLX workload scores (ECAM written English language/written Portuguese language QRH checklists) and participant response time (ECAM written English language/written Portuguese language QRH checklists).

Researcher performed a Pearson product moment (Pearson's *r*) correlation test to determine if a correlation exists between participant use of ECAM written English language/written English language QRH checklists and their NASA TLX workload scores, and their use of ECAM/written English language/written English language QRH checklists response times. Both variables are continuous scale variables, normal distribution, and had a linear relationship. Recall, participant ECAM written English language/written English language QRH checklists NASA TLX workload scores mean was ($M=34$; $SD=17.777$) and ECAM written English language/written QRH checklists response times was ($M=8.75$; $SD=3.811$) (lower workload and lower response time observed when participant utilized ECAM written English language/written English language QRH checklists, compared to their use of ECAM written English language/Portuguese language QRH checklists). The Pearson correlation value was $r=.150$ which indicates a minimal positive correlation. This result indicates as participant NASA TLX workload scores decrease so does their response time to electrical and hydraulic system faults. However, the significance value was $p=.428$ $(p>.05)$, d= 1.96. These results indicated no significant positive correlation between participant NASA TLX workload scores (ECAM written English language/written English language QRH checklists) and participant response time (ECAM written English language/written English language QRH checklists). The evidence suggests that the correlation observed is not generalizable to the population of ESL flight crewmembers. The researcher accepts the null hypothesis (H_O) that no significant positive correlation exists between participant NASA TLX workload scores (ECAM written English language/written English language QRH checklists) and participant response time (ECAM written English language/written English language QRH checklists).

T-tests performed to foster new future research (not part of experimental design—collected as a result of the experiment demographics)

The researcher performed several t-tests on other data collected during the experiment. Although these t-tests are not aligned to the researcher's experimental hypothesis testing, the results from these tests have the potential to foster new research on the flight deck. Aforesaid t-tests are followed by two 2-way ANOVAs, which were performed to determine if there would be a main effect and interaction between participant years of experience and proficiency, with respect to their response time and NASA TLX workload scores. The following are t-tests performed on demographic data collected ('years of experience') and participant response times/NASA TLX workload scores when they use the ECAM written English language/written English language QRH checklists and ECAM written English language/written Portuguese language QRH checklists. The researcher utilized alpha level $p=.05$ to perform each of the t-tests.

First t-test results indicated the mean (*M*=9.1667; *SD=4.310*) response time for participants with 20 years of airline experience or greater response time was longer compared to the mean (*M*=7.7778; *SD=2.1666)* response time for participants with less than 20 years of airline experience when they respond to ECAM written English language/written English language QRH checklist electrical and hydraulic system faults. Based on these mean response times, the researcher performed an independent samples t-test which determined no significant difference exists between participant airline years of experience 20 years of experience or greater, and participant years of experience less than 20 years of experience. The independent samples t-test values were: $t(28)=.912$; $F(28)=2.793$; *sig 2-tailed test* $p=.370$ ($p>.05$), $d=0.40$ and the means are insufficient. Since the researcher indicated years of experience was a factor that influences participant background knowledge on crew alerting systems and QRH checklists, future research may focus on participants range of airline years of experience (participants with more years of experience, less years of experience) Future research would determine if a significant difference/no significant difference exists between ESL flight crewmember years of experience and their response time using ECAM written English language/written English language QRH checklists when responding to electrical and hydraulic system faults. The research would be focused on other flight crewmembers with a different linguistic background. As the researcher performed a two-tailed test to determine if a relationship between the variables exists in both directions (negative and positive), future research may warrant a one-tailed test depending on new literature reviews and research aims regarding ESL flight crewmembers years of experience and response time.

Second t-test results indicated the mean (*M=15.3810; SD=4.590*) response time for participants with 20 years of airline experience or greater response time was longer compared to the mean (*M=12.2222; SD=4.535*) response time for participants with less than 20 years of airline experience when they respond to ECAM written English language/written Portuguese language QRH checklist electrical and hydraulic system faults. Based on these mean response times, the researcher performed an independent samples t-test which determined no significant difference exists between participant airline years of experience 20 years of experience or greater, and participant years of experience less than 20 years of experience. The independent samples t-test values were: $t(28)=1.733$; $F(28)=.627$; *sig 2-tailed test* $p=.094$ ($p>.05$), $d=0.69$ and the means are insufficient. Since the researcher indicated years of experience was a factor that influences participant background knowledge on crew alerting systems and QRH checklists, future research may focus on participants range of airline years of experience (participants with more years of experience, less years of experience). Future research would focus on ESL flight crewmembers with different linguistic background, and their response time using ECAM written English language/written Portuguese language QRH checklists when responding to electrical and hydraulic system faults. The researcher would also determine if a significant difference/no significant difference exists between the aforesaid variables, considering flight crewmembers with a different linguistic background. The researcher performed a two-tailed test to determine if a relationship between the variables exists in both directions (negative and positive). Future research may warrant a one-tailed test depending on new literature reviews and research aims regarding ESL flight crewmembers years of experience and response times.

Third t-test results indicated the mean (*M=32.6619; SD=17.227*) NASA TLX workload scores for participants with 20 years of airline experience or greater response time was lower compared to the mean (*M=37.4556; SD=19.637*) NASA TLX workload scores for participants with less than 20 years of airline experience when they respond to ECAM written English language/written English language QRH checklist electrical and hydraulic system faults. Based on these mean NASA TLX workload scores, the researcher performed an independent samples t-test, which determined no significant difference exists between participant airline years of experience 20 years of experience or greater, and participant years of experience less than 20 years of experience. Independent samples t-test values were: $t(28)=-.670$; $F(28)=1.092$; *sig 2-tailed test* $p=.508$ ($p>.05$), $d = -0.26$ and the means are insufficient. Since the researcher indicated years of experience was a factor that influences participant background knowledge on crew alerting systems and QRH checklists, future research may focus on flight crewmembers with a different linguistic background, and range of airline years of experience (participants with more years of experience, less years of experience). Future research would focus on ESL flight crewmember NASA TLX workload scores to determine if using ECAM written English language/written English language QRH checklists when responding to electrical and hydraulic system faults, results in a significant difference/no significant difference between the aforesaid variables. Researcher performed a two-tailed test to determine if a relationship between the variables exists in both directions (negative and positive). Future research may warrant a one-tailed test depending on new literature reviews and research aims regarding ESL flight crewmembers years of experience and NASA TLX workload scores.

Fourth t-test results indicated the mean (*M=43.0810; SD=21.541*) NASA TLX workload scores for participants with 20 years of airline experience or greater NASA TLX workload scores were lower compared to the mean (*M=67.6556; SD=17.587*) NASA TLX workload scores for participants with less than 20 years of airline experience, when they respond to ECAM written English language/written Portuguese language QRH checklist electrical and hydraulic system faults. Based on these mean NASA TLX workload scores, the researcher performed an independent samples t-test, which determined a significant difference exists between participant airline years of experience 20 years of experience or greater, and participant years of experience less than 20 years of experience. The independent samples t-test values were: $t(18)=-.3.010$; $F(18)=.333$; *sig 2-tailed test* $p=.004$ ($p<.05$), $d= -1.25$ and the means are insufficient. Since the researcher indicated years of experience was a factor that influences participant background knowledge on crew alerting systems and QRH checklists, future research may focus on participants range of airline years of experience (participants with more years of experience, less years of experience). Future research would focus on ESL flight crewmembers with a different linguistic background and their NASA TLX workload scores, when they use ECAM written English language/written Portuguese language QRH checklists to respond to electrical and hydraulic system faults. As the results from this analysis were significant, it will be more important to determine if flight crewmembers with other linguistic backgrounds results indicate a significant difference, or no significant difference exists between the aforesaid variables. As the researcher performed a two-tailed test to determine if a relationship between the variables exists in both directions (negative and positive), future research may warrant a one-tailed test depending on new literature reviews and research aims regarding ESL flight crewmembers years of experience and NASA TLX workload scores.

Researcher performed a paired samples t-test to determine a significant correlation and significant difference exists between participant years of experience (no years of experience range specified) and NASA TLX workload scores when they used ECAM written English language/written Portuguese language QRH checklists to respond to electrical and hydraulic system faults. Results indicated the mean was (M=24.0667; SD=*8.909*) years of experience for participants. Participant mean NASA TLX workload score was (M=50.4533; SD=*23.163*) when they respond to ECAM written English language/written Portuguese language QRH checklist electrical and hydraulic system faults. Based on the mean NASA TLX workload score and mean years of experience, the researcher performed paired samples t-test. Paired samples correlation value was *-.329* and the significance of the correlation value was *.076*, which indicated no significant correlation. Paired samples t-test indicated *t=-.5272 sig 2-tailed .000 ($p<.05$), d* = -1.50. These results indicated a significant difference between participant mean years of experience and mean workload score when using ECAM written English language/written Portuguese language QRH checklist to respond to electrical and hydraulic system faults, and the means are insufficient.

Since the researcher indicated years of experience was a factor that influences participant background knowledge on crew alerting systems and QRH checklists, future research may focus on participants average airline years of experience. In particular, future research would focus on ESL flight crewmembers with different linguistic backgrounds and their NASA TLX workload scores when they use ECAM written English language/written Portuguese language QRH checklists when responding to electrical and hydraulic system faults. As the researcher performed a two-tailed test to determine if a relationship between the variables exists in both directions (negative and positive), future research may warrant a one-tailed test depending on new literature reviews and research aims regarding ESL flight crewmembers years of experience and NASA TLX workload scores.

Researcher developed hypotheses and corresponding two-way ANOVAs (between-subjects design) to determine effect of participant English language proficiency, airline years of experience, and impact on their reaction time/NASA TLX workload scores.

Table 72 Two-Way ANOVAs Between Subjects Hypotheses

H_A: There will be a significant main effect and interaction between participant airline years of experience/English language proficiency and their reaction time when they read and comprehend written English language on the ECAM/QRH checklists.	H_O: There will not be a significant main effect and interaction between participant airline years of experience/English language proficiency and their reaction time when they read and comprehend written English language on the ECAM/QRH checklists.
H_A: There will be a significant main effect and interaction between participant airline years of experience/English language proficiency and their NASA TLX workload scores when they read and comprehend written English language on the ECAM/QRH checklists.	H_O: There will not be a significant main effect and interaction between participant airline years of experience/English language proficiency and their NASA TLX workload scores when they read and comprehend written English language on the ECAM/QRH checklists.

There was no significant main effect and interaction observed between participant airline experience, proficiency, and reaction time when they read and comprehend the written English language on crew alerting systems and QRH checklists. Results indicated F (1, 26)=.003, p>.05, partial η^2=.000. Participant airline experience less than 20 years, high level proficiency participants reaction time mean was M=7.63; SD=2.26. Participant reaction time mean for medium level proficiency participants was M=9.00; SD= 0. Participants with high level proficiency reaction time were faster than medium level proficiency participants. Results also indicated F (1, 26)= .046, p>.05; partial η^2=.002. Participant airline years of experience 20 years or greater and high level proficiency revealed their reaction time was M=9.62; SD= 4.66. Participants with medium level proficiency indicated M= 7.25; SD=1.32. Participants with high level proficiency had a longer reaction time than participants with medium proficiency level. Researcher accepts the null hypothesis.

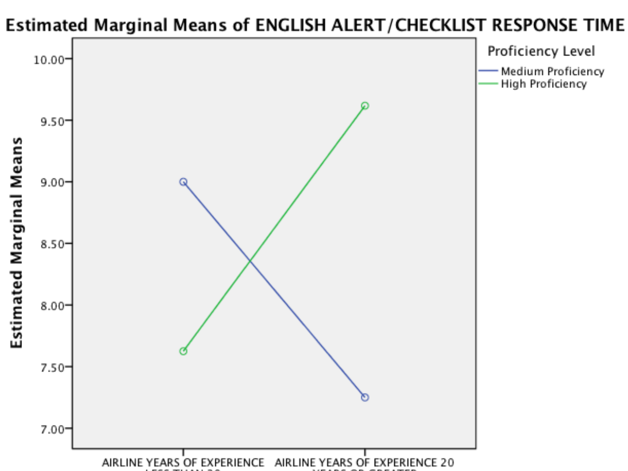


Figure 17 Two Way ANOVA Graphical Plot 1

There was no significant main effect and interaction observed between participant years of experience, proficiency, and NASA TLX workload scores when they read and comprehend written English language on crew alerting systems and QRH checklists. Results indicated F (1, 26)=.028, p>.05, partial η^2=.001. Participants with less than 20 years of experience high level proficiency NASA TLX workload scores indicated *M*=40.26; *SD*=18.96. Medium level proficiency participants NASA TLX workload scores were *M*=15.00; *SD*= 0. Participants with less than 20 airline years of experience high level proficiency had higher NASA TLX workload scores than medium level proficiency participants. Results also indicated F (1, 26)= 2.86, p>.05; η^2=.099. Participant airline experience 20 years or greater and high level proficiency indicated their NASA TLX workload scores *M*=34.66; *SD*= 17.21. Participants medium level proficiency participants, *M*= 24.15; *SD*=16.7. High level proficiency participants with 20 years of experience or greater had higher workload scores than participants with medium level proficiency. The researcher accepts the null hypothesis.

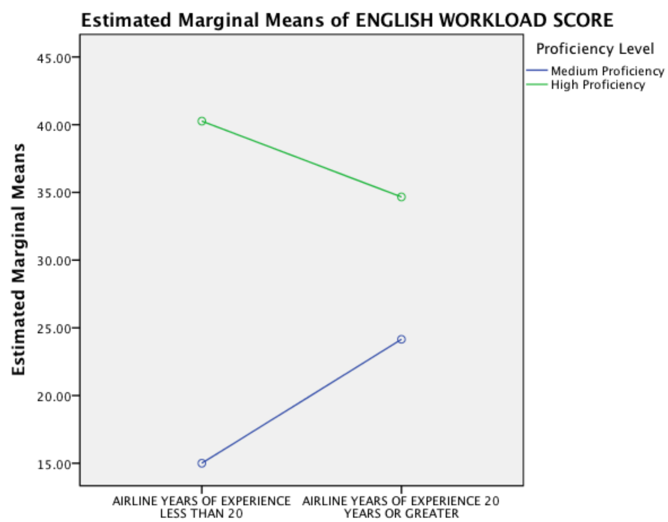


Figure 18 Two Way ANOVA Graphical Plot 2

Discussion (Experiment Research Study)

The results from the experiment support the researcher's intended experimental hypotheses, as well as provide indications of variables to investigate in the future to foster new research on the flight deck. The discussion section provides the reader with an understanding of how the experimental results coincide with the researcher's literature review content, and studies one and two. Figure 19 is an outline of information covered in the researcher's discussion.

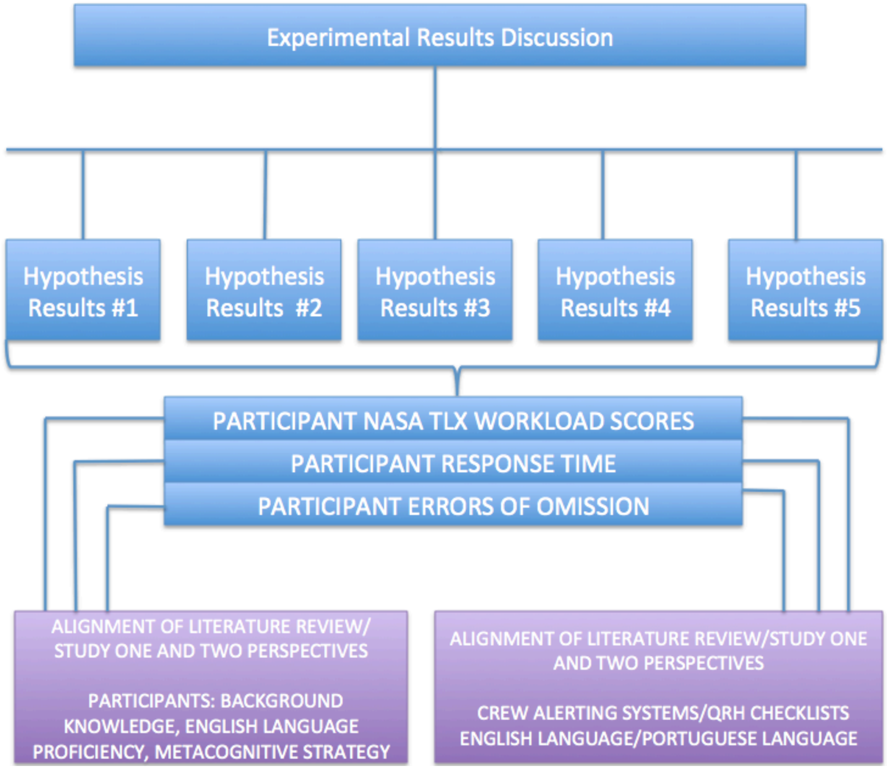


Figure 19 Experiment Results Visualization Roadmap

Figure 19 is a paradigm that describes the researcher's approach to the experimental results discussion section. Results from the five hypotheses tested will be discussed with respect to impact of written English language/written English language translated into Portuguese language, and dependent variables (NASA TLX workload scores, response time, and errors of omission), which measured participant performance during the trials. Furthermore, discussion on design and integration factors on crew alerting systems and QRH checklists that impacted/did not impact participant performance when they read and comprehend technical information on authentic English language text/translated English language into Portuguese language text will be discussed. Additional two-way ANOVAs (between subjects) results will also be discussed. The researcher will align the literature review, studies one and two and provide the reader with an understanding of factors that influenced participant performance during the trials. After the researcher provides a discussion on experimental results for the tested hypotheses, results from the researcher's qualitative study (post experiment questionnaire/interview schedule questions) will be reviewed, followed by a discussion of the results. Purpose of the qualitative study was to identify specific issues that participants discussed during the post interview, as well as provide an understanding of how other factors (i.e. English language proficiency, metacognitive strategies, crew alerting system design, QRH checklists design and integration) impacted participant performance. As the introduction, review of relevant literature, researcher's preliminary study one and two, provided insight on linguistic factors that negatively impact ESL adults' ability to read and comprehend written English language, each study indicated there would be an expectation of challenges to ESL adults when they read and comprehend English language.

Essentially, the researcher’s preliminary study one and two indicated that in a socio-technical environment (i.e. airline flight deck), written English language negatively impacts ESL flight crewmembers. It was noted that ESL flight crewmembers proficiency, background knowledge, and metacognitive strategy use are factors that influence how ESL flight crewmembers will read and interpret written English language on the flight deck. Specifically, crew alerting systems and QRH checklists contain technical information that ESL flight crewmembers use to respond to non-normal conditions and they are negatively impacted by the design and integration of written English language on crew alerting systems and QRH checklists. Based on these factors, an experiment was warranted and the researcher’s experimental design reflected a need to investigate these issues. As indicated in the aforesaid studies, it was expected that ESL flight crewmembers would be extremely challenged with reading and comprehending English language and on crew alerting systems and QRH checklists. However, the researcher’s observed results indicated the opposite finding. Written English language translated into Portuguese language was more difficult to read and interpret by participants during the experimental trials. The researcher found that participants in the study performed better with use of written English language than with English language translated into their native language. This was a surprise regarding the researcher’s expectations for the experimental study. Next section reveals why participant reading comprehension may have been negatively impacted with use of written English language on crew alerting systems/translated English language into Portuguese language, than with authentic written English language on crew alerting systems and QRH checklists. As prescribed in Figure 19, the researcher will discuss impact of each result with respect to the researcher’s hypotheses.

During experimental trials, participants indicated that use of ECAM written English language/written English language QRH checklists and ECAM written English language/Portuguese language QRH checklists impacted their performance when they responded to electrical and hydraulic system malfunctions. With respect to written English language on the ECAM and QRH checklists, participants mean response times revealed that they responded more quickly to electrical and hydraulic system faults than when they utilized English language translated into Portuguese language on QRH checklists. This is an interesting result because the findings results from study one and two revealed that ESL flight crewmembers incur long response times due to design and integration of English language. It was also indicated that flight safety is negatively impacted as well. Additionally, in studies one and two it was revealed that ESL flight crewmembers’ English language proficiency, background knowledge, and metacognitive strategy use were also factors than influence participant ability to read and comprehend written English language. The literature review also provided evidence that written English language would be a factor that negatively impacts ESL adult reading comprehension. So, why did the results indicate opposite findings from the researcher’s expectations? There are several theories that help explain why the results indicate the opposite expectations of the researcher.

All participants had background knowledge reading and interpreting written English language. They also had experience with use of technical information on the flight deck while responding to non-normal conditions (i.e. system faults). It was indicated in the demographics that participants had years of experience reading and comprehending text on crew alerting systems and QRH checklists. Specifically, participants had experience with different ECAM systems and QRH checklists. This enabled them to have an understanding of how written English language text was designed and integrated on the ECAM and QRH checklists. Participants indicated that they responded quickly to alerts and use of written English language because they were accustomed to the English language. It was noted that participants are trained on how to use technical information while responding to a system fault. Many of them indicated they have encountered non-normal conditions while flying aircrafts at their airline, and they had to understand written English language logic to respond effectively. During the experimental trials, the researcher observed most of the participants responding to the system faults very quickly and with precision, with respect to following published QRH checklist procedures. Moreover, participants did not indicate issues with their use of written English language on the ECAM system. Technical information on the ECAM system and QRH checklists (abbreviations and acronyms) were familiar to many participants. As Park's et al (2014) study revealed, less time is utilized to read and comprehend acronyms, if ESL adults have sufficient amount of background knowledge of the acronyms in text. If longer response times are needed to process information such as acronyms/abbreviations on a display, it could impact their ability to solve time critical system/aircraft problems. As the researcher did not regulate a time limit to complete each task, this could also be a reason that participant response time was fast when they responded to electrical and hydraulic system faults. Parks et al (2014) study also provided an indication that temporal demand on ESL adults was not regulated when they read written English language text. Regarding participant English language proficiency and metacognitive strategy use in the researcher's study, participants had high and medium levels of English language proficiency and they used QRH checklist references (published FCOM procedure text) to assist them with responding to electrical and hydraulic system faults. As Park's et al (2014) revealed, metacognitive strategy use such as referencing other sources is typical of ESL adults that have high level of English language proficiency. The researcher's findings support Park's et al (2014) study.

Recall, the researcher profiled each text that appeared on crew alerting systems and QRH checklists (i.e. electrical and hydraulic system faults). This exercise was needed to determine what the researcher would expect to during the experiment, with respect to how participants would perform while reading and interpreting written English language vocabulary words. This task was needed to understand if written English language vocabulary words have an impact on how participants cognitively process vocabulary words on crew alerting systems and QRH checklists. It was noted in the profiling exercise that there were many high frequency words (GSLEW) as well as academic words (AWL), and their were also many low frequency words, and technical/scientific acronyms/abbreviations and words. As the literature review suggested, written English language contains many high frequency words and they are more comprehensible due to their frequency in text (Nation, 2001). Academic words which were developed to catalog most frequently occurring words in academic text and assist learners of English-a-second language Coxhead (1998), with respect to their reading comprehension. As participants had background knowledge of general English language through different types of instructional learning, this could have prepared them for reading and understanding written English language. Regarding ESL adult English language proficiency levels, Kweon and Kim's (2008) study revealed that adequate written English language reading abilities help facilitate understanding of low frequency words. It should also be noted that the participants received written English language training in classes where there were different pedagogical approaches to teaching English language. This could also be a factor that influenced their ability to read and understand the language. The researcher's findings support Kweon and Kim's (2008) study as well as Wanpen's et al's (2013) study, which indicated that taking courses in an English language curriculum helps facilitate reading comprehension of written English language.

Sub-technical vocabulary words have generic meanings in other industries. On the other hand technical/scientific words are specific to an industry (i.e. aviation flight deck). As there was a combination of many of these different types of vocabulary words, it was expected that participants would be challenged while reading and comprehending them on each of the systems (ECAM/QRH checklists). There were some participants that were challenged with use of technical/scientific vocabulary words during the experimental trials. They utilized lexical inferencing techniques to assist them with decoding vocabulary words, and they were successful with decoding words. Nevertheless, since participants had background knowledge of the text genre, they were proficient with general English language, as well vocabulary words on technical information, this enabled participants to respond quickly to the ECAM alerts and subsequent use of the QRH checklists.

Regarding English language design and integration factors on QRH checklists, there were instances where participants noted that conditional statements and flow of information was challenging. This was due to how conditional statements are written on QRH checklists (i.e. electrical and hydraulic), especially the sentence structure, function, and layout. Conditional sentences have been considered difficult to read and understand by ESL adults (Ramirez, 2005). The primary challenge that an ESL adult experiences when reading if/then conditional statements in sentences, is the structure of the sentence. The structure of conditional statements has the potential to confuse ESL adults due to clauses (if/then), which are essentially the form and tense pattern (function) (e.g. present, future, past) (Jacobsen, 2012). As there were present and future conditional statements on the QRH checklists, form and function of their design should be adequate. As participants indicated the aforesaid challenges were prevalent as the read conditional statements, it is practical that manufacturers properly design and integrate conditional statements on QRH checklists. On the other hand, participants noted, as they gain experience using QRH checklists with the airline they are familiar with the form and function of the conditional statement. This could be the reason why participants responded quickly to the alerts. It was also found that conditional statements on the QRH checklists contained enhanced text (e.g. italicized font). Participants did not indicate that font on the conditional statements was a factor that negatively/positively impacted their performance. As (Saeidi et al, 2013) indicated, intermediate level ESL adults did not show any negative/positive impact when conditional statements were enhanced. Written English language text does not always change how a participant reads and interprets text. As this was the case in the researcher's experiment, this corroborates Saeidi's et al (2013) study. As the researcher's study indicated that participants had RCL proficiency H-level and M-level, this provides more evidence that other proficiency levels are not impacted by text enhancements in conditional statements.

Participants also noted that since they were accustomed to written English language, they were able to use various strategies like decoding words, and re-reading words to help them through the reading comprehension process. The researcher's findings support Dwaik and Shehadeh (2013) and Nylander's (2014) studies, with respect to decoding vocabulary words (lexical inferencing) and participant English language proficiency. As they indicated, there could be variability in lexical inferencing strategy use by ESL adults considering their different English language proficiency levels. Also, lexical inferencing strategy use can be beneficial, but the text genre and vocabulary word type may have an impact on ESL adults' vocabulary knowledge and thus impact their reading comprehension performance. In the researcher's study, participants performed well when they read and comprehended written English language on technical information.

Regarding authentic text and participant response time, since the researcher did not alter the text or simplify text is peculiar as to why participant response time was fast when they responded to electrical and hydraulic system failures. According to Hashemi and Bagheri's (2014) study, participant performance was different based on the situation (time and text length and the interaction between both). It was also indicated that ESL participant performance was better when they used a simplified version of text. Essentially, no time limit resulted in better comprehension of texts, whereas introducing a time limit within the task resulted in a negative impact to ESL participant reading comprehension. This result is contrary to the researcher's results regarding response time. In the researcher's study, using unaltered (un-simplified) text may be a factor that enhances ESL flight crewmembers' reading comprehension, and having no time limit could also aid ESL flight crewmembers with the ability to respond effectively to alerts on the ECAM and QRH checklists. As there are timed crew alerts on the flight deck that require immediate crew response, time limits may need to be further investigated with respect to how ESL flight crewmembers respond to crew alerts on the ECAM and QRH checklists.

Participants indicated they did not have background knowledge of written English language text translated into to Portuguese language on QRH checklists. Participants indicated they often unilaterally translate vocabulary words into their native language (Portuguese), and that translation process occurs mostly under non-normal conditions. But, they do not translate every word on QRH checklists. It was noted, that translation processes occur if they have background knowledge of the English language vocabulary word/sentence in Portuguese language. As the airline indicated, it receives published/certified QRH checklists from the manufacturer that do not contain any changes to text. Furthermore, Portuguese flight crewmembers are trained on text provided to them by the manufacturer.

Regarding participants response time when they use Portuguese language on QRH checklists, their response time was slow. This could be due to participants' lack of background knowledge of translated text, and it could be that, they were aware of particular vocabulary words that had the same meaning in Portuguese language. Participants indicated they re-read text due to uncertainties with word meaning in the translated text, monitored their reading speed due to their desire to make correct inferences on each word/sentence, and decoded words such as abbreviations/acronyms and other vocabulary words in the text. On the other hand, there were participants that read and comprehended Portuguese language text with ease, as they were familiar with text translated into Portuguese language that had an equivalent meaning. It was noted that aforesaid strategies used to read Portuguese language slowed their response time to electrical and hydraulic system faults. On the other hand, they were comfortable with the time they spent reading and comprehending text, so that they would not make incorrect inputs on the flight deck. They were concerned if they read the text too fast, they would miss a word or omit information, which could also lead to long response times.

Hutchins et al (2006) and Drury & Ma (2005) indicated that translation of written English language has the potential to impact ESL adults reading comprehension. It was also noted by Al-Sohbani and Muthanna (2013) that participants must have background knowledge of written English language, so that they may adequately understand translated language. They must also have adequate English language proficiency. As most participants indicated, they had background knowledge of abbreviations/acronyms on crew alerting systems and QRH checklists. There were some participants that indicated abbreviations/acronyms long form was difficult to understand in English language. This could have negatively impacted their ability to understand English language translated into Portuguese language on QRH checklists, and therefore respond quickly to electrical and hydraulic system faults. In Al-Sohbani and Muthanna (2013) study, participants did not have adequate knowledge of written English acronyms and abbreviations, and when acronyms and abbreviations were translated into their native language, they were difficult to read and understand. In the researcher's study, participants had adequate background knowledge and adequate English language proficiency when they use of written English language on crew alerting systems and QRH checklists. They indicated they had experience with text genre, vocabulary words, acronyms/abbreviations, and were very familiar with design features of the ECAM system and associated QRH checklists in English language. Therefore, it is peculiar as to why their response time was longer on the Portuguese language checklists than when they read and comprehended technical information on written English language crew alerting systems/QRH checklists.

Participants indicated that they did not experience issues when they initially responded to crew alerts on the ECAM and executed procedural steps on the QRH checklists. However, when they read Portuguese language checklists (electrical/hydraulic system faults), they experienced long response times due to their desire to carefully read and comprehend Portuguese language. They indicated, they wanted to ensure they made the correct inputs on the flight deck and this led to longer response times while using Portuguese language checklists, than with use of written English language checklists.

The Portuguese language checklists format remained the same as the written English language checklists format. In other words, line spacing, font color, and text size did not change from authentic text format. Participants indicated that design and integration of Portuguese language on the QRH checklists negatively impacted their response time. Particularly, technical vocabulary words, abbreviations, acronyms, were more difficult to read and understand on the Portuguese language QRH checklists than on the written English language checklists. More information on how these factors negatively impacted participant mental demand, interpretation, and workload issues when using Portuguese language QRH checklists will be reviewed in the forthcoming section, which focuses on participant workload during the experimental trials.

The NASA TLX workload rating scale was utilized in the researcher's study to understand the impact on participant performance during the experimental trials. The NASA TLX workload rating scale measures mental demand, physical demand, temporal demand, performance, effort, and frustration. Results from this analysis revealed participant workload was high when they used ECAM (written English language) written Portuguese language QRH checklists, and low when they utilized ECAM (written English language) written English language QRH checklists. This result was opposite of the researcher's expectations. But, there are several reasons as to why participants' workload scores were different during the experimental trials.

As prescribed in the NASA TLX workload rating scale, mental demand consists of mental capacity need to complete a task(s), it also considers complexity of the task. According to Smith-Jackson (2006); Riley et al (2006), understanding ESL flight crewmembers differences in their cognitive processing of written English language information is paramount, especially factors that may influence operator performance. Cognitive factors that may influence ESL flight crewmember reading comprehension of technical information include English language literacy and proficiency. In the researcher's experimental study, each of the aforesaid factors had an impact on participant ability to process information on crew alerting systems and QRH checklists (English) adequately.

Participant written English language proficiency (general English language, crew alerting systems and QRH checklists) was high or medium. This is an indication that participant proficiency levels were a factor that impacted their ability to read and comprehend information on crew alerting systems and QRH checklists. Participants indicated they had adequate background knowledge of technical information on ECAM system (written English language) and QRH checklists (written English language). They indicated use of many metacognitive strategies such as re-reading text, monitoring reading comprehension, and decoding abbreviations/acronyms. These types of metacognitive strategies did not lead to participant mental demand being negatively impacted. This was due to their familiarity with text on the ECAM system, as well as on the QRH checklists. Regarding temporal demand, it was noted that participants recognized many vocabulary words on the ECAM system and QRH checklists because they have encountered system malfunctions during typical phases of flight. Since they recognized many of the vocabulary words on the ECAM system and QRH checklists, they were able to respond adequately to the alert, as they were aware of the safety impact on the flight deck if they did not have adequate response time. This is also an indication that low frequency, high frequency, sub-technical, scientific/technical, and academic words were comprehended well by participants, which led to their abilities to respond effectively to the crew alert.

Participants used lexical inferencing (educated guessing) strategy to read and comprehend written English language on the ECAM systems and QRH checklists. It was noted that participants had background knowledge of text they read during the experimental trials. This finding corroborates Wang's (2011b) study, which indicated that there were many participants with high English language proficiency level that guessed words that were unknown to them because they did not know the meaning. In the researcher's study, many participants were challenged with interpretation of unknown words specifically in conditional statements, and thus did not recognize words in the text. Some participants made incorrect inferences of the unknown words, but quickly corrected themselves. In the researcher's study, high proficiency and medium proficiency level participants used lexical inferencing strategy to read and comprehend technical information on the ECAM system and QRH checklists. This is an indication that participant English language proficiency levels vary as well as their choice of metacognitive strategy to read technical information on the ECAM system and QRH checklists.

Regarding participant use of the ECAM system and QRH checklists, their mental demand and temporal demand impact may have been low due to no text alterations. According to Mehrpour and Riazi (2004) short text and long text have an impact on ESL adults' reading comprehension. Additionally, simplification of text may be beneficial, but has the potential to negatively impact reading comprehension of written English language. In the researcher's experiment, none of the texts were altered in this respect (i.e. simplification of text), therefore, it can be concluded that due to participant familiarity with vocabulary words on the ECAM system and QRH checklists, there mental demand was not as negatively impacted compared to their use of Portuguese language checklist.

Regarding participant physical demand (physical activity), participants did not indicate that their inputs on the flight deck negatively impacted their ability to complete the tasks using the software and hardware provided to them by the researcher. As the researcher provided an indication that written English language text genre would have potential negative implications on participant performance, it is interesting as to why participants did not have high mental demand. As Bielsa-Murcia (1999) indicated these types of instructional texts (i.e. QRH checklists) may be lengthy, or contain complex wording, which has the potential to effect ESL adults reading comprehension. But this was not the case with written English language on the crew alerting systems and QRH checklists. As Carrell's (2001) study alluded to, participants read procedure text with ease, likely due to format of the instructions. On the other hand, it was indicated that these results could be due to English language proficiency levels of each participant. This could have influenced their ability to read and comprehend the procedure text. It was also noted that using participants with different proficiency levels could have impacted the results. The researcher's results corroborate Carrell's (2001) study, design of procedure text indicated low mental demand and adequate performance. It also provides evidence that differences in participant English language proficiency levels are an indicator of how well they will perform reading and comprehending procedure text.

Regarding effort (participant mental model utilized to complete the tasks) physically and mentally, each participant indicated they utilized their background knowledge to complete the tasks. Additionally, they utilized top-down strategy and bottom-up strategies independently and collaboratively, which provides an indication they were knowledgeable of these strategies as well as comfortable using them to read and comprehend technical information. As participant English language proficiency levels were high and medium level (general English language, crew alerting systems and QRH checklists), this is an indication they had adequate written English language proficiency According to Liu (2014) bottom-up model is related to how an ESL adult may comprehend information considering the flow of information (linear text flow). In this model, the preliminary steps are decoding the syntax (letters, words, and phrases). Then, the individual decodes the sentence and makes meaning of the information they read. Use of this model is highly dependent on ESL adult English language proficiency, with respect to their vocabulary knowledge. Top-down model consists of the reader using previous knowledge of information they read to understand syntax. English-as-a second language adults may activate their content schema, or background knowledge of the topic to help facilitate an understanding of the subject (Lin and Chern, 2014). Paribarht, and Wesche (1999) indicated that background knowledge has the potential to influence model/strategy use by ESL adults. As the researcher's experiment revealed that both of these models were utilized to read and comprehend technical information, and proficiency was an indicator of type of strategy used, the researcher's experiment corroborates each of the author's results.

With regards to participant frustration and performance, it was indicated that participants low frustration and performed well with respect to their use of ECAM (written English language) and QRH checklists (written English language). Their low frustration led to better understanding of information on the ECAM system and QRH checklists due to their ability to use metacognitive strategies effectively to interpret written English language, adequate background knowledge of the texts, and adequate levels of written English language proficiency. This likely provided them ability to have high level of performance during the trials, and thus complete the trials successfully. According Hsiao and Oxford (2002) and Barnett (1989), metacognitive strategy use by ESL adults has the potential to aid in their ability to organize ideas and process written English language. The researcher's experimental study corroborates the aforesaid authors argument that metacognitive strategy use is an enables ESL adult reading comprehension processes and provides evidence that participant performance is impacted. Finally, participants did not indicate their flight safety was negatively impacted. This result is different than researcher's expectations. Since studies one and two provide details that performance impacts led to flight safety issues, it is peculiar as to why participants did not experience issues with written English language that impacted flight safety. There are likely three reasons for this result (1) participants exhibited sufficient background knowledge in written English language technical information (2) they had adequate written English language proficiency (3) they were aware of and utilized metacognitive strategies to read and understand written English language.

Participant use of the Portuguese language QRH checklists indicated many challenges. As indicated in the researcher's literature review, translating English language into a different language (i.e. participant native language) can negatively impact ESL adult reading comprehension, if written English language terminology does not have an equivalent meaning in a different language. As indicated earlier in the researcher's methods, a translation process was developed to mitigate this circumstance so that participants would not be cognitively negatively impacted by translated English language into Portuguese language.

As Ynfiesta et al (2012) indicated use of experts that have knowledge of translation into a native language and use reference materials helps facilitate adequate translation process. Throughout the researcher's experiment, participants often utilized metacognitive strategies to read and interpret Portuguese language (i.e. re-read sentences). They cognitively translated (unilaterally) Portuguese language into different vocabulary words to attain word meaning, and they also reverted back to using written English language. When participants re-translated Portuguese language text to attain other forms of vocabulary words in Portuguese language, this was most likely due to their misunderstandings of sentence syntax. They also reverted back to use of cognitive mental model of written English language on QRH checklists.

According to Kobayashi and Rinnert (1992), reverting back to English language can occur because an ESL adult lacks understanding of translated syntax meaning. This behavior by ESL individuals can result in inappropriate translation of technical information back into their native language. As this was the case in the researcher's study, why did participants revert back to written English language? Why did they re-translate Portuguese language to find other vocabulary word meanings? Why were participant NASA TLX scores high with use of Portuguese language than with use of English language on QRH checklists? Were participants proficient with written English language words and did their proficiency enable them to read Portuguese language vocabulary words? This section will provide justification as to why participants were challenged with English language translated into Portuguese language, and how it increased their workload scores to high level. It was also provide an indication of how their flight safety was negatively impacted as well as overall performance.

Regarding participant mental demand and temporal demand using Portuguese language checklists, participants experienced many difficulties while reading and comprehending technical information on electrical and hydraulic checklists. It was indicated that participants were unfamiliar with translated technical documentation. Since they are trained on English language and receive simulation training as well in fault isolation and crew alerting response, they indicated more time was needed to process information in their native language. They also indicated they did not have adequate background knowledge of information translated from English language into the native language Portuguese. It was noted that during non-normal conditions when workload is high, they tend to use their own language because they are comfortable with making adequate decisions.

Evidence from Barani and Karimnia's (2014) study suggested that many participants used metacognitive strategies such as re-read sentences and paraphrase words while they read English language text. It was indicated that they utilized these strategies for problem solving purposes, which were related to difficulties understanding word meaning. Part of Barani and Karimnia's (2014) study was corroborated in the researcher's study. The researcher found that participants re-read sentences to understand word meaning. Therefore, Portuguese language used on QRH checklists can be considered difficult to read and understand word meaning, if participants are accustomed to using written English language. Lexical inferencing was also utilized to guess word meaning due to participants' inadequate background knowledge. This led to long response times, inadequate educated guesses to vocabulary word meanings, and inadequate responses on the flight deck to non-normal conditions (i.e. electrical and hydraulic faults). As participants' English language proficiency was adequate (high and medium levels), it is peculiar as to why they did not understand the meaning some abbreviations and acronyms in the notes section of the QRH checklist.
Flight safety was also negatively impacted when participants utilized Portuguese language to solve electrical and hydraulic faults. It was indicate that long response times impacted their ability to recover the aircraft from electrical and hydraulic faults. Fault recovery technique was negatively impacted and thus other un-related to the fault, routine tasks (normal conditions) were abandoned due to difficulties with reading and understanding the Portuguese translated checklists.

Regarding participant physical demand and effort, participants indicated they used more physical effort to look up references using a Portuguese language dictionary for vocabulary words written in Portuguese language. Use of the dictionary was needed due to participant unfamiliarity with vocabulary words during the experimental trials, and this led to more effort needed to complete the tasks. Participant's frustration and performance were also key findings in the researcher's results. Participants noted that they were frustrated due to their inability to decipher (decode) many words written in Portuguese language. This was due to their inadequate background knowledge of technical information on the QRH checklists written in Portuguese language. They also indicated that the mental model was focused on written English language because their airline dictates the need to use English language on the flight deck. Overall, participant performance was low when they use Portuguese language QRH checklists; hence the reason for high NASA TLX workload scores during the experimental trials.

As Alfadly and AldeibaniFull (2013) indicated in their study, participants' reading comprehension was negatively impacted, due to challenges they experienced when trying to decode the meaning of sentences translated from English language to their native language. In the researcher's experiment, participant inability to decode words was a factor was found in the experimental trials and it negatively impacted their performance. Interestingly, as conditional sentences were a factor negatively impacted participants reading comprehension when using written English language checklists, participants did not indicate challenges with form and function of conditional sentences in written Portuguese language. As Alfadly and AldeibaniFull (2013) indicated, conditional sentences were considered very difficult to read, when translated from English language to their language. The major issue with conditional statements was use of proper tenses (e.g. if, then statements) when translating the sentence. This finding supports the researcher's results. This could be that participants were aware of issues with conditional statements in written English language vocabulary words in conditional statements, and experienced the same issues with Portuguese language.

Regarding participant use of the ECAM system and QRH checklists participants experienced challenges during the trials. They indicated their experience with QRH checklists text genre was written English language. However, when participants used the QRH checklists in Portuguese language, they experienced more issues. This was likely due to participant experience with QRH checklists and their knowledge of multiple vocabulary words types (i.e. technical/scientific, high frequency, and low frequency) in written English language. As these vocabulary word types are predicated on the fact that participants must have background knowledge on these types of words, when they are translated into a native language, this is likely a factor that negatively impacts interpretation of information in Portuguese language. In other words, participant background knowledge and experience was English language vocabulary words on the QRH checklists. When vocabulary words are translated, and participants are not accustomed to a translated language they experience challenges to their performance.

The researcher expected that errors of omission would be high with use of written English language QRH checklists. However, results indicated that participant errors of omission were higher on written Portuguese language QRH checklists than on written English language QRH checklists. Although there was no significant difference between participant errors of omission on the QRH checklists (English language) and QRH checklists (Portuguese language) it is still paramount to address the reason why there were errors of omission. Participants that utilized the English language QRH checklist indicated they were accustomed to certain vocabulary words and sentences that were verbose, unfamiliar, and contained many extraneous details. They omitted them due to their background knowledge (airline training) of written English language QRH checklists and their ability to notice vocabulary words that were not needed to complete the task. Omission of vocabulary words did not impact their performance or flight safety. In other words, participants were able to make correct inputs on the flight deck even though they omitted procedures. This finding corroborates the researcher's findings from Dordick (1996) study, which indicated words and sentences unfamiliar to an ESL individual can lead them to commit errors of omission. It can be concluded that errors of omission is still a factor that influences ESL adults' ability to read and comprehend written English language on procedure/expository text (QRH checklists).

On the other hand, when participants utilized Portuguese language QRH checklists they experienced many challenges when they omitted information. Omission of information on the Portuguese translated QRH checklists led to participants making incorrect inputs on the flight deck, and led to subsequent delays in processing information on the crew alerting systems. Although there was not an abundance of procedure omission on the Portuguese language QRH checklists, errors committed by participants led to flight safety impacts. These impacts were related to incorrect buttons pushed on the overhead panel and incorrect procedural shutdown processes for a hydraulic system unrelated to the hydraulic system utilized for the researcher's study.

Literature review provided an indication that participants would be challenged with use of written English language. Additionally, the studies one and two also indicated written English language negative impacts to ESL flight crewmembers' performance. As ESL flight crewmembers indicated they translate written English language into their native language, it was obvious to the researcher to translate English language into their native language, therefore making it easier for ESL flight crewmembers to read and comprehend text on the ECAM and QRH checklists, in the researcher's experiment. Considering these factors, the researcher expected to find a significant positive correlation between participants NASA TLX workload scores and their response time when they read and comprehend technical information on the ECAM (written English language) Portuguese language QRH checklists. As previously stated, this outcome was likely due to participant's lack of background knowledge with QRH checklists translated into their native language, and due to their English language proficiency and metacognitive strategies utilized to read and comprehend information on the written Portuguese language QRH checklists.

Literature review provided an indication that participants would be challenged with use of written English language. Additionally, the studies one and two also indicated written English language negative impacts to ESL flight crewmembers' performance. Therefore the researcher expected to find a positive correlation between participant NASA TLX workload scores and their response time when they read and comprehend technical information on ECAM (written English language) written English language QRH checklists. However, there was not a significant positive correlation between the two variables. Therefore, the data is not generalizable to the population of ESL flight crewmembers. As previously discussed, this outcome was likely due to participant's minimal difficulty they experienced while using written English language on the ECAM and QRH checklists. Their background knowledge, English language proficiency, and metacognitive strategies enabled them to perform well.

Researcher's experiment demographics indicated participant English language proficiency was either high level or medium level. Participant years of experience were also noted as an indicator of background knowledge, when they utilized crew alerting systems and QRH checklists during experimental trials. While understanding these factors are important demographic information, it was essential to measure impact of those factors alongside participant NASA TLX workload scores and reaction time. Government and industry (FAA, 1996) indicated that ESL flight crewmember response time to crew alerting and information systems is a factor that negatively impacts their ability to respond adequately to crew alerts, especially in non-normal conditions. Literature review revealed that levying time limitations or having no time limitations on ESL adults during a task, could impact their ability to perform. However, this is influenced by ESL adult English language proficiency and background knowledge of written English language. Two-way ANOVA analysis revealed no significant main effect and interaction observed between ESL participant years of experience and English language proficiency and their reaction time, when the read and comprehend written English language on crew alerting systems and QRH checklists. This is an opposite finding from the researcher's expectations. However, there are a number of factors that help explain these results. First of all, participants had a range of airline experience levels and experience related to background knowledge reading and comprehending written English language on crew alerting systems and QRH checklists. They were familiar with design and integration of written English language on crew alerting systems and QRH checklists. Participant familiarity with written English language design and integration on crew alerting systems and QRH checklists enabled them ability to understand text during the experimental trials. Second, there were participants that utilized metacognitive strategies to read and understand written English language. This may have helped them process information adequately during the experimental trials. Participant proficiency levels were adequate, and this could have also impacted their performance.

As the researcher separated participant airline experience into two levels (20 years or greater versus less than 20 years), having less than 20 years of airline experience with high level of proficiency resulted in faster response times to crew alerts. On the other hand, there were some participants that had a long response time to crew alerts with medium level proficiency. Participants with 20 years of experience and greater with high level of English language proficiency responded slower to crew alerts than medium level participants. Participant number of airline years of experience does not appear to be a factor with a significant main effect on participant reaction time. Perhaps, background knowledge and training may be more efficient variables to research without specific numerical value focus (i.e. less than 20 years of airline experience, 20 years or greater of airline experience) in future research. As this experiment measured flight crewmember performance that were Portuguese natives, it would seem practical to test other flight crewmembers that have an array of linguistic backgrounds. Results could be different if testing participants with other linguistic backgrounds (e.g. Mandarin) during experimental trials, and may convey an interaction between aforesaid variables.

Literature review indicated high/medium proficiency level participants use different strategies to read and comprehend written English language. There were participants that indicated they were highly proficient with reading and comprehending written English language, and aware of strategies to use while reading and comprehending written English language. They also indicated they were challenged with terminology on crew alerting system and QRH checklists. As Yildiz-Genc (2009) indicated, background knowledge and English language proficiency is a factor that influences ESL adults' ability to read and comprehend written English language. In the researcher's experimental study, participant proficiency levels were high and medium and they had adequate background knowledge in the text they read and comprehended during the trials. Therefore, this finding corroborates Yildiz-Genc (2009) finding that differences with participant English language proficiency are expected when they read and comprehend written English information.

Regarding time limitations during the experimental trials, no time limitation was levied on participants. This could have provided participants with more time to utilize metacognitive strategies and process information while they read and comprehend written English language on crew alerting systems and QRH checklists. If the researcher had imposed a time limitation on the trials, the results may have been different. As Hashemi and Bagheri's (2014) study indicated, no time limit resulted in better comprehension of texts, whereas a time limit had a negative impact on performance. The researcher's finding corroborates Hashemi and Bagheri's (2014) study. In conclusion, the aviation industry should continue focus on flight crewmember performance, when they read and comprehend information on crew alerting systems and QRH checklists. Even though there was no significant main effect and interaction observed from the data, it is still essential to focus on other regions where English is a second language (e.g. Asia). Supplemental investigation into effects of flight crewmember years of experience and English language proficiency with respect to response time is warranted.

Second two-way ANOVA also indicated no significant main effect and interaction between participant English language proficiency and NASA TLX workload scores, when they read and comprehend information on crew alerting systems and QRH checklists. Crew alerting systems and QRH checklists that were analyzed contained text genre that was technical/scientific and text corpora contained high number of high frequency words and academic words, this likely had an positive effect on flight crewmember ability to read and understand text on crew alerting systems and QRH checklists. Coxhead (1998) and West (1953) indicated that high frequency words and academic words in text have a higher comprehensibility than other words (e.g. low frequency). Participants in the researcher's study had background knowledge, years of experience, and training with technical words on crew alerting systems and QRH checklists. This likely reduced participant cognitive workload, enabled them to recognize, read and comprehend technical words, while perform tasks during non-normal conditions. Wanpen et al (2013) study indicated that participant technical vocabulary knowledge helped participants with reading text. As Mehrpour and Riazi (2004) indicated, high proficiency, background knowledge in text is important when reading and comprehending different words in text corpora. As the researcher did not alter sentence length or simplify text (text was authentic), this could be the reason why participants performed well reading and comprehending written English language text on crew alerting systems and QRH checklists. On the other hand, there were participants that experience higher cognitive workload compared to other participants. This could be due to participants with high proficiency using metacognitive strategies (e.g. lexical inferencing, monitoring reading comprehension). Based on results from participant airline years of experience and their NASA TLX workload scores, there may not need to be a primary focus on a specific number of airline years of experience, rather it should be on background knowledge and training in text corpora lexis on crew alerting systems and QRH checklists. Other QRH checklist types (e.g. engine fire, fuel system) and crew alerting systems may reveal different number of vocabulary word types and could have a different impact on flight crewmembers cognitive workload.

In conclusion, the aviation industry should continue focus on flight crewmember English language proficiency and effects of flight crewmember cognitive workload when they read and comprehend information on crew alerting systems and QRH checklists. Perhaps, a different region of ESL flight crewmembers may reveal different results, however more research is needed to understand if there will be an effect on flight crewmember performance. Even though there was no significant main effect and interaction observed from the data, it is still essential to develop other studies that focus on effects of flight crewmember English language proficiency and cognitive workload. As ICAO (2004, 2010) identified ELPRs (e.g. Level 4 operational) and importance of assessing English language proficiency, it is pertinent to focus on ESL flight crewmember reading comprehension proficiency levels as well. Since results indicated each flight crewmember experienced differences in reaction time and workload based on their proficiency levels, this is still a factor that impacts their performance. Differences in flight crewmember reaction time could impact their performance on the flight deck if there are crew-alerting systems that require the flight crewmember to respond in a timely manner. Also reviewed in the beginning of the thesis were aircraft accidents that highlighted ESL flight crewmember proficiency as a contributory factor to the accidents. Results from the researcher's experiment indicate there is still a need to assess adequacy of ESL flight crewmember English language proficiency, with respect to their performance during non-normal conditions. If the researcher measured participant performance using other linguistic backgrounds (e.g. Flemish, Chinese)/proficiency levels while they read and comprehended information on crew alerting and information systems, their performance could be different. According to IAC (2013), obtaining an adequate level of ICAO English language proficiency does not provide evidence that ESL flight crewmembers have the ability to adequately read, understand, and use written English language operational procedures documentation on the flight deck. As the researcher's experiment revealed, ESL flight crewmember English language reading comprehension proficiency levels is required, to assess their ability to read and understand written English language information on the flight deck.

Experimental Research Study Recommendations

The researcher's experiment revealed many details on factors that influence participants' ability to read and comprehend written English language. As the researcher's hypotheses indicated, written English language on the ECAM and QRH checklists was supposed to negatively impact ESL flight crewmembers' performance on the flight deck. The evidence in the researcher's preliminary studies one and two provided substantial evidence that written English language on technical on information would be a challenge. The researcher's literature review also indicated ESL adult reading comprehension would be negatively impacted when they read and comprehend different types of written English language vocabulary words, text genre, abbreviations/acronyms and sentences in text corpora. Collectively, the previous studies indicated written English language design and integration factors impact ESL flight crewmembers' performance, and their performance would be impacted by their English language proficiency level, metacognitive strategy use, and background knowledge. However, the results were opposite of the researcher's expected outcome. Participants' performed efficiently with written English language on ECAM and QRH checklists, and inadequately when they use written English language translated into their native language Portuguese. Many of the same factors that influence ESL adults' ability to read and comprehend written English language were found in ESL adults' ability to read and comprehend written Portuguese language. Particularly, adequacy of ESL flight crewmembers' ability to read and comprehend written Portuguese language is predicated on their ability to use metacognitive strategies, English language proficiency, and background knowledge. The researcher recommends eight issues that need to be further researched in postdoctoral studies. Each recommendation has a general theme, which was found in the researcher's experimental studies, followed by government agencies that should focus on implementing these types of studies with assistance from the researcher:

- General Theme: Determine impact of written English language and native languages on ESL flight crewmember ability to read and comprehend written technical information on flight crew alerting and information systems (i.e. EICAS, ECAM etc.) and QRH checklists (i.e. pneumatic systems) in different regions of the globe. In other words, future studies should focus on other flight crewmembers' ability to read and comprehend written English language and their native language, with respect to technical information. Also, develop future experimental studies that focus on ESL flight crewmembers English language proficiency, metacognitive strategy use, background knowledge, and years of airline experience.

    - Research support by ICAO, European Aviation Safety Administration (EASA), FAA, and CAST

- General Theme: Develop standardized ESL flight crewmember self-rating criteria (similar to ICAO ELPRs) for airlines that focuses on flight crewmembers written English language proficiency levels and establishes protocol for understanding ESL flight crewmembers general English language proficiency as well as written English language proficiency with crew alerting systems and QRH checklists.

    - Research support by ICAO and FAA

- General Theme: Develop standardized metacognitive strategy checklists for airline training departments. Focus should be on crew alerting systems design and integration and ESL flight crewmembers preferred metacognitive strategy use to read and interpret written English language or native language of ESL flight crewmembers.

    - Research support by ICAO and FAA

- General Theme: Develop an automated machine for flight deck researchers that identifies GSLEW, AWL, low frequency words, and technical/scientific words commonly utilized in checklists that are for non-normal system conditions.

    - Research support by ICAO and FAA

- General Theme: Develop an automated machine for flight deck researchers that identifies commonly utilized vocabulary words in a translated language that is based on particular regions of the globe (e.g. Asia, Africa).

    - Research support by ICAO and FAA

- General Theme: Develop QRH checklists for manufacturers to address crew alerting systems design and integration factors in the preliminary design of crew alerting systems and QRH checklists. Manufacturers continue to monitor design and integration throughout critical design review and lab/flight test. Specifically, researchers should orient themselves with different linguistic backgrounds and how flight crewmembers may perform when they read and understand technical information on QRH checklists.

    - Research support by ICAO and FAA

- General Theme: Provide written English language abbreviations and acronyms long form on QRH checklists as a way of assisting participants with a better understanding of these types of vocabulary words during non-normal conditions. Cross reference written English language on crew alerting systems, with respect to design and integration of vocabulary words on written English language QRH checklists.

    - Airline training departments
    - Flight Operations Quality Assurance (FOQA)

- General Theme: As there are many timed based crew alerting systems on the flight deck, it will be important to understand the effect of ESL flight crewmembers English language proficiency, background knowledge, and metacognitive strategy use and their ability to respond to crew alerts per manufacturer flight deck design philosophy. When comparing participants use of written English language QRH checklists and their use of Portuguese translated QRH checklists in the researcher's experimental study, there response times were slower on Portuguese language checklists than on written English language QRH checklists. Regarding written English language checklists, it will be important to test differences in how fast participants respond to specific crew alerting systems (ECAM versus EICAS etc.) and if response times are fast or slow, with respect to flight crewmembers with different linguistic backgrounds.

    - Research support by manufacturing industry

Experimental Research Study Conclusions

It can be concluded that written English language on the ECAM system and associated QRH checklists did not have a substantial negative impact on ESL flight crewmembers' performance. But, other languages should be investigated to determine if this is an expectation of other regions, and flight crewmembers with different linguistic backgrounds across the globe. In other words, is the issue of written English language still a factor in other regions of the globe? Since the researcher's experiment focused on one region, other regions should be investigated as well. On the other hand, since translating English language into flight crewmembers' native language was an issue that impacted their performance, other regions and languages of flight crewmembers should be included in future research studies. Overall, it can be concluded that written English language is an adequate form of presenting technical information to flight crewmembers when they respond to electrical and hydraulic system faults on the flight deck. But, it must understood that this result is predicated on the fact that ESL flight crewmembers had background knowledge of technical information, used metacognitive strategies to read and comprehend written English language, and had adequate written English language proficiency levels.

Qualitative Research Study (Narrative Coding Method from Questionnaire and Results)

Methods

Previously discussed, the researcher collected and analyzed data from the interview schedule that was given to participants after the study was completed. Central tendency (i.e. mean) statistics was utilized to analyze demographic information collected from each of the participants. Analysis of demographics was needed to convey similarities or differences with participant population. After the researcher transcribed, coded, and developed thematic data from the interviews and questionnaires, central tendency was utilized analyze frequency of themes. As previously indicated, the coding method utilized was inspired from the researcher's literature review. Theoretically, all of the elements that were reviewed in the literature review have the potential to impact participant reading comprehension of written English language on the flight deck. Furthermore, these elements could also be applicable for participants that read written Portuguese language. Participants use of metacognitive strategies to read and understand written English language, English language proficiency, and their background knowledge have the potential to impact their perception and processing of English language on crew alerting systems and QRH checklists, and Portuguese language on QRH checklists. Therefore, Figure 20 is the method developed, which was utilized to create themes for the written English language QRH checklists and Portuguese language QRH checklists.

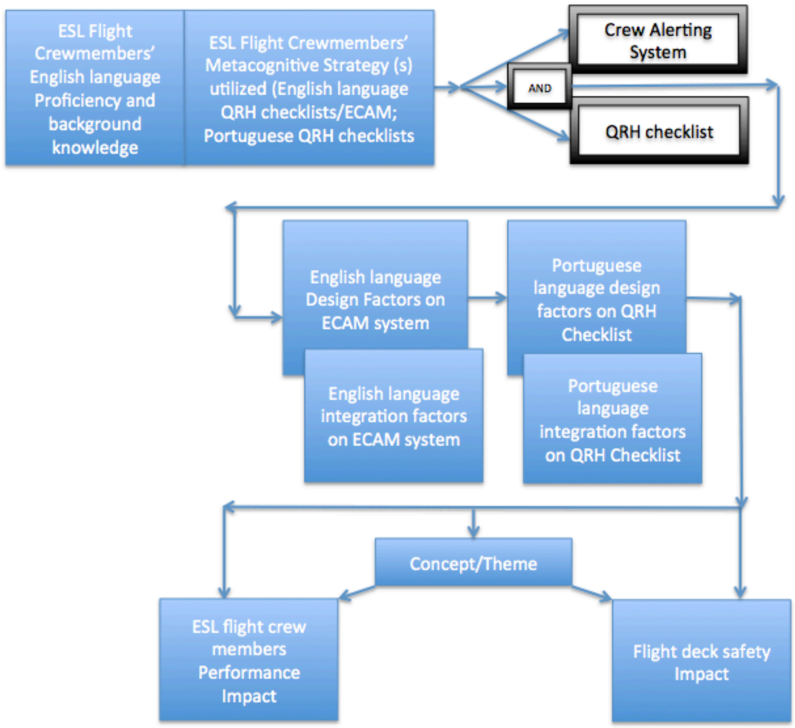


Figure 20 High-level coding method Addendum to Experiment

Coding transcription template overview

As described in the researcher's preliminary study one and two, coding transcription template was utilized to collect data from participants during the experimental study debrief interview discussion. Table 73 provides an overview of the coding transcription template utilized to code participant narratives regarding their use of written English language QRH checklists. Table 74 is the coding transcription template utilized to code participant narratives for written Portuguese language QRH checklists. It should be noted that the coding transcription template for Portuguese language checklists is different due to the debrief discussion related to participant metacognitive strategy use during the experimental trials, Portuguese language QRH checklists design and integration factors, performance and flight safety impacts.

Table 73 Coding transcription template (English language)

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language words/text genre Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***

# Denotes ESL flight Crewmembers Demographics Sub-Theme
*Denotes ESL flight crewmembers Cognitive Sub-theme
**Denotes ESL flight Crewmembers crew alerting systems and QRH checklists Design/Integration Impact Sub-theme

Table 74 Coding transcription template (Portuguese language)

PILOT	***Metacognitive Strategy(s) Factors/Portuguese QRH checklists)**	**** QRH Portuguese Language Checklists Design/Integration Factors**	**QRH Portuguese language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***

*Denotes ESL flight crewmembers Cognitive Sub-theme
**Denotes ESL flight Crewmembers QRH checklists Design/Integration Impact Sub-theme

Coding Keys Overview

Coding keys contain a variety of factors utilized to code each participant online discussion data. Factors are intended to be influences on participants' performance and flight safety. Intent of coding keys was to categorize each of the factors into a common sub-theme, so they may be utilized to understand the impact on participants' performance and flight safety (main themes). Factors found to be relevant during the experimental debrief discussion forum were utilized in the coding process. Note: All key codes were considered for this analysis. However, if factors in the key codes were not identified in the researcher's debrief they were highlighted in grey, indicating that they were not identified in the debrief session. Recall, many of these factors listed in each of the coding keys were from the researcher's review of relevant literature. Each of the coding keys contains bold face font, which corresponds to the bold face font on the coding transcription template. There are five key codes, each with a code number and letter. The number corresponds to the key code and the letter corresponds to the factor (i.e. 1D). There may be more than one code utilized on the transcription template to describe factors participants indicated during the experimental study debrief session.

Table 75 General Coding Matrix

Key 1 Coding		Key 2 Coding	
ESL flight crew members English language background knowledge and proficiency factors	**CODE**	**ESL flight crew members vocabulary words/text genre background knowledge factors**	**CODE**
English language –ICAO ELPR level 4, 5, or 6	1A	Knowledge of English language text genre on crew alerting systems (e.g. technical text)	2A
High School non-western region experience reading comprehension and speaking English language	1B	Knowledge of English language text genre on QRH checklists (e.g. technical text)	2B
High School western region experience reading and speaking English language	1C	Knowledge of English language elements on QRH checklists (e.g. typographical elements)	2C
Middle School non-western region experience reading and speaking English language	1D	English language experience with conditional statements on QRH checklists (e.g. structure, noticing)	2D
Middle School western region experience reading and speaking English language	1E	Background knowledge of abbreviations/acronyms (e.g. short form and/or long form)	2E
ATP Certification (ability to read English language)	1F	Background knowledge of text format on crew alerting systems and QRH Checklists (e.g. authentic, elaborated, or short text)	2F
Airline years of experience using crew alerting systems and QRH checklists	1G	ATP certification (knowledge of crew alerting systems /QRH checklists)	2G
Self rated English language proficiency RCL of general use of English language (H-level)	1H	Background knowledge of vocabulary word type on crew alerting systems	2H
Self rated English language proficiency RCL of general use of English language (M-level)	1I	Background knowledge of vocabulary word type on QRH checklists	2I
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (H-level)	1J		
Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (M-level)	1K		

Table 76 General Coding Matrix

Key 3 Coding	
ESL flight crewmembers metacognitive strategy factors	**CODE**
Lexical Inferencing (educated guessing of word meaning)	3A
Re-Reading Text	3B
Paraphrasing Text	3C
Underlining Text	3D
Referencing other Resources to clarify information (e.g. dictionary)	3E
Highlighting Text	3F
Translating written English/Portuguese language into ESL flight crewmembers native language	3G
Reverting back to native language to read English language	3H
Reading aloud text on flight deck	3I
Monitoring reading comprehension	3J
Taking Notes	3K
Breaking Apart Sentences	3L
Bottom up strategy (Decoding text)	3M
Top down strategy (prior knowledge of text; activating text schema)	3N
Interactive strategy (Combination of Bottom up and Top Down Strategy use)	3O
Monitoring reading speed	3P
Skipping words/omission of words	3Q
Key 4 Coding	
Crew alerting systems English language design and integration factors	
Sentence Length (Short)	4A
Acronyms/abbreviations	4B
Text Genre (e.g. technical)	4C
Number of Tokens in Text	4D
Authentic Text	4E
Sentence Length (Long)	4F
Simplification of Text	4G
Vocabulary Words Type	4H
Key 5 Coding	
QRH checklist English language design and integration factors	
Conditional Statements	5A
Number of Tokens in Text	5B
Authentic Text	5C
Sentence Length (Long)	5D
Simplification of Text	5E
Acronyms/Abbreviations	5F
Text Genre (e.g. technical)	5G
Vocabulary Words Type	5H
Sentence Length (Short)	5I

Inter-rater reliability

To ensure the researcher did not have any bias when categorizing participant proficiency levels, key code sub-themes, and main themes from interviews and questionnaires, inter-rater reliability analysis was conducted to ensure rater agreement in the data collected. Therefore, the researcher consulted two ESL flight crewmembers independent of the experimental study to review each theme created by the researcher. They had a background in flight operations and ESL flight crewmembers interface with crew alerting and information systems. The researcher developed an exercise named 'pin the proficiency level, key code sub-theme and main theme to each participant narrative'. Each expert pinned the appropriate key code/sub-theme and main theme to the narrative they thought is represented.

After the researcher collected the results from the exercise, the researcher reviewed the results to ensure the key codes, sub themes, and main themes the researcher developed were consistent with the experts' results. The researcher utilized Cohen's Kappa coefficient to analyze the rater results. Results indicated Cohen's Kappa coefficient was *k=.61*, which indicates substantial inter-rater reliability agreement between the raters. Next table provides an overview of the results. The reason for the coefficient level could have been due to the key codes needing further details to describe the factors; this could have improved the key code selections by the raters. Nevertheless, it can be considered a reliable method to code information from participant narratives.

Table 77 Inter-rater Reliability Results from Qualitative Study (Addendum to experiment)

Artifact	Rater 1	Rater 2	Agreement		Agreement Scale/Nomenclature
Pilot Narrative 1	1	1	1		1=agreement between raters
Pilot Narrative 2	1	1	1		1=agreement between raters
Pilot Narrative 3	0	1	0		0= Non-agreement between raters
Pilot Narrative 4	1	1	1		1=agreement between raters
Pilot Narrative 5	1	1	1		1=agreement between raters
Pilot Narrative 6	0	0	1		1=agreement between raters
Pilot Narrative 7	1	1	1		1=agreement between raters
Pilot Narrative 8	1	1	1		1=agreement between raters
Pilot Narrative 9	1	1	1		1=agreement between raters
Pilot Narrative 10	0	0	1		1=agreement between raters
Pilot Narrative 11	1	1	1		1=agreement between raters
Pilot Narrative 12	0	0	1		1=agreement between raters
Pilot Narrative 13	0	1	0		0= Non-agreement between raters
Pilot Narrative 14	1	1	1		1=agreement between raters
Pilot Narrative 15	1	0	0		0= Non-agreement between raters
Pilot Narrative 16	1	0	0		0= Non-agreement between raters
Pilot Narrative 17	0	0	1		1=agreement between raters
Pilot Narrative 18	1	1	1		1=agreement between raters
Pilot Narrative 19	1	1	1		1=agreement between raters
Pilot Narrative 20	1	1	1		1=agreement between raters
Pilot Narrative 21	0	0	1		1=agreement between raters
Pilot Narrative 22	1	0	0		0= Non-agreement between raters
Pilot Narrative 23	1	1	1		1=agreement between raters
Pilot Narrative 24	1	1	1		1=agreement between raters
Pilot Narrative 25	0	0	1		1=agreement between raters
Pilot Narrative 26	1	1	1		1=agreement between raters
Pilot Narrative 27	1	1	1		1=agreement between raters
Pilot Narrative 28	1	1	1		1=agreement between raters
Pilot Narrative 29	1	1	1		1=agreement between raters
Pilot Narrative 30	0	0	1		1=agreement between raters
				MATCH	25
				TOTAL	30
				ARR Percent	0.833333

		Rater 2			
		0	1		
Rater 1	0	7	2	9	30%
	1	3	18	21	70%
		10	20	30	
		33%	67%		
1=Agreement					
0=No Agreement					
REFERENCES					
Cohen's Kappa=					
k=Probability of agreement observed-Probability of agreement based on chance/1-Probability of agreement based on chance					
k=(Pr((a)-Pr(e))/1(1-Pr(e))					
Pr (a)	0.83333333				
Pr (e)		0.566667			
k=	0.61538462				

The following sample narratives are from the researcher's experimental study. Intent of these sample narratives is to provide the reader with the types of information collected from the participants during the study.

Sample Narratives From Experimental Study

SAMPLE 1 participant excerpt from narrative

"When I used the English checklist it seemed easy. When I used the Portuguese checklist it was very time consuming and my workload was high. The reason why it was time consuming was because I can remember second-guessing every input to the flight deck due to my interpretation of the checklist. My workload (mental/temporal/effort) was high because of the translation of technical acronyms and abbreviations—and sometimes sentences. When using the Portuguese checklist (ECAM actions) I think it was difficult because the flight deck is in English and the checklist was Portuguese. All of the aircraft manuals are written using the English language. There is an issue with the Airbus manuals on 'need to know' versus 'nice to know' but that is a separate issue with the complexity of Airbus language. However, when you combine wordy information and it being in a different language, it complicates the issue".

SAMPLE 2 participant excerpt from narrative

"I felt like the use of the English checklist workload was low because I was trained on how to use the checklist in English. In the beginning of my career, I struggled to learn the English language; but now I feel adequate using the language. Even the though my ICAO English language proficiency is ok, I still feel that I could improve some of my skills. When I used the Portuguese checklist I completely got caught off guard. What I mean by this is that I assumed that I knew most of the technical terms but I didn't in a different language. Since everything in English cannot be translated in to Portuguese, I felt like this impacted my response time to the failure/malfunction. Response time was longer because I had to comprehend the language. Workload using the Portuguese checklist was high in the following categories: mental, temporal, frustration, and effort. To summarize these four demands, I felt it was extremely difficult to interpret the checklist in another language and perform the inputs on the flight deck. This is in part because the flight deck is in English. I believe everything should be in English or flight crew members' performance may be impacted".

Results

Results indicated that participants that read and comprehend written English language QRH checklists during the trials did not indicate many negative performance impacts. Whereas, when participants utilized Portuguese language QRH checklists, they indicated negative performance impacts. Accordingly, next tables provide detailed information on results from the study. Collectively, participants' demographics data and findings from the coding/theme exercise conveyed noteworthy findings regarding design and integration of written English language on crew alerting systems and QRH checklists. Detailed coding analyses are located in Appendix B. Columns that contain 'N/A' indicate participants' did not indicate any demographic/design/integration factors/negative performance impacts.

Next tables are an overview of factors that influenced participant ability to perform using QRH checklists (English language and Portuguese language). Tables also provide a general review of negative impacts participants highlighted in their interviews and questionnaires regarding flight safety. Results on column one provide a description of participant performance impacts, column two participant metacognitive strategy utilized, and column three participant performance impact using QRH checklists. Note: Since participants that read English language QRH checklists indicated their performance did not impact flight safety; there is no column representing these impacts. On the other hand, participants indicated their performance was negatively impacted while reading and interpreting Portuguese language QRH checklists. Therefore, flight safety impact column is provided in the tables to explain their impact of reading and interpreting Portuguese language QRH checklists. Note: Boxes filled with grey indicate ESL flight crewmembers did not mention negative impacts on their performance or flight deck safety, with respect to their use of QRH checklists. Boxes with an ('X') indicate ESL flight crewmembers mentioned their performance was negatively impacted by use of QRH checklists. Boxes ('shaded with blue') indicate ESL flight crewmembers percentages of using QRH checklists; shaded blue boxes also provide overall theme. 'No impact' indicates there were no negative impacts to participant reading comprehension abilities when they read information on QRH checklists.

Table 78 CA, QRH checklists, and combination of both (QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=30) ENGLISH LANGUAGE

ESL flight crewmember description of impact on performance (N=30)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (QRH Checklists)
PILOT 1: No Impact	Y	
PILOT 2: Workload is low to medium depending on the type of sentence I read on electrical system QRH checklist. Conditional statements are difficult to read and lead to re-reading text.	Y	X
PILOT 3: No Impact	Y	
PILOT 4: No Impact	Y	
PILOT 5: No Impact	Y	
PILOT 6: Low workload when I have to troubleshoot using the QRH checklists when re-reading and guessing short sentences with acronyms and abbreviations, and conditional statements. Long sentences take longer to read on QRH checklists	Y	X
PILOT 7: Abbreviations and acronyms are not consistent on QRH checklists and leads to longer response times and re-reading and decoding abbreviations and acronyms	Y	X
PILOT 8: Abbreviations and acronyms are not consistent on QRH checklists and leads to longer response times and re-reading abbreviations and acronyms. Long sentences are a challenge to read on QRH checklists	Y	X
PILOT 9: No Impact	Y	
PILOT 10: Vocabulary words on QRH checklists often times are challenging and lead to low workload. Long sentences are sometimes difficult to read	N	X
PILOT 11: No Impact	Y	
PILOT 12: No Impact	Y	
PILOT 13: No Impact	Y	
PILOT 14: No Impact	Y	
PILOT 15: Response time was slightly longer due to re-reading conditional statements, acronyms and abbreviations on hydraulic QRH checklist	Y	X
PILOT 16: Response time was slightly longer due to re-reading acronyms and abbreviations on hydraulic QRH checklist	Y	X
PILOT 17: No Impact	Y	
PILOT 18: No Impact	N	
PILOT 19: No Impact	N	
PILOT 20: No Impact	N	
PILOT 21: No Impact	Y	

Table 79 CA, QRH checklists, and combination of both (QRH checklists) impacts on ESL flight crewmembers performance and flight safety (N=30) ENGLISH LANGUAGE

ESL flight crewmember description of impact on performance (N=30)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (QRH Checklists)
PILOT 22: No Impact	Y	
PILOT 23: No Impact	Y	
PILOT 24: Acronyms on QRH checklists do not contain long form of word and leads to longer than expected response time. Conditional statements are difficult to read and lead to re-reading text	Y	X
PILOT 25: No Impact	Y	
PILOT 26: No Impact	Y	
PILOT 27: Vocabulary words on checklists are not consistent at times leads to longer than expected response times and workload on QRH checklists	Y	X
PILOT 28: No Impact	Y	
PILOT 29: No Impact	Y	
PILOT 30: No Impact	Y	
Percentage= 9/30=30% description of Impact on performance	Percentage=26/30=86% Utilize Metacognitive strategies	Percentage=9/30=30%

Next tables are an overview of factors that influenced participants' ability to perform using QRH checklists (Portuguese Language). It also provides a general review of negative impacts participants highlighted in their interviews and questionnaires regarding flight safety. Results on column one shows descriptions that all participants' performance was negatively impacted with use of QRH checklists written in Portuguese language. Column two indicated all participants used metacognitive strategies to read and interpret written English language, while column three indicated all participants were impacted by use of QRH checklists, and column four conveyed impact on flight safety.

Note: Boxes with an ('X') indicate ESL flight crewmembers mentioned their performance was negatively impacted by use of QRH checklists. Boxes shaded with blue indicate ESL flight crewmembers percentages of using QRH checklists; shaded blue boxes also provide overall theme.

Table 80 QRH checklists impacts on ESL flight crewmembers performance and flight safety (N=30) (PORTUGUESE LANGAUGE)

ESL flight crewmember description of impact on performance (N=30)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (QRH Checklists)	Impact on flight safety
PILOT 1: Misinterpretation of vocabulary word meanings on QRH checklists. Sentence length is sometimes long read and too short	Y	X	Incorrect inputs on overhead panel and flight deck switches led to long response time
PILOT 2: Translated words/ unknown vocabulary words into native language to understand information on QRH checklists. Conditional statements are also difficult to read, as well as short sentences	Y	X	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
PILOT 3: Misunderstanding vocabulary words on QRH checklists due to unfamiliarity	Y	X	Misinterpretation of vocabulary words (technical) leads to re-reading text for comprehension and long response times
PILOT 4: Conditional statements are inherently too long and are not specific enough to complete tasks all of the time	Y	X	Re-reading conditional statements led to long response time and high workload
PILOT 5: Difficulties making sense of words on QRH checklists and associated words to make decisions. Sentence length is also sometimes long.	Y	X	Misunderstandings with word association and sentence syntax led to long response times and high workload
PILOT 6: Reverted back to my knowledge of English language to read Portuguese language	Y	X	Reverting back to English language led to long response times and confusion, which led to high workload
PILOT 7: misunderstood certain words on QRH checklists led to longer processing of information. Sentence length is sometimes long and short	Y	X	Misunderstandings with word association and sentence syntax led to long response times and high workload
PILOT 8: Translated Portuguese words to find different word meanings. Conditional statements are also difficult to read. Sentence length is sometimes long	Y	X	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
PILOT 9: Misinterpreted QRH checklist words and pushed incorrect buttons on flight deck	Y	X	Incorrect inputs on overhead panel and flight deck switches
PILOT 10: guessed meaning of certain words unfamiliar on QRH checklists	Y	X	Guessing meaning of vocabulary words led to high workload due to misunderstandings of word meaning

Table 81 QRH checklists impacts on ESL flight crewmembers performance and flight safety (N=30) (PORTUGUESE LANGAUGE) continued

ESL flight crewmember description of impact on performance (N=30)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (QRH Checklists)	Impact on flight safety
PILOT 11: Experienced difficulties with vocabulary words and associating them in a sentence. Sometimes sentences are too short for reading	Y	X	Misunderstandings with word association and sentence syntax led to long response times and high workload
PILOT 12: abbreviations and acronyms are difficult to read and comprehend in notes section and safety information. Conditional statements are also difficult to read	Y	X	Misinterpretation of abbreviations and acronyms on notes section led to long response times
PILOT 13: Translated Portuguese language to find other equivalent meanings	Y	X	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
PILOT 14: translated words in Portuguese language to find other meanings. Sentence length is sometimes long	Y	X	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
PILOT 15: Since my training is in English language, tried to read QRH checklists in English language	Y	X	Reverting back to English language led to long response times and confusion, which led to high workload
PILOT 16: Incorrectly guessed meaning of words	Y	X	Guessing meaning of vocabulary words led to high workload due to misunderstandings of word meaning
PILOT 17: Made incorrect inputs on flight deck due to misunderstanding of QRH checklists. Conditional statements are also difficult to read	Y	X	Incorrect inputs on overhead panel and flight deck switches
PILOT 18: Re-reading text due to unfamiliar vocabulary words	Y	X	Re-reading Portuguese language vocabulary words led to long response time
PILOT 19: Connecting word meaning on Portuguese language QRH checklists led to guessing words incorrectly. Sentence length is sometimes long	Y	X	Led to long response time, omission of vocabulary words, and high workload
PILOT 20: Misinterpreted information on QRH checklists led to incorrect inputs on flight deck panel	Y	X	Incorrect inputs on overhead panel and flight deck switches
PILOT 21: Connecting word meaning on Portuguese language QRH checklists led to guessing words incorrectly. Conditional statements are also difficult to read	Y	X	Tasks unrelated (but important) to hydraulic/electrical faults were abandoned

Table 82 QRH checklists impacts on ESL flight crewmembers performance and flight safety (N=30) (PORTUGUESE LANGAUGE) continued

ESL flight crewmember description of impact on performance (N=30)	Metacognitive Strategy Utilized? Y/N	ESL flight crewmember performance impact (QRH Checklists)	Impact on flight safety
PILOT 22: Translated words to find other meanings because of unfamiliar terminology	Y	X	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic system faults leads to misinterpretation of word meaning
PILOT 23: Did not understand certain vocabulary words in Portuguese language on QRH checklists	Y	X	Misinterpretation of vocabulary words (technical) led to re-reading text for comprehension and long response times
PILOT 24: Omitted certain vocabulary words that were unfamiliar to me	Y	X	Omission of vocabulary words (technical) led to misunderstandings with solving hydraulic and electrical system faults on flight deck, which led to long response times
PILOT 25: abbreviations/acronyms on QRH checklists were difficult to read and understand. Sentence length is sometimes long	Y	X	Misinterpretation of abbreviations and acronyms on notes section led to long response times
PILOT 26: Omitted words that were not familiar and led to misunderstanding of text	Y	X	Omission of vocabulary words (technical) led to misunderstandings with solving hydraulic and electrical system faults on flight deck, which led to long response times
PILOT 27: Difficulties understanding and associating word meaning and sentence syntax	Y	X	Misunderstandings with word association and sentence syntax led to long response times and high workload
PILOT 28: abbreviated text was difficult to understand and led to misunderstanding information	Y	X	Misinterpretation of abbreviations and acronyms led to high mental demand/workload
PILOT 29: Omitted words unfamiliar, which led to misunderstanding other text. Conditional statements are also difficult to read	Y	X	Omission of vocabulary words (technical) led to misunderstandings with solving hydraulic and electrical system faults on flight deck, which led to long response times
PILOT 30: Conditional statements are normally very difficult to read due to Airbus procedure design	Y	X	Misunderstandings with conditional statements in the notes section, with respect to form and function led to long response times
Percentage= 30/30=100%	Percentage = 30/30=100%	Percentage = 30/30=100%	Percentage=30/30=100%

Next results provide the reader with an understanding of demographics, specific factors and performance indicators that influenced participants' ability to read and comprehend written English language on crew alerting systems and QRH checklists.
Note: Since participants indicated no impacts to their use of the ECAM system while reading and interpreting information on written English language QRH checklists and Portuguese language checklists, there was no table representing CA design and integration factors. However, there are tables that represent participant metacognitive strategies use while reading information on CA (English language)/QRH checklists (Portuguese language). In addition, design and integration factors tables provide information as to why participants were challenged when they read and interpreted information on English language QRH checklists and Portuguese language QRH checklists during the experimental trials.

Table 83 ESL flight crewmembers English language background knowledge factors ('demographics sub-theme') (N=30)

Code	Description	Flight crewmembers Percentages
1A	English language-ICAO ELPR Level 4, 5, or 6	30/30 = (100%)
1B	High School non-western region experience reading comprehension and speaking English language	20/30 = (66%)
1C	High School western region experience reading and speaking English language	2/30= (~6.6%)
1D	Middle School non-western region experience reading and speaking English language	8/30=(~26.6%)
1E	Middle School western region experience reading and speaking English language	0/30= (0%)
1F	ATP Certification (ability to read English language)	30/30 (100%)
1G	Airline years of experience using crew alerting systems and QRH checklists	30/30 (100%)

First demographics sub-theme indicated that each participant had background knowledge of English language and claimed ICAO English language proficiency levels of four, five, or six. All participants indicated they had an ATP certification and years of experience using crew alerting systems and QRH checklists. Regarding participant English language experiences from educational institutions of learning, results indicated their experience was different with respect to institution type and western/non-western region.

Table 84 ESL flight crewmembers' English language proficiency factors ('demographics sub-theme') (N=30)

Code	Description	Flight crewmembers Percentages
1H	Self rated English language proficiency RCL of general use of English language (H-level)	27/30= (90%)
1I	Self rated English language proficiency RCL of general use of English language (M-level)	3/30= (10%)
1J	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (H-level)	25/30= (83.3%)
1K	Self rated English language proficiency RCL of English language on crew alerting systems and QRH checklists (M-level)	5/30= (16.6%)

Second demographics sub-theme indicated that participants had different written English language proficiency levels with respect to their RCL proficiency of general English language, crew alerting systems and QRH checklists.

Table 85 ESL flight crewmembers' English language vocabulary words/text genre background knowledge factors ('demographics sub-theme') (N=30)

Code	Description	Flight crewmembers Percentage
2A	Knowledge of English language text genre on crew alerting systems (e.g. technical text)	30/30 (100%)
2B	Knowledge of English language text genre on QRH checklists (e.g. technical text)	30/30 (100%)
2C	Knowledge of English language elements on QRH checklists (e.g. typographical elements)	30/30 (100%)
2D	English language experience with conditional statements on QRH checklists (e.g. structure, noticing)	30/30 (100%)
2E	Background knowledge of abbreviations/acronyms (e.g. short form and/or long form)	30/30 (100%)
2F	Background knowledge of text format on crew alerting systems and QRH Checklists (e.g. authentic, elaborated, or short text)	30/30 (100%)
2G	ATP certification (knowledge of crew alerting systems /QRH checklists)	30/30 (100%)
2H	Background knowledge of vocabulary word type on crew alerting systems	30/30 (100%)
2I	Background knowledge of vocabulary word type on QRH checklists	30/30 (100%)

Third demographics sub-theme indicated that all participants had experience with vocabulary words and text genre background on English language crew alerting systems and QRH checklists.

Table 86 ESL flight crewmembers' metacognitive strategies factors to read written English language on crew alerting systems and QRH checklists ('cognitive sub-theme') versus English language proficiency (N=30) (ENGLISH LANGUAGE)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
3A	Lexical Inferencing (educated guessing of word meaning)	12/30 (40%)	~33% H-level; ~6% M-Level	~36% H-Level; ~3% M-Level
3B	Re-Reading Text	8/30 (~26%)	20% H-Level; ~6% M-Level	20% H-Level; ~6% M-Level
3C	Paraphrasing Text			
3D	Underlining Text			
3E	Referencing other Resources to clarify information (e.g. dictionary)	6/30 (20%)	~16% H-level; ~3% M-level	~16% H-Level; ~3% M-Level
3F	Highlighting Text			

Table 87 ESL flight crewmembers' metacognitive strategies factors to read written English language on crew alerting systems and QRH checklists ('cognitive sub-theme') versus English language proficiency (N=30) (ENGLISH LANGUAGE) continued

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
3G	Translating English written language into ESL flight crewmembers native language	10/30 (~33%)	~26% H-level; ~6% M-Level	30% H-Level; ~3% M-Level
3H	Reverting back to native language to read English language	9/30 (30%)	~23% H-Level; ~6% M-Level	~26% H-Level; ~3% M-Level
3I	Reading aloud text on flight deck	14/30 (~46%)	40% H-Level; ~6% M-Level	~36% H-Level; 10% M-Level
3J	Monitoring reading comprehension			
3K	Taking Notes			
3L	Breaking Apart Sentences			
3M	Bottom up strategy (Decoding text)			
3N	Top down strategy (prior knowledge of text; activating text schema)			
3O	Interactive strategy (Combination of Bottom up and Top Down Strategy use)	11/30 (~36%)	30% H-Level; ~6% M-Level	30% H-Level; ~6% M-level
3P	Monitoring reading speed			
3Q	Skipping words/omission of words	4/30 (~13%)	~6% H-Level; ~6% M-level	10% H-Level; ~3% M-Level

Cognitive sub-theme (metacognitive strategy) indicated participants utilized different types of metacognitive strategies to read and interpret written English language on crew alerting systems and QRH checklists. Additionally, each participant had different English language proficiency level (written English language, crew alerting systems and QRH checklists) when they read written English language on crew alerting systems and QRH checklists.

Table 88 ESL flight crewmembers' metacognitive strategies factors to read written English language QRH checklists ('cognitive sub-theme') versus English language proficiency (N=30) (PORTUGUESE LANGUAGE)

Code	Description	Flight crewmembers Percentage
3A	Lexical Inferencing (educated guessing of word meaning)	28/30= ~93%
3B	Re-Reading Text	23/30= ~76%
3C	Paraphrasing Text	
3D	Underlining Text	
3E	Referencing other Resources to clarify information (e.g. dictionary)	6/30=20%
3F	Highlighting Text	

Table 89 ESL flight crewmembers' metacognitive strategies factors to read written English language QRH checklists ('cognitive sub-theme') versus English language proficiency (N=30) (PORTUGUESE LANGUAGE) continued

Code	Description	Flight crewmembers Percentage
3G	Translating written Portuguese language into ESL flight crewmembers native language	25/30= ~83%
3H	Reverting back to native language to read English language	19/30= ~63%
3I	Reading aloud text on flight deck	11/30= ~36%
3J	Monitoring reading comprehension	
3K	Taking Notes	

Table 90 ESL flight crewmembers' metacognitive strategies factors to read written English language QRH checklists ('cognitive sub-theme') versus English language proficiency (N=30) (PORTUGUESE LANGUAGE) continued

Code	Description	Flight crewmembers Percentage
3L	Breaking Apart Sentences	
3M	Bottom up strategy (Decoding text)	19/30= ~63%
3N	Top down strategy (prior knowledge of text; activating text schema)	
3O	Interactive strategy (Combination of Bottom up and Top Down Strategy use)	
3P	Monitoring reading speed	19/30= ~63%
3Q	Skipping words/omission of words	7/30= ~23%

Participants also utilized different metacognitive strategies to read Portuguese language on QRH checklists. The importance of participant metacognitive strategy use will be reviewed in the discussion section of this study.

Table 91 ESL flight crewmembers QRH Checklists English language design and integration factors (N=30)

Code	Description	Flight crewmembers Percentage	Flight crewmembers English language Proficiency and Percentage (RCL Proficiency General English language)	Flight crewmembers English language Proficiency and Percentage (crew alerting systems and QRH checklists RCL proficiency)
5A	Conditional Statements	4/30= ~13%	10% H-level; ~3% M-Level	10% H-Level; ~3% M-Level
5B	Number of Tokens in Text			
5C	Authentic Text	9/30= 30%	~26% H-Level; ~3% M-Level	~23% H-Level; ~6% M-Level
5D	Sentence Length (Long)	3/30= 10%	10% H-Level	10% H-Level
5E	Simplification of Text			
5F	Acronyms/Abbreviations	6/30=20%	20% H-Level	~16% H-Level; ~3% M-Level
5G	Text Genre (e.g. technical)	9/30= 30%	~26% H-Level; ~3% M-Level	~23% H-Level; ~6% M-Level
5H	Vocabulary Words Type	9/30= 30%	~26% H-Level; ~3% M-Level	~23% H-Level; ~6% M-Level
5I	Sentence Length (Short)	1/30= ~3%	~3% H-Level	~3% H-Level

Regarding written English language on QRH checklists, participants indicated their performance was negatively impacted by different written English language design and integration factors on QRH checklists. Additionally, each of the thirty participants indicated variability in their English language proficiency levels (general English language, crew alerting systems and QRH checklists). Written English language design and integration factors on QRH checklists relevance, with respect to participant English language proficiency level will be reviewed in the discussion section of this study.

Table 92 ESL flight crewmembers QRH Checklists Portuguese language design and integration factors (N=30)

Code	Description	Flight crewmembers Percentage
5A	Conditional Statements	8/30= ~26%
5B	Number of Tokens in Text	
5C	Authentic Text	30/30= ~100%
5D	Sentence Length (Long)	7/30= ~23%
5E	Simplification of Text	
5F	Acronyms/Abbreviations	3/30= 10%
5G	Text Genre (e.g. technical)	30/30= 100%
5H	Vocabulary Words Type	30/30= 100%
5I	Sentence Length (Short)	4/30= ~13%

Regarding written Portuguese language on QRH checklists, participants indicated their performance was negatively impacted by different written English language design and integration factors on QRH checklists. Written Portuguese language design and integration factors on QRH checklists relevance, with respect to participant English language proficiency level will be reviewed in the discussion section of this study.

Table 93 Flight safety impact (main theme) on ESL flight crewmembers (N=30) (PORTUGUESE LANGAUGE)

Main Theme: ESL flight crewmembers flight safety impact	PERCENTAGES
Incorrect inputs on overhead panel and flight deck switches led to long response time	3/30= 10%
Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning	5/30= ~16%
Misinterpretation of vocabulary words (technical) leads to re-reading text for comprehension and long response times	2/30= ~6%
Re-reading/misinterpretation of conditional statements led to long response time and high workload	2/30= ~6%
Misunderstandings with word association and sentence syntax led to long response times and high workload	4/30= ~13%
Reverting back to English language led to long response times and confusion, which led to high workload	2/30= ~6%
Guessing meaning of vocabulary words led to high workload due to misunderstandings of word meaning	2/30= ~6%
Misinterpretation of abbreviations and acronyms on notes section led to long response times	3/30= 10%
Omission of vocabulary words (technical) led to misunderstandings with solving hydraulic and electrical system faults on flight deck, which led to long response times	3/30= 10%
Tasks unrelated (but important) to hydraulic/electrical faults were abandoned	1/30= ~3%

Table 93 illustrates negative impacts on flight safety as a result of flight crewmember reading comprehension performance on the flight deck. Many different types of participant performance factors negatively impact flight safety. These factors were the result of participants reading the Portuguese language QRH checklists.

Discussion (Coded Narratives)

This section provides a discussion of each factor/performance factors that influenced participants' ability to read and comprehend written English language and Portuguese language. Goal of this discussion is to provide the reader with an understanding of how written English language concepts reviewed in the literature review are interrelated with the outcome of the researcher's experimental study. It also provides the reader with an understanding of impact of translating written English language into participants' native language Portuguese. Towards the end of the discussion, the reader should understand issues with written English language that led to participant performance challenges on the flight deck.

Figure 21 is a paradigm that describes how the researcher will approach the discussion for the follow-up questions from the researcher's experimental study. Second box from the top describe flight crewmembers' English language proficiency on written English language QRH checklists, while the third boxes describe metacognitive strategies to read and comprehend written English language and Portuguese language QRH checklists. Recall, it was indicated that participant background knowledge must be adequate in written English language, or there could be difficulties interpreting English language vocabulary words/sentences translated into participant native language, regardless of proficiency level (Al-Sohbani and Muthanna, 2013). Third box also describes written English language design and integration factors. Participant performance challenges with respect to their use of written English language QRH checklists will be reviewed. Finally, participant reading comprehension of written Portuguese language QRH checklists will be discussed and impact on flight safety.

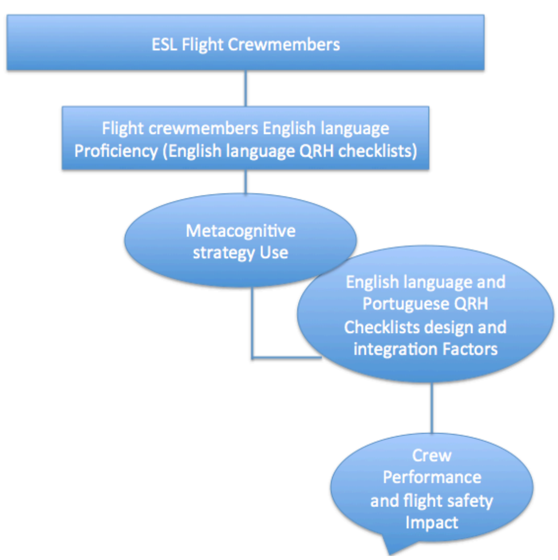


Figure 21 Follow-up Questions-Experimental Study Paradigm Discussion Points

As participants utilized many different metacognitive strategies to read and interpret written English language, the researcher will provide and overview of the top four strategies utilized most by participants during the experimental trials, as well as a review of their respective RCL English language proficiency. The researcher will also highlight other strategies utilized by participants to read and interpret written English language. Remainder of metacognitive strategies utilized by participants can be reviewed on Table 86 and Table 87. Participants indicated that their metacognitive strategies utilized to read and understand written English language on the ECAM system and QRH checklists was a practice they utilized all of the time during non-normal conditions. They indicated they regularly use metacognitive strategies because English language has some difficulties with the design and integration of English language on QRH checklists. It was indicated that participants (forty-percent) with RCL proficiency H-level and M-level (general English language, crew alerting systems and QRH checklists) utilized lexical inferencing to read and interpret written English language on ECAM system and QRH checklists. They indicated it is often challenging to read written English language, but if you have enough background knowledge of the information, you learn how to decode text on the checklists. As Wang (2011b) indicated advanced level participants were challenged with vocabulary words written in English language. When participants decoded words they made incorrect inferences. This result does not corroborate the researcher's results. In the researcher's study, participants with RCL H-level and M-level were challenged with written English language on QRH checklists, but they did not make incorrect inferences. Therefore, it can be concluded that participants in the researcher's study correctly guessed words they did not know, and they were successful with interpreting written English language on QRH checklists. Participants (forty-six percent) with RCL proficiency H-level and M-level (general English language, crew alerting systems and QRH checklists) utilized reading aloud text on the flight deck to read and understand written English language on the ECAM and QRH checklists. They indicated there airline requires them to read information aloud to mitigate misunderstandings with technical information.

Thirty-three percent of participants with RCL proficiency H-level and M-level (general English language, crew alerting systems and QRH checklists) indicated they translated written English language into their native language. It was noted that they are aware of certain phrases and abbreviations that are difficult to read on the QRH checklist, and they translated the text because it is easier for them. As Abdul-Hamid and Samuel (2012) indicated, their study focused on written English language scientific text and the impact on ESL adult reading comprehension. Their participants' range of English language proficiency was either proficient or less than proficient. Each of the participants had background knowledge of the texts in their native language. Each text contained several academic vocabulary words mixed with scientific words. Participants translated written English language words in to their native lexis to understand words that they did not know the meaning. Abdul-Hamid and Samuel's (2012) study corroborated many of the researcher's study findings, but there were some that were not supported. As participants in the researcher's study had background knowledge of the text they read in English language and they were proficient, this finding supports the authors' results from their study. On the contrary, participants in the researcher's study did not indicate they had background knowledge of the texts (written English language QRH checklists) in their native lexis, although they translated many words into their native lexis. It can be concluded that even though participants may have background knowledge of written English language text corpora, they many not have an adequate background of the text to translate all information on QRH checklists. In the researcher's study, participants did not indicate they translated information incorrectly.

Participants (thirty-six percent) with RCL proficiency H-level and M-level (general English language, crew alerting systems and QRH checklists) used interactive strategy (bottom up/top down) to read and understand information on the ECAM system and QRH checklists. It was noted that background knowledge of text corpora on ECAM and QRH checklists are utilized as well as decoding abbreviations and acronyms unfamiliar to them. As Fatemi et al's (2014) study indicated, participants with high English language proficiency use interactive model and other related strategies to read written English language. Fatemi et al's (2014) study corroborates the researcher's findings. Other notable factors indicated by participants that influenced their reading comprehension were that English language is often verbose on Airbus QRH checklists. Reading verbose language on QRH checklists automatically leads participants to re-read text, cognitively translating text into their native language (Portuguese) to find other meanings in their native language. Reverting back to English language was also considered a strategy utilized by participants in the study. Participants also indicated they were aware of issues with English language on Airbus QRH checklists and have been able to overcome these issues by using aforesaid strategies to read and interpret English language on QRH checklists. Although it was indicated that participants utilized metacognitive strategies to read and interpret written English language, use of these strategies may have an effect other flight crewmembers performance that speak a different language (i.e. Chinese). Therefore, metacognitive strategies utilized by participants to read written English language on QRH checklists in the researcher's study, should only be attributed to participants that completed the experimental trials.

As participants utilized many different metacognitive strategies to read and interpret written Portuguese language, the researcher will provide and overview of the top three strategies utilized most by participants during the experimental trials. The researcher will also highlight other strategies utilized by participants. It was indicated that when participants utilized Portuguese language QRH checklists, they often used different metacognitive strategies to understand the language. All participants indicated that it is not recommended to use a translated language on QRH checklists. Even though they utilized metacognitive strategies to read and understand information on both checklists it led to long response time, high workload, and errors of omission.

It was found that ninety-three percent of participants used lexical inferencing strategy; eighty-three percent utilized translating written Portuguese language back into their native lexis, and seventy-six percent utilized re-reading text strategy, to read Portuguese language QRH checklists. As Barani and Karimnia's (2014) indicated, their participants had background knowledge of English language, but they still re-read sentences and paraphrase words to understand their native lexis when it was translated. It was indicated that they utilized these strategies for problem solving purposes, which were related to difficulties understanding word meaning. This finding supports part of the researcher's study. Participants had background of written English language on QRH checklists, but they still re-read text in their native lexis to solve the hydraulic and electrical faults on the flight deck ECAM system and QRH checklists. Therefore, it can be concluded that having a background in English language is an indication that participants will use re-reading strategy to understand their native lexis. On the other hand, participants did not indicate they paraphrased text on the ECAM system or QRH checklists. As Drury and Ma (2005) indicated, certain pieces of aviation technical written information may be translated and still retain its understanding even if it were fully translated. They also indicated that certain written English language technical terms should not be translated because its translation may be very difficult to understand by the non-native English individual. Such technical terms like rudder and empennage are universally accepted technical terms and are understood by many cultures. As the researcher developed a systematic method to ensure that vocabulary words were translatable/not translatable in Portuguese language, this supports Drury and Ma (2005) perspectives on translation processes. It is still peculiar as to why participants experienced difficulties with use of the Portuguese language QRH checklists. Previously discussed, translation of written English words that have an equivalent meaning in ESL adults native language is practical, as long as the participants have an adequate understanding of text in English language. Participants had difficulty with written English language QRH checklists, but the difficult level was not considered a substantial impact to their performance. Drury and Ma (2005) also indicated that deleting or adding information as a result of a translated language by ESL individuals could be the result of misunderstandings with syntactic sentence structure. As participants omitted information on the Portuguese language QRH checklists and indicated they experienced issues with word association in sentences, this finding corroborates part of Drury and Ma's (2005) study. It was not indicated that participants added details/information to read and understand QRH checklists and ECAM system. Participants indicated that if flight crewmembers native language was to be utilized on QRH checklists as an alternative language, it should be researched thoroughly at the ICAO research level, considering flight crewmembers with different linguistic backgrounds. Research should also be conducted on ESL flight crewmembers' background knowledge of technical information in their native language and training courses would be helpful.

Summary

This section revealed participant metacognitive strategy use to read and comprehend written English language is a key component to understand written English language and Portuguese language. As many of the same quantity and variety of metacognitive strategies were utilized to read and understand each of the languages on crew alerting systems and QRH checklists, this is an indication that participants had adequate levels of written English language proficiency. It is also an indication that participants were familiar with using metacognitive strategies and comfortable with using them to read and comprehend written English language and Portuguese language. It was peculiar when participants indicated they were challenged with Portuguese language, since this is their native language, and they had adequate background knowledge (familiar) with written

English language vocabulary words design, integration, and format. As previously stated, this is likely due to their unfamiliarity of Portuguese language on QRH checklists and training on English language in a socio-technical environment (i.e. flight deck). Since they are trained using English language on the flight deck, words that appear in a different language, other than their expectations of English language negatively impact their performance.

It was indicated that written English language QRH checklists were easy to read and had minimal impact on their performance. As there were some issues participants experienced with their use of vocabulary words, abbreviations and acronyms, and conditional statements, this is an indication that there are issues with written English language QRH checklists, although the impact is low. Recall, if participant proficiency level is adequate then they will likely have a good understanding of written English language in different forms. As participant proficiency levels were RCL proficiency H-level and M-level, there ability to read and comprehend information on QRH checklists is likely due to their proficiency level and use of metacognitive strategies. As participants utilized re-reading and lexical inferencing strategies to read written English language, this is an indication they were knowledgeable of metacognitive strategies. Lexical inferencing strategy use led to participants correctly guessing vocabulary words on QRH checklists. As Dwaik and Shehadeh (2013) alluded to in their study, participants with high proficiency of written English language performed better (guessed more words correctly) with lexical inferencing strategy than low proficient readers of English language. English as-a-second language low proficient written English language readers' guessed more vocabulary words incorrectly. In the researcher's study, participants RCL proficiency was either H-level or M-level. Part of the researcher's results corroborates Dwaik and Shehadeh (2013) results. Participants with RCL proficiency H-level guessed vocabulary words correctly on the QRH checklists. On the other hand, there were no participants with RCL proficiency L-level, but there were participants with RCL proficiency M-level. This is an indication that participants with M-level proficiency also guess words correctly. Participants indicated that their airline provides simulation training on non-normal conditions on the flight deck, which includes review of QRH checklists procedures for clarity and use on the flight deck. As participants had background knowledge of texts they read during the trials, it can be concluded that this increased their reading comprehension ability to read and understand each text written in English language, and thus reduced negative impacts to their performance.

On the other hand, when participants read and comprehended information on Portuguese language QRH checklists, they indicated many challenges to their cognitive abilities to read and understand information related to system faults. Participants indicated they were 'caught off guard' when they read Portuguese language checklists. They indicated this was due to everything designed in English language and they had to read information in Portuguese language. This was contrary to the training they received prior to joining the airline (type rating training and fundamental pilot school) and airline specific training on aircraft system non-normal conditions in English language. They indicated text genre (technical vocabulary words), acronyms and abbreviations were difficult to read and understand, as they tried to cognitively translate words into their perspective of the word meaning. They also indicated that fundamental inconsistencies in written English language (mixing of verbose/elaborate text with short/simplified text) on QRH checklists from manufacturer Airbus (authentic text) negatively impacts their ability to understand written English language translated into their native language Portuguese.

Summary

This section revealed that participant use of written English language on QRH checklists during the experimental trials indicated minimal impact to participant cognitive abilities when they read and comprehended written English language on QRH checklists. In other words, their response time, errors of omission, and NASA TLX workload scores indicated minimal impact to their ability to respond effectively to crew alerts. This is likely due to participant written English language RCL proficiency levels (general English language and QRH checklists), background knowledge of text corpora on QRH checklists as well as their ability to use many different metacognitive strategies to read and comprehend written English language.

As discussed previously, participant use of written English language QRH checklists indicated minimal negative impacts to their performance and no impacts on flight safety. However, when participants utilized written English language QRH checklists translated into Portuguese language they were negatively impacted. Previously stated, participants utilized many metacognitive strategies to read and understand written Portuguese language on QRH checklists. Results indicated that vocabulary words on written Portuguese language QRH checklists were unfamiliar and difficult to understand, which led to misinterpretation of many vocabulary words, abbreviations and acronyms. It was noted during the experimental trials that when the crew alert was annunciated, participants read vocabulary words, pause, think about other vocabulary words in their native language that were similar to the words on the QRH checklists.

Participants indicated that acronyms and abbreviations were difficult to read and understand in their translated form. It was noted that misunderstandings of abbreviations/acronyms accounted for ten percent of participants flight safety impact. Fundamentally, this is peculiar since the researcher developed a process to mitigate any issues with word meaning on the QRH checklists. Recall, the mitigation strategy was developed in conjunction with an experienced translator that found equivalent words/word meaning in written Portuguese language. This result is most likely due to participants' background knowledge of written English language abbreviations and acronyms long form. As previously indicated, participants were challenged when they read acronyms and abbreviations on written English language QRH checklists. They indicated they experienced reading comprehension issues with acronyms and abbreviations, due to no references to their long form on the QRH checklists. Although participants had background knowledge of information on QRH checklists in English language, types of abbreviations and acronyms negatively impacted their reading comprehension. Therefore, when the QRH checklists were translated into their native language, they experienced the same challenges, but impact to the reading comprehension was intensified, due to acronyms and abbreviations translated into their native language.

As participants (sixteen percent) cognitively translated vocabulary words on the QRH checklists into other forms of Portuguese language, this led to re-reading text and long response times. This result was most likely due to participant inadequate background knowledge of text on the Portuguese language QRH checklists.

The time participants needed to process information on the checklists and monitor their reading speed, led to longer response times. There inability to adequately associate words in sentences led to long response times. It was indicate that word association on Portuguese language QRH checklists negatively impacted thirteen percent of participants. Furthermore, participants indicated a need to ensure that were making the correct inputs on the flight deck, so that they could respond adequately to crew alerts. As participants indicated (ten percent), they made incorrect inputs when they toggled switches/buttons and other related systems on the overhead panel due to incorrect decoding (lexical inferencing) of vocabulary words, which led to misunderstandings of Portuguese language. These misunderstandings led to frustration and high workload. Some tasks were abandoned that were unrelated to the task, but interrelated to continued safe flight processes (e.g. monitoring airspeed and distance to next waypoint). Ten percent of participants indicated they omitted procedures due to misunderstanding so vocabulary words.

Summary

This section revealed that flight safety was negatively impacted when translating written English language into Portuguese language. It is imperative that ESL flight crewmembers have a thorough understanding of written English language and have adequate background knowledge of written English language. Their English language proficiency levels should enable them to read and understand written English language. Particularly, participant RCL proficiency level (general English language, crew alerting systems and QRH checklists) should enable them to understand written English language vocabulary words, text genre, and text format. These are critical factors that impact their ability to read written English language translated into Portuguese language. In the researcher's experiment, these factors negatively impacted participant decision-making processes when responding to electrical and hydraulic system faults.

Qualitative Research Study Recommendations (Addendum to Experiment)

The researcher's experiment part two revealed important details regarding participants' background knowledge, English language proficiency, and metacognitive strategy use while reading English language and Portuguese language. In the researcher's introduction (chapter one) the FAA discussed the need to develop researcher that focuses on ESL flight crewmembers' English language proficiency. They also alluded, written English language factors on crew alerting systems and QRH checklists have an impact on ESL flight crewmembers' performance. As the researcher revealed, written English language on the ECAM system was not a factor that negatively impacted flight crewmembers performance. On the contrary, written English language QRH checklists did reveal some challenges (i.e. conditional statements), but these challenges did not indicate a major impact on flight crewmembers performance and there were no negative impacts to flight safety.

On the other hand, Portuguese language QRH checklists revealed significant issues that government and industry should focus their research efforts. Primarily, participants were challenged when they read and comprehended written Portuguese language according to debriefs after the experiment. Essentially, participant background knowledge of text written in Portuguese language confused them and led to misinterpretation of information, misdiagnosis to system faults (hydraulic and electrical), and long response times when they responded to crew alerts. They also indicated their high workload and response times were due to unfamiliar technical vocabulary words.

The researcher recommends more research in different regions of the globe that focus on qualitative studies that address participant background knowledge, metacognitive strategy use, and written English language proficiency. Since the researcher's focus was on one region (Portugal), results may be different in a different region. Other flight crewmembers that speak English as-a-second language should be considered, especially flight crewmembers with different levels of English language proficiency. With regards to research on ESL flight crewmembers ability to read and comprehend their native language on QRH checklists, it is recommended that the researcher's post doctoral studies focus on development of a dictionary or reference source containing specific technical vocabulary words that in different languages. Goal of this qualitative research would be to align system faults vocabulary words on QRH checklists that are in English language, and translate them into flight crewmembers' native language. Then, have participants rate each word on its applicability to the system function on the flight deck to determine the most appropriate vocabulary words to use on QRH checklists, to accommodate other regional languages. This type of research would support ICAO and FAA initiatives for future flight decks.

Qualitative Research Study Conclusions (Addendum to Experiment)

Based on the researcher's qualitative research study, it can be concluded that written English language on the ECAM system did not reveal challenges to participants' ability to read and comprehend written English language vocabulary words. However, when participants utilized the QRH checklists written in Portuguese language, they were negatively impacted. Factors discussed in the researcher's qualitative study were also found in the experimental study. Future research should continue focus on reducing the impact of written English language technical information (i.e. QRH checklists) on ESL flight crewmembers performance when they respond to non-normal conditions (i.e. electrical and hydraulic system faults) in different regions of the globe.

Chapter 9: Thesis Synthesis and Future Research

In the beginning of the researcher's thesis, it was noted that written English language was consider difficult for ESL flight crewmembers to read and comprehend while executing non-normal conditions on the flight deck. The FAA and ICAO provided evidence of factors that inhibit flight crewmembers' ability to perform adequately while reading and interpreting English language. Particularly, the FAA indicated that design and integration of English language abbreviations, acronyms and vocabulary words were factors that negatively impact flight crewmembers performance while reading information on crew alerting systems and QRH checklists. The ICAO indicated that there is a need to investigate flight crewmembers proficiency, as it is also an important factor that influences their ability to read and comprehend technical information. The ICAO ELPRs were discussed, as they were government initiatives that were developed to understand flight crewmembers proficiency and regulate standardization among flight crewmembers. Although ICAO ELPRs are only related to flight crewmembers speaking abilities with their use of radiotelephony to communicate, the researcher wanted to understand other features of English language that may be an impact, such as their reading comprehension of written English language. Aircraft accidents revealed claims from FAA and ICAO were evident in recommendations from several investigative agencies. These recommendations were related to further research needed to investigate ESL flight crewmembers ability to read and comprehend written English language. With regards to flight deck design, researchers revealed that ESL flight crewmembers are negatively impacted by design and integration of written English language on the flight deck. It was also indicated that these factors have the potential to negatively impact flight crewmembers performance. Particularly, vocabulary words on crew alerting systems and QRH checklists revealed challenges to ESL interpretation of technical information. Since there are an array of ESL flight crewmembers that utilize crew alerting systems and QRH checklists written in English language, emphasizing the importance of adhering to standardization of written English language is essential. In other words, written English language inconsistency on crew alerting systems and QRH checklists can cause flight crewmembers to misinterpret vocabulary words and lead to misdiagnosis of system non-normal conditions. Particularly, inconsistencies in vocabulary word meaning, abbreviations and acronyms (long and short forms) are two types of written English language that have an effect on flight crewmembers performance. Also discussed in flight deck design was the potential to mitigate misunderstandings flight crewmembers experience with reading and comprehending written English language, by translating written English language text into their native language. However, researchers provided caution on translating written English language text into flight crewmembers native language. It was indicated that haphazardly translating text into flight crewmembers native language would lead to misunderstandings and negative performance impacts. Particularly, word meaning has the potential to be impacted as well as misunderstandings of equivalent word meaning in flight crewmembers native language. Based on this evidence, it was clear that there would be a need to devise a plan that would include systematically translating text if the researcher's studies revealed a need to have such a process.

As these factors led the researcher to further investigate written English language problems on the flight deck, evidence from the literature review revealed English language problems were inherent in design and integration of English language. Fundamentally, vocabulary word types were touted as factors that influence ESL adult reading comprehension. It was noted that there are several different types of vocabulary words in English language (1) high frequency (2) academic (3) low frequency (4) sub-technical (5) technical/scientific. As the first two types of vocabulary words have established standardized references, the researcher found that these words are common in written English language. Low frequency, sub-technical, and technical scientific vocabulary words are specific to a particular industry (i.e. biology, aviation), which provided an indication that these types of words may be challenging if ESL adults do not have background knowledge of these types of vocabulary words, or their proficiency is not adequate. Inadequacy of background knowledge and English language proficiency has the potential to negatively impact reading comprehension. As the literature review featured many studies, one common factor that was revealed in each study was English language proficiency and background knowledge. It was noted, these are the fundamental background demographic factors that will drive ESL adults to perform negatively or positively regarding reading comprehension, alongside metacognitive strategy use. Depending on ESL adult background knowledge of text corpora and English language proficiency, they use different types of metacognitive strategies in order to attain an understanding of written English language.

It was evident that written English language has potential to be complex due to many different types of vocabulary words in written English text corpora. Particularly, text genre, abbreviations and acronyms, text length, simplification of text, and vocabulary word types impact ESL adults' ability to read and comprehend English language. When ESL adults read and comprehend English language, their performance is negatively impacted due to design and integration factors such as text genre (i.e. expository/instructional and/or scientific technical, number of tokens, and format of the text (i.e. paper and displayed text). English as-a-second language adults' reading speed, mental demand, and decision-making processes are negatively impacted when they read written English language. The literature review also revealed that ESL adult English language proficiency, background knowledge, and metacognitive strategy use were pivotal factors that shape ESL adult understanding of English language. As these factors were features of English language and were linked to participants ability to read, it was evident to further investigate these issues in the form of two preliminary studies and development of an experimental research design to measure participant performance.

Taking into account all of the aforesaid factors that influence ESL adults' ability to read and comprehend written English language, the researcher decided to develop studies in a socio-technical environment, which covered written English language use on the flight deck and impacts to ESL adults' reading comprehension. The researcher's preliminary study revealed that ESL flight crewmembers from different regions of the globe were negatively impacted when they read and comprehend written English language. As each flight crewmember indicated that design and integration features of written English language negatively impact their ability to read and comprehend written English language technical information on the flight deck, the researcher developed a secondary study to further substantiate claims in the preliminary study one.

Likewise, the secondary study corroborated the first study flight crewmember claims that written English language on crew alerting systems and QRH checklists negatively impact their performance. Temporal demand, workload, and errors of omission were factors that were prevalent in study two. It was indicated that these factor negatively impact their ability to perform on the flight deck during non-normal conditions. In each study, English as-a-second language flight crewmembers English language proficiency revealed they had different levels of proficiency, and proficiency levels were linked to amount and type of metacognitive strategies utilized by each flight crewmember. Likewise, crew alerting system and QRH checklist design and integration factors were linked to participant English language proficiency. Written English language factors on crew alerting systems and QRH checklists were linked to negative impacts to flight crewmembers performance and thus flight safety. As flight safety is an important factor on the flight deck and negative impacts to flight safety has the potential to interrupt crew performance, and lead to incidents and accidents, it was essential for the researcher to understand if the aforesaid factors were still prevalent.

Accordingly, the researcher developed a research experiment with repeated measures experimental design criteria and many detailed hypotheses that were tested. The experiment was designed to take into account each of the factors revealed in the literature review, studies one and two that were considered pivotal factors that negatively impacted flight crewmembers' performance. Study three featured two different crew alerting systems (ECAM electrical/hydraulic) and QRH checklists (electrical/hydraulic). Recall, electrical and hydraulic system faults were utilized as they are considered non-normal conditions, and they contain written English language and have the potential to impact flight crewmembers performance. As the researcher's studies one and two revealed that many flight crewmembers cognitively translated written English language text into their native language, the researcher systematically translated text as part of the experiment. Accordingly, QRH checklists were translated into flight crewmembers native language Portuguese. Since the literature review provided substantial evidence that written English language vocabulary words have the potential to impact ESL adult reading comprehension, the researcher analyzed written English language vocabulary words on the ECAM system and QRH checklists. These analyses revealed that there are many different types of vocabulary words on the ECAM and QRH checklists.

It was expected that flight crewmembers would be negatively impacted by use of these words during the experimental trials. When the experimental trials commenced, it was evident that written English language appeared to be easy for flight crewmembers to read and comprehend, which was opposite of the researcher's expectations. Why did this occur? There was a plethora of evidence that suggested the reasons that flight crewmembers performed better when the read written English language, than written Portuguese language. As flight crewmembers had background knowledge of written English language design and integration on the ECAM system and QRH checklists, this enabled them with the ability to read and understand text. It was indicated that these texts were familiar to flight crewmembers. Flight crewmembers had high and medium levels of English language proficiency and they utilized many different metacognitive strategies to read and interpret written English language. There were challenges noted with flight crewmembers reading comprehension of written English language texts, but they were minimal and did not impact their performance nor did it negatively impact flight safety. Even though there were not many impacts to flight crewmembers ability to read and comprehend written English language on QRH checklists, the impacts are still considered important to further investigate in future studies.

When flight crewmembers read and interpreted Portuguese translated QRH checklists, their performance was negatively impacted. Even though participants had background knowledge of written English language text and their English language proficiency was adequate, they were challenged by text written in Portuguese language. As the literature review suggested, ESL adults should have a good background of English language and be proficient with written English language, or there could be difficulties understanding written English language translated into their native language. This is an interesting finding because many flight crewmembers in studies one and two translated text into their native language for better understanding of text. Perhaps, metacognitive cognitive translation processes utilized by flight crewmembers to process English language is different than systematically translating text corpora into their native language. In other words, flight crewmembers may have their own method 'cognitively' to search for word meaning, and their choice of words could impact their ability to read and understand written English language on QRH checklists. Whereas, systematically translating text corpora is a different cognitive process and has different performance impacts. As there were noted challenges that flight crewmembers indicated when they read and interpreted information on written English language checklists, this was likely the reason for such performance challenges when they read Portuguese language checklists. As flight crewmembers had medium level and high level English language proficiency, their proficiency could be indicators that influenced their ability to read and comprehend written English language. Recall, medium level proficiency flight crewmembers indicated they experienced some challenges with certain vocabulary words in English language. Regarding the Portuguese language QRH checklist, flight crewmembers indicated they misinterpreted and misdiagnosed system fault logic due to their inability to use their background knowledge of the text, to understand how to make adequate decisions to solve the problem. Conclusions from the experiment suggest there is a need to further explore other flight crewmember languages and conduct further studies that examine impact of translating technical information into a different language. On the other hand, flight crewmembers indicated challenges to their reading comprehension during the experiment. So, there is still a need to investigate written English language challenges on QRH checklists and the impact on flight crewmembers performance.

As new flight decks are developed and designed in the next generation, it is important to understand impacts of designing crew alerting systems and QRH checklists on ESL flight crewmember performance. Critical analyses of written English language on aforesaid systems is paramount, as there can be an effect on flight crewmember performance. As misunderstandings and misdiagnosis of non-normal conditions by flight crewmembers have the potential to lead to incidents and accidents, it is important to mitigate written English language reading and interpretation issues in the preliminary design requirements phases. This will help facilitate better understanding of written English language challenges throughout flight deck prototype phases, simulation and lab testing, flight testing, and in the airline operational environment.

As airline training programs are important mechanisms to increase awareness of aviation safety, they do not evaluate reading comprehension challenges that flight crewmembers may experience while using written English language on crew alerting systems and QRH checklists (vocabulary words, sentences, etc.). The ICAO ELPRs are only a subset of ESL flight crewmembers English language abilities, and as previously discussed do not encompass all English language factors that influence flight crewmembers ability to perform on the flight deck. Mitigation of written English language issues on crew alerting systems and QRH checklists may reduce negative impacts on flight crewmembers performance. The following seven steps should be taken by the airline industry to mitigate negative impacts to flight crewmembers performance:

1. Understand and take action to ensure flight crewmember RCL proficiency of English language proficiency is adequate with use of crew alerting systems and QRH checklists.

2. Evaluate metacognitive strategy use periodically in training programs to understand impacts on flight crewmembers cognitive performance.

3. Review and evaluate flight crewmembers background knowledge of crew alerting systems and QRH checklists, not just how they execute procedures, but their fundamental understanding of vocabulary words, sentences, and word meaning, including acronyms and abbreviations.

4. Develop a process to mitigate challenges that are found on the flight deck with respect to flight crewmembers use of crew alerting systems and QRH checklists.

5. Evaluate vocabulary words use on crew alerting systems and QRH checklists and communicate with manufacturer to reduce vocabulary words that appear to negatively impact flight crewmembers reading comprehension processes.

6. Monitor initial risks and residual risks found during routine evaluations that have the potential to negatively impact safety on the flight deck.

7. Develop flight crewmember/flight training program communiqués that feature written English language challenges on the flight deck and techniques (metacognitive strategies) to alleviate reading comprehension challenges

To ascertain the aforesaid steps 1-7, the researcher created a preliminary strategy for steps 1-4 to start the process of identifying ways to increase awareness about written English language, since their were some impacts to flight crewmembers performance. Since use of written English language is currently a standard on design of crew alerting systems and QRH checklists on flight decks, the researcher devised a plan and created a strategy. Goal of the strategy is to further develop its contents while partnering with airlines, government, and manufacturers to implement into the industry.

The Airline Safety Strategy

The researcher named this strategy 'TIRP' (Technical Information Reading Protocol). The researcher created this strategy to assist airline safety management personnel (aviation safety training manager) with understanding ESL airline flight crewmembers performance impacts while using crew alerting systems and QRH checklists on the flight deck. This strategy could be utilized in conjunction with pilot Advanced Qualification Program (AQP) (training program) or equivalent program. Goal of this strategy is to have flight crewmembers discuss their background knowledge of crew alerting systems and QRH checklists, English language proficiency, and metacognitive strategy use with the aviation safety-training manager.

Design and integration factors (crew alerting systems and QRH checklists) will also be identified using a key code similar to the one used in the researcher's studies. Typically, background knowledge would be related to their years of experience, knowledge of text genre etc. As participants self-rated English language proficiency in the researcher's study, same protocol will be utilized for this strategy with respect to their ability to read and comprehend information on crew alerting systems and QRH checklists. English language proficiency is described/defined as High, Medium, or Low (Low=inadequate-does not understand English language), Medium= medium level understanding-experiences some difficulty with written English language, High= high level understanding-does not experience many issues with written English language). Depending on type (i.e. technical/scientific vocabulary words) of written English language flight crewmembers read and interpret, these levels may be developed further to include more specificity.

Flight crewmembers use of metacognitive strategies, crew alerting systems and QRH checklists design and integration factors during the simulated training will be identified using a key code similar to the ones in the researcher's studies. Next, the flight safety training manager will review how these factors may have impacted flight crewmember performance while flying a simulated mission. Results from this strategy has potential to increase awareness of pilot performance while reading and interpreting technical information on the flight deck as well as foster new approaches to enhance flight safety. As this process could seem cumbersome when flight safety training managers document pilot performance factors every flight, the research recommends a dedicated debrief session after each flight to collect these types of data.

The Protocol

Each flight safety manager fills out a card (TIRP Card) and reviews the information collected on the card with the flight crewmember. After discussion, the cards are collected and the data is saved in a typical data mining system. Goal of the data collection would be to understand the impact of flight crewmember background knowledge, English language proficiency, and metacognitive strategy has on their ability to perform (response time, workload, errors of omission). Previously stated, TIRP will identify written English language factors on crew alerting systems and QRH checklists that impact their ability to perform. A narrative (filled out by the flight safety manager) will provide additional information regarding flight crewmember detailed performance comments. These types of data could help with development of metrics for safety briefings at the airline. Particularly, this type of metric could support initiatives in airline's safety management systems (SMS). It will also help flight crewmembers understand how well they perform and issues identified in the simulated training that needed further scrutiny. As performance related issues could lead to discussion with airlines and manufacturers/FAA/ICAO, this strategy could help foster communication about written English language factors on the flight deck. A detailed description of the TIRP card use is located below, and Table 94 is an example of how the TIRP card should be utilized by aviation safety training managers and flight crewmembers during simulated training sessions.

Detailed Description of the TIRP card

First two columns to the left contain information regarding pilot Name, flight simulation session number, crew alerting system and QRH checklist to be evaluated, and system condition (Normal/Non-normal condition). Top three rows to the right provide information regarding pilot demographics, while the middle row provides information with regards to the pilot's flight simulation session performance. Final row provides information with regards to crew alerting systems/QRH checklists factors that could have impacted flight crewmembers performance during the session.

Table 94 The TIRP card

TIRP CARD		DEMOGRAPHIC FACTOR 1	DEMOGRAPHIC FACTOR 2	DEMOGRAPHIC FACTOR 3
Pilot Name Aircraft Captain/First Officer Language	Joe Simpson Airbus A-330 Captain Chinese	Background knowledge (crew alerting systems/QRH checklists) Years of Experience ___**10**________ Years of Experience Code ____**1A**_______ ATP Rating **Y**/N Circle/Highlight	English language Proficiency Reading Comprehension level (RCL) (H, M, L) RCL LEVEL______**2A**_____ RCL Level __________**2D**_____	Metacognitive Strategy (s) **3A** **3B** **3C**
Flight Simulation Session Number Airline Safety Training Manager Date	1 Joe Johnson 1/15/2018	PERFORMANCE IMPACT 1 (Workload) Circle/Highlight High **Medium** Low	PERFORMANCE IMPACT 2 (Response Time) Circle/Highlight **Fast** Slow	PERFORMANCE IMPACT 3 (Omission) **Y**/N Circle/Highlight
Crew Alerting System Evaluated	Pneumatic System			
QRH Checklist Evaluated	Pneumatic System	Crew Alerting Systems Factors	QRH checklists Factors	Crew Alerting System and QRH checklist Factors (used jointly)
System Condition and Phase of Flight	Non-Normal Procedures Cruise Phase of flight	**4A** **4B** **4C**	**5A** **5B** **5C**	**4A** **5B**

Simulated Flight Session Narrative-XYZ Airlines

The Key Codes

The key codes (similar to the ones utilized in the researcher's study) are provided so that flight safety training managers can code each pilot's information on the TIRP card. It should be noted that the airline and management should reserve the right to make changes to these key codes to collect specific data for their flight crewmembers. In other words, if there are different aspects of background knowledge, self rating of proficiency level, metacognitive strategies, crew alerting systems design factors, and QRH checklists design factors that the airline desires to include, it is practical to make changes. Data collected on the TIRP card after simulated sessions have potential to be different for each evaluation if the key codes are changed. So, it is important that airlines have an understanding of the impacts to data collection if they change the key codes. As flight crewmember performance and flight safety impacts are important to note during the simulated aircraft session, those aspects should be reported in the narrative of the flight simulation.

Table 95 Background Knowledge demographics, strategies, CA and QRH checklist factors

ESL flight crewmembers Background Knowledge	**CODE**
Years of Experience (less than 20 years)	1A
Years of Experience (greater than 20 years)	1B
ESL flight crewmembers RCL self rated level	
Self rated English language proficiency RCL Crew Alerting Systems (H)	2A
Self rated English language proficiency RCL Crew Alerting Systems (M)	2B
Self rated English language proficiency RCL Crew Alerting Systems (L)	2B
Self rated English language proficiency RCL QRH Checklists (H)	2C
Self rated English language proficiency RCL QRH Checklists (M)	2D
Self rated English language proficiency RCL QRH Checklists (L)	2E
ESL flight crewmembers metacognitive strategy factors	
Lexical Inferencing (educated guessing of word meaning)	3A
Re-Reading Text	3B
Paraphrasing Text	3C
Crew alerting systems English language design and integration factors	
Sentence Length (Short)	4A
Acronyms/abbreviations	4B
Text Genre (e.g. technical)	4C
QRH checklist English language design and integration factors	
Conditional Statements	5A
Number of Tokens in Text	5B
Authentic Text	5C

Regarding FAA aviation safety research initiatives, the agency should design and implement written English language protocol to address ESL flight crewmembers concerns about written English language on the flight deck. Particularly, existing safety mechanisms (aviation safety reporting system ASRS) should include a section in the database that provides ESL flight crewmembers ability to express their concerns about reading written English language on crew alerting systems and QRH checklists. This will aid FAA researchers with understanding scope of reading comprehension issues globally that negatively impact ESL flight crewmembers performance on the flight deck. This will also enable researcher's to focus their attention on specific situations where ESL flight crewmembers are negatively impacted.

The researcher's introductory chapters discussed several accidents, which determined that written English language was an issue that negatively impacted ESL flight crewmember performance. As many of these issues were referenced in the accident report recommendation section, there should be more structured emphasis in the accident analysis section on ESL flight crewmembers performance. Particularly, focus would be on their English language proficiency (reading comprehension level), metacognitive strategy use, and written English language design and integration issues that negatively impact their ability to read and interpret written English language on crew alerting systems and QRH checklists. As the recommendation section is one of the most important sections of an incident/accident report, providing these types of data in the recommendations section helps industry focus on new pieces of research. Investigating these types of factors shed light on other types of human factors issues that could impact ESL flight crewmember performance when they read information on crew alerting systems and QRH checklists.

Aircraft Accident Investigator Strategy

Last, many aircraft accident agencies (e.g. Australian Transport Safety Bureau-ATSB) focus on human factors related issues during on-scene field investigations. Part of their investigation paradigm should consist of highlighting human factors issues related to ESL flight crewmembers performance during each phase of flight. Below is a concept that may help facilitate new ideas and questions for investigators for inclusion of ESL flight crewmember performance issues in incident/accident investigation. The paradigm consists of Questions (left side) that highlight several different factors/issues potentially impacting ESL flight crewmembers performance during each phase of flight. During on-scene investigation processes, investigators can ask these questions during witness interviews or during review of information on Digital Flight Data Recorders (DFDR) and/or Cockpit Voice Recorder (CVR) transcript analyses. Review of CVR data may reveal flight crewmember discussion of issues they experienced with their reading comprehension of information on crew alerting systems and QRH checklists. Review of DFDR parameters may indicate specific phase of flight when flight crewmember/crew alerting and information system interface was not adequate. Follow-up questions on DFDR data with flight crewmembers may provide indication of their experience using crew alerting and information systems. This could help investigators with highlighting details useful for further investigation activities. If the investigator deems there was an impact assessed while reviewing information on-scene, 'yes' should be circled, if there was no impact 'no' should be circled (right box column). Regardless of the investigator disposition, they should provide comments that describe the issues/factors and transcribe that information into the box. Goal of providing comments is to highlight the issues/factors, thereby providing a focus on the types of information that should be included in a future factual report. Also, agencies would have the opportunity to foster new aviation safety research to help prevent similar occurrences. Furthermore, information collected could introduce new safety recommendations for industry best practices.

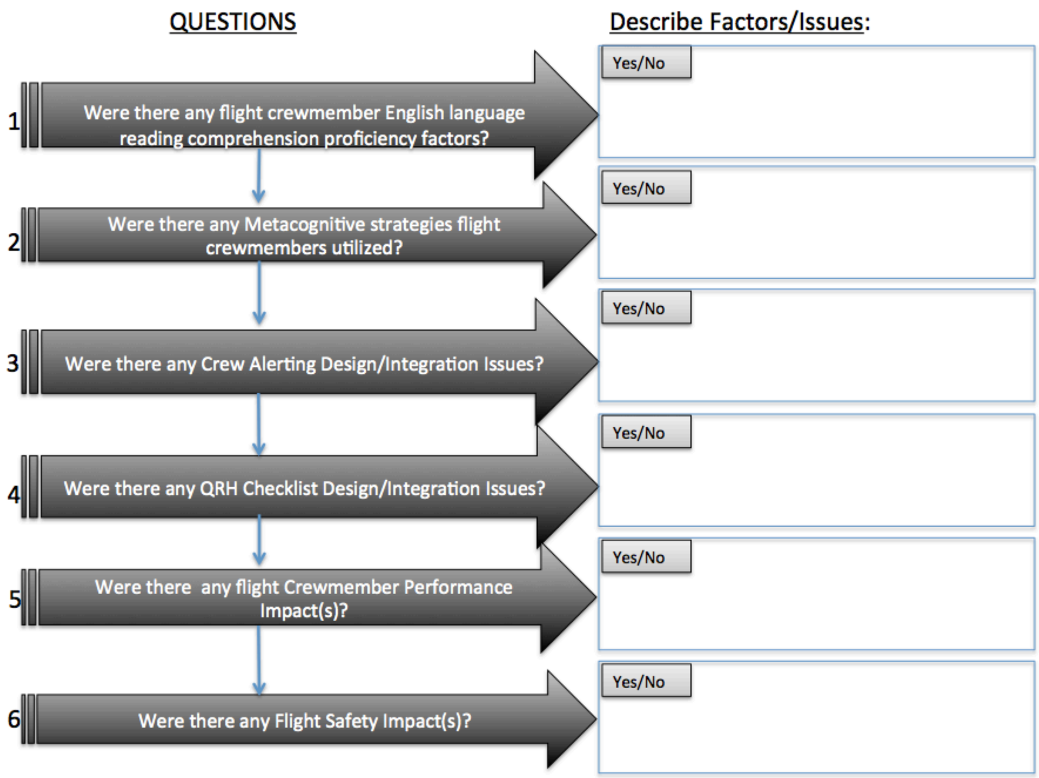


Figure 22 Aircraft Incident and Accident Investigation Questions

Continuous understanding of cognitive human performance challenges ESL flight crewmembers experience on the flight deck, with respect to reading and comprehending technical information is paramount. Although, many aspects of the researcher's studies and literature research did not indicate ESL flight crewmembers performance led to accidents, it is important to understand contributory causes similar to the researcher's studies, are worthy to constantly monitor in the aviation/aerospace industry.

Featuring written English language in a format consistent with flight crewmembers mental model enables them to perform at their highest level of safety, thus reduce negative impact on aviation safety. On the other hand, processes related to translating written English language into flight crewmember native language should be designed carefully and integrated on QRH checklists, to preclude flight crewmember performance challenges. As understanding lexis on technical information is an important aspect of flight deck design, it is also important to understand how flight crewmembers cognitive abilities will be impacted as a result of design and integration. Therefore, next generation design of flight decks should be designed considering factors that influence ESL flight crewmembers ability to read and comprehend written English lexis, while performing their tasks on the flight deck.

References

AAIB (2015). Air Accidents Investigations Branch: Department for Transport AAIB Bulletin August 13, 2015.

Abbott, K. (2000). Human Factors Engineering and Flight Deck Design. In *The Avionics Handbook*. Ed. Gary R. Spitzer, Boca Raton, CRC Press LLC.

Abdul-Hamid, S., & Samuel, M. (2012). Reading Scientific Texts: Some Challenges Faced by EFL Readers. *International Journal of Social Science and Humanity*, *2*(6), 509.

Adamski, A., & Stahl, A. (1997). Principles of design and display for aviation technical messages. Flight Safety Digest, *16*(1), 1-29.

Alderson, J. C. (2000). Assessing reading. Cambridge: Cambridge University Press.

Alfadly, H., & AldeibaniFull, A. (2013). An Analysis of some linguistic problems in translation between Arabic and English faced by Yemeni English majors at Hadramount University. *Journal of Islamic and Human Advanced Research, Vol. 3, Issue 1, January 2013, 15-26.*

Alemi, M., & Ebadi, S. (2010). The effects of pre-reading activities on ESP reading comprehension. *Journal of Language Teaching and Research*, *1*(5), 569-577.

Al-Sohbani, Y., & Muthanna, A. (2013). CHALLENGES OF ARABIC-ENGLISH TRANSLATION: THE NEED FOR RE-SYSTEMATIC CURRICULUM AND METHODOLOGY REFORMS IN YEMEN. *Academic Research International*, *4*(4), 442.

Amalberti, R. (1998). Automation in Aviation : A human factors perspective, in D.Garland, J.Wise & D. Hopkin (Eds) Aviation Human Factors, (pp. 173-192, chapter 7), Hillsdale- New Jersey: Lawrence Erlbaum Associates.

Anderson, N. J. (2002). *The role of metacognition in second/foreign language teaching and learning*. ERIC Digest. Washington, DC: ERIC Clearinghouse on Languages and Linguistics.

Anderson, N. J. (2003). Teaching reading. In D. Nunan (Ed.), *Practical English language teaching* (pp. 67-86). New York: McGraw-Hill.

Anderson, N. J. (2003a). Scrolling, clicking, and reading English: Online reading strategies in a second/foreign language. *The Reading Matrix*, *3*(3).

Anderson, N. (2004). Metacognitive reading strategy awareness of ESL and EFL learners. *The CATESOL Journal*, 16(1) 1-17.

Ashrafzadeh, A., Don, Z. M., & Meshkat, M. (2015). The Effect of Familiarity with Content Knowledge on Iranian Medical Students' Performance in Reading Comprehension Texts: A Comparative Study of Medical and TEFL Students. *Journal of Language Teaching and Research*, *6*(3), 524-534.

Babbitt, B.A. & Nystrom, C. O. (1989). Questionnaire Construction Manual. Fort Hood, TX: US Army Research Institute for the Behavioral and Social Sciences, Research Product 89-20.

Baker, L., & Brown, A.L. (1984). Cognitive monitoring in reading. In J. Flood (Ed.), *Understanding reading comprehension* (pp. 21-44). Newark, DE: International Reading Association.

Barani, M., & Karimnia, A. (2014). An investigation into translation students' English reading comprehension skills and strategies: A cross-sectional study. Elixir Ling. & Trans.73 (2014), pp. 26257-26262.

Barnett, M.A. (1989). *More than meets the eye: Foreign language reading*. Language in Education: Theory and practice, no.73. CAL / ERIC Series on Languages and Linguistics. Englewood Cliffs, NJ: Prentice Hall.

Bielsa-Murcia, S. (1999). Instructional Texts in English and Spanish: A Contrastive Study. University of Cordoba Spain. Published Student Thesis.

Boeing (2014). Boeing Submission for Asiana Airlines (AAR) 777-200 ER HL7742 Landing Accident at San Francisco—6 July 2013.

Brown, G., & Yule, G. (1983). Discourse analysis. Cambridge: Cambridge University Press.

Bureau d'Enquetes et d'Analyses. (BEA) (2012). Final Report on the accident 1st June 2009 to the Airbus A330-203 registered F-GZCP operated by Air France flight 447 Rio de Janeiro-Paris.

Burian, B.K (2006). Design guidance for emergency and abnormal checklists in aviation. In proceedings of the Human Factors and Ergonomics Society 50th annual meeting, San Fransciso.

Burian, B.K., Barshi, I., and Dismukes, K. (2005). The Challenge of Aviation Emergency and Abnormal Situations. Moffett Field, California.

Carrell, P., L. (2001). Influence of Purpose for Reading on Second language Reading: Reading Procedural Texts in ESL. *Reading in a Foreign language, 13(2), 2001*. Department of Applied Linguistics/ESL, Georgia State University, U.S.A.

Center for Investigation and Accident Prevention (CENIPA) (2013). CENIPA Final Report on Accident involving L410 Noar Linhas Aereas Flight 4896 July 13, 2011; RF A-019/CENIPA/2013.

Chung, T. M., & Nation, P. (2004). Identifying technical vocabulary. *System*, *32*(2), 251-263.
Coady, J., & Huckin, T. (1997). *Second language vocabulary acquisition: A rationale for pedagogy*. Cambridge University Press.

Condelli, L., & Wrigley, H. S. (2006). Instruction, language and literacy: What works study for adult ESL literacy students. *LOT Occasional Series*, *6*, 111-133.

Coxhead, A.J. (1998). *An Academic Word List*. English Language Institute Occasional Publication Number 18. Wellington: Victoria University of Wellington.

Crossley, S. A., Louwerse, M. M., McCarthy, P. M., & McNamara, D. S. (2007). A Linguistic Analysis of Simplified and Authentic Texts. *Modern Language Journal*, 15-30.

Dash, N., & Dash, M. (2007). *Teaching English as an additional language.* New Delhi: Atlantic Publishers & Distributors (P) Ltd.

DeBrito, G. (1998). Study of the use of Airbus Flight deck Procedures and Perspectives for Operational Documentation. G. Boy, C. Graeber, & J. M. Robert (Eds.), International Conference on Human Computer Interaction in Aeronautics (HCI-Aero'98) (pp. 195-201), Montreal, Canada: Ecole Polytechnique de Montréal: 27-29 May 1998.

Degani, A. (1992). *On the typography of flight-deck documentation*. National Aeronautics and Space Administration, Ames Research Center.

Degani, A., Wiener, E. (1993) Procedures in Complex Systems: The Airline Cockpit IEEE Transactions on Systems, Man, and Cybernetics, SMC-27(3) 1993. Pp. 302-312.

Degani, A., & Wiener, E. (1994). On the design of flight deck procedures (NASA Contractor Report 177642). Moffett Field, CA: NASA Ames Research Center.

Degani, A. & Wiener, E.L. (1998). *Design and Operational Aspects of Flight-Deck Procedures.* Montreal, Canada: Proceedings of the International Air Transport Association (IATA) Annual Meeting.

Dordick, M. (1996). Testing for a hierarchy of the communicative interference value of ESL errors, System, 24, 299-308.

DOT FAA (2010). U.S. Department of Transportation Federal Aviation Administration Advisory Circular: *Flight Crew Alerting; Released on December 13, 2010*. ANM-100, AC No: 25.1322-1.

Drury, C.G. and Ma, J. (2003). Do Language Barriers Result in Aviation Maintenance Errors? Human Factors and Ergonomics Society 47th Annual Meeting Proceedings, Denver, Colorado, October 13017, 2003.

Drury, C. G., Ma, J., & Krebs, W. K. (2003). Language errors in aviation maintenance: year 1 interim report. *University of Buffalo, State University of New York: Federal Aviation Administration research grant # 2002-G-025.*

Drury, C. G. and Ma, J. (2005). *Language Errors in Aviation Maintenance: Final Report*. Reports to William J. Hughes Technical Center, the Federal Aviation Administration under research grant #2002-G-025.

Dwaik, R. A., & Shehadeh, A. M. (2013). Guessing Patterns of Palestinian College Students. The Reading Matrix© 2013. *Reading*, *13*(1) April 2013.

Dycus, D. (1997). Guessing word meaning from context: Should we encourage it? *Literacy Across Cultures, 1*(2)*,* 1-6.

Dyson, M.C. (2004). How physical layout affects reading from screen. *Behaviour & Information Technology,* November –December 2004, Vol 23, No. 6, 377-393.

EASA (2012). Principles and guidelines relative to design of checklists and working methods in the cockpit. Research project EASA.2012/1. European Aviation Safety Agency Executive Directorate: Safety Analysis and Research Department. Report: Aviation checklists/normal/abnormal and emergency for fixed wing and helicopters.

ECFR (2015). Electronic Code of Regulations. 14 CFR 25.13222 Retrieved from http://www.ecfr.gov/cgi-bin/ECFR?page=browse on October 30, 2015.

ECFR (2016). Electronic Code of Regulations. 14 CFR 61.153 subpart B Retrieved from http://www.ecfr.gov/cgi-bin/ECFR?page=browse on January 27, 2016.

Eslami, H. (2014). The Effect of Syntactic Simplicity and Complexity on the Readability of the Text. *Journal of Language Teaching and Research*, *5*(5), 1185-1191.

FAA Human Factors Team. (1996). The interfaces between flight crews and modern flight deck systems. Washington, D.C: Federal Aviation Administration.

FAA (2013). Operational Use of Flight Path management Systems. *Report of the Performance based operations Aviation Rulemaking Committee/Commercial Aviation Safety Team Flight Deck Automation Working Group*.

Fatemi, A. H., Vahedi, V. S., & Seyyedrezaie, Z. S. (2014). The Effects of Top-down/Bottom-up Processing and Field-dependent/Field-independent Cognitive Style on Iranian EFL Learners' Reading Comprehension. *Theory and Practice in Language Studies*, *4*(4), 686-693.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence,* 12, 231-235. NY: Lawrence Erlbaum Associates.

Flight Safety Foundation (2015). *The Top 10 Safety Issues.* Aero Safety World-The Journal of Flight Safety Foundation December 2014-January 2015.

Gardner, D., & Hansen, E. C. (2007). Effects of lexical simplification during unaided reading of English informational texts. *TESL Reporter*, *40*(2), 27-59.

Gile, D. (1995): *Basic Concepts and Models for Interpreter and Translator Training*, John Benjamins, Amsterdam.

Hammadou, J. (1991). "Interrelationships among prior knowledge, inference and language proficiency in foreign language reading". *Modern Language Journal* 75: 27-38.

Hancock, O.H. (1998). *Reading skills for college students* (4th ed.). Upper Saddle Rivers, NJ: Prentice Hall.

Haastrup, K. (1991). Lexical inferencing procedures or talking about words. Tubingen: Gunter Narr.

HaCohen‐Kerner, Y., Kass, A., & Peretz, A. (2013). Initialism disambiguation: Man versus machine. *Journal of the American Society for Information Science and Technology*, *64*(10), 2133-2148.

Hartley, J. (1994). Designing Instructional Text for Older Readers: A Literature Review. British Journal of Educational Technology, 25, 3, 172-188. National Council for Educational Technology.

Hashemi, S. Z., & Bagheri, M. S. (2014). External factors influences on EFL learners' reading comprehension test performance. *International Journal of Language Learning and Applied Linguistics World (IJLLALW).* Volume 7 (1), September 2014; 150-166.

Holder, B. E. (2003). Improving the Boeing quick reference handbook. *Washington, DC: NASA*.

Ho-Li-Chi (1996). A critical analysis of airline safety management with reference to pilots and aviation authority officers. Cranfield University PhD Dissertation Issue Date: Dec. 1996.

Holzinger, A., Baernthaler, M., Pammer, W., Katz, H., Bjelic-Radisic, V. & Ziefle, M. (2011). Investigating paper vs. screen in real-life hospital workflows: Performance contradicts perceived superiority of paper in the user experience. *Int. J. Hum.-Comput. Stud.*, 69, 563-570.

Hsiao, T. Y., & Oxford, R. L. (2002). Comparing theories of language learn- ing strategies: A confirmatory factor analysis. *Modern Language Journal, 86,* 368-383.

Hutchins, E., Nomura S. & Holder B. (2006) The ecology of language practices in worldwide airline flight deck operations: The case of Japanese airlines. In *Proceedings of International Conference on Human- Computer Interaction in Aeronautics.* Seattle WA. September 2006: 290-96.

ICAO (2004). *Manual on the Implementation of ICAO Language Proficiency Requirements First Edition*, Doc 9835 AN/453; ICAO: Washington, DC.

ICAO (2010). *Manual on the Implementation of ICAO Language Proficiency Requirements Second Edition* Doc 9835 AN/453; ICAO: Washington, DC.

Interstate Aviation Committee Air Accident Investigation Commission (IAC) (2009). *Final Report on Boeing 737-505 VP-BKO Aircraft Accident.*

Interstate Aviation Committee Air Accident Investigation Commission (IAC) (2013). *Final Report on ATR-72-201 aeroplane Aircraft Accident; VJP-BYZ, Bermudas.*

Iwai, Y. (2007). Developing ESL/EFL learners' reading comprehension of expository texts. *The Internet TESL Journal*, *13*(7), 1-5.

Jacobsen, N. D. (2012). Applying cognitive linguistics and task-supported language teaching to instruction of English conditional phrases.

Karbalaei, A. (2010). A comparison of the metacognitive reading strategies used by EFL and ESL readers. *The reading Matrix, 10(2).*

Keshavarz, M.H. & Assar, M. (2009). Reading Comprehension Ability and Metacognitive Awareness of Reading Strategies among High, Mid and Low Ambiguity Tolerance EAP Students. Iranian Journal of Applied Linguistic Studies. 1(2), 71-108.

Kim, Hyoung il. (2006). Effects of Korean students' contextual and lexical knowledge on L2 text comprehension. *English Teaching, 61*(3), 83-103.

Kobayashi, H., & Rinnert, C. (1992). Effects of first language on second language writing: translation versus direct composition. *Language Learning, 42*, 183-215.

Komite Nasional Keselamatan Transportasi (KNKT) (2015). Aircraft Accident Investigation Report: PT. Indonesia Air Asia Airbus A320-216; PK-AXC; Karimata Strait. Republic of Indonesia; 28 December 2014.

Kuzmina, O. D, Fominykh, A.D, & Abrosimova, N.A. (2015). Problems of the English abbreviations in medical translation: An International Conference of Teaching and learning English as an Additional Language, Antalya, Turkey. *Procedia-Social and Behavioral Sciences 199 (2015) 548-554.*

Kweon, S. O., & Kim, H. R. (2008). Beyond Raw Frequency: Incidental Vocabulary Acquisition in Extensive Reading. *Reading in a foreign language*, *20*(2), 191-215.

Lally, C. (1998). The application of first language reading models to second language study: A recent historical perspective. *Reading Horizons*, *38*(4), 4.

Lai-chun, C. (2005). A study of the acquisition of English Conditionals by Chinese ESL learners. *The Chinese University of Hong Kong; Student Thesis.*

Laird, K. (2006). *Pedagogical Approaches to Phraseology and Communication Training in Collegiate Flight Programs*, Purdue University, Indianapolis, IN, 2006.

Larsen, T. J., & Hansen, R. A. (2010). L2 processing and comprehension of complex syntactic structures in English medical texts. Student Masters Thesis: Copenhagen Business School. Department of international studies and linguistics.

Larson, M.L. (1998). *Meaning-based translation: A guide to cross-language equivalence.* Maryland: University Press of America.

Laughery, K. R., and Paige-Smith, D. (2006). Explicit information in warnings. In M.S. Wogalter (Ed.), *Handbook of Warnings.* Mahwah, NJ: Lawrence Erlbaum Associates (Boca Raton, FL: CRC Press), chap. 31 pp. 419-428.

Levine, A. & Reves, T. (1990). Does the method of vocabulary presentation make a Difference? TESOL Canada Journal 8, 37- 51.

Lin, Y. H., & Chern, C. L. (2014). The Effects of Background Knowledge and L2 Reading Proficiency on Taiwanese University Students' Summarization Performance. *Contemporary Educational Research Quarterly*, *22*(4), 149-186.

Li Siu-Leung, E., & Pemberton, R. (1994). An investigation of students' knowledge of academic and sub-technical vocabulary. In *Proceedings joint seminar on corpus linguistics and lexicology, Guangzhou and Hong Kong (Language Centre, HKUST, Hong Kong, 1994)*.

Liu, S. (2014). L2 Reading Comprehension: Exclusively L2 Competence or Different Competences?. *Journal of Language Teaching and Research*, *5*(5), 1085-1091.

Mali Commission of Inquiry (MCI). 2016. Ministere De L'Equipment, Des Transports ET DU Desenclavement. Commission D'Enquete Sur Les Accidents Et Incidents D'Aviation Civile. Final Report. Accident on 24 July 2014 MD-83 registered EC-LTV operated by Swiftair S.A.

Mangen, A.W. K. (2013). Reading linear texts on paper versus computer screen: Effects on reading comprehension. International Journal of Educational Research: Vol. 58 (2013), No. 9, 61-68.

Maritime Accident Investigation Board-MAIB. (2005). Report on the investigation of the grounding of Jackie Moon; Dunoon Breakwater; Firth of Clyde, Scotland 1 September 2004: Report Number 5/2005.

McDonough, S. (1999). A hierarchy of strategies? In S. Cotterall & D. Crabbe (Eds.), *Learner autonomy in language learning: Defining the field and effecting change* (pp. 51-60). Frankfurt, Germany: Peter Lang.

McGraw, H. (2014). TABE Complete Language Assessment System—English. McGraw-Hill Education CTB 81360 Rev 9/14.

McInnes, B. T., Pedersen, T., Liu, Y., Pakhomov, S. V., & Melton, G. B. (2011). Using second-order vectors in a knowledge-based method for acronym disambiguation. In *Proceedings of the Fifteenth Conference on Computational Natural Language Learning* (pp. 145-153). Association for Computational Linguistics.

Mehrpour, S., & Riazi, A. (2004). *The Impact of text length on EFL students' Reading Comprehension.* Asian EFL Journal: The EFL Professional's Written Forum.

Meyer, B. J. F. (1982). Reading research and the composition teacher: The importance of plans. College Composition and Communication, 33, 37-49.

Moghadam, S. H., Zainal, Z., & Ghaderpour, M. (2012). A review on the important role of vocabulary knowledge in reading comprehension performance. *Procedia-Social and Behavioral Sciences*, *66*, 555-563.

Mohammed, M. A., & Swales, J. M. (1984). Factors affecting the successful reading of technical instructions. *Reading in a foreign language*, *2*(2), 206-217.

Nadarajan, S. (2008). Assessing in-depth vocabulary ability of adult ESL learners. *The International Journal of Language Society and Culture*, *26*, 93-106.

NASA (2013). Development and Test Simulator Guide (DTS). *National Aeronautics and Space Administration; NASA Langley. DTS Users Guide:* Revision 001, Oct. 2013.

Nassaji, H. (2004). The relationship between depth of vocabulary knowledge and L2 learners' lexical inferencing strategy use and success. *The Canadian Modern Language Review Journal, 61*(1), 107-134.

Nation, I. S. P. (2001). *Learning Vocabulary in Another Language*. Cambridge: Cambridge University Press.

Nielsen-Bohlman, L., & Institute of Medicine (U.S.). (2004). Health literacy: A prescription to end confusion. Washington, D.C: National Academies Press.

Nisbet, D. L. (2010). Vocabulary Instruction for Second Language Readers. *Journal of Adult Education*, *39*(1), 10-15.

NTSB (2011). Loss of Control While Maneuvering: Pilatus PC-12/45, N128CM; Butte, Montana March 22, 2009. NTSB/AAR-11/05 PB2011-910405.

NTSB (2014). Descent Below Visual Glide path and Impact with Seawall: Asian Airlines flight 214 Boeing 777-200ER, HL7742 San Francisco, California July 6, 2013. NTSB/AAR-14/01 PB2014-105984.

Nylander, E. (2014). The inferencing behaviour of Swedish EFL university students: A quantitative analysis of lexical inferencing in relation to vocabulary depth. Lund University: Centre for Languages and Literature.

Ogilvie, G. (1984). The impact of culture on communications: a study on the possible effects of culture on inter-cockpit communications. University of Hong Kong.

Oh, S. (2001). Two types of input modification and EFL reading comprehension: Simplification versus elaboration. [Electronic version] *TESOL Quarterly, 35*(1), 69- 96.

Ornato. J, & Peberdy (2014) Applying lessons from commercial aviation safety and operations to resuscitation. Resuscitation 85 (2014) 173-176.

Paribakht. T. S. & Wesche. M. (1999). Reading and "incidental" L2 vocabulary acquisition. An Introspective Study of Lexical Inferencing. Studies in Second Language Acquisition 21,195-224.

Park, J., Yang, J. S., & Hsieh, Y. C. (2014). University level second language readers' online reading and comprehension strategies. *Announcements & Call for Papers*, 148.

Park, Y. (2010). Korean EFL college students' reading strategy use to comprehend authentic expository/technical texts in English. Student Dissertation: University of Kansas 2010-04-19.

Parry, K. (1991). Building a Vocabulary Through Academic Reading. *Tesol Quarterly*, *25*(4), 629-653.

Perfetti, C. A. (1985). Reading skills. *Psychiatry*, *50*, 1125-29. Oxford University Press, New York.

Phoocharoensil, S. (2014). If-conditionals in Authentic Corpus-based English. *Review of European Studies*, *6*(3), p62.

Prinzo, V. (2008). *U.S. Airline Transport Pilot International Flight Language Experiences, Report 1: Background Information and General/Pre-Flight Preparation.* Oklahoma City, OK: FAA.

Ramírez, A. T. (2005). A grammaticality judgment test for the past hypothetical/counterfactual conditional in English. *RAEL: revista electrónica de lingüística aplicada*, (4), 192-230.

Rashed, S., Kamal, A. (2010). Maritime English holds a great stake in both safety and security of merchant vessels. Arab Academy for Science and Technology and Maritime Transport –AASTMT; College of Maritime Transport and technology; IMLA-IMEC 22: Alexandria, Egypt, October, 2010.

Rashidi, N., & Piran, M. (2011). The effect of extensive and intensive reading on Iranian EFL learners' vocabulary size and depth. *Journal of Language Teaching and Research*, *2*(2), 471-482.

Riley, D.M., Newby, C.A., and Leal-Almeraz, T.O. (2006). Incorporating ethnographic methods in multidisciplinary approaches to risk assessment and communication: Cultural and religious use of mercury in Latino and Caribbean communities. Risk Analysis, 26(5), 1205-1221.

Rouhi, A., Jafarigohar, M., Alavi, M.S., Asgarabadi, H.Y., (2015) Task Difficulty of Macro-Genres and Reading Strategies and Reading Comprehension. *International Journal of Asian Social Science. IJASS, 2015, 5 (11): 656-677.*

Saeidi, M., Aghdam, A., A. & Tamjid, N., H. (2013). The effect of input enhancement and metalinguistic awareness on learning conditionals by Iranian EFL Learners. Global Journal of Foreign Language Teaching. 3(2), 97-112.

SAIB. (2007) Swedish Accident Investigation Board: Report RL 2007:12e; Aircraft accident to LN-RDA at Kalmar airport, H county, Sweden on 6 April 2006. Case L-08/06.

Salle, G.P., Gibbons, D.M. (1998) AIA/AECMA Project Report on Propulsion System Malfunction Plus Inappropriate Crew Response (PSM+ICR). Volume 1; 1 November 1998.

Schmidt, R. W. (1990). The role of consciousness in second language learning. Applied Linguistics, 11(2),129-158.

Schmidt, R. W. (1993). Awareness and second language acquisition. Annual Review of Applied Linguistics 13, 206-226.

Sevillian D., Jarvis S. (2013). *Human mental models within flight deck crew alerting systems*. In Badiru A B (Ed) *Handbook of Industrial and Systems Engineering (2nd Edition)* Taylor & Francis, Chapter 26, p.487. Nov 2013.

Smith-Jackson, T.L., Wogalter, M.S., (2000). Applying cultural ergonomics/human factors to safety information research. In: *Proceedings of the XIVth Triennial Congress of the International Ergonomics Association and 44th Annual Meeting of the Human Factors and Ergonomics Society*, Vol. 6. Human Factors Society, Santa Monica, CA pp. 150-154.

Smith-Jackson, T.L., Wogalter, M.S., (2000b). Users' hazard perceptions of warning components: An examination of colors and symbols. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting,* 44:6-55. SAGE Publications.

Smith-Jackson, T.L. (2006). Culture and warnings. In M.S. Wogalter (Ed.), *Handbook of Warnings*, Mahwah , NJ: Lawrence Erlbaum Associates (Boca Raton, FL: CRC Press), chap. 27: pp. 363-372.

Song, M. & Suh, B. (2008). The effects of output task types on noticing and learning of the English past counterfactual conditional. System, 36, 295-312.

Storch, N. (2001). An investigation into the nature of pair work in an ESL classroom and its effect on grammatical development. PhD thesis, Department of Linguistics and Applied Linguistics, The University of Melbourne.

Ulijn, J., Strother, J.B (2012). The influence of culture on information overload. In information overload: An international challenge for professional engineers and technical communicators. First edition edited by Judith B. Strother, Jan Ulijn, Zohra Fazal. John Wiley and Sons.

Vinay, J.P., and Darbelnet (2000). "The Translation Studies Reader". *A Methodology for Translation*." In Jean Paul Vinay and Jean Darbelnet, Comparative Stylistics of French and English; The Translation Studies Reader; Routledge: London and New York.

Viera, J., Garrett, J. (2005). Understanding Inter-observer Agreement: The Kappa Statistic. Research Series: Family Medicine Vol. 37, No.5 pgs. 360-363.

Villain, X., and Pfeiffer, J. (2006). Smoke Procedure Finalization: Airbus: Flight Operations Engineering and Flight operations training data; OLM FBW 2006.

Wang, A. G. (2011a). A methodological probe to aeronautical English vocabulary instruction. Open Journal of Modern Linguistics, 1 (2). 45-51.

Wang, Q. (2011b). Lexical Inferencing Strategies for Dealing with Unknown Words in Reading - A Contrastive Study between Filipino Graduate Students and Chinese Graduate Students. *Journal of Language Teaching and Research,* 2:302-313.

Wanpen, S., Sonkoontod, K., & Nonkukhetkhong, K. (2013). Technical Vocabulary Proficiencies and Vocabulary Learning Strategies of Engineering Students. *Procedia-Social and Behavioral Sciences*, *88*, 312-320.

Waring, R., & Nation, I. S. P. (2004). Second language reading and incidental vocabulary learning. *Angles on the English speaking world*, *4*, 97-110.

West, M. (1953). A General Service List of English Words. London: Longman, Green & Co.

Wogalter, M.S., Begley, P.B., Scancorelli, L.F., Brelsford, J.W. (1997). Effectiveness of elevator service signs: Measurement of perceived understandability, willingness to comply and behavior. Applied Ergonomics. 28, 181-187.

Yeh, D., & Gentner, D. (2005). Reasoning counterfactually in Chinese: Picking up the pieces. In *Proceedings of the Twenty-seventh Annual Meeting of the Cognitive Science Society* (pp. 2410-2415).

Yildiz-Genc, Z. (2009). An investigation on strategies of reading in first and second languages. Selected papers from 18th ISTAL : 407-415.

Ynfiesta, B., Suarez, L., & Fernandez-Peraza, A. (2013). Translation of acronyms and initialisms in medical texts on cardiology. Cuban society of Cardiology: CorSalud 2013 Jan-Mar; 5(1): 93-100.

You, C. (2009). A comparative study of second language reading comprehension from paper and computer screen.

Zhang, B. (2013). An Analysis of Spoken Language and Written Language and How They Affect English Language Learning and Teaching. *Journal of Language Teaching and Research*, *4*(4), 834-838.

Zhao (2015). Using translation in ESL classrooms: An Asian perspective. *International Journal of Innovative Interdisciplinary Research*. Chengdu Institute Sichuan International Studies University, China; V2 14 2015.

Appendix A: Interview Questions Preliminary and Experimental Studies 1, 2, and 3

Structured Interview Objective-Language Interview Study 1 Part 1
DUE: December 18, 2012 and December 9, 2015 Population: 14 ESL Airline Pilots

Thank you for taking time out of your day to take part in this interview. The data collected from this interview will be for research purposes at Cranfield University, UK. No personal information is needed, as the data collected will only be utilized to further research pilot performance in the flight deck. Please be very descriptive with your answers so that the most accurate data may be analyzed. This interview was designed utilizing 'The Questionnaire Construction Manual' (Babbit & Nystrom, 1989). It was designed to further understand the impact of flight deck crew alerting and information systems on airline flight crewmembers that fly both domestic and international operations. All pilots must have valid ATP certification and currently fly with an airline. The aim is as follows: Impact of ESL flight crewmembers English language reading and interpretation on flight deck crew alerting and information systems.

Throughout the interview the use of term flight crewmembers was utilized. Flight crewmembers were operationally defined as first officer and captain. Some demographic questions were derived from Prinzo's (2008) study.

Background and Demographic Information

1.) Are you male or female
2.) What is the primary language you learned to speak?
3.) How old were you when you learned to speak the English language?
4.) Where did you learn the English language?
5.) What is your ICAO English language level proficiency?
6.) What country are you from?
7.) Are you a first officer or captain?
8.) How long have you flown for the airlines?

Flight Deck System Text Vernacular Questions

1.) Rate how well you perceive and comprehend system generated warning, cautions, and advisory text messages (that utilize English language characteristics) regarding functional status of the system. Describe any positives or negatives with the reading and comprehension of messages in English.

2.) Rate how well you read and comprehend system generated warnings, cautions, and advisory text messages (that utilize English language characteristics) regarding flight path related operational issues. Describe any positives or negatives with the perception and comprehension of messages in English.

3.) How often do you translate on paper the meaning of the system generated text messages regarding flight path related, or system related? Why?

4.) Do you prefer all warnings, cautions, and advisories text be written in English or your native vernacular? Why?

Flight Deck Electronic/Paper Checklists Vernacular Questions

1.) How often do you utilize the English language to interpret information on the electronic checklist? How often do you utilize a secondary language? Why?

2.) Do you prefer the use of paper checklists or electronic checklists? When utilizing a paper checklist do you find it difficult to communicate in English with other flight crewmembers regarding issues with utilizing the paper checklist? Why?

Survey Questions Part II of Study 1: 2012 and 2015-2016
Cranfield University

1.) What is your native language?
2.) What country are you from?
3.) What is your secondary language, third language learned?
4.) What is the language that you speak in the airplane?
5.) How old were you when you learned to read English language?
6.) Where or how did you learn the English language?
7.) How would you describe your English reading and comprehension skills?
8.) What is your ICAO English language level proficiency?
9.) Are you a first officer or captain?
10.) What is your gender? (Male or Female)
11.) How long have you flown for the airlines?
12.) How many years as a first officer?
13.) How many years as a captain?
14.) What type of aircraft do you fly?
15.) How many years in present aircraft?
16.) What is your age?

17.) Describe your experiences using crew alerting systems on the flight deck (e.g. EICAS, ECAM systems). In particular, describe your proficiency with reading and interpreting information from these systems.

18.) Describe and explain your experiences using English written technical documentation on the flight deck (e.g. QRH/FCOM checklist procedures).

19.) Do you experience challenges with interpreting English written technical documentation (e.g. QRH/FCOM checklist procedures on the flight deck? What strategies do you use to read and understand technical documentation? Please explain

20.) How well do you read and understand English written technical documentation on the flight deck? Describe and explain your workload (high/low) with reading and interpreting English written technical documentation (e.g. QRH, FCOM checklist procedures) on the flight deck?

Interview Schedule
30 ESL flight crewmembers interview questions and answers exhibit template (Second Cut) 2013 Study 2

1.) What is your native language?
2.) What is your secondary language, third language learned?
3.) Where or how did you learn English language?
4.) How would you describe your English listening and speaking skills? What is your ICAO English language level proficiency?
5.) What country are you from?
6.) Are you a first officer or captain? What is your gender (Male or Female)
7.) How long have you flown for the airlines? How many years as a first officer? How many years as a captain? What type of aircraft do you fly? How many years in present aircraft?
8.) What is your age?

1.) During the course of your flight segment (push back, taxi, takeoff, cruise, landing), do you ever feel that there are certain crew alerting systems that are confusing? For example: hydraulics/ fuel text cautions, warnings, and advisory signals. If the systems are confusing, how and why do they seem confusing? Do you ever feel the need to look at the system synoptic(s) to help interpret the text? If so under what conditions to you experience these issues?

2.) During the course of your flight segment, how effective do you find the text (i.e. altitude, airspeed) that is utilized to communicate information about flight path (i.e. PFD/TCAS) related cautions and warnings?

Interview Schedule Study 3: 30 ESL flight crewmembers

Researcher: Dujuan B. Sevillian
Institution: Cranfield university-Bedfordshire, U.K.
Department of integrated systems/air transport-school of engineering

Thank you for taking time out of your day to take part in this experiment. The data collected from this experiment will be for research purposes at Cranfield University, UK. No personal information from you is required, as the data collected will only be utilized to further research pilot performance in the flight deck. The experiment will last approximately 1 hour with interview schedule debrief questions. You reserve the right to excuse yourself from the experiment at anytime for any reason.

Researcher Signature:
Dujuan B. Sevillian

Participant Signature:

The aims are as follows:

- English as a second language (ESL) flight crew member's language differences in the flight deck
- flight crew member's use of system generated text/warnings, cautions, and advisories on the flight deck
- flight crew member's decision making process in response to the text/aural warnings, cautions, and advisories.
- Utilization of the Quick Reference Handbook (QRH) English/Portuguese for decision making

Participant Confidentiality Protection Statement
The researcher (Dujuan Sevillian) will make every effort to prevent anyone that is not part of the research experiment to have access to the information collected. The researcher will do the following to protect the confidentiality of the participant in the study:

- Utilize Encryption on personal computer and discs that may be utilized to keep the information safe
- Inform the participants that their data will be protected throughout the study and after the study

Participant Anonymity Protection Statement

The researcher (Dujuan Sevillian) will not record names, addresses or email information etc. with regards to the experiment. There will be no link to the participants for the life of the research conducted. No information regarding the airline name will be recorded; this is needed in order to ensure total anonymity.

1.) Describe your overall experience with utilizing the Electronic Centralized aircraft monitor (ECAM)?
2.) When trouble shooting electrical malfunctions/failures while utilizing the ECAM, describe your overall experience.
3.) When trouble-shooting hydraulic malfunctions/failures while utilizing ECAM, describe your overall experience.
4.) Describe your overall experience with utilizing the English written Quick Reference Handbook (QRH)
5.) Describe your overall experience with utilizing the Portuguese written/translated Quick Reference Handbook

Appendix B: Coding analyses artifacts preliminary and experimental Studies 1, 2, and 3

Study 1 Coding

Table 96 Study 1 Coding

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
1	1A, 1C, 1F, 1G, 1I, 1L	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3L	4B, 4C, 4F, 4E	Technical information in the form of abbreviations/ acronyms is difficult to read and comprehend	5C, 5F, 5G	Technical information in the form of abbreviations/ acronyms is difficult to read and comprehend	Difficulty understanding abbreviations and acronyms leads to Misunderstandings with reading and comprehending them in QRH Checklists and on Crew Alerting Systems	Diagnose improperly system malfunction or failure
2	1A, 1C, 1F, 1G, 1I, IL	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3N, 3G, 3F	4C, 4E, 4H, 4B	Vocabulary words on technical information is challenging to read and understand	5C, 5F, 5G, 5H	Acronyms on technical information are difficult, certain phrases are difficult to understand	Long reading times due to reading unfamiliar long form acronyms on QRH checklists and crew alerting systems	Long response time to respond to system malfunction
3	1A, 1C, 1F, 1G, 1I, IM	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3G, 3H, 3P	4E, 4B, 4C, 4G, 4H	Some vocabulary words on crew alerting systems are simplified into phrases, utilization of background knowledge to read and understand text	No Impact Identified	No Impact Identified	Omission of certain vocabulary words on Crew alerting systems that are simplified leads reverting back to my native language and long reading times	Longer response time, but still have time to respond in a timely manner

Table 97 Study 1 Coding continued

PILOT	#English Language Background knowledge and Proficiency Factors	#English language Background Knowledge Factors	*English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)	**CA English language Design/Integration Factors	CA English language Design/Integration Description	**QRH Checklist Design/Integration Factors	QRH Checklist English language Design/Integration Description	*THEME: Impact on ESL flight crewmembers performance:*	*THEME: Impact on flight safety*
4	1A, IE, IF, 1G, 1I, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3J, 3K, 3P	No Impact Identified	No Impact Identified	5A, 5G, 5H, 5C	Vocabulary Words on QRH checklist and FCOM are sometimes difficult to understand, especially in the notes section (if/then conditional statements)	Misinterpretation of certain vocabulary words in conditional statements on QRH checklists and FCOM procedures impacts reading time	Misinterpretation of certain words and longer response times to crew alert
5	1A, 1E, 1F, 1G, 1I, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3C, 3M	No Impact Identified	No Impact Identified	5D, 5B, 5C, 5H, 5G	Sentences are long on QRH checklists in the notes section and in other operational documents	Re-reading long text on QRH checklists leads to longer response times	Long response time to crew alerts negatively impacts timing for completing tasks (e.g. ATC coordination)
6	1A, 1E, 1F, 1G, 1J, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3M, 3N, 3A	No Impact Identified	No Impact Identified	5C, 5G, 5H	Vocabulary words on QRH checklists are challenging to read	Re-reading challenging text leads to better understanding of text on the QRH checklist	Impacts mental workload and takes time away from other tasks
7	1A, 1E, 1F, 1G, 1J, 1L	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3P, 3A	4B, 4C, 4E,	Abbreviations and Acronyms on ECAM system are sometimes skipped if unfamiliar	5F, 5G, 5C, 5A	Abbreviations and Acronyms on QRH checklists are skipped and re-read	Skipping and re-reading abbreviations and acronyms on ECAM system and QRH checklists leads to longer processing of information	Sometimes a missed step/skipped procedure on QRH checklist leads to misinterpretation of abbreviation/acronyms information on EICAS
8	1A, 1E, 1F, 1G, 1J, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3F	4E, 4B, 4C	Abbreviations and Acronyms on ECAM system are translated back into native language for better understanding	5C, 5F, 5G	Abbreviations and acronyms on QRH checklist are translated back into native language	Sometimes translation of acronyms and abbreviations into my native language on QRH checklist and ECAM system is effective other times not effective	Incorrect translation leads to more time to re-process information for correct word meaning

Table 98 Study 1 Coding continued

PILOT	#English Language Background knowledge and Proficiency Factors	#English language Background Knowledge Factors	*English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)	**CA English language Design/Integration Factors	CA English language Design/Integration Description	**QRH Checklist Design/Integration Factors	QRH Checklist English language Design/Integration Description	*THEME: Impact on ESL flight crewmembers performance:*	*THEME: Impact on flight safety*
9	1A, 1C, 1E, 1F, 1G, 1I, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3J, 3A	4H, 4E, 4C	Vocabulary Words on EICAS system are sometimes re-read, if they are not understood, notes are taken	5D, 5C, 5H, 5G 5B	Sentence length on QRH checklist (electrical system BUS malfunction) is long and takes time to process	Long sentence processing leads to more time reading for clarity purposes due to sentence length on QRH checklists. Vocabulary words on EICAS system are re-read if they are not understood	Sometimes leads to long response times to crew alerts
10	1A, 1E, 1F, 1G, 1I, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3C, 3E, 3A	No Impact Identified	No Impact Identified	5C, 5G, 5H	Reading aloud text, highlighting, and underlining text or QRH checklist helps me remember difficult vocabulary words if I need to go back and read again	Longer processing time and mental demands when highlighting or underlining vocabulary words on QRH checklists	Leads to longer concentration on task, and sometimes difficulty solving ECAM issues
11	1A, 1E, 1F, 1G, 1I, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O, 3K	4H, 4E, 4C	Difficulties processing a few vocabulary words on EICAS	5A, 5C, 5G, 5H	If/Then statements on QRH checklist are sometimes difficult to understand, some are written differently. Understanding time to respond criticality is sometimes challenging depending on the checklist when reading if/then statements on system malfunction (electrical)	Challenging vocabulary words on EICAS leads to high workload. If I don't understand the conditional statement on the QRH checklist or recognize the relationship between system malfunction it can lead to higher mental workload	High mental demand and workload leads to other tasks not completed on time

Table 99 Study 1 Coding continued

PILOT	#English Language Background knowledge and Proficiency Factors	#English language Background Knowledge Factors	*English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)	**CA English language Design/Integration Factors	CA English language Design/Integration Description	**QRH Checklist Design/Integration Factors	QRH Checklist English language Design/Integration Description	*THEME: Impact on ESL flight crewmembers performance:*	*THEME: Impact on flight safety*
12	1A, 1E, 1F, 1G, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A	None Impact Identified	No Impact Identified	5H, 5G, 5C	If words are unknown, I may re-read them for understanding purposes	Very detailed QRH checklists often leads to high mental demand, especially if vocabulary words are unknown	If words are unknown they don't usually lead to a flight safety issue, more just a frustration issue
13	1A, 1B, 1F, 1G, 1J, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3M, 3N	No Impact Identified	No Impact Identified	5G, 5H, 5D, 5C, 5B	QRH checklists, and FCOMs are written with highly detailed sentences and sophisticated written English language	Lengthy QRH checklists and too detailed procedures often lead to mental demand and high workload	High workload due to long reading, which is dependent on the type of system malfunction
14	1A, 1B, 1F, 1G, 1J, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3H, 3G, 3F, 3I	No Impact Identified	No Impact Identified	5C, 5G, 5H, 5E	QRH checklists are written in simple short precise sentences; however, I have to translate the words back into may native language due to several vocabulary words that I don't know the meaning to, so I revert back to my native language to understand	Low mental workload when I translate words back into my native language when I don't know them on the QRH checklist, because I step through each procedure and make sure it is right the first time	Takes more time diagnosing the system malfunction

Table 100 Study 1 Coding continued

PILOT	#English Language Background knowledge and Proficiency Factors	#English language Background Knowledge Factors	*English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)	**CA English language Design/Integration Factors	CA English language Design/Integration Description	**QRH Checklist Design/Integration Factors	QRH Checklist English language Design/Integration Description	*THEME: Impact on ESL flight crewmembers performance:*	*THEME: Impact on flight safety*
15	1A, 1C, 1F, 1G, 1J, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3F, 3G, 3L	4B, 4C, 4E	EICAS system terminology (abbreviations) is difficult to read. Words warning and caution are easy to read	5C, 5D, 5G, 5H	QRH checklists and FCOM procedures are difficult to read because they have very long and comprehensive sentences are too detailed.	Decoding Abbreviations on EICAS sometimes lead to high mental workload Lack of standardization of wording in certain areas on QRH checklist/ FCOM procedures and long sentences lead to longer processing time	Longer processing of abbreviations on EICAS and vocabulary words and sentences on QRH checklist/FCOM leads to re-reading sentences, Sometimes translating system issue into my native language incorrectly
16	1A, 1B, 1F, 1G, 1J, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3L, 3M, 3N, 3O	No Impact Identified	No Impact Identified	5C, 5H, 5G	QRH checklists and FCOM procedures terminology are sometimes difficult to read. Decoding text is a practice I use to understand information as well as my background knowledge (referencing texts that I am aware of) of the information.	When I pace myself reading QRH procedures and decode text, I have to make sure that I complete the procedure on time, which is sometimes medium to high workload	Rarely, but sometimes I do have a time lag where I read a procedure too long to understand it, and takes away from other tasks.

Table 101 Study 1 Coding continued

PILOT	#English Language Background knowledge and Proficiency Factors	#English language Background Knowledge Factors	*English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)	**CA English language Design/Integration Factors	CA English language Design/Integration Description	**QRH Checklist Design/Integration Factors	QRH Checklist English language Design/Integration Description	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
17	1A, 1E, 1F, 1G, 1I, 1L	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3M	No Impact Identified	No Impact Identified	5H, 5G, 5C	There are not many issues that I can identify that drive high workload. Every now and then, there may be a word or phrase that I am not familiar with. I use my experience with the system and its procedures to help me through it	Not much impact when I read text on QRH checklists. I sometimes re-read information that is unfamiliar to me. This sometimes leads to longer processing speed	No impact Identified
18	1A, 1C, 1F, 1G, 1I, 1L	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A	4H, 4C, 4E	Sometimes the terminology/words on the EICAS may not be obvious to the me, so I re-read the information to get a better understand	5C, 5D, 5G, 5H	Highly complex sentences, I re-read so that I have better understanding which sometimes leads to longer processing time. Sentences on the QRH checklist could be simple instead of complex	Slight challenges with interpreting technical information on the QRH checklist to complex sentences that I have to reread, which leads to longer time processing of information.	No Impact identified
19	1A, 1C, 1E, 1F, 1G, 1J, 1M	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3K, 3D	No impact Identified	No Impact Identified	No impact Identified	No impact Identified	No impact Identified	No impact Identified

# Denotes ESL flight Crewmembers Demographics Sub-Theme
*Denotes ESL flight crewmembers Cognitive Sub-theme
**Denotes ESL flight Crewmembers crew alerting systems and QRH checklists Design/Integration Impact Sub-theme

Study 2 Coding

Table 102 Preliminary Study part 2 Coding

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance :***	***THEME: Impact on flight safety***
1	1A, 1F, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3H	4B, 4C, 4E	Phrases (abbreviations and acronyms difficult to interpret on the PFD e.g. traffic advisories) due to not understanding the meaning of the phrase	5A, 5D	Long Paragraphs are difficult to interpret	Long Processing time	Difficult phrases on the crew alerting systems and long paragraphs on QRH checklists lead to misinterpretation of safety information
2	1A, 1F, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3G, 3H, 3P	4B, 4C, 4E	Abbreviations and acronyms on EICAS system are difficult to interpret due to unfamiliar acronyms and abbreviations Translation of written English language back to native language and reverting back to native language due to misunderstanding of word meaning	5C, 5G, 5H	Difficulty understanding vocabulary words on QRH checklists	Long Processing time	Difficult interpretation of abbreviations and acronyms on EICAS system and difficulty understanding vocabulary words on QRH checklists lead to longer response time to system warnings
3	1A, 1B, 1H, 1I, 1K, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3H	4B, 4C, 4E, 4F	Too many abbreviations on ECAM that are unfamiliar cause misinterpretation of long form word meaning	None Identified	None Identified	Misinterpretation of information on ECAM	Misinterpretation of information regarding ECAM warning led to mismanagement of airspeed on landing phase and a go-around maneuver.

Table 103 Preliminary Study part 2 Coding continued

PILOT	#English Language Background knowledge and Proficiency Factors	#English language Background Knowledge Factors	*English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)	**CA English language Design/Integration Factors	CA English language Design/Integration Description	**QRH Checklist Design/Integration Factors	QRH Checklist English language Design/Integration Description	*THEME: Impact on ESL flight crewmembers performance:*	*THEME: Impact on flight safety*
4	1A, 1D, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3H	4B, 4C, 4E	Abbreviations and Acronyms difficult to understand meaning on EICAS system	5C, 5F, 5G	Abbreviations and Acronyms are difficult to understand on QRH checklist non-normal conditions. Abbreviations are also not consistent in QRH checklist (e.g. Low Hyd versus L HD) negatively impacts interpretation.	Long Response time and misinterpretation of information	Misinterpretation of Abbreviations and acronyms lead to long and inadequate decision-making processes when responding to flight path warnings and advisories.
5	1A, 1B, 1H, 1I, IL, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3J, 3P	4B, 4C, 4E, 4G	Abbreviations in short form are difficult to understand due to unfamiliarity with long form word	5A, 5C, 5D, 5F, 5G, 5H, 5I	Simple vocabulary words, abbreviations and acronyms are difficult to understand due to their simplicity. (e.g. p failure versus Pump failure 1) Long sentences and paragraphs are difficult to interpret due to long length.	Longer response time and reading speed (too fast) leads to misinterpretation of information	Misinterpretation of abbreviations acronyms on EICAS and QRH checklists lead to incorrect button pushes on flight deck. Notes section containing conditional statements is not a direct link (logically) to fix system malfunction issue.

Table 104 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
6	1A, 1C, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3H	4C, 4E, 4H	Vocabulary words related to warnings, cautions and advisories are sometimes challenging to interpret due to them being unfamiliar	5C, 5G, 5H	Normal and Non-normal procedures wording is sometimes difficult to understand to challenging vocabulary words	Time needed to execute procedures is sometimes longer than expected	No Impact identified
7	1A, 1G, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3E, 3G, 3H, 3N	No issues identified	No issues identified	5C, 5A, 5G, 5H	Logical flow of written English language on QRH checklists leads is difficult to interpret due to layout of words on checklists when making decision on the flight deck	Decision making process is negatively impacted	Inadequate logical flow of information on checklists leads to negatively impacted decision-making process for flight critical or system critical issues when responding to an alert.
8	1A, 1G, 1H, 1I, 1K, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3H, 3L	4E, 4C, 4H	Technical information on crew alerting systems is difficult to interpret during the decision-making process of responding to an alert	5C, 5G, 5H	Vocabulary words on checklists (non-normal conditions) are difficult to read and interpret during alert decision-making process	Long response times due to reading and interpreting technical information	Reading and interpreting vocabulary words on crew alerting systems and checklists negatively impacts flight crewmembers decision making process responding to system issues

Table 105 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
9	1A, 1D, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3J, 3K, 3P	4C, 4E, 4H	EICAS system data can sometimes be difficult to read and interpret due to Acronyms on the display not utilized frequently	No issues identified	No issues identified	Slower than normal time respond regarding crew alerting systems	Unfamiliar acronyms on crew alerting system leads to slow response times and other tasks not completed in a timely manner
10	1A, 1B, 1H, 1I, 1K, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3H	4B, 4E, 4G, 4H	ECAM system vocabulary words are sometimes challenging to interpret. Acronyms are sometimes difficult if you don't know the acronym/long form of the word	No issues identified	No issues identified	Long Response time due to technical information on crew alerting systems	Misunderstandings in acronyms and vocabulary words lead to long length of time responding to system failures.

Table 106 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
11	1A, 1F, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3C, 3G, 3H, 3M	No issues identified	No issues identified	5A, 5C, 5G, 5H	Standard Operating Procedures in the FCOM are difficult to understand. Terminology is difficult to read and understand, especially words that require a logical understanding of how the checklist corresponds to an action on crew alerting display (e.g. electrical dual hydraulic failures)	Late timing to respond to alert due to misunderstandings of challenging vocabulary word on technical manuals	Misunderstanding of FCOM procedures lead to confusion, frustration and workload is sometimes high while responding to crew alerts
12	1A, 1B, 1G, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3B, 3D, 3K	No issues identified	No issues identified	5B, 5C, 5D, 5G, 5H	QRH/FCOM procedures are difficult to read and understand due to too much information provided in sentences. Logical understanding of how the words on the checklists relate to the information on the display is difficult to make decisions if words are unfamiliar.	Vocabulary words are misunderstood and lead to misunderstandings of technical information	Decision making processes are impacted which lead to high workload depending on the failure, especially cascading failures

Table 107 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
13	1A, 1G, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3I, 3N	No issues identified	No issues identified	5C, 5G, 5H	Vocabulary words on QRH checklist can be challenging if words are unfamiliar	Unfamiliar terminology leads to long response times and high workload	Unfamiliar terms on checklists lead to long response times and high workload, which negatively impact system malfunction response.
14	1A, 1G, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3B, 3I, 3Q, 3L, 3O	4B, 4C, 4E, 4H	ECAM messages are often difficult to understanding while using	5C, 5D, 5G, 5H	Vocabulary words on QRH checklist tend to have verbose technical information in sentences and are challenging to read and understand	Long response times and task saturation	More time troubleshooting system issues due to written English language on crew alerting systems and QRH checklists leads to delayed response, high workload and long response times to air traffic control and other tasks

Table 108 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
15	1A, 1G, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3G, 3H, 3N	4B, 4C, 4E	GPWS messages (acronyms) and TCAS messages (acronyms) are difficult to read and understand	5C, 5F, 5G	Acronyms are challenging due to no definitions or long form of the word on QRH checklist	Long response times to alert	Time needed to decipher acronyms negatively impacts response to system malfunction/failures
16	1A, 1B, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3K 3M,	4B, 4C, 4E, 4H	ECAM system written English messages (abbreviations, acronyms, and vocabulary words) are difficult to read and understand due to unfamiliar words that do not coincide with checklist words, in other words no logical trace of word terminology information back to display interface (e.g. VS1G, 1G)	5C, 5D, 5G, 5H	Text on QRH checklists are to verbose and difficult to understand, wording is too long and difficult to read and understand	Long response time to crew alerts	Difficulty deciphering vocabulary words on crew alerting systems and QRH checklists due to verbose/non-simplified text leads to long response times regarding system failures and/ fight path related issues.
17	1A, 1G, 1H, 1I, 1K, 1O	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3H, 3M	No issues identified	No issues identified	5C, 5D, 5F, 5G, 5H	Abbreviations, acronyms, long sentences and vocabulary words on QRH checklists are difficult with respect to information related to warnings, cautions, and advisory aircraft conditions	Long response time due to written English language crew alerts	Response to engine failures or other non-normal conditions is longer response due to deciphering long sentences and vocabulary words on the QRH checklists

Table 109 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
18	1A, 1B, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3G, 3H, 3L	4B, 4C, 4E, 4H	Difficult abbreviations and acronyms, and vocabulary words on ECAM system are difficult to read and understand while processing system failures	5C, 5D, 5F, 5G, 5H	Difficult to read and comprehend abbreviations /acronyms, and words (e.g. fuel synoptic wording on QRH checklist and long sentences	Long response time due to long sentences and challenging words on QRH checklists	Decision-making processes for non-normal conditions are negatively impacted due to processing difficult written English words on QRH checklists Long response times leads to other tasks not completed on time
19	1A, 1B, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3G, 3K, 3N	4B, 4C, 4E, 4G, 4H	Abbreviations and acronyms appear to be simplified, difficult to understand meaning of long form word (e.g. smoke barrier detection alert)	5C, 5D, 5E, 5F, 5G, 5H	Difficulties reading and interpreting abbreviations , acronyms and vocabulary word meanings. Sentences are often too long and sometimes too simplified to understand meaning of sentence. (e.g. smoke barrier detection checklists)	Misinterpretation of wording on crew alerting system and QRH checklist	Misinterpretation and difficulties reading and comprehending written English language text on crew alerting systems and QRH checklists leads to issues understanding system malfunction/issue

Table 110 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
20	1A, 1G, 1D, 1G, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3F, 3H, 3K	No issues identified	No issues identified	5C, 5D, 5G, 5H	Difficulties reading and interpreting written English language on QRH checklists. Sentences are too long and vocabulary words are too complex.	Confusion during non-normal conditions due to misunderstandings of written English vocabulary words on QRH checklists leads to longer response time	Misunderstandings that lead to longer response times negatively impact decision-making processes regarding system malfunctions
21	1A, 1B, 1H, 1I, 1K, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3H, 3K, 3N	4C, 4E, 4H	Vocabulary words are difficult to read and understand due to their complexity on ECAM system (e.g. electrical system malfunctions BUS 1 versus BUS 2)	5C, 5G, 5H	Vocabulary words on QRH checklists and FOM manuals are difficult to read and understand.	Negative impact on Decision making processes	System malfunctions or failures are difficult follow (cognitively) due to difficulties understanding vocabulary words.
22	1A, 1B, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3B, 3E	No issues identified	No issues identified	5C, 5D, 5E, 5F, 5G, 5H	Abbreviations, acronyms, and vocabulary words are difficult to read and understand. Long sentences tend to negatively impact reading comprehension of system malfunction (e.g. oxygen/pneumatic system checklist.	Negatively impacts response time (long response time to system malfunction/ failures	Misinterpretation of system malfunction/failure leads to long response time and other tasks not completed in a timely manner.

Table 111 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
23	1A, 1B, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3E, 3G	4B, 4C, 4E, 4H	Abbreviations, Acronyms, and vocabulary words are challenging to read and comprehend on ECAM system. Abbreviations are not consistent with abbreviations of same system malfunction in QRH checklist and FCOM (e.g. APU malfunction, pressurization and hydraulics)	5C, 5F, 5G, 5H	Abbreviations, acronyms, and vocabulary words are difficult to read and understand. Understanding meaning of words are difficult because different terminology of the same system malfunction is utilized on ECAM system (e.g. APU pressurization and hydraulics).	Negatively impacts interpretation of information (misinterpretation) and long response times	Misinterpretation of system malfunctions leads to ambiguous inputs on flight deck due to misunderstandings of technical information on crew alerting systems and QRH checklist

Table 112 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
24	1A, 1G, 1H, 1I, 1K, 1O	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3G, 3M, 3N, 3Q	4B, 4C, 4E, 4H	Abbreviations and Acronyms on electrical and hydraulics checklists are difficult to understand due to misunderstanding sin word meaning (e.g. CDU DISCO INSERTD AFTR)	5A, 5C, 5D, 5F, 5G, 5H	Conditional statements are difficult to recognize when reading them, which takes longer to process information Abbreviations and Acronyms are difficult to decipher, and guess meaning due to their lack of long form reference on the QRH checklists/FCOM procedures Long sentences lead to longer reading and comprehension times, and sometimes lose understanding of context	Long response time to crew alert due to misunderstanding ng of technical information	Misunderstanding of technical information on crew alerting systems and QRH checklists/ FCOM procedures leads to long response time on critical system failures and other task not accomplished in a timely manner.

Table 113 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
25	1A, 1B, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3C, 3G, 3H, 3K, 3Q	4B, 4C, 4E, 4F, 4H	Phrases (abbreviations) and acronyms are difficult to read and understand due to their complexity and meaning. Vocabulary words are not consistent with respect to how they appear on TCAS and ECAM systems, which leads to misunderstandings on QRH checklists	5C, 5E, 5F, 5G, 5H	Technical information (abbreviations and acronyms or QRH checklists do not correspond with same terminology on ECAM/TCAS systems. Vocabulary words are difficult to read and understand due to their meaning	Long response times and Misunderstanding of technical information	Misunderstanding of technical information and misdiagnosis negatively impacts decision —making process when responding to crew alerts (e.g. system failures) using QRH checklist and crew alerting system. Negative impacts with respect to flight crewmembers ability to isolate and locate system failure. High workload and long response time to alerts leads to difficulties executing other related tasks
26	1A, 1B, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3G, 3H, 3N	4C, 4E, 4H	Vocabulary words (ECAM system) are sometimes difficult to understand meaning	5C, 5G, 5H	Vocabulary words are sometimes difficult to understand meaning on QRH checklist (hydraulic failures)	Long response time and somewhat higher than normal workload	No issues identified

Table 114 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
27	1A, 1B, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3M	4B, 4C, 4E, 4H	Misunderstandings in abbreviations/acronyms short form on ECAM system due to insufficient information to understand the long form of the word (e.g. FCV INOP)	5C, 5F, 5G	Abbreviations and Acronyms in QRH checklist are misunderstood due to reading challenging written English language terminology (e.g. FCV INOP)	Misunderstanding of system malfunction	Misunderstanding of technical information related to system malfunction leads to negative impact to executing necessary steps to resolve system problem, especially during emergency conditions (improper system recovery).
28	1A, 1B, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3B, 3K, 3Q	4B, 4C, 4D, 4E, 4H	Challenging vocabulary words on ECAM system negatively impact reading comprehension. Abbreviations and Acronyms are difficult to understand their short form meaning	5C, 5D, 5F, 5G, 5H	Reading and Comprehension of vocabulary words on QRH checklists and FCOM procedures is negatively impacted due to misunderstanding of short form of abbreviation/acronym, and meaning of certain vocabulary words	Misinterpretation of technical information Long response time	Misunderstanding of crew alert and QRH checklist leads to misdiagnosis o system malfunction/failure and re-work of the issue, which leads to long response time.

Table 115 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
29	1A, 1B, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3E, 3K	4C, 4E, 4H	Vocabulary words can be challenging due to their technical nature and are sometimes difficult to understand	5C, 5G, 5H	Vocabulary words on QRH checklists and FCOM are difficult to read and interpret due multiple words written the same, but meaning of words are different on crew alerting system	High Workload and long response time	High Workload and long response time lead to inadequate time to complete other required tasks that are related to cascading failures.
30	1A, 1B, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3E, 3N	No issues identified	No issues identified	No issues identified	No issues identified	No issues identified	No issues identified
31	1A, 1B, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3E, 3L, 3O	4A, 4H	Often, short sentences have challenging vocabulary on ECAM and CPU but when trying to understand sentence, not enough information is in the sentence, you have to pull information from other resources.	5C, 5F, 5G	Abbreviations and Acronyms in text are sometimes difficult to understand due to differences in how they are used in the QRH checklist versus on ECAM screen	Long time and medium workload due to reading and comprehending written English technical information	Long time responding to system failure leads to other tasks not accomplished on time (e.g. ATC instructions)
32	1A, 1G, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3J, 3P	4E, 4F, 4H	Vocabulary words on EICAS are sometimes difficult to read and understand due to inconsistent terminology on EICAS and related terms on QRH checklist and FCOM procedures	5C, 5F, 5G	Technical information (e.g. vocabulary wording) is often inconsistent when used to solve EICAS alert issues	Medium Workload	No issues identified

Table 116 Preliminary Study part 2 Coding continued

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****CA English language Design/Integration Factors**	**CA English language Design/Integration Description**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
33	1A, 1G, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3I	4B, 4C, 4E	Abbreviations and Acronyms are difficult to understand in their short form, due to limited references of their long form regarding ECAM alerts	5C, 5F, 5G	Abbreviations and Acronyms are difficult to interpret due to their complexity in QRH checklist	High Workload	High workload when dealing with multiple system issues
34	1A, 1G, 1H, 1I, 1J, 1M	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3A, 3G, 3H	4C, 4E, 4H	Multiple vocabulary words on EICAS system (related to Electrical system failures) are difficult to understand when some vocabulary words are inconsistent when compared to QRH checklist	5C, 5G, 5H	Multiple vocabulary words on QRH checklist are difficult to understand and impact sentence meaning, due to checklist containing vocabulary words different that do not coincide with electrical system failure on alerting system.	Long response times	Long response time leads inadequate response time regarding system malfunction response
35	1A, 1G, 1H, 1I, 1J, 1N	2A, 2B, 2C, 2D 2E, 2F, 2G, 2H, 2I	3E, 3H, 3M	4A, 4C, 4E	Short sentences on ECAM lead to more time clarifying system problem	5E	Simplified text on QRH checklist sometimes takes away from sentence meaning and other sources are needed to clarify situation	Medium workload	Medium workload due to time taken away from other tasks to solve another system issue

\# Denotes ESL flight Crewmembers Demographics Sub-Theme
*Denotes ESL flight crewmembers Cognitive Sub-theme
**Denotes ESL flight Crewmembers crew alerting systems and QRH checklists Design/Integration Impact Sub-theme

Study 3 Coding

Table 117 Experimental Study Coding (ENGLISH LANGAUGE)

PILOT	**#English Language Background knowledge and Proficiency Factors**	**#English language Background Knowledge Factors**	***English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)**	****QRH Checklist Design/Integration Factors**	**QRH Checklist English language Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***
1	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3E, 3G, 3I			No Impact
2	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3H, 3E, 3G,	5A, 5C, 5G, 5H	When I read information (technical) on English language checklists there are terms that are challenging to read	Workload is low to medium depending on the type of sentence I read on electrical system QRH checklist. Conditional statements are difficult to read and lead to re-reading text.
3	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3E, 3G, 3I			No Impact
4	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3E, 3G, 3I			No Impact
5	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O, 3I			No Impact
6	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3E, 3G, 3H, 3I	5A, 5C, 5G, 5H, 5D, 5I, 5F	Troubleshooting information on QRH checklists with respect to the non-normal condition can be difficult due to abbreviations/acronyms	Low workload when I have to troubleshoot using the QRH checklists when re-reading and guessing short sentences with acronyms and abbreviations, and conditional statements. Long sentences take longer to read on QRH checklists
7	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3B, 3H, 3I	5C, 5G, 5H, 5F	The English language QRH checklists (manufacturer provided) have difficult abbreviations and various inconsistencies in terminology	Abbreviations and acronyms are not consistent on QRH checklists and leads to longer response times and re-reading and decoding abbreviations and acronyms
8	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3B, 3H	5C, 5G, 5H, 5D, 5F	Some terms on the QRH checklists (English) have always been difficult for met to read but I managed to get through reading it	Abbreviations and acronyms are not consistent on QRH checklists and leads to longer response times and re-reading abbreviations and acronyms. Long sentences are a challenge to read on QRH checklists
9	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3Q, 3O, 3I			No Impact
10	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I		5C, 5G, 5H, , 5D	Terms on the QRH checklists could be written more clearly for novice and experienced pilots	Vocabulary words on QRH checklists often times are challenging and lead to low workload. Long sentences are sometimes difficult to read
11	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3E, 3G			No Impact
12	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3G, 3H			No Impact
13	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O, 3I			No Impact

Table 118 Experimental Study Coding (ENGLISH LANGAUGE)

PILOT	#English Language Background knowledge and Proficiency Factors	#English language Background Knowledge Factors	*English Language Metacognitive Strategy(s) Factors (CA/QRH checklist)	**QRH Checklist Design/Integration Factors	QRH Checklist English language Design/Integration Description	*THEME: Impact on ESL flight crewmembers performance:*
14	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O, 3I			**PILOT 14:** No Impact
15	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3B, 3G, 3H, 3I	5A, 5C, 5G, 5H, 5F	Conditional statements are difficult to read (due to many conditions in one statement) when completing the task	**PILOT 15:** Response time was slightly longer due to re-reading conditional statements, acronyms and abbreviations on hydraulic QRH checklist
16	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3B, 3O, 3I	5C, 5G, 5H, 5F	I often re-read acronyms because I did not know the reference to the acronym on the flight deck panel	**PILOT 16:** Response time was slightly longer due to re-reading acronyms and abbreviations on hydraulic QRH checklist
17	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O, 3I			**PILOT 17:** No Impact
18	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I				**PILOT 18:** No Impact
19	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I				**PILOT 19:** No Impact
20	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I				**PILOT 20:** No Impact
21	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O			**PILOT 21:** No Impact
22	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O			**PILOT 22:** No Impact
23	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O			**PILOT 23:** No Impact
24	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3B, 3G	5A, 5C, 5G, 5H, 5F	I understood many acronyms, though some of them are difficult to read, if I had a reference word on the checklists it would help	**PILOT 24:** Acronyms on QRH checklists do not contain long form of word and leads to longer than expected response time. Conditional statements are difficult to read and lead to re-reading text
25	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3G, 3H			**PILOT 25:** No Impact
26	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3H, 3Q, 3I			**PILOT 26:** No Impact
27	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3A, 3H, 3O, 3I	5C, 5G, 5H	Airbus manuals are not consistent and has often led me to take longer time reading them	**PILOT 27:** Vocabulary words on the QRH checklists are not consistent at times, which leads to longer than expected response times and workload on QRH checklists
28	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3Q			**PILOT 28:** No Impact
29	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3Q			**PILOT 29:** No Impact
30	1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, 1K	2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I	3O			**PILOT 30:** No Impact

# Denotes ESL flight Crewmembers Demographics Sub-Theme
*Denotes ESL flight crewmembers Cognitive Sub-theme

**Denotes ESL flight Crewmembers QRH checklists Design/Integration Impact Sub-theme
Boxes filled with grey fill indicate ESL flight crewmembers did not indicate crew alerting systems/QRH checklists negative impacts and did not use metacognitive strategies to read and comprehend written English language

Table 119 Experimental Study Coding (PORTUGUESE LANGAUGE)

PILOT	*** Metacognitive Strategy(s) Factors /Portuguese QRH checklists)**	****QRH Portuguese language QRH Checklists Design/Integration Factors**	**Portuguese language QRH Checklists Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
1	3A, 3B, 3E, 3I, 3M, 3P, 3Q	5C, 5G, 5H, 5I, 5D	Vocabulary words on electrical and hydraulic checklists are difficult to read	Misinterpretation of vocabulary word meanings on QRH checklists. Sentence length is sometimes long read and too short	Incorrect inputs on overhead panel and flight deck switches led to long response time
2	3A, 3B, 3G, 3I, 3M, 3P, 3Q	5C, 5G, 5H, 5I, 5A	Words on checklists (electrical and hydraulic QRH checklists and conditional statements are not written in If/Then format in original English language text, problem still exists.	Cognitively Translating vocabulary words unknown to leads to misunderstandings of information on QRH checklists. Conditional statements are also difficult to read, as well as short sentences	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
3	3A, 3B, 3E, 3G, 3M, 3P	5C, 5G, 5H	Misinterpretation of technical words	Misunderstanding vocabulary words on QRH checklists due to unfamiliarity	Misinterpretation of vocabulary words (technical) leads to re-reading text for comprehension and long response times
4	3A, 3B, 3G, 3I, 3Q	5C, 5G, 5H, 5D, 5A	Conditional statements are long in format on QRH checklists	Conditional statements are inherently too long and are not specific enough to complete tasks all of the time	Re-reading conditional statements led to long response time and high workload
5	3A, 3G, 3H, 3I, 3M, 3P	5C, 5G, 5H	Vocabulary word association on QRH checklists difficult	Difficulties making sense of words on QRH checklists and associated words to make decisions. Sentence length is also sometimes long.	Misunderstandings with word association and sentence syntax led to long response times and high workload
6	3A, 3B, 3E, 3G, 3H, 3I, 3M, 3P	5C, 5G, 5H	Reverted back to English language for technical word meaning	Reverted back to my knowledge of English language to read Portuguese language	Reverting back to English language led to long response times and confusion, which led to high workload

Table 120 Experimental Study Coding (PORTUGUESE LANGAUGE) continued

PILOT	*** Metacognitive Strategy(s) Factors /Portuguese QRH checklists)**	****QRH Portuguese language QRH Checklists Design/Integration Factors**	**Portuguese language QRH Checklists Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
7	3A, 3B, 3H, 3M, 3P	5C, 5G, 5H, 5I, 5D	Terminology on QRH checklists is difficult to read. Inherently long and short text on English language QRH checklists, when translated has same issue due to design of original English language text	Misunderstood certain words on QRH checklists led to longer processing of information. Sentence length is sometimes long and short	Misunderstandings with word association and sentence syntax led to long response times and high workload
8	3A, 3E, 3G, 3I, 3M, 3P	5C, 5G, 5H, 5D, 5A	Translated words that were unknown and unfamiliar	Translated Portuguese words to find different word meanings. Conditional statements are also difficult to read. Sentence length is sometimes long	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
9	3A, 3G, 3H	5C, 5G, 5H	On the flight deck, incorrect misinterpretation of words leads to wrong inputs	Misinterpreted QRH checklist words and pushed incorrect buttons on flight deck	Incorrect inputs on overhead panel and flight deck switches
10	3A, 3E, 3G, 3H, 3M, 3P	5C, 5G, 5H	Guessed words incorrectly	Guessed meaning of certain words unfamiliar on QRH checklists	Guessing meaning of vocabulary words led to high workload due to misunderstandings of word meaning
11	3A, 3B, 3E, 3G, 3H	5C, 5G, 5H, 5I	Vocabulary words difficult to read and understand	Experienced difficulties with vocabulary words and associating them in a sentence. Sometimes sentences are too short for reading	Misunderstandings with word association and sentence syntax led to long response times and high workload
12	3A, 3B, 3G, 3H, 3I, 3M, 3P	5C, 5G, 5H, 5F, 5A	Abbreviations and acronyms and acronyms difficult rad and understand	Abbreviations and acronyms are difficult to read and comprehend in notes section and safety information. Conditional statements are also difficult to read	Misinterpretation of abbreviations and acronyms on notes section led to long response times

Table 121 Experimental Study Coding (PORTUGUESE LANGAUGE) continued

PILOT	*** Metacognitive Strategy(s) Factors /Portuguese QRH checklists)**	****QRH Portuguese language QRH Checklists Design/Integration Factors**	**Portuguese language QRH Checklists Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
13	3A, 3B, 3G, 3H, 3M, 3P	5C, 5G, 5H	Unilateral translation of Portuguese language	Translated Portuguese language to find other equivalent meanings	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
14	3A, 3B, 3G, 3H, 3I, 3M, 3P	5C, 5G, 5H, 5D,	Unilateral translation of Portuguese language	Translated words in Portuguese language to find other meanings. Sentence length is sometimes long	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic faults leads to misinterpretation of word meaning
15	3A, 3B, 3G, 3H, 3M, 3P	5C, 5G, 5H	Reverted back to English language	Since my training is in English language, I tried to read QRH checklists in English language	Reverting back to English language led to long response times and confusion, which led to high workload
16	3A, 3G, 3H, 3I, 3M, 3P	5C, 5G, 5H	Guessed vocabulary words (technical) incorrectly	Incorrectly guessed meaning of words	Guessing meaning of vocabulary words led to high workload due to misunderstandings of word meaning
17	3A, 3B, 3G, 3H, 3M, 3P	5C, 5G, 5H, 5A	Made wrong inputs on flight deck, went back and made corrections	Made incorrect inputs on flight deck due to misunderstanding of QRH checklists. Conditional statements are also difficult to read	Incorrect inputs on overhead panel and flight deck switches
18	3A, 3B, 3G, 3H, 3M, 3P	5C, 5G, 5H	Vocabulary words were unfamiliar to know knowledge of the text	Re-reading text due to unfamiliar vocabulary words	Re-reading Portuguese language vocabulary words led to long response time
19	3A, 3I, 3M, 3P	5C, 5G, 5H, 5D	Had issues with connecting word meaning on QRH checklists	Connecting word meaning on Portuguese language QRH checklists led to guessing words incorrectly. Sentence length is sometimes long	Led to long response time, omission of vocabulary words, and high workload
20	3A, 3B, 3G, 3I	5C, 5G, 5H	Vocabulary words were misinterpreted and led to wrong inputs	Misinterpreted information on QRH checklists led to incorrect inputs on flight deck panel	Incorrect inputs on overhead panel and flight deck switches
21	3A, 3B, 3G, 3H, 3M, 3P	5C, 5G, 5H, 5A	Word meaning was difficult to connect to task	Connecting word meaning on Portuguese language QRH checklists led to guessing words incorrectly. Conditional statements are also difficult to read	Tasks unrelated (but important) to hydraulic/electrical faults were abandoned

Table 122 Experimental Study Coding (PORTUGUESE LANGAUGE) continued

PILOT	*** Metacognitive Strategy(s) Factors /Portuguese QRH checklists)**	****QRH Portuguese language QRH Checklists Design/Integration Factors**	**Portuguese language QRH Checklists Design/Integration Description**	***THEME: Impact on ESL flight crewmembers performance:***	***THEME: Impact on flight safety***
22	3B, 3G, 3H	5C, 5G, 5H	Unfamiliar words led to translation of words to find other word meaning	Translated words to find other meanings because of unfamiliar terminology	Cognitively translating Portuguese vocabulary words into other meanings to solve electrical and hydraulic system faults leads to misinterpretation of word meaning
23	3A, 3B, 3G, 3H	5C, 5G, 5H	Vocabulary words difficult to read and understand on QRH checklists	Did not understand certain vocabulary words in Portuguese language on QRH checklists	Misinterpretation of vocabulary words (technical) led to re-reading text for comprehension and long response times
24	3A, 3B, 3G, 3H, 3Q	5C, 5G, 5H	Omitted vocabulary words in notes section	Omitted certain vocabulary words that were unfamiliar to me	Omission of vocabulary words (technical) led to misunderstandings with solving hydraulic and electrical system faults on flight deck, which led to long response times
25	3A, 3B, 3G, 3H, 3M, 3P	5C, 5G, 5H, 5F, 5D	Vocabulary words difficult to read/interpret	Abbreviations/acronyms on QRH checklists were difficult to read and understand. Sentence length is sometimes long	Misinterpretation of abbreviations and acronyms on notes section led to long response times
26	3B, 3Q	5C, 5G, 5H	Omission of vocabulary words on notes section	Omitted words that were not familiar and led to misunderstanding of text	Omission of vocabulary words (technical) led to misunderstandings with solving hydraulic and electrical system faults on flight deck, which led to long response times
27	3A, 3B, 3G	5C, 5G, 5H	Sentence syntax difficult to read in native language	Difficulties understanding and associating word meaning and sentence syntax	Misunderstandings with word association and sentence syntax led to long response times and high workload
28	3A, 3B, 3M, 3P	5C, 5G, 5H, 5F	Text abbreviation was difficult	Abbreviated text was difficult to understand and led to misunderstanding information	Misinterpretation of abbreviations and acronyms led to high mental demand/workload
29	3A, 3B, 3G, 3Q	5C, 5G, 5H, 5A	Omission of vocabulary words made it difficult to read other words	Omitted words unfamiliar, which led to misunderstanding other text. Conditional statements are also difficult to read	Omission of vocabulary words (technical) led to misunderstandings with solving hydraulic and electrical system faults on flight deck, which led to long response times
30	3A, 3G, 3H	5C, 5G, 5H, 5A	If/then statements difficult in English language. Same issue exists in Portuguese language	Conditional statements are normally very difficult to read due to Airbus procedure design	Misunderstandings with conditional statements in the notes section, with respect to form and function led to long response times

*Denotes ESL flight crewmembers Cognitive Sub-theme
**Denotes ESL flight Crewmembers QRH checklists Design/Integration Impact Sub-theme

Appendix C: NASA TLX analysis and Interview responses from Experiment Examples

Two examples of NASA-TLX forms that were filled out by two participants during the experiment are located on the next pages. The researcher's goal of providing these examples is to illustrate the types of data that was collected on the NASA-TLX. Note: Due to space limitations for this dissertation, the entire forms that were filled out during the experiment are not provided below. The raw data is located in a folder held by the researcher with the complete forms and data that was filled out by each participant. Note that data may have been updated due to ESL flight crew member debriefs, therefore the data on the next pages represents examples of the type of information collected during the researcher's experimental trials.

2nd Participant

INFORMED CONSENT FORM FOR EXPERIMENT and INTERVIEW SCHEDULE

RESEARCHER: DUJUAN B. SEVILLIAN
INSTITUTION: CRANFIELD UNIVERSITY-BEDFORDSHIRE, U.K.
DEPARTMENT OF INTEGRATED SYSTEMS/AIR TRANSPORT-SCHOOL OF ENGINEERING

Thank you for taking time out of your day to take part in this experiment. The data collected from this experiment will be for research purposes at Cranfield University, UK. No personal information is needed as the data collected will only be utilized to further research pilot performance in the flight deck. The experiment will last approximately 1 hour with interview schedule debrief questions. You reserve the right to excuse yourself from the experiment at anytime for any reason.

Researcher Signature:
Dujuan B. Sevillian

Participant Signature:
Aurelio

The aims are as follows:

- English as a second language (ESL) flight crew member's culture and language differences in the flight deck
- flight crew member's communication regarding system generated text/aural warnings, cautions, and advisories in the flight deck operational environment
- flight crew member's decision making process in response to the text/aural warnings, cautions, and advisories.
- Utilization of the Quick Reference Handbook (QRH) English/Portuguese for decision making

Participant Confidentiality Protection Statement

The researcher (Dujuan Sevillian) will make every effort to prevent anyone that is not part of the research experiment to have access to the information collected. The researcher will do the following to protect the confidentiality of the participant in the study:

- Utilize Encryption on personal computer and discs that may be utilized to keep the information safe
- Inform the participants that their data will be protected throughout the study and after the study

Participant Anonymity Protection Statement

The researcher (Dujuan Sevillian) will not record names, addresses or email information etc. with regards to the experiment. There will be no link to the participants for the life of the research conducted. No information regarding the airline name will be recorded; this is needed in order to ensure total anonymity.

Data Analysis Roll-up Pilot 2

ENG WKLD = 46.3 POR WKLD = 83.3 ENG TIME = 4.0min POR TIME = 12.0min	ENG NUM OF OMISSION = 1 POR NUM OF OMISSION = 1 ENG NUM OF COMISSION = 0 POR NUM OF COMISSION = 0	ENG TASK PERFORM = 1 POR TASK PERFORM = 1 NARRATIVE AVAIL ✓

2nd Pilot Participant

ESL Pilot Profile

Detailed Demographics Questions

1.) What is your native language? Portuguese

2.) What is your secondary language, third language learned? English

3.) What is the first language you learned to speak fluently? Portuguese

4.) What is the language that you speak in the airplane? Portuguese / English

5.) How old were you when you learned to speak the English language? 5 years old

6.) Where or how did you learn the English language? Home / School

7.) How would you describe your English listening and speaking skills? What is your ICAO Aeronautical English language level proficiency? Listening and Speaking - Good ICAO-6

8.) How many international flights have you made in the last five days? 2 flights

9.) What country are you from? Portugal

10.) Are you a first officer or captain? What is your gender (Male or Female) CAPTAIN - MALE

11.) How long have you flown for the airlines? 17 years How many years as a first officer? 6 years How many years as a captain? 8 years What type of aircraft do you fly? A320 How many years in present aircraft? 16 years

12.) What is your age?
43

Appendix B.

Sources-of-Workload Comparison Cards

Pilot 2

English Checklist

14

Effort or Performance	Temporal Demand or Frustration
Temporal Demand or Effort	Physical Demand or Frustration
Performance or Frustration	Physical Demand or Temporal Demand
Physical Demand or Performance	Temporal Demand or Mental Demand

15

Appendix D.

Subject ID: ____________ **Date:** ____________

SOURCES-OF-WORKLOAD TALLY SHEET		
Scale Title	*Tally*	*Weight*
MENTAL DEMAND	3	3
PHYSICAL DEMAND	2	2
TEMPORAL DEMAND	2	2
PERFORMANCE	3	3
EFFORT	4	4
FRUSTRATION	1	1

Total count = 15

(NOTE - The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5.)

18

Appendix E.

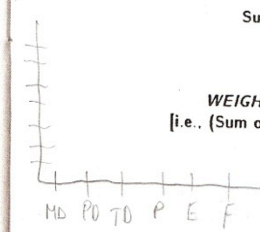
Subject ID: ____________ **Task ID:** ____________

WEIGHTED RATING WORKSHEET			
Scale Title	*Weight*	*Raw Rating*	*Adjusted Rating* (Weight X Raw)
MENTAL DEMAND	3	45	135
PHYSICAL DEMAND	2	30	60
TEMPORAL DEMAND	2	50	100
PERFORMANCE	3	60	180
EFFORT	4	40	160
FRUSTRATION	1	60	60

Sum of "Adjusted Rating" Column = 695

WEIGHTED RATING =
[i.e., (Sum of Adjusted Ratings)/15] $\boxed{46.3}$

19



P2

Appendix B.

Sources-of-Workload Comparison Cards

Portuguese checklist

14

Effort or Performance	Temporal Demand or Frustration
Temporal Demand or Effort	Physical Demand or Frustration
Performance or Frustration	Physical Demand or Temporal Demand
Physical Demand or Performance	Temporal Demand or Mental Demand

15

Appendix D.

Subject ID: 2nd Pilot **Date:** ______

SOURCES-OF-WORKLOAD TALLY SHEET		
Scale Title	*Tally*	*Weight*
MENTAL DEMAND	5	5
PHYSICAL DEMAND	0	0
TEMPORAL DEMAND	3	3
PERFORMANCE	1	1
EFFORT	3	3
FRUSTRATION	3	3

Total count = 15

(NOTE - The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5.)

18

Appendix E.

Subject ID: ______ **Task ID:** ______

WEIGHTED RATING WORKSHEET			
Scale Title	*Weight*	*Raw Rating*	*Adjusted Rating* (Weight X Raw)
MENTAL DEMAND	5	90	450
PHYSICAL DEMAND	0	10	0
TEMPORAL DEMAND	3	80	240
PERFORMANCE	1	80	80
EFFORT	3	80	240
FRUSTRATION	3	80	240

Sum of "Adjusted Rating" Column = 1250

WEIGHTED RATING =
[i.e., (Sum of Adjusted Ratings)/15] 83.3

19

Pilot 2

EXPERIMENT INTERVIEW SCHEDULE QUESTIONS (NARRATIVES)

1.) Describe your overall experience with utilizing the Electronic Centralized Aircraft Monitor (ECAM).

Good tool for the emergency drill. However due to the amount of information presented good discipline is required, otherwise one messes up the whole drill making it a time consuming situation. very much undesirable

2.) When trouble shooting electrical malfunctions/failures while utilizing the ECAM, describe your overall experience.

Again a good tool. The fault is presented with the actions to be executed. Easy to locate the push buttons to act on.

3.) When trouble shooting hydraulic malfunctions/failures while utilizing the ECAM, describe your overall experience.

ECAM presents the failure in English but dealing with a portuguese checklist and a English ECAM is more time consuming. Not as straight forward as if it would be if all in the same language

4.) Describe your overall experience with utilizing the English written Quick Reference Handbook (QRH)

Because everything (QRH/ECAM/cockpit) is in English it was easy to identify and locate the necessary push buttons required to cope with the failure.

5.) Describe your overall experience with utilizing the Portuguese written Quick Reference Handbook (QRH)

Portuguese QRH makes confusing. The QRH had some English words and abbreviations together with portuguese description. ~~Pilot~~ reads the QRH (Portuguese/English) and has to locate English push buttons in the cockpit/overhead panel. It's time consuming one having to mentally translate from one language to the other.

Pilot 11

ESL Pilot Profile

Detailed Demographics Questions

1.) What is your native language? Portuguese

2.) What is your secondary language, third language learned? English and a little of French/spanish

3.) What is the first language you learned to speak fluently? English

4.) What is the language that you speak in the airplane? Portuguese/English

5.) How old were you when you learned to speak the English language? 5 -

6.) Where or how did you learn the English language? With my parents and after in high school

7.) How would you describe your English listening and speaking skills? Good What is your ICAO Aeronautical English language level proficiency? 5

8.) How many international flights have you made in the last five days? none

9.) What country are you from? Moçambique - Portugal

10.) Are you a first officer or captain? What is your gender (Male or Female) Captain / Male

11.) How long have you flown for the airlines? Almost 37 years How many years as a first officer? F/O - 16 years How many years as a captain? Capt / 20 years What type of aircraft do you fly? How many years in present aircraft?

12.) What is your age? 66 years

Appendix B.

Sources-of-Workload Comparison Cards

Pilot #11

English check (13)

Effort

or

Performance

Temporal Demand

or

Frustration

Temporal Demand

or

Effort

Physical Demand

or

Frustration

Performance

or

Frustration

Physical Demand

or

Temporal Demand

Physical Demand

or

Performance

Temporal Demand

or

Mental Demand

Appendix D.

Subject ID: ____________ **Date:** ____________

SOURCES-OF-WORKLOAD TALLY SHEET		
Scale Title	*Tally*	*Weight*
MENTAL DEMAND	3	3
PHYSICAL DEMAND	2	2
TEMPORAL DEMAND	4	4
PERFORMANCE	5	5
EFFORT	1	1
FRUSTRATION	0	0

Total count = 15

(NOTE - The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5.)

18

Appendix E.

Subject ID: ____________ **Task ID:** ____________

WEIGHTED RATING WORKSHEET			
Scale Title	*Weight*	*Raw Rating*	*Adjusted Rating* (Weight X Raw)
MENTAL DEMAND	3	30	90
PHYSICAL DEMAND	2	20	40
TEMPORAL DEMAND	4	45	180
PERFORMANCE	5	60	300
EFFORT	1	60	60
FRUSTRATION	0	50	0

Sum of "Adjusted Rating" Column = 670

WEIGHTED RATING =
[i.e., (Sum of Adjusted Ratings)/15] $\boxed{44.6}$

19

Appendix B.

Sources-of-Workload Comparison Cards

Pilot # 11
Portuguese Checklist

Effort
or
Performance

Temporal Demand
or
Frustration

Temporal Demand
or
Effort

Physical Demand
or
Frustration

Performance
or
Frustration

Physical Demand
or
Temporal Demand

Physical Demand
or
Performance

Temporal Demand
or
Mental Demand

Appendix D.

Subject ID: ____________ **Date:** ____________

SOURCES-OF-WORKLOAD TALLY SHEET

Scale Title	*Tally*	*Weight*
MENTAL DEMAND	3	3
PHYSICAL DEMAND	1	1
TEMPORAL DEMAND	5	5
PERFORMANCE	4	4
EFFORT	2	2
FRUSTRATION	0	0

Total count = 15

(NOTE - The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5.)

18

Appendix E.

Subject ID: ____________ **Task ID:** ____________

WEIGHTED RATING WORKSHEET

Scale Title	*Weight*	*Raw Rating*	*Adjusted Rating* (Weight X Raw)
MENTAL DEMAND	3	70	210
PHYSICAL DEMAND	1	50	50
TEMPORAL DEMAND	5	70	350
PERFORMANCE	4	30	120
EFFORT	2	60	120
FRUSTRATION	0	60	0

Sum of "Adjusted Rating" Column = 850

WEIGHTED RATING = 56.6
[i.e., (Sum of Adjusted Ratings)/15]

19

Pilot 11

EXPERIMENT INTERVIEW SCHEDULE QUESTIONS (NARRATIVES)

1.) Describe your overall experience with utilizing the Electronic Centralized Aircraft Monitor (ECAM).

Take a little bit time to ~~be~~ used but the effort to use it not only in normal operations, but specially in emergency operations is quite low, except in one or ~~two~~ more complex

2.) When trouble shooting electrical malfunctions/failures while utilizing the ECAM, describe your overall experience.

It's a more complex c/L and the few times that I had to use it was very carefully and slowly; it's easy to ~~be~~ confused when we want to change pages

3.) When trouble shooting hydraulic malfunctions/failures while utilizing the ECAM, describe your overall experience.

It's a c/L more easy to deal with it but must also be in a carefully way, in order in not to get lost during the procedure

4.) Describe your overall experience with utilizing the English written Quick Reference Handbook (QRH)

I think that is more easy for me, because all the manuals are in English and since I learned English when using the language I also think in English. I made an effort to think in English and not translate from Portuguese to English.

5.) Describe your overall experience with utilizing the Portuguese written Quick Reference Handbook (QRH)

Not so easy. I had to compare, when thinking, the Portuguese, ~~better~~ I had to translate to English and act ~~accordingly~~ according.

Appendix D: Researcher's Literature Review Studies Compilations

Table 123 Literature Review Studies Compilation

Chapter/Section	Main Concepts	Shortcomings (factors not covered in studies)	Researcher Approach in Studies
1.1	Written English language challenges are inherent in the transportation industry	None Identified	Determine: Written English language impact on airline industry
1.2	Written English language challenges impact native flight crewmembers reading comprehension	English language proficiency, background knowledge, and metacognitive strategy use	Determine: If ESL flight crewmembers are impacted by their: English language proficiency Strategy to read and understand written English language Background knowledge to read and understand written English language
1.3	Written English language challenges impact ESL flight crewmembers reading comprehension	Vocabulary Word Type Text genre ESL English language Proficiency level ESL metacognitive strategy use to read and understand English language ESL flight crewmembers background knowledge to understand written English text	Determine: If ESL flight crewmembers reading comprehension of written English language technical information impacts their performance on the flight deck and flight safety If ESL flight crewmembers are aware of metacognitive strategy use and type of metacognitive strategy utilized to read and understand written English language technical information If ESL flight crewmembers English language proficiency impacts their ability to read written English language technical information. If ESL flight crewmembers possess adequate background knowledge to read and understand written English language
1.4	Aircraft accidents are indicators of written English language challenges on ESL flight crewmembers	ESL flight crewmembers English language proficiency ESL flight crewmembers English language background knowledge ESL flight crewmembers use of metacognitive strategies to read and comprehend written English language (e.g. vocabulary words, text genre)	Determine: If ESL flight crewmembers reading comprehension of written English language technical information impacts their performance on the flight deck and flight safety If ESL flight crewmembers are aware of metacognitive strategy use and type of metacognitive strategy utilized to read and understand written English language technical information If ESL flight crewmembers English language proficiency impacts their ability to read written English language technical information. If ESL flight crewmembers possess adequate background knowledge to read and understand written English language
1.5	ESL flight crewmembers English language Proficiency Government Standards	ESL flight crewmembers Reading comprehension of written English language technical information	Determine: If ESL flight crewmembers English language proficiency impacts their ability to read and comprehend written English language technical information.
1.6	Aircraft Accident: ESL English language Proficiency Issues	ESL flight crewmembers ability to understand complex sentences and vocabulary word type	Determine If ESL flight crewmembers English language proficiency impacts their ability to read and understand vocabulary words and sentences
1.7	Challenges designing crew alerting and information systems for ESL flight crewmembers Examples of written English language technical information on crew alerting systems	English language proficiency, background knowledge and metacognitive strategy use while reading English written technical information on crew alerting systems	Determine If ESL flight crewmembers reading comprehension of written English language technical information is impacted by design of information on crew alerting systems If ESL flight crewmembers English language proficiency and background knowledge is adequate to read and comprehend information on crew alerting systems If ESL flight crewmembers use metacognitive strategies to read and understand written English language on crew alerting systems.

Table 124 Literature Review Studies Compilation Continued

Chapter/Section	Main Concepts	Shortcomings (factors not covered in studies)	Researcher Approach in Studies
1.7.1 and 1.7.2	Challenges designing information systems for ESL flight crewmembers Example of information system (QRH checklist) design factors	English language proficiency, background knowledge and metacognitive strategy use while reading English written technical information on QRH checklists	Determine If ESL flight crewmembers reading comprehension of written English language technical information is impacted by design of information on QRH checklists If ESL flight crewmembers English language proficiency and background knowledge is adequate to read and comprehend information on QRH checklists If ESL flight crewmembers use metacognitive strategies to read and understand written English language on QRH checklists
2.1 Parry (1991)	ESL adults with low to intermediate levels of English language proficiency use bottom up model to read and understand written English language	Study does not describe effect of particular vocabulary words model use (e.g. technical, high frequency words) Study does not describe effect model use has on ESL adult ability to understand words in text corpora (e.g. expository text)	Determine: If ESL flight crewmembers use each of the mental models and if their performance on the flight deck is impacted by use of each strategy, while they read and comprehend written English language technical information on crew alerting systems and QRH checklists.
2.1 Yildiz-Genc (2009)	ESL adults with Intermediate Proficiency level of English language use top-down and bottom-up model to read and comprehend English language	Study does not describe effect of particular vocabulary words model use (e.g. technical, high frequency words) Study does not describe effect model use has on ESL adult ability to understand words in text corpora (e.g. expository text)	Determine: If ESL flight crewmembers use models to read and understand vocabulary words on crew alerting systems and QRH checklists Determine: If ESL flight crewmembers English language proficiency is a factor that influences use of mental models.
2.1 Fatemi et al (2014)	ESL adults that are highly proficient with English language use interactive models to read and comprehend English language	Study does not describe effect of particular vocabulary words model use (e.g. technical, high frequency words) Study does not describe effect model use has on ESL adult ability to understand words in text corpora (e.g. expository text)	Determine: If ESL flight crewmembers performance is impacted by using mental models to read certain text genre (expository text, instructional text) on QRH checklists and crew alerting systems.
2.2 Paribakht and Wesche (1999)	Lexical Inferencing used more often than other reading comprehension strategies	Text Genre (e.g. Instructional/Expository text) not reviewed with respect to ESL adults' ability to use lexical inferencing to read and understand vocabulary words	Determine: If ESL flight crewmembers reading comprehension is impacted with use of lexical inferencing to understand vocabulary words in text corpora (e.g. instructional/Expository text) on QRH checklists and crew alerting systems
2.2 Wang (2011b)	Advanced English language proficiency level ESL adults with background knowledge in English language, were challenged with use of lexical inferencing to read and understand English language. ESL adults made incorrect inferences on words in text	Vocabulary word types were not discussed, and if they had an impact on ESL adults' reading comprehension. Text genre not discussed	Determine: If ESL flight crewmembers reading comprehension is impacted with use of lexical inferencing to understand vocabulary word types in text corpora (e.g. instructional/Expository text) on QRH checklists and crew alerting systems Determine: If ESL flight crewmembers English language proficiency level and background knowledge is a factor that influences their ability to use lexical inferencing to read and understand written English language on QRH checklists and crew alerting systems.

Table 125 Literature Review Studies Compilation Continued

Chapter/Section	Main Concepts	Shortcomings (factors not covered in studies)	Researcher Approach in Studies
2.2 Dwaik and Shehadeh (2013)	High proficient English language ESL adults made more correct inferences on words unknown, than ESL adults that were low proficient ESL adults	Vocabulary word types were not discussed, and if they had and impact on ESL adult reading comprehension. Text genre and ESL adult background knowledge not discussed	Determine: If ESL flight crewmembers English language proficiency and background knowledge is a factor that influences their ability to use lexical inferencing when they read written English language technical information on QRH checklist and crew alerting systems.
2.2 Nylander (2014)	High proficient English language ESL adults' were familiar with text they read, had strong vocabulary background knowledge, and therefore were able to use lexical inferencing to read words	Vocabulary word types were not discussed, and if they had an impact on ESL adults' reading comprehension. Text genre not discussed	Determine: If ESL flight crewmembers performance on the flight deck is impacted with use of lexical inferencing to read written English language technical information on crew alerting systems and QRH checklists If ESL flight crewmembers English language proficiency is a factor that influences their ability to use lexical inferencing when they read written English language technical information on QRH checklist and crew alerting systems
2.3 Mehrpour and Riazi (2004)	ESL adults' proficient with written English language and years of experience using English language indicates that shorter sentences in text are more difficult to read and comprehend than longer text. Shorter sentences negatively impact ESL adult performance	Background knowledge of text not discussed. Background knowledge in technical text or academic text	Determine: If altering crew alerting systems text and QRH checklist text (longer versus shorter sentence length) is feasible to pursue in the researcher's experimental design. Determine: ESL flight crewmembers background knowledge of technical words/technical text on crew alerting systems and QRH checklists impacts their reading comprehension performance in the researcher's preliminary studies
2.3 Gardner and Hansen (2007)	ESL adults with beginning, low intermediate, high intermediate, and advanced English language proficiency level indicates simplified text is easier to read and comprehend, when using metacognitive strategies to read and comprehend English language.	Vocabulary word type not indicated in the study	Determine: If vocabulary word type influences ESL flight crewmembers reading comprehension of words on crew alerting systems and QRH Checklists that are simplified in the researcher's preliminary studies Determine: If ESL flight crewmembers English language proficiency is a factor that influences their ability to read and comprehend simplified text in the researcher's preliminary studies
2.3 Hashemi and Bagheri's (2014)	ESL adults with intermediate to high English language proficiency levels perform well with reading and comprehending simplified text. Time pressure to read simplified text negatively impacts performance. Having no time pressure levied on ESL adults does not negatively impact performance.	Type of metacognitive strategy utilized to read simplified text not discussed	Determine: If ESL flight crewmembers use of metacognitive strategy are utilized to read and understand text that is simplified, alteration of sentences (short versus long sentences) in the researcher's preliminary studies Determine: If time pressure/no time pressures impact ESL flight crewmembers ability to solve crew alerts and use QRH checklists when text is longer or simplified in the researcher's preliminary studies
2.3 Eslami (2014)	ESL adults with low, intermediate, and high level of English language proficiency indicate simplified text is easy to read and comprehend.	Vocabulary word type not indicated in the study	Determine: If ESL flight crewmembers English language proficiency is a factor that influences their ability to read and comprehend simplified text in the researcher's preliminary studies

Table 126 Literature Review Studies Compilation Continued

Chapter/Section	Main Concepts	Shortcomings (factors not covered in studies)	Researcher Approach in Studies
3.1.1 Ashrafzadeh et al (2015)	Academic sub-technical words and highly complex technical text was deemed more difficult to comprehend by ESL participants studying English language than participants with a medical background Participants with adequate background knowledge of medicine, and intermediate level of English language proficiency, comprehended sub-technical and technical written English language better than participants' with less background knowledge	Impact of sentence length (short text versus long text) Impact of metacognitive strategy use on reading highly complex text	Determine: If ESL flight crewmembers indicate that sentence text on crew alerting systems and QRH checklists is short or long, and if it negatively impacts ESL flight crewmembers reading comprehension of technical information Determine: If ESL flight crewmembers English language proficiency and background knowledge is a factor that influences their ability to read technical and academic words on crew alerting systems and QRH checklists
3.1.2 Wanpen et al (2013)	Participants with vocational backgrounds were rated high regarding technical vocabulary proficiency. Participants' with general education rated low regarding technical vocabulary proficiency. Individuals with an academic background used metacognitive strategies more often than those with a vocational background. Individuals' with vocational background likely had knowledge of the text.	None identified	Determine: If ESL flight crewmembers English language proficiency is factor that influences their ability to read and comprehend technical vocabulary words on crew alerting systems and QRH checklists Determine: If ESL flight crewmembers background knowledge of crew alerting systems and QRH checklists enable them to use metacognitive strategies to read and comprehend written English language
3.1.2 Abdul-Hamid and Samuel (2012)	High, medium, and low level of English language proficiency impact ESL adult ability to read technical vocabulary words in text Participants' English language proficiency (adequate/less than adequate) could have contributed to their difficulties understand scientific text. Academic vocabulary was difficult to interpret within the scientific text. Participants' background knowledge of text, impact how effective they are reading and comprehending written English text with academic and technical words in text.	None identified	Determine: If ESL flight crewmembers English language proficiency and background knowledge of text impact their ability to read and understand academic words and technical words in text corpora on QRH checklists and crew alerting systems. Determine: If ESL flight crewmembers translate vocabulary words back into their native language, so that they are able to read and understand written English language text with academic and technical vocabulary words.
3.1.3 Kweon and Kim (2008)	ESL adults that were proficient with English language retention rate were faster for high frequency words than for low-frequency words. High frequency words were easier to learn than low-frequency words. On the contrary, low frequency words were easier to learn than high frequency words when ESL participants needed to understand the meaning of low frequency words. Background knowledge (taking classes with English language emphasis) of technical/scientific text may impact ESL adults' ability to read and comprehend low frequency words Un-simplified text with nouns was easy to understand, whereas un-simplified text with verbs and adjectives was difficult	None Identified	Determine: If ESL flight crewmembers use metacognitive strategies to read words that do not occur frequently in scientific/technical text, and if their performance was negatively impacted. If ESL flight crewmembers identify nouns, verbs, or adjectives in un-simplified text as easy or difficult to read on crew alerting systems and QRH checklists. If ESL flight crewmembers English language proficiency and background knowledge has an effect on how they read and understand written English language with low frequency words emphasis.

Table 127 Literature Review Studies Compilation Continued

Chapter/Section	Main Concepts	Shortcomings (factors not covered in studies)	Researcher Approach in Studies
3.2 Carrell (2011)	ESL adults text familiarity has impact on reading comprehension Lexical Inferencing is utilized to read and comprehend procedure text ESL adults with intermediate and advanced level of English language proficiency read and comprehend procedure text well.	None Identified	Determine: If ESL flight crewmembers English language Proficiency is impacted with use of instructional text ('to do lists') with technical vocabulary Determine: If background knowledge is a factor that impact ESL flight crewmembers ability to read and understand text on crew alerting systems and QRH checklists.
3.2 Park (2010)	ESL adults from a western region (i.e. U.K.) that self rated their proficiency (adequate, fairly adequate and inadequate) English language proficiency used metacognitive strategies ESL adults with adequate English language proficiency used strategies more frequently to understand expository text with technical vocabulary. ESL adults that read expository text had difficulties understanding text structure	None Identified	Determine: If ESL adults that are from a western region of the globe perform well with expository text on crew alerting systems and QRH checklists Determine: If ESL adults' self-rated English language proficiency is a factor that influences their ability to read and comprehend expository text on crew alerting systems and QRH checklists
3.3 Yeh and Gentner (2005)	ESL adults with low English language proficiency levels are not efficient with reading comprehension of counterfactual statements ESL adults appear to be efficient with reading comprehension of factual conditionals. English as-a-second language adults' ability to detect conditionals accurately in texts is an indicator of how well they perform reading conditionals in texts	Non identified	Determine: If ESL flight crewmembers experience difficulties with conditional statements regarding ability to detect form and function on QRH checklists Determine: If ESL adults identify certain types of conditional statements more difficult to read than other conditional statements on QRH checklists (present counterfactual and present factual conditionals)
3.3 Saeidi et al (2013)	ESL adults with intermediate English language proficiency use background knowledge to read and understand enhanced text and unenhanced text. ESL adults with intermediate English language proficiency performance does not change when they read and comprehend enhanced conditional statements (past and future counterfactual conditional statements)	None Identified	Determine: If enhanced and/or unenhanced past and future counterfactuals impact ESL flight crewmembers reading comprehension of text on the QRH checklist Determine: If ESL flight crewmembers English language proficiency and background knowledge is a factor that influences their ability to read and comprehend enhanced or unenhanced text on QRH checklists Determine: If ESL flight crewmembers utilize metacognitive strategies to read and comprehend enhanced and/or unenhanced past and future counterfactuals on QRH checklists
3.4 Kim (2006)	ESL adult translation of written English language into their native language was a common metacognitive strategy utilized to understand abbreviations/acronyms, but led them to misinterpret the words.	Lack of discussion regarding text genre	Determine: If text genre is a factor that influences how acronyms are read and interpreted by ESL flight crewmembers on QRH checklists and crew alerting systems.

Table 128 Literature Review Studies Compilation Continued

Chapter/Section	Main Concepts	Shortcomings (factors not covered in studies)	Researcher Approach in Studies
3.4 Kim (2006)	Background knowledge of English language in a western region (U.S.A.) helps facilitate understanding of written English language. Low and high levels of English language proficiency are factors that influence how ESL adults interpret meaning of acronyms	Lack of discussion regarding text genre	Determine: If ESL flight crewmembers use metacognitive strategies (e.g. translating English language into their native language)
3.4 Larsen and Hansen (2010)	Longer length texts are difficult to read and comprehend by ESL adults with very good English language proficiency. Difficulties reading and comprehending text occurs when technical/scientific abbreviations are in technical/scientific text ESL adults that use metacognitive strategies to read text spend more time reading longer text with abbreviations, and negatively impact their performance.	None Identified	Determine: If background knowledge of English language helps facilitate understanding of English language on crew alerting systems and QRH checklists. Determine: If English language proficiency levels (e.g. low and high) impact ESL adult ability to read and comprehend written English language text on crew alerting systems and QRH checklists.
3.4 Park et al (2014)	ESL adult with very good English language proficiency and experience in a western region and background knowledge of technical text reading comprehension of acronyms are difficult. ESL adults use metacognitive strategies (e.g. predicting word meaning) to understand acronyms	None Identified	Determine: If abbreviations in technical/scientific text impact ESL flight crewmembers ability to read information on crew alerting systems and QRH checklists. Determine: If background knowledge in a western region (e.g. U.S.A.) influences ESL flight crewmembers ability to read and comprehend written English language. Determine: If ESL flight crewmembers time spent reading and comprehend written English language on crew alerting systems and QRH checklists is long or short to process information.
4.0 You (2009)	Adults with low English language proficiency did not perform well when text was unfamiliar to them; this was related to their reading comprehension performance when they read information on paper format and a computer screen. Adults with medium and high English language proficiency levels performed well when text was familiar to them in both formats (paper and screen) Participants performed better when they read written English language text from paper, than when they read from a computer screen. Adults performed better when they read text that was familiar to them, rather than reading unfamiliar texts. Adults utilized metacognitive strategies like re-reading and highlighting text when they read the texts in different formats.	None Identified	Determine: If ESL flight crewmembers English language proficiency is a factor that influences their ability to read written English language text on crew alerting systems Determine: If ESL flight crewmembers background knowledge of text (text familiarity) on computer screen is a factor that influences their ability to read and comprehend written English language. Determine: If ESL flight crewmembers use metacognitive strategies to read written English language text on crew alerting systems

Table 129 Literature Review Studies Compilation Continued

Chapter/Section	Main Concepts	Shortcomings (factors not covered in studies)	Researcher Approach in Studies
4.0 Anderson's (2003a)	ESL adults with intermediate to high level of English language proficiency use metacognitive reading strategies to read written English language on computer screens ESL adults with background knowledge of English language and background knowledge of written text use certain strategies more often (i.e. lexical inferencing, re-reading text) than other strategies (i.e. highlighting text and translating information back into native language) when reading information on a computer screen	None Identified	Determine: If ESL flight crewmembers use certain strategies to read written English language on crew alerting systems more often than other strategies Determine: If ESL flight crewmembers English language proficiency is a factor that influences their ability to read English language on crew alerting systems
5.0 Zhao (2015)	Translation of written English language into ESL adult native language has complexity and benefits associated with how an ESL adult reads and comprehends the translated language.	None Identified	Determine if translating written English language into ESL adult language impacts reading comprehension and thus performance.
5.0 Ynfiesta et al (2013)	ESL adult translator's insufficient background knowledge of written English language long form of acronyms, results in difficulties processing written English language acronyms into another language Results in misunderstandings of acronyms in text (e.g. technical vocabulary emphasis) that was translated into another language Expert knowledge is needed to effectively translate written English language words into another language so that the meaning of the word is not lost	None Identified	Determine: If ESL adult translator has background knowledge with translation processes, when translating acronyms on QRH checklists Determine: If ESL adults misunderstand words translated into another language on QRH checklists
5.0 Barani and Karimnia (2014)	ESL adult background knowledge in text translation is paramount ESL adult translator considered design of phrases, sentences, and vocabulary words in written English scientific text prior to translating their meanings into another language	None Identified	Determine: If ESL adult translator has background knowledge in text translation process and if the translator considers translation of vocabulary word meanings, phrases, and sentences on QRH checklists
5.0 Al-Sohbani and Muthanna (2013)	Highly proficient ESL adults were challenged reading written English language text translated into their native language. The primary issue was participants' lack of vocabulary background knowledge of the text they read. They indicated they did not have adequate knowledge of written English acronyms and abbreviations, and when acronyms and abbreviations were translated into their native language, they were difficult to read and understand.	None Identified	Determine: If highly proficient ESL flight crewmembers experience difficulties with translation process of written English language into another language, and if the translation process impacted their ability to understand word meaning Determine: If ESL flight crewmembers have adequate background knowledge in written English language text on QRH checklists translated into their native language
5.0 Alfadly and AldeibaniFull (2013)	Translation of written English language into another language led to verbose, and multiple meanings of words. ESL adults translated parts of words, which impacted the meaning of the sentence. Certain languages cannot be translated adequately, due to their orthographic nature (the way in which words are formed) in other cultures.	None Identified	Determine: If ESL adult translator considers multiple meanings of written English language words on a QRH checklist and how word meaning can be negatively impacted if translated improperly into another language Determine: If ESL flight crewmembers performance (temporal demand) is impacted due to translation of written English language into another language.