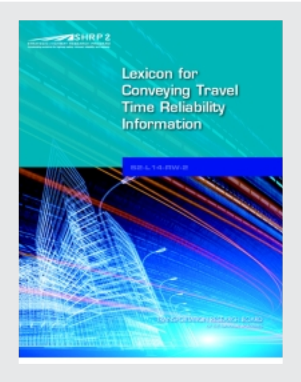

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SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
Accelerating solutions for highway safety, renewal, reliability, and capacity

Lexicon for Conveying Travel Time Reliability Information

S2-L14-RW-2

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

THE SECOND STRATEGIC HIGHWAY RESEARCH PROGRAM

Lexicon for Conveying Travel Time Reliability Information

SHRP 2 Report S2-L14-RW-2

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THE SECOND STRATEGIC HIGHWAY RESEARCH PROGRAM

America's highway system is critical to meeting the mobility and economic needs of local communities, regions, and the nation. Developments in research and technology—such as advanced materials, communications technology, new data collection technologies, and human factors science—offer a new opportunity to improve the safety and reliability of this important national resource. Breakthrough resolution of significant transportation problems, however, requires concentrated resources over a short time frame. Reflecting this need, the second Strategic Highway Research Program (SHRP 2) has an intense, large-scale focus, integrates multiple fields of research and technology, and is fundamentally different from the broad, mission-oriented, discipline-based research programs that have been the mainstay of the highway research industry for half a century.

The need for SHRP 2 was identified in TRB Special Report 260: Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life, published in 2001 and based on a study sponsored by Congress through the Transportation Equity Act for the 21st Century (TEA-21). SHRP 2, modeled after the first Strategic Highway Research Program, is a focused, time-constrained, management-driven program designed to complement existing highway research programs. SHRP 2 focuses on applied research in four areas: Safety, to prevent or reduce the severity of highway crashes by understanding driver behavior; Renewal, to address the aging infrastructure through rapid design and construction methods that cause minimal disruptions and produce lasting facilities; Reliability, to reduce congestion through incident reduction, management, response, and mitigation; and Capacity, to integrate mobility, economic, environmental, and community needs in the planning and designing of new transportation capacity.

SHRP 2 was authorized in August 2005 as part of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The program is managed by the Transportation Research Board (TRB) on behalf of the National Research Council (NRC). SHRP 2 is conducted under a memorandum of understanding among the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the National Academy of Sciences, parent organization of TRB and NRC. The program provides for competitive, merit-based selection of research contractors; independent research project oversight; and dissemination of research results.

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NOTICE

The project that is the subject of this report was a part of the second Strategic Highway Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical committee and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

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SHRP 2 STAFF

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The research reported on was performed by Texas A&M Transportation Institute, supported by Noblis, Inc., and Dudek & Associates. Beverly Kuhn, Texas A&M Transportation Institute, was the principal investigator with Susan Chrysler, University of Iowa, when she was with Texas A&M Transportation Institute. The other authors of the report are Laura Higgins, Alicia Nelson, Melisa Finley, and Gerald Ullman of Texas A&M Transportation Institute; Karl Wunderlich and Vaishali Shah of Noblis, Inc.; and Conrad Dudek of Dudek & Associates. The authors acknowledge contributions to this research from Katie Connell, Sarah Hammond, Brenda Manak, Kristine Miller, Lisa Minjares, Lisa Patke, Roma Stevens, Sandra Stone, Luann Theiss, Nada Trout, Brooke Ullman, and Christine Yager of Texas A&M Transportation Institute and from Jim Larkin of Noblis, Inc.

FOREWORD

Abdelmename Hedhli
SHRP 2 Visiting Professional, Reliability

Travel time reliability can be defined as consistency of travel time over time. The primary goal of SHRP 2 Reliability research is to improve the reliability of highway travel times by mitigating the effects of events that cause travel times to fluctuate unpredictably. Seven sources of unreliable travel times are now generally accepted: traffic incidents, work zones, demand fluctuations, special events, traffic control devices, weather, and inadequate base capacity.

A key component to addressing the reliability issue related to urban mobility is conveying reliability-related information to system users so that they can make informed decisions about their travel. The goal of the SHRP 2 L14 project, Effectiveness of Different Approaches to Disseminating Traveler Information on Travel Time Reliability, is to examine what combination of words, numbers, and other features of user information messages, along with communications methods and technology platforms, best communicate information about travel time and reliability to travelers so that they can make optimal travel choices from their point of view, such as whether to take a trip, departure time, mode choice, and route choice.

The lexicon is one of the main L14 project work products. It offers recommendations to system operators on appropriate ways to provide travel time reliability information to travelers so that the information is most likely to be understood and used by travelers to influence their travel choices.

On the basis of the results of human factors studies and current traffic engineering practices regarding communicating to drivers, recommendations were made in the lexicon for using the following terms related to travel time reliability: *95th percentile, arrival time, average travel time, buffer time, delay time, departure time, free-flow travel time, peak travel time, planning time, planning time index, recommended departure time, recommended route,* and *reliability.* There is also input from a literature review, expert interviews, and a technology and innovation scan done as part of the research project.

For each of the travel time reliability terms listed, the lexicon includes a technical travel time reliability term, the definition of the term or concept within the reliability framework, a description of when or for what purpose an agency might use the term, and recommendations for terminology, phrases, or graphics to be used, in order of preference. Finally, the lexicon identifies appropriate media and technology interfaces for each listed term, phrase, or graphic.

CONTENTS

EXECUTIVE SUMMARY

The second Strategic Highway Research Program (SHRP 2) Reliability Program aims to improve trip time reliability by reducing the frequency and effects of events that cause travel times to fluctuate unpredictably. Congestion caused by unreliable, or non-recurring, events is roughly as extensive as congestion caused by routine bottlenecks (Cambridge Systematics, Inc. 2003). Nonrecurring events such as crashes, work zones, special events, and weather disrupt normal traffic flow by causing reduced speeds, lane closures, and erratic driving maneuvers. The goals of the SHRP 2 Reliability focus on travel time variation—the characteristic of the transportation system that can cause a driver's trip to take much longer than normally expected. For example, a driver must allow an hour to make a trip that normally takes 30 minutes. This transportation system characteristic is important for travelers and shippers and is a component of the congestion problem in which transportation agencies can make significant and measurable gains even as travel demand grows. Reducing delays related to reliability has the added benefit of reducing primary and secondary crashes, vehicle emissions, and fuel use, as well as other benefits.

Travel time reliability information includes cumulative data about traffic speeds and trip times that take into account historical variations from day to day and enable individuals to understand the level of variation in traffic. Unlike real-time travel time information, which provides a current or recent snapshot of trip conditions and travel time, reliability information can be used to plan and budget in advance for a trip. Three points at which travelers might want to access travel time reliability information include the following:

- Trip planning for habitual trips, such as commutes, when new to an area;
- Pre-trip planning immediately before departure, to make decisions about departure time or mode on the basis of real-time and historical travel time trends, or both; and
- En route before a route or mode choice point (again to make decisions on the basis of both real-time and historical information regarding particular routes at particular times of the day).

A key component in addressing the reliability issue related to urban mobility is conveying reliability-related information to system users so they can make informed decisions about their travel. The challenge for transportation professionals lies in selecting the best means of conveying that information so it is usable and effective. This project developed a lexicon to provide information on appropriate ways to introduce and provide travel time reliability information to travelers so that the information is most likely to be understood and used by the travelers to influence their travel choices, while not presenting a safety hazard in the process. The lexicon is based on the results of a series of human factors experiments, with input from a literature review, expert interviews, and a technology and innovation scan done as part of the research project.

COMMUNICATING TRAVEL TIME RELIABILITY: HUMAN FACTORS STUDIES

Cognitive science has demonstrated that most people are not good at understanding statistical concepts, on which reliability information is based. Similarly, the human factors studies conducted for this project found that several terms that are commonly used within the transportation field to describe travel time reliability concepts are not well understood by drivers, such as *95th percentile travel time*, *buffer index* or *buffer time*, and *average travel time*. The following is a summary of results for travel time reliability terms that were tested in the human factors studies:

- *95th percentile travel time*: The tested phrase that seemed to best communicate this concept to study participants was *the majority of the time your trip will take XX minutes or less*. Other phrases that were tested included *most of the time your trip will take XX minutes or less*, *95th percentile trip time*, and *travel time for planning*.
- *Arrival time*: The phrase that most participants chose to designate a preferred arrival time (which they would input into a trip planning system) was *arrive by*. Other options tested included *arrive at*, *What time do you want to get there?*, *What's the earliest you can arrive?*, and *What's the latest you can arrive?*
- *Average travel time*: The tested phrase that was preferred by most study participants was *estimated travel time*. Other phrases tested included *average travel time*, *expected travel time*, *typical travel time*, and *historical travel time*.
- *Buffer time*: For this concept, *extra time* was preferred by the most participants in the computer survey, followed by *departure window*. In the open-ended survey, *recommended cushion*, *added time,* and *extra time* all performed well. *Buffer time*

was preferred by the fewest number of participants in the computer survey and so was not tested in the open-ended survey.

- *Departure time*: Among participants in the computer survey, the top three choices for a time that a driver would input into a trip planning system to indicate the preferred time to begin a trip were *departing at*, *leave at*, and *What time will you start your trip?* Other terms tested included *leave by*, *departing by*, *What's the earliest you can start your trip?*, and *What's the latest you can start your trip?*
- *Recommended departure time*: The phrase that most participants preferred for a departure time recommended to them by a trip planning system (on the basis of an input arrival time) was *recommended departure time*, followed by *suggested departure time* and *estimated departure time*; *95th percentile departure time* was the least preferred.
- *Recommended route*: From the terms tested in the computer survey to describe a route provided to a traveler by a traveler information system, participants most frequently preferred *best route*, followed by *forecasted trip* and *most reliable trip*. Other terms tested included *most predictable trip*, *most consistent trip*, *historical trip conditions*, and *least variable time*. Although the term *recommended route* was not tested, its similarity to terms like *recommended departure time* and *recommended cushion* indicates that *recommended route* may also be a strong candidate.
- *Reliability*: Participants viewed the terms *predictable*, *reliable*, *consistent*, and *best* similarly when those terms were used to describe trips. When asked to fill in the sentence "Your trip time may ______ from the average trip time by 15 minutes," participants preferred the term *vary* much more often than the other tested options (*differ*, *fluctuate*, *change*, *go up or down*, *increase or decrease*, *deviate*, and *be longer or shorter*).

DEVELOPMENT OF THE TRAVEL TIME RELIABILITY LEXICON

The goals for establishing a lexicon to convey travel time reliability information were the following:

- Communicate a useful message.
- Improve on-time performance.
- Encourage trust in the message.
- Communicate the "riskiness" of a route.
- Distinguish travel time reliability from real-time traveler information.

On the basis of the results of the human factors studies as well as current traffic engineering practices regarding communication to drivers, recommendations were made in the lexicon for the use of specific terms related to travel time reliability concepts. Each lexicon entry includes a technical travel time reliability term, the definition of the term or concept within the reliability framework, a description of when or for what purpose an agency might use the term, and recommendations for terminology, phrases, or graphics to be used, in order of preference. In some cases, alternate terms or phrases suitable for selected technology platforms are also provided. Finally, the lexicon entries identify appropriate media and technology interfaces for each listed term, phrase, or graphic.

LIMITATIONS OF LEXICON INFORMATION

Note that the studies conducted in this project were performed in a laboratory setting, and none of the terms were tested in a field environment. Only in a field test with specific, detailed travel behavior data can researchers determine the true effects and benefits of the use of travel time reliability information on behavior and resulting trip performance. Also note that nowhere in the various human factors studies were the specific phrases tested as being displayed on a dynamic message sign (DMS) and as en route information. Those phrases suggested for display on DMSs were developed by the research team on the basis of the results discussed for the related terminologies. The team developed the phrases using the general guidance for DMS message development provided in the *Manual on Uniform Traffic Control Devices* (MUTCD). Note that the formatting of these travel time reliability messages is very different from the standard messages state transportation agencies use on DMSs. For many of the travel time reliability terms, their use on a DMS would present various challenges to the traveler, including the following:

- Drivers are conditioned to see real-time travel information displayed on DMSs on freeway corridors, and reliability information may confuse them when placed on a DMS.
- Any reliability information displayed on a DMS would need to be relative to the specific location of the sign on the freeway facility, as drivers would have begun their trips from various locations in the region's transportation network.
- Messages providing departure time or buffer time information are not appropriate for DMSs because travelers would need to see the messages before starting their trip, not en route.

1 INTRODUCTION

The second Strategic Highway Research Program (SHRP 2) Reliability Program aims to improve trip time reliability by reducing the frequency and effects of events that cause travel times to fluctuate in an unpredictable manner. As the SHRP 2 Reliability Program points out, congestion caused by unreliable, or nonrecurring, events is roughly as large as congestion caused by routine bottlenecks (Cambridge Systematics, Inc. 2003). Nonrecurring events such as crashes, work zones, special events, and weather disrupt normal traffic flow by causing reduced speeds, lane closures, and erratic driving maneuvers. The goals of the SHRP 2 Reliability Program focus on travel time variation—that characteristic of the transportation system that means the driver's current trip will take longer than normally expected. For example, a driver must allow an hour to make a trip that normally takes 30 minutes. This transportation system characteristic is important for travelers and shippers and is a component of the congestion problem in which transportation agencies can make significant and measurable safety and traffic operational improvements, even as travel demand grows. Reducing delay related to reliability has the added benefit of reducing primary and secondary crashes, vehicle emissions, and fuel use, and yields other benefits.

TRAVEL TIME RELIABILITY INFORMATION

Travel time reliability information either conveyed to travelers or used by the transportation profession is based on data about trip times that capture historical variations from day to day and that enable individuals to understand the level of variation in travel times. Unlike real-time travel time information, which provides a current snapshot of trip conditions and travel time, reliability information can be used to plan and budget in advance for a trip.

A key component in addressing the reliability issue related to urban mobility is conveying reliability-related information to system users so they can make informed decisions about their travel. The challenge for transportation professionals lies in selecting the best means of conveying that information so it is usable and effective. The goal of this research project was to examine what combination of words, numbers, and other features of messages for road users, along with communications methods and technology platforms, best communicates information about travel time and reliability to travelers so that they can make optimal travel choices from their own point of view. Such choices include whether to take a trip, departure time, mode choice, and route choice.

Past research related to travel time reliability has, for the most part, examined how people use their own experience to judge travel time reliability with regard to route choice or time of departure. Researchers have not specifically examined when people prefer to have this information or how they will use it. Many stated preference surveys allow users unlimited time to consider all of the possibilities. In an unpressured situation, the message content and display are not as critical as they would be in a time-pressured situation immediately before departure or actually en route in the vehicle. Thus, message content and display—that is, the optimal display, sequence of inputs required, and display of search results—were the main focus of this project.

Logically, the trip-making process includes three points at which users would want to access travel time reliability information:

- *Trip planning for habitual trips when new to an area.* When people move to a new area or start a new job, they must find the best mode, time of departure, and route for their commute. This can be accomplished by talking with neighbors and colleagues, trying different times if their work schedule allows, and trying different routes. Once the decision is made, the trip becomes routine. Users may find travel time reliability information helpful at this point to make direct comparisons across modes, routes, and times. System users would most likely seek out this information through an Internet source outside of the vehicle under no particular time pressure. The user may desire maps and tables as outputs and may wish to input two distinct scenarios and directly compare the results. In essence, the user would use the travel time reliability information in a series of what-if scenarios and weigh the potential travel time savings against the volatility in that travel time. This type of use may require a rich user interface with many input options, including specific origin-destination pairs. An analogous situation would be using a service like MapQuest to get door-to-door driving directions with specific addresses.
- *Pre-trip planning immediately before departure.* Many users may want to check traffic or check how transit is running just before they depart. They may do this by visiting a traffic management center (TMC) website, consulting a smartphone or navigation system that includes real-time traffic information, or listening to a traffic advisory radio or television broadcast. This information is sought immediately before beginning the trip (i.e., not while driving, particularly if the weather is less than ideal). These users may be able to delay their departure time, choose a

known alternate route, or choose to take the bus rather than the train. For these purposes, users may want a subscription system into which they have entered their origin-destination or typical route information once; then the system is able to show them the travel time information specifically for their route. The display can be simple text or a color-coded travel time system map common on many TMC websites. These users are not necessarily looking for the best route. Rather, they more likely want to change their mode or departure time to avoid congested conditions and incidents. The ability to compare historical information for these alternatives could be helpful in this type of decision making.

- *En route before a route or mode choice point.* Some users may use these same sources—TMC website, smartphone, global positioning system (GPS), or radio report—to seek information en route before a major interchange or key decision point along their route. Because travel time reliability shifts throughout the day depending on traffic volume variations and when incidents occur, these users may want to know reliability associated with current conditions. For instance, route A may be the shortest mileage and trip time under level of service A; but when conditions deteriorate because of traffic volume or an incident, reliability suffers and route B (though longer in distance) may have a more reliable trip time. For these users, en route information becomes useful because people cannot remember a whole set of values, such as when the travel time is 20 min on route A, the variability is ±5 min; but when travel time is 40 min, the variability is ±15 min. Likewise, with mode shifts, users may use travel time reliability information to prompt the decision to divert to a park-and-ride lot and take transit. These users may not want to risk being caught in traffic for a long period of time and prefer to ride the bus or train during congested conditions.

Travel time reliability information delivered en route must take a different form because of safety concerns of distracted driving. Research has shown that displays that have been designed and tested with users sitting in front of a computer screen with their full attention devoted to the task will not fare well in a moving vehicle. The safety concerns of requiring long eyes-off-the-road glances to displays are considerable. Although designing in-vehicle and portable device displays was beyond the scope of this project, determining the key elements that should be present was part of the scope. Automotive suppliers and smartphone manufacturers can include the information contained in this report in systems that are already used to display travel time in-vehicle. Some systems use auditory messages as another way of presenting this information in-vehicle. As communications technology continues to improve, it will continue to create new avenues for disseminating travel information to system users.

Users' diverse needs for reliability information, the times at which users may want that information, and the broad range of communications media and information formats already in the marketplace and on the horizon present a challenge for the transportation profession set on conveying travel time reliability. Consequently, this project sought to answer the critical questions of *what*, *when*, and *how* to deliver travel time reliability information.

SCOPE AND PURPOSE OF LEXICON

This project developed a lexicon to provide information on appropriate ways to introduce and provide travel time reliability information to travelers so that such information is most likely to be understood and used by the travelers to influence their travel choices, while not presenting a safety hazard in the process. This document is based on the results of a series of human factors experiments, with input from a literature review, expert interviews, and a technology and innovation scan done as part of the research project.

GOALS OF PROVIDING TRAVEL TIME RELIABILITY

The challenge in conveying travel time reliability information to users is ensuring that they understand the message. Without this fundamental understanding, the message is lost. Thus, any agency considering the establishment of a program for communicating travel time reliability information should be aware of the challenges of conveying the information and the importance of understanding the goals of providing that information.

Cognitive science has shown that most people are not good at understanding statistical concepts (e.g., percentages, proportions, ratios, probabilities) and applying them to everyday situations, such as medical diagnoses, gambling odds, and variability in stochastic processes such as traffic (Gal 2002). Statistical literacy is related to overall aptitude with numbers, literacy, and cultural components. Research has shown significant cultural differences in understanding statistical concepts, and those related to risk in particular (Wright et al. 1978).

A medical diagnosis or a decision about possible courses of treatment usually involves probabilistic data—the probability that a test result is accurate and the likelihood of various outcomes of a treatment. In a 2003 article for the *British Medical Journal*, several techniques were recommended for helping patients understand the risks and benefits associated with medical treatments:

- Avoid the use of purely descriptive terms and supplement qualitative language with numbers.
- Use a consistent denominator or numerical scale.
- Provide both positive and negative outcomes (e.g., a 3% chance of a negative outcome and a 97% chance of a positive outcome).
- Express probabilities as absolute numbers (75% of cases have outcome A, 25% have outcome B) rather than in relative terms (three times as many cases have outcome A as have outcome B).
- Use visual aids such as pie charts and graphs to illustrate probabilities (Paling 2003).

Studies examining doctors' and patients' comprehension of probability-based information have found that many people understand frequencies (e.g., 19 out of 20) better than percentages or proportions (95% or 0.95). Presenting probabilities related to cancer screenings as a set of frequencies rather than as a set of percentages resulted in quicker and more accurate comprehension of those probabilities by study participants, particularly if several probabilities had to be considered in tandem (Hanoch 2004).

People presented with quantitative health risk information in pictograph formats perceived the information more accurately when it was presented in one compound graph (in which the proportions or percentages of the potential outcomes add up to 100%) than if the same information was presented as two side-by-side graphs (Price et al. 2007).

Thus, presenting information that has a mathematical foundation can be a challenge in any field. With respect to travel time reliability information, the goals listed in the following subsections—which are also presented in Table 1.1 in no particular order—are the high-level goals for providing travel time reliability information that served as the guiding force of this lexicon.

TABLE 1.1 GOALS AND OBJECTIVES FOR PROVIDING TRAVEL TIME RELIABILITY INFORMATION

	Objectives					
Goals	Use Familiar Concepts	Use Familiar Terminology	Communicate the Buffer Time Needed	Assist in Departure Time and Route Decision Making	Consider How Information Needs Vary for Familiar and Unfamiliar Travelers	Consider How Information Needs Vary for Pre-Trip and En Route Decision Making
Communicate a useful message	X	X			X	X
Improve on-time performance			X	X	X	X
Encourage trust in the message	X	X	X			
Communicate the riskiness of a route		X	X	X	X	
Distinguish travel time reliability from real-time traveler information				X	X	X

Communicate a Useful Message

A travel time reliability message should relay information that a motorist can use to decide what is the best time to depart for a trip or which is the best route to take based on driving experience and preference for shortest route, shortest drive time, or most dependable route on the basis of that message.

Improve On-Time Performance

The use of travel time reliability information by a system user should result in an on-time arrival at the intended destination for the selected departure time and route. Over time, the regular use of this information would decrease the number of times a motorist arrives late for a variety of trips.

Encourage Trust in the Message

A message can be easily understood and provide useful information. However, if a motorist does not trust the information, it is not valuable to him/her personally. Particular words and phrases can instill more confidence in the information conveyed. For example, because of its ambiguity, "The trip could possibly take 55 minutes" might instill less confidence than "The average trip time is 55 minutes."

Communicate the Riskiness of a Route

The purpose of travel time reliability is to communicate the riskiness or variability in travel time of a particular route and, more specifically, of a particular route at a particular time of day. Special care must be taken in communicating a message that describes the likelihood that the estimated travel time for a particular trip or trip segment will be dependable.

Distinguish Travel Time Reliability from Real-Time Traveler Information

Real-time travel time messages have been in use in the United States for well over a decade, ever since traffic monitoring and integration systems became reliable. As a result, travelers have become accustomed to seeing this type of information, primarily on DMSs and transportation agency websites, but also with the widespread use of cell phones and other mobile devices. Real-time travel time estimates are most often provided for a particular roadway segment or a particular transit route and are based on recent travel speeds or conditions; historical information may or may not be incorporated into the estimates, and travelers may or may not know if that is the case. Therefore, transportation agencies and other providers need to emphasize that the times reported in a travel time reliability message are based on historical information and not on real-time information.

OBJECTIVES OF PROVIDING TRAVEL TIME RELIABILITY

Once a transportation agency identifies specific goals for conveying travel time reliability information, it can further refine those goals by selecting related objectives. In general, objectives present more specific targets for an agency to attain related to reliability and driver behavior in response to reliability information. The objectives for providing travel time reliability information that can help an agency meet the goals listed above are described in the following subsections. Table 1.1 shows how these objectives are matched to specific goals.

Use Familiar Concepts

Communicating probabilities or risks using only qualitative language can lead to misunderstandings, simply because the reader (or listener) may ascribe a different meaning to a descriptive word than was intended. The English language has a multitude of terms for concepts of uncertainty and risk, but attempts to systematically map them to numerical probabilities have failed (Teigen 1988). Research has shown that people switch between numerical quantitative (e.g., 50-50 chance) and verbal qualitative (e.g., probably) concepts in unpredictable ways controlled more by grammar than by probability values (Wallsten et al. 1993). In one study, tests of various probability terms (e.g., *certainly*, *definitely*, *possibly*, *probably*, *rarely*) with adolescents and young adults indicated that individual definitions of the terms were not consistent enough to convey information effectively to the general public. Absolute numbers, such as percentages or percentage ranges, were recommended instead of qualitative language (Biehl and Halpern-Felsher 2001).

Use Familiar Terminology

Some suggestions and recommendations for communicating risk and probability to the public come from two nontransportation fields: weather forecasting and medicine. Although most people are familiar with weather forecasts on television and in other media, the probabilities used in those forecasts (e.g., 20% chance of rain) are not widely understood. In a study comparing several weather report formats, 43% of participants correctly interpreted a weather forecast that included symbolic icons depicting a weather condition (such as rain) and graphs showing the percent likelihood of that condition. When forecast information included graphs that showed the chance of rain *and* the chance of no rain, the number of participants correctly understanding the forecast rose to 52% (Schwartz 2009). An experiment conducted with university students in the United Kingdom found that participants who were given a graph of forecast temperatures that included information about the probability, or uncertainty, of those temperatures answered questions about the forecast more accurately than the participants who were given the temperature graph by itself (BBC News 2007). Use of unfamiliar terminology in a message displayed on a DMS results in longer reading times and motorists' inability to read the entire message before passing the DMS (Dudek 2004).

Communicate the Buffer Time Needed

The buffer time, or extra time travelers need to allow for unexpected traffic congestion or incidents, should be communicated in a travel time reliability message either directly or by providing information such as an average and a worst-case time that a traveler can use to calculate a buffer time.

Assist in Departure Time and Route Decision Making

Messages should be anchored to a time of day to be the most useful and help drivers determine when they want to leave for a trip. Furthermore, the information should help travelers identify the best route to help ensure on-time arrival.

Consider How Information Needs Vary for Familiar and Unfamiliar Travelers

Unfamiliar drivers may require more information than familiar drivers, and information intended for familiar drivers can be briefer. Also, the benefits of reliability information will decline over time as travelers learn and internalize an understanding of underlying travel time variability for their selected routes and departure times as well as for the transportation network as a whole.

Consider How Information Needs Vary for Pre-Trip and En Route Decision Making

Provisions need to be made to provide travel time reliability information in a safe manner when the motorist is en route. The potential for technology-based distractions in the vehicle is a serious and timely issue, so providers must take heed when developing new information interfaces and information content. Further research is needed to identify the most appropriate method for conveying this information without compromising safety.

ORGANIZATION OF LEXICON REPORT

There are five chapters, including this introductory chapter. Chapter 2 discusses the concept of travel time reliability and the role it plays in travel behavior and system operations and performance along with key messages typically conveyed within the transportation community regarding travel time reliability. Chapter 3 provides a list and definitions of relevant travel time reliability terms that can be used by agencies and other stakeholders to convey key information to system users. Chapter 4 presents the lexicon of relevant travel time reliability terms and provides a matrix of information formats and technology platforms in which the terms can be displayed to enhance comprehension by system users. Chapter 5 provides final remarks and future directions for research on the conveyance of travel time reliability information.

2 CONCEPT OF TRAVEL TIME RELIABILITY

In the many cities where congestion on the transportation system is commonplace, drivers are accustomed to congestion and expect and plan for some increase in travel time, particularly during peak driving times. Many system users either adjust their schedules to avoid peak hours or budget extra time to allow for unexpected traffic congestion or incidents. However, problems arise when travel times are much higher than anticipated. Most travelers are less tolerant of unexpected travel time increases because those longer travel times cause travelers to be late for work or important meetings, to miss appointments, or to incur extra child-care fees. Moreover, shippers who face unexpected delays may lose money, experience disruptions in just-in-time delivery and manufacturing processes, and lose their competitive edge (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006). Thus, transportation agencies should have a good grasp of those factors that affect travel time reliability and how travelers react to that variability; they must understand how information can be used by travelers to accommodate variability in their travel behavior.

CONTEXT

Transportation professionals most commonly discuss travel time reliability in terms of historical average travel times calculated over periods of a year or longer, as illustrated in Figure 2.1. A typical definition for travel time reliability is this:

> The consistency or dependability in travel times, as measured from day to day and/or across different times of the day.

However, most travelers do not experience the same average travel time each day. As shown in Figure 2.2, travelers experience and remember something much different than the average throughout a year of commutes. Their travel times vary greatly from day to day, and they remember those few bad days they suffered through unexpectedly longer travel times. Research within the profession has shown that travel time reliability information can provide transportation system users with a more complete picture of the expected travel time along a particular route. The challenge is how to communicate that reliability information effectively to system users so that they understand it clearly.

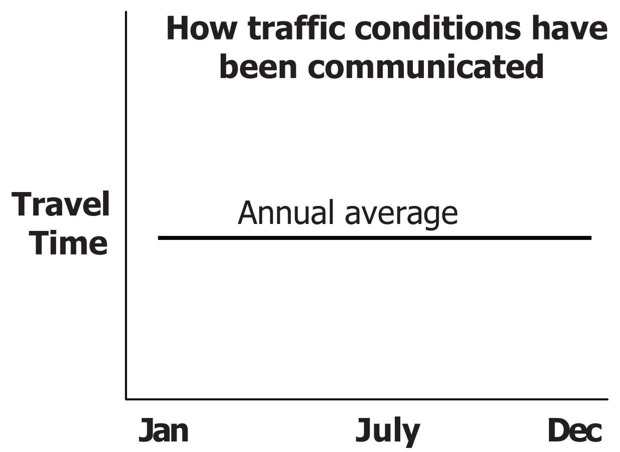


Figure 2.1. *Average travel time used by professionals.*
Source: Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006.

Figure 2.2. *Travelers' travel time experiences.*
Source: Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006.

TRAVELER INFORMATION NEEDS

Travel time reliability information for travelers can be interpreted through two distinct lenses: (1) information on historical travel time variability of a specific trip, and (2) the reliability of traveler information (e.g., How reliable is the message “expect delays” or “20 minutes to downtown”?). For the first interpretation, one use of reliability information is to help users determine an appropriate departure time and route based on a traveler’s risk acceptability for late arrivals. For example, a traveler may budget 75 min for a trip to the airport because he or she has been informed that historically the average travel time to the airport on a rainy Friday afternoon is 45 min, but the 95th percentile travel time is 70 min. For the second interpretation, the traveler—while driving to the airport—may be informed that the travel time is between 40 min and 50 min with a 10% probability that the trip will take more than 50 min given current traffic conditions. This example is one of many metrics through which trip reliability can be delivered to the traveler.

Travelers require information for three main purposes: to identify travel options (e.g., mode, route, timing, and destination), to assess characteristics of alternatives (e.g., the times of different options), and to complete a trip successfully. Travel time reliability information will aid in the latter two purposes; demand for specific reliability information will depend on the travel context and user characteristics. In reality, most people, most of the time, do not consult travel information because the majority of trips are familiar and local, have minimal day-to-day variability, and are of a nature that does not necessitate a stringent on-time arrival (Peirce and Lappin 2004).

For the trips when travelers are not fully familiar with the road network and have less knowledge of day-to-day variability, travel time reliability information will prove valuable. For example, when planning a trip to a new client, a motorist might benefit from knowing that the reliability of travel on a major arterial is far greater than the freeways on Friday mornings; and though that route might take a few more minutes, it would reduce the risk of a late arrival. This example demonstrates the value of situational reliability information—reliability for a roadway or trip based on factors such as time of day, day of week, weather conditions, and other considerations (e.g., major sporting events or holiday travel).

Travel time reliability information can be tailored to encompass driver characteristics as well—perhaps offering data on ranges of likely travel time that reflect differences in outcomes for a traveler whose driving style is to go with the flow compared with one who prefers to lead. Travel time reliability data can also be valuable for traveler information systems that provide information based on levels of user tolerance for travel time variability. The system might use reliability data in the system database to provide the route with the greatest likelihood of arriving on time.

TRAVEL TIME RELIABILITY AND HIGHWAY TRAVEL

Travel time reliability information is valuable to transportation agencies because it better quantifies the benefits of traffic management and operation activities than simple averages. For example, consider a typical before-and-after study that attempts to quantify the benefits of an incident management or ramp metering program. The improvement in average travel time may appear to be modest, as shown on the left side of Figure 2.3. However, reliability measures will show a much greater improvement—as illustrated on the right side of Figure 2.3—because they show the effect of improving the worst few days of unexpected delay.

For drivers, travel time reliability information can be valuable when they are selecting a route. For example, the value of travel time reliability was assessed through a mail survey, trip diaries, and loop-detector data (Lam and Small 2001) soon after the first high-occupancy/toll (HOT) lane opened on State Route 91 in Riverside, California. The researchers found that, for women in this study, the value of travel time reliability was actually higher than simple travel time information. For men, the value of travel time was roughly 50% higher than the value of reliability information. The reasons for this difference were not clear from the data collected, though some have interpreted the data to indicate that women have more time critical commitments related to child-care trips. For this study, the researchers defined travel time as the 90th percentile travel time minus the median. The authors discuss further how the transponder usage records of participants show that few drivers habitually used the HOT lane. Rather, people made the decision whether to pay for the HOT lane on a daily basis depending on trip purpose and traffic conditions.

In applications such as HOT lanes, travel time reliability information may be most useful en route to help drivers make the purchase decision to use the HOT lanes. The influence of pre-trip and en route travel information on route decisions has been

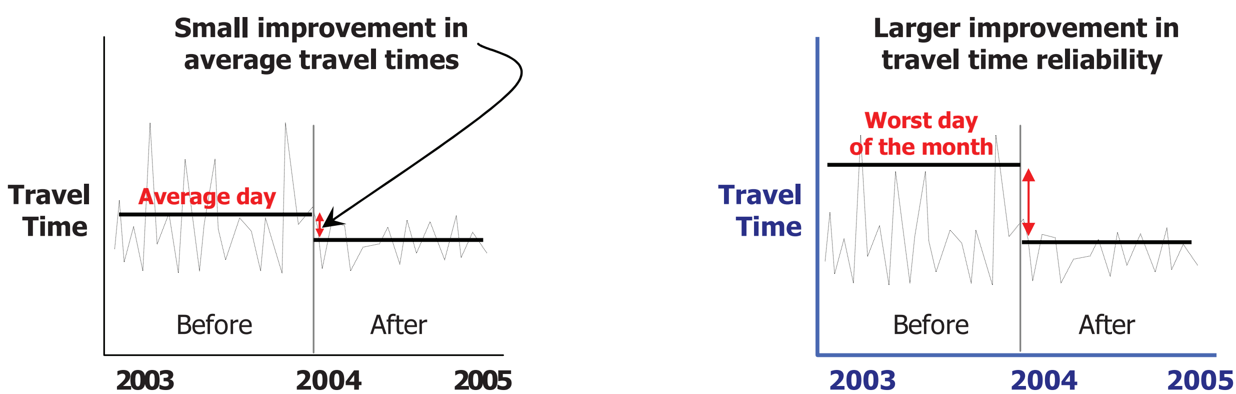


Figure 2.3. *Reliability measures capture the benefits of traffic management.*
Source: Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006.

demonstrated in other studies: An evaluation of the Washington State DOT's 511 travel information system in 2005 found that 21% of respondents changed their original travel plans on the basis of information they got from the 511 system (PRR, Inc. 2005). Drivers on an Orlando, Florida, toll road who stated that they used information from the state's 511 service or from DMSs (which displayed estimated delay times for the road) were more likely to change their route in response to unexpected congestion.

A review of research on travel time and travel time reliability conducted by the Center of Urban Transportation Research (University of South Florida) includes the finding that most travelers value trip time reliability at least as much as actual trip time. In fact, when travelers' arrival and departure times were inflexible because of the nature of the trip, the value of reliability was as much as three times that of trip time (Concas and Kolpakov 2009).

TRAVEL TIME RELIABILITY AND TRANSIT

Studies of transit ridership have shown that trip time reliability (including the reliability of a rider's wait time at transit stops) is more important to retaining riders than the trip and waiting times. Wait-time reliability is particularly important, as transit riders tend to perceive time spent waiting for a transit vehicle as being longer than an equivalent amount of time spent riding in the vehicle. Real-time information that allows transit riders to schedule their own arrival at a transit stop and/or to monitor the wait time remaining until the vehicle's arrival increases rider confidence in the service (Perk et al. 2008). Transit passengers surveyed in two cities ranked knowledge of when their bus would arrive and knowledge that it would arrive on time as the two most important factors affecting their decision to ride transit (Peng et al. 2002).

TRAVEL TIME RELIABILITY AND FREIGHT

In terms of economic value, reliability is probably more important to freight carriers and shippers than to personal travelers. With the rise in just-in-time deliveries (largely as a replacement for extensive warehousing), providing dependable (reliable) service has become extremely valuable, while failure to provide dependable service can increase costs considerably (Cambridge Systematics, Inc. 2007). For example, improvements in transportation reliability play an important role in reducing inventory in the chemical supply chain for freight shippers. Because of the many nodes in the supply chain, upwards of one-third of all chemical inventory is in transit at any point in time. Inventory managers keep safety or buffer supplies to cushion against variability of inbound arrivals, and the amount of safety supplies increases with the degree of unreliability and the number of stocking locations (Cambridge Systematics, Inc. 2007). However, the capacity to receive chemical supplies is limited by the size of the liquid storage silos. Balancing capacity with demand is a challenge. As transportation reliability decreases, wait time, dead freight, and cost increase (Cambridge Systematics, Inc. 2006).

TRAVELER INFORMATION: STATE OF THE PRACTICE

To date, the primary travel time information conveyed to travelers, either pre-trip or en route, is real-time information. Real-time travel time messages have been in use in the United States for well over a decade, ever since traffic monitoring and integration systems became reliable. The most commonly used media for these messages are DMSs and transportation agency websites; but the widespread use of cell phones and other mobile devices is prompting a growing number of transportation agencies and providers to offer real-time updates on transportation conditions and options via e-mails, text messages, and Twitter feeds.

Real-time travel time estimates are most often provided for a particular roadway segment or a particular transit route on the basis of recent travel speeds or conditions. Some agencies also provide travel time comparisons among two or more routes or roadways to help travelers make decisions about the route or transportation mode to take. Most recent and most rare are the information sources that advise travelers about travel time reliability—that is, the likelihood that the estimated travel time for a particular trip or trip segment can be relied on. This section describes some of the real-time travel information messages that are being provided to travelers on DMSs, on websites, and via mobile devices, as well as some of the lessons learned about providing travel information.

Dynamic Message Signs

Past surveys of state and local agencies have found that incident reports were the most common form of real-time traffic information provided to travelers in large metropolitan areas in the United States, followed by travel times and then travel speeds (U.S. Government Accountability Office 2009). When provided, real-time travel time messaging tends to be most effective on a road on which travel times are likely to change with reasonable frequency. If travel times are too static, drivers tend to view the messages as static rather than dynamic and therefore less credible (Meehan 2005). This “freshness factor” may hold true for travel time reliability information as well. Some agencies such as Houston TranStar provide a time stamp to their travel time signs and web-based information to alert users to the time at which the information was provided.

Some agencies have started to show comparative travel times to certain destinations via different routes. The Washington State DOT recently installed new travel time signs at specific locations in the Seattle area to add information about travel time reliability along the two routes. Signs showing comparative travel time reliability information for general purpose and HOT lanes could prove useful to motorists making route decisions during a trip.

The presentation of travel time is not limited to highways and highway travel. The Wisconsin DOT provides highway travel times to specified destinations via the freeway on selected arterials before freeway entrance ramps to provide drivers with information to make route choices (Peng et al. 2004). A DMS pilot program in the San Francisco Bay Area provides travelers with both highway and Caltrain (transit) travel times to selected destinations, along with the arrival time of the next train (Mortazivi 2009).

Real-time bus and/or train arrival information is available in increasing numbers of U.S. cities, posted on DMS at transit centers and on transit websites. Some transit providers also provide real-time notifications about route delays and diversions. Real-time arrival signs tend to be viewed positively by transit customers. Customer surveys conducted by transit agencies in the United States and abroad found that real-time arrival information at transit stops made riders feel more confident, particularly at night, and even improved riders' overall perception of the quality of transit service provided (Schweiger 2003).

Travel Websites

Many TMCs and partner transportation agencies provide users with real-time (or recently calculated) travel information via websites. The format and features of these websites vary considerably. Some reproduce the travel time information displayed on DMSs in the region; others provide real-time travel information to online users by posting real-time photographs of the travel time DMSs, as well as color-coded highway maps showing road conditions (hazardous, patches of ice/snow, flooding), traffic flow, incident and construction locations and descriptions, and real-time camera views of highway locations (Tennessee Department of Transportation 2012; *Utah Commuter link* 2012). Others provide advance notification of future construction sites and expected future events (such as holiday travel) that are likely to affect roadway conditions and traffic speeds (*Traffic England* 2012).

Travel time reliability information is starting to make appearances on transportation websites. The Wisconsin DOT website provides a table of current and "normal" travel times for Milwaukee-area highways. Travel times that are 20% or more above normal are shown in bold print. The travel information website for the Gary–Chicago–Milwaukee corridor also displays a table of current and average travel times and traffic speeds for highways along the corridor (RoadStats, LLC 2012). The user can click on the average travel time number for each segment to view a graph detailing the most recently collected travel time, the average travel time for all historical data samples, and the normal range of travel time values by time period over a 24-hour period each day. The graph also includes three speed thresholds, indicating what the travel time would be for the segment with no traffic congestion (traffic moving at 55 mph or higher), with moderate traffic congestion (54 mph to 35 mph), and with heavy traffic congestion (35 mph to 15 mph).

The Washington State DOT recently added a feature to its travel time website that displays 95th percentile travel times (Washington State DOT 2012). A user enters an origin-destination pair from a drop-down menu containing names of suburbs, and the system displays a text message providing reliability information. The Driving Times feature on the San Francisco Bay Area's 511 website also allows users to enter the origin and destination of their driving trip; in return, the website generates multiple potential routes for the trip, displaying the current and typical/historical trip times for each route, along with a table of minimum, maximum, and average current traffic speeds (and typical historical speed) on each of the route's roadway segments. The site's Predict-a-Trip feature allows users to view the typical traffic speeds and travel times of the same route options for some future trip by inputting the day and time period (*511 SF Bay* 2012).

Many airlines now provide on-time performance histories for particular flights and times, which can be viewed by customers making online reservations. In addition, third-party websites compile information from multiple airlines and airports to provide estimates, or forecasts, about a flight's on-time performance. The FlightCaster Inc. website tracks both current delays and historical on-time performance for U.S. domestic flights to estimate a specific flight's departure time; six delay factors are also shown on the forecast, with color-coded icons to signal potential problems (*FlightCaster* 2012).

Route-by-route reliability information is generated by many transit systems for planning purposes but is only rarely provided as part of transit customer information. Rutgers University in New Jersey has posted similar information for its campus bus routes, including percentages for on-time, early, and late arrivals (Rutgers Department of Transportation 2012). More transit systems may follow, especially if traveler demand for this information grows.

E-Mails, Texts, Tweets: Mobile Device Messaging

In addition to accessing the California Department of Transportation (Caltrans) website for travel times in the Los Angeles area, motorists may also subscribe to a free service that sends the same information to their mobile device. Similarly, Houston TranStar offers free, personalized e-mail alerts to its system users about incidents and travel times on Houston-area freeways. The alerts can be sent to any device capable of receiving e-mail or text messages, including personal computers, mobile phones, personal digital assistants, and text pagers (Houston TranStar 2012). A similar messaging service is provided by the Regional Transportation Commission of Southern Nevada's Freeway and Arterial System of Transportation program (Regional Transportation Commission of Southern Nevada 2012). The Arkansas State Highway and Transportation Department has begun using Twitter to notify motorists about statewide highway conditions (Arkansas State Highway and Transportation Department 2012).

The Washington Metropolitan Area Transit Authority's (WMATA) MetroAlerts provide information on major Metrorail and Metrobus delays and service disruptions as well as Metrobus schedule changes and detours. The ELstat application notifies users of elevator availability in the Metrorail system. (Washington Metropolitan Area Transit Authority 2012). WMATA has also begun to broadcast alerts via Twitter. Real-time rail and bus arrival information are available on WMATA's website and through mobile device applications developed by third parties.

The Bay Area Rapid Transit system in San Francisco provides real-time service information to its passengers via its mobile website (for those with access to an Internet connection), via emailed and text-messaged service advisories, and, most recently, via Twitter updates (Rhodes 2009). Boston's T-Alerts provide the same service for passengers on Massachusetts Bay Transportation Authority buses and trains (Massachusetts Bay Transportation Authority 2012).

3 RELEVANT TRAVEL TIME RELIABILITY TERMS

The measurement of travel time reliability is an emerging practice. However, a few measures appear to have technical merit and are considered to be easily understood by nontechnical audiences. Most of these measures compare days with high travel times with days with average travel times. Four recommended measures are as follows:

- 90th or 95th percentile travel time;
- Buffer index;
- Planning time index; and
- Frequency with which congestion exceeds some expected threshold (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006).

FREQUENTLY USED TERMS

The 90th or 95th percentile travel time is a time identified for a specific travel route that indicates how bad the delay will be on the heaviest travel days (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006). These travel times, reported in minutes and seconds, were thought to be easily understood by commuters familiar with their trips. For this reason, this measure appears to be ideally suited for traveler information. This measure has the disadvantage of not being easily compared across trips, as most trips will have different lengths. Nor can it be easily used to combine route or trip travel times into a subarea or citywide average. Several reliability indices are presented below that enable comparisons or combinations of routes or trips with different lengths.

The buffer index represents the extra time cushion (or buffer) that most travelers add to their average travel time when planning trips to account for unforeseen delays and to ensure on-time arrival (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006). The buffer index is expressed as a percentage, and its value increases as reliability gets worse. For example, a buffer index of 40% means that for a 20-min average travel time, a traveler should budget an additional 8 min (20 min × 40% = 8 min) to ensure on-time arrival most of the time. In this example, the eight extra minutes is called the buffer time. The buffer index is computed as the difference between the 95th percentile travel time and average travel time, divided by the average travel time.

The planning time index represents the total travel time that a traveler should expect or plan on when an adequate buffer time is included (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006). The planning time index differs from the buffer index in that it includes typical delay as well as unexpected delay. Thus, the planning time index compares near-worst-case travel time to a travel time in light or free-flow traffic. For example, a planning time index of 1.60 means that for a 15-min trip in light traffic, the total time that should be planned for the trip is 24 min (15 min × 1.60 = 24 min). The planning time index is useful because it can be directly compared with the travel time index (a measure of average congestion) on similar numeric scales. The planning time index is computed as the 95th percentile travel time divided by the free-flow travel time.

From a data perspective, continuous travel time data is the only way to establish reliability patterns empirically. These data may be collected using infrastructure-based vehicle volume and speed detectors, as well as automatic vehicle location (AVL) and automatic vehicle identification (AVI) systems such as vehicle-based or cell-phone-based GPS and Bluetooth. More information on travel time data collection methods is detailed in the guidebook developed by the SHRP 2 L02 project, *Establishing Monitoring Programs for Travel Time Reliability* (Institute for Transportation Research and Education 2012). Although predictive methods—such as the ones being developed by the project team for the SHRP 2 L03 project *Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies* (Cambridge Systematics, Inc. 2007)—may be used in a reliability monitoring system when these data are unavailable, only continuously collected travel time data can produce the actual travel time distribution from which all reliability metrics are derived. For example, the reliability metrics being used in the SHRP 2 L03 project, as shown in Table 3.1, are all derivatives of the travel time distribution.

What is clear is the lack of agreement within the transportation profession on the terms to be used or what the mathematical calculations for each of the terms should be. If the professionals cannot reach consensus on the technical terms, then the general public certainly will not do so. The purpose of the L14 project was to discover what terms the layperson would use to refer to travel time reliability concepts and to encourage the use of those terms by transportation agencies in communications with transportation system users.

TABLE 3.1. RECOMMENDED RELIABILITY PERFORMANCE METRICS FROM SHRP 2 PROJECT L03

Reliability Performance Metric	Definition	Unit
Buffer index (BI), mean-based	The difference between the 95th percentile travel time and the average travel time, normalized by the average travel time	Percent
Buffer index, median-based	The difference between the 95th percentile travel time and the median travel time, normalized by the median travel time	Percent
Failure or on-time measures, median-based	Percentage of trips with travel times less than 1.1 × median travel time and/or 1.25 × median travel time	Percent
Failure or on-time measures, speed-based[a]	Percentage of trips with space mean speed less than 50, 45, and/or 30 mph)	Percent
Misery index (modified)	The average of the highest 5% of travel times divided by the free-flow travel time	None
Planning time indices	95th, 90th, and 80th percentile travel times divided by the free-flow travel time	None
Skew statistic	The ratio of (90th percentile travel time minus the median) to (the median minus the 10th percentile)	None

[a] *Speed* is the space mean speed over the study section.
Source: Cambridge Systematics, Inc. (2007).

TERMINOLOGY ASSESSMENT

The most basic considerations for trip reliability information relate to the points during a trip at which travel time reliability information should be provided, the content of the reliability information to be provided, and how content might differ as a trip is made by the traveler (i.e., pre-trip planning, departure from origin, in transit, arrival at ultimate destination). Another consideration is how reliability information needs differ among travelers: those with familiarity and experience with a recurrent trip compared with those who make a trip without the benefit of day-to-day experience of its reliability. Likewise, how might transmission media and message content differ according to the needs of different driver types and trip purposes (e.g., older drivers versus newer drivers, commercial vehicle operators versus carpool organizers)? Furthermore, what innovations can help providers efficiently meet these varying needs?

The literature review, expert interviews, and technology scan completed in Phase 1 of the L14 project identified the reliability terms used by the transportation profession to describe the travel time reliability of a transportation system. The initial list, shown in Table 3.2, was drawn primarily from the FHWA Travel Time Reliability information brochure (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006) and the Texas A&M Transportation Institute (TTI) Urban Mobility Report (Schrank et al. 2011). The list also includes user interface terms identified through the review of traveler information websites conducted in preparation for the surveys. The goals of the human factors studies conducted as part of the L14 project (focus group discussions, a computer-based multiple-choice survey, an open-ended survey, an initial travel behavior laboratory study, and an enhanced laboratory study) were twofold: (1) to discover what terms the layperson would use and understand to refer to these travel time reliability concepts, and (2) to determine to what extent travel time reliability information would inform travel decisions and the value of this information to system users.

Some of the descriptors for the listed terms and concepts were not tested in the human factor studies for one or more of the following reasons: (1) terms that have few or no logical alternatives and that were considered by the research team to be words and phrases readily recognized by laypeople; (2) terms pertaining to reliability measures that would be unlikely to be used by laypeople (e.g., buffer and travel time indices); or (3) terms that were close parallels to other tested parameters (e.g., planning time, which is similar to 95th percentile trip time). The following sections describe the terminology tested in the various human factors studies and results that influenced the development of the travel time reliability lexicon provided in Chapter 4.

TABLE 3.2. PROPOSED TRAVEL TIME TERMS AND CONCEPTS TO BE INCLUDED IN LEXICON

Technical Term	Technical Definition
95th percentile	The point on a travel time frequency distribution at which 95% of the trips made would arrive at or before the identified time
Arrival time	The time at which a traveler would arrive after a trip
Average travel time	An average of all travel times calculated over a specified time interval for a specified trip or roadway segment[a]
Buffer index	A multiplier that represents the extra time or time cushion a traveler must add to his or her average travel time when planning trips to ensure on-time arrival
Buffer time	The average travel time multiplied by the buffer index
Delay time	The amount of extra time spent traveling due to congestion
Departure time	The time at which a traveler would depart for a trip
Free-flow travel time	Travel time for a trip under free-flow conditions (level of service A)
Peak travel time	The free-flow travel time added to the delay time
Planning time	The free-flow travel time multiplied by the planning time index
Planning time index	A multiplier that represents how much total time a traveler should allow to ensure on-time arrival
Recommended departure time	A time of departure calculated by a traveler information system that would ensure an on-time arrival for a given level of risk tolerance
Recommended route	A route between two points calculated by a traveler information system that would ensure an on-time arrival for a given level of risk tolerance
Reliability	Consistency or dependability in travel times, as measured from day to day or across different times of day
Total trip time	The total time a trip would take, door to door
Travel time index	Peak travel time divided by free-flow travel time
Travel time range	The range of travel times that can be expected and could be anchored by any two points on the travel time frequency distribution
Trend information	An indication that congestion is changing

[a] The period of time over which the average is calculated is not consistent within the profession.

95th Percentile Travel Time

The 95th percentile travel time is a time identified for a specific travel route that indicates how long a given trip could take on the heaviest travel days (Texas A&M Transportation Institute with Cambridge Systematics Inc., 2006). The following terms for communicating 95th percentile travel times were discussed in the focus groups and/or tested in one or both of the surveys:

- 95th percentile trip time;
- Majority of the time;
- Most of the time;
- Travel time for planning;
- Maximum trip time;
- Worst-case trip time; and
- X out of Y days (e.g., 19 out of 20 days).

Of these terms, *maximum trip time* and *worst-case trip time* were not tested because of potential credibility concerns on the part of a public transportation agency. The phrase *19 out of 20 days* was not tested in surveys but is a probability expression that has been shown in the literature to be more readily understood by the general population than percentages or percentiles.

Majority of the time, used as part of the sentence "The majority of the time your trip will take *XX* minutes or less," was most likely to be interpreted correctly by participants as representing a trip time that would apply to unusually heavy traffic and unusual delays and also cover nonpeak periods. This term was evaluated in the enhanced laboratory study.

The term *95th percentile* was not well understood by survey participants, and participants who were presented with a 95th percentile trip time were less confident about arriving on time compared with participants who viewed the same trip time described with other tested terms (e.g., *majority of the time*, *most of the time*). Participants viewing *95th percentile trip time* were likely to add their own buffer time on top of the total trip time provided.

Most of the time, used as part of the sentence "Most of the time your trip will take __ minutes or less," produced the greatest (expressed) confidence in arriving by the time shown; but participants still tended to add their own buffer time to the time provided.

Participants given a trip time described as *travel time for planning* were more likely to view that time as a maximum trip time or worst-case scenario rather than the 95th percentile time that was intended.

Arrival Time

Alternate terms for arrival time—the time that a traveler arrives at his or her destination at the end of a trip—were not tested because the phrase is commonly used. However, phrases that a traveler might use to describe a desired arrival time were presented in the computer survey.

For a scenario in which a traveler would enter a preferred arrival time into a travel time calculator (to receive a recommended departure time), the survey offered the following phrases:

- Arrive by;
- Arrive at;
- What time do you want to get there?
- What's the earliest you can arrive?
- What's the latest you can arrive?

By a statistically significant margin, the largest percentage of participants preferred the phrase *arrive by*, with *arrive at* the second most frequently selected option. These responses showed a willingness to accept either an on-time or an early arrival, since *by* can mean "no later than." The other three phrases were selected much less frequently by participants. The research team concluded from the survey results that *arrive by* is the best of the tested phrases to use to ask for desired arrival time input.

Average Travel Time

The technical definition of *average travel time* is an average of all travel times calculated over a specified time interval for a specified trip or roadway segment. (The period of time over which the average is calculated is not consistent within the profession.) Terms to communicate average travel time were discussed in focus groups and tested in both surveys:

- Average travel time;
- Estimated travel time;
- Expected travel time;
- Typical travel time; and
- Historical travel time.

Average, *estimated*, *expected*, and *typical travel time* were all terms that were mentioned by focus group participants. *Historical travel time* is used by some travel time websites to distinguish an average trip time based on past travel time data. In the open-ended survey, researchers found no clear preference for or effect on comprehension among the terms *average*, *estimated*, *typical*, and *expected* travel times. However, in the computer-based survey, *estimated travel time* was preferred by the largest number of participants, followed by *average travel time*. *Typical travel time* and *historical travel time* were selected least frequently by participants in the computer-based survey.

Estimated travel time was selected to describe a calculated average travel time in the enhanced laboratory study.

Average travel time was addressed in two additional ways in the focus groups and in the computer survey. The sentence "It will take ___ 20 minutes to make your trip" was presented to focus groups to elicit potential terms for describing average trip time. Responses included *about*, *an estimate of*, *approximately*, *around*, *an average of*, *roughly*, *give or take*, and *at least*. When tested in the computer-based survey, *approximately* was preferred by a majority of participants, followed by *about*, *an estimate of*, and *an average of*.

When the sentence "It is ____ that your trip will take 45 minutes" was completed by focus group participants and was included in the computer survey, *estimated* was preferred by the highest number of participants, followed by *likely* and *predicted*.

Buffer Index

As previously noted, the buffer index is the extra time cushion (or buffer) that most travelers add to their average travel time when planning trips to account for unforeseen delays and to ensure on-time arrival (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006). Terminology for the buffer index was not tested in the human factors studies, as this is a metric that is unlikely to be used by roadway users.

Buffer Time

Buffer time is defined as the average travel time multiplied by the buffer index. When speaking about the additional time added to a trip to ensure on-time arrival, focus group participants suggested terms and phrases including *additional time*, *traffic time*, *leeway*, *driving time*, *just in case time*, *fluff time*, *additional drive time*, *cushion*, *allow an additional X minutes for variables*, *tack on extra*, and *extra time*. Terms that were tested in one or both surveys included the following:

- Added time;
- Buffer time;
- Cushion;
- Departure window;
- Extra time;
- Leeway; and
- Recommended cushion.

Of the tested terms, *extra time* was preferred by the most participants in the computer survey, followed by *departure window*; in the open-ended survey, *recommended cushion*, *added time*, and *extra time* all performed well. *Buffer time* was preferred by the fewest number of participants in the computer survey and so was not tested in the open-ended survey. Despite the popularity of *departure window* in the computer survey, the research team does not recommend its use as a synonym for *buffer time* because preference was shown for other terms across all of the studies.

Extra time was used to describe buffer time in the travel time information provided to participants in the enhanced laboratory study.

Delay Time

Terminology for delay time was not tested in human factors studies; instead, terms were tested for the related concept of buffer time.

Departure Time

Focus group participants wanted the ability to specify a trip calculation based on time of departure or time of arrival. The computer survey continued investigation on this topic by addressing the preferred terminology to be used for the departure and arrival times. Terms and phrases tested in the survey included the following:

- Departing at;
- Leave at;
- What time will you start your trip?
- Leave by;
- Departing by;
- What's the earliest you can start your trip?
- What's the latest you can start your trip?

Departing at, *leave at*, and *what time will you start your trip?* were the top three terms selected by participants, showing a preference for specific departure times versus a range of potential departure times (as could be implied by the other four tested phrases).

Free-Flow Travel Time

Terminology for free-flow travel time (i.e., travel time for a trip under free-flow conditions) was not tested in the focus groups or surveys. In the enhanced laboratory study, one of the graphical travel time information formats included projected trip times on a great day for travel speeds, along with corresponding times for average/typical and bad days. The "great day" trip time was intended to represent free-flow travel time.

Peak Travel Time

Terminology for peak travel time (free-flow travel time added to delay time) was not tested in the human factors studies. Terms for the similar concept of 95th percentile travel time were tested instead.

Planning Time

Terminology for planning time (free-flow travel time multiplied by the planning time index) was not tested in the human factors studies. Terms for the similar concept of 95th percentile travel time were tested instead; *travel time for planning* was one of the alternatives tested to represent 95th percentile travel time.

Planning Time Index

As noted earlier, the planning time index is used to calculate the total travel time that a traveler should expect or plan on when an adequate buffer time is included (Texas A&M Transportation Institute with Cambridge Systematics, Inc. 2006). Terminology for planning time index was not tested in human factors studies, as this is a metric that is unlikely to be used by roadway users.

Recommended Departure Time

Recommended departure time is defined as the time of departure calculated by a traveler information system that would ensure an on-time arrival for a given level of risk tolerance. The following terms were tested in the computer-based survey to describe this calculated time of departure:

- Recommended departure time;
- Estimated departure time;
- 95th percentile departure time; and
- Suggested departure time.

Of the tested terms, *recommended departure time* was preferred most frequently by survey participants, followed by *suggested* and *estimated*; *95th percentile departure time* was the least preferred.

Recommended Route

A recommended route in the context of travel time reliability is defined as the route between two points calculated by a traveler information system that would ensure an on-time arrival for a given level of risk tolerance. Terms tested in the computer survey to describe a route provided to a traveler by a traveler information system included the following:

- Best route;
- Forecasted trip;
- Most reliable trip;
- Most predictable trip;
- Most consistent trip;
- Historical trip conditions; and
- Least variable time.

Of the tested terms, the most frequently preferred was *best route*, followed by *forecasted trip* and *most reliable trip*. Although the term *recommended route* was not tested in the surveys, its similarity to participant-preferred terms like *recommended departure time* and *recommended cushion* likely indicates that *recommended route* would also be a strong candidate.

Reliability

Terms for both reliability and variability were discussed in focus groups and tested in the computer survey. Most often, focus group participants chose general words such as *possibly*, *probably*, *chance*, or *likely* to describe variability at a certain time of day. Generally, they preferred that those words have a descriptor in front, such a "X% chance" or "highly likely" to make the term less general. When talking about traffic patterns at a specific time of day, participants used *varie*s, *changes*, and *increases/*

decreases most often. Focus group participants preferred the terms *reliable* and *consistent* when describing the reliability of a roadway or mode.

The computer survey described four different fictional trips that were actually trip times presented in different ways: a typical/average trip time, a maximum trip time, a small trip time range, and a large trip time range. Participants were then asked to select a term that they felt described each of those trip times:

- Predictable;
- Reliable;
- Consistent; and
- Best.

All four terms were treated similarly by participants: they were selected to describe the typical and maximum trip times much more frequently than to describe either of the trip time ranges.

Terms for trip time variability were also tested in the computer survey, using the sentence "Your trip time may ___ from the average trip time by 15 minutes." Response options included the following:

- Vary;
- Differ;
- Fluctuate;
- Change;
- Go up or down;
- Increase or decrease;
- Deviate; and
- Be longer or shorter.

Of these options, survey participants preferred *vary* most frequently—by far.

Total Trip Time

Terminology for total trip time was not tested in human factors studies because the phrase is commonly used and few synonyms exist.

Travel Time Savings

Terminology for travel time savings was not tested in human factors studies because the phrase is commonly used and few synonyms exist.

Travel Time Range

In focus groups, terms used to complete the sentence "It will take _____ 10 to 30 minutes to make your trip" were *about*, *approximately*, *between*, *around*, *on average*, *likely*, *anywhere from*, *somewhere between*, *usually*, and *ideally*.

In the computer survey, two hypothetical trips for which travel time ranges were provided were not as frequently described by participants as *reliable*, *predictable*, or *consistent* compared with trips for which a single (typical/average or 95th percentile) trip time was provided.

Historical travel time information in the first travel behavior laboratory study was presented in the form of trip time ranges.

Trend Information

Terms for trend information (an indication that congestion is changing) were not tested in the human factors studies. Travel planning websites that were reviewed during focus group preparation and survey development often indicated trend information graphically (if they indicated it at all).

4 A LEXICON FOR COMMUNICATING TRAVEL TIME RELIABILITY

As noted previously, the goals for establishing a lexicon to convey travel time reliability information were as follows:

- Communicate a useful message.
- Improve on-time performance.
- Encourage trust in the message.
- Communicate the “riskiness” of a route.
- Distinguish travel time reliability from real-time traveler information.

A variety of terms are currently being used to describe travel times and the likelihood or reliability of travel times. *Average*, *historical*, *95% reliable*, and *typical* are just some of the terms used, and these may have different meanings to drivers depending on the context in which they are used. A variety of formats is also seen for estimated travel times presented to travelers. Early studies warned practitioners about the presentation of travel time information (whether in terms of actual times, delays, time saved, etc.) because of the potential for the information to be refuted by travelers and thus reduce credibility of the system with drivers. However, more recent research suggests that drivers recognize (to some degree) the inherent variability and potential for change in travel time information (Dudek et al. 2000). Furthermore, such variance does not reduce the information’s credibility among drivers, nor does it reduce the desire for such information.

LEXICON FORMAT

The research team identified several key elements of a lexicon entry that were deemed necessary to completely present each term. The elements are as follows:

- *Technical Term*—the formal travel time reliability term to be defined;
- *Definition*—a definition of the term within the reliability framework;
- *Usage*—a general description of when an agency might use the reliability term or for what purpose it would use the term in the traveler information system;
- *Recommendation*—the ranking of the messages and/or terms to be used in order of preference:
  - *Best*—represents the term(s), phrase(s), and/or format(s) that performed the best in the human factors studies and will most likely yield the desired behavioral results when conveyed to system users;
  - Adequate—represents term(s), phrase(s), and/or format(s) that performed reasonably well in the human factors studies and will not likely present significant comprehension problems for system users; and
  - Avoid—represents terms(s), phrase(s), and/or format(s) that did not perform well in the human factors studies or are recommended to avoid for noted reasons;
- *Alternate Phrase*—an alternative term or phrase of different lengths that would work on some technology platforms but not on others; and
- *Information Technology Platforms*—identification of appropriate media and technology interfaces for each alternative. The list of technology platforms could continue to evolve as new media are introduced. These might include portable navigation devices, Connected Vehicle (formerly IntelliDrive) on-board equipment, and advanced car stereo or satellite radio systems. An initial list is included in Table 4.1 and includes the following:
  - *Web*—intended to mean full website format viewed from a full-sized personal computer screen in a full-featured Internet browser;
  - *Mobile Web*—intended to mean a website format viewed from mobile devices such as smartphones and tablet computers;
  - *Text*—including short message service (SMS) text messages and social network text messages, such as Twitter, viewed on a mobile device;
  - *Mobile Application*—specially designed user interfaces optimized to work on a specific smartphone operating system. These "apps" include user input and output screens and data entry mechanisms, such as drop-down text boxes and scrolling menus, specifically designed for the touchscreen or keyboard supported by that operating system; and
  - *Dynamic Message Sign*—roadside dynamic message sign.

An example format for the data elements the research team identified for travel time reliability is illustrated in Table 4.1. This structure organizes the data elements in a way that can be applied to both reliability terms at a concept level and user interface phrases and terms. This structure also provides a convenient checkbox matrix indicating the platforms for which each variant of the term is recommended.

TABLE 4.1. LEXICON FORMAT

Technical Term	**95th Percentile**						
Definition	The point on a travel time frequency distribution at which 95% of the trips made would arrive at or before the identified time						
Usage	To describe the longest time a driver can expect a trip to take						
			Information Technology Platforms				
Recommendation	**Alternate Phrase**	**Wording Context/ Additional Information**	**Web**	**Mobile Web[a]**	**Text**	**Mobile Application[a]**	**Dynamic Message Sign**
Best			√	√	√+	√+	X
Adequate			√	√	√+	√+	X
Avoid			na	na	na	na	na

Note: na = not applicable. + = Underlined terms to be removed from this platform (in the Wording Context/Additional Information column); other phrase shortening may be possible depending on user preference.
[a] Mobile Web and Mobile Application did not include auditory messages.

LIMITATIONS OF LEXICON INFORMATION

Note that the studies conducted in this project were performed in a laboratory setting, and none of these terms was tested in a field environment. Only in a field test with specific detailed travel behavior data can researchers determine the true impacts and benefits of the use of travel time reliability information on behavior and resulting trip performance. Note especially that nowhere in the various human factors studies were the phrases suggested for display on DMSs tested specifically as being displayed in that format or as en route information. The phrases suggested for display on DMSs were developed by the research team on the basis of the results discussed for the related terminologies. The team developed these phrases using the general guidance for DMS message development provided in the *Manual on Uniform Traffic Control Devices* (MUTCD). Also note that the formatting of these travel time reliability messages is very different from the standard messages used by state transportation agencies on DMSs. For many of the travel time reliability terms, their use on a DMS would present various challenges to the traveler including the following:

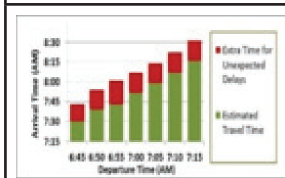
- Drivers are conditioned to see real-time travel information displayed on DMSs on freeway corridors, and reliability information may confuse them when placed on a DMS;

- Any reliability information displayed on a DMS would need to be relative to the specific location of the sign on the freeway facility, as drivers would have begun their trips from various locations in the region's transportation network; and
- Messages providing departure time or buffer time information are not appropriate for DMSs because travelers would need to see the messages before starting their trip, not en route.

TRAVEL TIME RELIABILITY LEXICON

Tables 4.2 through 4.9 present the specific lexicon of phrases for each travel time reliability term tested in the various human factors studies. The evaluation of the effectiveness of various messages was based in part on the improvement of travelers' outcomes (reduction of early and late schedule delay, better on-time performance, and reduced delay). The Mobile Web and Mobile Applications noted on the tables do not include auditory messages; however, SHRP 2 IDEA Project L15A explored text and auditory travel time reliability information.

TABLE 4.2. TRAVEL TIME RELIABILITY LEXICON FOR *95TH PERCENTILE*

Technical Term	**95th Percentile**							
Definition	The point on a travel time frequency distribution at which 95% of the trips made would arrive at or before the identified time							
Usage	To describe the longest time a driver can expect a trip to take							
			Information Technology Platforms					
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Web**	**Mobile Web**	**Text**	**Mobile Application**	**Dynamic Message Sign**
Best	**Majority of the time**	*"<u>The</u> majority of the time, <u>your</u> trip will take X minutes or less."*	√	√	√[a]	√[a]	X
		MAJORITY OF TIME TRIP TO [DESTINATION] X MIN OR LESS	√	√	√	√	√[b]
		Graphical representation of the average + 95th percentile	√	√	X	√	X
Adequate	**Most of the time**	*"Most of the time, <u>your</u> trip will take X minutes or less."*	√	√	√[a]	√[a]	X
		MOST OF THE TIME TRIP TO [DESTINATION] X MIN OR LESS	√	√	√	√	√[b]
	Travel time for planning	*"Travel time for planning <u>is</u> X minutes or less."*	√	√	√[a]	√[a]	X
	95th percentile trip time	*"The 95th percentile trip time <u>is</u> X minutes or less."* Provide description such as "19 out of 20 days."	√	√	√[a]	√[a]	X
Avoid	**Maximum trip time** **Most common trip time** **Worst-case trip time**	Agency concerns regarding liability and credibility	na	na	na	na	na

Note: √ = recommended; X = not recommended; na = not applicable.
[a] Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.
[b] The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.

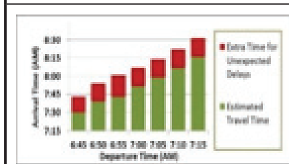
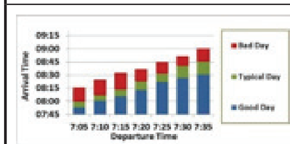
TABLE 4.3. TRAVEL TIME RELIABILITY LEXICON FOR *ARRIVAL TIME*

Technical Term	**Arrival Time**							
Definition	The time at which a traveler would arrive after a trip							
Usage	To tell the driver when he/she can expect to arrive at his/her destination							
			Information Technology Platforms					
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Web**	**Mobile Web**	**Text**	**Mobile Application**	**Dynamic Message Sign**	
Best	**Arrive by**	*"Arrive by X:XX a.m./p.m."*	√	√	√	√	X	
		ARRIVE BY X:XX AM/PM	√	√	√	√	√[a,b]	
Adequate	**Arrive at**	*"Arrive at X:XX a.m./p.m."*	√	√	√	√	X	
		ARRIVE AT X:XX AM/PM	√	√	√	√	√[a,b]	
	What time do you want to get there?	This question would be used by a traveler to enter a preferred arrival time into a travel time calculator to receive a recommended departure time.	√	√	X	√	X	
	What's the earliest you can arrive?	This question would be used by a traveler to enter a preferred arrival time into a travel time calculator to receive a recommended departure time.	√	√	X	√	X	
	What's the latest you can arrive?	This question would be used by a traveler to enter a preferred arrival time into a travel time calculator to receive a recommended departure time.	√	√	X	√	X	
Avoid								

Note: √ = recommended; X = not recommended.
[a] The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.
[b] Term may present ambiguity to the viewers, as they would not see a specific destination.

TABLE 4.4. TRAVEL TIME RELIABILITY LEXICON FOR *AVERAGE TRAVEL TIME*

Technical Term	**Average Travel Time**
Definition	An average of all travel times calculated over a specified time interval for a specified trip or roadway segment[a]
Usage	To describe the typical travel time a driver can expect a trip will take

Recommendation	Alternate Phrase	Wording Context/Additional Information	Information Technology Platforms: Web	Mobile Web	Text	Mobile Application	Dynamic Message Sign
Best	**Estimated travel time**	*"Estimated travel time is X minutes."*	√	√	√[b]	√[b]	X
		"It is estimated that your trip will take X minutes."	√	√	√[b]	√[b]	X
		EST THAT TRIP TO [DESTINATION] WILL TAKE X MIN	√	√	√	√	√[c]
	Approximate travel time	*"It will take approximately X minutes to make your trip."*	√	√	√[b]	√[b]	X
		APPROX X MIN TO [DESTINATION]	√	√	√	√	√[c]
Adequate	**Typical travel time**	*"Typical travel time is X minutes."*	√	√	√[b]	√[b]	X
		Graphical representation of the average + 95th percentile (typical day and bad day)	√	√	X	√	X
		Graphical representation of the 20th percentile + average + 95th percentile (good, typical, and bad day)	√	√	X	√	X
	Average travel time	*"Average travel time is X minutes."*	√	√	√[b]	√[b]	X
	Expected travel time	*"Expected travel time is X minutes."*	√	√	√[b]	√[b]	X
Avoid	**Historical travel time**	Difficult to determine relevance with no comparison to real-time information	na	na	na	na	na

Note: √ = recommended; X = not recommended; na = not applicable.

[a] The period of time over which the average is calculated is not consistent within the profession.

[b] Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.

[c] The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.

TABLE 4.5. TRAVEL TIME RELIABILITY LEXICON FOR *BUFFER TIME*

Technical Term	**Buffer Time**						
Definition	The average travel time multiplied by the buffer index						
Usage	To describe how much extra time a driver should plan for a trip he/she wishes to take						
			Information Technology Platforms				
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Web**	**Mobile Web**	**Text**	**Mobile Application**	**Dynamic Message Sign**
Best	**Extra time**	*"Extra time for trip is X minutes."*	√	√	√[a]	√[a]	X
		EXTRA TIME TO [DESTINATION] IS X MIN	√	√	√	√	X
Adequate	**Added time**	*"Added time for trip is X minutes."*	√	√	√[a]	√[a]	X
		ADDED TIME TO [DESTINATION] IS X MIN	√	√	√	√	X
	Recommended cushion	*"Recommended cushion for trip is X minutes."*	√	√	√[a]	√[a]	√
Avoid	**Cushion**	Preference shown for other terms	na	na	na	na	na
	Buffer time						
	Departure window						
	Leeway						

Note: √ = recommended; X = not recommended; na = not applicable.

[a] Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.

TABLE 4.6. TRAVEL TIME RELIABILITY LEXICON FOR *DEPARTURE TIME*

Technical Term	**Departure Time**						
Definition	The time at which a traveler would depart for a trip						
Usage	To indicate the time a traveler departs for a trip. For DMS applications, message would need to be set in context with other information, such as destination, travel time, or route.						
			Information Technology Platforms				
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Web**	**Mobile Web**	**Text**	**Mobile Application**	**Dynamic Message Sign**
Best	**Departing at**	*"Departing at X:XX a.m./p.m."*	√	√	√	√	X
	Leave at	*"Leave at X:XX a.m./p.m."*	√	√	√	√	X
Adequate	**What time will you start your trip?**	This question would be used by a traveler to enter a start time into a travel time calculator to receive an arrival time.	√	√	X	√	X
	Leave by	*"Leave by X:XX a.m./p.m."*	√	√	√	√	X
	Departing by	*"Departing by X:XX a.m./p.m."*	√	√	√	√	X
	What's the earliest you can start your trip?	This question would be used by a traveler to enter a start time into a travel time calculator to receive an arrival time.	√	√	X	√	X
	What's the latest you can start your trip?	This question would be used by a traveler to enter a start time into a travel time calculator to receive an arrival time.	√	√	X	√	X
Avoid							

Note: √ = recommended; X = not recommended.

TABLE 4.7 TRAVEL TIME RELIABILITY LEXICON FOR *RECOMMENDED DEPARTURE TIME*

Technical Term	**Recommended Departure Time**						
Definition	A time of departure calculated by a traveler information system that would ensure an on-time arrival for a given level of risk tolerance.						
Usage	To indicate the time a driver should depart for a trip to ensure he/she arrives at his/her destination on time. For DMS applications, message would need to be set in context with other information, such as destination, travel time, or route.						
			Information Technology Platforms				
Recommendation	**Alternate Phrase**	**Wording Context/Additional Information**	**Web**	**Mobile Web**	**Text**	**Mobile Application**	**Dynamic Message Sign**
Best	**Recommended departure time**	*"Recommended departure time is X:XX a.m./p.m."*	√	√	√[a]	√[a]	X
Adequate	**Suggested departure time**	*"Suggested departure time is X:XX a.m./p.m."*	√	√	√[a]	√[a]	X
	Estimated departure time	*"Estimated departure time is X:XX a.m./p.m."*[b]	√	√	√[a]	√[a]	X
	95th percentile departure time	*"The 95th percentile departure time is X:XX a.m./p.m."* Provide description such as "19 out of 20 days."	√	√	√[a]	√[a]	X
Avoid							

Note: **√** = recommended; **X** = not recommended.

[a] Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.

[b] Can be used if term is NOT being used to mean average trip time.

TABLE 4.8. TRAVEL TIME RELIABILITY LEXICON FOR *RECOMMENDED ROUTE*

Technical Term	**Recommended Route**
Definition	A route between two points calculated by a traveler information system that would ensure an on-time arrival for a given level of risk tolerance.
Usage	To describe the route a driver should take for a planned trip to ensure he/she arrives on time to his/her destination

Recommendation	Alternate Phrase	Wording Context/Additional Information	Information Technology Platforms: Web	Mobile Web	Text	Mobile Application	Dynamic Message Sign
Best	**Best route**	*"Best route is via [facility]."*	√	√	√[a]	√[a]	X
		BEST ROUTE TO [DESTINATION] TAKE [FACILITY]	√	√	√	√	√[b]
Adequate	**Forecasted trip**	*"Forecasted trip is via [facility]."*	√	√	√[a]	√[a]	X
		FORECASTED TRIP TIME VIA [FACILITY] X MIN	√	√	√	√	√[b]
	Most reliable trip	*"Most reliable trip is via [facility]."*	√	√	√[a]	√[a]	X
		MOST RELIABLE TRAVEL TIME TO [DESTINATION] TAKE [FACILITY]	√	√	√	√	√[b]
	Most predictable trip	*"Most predictable trip is via [facility]."*	√	√	√[a]	√[a]	X
		MOST PREDICTABLE TRAVEL TIME TO [DESTINATION] TAKE [FACILITY]	√	√	√	√	√[b]
	Most consistent trip	*"Most consistent trip is via [facility]."*	√	√	√[a]	√[a]	X
		MOST CONSISTENT TRAVEL TIME TO [DESTINATION] TAKE [FACILITY]	√	√	√	√	√[b]
Avoid	**Historical trip conditions**	Difficult to determine relevance with no comparison to real-time information; preference shown for other terms	na	na	na	na	na
	Least variable time						

Note: √ = recommended; X = not recommended; na = not applicable.

[a] Underlined terms to be removed for this platform; other phrase shortening may be possible depending on user preference.

[b] The formatting of this travel time message is very different from the standard messages used by state transportation agencies on DMSs.

TABLE 4.9. TRAVEL TIME RELIABILITY LEXICON FOR *RELIABILITY*

Technical Term	Reliability						
Definition	Consistency or dependability in travel times, as measured from day to day or across different times of day						
Usage	To describe the variability of travel times to drivers so they can plan their trip with more robust information						
			Information Technology Platforms				
Recommendation	Alternate Phrase	Wording Context/Additional Information	Web	Mobile Web	Text	Mobile Application	Dynamic Message Sign
Best	**Predictable**	*"Most predictable trip"*	√	√	√	√	X
Adequate	**Reliable**	*"Most reliable trip"*	√	√	√	√	X
	Consistent	*"Most consistent trip"*	√	√	√	√	X
	Vary	*"Trip varies."*	√	√	√	√	X
Avoid	**Differ**	Preference shown for other terms	na	na	na	na	na
	Fluctuate						
	Change						
	Go up or down						
	Increase or decrease						
	Deviate						

Note: √ = recommended; X = not recommended; na = not applicable.

5 FINAL REMARKS AND NEXT STEPS

The SHRP 2 Reliability Program aims to improve trip time reliability by reducing the frequency and effects of events that cause travel times to fluctuate in an unpredictable manner. As the program planning document points out, congestion caused by unreliable, or nonrecurring, events is roughly as extensive as congestion caused by routine bottlenecks (Cambridge Systematics, Inc. 2003). Nonrecurring events such as crashes, work zones, special events, and weather disrupt normal traffic flow by causing reduced speeds, lane closures, and erratic driving maneuvers.

Travel time reliability information includes static data about traffic speeds or trip times that capture historical variations from day to day and enable individuals to understand the level of variation in traffic. Unlike real-time travel time information, which provides a current snapshot of trip conditions and travel time, reliability information can be used to plan and budget in advance for a trip.

A key component to addressing the reliability issue related to urban mobility is conveying this reliability-related information to system users so that they can make informed decisions about their travel. The challenge for transportation professionals lies in selecting the best means of conveying that information so that it is usable and effective. The goal of this research project was to examine what combination of words, numbers, and other features of user information messages along with communications methods and technology platforms best communicates information about travel time and reliability to travelers so that they can make optimal travel choices from their own point of view. Such choices include whether to take a trip or not, departure time, mode choice, and route choice.

This project developed a lexicon to provide information on appropriate ways to introduce and provide travel time reliability information to travelers so that such information would most likely be understood and used by the travelers to influence their travel choices, while not presenting a safety hazard in the process. This document was developed on the basis of an increasingly detailed series of human factors experiments and the development of a utility function, with input from a literature review, expert interviews, and a technology and innovation scan. All of these provided key information and insight into (1) how individuals comprehend and interpret travel time reliability information, (2) how they use that information to make trip decisions, and (3) how reliability terms can be phrased to reach the highest percentage of travelers so that their travel decisions yield some benefit to them.

The research team developed a structure for the lexicon which organizes various data elements for each term in a way that can be applied to both reliability terms at a concept level and user interface phrases and terms. These elements include a definition, the usage of the term, the ranking of messages and/or terms to be used in order of preference, alternate phrases, and information technology platforms. This structure also provides a convenient checkbox matrix indicating the platforms for which each variant of the term is appropriate.

STUDY LIMITATIONS

Note that the studies conducted in this project were laboratory studies, and none of the terms was tested in a field environment. Only in a field test with specific detailed travel behavior data can researchers determine the true impacts and benefits of the use of travel time reliability information on behavior and resulting trip performance. Note especially that nowhere in the various human factors studies were the phrases suggested for display on DMSs tested specifically as being displayed in that format or as en route information. The phrases suggested for display on DMSs were developed by the research team on the basis of the results discussed for the related terminologies. The team developed these phrases using the general guidance for DMS message development provided in the MUTCD. Also note that the formatting of these travel time messages is very different from the standard messages used by state transportation agencies on DMSs.

CONSIDERING SAFETY

At the same time that more complex data are being made available to travelers, lawmakers are contending with the ever-growing issue of how technology leads to driver distraction. Several state legislatures have begun passing legislation to limit many in-vehicle behaviors, such as texting and otherwise communicating on handheld devices. Visual distraction is the primary concern with mobile devices. As of 2012, 6 states had banned the use of handheld cell phones, 39 states had banned text messaging for all drivers, and 32 states and the District of Columbia had banned all cell phone use (handheld and hands-free) by novice drivers (Governors Highway Safety Association 2012). Given this movement against in-vehicle distractions, the providers of ever-complicated map-based products may also find limitations placed on their use.

The potential for technology-based distractions in the vehicle is a serious and timely issue. In response, providers of mobile applications have begun shifting from visual directions and manual entry to auditory directions and verbal entry. Because of the potential risks associated with in-vehicle distractions, the research team did not investigate such delivery mechanisms in L14. In the same vein, providers of traveler information, including trip reliability information, must take heed when developing new information interfaces and information content. Further research is needed to identify the most appropriate method for conveying this information without compromising safety.

KEY STUDY OBSERVATIONS ON USER BEHAVIOR

After careful assessment of travel time reliability terms and the results obtained in the various human factors studies and experiments conducted throughout the course of the L14 project, the research team established three key hypotheses related to the use and value of travel time reliability information from the user's perspective. These hypotheses were tested in the enhanced laboratory study. The following sections highlight the hypotheses and the results from the study—all of which were combined with the results from the other human factors experiments to develop the lexicon presented in Chapter 4.

Hypothesis 1

Hypothesis 1 states that the provision of accurate reliability information (in an easy-to-understand format) will result in improved on-time performance and lower generalized travel disutility compared with a control group receiving no reliability information.

The results of the enhanced laboratory study strongly supported this hypothesis. Of the seven different forms of delivery of reliability information tested in the experiment, users presented with five of the options demonstrated statistically significant reductions in weekly schedule offset costs compared with the control group receiving no reliability information. These five were also the simplest of the forms of reliability information, focusing on average and 95th percentile travel time values, delivered in various forms. Participants receiving these simple forms of reliability information reduced schedule offset costs by 9% to 21% compared with the control group.

Hypothesis 1a

Hypothesis 1a states that while travel outcomes improve with the provision of travel time reliability information, participants' perceived value of the reliability information will underestimate the realized benefit in terms of reduced delay, improved on-time reliability, and reduced stress.

The enhanced laboratory study results strongly supported this hypothesis. For each of the simple forms of reliability information tested, improvements in trip outcomes were clear and statistically significant. For example, frequency of late arrivals declined 16% to 40% when participants received reliability information in these forms compared with when they did not receive reliability information. Reduction in stress reported at the end of each week was also statistically significant, in a similar range, from 10% to 31%. However, participant willingness to pay for reliability information compared with willingness to pay for baseline (real-time) information was often not statistically significant. For example, participants receiving the simple text-based plus 95th percentile reliability information reduced late arrivals by 40% and reported a 10% reduction in stress. However, the same participants were willing to pay on average only $0.10 more for reliability information ($2.78 versus $2.68 per trip), a difference too small to be statistically significant. These results are similar to those reported in other research (Carrion and Levinson 2012).

Hypothesis 1b

Hypothesis 1b states that the provision of travel time reliability information using different text-based, graphical, and auditory forms will result in differences in both accrued on-time reliability benefits as well as perceived benefits. These differences among experimental groups were expected to be smaller than between any group and the control (no reliability information) group.

The enhanced laboratory study supported this hypothesis. Provision of simple forms of reliability information had similar results whether provided in text-based, graphical, or auditory forms. The more complex graphical and signposting concepts were not effective.

Hypothesis 2

Hypothesis 2 states that experimental subjects receiving contextual information on underlying variation with numeric indicators reinforced with en route information (travel time reliability signposting) will have improved on-time performance compared with both an experimental group that receives reliability information but no contextual information as well as a control group that receives no reliability information.

Hypothesis 2 was not supported by the enhanced laboratory study. The signposting concept was not successful for participants in the management of trip outcomes and stress reduction. To some degree, this was because of the complexity of the presentation. Signposting may still be a valuable concept to pursue for providing reliability information, but work remains to convey this concept in a more accessible manner.

Hypothesis 3

Hypothesis 3 states that the benefits of travel time reliability information will decline over time as both experimental and control subjects learn and understand the underlying travel time variability. That is, the benefit from reliability information during the first weeks will be larger than during the last weeks.

The enhanced laboratory study supported hypothesis 3. Participants using travel time reliability information were equally effective in managing trip outcomes (late arrivals, schedule delays, and offset costs) in the first week of exposure to unfamiliar travel time variability patterns as their counterparts without reliability information after 4 weeks. Within the 4-week constraints of the experiment, both reliability information users and control group counterparts reduced offset costs through week three, at which time costs leveled off. That said, the difference in realized offset costs (i.e., monetary costs defined within the context of the experiment for early and late arrivals) between the two groups was still significant even in week three and week four: roughly 25% ($40 versus $50). This implies that reliability information still has value at 4 weeks of experience, and presumably may still have value longer than 4 weeks since the gap in performance between week one and week four between the two groups narrowed only from 40% to 25%.

POTENTIAL NEXT STEPS

Given the complexity of the travel time reliability concept and the myriad ways the information may affect system users, system operators, and service providers, the project team identified several potential issues that can be addressed in further detail and refined through additional investigation. These issues are discussed in the following sections. A structured review and discussion by a larger group of public- and private-sector practitioners of the results of this project and the topics described in this section may be useful in prioritizing further research.

Graphical Formats for Reliability Information

Two graphical formats were tested in this study's second laboratory experiment as alternatives for presenting reliability information to drivers. These two formats were rated by participants as being "more complex" and therefore less easy to use than the same information presented in a text format. However, other graphical formats may prove useful as alternative or supplemental methods for communicating reliability information to drivers. Further research should be conducted to assess the potential usefulness and usability of "star" ratings, Harvey Balls, and other graphical formats for conveying reliability information.

Auditory Messages to Communicate Reliability Information

Auditory messages were included as one format for communicating reliability messages in the enhanced laboratory experiment. The SHRP 2 IDEA Project L15A, *Forecasting and Delivery of Highway Travel Time Reliability Information*, also examined auditory messages as a delivery mechanism for travel time reliability information. Future research should further examine auditory options for both message delivery and, potentially, verbal inputs by system users.

Reliability Information in the Context of More Complex Trip Planning

This study looked only at single-occupancy highway trips with time of departure choice. The more complex the range of travel choices available to the user (with low overall travel time variance correlation), the more valuable travel time reliability information will be in reducing late trip arrivals and schedule offset costs. The availability of priced facilities such as high-occupancy/toll (HOT) lanes is one example of a scenario that offers travelers an additional travel decision for which comparative reliability information may be valuable.

Mechanisms of Reliability Information Under-Valuation by Users

Although this work makes clear that travelers do not associate improved trip outcomes with access to travel time reliability information, the reason why is not clear. Participants may have seen the experiment as a game in which they were actively learning and discounted inputs to the learning process compared with an assessment of their own innate powers of deduction. A set of structured experiments to uncover the mechanisms of the perception of travel time reliability information can be constructed to investigate this interesting result. Another approach could be to conduct a real-life experiment where the availability and use of reliability information have a real impact on trips, which would remove the game aspect from the experiment and further delve into the perception of the value of the information from the user's perspective.

Predictive Reliability Information and the Experienced Traveler

One tantalizing morsel from the second (enhanced) experiment calls into question the assumption from the focus group activity that travel time reliability information will have value primarily for unfamiliar travelers. In the second experiment, the difference in schedule offset costs between users of reliability information and the control group declined from 40% in the first week to 25% in the fourth week. The experiment begs the question of how many weeks would be required until the performance of the two groups was the same, or if indeed such a convergence would actually occur. This may imply that there is some inherent value in providing accurate data to the users even if they have acclimated themselves to the information in a nonquantitative way. Another key observation is that the underlying patterns of travel time variation do not change in the experiment; therefore, there may be a value in predicting trends in travel time variability and tailoring reliability information even for the most experienced traveler.

Impact of Reliability Information on Broader Range of Travel-Related Choices

The provision of travel time reliability information may have benefits in other choices not studied in this experiment. These choices might include decisions on telework—both the practical value of telework on a regular basis and dynamic telework decisions to remain at home rather than risk being en route at the time of a critical meeting (whether in person or virtual). Other decisions potentially informed by reliability information include a home purchase or new job with travel-related impacts, as well as facility location decisions for businesses and supply chain managers.

Monetization of Reliability Information Impacts

The precursor experiment in this study looked specifically at the monetization of travel time reliability information impacts and derived a parameter for serenity benefits associated with knowing as early as possible about possible trip outcomes (late or otherwise). The experience with the new set of experiments suggests additional work is warranted. This work could include developing utility functions that cover a broader range of serenity impacts as a function of reliability information and a new class of multimodal functions addressing more complex trip chains and tours and how reliability information might impact those functions. Further, the development and documentation of practical methods of data collection for the local calibration of reliability information-sensitive utility functions is another valuable extension to this research. Additional exploration of serenity impacts under constrained and unconstrained rescheduling options would also be of value using an experimental structure similar to the one designed for this study. A real-world experiment could also shed light on the monetization aspects of reliability information, as the effects are real within the user's framework of trips.

Use of Reliability Information by the Freight Industry

Commercial drivers plan routes primarily on the basis of cost-effectiveness and tend to select the most direct route (based on distance) or a route that allows them to avoid traffic congestion or other obstructions. Drivers and dispatchers consider time of day, traffic patterns in major metropolitan areas, and construction when planning routes and when considering route diversions during a trip. A driver who delivers to regular repeat customers will often develop "usual" routes and will stick to them unless conditions dictate otherwise. If a driver has a time-sensitive delivery, the travel time along a given route becomes more important, and the driver and the company will be more likely to opt for a toll facility or other route option that provides a more reliable trip time (L. Higgins, in preparation). The research team hypothesizes, therefore, that commercial drivers would not only value TTR information, but would also be better able (compared with commuters) to express that value monetarily. Research should be conducted to examine the potential valuation and use of travel time reliability information by the freight industry.

Reliability Information in Public Transit

The human factors studies and utility function development conducted in this study focused on drivers; however, the literature indicates that reliability information is also valuable to transit riders. Similar research should be developed to further examine the effects of information about transit travel time and arrival reliability on riders' mode decisions, departure time decisions, stress levels, and satisfaction with the transit service.

Combining Real-Time and Reliability Information

Feedback from the focus groups and computer survey indicated that travelers consider real-time travel time information to be a valuable and even necessary addition to historical data when planning trips. Research is needed to determine how best to combine real-time and historical travel time information to provide the most useful and accurate information to travelers. SHRP 2 Project L15A, *Forecasting and Delivery of Highway Travel Time Reliability Information*, developed a prototype of a forecasting website (http://MyRoadTripAdvisor.com) that predicts travel time for a given route on the basis of both historical patterns and current conditions, including incidents, weather, and work zones. The website offers registered users the options to save frequent trips by name and to have travel time forecasts for scheduled trips pushed to them by e-mail, text message, or telephone. This demonstration project provided real-time and travel time reliability information for portions of I-66 in Northern Virginia. Because the two projects (L14 and L15A) were conducted during the same time period, different sets of terminology were developed for communicating reliability concepts; future research might involve testing MyRoadTripAdvisor with terminology from L14's lexicon, as well as testing additional auditory or graphical options for communicating real-time and reliability information to travelers.

Field Tests of Reliability Terminology

A field test of the lexicon terminology is one way to implement and validate the results of this project's human factors studies and utility function development, by collecting data about travelers' use of pre-trip and en route reliability information in a real-world environment. A field test would use recommended reliability terms and formats from the lexicon as part of the provided information on a localized travel website, on DMS, and via other media and messaging techniques in a selected city or cities. As mentioned above, the prototype website developed by Project L15A would be a potential starting point for such a field test.

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RELATED SHRP 2 RESEARCH

Forecasting and Delivery of Highway Travel Time Reliability Information (L15A)

Establishing Monitoring Programs for Travel Time Reliability (L02)