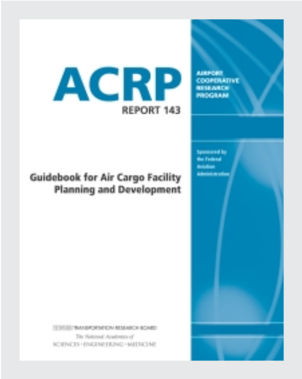

Guidebook for Air Cargo Facility Planning and Development

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 143

Guidebook for Air Cargo Facility Planning and Development

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). ACRP carries out applied research on problems that are shared by airport operating agencies and not being adequately addressed by existing federal research programs. ACRP is modeled after the successful National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP). ACRP undertakes research and other technical activities in various airport subject areas, including design, construction, legal, maintenance, operations, safety, policy, planning, human resources, and administration. ACRP provides a forum where airport operators can cooperatively address common operational problems.

ACRP was authorized in December 2003 as part of the Vision 100—Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academy of Sciences formally initiating the program.

ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

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Primary emphasis is placed on disseminating ACRP results to the intended users of the research: airport operating agencies, service providers, and academic institutions. ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties; industry associations may arrange for workshops, training aids, field visits, webinars, and other activities to ensure that results are implemented by airport industry practitioners.

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COOPERATIVE RESEARCH PROGRAMS

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FOREWORD

By Lawrence D. Goldstein
Staff Officer
Transportation Research Board

ACRP Report 143: Guidebook for Air Cargo Facility Planning and Development includes the guidebook along with a CD-ROM containing the Air Cargo Facility Planning Model in spreadsheet format. The guidebook presents a broad discussion of the various issues that must be addressed in planning air cargo facilities. It describes tools and techniques for sizing facilities, including data and updated metrics necessary to forecast future facility requirements as a function of changing market and economic conditions. The procedures offered support airport operators in crafting effective business plans and development decisions that meet the industry's current and future technological, operational, and security challenges in a cost-effective, efficient, and environmentally sensitive manner. The beneficiaries of *ACRP Report 143* include airport owners and operators, airlines, integrated cargo carriers, developers, financial institutions, and others linked to the airport community.

Procedures for planning, developing, and implementing air cargo facilities are incorporated into a comprehensive model that can be adapted and applied by users to reflect local requirements and development conditions for cargo facilities serving a wide variety of markets, including international gateways, national cargo hubs, domestic airports, and others.

In addition, a comprehensive research report is available as *ACRP Web-Only Document 24* (WOD 24). The research report offers an extensive review of the process and information used in preparing the guidebook. Both the spreadsheet model and WOD 24 are available for download from the TRB website by searching for *ACRP Report 143* at www.trb.org. The spreadsheet model is also available as a CD-ROM bound into the printed report.

Under ACRP Project 03-24, the CDM Smith team identified effective strategies for responding to changing conditions affecting air cargo demand. Air cargo is a significant component of the world's manufacturing and retail supply distribution chain in general and an important revenue source for the airport industry in particular. As a result, making long-term investment decisions regarding air cargo facilities at our nation's airports is exceedingly important; however, these decisions can often be difficult given the complex and dynamic nature of the business of air cargo. Over time, these complexities have grown as a function of modal shift, airport access, regulatory and security compliance issues, changing economic conditions, increased sensitivity to environmental issues, changing aircraft configurations and size, and other challenges.

What often complicates the issue is that many airports rely on antiquated air cargo facilities that no longer meet demand or service requirements nor accommodate changes to cargo handling procedures and evolving security requirements. As airports develop, redevelop, expand, and modernize their cargo facilities, planners are often forced to rely on incomplete and inconsistent air cargo activity data coupled with a lack of generally accepted air cargo planning standards and design guidelines. Variations in reporting can affect how airport planners allocate space for priority on-airport cargo activity, possibly limiting consideration of the many factors that have to be taken into account: facility throughput area, storage/sorting space, aircraft parking, cargo tug lanes, ground handling equipment storage areas, landside truck docks, and overall traffic circulation. Given this complex environment, airport management requires current and accurate information coupled with effective planning and development guidelines to ensure that future airport cargo needs will be accommodated.

Changes in air cargo demand, coupled with increasing competition among modes, have increased the need for and complexity of facility planning. Using a systematic decision-making approach, as presented in this guidebook, improves the ability of airport planners and managers to incorporate flexible, realistic long-term objectives in response to a constantly changing environment.

CONTENTS

CHAPTER 1

Introduction

1.1 Purpose and Organization of the Guidebook

1.1.1 Purpose

The purpose of this guidebook is to provide general guidelines regarding the planning and development of airport air cargo buildings, apron areas, and support facilities in the United States. This guidebook's intended audience includes airport managers and their staff, airport planners, consultants, third-party airport facility developers, and the air cargo industry in general. This guidebook represents a snapshot in time within continuously evolving air cargo industry practices and federal regulations affecting planning and cargo operations.

1.1.2 Organization of the Guidebook

This guidebook is organized to provide the user a thorough understanding of air cargo demand, airport facilities needed to meet the demand, and best practices for planning facilities to meet current and future demand. This guidebook's organization flows from a high-level view of air cargo activity on airports and air cargo facilities to a broad discussion about airport and air cargo facility planning. The guidebook then focuses on specific guidance for cargo facility development on the airside and landside of the airport's cargo areas. The guidebook can be used by the airport planner to assist in going through the steps involved in the air cargo element of a master plan and provides guidance for a stand-alone air cargo facility strategic development plan. More specifically, the guidebook includes the following:

- Chapter 1: Introduction provides the airport planner with an overview of the purpose and organization of the guidebook. This overview is followed by a brief retrospective of air cargo facility trends.
- Chapter 2: Airports and Air Cargo—Overview provides a general overview of the role the airport plays in the transport of air cargo. The chapter identifies the types of cargo carriers operating at airports and provides a high-level view of airports and how they contribute to air cargo transport.
- Chapter 3: Air Cargo Planning Approach and Process provides a general overview of the airport master planning process as it relates to air cargo. The chapter focuses on inventory data collection and air cargo data sources. Data collection challenges are identified, and data gathering techniques are presented. Tools useful to airport planners for collecting air cargo information and examples are discussed.
- Chapter 4: Planning Considerations and Metrics provides airport planners with a framework that can be used to guide airport decision makers in planning and developing air cargo facilities. This framework is intended to be applicable to a range of airports and facility types based on current conditions at airports and forecasted change. Air cargo building throughput metrics are presented to provide guidance on future facility requirements.

- Chapter 5: Air Cargo Forecasting provides an overview of the techniques for forecasting future cargo traffic demand with emphasis on how this relates to the air cargo facility requirements.
- Chapter 6: Air Cargo Facility Planning—Sustainability Considerations provides an overview of sustainable air cargo facility design and gives an example. The Sustainable Aviation Guidance Alliance is discussed, and the chapter provides information on its application to air cargo facilities.
- Chapter 7: Air Cargo Facility Planning—Security Considerations is an overview of security trends as they relate to airside and landside cargo facilities.
- Chapter 8: Air Cargo Facility Planning—Funding Strategies considers the development and financial alternatives available to the airport planner. An example pro forma plan related to the development of an air cargo building is provided.
- Chapter 9: Air Cargo Facility Planning Model discusses a key component of these guidelines, the Air Cargo Facility Planning Model, which provides airport planners a single source for calculating space and facility utilization for future air cargo buildings, apron area, and parking space.

The guidebook also contains a resource listing and a listing of terms and abbreviations related to air cargo facility planning.

1.2 Retrospective on Air Cargo Trends

The air cargo industry experienced significant growth in the 1990s that was driven by several factors, including an expanding global economy, the development of the Internet, the dot-com boom, and industry reliance on air cargo utilization for supply-chain management and just-in-time business models within the manufacturing sectors. In the 1990s, the compounded annual growth rate (CAGR) for U.S. international air cargo was measured at 8.2% for the period. From 2000 to 2010, the CAGR for U.S. international air cargo was measured at just 2.5%, which is reflective of a difficult economic period that included the September 11, 2001 (9/11) attacks, the severe acute respiratory syndrome (SARS) pandemic, and the spike in fuel prices and economic recession beginning in the autumn of 2008. The difference in the growth rates for the last two decades is also reflective of changes in shipper demand and a maturing air cargo market within North America. For the vast majority of U.S. airports, the period from calendar year (CY) 2000 through CY 2010 was marked by double-digit losses in annual tonnage.

1.2.1 Cargo Facility Occupancy Trends

U.S. integrator hub airports accounted for at least 40% of the air cargo processed at U.S. airports in CY 2010 and experienced a group total of 6.4% growth during the period CY 2000 through CY 2010. However, individual performances were asymmetrical in that the two national hubs, Memphis, TN (FedEx) and Louisville, KY (UPS), enjoyed 57.4% and 42.6% growth, respectively, while double-digit losses were experienced at almost all of the FedEx Express and UPS regional hubs. The exception is Greensboro, NC, which benefitted from having its hub begin operations during the period.

Several carriers—including Airborne Express, BAX Global, DHL, Emery Worldwide, and Kitty Hawk—terminated their domestic air cargo operations (DHL) or disappeared altogether. As a result, both hub airports and airports serving as spokes have been left with significant vacancy rates. Consequently, FedEx Express and UPS form a duopoly of domestic express air cargo, and many U.S. airports have only one or two air cargo tenants. DHL is still in the U.S. market but transports international air cargo only.

Vacancy rates have also been affected by the proliferation of third-party ground handlers that gain labor and equipment efficiencies to accommodate a variety of carriers in the space previously required by only one carrier's operations. In fact, carriers at many airports, both passenger and cargo, may have no local management but rather outsource these services to handlers.

1.2.2 Modal Shift

At many airports, vacancy was also created by the shift of U.S. mail from the U.S. Postal Service to private carriers such as FedEx, from air to trucks, and in the case of bills and payments, from air to electronic communications. Increasingly, the U.S. Postal Service has moved off airport.

Modal shifts from air to sea negatively affected transpacific volumes, while trucks replaced aircraft for many shipments that were either entirely domestic or the domestic segment of international shipments that were previously flown between secondary U.S. cities and international gateways. As early as the 1990s but continuing through the next decade, shift in traffic also occurred as the United States and Europe favored increased trade with Asia over trade with one another. Modal shifts from air to trucks also occurred simply because faster growth rates are priorities for new aircraft utilization compared with mature, slow-growing U.S. markets that can often be served by truck.

Another incentive for trucking to international gateways has arisen from security screening requirements that require 100% screening of enplaned belly cargo. Given the need to capitalize investments in technology and training, many freight forwarders and air carriers have maximized the use of gateway resources rather than screening at the point of origin.

Simultaneously, carriers increasingly used ground transport to offset the cost of air cargo. Trucking replaced air cargo to and from many destinations. Time-definite ground transport is a wonderful product for consumers and producers alike, but not for airports, since ground product does not typically move through airport facilities. Compounding the situation is the general consolidation of air cargo and logistics industries, from the carriers on down through the handlers as well as the forwarders and third-party logistics providers. The result has been a reduction in the need for on-airport building space because of facilities redundancies, tenant financial stresses and mergers, and the utilization of fewer consolidation points to the large international hubs.

1.2.3 Planning Implications—Cargo Buildings

The effect of these industry trends on capacity utilization has been more derived than direct. Cargo building utilization rates—measured by annual tons per square foot handled—have often fallen precipitously due to severe drops in throughput rather than inefficiencies. The ACRP Project 03-24 researchers have attempted to reconcile that issue in this guidebook by using occupied rather than total capacity—netting out vacancies—but often cargo operators have retained excess space either due to long-term leases or because of the hope for a near-term improvement that has not occurred to date.

In addition to the effect of the drop in annual tonnage (with throughput being the numerator in measures of utilization), the shift in market share between belly carriers and all-cargo carriers—particularly integrators—has also affected utilization. For operational reasons, belly carriers have relatively lower utilization rates than all-cargo carriers, so the migration of market share from relative parity between belly and all-cargo tonnage in the early 1990s when many cargo facilities were built versus the present dominance by integrated carriers necessarily affects expectations for cargo building utilization. That change would be less evidenced by changes within the utilization matrix than in how market shares have been reapportioned between types of carriers.

As has been previously noted, the most negative effect of this migration of market share for most U.S. airports has been the obsolescence of some legacy cargo facilities. These facilities may not have exhausted their engineered lifespan but have no near- to mid-term prospects for their designed utilization, given the dearth of air cargo carriers left in the U.S. domestic market. In building their dominant market shares, FedEx and UPS were most likely to move into dedicated single-tenant facilities, which only exacerbated the vacancies in legacy multi-tenant facilities where the remaining tenants had plummeting cargo tonnage.

With such chronic shortages of tenants and no relief in sight, airport operators may need to confront whether some existing legacy facilities should be either designated for reuse or even razed. In terms of cargo building utilization ratios, the net effect would be to decrease the denominator (square footage). However, the driver would not be a gain/loss in operating efficiency but rather the elimination of unneeded capacity.

While much of the preceding discussion has applied to the vast majority of U.S. commercial airports at which at least 90% of annual tonnage is now carried by FedEx and UPS, other shifts have been common at international gateways. The outsourcing of cargo handling has commonly resulted in higher utilization rates as multiple carriers may be handled in the same space formerly occupied by one or two—often by handlers' adding of labor and shifts. The same basic efficiency gain has also accrued to arrangements in which carriers (often a passenger hub carrier) leverage their staff and facilities to handle other carriers' cargo needs.

1.2.4 Air Cargo Market Realities and the Role of This Report

The net result of the preceding developments is that there is an unprecedented surplus of existing on-airport air cargo facilities at both hubs and non-hub terminals. Consequently, an airport planner's cargo facilities analysis must begin with realistic assessments of market demand. In some markets, the principal need may be for replacement of outdated facilities, while in others, considerable economic recovery may still have to occur before any new or improved facilities can be justified.

The primary goal of this report is to assist airport planners and consultants in the development of air cargo facilities on airports given today's market dynamics. This report takes the airport planner through the air cargo data collection effort, forecasting techniques, and cargo facility requirements modeling. This report will point the way for airports, both large and small, to estimate the facilities they need to meet future demand. Airports may find that they have excess capacity and need not expand facilities, while others will find that, while their facilities have adequate space, they may want to update their airport layout to include relocating current cargo facilities to better accommodate the air cargo industry. Another goal of this report is to point out to the airport planning community the importance of air cargo facility planning in the entirety of the airport master planning process. The Airport Cargo Facility Planning Model, on the CD-ROM that accompanies this report, is a single source for calculating space and facility utilization for future air cargo buildings, apron area, and parking space. The model is flexible in that it can estimate spatial utilization for all cargo areas and specific facilities at an airport. It is designed with two types of airports in mind: airports serving primarily domestic air cargo demand and airports serving international air cargo demand.

CHAPTER 2

Airports and Air Cargo—Overview

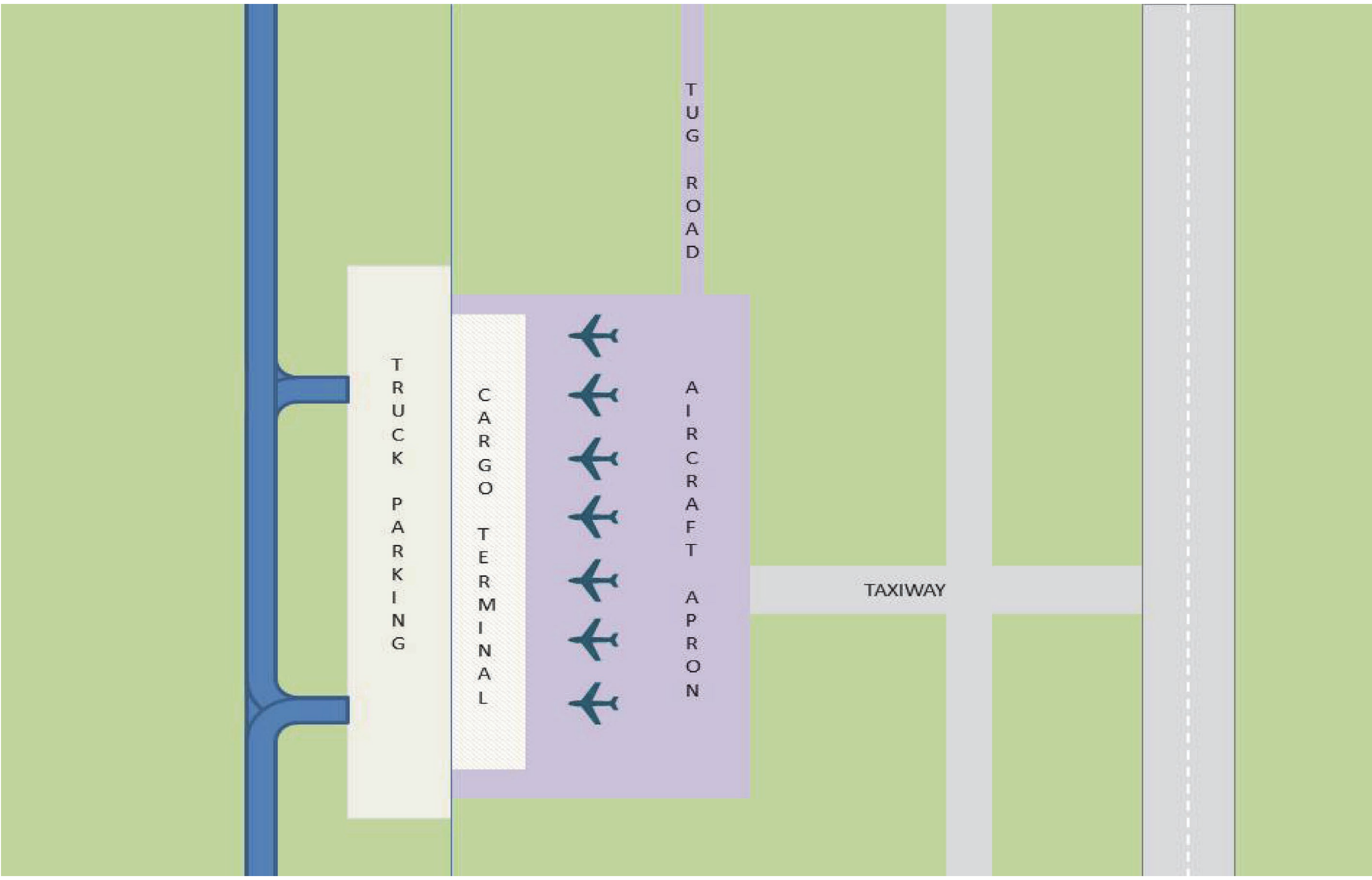
2.1 The Role of the Airport in Air Cargo Transport

The cargo industry changed significantly over the 25 years of 1988 to 2013. As the world economy has become more global, markets and manufacturing have developed, shifted, and in many instances, relocated to markets with low labor rates. New logistics and supply-chain concepts based on low fuel costs and labor costs developed along with trends in just-in-time production and final manufacturing assembly at destination. As new product shelf life decreased, such as for consumer electronics, during this time period, and as the value of goods shipped has increased, the demand for expeditious transport and control, as well as transparency, has correspondingly increased. Domestic air cargo in the United States also experienced shifts, particularly as fuel costs increased in recent years and integrated express carriers developed deferred delivery business models, reducing the demand for overnight delivery by aircraft and relying increasingly on truck networks.

The air cargo terminal is a critical part in the air cargo supply chain. An inadequately sized air cargo building that is unable to accommodate peak volumes may result in shipment delays, while a cargo warehouse that is not designed with flexibility in mind to meet demand may become obsolete during its service life. Airports routinely accommodating air cargo operations typically have space dedicated to support this activity (Figure 2-1). The space is commonly made up of aircraft parking apron, air cargo buildings, and truck parking and maneuvering areas. Cargo throughput between the land and air mode is either through the warehouse buildings or a through-the-fence security gate. These air cargo installations on airports function as a platform that allows for the interface between land and air modes, with the goal of providing the expeditious processing of cargo. This platform has a role to play in ensuring that cargo products arrive at their destination on time and intact, that customers have easy access to the cargo facilities for collection and delivery, and that the truck access is relatively uncongested and does not interfere with passenger-related traffic. Cargo storage is an attribute of these facilities, but the duration is to be limited by design. For the cargo carrier, it is most optimal for air cargo to arrive at the precise time for loading onto aircraft with no on-airport storage or processing time needed. Since there are typically numerous arrivals on cargo trucks to an air cargo terminal, space for processing, build up, and storage is required. These space requirements vary with carrier type and the size of the airport's air cargo market.

2.1.1 Air Cargo Demand

Air cargo demand is generated when there is a need for expeditious transportation of material and goods between two points. In the business world, logistics managers must justify the use of



Source: CDM Smith.

Figure 2-1. Simple air cargo area diagram.

air cargo as their preferred mode of transport since shipping by air is of greater cost than shipping via truck, rail, or water. Factors involved in deciding to transport via air include:

- Cost of transporting the material,
- Level of service commitment to the customer or end user,
- Value of the material, and
- Time sensitivity of the material.

Products that benefit from increased speed of distribution or better stock availability provided by air cargo shipping include those that are of high value, are relatively lightweight, and where shipping is time critical. These include:

- Aerospace—equipment and parts;
- Automotive—equipment and parts;
- Documents;
- Banking materials;
- Pharmaceuticals;
- Pharmaceuticals—active product ingredients;
- Jewelry;
- Medical diagnostic equipment;
- Medical devices;
- Textiles—garments, apparel, shoes, and textile parts;

- Consumer electronics;
- Computers and computer components;
- Telecommunications equipment—cell phones, iPhones;
- Perishables—flowers, fruit, vegetables, and seafood; and
- Economically perishable materials—printed material.

The following four economic factors are the general primary drivers behind air freight growth:

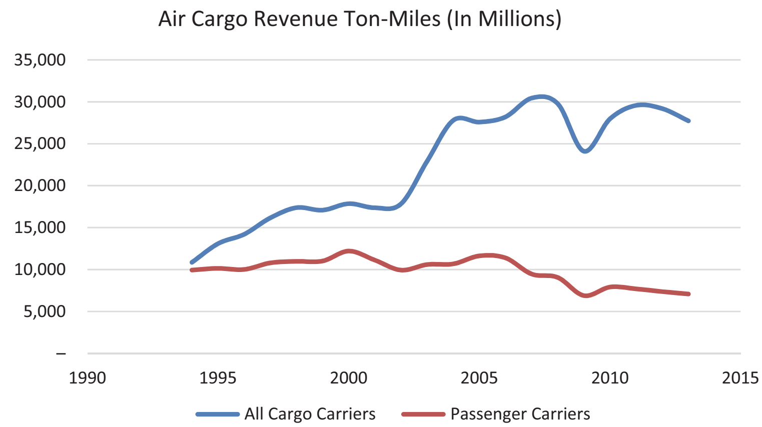
- Economic growth. Air freight is a subset of world trade, which is directly related to world economic growth. Trade has grown explosively over the past four decades. From 1970 to 2010, the value of exports has grown by a factor of 48 if measured in current dollars, while gross domestic product (GDP) increased 22 times and population increased 1.8 times.
- Globalization. Each day, the world economy becomes more integrated and interdependent. Progressive economic integration and steady reduction in protectionism boost overall trade flows and, in conjunction, air freight traffic. Air freight accounts for 35% of global freight value (some $6.4 trillion) due to small, high-value categories of inventory and just-in-time processes inherent in parts of the supply chain.
- Lean-inventory strategies. More companies, large and small, are focusing on order-cycle time reduction and lean-inventory strategies—including just-in-time and make-to-order—as a competitive advantage. Firms use air freight to shorten delivery times to the end customer.
- E-Commerce. Increased sales in both the business-to-business (B-to-B) and business-to-consumer (B-to-C) areas via the Internet have made E-commerce a $220-billion industry, growing at almost 20% per year. E-commerce, whether B-to-B or B-to-C, has had a significant impact on the growth of air freight.

2.1.2 Air Cargo Process

Air freight is transported in dedicated cargo aircraft and in the cargo space of passenger aircraft (belly cargo). Inbound belly cargo is unloaded and transported to cargo facilities or from one aircraft to another aircraft, while outbound belly cargo is transported from trucks to the cargo terminal and loaded onto the aircraft prior to departure. International cargo arriving as imports may have been pre-cleared electronically or may be subject to additional inspection by regulators before being cleared to leave the airport. As with baggage handling, cargo on narrow-body and smaller aircraft is loaded individually, while cargo on wide-body aircraft is containerized.

Perhaps one of the most unique attributes of the air cargo industry is the rapid loading and unloading of commodities onto wide-body and narrow-body freighter aircraft via unit load devices (ULDs), including pallets and igloos. Cargo aircraft have large doors and rollers fastened to the deck of the aircraft. These aircraft allow containers and pallets laden with freight and mail to be rolled on and off either manually or through a mechanized system.

All large domestic air carriers report annual operating statistics to the U.S. Department of Transportation (U.S. DOT) by filing Form 41, which includes information on revenue passenger miles, revenue ton-miles, and fuel consumption. Figure 2-2 shows trends during the 1990s in air freight revenue ton-miles by U.S. carriers (domestic and international service). In 1994, passenger and all-cargo carriers handled approximately equal amounts of air freight. Since that time, air freight on all-cargo aircraft has grown 64%, while air freight on passenger carriers has remained nearly constant. This is in part a reflection of the trend toward improving passenger load factors, changes in the aircraft gauge of passenger airlines, and reductions in domestic wide-body aircraft lanes, which result in less capacity for freight. Looking at just domestic flights, air freight handled by passenger carriers declined 28% between 1994 and 2002 as freight and mail shifted to the integrated express carriers, and the U.S. Postal Service relied less on passenger airlines and more on integrated express carriers to transport mail. While domestic cargo has



Source: FAA Aerospace Forecasts (multiple years).

Figure 2-2. Air freight revenue ton-miles by carrier type, 1994–2013.

been increasingly dominated by integrated carriers operating all-cargo aircraft, gateways serving transcontinental routes have recently experienced the opposite trend as more cargo-friendly passenger aircraft have taken market share from freighters.

2.2 Existing Conditions

Many cargo buildings at airports today were constructed in an era that had many more passenger and air cargo airlines. Today the air cargo industry on the U.S. domestic front has four remaining legacy passenger carriers and two integrated express carriers. The duopoly of FedEx Express and UPS dominate the U.S. domestic market since DHL pulled out of domestic cargo and transports only international cargo. This reduction in carriers is the result of airline mergers as well as the realities of a difficult economic period. Even low-cost passenger carriers have merged (Southwest and AirTran, for example), as well as integrated express carriers (such as DHL and Airborne and UPS and Menlo/Emery). The result of this shaking out within the domestic air cargo industry in terms of air cargo facilities is that many air cargo facilities at airports no longer have a wide customer base. This has led to many vacant cargo facilities or space that is not well utilized. For example, the U.S. Postal Service used to have airmail sorting facilities at most medium and large airports but has closed many since 2001 since much of its Express and Priority Mail has switched from passenger airlines to contract agreements with FedEx Express and UPS. On the international air cargo front, the passenger gateway airports continue to experience greater tonnage growth than the domestic airports, and more passenger routes and freighter routes continue to expand into U.S. airports.

2.2.1 Carrier Types

There are three primary air cargo transport business models that affect airport facility planning. These are passenger airlines, all-cargo companies, and integrated express carriers (FedEx Express and UPS). A fourth type of carrier, albeit a rarity in the industry, is a carrier that has both passenger and freighter aircraft in its fleet. Descriptions of each type of carrier are presented.

2.2.1.1 Passenger Airlines

A passenger airline provides cargo services to the industry by offering for sale the capacity of the belly compartment of its aircraft (see Figure 2-3) that is available after the passenger-related

Source: Wikimedia Commons, by Asiir.

Figure 2-3. Airbus A300 aircraft cross-section displaying cargo containers on lower deck.

items such as food/beverages, company material, and passenger luggage are loaded. Delta Air Lines and Southwest Airlines are examples of passenger carriers that sell belly space for cargo. Passenger airlines have limitations in the size of cargo they accept since they face capacity restrictions because of the combined services they offer, the size of cargo doors and payload capacity, and airframe limitations. However, these airlines can provide the industry with air cargo transport flexibility in the form of frequent flights to destinations. Moreover, in the case of Southwest, they use the same gauge of aircraft in their system, making flight transfers easier for shippers. Such service capability reduces the chances of the cargo being bumped from a flight.

Air cargo services provided by passenger airlines vary in scope and size from airline to airline, based on the gauge of aircraft operating within their fleets. A regional airline, with a fleet of turboprop and regional jets, cannot accommodate bulky cargo due to limited cargo capacity in baggage compartments. Many passenger airlines operating transcontinental service do so with wide-body aircraft capable of accommodating containerized cargo and larger shipments, although narrow-body aircraft are increasingly being used on transcontinental routes. Passenger airlines generally provide airport-to-airport service, with freight and mail carried as belly cargo. Freight on passenger airlines is dropped off at a warehouse at the origination airport by a freight forwarder (or the shipper); the freight is then picked up at the destination airport by the customer (or freight forwarder) after arriving on the passenger airline.

2.2.1.2 All-Cargo Carriers

All-cargo carriers operate airport-to-airport air cargo and freight services for their customers but do not offer passenger service. All-cargo carriers include Polar Air Cargo, Atlas Air, and Kalitta Air Cargo, to name a few. Prior to its merger with Delta Air Lines, Northwest Airlines was one of the world's largest cargo airlines, operating a dedicated fleet of 14 B747F freighters. It was the only U.S. combination carrier (passenger and cargo service) to operate dedicated 747 freighters. As a result of the Northwest/Delta merger, the dedicated Northwest cargo freighters have been phased out, and Delta Cargo is focused on being a belly-only carrier. Internationally, Korean Air, China Airlines, Singapore Airlines, Lufthansa, and Emirates are also passenger airlines with their own fleet of dedicated freighter aircraft. All-cargo carriers offer scheduled service to major markets throughout the world using wide-body or containerized cargo aircraft.

Heavy-lift cargo freighters fall into the all-cargo carrier category and are operated by charter cargo airlines such as Volga-Dnepr Airlines and Antonov Airlines, which provide specialized heavy-lift operations with their fleets of Antonov An-124 and An-225 aircraft, respectively. Limited numbers of these aircraft exist since they are some of the largest aircraft in the world; therefore, operations are typically highly specialized charters and are seldom done on a scheduled basis. These carriers transport goods and equipment for businesses and governments. This type of cargo operation is commonly referred to in the industry as "project cargo."

2.2.1.3 Integrated Express Carriers (FedEx Express, UPS, and DHL)

Integrated express operators move the customer's goods door-to-door, providing shipment collection, transport via air/truck, and delivery. Dominant integrated express operators in North America include FedEx Express, UPS, and DHL. (DHL's U.S. domestic pickup and delivery service was discontinued in January 2009.) Express companies provide next-day and deferred, time-definite delivery of documents and small packages (2 to 70 pounds). Integrated express operators are increasingly transporting heavy freight (over 70 pounds). This is the next logical step in leveraging the unique scale of operations, network, and other resources that operators can bring to each business sector.

Additionally, with the bankruptcies of heavy cargo carriers such as Kitty Hawk and the merger of Menlo and UPS, the integrators are increasing market share in heavy freight. Integrated express operators use a hub-and-spoke transport model, similar to that used by passenger airlines. The air cargo hub used for package sortation and aircraft transfer is the backbone of integrated express operators. This allows for total product connection to each market in the operator's system. Each day of operation, flights from around North America arrive at the hub, where packages are unloaded, sorted by destination market, and loaded onto outbound aircraft. Integrators often make heavy use of automated sorting at their hub terminals in order to achieve desired turnaround times and delivery commitments.

Regional air cargo carriers operate smaller turboprop aircraft between origin-and-destination (O&D)/local market stations and smaller or more remote cargo markets, typically in support of a larger integrated express cargo operator such as FedEx, UPS, or DHL. Wiggins Airways and Mountain Air Cargo are examples of contracted feeder airlines to both UPS and FedEx. Feeder flights often transport cargo from a smaller market and feed cargo to an awaiting cargo jet bound for the carrier's hub. Feeder aircraft may also fly directly to a hub.

2.2.1.4 Combination Aircraft Carriers

Carriers that have both passenger and freighter aircraft in their fleet are considered "combination carriers." These carriers include Cathay Pacific, Emirates, and Lufthansa. For example, Lufthansa operates freighter versions of the MD-11F and the B777F. Combination aircraft carriers are often confused with a type of aircraft that carries both passengers and cargo on the main deck of the aircraft. Combination (combi) aircraft in commercial aviation are aircraft that can be used to carry either passengers (as an airliner) or cargo (as a freighter) and may have a bulkhead partition in the cabin to allow both uses at once. These combi aircraft typically feature an oversized cargo door as well as tracks on the cabin floor to allow the seats to be added or removed quickly. These aircraft were marketed early on by Boeing as "convertible" or "QC" (quick change), since they facilitated a rapid conversion between roles. Alaska Airlines operates B737-400 combi aircraft primarily to service airports in Alaska. At the international level, Asiana and KLM continue to operate B747-400 combi aircraft, which allow ULD containers and pallets to be loaded onto the rear portion of the main deck through a large cargo door while passengers travel in the forward portion of the main deck.

2.3 Airport Types

While the public generally understands the difference between commercial service airports and general aviation airports, the FAA provides a detailed classification of airports based on their levels of activity. These classifications are useful to airport planners in assessing the size and scale of aviation activity at these facilities. The guidelines presented in this report go a step further and provide descriptive groups of airports based on the type of air cargo activity that takes place on a regular basis. These groupings are not terms recognized by the FAA but are commonly used within the air cargo industry to describe the function of cargo carrier activity at an airport.

2.3.1 FAA Airport Classifications

The FAA places airports into five categories of airport activities:

1. **Commercial service airports** are publicly owned airports that have at least 2,500 passenger boardings each calendar year and receive scheduled passenger service. Passenger boardings refer to revenue passenger boardings on an aircraft in service in air commerce, whether or not in scheduled service. The definition also includes passengers who continue on an aircraft in international flight that stops at an airport in any of the 50 states for a non-traffic purpose, such as refueling or aircraft maintenance, rather than passenger activity. Passenger boardings at airports that receive scheduled passenger service are also referred to as "enplanements."
2. **Non-primary commercial service airports** are commercial service airports that have at least 2,500 and no more than 10,000 passenger boardings each year.
3. **Primary airports** are commercial service airports that have more than 10,000 passenger boardings each year.
4. **Cargo service airports** are airports that, in addition to any other air transportation services that may be available, are served by aircraft providing air transportation of only cargo with a total annual landed weight of more than 100 million pounds. "Landed weight" means the weight of aircraft transporting only cargo in intrastate, interstate, and foreign air transportation. An airport may be both a commercial service and a cargo service airport.
5. **Reliever airports** are airports designated by the FAA to relieve congestion at commercial service airports and to provide improved general aviation access to the overall community. These may be publicly or privately owned. This classification is a FAA National Plan of Integrated Airport Systems (NPIAS) classification (Federal Aviation Administration 2014).

The remaining airports, while not specifically defined in Title 49 United States Code (USC), are commonly described as general aviation airports. This airport type is the largest single group of airports in the U.S. system. This category also includes privately owned, public-use airports that enplane 2,500 or more passengers annually and receive scheduled airline service.

2.3.2 Airport Roles

In order to gain a better understanding of what drives air cargo operations to one particular airport versus another, it is important to differentiate the roles and uses of air cargo facilities, the operations they conduct, and the markets they serve. The function of an air cargo facility can be divided into the following six distinct roles, which are not mutually exclusive:

- International gateways,
- National cargo hubs,
- Regional hubs,
- O&D/local market stations,

- Cargo airports,
- Intercontinental hubs, and
- Alternate gateways.

It is important to point out that these roles describe how an airport functions in the air cargo industry and are not used by the FAA as airport classifications.

2.3.2.1 International Gateways

The gateway functions as a consolidation, distribution, and processing point for international air cargo. To a certain extent, an international air cargo gateway is similar to a hub airport in that the gateway airport is not reliant on the surrounding market area to generate sufficient cargo to justify air cargo–related operations. As with the air cargo hub, much of the cargo moving through a gateway airport does not originate and is not destined for the gateway airport's surrounding market area. Airports in the United States that are considered international gateway airports include those serving Miami, New York (JFK), Los Angeles, and Chicago. Evolving gateway airports include those serving Atlanta, Dallas, and Houston. The Detroit airport functions as a gateway to a lesser degree since it accommodates Delta international flights to Asia and Europe.

2.3.2.2 National Cargo Hubs

The hub is the backbone of an integrated express carrier since it provides connections to each market in the integrator's system. Each day of operation, flights from around the world arrive at the hub. Once at the hub, packages are unloaded, sorted for the appropriate destination market, and loaded onto the appropriate outbound aircraft. The majority of enplaned air cargo traffic at a hub/sort facility is generated from the aircraft-to-sort-to-aircraft process. The cargo traffic originating or destined for the local market is often a small percentage of the airport's total enplaned cargo traffic. In effect, the hub imports and exports demand for air cargo facilities and operations at the host airport. Major hub airports in the United States include those serving Memphis, where FedEx Express operates its "super" hub; Louisville, where UPS has its global hub; and Cincinnati, where DHL operates its U.S. hub. The market area of an airport's cargo hub is typically located within a 3-hour driving radius of the airport. Typically there are no cargo flights from the hub to airports within this radius since trucking is a less expensive alternative.

2.3.2.3 Regional Hubs

Regional hubs serve the region in which they are located by performing the cargo sorting and distribution functions of that specific carrier's primary hub. UPS has regional hubs in the following locations: Dallas, Texas; Rockford, Illinois; Columbia, South Carolina; and Ontario, California. Cargo within those markets is able to bypass UPS' main hub in Louisville. UPS operates deferred parcel hubs in Des Moines, Iowa, and Spokane, Washington. Similarly, FedEx Express has regional hubs in Oakland, California; Fort Worth (Alliance), Texas; Greensboro, North Carolina; and Indianapolis, Indiana, enabling cargo within those markets to bypass FedEx's main hub in Memphis.

2.3.2.4 O&D/Local Market Stations

The criteria for a local market station, or direct air cargo service (O&D service to an airport's surrounding market area), generally coincide with population centers where there is a concentration of industry, commerce, and transportation infrastructure. Often referred to as a "node" within a cargo carrier's network, the local market station is the simplest and most common type of air cargo facility. These airports represent the spoke in a hub-and-spoke air carrier network. For airport-to-airport service providers, the local market station represents the origin or destination point for the cargo they are transporting.

The sole function of a direct air cargo service facility is to collect outbound air cargo from customers and distribute customers' inbound air cargo to the airport's surrounding market area. In order to make direct air cargo service economically feasible, the airport's surrounding market area (or catchment area) must generate enough inbound and outbound cargo and revenue to offset the carrier's aircraft operational costs. If the carrier cannot meet the aircraft operational costs, the cargo is trucked to the hub or another local market station where it is loaded onto an aircraft.

2.3.2.5 Cargo Airports

Cargo airports are dedicated to the movement of air cargo and offer the advantage of uncongested airspace relative to airports with passenger airline service. Just as the lack of passenger service is an advantage to cargo carriers operating at these airports, it is also a disadvantage for forwarders and other customers since belly space for cargo parcels is unavailable. As a result, few examples of strictly cargo airports exist. Prior to closure in 2009, Airborne Airpark, located in Wilmington, Ohio, was the only true cargo airport as it was owned and operated by DHL (and formerly Airborne Express) solely as its primary integrated express hub.

2.3.2.6 Intercontinental Hubs

An intercontinental hub connects two or three continents by air cargo and passenger aircraft and can be located in a relatively remote part of the world, away from dense populations. These airports offer cargo hub capability as well as aircraft service centers for aircraft needing to refuel and change crews. Ted Stevens–Anchorage International Airport falls into this category.

2.3.2.7 Alternate Gateways

There are several airports in the United States that have earned the reputation of operating as alternate gateways or cargo airports for the air cargo industry. These airports either marketed themselves heavily to the air cargo industry during the industry's formative years (during the late 1980s and early 1990s), or they have locations in proximity to major distribution or production centers of time-sensitive commodities. These airports and their anchor industries are shown in Table 2-1.

Airports pursuing development of freighter routes often argue that operations at their airports offer a less congested environment for cargo aircraft. While there are savings to operating in less busy airports, air carriers prefer dealing with congestion, as well as frequently higher airport costs and land rents, in order to locate where steady demand exists and profits can be attained. Connectivity—sheer volume and diversity of frequencies, destinations, and carriers—is important to garnering consolidations that also attract competition in supporting vendors such as for ground handlers and trucking. It is also important to point out that non-American air cargo carriers do not have comparable U.S. domestic networks, so they interline with U.S. passenger and cargo carriers and rely on allied service providers—extensively trucking—for interior transport. Therefore, the flow of international carriers from one gateway to another is unsurprising. This service superiority attracts shippers and forwarders, whose demand then supports even more service at the gateway.

Table 2-1. Examples of alternate air cargo gateways.

Airport	City	Anchor Industry
Rickenbacker International Airport	Columbus, OH	Apparel
Huntsville International Airport	Huntsville, AL	Automotive, defense, aerospace
Indianapolis International Airport	Indianapolis, IN	Pharmaceuticals

Source: CDM Smith.

Air forwarders rely on a mix of belly and freighter capacity. Consolidations lead to gravitation to gateways where air options are greatest. Network offices merely feed those consolidations, mostly with trucks. Simply having a variety of forwarders in an area does not guarantee alternative gateways the critical mass required to support international operations. Local forwarder station managers have little autonomy in routings when the company must satisfy volume-dependent block-space guarantee agreements with passenger and freighter carriers at major gateways. As such, developing an airport as an alternative gateway is often an uphill battle since well-established gateway airports have considerable inertia—in the form of lift and supporting services—in their favor.

CHAPTER 3

Air Cargo Planning Approach and Process

The air cargo industry is a service industry that provides shippers transportation of their products, goods, and materials. Unlike passenger transport, whose customers typically travel round trip on aircraft, air cargo packages and parcels are one-way shipments. In addition to using aircraft for their operations, the industry also relies heavily on a wide range of truck types. The industry is labor intensive, fast paced, and operates on a 24/7 schedule. In general, it is profit focused and will only operate aircraft at an airport when it is deemed profitable. It is also important to point out that the air cargo industry, particularly on the aviation side of the business, is heavily regulated by the federal government. These factors are directly linked to sound airport planning practices and management.

3.1 Approaches to Air Cargo Planning

Airport air cargo planning studies typically focus on development of new cargo facilities, expansion/renovation of existing facilities, or a combination of developing new facilities and improving existing ones. These guidelines are to assist the airport community in using a consistent and thorough study approach in air cargo facility solutions. This section describes the major steps in this process. It is important to note that air cargo facility planning may be included as an element of an airport master plan, which takes into consideration planning for a wide variety of airport facilities, such as passenger terminals, automobile parking, roadway access, runway and taxiway lengths and layout, and general aviation facilities. The airport sponsor may also choose to plan specifically for air cargo facilities in a separate airport master plan focusing solely on the air cargo areas and activities at the airport. This plan may fall under the categories of a stand-alone cargo master plan, an air cargo business development strategy, or an air cargo development plan.

The planning and development of air cargo facilities follow the airport master planning process typically used to plan and design an entire airport or specific airport projects. A general outline of the cargo facility planning process is provided in Table 3-1. It is important to consider all of these steps, but the process should be tailored to the needs of the individual airport.

3.2 Facility Inventory and Data Collection

When comparing the airport passenger terminal master planning process to that of the air cargo terminal or warehouse master planning process, the passenger terminal planning process has far more data available to the airport planner. Airports often have better data on passenger terminals since they have command and control of the terminal throughput information. Airports collect information on passenger movements through the curbside, ticketing, security, and gate hold rooms. Airports also collect data on passenger expenditures related to concessions as

Table 3-1. Cargo facility planning process.

Master Plan Step	Master Plan Goal
Identification of need: Identify the need for a new cargo facility(s), modification of an existing cargo facility, or other reconfiguration or repurposing of an air cargo facility area, which may be identified by one or more entities.	Define, as clearly and specifically as possible, the air cargo planning and design objectives, as they can influence the project.
Inventory: Upon identifying a potential need for air cargo facilities, existing air cargo and non–air cargo facilities should be inventoried to provide a basis for understanding the capacity and operation of existing facilities as well as the physical and operational characteristics and constraints of the airport and project vicinity.	Have a thorough understanding of the physical, environmental, business, and operating environment to ensure appropriate consideration during the planning and design processes.
Demand forecasts: Future air cargo demand can be obtained from the requesting stakeholder(s) or developed by a planner/designer or airport management through a forecasting process. Forecasted activity at the air cargo facility, including the fleet serving the airport and the peak demand on the apron throughout the day, is necessary to determine air cargo facility area requirements.	Quantify, to the degree possible, what the planned air cargo facility must be able to accommodate.
Air cargo facility requirements: The demand forecasts and the inventory information are used to derive air cargo facility requirements for the anticipated aircraft fleet and the ground support equipment expected to use the air cargo facility.	Define the physical, operational, and dimensional parameters that must guide the air cargo facility planning and design process and be met during it.
Alternatives development: Once the air cargo facility requirements have been determined, alternatives to meet these requirements are defined, considering the operation of the air cargo facility, impacts to proximate facilities, and other planning criteria or guidelines.	Define air cargo facility alternatives that are anticipated to satisfy the project requirements, recognizing that these alternatives will be further evaluated in a later step.
Evaluation of alternatives: If more than a single alternative is considered, all alternatives should be evaluated in this step to reduce the number of alternatives to a preferred one. This evaluation is usually completed by using a set of criteria agreed on by stakeholders.	Review the candidate air cargo facility alternatives and determine which best meet the goals of the project sponsor and its stakeholders, balanced against the costs, impacts, potential environmental consequences, and other relevant criteria.
Refinement of preferred alternative: In this step, the preferred project alternative is refined to resolve shortcomings identified in the evaluation process or from additional input from stakeholders. The refinement can include value engineering to maximize project cost-effectiveness.	Define the preferred project alternative at an appropriate level of detail for implementation.
Implementation planning: This step in the planning and design process enhances the understanding and definition of the conceptual project by providing a summary description and schedule of the recommended improvements, estimated associated costs, potential environmental impacts, and National Environmental Policy Act (NEPA) documentation.	Examine the project in light of the steps that would typically be necessary prior to project construction to minimize the potential for unexpected influences or constraints to affect eventual project implementation.
Environmental processing: If a federal action is associated with the air cargo facility project [approval of an airport layout plan (ALP), acceptance of federal grant funding, etc.], NEPA documentation may be required to accurately disclose potential environmental impacts related to the proposed federal action and reasonable alternatives to the proposed project.	Develop an understanding of and document the potential environmental impacts, particularly in those cases where such impacts could influence the project.

Table 3-1. (Continued).

Master Plan Step	Master Plan Goal
Air cargo facility design: Air cargo facility design may begin before or after environmental processing, depending on the level of environmental documentation required. Initiating design prior to NEPA approval could be risky in that the design may need to be changed to address environmental concerns. The design of an air cargo facility is usually coordinated with the airport operator and tenants through a design review process. Air cargo facility design also requires additional information not necessarily detailed in the description of the planning and design processes, such as topographical surveys. Final design usually includes the preparation of construction documents and bid specifications.	Design an air cargo facility that meets current and future industry needs as well as FAA and NEPA standards.
Air cargo facility construction: After selection of a contractor, construction of the air cargo facility is completed in accordance with the air cargo facility design information.	Construct an air cargo facility that meets current and future industry needs as well as FAA and NEPA standards.

Source: *ACRP Report 96* (Quinn 2013), amended by CDM Smith.

well as baggage claim information. The challenge for the airport planner then is the lack of data on air cargo movement and throughput within air cargo buildings and support infrastructure. For decades, airport management has provided space for air cargo carriers and other cargo-related businesses without a thorough understanding of the methods and practices of cargo carriers. In the United States there is in fact a veil of obscurity between the air cargo industry and airport management. Airport planners understand the general movements of cargo through the landside and airside cargo infrastructure, but the carriers and third-party handler businesses have the best grasp of the cargo activities at airports. Even third-party facility providers lack detailed information on cargo building throughput since their air cargo–related tenants internally perform facility strategies and plans. The carrier may choose to move cargo primarily via forklift and pallets, or it may choose a slide-sortation system since the carrier will move primarily small packages. Large cargo facilities at international gateways may rely heavily on roller floors for ease of ULD movement. These design and planning decisions are often made at the corporate level by the carrier's industrial engineers.

The airport planner who has been given the air cargo planning task may also find that air cargo master planning is at the low end of the priority list in an airport's master planning process. As a result, the planner may have limited funds to perform a thorough cargo data collection effort since, for example, the passenger terminal planning was given higher priority. The planner then must make wise choices on the best methods of collecting information on cargo activity without depleting the planning budget. The purpose of this guidebook is to provide detail on a number of methods available for airport planners to assess what air cargo data is available and what is missing and to develop cost-effective strategies to fill information gaps to improve the air cargo facility planning process.

3.2.1 Inventory Strategies

The first step in developing the air cargo master plan is to define the current situation at the airport. Airport planners should complete an inventory of current air cargo facilities, associated ramp space and truck circulation space, their capacity, and the percentage of that capacity the users of those facilities are currently using to process the current level of air cargo handled at the airport. Surveys should include online or paper surveys as well as face-to-face interviews with air cargo stakeholders. This will provide insight into whether the current air cargo facilities and ramp space have ample capacity to accommodate increases or whether additional air cargo facility capacity will be required in the near or long term. When conducting this inventory, airport planners should focus on the land and facilities required by airlines, integrated carriers, and air cargo handlers for both air cargo handling and ground support equipment (GSE) storage and maintenance. Larger airlines, integrated carriers, and ground handing companies with large fleets of GSE require sizable facilities to maintain their GSE fleets and equipment. If the integrated carriers choose to maintain their delivery trucks at airports, larger maintenance facilities may be required due to the magnitude of their truck fleets.

When completing an inventory of air cargo facilities, airport planners should also consider the air cargo facilities located off airport and the economics of a user having an off-airport air cargo facility versus locating that facility on airport. In many cases, it is more economical for a user to purchase land off airport and construct an air cargo facility versus leasing land and constructing an air cargo facility on airport. By understanding the economics of developing or operating an off-airport versus on-airport air cargo facility, airport planners will gain insight into the competitiveness of the airport's rates and charges and may have to adjust land and facility rents. This will be addressed in Chapter 8: Air Cargo Facility Planning—Funding Strategies.

Once a comprehensive inventory of all air cargo and support facilities has been completed for a given level of air cargo volume, airport planners should focus on the development of an air cargo forecast. The research team arrived at similar conclusions to those in *ACRP Report 96: Apron Planning and Design Guidebook* in that the inventory effort should include:

> Interviews with stakeholders, including airport management, airlines serving the airport, airport tenants, and third-party providers. The goal of the inventory process is to ensure a thorough understanding of the physical, environmental, business, and operating environment to ensure appropriate consideration during the planning and design processes (Quinn 2013).

A paper or online survey may not collect some of the nuances of the air cargo industry's on-airport operations.

3.2.2 Stakeholder Involvement

There are a variety of users of airport-related facilities. These stakeholders will have different needs, wants, and demands. The following is a list of some of these users:

- Passenger airlines
- Integrated express carriers
- All-cargo carriers (freighters)
- Cargo and ground handling companies
- General sales agents
- Freight forwarders and third-party logistics providers
- Air cargo–related trucking companies
- Special handlers (cool chain, high value/security)
- Security screeners
- GSE maintenance providers
- Customs, Transportation Security Administration (TSA), and related border protection agencies
- Other government agencies that can benefit from being on airport
- Service providers related to air cargo and airport operations
- Airport management
- Postal service providers
- Delivery service providers

Many users, such as passenger airlines, freighter airlines, and integrated carriers, require their own buildings. Some airlines will share their buildings with their strategic partners and service providers. Other users will share multi-tenant cargo buildings and can easily adapt to most existing spaces. But the utilization of airport-related space has shifted considerably in the past few years. Many years ago, most cargo facility leases were signed by airlines. Now, service providers such as ground handlers are as likely to be required to take on the facility's leasing, then lump the real estate costs into the overall fees the service providers charge to the airlines.

3.3 Data Collection Challenges

Air cargo master planning revolves around two key aspects of air cargo activity: spatial needs for the movement and storage of air cargo vehicles (trucks, aircraft, and GSE) and space for the storage of air cargo. (Storage of cargo may last from several days to mere minutes.) This section identifies sources of air cargo data that will assist the airport planner in developing an inventory of facilities and traffic volumes. While a survey of cargo businesses is often the best method of collecting data, it is important that the airport planner use in-house data whenever possible as well as develop a continuous data collection effort for a wide variety of cargo activities. Additionally, the air cargo industry in many of the larger cargo markets has air cargo associations that include both carriers and air forwarders. These organizations may assist in data collection efforts, and airport management benefits by supporting these groups.

3.3.1 Cargo Volume

Data on cargo volume or traffic at airports is typically collected by airport management in its operations division, planning division, air service development division, or business planning division. Types of cargo volume data collected usually include air cargo (freight and mail) weight in tons or pounds (monthly and annually). Usually one or two people in airport management are required to collect the data from the air carriers and enter the data into a database. This data is typically prepared to be presented in report or spreadsheet format. It is noteworthy that some airports gather cargo data as landed weight by carrier, which includes both the aircraft weight and the payload weight. While this type of data collection follows an FAA method of gathering data on cargo, it is an incomplete data source and is difficult to use in cargo facility analysis.

Some airports will track and provide air cargo weight statistics by carrier market share. This data is beneficial to the airport planner since it provides information on how much cargo each carrier is moving through its assigned area on the airport. Annual air cargo tonnage by market share should be broken down by category of carrier. Carriers include integrated express carriers such as UPS, FedEx Express, and DHL; passenger airlines (belly cargo) such as American Airlines, Delta, and United; all-cargo carriers, which operate only freighter aircraft, including Cargolux and Centurion Air Cargo; and combi carriers. Combi carriers are passenger airlines with a separate fleet of cargo aircraft, such as Lufthansa.

Air traffic control towers also have air cargo carrier operations data by type of aircraft (passenger or cargo, etc.), carrier name, and aircraft design type. Air traffic control tower data is also useful for determining peak hours of cargo operations. Air cargo traffic arrival and departure data may also be obtained relatively inexpensively through Official Airline Guide (OAG) schedules, FAA instrument flight rules (IFR) data, and Flightaware.com data.

Data on air cargo volume arriving and departing airport cargo facilities on trucks is difficult to obtain. This information would only be known by the truck operator or carrier, and airport management does not require this data. A survey of carriers may provide information on truck volumes, but it is again proprietary information and may not be easily obtained. Air forwarders that are located off airport often will not provide this information if requested by airport management.

Import and export information based on international air freight data can be obtained from the Bureau of Transportation Statistics (BTS), Research and Innovative Technology Administration, and the U.S. DOT, Office of Airline Information. The *Journal of Commerce*'s Port Import Export Reporting Service (PIERS) is a private-sector data provider.

3.3.2 Cargo Operations

Cargo operations take place in three primary areas on an airport. On the landside, truck operations take place at building/warehouse loading docks and parking lots. Operations also take place at the cargo building where cargo is handled and stored as well as sorted in the case of integrated express carriers. Cargo operations also take place on the aircraft ramp or apron area and where aircraft and GSE vehicle operations intermingle as well as the taxiway and runway systems. The discussion here, however, is limited to the immediate areas of an airport operating environment designated for air cargo activity.

3.3.2.1 Cargo Security Operations

Collecting data on warehouse space designated for security is challenging since air cargo operators are reluctant to discuss or provide this information due to the sensitive nature of the topic. Also, the utilization rate for security equipment varies greatly. For example, a passenger carrier may have a single workbench-sized platform for operating trace detector equipment, while another cargo warehouse for passenger carrier hub operations may have three scanner detection systems, two of which are used for scanning packages and the other used for scanning oversized cargo positioned on wooden pallets.

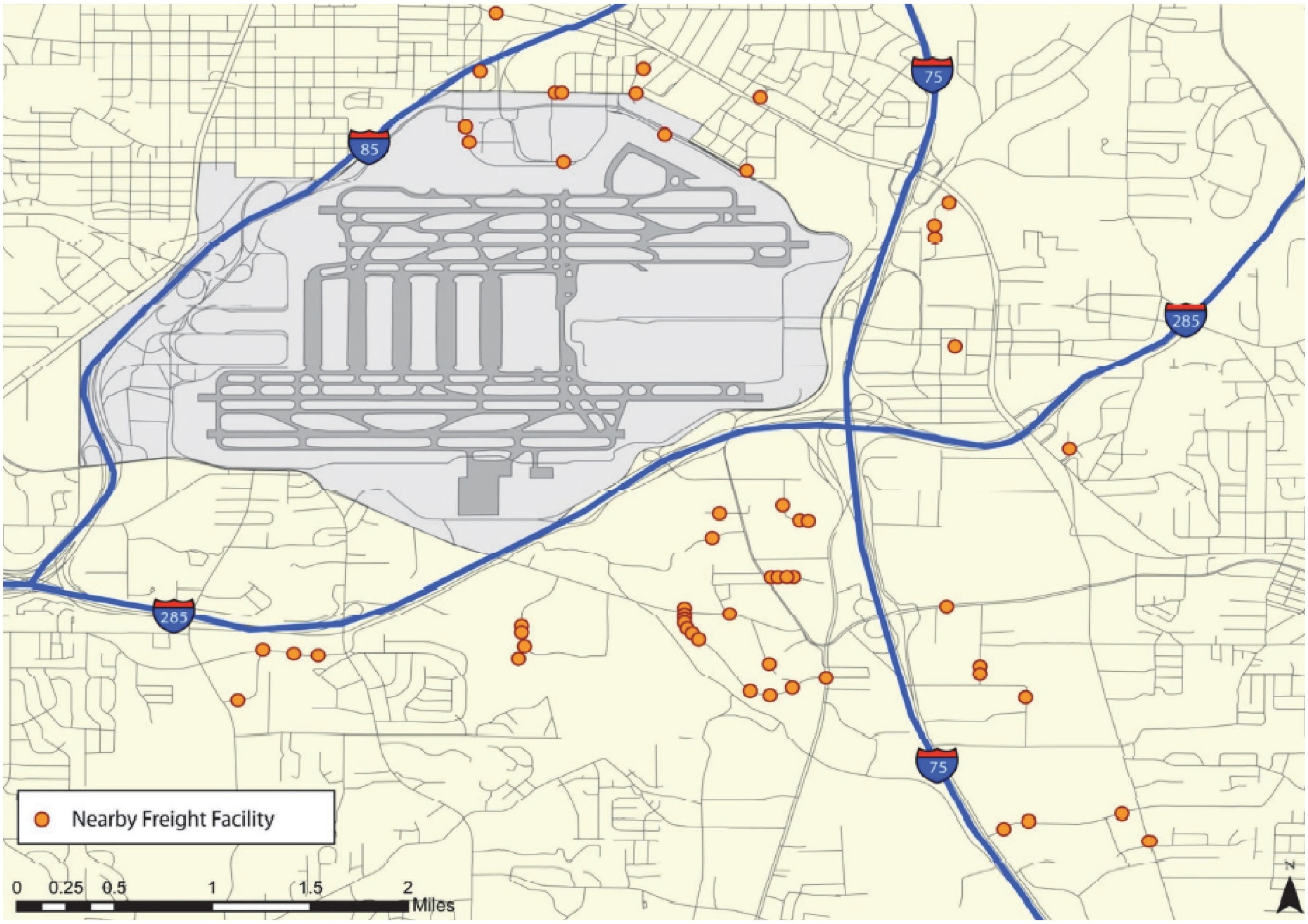
3.3.2.2 Air Forwarders

Air forwarders are often located at off-airport locations, which makes gathering data for these facilities extremely difficult. Air forwarders are located on an airport when they need the direct advantage of access to aircraft. Since lease rates are almost always lower at off-airport warehouses in the vicinity of an airport, air forwarders often choose to locate at these facilities. Figure 3-1 identifies air forwarder locations in the vicinity of Hartsfield-Jackson Atlanta International Airport (ATL). An airport planner's work efforts may include collecting data from off-airport forwarders to gather information on the number of truck movements to the local airport.

3.3.2.3 Truck Parking/Movements

Truck movements on the landside area of the airport include truck trips on airport access roads as well as truck parking in designated lots in the air cargo area. These lots may be adjacent to air cargo buildings or in separate designated truck parking lots. Data for truck parking can be collected by airport planners by conducting an air cargo truck parking survey. This would entail collecting truck parking data through observation as well as truck driver surveys. Survey questions would request information related to arrival time, departure time, parking duration (waiting time), truck type and size, commodities carried, and origin/destination data. Other data that could be collected includes frequency of trips to the airport cargo area on a weekly or monthly basis. Surveys would need to be conducted at various predetermined times throughout the week. Other tools used to collect truck operations and fleet mix data could include traffic counters as well as webcams or security cameras.

In 2011, the Federal Motor Carrier Safety Administration concluded a study using webcams to evaluate a technology capable of collecting data to determine whether a truck parking area is full, and if not full, to indicate the number of spaces available (Figure 3-2). The program used



Source: Atlanta Regional Freight Mobility Plan, 2008.

Figure 3-1. Freight forwarder location map, Hartsfield-Jackson Atlanta International Airport.

the SmartPark video system, which has software that automatically counts vehicles entering and exiting a rest area truck parking facility by using video cameras that monitor the entrance and exit ramps to the truck parking area without the involvement of human operators. It used this information to determine a count of available truck parking spaces. Image processing software in the cameras was designed to detect when a vehicle appears in the image. The image processing software distinguished between trucks, tractors, and other vehicles based on overall vehicle

Source: Federal Motor Carrier Safety Administration.

Figure 3-2. Example truck parking camera system.

length. Vehicle detections were transmitted from the cameras to the on-site computer. The Autoscope Solo Terra video detection system is the key element of the SmartPark video system.

3.3.2.4 Truck Access/Movements

Air cargo roadway access data is often needed at airports with significant cargo trucking operations. Data collection tools include manual or handheld counters that are used for intersection and other visual count or classification studies performed by a field surveyor. For automated data collection, the most common short-term data collection method for traffic counting and classification is known as the "road tube" method. The main reason for this is that the data collected is accurate and economical compared with other detection methods. Road tubes are used to detect vehicle axles by sensing air pulses that are created by each axle (tire) strike of the tube in the roadway. This air pulse is sensed by the unit and is recorded or processed to create volume, speed, or axle classification data. While one road tube is used to collect volume, two road tubes can be used to collect speed and class data. When a pair of wheels (on one axle) hits the tube, air pressure in the compressed tube activates a recording device that notes the time of the event. Based on the pattern of these times (for instance, the length of the interval between the time that two axles of a typical vehicle activate the counter), the device will match each compression event to a particular vehicle according to a vehicle classification scheme.

3.3.2.5 Warehouse Bypass Truck Traffic

Some airports permit trucks transporting air cargo to pass through security gates to deliver or pick up air cargo directly on the aircraft apron. This practice allows for expedited cargo handling of large project cargo, cargo contained in ULDs, and bulk-loaded or loose cargo. Data related to this activity may be collected, via survey or interview, from air cargo businesses using this practice or through observation of activity. Data collected would be similar to data collected for the truck parking area, with a focus on truck on ramp duration, size of truck, and average tonnage transferred directly from the truck to the aircraft or vice versa. The cost of collecting the data via observation can be expensive since a field surveyor will need to be in position to collect the data for a period of time. Other sources of data include collecting of information from airport security records on who (what company) has accessed the ramp via a cargo area security gate and the length of time these trucks were on the ramp. This data would not have the type and size of truck, however. Another data collection tool would be webcams or security cameras that record traffic through these gates.

3.3.2.6 Cargo Tug Traffic to Passenger Terminal

Data collection regarding tug operations for transporting cargo to passenger airline aircraft is commonly overlooked in an airport master plan. Data needed for accurate analysis of these operations includes distance from the passenger airline's warehouse to the passenger terminal as well as average tug time and frequency of these operations. Data collection should also include the user's estimates of the sufficiency of the tug time and distance as well as ways to improve connectivity between the terminals and the warehouses. Surveys or interviews of tug-lane users provide the best means of collecting the data. Observation by data collection team members is also a viable, but more expensive, method. Observation data will also miss the volume of air cargo transported per vehicle during each movement.

3.3.2.7 Ground Support Equipment

GSE needs space for: maneuvering equipment between the warehouse and aircraft, storing equipment when it is not in use, and storage of ULDs that may contain cargo. Data collection efforts regarding GSE needs should also take into consideration the type of entities using space for GSE. These primarily are integrated express carriers, third-party ground handlers, passenger airlines moving belly cargo, and cargo carriers with freight aircraft, all of which have varying needs related to GSE. Passenger airlines, for example, do not need aircraft ramp space adjacent to the cargo warehouse but still require space for maneuvering and storage of tugs and carts. Surveys or interviews of carriers with GSE needs provide the best means of collecting the data. Aerial photographs can be used by airport planners but would be fairly limited in determining the flow of GSE during peak periods of operation.

3.3.2.8 Hydrant Fueling

Hydrant fueling is typically required at cargo areas on airports where high volumes of Jet-A fuel are required for large aircraft. Airports that serve as air cargo hubs or international gateways to the air cargo industry benefit from hydrant fueling beneath the cargo apron as it reduces fuel truck traffic as well as expense. Data collection to determine whether a need for it exists within the airport's air cargo carrier community must take place with direct consultation with a cargo carrier's facilities planning/engineering division.

3.4 Techniques to Backfill Missing Facility Space Data

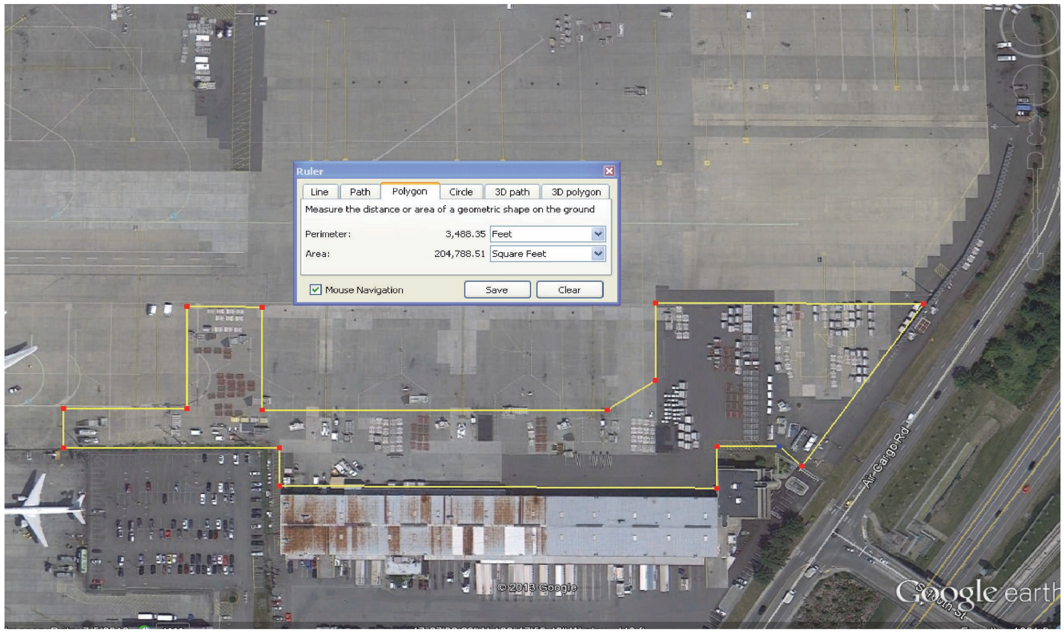
Airport planners may use various online sources such as Google Earth Pro, Bing Maps, and government records to obtain missing information on building size, occupant space in square feet, and space used by air cargo businesses for truck parking, truck docks and truck door counts, gate access, aircraft ramp space, and GSE storage. This section presents methods and tools for collecting data for air cargo facility space and uses where gaps exist.

It is advised that airport planners with aerial photograph interpretation skills conduct an analysis of air cargo facilities. Airport planners with an understanding of airline and air cargo operations as well as skills in air photograph interpretation will be able to determine several patterns in activities on the ground related to air cargo operations by type of carrier and building occupant. Information and land use patterns can be ascertained through aerial images regarding aircraft ramp space, GSE space, warehouse space, truck parking, loading docks, and loading doors. Information may also be obtained for cargo roadway access, aircraft taxiway and taxi-lane access, and security gates.

One of the primary tools for gathering information on space used for air cargo activity on an airport is the analysis of aerial and satellite images using Google Earth Pro or Bing Maps. Google Earth Pro allows the user to measure areas via a polygon measuring tool. This tool provides options for measuring area in square footage, square yards, acres, meters, and so forth, and can be applied to air cargo warehouses, GSE area, aircraft parking ramps, and truck parking. Google Earth Pro also has options for viewing buildings and structures from a street-view perspective as well as a three-dimensional (3-D) building option. (Not all buildings have the 3-D data input into Google Earth.) Bing Maps provides aerial views of airports and has an oblique or bird's eye view that allows for views of the sides of buildings. Airport layout plans (ALPs) are also useful tools for airport planners to gather data on facilities, but the advantage of aerial photographs is that aircraft types and the types of ground handling equipment in the GSE area can be determined.

3.4.1 Ground Support Equipment Storage

GSE storage locations are typically adjacent to air cargo warehouses and are often placed on pavement near the aircraft parking ramp. GSE storage also commonly follows security fence lines and consists of a mix of equipment. GSE typically includes ULDs, dolly trailers for towing ULDs, portable air stairs, tugs, belt loaders, and K loaders for loading cargo onto aircraft main decks. Equipment may also include auxiliary power units (APUs), forklifts, slave pallets, and aircraft maintenance vehicles. Deicing equipment may be stored in GSE areas during the winter months. GSE areas may be divided by a tug lane that is marked on the pavement. Aircraft taxi lanes may also be adjacent to the GSE area and should not be included in the size



Source: Google Earth Pro, CDM Smith Analysis.

Figure 3-3. GSE area estimate for FedEx Express at Seattle-Tacoma International Airport.

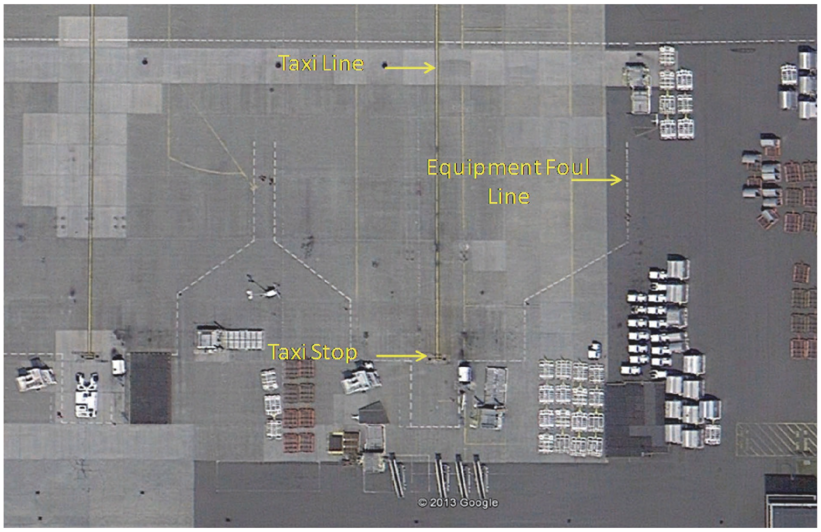
analysis. Figure 3-3 shows an example of GSE space analysis in Google Earth Pro for the FedEx Express facility at Seattle-Tacoma International Airport (SEA). The yellow polygon identifies the assumed boundary for the GSE space, with the total area being just over 200,000 ft^2. It is noteworthy that the hardstand area for ATR-73 aircraft in the far right portion of the polygon (light-colored pavement) is used for GSE storage. GSE areas adjacent to passenger belly cargo warehouses typically do not include space for aircraft ramps since air cargo is tugged to the passenger ramp area near the terminal.

3.4.2 Aircraft Parking Ramp

Aircraft parking areas can be ascertained by noting where aircraft are parked in an aerial photograph, but often cargo aircraft are not present when the image is taken. Airports typically mark aircraft hard stands by painting parking positions and other important demarcations on the pavement. Figure 3-4 illustrates the typical parking position markings for the FedEx Express hard stand (ramp) at SEA. The yellow taxi line is at the center of the parking position, with the equipment foul line marked in white, which forms the shape of an aircraft profile. Figure 3-5 is an example aircraft ramp space analysis in Google Earth Pro for the FedEx Express facility at SEA. The yellow polygon identifies the assumed boundary for the aircraft parking space. The total area is approximately 180,000 ft^2 of space.

3.4.3 Air Cargo Warehouse

A number of tools are available to the airport planner for determining the space associated with air cargo warehouse areas when this information is not available from lease/sublease documents and tenants are unresponsive to requests. A cargo building with a single tenant occupying 100% of the space is fairly easy to assess. Using Google Earth Pro, the cargo building perimeter can be outlined. Care should be taken to not include office space as warehouse space. Office space may be located in a wing of the building or it may be carved out of warehouse space.

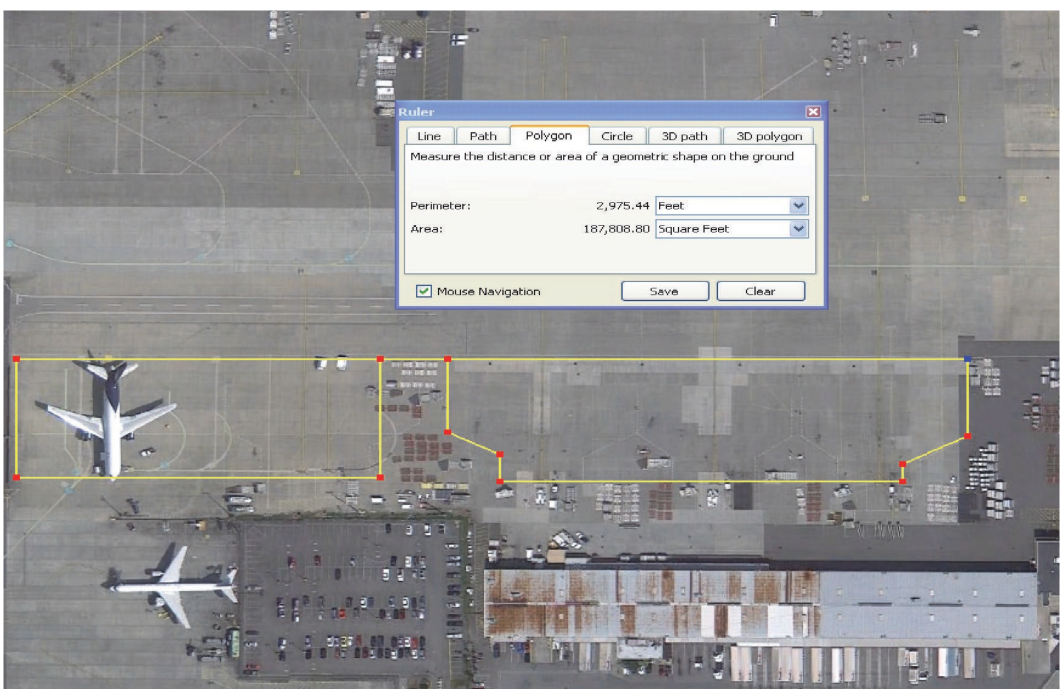


Source: Google Earth Pro, CDM Smith Analysis.

Figure 3-4. Example cargo aircraft parking position—FedEx Express at Seattle-Tacoma International Airport.

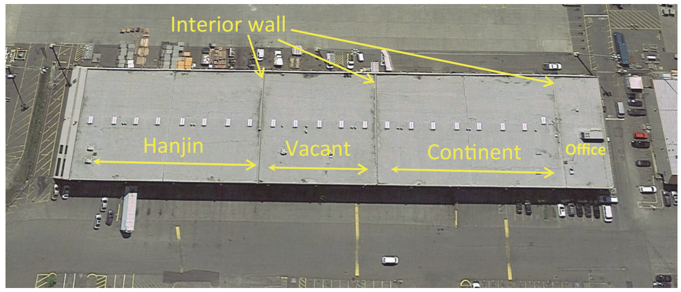
Carved-out office space information can usually be obtained through the building landlord or by requesting it from the tenant. Typically, office space in a warehouse that has adjacent aircraft parking is kept to a minimum to optimize the use of the warehouse floor. Office space may also be located on a mezzanine level within the building.

One of the more challenging aspects of remotely assessing the space of a warehouse is determining the amount of space assigned to each occupant. In the case of Building B at SEA, square



Source: Google Earth Pro, CDM Smith Analysis.

Figure 3-5. Aircraft parking area estimate for FedEx Express at Seattle-Tacoma International Airport.



Source: Google Earth Pro, CDM Smith Analysis. For illustration purposes, the top of the photograph is oriented to the south.

Figure 3-6. Example estimating technique for Building B at Seattle-Tacoma International Airport.

footage was ascertained through a combination of air photographs (Bing Maps) and tenant surveys. In Figure 3-6, Hanjin provided the square footage for its office and warehouse space for this study. The square footage of the remainder of the building was unknown because it was not available from lease/sublease documents, and tenants were unresponsive to requests. Air photograph analysis in Google Earth and Bing Maps and assessment of the remaining facility from the exterior during the fieldwork portion of the study assisted in estimating the remaining warehouse space.

Warehouse occupant space information may also be obtained, as a last resort, through local building permits and county auditor/assessor websites. For example, for the UPS cargo building at Lambert-St. Louis International Airport, the St. Louis County Revenue Division has information on the building size, lot acreage, year built, lists of improvements, and heating systems, among other criteria. Nearly every county in the United States has similar property databases, with some being more robust than others. An additional source for cargo building occupancy and space breakouts are third-party developers, which lease these buildings to the air cargo industry. The air cargo building profile for the Aeroterm Building located at Southwest Florida International Airport provides an example of this (http://www.aeroterm.com/documents/RSW_LeaseSheet.pdf).

Google Earth Pro also has 3-D modeling capabilities, and some airports are using this function. 3-D models help airport planners visualize the relationship new buildings will have with existing facilities. Figure 3-7 illustrates the 3-D capabilities for an airport by plotting the location of the Korean Air facility at Los Angeles International Airport.

Source: Google Earth Pro, CDM Smith Analysis.

Figure 3-7. Google Earth Pro 3-D—Korean Air 3-D rendering at Los Angeles International Airport.

Source: Google Earth Pro, CDM Smith Analysis.

Figure 3-8. Google Earth Pro Street View—Cargo Building B at Baltimore-Washington International Airport.

3.4.4 Air Cargo Warehouse Truck Docks and Doors

Air cargo warehouse throughput is often related to the number of available truck docks and truck doors to service the trucking side of the industry. Airport planners can obtain the number of warehouse truck docks and doors by using Bing Maps' Bird's Eye view function. By rotating and viewing all sides of the facility, the number of doors and docks can be ascertained. Google Earth Pro Street View is also a useful tool since it provides a direct side view of the facility (see Figure 3-8).

3.4.5 Air Cargo Warehouse Truck Parking

Truck parking capacity needs to be accounted for in the air cargo master planning process. Truck parking includes stalls adjacent to the cargo building at either truck docks or doors as well as stalls in the building's parking lot. Both Google Earth Pro and Bing Maps are useful tools for ascertaining the number of truck parking positions as well as total area.

CHAPTER 4

Planning Considerations and Metrics

The intent of this chapter is to provide airport planners with a planning and development framework that can be used to guide airport decision makers in planning and developing air cargo facilities. This framework is intended to be applicable to a range of airports and facility types based on current conditions at airports, forecasted change, and the metrics presented in this chapter. This chapter also provides guidance for development and implementation of a strategic development plan for airports to accommodate air cargo volumes in the future. The methodology for developing an air cargo strategic development plan is much the same as the process employed for air cargo in development of an airport master plan.

4.1 Air Cargo Planning Challenges

Airport planners face the challenges of designating land for air cargo facilities, planning for air cargo facilities, and, when needed, choosing whether to construct or renovate air cargo facilities. The absence of reliable air cargo forecasts to assist them and the current uncertainty in the future of air cargo volumes do not absolve airport planners of ensuring that there is enough air cargo facility capacity to meet future demand; these factors just make their jobs more difficult, and they must rely more heavily on other indicators and methods for determining their airports' needs.

One overriding complexity in meeting these challenges is the fact that there are significant differences in the air cargo facilities between large-hub international gateway airports and domestic airports. While large-hub international gateway airports can have a significant portion of their air cargo flown in on international passenger and cargo-only airline flights, many domestic airports have the majority of their air cargo flown in and out of their airports by integrated express carriers. As a result, cargo facilities at domestic airports are quite simplified when compared to complex cargo facilities at international gateway airports. One common thread between the various sizes of airports, however, is that at most airports some air cargo volume is still transported on domestic passenger airline aircraft, and airports need to have appropriate air cargo facilities to accommodate them. The difference in the volume of air cargo handled between large international gateways and smaller domestic airports produces a wide range of air cargo facility requirements at airports across the nation.

4.1.1 Air Cargo Strategic Development Plan

An air cargo strategic development plan can be used by airport planners to evaluate the volume of air cargo and mail forecasted to pass through an airport. The critical elements of the plan are development of a realistic air cargo volume forecast and determination of how much land and air cargo facility capacity are required to accommodate forecasted air cargo. With air cargo volumes down by a substantial percentage since the beginning of 2000, some airports have surplus air cargo capacity that could accommodate future increases in air cargo volume but may require relocation of users to larger surplus facilities or renovation of existing facilities. Other airports may need to create additional air cargo facility capacity through the designation of land and construction of air cargo facilities. Whatever the case, airport planners should, through the development of a strategic development plan, determine what action is required to accommodate the forecast.

4.1.1.1 Determining Land and Facility Requirements

Once the air cargo forecast has been developed, facility utilization ratios (discussed in a subsequent section) can be applied to determine if additional land needs to be designated on the airport for air cargo facilities or if air cargo facilities need to be constructed or expanded. In the short term, input from the airlines, integrated express carriers, and ground handling companies is critical. In the longer term, where specific long-term requirements of the airlines, integrated carriers, and cargo handlers are not available, airport planners should rely on the air cargo forecast and the facility utilization ratios to plan for additional air cargo facilities or designate additional land for air cargo facilities. Depending on the volume of air cargo handled and whether the airport is an international gateway or a domestic airport, there are several different air cargo and associated support facility sizes required.

4.1.1.2 International Gateway Airports

International gateway airports are quite different from domestic airports. In addition to the integrated express carriers' air cargo facilities, these airports may have large U.S.-based airline hubs and several international flag carriers that carry a substantial amount of air cargo in the belly of their passenger aircraft or operate cargo freighters. At these airports, it is common for the airlines and integrated carriers with larger operations to have their own dedicated air cargo facilities that can be as large as 200,000 ft^2 and have large aircraft parking aprons and as many as 50 truck dock doors. For those operating freighters, it is common to have large aircraft parking aprons capable of parking two to ten B747Fs, along with space for B747-8s in coming years. Some airports have constructed large common-use air cargo parking aprons for freighters where the load/unload functions are performed rather than having exclusive-use aircraft parking aprons located directly behind their air cargo facilities. In this case, the air cargo is transported by tug from the aircraft to/from the respective air cargo facility, which is ideally located within a reasonable proximity of the air cargo parking apron.

In addition, at many international gateways there are ground handling companies that provide cargo warehousing services for a single airline or multiple airlines, either in their own facility or a client's facility that needs air cargo warehouse space, ramp space to store ground support equipment, and facility space to maintain ground support equipment.

4.1.1.3 Domestic Airports

At domestic airports, there are air cargo facilities that accommodate the needs of passenger airlines' belly cargo in addition to the integrated express carriers' facilities. Usually the airlines' air cargo warehousing areas are situated in multi-tenant facilities with truck dock doors on one side and access to the airport operations area on the other side. The air cargo facility usually divides the airport operations area from airport land outside of the airport operations area. Often the airports build these facilities and lease a portion or bay to the airlines. The airlines in many cases construct administrative offices for their air cargo support staff within their air cargo facility and install secured areas for bonded shipments, high-value shipments, and aircraft parts storage.

At smaller airports where airlines handle around 1,000 tons of cargo per year, airports will have one airline air cargo building consisting of about 50,000 ft^2 with eight to ten bays of about

6,500 ft^2, with two truck dock doors and access to the airport operations area. In addition to the airline air cargo facility, many domestic airports have the vast majority of the air cargo handled by integrated express carriers. At smaller domestic airports, the integrated carriers can handle as much as 50,000 tons of air cargo per year. The integrated express carriers either have a smaller sortation facility on the airport and transport much of the air cargo off airport to a larger regional sortation facility, or they have a larger facility on the airport for sortation. The integrated express carriers may require sufficient aircraft parking apron to park one or two B757F.

For example, if a warehouse needed 50,000 ft^2, the truck parking space required would be 90,000 ft^2 (50,000 × 1.8). Using the truck dock and door ratios for the same-size facilities results in 33 doors and docks (50,000/1,500).

In planning for the airlines and integrated express carriers, the amount of space required to maintain the GSE also needs to be considered. If the GSE cannot be maintained within the air cargo facility, then additional facility space is required elsewhere at the airport.

4.2 Air Cargo Area Land Use Considerations

4.2.1 Cargo Terminal Facilities Location Strategies

A conventional air cargo terminal servicing passenger airline cargo operations should be located as close to the passenger terminal as possible to minimize the distance required to tug the cargo from the building to the passenger terminal. The location should allow space for expanding the facilities when demand warrants, commensurate with master planning processes and facility requirements. New facilities must have geotechnical site constraints; earth-moving, drainage, utilities, and so forth must be taken into consideration. A cargo hub facility for an integrated express carrier should, in contrast, be separated as far as possible from other facilities unless there is likely to be substantial cross transfer with the combination passenger carriers. Many integrators prefer to be on the opposite side of the runway, with their own taxiway systems for both air cargo hubs and cargo terminal buildings. The all-cargo terminal for freighters should also be as close to the runway as possible, without infringing on any of the runway transitional surfaces, either from the building or from the tails of parked aircraft.

Based on analysis of case study airports, the locations of air cargo terminals followed three basic layout patterns:

- Split cargo areas. Passenger belly cargo building(s) in proximity to passenger (pax) terminal but separated from all-cargo terminal area—Austin Bergstrom International Airport (AUS).
- Contiguous cargo area. Passenger belly cargo building(s) in proximity to pax terminal and adjacent to all-cargo buildings—Washington Dulles International Airport (IAD).
- Scattered cargo areas. Passenger belly cargo building(s) in proximity to pax terminal but separated from a scattered all-cargo terminal area(s)—Indianapolis International Airport (IND).

Air cargo that is transported in passenger aircraft is off-loaded and loaded at the passenger terminal gate. It is typically transported to the cargo terminal for handling by a tug-and-cart/dolly system (also referred to as cargo train) or flatbed truck over a restricted service road accessible only to cleared personnel. The transit time to and from the passenger terminal is an important planning consideration. At IND, a newly constructed midfield passenger terminal was separated from the existing cargo area by a distance of 3 miles, with a tug time of greater than 15 minutes on average. A new passenger belly cargo complex was constructed in proximity to the new IND passenger terminal to remedy this problem. At Miami International Airport, a cargo access tunnel built under diagonal Runway 12-30 is used to transport belly cargo to/from the east side passenger belly cargo terminal area to the midfield passenger terminals of the airport. The tunnel

Table 4-1. Viable tug driving time.

ACI-NA Airport Grouping*	Annual Volume of Cargo	Viable Tug Driving Time Between Belly Cargo Area and Passenger Terminal
Small	100,000 or fewer metric tons	1 to 5 min
Medium	100,000–499,999 metric tons	5 to 10 min
Large	500,000 or greater metric tons	10 to 20 min

*The 2002 ACI-NA Air Cargo Facility and Security Survey separated airports into three groups, which the research team followed. ACI-NA = Airports Council International–North America.

has cut the trip down from an average of 45 minutes to less than 15 minutes, and from 7 miles to 2 miles. The Miami example is provided to identify the level of importance in providing quick access from the belly cargo area to the passenger terminal. It is important to note that the speed limit on air operations areas (AOAs) is typically 25 mph in driving lanes and 5 mph in close proximity to aircraft, buildings, and construction in progress. It is also important for the airport planner to ensure that there is enough room on the apron and within the building for the tug cargo trains to stage, load, unload, and pass each other with a safe amount of clearance. This results in a safer work environment for the employees and less wear and tear on the equipment, ramp area, and cargo buildings.

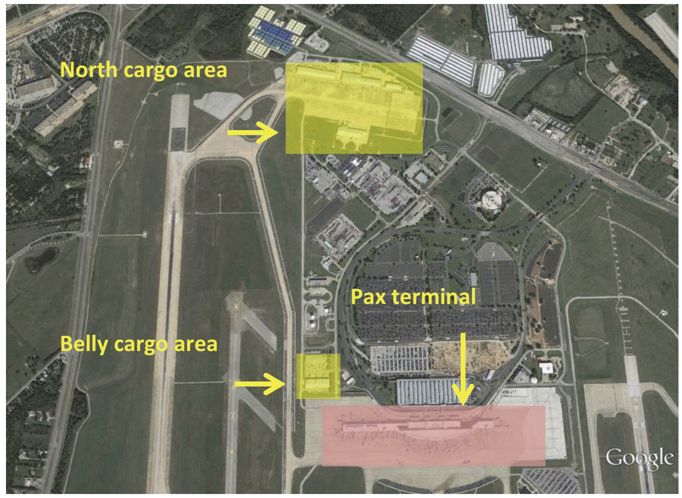
Conversations with operators of belly cargo terminals indicated that tug time to the passenger terminal is of paramount importance to the carrier. Based on evidence provided by carriers and the research associated with this study, a table of viable tug times between belly cargo areas and passenger terminals was developed based on airport cargo traffic volumes. Generally speaking, the larger the airport, the greater the tug driving time from cargo building to passenger terminal. Table 4-1 identifies viable tug times for airports based on cargo tonnage.

4.2.1.1 Example Split Cargo Areas

Cargo facilities at AUS are a good example of a split cargo areas location strategy. The airport has two cargo development areas. The belly cargo area is located 0.6 miles from the passenger terminal, and the airport's north cargo area (from the center of the passenger terminal ramp), designed for all-cargo operators, is located directly at the front of the airport, on Highway 71, the main road leading to central Austin. The north cargo area provides immediate access to the airport's taxiway system and Runway End 17 R. Both cargo areas share the same entrance, appropriately named "Cargo Road," and have a prominent position at the airport site. Figure 4-1 identifies the belly cargo and all-cargo areas at the airport. The city of Austin chose to have 100% of its cargo facilities developed by third-party developers—one of the few completely privatized airport sectors in the country. Three different developers built and operate the facilities to this day. Few airports have such competition, and the result is a wide range of options and a focus on the customers' requirements.

4.2.1.2 Example Contiguous Cargo Area

Cargo facilities at IAD are a good example of a contiguous cargo area location strategy (Figure 4-2). Contiguous cargo areas have passenger belly cargo buildings in proximity to the passenger terminal and are adjacent to all-cargo buildings. Also, in designating land for future air cargo development, airports can reduce the overall cost of developing an air cargo facility by designing a common-use aircraft parking apron. Common-use aprons such as these are eligible for FAA grant funding, which removes much of the cost of the aircraft parking apron from the facility development cost.



Source: Google Earth Pro, CDM Smith Analysis.

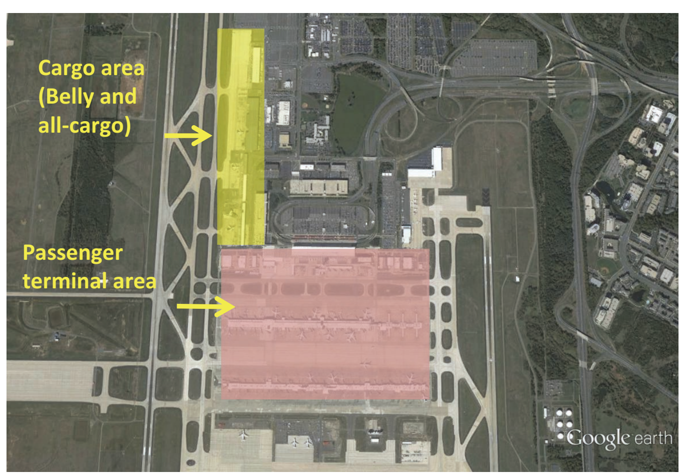
Figure 4-1. Austin Bergstrom International Airport—cargo area location.

Dulles' air cargo facilities primarily consist of four relatively large cargo buildings totaling about 500,000 ft^2 of space that are all contiguous to each other. The cargo is carried through belly cargo on passenger airlines, with the exception of FedEx Express, UPS, and DHL. Metropolitan Washington Airports Authority (MWAA) is also seeking to attract all-cargo carriers with trans-oceanic international routes.

It is noteworthy that MWAA has 400 acres on the west side of the airport earmarked for air cargo expansion to double the cargo capacity. Should this be developed, the airport would fall into the split cargo areas strategy.

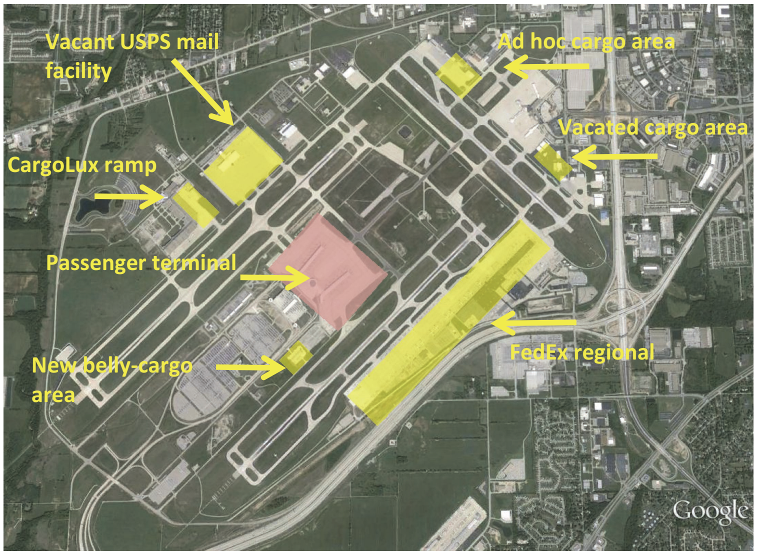
4.2.1.3 Example Scattered Cargo Area

Cargo facilities at IND are a good example of a scattered cargo areas location strategy (Figure 4-3). As stated previously, a newly constructed midfield passenger terminal at IND was separated from the existing cargo area by a distance of 3 miles and a tug time of greater than



Source: Google Earth Pro, CDM Smith Analysis.

Figure 4-2. Dulles International Airport—cargo area location.



Source: Google Earth Pro, CDM Smith Analysis.

Figure 4-3. Indianapolis International Airport—cargo area location.

15 minutes on average. A new passenger belly cargo complex was constructed in proximity to the new IND passenger terminal to remedy this problem. The distance between the new belly cargo area and the center of the midfield passenger terminal ramp is 1 mile, or less than 5 minutes.

4.3 Airside Cargo Facility Planning

4.3.1 Facility Requirements: Air Cargo Apron

The role of the air cargo apron is to provide aircraft parking adjacent to the air cargo terminal building, provide sufficient space for ground handling operations for the loading and unloading of cargo aircraft as well as to service the aircraft, and provide sufficient space for the storage of GSE as well as ULD and pallet storage. For operations at international gateways and O&D domestic markets, the space must be large enough to park an optimal number of aircraft and accommodate aircraft tugs, cargo containers and trailers, cargo vehicles, mobile stairs, tail stands, and fueling vehicles or carts. For airports supporting integrated express hubs, the apron would include all the aforementioned attributes in addition to providing space for cargo sortation, 53-ft tractor-trailers, and tail-to-tail cargo transfer and bypass containers.

Some cargo aprons contain fixed equipment that includes cargo loading platforms and in-ground nose tethers. The air cargo apron must be relatively level and provide access to the airport's taxiway system, and should be in close proximity to the airport's runways in order to reduce taxi times. Some air cargo aprons may be located at areas of the airport without adjacent terminal buildings, but this is the exception and not the rule.

Since large cargo aircraft will be parking on the apron, the asphalt or concrete pad must provide sufficient strength to support these aircraft. Aircraft parking areas, also called "hard stands," typically have weight-bearing strength greater than that of the taxiway system since aircraft will be positioned on these for longer periods of time. Hard stands are designed differently than taxiways since they require greater steel reinforcement and more stringent expansion joint systems. Hard stands need to be designed by aircraft type and take into consideration gear spacing and

Table 4-2. Aircraft categories.

Aircraft Category	Approach Speed	Typical Aircraft
A	<91 knots	Cessna 172
B	91 to <121 knots	Cessna Citation III
C	121 to <141 knots	CRJ, Lear 25
D	141 to <166 knots	Airbus A380, Boeing 747
E	166 knots or more	Future aircraft

Source: FAA Advisory Circular (AC) 5300/13.

number of wheels; therefore, the aircraft types that are anticipated to operate in the cargo area need to be accurately forecasted by the airport planner.

4.3.2 Critical Aircraft Implications for Apron

The development of airport facilities is affected by the demand for those facilities, typically represented by total based aircraft and operations at an airport, and the type of aircraft that will make use of the facilities. In general, airport infrastructure components are designed to accommodate the largest or most demanding type of aircraft (referred to as the critical aircraft) expected to use the infrastructure on a regular basis (at least 500 annual operations). Once the critical aircraft has been identified, its approach speed and wingspan are used to characterize the runway design standards and specifications required for an airport to safely and effectively serve that aircraft.

The FAA groups aircraft into aircraft categories and Airplane Design Groups (ADGs) based on their approach speed and wingspan, respectively. The criteria for these categories are presented in Tables 4-2 and 4-3.

After identifying an airport's critical aircraft, it is possible to determine the Airport Reference Code (ARC). The ARC system is a coding system that relates airport design criteria to the operational and physical characteristics of the airplanes that are intended to operate at an airport. An ARC is a composite designation based on the aircraft category and ADG of the critical aircraft.

Critical aircraft not only govern the size of the runway design but also govern the design of the taxiway system, apron, and other pavements' strength and parking dimensions. For commercial service airports, critical aircraft are typically large passenger aircraft serving the airport, but it is not unusual for a specific cargo aircraft operating on a scheduled basis to be the critical aircraft. For example, at Indianapolis International Airport the largest passenger aircraft serving the

Table 4-3. Airplane design groups.

Airplane Design Group	Wingspan	Typical Aircraft
I	<49 ft	Cessna 172, Cessna 401
II	49 to <79 ft	Falcon 50, Gulfstream III
III	79 to <118 ft	B-727, B-737, DC-9
IV	118 to <171 ft	A-300, B-757, B-767, DC-10
V	171 to <197 ft	B-747
VI	197 to <262 ft	A380, B747-8

Source: FAA AC 5300/13.

airport is the B737-800, while the largest cargo aircraft operating at the airfield on a scheduled basis is Cargolux's B747-400. This aircraft may be upgraded to the B747-8 in the near future.

4.3.3 Role of Aircraft Manufacturers in Airport Master Planning

Space for large cargo aircraft parking, hardstand usage, ground operations, and runways is best measured against the needs of the specific cargo aircraft being accommodated rather than forecasted tonnage throughput. It is at this point in the planning process that airport planners work most closely with the airlines and airplane manufacturers.

To assist airport planners and engineers, Boeing produces airport planning manuals, entitled Airplane Characteristics for Airport Planning (http://www.boeing.com/boeing/commercial/airports/plan_manuals.page), for all Boeing- and Douglas-designed commercial airplanes. These manuals describe specific airplane characteristics such as dimensions, performance, ground maneuvering, terminal servicing, jet-engine wake and noise, and pavement requirements. Airbus has a similar airport planning manual for its family of aircraft (http://www.airbus.com/support/maintenance-engineering/technical-data/aircraft-characteristics/). These manuals provide information on basic airplane runway-length requirements, performance, typical interiors, pavement requirements, and jet-blast attributes. The Boeing Airplane Characteristics for Airport Planning manuals are made available by the manufacturer for any transport-category airplane having maximum takeoff weights of 35,000 lb (15,875 kg) or more (http://www.boeing.com/assets/pdf/commercial/airports/faqs/arcandapproachspeeds.pdf).

Airlines, airports, and airplane manufacturers together walk a fine line, balancing the desire for increased airplane capacity, range, and operating economy with the need for airport improvements and modifications.

4.3.3.1 Cargo Apron Aircraft Space Requirements

Cargo aircraft are commonly parked adjacent to the air cargo terminal building perpendicular or on a diagonal to the building. There are instances where the cargo apron is designed for parking the aircraft parallel to the building, but straight in at perpendicular is the most typical configuration. The aircraft should be parked as near as possible to the freight terminal in order to reduce the amount of ground traffic movement. The distance between the nose of the aircraft and the terminal exterior wall will vary depending on the size of the aircraft and whether it has a nose-loading door.

Airport planners must consider the entire fleet of aircraft planned to use the cargo apron and any equipment that may need to operate in front of the aircraft. Sufficient length and maneuvering space must be available for aircraft tugs and towbarless tractors, and this is dependent on the position of the nose gear relative to the aircraft nose. Also, sufficient space must be provided for loading equipment operating in front of a nose-loaded cargo aircraft and clearance for the nose cone in the upright position. Defining the minimum distance needed between the aircraft nose and a structure or other barrier is critical to ensuring that adequate apron depth is provided to fully accommodate parked aircraft within the apron area.

Adequate separation is needed between the wingtips of aircraft occupying adjacent parking positions as well as between wingtips and any fixed or movable object. The cargo aircraft parking apron requirement should be calculated based on the number of aircraft that are projected to be simultaneously parked on the apron and using the wingspan sizes of the aircraft types projected in the air cargo fleet mix along with allowances for wingtip clearances (25 ft between aircraft and objects). Table 4-4 provides separation distances from the aircraft nose to the rear wall of the terminal building as well as separation distances from aircraft wingtips and service roads. It is common to provide 5 ft of clearance between the wingtip of a parked aircraft and the edge of the marked service road to protect against vehicles that may deviate from the marked roadway.

Table 4-4. Aircraft-building separation distances.

Separation Distances	Aircraft Design Group[1] III to VI	Aircraft w/ Nose Door[2] (B747, Antonov 124)
Minimum nose-to-structure distance in linear feet	55	80
Minimum wingtip-to-object distance in linear feet	25	25
Minimum wingtip- and tail-to-service-lane distance in linear feet	5	5
Minimum tail-to-taxi-lane-edge distance in linear feet	75	75

Notes: (1) As noted in *ACRP Report 96: Apron Planning and Design Guidebook*, for passenger aircraft the FAA recommends minimum nose-to-building distances of 15 ft for ADG III aircraft, 20 ft for ADG IV aircraft, and 30 ft for ADG V aircraft, but cargo aircraft require larger buffers. (2) Some freighter aircraft models are equipped with a nose door that allows cargo loading/unloading. Source: CDM Smith.

Another factor to be considered by airport planners is that when planning/designing new aprons or modifying existing aprons, blended-wing/-winglet technology, which adds to the length of an aircraft's wingspan, needs to be taken into account. Blended-wing technology is available as a retrofit to an existing aircraft fleet and as an option on new aircraft.

Airport planners must be aware of the variety of cargo aircraft operating on a scheduled basis at airports throughout the United States. Table 4-5 provides a list of cargo jet aircraft typically operating at U.S. airports on a scheduled basis as well as each aircraft's ADG, which categorizes

Table 4-5. Representative sample of cargo jet aircraft and carriers operating at U.S. airports.

Jet Cargo Aircraft	AAC	ADG	FedEx Express	UPS	ABX	American Transp. Int'l	Southern Air	Amerijet	Centurion Air Cargo	ATLAS	Polar Air Cargo	Cargolux	Avianca	Korean Air	Cathay Pacific
Airbus A300-600	C	IV	✈	✈											
Airbus A310-200	C	IV	✈												
Airbus A310-300	C	IV	✈												
Airbus A330-200F*	C	V											✈		
Boeing 727-200*	C	III						✈							
Boeing 747-200	D	V							✈						
Boeing 747-400*	D	V		✈			✈			✈	✈	✈		✈	
Boeing 747-400ERF	D	V													✈
Boeing 747-8	D	VI								✈	✈	✈		✈	✈
Boeing 737-700C*	C	III													
Boeing 757-200	C	IV	✈	✈		✈									
Boeing 767-200	C	IV			✈	✈		✈		✈			✈		
Boeing 767-300F	D	IV	✈	✈	✈	✈				✈			✈		
Boeing 777-200	C	V	✈				✈								
Douglas DC-8-70	C	IV				✈									
McDonnell Douglas MD10	D	IV	✈												
McDonnell Douglas MD11	D	IV	✈	✈					✈						

Notes: ABX, American Transport International, and Southern Air contract extensively to DHL.*Includes winglets.
Source: FAA AC 15/5300, carrier websites.

aircraft by wingspan, and the FAA's Aircraft Approach Category (AAC). The AAC categorizes aircraft by approach speed when landing. Aircraft in Category A approach the runway at much slower speeds than aircraft in Category D. Table 4-5 takes only into consideration all-cargo aircraft and does not include passenger aircraft.

When planning for cargo apron space, the airport planner essentially has two methods for determining the amount of cargo apron space needed. The planner can use a throughput metric based on tonnage handled on the ramp on an annual basis or on a peak-period basis. The planner can ascertain from the airport's cargo carriers their anticipated aircraft types that are likely to operate on the airfield during the planning period. A typical master plan requires at least a 20-year planning period for facilities, while an air cargo carrier typically plans its fleet in 5- to 10-year increments. Planners may also be required to modify or reconfigure existing cargo ramp space to support a cargo carrier when a change in aircraft types is imminent. While this prospect does not directly involve master planning, it falls into the airport planner's day-to-day planning responsibilities. Table 4-6 provides the airport planner a tool to use for determining the amount of space required for cargo aircraft parking. The total space required per aircraft type takes into consideration the aircraft's wingspan as well as overall length. Buffer space is also included in the total square footage requirements to separate aircraft from other aircraft as well as buildings and service lanes. Buffer space allows space for aircraft service and GSE storage and utilization. While the FAA does not specify cargo apron design standards, Airports Council International–North America (ACI-NA) and Airlines for America (A4A) do provide apron facility guidelines. *ACRP Report 96* provides guidelines on apron planning but is primarily focused on airline terminal apron areas (Quinn 2013). Aircraft tail height is provided to assist in determining line-of-sight issues as well as potential airspace penetration issues. Planners should allow 25 linear feet between aircraft wingtips when designing aircraft parking positions on the apron as well as sufficient distance between the nose of the aircraft and any structures. Table 4-6 includes the recommended distances based on ADG presented in Table 4-5.

Table 4-6. Parking space requirements for cargo jet aircraft operating at U.S. airports.

Common Jet Cargo Aircraft	AAC	ADG	Length	Wing-span	Tail Height	Length Including Nose/Tail Buffers	Wingspan + 25'	Total Area (ft^2)
Airbus A300-600	C	IV	177.0	147.1	55.0	307.0	172.1	52,834.7
Airbus A310-200	C	IV	153.1	144.0	52.1	283.1	169.0	47,843.9
Airbus A310-300	C	IV	153.1	144.0	52.1	283.1	169.0	47,843.9
Airbus A330-200F*^	C	V	191.5	197.8	57.1	321.5	222.8	71,630.2
Boeing 727-200*	C	III	153.2	109.3	34.9	283.2	134.3	38,033.8
Boeing 747-200^	D	V	229.2	195.8	64.3	359.2	220.8	79,311.4
Boeing 747-400*^	D	V	231.9	213.0	64.0	361.9	238.0	86,132.2
Boeing 747-400ERF^	D	V	232.0	212.9	64.3	362.0	237.9	86,119.8
Boeing 747-8^	D	VI	250.2	224.4	62.7	380.2	249.4	94,821.9
Boeing 737-700C*	C	III	110.2	117.5	41.7	240.2	142.5	34,228.5
Boeing 757-200	C	IV	155.2	125.0	45.1	285.2	150.0	42,780.0
Boeing 767-200	C	IV	159.1	156.2	52.9	289.1	181.2	52,384.9
Boeing 767-300F	D	IV	180.1	156.2	52.6	310.1	181.2	56,190.1
Boeing 777-200	C	V	209.0	199.8	61.5	339.0	224.8	76,207.2
Douglas DC-8-70	C	IV	187.3	148.3	43.3	317.3	173.3	54,988.1
McDonnell Douglas MD-10	D	IV	183.0	165.0	58.8	313.0	190.0	59,470.0
McDonnell Douglas MD-11	D	IV	202.1	170.5	58.8	332.1	195.5	64,925.6

*Includes winglets; ^assumes nose-door aircraft. Source: FAA AC 15/5300, carrier websites.

Table 4-7. Regional turboprop cargo aircraft/carriers operating at U.S. airports.

Common Cargo Turboprop	AAC	ADG	Wiggins	Empire	Mountain Air Cargo	Ameriflight	Air Cargo Carriers	Alpine Air
ATR42	B	III	✈	✈	✈			
ATR72	B	III	✈	✈	✈			
B1900	B	II				✈		✈
Beech B99/C99	B	I				✈		✈
Cessna Caravan 208	B	II	✈	✈	✈			
DeHavilland DASH 8	A	III						
EMB-120	B	II				✈		
Fairchild Dornier SA-227DC	B	III				✈		
Metroliner III	B	I				✈		
SHORT SD3-60	B	II			✈	✈	✈	

Source: FAA AC 15/5300, carrier websites.

Turboprop aircraft are also used to transport air cargo on a scheduled basis. The majority of these operations are related to regional cargo aircraft that feed cargo to awaiting integrated express cargo jets. In some instances these aircraft fly directly to an integrated express cargo hub. Table 4-7 identifies turboprop cargo aircraft, their AAC and ADG category, and carriers that currently operate these aircraft for cargo operations. It is noteworthy that these aircraft may be located on an integrated express origin-and-destination station which is supported by the carriers' staff, or these facilities may have a small cargo shed, hangar, or tie-down spot on the air cargo apron. These aircraft may also be solely supported by the airport's fixed-base operator (FBO) and, subsequently, are reliant on FBO staff to load and fuel. These operations often take place on the general aviation apron and blend in with the other general aviation traffic. An integrated express operator would likely drive its truck(s) to the aircraft for loading and unloading. Many of the regional cargo aircraft are contracted carriers, and their aircraft may be painted in the client's logo and paint scheme. Mountain Air Cargo, for example, is a contractor to FedEx Express and flies C208 aircraft with FedEx branding. Where regional cargo aircraft feed into the cargo jet, the apron area may have parking positions for large cargo jets and several turboprop feeder aircraft.

Table 4-8 provides the airport planner a tool to use for determining the amount of space required for regional cargo aircraft parking. The total space required per aircraft type takes into consideration the aircraft's wingspan and its overall length. A 12.5-ft buffer space is also included in the total square footage requirements to separate aircraft from other aircraft as well as buildings. This area provides sufficient space for aircraft parking and servicing and loading the aircraft. Planners should allow 25 linear feet between aircraft wingtips and sufficient distance between the nose of the aircraft and any structures.

4.3.4 Air Cargo Facility Requirement Ratios

The facility requirements element of the airport master plan summarizes a technical analysis of the aviation and allied facilities that will be required to accommodate the aeronautical activity (passenger, air cargo, and general aviation/corporate) identified in the aviation forecasts element. During the airport master planning process, planners determine what (if any) additional facilities will be required to accommodate forecast activity. This task begins with an assessment of the ability of existing facilities to meet current and future demand. If they cannot, planners must

Table 4-8. Parking space requirements for regional turboprop cargo aircraft operating at U.S. airports.

Common Cargo Turboprop	AAC	ADG	Length	Wing-span	Tail Height	Length Including Nose/Tail Buffers	Wingspan + 25'	Total Area (ft^2)
ATR42	B	III	74.5	80.6	24.9	109.5	105.6	11,563
ATR72	B	III	89.2	88.8	25.0	124.2	113.8	14,128
Beech B1900	B	II	57.9	58.0	15.5	82.9	83.0	6,881
Beech B99/C99	B	I	45.0	45.9	14.3	70.0	70.9	4,964
Cessna Caravan 208	B	II	42.0	52.1	14.8	67.0	77.1	5,166
DeHavilland DASH 8	A	III	84.3	89.9	24.1	119.3	114.9	13,708
EMB-120	B	II	65.6	65.0	20.9	90.6	90.0	8,154
Fairchild Dornier SA-227DC	B	III	59.3	95.2	27.5	94.3	120.2	11,335
Metroliner III	B	I	59.5	46.2	16.7	84.5	71.2	6,016
SHORT SD3-60	B	II	70.7	74.8	23.1	95.7	99.8	9,550

Source: FAA AC 15/5300, carrier websites.

determine what additional facilities will be needed to accommodate the unmet demand. This section is normally referred to as the facility requirements section of a master plan document.

Air cargo warehouse, ramp, GSE storage, and parking area data collected are used in the facility requirements analysis to define planning metrics and ratios into functional relationships related to air cargo facilities. ACRP Project 03-24 identified two primary cargo building throughput formulas used in the master plan process: (1) area per annual ton ratio, and (2) annual tonnage per area ratio (TAR).

- **Area per annual ton ratio.** Many master plans indicate that average building throughput rates at U.S. airports vary between 1.0 and 2.5 ft^2 per annual ton. A throughput rate of 1.0 ft^2 per annual ton typically indicates that the facilities are well utilized and some near-term expansion may be required. The higher rate of 2.5 ft^2 per annual ton indicates that existing tenants have ample—even surplus—space. These throughput rates, however, are all-inclusive and incorporate a wide variety of air cargo occupants such as passenger airlines, all-cargo carriers, integrated express carriers, and third-party providers. This analysis breaks out throughput ratios by air cargo carrier type and airport role—either international gateway or domestic market. It is also important to point out that this analysis does not take into consideration air cargo that bypasses the cargo building and is trucked directly to aircraft on ramps as well as any cross-docking operations taking place within the air cargo building.
- **Annual tonnage per area ratio.** Another method of determining air cargo warehouse area is to use a tonnage per area ratio. The TAR is defined in units of total annual tons of freight per square foot of cargo floor space. This ratio can then be compared to a derived maximum TAR value, which will typically range from 0.5 tons/ft^2 to 3.0 tons/ft^2, with the latter being representative of a highly efficient automated sort operation. Achieving a higher value of TAR is dependent on the degree of mechanization, the layout of the building, the type of cargo (e.g., international versus domestic, refrigerated), and how the cargo is typically packaged for shipping (e.g., pallets, containers). The Air Cargo Facility Planning Model presented in Chapter 9 uses this method (annual tons per square foot ratio), which presents the less efficient facilities with a lower value.

4.3.5 Utilizing Facility Planning Metrics for Cargo Apron Design

Airports were analyzed in this study to estimate the annual ton per square footage utilization of air cargo for warehouse ramp space and GSE storage space. Truck and automobile parking

Table 4-9. Air cargo facility requirements ratio matrix.

	Integrated Express	Pax Belly	Third-Party Providers and All-Cargo Carriers
Building			
Domestic	0.92	0.64	0.81
International gateway	0.37	0.64	0.81
Master plan review ratios*	0.93	0.63	0.57
Ramp			
Domestic	0.19		0.16
International gateway	0.19		0.91
GSE Storage			
General	0.57	0.36	1.11

*Various airport master plans from literature review. Source: CDM Smith.

facility development is based on building size. Table 4-9 provides a facility requirements data matrix of ratios for cargo buildings, ramp area, and GSE storage based on the cargo operator types of:

- Integrated express carriers,
- Pax belly, and
- Third-party providers/all-cargo carriers.

Dedicated cargo apron space for passenger carriers is not presented since most passenger carrier facilities do not have a need for designated air cargo ramp area to park aircraft since cargo for passenger carriers is typically tugged to the aircraft parked at the passenger terminal ramp. It is important to note that these ratios are generic in nature to provide high-level guidance for air cargo area facility planning and are not typically applicable to individual carrier practices, which will likely have substantial variations in space requirements. These ratios, however, provide capacity requirements for air cargo activity at an airport. Carrier-specific utilization data should be obtained during the inventory process.

4.3.5.1 Ramp Throughput Analysis

Ramp throughput rates are the standard measures to define the capacity of freight facilities; this rate is expressed in annual tons of freight per square foot of ramp. Airport master plans use several methods for determining ramp space. For example, one accepted planning criterion for cargo aprons is to allow 5 ft^2 of apron per square foot of cargo building space (HNTB 2008). Another method is to use an average area per aircraft based on the fleet mix in the master plan cargo forecast. These parking areas incorporate standard wingtip clearances and allow room for GSE and a taxi lane to service the area. Both these ratios, however, often include ramps used for both aircraft parking and GSE storage and operating space.

4.3.5.2 Integrated Express Aircraft Parking Apron

This analysis provides ratios for determining space requirements for both aircraft parking and GSE storage for a combined air cargo apron planning metric. These ratios are based on survey data from an extensive data collection effort. As presented in Table 4-9, cargo aircraft parking space utilization based on annual cargo tonnage throughput is approximately 0.19 annual tons per square foot for domestic cargo for integrated express carriers and 0.19 for the same carrier type at international gateway airports. Ratios for GSE are typically not broken out in a master plan's facility requirements but are provided here. Cargo ramp or apron facility requirements in a typical master plan combine aircraft parking ramp areas and GSE storage areas. Since the data collection effort focused on data related to GSE spatial needs, this analysis provides GSE space ratios for integrated express carriers.

4.3.5.3 Integrated Express GSE Storage Apron

The weighted average analysis related to average ton per square foot for integrated express carriers' GSE storage requirements, located at both international gateway and domestic airports, is 0.57 annual tons per square foot.

4.3.6 Applying the GSE Storage and Aircraft Parking Ratios

The air cargo facility requirements ratio matrix (Table 4-9) provides the metrics for converting annual cargo tonnage flows into cargo aircraft parking and GSE storage area requirements. Simplified calculations based on empirical data from this study's research can assist in providing an estimate of the air cargo apron requirements in a preliminary design stage. For example, the size of the apron area required for the typical cargo volume can be calculated by dividing the annual cargo volume by the throughput per unit of apron area. This methodology can be applied to current conditions at the airport as well as forecasted air cargo tonnage. Representative values for integrated express O&D station aircraft parking, based on the research and analysis of this project, are 0.19 U.S. ton/square feet per year for the U.S. domestic and international operations and 0.57 U.S. ton/square feet per year for GSE storage. (Note that the representative, or indicative, value is based on a series of measurements and is the one that is closest to the real value of the measurement. If one carries a series of measurements, the representative value will be their average, excluding those outlier values that have proved to be far from the true value.) For example, if an airport had an integrated air express tenant moving 80,000 U.S. tons annually, it would require 413,600 ft^2 (9.5 acres) of apron space to accommodate its aircraft operations (see Table 4-10). For the same amount of cargo volume, an additional 139,200 ft^2 of apron space for GSE would be needed. Combining the two requirements results in 552,800 ft^2 (12.7 acres) of apron to accommodate the 80,000 annual tons. The integrated express industry operates on average 5.5 days per week; 80,000 annual tons then translates to approximately 559,400 pounds of inbound and outbound cargo per day, or about eight fully loaded B757s (inbound and outbound).

Table 4-10 also provides metrics for converting annual cargo tonnage flows into cargo aircraft parking and GSE storage area requirements for third-party handlers and all-cargo carriers. Representative values for an all-cargo freighter station aircraft parking area are 0.91 U.S. tons/square feet per year for U.S. international operations and 1.11 U.S. tons/square feet per year for GSE storage. For example, if an airport had an all-cargo carrier tenant moving 80,000 U.S. tons annually, it would require 87,912 ft^2 (2.0 acres) of apron space to accommodate its aircraft operations (see Table 4-11). For the same amount of cargo volume, an additional 72,000 ft^2 of apron space would be needed for GSE storage. Combining the two requirements results in approximately 159,912 ft^2 (3.7 acres) of apron to accommodate the 80,000 annual tons.

Table 4-10. Air cargo facility requirements ratio application: integrators.

Integrated Express Carrier	Annual Tonnage		Ton/Ft^2 Ratio		Apron Required (Square Feet)	Apron Required (Square Yards)	Apron Required (Acres)
Apron	80,000	/	0.19	=	413,600	45,956	9.5
GSE storage	80,000	/	0.57	=	139,200	15,467	3.2
Total					**552,800**	**61,422**	**12.7**

Source: CDM Smith.

Table 4-11. Air cargo facility requirements ratio application: freighters.

Third-Party Handler and All-Cargo Carrier	Annual Tonnage		Ton/Ft² Ratio		Apron Required (Square Feet)	Apron Required (Square Yards)	Apron Required (Acres)
Apron	80,000	/	0.91	=	87,912	9,767	2.0
GSE storage	80,000	/	1.11	=	72,000	8,000	1.7
Total					**159,912**	**17,767**	**3.7**

Source: CDM Smith.

While passenger airlines do not have air cargo apron requirements related to parking of cargo aircraft, they do have pavement requirements related to the operations adjacent to their air cargo terminal facilities. A representative value for an air cargo terminal apron for passenger airlines is 0.36 U.S. ton/square feet per year for the United States. If a passenger airline terminal is moving 10,000 tons per year, it would require 27,777 ft^2 of paved space (10,000/0.36) to accommodate tugs and cargo trains.

An important factor that airport planners need to take into consideration related to the cargo tonnage throughput methodology is the industry practice of air cargo carriers sharing one aircraft to serve two markets. For example, UPS operates an Omaha–Cedar Rapids–Louisville route with a B757-200 aircraft, yet the Cedar Rapids station may only be allotted 30% of the capacity. When aircraft are shared in these types of situations, the annual volume does not necessarily translate into a corresponding ramp size. In other words, the aircraft serving the market may be larger than the market demands and thereby require a larger apron area than one would expect. That is why it is important for airport planners to interview the key cargo stakeholders in order to better understand their needs and plans for aircraft equipment anticipated to operate in the market.

Several practices within the industry also affect the amount of space needed for aircraft parking. For one, at spoke airports many integrated express operators park their aircraft during the day on the apron and fly to their respective hubs at night where packages are sorted. But it is not unusual for integrators to only stop an aircraft in a market then fly on to its final destination where it remains parked all day. The airport planner then must take into consideration the peak hour of demand for cargo aircraft parking. In Casper, Wyoming, for example, FedEx Express schedules two B757s that arrive from the Memphis hub, but one continues on to Grand Junction, Colorado, and the other to Boise, Idaho. In addition, FedEx operates about six Cessna 208 feeder flights into the airport. All of these operations require considerable apron space for an airport with a relatively small market area. Also at Casper, UPS operates a single contracted Metro III aircraft, which is supported by the airport's FBO and requires limited space on the general aviation ramp.

The all-cargo freighter businesses may also share aircraft with airports in other markets. For example, Kalitta Air Cargo operates a B747-400 from Hong Kong to Rickenbacker International in Columbus, Ohio, which then continues empty to JFK International where it is loaded with backhaul to Hong Kong. Tonnage on this route then is only reflective of inbound cargo. These types of nuances within the industry may not necessarily translate well when applying the air cargo facility requirements ratio matrix, which emphasizes the importance of airport planners' understanding of industry practices at their airports.

4.3.7 Cargo Apron Design Considerations

Older versions of air cargo planning documents often made algorithmic associations between cargo building and ramp size on the basis of the payload capacity of aircraft. While still an intuitively logical approach, it requires considerable more nuance than such a simplistic computation may suggest.

The freighter fleet itself has changed dramatically since older methodologies were created, although smaller spoke markets may have been left largely unaffected as Cessna Caravan feeder aircraft flying one or two more daily operations would have less dramatic effects than large international gateways that may have planned for earlier versions of the Boeing 747 freighter fleet to be the permanent workhorse of the industry. While only applicable to transcontinental gateways for now, airports have been challenged to either build or expand aprons to accommodate new, larger freighters, often having to sacrifice the number of positions in the process.

While cargo building utilization rates can be raised by adding labor and automation, ramps are much less forgiving. Domestically, carriers have windows in order to meet the sortation operations at their regional and national hubs, so peak periods for aircraft on the ground tend to be bundled. Similarly, international carriers with transatlantic and transpacific operations will have their own windows, albeit possibly countercyclical to those of domestic operators (due to stage length and time zone differences).

Further complicating the planning issues, partial freighters have become a useful tool for airlines that may not have enough demand in individual U.S. markets to justify a transpacific flight but can improve payloads by allocating portions to multiple markets, such that a freighter may stop in Atlanta and Dallas/Ft. Worth prior to refueling in Anchorage and returning to Asia. On a theoretical basis, cargo building demand should only be affected by the amount of payload dedicated to the local market. While it is also possible that the aircraft may be unloaded and loaded more quickly when only a portion is to be handled in a market, there is no similar effect on the ramp size required; the ramp must be large enough to accommodate the largest freighter that will use it.

At least for near- to mid-term planning, flight schedules are critically important tools for ramp planning. While schedules are fluid and often seasonal, a single ramp position can be reused multiple times per day if schedules permit. For carriers and handlers, this is also true for labor and GSE utilization. As an example, a gateway that is almost exclusively either a transatlantic or transpacific gateway may anticipate lower utilization rates for ramp space as carriers will tend to require the same operating windows. Gateways with a healthy mix of transatlantic and transpacific freighters may be more able to reuse ramp positions. Gateways with multiple daily operations by a single international carrier will also tend to be able to reuse positions as the carrier typically is trying to meet multiple windows in its own schedule and will attempt to not have redundant flights on the ground. However, gateways at which an international carrier may have both passenger and freighter flights could easily have both all-cargo and belly cargo throughput in the cargo building concurrently.

While much of the preceding focused on international gateways, planners at domestic cargo hub-and-spoke cities must also pay attention to integrator fleets and schedules. Declarations in late 2012 by FedEx signaled an intention to potentially fly larger domestic freighters but at lower frequencies and possibly fewer destinations served by air. Trucking would continue to be the beneficiary in terms of shares of domestic cargo transported by all modes. Some industry observers anticipate that UPS would likely follow suit.

Therefore, U.S. airports should be prepared for the possibility that larger ramp positions may be required in the near- to mid-term, or alternatively that need could be diminished, depending on whether the market is a beneficiary or victim of the trend. Either way, the dominant cargo carriers at the majority of U.S. commercial airports are in a prolonged period of operational transition that will require airports to remain flexible in their planning and development of air cargo facilities.

4.3.8 Cargo Apron Markings

The FAA usually does not control aircraft activity on aprons and does not publish guidance related to markings in the leased portions of the cargo apron. However, ACI-NA, the International Air Transport Association (IATA), ICAO, and A4A do publish passenger terminal and cargo apron marking guidelines. Airports and carriers need to coordinate the development of a consistent cargo apron marking protocol and have it applied to all appropriate aircraft aprons. The following section contains a generalized discussion related to common air cargo apron markings and guidelines available to the airport planner.

4.3.8.1 Lead-in/Lead-out Lines

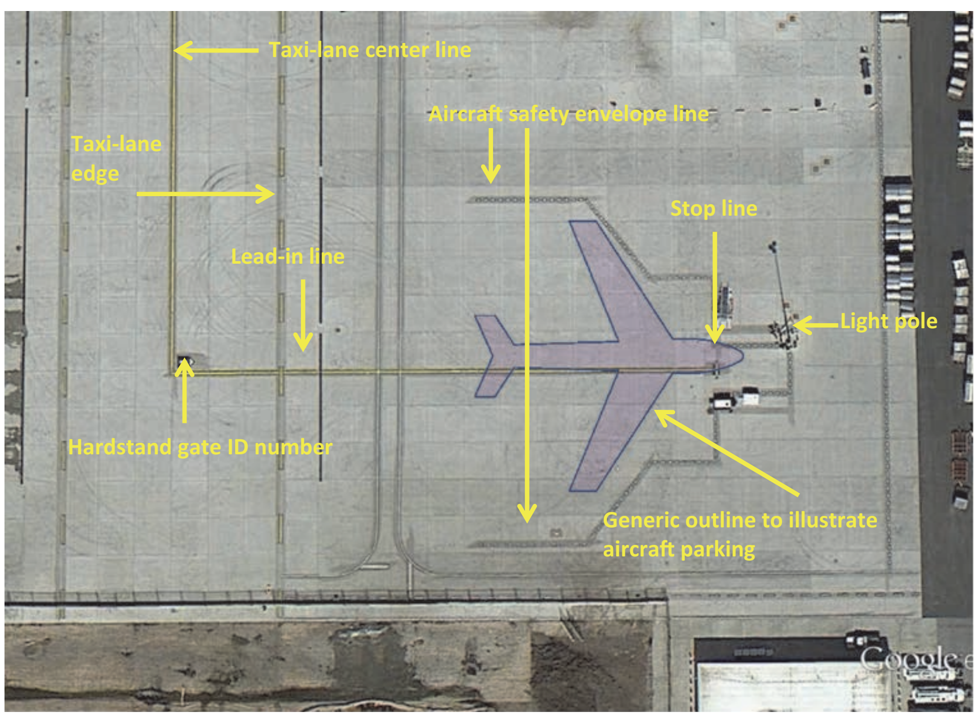
Lead-in and lead-out lines are gate-specific pavement markings that allow an aircraft to taxi under its own power or be towed to a gate or aircraft parking position. When an aircraft is parked appropriately, the center of the aircraft fuselage will be centered above the marking on the pavement. These lines are typically yellow and are the same width as the taxiway/taxi-lane centerlines, but in certain instances, a lead-in line is in black to provide contrast for light-colored pavement such as concrete (see Figure 4-4).

4.3.8.2 Stop Lines

Nose-wheel stopping points along a parking centerline are typically labeled by aircraft type (B-757, B727, etc.) and are provided to aid aircraft marshallers and aircraft tug drivers in positioning aircraft.

4.3.8.3 Aircraft Safety Envelope

Aircraft safety envelopes define the areas where no vehicles or GSE should be positioned unless they are specifically servicing the aircraft occupying that particular gate. These lines, also called "foul lines" by ramp workers, provide a necessary buffer from vehicles and equipment in



Source: Google Earth Pro, CDM Smith analysis.

Figure 4-4. Air cargo ramp markings.

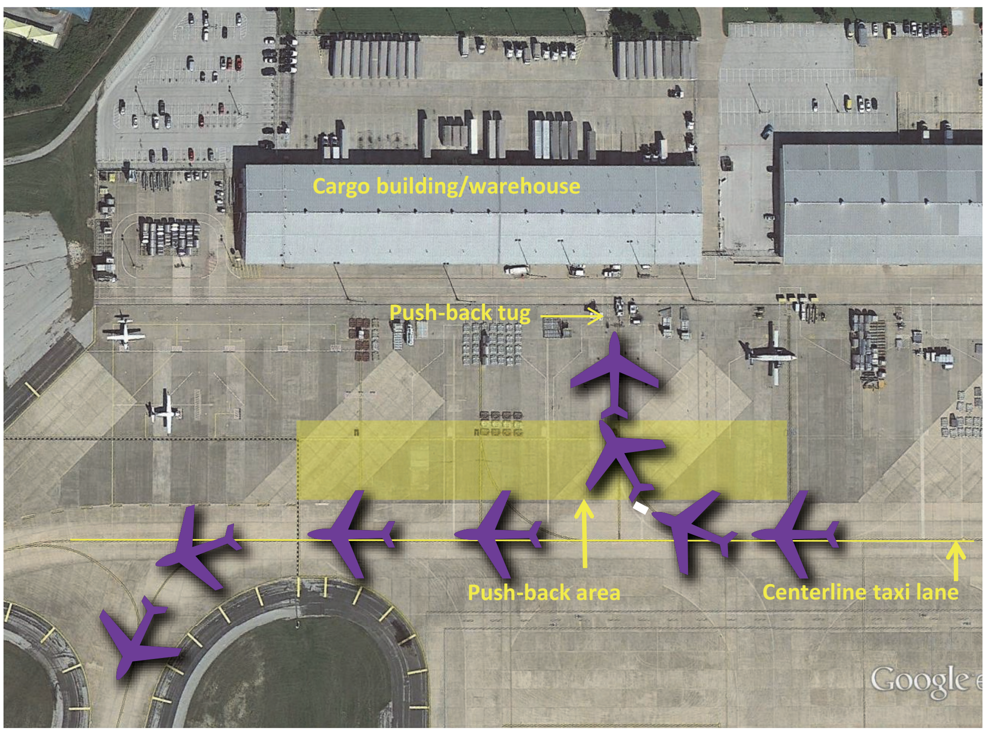
the gate area that are servicing other aircraft on the ramp. The area outside the aircraft parking and service envelopes up to the cargo building face can be used for GSE parking, ULD storage, and other apron activities. Many cargo operators use only white markings to identify the aircraft safety envelope. A4A recommends 10 ft as the minimum distance that the safety envelopes should protect from any point on the aircraft.

4.3.8.4 Push-Back Area

When an aircraft is parked perpendicular or diagonal to a cargo building, a tug vehicle must push it away from the structure to position it for access to the taxiway system. The push-back process may move the aircraft into the aircraft movement area, such as a taxi lane, and through the tail-stand roadway. [Movement areas are under the control of the FAA air traffic control tower (ATCT), whereas non-movement areas are not under ATCT control, but aircraft may be under the control of ramp tower controllers when in non-movement areas.] If there is ample space, it is ideal for airport planners to provide a push-back area to support aircraft departing from an apron, optimally without affecting airfield or apron area taxiing flows. The provision of an aircraft push-back area can be made to accommodate aircraft maneuvers, allowing aircraft to safely push back and start engines without adverse jet-blast impacts or without penetrating the movement area or encroaching on any apron taxi lanes used for the directional movement of aircraft. (Coordination with ATCT personnel would be required if penetration is unavoidable.) Figure 4-5 provides an example push-back area between the hardstand and the taxi lane.

4.3.8.5 Jet-Blast Fence

Jet blast is the thrust-producing exhaust from a running jet engine and propeller wash pushed to the rear of the aircraft when it is in motion. Some air cargo aprons require jet-blast fences to deflect jet blast, propeller wash, and noise when taxiing to and from the cargo apron (Figure 4-6).



Source: Google Earth Pro, CDM Smith analysis.

Figure 4-5. Air cargo apron push-back area and process.

Source: Google Earth Pro, CDM Smith analysis.

Figure 4-6. Air cargo ramp jet-blast fence at SEATAC International Airport.

4.3.9 Ground Support Equipment

GSE is the support equipment found at an airport, usually on the ramp, which is the servicing area by the terminal. This equipment is used to service the aircraft prior to and after air carrier flights. As its name implies, GSE is there to support the operations of aircraft and involves ground power operations, aircraft mobility, and loading operations (for both cargo and passengers). GSE used to service all-cargo aircraft and the facilities that support all-cargo aircraft operations are substantially different from those used in passenger terminal facilities and are usually best located in a designated cargo area. When ULDs are loaded onto the lower decks of aircraft, air cargo GSE is likely located on the passenger terminal apron. GSE related to air cargo on the passenger ramp will include tugs, dollies, and lower-deck loaders.

4.3.9.1 GSE Storage

GSE storage areas are used to park and stage GSE when it is not in use. These areas are often located on the apron in close proximity to aircraft parking positions but outside the aircraft safety envelope. The position of aircraft parked on an apron typically provides large areas in front of its wings that are used for GSE storage and maneuvering. Prior to a flight's arrival, GSE may be positioned by carrier personnel just outside the aircraft safety envelope to minimize aircraft access time. During periods on inclement weather and in latitudes where winters are severe, cargo carriers may opt to store motorized GSE in a cargo terminal building or hangar. Battery powered GSE with an electric motor will need access to power plug-in outlets during storage.

4.3.9.2 Stationary GSE

When aprons consistently service one cargo aircraft type and park consistently at the same gate, it often makes sense for the carrier or ground handler to install affixed GSE. This would include mounted preconditioned air units, APUs, lower-deck loading units, and potable water supply cabinets. Nose-load docks may also be a fixed to the apron and lead out of the cargo terminal building. Some carriers also install covered side door loaders (as shown later in Figure 4-10). The use of fixed equipment expedites ground handling and reduces congestion around the aircraft parking position by eliminating additional stand-alone carts or vehicles.

4.3.9.3 Mobile GSE

Most GSE is mobile and is transferred to and from the aircraft while the aircraft is being serviced. Equipment that is pulled up to the aircraft may include tugs, belt loaders, cargo (baggage) carts, empty dollies, loaded dollies (with ULDs and pallets), loaders, fuel trucks, lavatory and potable water vehicles, stairs, main deck (nose-door) loaders, and air start trucks.

4.3.9.4 GSE Use

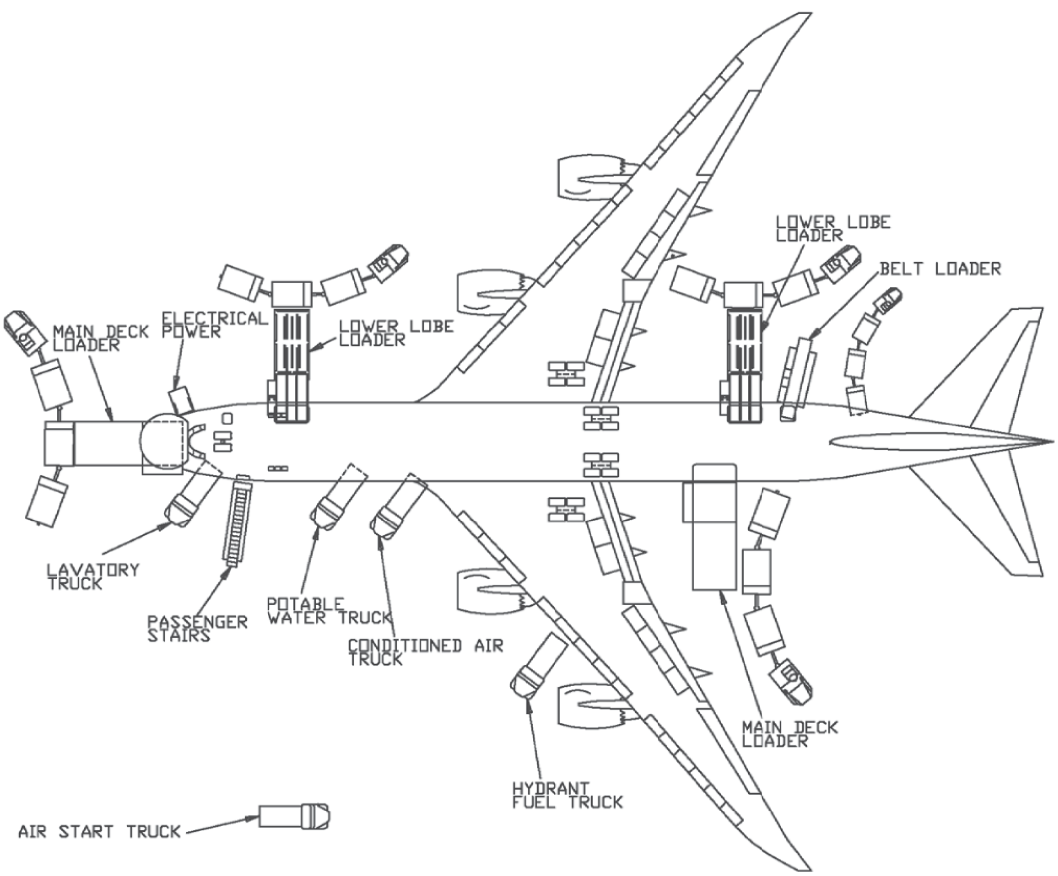
Generally speaking, the larger the gauge of cargo aircraft being serviced, the larger the number of vehicles required to service it, which increases demand for GSE storage. Figure 4-7 identifies GSE in position to service a Boeing 747 with a cargo nose door.

4.3.9.5 Security Gates

The security of the apron is largely controlled by ensuring that only authorized individuals or vehicles are provided access through security gates at the edges of the AOA or in cargo buildings. Cargo security gates are primarily used by airline support vehicles, and entrance is gained by use of a magnetically coded card, lock and key, an electronic device, or a proximity badge. Access to service and cargo gates is restricted and typically requires cargo employees to complete specific training in order to obtain permission to use them.

4.3.9.6 Apron Lighting

Artificial lighting on the cargo apron enables nighttime cargo operations at airports. By providing nighttime illumination of the apron, air cargo aircraft handling, parking, and cargo sorting and processing are maximized. Safety and security are enhanced as well. There needs to be enough lighting on the apron to read labels, placards, and documents as well as to provide safety for ramp workers. Multiple zones of illumination can be achieved by the installation of both fixed and portable lighting equipment. Lighting is commonly affixed to the air cargo terminal building, and where aprons are extensive in size, light poles are used.



Source: Boeing 2002.

Figure 4-7. Air cargo GSE service areas for a B747.

4.3.9.7 Deicing Apron or Pads

When aircraft are covered with frost, snow, or ice contamination on their wings and other critical aeronautical surfaces prior to departure, deicing fluid is applied to remove the contamination and to prevent the accumulation of snow or slush for a period of time. If an apron is not equipped with the proper deicing fluid collection system, deicing fluid recovery vehicles or glycol recovery vehicles are used to recover deicing fluids from the airport pavement. Deicing pads may also be located adjacent to cargo aprons to consolidate the deicing activity and collect fluids, which are piped into storage tanks for recycling.

4.3.9.8 Hydrant Fueling

Hydrant fueling systems consist of a network of underground pipes from airport fuel farm tanks to cargo hardstand locations. Fuel is pumped through the hydrant via a fuel cart to transfer fuel from the hydrant fueling network to an aircraft. Hydrant fuel pits are to be located near aircraft fuel ports, which are typically under the aircraft wing. The vehicles or carts are positioned by air carrier or contracted fuel staff near the underground hydrant pit and connected to the aircraft fuel tank port via a fuel hose and pressure coupling system. Once the hydrant fueling system is connected to the cart and grounded, fuel is transferred to the aircraft from the underground pipe system. When no hydrants are available, fuel is transferred from a fuel truck to the aircraft via a fuel hose and pressure coupling system.

4.3.10 Ground Vehicle Access

Apron service roads serve as the main vehicle circulation arteries in and around the air cargo terminal core and other apron facilities. The purpose of apron service roads is to channelize the movement of air cargo–related vehicles so that pilots know where these vehicles are and to prevent conflicts with aircraft or engine jet blast.

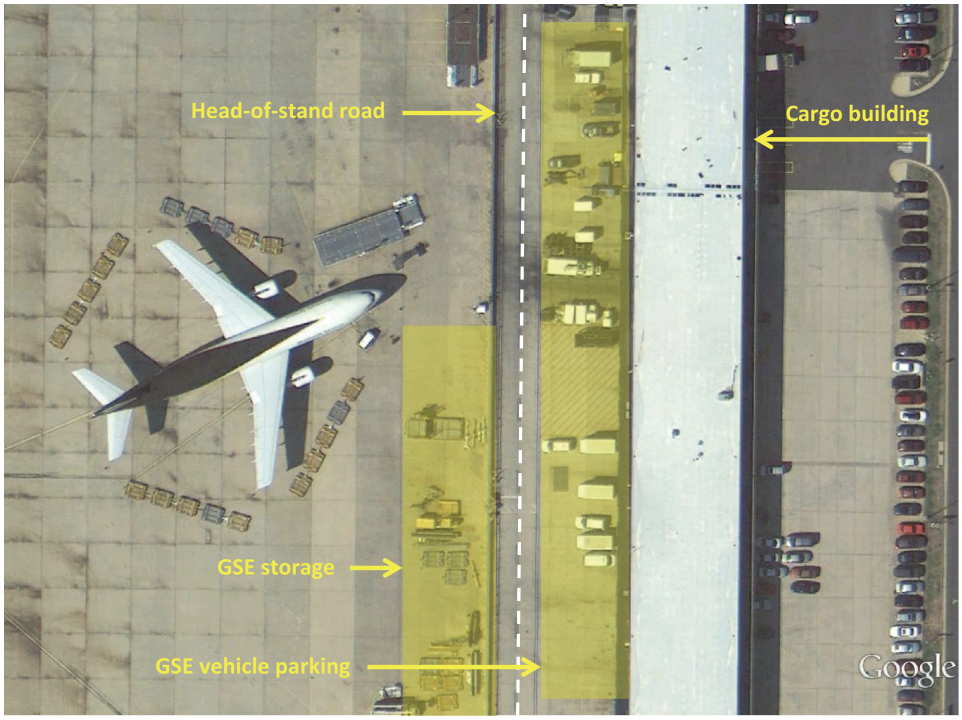
4.3.10.1 Head-of-Stand Road

A head-of-stand road is located between the nose of the parked aircraft and a cargo building. This configuration allows for uninterrupted access to aircraft because vehicle movements are not stopped for aircraft entering or exiting a gate. With this configuration, vehicles and GSE can travel from storage/staging areas around the gate areas directly to aircraft for servicing without accessing taxiways or taxi lanes, having to wait for aircraft pushing back or pulling into a gate position, and without other potential interactions. Head-of-stand road alignments also tend to increase apron depth. Figure 4-8 shows an example head-of-stand road at the UPS cargo ramp at Dulles International Airport. It is noteworthy that head-of-stand roads require apron dimensions with greater depth, especially to accommodate aircraft tugs without interfering with vehicle movements on these roads. These roads may create conflicts with apron-level cargo terminal door exits for personnel and ground vehicles. Overall, the head-of-stand configuration enhances safety by limiting interactions between vehicles and moving aircraft.

4.3.10.2 Tail-Stand Road

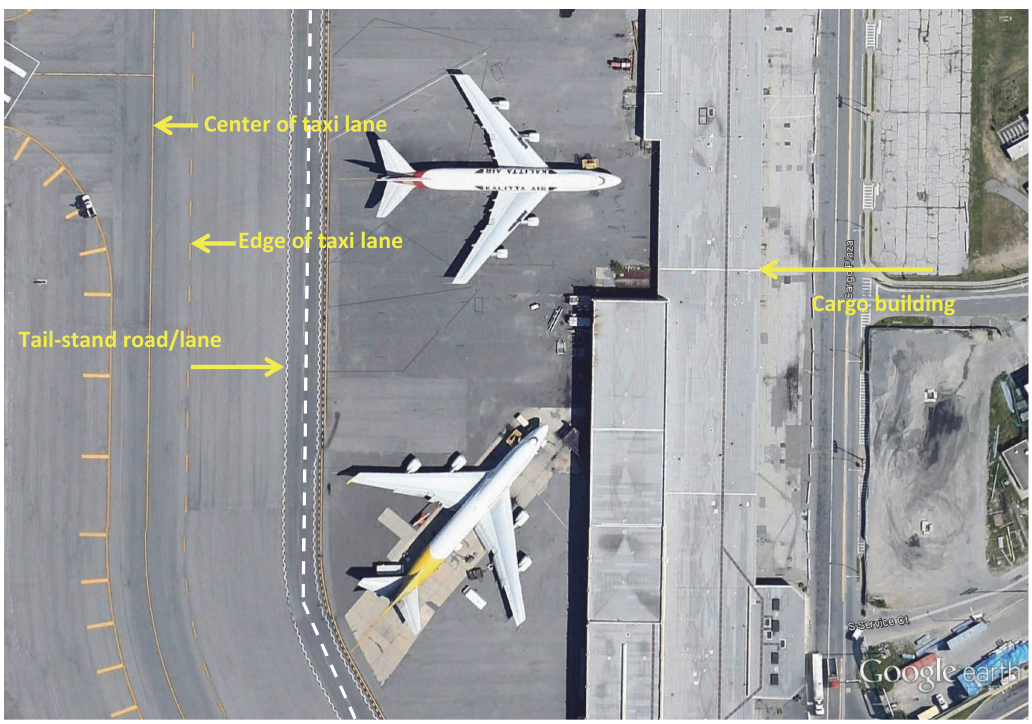
A tail-stand road is located at the tail of the aircraft where they are parked on the cargo apron and is at times referred to as an apron-edge service road because the road can delineate the limit of the leased areas. As shown in Figure 4-9, the layout of this type of service road usually reflects the physical limits of aircraft parking areas; it may also reflect the taxiway/taxi-lane alignment. Tail-stand roads can result in potential conflicts between vehicles and aircraft since aircraft must cross them to enter or exit gates. Figure 4-9 provides an example tail-stand road at the DHL cargo ramp at JFK International Airport.

To avoid operational consequences, tail-stand service roads must be located outside all taxiway and taxi-lane object-free areas (OFAs) since penetrations of these areas can result in



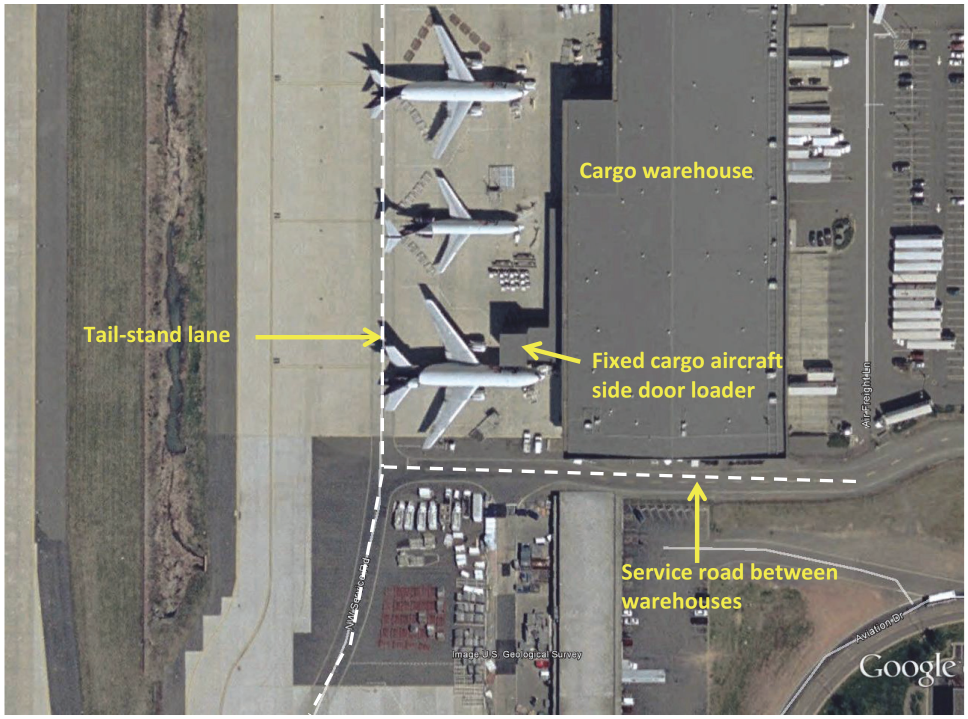
Source: Google Earth Pro, CDM Smith analysis.

Figure 4-8. Head-of-stand road and GSE storage configuration.



Source: Google Earth Pro, CDM Smith analysis.

Figure 4-9. Tail-stand road and taxi-lane configuration.



Source: Google Earth Pro, CDM Smith analysis.

Figure 4-10. Roads between cargo buildings and apron configuration.

limitations on the size of aircraft that can use the affected taxiways/taxi lanes. On aprons with tail-stand roads located on each side of a taxiway or taxi lane, it is common for these tail-stand roads to be connected across the taxiway/taxi lane by a service road marked on the pavement to provide vehicles a defined route to cross pavement areas, which can be expansive.

4.3.10.3 Roads Between Cargo Terminal Buildings

It is not uncommon for air cargo aprons to be supported by a vehicle pass-through road between air cargo terminal buildings. These two-lane roads provide access to the landside parking areas through a secured gate. Vehicles that use these roads include trucks transporting bypass ULDs or loose freight as well as emergency and delivery vehicles. Figure 4-10 shows an example service road between two cargo buildings on the FedEx cargo ramp at Dulles International Airport.

4.4 Landside Cargo Facility Planning

Landside air cargo facilities include cargo buildings (warehouses), truck parking and maneuvering lots, and automobile parking lots for employees and customers. Integrators, passenger airlines, and all-cargo carriers have multiple operating models within the landside facilities. This section identifies the types of carriers operating within the landside area, the throughput implications of each carrier, and the types of cargo buildings serving these carriers and their respective design attributes.

4.4.1 Utilizing Facility Planning Metrics for Cargo Building Design

As indicated in the cargo apron discussion in Section 4.3.5, facility utilization data was based on analysis of 31 air cargo facility surveys for apron area, warehouse space, GSE storage, and truck/auto parking. Airports were analyzed in this study to estimate the annual ton per square footage utilization of air cargo for warehouses. This section provides a facility requirements data matrix of ratios for the following cargo facilities based on cargo operator type, which include:

- Integrated express carriers,
- Passenger airlines, and
- Third-party providers/all-cargo carriers.

It is important to point out that these ratios are generic in nature to provide high-level guidance for air cargo area facility planning and are not typically applicable to individual carrier practices, which will likely have substantial variations in space requirements. These ratios, however, provide capacity requirements for air cargo activity at an airport. Carrier-specific utilization data should be obtained during the inventory process.

4.4.1.1 Cargo Building Throughput Analysis

Air cargo arrives via truck to the cargo building landside in one of two forms: as loose, bulky cargo, including cargo bundled on wooden pallets, or as containerized, loaded ULDs and cookie sheet pallets. Cargo building throughput rates are the standard measures to define the capacity of freight facilities, and these rates are expressed in annual tons of freight per square feet of cargo building. Airport master plans can use several other methods for determining warehouse space. Air cargo throughput rates can include the number of ULDs arriving per year, annual bulk tons per year, annual tons per ULD storage position, storage positions per elevated transfer vehicle (ETV), and annual tons per truck dock. For the purposes of this framework, the suggested throughput ratios are expressed in annual tons of freight per square feet of cargo building.

4.4.1.2 Integrated Express Cargo Building

Integrated express carriers operate at most airports and have air cargo buildings with truck dock doors and an aircraft parking apron. However, one integrated express carrier commonly has a larger sortation facility on airport, and another maintains a much smaller cargo building and trucks air cargo off airport to a regional sortation facility. While these produce substantial variances in the amount of air cargo facility space required at an airport, both commonly have aircraft parking aprons at an airport if the airport does not provide a non-exclusive aircraft apron for loading and unloading of air cargo.

When planning for the amount of land required to accommodate a certain volume of air cargo at an airport, airport planners would be well advised to assume that both of the major integrated express carriers would eventually need air cargo facilities that include larger cargo buildings, aircraft parking aprons, and truck circulation space and set aside ample land to accommodate a complete on-airport air cargo facility.

Based on the survey data, air cargo buildings for integrated express carriers at domestic airports average 29,100 ft^2 and at international gateway airports average 81,200 ft^2, and aircraft apron averaged 138,000 ft^2 at domestic airports and 305,000 ft^2 at international airports. GSE support space for integrated express carriers averaged 79,000 ft^2 at domestic airports and 171,000 ft^2 at international gateway airports.

This analysis provides airport planners ratios for determining space requirements metrics for the integrators. These suggested ratios are based on survey data from an extensive data collection effort. As presented in Table 4-12, cargo building space utilization based on annual cargo tonnage throughput is approximately 0.92 annual tons per square foot for domestic cargo for integrated express carriers and 0.37 for the same carrier type at international gateway airports.

Table 4-12. Air cargo facility requirements ratio application: cargo building.

	Annual Tonnage		Tons/Ft² Ratio		Cargo Building Required (ft²)
Integrated Express Carriers					
Domestic building (warehouse)	80,000	/	0.92	=	86,957
Int'l gateway building (warehouse)	80,000	/	0.37	=	216,000
Passenger Airlines					
Domestic building (warehouse)	80,000	/	0.64	=	125,467
Int'l gateway building (warehouse)	80,000	/	0.64	=	125,467
Third-Party Providers and All-Cargo Carriers					
Domestic building (warehouse)	80,000	/	0.81	=	98,400
Int'l gateway building (warehouse)	80,000	/	0.81	=	98,400

Source: CDM Smith.

4.4.1.3 Ground Handling Companies/All-Cargo Carriers

As presented in the previous sections, ground handling companies operate at both international gateway airports and domestic airports. Due to the similar operating nature of ground handling companies and all-cargo carriers at airports, this analysis combines the requirements of each into one category.

4.4.2 Applying the Air Cargo Building Ratios

As for the apron ratios, the air cargo facility requirements ratio matrix provides the metrics for converting annual cargo tonnage flows into cargo building requirements. Simplified calculations based on empirical data from this study's research assist in providing a range of air cargo building requirements in a preliminary design stage (see Table 4-12). The size of the cargo building required (in ft²) for the typical cargo volume can be calculated by dividing the annual cargo volume by the appropriate ratio (in tons per ft²) found in Table 4-12. A representative value for an integrated express domestic O&D station cargo building is 0.92 U.S. tons/ft² per year. For example, if an airport had an integrated air express tenant moving 80,000 U.S. tons annually, it would require approximately 87,000 ft² of floor space (80,000 tons divided by 0.92 ft²/ton). For the same amount of cargo volume at an integrated express international gateway, 216,000 ft² of cargo building space would be needed because it has a lower efficiency, as reflected in its smaller ratio. When applying the passenger airline ratio of 0.64 ton/ft², the amount of cargo building space required to handle 80,000 annual tons indicates a less efficient use of space for domestic cargo. (The average tons/ft² ratio was obtained from master plans analyzed in the literature review; ratios from this study's survey effort were too low for facility forecasts.) Third-party handlers and all-cargo carriers would need nearly 100,000 ft² of space to accommodate the same amount of annual volume. This methodology can be applied to current conditions at the airport as well as forecasted air cargo tonnage.

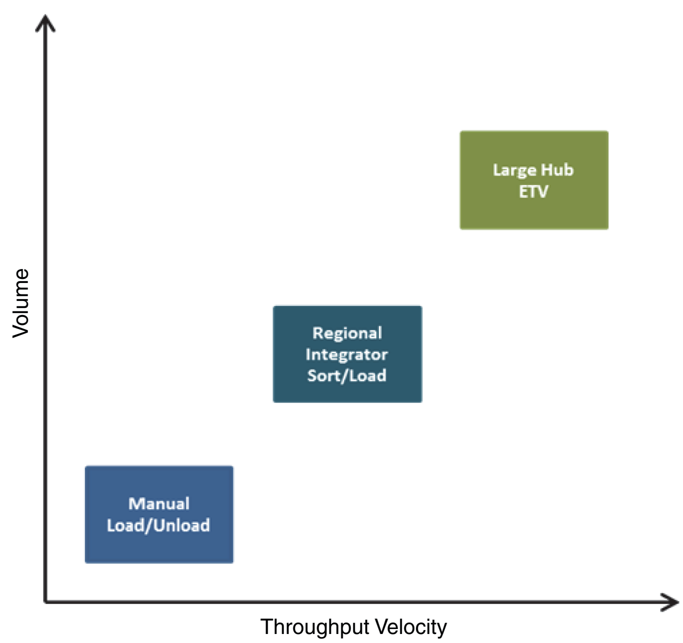
4.4.3 Cargo Building Occupants and Activity

When considering the entire universe of air cargo within the United States, one finds the majority of tonnage concentrated at cargo hubs and gateway airports rather than being equally spread across the entire U.S. airport network. In fact, analysis of ACI-NA cargo tonnage data indicates that the total cargo tonnage of the top 20 airports in the United States makes up 80% of all cargo enplaned and deplaned at the top 150 airports. The primary drivers for these large volumes of cargo at these top 20 airports are integrated express hubs (making up seven of the 20) and the global trade reflected in large volumes of imports and exports. These international gateway and hub airports must be able to accommodate a large amount of cargo in a relatively short period of time. Cargo buildings then are not really warehouses at all but are terminals, similar to passenger terminals, with capabilities to handle rapid change and flux and dramatic variations in hourly demand. The cargo terminal serves four principal functions:

- Conversion (break down and buildup of cargo pallets and ULDs),
- Sorting (arranging ULDs and cargo by airline, destination, and flights),
- Storage (on a short-term basis), and
- Facilitation (customs, etc.) and documentation.

Typical air cargo handling methods range from being manual and labor intensive to highly automated, and depend largely on the volume and speed of cargo handling required at the airport. The air cargo marketplace offers a wide variety of systems, ranging from fairly basic to technically sophisticated. Each has its place, form, and function. As illustrated in Figure 4-11, the type of handling system used is dependent to a large degree on the amount of cargo being handled and the speed at which it is being processed.

Most landside air cargo terminal systems are simply dock doors to allow surface transportation (mostly trucks) to deliver goods to the building. However, not all surface cargo goes through buildings. Many shipments are built up (prepared to be placed in the aircraft, either inside containers/ULDs or as break-bulk) and delivered through the airport's airside security gates, which allow trucking directly to the aircraft ramp, bypassing the cargo building, where they are loaded onto the aircraft. However, most shipments arrive through typical dock doors located along the landside of the cargo buildings. Again, some cargo has already been prepared off-site for shipment, while other cargo must be built up on-site inside the cargo building.



Source: Lynxs Group.

Figure 4-11. Determining appropriate handling systems.

For purposes of this research, airports in the United States are divided into two categories: domestic O&D airports and international gateways. This analysis does not take into consideration the express carrier hubs. Integrated express hubs are highly specialized facilities designed to move large cargo volumes in a short span of time. Integrated express hubs are typically planned and developed by the carrier's own industrial engineers or their hired engineering consultants. Hub development in the United States is considered fully developed, and no new hubs are anticipated to be constructed in the next decade, and likely not in the next two decades. It is worthwhile to note that there are several integrator hub facilities in the Ohio Valley that have been vacated and will likely never be used again as air cargo hubs. (The U.S. integrator hub and regional hub systems are fully developed for the near- to medium-term, at least. FedEx and UPS have adequate spacing and capacity in their current networks.)

4.4.3.1 International Gateways

The gateway functions as a consolidation, distribution, and processing point for international air cargo. Gateway airports typically have substantial passenger airline activity, with wide-body aircraft capable of accommodating large volumes of air cargo in the belly-hold compartments. Based on historic trends, gateway airports are the airports best positioned to experience growth in international cargo traffic. To a certain extent, an international air cargo gateway is similar to a hub airport in that the gateway airport is not reliant on the surrounding market area to generate sufficient cargo to justify air cargo–related operations. As with the air cargo hub, much of the cargo moving through a gateway airport does not originate and is not destined for the gateway airport's surrounding market area. Airports in the United States that are considered international gateway airports include those in Miami, New York (JFK), Los Angeles, and Chicago. Evolving gateway airports include those in Atlanta, Dallas, and Houston. Detroit International Airport functions as a gateway to a lesser degree since the airport accommodates Delta international flights to Asia and Europe.

4.4.3.2 Domestic O&D/Local Market Stations

The criteria for a local market station (a term developed for this research to identify the spoke facilities serviced by the hubs) or direct air cargo service (O&D service to an airport's surrounding market area) generally coincide with population centers where there is a concentration of industry, commerce, and transportation infrastructure. Often referred to as a "node" within a cargo carrier's network, the local market station is the simplest and most common type of air cargo facility. For airport-to-airport service providers, the local market station represents the origin or destination point for the cargo they are transporting.

The sole function of a direct air cargo service facility is to collect from a customer's outbound air cargo and distribute the customer's inbound air cargo to the airport's surrounding market area. In order to make direct air cargo service economically feasible, the airport's surrounding market area, or catchment area, must generate enough inbound and outbound cargo and revenue to offset the carrier's aircraft operational costs. If the carrier cannot meet the aircraft operational costs, the cargo is trucked to the hub or another local market station, where it is loaded onto an aircraft. Trucking to an airport outside the market area is detrimental to the carrier's service delivery and pickup times. Air cargo terminals or cargo buildings are either occupied by a single tenant or by several tenants.

4.4.3.3 Single-Tenant Facility

This warehouse type is an air cargo building/warehouse with one occupant occupying the entire facility. At most airports, single-tenant warehouses are not the predominant facility. For domestic air cargo facilities, single-tenant facilities are almost always occupied by an integrator. At international gateways, single-tenant facilities may be occupied by an all-cargo carrier and a third-party handler. There are also instances where the single tenant at gateway airports is a combi carrier (passenger airline with a dedicated freighter fleet).

4.4.3.4 Multi-Tenant Facility

This warehouse type is an air cargo building/warehouse with several occupants occupying assigned areas. Tenants may be solely air cargo businesses and carriers or may be a mix of carriers and supporting businesses. Some may have no relationship with the air cargo industry but may only provide services to the passenger carriers.

4.4.4 Cargo Handling and Building Design Considerations

A ULD (see Figure 4-12) is a container or a pallet that is loaded onto the aircraft and unloaded at its destination. Containers are aluminum, Plexiglas, or Fiberglass boxes that are shaped to fit the contoured sides of an aircraft. Pallets are solid wood, metal, or plastic transport structures on which shipments are stacked and wrapped in plastic and netting. The advantages of pallets over containers are that pallets are lower in tare weight, cheaper to own/repair, easier to handle, and can be stacked empty. The main advantages of containers are that they are fully enclosed, protecting their contents from the elements and theft. A disadvantage of both is that they are easy to damage. ULD loads can be assembled at the airport or arrive pre-assembled.

Wide-body aircraft have rollers on both the main and lower decks, while narrow-body aircraft have rollers strictly on the main deck. The lower decks of these aircraft are bulk loaded or loaded manually. Specialized ground handling equipment lifts containers and pallets to the main deck. Containers and pallets are typically loaded and unloaded in a warehouse that may be located at an airport. Containerizing or palletizing air cargo allows for quick and efficient loading and unloading of aircraft as well as trucks. In addition, some warehouses have roller-deck flooring, which allows for movement of pallets and containers without the need for forklifts, dollies, or tugs. Igloos are similar to ULDs but are designed and contoured to load onto the main deck of a passenger airline equipped to accommodate both passengers and igloos.

Approximately 50% of international air cargo travels in the baggage compartment, or lower deck, of passenger aircraft; this cargo is also referred to as "belly cargo." The wide-body aircraft that typically serve these routes offer substantial freight capacity in lower-deck containers.

Narrow-body jet aircraft, such as freighter versions of the Boeing 757, Boeing 737, and McDonnell Douglas DC9, are typically used for short-haul domestic routes, while feeder aircraft serve small market needs. Narrow-body aircraft payloads range from 18,000 to 95,000 pounds.

(i) Upper Deck Container

(ii) Lower Deck Container

(iii) Upper Deck Pallet

Source: (i) and (ii) CDM Smith; (iii) Rickenbacker International Airport.

Figure 4-12. Examples of ULDs.

Feeder aircraft payloads can range from 2,000 to 10,000 pounds. Upper decks on narrow-body aircraft accommodate containers, while the lower deck is bulk loaded in a process where individual pieces of freight are placed directly into the aircraft without the benefit of containers. Feeder aircraft are typically bulk loaded only.

4.4.5 Cargo Handling Systems and Storage

Air cargo (mail and freight) typically arrives on the landside of an air cargo building in two forms: containerized on air cargo pallets and ULD containers and in bulk, which is loose parcels and packages that require sorting and batching prior to loading onto air cargo pallets or being packed into ULDs. Additionally, some air cargo parcels, boxes, and packages may arrive on wooden pallets, which require forklift transfers into ULDs or air cargo pallets. Cargo arriving on the landside is unloaded from trucks, typically via a truck loading dock.

Typical storage methods are conventional-pallet single-deep racks, double-deep racks (allowing for two pallets to be inserted into a slot), drive-through racks (can be entered from either end), cantilever racks, pallet staking frames, and gravity-flow racks. Similarly, typical equipment in an air cargo building includes forklift vehicles, narrow-aisle trucks, transfer devices, elevating transfer devices, and storage-retrieval machines. The amount and type of equipment depend primarily on the type of carrier or operator using the space. In a terminal dedicated to integrated express parcel processing, the operations (mainly sorting) may be performed at ground level as well as using an elevated conveyor and slide system. Arriving air cargo is handled with a number of methods depending on the level of warehouse automation, but four categories of cargo building emerge as the most common types:

- Manual-load facilities
- Moderately mechanized sort and load
- Automated terminals and gateways
- Regional integrator sort-and-load facilities

4.4.5.1 Manual-Load Facilities

These are often, but not necessarily, low-volume terminals. Where manpower is available and inexpensive, freight may be moved by hand and forklifts. Extensive layouts of roller beds and transfer tables may be used. Racks may be used to store lose cargo but not ULDs. Such terminals are also desirable when there are limited funds to purchase equipment and where the operator lacks skilled labor for equipment maintenance (see Figure 4-13).

4.4.5.2 Moderately Mechanized Sort and Load

ULD containers are moved by extensive layouts of roller beds, mobile lifting, and transfer equipment, such as forklift trucks. Conveyor systems and sortation platforms and slides may make up the integrated express terminal interiors. ULDs may be stored on racks. These open, mechanized terminals are suitable for medium freight flows but have two major disadvantages: they are space intensive, and the forklift operations incur high levels of ULD container damage (Figure 4-14).

4.4.5.3 Automated Terminals and Gateways

Involving transfer vehicles and ETVs, these heavily automated facilities use single- or multiple-level storage of containers, which are moved within the terminal mainly by railed transfer vehicles. ETV operations produce high throughputs per square foot, with minimum container damage and reduced labor requirements. These facilities are expensive to construct and operate and require a steady stream of demand for return on investment. The advantages of this system include the

Source: CDM Smith.

Figure 4-13. Manual-load facility.

savings in the number of workers and floor area, the potential for the maximum utilization of cargo terminal space, the minimization of accidents, enhanced security of the air cargo, and the minimization of damage to cargo and ULDs (see Figure 4-15).

4.4.5.4 Regional Integrator Sort-and-Load Facilities

Conveyor systems and sortation platforms and slides may make up the integrated express terminal interiors. Containers are moved by mobile lifting and transfer equipment—for example, forklift trucks. ULDs may be stored on racks and moved on ball decks (see Figure 4-16).

Source: CDM Smith.

Figure 4-14. Moderately mechanized sort-and-load example.

Source: Lynxs Group.

Figure 4-15. Automated terminal facilities.

4.4.6 Cargo Handling Systems

The cargo storage system (CSS) is used for storing ULDs. Each cargo compartment can be designed for holding one or multiple standard IATA ULDs or pallets. Each compartment is provided with a roller deck on which the ULD moves. In the case of multiple ULDs stored in one compartment, the system ensures that they do not collide. Two types of roller deck normally installed in the storage rack are powerless storage roller decks and motor-driven roller decks.

The powerless storage roller deck is driven by the ETV/stacker friction drive, which moves the ULD in or out of the storage deck. The ULDs are pushed onto or retrieved from the roller conveyor by these devices. Motor-driven roller decks are used on both the airside and landside, together with ETVs/stackers.

An ETV lifts and carries aircraft ULD containers between the floor-level working and transfer environment and storage positions in the CSS structure. ETVs work best in warehouses where the cargo arrives off trucks pre-packed in ULDs or on cookie sheet pallets.

Source: Lynxs Group.

Figure 4-16. Regional integrator sort-and-load facility (FedEx Express sorting system).

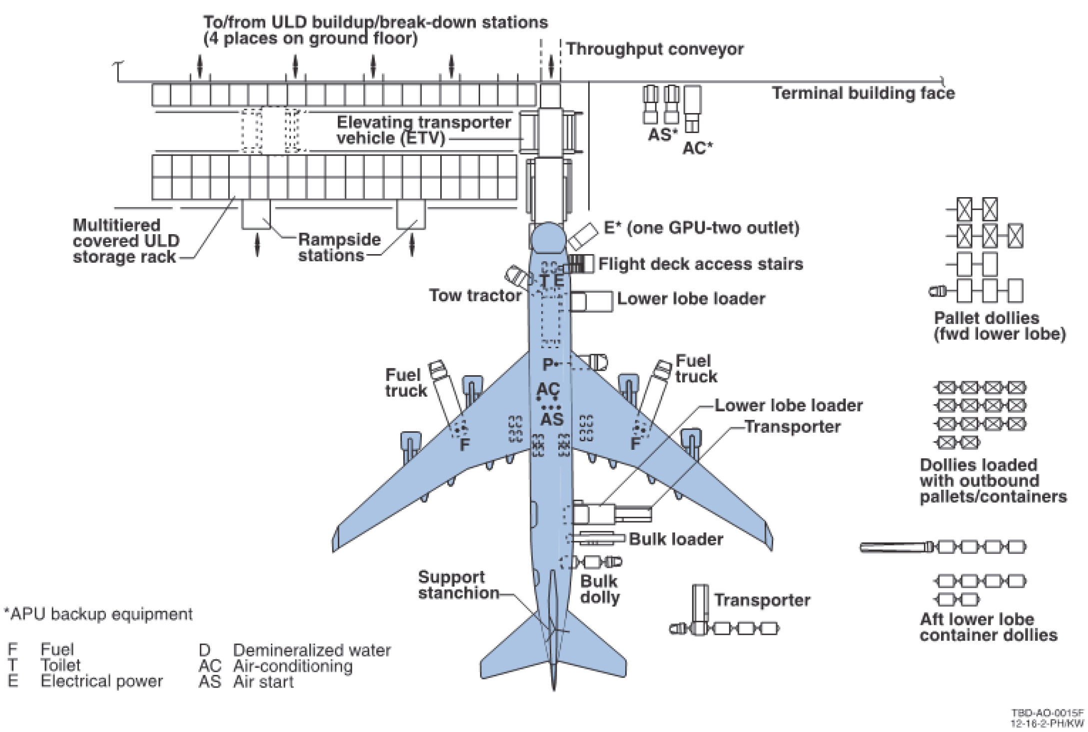
Transfer vehicles and transfer shuttles are the traditional rail-mounted prime movers within the floor-level ULD storage and transfer systems of large airport cargo terminals. Transfer vehicles are operated by an onboard driver, while transfer shuttles are driven remotely by an operator or automated control system.

Ball decks provide a multi-directional transfer medium to allow staff to manually maneuver, redirect, and reorient ULDs. Small deck areas may be installed as junctions between conveyors and other equipment, while in more extensive installations, large ball decks act as the prime mover and are used to manually transfer and manipulate ULDs between an array of interfacing equipment.

Castor decks provide a high-performance alternative suitable for lighter-weight ULDs typical of express operations. Castor decks fully encapsulate the castors with treaded walkway plates, providing a safe surface on which staff can manipulate the containers.

Nose-dock loading systems (see Figure 4-17) allow nose-loading aircraft (e.g., B747) to load directly from the ETV system (see Figure 4-18) through the open nose of the aircraft, which is parked immediately adjacent to the system within the cargo terminal building.

Cargo terminal buildings supporting CSS vertical storage systems have ceiling heights up to 40 ft high, depending on roof trusses and fire sprinkler systems. Cargo terminal warehouses for airports supporting largely domestic cargo activity typically have ceiling heights ranging from 20 to 23 ft in height. Building heights need to be taken into consideration by airport planners since higher structures typically need to be set further back from runways to avoid penetrating the airport's controlled airspace.



Source: Boeing 2012.

Figure 4-17. Nose-dock loading system.

Source: CDM Smith.

Figure 4-18. ETV system being installed at Centurion air cargo facility.

4.4.7 Cargo Building Height

Air cargo buildings in the past were often merely concrete pads with a roof and walls to function as cargo consolidation and sorting stations for passenger airlines. The early cargo buildings were often refitted aircraft maintenance hangars located on a remote part of the airport. Transporting the cargo within the building from the storage area to the processing area and truck doors was often inefficient and space intensive. Placing the cargo on racks improved the efficiency, but tug times to the aircraft did not improve due to the remote location. First-generation cargo-exclusive buildings were low-rise structures with lower productivity per square foot since racking cargo vertically was limited. These buildings were placed closer to the terminal but were limited in footprint, and the number of truck doors was limited when compared to today's standards.

The international passenger gateway airports were often land-constrained, and space for air cargo terminals came at a high cost. Airport planners and industrial engineers had no choice but to design and build taller air cargo buildings in order to fit them on a limited land envelope. Today, at the largest international gateway airports, air cargo facilities may have up to 40-ft ceiling heights with multiple levels of build and break space as well ULD and pallet storage. These facility's operators use information technology systems to anticipate loads based on bookings, airline schedules, and truck delivery schedules. These modern facilities are designed for specific airlines or third-party handlers with a particular profile in commodity types; operating equipment and schedules thereby increase facility efficiency. If these facilities are vacated, however, it is often difficult to find a replacement tenant that requires identical industrial designs. Retrofitting these facilities can come at a great expense to the facility owner.

The maximum storage height depends on the cargo handling and ETV equipment capabilities, the quality of floor leveling (which can affect racks and ETV installation), and the storage policy of the terminal. (Priority cargo is stored at low levels for faster access.) In multi-rack storage systems, pallets are placed into fixed-dimension slots, and the typical height of a commodity pallet plus a height margin multiplied by the number of rack levels leads to the total height requirements in the warehouse area. When this height is already determined (e.g., in the reengineering of an existing air cargo facility), a similar calculation will provide the maximum number of levels in the multi-rack storage system. A typical height dimension for an automated-terminal warehouse is 35 ft, but the planner should take into account the specifications for the minimum distance between the fire sprinklers systems, skylights, and roof trusses.

Airports that are land rich have the advantage of not necessarily having to build tall air cargo facilities since there is typically ample space for building horizontally. These facilities may require vertical space for storage racks but may only need ceiling heights of 20 to 25 ft. The manual-load facilities and the moderately mechanized sort-and-load facilities typically can function in these lower ceiling facilities, while the automated terminals and gateways typically require greater ceiling heights.

An additional advantage of warehouses with higher vertical capabilities is that office space can be accommodated on a mezzanine if the warehouse is equipped with one. Mezzanines provide cargo or equipment storage below and office space above. Airport planners need to be aware that Americans with Disabilities Act (ADA) guidelines and requirements may apply to mezzanine installation.

4.4.8 Truck Parking and Maneuvering Space Considerations

The landside portion of an air cargo facility must have sufficient space for truck operations. While trucking companies make up the surface component of air cargo operations, they rarely lease space at an airport, yet airport planners must ensure that air cargo buildings where integrators, all-cargo carriers, and third-party handlers lease space be designed to accommodate trucking, including frontage, access, and roadway geometry. In many airports, older cargo facilities were designed to accommodate smaller 40-ft-long trucks but not today's larger trucks (up to 75 ft) typically used for long-haul trucking.

Another critical element of landside planning are the employee and customer automobile parking requirements for the air cargo facility. Ideally, both must have close-in parking that is physically separated from the trucking operations, but often it is not. In instances where automobile parking is limited, employee parking is usually shifted to a remote lot.

Most air freight facilities have to interact with trucks for pickups and deliveries. The place this occurs is the loading bay, which by definition is the area where goods are loaded onto and unloaded from vehicles and where the freight facility interacts with the outside world. Loading bays have the following physical features:

- At the truck-building interface are loading docks. Loading docks lead directly to staging areas inside the facility and, in taller warehouses, to ETV systems.
- Outside the warehouse building are berths, parking pads, parking aprons, parking area, and sometimes gates.

The loading dock is the crucial element that bridges the building and the truck. What should loading docks look like and how should they function? According to the Whole Building Design Guide (a web-based information base providing comprehensive guidance on building design and has been developed collaboratively by federal agencies, private-sector companies, non-profit organizations and educational institutions), an information resource established by the National Institute of Building Sciences, loading docks should have the following design features (Greenbaum 2011):

- Location: Away from the main entrance and away from pedestrian traffic for safety reasons.
- Height: Typical loading docks are platforms built 55 in. high in order to accommodate most trucks. If the height of incoming vehicles' truck beds varies by more than 18 in., at least one berth should have a dock leveler to adjust the height. Furthermore, there should be a ramp of 1:12 grade from the loading dock to the parking area in order to facilitate unloading from the parking lot.

- Depth: They should be deep enough for forklifts and other loading and unloading equipment, for rough sort, and should be easy to pull forward into the facility. [For distribution centers, the modern standard is depths of 100 feet (KOM International 2010)].
- Doors should be of the overhead coiling type, and a small personnel door should be provided.

Within the facility, staging areas need to be big enough to keep the dock clear while goods are readied for movement deeper into the building. In multi-story structures, they should be adjacent to freight elevators, which themselves must be large enough to accommodate bulky items.

The property outside the building allows the truck to enter from the street, wait for entry to the loading dock, and maneuver in and out of the dock amidst other vehicles. For operations using drop trailers, there needs to be space sufficient to park a loaded trailer and to collect an empty trailer from an inventory in the yard. The outside components are berths, trucking parking, landing strips, aprons, and gates.

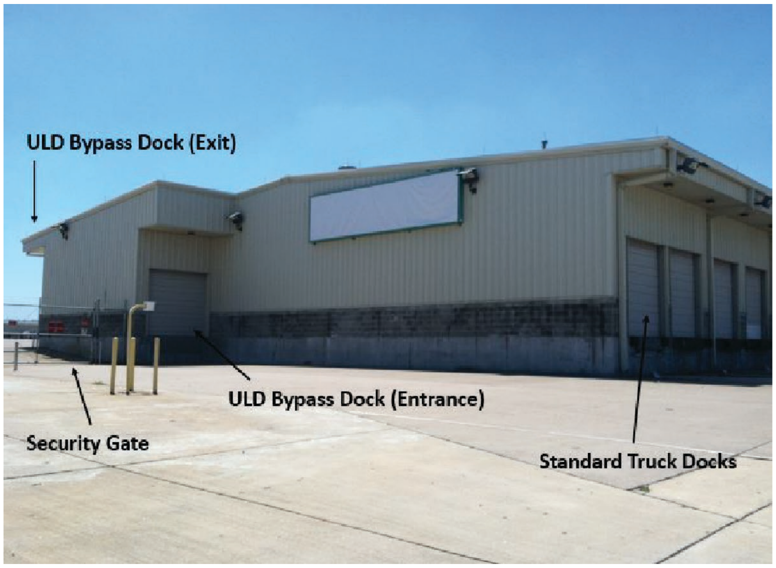
- Berths are where the truck pulls in. Loading docks typically are divided into individual dock doors, with the berth serving as the entry point. Given a width of tractor-trailers at parking pads of 102 in. (8 ft 6 in.), the width of berths should be at least 12 ft, and 18 ft is recommended.
- Parking pads are the concrete parking areas adjacent to the loading docks, sized to meet the needs of the largest trucks.
- Parking aprons are the maneuvering area for trucks to get in and out of berths and parking spaces.
- Parking area: The rule of thumb is that the number of truck parking spaces should be equal to the maximum number of trucks loading and unloading at any time (Tompkins and Smith 1998). In the majority of situations where trucks are actively engaged in transferring freight, parking space is used for queuing and holding and not for down time; in the absence of a loading dock, parking serves as a berth. Additional space is needed if trailers are being dropped, both to hold the loaded vehicle and to replace it from a supply of empties; aprons must be able to accommodate this activity as well.
- Gates are security features typical of higher-volume operations such as those at large air cargo hubs and international gateways, or are used for valuable goods needing protection. Because trucks will queue as they enter and exit gates, approach areas or driveways should exist to allow this.

4.4.9 Truck Traffic

At the larger international gateway airports where the airlines and integrated express carriers have large air cargo facilities that drive a substantial amount of truck traffic, and even at domestic airports where the integrated express carriers have substantial truck traffic, air cargo facilities are best positioned in an area that has direct access to major roadways or freeways as well as the airside taxiway system. If at all possible, airports do not want air cargo trucks comingled with vehicles going to or coming from the airport passenger terminals. For example, at George Bush Intercontinental Airport, international freighter operations are located on the opposite side of the airport from passenger terminals and have direct access to the Houston freeway system.

4.4.9.1 Cross-Docking

In some cases, air cargo may be cross-docked to transfer inbound air cargo at one airport to an outbound truck destined for another airport. For example, an airline in a large market with multiple airports to choose from may use one major gateway airport as a drop station for another major gateway airport. Reasons for this could be that the airline does not have dedicated freighter/main deck service at one airport but does have it at another, or one airport has a strong market but that airline does not have the uplift capacity at that airport but has it at another airport. This cargo would not typically be reported to the airport by an airline as enplaned cargo,



Source: CDM Smith.

Figure 4-19. ULD bypass dock at Austin Bergstrom International Airport.

and therefore, the airport will likely not know exactly how much cargo was being handled in that facility. These type of operations may be significant at some airports, and one study at JFK International Airport estimated that 25% of cargo volumes within an air cargo building may be cross-dock related. This would significantly affect an airport's ability to plan future facilities and capacity since simply adding up tonnage from the airlines that use a facility may not always lead to an accurate portrayal of actual usage. In fact, a facility may not appear to be operationally full when the reported enplaned and deplaned volumes are reviewed, yet it may be operating above throughput capacity without an airport being aware of the constraint.

4.4.9.2 Warehouse Bypass

It is not uncommon for air cargo buildings and aircraft parking aprons to be supported by a vehicle pass-through road adjacent to air cargo terminal warehouses. These two-lane roads provide access from the ramp to the landside parking areas through a secured gate. Some carriers load ULDs at off-airport warehouses, then truck them to the airport. Some airports, however, do not allow trucks to pass through the security gates directly to the apron where aircraft are loaded. As a result, some carriers have installed special docks for trucks to unload ULDs and bypass the main warehouse staging area. This facility design expedites the ULD container unload without the need for the truck to drive onto the air cargo ramp area. Figure 4-19 shows an example bypass dock at Austin Bergstrom International Airport.

CHAPTER 5

Air Cargo Forecasting

Cargo forecasts are generally undertaken as part of an airport's master planning activity, as part of an environmental assessment, to accommodate facility improvements, or in response to unforeseen demand or expectations of the local business community. They are then used to assist planners in the identification of future cargo facility and apron requirements.

5.1 Data Sources

Virtually all U.S. airports track total cargo volume, as well as subsets of cargo such as freight (including express) and mail, on a directional (inbound and outbound) basis. Commonly, these data sets are managed by airport accounting departments and are compiled from monthly operations reports used to settle landing fees and satisfy other carrier reporting requirements. Whether disseminated publicly or not, this data is kept by the airport on a carrier-level basis, which can be organized into market share by individual carrier or type (all-cargo versus belly). For those airports to which it is applicable, cargo will also be organized into domestic and international increments. In addition to tonnage data, monthly airline reports provide critical inputs related to monthly frequencies and aircraft types. There is no single standard for how or if airports generate public reports from this and other data. While the web page of the Port Authority of New York & New Jersey contains extensive monthly data sets pertaining not only to airport operations but also to customs entries by country and commodity, for example, other airports may include nothing more than a single entry for total annual cargo in their public reports. Almost all member airports report annual tonnages to ACI-NA, which publishes a top 50 data set by year on its web site and a more extensive set for members only. However, U.S. airports are not compelled to join ACI-NA, and major cargo airports, such as UPS's regional hub in Rockford, IL, will not be found in ACI-NA's statistics.

Air cargo tonnages are typically reported by airport commissions and are reported to the public on an annual basis, but monthly reports are useful to isolate seasonal trends. While it is uncommon for carriers to report weekly or daily tonnage numbers, planners can use secondary references (such as OAG's Cargo Flight Guide) or request carrier schedules to record flight operations in peak-period analysis; this is critical where aircraft parking ramps are at a premium. Because of the limitations of individual references, it is advisable to use multiple sources of primary and secondary inputs. OAG's Cargo Flight Guide, for example, does not include schedules for integrated carriers and may also identify flights by ACMI (aircraft, crew, maintenance, and insurance) carrier rather than client.

A variety of institutional sources are commonly used to calibrate individual airport forecasts, including forecasts by Boeing, Airbus, IATA, and the FAA. These are detailed later in this chapter with an assessment of the strengths and weaknesses of each source. For specialized facilities—such as cold storage facilities—airport planners may seek trade data originating with U.S. Customs and Border Protection (CBP) that can quantify monthly and annual tons by commodity type for both import and export shipments cleared at the local customs port. Much trade data can be accessed at no cost from the U.S. Census Bureau and through subscriptions to governmental sources such as the BTS TranStats service. Secondary commercial providers also sell packaged reports that often blend public and proprietary sources.

There is no substitute for the unique perspectives obtained through original interviews and surveys with on-airport cargo-related tenants and key off-airport constituencies. The former may include local station managers as well as corporate property managers and route planners who commonly have distinctive insights into carriers' intentions for the local market. Off-airport constituencies may include freight forwarders, trucking companies, and major shippers (manufacturers and distributors) of time-sensitive commodities. Area economic developers may also provide insights and data characterizing the local origin-and-destination market. It is essential that the planner preparing the air cargo forecast understands the cargo market(s) under consideration in terms of commodities being shipped and received, as well as the economics of modal alternatives and nearby competing airports.

5.2 Methodologies

5.2.1 Time-Series Trend Analysis

One of the most common forms of statistical analysis is the discrete time series, which observes phenomenon through regularly spaced intervals (contrasted with the *continuous* time series, which records an observation at *every* instant of time). This analysis can be organized to measure trends that may be extended to forecast future values. To be used as a predictor, time-series analysis requires confidence that the period to be forecasted will be much like the period from which the trend multiplier (usually a CAGR) was derived. ($CAGR = (\text{ending value} \div \text{starting value})^{1/(\text{number of years})} - 1$). CAGR provides a smoothed rate of return describing yield on an annually compounded basis. One of its weaknesses is that it does not reflect volatility, which can be substantial from one year to another, but rather creates the illusion that there is a steady growth rate.

For many years, a 20-year horizon was the accepted time frame for forecasting. Clearly, the early years had the greatest credibility and the most distant years the weakest. Airport activity has been volatile as the airline industry has been affected by uncontrollable factors such as escalating fuel prices, economic swings, and labor issues.

Longer historical periods are still often preferred, but the beginning and ending years of the time series should be closely scrutinized for the effect that anomalous years can have on trend analysis. While it is customary to use increments such as decades in a time series, a 10-year time series initiated with the extraordinary losses in 2002 would likely miss common peak years (useful in gauging historical capacity) from the late 1990s through 2000.

On the other hand, a longer time series must be qualified in terms of applicability because the industry itself has changed so greatly since the 1990s. In fact, the demise of former all-cargo tenants such as Airborne Express, BAX Global, Emery Worldwide, and Kitty Hawk has left sprawling vacancies at on-airport cargo facilities. In many predominantly domestic air cargo markets, market shares of FedEx and UPS have risen from around 50% 20 years ago to over 90% in 2012. Such market consolidations may have the twin effect of emptying multi-tenant buildings of folded former legacy carriers while leaving the surviving dominant carriers more likely to have required single-tenant (stand-alone) facilities dedicated to their individual operations. The ultimate outcome is a dearth of prospects to fill vacancies.

In international gateways, gains in international cargo tonnage have at least partially masked losses in domestic cargo. Total cargo tonnage may have changed very little in the course of 20 years, but the carrier composition may have changed dramatically. Similar changes may have transpired in the mix of belly cargo market share versus freighter share.

Forecasts created in the last 10 years have typically assumed that the bottom of the air cargo demand cycle had already been found and that recovery would begin immediately. Unfortunately, many forecasts based on that assumption have proven overly optimistic to date.

Even if only to provide a contrast, time-series analysis remains a useful planning tool. If concerns exist related to anomalous years of data, multiple analyses can use a variety of beginning and ending years. Regardless of the interval, charting market deterioration since past peaks illuminates how much facilities capacity may exist from an airport's past peak demand. The ideal use for trend analysis has been described as a mature industry experiencing relatively consistent, gradual growth—a description that contrasts greatly with the recent experience of the U.S. air cargo industry.

5.2.2 Regression Analysis (Econometric Modeling)

Regression analysis is a statistical technique for estimating relationships between a dependent variable and one or more independent variables. Regression analysis helps explain how the typical value of the dependent variable changes when any one of the independent variables is varied while the other independent variables are held fixed.

Regression analysis is widely used for prediction and forecasting. Regression analysis is also used to understand which independent variables are related to the dependent variable and to explore the forms of these relationships. In restricted circumstances, regression analysis can be used to infer causal relationships between the independent and dependent variables, with the critical caveat that correlation does not by itself prove causation.

The dependent variable of air cargo growth may be associated with such independent variables as jet fuel prices, GDP, composite leading indicators (CLIs), and population—customarily using a combination of time-series and growth curves. Most U.S. airports only serve local or regional O&D markets. Therefore, cargo growth may track closely with local or regional economic attributes, so reliable functional relationships may exist between an airport's cargo growth and the area GDP, income, and population growth. However, at international gateways, air cargo growth may be at least as influenced by economic conditions in O&D countries as by local economic conditions since air cargo is often trucked great distances across several states, or across the country in many instances, to these international gateway airports.

Econometric modeling (such as multiple regression analysis) is often perceived as more effective with broadly defined markets (countries and entire continents) in which multiple factors influence aggregate growth and other variables may be held constant. A flaw is this assumption that supply is unconstrained, which contrasts starkly with individual airports, where cargo capacity is constrained by the hub-and-spoke systems of carriers and limited aircraft fleets. The ability of carriers to shift capacity between airports as well as between air transport and other modes (particularly trucking) poses substantial risks to the assumption of unlimited capacity supply that meets graduated demand. U.S. airports have experienced extraordinary growth (Greensboro, NC, with FedEx) and losses (Des Moines, IA, with UPS) attributable to network adjustments by integrated carriers that seemingly had nothing to do with local cargo demand generation.

Like time-series analysis, regression analysis is a useful tool to evaluate historical relationships between cargo growth and other econometric elements. However, it is an imperfect (wildly so in some circumstances) predictor of future trends—not least because of its assumption of unlimited capacity supply—and, therefore, should be considered only one of several potential analytical tools.

5.2.3 Market Share Analysis

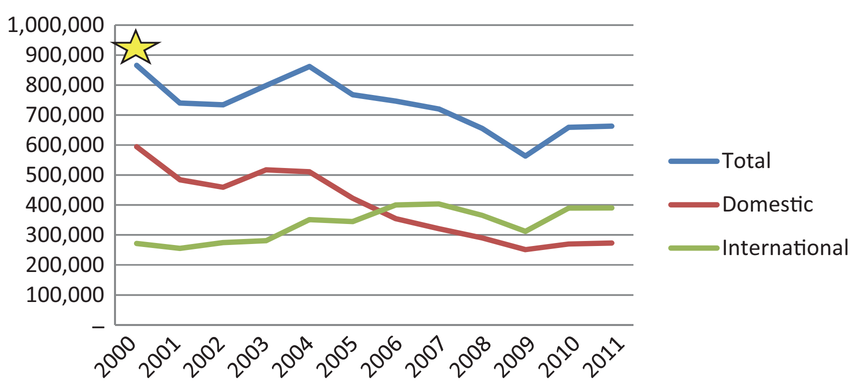
Market share analysis compares local activity levels with a larger entity, most commonly in comparisons between a particular airport and its regional traffic or with total national traffic. Historical data is used to establish the ratio of local airport traffic to total national traffic—customarily using source data from the FAA Aerospace Forecasts document for national data.

Much like the preceding methodologies, market share analysis has limitations as a predictor. Most obviously, this methodology assumes that the proportion of activity that can be assigned to the local level is a regular and predictable quantity. As has already been established, the U.S. air cargo industry remains in the midst of a prolonged period of contraction that has touched most airports but not equally. For example, as in Figure 5-1 depicting Hartsfield-Jackson Atlanta International Airport, some gateways were able to offset some domestic losses with international gains.

Indications in late 2012 from the two dominant integrators suggested that near- to medium-term domestic fleet utilization strategies may favor up-gauging aircraft size but serving fewer U.S. markets by air, while expanding the utilization of trucks for domestic feeder service. The impact may negate organic air cargo growth at many small and medium-sized markets or, conversely, may support growth at strategically located airports that can potentially serve as access points to multiple, possibly larger, markets. All of the preceding suggest that imperfections exist in market share modeling as it pertains to projecting local airport trends relative to regional and national growth.

Market share analysis at the individual airport level is integral to understanding how the market has evolved and, therefore, may indicate potential direction going forward. At the individual airport level, market shares of international and domestic as well as belly cargo versus freighter cargo are essential for facilities planning since this analysis informs judgments about future demand for freighter positions and other related considerations. Carrier market share—possibly through the prism of ground handlers possibly serving multiple carriers in a common warehouse and ramp space—is necessary for calculating the individual utilization rates of cargo facilities.

In summary, market share analysis is an essential piece of air cargo analysis at the individual airport level, but as a predictor of future relationships between local and national trends, it must be qualified.



Source: Airports Council International, Webber Air Cargo analysis. The star represents peak total tonnage.

Figure 5-1. ATL annual cargo (metric tons): CY 2000–2011.

5.2.4 Institutional Forecasts

The introductory section cited several sources of institutional forecasts commonly used by airport planners and others to calibrate local cargo forecasts. For the vast majority of U.S. airports, only domestic cargo is materially significant since international shipments of local O&D cargo will either be trucked or flown on a domestic segment to a gateway, with trucking increasingly likely and therefore having a negligible impact on the feeder airport's cargo totals. Forecasting inbound and outbound domestic cargo (and related translation into freighter operations) will suffice. However, at international gateways, directional (import and export) forecasts will often be segregated by region (for gateways with multiple transcontinental routes), although often a composite international multiplier entails the international market share and growth rates of each individual segment.

Using institutional forecasts is not a substitute for other methodologies but more accurately is a surrogate for the labor involved. Entities such as Boeing and Airbus perform intensive econometric modeling (GDP and fuel prices, to name two independent variables) to inform their biennial forecasts—typically with budgets and other resources well beyond the means of airport planners and even most consulting firms. In fact, the FAA often cites the Boeing forecast, in particular, for use in its own efforts. However, just as the U.S. economy is composed of regional economies that may little resemble one another—the Rust Belt versus the Farm Belt, for example—local airports may not conform precisely to national economic expectations. If such institutional forecasts are used as the basis for individual airport forecasts, adjustments should be made to recognize local conditions.

The latest Airbus effort is their "Global Market Forecast: 2012–2031." It is an integrated document entailing both passenger and cargo forecasts—contrasted with Boeing, which releases separate reports. Passenger forecasts are available from both sources and may be of particular use in incremental considerations of belly cargo capacity versus freighter demand. Both Airbus and Boeing forecasts are available as free downloads from the respective corporate websites. Significantly, both companies' cargo forecasts project growth rates in terms of revenue-ton-kilometers [1 ton of revenue-producing cargo flown 1 mile (Boeing) or kilometer (Airbus)], which clearly puts a premium on longer-haul segments (such as those over the Pacific), while airport cargo forecasts are typically expressed in cargo tons and flight operations as a derivative forecast.

A significant liability of the Airbus forecasts has been that detailed cargo forecasts have been produced in less reliable intervals—not surprisingly for a manufacturer that has struggled competitively in the freighter market. A significant advantage is that Airbus' market forecasts tend to be segmented into much smaller sub-continental groupings, allowing more precisely delineated pairing of routes and markets. For international gateways with diverse networks of direct destinations, this advantage is invaluable. For airports where only domestic or perhaps only modest international service is offered, planners may use either (or both) the Airbus or Boeing forecasts for guidance. Whether one source is more conservative than the other is only evident on a segment-by-segment basis but not as a whole.

Boeing's "World Air Cargo Forecast 2014–2015" is the latest biennial installment of the cargo-specific document. Like the Airbus version, the Boeing 20-year (through 2033 in the latest installment) forecast is compiled from econometric models and airline interviews undoubtedly enriched by Boeing's dominance in the freighter market and resultant access to the insights of the world's dominant freighter operators. While the Boeing forecasts are not as narrowly stratified as those of Airbus in terms of market segmentation, it has the significant advantage of a timely production schedule and relatively uniform structure over time—facilitating the reuse of forecast templates by airport planners. Perhaps the Boeing cargo forecast's greatest virtue is that it is unlikely to meet any critical opposition since it is so ubiquitous in the efforts of the FAA and others. Clearly, the popularity of Boeing's forecast derives in large part from the acceptance of its methodology and its history of reliability.

The FAA Terminal Area Forecast (TAF) provides summary historical and forecast statistics on passenger demand and aviation activity at U.S. airports based on individual airport projections. The TAF model can be accessed from the FAA website, and model users can relatively easily generate their own forecast scenarios.

The principal input for the TAF is the FAA Aerospace Forecasts, which are developed from econometric models intended to explain the relationships and emerging trends for all major segments of air transportation. Typical of econometric models, the FAA forecasts assume unconstrained capacity. They also assume no further contractions of the industry through bankruptcy, consolidation, or liquidation. These assumptions are likely to change after forecast publication, and the FAA provides cautions accentuating the recent unpredictability of commercial aviation. Both the FAA Aerospace Forecasts and the TAF are repositories of economic data that may be useful in conducting regression analyses. They also possess forecasts for passenger activities useful in considerations of potential belly capacity available for cargo.

The air cargo element of the FAA Aerospace Forecasts [in revenue ton-miles (RTMs)] assumes that security restrictions on air cargo transportation will remain in place and that most of the shift from air to ground transportation has already occurred. Finally, the forecasts assume that long-term cargo activity will continue to be tied to economic growth. While obviously uncertain, these assumptions are defensible. The forecasts of RTMs are based on models linking cargo activity to GDP, with domestic cargo RTMs linked to real U.S. GDP as the primary driver and international cargo RTMs based on world GDP growth (adjusted for inflation). Distribution between belly and all-cargo carriers is forecasted on the basis of historic trends in market shares, changes in industry structure, and market assumptions.

IATA produces an annual cargo-specific forecast that is stratified into more narrow market segments than any of the preceding forecasts. Its liabilities include that the detailed version must be purchased (unlike those previously cited), and it is only completed in 5-year increments. It should be noted that IATA only forecasts in 5-year increments due to the belief that forecasts beyond that horizon are so seriously compromised as to be virtually meaningless. That is an assessment with which many industry observers agree.

Potentially among the most illuminating sources of forecasts would be the air carriers, which commonly develop in-house forecasts with 5-year increments being common for traffic and 5- to 10-year increments for fleet forecasts. Particularly at hub airports, where a single carrier has a commanding share of belly cargo, and at the many airports where FedEx and UPS may have combined market shares in excess of 90%, carrier forecasts would be invaluable. Unfortunately, these forecasts are considered commercially sensitive and are rarely shared with airport operators or their consultants. However, the preferred collaborative process of developing forecasts should present the opportunity to at least test the airport's own forecasts against perceptions of the carrier-tenants. Moreover, the carriers will typically provide input into operations forecasts related to fleet expectations for the near- to mid-term.

5.2.5 Operations Forecasts

Airports' cargo operations forecasts are principally derived from tonnage forecasts. As much as tonnage is a critical input for planning warehouse capacity, operations are critical for planning ramp capacity.

Airport planners need as much feedback as possible related to carriers' fleet and route planning. While the gauge of aircraft is critical to calibrate aircraft capacity, it is also critical to know how much of the payload is dedicated to the local market. If the aircraft continues to other cities to build/break loads before returning to the hub, partial loads decrease throughput anticipated for the warehouse and may shorten the time the aircraft will be on the ground.

A thorough understanding of airline schedules may allow airport planners to maximize the use of aircraft ramp positions by getting multiple turns on a single position when schedules are compatible. Moreover, a carrier may be able to double or triple its local tonnage without adding another operation if its current payload dedicated to the local market is small. These considerations are particularly important at international gateways such as ATL and Dallas/Ft. Worth International Airport (DFW), where international freighter operators commonly share multi-stop service with other gateways. Clearly, this information must also be reconciled with the actual capacity of each ramp position in terms of the maximum gauge of aircraft that can be accommodated.

Airport planners can extract current fleet and flight operations data from landing reports and flight schedules from proprietary sources such as OAG Cargo Flights (www.oagcargo.com). Industry-wide fleet information can also be gained from Airbus and Boeing, as well as from secondary sources such as Air Cargo Management Group's Cargo Facts (www.cargofacts.net). Both Cargo Flights and Cargo Facts are available on a subscription basis. No matter how credible the secondary sources, interviews with cargo carriers (and handlers where applicable) are indispensable for verifying potentially outdated secondary sources as well as for gaining unique forward-looking insights into prospective future operations on a specific market basis.

In order to derive operations from tonnage, airport planners must first determine the market share presently transported by passenger carriers (therefore not contributing to freighter operations) and then make assumptions about future trends regarding that distribution. The FAA Aerospace Forecast provides such forecasts for both domestic and international cargo on a national airport system basis.

Once that belly cargo has been deducted from total cargo to isolate the tonnage that specifically drives demand for freighter operations, planners must make assumptions about the carriers' payload limits that would trigger either additional frequencies or a change in gauge of aircraft. Again, it is also critical to know how the local market is presently served by the carriers—as a stand-alone destination or as part of a multi-stop routing—in order to evaluate how much capacity is available before another frequency would be required. Unlike passenger service, which mostly is daily, freighter service at many U.S. airports may occur on weekdays, with perhaps partial service on weekends. Consequently, airport planners may use an annual standard of 282 annual cargo days (5.5 days/week), adjusting according to local schedules, which may only have weekday (5 days/week or 260 days/year) or alternatively full calendar (7 days/week) service. Operations will typically be forecasted on a three-tier basis compatible with tonnage forecasts on low-, base-, and high-case scenarios. Additional matrices can easily be formed to create alternative forecasts on the basis of a range of load factors.

While the approach just described for deriving operations from tonnage is appropriate for airports served by a variety of carriers, planners at airports with relatively modest cargo operations may opt for a simpler approach comparable to the market-share methodology described earlier. Applied to operations, the approach would entail simply calculating the tons/operation that the airport has recently experienced and then applying that average to future tonnage forecasts. On an applied basis, airport planners may combine the tons/operation with the airport's number of ramp positions (recognizing variable capacity) and aircraft turns per day per position in order to determine total ramp capacity in tonnage terms.

CHAPTER 6

Air Cargo Facility Planning—Sustainability Considerations

6.1 Airport Facility Sustainability Issues

ACRP Synthesis 10: Airport Sustainability Practices defines airport sustainability as "... a broad term that encompasses a wide variety of practices applicable to the management of airports" (Berry et al. 2008). The report refers to practices that ensure:

- Protection of the environment, including conservation of natural resources,
- Social progress that recognizes the needs of all stakeholders, and
- Maintenance of high and stable levels of economic growth and employment (Berry et al. 2008).

These practices are often referred to as the "triple bottom line" of sustainability—economic growth, social responsibility, and environmental stewardship. The tenets of the triple bottom line are frequently incorporated into sustainability definitions and programs. These practices are often incorporated into the construction and design of airport infrastructure; however, the use of green building products in an airport does not necessarily signify that a structure is sustainable or energy efficient. Likewise, if a building is energy efficient, it is not automatically assumed to be specifically designed for sustainability.

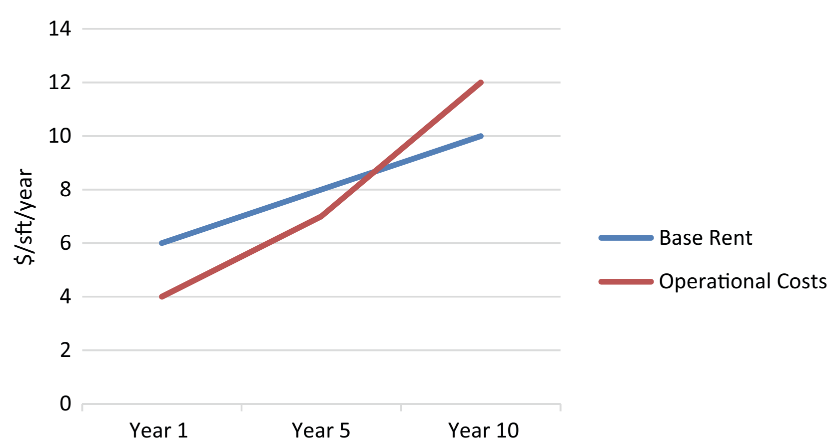
The best approach to sustainable architecture, which is environmentally sensitive and reduces energy use over the life of a building, is to adopt a program designed to meet all three sustainability tenets. The LEED (Leadership in Energy and Environmental Design) certification program was developed in 1994 by the U.S. Green Building Council (USGBC) to encourage sustainable practices in design and development by mode of tools and criteria for performance measurement. The program is a voluntary, market-driven building rating system based on existing technologies. The USGBC has established standards for new construction and major renovations to existing structures. These standards can be applied to many different project types, including airports, schools, retail locations, homes, and neighborhood development. The USGBC's LEED certification program provides independent, third-party verification that a building was designed and built using strategies aimed at achieving high performance in essential areas of human and environmental health that include sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

6.1.1 Sustainable Cargo Facilities

The USGBC estimates that between 40% and 48% of new non-residential construction in the U.S. will be green (U.S. Green Building Council 2015). As sustainable practices burgeon in other modern structures, air cargo facilities should also be constructed or refurbished with sustainability as a prominent application. Sustainability has previously been considered a luxury or a reaction to government regulation; however, those responsible for design and construction increasingly observe sustainability in terms of corporate image, utilization, and economic improvements. Sustainable design can additionally save the customer money through lower operating costs, maintenance costs, and energy usage. Sustainable buildings can often be more flexible, especially if there is an effort to define sustainability in terms of simplicity. Finally, sustainable structures can correspond with and adapt effectively to corporate image and culture, especially when carbon footprint and employee workplace conditions are considered.

Sustainable design does not necessarily equate to higher costs, although a design that leads to complicated structures frequently results in more construction costs. [Recent analysis shows that the "green premium" for buildings ranges from 1% to 7%. LEED-rated buildings have premiums of 1% for certified projects and 1.9%, 2.2%, and 6.8% for silver, gold, and platinum, respectively (San Diego Business Journal 2013.)] When the movement to add more sustainable features began in 2000 with the USGBC's LEED certification program, contractors and developers automatically added 1% to 10% to all costs. The compromise for higher initial costs, also known as the "green premium," was the long-term cost reduction associated with sustainability. Payback periods, or the time to accumulate a return on the investment, of 10 or more years were common. Currently, the initial costs for sustainable features have declined dramatically, while the costs of utilities and other operations have continued to rise. This decline in initial costs results in a more expeditious payback period. For example, light-emitting diode (LED) lighting installation provides a dramatic advantage of cost versus savings.

This trend is clearly illustrated in the ratio of base rent to operating costs outlined in Figure 6-1. Roughly 10 years ago, operating costs, including all utilities, would often be less than 20% of the base rent of a building space (lease rate per square foot/meter, excluding any pass-through or extra operating costs). It is currently not uncommon to encounter operating costs above 50% of the base rent. In the future, one might find certain buildings wherein the operating costs are actually more than the base rent. Since base rent is the reflection of the actual cost to construct the building, and operating costs are mostly a reflection of a combination of the age and efficiency of the building plus the cost of operations including utilities, the base rent and operating costs ratios suggest that operating costs are rising faster than building costs. Therefore, sustainable features are increasingly a competitive economic advantage as well as a response to community standards.



Source: Lynxs Group. Note: sft = square feet.

Figure 6-1. Comparison of base rent to operational costs.

Sustainability is a broad and often politically charged term. If adherence to compliance issues is the primary concern, sustainability can be construed as only what building codes are required by design and building standards. LEED certification standards generally give guidance for this concern, although local codes, as well as airport requirements, might have important variances. LEED certification standards are well known, and there is subsequently a large community of consultants willing to lead any building design or refit project in the direction of LEED compliance. However, as has been previously suggested, one can view sustainability as much more than the compliance to codes and standards.

Sustainability issues related to airports should not only be associated with new construction but also with repurposed or rebuilt sites. Sustainable design is often assumed in the majority of new projects; however, the transformation of older, legacy sites is more valuable if dynamic sustainable design and practices are incorporated into plans. Structures are often rebuilt to update facility usage, generally to accommodate the urgent and current demands of an airport. While this is essential, those making these updates should also consider increasing the sustainability and efficiency of any airport site.

6.1.1.1 FedEx Express Green Roof Project

FedEx Express recently opened a package sorting center that conducts operations under the largest continuous vegetated roof at any airport in the United States. The cargo building is the size of three football fields, just under 175,000 ft^2, and is located at Chicago O'Hare International, one of the world's busiest airports. The recently opened building is also the largest green roof on a freestanding building in the greater Chicago area.

These roofs benefit the environment by:

- Reducing air pollution,
- Reducing stormwater runoff,
- Extending the average life of a roof from 15 to 20 years to 40 to 50 years,
- Lowering energy costs by 35% a year, and
- Reducing airport noise.

The project is a cooperative effort between FedEx Express and the Chicago Department of Aviation's O'Hare Modernization Program (OMP) that creates value for both businesses and the community. FedEx Express maintains that the project has integrated responsible environmental practices into its daily operations toward its goals to increase efficiencies, reduce waste and emissions, and provide innovative solutions for its customers. FedEx Express and the OMP are also pursuing LEED gold certification for the facility.

6.1.2 Sustainable Aviation Guidance Alliance

A compilation of sustainability issues and practices specific to airports is published by the Sustainable Aviation Guidance Alliance (SAGA, http://www.airportsustainability.org/database). A review of the major topics reveals how broad the field and definition of sustainability is. The SAGA Sustainability Database of Practices contains over 850 distinct ideas for consideration. The technical report provides a condensed version of the database, presenting only ideas for consideration that apply to cargo/warehousing and freight forwarding facilities. The database starts with administrative policies and procedures, and while administration is not a hallmark of sustainability, a quick read indicates that there are many practices that are easily implementable without requiring significant capital expenditures. This area of sustainability revolves around foresight, good planning, a thoughtful implementation of sustainable standards at any location; it is appropriate for cargo facilities at any airport. Moreover, this is a practice area equally applicable for refurbishment/repurposed sites and newly constructed sites.

The SAGA database addresses more familiar sustainability subjects such as stormwater management, water efficiency, and landscaping. Practices in these areas are equally important in both the construction and operational phases of the facility.

Ground transportation issues are discussed in great detail. While air cargo facilities are, by definition, intermodal, much of the operational sustainability of the site happens landside. Heavy truck traffic and flow as well as ground handling equipment usage are obvious targets. Less obvious might be public transportation access for airport employees. This is a good example of multi-beneficial sustainability practices. Access to public transport not only helps the environment and benefits employees who wish to use it, but it also makes more efficient use of the air cargo site by reducing the need for more employee automobile parking, ultimately increasing the ratio of productive building usage to site size.

Even though ground transportation can provide important sustainable benefits, building design and operations provide the best opportunity for sustainable benefits. LEED certification standards are always a valuable foundation, but they are meant to provide guidance while serving as a target for compliance. Standard design features and solutions for sustainable buildings include:

- Wall and window insulation,
- Cool roofs,
- Efficient heating, ventilating, and air conditioning (HVAC),
- Efficient lighting, including LED lights and skylights,
- Good maintenance practices,
- Rainwater recapturing,
- Utilization of renewable energy sources, and
- Building orientation.

These features may not only comply with LEED certification, but make the facilities better, more user-friendly, and more valuable. The object is to ensure that sustainable buildings can be built and operated at competitive costs rather than at a cost penalty. Recent advances in design and practice indicate a positive course for cost reduction in sustainable development. For instance, the simple replacement of 100 typical A-19 incandescent 60-watt bulbs with 13-watt compact fluorescent light (CFL) bulbs would cost an additional $80, but energy efficiency would yield an operational savings of nearly $2,800/year. About 5 years ago, purchase costs for these bulbs were considerably higher, and savings were not as dramatic, but now, the choice is apparent and is as much about economics as sustainability. Comparable cost-to-savings ratios are found in a variety of other areas, such as water conservation, roofing, and window treatments, along with frequent maintenance routines. Further savings can be gained from proper design features that influence efficiency and that might not actually cost anything but have inherently tangible savings. For these cases, sustainable choices arrive directly at one of the triple bottom line items—profitability.

Quality of life and workplace conditions are also key sustainability features for any facility. Indoor environmental issues, daylight exposure and views, and noise control should be addressed. In this respect, sustainability takes on not only the usual meaning but also becomes about sustaining a quality, stable, and happy workforce.

6.1.3 Sustainability Issues Related to Air Cargo Facility Location

One final sustainability issue of primary importance that should be considered is the on-airport cargo building warehouse site selection. Warehouses ideally need to be located in close proximity to the passenger terminal for passenger airlines transporting cargo in the belly of the aircraft. For integrated express carriers, warehouses should be located close to an airport's taxiway and runway system. Cargo buildings need to be located with consideration to cargo lead time. Passenger carriers will make frequent trips to the passenger terminal with tugs pulling trains of carts carrying freight and mail; therefore, the shorter the distance, the less time, fuel, and carbon output it takes to transport the cargo.

Many on-airport cargo buildings are not appropriately located to interact with the forwarder and logistics community, which is commonly located off airport. Proper cargo facilities should also be situated so that cargo-related truck traffic does not have to mix with passenger traffic since this interaction slows down both vehicle types, is dangerous, and goes against the principles and practices of sustainability. If airports have inappropriate air cargo site locations in operation today, and if consideration is given to making these sites more sustainable, one of the first questions airport planners should consider is if the site location itself is sustainable.

New cargo areas at airports can be costly, and relocation can be complicated and increase aggregate costs. If better utilization of the current site through alternative use is an option, starting anew at a new on-airport site is a more viable option. If relocating cargo operations is not feasible, existing air cargo sites can still be improved in ways that make a profound difference. New truck access entrances, traffic flow patterns, utilities, and amenities can infuse vitality into vintage sites and form the basis of sustainable design and function for new sites. Sustainability strategies start with the site location itself, and all efforts toward cargo facility design and operation should use this as a foundation of their planning efforts.

6.1.4 Sustainability Issues Summary

While the triple bottom line of sustainability (economic growth, social responsibility, and environmental stewardship) is important to air cargo facility development at airports, the key factor for the air cargo sector is economic growth. The industry benefits when lower operating costs are achieved in the air cargo supply chain. Certain on-airport sustainability programs have been primarily showcases of the possibilities of sustainability, and while they promote sustainability, they are not viable. Sustainability must ultimately also be market driven. Fortunately, sustainability costs are intersecting with favorable savings. Therefore, the balance of influence may be steering toward valuable sustainable design and practice, particularly if other benefits of sustainability are taken into consideration.

CHAPTER 7

Air Cargo Facility Planning—Security Considerations

7.1 Air Cargo Security Overview

Since 9/11 there have been numerous security changes in the industry to implement anti-terrorism requirements. These changes include restrictions of the "known shipper" rule that have made it more difficult for shippers and forwarders to use different business partners and grow their businesses. Forwarders now hold shipments as long as they can prior to a flight, resulting in a large number of trucks arriving at the airport in a 2- or 3-hour time frame. At some airports, cargo complexes now have separate parking areas for trucks and cars, and many perform checks of the driver and cargo manifest at the cargo area entrance. A number of operating guidelines and technological innovations have been developed that have made air cargo facilities more secure. In addition, personal and vehicle access to the aircraft operating area is continuously being examined, and limitations on who is eligible for access are in flux. This section addresses the policies and outcomes of air cargo screening for air cargo transport and provides guidelines regarding security considerations when planning air cargo facilities. Changes in these policies would affect several of the integrated carriers.

7.1.1 Air Cargo Security Trends

7.1.1.1 Security Impacts

Air cargo security issues affect airline operations and the airport facilities used by air cargo carriers. Cargo screening is now mandated for all cargo loaded onto passenger aircraft. These mandates require refitting cargo facilities at airports to accommodate screening equipment and personnel.

7.1.1.2 Air Cargo Security Related to Passenger Aircraft

In the United States, the TSA is responsible for transport security, which includes air cargo. The legislation that mandates the air cargo security regulations is the Implementing the 9/11 Commission Recommendations Act of 2007, also known as the 9/11 Act. The act directed the Secretary of Homeland Security to establish a system to enable industry to screen 100% of cargo transported on passenger aircraft at a level of security commensurate with the level of security of passenger checked baggage within 3 years. The legislation set interim milestones for the industry to screen 50% of all cargo shipped on a passenger aircraft by February 2009, with 100% screening by August 2010.

The TSA implemented three programs to meet the air cargo screening goals. The first, narrow-body aircraft screening, became effective in 2008. This program required that all cargo on narrow-body aircraft must be 100% screened individually before it is netted, containerized, or shrink-wrapped. The second, the Certified Cargo Screening Program (CCSP), allows freight forwarders and shippers to pre-screen cargo. Scanning equipment can cost between $30,000 and $100,000 (Morrell 2011), which can be cost-prohibitive for smaller forwarder and shipper firms. The third program was international collaboration. International collaboration has been initiated with the European Union (EU), Canada, and Australia. By mid-2010, almost all domestic and outbound U.S. cargo on passenger services complied with the act. The TSA, along with CBP and international partners, also developed risk-based targeting to increase screening of air cargo. Among the risk-based strategies is to use the Known Shipper Program. This program established an industry-wide Known Shipper Database (KSDB) for vetting all shipments placed on passenger aircraft. Shipments from parties that do not appear on the database cannot be placed aboard passenger aircraft, even if they are screened or inspected physically. This applies to inbound international as well as domestic flights.

7.1.1.3 Air Cargo Security Related to Freighters

While there are currently no statutory or regulatory requirements mandating screening all cargo loaded onto cargo-only aircraft, the industry has been proactive in developing internal processes and protocols for accepting and screening of cargo prior to loading onto aircraft. The TSA extensively regulates aviation security through rules, regulations, and security directives that are designed to prevent unauthorized access to passenger and freighter aircraft and the introduction of prohibited items, including firearms and explosives, onto an aircraft. Combi carriers and all-cargo carriers operating freighter aircraft currently operate pursuant to a TSA-approved, risk-based security program that, carriers believe, adequately maintains the security of their personnel and aircraft in their fleets. These carriers work closely with the TSA to ensure that they have available security research and intelligence information to assist them. Many carriers and trade organizations representing the industry indicate that any additional security requirements imposed by TSA or by the U.S. Congress will impose substantial costs on the carriers and will have an adverse effect on freighter operations and customer commitments. To mitigate any such increase, carriers work closely with the Department of Homeland Security and other government agencies to ensure that a risk-based management approach is used to target specific at-risk cargo. This approach will limit any exposure to regulation that would require 100% screening of all cargo and the cost of this to the industry.

7.1.2 Airside Air Cargo Security–Related Infrastructure

7.1.2.1 Security ID Display Area

Many of the air cargo operations facilities are considered secured areas on the airport and must include an area where security identification badges on air cargo personnel are displayed and attendant security practices are performed. These areas are called Security Identification Display Areas (SIDAs). Areas of the airport that are not included in the secured area but are within the airport perimeter are identified as AOAs. Some AOA areas require SIDA protocols such as locations where cargo is loaded and unloaded. Other areas, such as the general aviation operations area on the airport, do not require a SIDA.

7.1.2.2 Air Cargo Apron Area

Security of air cargo aprons is largely controlled by ensuring that only authorized individuals or vehicles are provided access through security gates (see Figure 7-1) at the edges of the AOA or cargo buildings. The threat of intrusions onto an airport through a perimeter fence line or security access gate has resulted in many airports using closed-circuit television (CCTV) to provide views of aprons to security personnel. Coordination with the TSA and airport operations staff is recommended to ensure that air cargo facilities planning and design do not introduce security weaknesses or vulnerabilities.

Source: Google Earth Pro street-level view.

Figure 7-1. Apron area automated electric security gate at Dayton International Airport.

Beyond this, security on cargo aprons and in cargo buildings is largely the responsibility of airline personnel and security personnel monitoring the cargo building and apron area. Personnel assigned with security badges at most airports are required to challenge individuals not displaying proper security badges and to report any suspicious or unusual behavior.

7.1.2.3 Air Cargo Perimeter Fence

Considerations for the installation of a perimeter fence depend largely on the location of the facility, access control, and space designated for air cargo operations. Perimeter fencing must be continuous, with fencing creating a barrier for all airport facilities such as the passenger terminal and general aviation areas. The fence line needs to meet or exceed requirements of the airport sponsor's standard security fence height and fabric gauge. Chain-link fences are often constructed with 7 ft of fabric plus one or more coils of stranded barbed wire on top, which may be angled outward at a 45-degree incline from the airside (TSA 2011).

7.1.2.4 Air Cargo Area Access Points

Fences require adequate pedestrian (see Figure 7-2) and vehicle access points to support routine operations, maintenance operations, and emergency access. The number of through-the-fence access points should be kept to a minimum for both cost-effectiveness and security reasons.

Devices such as turnstiles, roll gates, pop-up barriers, or a remotely operated drop barrier gate may be used to impede passage through the fence until access authority is verified either by security staff or a card reader/pin-pad device. In the case of vehicle access points, gates and barriers should provide the same or a greater standard of security than any adjacent fencing to maintain the integrity of the area.

7.1.2.5 Security Guard Stations

When high volumes of air cargo traffic are anticipated, a staffed guard station may be appropriate to control access to a security area. Guard stations provide a point of entry at which personal identification can be established and persons and vehicles can be permitted to enter the AOA or even high-activity air cargo truck parking areas. Vehicle search programs may be required by the air carrier operating the facility or the airport sponsor.

Airport planners need to allow sufficient space to direct a vehicle driver to the side for further inspection without blocking access for other vehicles. There should also be:

- Turnaround space for non-permissible vehicles,
- A sufficient quantity of vehicle lanes to meet the expected traffic volumes,
- Space for the largest vehicle entering the checkpoint, and
- Special expedited clearance lanes for recognized deliveries.

Source: CDM Smith.

Figure 7-2. Pedestrian turnstile allows access to the cargo area.

7.1.2.6 Air Cargo Area Security Lighting

Since air cargo operations on air cargo aprons often take place at night, ample lighting is needed for workers and crews to load and unload aircraft as well as prepare aircraft for flight. Lighting is also necessary in the air cargo area near gates and selected areas of fencing for security purposes. Lighting can ensure that fence/gate signage is readable and that card readers, keypads, phones, intercoms, and other devices at the gate are visible and usable. Similarly, sufficient lighting is required for any area in which a CCTV camera is intended to monitor activity. For energy conservation and sustainability programs, sensor-activated lighting is acceptable for areas that have minimal traffic throughput in the off-peak hours.

7.1.3 Landside Air Cargo Security–Related Infrastructure

7.1.3.1 Cargo Building

Facility access must be tightly controlled. Public access to a facility should be limited to a counter area that is separate from the actual warehouse and has direct landside access that allows for the transaction of any business but prevents unauthorized access to such restricted areas as administrative offices, the ramp, cargo screening areas, and screened or unscreened cargo within the warehouse.

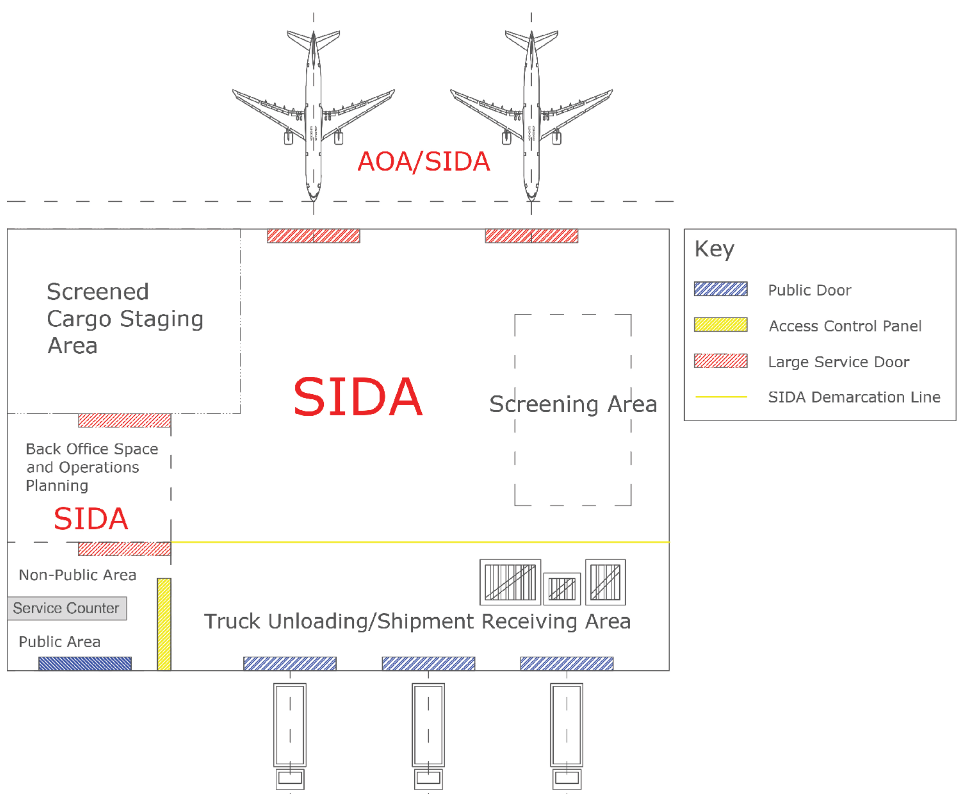
At one air cargo handler's facility at Washington Dulles International Airport, the separation of the non-sterile area from the sterile area is accomplished with a service counter arrangement that allows visitors to interact with badged cargo staff so that cargo and paperwork can be processed while maintaining the sterile environment (see Figures 7-3 and 7-4). Adjacent to this space in the warehouse, third-party security providers screen anyone accessing the sterile area. This staff also screens all cargo passing through the sterile area prior to loading it onto aircraft. A combination of trace detection and large x-ray equipment is used to provide 100% package screening.

Source: CDM Smith.

Figure 7-3. Cargo sterile office areas and screening equipment at Washington Dulles International Airport.

7.1.3.2 Security Related to Truck Docks and Doors

Cargo facilities, with their extensive truck bays, offer a number of points of entry that must be controlled by observation and physical barriers. Control can be as basic as keeping the bay doors closed until a truck is in the dock, or monitoring and enforcement of the SIDA demarcation line, which is usually a painted yellow line on the floor and is typically parallel to the front of the building. This line is usually 20 ft from the bay doors and defines the point beyond which unauthorized personnel may not pass. This concept is generally recognized by the trucking



Source: CDM Smith.

Figure 7-4. Cargo building diagram.

industry, whose drivers need to be inside the cargo building to load and unload the vehicles. Truck drivers picking up or delivering air cargo may not have SIDA badges at the airport they are visiting.

7.1.3.3 Security Screening Equipment

Security screening technology related to screening both large and small pieces of air cargo is rapidly changing. As a result, when designing air cargo buildings, airport planners need to keep in mind that security screening equipment dimensions, flows, and processes may change. The airport planner's task will be easier if the original design incorporates flexibility by providing ample space for adjustments and expansion.

CHAPTER 8

Air Cargo Facility Planning—Funding Strategies

8.1 Financial Planning for Cargo Facilities

Financial planning is an important component of air cargo facility planning. A sound financial plan addresses both the capital funding of the facilities and their operation. The financial plan answers key questions, such as:

- How will the capital costs be funded, and is developing the plan financially feasible?
- What options are available to the airport for funding resources?
- Will the facilities be a benefit to economic development of the airport, the community, and the air cargo industry?
- Will the facilities help the airport be as self-sustaining as possible?

This section considers the development and financial alternatives available to the airport planner.

8.1.1 Alternatives for Developing Air Cargo Facilities

When airport planners determine that additional air cargo capacity is needed, there are alternatives for addressing additional capacity needs. These are:

- Do nothing,
- Redevelop existing facilities,
- Repurpose facilities, and
- Develop new facilities.

8.1.1.1 Do-Nothing Approach

Airport management has the option of taking no action related to cargo facility development, which forces the airlines, integrated express carriers, and third-party air cargo ground handling companies to solve air cargo facility capacity issues themselves. Once the airlines determine their facility needs, they will initiate discussions with the airport planners concerning where their facility should be located. However, it is optimal for airport planners to be ahead of the planning cycle and in a position to guide development of these facilities to best serve the air cargo industry. Designation of land on the ALP for development of air cargo facilities is ideal, with input from the airlines, integrated express carriers, and ground handling companies included beforehand.

8.1.1.2 Redevelop Existing Facilities

Whether or not the airport is experiencing overall growth in air cargo volume, some air cargo operators grow out of their existing facilities, leaving an opportunity for the airport to redevelop those facilities to meet another operator's need at the airport. For example, if an integrated express carrier decides to construct a new air cargo facility and vacate its existing facility, the airport has the opportunity to renovate or revamp the vacated facility to provide capacity for smaller airline air cargo operators, non-cargo users, or ground handling companies.

Assuming that the title to that facility has reverted to the airport, the airport could subdivide the facility into several bays, each with truck dock doors and access to the airport operations area. The airport could lease space in this converted facility to tenants and generate additional revenue for the airport. Another possibility is to lease the space to a ground handling company that could provide air cargo handling services to an airline or third party or use the space for GSE maintenance and administration offices. Ground handling companies seldom want to construct new facilities at an airport and usually lease space in existing facilities that are somewhat older and more economical.

8.1.1.3 Repurpose Facilities

In today's environment, airports may find that they have surplus air cargo space or even vacant air cargo facilities. In this situation, the airport may be best off converting that space to non–air cargo use or removing those facilities and making the land available for other uses. Example reuses are space converted to airport maintenance equipment repair and storage, deicing support space, automobile rental support space, GSE maintenance and repair, and airline provision centers.

8.1.1.4 Develop New Facilities

There are four approaches to developing new air cargo facilities at an airport:

- The airport develops the facilities internally.
- The airport outsources the development to a third party on leased airport land.
- The tenant develops its own new facilities on airport land.
- The airport and tenant develop a public/private partnership (PPP).

8.1.2 Cargo Facilities Developed by Airport Management

Prior to an airport electing to develop an air cargo facility, securing necessary funding, and developing a pro forma business plan that projects a satisfactory return on invested capital, the airport needs to ensure that the tenants are committed to leasing space in the proposed air cargo facility. The best way to ensure that the prospective tenants will lease the facility upon completion is to have the tenants execute a facility lease prior to breaking ground on the development.

When a new air cargo facility is needed at an airport, the airport can serve as the developer, manage the design and construction of the new cargo facility, and, upon completion, serve as the landlord to the facility's tenants. Whether the air cargo facility is a smaller multi-tenant facility or a larger, single-user facility, the development of a pro forma business plan is necessary to forecast the lease revenue to be generated, the cost of operating the facility, the cost of construction, the cost of funding, and the return on investment. When an airport is the developer, the airport is responsible for securing the development's funding and long-term building maintenance and administration, as well as meeting tenant needs.

Funding can come from several sources. The airport can use available cash but should be aware of the lost opportunity to fund other airport public infrastructure projects. Tax-exempt bonds could be sold to fund the development. Private financing through a bank or financial institution is an option but is probably the most expensive alternative. Airport Improvement Plan (AIP) funding through entitlements, passenger facility charges (PFCs), or FAA grants is another alternative. Entitlement funding for cargo projects is available if the airport handles over 100 million pounds of air cargo landed weight per year. Common-use infrastructure that is not exclusively used by a single user may be eligible for grants either from the FAA or from local economic development agencies. Of all the alternative funding sources, grants represent the ideal source of funding. While there is a local matching payment required, grant funding is more cost-effective than the alternatives. The most important objectives when an airport is deciding whether to develop an air cargo facility in-house and is reviewing funding alternatives are to maximize the airport's revenue and to ensure the ongoing financial sustainability of the airport.

Airports can design the air cargo facility in-house, if they have the expertise on staff, or engage a private-sector architectural firm that specializes in the design of air cargo facilities or warehouses. Once the concept design has been completed, airport planners need to ensure that the development conforms to state and federal environmental regulations. If federal grant monies are used, then an environmental assessment (EA) study will be required. Some airports complete this analysis as part of their master plan, but if not already completed and approved, then an EA is required to determine the specific environmental analysis needed. If the land is envisioned for future air cargo facility development, for example, the environmental analysis will be more complex and may require an environmental impact statement (EIS). If the land does not have to be significantly altered, the study could be much easier and a lot less expensive. Even if initial designation of a site for an air cargo development occurs through the development of an airport master plan, an EA and subsequent environment analysis will eventually be required. The cost to complete the necessary environmental analysis usually ranges from $30,000 to $500,000, depending on the complexity of the land preparation envisaged.

Environmental impact studies are usually outsourced to environmental firms that specialize in environmental analysis. Traffic and roadway studies may also be required, particularly in the busy gateway airport areas such as San Francisco, New York, and Miami. After the requisite airport layout plan has been approved by the FAA, and environmental analysis has been completed and found to be in compliance with National Environmental Policy Act (NEPA) rules, the airport's architect can begin the detailed facility design, preparation of construction plans, and acquisition of the necessary permits. Like most other airport projects, competitive bids are required. At the completion of the bidding process, a construction company is selected, and the airport executes a contract with the company to build the facility. The selection normally requires the approval of the airport's governing body, and the construction company has to produce the required insurance certificates and completion bonds before ground can be broken. Upon completion of the facility's construction, the agency responsible for permitting and code compliance issues a certificate of occupancy permitting the airport and its tenants to use the facility.

The benefit of an airport constructing the facility itself is that the airport not only enjoys the ground lease revenue but also the revenue from leasing the facility to a tenant. Again, airport planners need to ensure that there is a favorable return on the airport's invested capital and review all the risks associated with this type of development. Risks include loss of tenants due to airline mergers, third-party handler consolidations, and airline bankruptcies.

8.1.3 Cargo Facilities Developed by Third-Party Developers

When an airport needs an air cargo facility built for a tenant, or when a tenant wants an air cargo facility constructed but does not want to lease the airport land itself, it will engage a third-party developer to lease the required land, design the facility, develop the site, and construct the facility. Third-party developers are interested in taking on projects of this nature provided that the tenant is a reputable company and a good credit risk. The developer will usually lease the land from the airport for 20 years, secure the necessary funding, and manage the entire design and construction process. The developer will go through the same vetting process outlined in the previous section to ensure that the development is economically viable, will complete the environmental analysis required, and will secure the necessary permits to construct the facility. The difference is that the developer will ensure that the funding is in place and pay for the design, environmental studies, permitting fees, and construction. Once the facility has been constructed, the developer will lease the facility to its tenants. There are several large air cargo development companies that specialize in this kind of development.

The benefit of having a third-party developer construct the facility is that the airport receives the ground lease revenue for the duration of the lease term and does not have to manage and fund the development but takes title to the facility on termination of the ground lease. Most cargo facilities have a useful life beyond the average ground lease term. After the title has reverted to the airport, the airport can lease the ground, the improved areas around the facility, and the facility itself for several more years, creating an additional revenue stream without having to invest any capital. While airport ground leases for air cargo facilities range from 20 years to 60 years, the average ground lease term is in the 30- to 40-year range.

8.1.3.1 User/Tenant Developments

Some airlines, integrated express carriers, and ground handling companies prefer to lease land at an airport and construct an air cargo facility to their own specifications. At many international gateway airports where the airlines have larger air cargo facilities, the usual practice is for the user or tenant to lease the land and construct or have a third party construct the facility. Normally, users or tenants in this case will engage a third-party developer to design and construct the facility. The funding for construction of the facility would be provided by the user or tenant.

8.1.3.2 Public/Private Partnership

One alternative to constructing an air cargo facility is to develop an arrangement with a third-party developer or tenant/user that allows the development of an air cargo facility to be financed through governmental loans at rates much lower than through a bank or commercial lending institution. The lower financing costs can take a marginally profitable project and make it more economically viable.

At Anchorage International Airport, Alaska DOT, the airport's sponsor, was able to secure state funding at favorable rates that improved the pro forma business plan for an air cargo development. The airport, however, had to take title to the facility and lease it back to the developer in order to qualify for the favorable state funding. While these public/private partnerships can be economically advantageous, they can be somewhat complex and require a fair amount of creativity.

Another example of a public/private partnership is a case where an airport was able to secure funding from a state economic development agency to construct a facility. A third party was engaged to construct the facility, and on completion, the airport took title to the facility and leased it back to the ultimate user. The benefit of public/private partnerships is that the grant funding or state financing reduces the cost, which improves the overall economics of a development. In these cases, the airport benefits by leasing the ground and facility to the user and enhancing service at the airport. In this type of arrangement, the airport has the option of serving as the developer, engaging a third-party developer to construct the facility, or having the tenant be the developer.

8.2 Development of a Pro Forma Statement

When an airport is interested in constructing an air cargo terminal and being the developer, it is imperative that the airport planners develop a financial pro forma statement. A pro forma statement is a hypothetical statement showing income and expenses that may be recognized in the future from a business venture or a real estate development. For an airport air cargo development, a pro forma statement captures the various sources of income that can be derived from the development; the expense associated with operating the facility, including debt service, if applicable; and the construction soft and hard costs. When all of the revenue and costs have been determined, the airport planners can calculate the net present value (NPV) of the development and the internal rate of return (IRR), which illustrates the financial viability of the development and return on investment.

Table 8-1 illustrates the construction cost budget for the development of a 200,000-ft^2 air cargo facility on 15.57 acres with 162,165 ft^2 of warehouse space, 37,835 ft^2 of office space, 217,800 ft^2

Table 8-1. Airport-developed cargo facility construction cost budget.

Construction Cost Budget				
Infrastructure Costs	**Total Cost: $**	**Cost/ft^2**	**% of Total**	**Comments**
Site acquisition	–	0.00	0.0%	Ground lease – no acquisition cost
Fees and allowances	300,000	1.50	1.4%	Infrastructure fees and permits
Title/document fees	15,000	0.08	0.1%	May not be required because airport land
Title insurance	–	0.00	0.0%	Lenders may require anyway
Acquisition expenses	60,000	0.30	0.3%	Contingency for unanticipated costs
Total infrastructure costs	**375,000**	**1.88**	**1.8%**	
Financing Costs	**Total Cost: $**	**Cost/ft^2**	**% of Total**	**Comments**
Debt fee	210,000	1.05	1.0%	Commission: third-party placement of debt
Equity arrangement fee	–	0.00	0.0%	
Loan closing expenses	157,500	0.79	0.7%	Closing costs and legal fees
Appraisals	25,000	0.13	0.1%	May be required by lender
Independent inspector	25,000	0.13	0.1%	May be required by lender
Construction period interest	735,000	3.68	3.5%	Interest on debt during construction
Total finance costs	**1,152,500**	**5.76**	**5.5%**	
Soft Costs	**Total Cost: $**	**Cost $/$ft^2$**	**% of Total**	**Comments**
Feasibility study and due diligence	75,000	0.38	0.4%	May be required by lender
Surveys and soil studies	50,000	0.25	0.2%	Required for design
Environmental studies	25,000	0.15	0.1%	Required for jurisdictional compliance
Mechanical and electrical	240,000	1.20	1.1%	Specialized engineering
Architecture	500,000	2.50	2.4%	Building design and working drawings
Civil/structural engineering	240,000	1.20	1.1%	Required for design
Site security and perimeter fencing	75,000	0.38	0.4%	Construction site requirements
Professional accounting	15,000	0.08	0.1%	May be required
Taxes and insurance	180,000	0.90	0.9%	Construction insurance required
Legal fees	150,000	0.75	0.7%	Ground lease and professional services
Administration and management	50,000	0.25	0.2%	Developer overhead
Travel and lodging	25,000	0.13	0.1%	Developer overhead
Development fee	860,000	4.30	4.1%	Developer fee and profit
Project management	210,000	1.05	1.0%	Third-party project management
Leasing commissions	–	0.00	0.0%	Third-party lease sales commission
Soft-costs contingency	315,000	1.58	1.5%	Unforeseen cost contingency
Total Soft Costs	**3,010,000**	**15.05**	**14.3%**	
Hard Costs	**Total Cost: $**	**Cost $/$ft^2$**	**% of Total**	**Comments**
Warehouse and office	15,333,176	76.67	72.9%	Construction of shell structure
Tenant improvements	–	–	0.0%	Finishing specified by tenant
Specialized tenant improvements	–	–	0.0%	Special finishing required by tenant
Utilities hook up	75,000	0.38	0.4%	Utilities connection from perimeter of site
Signage and graphics	35,000	0.18	0.2%	Tenant required and directional signage
Hard-costs contingency	1,050,000	5.25	5.0%	Percentage of total development cost
Total Hard Costs	**16,493,176**	**82.47**	**78.4%**	
Total Development Budget	**21,030,676**	**105.15**	**100.0%**	

Source: Lynxs Group, RMJ Associates.

of aircraft parking apron, 174,240 ft^2 of truck access, and vehicle parking using average construction costs. In the comments column, a description of each line is included along with whether the cost item is applicable in this example.

Table 8-2 shows the basic components of a development financial pro forma statement for an airport air cargo development assuming that the land/facility is leased to the tenant on a triple net basis, with the tenant paying facility rent, facility operating expenses, taxes, maintenance, and insurance.

For this development, a hypothetical development financial pro forma statement has been included to illustrate the financial plan for this development based on the assumed airport lease rates in Table 8-3.

Some airports lease the ground, warehouse, offices, apron area, and parking area for one all-inclusive lease rate. In this example, the airport leases the ground at one rate, but then seeks to recover the cost to construct the apron and the parking lot by adding a premium over and above the ground rate for the improved areas. The airport also charges a different rate for the warehouse space and the office space in recognition that the office space, including tenant improvements, was more expensive to construct. It is assumed that the tenant will be leasing the entire development for at least 20 years, so a vacancy factor has been included in the pro forma statement in Table 8-2.

The financial analysis assumes that the airport secured a 20-year loan to finance the entire development and amortized the capital investment over a 20-year period. Only the first 5 years of the development financial pro forma statement are shown in Table 8-4.

Table 8-2. Income pro forma statement.

Revenue	
Ground lease	The revenue that an airport would receive from a tenant for leasing the parcel of land on which an air cargo facility development would be built. Any increase in the ground rent due to consumer price index (CPI) increases or ground rent appraisals should be included.
Improved ground lease	The revenue that an airport would receive from a tenant for leasing areas that have been improved, such as the aircraft parking apron, truck dock access area, or parking lot area. Any increase in the improved ground rent due to CPI increases or ground rent appraisals should be included.
Facility lease	The revenue that an airport would receive from a tenant for leasing the facility that the tenant would be occupying. This could be subdivided into warehouse space versus office space. Any increase in the facility rent due to CPI increases or facility rent appraisals should be included.
Vacancy factor	If any turnover is anticipated during the planning horizon, then the lost revenue due to a turnover vacancy should be included.
Expense	
Maintenance	The cost that the landlord/airport would incur annually to maintain the facility or the major components of the facility.
Salaries	The cost of the human resource required to oversee, manage, and account for an air cargo facility. This may consist of a portion of staff time required, but in any case the staff's fully allocated overhead burden should be included.
Debt service	The cost the airport would incur to pay off the principal and interest on capital borrowed to finance the development. Usually there is an initial construction loan that is replaced with long-term financing. The principal and interest for the long-term financing would be included here.
Income (the revenue less the expense)	
Capital investment	The cost to construct the facility, which is shown on the same line as the income as a negative number.
Net present value	All costs and revenues in future years are discounted back to the base year. When the sum of the discounted revenues is greater than the sum of the discounted costs, the NPV is positive, and the investment is deemed to be financially viable.
Internal rate of return	The discount rate that makes the net present value of all cash flows from a particular development equal to zero. Generally speaking, the higher a project's internal rate of return, the more desirable the project. Many organizations have an established hurdle rate or investment criteria. If the IRR is greater than the hurdle rate, the investment in the development is acceptable.

Source: Lynxs Group, RMJ Associates.

Table 8-3. Lease rates.

Lease Area	Rate/ft²/year	Area (ft²)
Ground	$2.40	478,126
Improved ramp	$0.24	217,800
Warehouse	$10.00	162,165
Office	$15.00	37,835
Paved parking lot	$0.12	174,240

Source: Lynxs Group, RMJ Associates.

In this example, the NPV using a 9% discount factor is $820,559, which indicates that the sum of the discounted revenues is greater than the sum of the discounted costs and the investment is deemed to be financially viable. The IRR for this example is 10%, which represents a reasonable return on investment.

8.3 Air Cargo Facility Finance and Funding

Airports are required by the federal government to be as self-sustaining as possible. Within this context, airports must often fund expensive projects. Funding sources for airport projects include the airlines, capital markets, state and federal governments, and the fees charged by the airport itself for operations. Funding sources can vary by aviation function for a project. For example, funding options for apron areas differ from cargo warehouse options. On-airport development has many models, ranging from totally publicly owned to entirely privately owned.

8.3.1 Public Funding

Users of the air transportation system pay for the costs of developing and running the U.S. National Airspace System (NAS), which includes public-use airports. Users include airline passengers, air cargo carriers, private pilots, corporate aircraft owners, and air cargo shippers. For example, a portion of the U.S. air transportation infrastructure is funded by taxes on all aviation

Table 8-4. Development financial pro forma statement.

		Year				
Revenue ($)	**Capital**	**1**	**2**	**3**	**4**	**5**
Ground lease		1,147,502	1,170,452	1,193,861	1,217,739	1,242,094
Improved ramp lease		52,272	53,317	54,384	55,471	56,581
Warehouse lease		1,621,650	1,654,083	1,687,165	1,720,908	1,755,326
Office lease		567,525	578,876	590,453	602,262	614,307
Parking lot lease		20,909	21,327	21,754	22,189	22,632
	Total Revenue	3,409,858	3,478,055	3,547,617	3,618,569	3,690,940
Expense ($)		**1**	**2**	**3**	**4**	**5**
Maintenance		50,000	51,000	52,020	53,060	54,122
Management and accounting		50,000	51,000	52,020	53,060	54,122
Principal and interest		1,375,839	1,375,839	1,375,839	1,375,839	1,375,839
Other		25,000	25,500	26,010	26,530	27,061
	Total Expense	1,500,839	1,503,339	1,505,889	1,508,490	1,511,143
Operating income	(21,030,676)	1,909,019	1,974,716	2,041,728	2,110,079	2,179,797
NPV	**820,559**					
IRR	**10%**					

Source: Lynxs Group, RMJ Associates.

fuels. State and federal agencies tax this fuel to provide the funds needed to make the NAS work. Passengers on commercial aircraft pay the fuel tax as part of their ticket price. They also pay a 7.5% tax levied by the federal government on all passenger airfares. These funds are collected and then spent on labor and equipment to operate the NAS, but they are also distributed back to airports in the form of AIP funds and discretionary grants.

8.3.1.1 Airport Improvement Program

The AIP is an FAA-administered grant program established by the Airport and Airway Improvement Act of 1982. The FAA provides AIP grants to airport owners/operators for airport construction and safety projects. AIP grants are funded from the Airport and Airway Trust Fund, which gets its revenue from user taxes on airline passenger tickets, aviation fuel, and air cargo waybills. In addition to AIP grants, the trust fund pays for FAA operating costs (e.g., costs associated with operating the air traffic control system) and air traffic control system upgrades. In federal fiscal year (FY) 2011, the FAA Reauthorization and Reform Act of 2011 authorized the following for the AIP: $3.1 billion for FY 2011 and $3 billion for each fiscal year 2012 through 2014. AIP grants can be used for airport planning, airport development, or noise compatibility projects. Grants for airport development generally focus on projects associated with construction, improvement, and preservation of airport infrastructure, or the acquisition of land or equipment. Typical work items included under AIP development are (1) site preparation; (2) construction, alteration, or repair of runways, taxiways, aprons, and ground access roadways on airport property; (3) construction and installation of lighting, utilities, navigational aids, and aviation weather–related reporting equipment; (4) safety equipment required for certification of an airport facility; (5) security equipment required by rule or regulation; (6) snow removal equipment; (7) limited public-use terminal development at commercial service airports; (8) equipment to measure runway surface friction; (9) land acquisition; and (10) aircraft noise mitigation. AIP grants have not been made available for routine maintenance, construction of hangars, and revenue-producing public parking areas for most airports, but funding for maintenance, hangars, and revenue-producing areas is available for non-primary airports and airports in the military airport program. AIP grants are either entitlement or discretionary funds.

Entitlement funds are awarded to airport owners/operators through a formula based on the number of enplaning passengers and cargo tonnage. Discretionary funds are intended to provide flexibility for the FAA to meet important national airport system needs. They are used to fund capacity enhancement, noise abatement and compatibility projects, and safety and security improvements.

AIP funds are distributed as either a grant, which is reimbursed as funds are expended by the airport owner/operator, or under a Letter of Intent (LOI). An LOI is a document that conveys the FAA's intention to obligate AIP funds to an airport for a specific capacity-related project over a multi-year period. Because the federal budget is only appropriated on a 1-year cycle, with an LOI, an airport can begin a project using bonds or short-term loans with the expectation of receiving reimbursement as the project progresses.

In order to obtain AIP funds, the FAA requires an airport to have a 5-year Airports Capital Improvement Plan (ACIP), which details and prioritizes the airport's capital improvement needs for AIP funding. In addition to an ACIP, the project must be on an approved ALP and have environmental analysis in the form of an EA or an EIS. Most U.S. public airports have received FAA AIP grant funding for parts of their facilities, especially the airfield. Because of this, the airports are subject to federal grant assurances/obligations, which may create limitations on their ability to market and provide favorable terms to developers, notably the need for fair market value, revenue diversions, and limitations on duration of leases.

8.3.1.2 State/Local Government Grants

Many state and local governments provide funds for airport improvements that may fund air cargo development. Each airport will need to research and coordinate with local and state government agencies to see which grants can be applied to airport cargo projects.

8.3.1.3 Passenger Facility Charges

PFCs are imposed on enplaning passengers, usually $3 or $4.50 per enplaning passenger, and can be applied to FAA approved projects. PFCs are collected by the airlines when passengers purchase tickets and forwarded to the airport owner/operator, less a handling charge. To be eligible for PFC funding, a project must (1) preserve or enhance capacity, safety, or security; (2) reduce noise or mitigate noise impacts; or (3) enhance airline competition. PFCs are considered local (not federal) funds, but the FAA still approves the imposition and use of PFCs, and PFC-funded projects require consultation with the airlines. As with AIP grants, PFCs may be used to construct non-exclusive–use terminals and related facilities, but certain revenue-producing portions, such as concessions, parking facilities, and rental car facilities, are excluded. If PFCs are collected at $4.50 per enplaned passenger, the airport owner/operator must forgo 75% of its AIP entitlement funds.

8.3.1.4 Debt Financing

Many airport sponsors such as municipal or county governments have the ability to finance capital projects by borrowing money and incurring either short-term or long-term debt. These types of debt include general obligation bonds and revenue bonds.

8.3.1.5 General Obligation Bonds

General obligation bonds, which usually require voter approval, pledge the full faith and credit of a municipal entity as security to the investor. This commitment is based on the entity's ability to levy property, sales, or income taxes. The entity gives the bondholders (investors) a first claim on its general fund, and the community pledges the ability to pass any legislation needed to increase general fund revenues to pay the debt service.

8.3.1.6 Revenue Bonds

Revenue bonds are issued by an airport owner/operator for projects that are anticipated to generate sufficient revenue to pay the debt service. Unlike the general obligation bonds of a municipal entity, they are backed by a specific source or sources of revenue. They do not usually require voter approval. However, because the payment of debt service is limited to the revenue generated by the project, a feasibility study analyzing the projected revenues and operations of the facility being financed or improved is typically required to market and sell the bonds.

Revenue bonds may be issued tax exempt for qualifying projects, including terminals, runways, hangars, repair shops, and land-based navigational aids. Construction of facilities such as airport hotels, retail facilities, industrial parks, and commercial office buildings at the airport generally do not qualify for tax-exempt status. Generally, most types of airport projects can be financed using revenue bonds.

Revenue bonds may also be issued and backed by PFCs, either alone (stand-alone) or in combination with other sources of airport revenue (called double-barreled bonds).

8.3.2 Private Funding

8.3.2.1 Tenant or Third-Party Financing

An airport may elect to use tenant or third-party financing for capital projects. For example, an airport might lease a parcel of airport land to a tenant to construct a hangar or cargo facility.

The airport sponsor collects ground rent for the duration of a long-term lease (usually 20 or more years). At the end of the lease, the capital improvements constructed by the tenant usually become the property of the sponsor. In the case of third-party financing, the third party leases the parcel from the airport, constructs the improvements, and then rents them to one or more tenants.

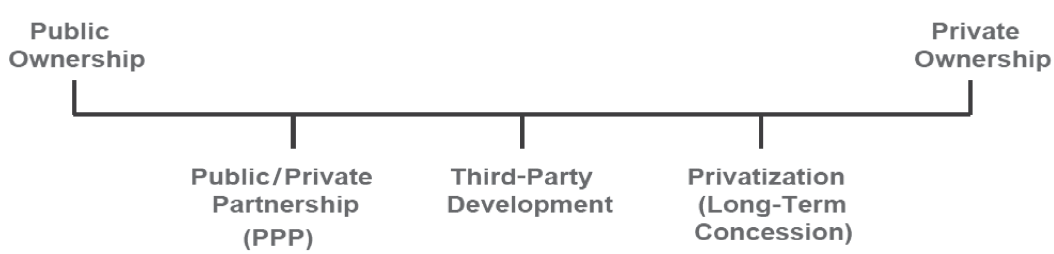
Airports have explored other ways of financing airport facilities that involve varying degrees of private-sector involvement in the management, capital investment decision making, financing, and pricing of airport facilities and services. Another option that is available but not widely implemented is the privatization of airports, which is being encouraged as a financing option through the FAA's Airport Privatization Pilot Program.

8.3.2.2 Cargo Facilities Funding Strategies

There are five types of cargo facility development in what is called the Five Ps Development Model. They are:

- Public Ownership—Airport sponsor owns the air cargo ground and structures. The airport functions as the landlord and leases the facility to aviation-related businesses while providing facility maintenance and upkeep.
- Public/Private Partnership—Airport project financial transactions for special-purpose facilities accommodating one or more cargo tenants. Sometimes the developer is required to put its own equity capital at risk, but more frequently the project is financed with bonds that are secured solely from the revenues of the facility being financed.
- Third-Party Development—Third-party development is a project delivery method in which an airport owner enters into a long-term ground lease (typically 30 years) with a third-party developer to design, construct, and operate a cargo handling facility. In some cases the third party develops the cargo facility for a single tenant where the term of the tenant's lease may be coterminous with the third party's lease.
- Privatization (Long-Term Concession)—Under the full privatization models, the airport owner enters into a long-term lease/concession or sale of an airport with a private operator. Under a long-term lease or concession agreement, the airport owner grants full management and development control to the operator in return for the operator undertaking full capital improvements and other obligations (e.g., up-front payment, responsibility for outstanding debt). Under a sale, the airport is transferred on a freehold basis with the requirement that it continue to be used for airport purposes.
- Private Ownership—The airport is sold to a private enterprise with the intent of continuing the facility as an airport.

The five Ps can be viewed as a continuum of choice, as shown in Figure 8-1, ranging from complete airport sponsor control at the left to handing over the entire process to private developers at



Source: Lynxs Group.

Figure 8-1. Continuum of airport development models.

Capacity	Control	Capital	Cost
- Master Plan	- Need vs. Want	- Constraints	- Efficiency
- Timing	- Effective vs. Active	- Opportunity Cost	- Total Occupancy Costs
- "Right-sizing"	- Duration	- Allocation	- Competitive Proposition
- Prioritization	- Governance	- Leverage	
- Resources		- ROC	

Source: Lynxs Group. Note: ROC = return on capital.

Figure 8-2. Criteria considered by airports in airport development.

the right. What is best for each airport and stakeholder in the process depends on a wide variety of data points and preferences, which are known as the Four Cs and are shown in Figure 8-2.

Since the decision-making process usually starts at the airport, the airport's point of view must be considered. Public or private development preferences and data points can be organized using the Four Cs methodology. The airport sponsor must determine its level of commitment in the cargo development by analyzing the facility capacity, the desired level of control, capital/funding sources, and the costs associated with the project.

The criteria considered by airports in airport development are as follows:

- Capacity—Master planning air cargo facility capacity allows for the development, maintenance, and operations of air cargo facilities for future needs. Facility development must be timed to meet future demand without over or under building.
- Control—Control can be variable and circumstantial if structured as such. Airport governance may require airport management to have complete control of all airport development, or perhaps it allows various forms of cooperation with other parties with airport management oversight.
- Capital—This issue is clearly one of the driving forces in selecting which of the five Ps is preferred. Most decisions to not self-develop are driven either by capital constraints or the recognition that available capital can be spent on other projects that have a higher return on investment than the proposed cargo projects.
- Costs—Public institutions can often raise capital at far lower rates than private parties. This point alone guides many projects into the public domain. However, often the exact opposite is true when it comes to project pricing, particularly when the costs of expensive bidding procedures and procurement requirements are considered. The cost of risk must also be considered. Some public entities are averse to the risk of low occupancy or the potential of profitability miscalculations. Having a steady, guaranteed stream of income through partial or complete collaboration with private parties can be attractive. In other instances, the costs of having to share the positives may appear to exceed the benefits of partnering or turning projects over to third parties.

An overarching factor of each of the Cs is risk. How much risk appetite does an airport or other stakeholder have for any particular project? Public institutions may be the only players who can absorb a highly speculative venture because the risks are too great for private players and financing. Other times, any semblance of risk will drive public players out of the game because public mandates often do not accommodate project risk profiles typically associated with real estate development and investment. Each market, airport, and player mix creates a unique matrix of factors. This methodology allows each circumstance to be individually evaluated.

CHAPTER 9

Air Cargo Facility Planning Model

An important component of the guidelines developed in this project is the Air Cargo Facility Planning Model, which provides airport planners a single source for calculating space and facility utilization for future air cargo buildings, apron area, and parking space. Professional airport planners tested this model as part of the project's validation process. The model can be accessed on the CD-ROM that accompanies this report.

This model is designed to be used to estimate space utilization for air cargo facilities at airports. The model is flexible in that it can estimate spatial utilization for all cargo areas and specific facilities at an airport. It is designed with two types of airports in mind: those serving primarily domestic air cargo demand and those serving international air cargo demand. The latter are considered international gateway airports. The purposes of this model include:

- Modeling all air cargo facilities (buildings, apron areas, and vehicle parking),
- Modeling a single air cargo facility (building, apron, and vehicle parking),
- Modeling an integrated express air cargo hub,
- Determining whether all air cargo facilities currently offer adequate space, and
- Determining whether an air cargo facility currently offers adequate space.

9.1 Getting Started

Since the model follows the basic structure of an airport master plan, several preliminary steps are required for testing the model. If data inputs are not readily available, significant research may be needed to collect the data prior to entering it into the model. Items needed for air cargo facility analysis include:

- List of all cargo buildings, vehicle parking, and apron areas dedicated to air cargo activity.
- List of all cargo-related tenants on the airport and their location.
- List of unoccupied space in air cargo buildings, vehicle parking, and apron areas.
- A copy of the airport's most recent master plan.
- A copy of the airport's most recent ALP.
- Access to Google Earth, Google Earth Pro, or other aerial photography of the airport environs.
- A scale ruler and aerial photograph to determine space in air cargo buildings, vehicle parking, and apron areas if an inventory of these facilities does not exist. Google Earth Pro provides an area calculation function.
- A forecast of air cargo tonnage. This may be found in the most recent master plan or developed by airport planning staff or the airport's planning consultant.
- Current air cargo tonnage by carrier. This data will be used to determine cargo volume market share by carrier type.

9.2 Collect Air Cargo Facility Data

The airport master planning process includes completing an inventory of all facilities at an airport, including air cargo facilities. The Air Cargo Facility Planning Model requires air cargo facility data to be separated into the five categories that are provided in the model. Once data has been collected, it can be entered into the inventory sheet in the model. Airport planners can use ALPs and as-built schematics, as well as aerial photos, to determine the dimensions and area of cargo buildings, ramp area for aircraft parking, and space dedicated to ground support equipment storage and vehicle parking areas. For this model, area values should be entered in terms of square feet.

9.2.1 Step 1: Enter Air Cargo Facility Data

Open the Air Cargo Facility Planning Model Excel file found on the CD-ROM. A worksheet entitled "Cargo Facility Inventory" (see Figure 9-1) allows for cargo facility metrics to be entered into the model.

Air cargo facilities are divided into five categories representing each of the types of cargo carriers operating at airports today. Air cargo facilities are commonly occupied by integrated express carriers such as UPS, FedEx Express, and DHL; passenger airlines (belly cargo carriers) such as American Airlines, Delta Air Lines, and United Airlines; all-cargo carriers, which operate only freighter aircraft and include Cargolux and Centurion Air Cargo; and combi carriers, which operate both passenger aircraft and freighter aircraft. The inventory also allows input for third-party handlers; examples include Swissport and Worldwide Flight Services. Third-party handlers are contracted with passenger and cargo airlines and provide freight and baggage handling and aircraft handling. Integrated express carrier facilities are divided into two types to distinguish between hub and non-hub facilities. The model allows inputs for 11 attributes of air cargo building facilities; these are:

- Cargo Building Name—The building name may be the recognized name of the building by the airport sponsor, which may be that of the dominant tenant, of the developer, or perhaps

Cargo Building Name	Usage	Tenant Names	Tenant Type	Warehouse Space (sf)	Dedicated Ramp/Aircraft Hardstand Area	Dedicated Ground Service Equipment [GSE] Storage (sf)	Total Apron (sf)	Landside Truck and Auto Parking (sf)	Number of Landside Truck Docks/Doors	Number of Airside Truck Docks/Doors
Building A	Cargo Related	ABC Express	Integrated Express	50,000	100,000	80,000	180,000	22,000	7	2
Building B	Cargo Related	XYZ Airlines	Passenger Airline Belly Cargo	10,000	-	16,000	16,000	22,000	6	5
Building C	Cargo Related	Quick Cargo	All Cargo Carriers	10,000	20,000	16,000	36,000	22,000	6	5
Building D	Cargo Related	A1 Freight Services	Third Party Handler	7,500	15,000	2,000	17,000	25,000	10	5
Building E	Cargo Related	Red Express	Integrated Express - Hub	10,000	26,000	47,000	73,000	63,000	9	3
							-			
							-			
							-			
							-			
							-			
							-			
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							-			
							-			
							-			
							-			
Total			Integrated Express	50,000	100,000	80,000	180,000	22,000	7	2
Total			Passenger Airline Belly Cargo	10,000	-	16,000	16,000	22,000	6	5
Total			All Cargo Carriers	10,000	20,000	16,000	36,000	22,000	6	5
Total			Third Party Handler	7,500	15,000	2,000	17,000	25,000	10	5
Total			Combi Carriers (Passenger and Freighter)	-	-	-	-	-	-	-
Total			Integrated Express - Hub	10,000	26,000	47,000	73,000	63,000	9	3
Total			Vacant	-	-	-	-	-	-	-
Total			Non Cargo Related	-	-	-	-	-	-	-
Total				87,500	161,000	161,000	322,000	154,000	38	20

Source: CDM Smith.

Figure 9-1. Air cargo facility inventory data.

simply a building number. The choice should reflect what is most commonly understood by the airport staff and relevant constituents.

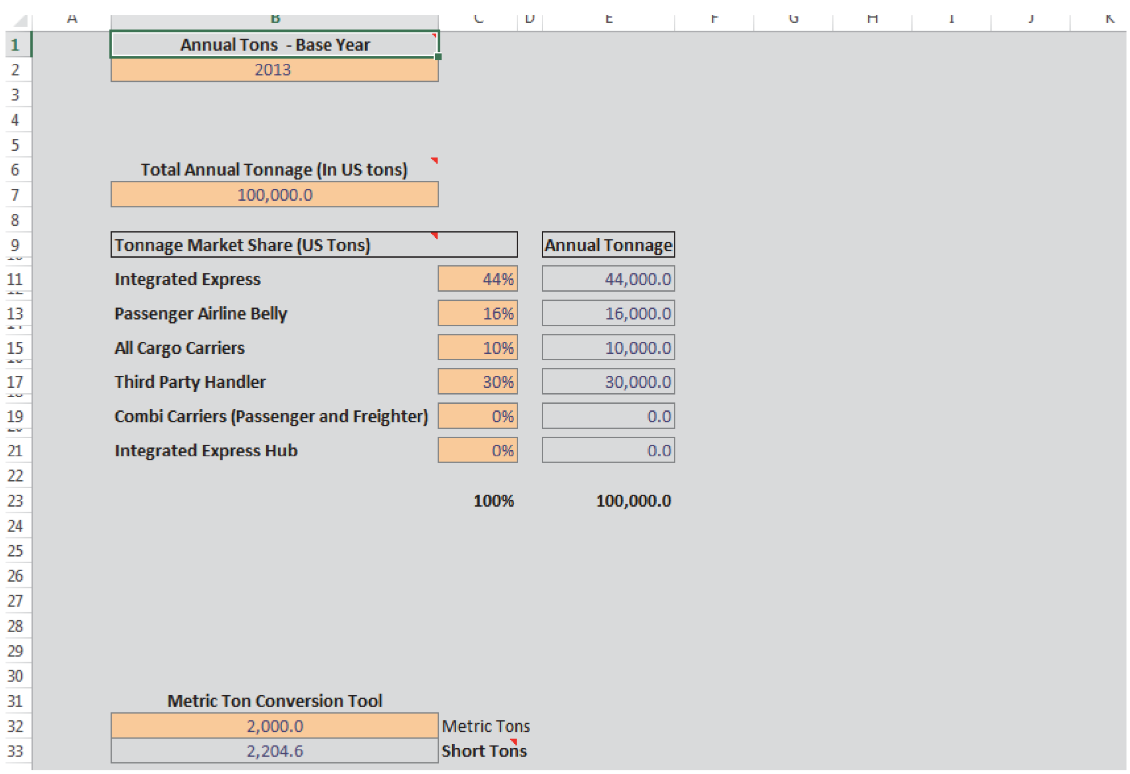
- Usage—Allows for input of type of usage, such as cargo related, non-cargo use, or vacant.
- Tenant Name—Enter the name of the organization assigned to the space. If the space is unoccupied, enter "vacant."
- Tenant Type—By clicking on the cell, the user can enter one of the six categories of cargo occupants or carriers operating at airports today. The user may also select "vacant" for unoccupied space or "non-cargo related" for tenants that may not be affiliated with cargo activity. The selections include:
  - Integrated express,
  - Passenger airline belly cargo,
  - All-cargo carriers,
  - Third-party handlers,
  - Combi carriers (passenger and freighter),
  - Integrated express—hub,
  - Vacant, and
  - Non-cargo related.
- Building Space [sf (square feet)]—Building space includes all space under building roofs, including warehouse and office space. A portion of a warehouse building can be entered into the inventory data sheet under the appropriate category. For example, if an integrated express carrier occupies the north half of a building and passenger carriers occupy the south half, space occupied by the integrated express carrier must be entered as "integrated express" on the inventory sheet, while space occupied by the passenger carriers must be entered as "passenger carrier" on the inventory sheet, but the same building name should be used.
- Dedicated Ramp/Aircraft Hardstand Area (sf)—Air cargo buildings often have aircraft aprons associated with them. For this model, air cargo aircraft aprons are divided into two types: aircraft hardstand or parking aprons, and GSE storage aprons. Aircraft parking on cargo aprons is typically demarcated with pavement markings such as the taxi line, nose-wheel indicators, hardstand boundaries, and engine intake markings.
- Dedicated Ground Support Equipment Storage (sf)—Air cargo aprons are nearly always used to store equipment, to move air cargo, and to transfer it to/from aircraft. This area is also used for maneuvering equipment to and from the warehouse and aircraft. Paved aprons that are not assigned to the regular parking of aircraft are considered the GSE storage area for modeling purposes. Enter values in square feet. Most passenger airlines do not require aircraft parking ramps dedicated to their cargo warehouse since their aircraft park at the passenger terminal. However, passenger airlines (or their handlers) do require pavement space to store GSE as well as maneuver equipment. The model requires input for GSE space for passenger carrier cargo buildings.
- Total Apron (sf)—This cell sums the area (sf) values for aircraft parking area and GSE.
- Landside Truck and Auto Parking (sf)—Cargo buildings typically have paved parking on the landside area of the building. This paved area allows parking, primarily for trucks dedicated to truck docks but also for employee and customer parking, as well as truck maneuvering.
- Number of Landside Truck Docks/Doors—An inventory of landside truck docks and doors is necessary to determine if cargo buildings have sufficient entry points for cargo.
- Number of Airside Truck Docks/Doors—Entry points are also needed on the airside of the building in order for vehicles to have access to the aircraft ramp. A count of the number of vehicle doors on the airside of the building (accessing the ramp and GSE area) is needed for the model.

It is important to note that prior to conducting the inventory, airport planners will need work in concert with airport real estate/properties staff to decide whether some cargo buildings are worth including in the cargo inventory if they are in poor condition and beyond repair, are poorly designed for today's cargo industry requirements, or have evolved into repurposed facilities, in that they no longer serve the air cargo industry.

9.2.2 Step 2: Enter Air Cargo Volume Data

A worksheet entitled "Base-Year Cargo Volume" (see Figure 9-2) allows for an airport's annual air cargo tonnage to be entered into the model.

- Base Year—Enter the base year of the total annual tonnage (enplaned and deplaned) for the subject airport (U.S. short tons). An airport's base year may be a calendar year or fiscal year. Depending on the purpose of the modeling exercise, it may also be annual tonnage identified in the airport's most recent master plan.
- Total Annual Tonnage (U.S. tons)—Enter the total annual tonnage (enplaned and deplaned) for the subject airport.
- Tonnage Market Share (U.S. tons)—Annual air cargo tonnage needs to be entered by market share of each category of carrier. Categories include integrated express carriers such as UPS, FedEx Express, and DHL; passenger airlines (belly cargo) such as American Airlines, Delta, and United; all-cargo carriers, which operate only freighter aircraft, including Cargolux and Centurion Air Cargo; third-party handlers; and combi carriers. Also, some airports in the United States have integrated express carrier hub facilities and, a market share allowance is available in the model for these.
- Enter market share of annual tonnage for each carrier type operating at the airport (e.g., 75% for integrated express carriers).
- Metric Tonnage Conversion—Some airports measure air cargo in metric tons. There is a metric to a U.S. short tons conversion calculator at the bottom of the worksheet.



Source: CDM Smith.

Figure 9-2. Entering base-year air cargo volume data.

9.2.3 Step 3: Enter Forecasted Air Cargo Volume Data

A worksheet entitled "Forecasted Air Cargo Volume" (see Figure 9-3) allows for an airport's air cargo tonnage forecast to be entered into the model. The model allows for volumes to be input at 5-year, 10-year, and 20-year increments, which are typically presented in an airport master plan as the preferred air cargo tonnage forecast. Total forecasted annual tonnage will need to be entered from an existing master plan or an updated air cargo tonnage forecast for the subject airport.

- Market Share Assumption – Assumptions for annual market share need to be input into the model on this worksheet. The subject airport's master plan forecast may include this information. If unknown, market share assumptions can be held constant at base-year levels throughout the 20-year planning period, or they can follow historic trends (e.g., integrated express carriers are gaining 1% market share annually at the airport). Airport planners may find alternate methods of determining their forecasted market share based in information gathered during their inventory and data collection effort. Market share needs to be applied to integrated express, passenger airline (belly cargo), all-cargo carriers, third-party handler, combi carriers (passenger and freighter), and integrated express hub (if applicable). If a specific carrier type is not anticipated to operate at the airport during the 20-year planning period, the assumption would remain 0% over the period. It should be noted that the base-year column in this worksheet is linked to the base-year market share inputs on the Base-Year Cargo Volume worksheet.

9.2.4 Step 4: Enter Facility Size Ratio Inputs

A worksheet (tab) entitled "Ratios-Matrix" provides air cargo throughput ratios. The model uses these ratios to estimate facility size required/recommended to accommodate air cargo traffic (tonnage). A tons-to-square-foot ratio is used to derive cargo building/warehouse space, ramp space, and GSE storage space, which are presented in the Domestic Report and the International Gateway Report tabs. Total apron space is the sum of ramp and GSE storage. These ratios are used to ascertain whether facilities are adequate for the base year as well as for forecasted years. Facility ratios are applied to air cargo tonnages for integrated express, passenger airline (belly cargo), all-cargo carriers, third-party handlers, combi carriers (passenger and freighter), and integrated express hub (if applicable).

	Total Annual Tonnage in US Tons
Forecasted Year 5 Annual Tonnage	100,000.0
Forecasted Year 10 Annual Tonnage	120,000.0
Forecasted Year 20 Annual Tonnage	140,000.0

Market Share Assumption

	Base Year	5-Year	10-year	20-year
Integrated Express	44%	40%	40%	40%
Passenger Airline Belly	16%	20%	20%	20%
All Cargo Carriers	10%	10%	10%	10%
Third Party Handler	30%	30%	30%	30%
Combi Carriers (Passenger and Freighter)	0%	0%	0%	0%
Integrated Express Hub	0%	0%	0%	0%
		100%	100%	100%

Source: CDM Smith.

Figure 9-3. Entering forecasted air cargo volume data.

The Ratios-Matrix worksheet provides default ratios (rows 13 to 22) that are based on the ACRP Project 03-24 research of over 400 U.S. air cargo facilities (cargo bays and buildings) and the annual cargo handled within them. Adjustments were made related to unoccupied space and facilities, for instance where two airlines had recently merged. However, airport planners using this tool may find it advantageous to conduct their own research to derive ratios suitable to their airport's air cargo facilities. If a planner chooses to adjust the ratios, it must take place in the corresponding ratio inputs (salmon-colored cells) on the Ratios-Matrix tab. These inputs affect the cargo facility sizes presented in the Domestic Report and International Gateway Report tabs. If the planner chooses to reenter the default values, they are located in rows 13 to 22 for reference.

The Ratios-Matrix worksheet (see Figure 9-4) presents three tables related to facility size.

- Ratio Inputs (Tons/Square Feet)—This table allows the airport planner to input the facility ratios for the subject airport. These ratios are then used within the model for ascertaining current and future warehouse, aircraft ramp, GSE storage, and truck parking facility sizes.
- Default Ratios Based on ACRP Project 03-24 Research (Tons/Square Feet)—This table provides ratios based on air cargo facility research related to this study. These are suitable for use when the airport's own utilization ratios are unknown. However, for more accurate ratio inputs, it is strongly suggested that airport planners conduct their own research to derive their airport's throughput ratios.

	A	B	C	D	E	F	G	H
2		RATIO INPUTS (Tons/Square Feet)	Integrated Express	Hub-Integrated Express	Passenger Airline (Belly Cargo)	All Cargo Carriers	Third Party Handler	Combi Carriers (Passenger and Freighter)
3		Warehouse						
4		Domestic	0.92	1.00	0.64	0.81	0.81	0.81
5		International Gateway	0.37	1.00	0.64	0.81	0.81	0.81
7		Aircraft Parking Ramp						
8		Domestic	0.40	0.20		0.40	0.40	0.40
9		International Gateway	0.40	0.20		0.91	0.91	0.91
10		GSE Storage						
11		General (Domestic or Int'l)	0.57	0.20	0.36	1.11	1.11	1.11
13		DEFAULT RATIOS BASED ON ACRP 03-24 RESEARCH (Tons / Square Feet)	Integrated Express	Hub-Integrated Express	Passenger Airline (Belly Cargo)	All Cargo Carriers	Third Party Handler	Combi Carriers (Passenger and Freighter)
14		Warehouse						
15		Domestic	0.92	1.00	0.64	0.81	0.81	0.81
16		International Gateway	0.37	1.00	0.64	0.81	0.81	0.81
18		Aircraft Parking Ramp						
19		Domestic	0.40	0.20		0.40	0.40	0.40
20		International Gateway	0.40	0.20		0.91	0.91	0.91
21		GSE Storage						
22		General (Domestic or Int'l)	0.57	0.20	0.36	1.11	1.11	1.11
24		RANGE OF TONS/SF BASED ON ACRP 03-24 RESEARCH	Integrated Express	Hub-Integrated Express	Passenger Airline (Belly Cargo)	All Cargo Carriers	Third Party Handler	Combi Carriers (Passenger and Freighter)
25		Warehouse						
26		Domestic	.46 to 1.84	.40 to 1.80	.32 to 1.28	.41 to 1.63	.41 to 1.63	.41 to 1.63
27		International Gateway	.19 to .74	.40 to 1.80	.32 to 1.28	.41 to 1.61	.41 to 1.61	.41 to 1.61
29		Aircraft Parking Ramp						
30		Domestic	.20 to .8	.15 to .4		.20 to .8	.20 to .8	.20 to .8
31		International Gateway	.20 to .8	.15 to .4		.46 to 1.82	.46 to 1.82	.46 to 1.82
32		GSE Storage						
33		General (Domestic or Int'l)	.29 to 1.15	.15 to .4	.18 to .71	.55 to 2.22	.55 to 2.22	.55 to 2.22

Source: CDM Smith.

Figure 9-4. Air cargo facility ratios-matrix worksheet.

- Range of Tons/Sf Based on ACRP Project 03-24 Research—This table provides an estimated range of throughput ratios that airport planners may derive from their analysis. There will always be exceptions, but these ratios provide general guidelines. Any ratios outside these parameters should only be considered with additional scrutiny.

Ratios inputs for each carrier type are provided that take their unique cargo demands and operations into consideration. Ratios are provided for integrated express, passenger airline (belly cargo), all-cargo carriers, third-party handler, combi carriers (passenger and freighter), and integrated express hub (if applicable) and are required to estimate the air cargo tonnage to be entered into the model. Facility ratios are applicable for building space, aircraft parking ramps, and GSE storage. Also, ratios are available for airports accommodating either domestic or international air cargo traffic (a gateway airport). Passenger airlines do not require designated air cargo aircraft parking and therefore do not have inputs for ramp area tonnage-to-square-foot ratios. (These inputs are crossed out on the table.) The GSE storage ratio for both domestic and international gateway airports uses the same ton-per-square-foot ratio.

9.2.5 Step 5: Review Truck Parking Ratio Inputs

Truck parking ratios were derived from research of over 400 air cargo facilities (cargo buildings and parking lots). In the model, ratios for truck parking are based on a warehouse's size. For example, buildings with areas of 50,000 ft^2 or less require 1.8 ft^2 of parking space for every 1 ft^2 of building space. Ratios can be adjusted by airports planners, if needed, in the salmon-colored cells in the Truck Parking Ratios worksheet (see Figure 9-5). Default ratios are presented on the right, while inputs are on the left. These inputs affect the parking facility sizes presented in the Domestic Report and the International Gateway Report tabs.

9.2.6 Step 6: Review Warehouse Truck Dock/Door Ratio Inputs

Air cargo buildings require ample doors and docks for cargo throughput to trucks on the landside of the warehouse and vehicles and aircraft on the airside of the warehouse. Ratios for cargo doors and docks were derived based on analysis of hundreds of cargo buildings. Cargo buildings with less than 50,000 ft^2 of space require one truck door for every 1,500 ft^2 of space. For all warehouses, 25% of doors are required on the airside of the building, while 75% are required on the landside. In Figure 9-6, default values are presented on the right, while ratios (in salmon-colored cells) are adjustable.

	Warehouse to Truck Parking Ratio	Default Warehouse to Truck Parking Ratio
	1.8	1.8
Buildings <50,000 sf	1.8	1.8
Buildings 50,000 to 99,999 sf	1.7	1.7
Buildings 100,000 to 199,999 sf	1.2	1.2
Buildings >200,000 sf	1.4	1.4

Source: CDM Smith.

Figure 9-5. Review of truck parking ratio inputs.

	2	Default			
	Square Feet to Dock/Door Ratio	Square Feet to Dock/Door Ratio	Airside to Landside Ratio		Default
	1,500	1,500			
Buildings <50,000 sf	1,500	1,500	75%	% Landside doors	75%
Buildings 50,000 to 99,999 sf	2,400	2,400	25%	% Airside doors	25%
Buildings 100,000 to 199,999 sf	2,900	2,900			
Buildings >200,000 sf	4,000	4,000			

Source: CDM Smith.

Figure 9-6. Review of warehouse truck dock/door ratio inputs.

9.2.7 Step 7 (Optional): Ramp Area Space Utilization During Peak-Hour Aircraft Parking

Ramp areas for aircraft parking may experience schedules that require several aircraft to be parked simultaneously adjacent to their designated cargo building facility. The model makes provision for determining aircraft ramp area space utilization based on current and forecasted air cargo aircraft fleet parking during peak-hour periods. This module within the model overrides the ramp area sizing by tonnage if the peak-hour demand is greater than in the tons/ft^2 module. An airport planner desiring to use peak-hour aircraft parking solely to determine aircraft parking space utilization may do so by changing the tons-per-square-feet ratio to zero in the Ratio-Matrix worksheet, which will turn off the override function.

A worksheet entitled "Peak-Hour Aircraft Parking" (see Figure 9-7) allows for an airport's current and forecasted peak-hour cargo aircraft parking to be entered into the model. The worksheet allows for aircraft fleet mix and quantity for integrated express, passenger airline (belly cargo), all-cargo carriers, combi carriers (passenger and freighter), and integrated express hub

	A	B	C	D	E	F	G	H
1								
2	Existing Demand:		Number of		5-year Demand:		Number of	
3			Aircraft Parked				Aircraft Parked	
4	FAA ARC	Hardstand	On Ramp		FAA ARC	Hardstand	On Ramp	Total sf
5	Aircraft Type	Size sf	Simultaneously	Total sf	Aircraft Type	Size sf	Simultaneously	
6	Integrated Express Carriers							
7	A-II	5,100	0	-	A-II	5,100	0	-
8	A-III	14,000	0	-	A-III	14,000	0	-
9	B-II	10,100	0	-	B-II	10,100	0	-
10	B-III	11,400	0	-	B-III	11,400	0	-
11	C-III	36,100	0	-	C-III	36,100	0	-
12	C-IV	51,700	0	-	C-IV	51,700	0	-
13	C-V	72,000	0	-	C-V	72,000	0	-
14	D-IV	58,700	0	-	D-IV	58,700	0	-
15	D-V	76,200	0	-	D-V	76,200	0	-
16	D-VI	125,000	0	-	D-VI	125,000	0	-
17			0	-			0	-
18	Total	Existing Demand:	Integrated Express Carriers	-	5-year Demand: Integrated Express Carriers			-
19	All Cargo Carriers							
31	Existing Demand: All Cargo Carriers			-	5-year Demand: All Cargo Carriers			-
32	Third Party Handler							
44	Existing Demand: Third Party Handler			-	5-year Demand: Third Party Handler			-
45	Combi Carriers (Passenger & Freighter)							
57	Existing Demand: Combi Carriers (Passenger & Freighter)			-	5-year Demand: Combi Carriers (Passenger & Freighter)			-
58	Integrated Express Hub							
70	Existing Demand: Integrated Express Hub			-	5-year Demand: Integrated Express Hub			-
71								
72				-				-

Source: CDM Smith.

Figure 9-7. Ramp area space utilization during peak-hour aircraft parking.

(if applicable). The optimal way to collect this information is for the airport planner to question each air cargo carrier operating at the airport to determine its peak-hour aircraft parking needs. These carriers can also estimate aircraft parking needs by aircraft type for 5-, 10- and 20-year planning milestones (based on FAA ARC, which takes into consideration wing span and approach speed). Clicking on the plus symbol on the left side of the worksheet will expand the ARC aircraft list for each carrier type. Enter in the number of aircraft for each aircraft anticipated or currently parked on the ramp at the peak hour. Square footage utilization is summed at the bottom of the column. The worksheet entitled "Ref-Common Air Cargo Aircraft" identifies common air cargo aircraft and their FAA ARC codes. For example, if an airport has one B757 and two C208s parking at it on a regular basis, the airport planner would enter a quantity of one C-IV aircraft and two A-II aircraft, which results in a total of 61,900 ft^2 of parking stand required.

9.3 Reports

9.3.1 Air Cargo Facility Utilization Reports

There are two types of reports generated in the model, one for airports serving primarily U.S. domestic cargo and the other for airports serving as international gateways. Each report is differentiated by the utilization ratios found on the Ratio-Matrix tab. Results are presented in tables for each carrier type: integrated express, passenger airline (belly cargo), all-cargo carriers, third-party handlers, combi carriers (passenger and freighter), and integrated express hub (if applicable). The printing defaults provide one page per table, so there is a single page for integrated express, one for passenger airline (belly cargo), and so forth.

The inputs in each table are linked to key drivers in the model. This paragraph briefly explains the links in the model to each table found on the Report-Domestic and Report-International worksheet. The existing space portion of the table (left side) is based on the air cargo facility inventory entered on the worksheet entitled "Cargo Facility Inventory." The Required Space to Meet Demand portion of the table is based on current annual tonnage, from the Base-Year Cargo Volume worksheet, divided by the corresponding tons-to-square-feet ratio found on the Ratio-Matrix worksheet. The forecasted space utilization is derived by the forecasted annual tonnage, from the Forecasted Cargo Volume worksheet, divided by the corresponding tons-to-square-feet ratio found on the Ratio-Matrix worksheet. Surplus or deficient space and facilities are identified on the right side of the table. Values presented in red text identify deficiencies in space and facility utilization, while black text indicates surplus space.

9.3.2 Modeling a Single Air Cargo Facility (Building, Apron, and Vehicle Parking) at an Airport

For modeling a single cargo building or area, the airport planner need only input the single building into the inventory and identify the tenants by type using the building. The Cargo Facility Inventory tab provides planners the inputs on which cargo facilities they choose to analyze. Cargo tonnage entered into the Base-Year Cargo Volume tab must only apply to cargo tenants operating in the subject building. Forecasted cargo volume must also apply only to the tenants anticipated to occupy the building during the forecast period. Market share must also be provided for both the current and forecasted volumes.

9.3.3 Determining Whether All Air Cargo Facilities Currently Offer Adequate Space

The model may also be used solely for determining whether an airport's current air cargo facilities are providing adequate space. This can be done by completing Steps 1 to 3 and leaving forecasted cargo volumes at base-year levels.

9.4 Saving the Results

It is important for the user to save the results for each case analyzed by saving the Excel files under a different naming convention for electronic filing and organization purposes. This allows for successive analyses without having to reload the entire model.

9.5 Conclusion

The Air Cargo Facility Planning Model may be used to plan for all cargo facilities at an airport as well as to focus on a single cargo building or cargo area. It may also be used to ascertain the efficiency of a single cargo bay within a cargo building. The model allows for editing by airport planners, providing them the opportunity to tailor it to their specific needs.

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Acronyms and Abbreviations

A4A	Airlines for America
ACI-NA	Airports Council International–North America
AIP	Airport Improvement Program
ALP	Airport Layout Plan
ARC	Airport Reference Code
CAGR	Compound Annual Growth Rate
CBP	Customs and Border Protection
CLI	Composite Leading Indicators
CSS	Cargo Storage System
CY	Calendar Year
DFW	Dallas-Fort Worth
ETV	Elevated Transfer Vehicle
EU	European Union
FBO	Fixed-Base Operator
GDP	Gross Domestic Product
GSE	Ground Support Equipment
ICAO	International Civil Aviation Organization
IATA	International Air Transport Association
KSDB	Known Shipper Database
LEED	Leadership in Energy and Environmental Design
LTL	Less-Than-Truckload
NPIAS	National Plan of Integrated Airport Systems
NPV	Net Present Value
O&D	Origin and Destination
OFA	Object-Free Areas
PFC	Passenger Facility Charge
PPP	Public/Private Partnership
SAGA	Sustainable Aviation Guidance Alliance
TAF	Terminal Area Forecast
TAMP	Terminal Area Master Plan
TAR	Tonnage per Area Ratio
TSA	Transportation Security Administration
ULD	Unit Load Device
UPS	United Parcel Service
USGBC	United States Green Building Council
USPS	United States Postal Service

Glossary

Air cargo Freight and mail carried by passenger airlines, integrated express carriers, and all-cargo carriers.

Air cargo apron/ramp area Portions of the airport tarmac designated for air cargo aircraft parking and operations.

Air forwarder Firm specializing in arranging storage and shipping of merchandise and materials on behalf of its shippers. It usually provides a full range of services, including tracking inland transportation, preparation of shipping and export documents, warehousing, booking cargo space, negotiating freight charges, freight consolidation, cargo insurance, and filing of insurance claims.

Air freight That portion of air cargo that does not include mail. Air freight ranges in size from parcels weighing several ounces to large shipments weighing thousands of pounds.

Airmail That portion of air cargo that does not include freight; typically composed of letters, parcels, and packages.

Airport Reference Code (ARC) classification The ARC is a coding system developed by the FAA to relate airport design criteria to the operational and physical characteristics of the airplane types that will operate at a particular airport. The ARC has two components relating to the airport design aircraft. The first component, depicted by a letter, is the aircraft approach category and relates to aircraft approach speed. The second component, depicted by a Roman numeral, is the airplane design group and relates to airplane wingspan. Generally, aircraft approach speed applies to runways and runway-length–related features. Airplane wingspan primarily relates to separation criteria and width-related features.

All-cargo carriers All-cargo carriers operate airport-to-airport air cargo and freight services for their customers but do not offer passenger service.

Cargo airports Cargo airports are dedicated to the movement of air cargo and offer the advantage of uncongested airspace relative to airports with passenger airline service.

Cargo buildings Warehouses, buildings, and retrofitted hangars dedicated to facilitating the transport of air cargo at airports.

Cargo terminal A cargo terminal is a facility designed to move cargo containers between different transport vehicles for onward transportation. At an airport, the cargo terminal is used to move cargo between aircraft and trucks. Only a few such examples of pure cargo terminals exist in the world, including SuperTerminal 1 at Hong Kong International Airport and Emirates' Cargo Mega Terminal at Dubai International.

Compact fluorescent light (CFL)/light-emitting diode (LED) lighting A CFL bulb is a fluorescent lightbulb that has been compressed to the size of a standard-issue incandescent lightbulb. An LED is a semiconductor device that emits visible light when an electric current passes through it. Both CFL and LED lighting are considered energy efficient.

Consolidation center/drop station A consolidation center, or drop station, is intended to reduce truck congestion at large international gateway airports by consolidating the loads of multiple trucks at a point well outside the airport prior to transporting to the destination airport.

Converted hangar/warehouse A converted hangar/warehouse is a stand-alone building originally designed as an aircraft hangar, converted to be used as a warehouse for the storage and transfer of air cargo. DHL's converted warehouse at San Francisco International Airport is a prime example of this type of facility. Brussels Airport is also home to a converted Sabena hangar that was used for air cargo sorting by DHL.

Cross-dock less-than-truckload (LTL) warehouse A cross-dock LTL warehouse is a facility where materials from trucks or rail cars are unloaded and directly loaded onto outbound trucks or rail cars, with little or no storage in between.

Dedicated truck parking Parking for trucks/trailers on the landside of cargo buildings. Includes spaces in the building's truck-bay doors/docks and parking lot truck/trailer spaces.

Elevated transfer vehicle (ETV) ETVs are specifically designed for the efficient storage and retrieval of ULDs and air cargo pallets. The ETV's functions are to store all types of ULDs and pallets on multiple levels in a cargo building using friction-driven or motorized roller decks.

First-line air cargo facilities First-line air cargo facilities have direct airside access and are typically used by airlines as well as ground handlers that require direct access to the aircraft and usually park adjacent to the cargo building.

Freighter Aircraft capable of carrying only cargo.

Ground handler Businesses that provide aircraft handling services to air cargo and passenger airlines. These businesses assist with the loading and unloading of aircraft, cargo transport, and material handling.

Ground support equipment (GSE) Tugs, K loaders, push-back tractors, trucks, belt loaders, dollies, ULDs, and other vehicles and equipment used to service air cargo aircraft.

Heavy-lift cargo freighters Heavy-lift cargo freighters are operated by charter cargo airlines such as Volga-Dnepr Airlines and Antonov Airlines, providing specialized heavy-lift operations with their fleets of Antonov An-124 and An-225 aircraft, respectively.

Hybrid non-conveyables A hybrid non-conveyables building is a warehouse that is capable of moving bulky or oversized items via forklift. These items are non-conveyable in the sense that they cannot be moved by conveyor systems. Once deplaned, they enter the facility and are sorted then transferred to truck or aircraft for further transport.

Integrated express cargo carriers Cargo carriers offering door-to-door service typically under one brand. For example, FedEx Express, UPS, and DHL.

Intercontinental hubs An intercontinental hub connects two or three continents by air cargo and passenger aircraft and can be located in relatively remote parts of the world, away from dense populations. These airports offer cargo hub capability as well as aircraft service centers for aircraft needing to refuel and change crews.

International gateways The international gateway functions as a consolidation, distribution, and processing point for international air cargo. To a certain extent, an international air cargo gateway is similar to a hub airport in that the gateway airport is not reliant on the surrounding market area to generate sufficient cargo to justify air cargo–related operations.

Leadership in Energy and Environmental Design (LEED) certification LEED is an internationally recognized green-building certification system, providing third-party verification that a building or community was designed and built using strategies intended to improve performance in metrics such as energy savings, pollution, and waste.

Material handling or sorting system Equipment installed in an air cargo building to facilitate the movement of air cargo packages, parcels, pallets, and ULDs. These include motorized and nonmotorized conveyors, roller decks, slides, and lifts.

Multi-tenant facility An air cargo building/warehouse with several occupants occupying assigned areas in the cargo building.

National cargo hub The cargo hub is the backbone of an integrated express carrier since it provides connections to each market in the integrator's system. Each day of operation, flights from around the world arrive at the hub. Once at the hub, packages are unloaded, sorted for the appropriate destination market, and loaded onto the appropriate outbound aircraft.

Non-integrated all-cargo carriers Cargo carriers offering airport-to-airport cargo service, such as Atlas, Cargolux, and Evergreen. These carriers rely heavily on air forwarders to transport cargo to and from the aircraft.

Occupants An air cargo business, carrier, third-party provider, or passenger airline that occupies space in an air cargo building.

Origin-and-destination (O&D)/local market stations Local market stations, or direct air cargo services (O&D service to an airport's surrounding market area), are generally near population centers where there is a concentration of industry, commerce, and transportation infrastructure. These airports represent the spoke in a hub-and-spoke air carrier network.

Pallet A pallet is a solid wood, metal, or plastic transport structure on which shipments are stacked and wrapped in plastic and netting.

Passenger airlines Passenger airlines generally provide airport-to-airport service, with freight and mail carried as belly cargo. Air cargo services provided by passenger airlines vary in scope and size from airline to airline, based on the type of aircraft operating within their fleets.

Passenger belly cargo Cargo loaded into the belly (and tail) compartments of passenger aircraft.

Perishable centers Perishable centers are specialized facilities designed to handle goods that require refrigeration, such as flowers, fruits, vegetables, seafood, and pharmaceutical products. These facilities are often refrigerated or contain large coolers capable of maintaining the desired temperature.

Perishable storage Freezer and refrigerated cargo storage facilities.

Regional hubs Regional hubs serve the region in which they are located by performing the cargo sorting and distribution functions of a specific carrier's primary hub.

Roller/castor deck or floor Floor designed for the conveying of ULDs within a warehouse or onto a ramp. Roller decks can be motor or gravity operated for the staging of cargo with different dimensions. Ball-bearing or castor-like inserts in the deck provide a friction-free surface.

Second-line air cargo facilities Second-line air cargo facilities may be on the airport premises but do not offer direct airside access. They work well for tenants who do not have aircraft or can access the aircraft through other through-the-fence access points.

Single-tenant facility An air cargo building/warehouse with one occupant occupying the entire facility.

Sorting facility Sorting facilities are designed to consolidate and process air cargo, routing it through the appropriate channel for further transport or local delivery. Automated sorting is used by integrators at their hub terminals in order to achieve their desired turnaround times and delivery commitments. These facilities do not necessarily need to be located on the airport premises.

Surplus space Any building space not used on a consistent basis for the handling of air cargo.

Telecommunications systems Wi-Fi/wireless Internet, two-way radios, cellphone/iPhone/iPad technology and devices, public address systems/intercoms, and phone landlines.

Third-line air cargo facilities Third-line air cargo facilities are located in areas surrounding airports and may be owned by private landlords but are not directly connected with the airport. Although not on airport property, these facilities offer aviation service providers the proximity to the airport they desire.

Third-party developer Real estate developers that lease airport land and construct air cargo facilities. These firms lease warehouse space to passenger airlines, cargo carriers, and integrated express carriers.

Through-the-fence gate airside access Security gates in the vicinity of cargo buildings that allow vehicles access from landside to the air cargo ramp/apron.

Unit load device (ULD) A unit load device is a pallet or container used to load luggage, freight, and mail onto wide-body aircraft and specific narrow-body aircraft.

Warehouse Warehouses are buildings with many different functional definitions, depending on the operator's role. Activities that take place in a warehouse relating to air cargo include unloading/breakdown, buildup/loading, import/export document processing, security screening, tracking/tracing, inventory/control, perishables refrigeration, product inventory, delivery and receipt of goods, scanning and processing, and administration.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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