Apron Planning and Design Guidebook

DETAILS

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 96

Apron Planning and Design Guidebook

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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). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The 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) the 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 Academies formally initiating the program.

The 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.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

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

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The opinions and conclusions expressed or implied in this report are those of the researchers who performed the research and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.

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The research team would like to express its gratitude to the members of the ACRP 07-09 Project Panel for their input throughout this research project.

FOREWORD

By Theresia H. Schatz
Staff Officer
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ACRP Report 96: Apron Planning and Design Guidebook provides best practices for planning, designing, and marking apron areas for all sizes and types of airports in the United States. This guidebook is intended to be used by airport operators, tenants, and planning and design consultants. The apron planning and design considerations include facility geometrics, aircraft maneuvering, apron/airfield access points, operational characteristics, markings, lighting, and aircraft fleets. In addition, the types of aprons include terminal area, deicing, general aviation, cargo, maintenance, and remote aprons and helipads. The guidebook summarizes apron planning and design best practices for incorporating flexibility, increasing efficiency, and enhancing safety of apron facilities.

Proper aprons design is critical to the safety and efficiency of aircraft and ground support equipment operations, personnel activities, and passenger movements. Aprons facilitate the on- and off-loading of passengers and cargo, as well as aircraft servicing. Planning and design of aprons needs to consider many factors, including the operational and physical characteristics of the aircraft to be served; the maneuvering, staging, and location of ground support equipment; and the dimensional relationships of parked aircraft relative to the terminal or other facilities.

There exists, however, no single document that provides consistent and thorough guidance on apron planning, design, and markings. This has resulted in apron layouts and markings that not only vary from airport to airport, but within airports. As a result, this comprehensive guidebook addresses the best practices applicable to apron planning and design that will lead to enhanced operational efficiency and safety.

This research was conducted under ACRP Project 07-09 by Ricondo & Associates, Inc., Kimley-Horn and Associates, Inc., Airport Development Group, Inc., Aviation Safety and Security Education Training, LLC, and Two Hundred, Inc. As part of the research, the team observed apron design and usage during visits at 12 different airports. Information gathered during their visits along with other research provided the team with an extensive understanding of specific layouts, operational procedures, and designs that perform well in supporting safe and efficient apron operations.

Additional information is contained in the contractor's final report, which provides background on the research conducted in support of the guidebook and has been posted on the ACRP Project 07-09 web page that can be found by searching the TRB website (www.trb.org) for *ACRP Report 96*.

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Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

CHAPTER 1

Introduction

Purpose of the Guidebook

Efficient and effective aprons are critical to the safety of aircraft and ground support equipment (GSE) operations, employees, and passengers on and around aircraft parking areas. Although aprons are most typically understood in the context of terminal facilities, they also encompass hold pads, cargo areas, hardstand positions, deicing areas, maintenance areas, heliports, and other airport facilities and operations.

Aprons are among the most active and, at times, congested areas at an airport. Aircraft taxi to and from aprons, while GSE used for aircraft servicing, fueling, deicing, and cargo and baggage loading and unloading operate in close proximity to aircraft in the apron environment. Additionally, there is potential for aircraft congestion and interaction, particularly at busy airports during periods of concentrated aircraft activity and in physically or operationally constrained areas. In addition to the dynamic aspects of the apron environment, facilities and equipment also influence apron planning and design. This is particularly true where the facility geometry/footprint is unique or constrained and at facilities with significant apron equipment (passenger loading bridges, hydrant fuel pits, and related items).

All apron areas must be appropriately configured and sufficiently delineated to protect the safety of aircraft occupying these areas: to enable personnel and equipment to safely and efficiently move to, from, and among aircraft to service them between operations; and to accommodate the safe, secure, and orderly transfer of passengers, baggage, and cargo among aircraft and facilities. Aprons must also provide sufficient area for the safe and efficient maneuvering of aircraft without significantly affecting adjacent parked aircraft or aircraft taxiing through or near apron areas. Apron planning considerations reflect the role of each airport in the national aviation system as well as the size and operational capabilities of aircraft reasonably expected to operate at each airport in the near term and in the longer term future. Clear definition of specific areas of the apron (for aircraft parking, GSE staging, aircraft taxiing, aircraft pushbacks, vehicle service roads, and other specific functions) is critical to maximizing the safety and efficiency of operations.

Technical apron requirements include the application of appropriate industry standards for apron layout, marking, and lighting; access for emergency vehicles; and fixed or mobile services for aircraft servicing. Aircraft apron areas must provide safe and economical facilities while maintaining the flexibility to accommodate reasonably anticipated changes in a dynamic industry. Evolving trends in aircraft types and characteristics, such as regional jets and new large aircraft (FAA Airplane Design Group [ADG] VI), devices mounted on wingtips, and related requirements must be evaluated in planning and designing apron facilities, in addition to new technologies for aircraft handling and servicing.

As the aviation industry continues to evolve (equipment, operational practices, technological advancements, etc.) and as more emphasis is placed on optimizing the use of airport infrastructure, incorporating flexibility into apron planning and design becomes a fundamental consideration. Accomplishing this requires specific evaluation and analysis during the planning and design process to ensure future options are not unnecessarily constrained by near term decisions.

Apron planning and design guidance is available, but the guidance is not typically comprehensive, fully inclusive of all apron types, or robust, but rather is most often available as discrete elements of other related industry guidance. This lack of consolidated, cohesive, consistent, and thorough guidance challenges planners, designers, airlines, airport operators, and others to plan, design, mark, light, and sign apron facilities with the necessary safety, commonality, and flexibility that meets the needs of apron users.

This guidebook is intended to describe best practices for comprehensive apron planning and design to assist planners, designers, airport operators, and other stakeholders in enhancing the operational efficiency, safety, and flexibility of aprons. The guidance presented in this document is not intended to standardize apron planning, but rather to provide planners and designers with an understanding of the apron environment, the planning process, and planning and design guidance that will enable them to use solid professional judgment in apron planning and design. Given the unique physical, environmental, and operational nature of individual airports, it is critical that planners and designers interpret and apply the best practices in this guidebook in a thoughtful and appropriately creative manner to maximize the objectives of each project, while prioritizing the safety, flexibility, and efficiency of aprons in accommodating aircraft, equipment, employees, and passengers.

Use of the material in this guidebook does not relieve the planner or designer of the need to thoroughly understand the operating environment at a specific airport and in the vicinity of a proposed project and to coordinate appropriately with operators on the apron, and other stakeholders when warranted by the specific nature of an individual project. In fact, this guidebook encourages those approaches to maximize the safety and effectiveness of apron projects.

It is important to recognize that the applicability of this guidance, both in scope and level of detail, will vary based on the nature of specific projects. Projects can range from high level master planning, in which the goal is to ensure that sufficient analysis is performed to provide for long-range needs to be accommodated within an available development envelope, to detailed facility design, in which subsequent project implementation is expected. It is up to the user of this guidebook to determine the optimal use of, or alignment with, the information presented herein.

Organization

This guidebook is organized in four chapters that provide guidance for apron planning or design projects, developing an understanding of the apron environment, and incorporating detailed guidance on planning considerations and design implications. More specifically, the guidebook consists of the following:

- **Chapter 1, Introduction:** This chapter presents background on the research project and explains the organization of the guidebook.
- **Chapter 2, Apron Planning and Design Process:** This chapter describes the general apron planning and design process and provides guidance on initiating the planning and design of aprons, including incorporating stakeholder and agency involvement. This chapter also explains the typical steps necessary for planning and designing operationally efficient, flexible, and safe apron facilities.

- **Chapter 3, Understanding the Apron Environment:** This chapter summarizes the different types of aprons, activities (aircraft, passengers, employees, vehicles) that occur in apron environments, and GSE used to support these activities. This chapter provides a comprehensive overview of operations and other activities that occur on and around aprons so that the reader is aware of the factors and influences that warrant consideration when planning and designing apron facilities.
- **Chapter 4, Apron Planning and Design:** This chapter provides detailed guidance on various apron planning considerations, design implications, and related regulations/guidance.

Given the number of sources that provide guidance on various aspects of apron planning and design, relevant sources of information are provided at the end of certain sections to provide the reader with easily identifiable references to more detailed information relating to specific topics. Users of this guidebook are encouraged to review these sources for additional apron planning and design guidance.

Additional Guidance

Airport Cooperative Research Program, *ACRP Report 96: Apron Planning and Design Guidebook,* 2013.

CHAPTER 2

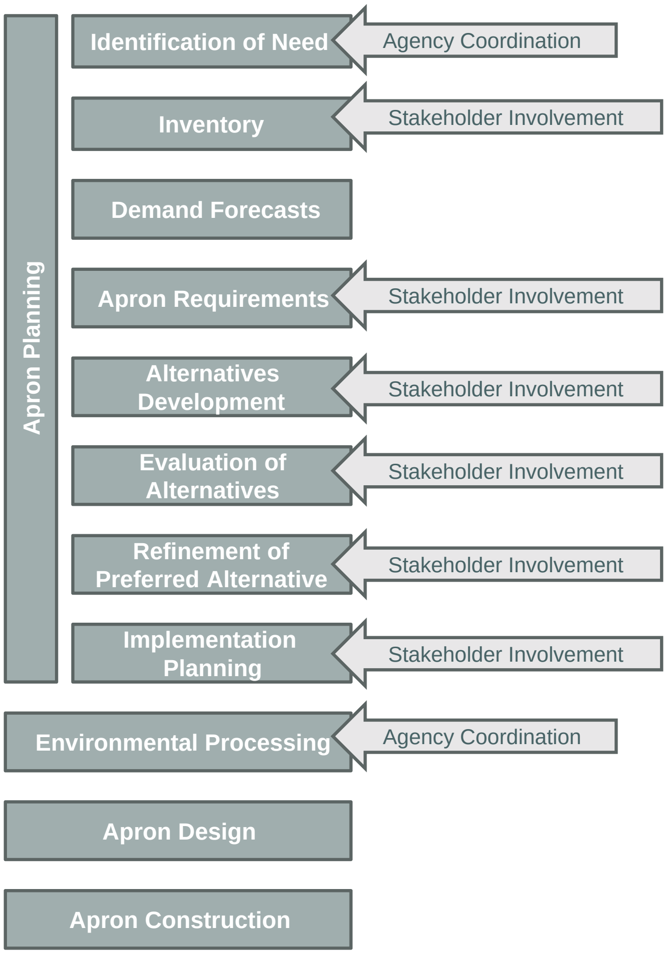
Apron Planning and Design Process

Project Approach

The planning and design of aprons follow a process similar to the process used to plan and design other airport projects. A general outline of the apron planning and design process is provided on Figure 2-1. It is important to consider all of these steps, but the process should be tailored to the needs of the individual airport.

The definitive steps in this general process are defined here. It is important to note that (depending on a number of factors) not every project will require every step listed. Planning projects will not typically include the later steps in the process, which reflect more immediate project implementation. Additionally, the level of planning detail will also influence which steps are completed, with master planning typically requiring less definitive and specific planning than that associated with a terminal development program or similar project.

- **Apron Planning**
  - **Identification of need:** The planning process begins with identification of the need for a new apron facility(s), modification of an existing apron, or other reconfiguration/repurposing of an apron area, which may be identified by one or more entities. Most typically, tenants or airport operators may seek additional apron facilities to improve inefficient and constrained operations or to accommodate planned growth. Understanding the needs and issues that drive a potential project is important to best define the later steps in the planning/design analysis. Coordination with the FAA may be advised if federal moneys are being sought for construction or modification of the apron or if the project has potential operational consequences. The goal of the identification of need process is to define, as clearly and specifically as possible, the apron planning/design objectives, as they can influence the project.
  - **Inventory:** Upon identifying a potential need for apron facilities, existing apron and non-apron 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. Other information that may be collected includes existing apron utilization statistics, leases, environmental factors, financial information, and demand forecasts. It may also be helpful to conduct 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.
  - **Demand forecasts:** Future apron demand can be obtained from the requesting stakeholder(s) or developed by a planner/designer or airport management through a forecasting process. Forecasted activity on the apron, including the fleet serving the airport and the peak demand on the apron throughout the day, is necessary to determine apron area requirements. The



Source: Ricondo & Associates, Inc.

Figure 2-1. Apron planning and design processes.

potential for changes in the number of operations or an evolving fleet serving the airport is important to consider during this step to ensure flexibility and the longevity of the useful life of the apron. The goal of the demand forecasting step is to quantify, to the degree possible, what the planned apron must be able to accommodate.

- **Apron requirements:** The demand forecasts and the inventory information is used to derive apron requirements for the anticipated aircraft fleet and the GSE expected to use the apron. Other functional and operational requirements should also be identified at this time and considered in the planning/design of the facility. Multiple uses for the apron and the required equipment or infrastructure to accommodate those uses should be identified during this step. Coordination with stakeholders is also important during this step to ensure that all user needs are considered and incorporated into the requirements definition. The goal is to define the physical, operational, and dimensional parameters that must guide and be met during apron planning and design.
- **Alternatives development:** Once the apron requirements have been determined, alternatives to meet those requirements are defined, considering the operation of the apron, impacts to proximate facilities, and other planning criteria or guidelines. This iterative process often involves close coordination with stakeholders to gather input on the layout of alternatives and to ensure that concerns can be resolved. The goal of this step is to creatively define apron alternatives that are anticipated to satisfy the project requirements, recognizing

  that these alternatives will be further evaluated in a later step. It is possible that, in some cases, the project requirements may be satisfied by implementing operational solutions rather than modifying, expanding, or otherwise reconfiguring the apron area.
  - **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 alternative. This evaluation is usually completed by using a set of criteria agreed upon by stakeholders. The goal of this step is to review the candidate apron 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. The goal of this step is to 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. This step can include a financial or business plan that demonstrates the financial feasibility of the apron project. This step also includes identifying any potential operational impacts that may occur during construction. The goal of this step is to 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 apron 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. Coordination with the FAA is necessary to determine the required level of documentation (categorical exclusion, environmental assessment, or environmental impact statement). State environmental reviews or permits may also be necessary. The goal of this step is to develop and document an understanding of the potential environmental impacts, particularly in those cases where such impacts could influence the project.
- **Apron design:** Apron 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 apron is usually coordinated with the airport operator and tenants through a design review process. Apron 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.
- **Apron construction:** After selection of a contractor, construction of the apron is completed in accordance with the apron design information.

Stakeholder Involvement

Often, several individuals or groups have an interest or need to be included in the apron planning and design processes. Stakeholders can include the primary users or operators of an apron (fixed-base operator, airlines, etc.); regulatory agencies, such as the FAA; airport representatives; and parties responsible for the cost, operation, environmental impacts, and safety of the apron facilities. Stakeholder involvement is critical to ensuring that the needs and requirements of these parties are considered throughout project planning and implementation. Involvement of these stakeholders helps ensure that the needs and priorities of all relevant users are considered during the planning process, increasing the likelihood of stakeholder support for the project before and after construction. This involvement also helps reflect broader industry perspectives in the planning and design of apron facilities, informing the planner/designer of technologies, operational procedures, and other relevant factors that may warrant consideration. A stakeholder involvement strategy and plan should be established early in the planning process to facilitate balanced stakeholder representation and involvement. The strategy and plan to implement it will vary by project type (e.g., rehabilitation, new construction, facility expansion) and size, as well as the airport operational characteristics, tenant composition, affected parties, and other factors.

It should be recognized that there is often some level of tension between airports, owners of apron facilities, and airlines as predominant users of apron facilities (at commercial service airports). This tension, which tends to ensure that there is ultimately productive coordination among the parties, reflects the challenges associated with optimizing the productive utilization of available apron (a limited resource at many airports) without compromising safety in any way. Both airlines and airports prioritize safety above other factors; however, airlines are also challenged to meet flight schedules, accommodate irregular operations, and plan for fleet and passenger growth and other operational objectives. While standardization of the apron environment (physical, operational, dimensional, environmental, etc.) has advantages and may be desirable to varying degrees, maintaining apron flexibility is critical in being able to safely optimize its use and configuration. Both airline and airport representatives recognize this. In the context of this guidance document, the need for balance among the needs and concerns of operators, users, and owners of apron facilities is emphasized. The most functional and efficient facilities are planned and designed with input from both the airport perspective and the airline/user perspective.

Airport Tenants

Coordination with airport tenants is recommended to ensure that specific requirements are considered in the planning and design of aprons. Tenants will typically consist of airlines, cargo operators, and fixed base operators, each of which will have specific requirements for apron facilities. Examples of specific requirements, in addition to operational factors, include the desired passenger level of service (e.g., loading bridges versus apron boarding), minimum acceptable dimensional clearances, GSE storage requirements, proximity of support areas, need for fueling facilities, and lighting. Understanding specific and sometimes unique user requirements facilitates the planning of a facility that emphasizes those aspects of an apron that the user considers to be a priority. Coordination with tenants early in the planning process provides an opportunity to discuss airport operator rules, regulations, or guidelines. By clearly identifying these, compromises can be discussed and potential conflicts caused by unmet expectations can be avoided. Tenants are also the best source of information on the operational profile of the activity that influences apron planning and design.

Airport Management and Staff

Airport management and staff have important roles in apron planning and design. Many individual staff members or airport departments are affected by apron development and should be included in the planning process. Involvement of the following departments (or individuals at smaller airports) should be considered for the reasons identified.

- Planning and development (includes engineering)
  - Ensuring compatibility with the airport master plan or ALP and longer range planning and development objectives.
  - Application of airport apron planning standards.
  - Consistency of apron activity forecasts with overall airport forecasts.

- Finance
  - Assessing the financial feasibility of proposed apron facilities.
  - Determining the potential for apron lease fees to provide a positive return on investment.
  - Assessing alignment with relevant tenant business arrangements.
- Operations
  - Obtaining input on unique airport operations (e.g., snow removal/melters, storm water drainage, deicing operations).
  - Implementation planning and assessing impacts of apron area construction on airport operations.
  - Ensuring compatibility with ramp control tower line of sights.
- Facilities and maintenance
  - Obtaining information on existing conditions and maintenance of aprons and related equipment (e.g., passenger loading bridges, apron equipment).
- Information technology
  - Coordination of specific data needs and infrastructure requirements.
- Construction (can include engineering)
  - Understanding airport or local construction methods and materials.
  - Determining unique soils or other design considerations or conditions.
  - Providing input on bid specifications and documents.
- Environmental
  - Identifying potential environmental constraints.
  - Identifying permitting requirements or assessing compliance with existing permits.
  - Strategizing on potential NEPA processing needs.
- Airport security, police, emergency response, fire department
  - Ensuring that apron plans comply with airport security procedures.
  - Providing roadway access and parking areas for police and security vehicles.
  - Providing dedicated access for firefighting and emergency response.

Third-Party Providers

At some airports, aircraft servicing and other activities that occur on aprons are provided by a third party. These activities can include, but are not limited to, baggage handling, fueling, deicing, catering, cleaning, lavatory servicing, maintenance, and cargo loading. Discussions with third-party providers early in the planning and design processes may provide a greater understanding of existing apron operations and the need for planned apron activities. Throughout the planning process, third-party providers can help provide a thorough understanding of the local operation, especially in terms of identifying strengths and weaknesses of existing facilities, which can be used as input to the apron planning process.

Agency Involvement

FAA

FAA involvement at relevant milestones throughout the apron planning and design processes is recommended for several reasons:

- **Funding:** When airport owners, sponsors, or other organizations accept grant funding from FAA-administered financial assistance programs (e.g., the Airport Improvement Program) they must agree to certain obligations, referred to as grant assurances. These grant assurances generally require the owner/sponsor to operate the airport in a safe and efficient manner along with other specific obligations. If FAA grant funding is being sought for the project, coordination with the FAA is recommended to ensure that the application for funding complies with facility use, environmental, and safety requirements.

- **Environmental requirements:** FAA involvement is needed to ensure that a planned apron project complies with relevant environmental requirements. The FAA will often assist in determining the level of documentation (categorical exclusion, environmental assessment, environmental impact statement) required for specific apron projects.
- **Compliance with aeronautical surfaces and planning/design guidance:** Depending on the location of a planned apron, parked aircraft could affect airfield navigational signals or penetrate aeronautical surfaces. The FAA has a role in ensuring that planning apron facilities and associated parking plans comply with restrictions on such occurrences. Additionally, the FAA seeks adherence to established planning and design criteria except in limited and unusual situations.
- **Airport traffic control tower:** In cases where aircraft movements on a planned apron are controlled by air traffic control or located adjacent to a controlled area, coordination with FAA Airport Traffic Control Tower staff is important to ensure that aircraft can safely move into and out of the aircraft apron.

TSA

The TSA has authority over the security of transportation in the United States. The TSA is responsible for the screening of passengers and baggage at airports, while the airport operator is responsible for the security of most other airport areas, primarily through enforcement of an airport security program (ASP). As aprons are where people interact with aircraft, the TSA and airport security personnel should be included in the development and review of apron alternatives to ensure the integrity of airfield security. Additionally, cargo screening must be considered in the planning and design of cargo apron facilities.

U.S. Customs and Border Protection

U.S. Customs and Border Protection (CBP) should be included in the planning process for apron facilities used to process passengers or cargo from arriving international flights (e.g., terminal, cargo, general aviation). International flights arriving to the United States—including all baggage, cargo, passengers, and crew—are under CBP jurisdiction. Most terminal complexes include facilities to process arriving passengers and crew. At airports without CBP passenger processing facilities, apron areas are usually identified for the purpose of isolating and searching aircraft upon arrival.

Local Police and Fire Departments

Local police and fire departments, including providers of aircraft rescue and firefighting (ARFF) services, should be involved in the planning and design of apron facilities. This involvement includes ensuring that aprons, especially adjacent to buildings, provide sufficient access and are in compliance with any local standards. Coordination with a local fire marshal may be required to ensure that apron plans comply with appropriate criteria.

At larger airports, ARFF personnel respond to evacuation and possible rescue of passengers and crew involved in a ground emergency. In planning aprons, planners must ensure that the apron location does not interfere with ARFF operations, especially response times to all locations on an airfield. In addition, the layout of aprons must provide for ARFF equipment to be able to access aircraft during emergencies.

Additionally, ARFF personnel are usually responsible for responding to fire emergencies related to buildings and vehicles on an airport. Apron locations and configurations need to accommodate access for firefighting equipment to all required buildings or other structures. At airports without ARFF services, local fire departments or airport personnel with special training typically respond to fire emergencies. Early in the planning process, coordination with ARFF or fire departments is strongly recommended to ensure that the selection and development of the preferred alternative does not introduce undesirable operational challenges to firefighting or emergency response operations.

Federal, State, and Local Government Agencies

In addition to the coordination described above, various other federal, state, and local government agencies may be involved with apron planning and design. Some states, through their departments of transportation or aeronautics departments, enforce regulations for airports that supplement FAA planning criteria. These regulations can range from requiring consideration of state-specific aeronautical surfaces to requiring approval of an ALP. In addition, many state aeronautics departments provide grant funding for apron-related facilities.

Many states and local jurisdictions also have environmental laws and regulations that need to be considered in apron planning and design, along with federal environmental laws and regulations (see Section 4.3.4). Although federal environmental regulations apply to all U.S. airports, the issues addressed in these regulations vary based on local environmental conditions. Environmental requirements themselves vary among states and local jurisdictions. Examples of the environmental categories that may require coordination at the federal, state, or local level are listed here; however, it is critical that the applicable state and local regulations that apply to an individual airport are identified.

- **Air quality:** Many states have adopted air quality plans, referred to as state implementations plans (SIPs), to evaluate whether a project is consistent with the state's planned progress toward attaining and maintaining compliance with National Ambient Air Quality Standards (NAAQS) pursuant to the federal Clean Air Act.
- **State wildlife:** Along with U.S. Department of the Interior, Fish and Wildlife Service, coordination with appropriate state wildlife agencies may be required to identify the potential effects of an apron project on state-listed threatened and endangered species.
- **State and local historical/archaeological agency:** Pursuant to the National Historic Preservation Act, the state and local Historic Preservation Officer should be requested to evaluate potential impacts of an apron project on cultural resources.
- **Wastewater:** Apron projects that may result in increased demand on wastewater facilities should be discussed with local wastewater agencies to ensure that the airport operator has the proper permits and that the wastewater facility has sufficient capacity to accommodate the new apron-related demand.
- **Water quality:** Coordination with water quality agencies may be required to evaluate compliance of apron storm water runoff with local and state regulations.
- **Storm water quantity:** Regulation of storm water quantities associated with a project occurs primarily on the municipal, regional, or state level. Coordination with agencies may be required to evaluate the effect of storm water to minimize flooding and protect downstream infrastructure.
- **Wetlands:** Coordination with the U.S. Army Corps of Engineers and appropriate local/state agency may be required regarding potential effects of constructing an apron on existing wetlands.

CHAPTER 3

Understanding the Apron Environment

Understanding the apron environment is critical to responsive and effective planning and design. This chapter summarizes the different types of aprons, activities (aircraft, passengers, vehicles) that occur on aprons and in the surrounding area, and equipment used to support those activities. This chapter is intended to provide a comprehensive understanding of operations and activities that occur in and around aprons and the factors and influences that should be considered when planning and designing apron facilities. However, it is important to note that airports, by their inherently unique natures, can present diverse apron environments and it is the responsibility of the apron planner/designer to understand the environment of the specific airport apron area.

Apron Types

Several different types of aprons have been developed at airports. The following sections describe the physical apron facilities and identify the activities that occur on each type of apron.

Terminal Area Aprons

The terminal area apron is the interface between the terminal building and the airfield and is one of the most congested and active areas at a commercial service airport. Passengers are enplaned on and deplaned from aircraft while GSE used for aircraft servicing, including catering, fueling, deicing, and loading and unloading of baggage and cargo, operates in close proximity. These activities, coupled with aircraft taxiing to and from the gates, drive the need for proper apron planning to enhance safety for ramp workers, aircraft operations, ground vehicle operations, and, in some cases, passengers while maximizing the use of available apron area.

Terminal area aprons are identified as any pavement used for the enplaning and deplaning of passengers from an aircraft. There are generally two categories of terminal aircraft parking positions—close-in and remote. Close-in gates consist of contact gates and noncontact gates. Contact gates are those located directly adjacent to a terminal building and passenger loading bridges are used to connect the aircraft to the building. Noncontact gates also have aircraft parking positions sufficiently close to the terminal building to facilitate the use of air stairs (stairs built into the aircraft), ramps, or mobile stairs to enplane and deplane passengers. These are referred to as noncontact gates because there is no direct link between the aircraft and the building. Passengers follow designated walkways to doorways into a terminal or concourse building. Ground loading with noncontact gates is common for regional jet or propeller aircraft serving airports with limited or no passenger loading bridges. Ground loading can also be used for narrowbody or widebody aircraft.

Figure 3-1 illustrates several terminal area aprons at a variety of airports. As depicted in the exhibit, terminal area aprons can vary substantially in their configuration, size, location relative

Source: Google Earth Pro.

Figure 3-1. Terminal area aprons.

to airfield elements, availability of push-back area, proximity to vehicle service roads, accommodation of ground vehicle storage and staging, and apron/gate equipment.

With the use of remote hardstands, passengers are enplaned or deplaned at a location sufficiently far from the terminal that a bus or other vehicle is used for the safe transport of passengers to and from the terminal. Remote hardstands are also served by air stairs, ramps, or mobile stairs.

While passengers are being enplaned and deplaned, several aircraft servicing activities occur on the terminal area aprons:

- **Fueling:** Aircraft fueling entails filling the aircraft fuel tanks with a typically predetermined amount of fuel to meet the requirements of the scheduled flight. Depending on the airport, aircraft fueling is accomplished with fueling trucks or through a hydrant fueling system.

- **Baggage handling:** Baggage is typically transferred to and from the aircraft during the servicing of aircraft after arrival and prior to departure. Outbound (departing) baggage is collected, screened, and sorted in the terminal building before being loaded onto the aircraft. Inbound (arriving) baggage is unloaded and either transported to baggage claim units in the terminal or transferred to other flights. Baggage on narrowbody and smaller aircraft is typically bulk loaded, using belt loaders that move bags on a conveyor, into the lower deck of the aircraft. Alternatively, baggage on smaller aircraft may be handled individually by personnel from a manual baggage cart and placed directly into the aircraft. Widebody aircraft bundle baggage into containers, also known as unit load devices, to reduce the time to load and unload baggage onto the aircraft.
- **Cargo handling:** Inbound belly cargo, defined as cargo placed in the belly compartment of the aircraft in addition to passenger baggage, is unloaded and transported to cargo facilities or other aircraft, while outbound belly cargo is prepared and loaded onto the aircraft prior to departure. Similar to baggage handling, cargo on narrowbody and smaller aircraft is loaded individually while cargo on widebody aircraft is containerized.
- **Ground power:** Ground power is required for operation of the aircraft's electrical equipment while the aircraft is parked and the aircraft's auxiliary power unit (APU) is shut down.
- **Preconditioned air:** Preconditioned air systems are required to heat/cool an aircraft while it is parked at a gate, depending on the ambient air temperature. The preconditioned air system can also be used to preheat/precool passenger loading bridges in advance of passenger use.
- **Lavatory servicing:** After an aircraft arrives, a lavatory vehicle is used to empty lavatory waste into a tank and replenish the aircraft with a mix of water and disinfecting concentrate, often referred to as "blue water." The lavatory waste is then emptied at the airport where it is discharged into a sanitary waste system.
- **Potable water:** Potable water is provided to aircraft during servicing, typically through a hose connection on the aircraft, which transfers water from a potable water servicing vehicle or through a potable water cabinet located at each gate.
- **Engine air starts:** When aircraft systems (such as APUs) are not available or are inoperative, some aircraft are equipped with pneumatic engine air start equipment, which can be used to start the aircraft engines once aircraft servicing is complete. Air start of the aircraft engines uses high volume air conveyed through an air discharge hose from a mobile power unit to start the aircraft engines.
- **Catering:** Catering consists of restocking the aircraft galley with food and beverages prior to departure and hauling away any garbage. Catering occurs close to the scheduled aircraft departure time. Garbage from international arriving flights must be disposed of and destroyed properly and according to U.S. CBP and U.S. Department of Agriculture regulations and cannot be mixed with garbage from domestic flights.
- **Maintenance:** Light mechanical checks or on-call maintenance work on aircraft is often performed on aprons.
- **Deicing:** Aircraft are deiced to remove frost, snow, and ice contamination from critical aeronautical surfaces prior to departure and deicing fluid is applied to prevent the accumulation of snow or slush for a period of time. If aprons are not equipped with the proper deicing fluid collection system, deicing fluid recovery vehicles or glycol recovery vehicles are used to recover deicing fluids on airport pavements. Use of these vehicles on the terminal apron may extend gate occupancy time.

Airport operators typically use one of three types of agreements to lease terminal gates to airlines, which can be material to the planning and design of apron facilities. Exclusive use agreements grant an airline the sole right to use and occupy a gate. This typically provides the leasing airline the maximum flexibility to configure, equip, and mark the apron to best support the operational needs of that user. Preferential use agreements grant an airline the primary right to use a designated gate to support its scheduled operations, but also allows operations by other airlines at that same gate, generally subject to gate availability based on the primary airline's schedule. There can be reduced flexibility associated with preferential use gates/apron based on the expectation that users may have different operating profiles, procedures, physical constraints, and other factors. While the primary airline may dictate the apron configuration, equipment, markings, GSE parking, and other aspects of the terminal area apron, without sole rights to the use of preferentially leased gates there may be requirements imposed by the airport operator to ensure a minimum level of flexibility in assigning other users to these gates when the primary user's schedule allows. Common use agreements are used for gates that are under the control of an airport operator and allocated or assigned to airlines on a dynamic basis, typically for temporary or short terms. Common-use gates do not necessarily have a primary user, as the airport operator has the ability to assign the gates using what it defines to be appropriate scheduling priorities or preferences. In these instances, apron planning and design will typically follow specific standards defined by the airport operator to ensure required levels of scheduling flexibility. Specific user needs must be accommodated within the standards defined by the airport operator in these cases.

Deicing Aprons

As mentioned earlier, aircraft are deiced to remove frost, snow, and ice contamination from critical aeronautical surfaces prior to departure and deicing fluid is applied to prevent the accumulation of snow or slush for a period of time. This period of time, known as holdover time, is the estimated time that the deicing fluid prevents the formation of frozen contamination on the critical surfaces of the aircraft.

Deicing occurs either at the terminal apron (either at the gate parking position or nearby), at a designated remote area, or on other aprons that are properly equipped to accommodate the activity. During deicing operations on a terminal apron, aircraft usually remain in the original parked position with GSE located away from the aircraft to allow for the maneuvering of deicing vehicles. Alternatively, aircraft are pushed away from the specific parking position, but are still adjacent to that position. Deicing is typically accomplished using deicing vehicles that have elevating booms to allow personnel to apply heated deicing fluid on appropriate parts of the aircraft. The deicing vehicles are typically positioned on each side of the aircraft, either simultaneously or alternately depending on aircraft size.

Deicing on the terminal apron presents challenges compared to deicing in remote areas. Deicing at the gate can have significant operational consequences, as it can extend gate occupancy time and introduces more vehicles to the apron/gate area. In addition, deicing fluids are slippery and potentially create added risk on the apron pavement, both to ramp personnel and to passengers during ground loading operations. These risks are typically managed through operating procedures or the vacuum collection of deicing fluids (resulting from overspray and from fluids that run off the aircraft after application) that pool on the pavement. The fluids can also enter and migrate within pavement joints and utility conduits, potentially causing damage to building environments and airfield lighting systems, and possibly contaminating clean storm water or groundwater. Additionally, deicing fluid overspray may reach the terminal building, which may require it to be cleaned more frequently. A potential benefit of gate deicing is the melting of snow resulting from deicing fluid that falls to the pavement.

Remote deicing facilities (often called deicing pads) are provided at some airports, to which aircraft are routed prior to taxiing to the runway for departure. Remote facilities are typically located away from the terminal area, sometimes near the departure end of runways, to reduce the time between treatment and aircraft departure. The use of remote deicing pads reduces vehicular traffic on the terminal and cargo aprons. In addition to the terminal apron, other aprons at an airport are often designated for deicing, such as general aviation, cargo, maintenance or remain overnight (RON) parking aprons. During some types of storm events, aircraft critical surfaces must be deiced (limited deicing) to ensure that the aircraft can safely taxi to these remote deicing locations. In those cases, limited deicing must occur at the terminal gates, but full deicing occurs at remote deicing pads. Figure 3-2 shows remote deicing pads located in proximity to the runway ends at Minneapolis-St. Paul International Airport.

The use of deicing fluid can create a number of environmental issues and trigger compliance with specific environmental regulations. At many airports, the runoff of these fluids must be separated from ambient storm water runoff and treated or recycled, or detained and metered into the runoff at regulated (permitted) levels. Storm water collection, detention, conveyance, and treatment systems must be designed to accommodate these requirements. Many aprons where deicing activities occur incorporate pavement drains and piping to route deicing fluid runoff to lined collection/detention ponds. These ponds are used to store runoff contaminated with deicing fluid until it is recycled or released to a wastewater treatment facility. Deicing pads usually facilitate a more concentrated collection of deicing fluid runoff, as they tend to encompass less area than a terminal apron and, therefore, accumulate less precipitation. Similar to terminal area aprons, if deicing pads are not equipped with the proper collection system, deicing fluid recovery vehicles or glycol recovery vehicles are used to vacuum deicing fluid runoff and overspray that reaches the pavement. Use of these vehicles on aprons may extend occupancy time.

At many airports, deicing fluid recycling facilities are used to process and concentrate collected runoff and oversprayed deicing fluids by separating the water and the deicing fluid. The distilled captured deicing fluid is then repurposed for industrial uses as industry regulations and specifications do not support the reuse of the fluids for aircraft deicing. The remaining

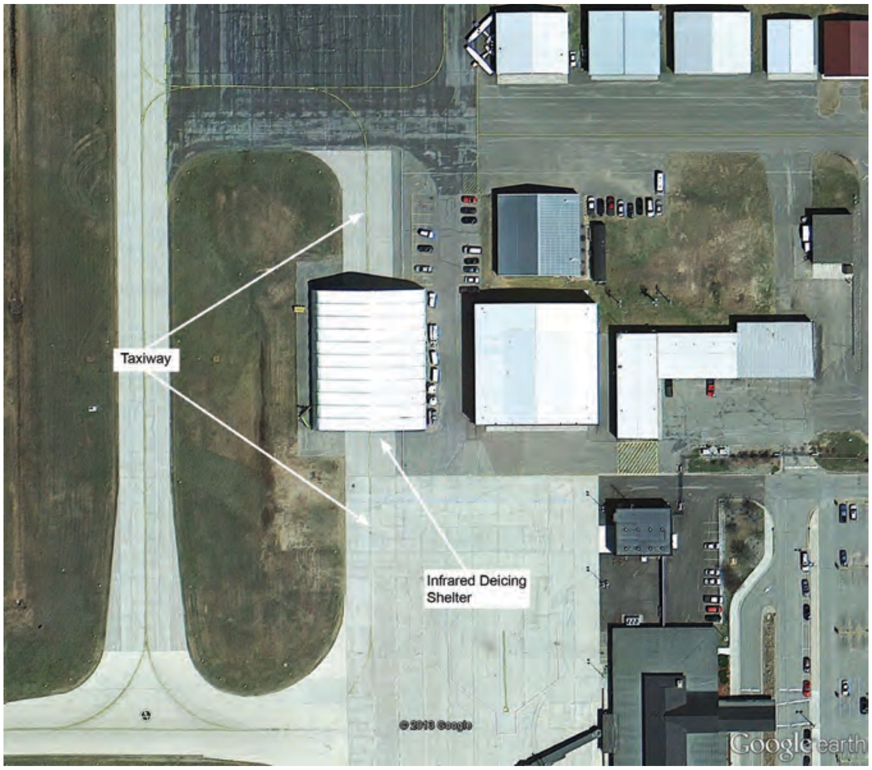
Source: Google Earth Pro

Figure 3-2. Remote deicing pad at Minneapolis-St. Paul International Airport.

liquid (separated water) is typically processed at a wastewater treatment facility or metered into a receiving waterway consistent with applicable permits and regulations.

Although not widely used, aircraft can also be deiced without the use of chemicals, relying instead on infrared heat sources. As shown on Figure 3-3, radiant heating units are installed within an open-ended hangar-type shelter into which aircraft taxi for deicing. These are stand-alone facilities that can be used independently or in combination with liquid anti-icing products to ensure that no icing on the aircraft occurs prior to departure.

Deicing operations are usually conducted by airlines or third-party providers. The type of deicing provider is often controlled by the airport operator. The selection of a deicing provider can sometimes influence aircraft deicing operations and procedures. For example, airports with a limited number of deicing pads may benefit from use of a third-party provider because coordination of access by different airlines to the pads can be challenging and inefficient. Also, assigning



Sources: Google Earth Pro (top); Rhinelander/Oneida County Airport, 2013 (bottom).

Figure 3-3. Infrared deicing facilities at Rhinelander/Oneida County Airport, Rhinelander, Wisconsin.

or dedicating deicing positions to specific airlines can result in unused deicing capacity if the dedicated positions are not available to other airlines when not in use by the primary airline.

Cargo Aprons

The transportation of goods throughout the United States and worldwide provides a necessary link that enables trade between companies, organizations, and people and is an economic engine for the world. One primary method for the transportation of goods, particularly perishable or time-sensitive goods, is air transportation of cargo. Many airports, ranging from large hub to general aviation airports, have infrastructure to accommodate air cargo operations. The type of cargo facilities at an airport is largely dependent on the type and frequency of cargo airline service. Cargo airline service is largely driven by factors external to the airport, such as geographic location, competing airports, the availability of other modes of cargo transport (e.g., rail), supporting transportation networks (highways and railways), and the presence of businesses and industries that drive demand for cargo services. Two categories of cargo services at airports, belly cargo and all cargo, are described here.

Belly Cargo

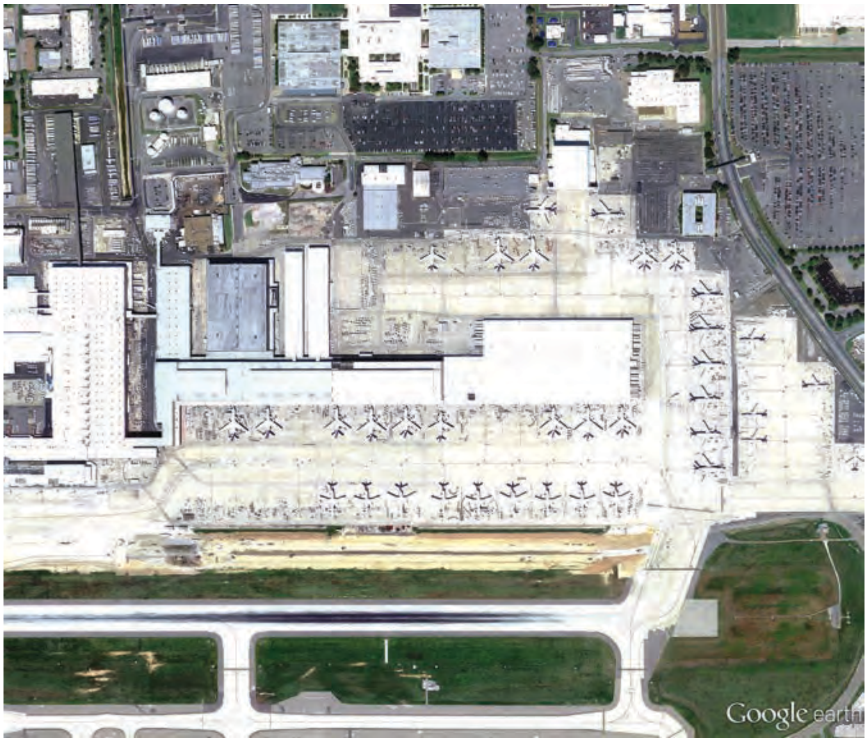
While the primary function of the passenger airlines is the transportation of passengers, most airlines use the lower aircraft deck for transporting passenger baggage and cargo. Belly cargo, defined as that transported in the belly compartments of passenger aircraft, is typically processed and sorted at cargo facilities located away from the terminal gates, but with vehicle access to landside and airside facilities. Belly cargo is transported to the terminal apron, where it is loaded onto aircraft parked at the gate(s). Depending on the size or configuration of the aircraft, cargo may be containerized prior to loading onto the aircraft. Container loaders consist of lifts with ball bearings that raise containers level with the aircraft door sill so that containers can be easily rolled into the aircraft. Cargo that is not containerized is loaded and secured within the aircraft similar to passenger baggage. Belly cargo can introduce additional vehicles into the apron area as cargo is brought to departing aircraft and picked up from arriving aircraft.

All Cargo

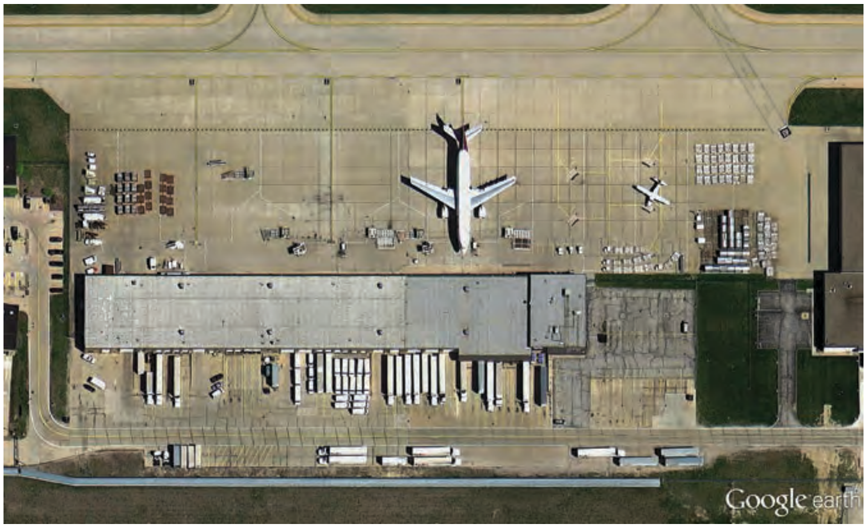
All-cargo airlines transport only cargo and are either dedicated to transporting cargo or a division of a passenger airline that transports cargo. As shown in Figure 3-4, aprons for all-cargo aircraft are usually separated from terminal aprons. This is largely due to the landside access and vehicle maneuvering and parking areas needed to accommodate large cargo delivery/transfer vehicles and, in some cases, large numbers of vehicles at peak times (e.g., to support overnight delivery operations). Placement of all-cargo aircraft facilities away from terminal facilities reduces cargo vehicle interactions with passenger-related traffic and allows for better utilization of terminal area aprons required to efficiently accommodate passenger activity that requires proximity to the terminal building. Furthermore, the type and quantity of GSE used to service all cargo aircraft and the facilities that support all-cargo aircraft operations are substantially different from passenger terminal facilities and are usually best located in a designated cargo area.

Cargo operators use a variety of aircraft types to serve individual markets. The size of all-cargo aircraft serving an airport is largely driven by cargo demand in the local service area, as well as larger cargo collection/distribution networks. Large widebody aircraft typically serve international cargo markets, larger cities, and cargo operator hubs, while narrowbody aircraft serve smaller domestic cargo operations. Turboprop aircraft are also used to transport time-sensitive cargo to smaller communities.

All-cargo aircraft facilities at airports generally consist of an aircraft parking apron, fixed or movable GSE, and a cargo building for sortation, screening, and transitioning cargo between the



(a)



(b)

Source: Google Earth Pro.

Figure 3-4. Cargo aprons: (a) FedEx Super Hub, Memphis International Airport; and (b) FedEx cargo facility at Cleveland Hopkins International Airport.

secure airside and landside ground transportation connections. Areas adjacent to the aircraft apron are used for storage of GSE. Similar to terminal aprons, cargo aprons are where aircraft are serviced, including fueling, lavatory service, deicing, and maintenance. An airport operator may limit certain cargo activities on the apron, such as the sorting of cargo or the presence of landside vehicles. The established operational and security guidelines at an airport may influence the layout and equipment present on the cargo apron.

Cargo aircraft are equipped with large doors on the left and right sides and upper and lower decks. Some cargo aircraft are loaded through an opening at the front of the aircraft, which is revealed when the nose is lifted. Cargo aircraft with nose-loading capabilities can accommodate large items that do not fit through side cargo door openings. To achieve the proper weighting and balancing of cargo aircraft during loading, and to ensure that the aircraft does not tip (nose up) from unbalanced loading, cargo operators have developed specific plans and procedures for loading each aircraft type to maintain balance and proper weighting throughout the loading operation. Alternatively, a nose tether (linking the aircraft nose to an anchor in the apron) or a tail stand (supporting the tail of the aircraft) can be used to secure the aircraft, allowing greater flexibility in aircraft loading.

A variety of GSE is used on cargo aprons, including aircraft tugs, cargo containers and trailers, cargo vehicles, mobile stairs, tail stands, and fueling vehicles or carts. Some cargo aprons contain fixed equipment that includes cargo loading platforms and in-ground nose tethers.

The operational characteristics of cargo aprons largely depend on the role of an airport in the all-cargo airline's network. Many all-cargo airlines operate hub-and-spoke networks, similar to some passenger airlines. For cargo airlines, hubbing airports are used as cargo transfer points and typically result in operations with a high amount of cargo and aircraft activity. Spoke airports may serve one or more cargo hub airports and experience lower cargo volume levels. Spoke airports may also accommodate cargo feeder aircraft. Feeder aircraft are typically smaller, propeller-driven aircraft used to serve smaller nearby destinations.

Cargo operations at airports used as hubs for package delivery companies typically experience peak activity during the overnight hours. At these hubs, aircraft arrive in the evening and cargo is unloaded, sorted, and loaded on the destination aircraft. The aircraft then departs in the early morning to reach its destination and to allow sufficient time for unloading, sorting, and loading onto ground vehicles used for door-to-door package delivery. The arrival and departure times of cargo operations at spoke cargo airports largely depend on the airport's geographic location relative to the hub airport. Feeder aircraft depart shortly after the cargo aircraft arrives from the hub and arrives back to the spoke airport prior to the aircraft departing for the hub airport. This daily schedule usually results in aircraft parked for extended periods of time on cargo aprons, including over weekends when package companies operate on a more limited basis. Cargo operations at airports serving all-cargo airlines that do not operate door-to-door package delivery services, mail operations, or charter operations may vary greatly and are largely dependent on the airlines' networks.

Maintenance Aprons

Aircraft maintenance activities include inspections that must be completed on demand or at specific intervals of aircraft operation, such as hours flown or numbers of takeoffs and landings (cycles). Each airline is required to prepare an aircraft maintenance program that outlines the activities to be performed during each inspection. Aircraft maintenance facilities, generally consisting of hangar buildings sufficiently sized to accommodate the aircraft fleet, are critical to ensuring that aircraft are adequately maintained and safe for flight. Aircraft maintenance facilities vary among airports and include those serving general aviation aircraft, cargo and passenger airline aircraft, and large maintenance, repair, and overhaul (MRO) operations.

As shown in Figure 3-5, maintenance aprons are typically located adjacent to these hangar buildings and are used for performing light maintenance or for aircraft storage and staging. Maintenance aprons are also used for staging maintenance equipment. Some maintenance aprons incorporate run-up areas with blast fences to deflect jet blast, propeller wash, and noise when performing engine run-ups. Jet blast is the thrust-producing exhaust from a running jet engine and propeller wash is the mass of air pushed to the rear of the aircraft by the propeller when in motion. Maintenance aprons are often equipped with lighting, movable stairs, and GSE, such as

Source: Google Earth Pro.

Figure 3-5. Maintenance apron.

ground power units or engine air start carts. Maintenance aprons are often used more intensely than terminal or cargo aprons as there is less need for GSE to maneuver among parked aircraft and less need for independent aircraft parking on maintenance aprons. Aircraft parking can occur with reduced separations, particularly when the maintenance apron is operated by a single airline.

Remote Aprons

Remote aprons are located away from terminal or cargo areas and used for storage or staging of aircraft. Most passenger aircraft do not operate overnight and remain parked at the airport overnight. At airports where the number of aircraft parked overnight exceeds the number of terminal parking positions/gates, RON aprons are used to store aircraft overnight. RON aprons can also be used to accommodate aircraft in the daytime during extended layovers to allow the use of gates that would otherwise be occupied by aircraft during these extended periods. These aprons can also be used for light aircraft maintenance and servicing during the day.

Aprons located near runway ends are often referred to as holding pads and are used to position aircraft awaiting air traffic control (ATC) clearance. These holding bays are often used in lieu of bypass taxiways and vary in size, shape, and function. Many deicing pads located near a runway end are used as holding pads when not required to support deicing operations. Holding pads can also be located in proximity to terminal areas. These holding pads are used as a pullout area to position aircraft when a gate is not available because of the early arrival or late departure by the aircraft occupying the intended gate. Figure 3-6 shows several types of remote aprons (RON, terminal, and runway holding pads).

General Aviation Aprons

General aviation is defined as all aviation other than military and commercial airline operations. This category of aviation encompasses private pilots flying ultralight and single-engine aircraft, corporate jet flights, air ambulance activity, forest fire fighting operations, air charters, agriculture spraying, and narrowbody and widebody aircraft transporting sports teams, race horses or other critical wildlife, or dignitaries. General aviation facilities vary in size and configuration, ranging

(a) (b)

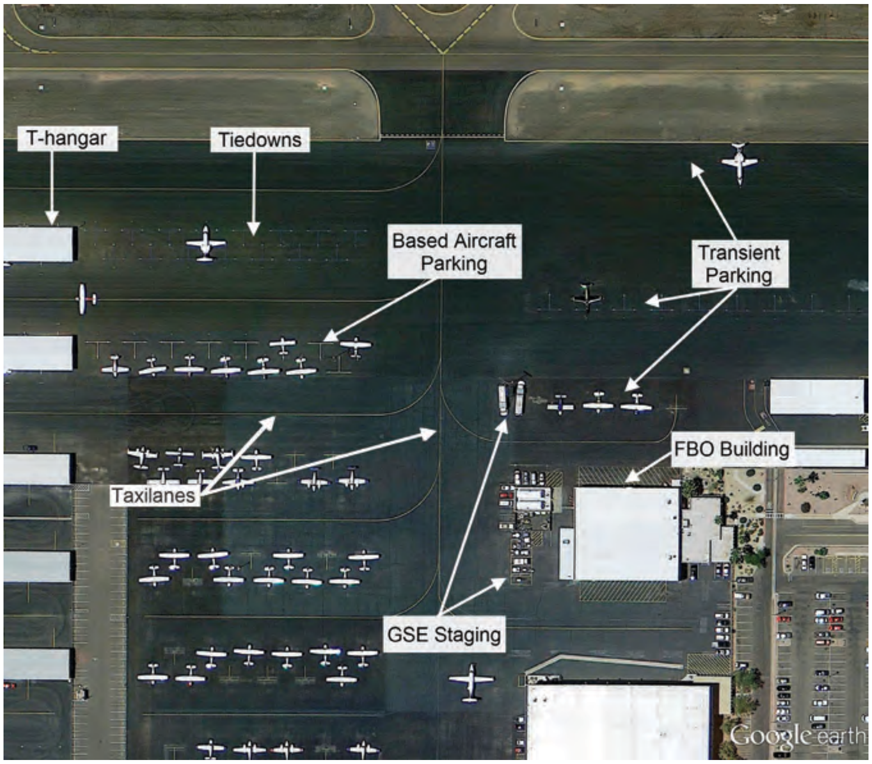
(c) (d)

Source: Google Earth Pro.

Figure 3-6. Remote pads: (a) remote aircraft parking apron; (b) holding pad near terminal area; (c) holding pad between runway ends; and (d) holding pad near runway end.

from facilities at airports that accommodate only small piston aircraft to facilities at larger airports that accommodate widebody jets.

At general aviation airports (those without scheduled commercial service), aprons are used either for the temporary parking of transient aircraft or the long-term parking of based aircraft. For light propeller aircraft, general aviation aprons are equipped with tiedowns, which anchor the aircraft to the apron to avoid unintended movement of aircraft during unstable weather conditions. General aviation aprons also provide access to T-hangars and commercial hangars used to accommodate some aircraft.



Source: Google Earth Pro.

Figure 3-7. General aviation apron.

Many general aviation aprons are leased and operated by a fixed-base operator (FBO), which is a business that provides services such as aircraft fueling, maintenance, lavatory service, pilot support and training, and parking. Figure 3-7 shows a general aviation apron collocated with a FBO and T-hangars. On aprons used by FBOs, the marking of designated parking positions is often minimized to maximize the flexibility to accommodate various aircraft types on the apron simultaneously. Typically, mobile GSE is preferred to stationary GSE to maintain flexible use of the apron. To reduce vehicle congestion, general aviation aircraft are fueled at self-service fueling areas operated by FBOs.

Most airport operators lease development areas to FBOs, which configure the leaseholds as needed to meet their operational objectives. In order to ensure that FBOs are able to serve all airport users, airport operators often incorporate rules, regulations, and guidelines into leases that require each lessee to configure, operate and maintain their apron(s) to best serve airport users, and maintain an efficient and secure operating environment. Airport operators may also require FBOs to provide aircraft parking and traffic flow plans for review to ensure that these are compatible with adjacent airport activities. Other lease requirements may include providing a minimum number of tiedowns or parking positions based upon the size of the leasehold or building.

Helipads

A helipad is an apron that provides a landing area for helicopters. At airports, helipads are used to separate helicopters from fixed-wing aircraft and ensure that proper safety areas and liftoff and takeoff areas are protected. Helipads generally include helicopter parking positions, taxiing routes, and passenger access routes. These features are generally delineated and marked accordingly. Helipads are often located on aprons that also accommodate fixed-wing aircraft or on designated positions on taxiways. Figure 3-8 shows both a helicopter-only facility and a helipad located on a

Source: Google Earth Pro.

Figure 3-8. ***Helipads.***

taxiway. Helicopter operations are controlled by ATC when available at the airport. If the airport is not controlled by ATC, helicopter pilots follow visual flight rules.

Helicopters are used for a variety of purposes, including transportation of people and cargo, firefighting, tourism, aerial observation and photography, air ambulance, search and rescue, aerial craning, and military operations. Activities that occur on helipads may vary depending on the use of the helicopter. For example, on aprons used to accommodate forest firefighting helicopters, the aircraft may be refilled with water while positioned on the apron; on aprons serving tourism helicopters, passenger activities that may require walkways and a passenger terminal building must be safely accommodated.

Activities on the helipad are generally the same as those on aprons that accommodate fixed-wing aircraft, including, but not limited to, passenger enplaning and deplaning, fueling, maintenance, storage, and cargo loading. GSE for helicopters is either portable or fixed and is typically positioned at the edge of a helipad.

Aircraft Maneuvering

Three basic types of aircraft maneuvering take place in the apron areas of airports: power in, power out; power in/push back; and tug in, push back. These maneuvers are discussed in the following sections.

Power-In, Power-Out Maneuvers

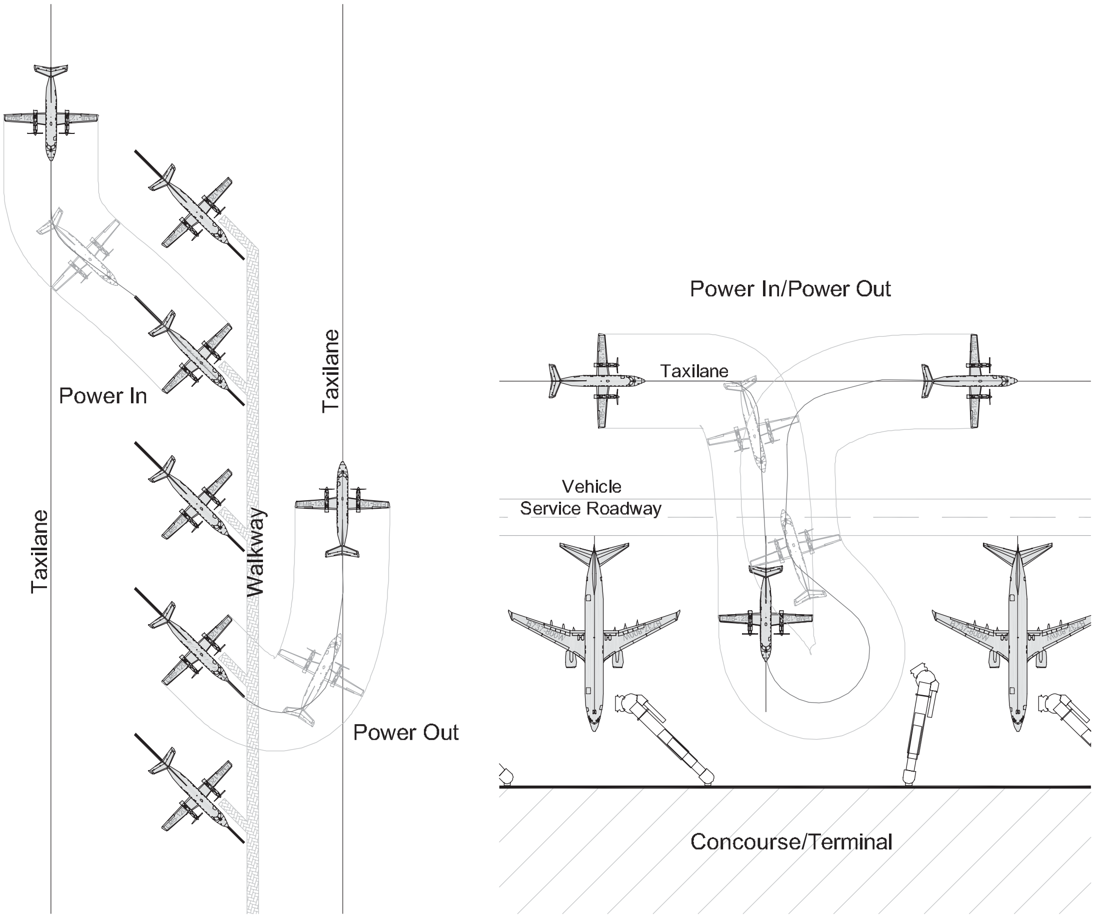
As illustrated on Figure 3-9, with the power-in, power-out maneuver, the pilot pulls the aircraft into a parking position under the aircraft's own power, and sufficient clearance or access to a taxilane or taxiway is available to allow the pilot of that aircraft to subsequently pull out of the parking position under the aircraft's own power. This maneuver is more common on terminal aprons that accommodate aircraft ground loading and unloading, as no equipment, such as passenger loading bridges, are present to obstruct aircraft movement. Although some aircraft are equipped with reverse thrust to move backward, jet blast or propeller wash can have adverse effects in the apron area, potentially damaging terminal, cargo, or other buildings or creating hazards for personnel or passengers.

This type of aircraft maneuver is common on flow-through deicing pads and hold pads near runway ends. A power-in, power-out maneuver is generally more efficient than a push-back maneuver, especially for regional jets or turboprops because tug equipment is not required.

Power-In, Push-Back Maneuvers

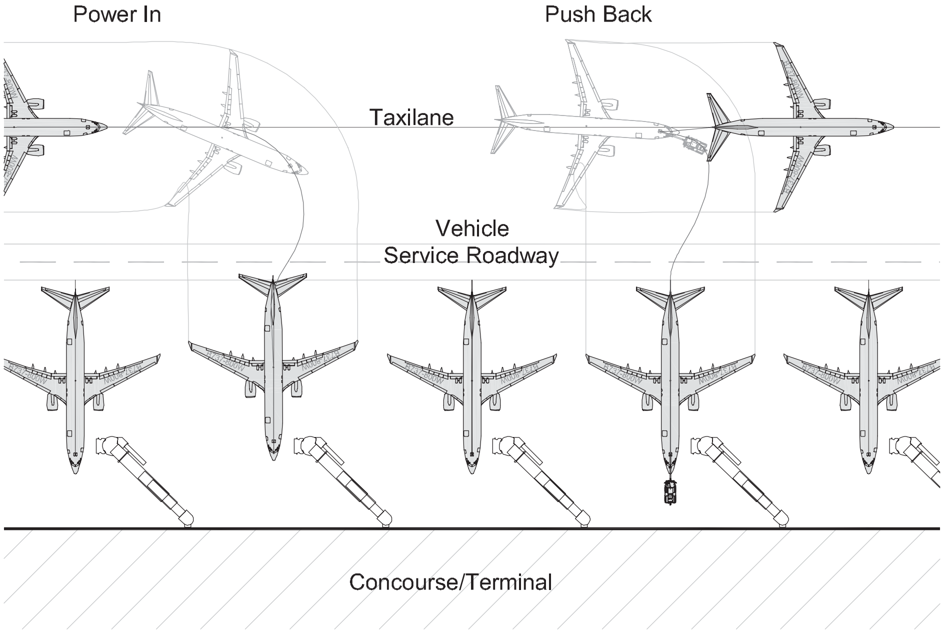
The most common aircraft maneuver used in terminal and cargo apron areas is the power-in, push-back maneuver. As shown on Figure 3-10, this maneuver involves the pilot of an arriving aircraft pulling into a gate or parking position, nose first, under the aircraft's own power, usually generally perpendicular to a building or a taxilane. When the aircraft is ready to leave the gate or parking position, a tractor or tug is used, attached to the aircraft nosewheel, to push the aircraft to an apron, taxilane, or taxiway, where the aircraft has adequate maneuvering room and can safely be started up without the adverse effects of jet blast. In some cases, aircraft are also pulled forward as part of this maneuver to avoid the adverse effects of jet blast on buildings, equipment, personnel, or other aircraft.

The tractor or tug is then detached from the aircraft and moved out of the way. The aircraft is then moved forward under the aircraft's own power. Although this type of maneuver is the most



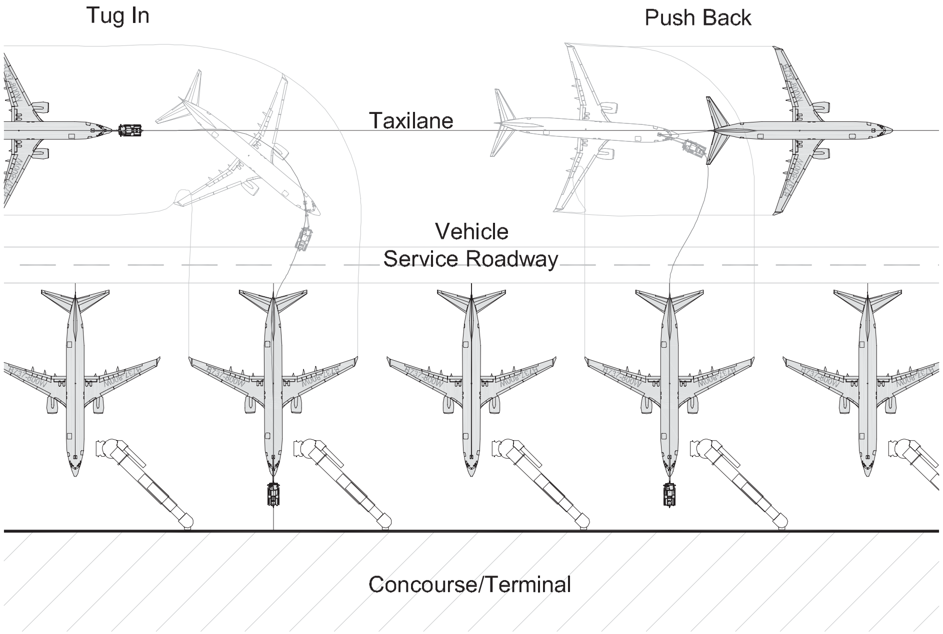
Source: Ricondo & Associates, Inc.

Figure 3-9. Power-in, power-out aircraft maneuvers.



Source: Ricondo & Associates, Inc.

Figure 3-10. Power-in, push-back aircraft maneuvers.



Source: Ricondo & Associates, Inc.

Figure 3-11. Tug-in, push-back aircraft maneuvers.

labor intensive, it requires the least amount of apron area compared with aircraft taxiing in and out under their own power because the ground crew has better visibility of the apron environment and can more precisely direct aircraft maneuvers in dimensionally tight areas.

Tug-In, Push-Back Maneuvers

At terminal or other aprons with constrained space and limited dimensional clearance, aircraft are tugged into the gate to reduce the potential for collisions or the negative effects of jet blast. This type of maneuver can be required by airport operational procedures or requested by a pilot. This type of aircraft maneuver takes additional time to allow for the tug vehicle to be hooked onto the aircraft nosewheel and for the aircraft to be towed into the gate. As shown in Figure 3-11, typically, aircraft that are towed into the gate require a tug to push the aircraft away from the apron at the time of departure. There is also a potential for aircraft powering in to a gate to be tugged in if the aircraft unexpectedly had to stop. Powering in is often required because of jet blast concerns where idle or taxi thrust is acceptable and break away thrust is not allowed.

Passenger Enplaning and Deplaning

When planning terminal aprons, the planners must consider the transfer of passengers between the aircraft and the terminal/concourse. Passengers and baggage can be transferred with minimal use of equipment, or may involve a sophisticated system of equipment. Passengers are generally enplaned and deplaned from aircraft using one of three approaches: bridge loading, ground loading, or remote loading.

Bridge Loading

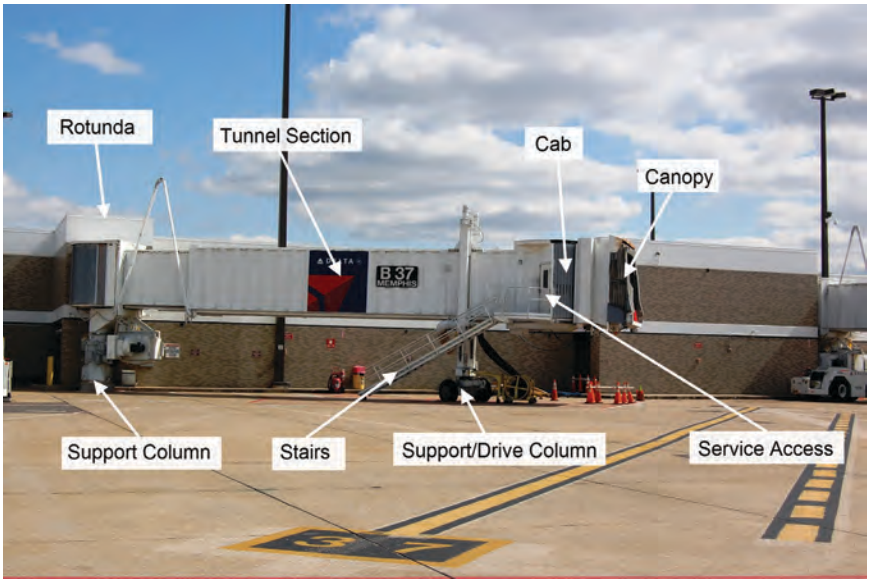
A passenger loading bridge (PLB) is a movable enclosure that facilitates the transfer of passengers between the terminal/concourse and the aircraft in a secure and environmentally controlled environment. A PLB accommodates differences in elevation between the terminal and aircraft door sill. PLBs also provide a level of security for aircraft boarding and protect passengers from adverse weather conditions, potential jet blast exposure, and other ramp activity, while also providing improved access for passengers using wheelchairs. When aircraft are parked sufficiently far from the terminal building, fixed bridge segments can be used to span the gap between the building and the aircraft, with a PLB placed at the distal end of the fixed bridge segment. These fixed segments are also used when a PLB would not meet maximum slope requirements (typically defined by the Americans with Disabilities Act [ADA]) and a longer bridge length is necessary to lessen the bridge slope.

PLBs usually provide the most direct access to a terminal building and generally provide a safer environment compared with ground loading. PLBs almost always interface with aircraft from a left-side door, usually forward of the aircraft wings, but not necessarily the most forward door. Although most aircraft are served by a single PLB, the use of multiple bridges can significantly reduce the time required to enplane and deplane passengers by providing for two streams of enplaning or deplaning passengers, especially for widebody aircraft or dual-level aircraft. Multiple PLBs to serve a single aircraft are most commonly used with widebody and dual-aisle aircraft in which the first and second loading doors are both forward of the aircraft wing. In the case of the double-decked A380, bridges may extend to the upper level of the aircraft. Gates equipped with multiple bridges can often accommodate either one widebody aircraft or two narrowbody or smaller aircraft. This type of gate configuration is referred to as a multiple aircraft ramp system.

The two main categories of PLBs are apron drive loading bridges and fixed loading bridges, as described in the following subsections.

Apron Drive Loading Bridges

Apron drive PLBs provide the most operational flexibility. As shown on Figure 3-12, these bridges consist of a rotating rotunda, typically attached to the terminal/concourse building and usually placed on top of a foundation and pedestal support. The rotunda is connected to two or three telescoping tunnels that extend and retract along their longitudinal axes to connect with aircraft on the apron. A rotating cab is also located at the far end of the tunnels, with the tunnels



Source: Kimley-Horn and Associates, Inc.

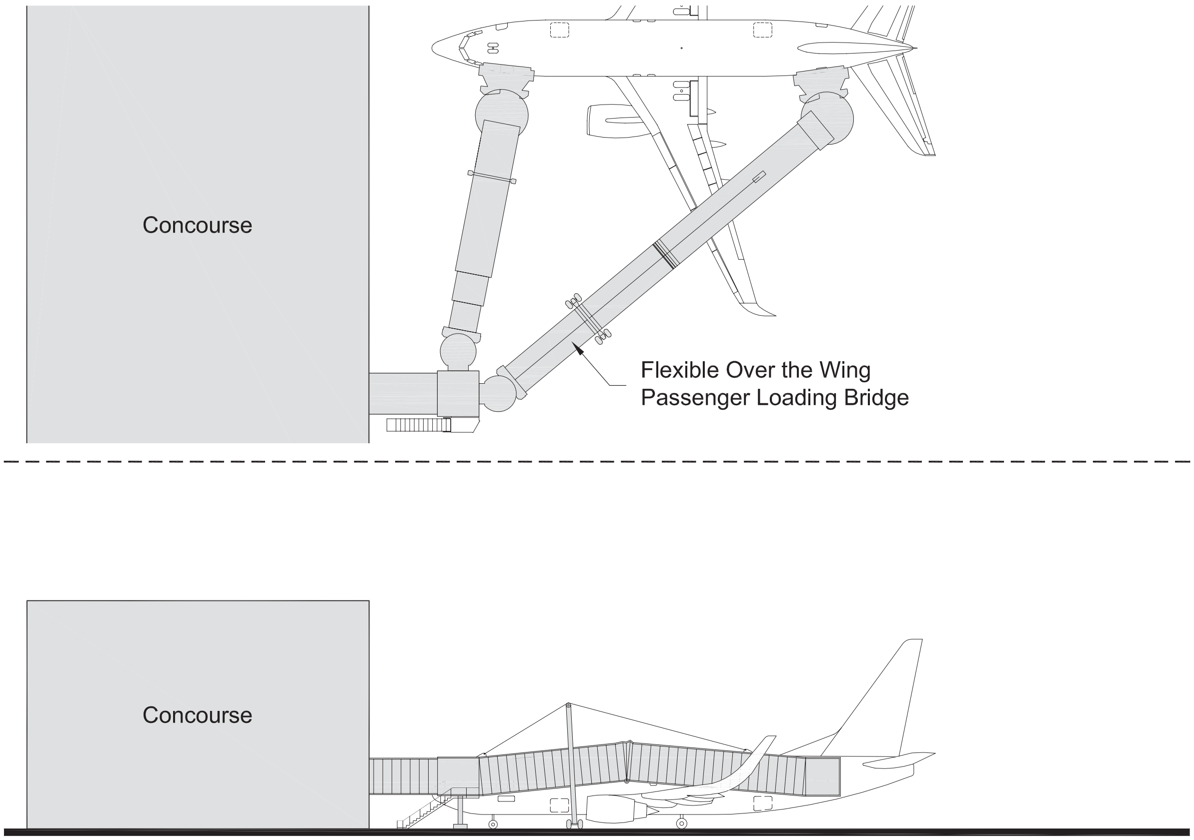
Figure 3-12. Apron drive PLBs.

and rotunda dynamically elevated by a vertical support under the tunnel section and a set of wheels that can be rotated to move the bridge to meet the door sill of an aircraft.

Each bridge has maximum and minimum operational ranges for all three movements (vertical, rotation, and extension), which are defined by the manufacturer. When planning for apron drive bridges, planners must consider these operational limits to determine the slope of the tunneled sections for the bridge interfaces with aircraft on the apron. A three-tunnel bridge provides the greatest range of extension and is usually used on aprons with sufficient apron depth and when aircraft of varying door sill heights must be accommodated. To accommodate apron drive bridges, the apron configuration must reflect consideration of the equipment's maximum extension and retraction, its maximum rotation at the rotunda, and its maximum vertical range.

In situations where a road is located between the parked aircraft and the terminal building, referred to as a head-of-stand road, fixed bridge segments spanning the road are used to connect the terminal building with the rotating cab, which sits on a pedestal mounted to a foundation in the apron. In these situations, sufficient vertical clearance must be provided for vehicles passing beneath the fixed segment of the bridge. On the apron, bridge maneuvering area markings are important to ensure that vehicles or GSE do not interfere with the movement of the bridge.

An over-the-wing apron drive bridge is a unique type of loading bridge used to access doors located behind an aircraft wing to provide multiple access points to the aircraft. As shown on Figure 3-13, these bridges are configured with a rotating cab attached to a fixed segment, which is horizontally hinged to allow the bridge to be elevated over-the-wing and then slope down to



Source: Ricondo & Associates, Inc.

Figure 3-13. Over-the-wing apron drive bridge.

a rear aircraft door. A fail-safe stopping or braking mechanism is used to prevent damage to an aircraft wing in the event of bridge failure.

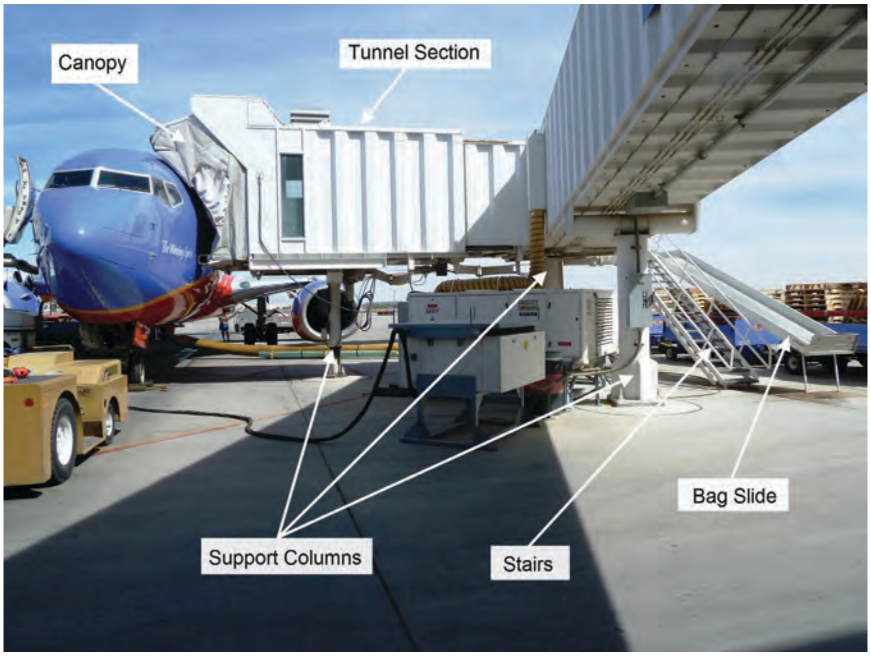
The use of over-the-wing PLBs allows two loading bridges to serve an aircraft, potentially reducing the amount of time required to enplane and deplane passengers. While similar to the use of multiple PLBs, over-the-wing PLBs are typically used with narrowbody single-aisle aircraft in which the second loading door is located behind the aircraft wing. The use of this type of bridges reduces the available apron space on the side of the aircraft that the bridge serves, as well as the space for GSE storage.

Fixed Loading Bridges

Fixed PLBs consist of a fixed link from the building to a stationary pedestal on the apron and a telescoping segment located between the pedestal and the parked aircraft, as depicted on Figure 3-14. These bridges are positioned perpendicular to the aircraft with a tunnel section that extends to the aircraft after it has pulled into the gate and retracts when the aircraft is loaded. With a fixed PLB, the accuracy in the final positioning of the aircraft is more critical, given the limitations in cab movement and the inability for the bridge to move along the axis of the aircraft. This type of bridge is typically more economical than apron drive bridges and is used when reduced flexibility is acceptable, such as when a narrow range of aircraft with similar door sill heights are parked at a particular gate. As fixed bridges are largely stationary, a smaller amount of apron area must be protected compared to that needed to support an apron drive bridge.

Door Sill Height Adapters

Many PLBs are not able to reach regional jet or turboprop aircraft because the stairs or other equipment on the aircraft exterior can be damaged when a PLB extends to the aircraft. PLBs are also limited in the distance that the cab can drop because of equipment limitations. Adapters are used to reach the aircraft and securely bridge the gap from the edge of the loading bridge to



Source: Ricondo & Associates, Inc.

Figure 3-14. Fixed PLB.

Source: Ricondo & Associates, Inc.

Figure 3-15. Low door sill height adapters for regional jets.

the aircraft. These adapters are either portable or integrated into the bridge under the rotunda. With portable bridge adapters, the loading bridge is moved as close to the aircraft as permissible and the portable adapter is extended and lowered onto either the aircraft sill or, if the aircraft is equipped with stairs, onto the top step. Permanent adapters allow for the bridge to approach the aircraft without making contact, and final docking is completed by extending the retractable portion of the bridge floor to the aircraft. Figure 3-15 illustrates the two types of adapters. There are also aircraft with passenger door configurations where the bottom of the door is lower than the sill height when it is opened all the way. This may require the PLB to be positioned below the door sill and require special ramps to bridge the vertical difference between the aircraft and the PLB.

Ground Loading

Depending on the size of the aircraft and the configuration of the terminal/concourse or FBO facility, aircraft may be ground loaded, which entails passengers walking to the aircraft at ground level and accessing the aircraft by using stairs built into the aircraft, also known as air stairs, or a mobile stairway that is positioned at the aircraft loading door. Ground loading is primarily used to enplane and deplane passengers when gates with PLBs are unavailable, aircraft size does not warrant a bridge, or aircraft parking configurations preclude the use of bridges, such as with lower-level facilities. Additionally, regional jet or turboprop aircraft are often ground loaded and unloaded, especially at airports with a large airline hubbing operation where loading bridges are used for larger aircraft. Figure 3-16 provides two examples of apron layouts for ground loading and unloading of passengers.

Passengers on regional jets and turboprop aircraft are often enplaned and deplaned using air stairs. Some larger regional jet and turboprop aircraft are not equipped with air stairs and either ramps or movable stairs are used to enplane and deplane passengers. The use of loading ramps enables passengers using wheelchairs to more easily enplane and deplane the aircraft. As shown on Figure 3-17, a variety of ramps can be used. The first photograph shown is a ramp anchored at the base, which remains in position and is rotated into the aircraft during use. Other loading ramps or stairways double back to reach aircraft with higher door sills, as shown Figure 3-17b.

Source: Google Earth Pro.

Figure 3-16. ***Ground passenger loading apron layouts.***

(a) (b)

Source: Ricondo & Associates, Inc.; Airport Development Group, Inc.

Figure 3-17. Ground passenger loading equipment.

Many of these ramps or stairways are towable and use brakes to prevent slippage. Aircraft stair vehicles are also used to enplane and deplane passengers. These vehicles are equipped with stairs that can be raised or lowered to meet the sill of the aircraft and can accommodate both narrowbody and widebody aircraft. Other ground passenger loading equipment includes wheelchair lifts that are used to provide access to an aircraft that has built-in air stairs.

Ground loading of aircraft, which may require more or less time to complete than enplaning and deplaning through a PLB depending on the size and sill height of the aircraft, introduces safety and security concerns because passengers must transit an area occupied by operating aircraft and GSE. In addition, ground loading of aircraft often does not provide meaningful protection for passengers during adverse weather conditions, although, in some cases, a fixed or movable covered walkway extending at least a portion of the distance between the building and the aircraft can be installed.

Remote Loading/Hardstands

At airports where space is not available in the terminal area for passenger enplaning and deplaning, remote aprons are used to supplement terminal gates. Also known as hardstands, these remote aprons are usually located sufficiently far from the terminal that walking is not desirable or acceptable (particularly in an active operating environment). Although the construction cost of these remote hardstands can be lower than that for a terminal gate, the operational costs are higher because of the need to transport passengers to and from the terminal building. In addition, remote loading often increases bus and vehicle activity on the airfield. Remote hardstands require the use of air stairs or mobile stairs (as described in the previous section) to enplane and deplane passengers. Hardstands can be equipped with hydrant fueling systems, but typically require cart-mounted ground power units (GPUs) and preconditioned air (PCA) units, thus increasing the amount of equipment on the apron.

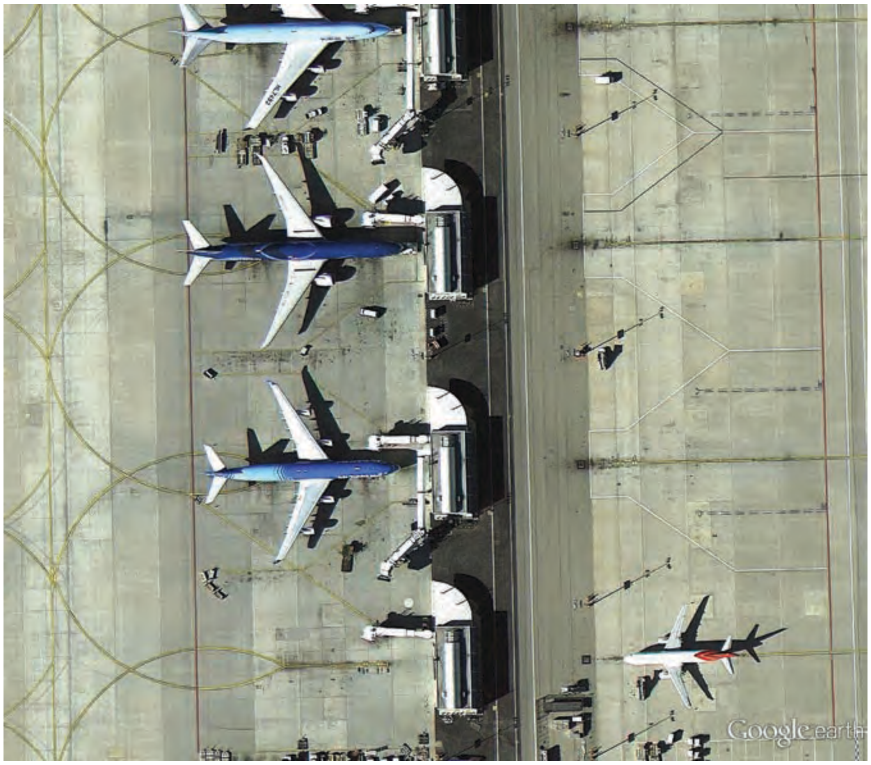
Passengers are transported between the terminal and remote hardstands using shuttles or buses, which can vary in size. The larger vehicles accommodate approximately 130 passengers. The size and frequency of bus service depends on the size (seating capacity) of the aircraft and the passenger load. Although not common, mobile lounges are specialized vehicles that are used to enplane and deplane passengers at remote hardstands. Mobile lounges have ramps on one end that can be raised or lowered to meet the door still of an aircraft. A variation of a mobile lounge

Source: Ricondo & Associates, Inc.

Figure 3-18. Plane mate mobile lounge.

is a plane mate which consists of a passenger compartment that can be raised or lowered using a screw assembly to meet the height of an aircraft loading door and terminal dock. An example of a plane mate mobile lounge is shown on Figure 3-18.

Some remote hardstands contain supporting structures that are equipped with a PLB and ramps, escalators, or stairs that provide vertical circulation to a bus station on the apron level. These structures typically protect a vertical corridor to the aircraft and may provide some passenger facilities, such as restrooms. Figure 3-19 shows remote hardstands at Los Angeles International Airport.



Source: Google Earth Pro.

Figure 3-19. Remote hardstands at Los Angeles International Airport.

Vehicle Roadways

Vehicle roadways are of vital importance to the efficiency of daily airport operation. A well-designed and properly maintained roadway system enhances safety; reduces delays for airlines, cargo operators, and other aircraft users; and facilitates the controlled and channelized movement of vehicles throughout the airport. Vehicle roadways are best described as a path (or means) of channelizing the flow of vehicles to enhance safety, reduce vehicle and aircraft interactions, control vehicle traffic, support wayfinding, and connect various parts of the airport. The following describes the types of apron service roads, emergency access roads and busing operations on aprons.

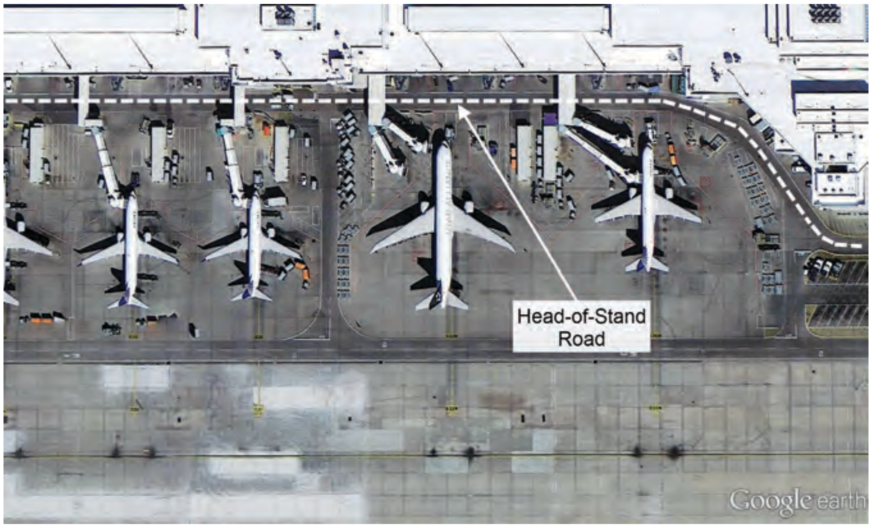
Apron Service Roads

Apron service roads serve as the main vehicle circulation arteries in and around the terminal core and other apron facilities. The purpose of apron service roads is to channelize the movement of vehicles so that pilots know where these vehicles are and to prevent conflicts with aircraft or engine jet blast. Apron service roads provide access to aircraft parking positions for GSE and other vehicles and connection to other terminal, cargo, or GSE storage facilities via airfield service roads.

There are three generally accepted locations for apron service roads: head-of-stand, tail stand (apron edge), and between aircraft. A number of newly constructed airports, with ample space available, have incorporated a combination of both head-of-stand and tail-stand designs. These service roads are defined by the position of the service road in relation to parked aircraft.

Head-of-Stand Road

A head-of-stand road is located between the nose of the parked aircraft and a terminal or cargo building. This configuration allows for uninterrupted access to aircraft as 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 taxilanes, having to wait for aircraft pushing back or pulling into a gate position, or other potential interactions. Head-of-stand road alignments also tend to increase apron depth and require additional PLB segments. As shown on Figure 3-20, fixed bridge segments



Source: Google Earth Pro.

Figure 3-20. Head-of-stand service road configuration.

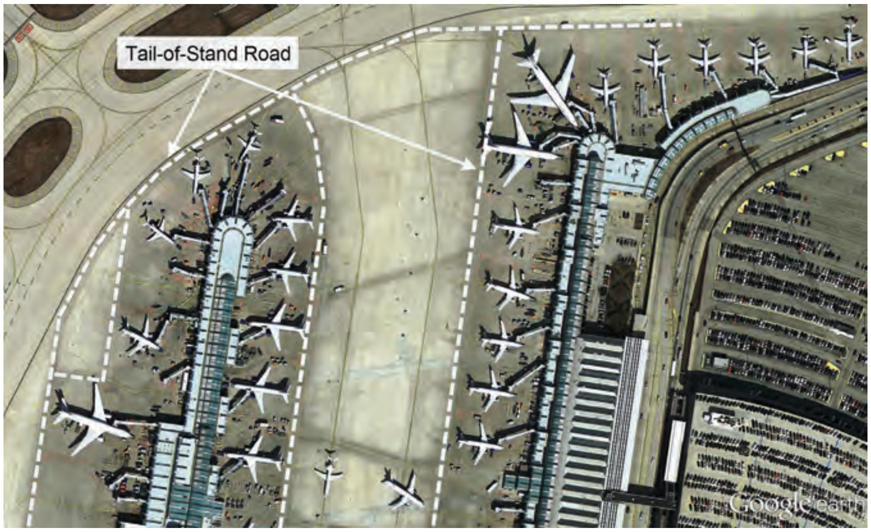
must span head-of-stand service roads and must provide adequate clearance to allow the tallest vehicles to pass beneath them, which can affect the planned floor elevation of the terminal building. Head-of-stand roads require aprons with greater depth, especially to accommodate aircraft tugs without interfering with vehicle movements on these roads. These roads can create conflicts with apron level door exits for personnel and ground loading of passengers. Overall, the head-of-stand configuration enhances safety by limiting interactions between vehicles and moving aircraft.

Tail-Stand Road

A tail-stand road is located at the tail of the aircraft, at times referred to as an apron edge service road because the road can delineate the limit of the leased areas. As shown on Figure 3-21, the layout of this type of service road usually reflects the physical limits of aircraft parking areas, but may also reflect the taxiway/taxilane alignment. Tail-stand roads can result in potential conflicts between vehicles and aircraft, as aircraft must cross the tail-stand roads to enter or exit gates. To avoid operational consequences, tail-stand service roads must be located outside all taxiway and taxilane object free areas (OFAs), as penetrations of these areas can result in limitations on the size of aircraft that can use the affected taxiways/taxilanes. On aprons with tail-stand roads located on each side of a taxiway or taxilane, it is common for these tail-stand roads to be connected across the taxiway/taxilane by a service road marked on the pavement to provide vehicles a defined route to cross what can be expansive pavement areas. Figure 3-21 illustrates marked vehicle roads crossing dual taxilanes between concourses.

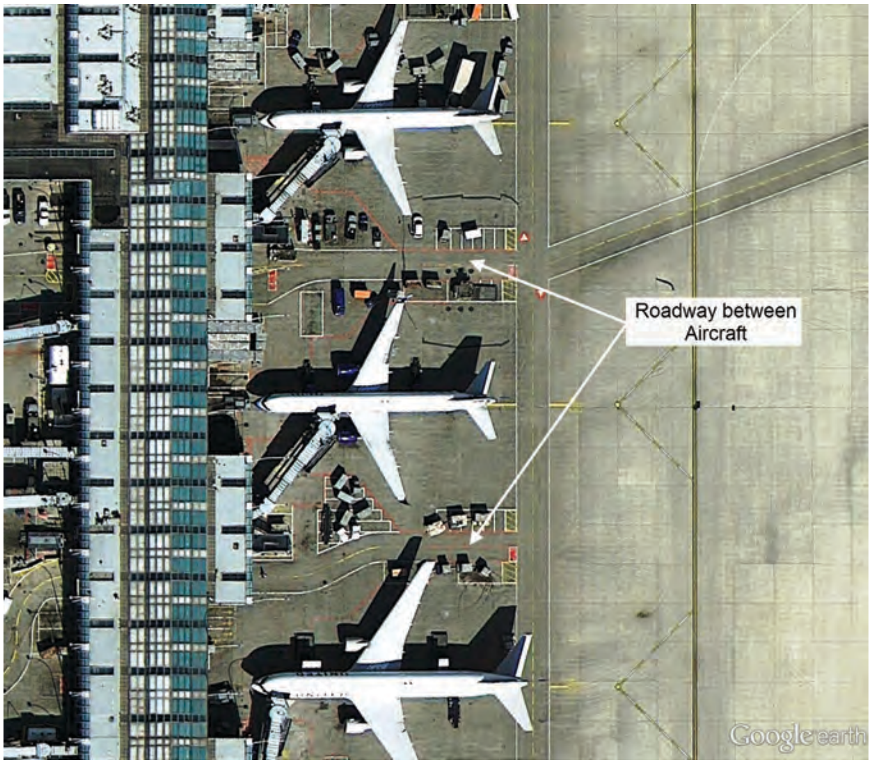
Roads Between Aircraft

It is not uncommon for tail-stand roads to be supported by a vehicle pass-through of the apron level of the terminal/concourse or cargo building, allowing ground vehicles of a limited size to drive into or through the apron level of a building rather than around the building. Such a pass-through can be particularly beneficial in the case of linear concourse piers when an airline operates gates on both sides of the pier. Vehicle pass-throughs are typically supported by defined vehicle routings, enhanced with traffic control signage and markings on the pavement. These routings often pass between parked aircraft positions, linking a tail-stand or other service road with the building pass-through entry/exit point. As shown on Figure 3-22, when a vehicle



Source: Google Earth Pro.

Figure 3-21. Tail-stand service road configuration.



Source: Google Earth Pro.

Figure 3-22. Service road between aircraft.

pass-through is planned with aircraft parked on both sides of the vehicle routing, aircraft wingtip separation increases. These roads can also provide access to the building for emergency and delivery vehicles. Roads between aircraft routings can also support airside employee bus stops, concessions delivery/storage facilities, and other non-GSE vehicle movements.

Emergency Access Roads

Emergency access is required in all apron areas to allow swift and effective response to emergencies involving aircraft, personnel, passengers, medical illness or trauma, structural damage/fires, law enforcement response, security issues, and other emergent situations. In the event of an emergency, response can originate on the airside or landside, including airside ARFF vehicles, landside police or fire department vehicles, ambulances, and other types of vehicles. The effectiveness of an airside response, irrespective of vehicle type, is maximized when the responding vehicle(s) can proceed as close to the emergency scene as safely possible. In some situations, response vehicles or equipment will have to drive between parked aircraft and among apron equipment and parked GSE.

Emergency response is a function of the type and severity of the triggering incident, but, in all cases, the highest priority of the responder is providing assistance, even if that temporarily interferes with apron activities or operations.

Busing on Aprons

Busing operations on aprons are either scheduled or unscheduled. Some airport operators provide scheduled buses to transport airport and airline employees to and from remote parking facilities and terminal or other airport buildings, often using apron roadways to access these facilities. Buses may also be used to transport passengers between terminal buildings or concourses on a recurring schedule, particularly when a hubbing airline operates from multiple terminals or concourses. Mobile lounges and plane mates are also used to transport passengers between terminals and concourses. Figure 3-23 shows a passenger and employee bus stop on a terminal apron. Bus stops for passengers provide access to secure portions of the terminal while employees may be dropped off in nonsecure areas. Separate bus stops are provided for arriving international passengers because these passengers must be connected to a sterile corridor system connecting to U.S. CBP arrival facilities.

Unscheduled bus operations can be provided in response to airfield incidents that require the transportation of passengers from an aircraft back to the terminal or other facility. Such incidents would usually be the result of an aircraft emergency or act of nature.

Where terminal gates are not available, passengers may be deplaned at remote aprons and bused back to terminal facilities. Busing is also used to transport passengers when the primary form of transportation between a terminal and concourses, such as an automated people mover, is unavailable.

Unscheduled bus operations are either escorted (e.g., if transiting the airfield to meet a disabled aircraft), particularly if the bus is operating on or crossing taxiways or runways, or unescorted following marked and signed service and access roads. To the maximum extent possible, bus drivers will be trained in the safe operation of buses in the secure environment; however, an airport operator may opt to require escorts even in these cases.

Source: A.S.S.E.T., LLC.

Figure 3-23. Terminal apron bus stop.

Apron Equipment and Systems

Various types of apron equipment and systems, such as aircraft towing equipment, preconditioned air units, GPUs, potable water system, aircraft fueling systems, other aircraft servicing vehicles, and baggage vehicles, are used to service aircraft parked on the apron.

Aircraft Towing Equipment

Gating, parking, or other limitations can preclude aircraft from vacating their parking positions under their own power. Only a limited number of aircraft types can power in reverse (i.e., power back) out of their parking positions, such as the DC-9 aircraft series, but they are usually restricted from doing so (by the FAA, airline, or airport operator) because of foreign object debris damage concerns, increased noise, increased fuel consumption, weather conditions, and other safety-related factors. The method preferred by the airlines is the use of tug tractors or towbarless tractors to push aircraft away from the gate/parking areas to a location where it is safe and efficient for the aircraft to taxi forward under its own power.

Tug tractors and towbarless tractors are also commonly used to reposition aircraft to other gates, hardstands, or RON positions; tow aircraft to or from aircraft maintenance facilities; and move or recover aircraft on the airfield that are unable to move under their own power.

Tug Tractors

Tug tractors, also known as conventional tugs, are a specialized form of apron equipment used to push or pull aircraft from parked or stationary positions, as shown in Figure 3-24. These conventional tugs use a pivoting towbar to connect the tug to the nosewheel of the aircraft. The tugs must have a low profile to avoid coming into contact with the nose of the aircraft to which they are connected, while also being heavy enough to maintain the traction needed to move the aircraft. Conventional tugs used for A380 pushbacks, for example, can weigh more than 155,000 pounds. Conventional tugs use high torque engines and low gear ratios to slowly push aircraft back from the gate or parked/stationary positions.

The towbars that connect conventional tugs to aircraft are aircraft-type specific. Conventional tug operators must have a variety of towbars available to connect their tugs with different aircraft types. Towbars are commonly equipped with wheels to allow transport of the towbar and to

Source: Ricondo & Associates, Inc.

Figure 3-24. Tug tractor.

assist tug operators in positioning heavy towbars. Shear pins are designed to prevent damage to aircraft by breaking if the tug operator places too much stress on the aircraft nosewheel during tugging operations. The length of the tractor and the bar connected to the aircraft can influence apron depth.

Towbarless Tractors

Towbarless tractors, also known as towbarless tow vehicles (shown in Figure 3-25), are used in addition to conventional tugs to tow and push back aircraft, ranging from regional jets to wide-body aircraft. Instead of relying on a towbar, towbarless tractors rely on a pickup device located in the center of the vehicle to lift and cradle the nosewheel tires to move the aircraft. The lack of a towbar removes two pivot points in the connected aircraft-tug mechanism, resulting in simpler maneuvering of the aircraft. Similar to conventional tugs, towbarless tractors must also have a low profile and sufficient weight appropriate for the aircraft they are designed to move. These tractors are typically larger and wider than tug tractors, with vehicle widths up to approximately 15 feet. In addition to gate maneuvers, towbarless tractors are also used to move aircraft on the airfield (between gates, remote hangars, runway departure ends) because their use reduces jet fuel consumption and resulting engine emissions during taxiing.

The absence of various towbars and the ability to operate at higher speeds than conventional tugs mean that aircraft movements, pushbacks, repositioning, and maintenance towing can be conducted faster than with conventional tugs.

PCA Units

PCA units provide conditioned outside air for ventilation and temperature control (heating or cooling) in parked aircraft. The PCA unit is attached to an aircraft via one or more air hoses through a port typically located on the underbelly of the aircraft.

PCA units can be engine driven (using diesel or jet fuel) or electric, connected to an airport's electrical distribution system. The use of PCA units for passenger aircraft is common at most airports. The main benefits associated with PCA units, in conjunction with GPUs, is a reduction in jet fuel use, which reduces aircraft emissions, as the use of this equipment allows the APU engines to be shut off while the aircraft is parked for cabin preparation, aircraft servicing, or maintenance.

PCA units are generally categorized as mobile, stationary/bridge mounted, or centralized.

Source: A.S.S.E.T., LLC.

Figure 3-25. Towbarless tractor.

Mobile PCA Units

As shown in Figure 3-26, mobile PCA units are mounted on trailers allowing for movement/repositioning around the apron and are not limited to serving a single gate. The advantages of mobile PCA units are that they can be moved out of the way when not in operation and can be used at multiple locations as needed. Typically, mobile PCA units are plugged into an airport's electrical distribution system at dedicated receptacles, but some units have built-in engine generators that locally produce electricity to power the aircraft air conditioning (refrigeration) system and blower, and for the electric heating of the outside air, if necessary. The main disadvantage of mobile PCA units is that they add to gate congestion. Trailer-mounted PCA units can be as large as 150 square feet, which is significant in already congested gate areas.

Engine generator mobile units are generally usable in any location throughout the airport, but may be prohibited in certain locations because of noise restrictions. Engine generator units typically produce noise in the 80 dB range, which is just below the National Institute of Occupational Safety and Health threshold for an 8-hour shift before hearing damage can occur. In addition to employee concerns, this level of noise is typically undesirable near passenger areas. Engine generator PCA units may also be prohibited in some locations because of exhaust and combustibles associated with diesel engines. Battery-operated units eliminate noise and emissions concerns, but require recharging and battery maintenance. Battery units are typically useful up to 2 hours before recharging is required.

Electrically powered PCA units sacrifice flexibility because they rely on connection to an electrical distribution system. Limitations associated with receptacle locations can often be mitigated by increasing the discharge hose length; however, this approach adds to the equipment congestion and introduces trip hazards around the gate area. The airport's electrical distribution system must also be designed and sized properly to allow electrically powered PCA units with varying electrical demands to simultaneously be plugged in at different locations.

Stationary/Bridge-Mounted PCA Units

Stationary PCA units are fixed on a pad mounted near the aircraft parking location or attached to the underside of a PLB. Stationary PCA units attached to a PLB are powered by a standard electrical distribution system. The main advantage of PCA units attached to a PLB is the reduction in gate area congestion. PCA units can be mounted under a PLB, as shown in Figure 3-27, or mounted to the top of the bridge.

Source: Ricondo & Associates, Inc.

Figure 3-26. Mobile preconditioned air unit.

Source: Kimley-Horn and Associates, Inc.

Figure 3-27. Bridge-mounted preconditioned air unit.

Figure 3-28 shows a stationary PCA unit mounted on the apron. Apron-mounted units can be installed when there is not sufficient space available on a PLB. These units are also typically powered by the airport's electrical distribution system, but can also be powered by a diesel engine generator. The PCA units, which vary by aircraft size and required cooling capacity are usually sized for the largest aircraft that is reasonably expected to be accommodated at the gate. Sufficient hose length is usually provided to serve a range of aircraft sizes. Hoses can be extended to aircraft parked away from the PCA unit, such as regional jets or propeller aircraft not using the PLB and parked away from the bridge.

Both bridge-mounted and stationary PCA units can be equipped with diverting valves that provide conditioned air to the PLBs. Higher-capacity PCA units may be required to sufficiently heat or cool the PLB and the aircraft.

Centralized PCA Systems

Centralized PCA systems differ from stationary/bridge-mounted units in that the refrigeration is generated remotely (e.g., within the terminal building) and distributed via chilled and

Source: Ricondo & Associates, Inc.

Figure 3-28. Stationary preconditioned air unit.

heated liquid to the individual point-of-use air handling units. The individual PCA units are smaller and lighter because their function is limited to blowing outside air past the heating or cooling coils. Some centralized PCA systems use an underground distribution system and pop-up hatch pits that reduce the amount of equipment on the apron.

GPUs

GPUs provide the 400 Hz power required by aircraft electrical systems, rather than the standard 60/50 Hz power available from utility companies; 400 Hz power is used in aircraft as the power supply equipment is smaller and lighter, thereby reducing the weight and amount of space required in the aircraft. Traditionally, 400 Hz power has been motor-generated (i.e., 60 Hz or 50 Hz electric motors drive a 400 Hz generator) or engine generators directly produce 400 Hz power. However, with advancements in electronics, solid state 60/50 Hz to 400 Hz frequency converters are becoming the standard for GPUs. GPUs connect to the aircraft via specialized seven-conductor cables plugged into receptacles on the aircraft fuselage. The number of receptacles is dependent on the aircraft size and diversity demands. Most commercial aircraft use only a single receptacle, but larger aircraft, such as the A380, use up to four receptacles. Airline-specific requirements often dictate the quantity of GPU receptacles assembled on an aircraft, which may result in differences in the number and configuration of the GPU receptacles on the same aircraft type among various airlines. Many regional jets require 28.5 volts direct current (DC) power supply at the gate. This type of power is supplied by equipment that either converts 60/50 Hz power to 28.5 volts DC or produces DC from an engine generator.

One of the main benefits associated with GPUs is the reduction in aircraft emissions, accomplished by allowing aircraft to shut down the APU engines while the aircraft is parked for cabin preparation, aircraft servicing, or maintenance. The FAA initiated the Voluntary Airport Low Emissions (VALE) Program in 2004, which includes gate electrification, to help airport operators pay for these low emission products.

GPU equipment can be categorized as mobile, stationary, or centralized.

Mobile GPUs

A mobile GPU is typically mounted on a trailer and can be moved among gates or to storage when not in use, as shown on Figure 3-29. These units are either plugged into an airport's traditional 60 Hz or 50 Hz electrical distribution system at dedicated receptacles or coupled with a diesel engine generator. The main advantage of a mobile GPU is that a single unit can be used

Source: Kimley-Horn and Associates, Inc.

Figure 3-29. Mobile ground power unit.

in various parking positions, making them popular for both cargo and terminal aprons, as well as RON aprons.

Engine generator mobile GPUs are technically usable in any location throughout the airport, but may be prohibited in certain locations because of noise restrictions. Similar to PCA units with engine generators, these GPUs can produce noise in the 80 dB range, which may be bothersome to passengers and detrimental to personnel working in the apron environment. Engine generator units may also be prohibited because of exhaust and combustibles associated with diesel engines.

Solid state frequency converters typically operate in the 60-65 dB range, which makes them more desirable in areas where passengers or apron workers are present. However, solid state or electric motor-generator units sacrifice flexibility because they are dependent on a connection to a 60/50 Hz power distribution system.

Trailer-mounted GPUs can occupy up to 40 square feet of apron space. Mobile units also introduce trip hazards caused by connections to the aircraft or the 60/50 Hz distribution line being strung along the apron to the point of connection.

Stationary/Bridge-Mounted GPUs

Stationary GPUs are installed on the apron or mounted to the underside of a PLB. GPUs installed on the apron are either hardwired into a traditional 60 Hz or 50 Hz electrical distribution system or coupled with a diesel engine, as shown on Figure 3-30.

A GPU mounted on a PLB is shown on Figure 3-31. This type of GPU is usually a solid state frequency converter and relies on a dedicated 60/50 Hz electrical distribution system. These GPUs and the electrical distribution system need to be sized to accommodate the largest aircraft that could reasonably park at the gate where the GPU is located. However, smaller aircraft that may not use a PLB and are parked further from the bridge-mounted or stationary GPU must also be considered. In these cases, longer aircraft cables may be needed. The main advantage of a bridge-mounted GPU over a mobile GPU is a reduction in equipment on the apron, which results in the increasing popularity of bridge-mounted units for gate areas.

Source: Ricondo & Associates, Inc.

Figure 3-30. Stationary ground power unit.

Source: Ricondo & Associates, Inc.

Figure 3-31. Bridge-mounted ground power unit.

Centralized Ground Power

Centralized ground power systems differ from mobile or stationary/bridge-mounted GPUs in that the power distribution to multiple gates is provided at 400 Hz rather than the traditional 60/50 Hz. Some centralized GPU systems use pop-up hatch pits or other underground distribution systems that reduce the amount of equipment on the apron compared with mobile or apron-mounted GPUs. The aircraft is connected to the receptacle in the hatch pit.

The benefit of a centralized ground power system is the reduction of equipment on the apron. Centralized systems present some challenges that mobile or stationary units do not, such as requiring specialized distribution equipment, large cooling demand, possible voltage decreases, and magnetic interference.

Potable Water System

Potable water supplied to aircraft for consumption is jointly regulated in the United States by the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and the FAA. As a World Health Organization member, the United States supports international guidelines on aircraft drinking water to comply with international health regulations. The underlying focus of these regulations is the provision of hygienic water for public consumption onboard aircraft. The cleanliness of the water is regulated to prevent the transfer of disease and illness.

The main elements of a potable water system affecting aircraft aprons include water source location, connection to the public water system, underground routing of utilities, utility location relative to aircraft and aircraft main gear, water transfer equipment, and GSE access/operation. The source of aircraft potable water is generally a public water system, controlled by the airport operator. All water source connections are required to be an approved FDA watering point. Several types of water transfer equipment can be used to transport potable water intended for consumption onboard aircraft. Water transfer equipment consists of trucks, carts, and water cabinets. The type of water transfer equipment used depends on the aircraft's relative location to the watering point, aircraft water capacity, availability at an airport, and airline/FBO ground handling procedures.

Transfer Vehicles

Several types of vehicles are used by airlines and ground support providers to transfer potable water from an approved watering point to an aircraft. The type and size of each transfer vehicle is based on the aircraft being serviced, as well as provider preferences. Vehicles used include small hand carts (low capacities of 20 to 50 gallons), towable tanks and carts (capacities of 50 to 300 gallons), truck bed-mounted tanks (capacities of 200 to 300 gallons), and self-propelled vehicles (capacities of 200 to 500 gallons). Figure 3-32 shows a potable water tank trailer.

Tank transfer vehicles are routed to the approved public water system watering point for supply filling. Tanks are then staged at the aircraft gate location in accordance with each airline's operational access plan. Towed or self-propelled vehicles access the aircraft at the potable water access panel. The access location varies based on the aircraft type, but is typically located on the belly of the fuselage at the wings or tail. Safe ground handling requires consideration of the height of the transfer/tow vehicle operating near aircraft.

Water Cabinets

A potable water cabinet is connected to a public water system and is an approved FDA water source. Water cabinets are either mounted to a building, mounted on the apron, or mounted onto a PLB. The cabinet is typically insulated to prevent the water from overheating or freezing. The cabinet contains a pump system, pressure regulation, backflow prevention, and system shut off and drainage. Water is transferred via a hose and reel system, which are required to meet FDA requirements.

As shown on Figure 3-33, water cabinets are typically mounted a few feet off the ground and located near the PLB or at the head of the parking position. The location of potable water service connection on an aircraft varies, but is typically located on the underside of the aircraft near the front or tail of the aircraft. An aircraft may have more than one potable water service connection.

Aircraft Fueling Systems

Aviation fueling includes many different components, distribution methods, categories, and fuel grades. The number one concern regarding any fueling system and operation is fire protection. Aircraft fuel is distributed by fuel trucks, hydrant fueling system, or self-service direct from a stationary fuel tank.

Source: Ricondo & Associates, Inc.

Figure 3-32. Potable water tank trailer.

Source: Ricondo & Associates, Inc.

Figure 3-33. Potable water cabinet.

Fuel tanks are generally located in the wings of an aircraft. Aircraft refueling is through gravity feed ports on the top of each wing or through a pressure connection port generally located at or under the wing edge. Many aircraft have fuel tank vents on top of each wing tip, which is considered a potential fuel spill point. Although many different grades of aviation fuel are used worldwide, two main types are used commercially, jet fuel and aviation gasoline (avgas). Jet fuel used at commercial service airports is usually type Jet A or Jet A-1. General aviation aircraft typically use avgas that is 100 octane, low lead (100LL) or Jet A. In addition, airports with military aircraft activity may provide military grade fuels, which are similar to commercial jet fuels and are commonly identified as JP-4, JP-5, and JP-8. The FAA allows passengers to be onboard an aircraft during fueling, but requires supervision and protection of passengers during fueling.

Fuel Trucks

Fuel trucks are specially designed with a fuel tank to transport fuel to and from aircraft, as shown on Figure 3-34. These trucks range in capacity, with avgas trucks typically having a capacity of 1,000 gallons. Jet fuel trucks have capacity to serve aircraft of different sizes, ranging between 3,000 gallons and 17,500 gallons. Fuel trucks refuel an aircraft by parking next to an aircraft fuel port. After the truck is secured, it is grounded to the aircraft by connecting a wire (to prevent sparks during refueling caused by static electricity), a fuel hose is coupled to the aircraft, and fuel is then pumped into the aircraft. After the correct amount of fuel is pumped into the

Source: Kimley-Horn & Associates, Inc.

Figure 3-34. Fuel truck.

aircraft, the hose is disconnected and reeled back onto the truck. Fuel trucks are refilled at stations that are connected to an airport's fuel tanks or fuel farm. Given the large size of these trucks, a large area of the apron adjacent to the aircraft wings must be vacated to accommodate the trucks. Fuel trucks are often used at airports with small aircraft or low activity and at older facilities where it is not economically feasible to install a hydrant fueling system in existing apron areas.

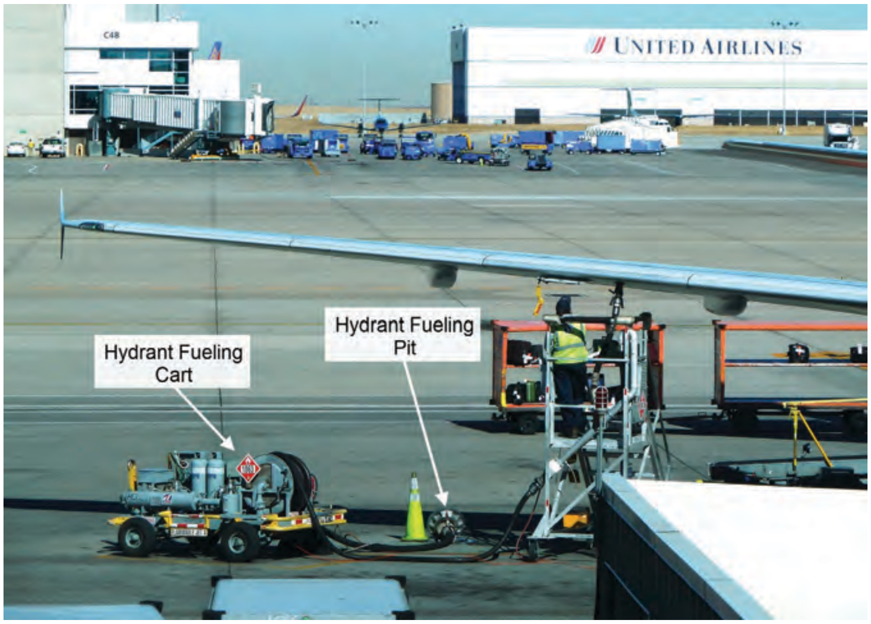
Hydrant Fueling System

Hydrant fueling systems consist of in-ground piping from airport fuel farm tanks to aircraft gate locations. System elements include looped distribution piping, hydrant fuel pits, high point vent pit assemblies, isolation valves, emergency shutoff valves, and low point drainage pits.

As shown on Figure 3-35, a hydrant fueling cart is used to transfer fuel from a hydrant fueling system to an aircraft. Hydrant fuel pits are located near the fuel ports of aircraft parked at a gate. The vehicles or carts are positioned near the in-ground hydrant pit and connected to the aircraft fuel tank port via a pressure coupling system. Once the hydrant fueling system is connected to the cart and grounded, fuel is transferred to the aircraft from the in-ground piping system. Most aircraft fueling systems allow fuel to be transferred to all tanks on the aircraft so that the aircraft can be fueled through a single fuel port, even though a second fuel port may be available. A fuel pit system is equipped with a hose and reel and is contained under the apron. This hose is attached to the hydrant fueling cart in fueling the aircraft.

Self-Service Fueling

Self-service aircraft fueling is typically available at general aviation airports with limited FBO services. The fuel is dispensed into the aircraft by an individual other than an FBO or fuel service operator. A self-service storage tank is a self-contained unit that is generally located at the edge of an aircraft parking apron, as shown on Figure 3-36. A separate taxilane with OFA clearances is often provided for aircraft access to the fueling location. Self-serve fueling is most commonly available for avgas. Given the relatively small amounts of fuel dispensed as avgas, self-fueling facilities limit the number of fueling staff and reduce vehicular traffic on general aviation aprons.



Source: Ricondo & Associates, Inc.

Figure 3-35. Hydrant fueling cart.

Sources: Ricondo & Associates, Inc.; Google Earth Pro.

Figure 3-36. Self-service aircraft fueling facility at Centennial Airport, Englewood, Colorado.

Other Aircraft Servicing Vehicles

In addition to the apron equipment discussed above, FBOs, airlines, airline contractors and service providers, and the military may use additional equipment to assist with the servicing and operation of aircraft. These additional aircraft servicing vehicles include lavatory servicing vehicles and carts, cabin/galley/catering vehicles, air start vehicles and carts, mobile stairs, and aircraft maintenance vehicles.

Lavatory Servicing Vehicles and Carts

Lavatory servicing vehicles are used to empty waste from lavatories and refill the flush/fill tanks onboard aircraft. These vehicles are either small carts that can be towed behind other vehicles or powered vehicles that can be the size of large pickup trucks, as shown on Figure 3-37.

Source: Ricondo & Associates, Inc.

Figure 3-37. Lavatory servicing vehicle.

These vehicles or carts are equipped with waste tanks for storing the waste removed from aircraft lavatories and separate tanks to refill the flush/fill tanks onboard the aircraft with "blue water." These tanks, depending on the size of vehicle or cart and the type of aircraft being serviced, can range in size from a few gallons to hundreds of gallons. Hoses are used to connect the waste and fill tanks to the aircraft's lavatory servicing ports, which are located along the bottom or sides of the aircraft fuselage. These vehicles are not aircraft specific and can generally be used to service multiple aircraft types.

Lavatory servicing trucks dispose of the collected aircraft waste at a triturator facility, typically located in general proximity to the terminal/gate area. A triturator is a sanitary sewage facility equipped to accept, hold, and pulverize aircraft waste prior to its discharge into the sanitary sewer system for eventual wastewater treatment. The facility is typically covered and includes measures to minimize the potential for sanitary waste to reach the storm water system.

Cabin/Galley/Catering Vehicles

Cabin/galley/catering vehicles are used to service the cabins of passenger aircraft, which may include cleaning the cabin environment, emptying and restocking the onboard kitchens (galleys), and delivering other goods or catering supplies to aircraft. Vehicle size generally depends on the aircraft type being serviced; however, small corporate aircraft are serviced by small trucks, and air carrier aircraft are generally serviced by large box-type trucks equipped with scissor lifts, allowing the rear portion of the servicing truck to be raised to cabin height, as shown on Figure 3-38.

Source: Ricondo & Associates, Inc.

Figure 3-38. Cabin servicing vehicle.

The servicing crew can then use the additional doors on aircraft (generally opposite the enplaning door or in the rear of the aircraft) to enter and exit directly into the galley/cabin without interfering with passenger enplaning or deplaning processes. Because of the ability to raise and lower the servicing vehicle height, these servicing vehicles are not generally aircraft specific and can be used to service a range of aircraft types. Cabin servicing vehicles are also used to remove garbage from aircraft. Local and state health and agriculture codes may require garbage to be disposed of properly or incinerated.

Air Start Vehicles and Carts

Air start vehicles are used to generate high-velocity air for starting aircraft jet engines. Air start vehicles, commonly known as "start carts," are usually small- to medium-sized carts that are towed behind other vehicles.

While the engines of most civil aircraft now in service can be started using onboard power and air, external assistance from the start cart may sometimes be necessary, such as when an aircraft's APU is out of service. When a start cart is necessary to assist in starting an aircraft, it is positioned near the aircraft (generally near an engine). Start carts contain either a piston or turbine engine, which produces high-velocity air that is then delivered via hose to the aircraft to spool up the jet engine, beginning the starting process.

Mobile Stairs

Mobile stairs are used to enplane and deplane passengers from aircraft when jet bridges or onboard stairs (or air stairs) are not available or may be inconvenient to use. Additionally, mobile stairs are commonly available at remote hardstands, and cargo and maintenance aprons where no other enplaning facilities are available. As shown on Figure 3-39, mobile stairs can vary from a simple metal staircase with wheels to covered telescoping stairs mounted on vehicles. Simple mobile stairs that are fixed in height are generally aircraft specific, as they cannot be adjusted to reach the varying door levels of multiple aircraft types. More complex mobile stairs can be adjusted in height, allowing a single staircase to serve multiple aircraft types. When the use of mobile stairs is necessary to access parked aircraft, the stairs are rolled or driven into position near an aircraft door and locked into place to prohibit movement, thus allowing passengers to enplane and deplane at the apron level.

Source: Ricondo & Associates, Inc.

Figure 3-39. Mobile stairs.

Aircraft Maintenance Vehicles

Aircraft maintenance vehicles are used to transport aircraft mechanics and their tools to parked aircraft for servicing. Aircraft maintenance vehicles can vary from simple pickup trucks to large box trucks and vans. Typically these vehicles, which move between aircraft maintenance facilities and parked (or disabled) aircraft, use signed and marked access and service roads.

Baggage Vehicles

Different types of baggage vehicles are used to load, unload, and transport baggage between the terminal and aircraft. These vehicles generally include conveyor belt loaders, used to load and unload baggage from aircraft, and tugs pulling baggage cart trains, used to transport baggage between the terminal/baggage sortation facilities and the aircraft. Baggage is typically bundled into containers and loaded onto widebody aircraft. The equipment for loading and unloading containers is the same used for cargo.

Conveyor Belt Loaders

Conveyor belt loaders are used to transfer baggage to and from the apron level and the baggage compartment of an aircraft. Two common types of loader belts are used in the apron environment: induction belts that are rolled or towed into place and belts that are self-driven, as shown on Figure 3-40.

Both types of vehicles generally have a motor-driven conveyor belt mounted on a frame that allows the loading height to be adjusted to reach the varying heights of aircraft baggage doors. These belts/conveyors may be equipped with railings that rotate upward to prevent baggage from falling off the sides of the conveyor belt. To load or unload baggage from an aircraft, the induction belt operator positions the vehicle near the baggage compartment and raises the conveyor belt to the appropriate height. The conveyor belt can then be operated toward the aircraft, allowing baggage to travel into the baggage compartment from the apron level, or away from the aircraft, allowing baggage to travel to the apron level from the aircraft baggage compartment.

Tugs Pulling Baggage Cart Trains

Baggage carts and containers are used to deliver outbound baggage to the aircraft where it is placed on a belt loader that moves the bags up to the aircraft for loading. Similarly, arriving bags

Source: Ricondo & Associates, Inc.

Figure 3-40. Conveyor belt baggage loader.

Source: Ricondo & Associates, Inc.

Figure 3-41. Baggage vehicle and carts.

and bag containers are removed from the aircraft and transported to the terminal baggage claim devices or for sorting to a connecting flight. At airline hubs, bags are often "ramp transferred" from aircraft to aircraft without being taken to the terminal/baggage sortation facilities in order to meet minimum connection times, which increases apron vehicle activity as a result. Ramp-transferred bags are moved among aircraft using tugs and carts.

As shown on Figure 3-41, baggage tugs are generally the size of small tractors and pull trailers or carts in which the baggage is transported. The tugs are commonly used in conjunction with induction belts to load and unload aircraft. The most frequent uses of baggage tugs and carts are to transport baggage between aircraft and baggage claim facilities, and to transport baggage among aircraft for connecting flights. To aid in operational flexibility, the number or trailers or carts that the baggage vehicle tows can be adjusted according to need, with larger aircraft requiring more carts to accommodate larger passenger and baggage loads. Aircraft may be served by more than one cart train depending on the flight. Baggage handling personnel may load one cart train of baggage onto the aircraft and then pick up the last load of baggage shortly after the check-in deadline has passed. Similarly, upon aircraft arrival, baggage handlers may deliver an initial load of baggage to the assigned baggage claim device and drive back to the aircraft for a second load.

Baggage Handling System Induction on the Apron

Baggage handling systems can also incorporate induction belts on the apron. These systems contain input and/or output belts to move outbound baggage directly from the baggage system input to the gate and to move inbound baggage from the apron induction point to the baggage claim device or to another induction location in the terminal or concourse. Instead of driving tugs between an aircraft and baggage makeup facilities in a terminal area, baggage handlers only drive tugs between these baggage induction facilities and the aircraft, as shown in Figure 3-42. By incorporating baggage induction facilities, the amount of vehicle traffic is greatly reduced because the number of tug trains would be substantially reduced.

Other Baggage Equipment

It is not unusual for passengers to check carry-on baggage at the gate prior to boarding the aircraft, either because of a lack of available overhead bin space, dimensional limitations of the overhead bins, or requests by the airline gate crew. During aircraft ground loading, the airline ground crew often positions a baggage cart alongside the passenger walkways to collect bags as passengers head to the aircraft for boarding. In these instances passengers often carry their bags

Source: Google Earth Pro.

Figure 3-42. Baggage induction.

to the pre-positioned cart, which is ultimately rolled to the aircraft for loading once all passenger bags have been deposited. These carts are used to transmit the traditional carry-on bags to the aircraft prior to departure and to transmit the bags to passengers on the arriving aircraft upon deplaning. It is typical for arriving passengers to claim their gate-checked bags directly from the cart rather than at baggage claim facilities.

When loading bridges are used with regional jet or turboprop aircraft, passengers may leave their gate-checked bags at the end of the bridge near the entrance of the aircraft in the bridge cab. The bags are then manually lowered to the apron level using the bridge stairs, a bag elevator, or a bag slide located adjacent to the stairs. Some PLBs designed specifically for regional jets are equipped with a baggage cart on an enclosed elevator located at the entrance of the bridge, just outside of the terminal or concourse building. Passengers deposit gate-checked bags on the cart during the boarding process. This type of system is typically enclosed to maintain security and protection from weather conditions. Prior to aircraft departure, the cart is lowered and moved to the aircraft for baggage loading. Upon aircraft arrival, the cart is loaded by airline personnel and placed on the elevator where it is lifted to the loading bridge for passengers to access their arriving bags.

Cargo Loading

Various types of equipment are used to move cargo around an airport and to and from aircraft. Once departing cargo is positioned near the aircraft, cargo loading equipment is used to lift cargo containers or pallets into aircraft. In general, this equipment can be operated by FBOs, airlines, airline contractors, or freight forwarders, and consist of either vehicles or stationary equipment. Belly cargo is typically loaded and unloaded on the terminal apron, while the all-cargo airlines use dedicated cargo aprons for loading and unloading.

Vehicles

Cargo loading vehicles include, but are not limited to, tractors, forklift trucks, and cargo platforms. The tractors used to transport cargo cart trains are similar to those used to transport baggage. Belly cargo is typically transported in carts similar to baggage carts, while containerized cargo is placed on a cargo dolly. Cargo dollies are equipped with rollers, wheels, or ball bearings

Source: Ricondo & Associates, Inc.

Figure 3-43. Cargo transportation equipment.

that allow cargo containers to easily slide onto the dolly and then be locked into placed. Figure 3-43 illustrates different examples of cargo transportation equipment.

Forklift trucks range from non-powered hand trucks the size of a wagon to diesel-powered telescoping trucks capable of lifting thousands of pounds more than 15 feet. Cargo loaded by a forklift truck is typically positioned on a pallet, which is a flat transport structure that supports the cargo while it is being lifted by the truck's tines.

Narrowbody and widebody aircraft usually consist of a main deck and a lower deck, also known as the lower lobe. The main deck is typically larger than the lower deck and can accommodate a larger volume of cargo. The lower deck is usually separated into a forward and aft compartment by the wing structure, landing gear, and fuel tanks.

Cargo platforms consist of two movable platforms that can be raised and lowered to the level of an aircraft cargo hold, as shown on Figure 3-44. Cargo platforms are generally available in two sizes: (1) lower lobe/narrowbody loader and (2) main deck loader. Lower lobe/narrowbody platforms have the ability to load cargo onto the main and lower decks of a narrowbody aircraft and the lower deck of a widebody aircraft. Main deck loaders are more adaptable and can be used to load both upper and lower decks of narrowbody and widebody aircraft and typically can lift heavier loads than lower lobe/narrowbody loaders. Both types of cargo platforms have two separate areas that can be independently raised and lowered. Cargo containers are moved

Source: Ricondo & Associates, Inc.

Figure 3-44. Cargo platform.

onto the platform via integral rollers or belts. The platform is then raised or lowered to the desired height and the cargo is loaded or removed using the same roller system.

Stationary Equipment

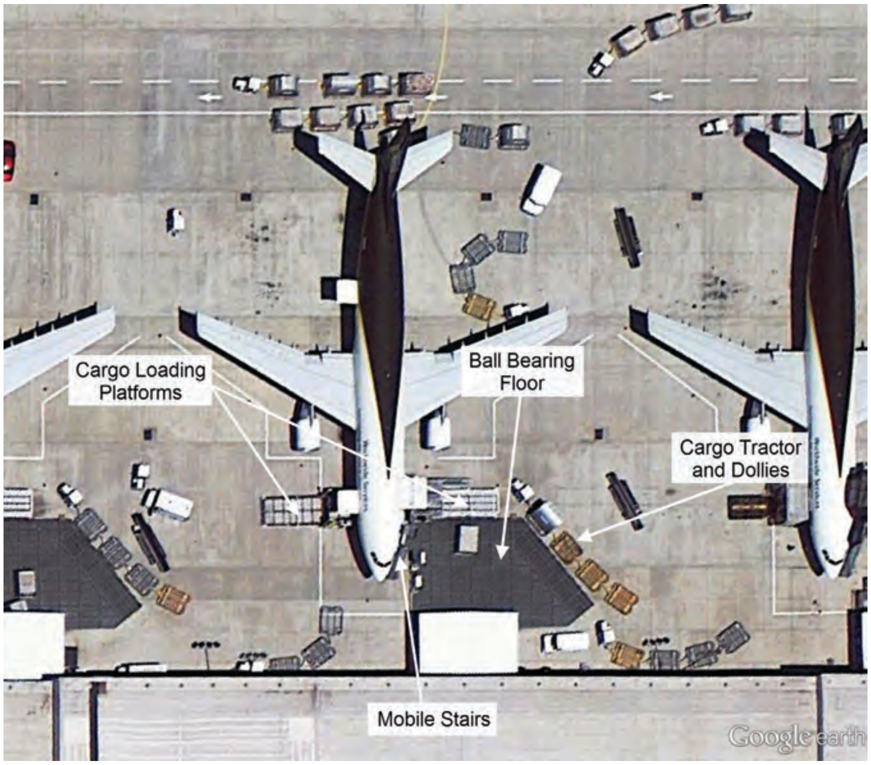
Stationary equipment includes semi-fixed cargo platforms, floors lined with ball bearings, and aircraft tilt prevention apparatuses, all necessary for the safe and timely loading of cargo onto aircraft.

Airports with express cargo operators may use semi-fixed dedicated cargo platforms for loading at each aircraft parking position. These cargo platforms can be moved forward or backward to match the aircraft door sill height. Often, the platforms are connected to a ball-bearing-covered area at the apron level, as shown on Figure 3-45. Cargo pallets and containers can be pushed across the ball-bearing-covered area by cargo handling personnel without the use of tugs or other equipment.

As cargo aircraft are loaded, they can become "tail heavy" (imbalanced as the result of more weight behind the main gear than in front of it), causing the aircraft to tip back on the main gear and rest on the tail of the aircraft. To prevent the aircraft from tipping, two types of tilt prevention apparatuses are used: tail stands and nose tethers. A tail stand is a pole or tripod that is temporarily positioned under the aircraft tail, preventing the tail from tipping down toward the apron; a nose tether anchors the nosewheel of an aircraft to fasteners mounted in the apron pavement. As nose tether anchors are built into the apron, their use reduces the amount of equipment on the cargo apron.

Aircraft Docking Systems

Aircraft docking systems provide visual cues to pilots parking aircraft. The cues aid pilots in remaining clear of obstructions and ensure that the aircraft stops in the correct position. Docking systems are most often used when aircraft docking precision is critical, such as in



Source: Google Earth Pro.

Figure 3-45. Stationary cargo equipment.

Source: Ricondo & Associates, Inc.

Figure 3-46. Aircraft docking system.

congested and constrained gate areas. The most advanced systems in use today have three three-dimensional scanning lasers to monitor aircraft position and provide visual feedback to the pilot via an electronic display mounted at the head of the stand. Prior to an aircraft entering the parking position, ground crew input the aircraft type to the docking system. The system then checks compatibility with the parking position, including the location of the PLB. As an aircraft begins to enter the parking position, the system alerts the pilot to the aircraft position relative to the lead-in line and stop bar. Figure 3-46 shows an aircraft docking system.

In addition to providing guidance for aircraft maneuvering, aircraft docking systems can be used to track and analyze gate use. Such information can be used to quickly determine which gates are occupied or available and to integrate various airline and airport information systems. Use of an aircraft docking guidance system can facilitate more precise aircraft movements in the apron/gate area and enhance the efficiency of apron use. These systems reduce dependence on wing walkers, which may allow gates to be used during adverse weather conditions when apron/airline personnel are evacuated from aprons (e.g., during lightning conditions).

Deicing Equipment

There are generally two categories of deicing equipment: mobile deicing vehicles and stationary equipment; mobile equipment is far more prevalent, particularly at U.S. airports. This equipment is described in the following subsections.

Mobile Deicing Vehicles

As shown on Figure 3-47, mobile deicing vehicles have maneuverable vertical booms, which are equipped with hoses that provide the ability to spray deicing solution on all critical parts of the aircraft. These vehicles typically have two heated tanks that contain different types of deicing fluid. Type I and Type IV deicing fluids are the most widely used. Type I deicing fluid (typically dyed orange) generally has a low viscosity and is heated and sprayed at higher pressures

Source: A.S.S.E.T., LLC.

Figure 3-47. Mobile deicing vehicles.

to remove snow and ice from aircraft. Type IV deicing fluid (typically dyed green) is used as an anti-icing agent, as it is more viscous and typically provides longer holdover times. Within their holdover time limits, these fluids protect the aircraft from snow and ice accumulation and frost formation until the aircraft reaches a specific speed at which the fluid shears off the surfaces of the aircraft. Both Type I and Type IV deicing fluids are diluted with water at concentrations that vary, depending on the outside air temperature, approximate holdover time, and precipitation (snow, drizzle, rain, fog) conditions. Many mobile deicing vehicles are equipped to apply forced air or a forced air/fluid mix to remove snow and ice contaminants from aircraft. During certain weather conditions, forced air can be used to remove snow and ice, which typically reduces the amount of deicing fluid required.

Mobile deicing vehicles vary in size. Vehicles used to service small general aviation and regional jets have fluid capacities of 200 to 500 gallons; larger widebody aircraft may require several deicing vehicles, with fluid capacities up to 2,200 gallons each.

Mobile deicing equipment is usually staged close to the deicing aprons (at terminal gates or deicing pads) to allow for the quick initiation of deicing operations when conditions warrant. During non-winter months, this equipment is often remotely parked or staged away from the terminal and deicing pads.

Fixed Fluid Applicators

As shown on Figure 3-48, fixed fluid applicators consist of telescopic booms mounted to a deicing pad. These applicators have an enclosed cab at the end from which deicing personnel can control the height and extension of the cab and the spray hoses. The spray hoses are connected to pumps and fluid tanks that control the dilution of the fluid. Although these applicators do not require refilling, their fixed nature may restrict the size of aircraft that can use the deicing pad. When fixed fluid applicators are used, aircraft taxi into predefined positions on the apron, stopping to allow the deicing operation to be completed before taxiing out of the deicing pad.

Tanks and Buildings

Deicing operations require storage tanks for deicing fluids and pumping stations to refill mobile deicing vehicles. Typically, these tanks and pumping stations are located adjacent to deicing pads or near the terminal areas if aircraft are deiced at gate positions. Vehicle refueling areas or fuel tanker trucks may also be located near deicing pads to allow for more efficient vehicle

Source: City and County of Denver, Department of Aviation.

Figure 3-48. Fixed fluid applicators.

refueling during deicing operations. In close proximity to many deicing pads, small buildings are available for coordinating and managing deicing operations and providing restrooms and break rooms for personnel.

Other Equipment

In addition to the equipment mentioned, several other aircraft support areas and GSE are often located on or near apron areas. These include GSE fueling islands and gas pumps; charging units for electric-powered vehicles; and waste-related containers, such as trash compactors, trash containers, and waste oil containers. All equipment placement requires consideration of convenient access for service and operation and adequate and safe separation from other apron functions and parked and maneuvering aircraft. In many cases, curbs or bollards are required for protection around fixed equipment in the apron environment.

Types of Airline Operations

Airlines typically operate their systems in one of two ways: hub-and-spoke, and point-to-point. Hub-and-spoke airlines utilize hub airports as passenger transfer points between flights from spoke airports or other hub airports in their network. Airports that operate as an airline hub typically have more activity (passengers and operations) than spoke airports. Spoke airports may serve one or more airline hub airports and accommodate lower activity levels, both overall and on an individual airline basis, than a hub airport.

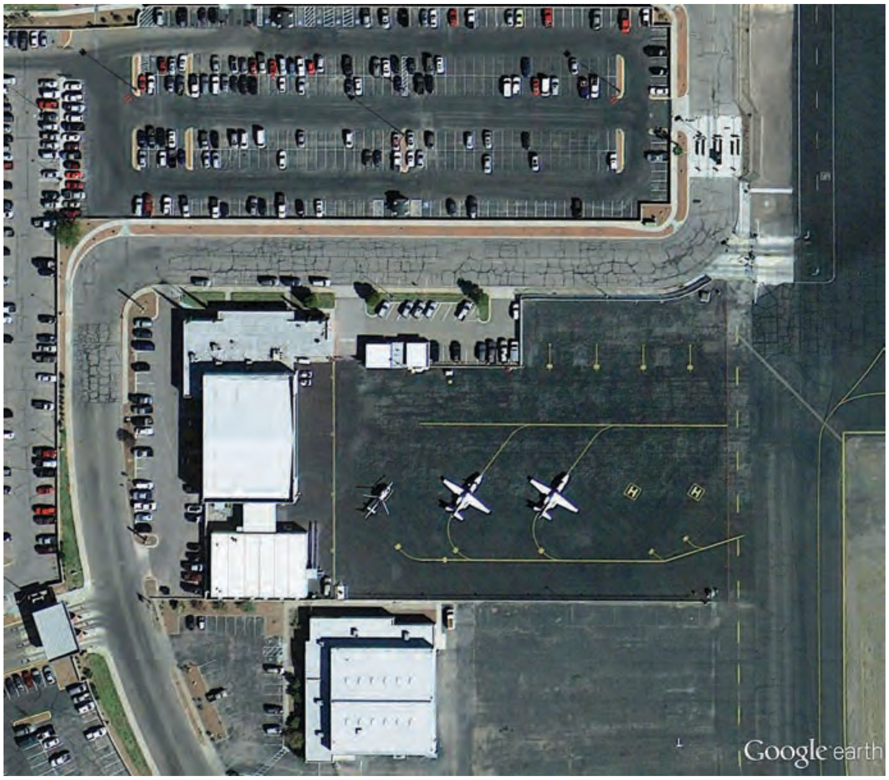
Point-to-point airlines transport passengers directly between city pairs rather than routing them through hub airports and generally operate with schedules similar to those of spoke airports, with activity occurring relatively evenly throughout the day.

Terminal aprons at airports with an airline hub tend to experience peak periods of demand during which nearly all gates and parking positions are occupied. During these peak periods of connecting operations, there is a commensurately high level of GSE activity, especially related to the movement of baggage tugs between aircraft and the terminal. The amount of GSE in use at hub airports is generally higher than at non-hub airports because of the peaking characteristics and the need to simultaneously serve many gates. At non-hub airports, aircraft activity typically occurs more evenly throughout the day.

International Arrivals

The CBP controls and processes passengers, baggage, and cargo on aircraft arriving from origins outside the United States, which require special consideration. Some of these aircraft arrivals affect apron markings and operations. Passengers on arriving international flights (from airports in countries that do not have preclearance agreements with the United States and that do not have CBP preclearance facilities) must be isolated within a sterile corridor system to prevent commingling with secure passengers in the terminal until they have been appropriately processed. If aircraft arrive at an airport's remote hardstand, secure transport to an isolated dock connected to a sterile corridor system is required. Additionally, to prevent the spread of agricultural or animal disease, all arriving international garbage must be incinerated or sterilized properly. Specialized vehicles or dumpsters may be required to ensure that the garbage is not commingled with garbage from domestic flights. Terminal aprons are usually equipped with closed-circuit television (CCTV) systems that allow CBP personnel to monitor passenger and baggage on aprons used for international arrivals.

General aviation facilities that accommodate arriving international passengers traditionally consist of a building adjacent to an apron, usually isolated from the terminal building and airfield, as shown on Figure 3-49. Aprons adjacent to CBP facilities often have multiple marked parking positions, including helicopter landing pads. These aprons often accommodate searches



Sources: Google Earth Pro; DigitalGlobe, 2013.

Figure 3-49. U.S. CBP general aviation facility.

of arriving aircraft and cargo. At airports with less activity, a portion of an apron may be identified for CBP use only. Alternatively, at airports where the CBP is not routinely staffed, arrangements for the aircraft to be met by CBP personnel can be made ahead of the arrival; however, the arriving aircraft and its passengers and cargo must remain isolated until the CBP inspection and processing are complete. At airports where this situation occurs, a dedicated apron position is often designated as a place for an arriving international aircraft to await CBP inspection and processing.

Additional Guidance

U.S. CBP, *Airport Technical Design Standards Passenger Processing Facilities*, August 2006.

Ground and Ramp Tower Control

At airports with an airport traffic control tower (ATCT), areas of the airport that support aircraft operations are categorized as either movement or nonmovement areas. In movement areas, aircraft are maneuvered under the direction of ATC ground control personnel working in an ATCT. An airport's runways and the taxiways serving those runways are typically classified as movement areas and are under the strict control of FAA ATC personnel.

In nonmovement areas, aircraft are moved at the discretion of the pilot, sometimes under the guidance of a ramp tower controller, if present. ATCT controllers do not control aircraft in nonmovement areas. Taxilanes and terminal and cargo aprons are typically classified as nonmovement areas. The location where responsibility for the safe movement of the aircraft transitions from the pilot in command of the aircraft to the controlling entity (ATC or ramp control) is referred to as a hand-off point. The location of hand-off points varies depending on the layout of aprons and access points to the airfield. Aprons directly adjacent to taxiway movement areas may be controlled by ATC and defined hand-off points may not be designated. The control of aprons and the locations of hand-off points for aircraft departing from aprons vary by airport and are influenced by apron configuration and local ATC preferences. Hand-off points can also function to meter aircraft awaiting departure at peak times to avoid creating airfield congestion due to the near simultaneous push-back of aircraft from multiple gates during the peak. Aprons in the terminal area or near runway ends may be used by ATC for metering aircraft for departure as aircraft are held on the apron until sequenced into the departure queue.

Control Towers

ATCTs are used by the FAA to house air traffic controllers with responsibility for the control of movement areas at airports. Ramp towers are used by airlines, airport personnel, or third-party operators to house ground traffic controllers with responsibility for controlling aircraft in nonmovement areas of an airport.

Generally, ramp towers are used at airports with higher levels of activity on the apron. As shown on Figure 3-50, ramp towers are often co-located with terminal, concourse, or cargo buildings to provide sufficient line-of-sight to non-movement areas in the vicinity of the associated building. Most ramp tower controllers are able to view the top of aircraft fuselages or, at a minimum, an aircraft tail in the areas under their control.

Surface Management Software

Surface management software is used by airport, airline, and ramp tower personnel to track aircraft using surveillance data from airport navigational aids and sensors located throughout an airport. The software often uses aircraft departure and arrival information to predict gate and parking position demand and to aid in ramp tower controller decision making. The software provides a visual map of aircraft movements and locations and can be enhanced with additional capabilities that support decision making related to managing apron traffic. For example, the

Source: Ricondo & Associates, Inc.

Figure 3-50. Ramp tower.

software can be used to reduce queues and delays at deicing pads by predicting demand and informing ramp controllers as to the optimal time to push back and taxi aircraft to the deicing pads.

Interface with Nonapron Areas

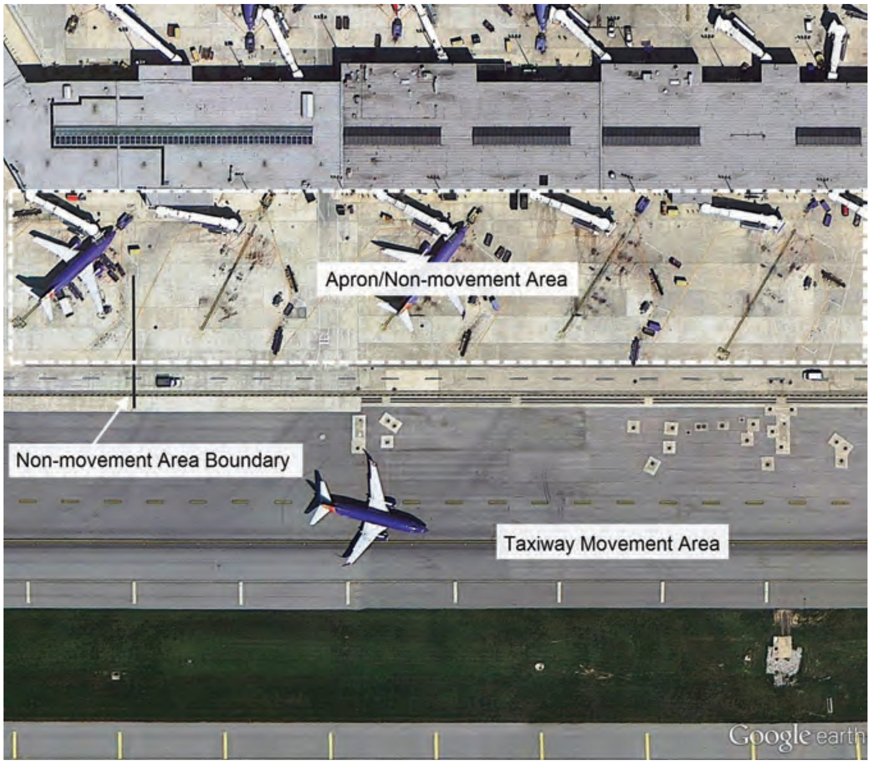
The FAA requires the accurate and clear definition of the interface between the nonmovement areas and the movement areas of an airport. As defined by the FAA Advisory Circular 150/5300-13A, the movement areas include “the runways, taxiways, and other areas of an airport which are used for taxiing or hover taxiing, air taxiing, takeoff, and landing of aircraft, exclusive of loading ramps and aircraft parking areas.” Many aprons are located within or near movement areas. The configuration of aprons and taxiways/taxilanes reflects the configuration of the terminal and airfield, especially the locations of runways.

At airports with an ATCT, the transition of aircraft from nonmovement areas to movement areas is controlled by FAA ATC. Figure 3-51 depicts a terminal apron located adjacent to a single taxiway as part of a movement area. In this apron configuration, the pilot must obtain permission to push back onto the taxiway. This type of apron configuration is the most operationally restricted and can cause delays because of the time needed to push the aircraft back, decouple the tug, and start up the aircraft. This delay may prevent other aircraft from passing through the area or from pushing back from adjacent gates.

Many terminal aprons are configured with push-back areas that allow aircraft to push back without blocking the movement of aircraft on taxiways or taxilanes, as shown on Figure 3-52. Aprons are also configured with either single or dual taxiways or taxilanes. Dual taxiway/taxilanes allow for more flexible operations, as one aircraft can pass another while being pushed back or taxiing in the opposite direction. Aprons configured with dual taxiways/taxilanes often use one taxiway/taxilane as a push-back area, while using the other for the directional movement of aircraft taxiing through the area. An apron with both dual taxiways/taxilanes and push-back areas provides the greatest operational flexibility, but requires the most pavement area.

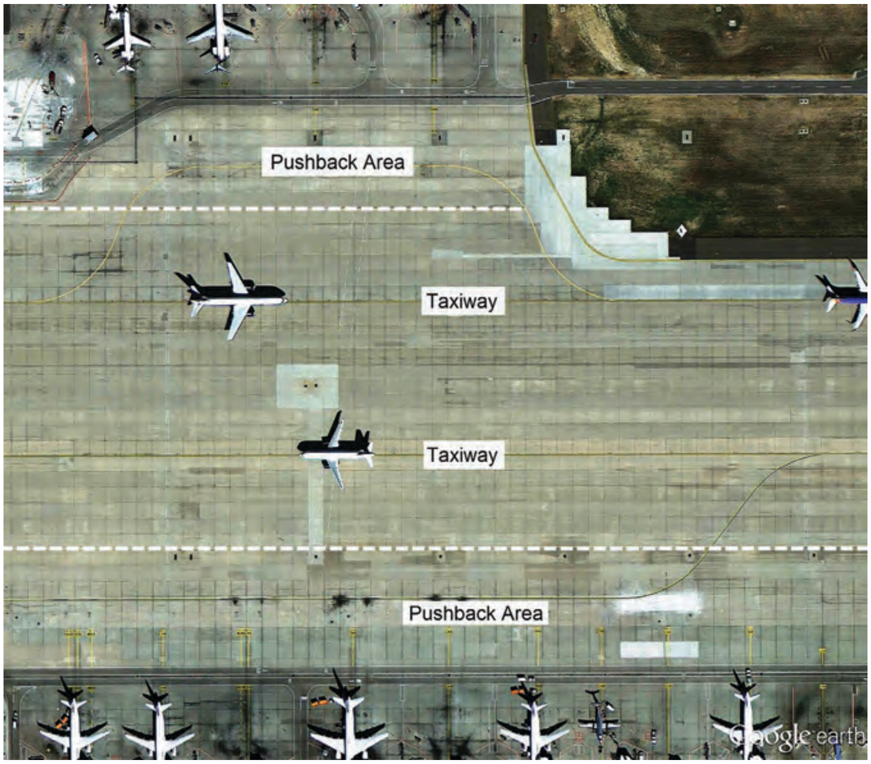
Security

Safety and security are two of the most important aspects of operations at any airport. Airport security is very detailed, complicated, and comprehensive, with procedures, rules, and requirements that are continually evolving and changing. Each airport is unique in terms of size, location, and layout. A portion of security relates to protection of the terminal core and apron area.



Source: Google Earth Pro.

Figure 3-51. Apron adjacent to movement area.



Source: Google Earth Pro.

Figure 3-52. Apron with push-back area.

Security of apron is largely controlled by ensuring that only authorized individuals or vehicles are provided access through security gates at the edges of the air operations area (AOA) or in terminal or cargo buildings. Beyond this, security on aprons is largely the responsibility of apron personnel and security personnel monitoring the apron environment. Badged personnel at most airports are required to challenge individuals not displaying proper security badges and to report any suspicious or unusual behavior. Access to aprons is provided through security gates at the edges of the AOA or in terminal 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 CCTV to provide views of aprons to security personnel. Coordination with the TSA is recommended to ensure that apron planning and design do not introduce security weaknesses or vulnerabilities.

Additional Guidance

Transportation Security Administration, *Security Guidelines for General Aviation Airports,* May 2004.

Transportation Security Administration, *Recommended Security Guidelines for Airport Planning, Design and Construction,* May 2011.

Snow Removal and Prevention

Snow removal is a complex operation that must be managed by airport operators to ensure a safe operating environment. This is especially true for apron areas that are typically expansive and require the removal of large volumes of snow. The variables and dynamics of a snow storm can change the means and methods of snow removal from one day to the next. For this reason, a fleet of different types of snow removal equipment is usually available to handle a variety of weather scenarios.

Airports differ in responsibility for apron snow removal operations. General aviation and small hub airports may rely solely on airport maintenance personnel for all snow removal, while the operators of medium to large hub airports may contract apron and hold pad snow removal operations to a third party. In most cases, lease agreements between airlines and airport operators clearly identify each party's responsibilities. At medium to large hub airports, agreements may designate responsibility for the removal of snow within leased areas to the leasing airline, with airport personnel or third-party contractors responsible for snow removal outside of the leased areas.

Snow removal on aprons, especially on terminal aprons, is challenging given the presence of aircraft, the amount of equipment in the apron environment, and reduced visibility during snow storms. Depending on the timing of the snow storm event, snow removal may occur during aircraft loading, unloading, and servicing. GSE is usually required to be relocated out of the way, if not in use, to allow effective snow removal operations.

Snow Removal Vehicles

Terminal aprons are usually cleared by vehicles with snow plow attachments or brushes, as shown in Figure 3-53a. The snow is pushed to a designated location, usually the end of the aircraft parking area or a closed gate. Larger snow plows or front end loaders (Figure 3-53b) are used to remove the snow from these locations to stockpiles or snow melters. Aprons outside of the terminal area are usually cleared of snow by airport staff or contractors that use snow removal equipment similar to that used on taxiways and runways.

Small trucks used for snow removal are often parked on the terminal apron while larger snow removal vehicles are staged at facilities located away from the terminal because of their size and the relative infrequency of use.

Haul Routes and Stockpile Areas

In most instances, snow removal vehicles operate on existing service or access roads to either enter or exit the apron area to access snow stockpiling areas. During heavy snow conditions, alternative routes may be necessary as primary routes can become impassable. Safety during

(a)

(b)

Source: Ricondo & Associates, Inc.

Figure 3-53. Snow removal vehicles.

snow removal operations greatly increases when snow removal vehicles can be kept away from the tails of aircraft and avoid aircraft pulling in or departing from a gate or the effects of jet blast from taxiing aircraft.

Apron size and location must be considered for snow stockpiling. Smaller airports usually have stockpile locations of 1,000 square feet to 2,000 square feet, while larger airports may need several areas up to several thousand square feet for adequate snow stockpiling, as shown on Figure 3-54.

Snow Melting

Snow melting at airports has been occurring for many years. Melting operations allow for the fast and effective removal of snow from apron and other areas of the airport with minimal disruption to aircraft or airline operations. Snow melting equipment is placed near snow piles and one or two front end loaders are used to load the snow melters.

Many benefits are associated with snow melting rather than trucking snow from the apron areas. Melting reduces the need for large numbers of trucks to move snow and also reduces the need to stage or park trucks. There are two types of melters: stationary and mobile.

Source: A.S.S.E.T., LLC.

Figure 3-54. Snow stockpile.

Stationary melters are permanent units installed in the apron. These units are limited because they cannot be moved and snow must be pushed to the location of the melter. The current maximum capacity for a stationary snow melter is approximately 350 tons of melted snow per hour.

Mobile melters are built into trailers that can be pulled around the airport by semi-trailer trucks, as shown on Figure 3-55. Mobile melters must be operated near sufficiently sized drains to accept the melted snow runoff. The melters provide more mobility and operational flexibility as they can be easily moved where needed. Mobile melters have a higher snow melting capacity, typically up to 500 tons per hour.

Heated Pavement

Heated pavement, while not a new concept, has mainly been used in private and residential applications. Heated pavement aids in the prevention of snow/ice accumulation without mechanical or chemical actions. It can have the benefit of reducing the amount of vehicular activity during adverse weather conditions. The heated pavement system may incorporate a "sandwich" method of construction, with the electrically conductive asphalt insulated between

Source: A.S.S.E.T., LLC.

Figure 3-55. Mobile snow melter.

layers of pavement. As current passes through the conductive layer, heat is generated to a cycled temperature of approximately 34°F, melting the surface snow. The system may also incorporate tubes or pipes in the pavement, wherein a heated fluid is pumped through the system. Heat for the system can come from traditional heat sources or a geothermal heat pump that uses heat from the ground. Both systems typically involve a complex installation process and require high initial costs, although these costs may be offset by a reduction in personnel needed to mechanically clear snow with plows and sweepers. The benefits of these systems include a reduction in the use of chemical deicers and a reduction in the time required to remove snow from priority areas.

Additional Guidance

FAA Advisory Circular 150/5370-17, *Airside Use of Heated Pavement Systems,* March 29, 2011.

While the construction of large expanses of heated pavement for aircraft aprons has not occurred, smaller-scale applications, in which limited sections of heated pavement are used for apron walkways, have been proposed. The loading and unloading of passengers in the apron area can contribute to hazardous conditions during snow events. The benefits of heated pavements in walkway areas are that they tend to stay free of snow/ice accumulation for longer periods during snow/ice events.

Pavement Deicing Products

At many airports, pavement deicing products are used on runways, taxiways, and aprons. These chemical products help mitigate snow and ice formation and accumulation on pavements. Common pavement deicing products used on airfield pavement include urea, sodium formate, sodium acetate, potassium acetate, and propylene and ethylene glycol-based fluids. In selecting pavement deicing products, consideration must be given to the compatibility and acceptability of the use of these chemicals in the vicinity of aircraft and airfield equipment, given concerns with potential corrosion and adverse environmental impacts.

FAA Advisory Circular 150/5200-30C, *Airport Winter Safety and Operations,* December 9, 2008.

Automated spray deicing systems have been used by highway departments for many years as a self-contained and fully automated means of deicing bridge decks in remote locations. Limited testing for airfield use has not yielded sufficient benefits to warrant larger-scale installation in the apron or airfield environment.

CHAPTER 4

Apron Planning and Design

This chapter provides guidance on apron planning, design implications, and related regulations/guidance for various types of airport aprons. The guidance provided incorporates standards and guidance promulgated by the FAA and other industry organizations and sources, as well as apron planning and design best practices. These best practices are not intended to standardize apron facilities at all airports, but to provide planners and designers with guidance that encourages the use of solid professional judgment in planning and designing apron facilities to maintain a safe, secure, and efficient operating environment, while also recognizing the need for flexibility, given the inherently dynamic nature of the aviation industry. This chapter is divided into three sections: planning; design implications and considerations; and related regulations and guidance.

Planning

Planning Considerations

Apron planning requires an understanding of the operations and priorities of the primary users of the apron facilities, as well as the way these facilities interface with the overall airport. Airport operators, airlines, tenants, users, and aircraft servicing companies all operate in apron areas. In terms of apron use and operation, various stakeholders have differing needs and priorities that need to be considered in planning these airport components, including functional apron capacity, operational efficiency, flexibility, operational factors, and site constraints.

Functional Apron Capacity

Apron capacity is typically determined by the number of aircraft that simultaneously can be positioned on the apron and appropriately serviced. However, functional capacity can be characterized and assessed in multiple ways. For example, airline and cargo apron users assess functional capacity in terms of the capability of the area to support the intended aircraft fleet, both in number and size, as well as the storage of GSE necessary to service those aircraft. Airlines consider their planned or projected schedule of aircraft activity (including the fleet mix) in assessing the capacity of the apron and gate area to ensure that peak demand can be accommodated. Peaks in demand often vary over the course of a day or night, particularly when aprons accommodate a diverse aircraft fleet over the time period. Examples of activity during demand peaks that may require specific assessment include narrowbody aircraft parking, widebody aircraft parking, international aircraft parking, and overnight aircraft parking.

Airport operators assess functional apron capacity in the context of the capability of the apron area to accommodate irregular operations, new users or tenants, or aircraft that are larger than those that were anticipated to be accommodated on the apron. Current aviation demand is relatively easy to quantify, but future aviation demand is more difficult to clearly determine.

It is prudent to coordinate with the airport operator to assess whether there are known or desired air service changes that could result in a change in the fleet over time. If not considered, it is possible that apron and adjacent taxiway/taxilane facilities would limit the ability to efficiently and safely accommodate larger aircraft, which could introduce a barrier to effective increases in air service. While this is challenging to predict, an airport's master plan provides insight into potential fleet growth. An airport operator can often enhance this insight with more specific air service marketing plans or analyses.

Irregular operations associated with weather events that ground aircraft or special events (air shows, major community events, such as sporting events or conventions, etc.) that may result in extreme peaks in demand for apron parking should be considered in assessing functional apron capacity.

Key Points:

- Understand the current and future aircraft fleet and related and potential air service demands.
- Understand current and forecast schedule fluctuations and peaks over the course of the day/night.
- Define potential irregular operations (qualitatively and/or quantitatively).

Operational Efficiency

Operational efficiency, which is a measure of how effectively an apron area supports day-to-day aircraft operations, influences the planning of apron facilities. The primary measure of operational efficiency is the degree to which aircraft parking and servicing demands can be met without creating dependencies in aircraft parking or maneuvering and without compromising operational safety. Independent aircraft parking is achieved when aircraft approaching or departing from a parking position can enter or exit that position at all times without depending on the exit or repositioning of another aircraft or other equipment on the apron. Dependent aircraft parking typically provides for increased size, type, or number of aircraft that can be accommodated within a specific apron area; however, dependencies among parked aircraft or servicing equipment are created to achieve this increase. The provision of increased parking capability compromises operational efficiency by constraining GSE access to parked aircraft, limiting the ability of aircraft to operate independently, and, in some cases, restricting aircraft access to certain areas of the apron.

Operational efficiency is also a function of aircraft taxiing flows to and from an apron. Efficiency is maximized with minimal conflict in taxiing flows (intersecting taxiing routes or bidirectional flow on a single taxiing route) to, from, and within an apron. Taxiing conflicts require aircraft to slow or stop to safely accommodate other taxiing aircraft, potentially resulting in congestion and queuing; obstruction of adjacent gates/aprons; and reduced apron efficiency. Where sufficient space exists, incorporation of dual taxiways/taxilanes or push-back areas within or adjacent to aprons provides bypass capability that minimizes taxiing conflicts and delays. Separating taxiing routes and GSE routes through dedicated vehicle service roads enhances the safety of both operations and minimizes compromises in operational efficiency.

Aircraft servicing requirements, determined in part as a function of the size and type of the aircraft, can involve a significant amount of GSE. Defining an apron layout that facilitates efficient aircraft servicing is critical for airline, cargo, and general aviation activities as the efficiency, or inefficiency, of the apron layout can affect schedule integrity, leading to flight delays. Sufficient space is necessary to maintain the efficiency of aircraft servicing by allowing unimpeded and independent GSE access to the aircraft. GSE should be able to approach an aircraft from both sides, and be positioned on all sides during servicing.

Key Points:

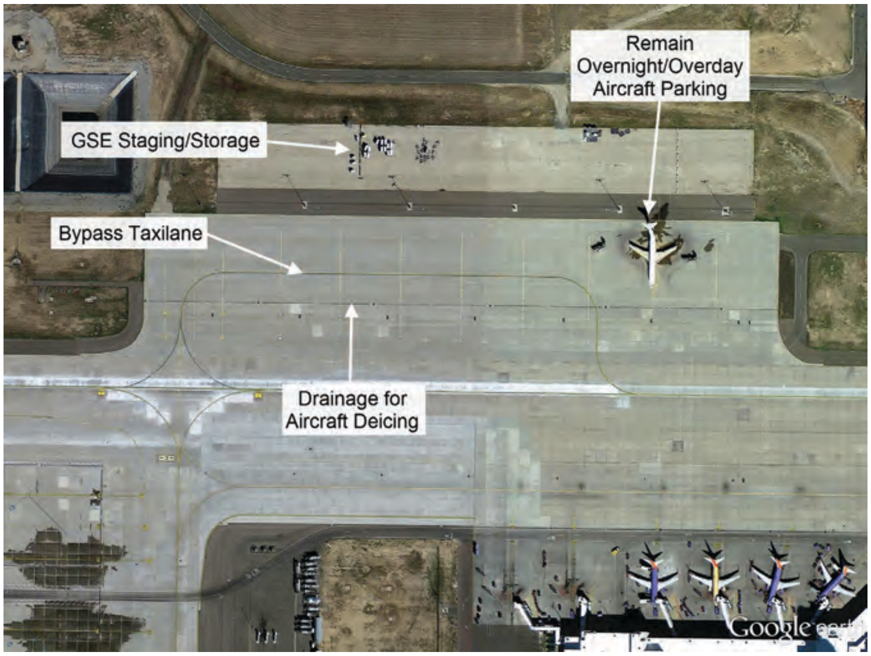
- Conceptualize aircraft access and circulation routes within and adjacent to the apron.
- If available space or operational factors are limiting, consider whether creating dependencies in parking or servicing would provide for the achievement of objectives. If so, assess the consequences to determine acceptability.
- In some cases, compromises in operational efficiency may be acceptable in order to accommodate apron demand.

Flexibility

Recognizing that aircraft fleets are not static and that equipment continues to evolve dimensionally, operationally and technologically, the flexibility of an apron is critical to accommodating short-term and long-term aircraft parking demand. Additionally, the way that airport operators use aprons can change to reflect changing operational characteristics (hourly peak activity, hubbing operations, deicing, overnight parking, temporary aircraft staging, etc.), particularly compared to the characteristics that were current when the aprons were originally planned/designed. To maximize the capability of an apron and gate area to accommodate changes in equipment, flexibility must be prioritized throughout the planning process.

In addition to the evolution of aircraft fleets, airlines/tenants operating at a specific terminal can change, resulting in tenants with significantly different fleets or characteristics operating on aprons originally planned and designed with different user parameters. Similarly, an airline's schedule at an airport or specific terminal may increase over time, requiring more flexible and intensive use of the apron area if additional terminal space or facility expansion is not possible.

It is also judicious to ensure that aprons can be used for multiple purposes. As shown on Figure 4-1, an apron that is primarily used for RON aircraft parking is typically equipped with a storm



Source: Google Earth Pro.

Figure 4-1. Flexible apron layout.

water collection system and can be used for deicing operations. Taxilane markings on the apron also allow it to be used as a bypass taxilane if operational demand warrants. Also, multiple aircraft parking lead-in lines allow the apron to be used to accommodate a diverse aircraft fleet, while an adjacent pavement area provides storage for GSE. Incorporating flexibility into apron planning is a best practice that benefits airport operators and users by allowing facilities to be used not only for their primary purpose, but also to accommodate irregular operations, special events, and other secondary purposes, thereby maximizing the benefits associated with the capital investment in the apron.

Key Points:

- Understand the potential for aircraft fleet evolution to affect apron layout/design.
- Prioritize apron flexibility to maximize its short-term capabilities and preserve its long-term usefulness.
- Consider potential expansion opportunities when assessing apron flexibility.

Operational Factors

Operational factors reflect the unique environment of each airport. Examples of operational factors that influence apron planning include the type(s) of operation (airline hubbing/connecting, origin/destination, international/domestic), aircraft turnaround times, aircraft fleets, common/preferential/exclusive use leases with tenants, maintenance, cargo handling, deicing activities, general aviation aircraft fleets, and the like.

Overall airport operational characteristics (airline, cargo, general aviation), both historical and forecast, must be reviewed during the planning process since it is possible to plan an apron facility that will have a different operating environment than that historically experienced at the airport. Activity characteristics also dictate the operational environment. Total airport activity, in concert with the peaking dynamics of that activity, will impose specific demands on apron facilities and must be addressed in the planning process. Planners must also understand any unique operations that may occur on the apron. This is especially important for general aviation apron planning given the wide variety of aircraft types and operations categorized as general aviation.

The type of leasehold agreement can also affect utilization of a gate or apron parking position. The level of apron utilization with exclusive-use agreements is largely dependent on the leasing airline since they typically have a sole right to use and occupy. Preferential-use and common-use agreements usually result in higher average apron/gate utilization since the facilities can be used by multiple airlines on a dynamic basis. As a means of increasing overall apron utilization, many airport operators require exclusive use lessees to conduct a minimum number of aircraft turns per gate on a daily basis in order to maintain the exclusivity of subject gates. In planning new or expanded apron facilities, coordination with the airport operator is recommended to assess whether there are anticipated or pending changes in lease and use agreements that could influence the operation of gates/apron areas.

Key Points:

- Identify the various types of airline operations for the apron design.
- Identify the key users of the apron area.
- Understand whether leasehold agreements are a current factor in planning/designing apron facilities. Consider potential changes in leasehold agreements, particularly if current agreements will expire in the near future.

Site Constraints

Understanding the specific site constraints at a particular airport is crucial in planning an effective apron. Site constraints include both physical and operational conditions at an airport, such as the adjacent airfield layout; established aircraft ground flow operating configurations (particularly related to aircraft routing to and from the apron); existing facilities and infrastructure; critical aeronautical surfaces and clearance areas; and environmental considerations, such as state and local codes, laws, and noise agreements, and environmental features, such as adjacent waterways, wetlands, and protected habitats.

Key Points:

- Define known or potential physical, operational, and environmental site constraints at the start of the apron planning process.
- In some cases, it may be possible to mitigate particular site constraints if doing so can be justified in the apron planning/design process.

Apron Demand

Different methods of determining apron demand are used when planning is focused on a new apron or expanding/modifying or reconfiguring/repurposing an existing apron. During most apron planning projects, ways to accommodate incremental growth in demand or activity are identified. Apron planning often requires determining aircraft demand for a specific-use apron, or the increment of capacity necessary to accommodate overall demand after considering existing apron capacity. The level of detail necessary for apron planning is largely dependent on the alternatives being explored. For example, forecasting apron needs to support master plan alternatives is different from forecasting demand for a deicing pad, a cargo facility, or reconfiguration of an existing apron.

Determining future apron demand can be as simple as obtaining direction from the airport operator, tenant, or lessee or as complex as developing activity and demand forecasts. Often, apron demand forecasts are derived from differently focused activity forecasts. Forecasting (or projecting) activity on the apron, including aircraft fleet mix and the peak demand on the apron throughout the day, is necessary to determine apron facility requirements. The method for determining the drivers of peak activity and the aircraft fleet mix expected to operate on the apron is largely dependent on the type of user, as follows:

- **Air carrier:** Forecasts of air carrier aircraft operations can be based on national trends and FAA forecasts, existing aircraft fleet mixes and airline orders, and an examination of potential domestic and international markets using a variety of industry standard data sources. Forecasts of passenger airline aircraft operations are typically based on historical relationships among enplaned passengers, load factors, and average seating capacities of the existing and projected fleet mixes.
- **Cargo:** Cargo forecasts are typically developed by examining historical cargo trends at the airport, the airport's share of total U.S. cargo, and the amount of cargo leakage to other competing regional airports. Operations forecasts for cargo aircraft are based on existing operations and anticipated trends in the average tons of air cargo per all-cargo aircraft departure, combined with existing cargo fleet activity and aircraft orders by the all-cargo carriers. Peak period activity for the all-cargo carriers is largely dependent on network scheduling, while the passenger airline aircraft carrying cargo could be scheduled throughout the day.

- **General aviation:** Forecasts of general aviation activity are based on historical activity and on planned leases or developments at the airport that would increase aircraft operations. As general aviation activity is largely unscheduled, historical daily activity should be used to determine peak period demand. FBO business models can also be referenced to determine apron demand for general aviation operations. It is important to understand the characteristics of historic activity as it can be relevant to apron planning/design. General aviation activity reflects that of both based aircraft and itinerant aircraft. Based aircraft are reliably parked at the facility when not in use. Itinerant aircraft will be present for variable length periods of time, depending on the purpose of the trip.
- **Helicopter:** Helicopter fleets are less variable than fixed-wing aircraft, with a majority of helicopters having an overall length that ranges between 40 feet and 60 feet and a rotor diameter between 25 feet and 50 feet. Some helicopters exceed these ranges and are generally used for aerial craning, heavy lift, military, or passenger transport. The maximum takeoff weight for most helicopters ranges between 3,000 pounds and 15,000 pounds, with the largest helicopters having a maximum takeoff weight of up to 74,000 pounds. Apron planning and design for helicopter facilities are heavily contingent on the helicopters anticipated to operate at the airport. Coordination with airport operators and tenants is necessary to determine the primary fleet using the airport and if any operations by large or heavy helicopters are expected.

The FAA also develops forecasts for each airport included in the National Plan of Integrated Airport Systems (NPIAS) as part of its annual *Terminal Area Forecast* (TAF) publication, which includes forecasts of based aircraft as well as aircraft operations. Depending on the nature of the planning project, the TAF may be sufficient to determine and verify apron demand. Airports with more activity may require the development of activity forecasts to accurately quantify apron demand. Numerous FAA and ACRP sources describe in detail the methodologies used to forecast aviation activity and should be referenced to determine apron demand. Additionally, forecasts and sources of historical activity are available from the FAA, the U.S. DOT, and independent sources. These sources may include:

- FAA TAF and Aerospace Forecasts
- FAA Form 5010, Airport Master Record
- FAA air traffic databases, including the Operations Network (OPSNET), Enhanced Traffic Management System Counts (ETMSC), and Air Traffic Activity System (ATADS)
- U.S. DOT T-100 data and 10 percent ticket sample
- Official Airline Guides, Inc. (OAG)
- Previously completed airport forecasts
- Airport operator records for based aircraft and fleet mix
- Aircraft manufacturer forecasts

Key Points:

- Define current and future demands for the apron.
- Use available resources to forecast potential apron uses and capacity.
- Seek concurrence with or consensus on projected apron demand prior to initiating planning/design to support an efficient process and a solid project justification.

Additional Guidance

ACRP Synthesis 2, *Airport Aviation Activity Forecasting*, 2007.

Aircraft Fleet Evolution

Changes in the aircraft fleet continue to require changes to the physical layout and operational needs for aprons. The introduction of new large aircraft (NLA), such as the Airbus A380 and Boeing 747-8, has created apron planning challenges. Many airports do not have the depth (dimension from the building face to the aircraft parking limit line) to accommodate these NLA on existing aprons and have implemented Modifications of Standards (MOSs) to accommodate operation of NLA on existing airport taxiways and aprons. These NLA may also require more demanding servicing. One such requirement relates to the enplaning and deplaning of passengers. Given the substantially larger numbers of passengers that NLA can accommodate and the dual-level configuration of some NLA, multiple passenger loading and unloading points may be required for efficient servicing, including a direct connection to the second level of the aircraft.

Other changes in the aircraft fleet can include gradual increases in overall aircraft size or aircraft retirement. For example, smaller regional jet aircraft are being phased out industrywide, given the increased cost of fuel. While this trend may change at some point, as dictated by industry practices, economic factors, operational needs, and other considerations, it is important that the planner/designer consider anticipated or predicted evolutions in the aircraft fleet. In addition, airlines continually replace older aircraft models with newer models or derivative generations of existing models. Another change is the increase in aircraft wingspan caused by the introduction of wingtip devices in response to the industry's focus on improved fuel efficiency. Some newer models of aircraft also may have higher or lower door sills that can affect the capability of PLBs.

New aircraft models may also have different GSE requirements. For example, the Boeing 787 requires a data connection to upload and download aircraft maintenance and performance information, weather conditions, aeronautical charts, and other flight information. The Boeing 787 uses two GPUs, but may require a third for engine startup if the APU is inoperative. Also, the Boeing 787 uses electrical power for engine start rather than pneumatic power, resulting in air start carts being unnecessary for this aircraft. Aircraft manufacturers often publish information on trends for future aircraft concepts and models.

Airports that have traditionally primarily served general aviation users may need to accommodate commercial aircraft. New commercial airline service can range from regional jets providing frequent service by hubbing airlines at airports to narrowbody aircraft providing less frequent service to tourist destinations. Planning for possible changes in the fleet and service enables planners to provide for aprons that serve the overall and long-term needs of the airport.

Key Points:

- Identify aircraft fleet that will utilize the apron and parking areas.
- Consider planning for an eventual evolution in the facility-specific fleet, even if not predicted, by increasing facility size, dimensions, and/or aircraft circulation capabilities, or allowing/protecting for future expansion to accommodate the changes.
- Identify specialty GSE that may be required for newer generation aircraft, particularly large aircraft.

Additional Guidance

FAA Report AR-97/26, *Impact of New Large Aircraft on Airport Design*, March 1998.

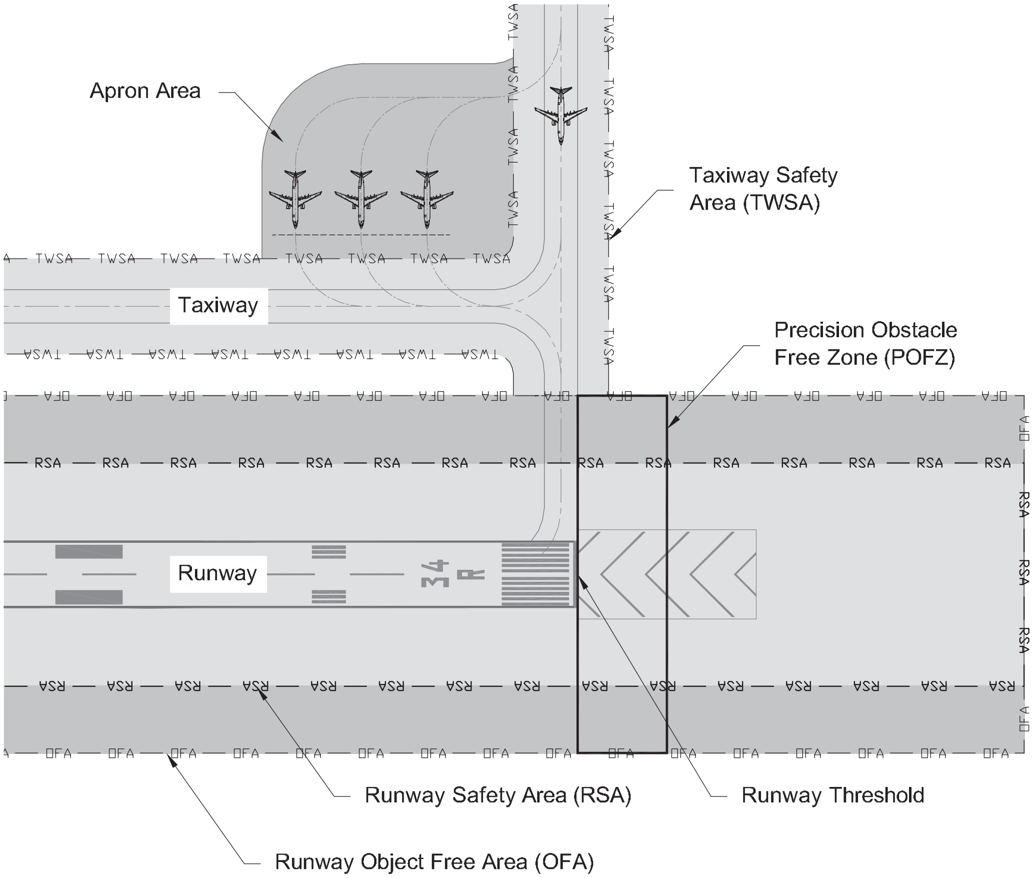
Aeronautical Surfaces/Areas

The FAA has set forth many aeronautical surface and critical area requirements intended to protect aircraft ground movements and the transition of aircraft between ground and airborne operations. Apron planning and design must consider these surfaces and areas and conform to them where applicable. These areas and surfaces can influence the layout of aprons and may limit the allowable tail heights of aircraft that use them. Penetrations of or encroachments into aeronautical surfaces/areas by aircraft or the equipment serving the aircraft (e.g., deicing vehicles) have the potential to create limiting or adverse operational consequences. Penetrations or encroachments may result from aircraft maneuvering (e.g., push-back from terminal gate) during typical operations and should be reviewed during apron planning and design to ensure that operating conditions are considered as well as the final parked (aircraft or equipment) configuration.

The following subsections summarize the relevant runway and taxiway areas and aeronautical surfaces that may influence apron planning. These areas may also impact the flexibility of existing apron facilities that are considered for alternate uses (e.g., special event or overnight parking of aircraft) or for repurposing since the original design and construction. It is important to recognize that this section provides an overview of potentially relevant aeronautical surfaces and areas as a reminder to planners and designers to not overlook the possibility that they could influence apron use, configuration, flexibility, and location.

Runway and Taxiway Critical Areas and Surfaces

The various protection and safety areas associated with runways and taxiways are shown on Figure 4-2. These areas limit the proximity to, and types of objects allowable in and around, runways, taxiways, and taxilanes and may affect aircraft parked on an apron. Additional critical areas associated with navigational aids associated with instrument landing systems (ILSs) are discussed in greater detail later in this chapter.



Sources: Ricondo & Associates, Inc.; FAA Advisory Circular 150/5300-13A, Airport Design, September 28, 2012.

Figure 4-2. Runway and taxiway elements.

An overview of these surfaces is presented in the following paragraphs. However, it is the responsibility of the planner/designer to use the resources identified at the end of the subsections below to definitively understand the relevant aeronautical surfaces and areas that may influence apron planning/design.

Runway Safety Area. A runway safety area (RSA) is centered on a runway centerline and is designed to protect aircraft that leave the paved runway surface or undershoot or overrun a runway end on approach or departure. It is intended to support the occasional passage of aircraft, as well as emergency equipment that may be required to respond to an airfield incident. The RSA width varies from 120 feet for small aircraft to 500 feet for large aircraft and typically extends 240 feet beyond the runway end for small aircraft and 1,000 feet beyond the runway end for large aircraft. The RSA must be free of objects other than navigational aids or other structures that must be located within the RSA and mounted on frangible mounts or those fixed by function. Aircraft parking and holding are not allowed within the RSA.

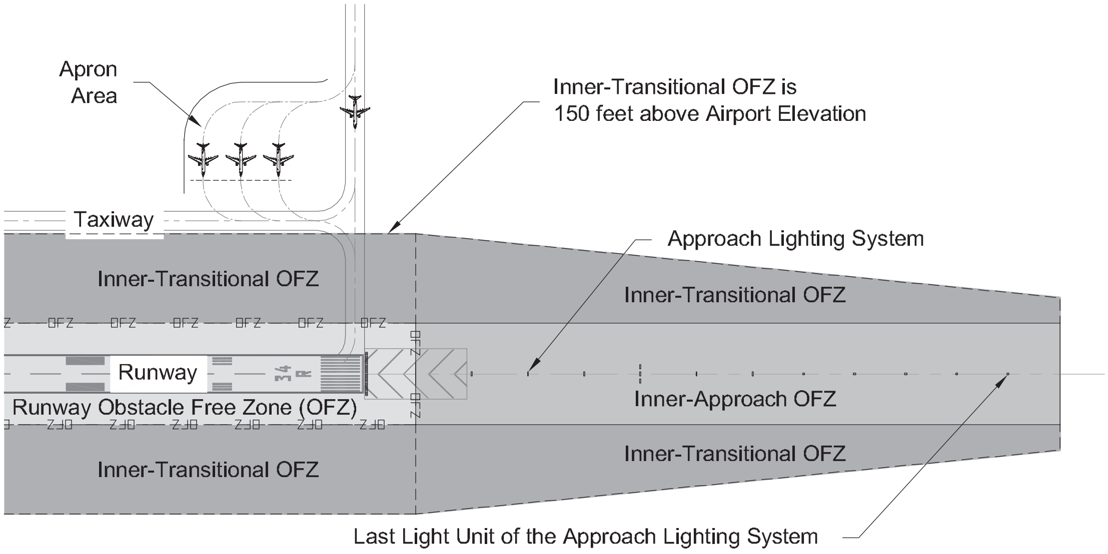
Runway Object Free Area. The runway object free area (ROFA) is centered on the runway centerline and is required to be clear of objects other than navigational aids, terrain penetrations, and those that are otherwise "fixed by function." The ROFA is intended to enhance safety should an aircraft leave the runway pavement. The dimensions of the ROFA vary from 400 feet wide and 240 feet long beyond the runway end for small aircraft to 500 feet wide and 1,000 feet long beyond the runway end for large aircraft.

Taxiway Safety Area. A taxiway safety area is centered on a taxiway centerline and is designed to limit the encroachment of objects onto aircraft movement areas and to allow airport emergency vehicles to readily access aircraft on a taxiway. The taxiway safety area must also be free of nonessential objects; any structures that must be located within the area are required to be frangibly mounted. Taxiway safety area standards are based on the ADG to be accommodated and range in width from 49 feet for ADG I aircraft to 262 feet for ADG VI aircraft.

Obstacle Free Zone (OFZ). The OFZ is a three-dimensional area centered along the runway centerline and is designed to keep the runway and adjacent areas clear of objects, other than frangibly mounted navigational aids. The OFZ extends 200 feet beyond the runway end and varies in width from 120 feet for small aircraft to 400 feet for large aircraft. The OFZ is further subdivided when an approach lighting system (ALS) or ILS is present. The following variations of the OFZ are depicted on Figure 4-3 and may not be penetrated by aircraft tails.

- **Inner-approach OFZ:** The inner-approach OFZ applies to runways with an ALS. The zone extends upward and outward from a point 200 feet prior to the runway threshold, at the same elevation as the runway threshold at a slope of 50:1. The zone terminates 200 feet beyond the last light in the ALS.
- **Inner-transitional OFZ:** The inner-transitional OFZ applies to runways with visibility minimums lower than three-quarters of a statute mile [Category (CAT) I or CAT II/III ILS]. The inner-transitional OFZ slopes upward and outward from the edges of the runway OFZ to a height of 150 feet above airport elevation. The inner-approach OFZ slope varies based on the type and size of aircraft using a particular runway and, in some cases, the runway threshold elevation.

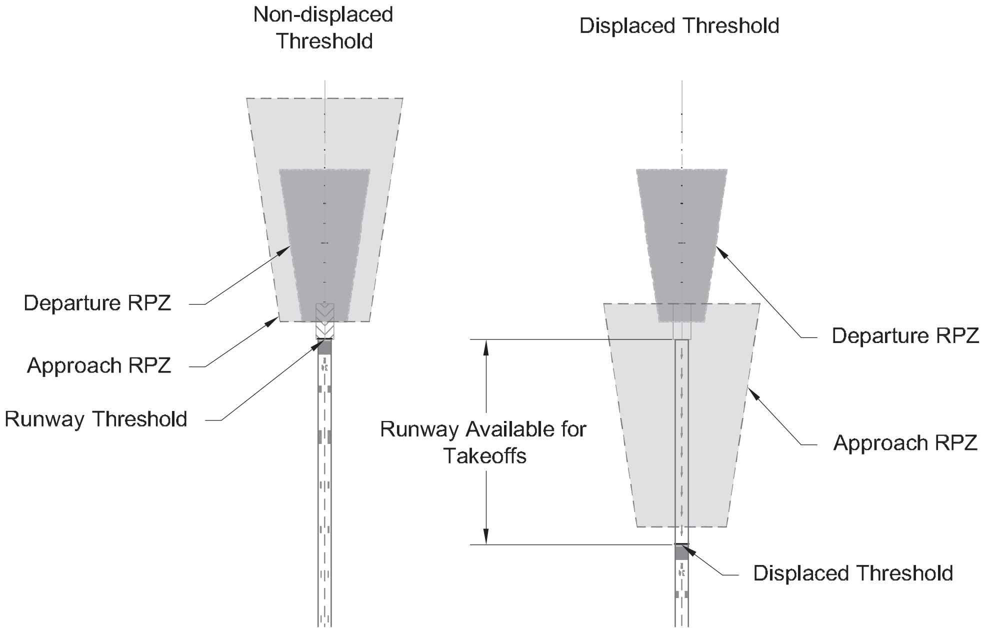
Precision OFZ. The precision OFZ (POFZ) is centered along the extended runway centerline originating at the runway arrival threshold. The POFZ is 800 feet wide (centered on the runway) and 200 feet long. The airport operator is responsible for clearing objects from this area. If the POFZ is not clear, visibility minimums cannot be reduced beyond a 250-foot height above touchdown and three-quarters of a statute mile.



Sources: Ricondo & Associates, Inc.; FAA Advisory Circular 150/5300-13A, Airport Design, September 28, 2012.

Figure 4-3. OFZ.

Runway Protection Zone. Runway protection zones (RPZs) are designed to enhance safety for people and assets located beyond the runway ends. The types and heights of objects within the RPZ are typically controlled by the airport operator. As shown on Figure 4-4, there are two types of RPZs, approach and departure, which are both trapezoidal in shape. The dimensions of approach RPZs are a function of the aircraft approach category and the visibility minimums associated with the approach for the runway end; the dimensions of departure RPZs are associated with the departure procedures associated with the runway. Approach and



Sources: Ricondo & Associates, Inc.; FAA Advisory Circular 150/5300-13A, Airport Design, September 28, 2012.

Figure 4-4. RPZs.

departure RPZs are described in FAA Advisory Circular 150/5300-13A, *Airport Design.* The dimensions for approach and departure RPZs vary greatly and are addressed in this advisory circular.

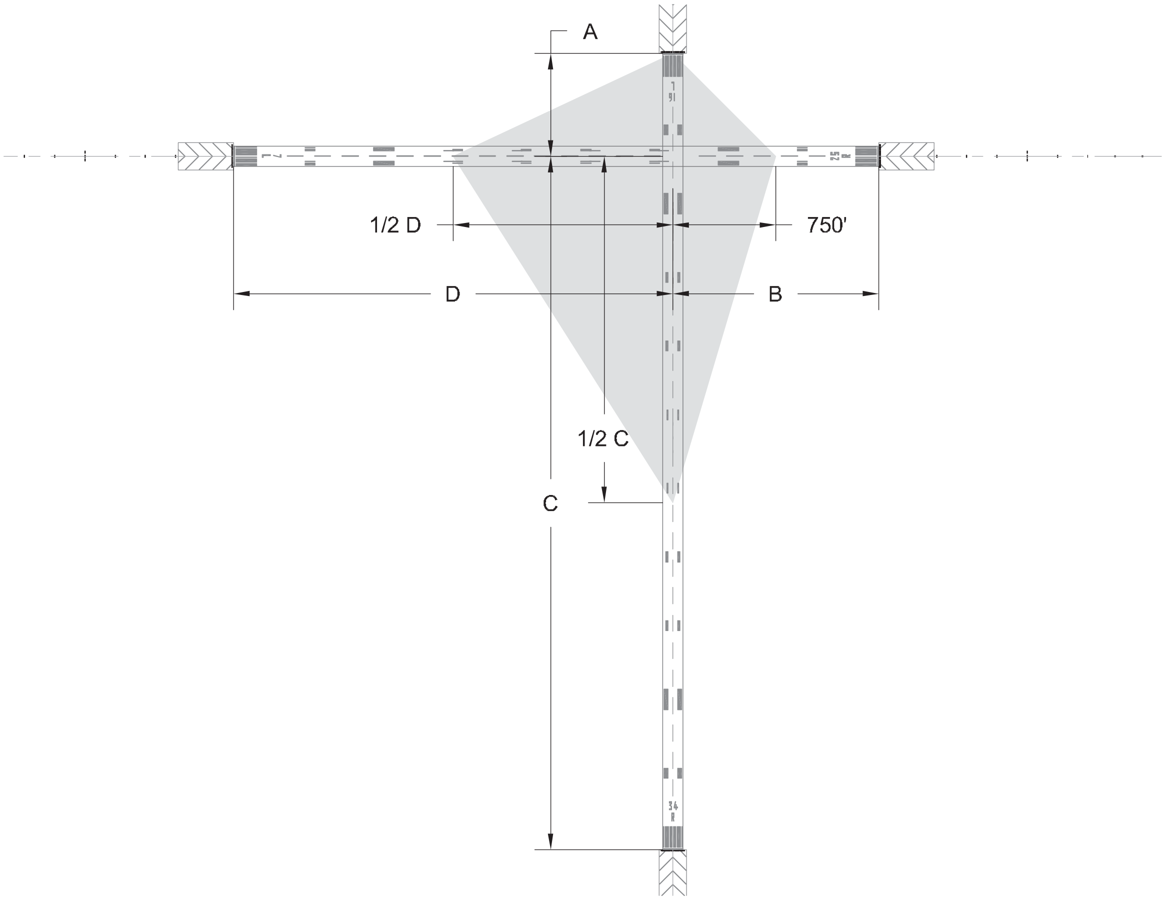
Runway Visibility Zone. The runway visibility zone (RVZ) is defined by imaginary lines connecting runway line-of-sight points, and is designed to maintain clear ATC line-of-sight of a runway. As shown on Figure 4-5, the RVZ is created by connecting lines between various runway line-of-sight points. These points are located as follows:

- The end of a runway, if the runway end is located within 750 feet of a crossing runway.
- 750 feet from the runway intersection, if the end of the runway is located within 1,500 feet of the crossing runway.
- Half the distance from an intersecting runway, if the end of the runway is at least 1,500 feet from the crossing runway.

RVZs may contain objects and structures so long as they do not interfere with ATC runway lines-of-sight. Any point 5 feet above the runway centerline elevation must be visible to controllers, within the RVZ, at all times. The placement of aprons within the RVZ must ensure that parked aircraft do not block ATC visibility of this zone. Historically, a modification to this standard may be approved by the FAA if the airport has a 24-hour ATCT and operation of the ATCT is anticipated to continue based on accepted activity forecasts.

Additional Guidance

FAA Advisory Circular 150/5300-13A, *Airport Design,* September 28, 2012.



Sources: Ricondo & Associates, Inc.; FAA Advisory Circular 150/5300-13A, Airport Design, September 28, 2012.

Figure 4-5. RVZ.

Key Points:

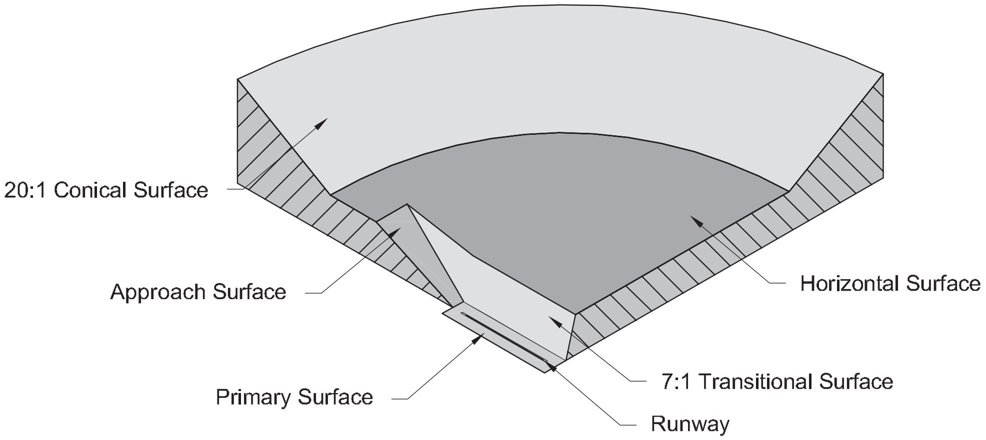
- Identify runway and taxiway critical areas that may affect apron design.
- Design apron and parking areas outside AOA critical areas, considering parked positions, aircraft maneuvering within the apron, and entry/exit movements to the airfield.

14 CFR Part 77 Imaginary Surfaces

Title 14, Code of Federal Regulations, Part 77 (14 CFR 77), *Safe, Efficient Use, and Preservation of the Navigable Airspace* is a regulatory document produced by the FAA and used to evaluate above-ground objects within the airport environment and in its vicinity for their potential effects on arriving and departing aircraft. 14 CFR 77 also describes the evaluation of potential effects of new construction or alteration to existing structures on aircraft in the vicinity of an airport. Any obstruction to Part 77 imaginary surfaces must be reviewed by the FAA to determine if it constitutes a potential hazard to air navigation and identify a course of action to mitigate the obstruction. This usually results in the obstruction being removed, lowered, or identified by marking and lighting. Subpart C of 14 CFR 77 outlines specific dimensions and slopes for evaluation of imaginary airspace surfaces directly related to the anticipated uses and types of approach to a given runway. The types of use are utility (runways constructed for and intended to be used by aircraft less than or equal to 12,500 pounds), and non-utility (runways constructed for aircraft greater than 12,500 pounds). Types of approaches include precision approaches, which directly relate to ILSs and other precision-type approaches; nonprecision instrument approaches, which include approaches based on the use of global positioning systems (GPS); and visual approaches, which include visual-only or noninstrument-type approaches. Each type of approach directly affects the dimensions and slopes of 14 CFR 77 imaginary surfaces. All slopes discussed in this subsection are expressed as a ratio of horizontal distances to vertical distances (i.e., horizontal:vertical or xx:1).

The following describes the surfaces in Subpart C, as depicted on Figure 4-6.

Primary Surface. The primary surface is horizontally centered on a runway, extending 200 feet beyond the runway ends. The width of the primary surface varies from 250 feet to



Sources: Ricondo & Associates, Inc.; Title 14, Code of Federal Regulations, Part 77, Safe, Efficient Use, and Preservation of the Navigable Airspace, July 21, 2010.

Figure 4-6. 14 CFR 77 imaginary surfaces.

1,000 feet and may only include certain navigational aids and other airport structures required for air navigation. The elevation of the primary surface is the same as that of the runway centerline.

Approach Surface. Approach surfaces vary significantly in dimension and relate directly to the type of approach, either existing or planned, to a runway. Approach surfaces begin at the end of the primary surface and extend upward and outward. The approach surface is subdivided into three types depending on the approach: precision, nonprecision instrument, and visual. These surfaces have varying lengths and slopes.

Transitional Surface. The transitional surface rises from the edge of the primary and approach surfaces at a slope of 7:1. This surface connects the primary and approach surfaces with the horizontal and conical surfaces.

Horizontal Surface. The horizontal surface is a flat planar surface 150 feet above the airport elevation and consists of connecting swinging arcs of varying radii, depending on the type of runway approach capability.

Conical Surface. The conical surface extends upward and outward from the edge of the horizontal surface for a distance of 4,000 feet horizontally, at a slope of 20:1.

Key Points:

- Identify potential airspace issues for taxiing, stopped or parked aircraft for all locations/areas within the apron design area.
- Understand the process for FAA coordination in the event that penetrations of Part 77 surfaces are contemplated during the planning/design of any apron facility. Initiate early coordination with the FAA in these instances.

Additional Guidance

Title 14, Code of Federal Regulations, Part 77, Safe, Efficient Use, and Preservation of the Navigable Airspace, July 21, 2010.

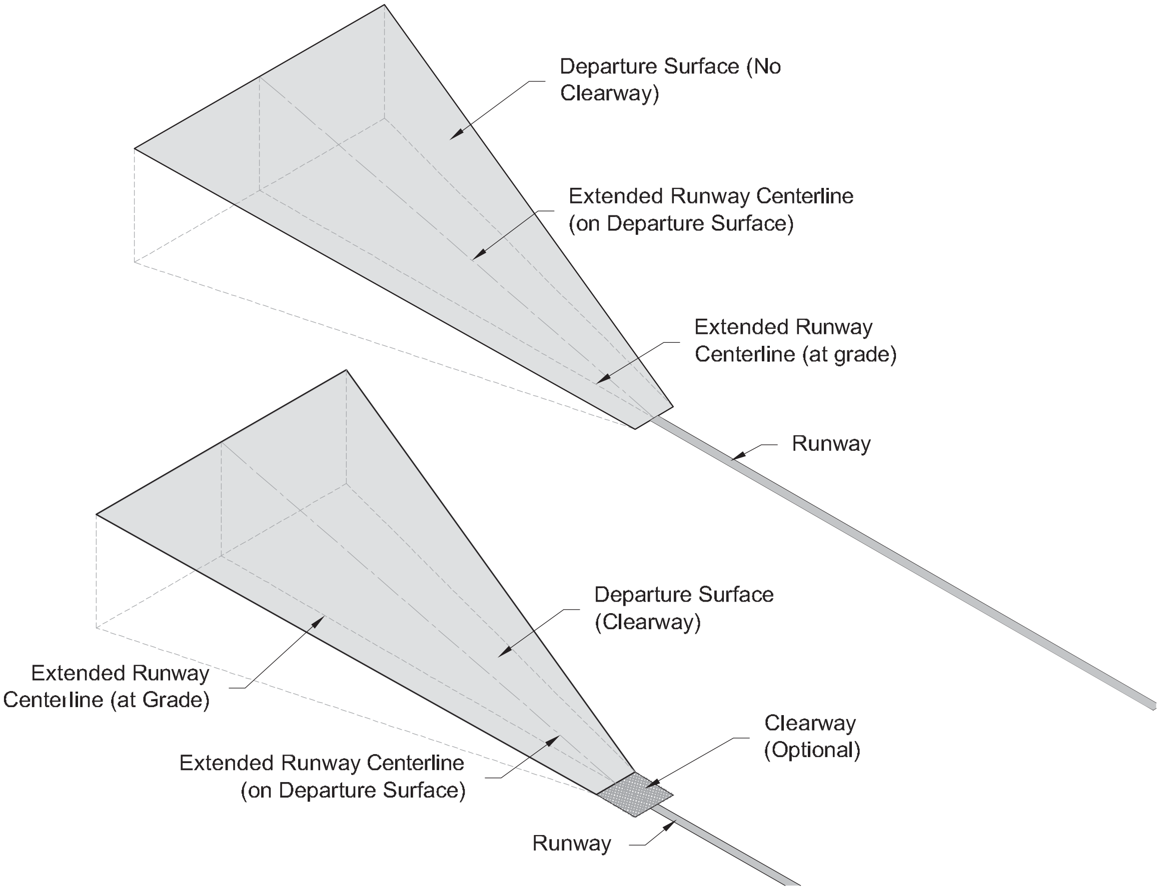
TERPS (Terminal Instrument Procedures) Obstacle Clearance Surfaces

FAA Order 8260.3B, *United States Standard for TERPS* is a regulatory document produced by the FAA to assist in developing aircraft approach and departure procedures. Each runway instrument approach and departure procedure has an associated obstacle clearance surface (OCS), which is expressed as a value of required obstacle clearance (ROC). This ROC provides a safe distance from the top of an object to an aircraft. TERPS surfaces may not be penetrated by existing or planned objects. Penetration of an OCS de-authorizes an instrument procedure.

All slopes discussed in this subsection are expressed as a ratio of horizontal distances to vertical distances (i.e., horizontal:vertical or xx:1).

The following surfaces are the most commonly encountered surfaces and are typically the most restrictive in terms of aircraft parked on an apron and height of buildings or other tall structures.

Departure OCS. The departure OCS is designed to protect departing aircraft. As shown on Figure 4-7, this surface slopes upward and outward from the departure end of a runway, relative to the published takeoff climb gradient, typically 40:1. The departure OCS is 1,000 feet wide at the origin (departure end of the runway) and expands uniformly at 15 degrees relative to the runway centerline for a distance of 2 nautical miles. Departure OCSs may not be penetrated except in special circumstances, which are evaluated on a case-by-case basis by the FAA. When planning aprons located adjacent to and near a runway end, this surface needs to be considered.



Sources: Ricondo & Associates, Inc.; FAA Advisory Circular 150/5300-13A, Airport Design, September 28, 2012.

Figure 4-7. TERPS departure OCS.

Precision Approach OCS

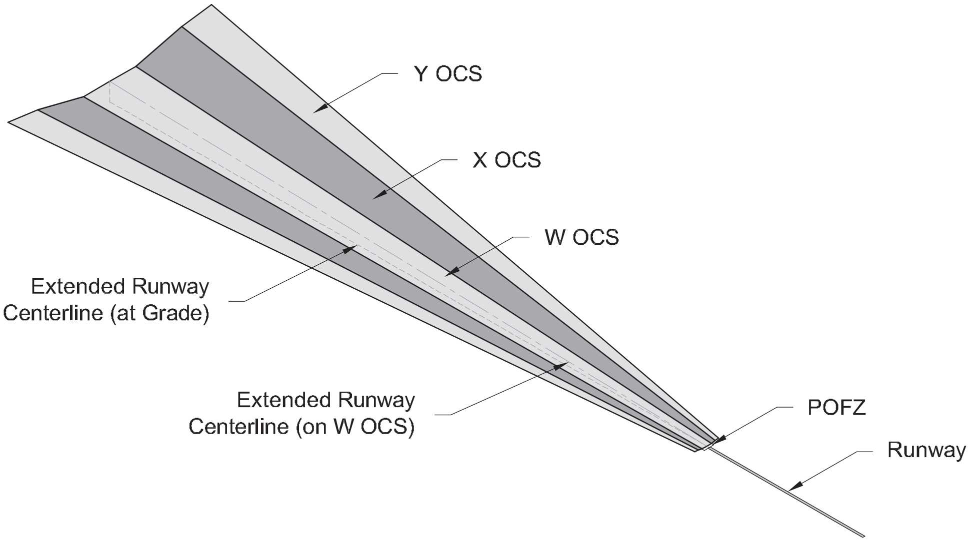
The precision approach surface, also typically referred to as the "ILS approach surface," protects arriving aircraft from near-airport objects during an approach to a runway. The precision approach surface begins 200 feet from the arrival threshold and extends for a total length of 50,000 feet. This surface contains three sub-surfaces, known as the W OCS, X OCS, and Y OCS, as depicted on Figure 4-8.

The W OCS is considered a "primary area," which means it is the main OCS under an arriving aircraft. This surface expands from a width of 800 feet at the origin to a width of 2,200 feet at its terminus, 50,000 feet from the surface origin. The W OCS slopes upward and outward relative to the glide path angle (GPA) or glideslope for a given runway, equal to 102 divided by the GPA (i.e., a 3 degree GPA would have a slope of 34:1).

The X OCS is considered a "secondary area," which typically refers to a transitional area. This surface extends from an origin width of 300 feet to a terminating width of 3,876 feet. The X OCS slopes upward and outward from the edge of the W OCS at a 4:1 slope.

The Y OCS is also considered a "secondary area." This surface extends from an origin width of 300 feet to a terminating width of 2,500 feet. The Y OCS slopes upward and outward from the edge of the X OCS at a 7:1 slope.

Category II/III ILS Missed Approach OCS. The missed approach surface associated with a CAT II/III ILS must remain clear of objects and is designed to keep the vicinity of a runway clear

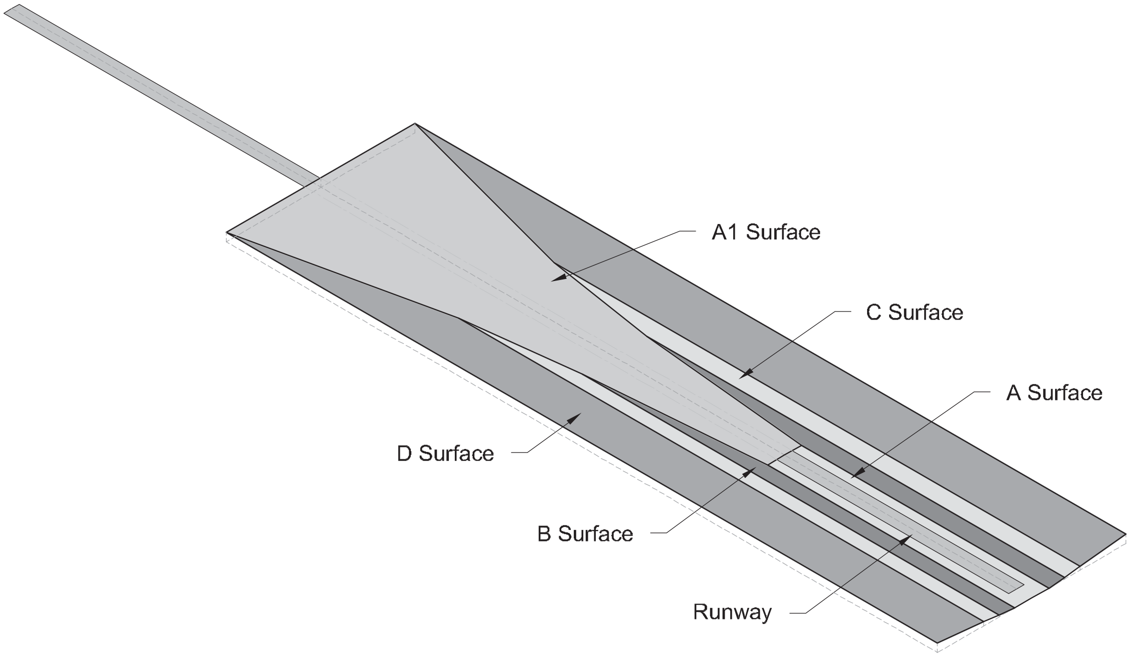


Sources: Ricondo & Associates, Inc.; FAA Order 8260.3B, U.S. Standard for Terminal Instrument Procedures (TERPS), March 9, 2012.

Figure 4-8. TERPS precision approach OCS.

in the event an aircraft cannot continue an approach to a runway, especially in poor weather conditions when CAT II/III minimums are in effect. As shown on Figure 4-9, the CAT II/III missed approach surface consists of the following five surfaces:

- **A surface:** The A surface is centered on the runway centerline and extends from a point 200 feet prior to the arrival threshold to a point 3,000 feet down-runway from the arrival threshold. This surface is 400 feet wide plus "K" where "K" is defined as 0.01(E-1,000), where



Sources: Ricondo & Associates, Inc.; FAA Memorandum, Interim Criteria for Precision Approach Obstacle Assessment and Category II/III ILS Requirements, August 16, 2011.

Figure 4-9. Category II/III ILSs missed approach OCS.

"E" is the established airport elevation. The A surface elevation is consistent with the runway centerline elevation.

- **A1 surface:** The A1 surface extends upward and outward from the end of the A surface at a slope of 40:1.
- **B surface:** The B surface is considered a "secondary surface" and slopes upward and outward from the edge of the A surface for a horizontal distance of 200 feet at a slope of 40/11:1.
- **C surface:** The C surface is also considered a "secondary surface" and slopes upward and outward from the edge of the B surface for a horizontal distance of 200 feet at a slope of 40/7:1.
- **D surface:** The D surface is an additional "secondary surface" and slopes upward and outward from the edge of the C surface for a horizontal distance of 600 feet at a slope of 10:1.

Additional Guidance

ACRP Report 38: Understanding Airspace, Objects, and Their Effects on Airports, 2010.

FAA Memorandum, *Interim Criteria for Precision Approach Obstacle Assessment and Category II/III Instrument Landing System Requirements,* August 16, 2011.

FAA Order 8260.3B, *U.S. Standard for Terminal Instrument Procedures* (*TERPS*), March 9, 2012.

Key Points:

- Identify potential TERPS issues for taxiing, stopped or parked aircraft for all locations/areas within the apron design area.
- Understand the process for FAA coordination in the event that penetrations of any TERPS surfaces are contemplated during the planning/design of any apron facility. Initiate early coordination with the FAA in these instances and ensure that the potential operational consequences are understood by appropriate stakeholders.

Aircraft Clearances/Separations

The dimensional, operational, and servicing needs of aircraft must be accommodated on apron facilities. Dimensional factors relevant to the planning and design of apron facilities are described in this section.

ADG

Specific aircraft models or categories of aircraft are used for dimensional planning of aprons. The FAA uses a classification of aircraft based on wingspan and tail height, referred to as the ADG. For apron planning purposes, wingspan is the main driver and tail height is not usually considered except when determining if an aircraft would penetrate any aeronautical surfaces and assessing potential line-of-sight impacts. Table 4-1 sets forth the wingspans and example aircraft for each ADG, as defined by the FAA. The International Civil Aviation Organization (ICAO) uses similar categories of aircraft, referred to as aircraft codes, which are approximately equal to the FAA ADG.

Key Points:

- Define all types of aircraft to utilize and operate within the apron area.
- Consider an airport's long-range development plans (e.g., ALP) to determine whether to plan for ADGs that do not currently operate at the facility but that may in the reasonably foreseeable future.

Fixed Object/Structure Clearance

Sufficient clearance must be provided between the front of a parked aircraft and a building face or other physical barrier (e.g., fence) to accommodate tug maneuvering or cargo nose

Table 4-1. ADGs.

FAA Airplane Design Group	ICAO Aircraft Code	Wingspan Range (feet)	Example Aircraft
I	A	< 49	Cessna 172, Cessna 525 CitationJet, Piper PA-28 Cherokee
II	B	49 < 79	Bombardier CRJ100/200/700, Embraer ERJ-135/140/145
III	C	79 < 118	Airbus A318/A319/A320/A321, Boeing 737 (All Models), Bombardier CRJ705/900/1000, Embraer E-170/-190 (All Models), McDonnell Douglas, MD-80/-90 (All Models)
IV	D	118 < 171	Boeing 757 (All Models), Boeing 767 (All Models)
V	E	171 < 214	Airbus A340 (All Models), Boeing 747-400, Boeing 777 (All Models), Boeing 787 (All Models)
VI	F	214 < 262	Airbus A380, Boeing 747-8

Note: The wingspans for ICAO aircraft codes are approximately equal to the FAA's ADGs, but can vary by up to 1.5 feet.
Sources: FAA Advisory Circular 150/5300-13A, *Airport Design*, September 28, 2012; ICAO Annex 14, Volume I, *Aerodrome Design and Operations*, July 2009.

loading in front of the aircraft. The clearance must be sufficient to allow the tug to maneuver into position and engage/disengage the aircraft nosewheel. The amount of clearance required varies by type of aircraft (reflecting differing locations of the nosewheel relative to the nose of the aircraft), tug, and towbar used, and can be influenced by building configuration if the upper level is cantilevered over the lower level.

The FAA recommends minimum nose-to-building distances of 15 feet for ADG III aircraft, 20 feet for ADG IV aircraft, and 30 feet for ADG V aircraft. Apron planners must consider the entire fleet of aircraft planned to use the 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, which 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 nosecone in the upright position. Defining the minimum distance 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.

Key Points:

- Apron design must allow for adequate spacing between parked aircraft and fixed objects.
- The distance from the nosewheel of an aircraft to the nose of the aircraft can vary substantially among aircraft.
- Consider all activities that will occur in the vicinity of the aircraft nose in determining the necessary nose clearance and apron depth for apron planning and design.

Aircraft Wingtip Clearances

Adequate separation is needed between the wingtips of aircraft occupying adjacent parking positions, as well as between wingtips and any fixed or movable object that the aircraft must

Table 4-2. ICAO apron aircraft wingtip clearances.

ICAO Aircraft Code	FAA ADG	Clearance (feet)	Clearance (meters)
A	I	10	3.0
B	II	10	3.0
C	III	15	4.5
D	IV	25	7.5
E	V	25	7.5
F	VI	25	7.5

Note: Wingtip clearances in feet were rounded to the nearest foot. The wingspans for ICAO aircraft codes are approximately equal to the FAA's ADGs, but can vary by up to 1.5 feet.

Sources: FAA Advisory Circular 150/5300-13A, *Airport Design*, September 28, 2012; ICAO Annex 14, Volume I, *Aerodrome Design and Operations*, July 2009.

pass while entering or exiting a position. As of the time this guidebook was prepared, the FAA does not enforce separation standards for aprons, with the exception of deicing pads. Table 4-2 outlines ICAO planning criteria recommended wingtip clearances for each ICAO aircraft code and the associated FAA ADG.

In the United States, minimum wingtip clearances for parked aircraft and for aircraft gate entry/exit maneuvers are usually determined by airlines or airport operators. Airport operators may impose minimum wingtip clearances for all gates. Alternatively, they may enforce minimum wingtip standards only for common-use or preferential-use gates and for gates where different airline parking positions are adjacent to each other. This approach ensures that an airline's separation standards are not compromised if an aircraft owned by an airline that uses tighter wingtip clearances is parked at an adjacent gate. It is recommended that airport operators document required wingtip clearances so that new and existing tenants are aware of these requirements as changes may occur at specific gates.

Minimum aircraft separation is usually stipulated for all segments of gate entry and exit maneuvers, not just the final parked position; however, in some cases, airlines will allow reduced clearances during maneuvering past a stationary object (e.g., parked aircraft). Often, gate maneuvers are not simply straight-in and straight-out, but rather are segmented to maximize the efficient use of the available space while still maintaining the wingtip separation clearances. Wingtip clearance requirements often vary by the size of aircraft using the gate area, with the separation increasing as the size of the aircraft increases. Separations tend to be greatest for widebody aircraft and smallest for turboprop and regional jet aircraft.

Horizontal wingtip separation is typically the defining parameter at U.S. airports, although on rare occasions, vertical wingtip clearance (e.g., a higher aircraft wing passing over a lower aircraft wing) has been used to compensate for reduced horizontal clearances. Planners must consider aircraft wing height and vertical characteristics, including incorporation of wingtip devices and the potential for wingtips to drop during aircraft refueling.

Apron planners must also consider the effect of wingtip clearances on the amount of space available for maneuvering vehicles and GSE. One drawback of decreasing wingtip separations is a reduction in maneuvering space for vehicles that service the aircraft forward of the wing and for emergency response vehicles. When determining wingtip clearances, planners must also consider the potential effects of incorporating a service road between aircraft parking positions. A service road between parking positions may require greater separation between the aircraft. Additionally, it is common to provide 5 feet 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.

Another factor to be considered in modifying existing aprons and planning/designing new aprons is the introduction of wingtip devices. Blended wing and wingtip technology has been developed in response to the industry's focus on improved fuel efficiency. Blended wing technology is available as a retrofit to an existing aircraft fleet and as an option on new aircraft. Airport operators and airlines must contend with the increase in wingspan with the incorporation of wingtip devices. Table 4-3 sets forth the increased aircraft wingspans with wingtip devices.

The increased wingspan of aircraft with this modification reduces the effective spacing between parked aircraft, potentially to a degree that reduces the utility of existing gates. At airports with parking layouts that provide sufficient wingtip clearances, reduced clearance may be acceptable to accommodate aircraft with wingtip devices. At aprons with limited wingtip clearances, the airport operator may be required to eliminate, or reduce the size of, one or more aircraft parking positions to accommodate the increase in wingspan resulting from wingtip devices for one or more gates. Coordination and open communication between the airport operator and apron users are important to identify specific parking positions where this may occur and to explore a range of feasible solutions.

Table 4-3. Wingspan increases for wingtip devices.

	Wingspan		Wingspan with Wingtip Devices	
Aircraft	Feet/Inches	Meters	Feet/Inches	Meters
Airbus A318	111/11	34.1	117/6	35.8
Airbus A319	111/11	34.1	117/6	35.8
Airbus A320	111/11	34.1	117/6	35.8
Airbus A321	111/11	34.1	117/6	35.8
Boeing 737-300	94/9	28.9	102/1	31.1
Boeing 737-500	94/9	28.9	102/1	31.1
Boeing 737-700	112/7	34.3	117/5	35.8
Boeing 737-800	112/7	34.3	117/5	35.8
Boeing 737-900	112/7	34.3	117/5	35.8
Boeing 757-200/-300	124/10	38	134/9	41.1
Boeing 767-300ER	156/1	47.6	167/0	50.9
Boeing BBJ/BBJ2	112/7	34.3	117/5	35.8
Boeing BBJ3	112/7	34.3	117/5	35.8

Sources: Aviation Partners Boeing, Airbus S.A.S, Aircraft Characteristics Airport and Maintenance Planning.

Key Points:

- Identify changes or advancements in aircraft wing and wingtip design that may affect spacing between parked and taxiing aircraft.
- Consider the operational requirements and procedures of aircraft operators (in some cases reduced horizontal wingtip clearance or reliance on vertical clearance may be allowed during an entry/exit maneuver as long as the clearance requirements are achieved in the final parked position).

Taxiways and Taxilanes

Taxiway and taxilane access routes are necessary to safely and efficiently move aircraft between aprons and the airfield. Taxiways are defined paths established for the taxiing of aircraft from one part of an airport to another. Taxilanes are designed for lower speed and more precise taxiing and are usually located in nonmovement areas, typically not controlled by ATC. Large apron areas may also incorporate apron taxiways, which provide taxiing routes through aprons, but provide taxiway separation clearances. Apron taxiways may be inside or outside of the movement area and allow for higher taxiing speeds. Depending on the configuration of the airfield, both taxiways and taxilanes provide access to apron areas. At some airports, taxilanes also function as push-back areas and some level of ramp control is provided to ensure a safe operating environment.

The FAA defines required separations between taxiways and taxilanes and from taxiways/taxilane centerlines to fixed or movable objects. Table 4-4 sets forth the separations required by the FAA for each ADG. As identified in the table notes, the FAA also publishes taxiway and taxilane clearance criteria for specific aircraft wingspans.

Usually, taxiways and taxilanes are planned to provide the necessary clearances to accommodate the maximum wingspan within a selected ADG. At some airports, aprons are designed

Table 4-4. Taxiway/taxilane separations.

	ADG (feet)					
Separation Parameter	I	II	III	IV	V	VI
Taxiway centerline to:						
Parallel taxiway/taxilane centerline[1]	69.0	105.0	152.0	215.0	267.0	324.0
Fixed or movable object[2]	44.5	65.5	93.0	129.5	160.0	193.0
Taxilane centerline to:						
Parallel taxilane centerline[3]	64.0	97.0	140.0	198.0	245.0	298.0
Fixed or movable object[4]	39.5	57.5	81.0	112.5	138.0	167.0

Notes:
[1] The required distance between a taxiway centerline and a parallel taxiway or taxilane centerline is equal to 1.2 times the aircraft wingspan plus 10 feet.
[2] The required distance between taxiway centerlines and any object is equal to 0.7 times the aircraft wingspan plus 10 feet.
[3] The required distance between taxilane centerlines is equal to 1.1 times the aircraft wingspan plus 10 feet.
[4] The required distance between taxilane centerlines and any object is equal to 0.6 times the aircraft wingspan plus 10 feet.
Source: FAA Advisory Circular 150/5300-13A, *Airport Design*, September 28, 2012.

to accommodate a specific aircraft model, referred to as aircraft-specific designs. For example, as a result of operating agreements or other airfield operating restrictions (e.g., runway length, taxiway OFAs), the operators of airports that accommodate up to a Boeing 757, an ADG IV aircraft with a wingspan of 124 feet, 10 inches, may choose to provide Boeing 757-specific taxiway/taxilane clearances for this aircraft rather than providing clearances for all ADG IV aircraft (wingspans up to 171 feet) if the Boeing 757 is the largest aircraft anticipated to operate at the airport or in specific areas of the airport. In many cases, using a specific fleet to determine taxiway or taxilane OFAs allows airport operators to reduce pavement sizes and dimensional clearances, but may also limit unrestricted operations by larger aircraft in the future.

Planning and design of taxiway and taxilanes in the apron area, including widths, pavement fillet dimensions, and taxiway edge safety margins, are based on the undercarriage dimensions of the aircraft. FAA Advisory Circular 150/5300-13A defines a classification of airplanes known as Taxiway Design Group (TDG). This classification of airplanes is based on the outer to outer main gear width and the cockpit to main gear distance of the aircraft. Use of TDG planning guidance provides sufficient pavement fillets to ensure that aircraft are able to maneuver with the cockpit over the centerline instead of aircraft over-steering, which requires pilot judgment to maneuver an aircraft on taxiways and taxilanes that do not have sufficient wheel clearance. In lieu of this guidance, computer-aided design (CAD) can be used to model aircraft ground movements.

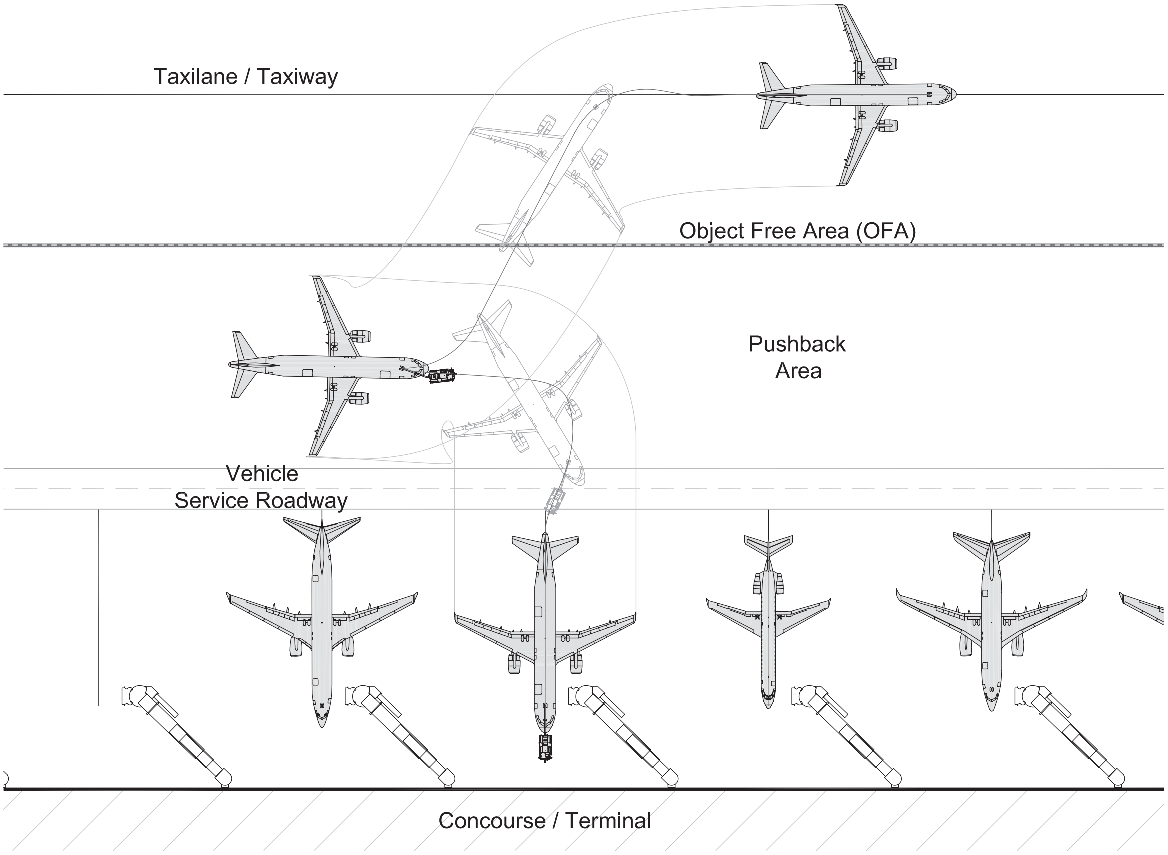
Key Points:

- Identify movement of aircraft through an apron area to design effective taxi methods/routes.
- Consider internal aircraft circulation on expansive apron areas. Strive to prevent dependent aircraft positioning in which entry/exit is compromised or inhibited by other aircraft positions and/or the lack of taxiways/taxilanes.
- Avoid configuring an apron access taxiway to lead directly to a runway from the apron or apron edge taxiway/taxilane to minimize the potential for resulting runway incursions.

Push-Back Areas

Sufficient space must be provided 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 accommodate aircraft maneuvers, allowing aircraft to safely push back and start engines without adverse jet blast impacts or without penetrating the movement area (coordination with ATCT personnel would be required if penetration is unavoidable), or encroaching on any apron taxilanes used for the directional movement of aircraft.

As shown on Figure 4-10, a push-back area should be sized to accommodate the wingspan of the largest aircraft anticipated to be pushed back from a gate plus the desired wingtip clearance. Depending on the space available and the anticipated aircraft fleet, planners may decide to accommodate all but the largest aircraft, which would reduce the amount of pavement necessary while accommodating larger aircraft by pushing them back onto a taxilane or taxiway. On aprons with dual taxilanes or taxiways, this operation may be acceptable because the capability for aircraft to bypass each other would be available. Planners of push-back areas should consider other possible uses for them, such as deicing and snow removal.



Source: Ricondo & Associates, Inc.

Figure 4-10. Push-back areas.

Key Points:

- Determine effective size for push-back areas, considering the aircraft fleet utilizing the gates/apron and the need to remain clear of the adjacent OFA.
- Where possible, utilize push-back areas for other apron operations and activities (multi-use areas).
- Do not rely on push-back areas for the directional movement of aircraft without specific concurrence by the FAA and appropriate stakeholders.

Accommodating Power-Out Maneuvers

To accommodate aircraft power-in, power-out maneuvers, sufficient space is necessary to enable the aircraft to depart from an apron without affecting airfield movements, OFAs, or adjacent apron space. At some airports, an aircraft can depart from an apron under its own power rather than being pushed from the parking position by a tug, referred to as a power-out operation. On the terminal apron, this type of maneuver is more common with general aviation, regional turboprop, and regional jet aircraft than with narrowbody or widebody jets because of the dimensional requirements, limited maneuvering space, and the presence of terminals or other structures. Power-out maneuvers are common on hold pad aprons, particularly those positioned along a taxiway. Sufficient wingtip clearance must be provided for all anticipated aircraft maneuvers, irrespective of aircraft size.

Power-out maneuvers can require more apron area if aircraft turning movement must be accommodated, either at the time of gate entry or at the time of gate exit. Alternatively, some aircraft can power out of an apron or gate parking position by moving in reverse, referred to as a "power back" maneuver, although pilot visibility and jet blast can be of concern. Consideration of airline operating procedures and aircraft maneuvering requirements is necessary in planning for power-out operations.

Airport planning manuals published by aircraft manufacturers contain information on ground maneuvering of aircraft. These manuals typically provide information on airplane characteristics, such as the maximum turning angle or apron size required for power-out maneuvers. When planning for power-out movements, planners should not assume the maximum turning angle because of the stress it imposes on the aircraft nosewheel. A more conservative angle should be assumed to avoid excessive tire wear and to account for tire slippage (coordination with the airlines is the best method for determining the maximum angle to be used in analysis). Software programs that simulate aircraft movements are also available.

Planning for power-out areas must also ensure that jet blast does not cause any adverse effects to vehicles, equipment, passengers or workers, or other aircraft on the apron. A power-out maneuver on a terminal apron is illustrated on Figure 4-11. This maneuver can be used for narrowbody and widebody aircraft, but is not prevalent because of concern regarding jet blast and the additional amount of apron space and terminal frontage required to accommodate the turning movements.

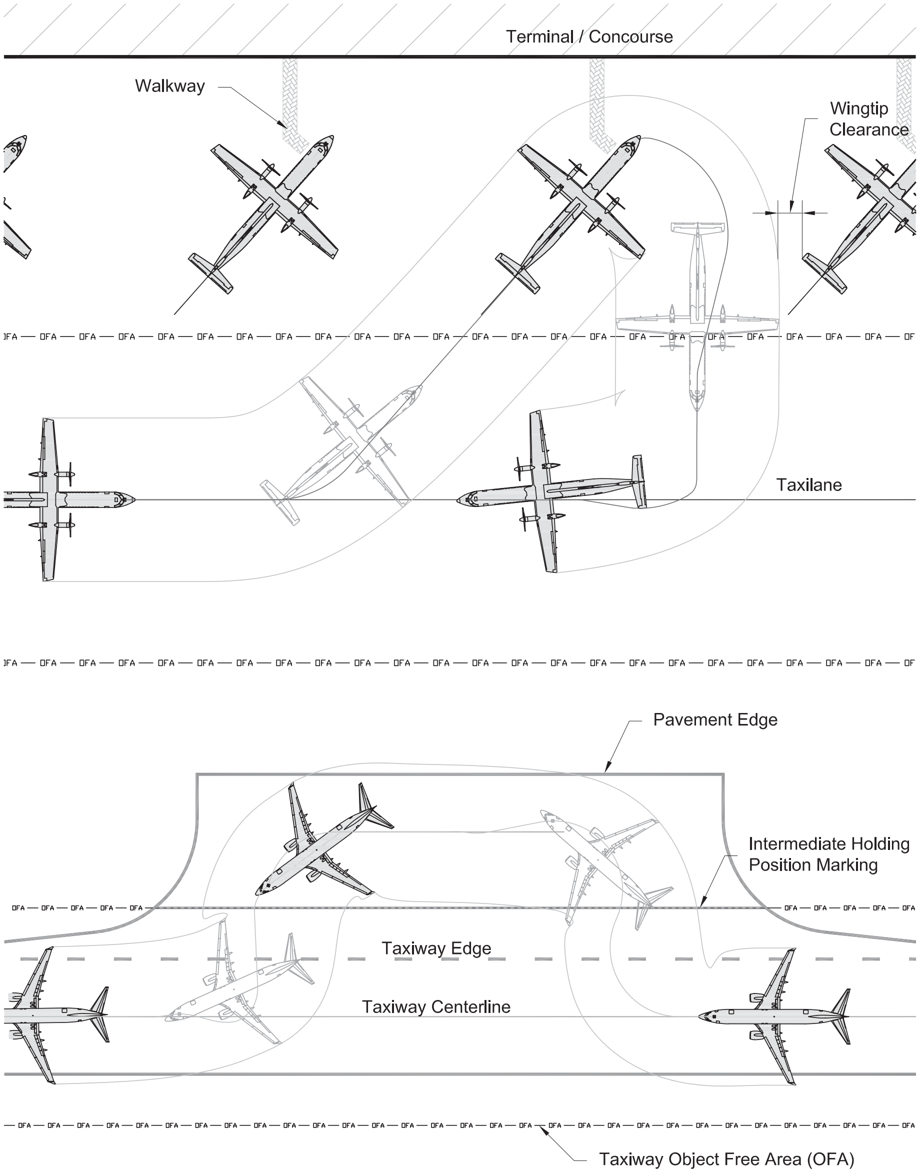
Power-out maneuvers are common on hold pads located along taxiways or taxilanes. As shown on Figure 4-11, aircraft typically turn onto the pad, maneuver along the taxiway/taxilane, turn toward the taxiway/taxilane, and park at either a 45-degree or 90-degree angle behind the holding position marking.

Key Points:

- Power-out procedures are most common for GA, regional turboprop, and regional jet aircraft.
- There are numerous potential hazards associated with power-out procedures for larger aircraft.
- Planning for power-out maneuvers typically requires more space than tug-out positions.
- Power-out maneuvers are common practice for hold pads and hardstand gate positions.

Deicing Pads

The FAA recommends that deicing pads have sufficient OFA, vehicle maneuvering area (VMA) for each parking position, and a vehicle safety zone (VSZ) located between positions, as shown on Figure 4-12. Deicing pad OFAs incorporate the clearances defined for taxilanes and taxiways, depending on the apron location in a nonmovement area or movement area, respectively. VMAs are accommodated by providing a minimum clearance of 12.5 feet around the entire aircraft. OFA clearances are usually sufficient to accommodate 12.5-foot VMAs. OFAs for ADG I and ADG II aircraft may not provide sufficient clearances for VMAs, requiring the space between the VSZ and the wingtip to be greater than the OFA. VSZs are located between parking positions to accommodate deicing vehicles, personnel, and other equipment when aircraft are taxiing into and out of the deicing pad. The FAA recommends a minimum VSZ width of 10 feet.



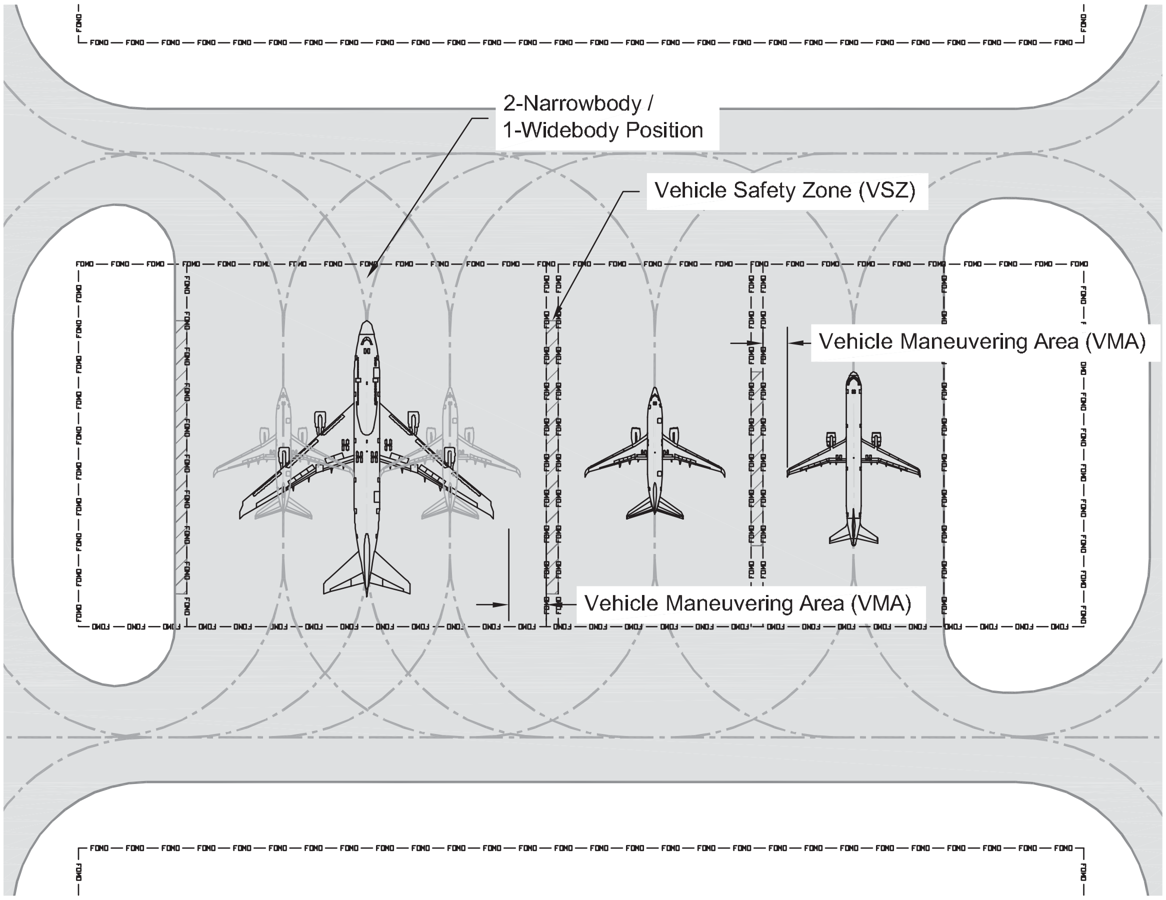
Source: Ricondo & Associates, Inc.

Figure 4-11. Power-out maneuvers.

Deicing pad positions can also be configured to alternately accommodate one widebody or two narrowbody aircraft. In these configurations, two VSZs can be provided outside of the outer wingtips of the narrowbody aircraft to avoid placement of a VSZ on the centerline for the widebody aircraft, as shown in the left side of Figure 4-12.

Key Points:

- Identify the size and number of aircraft that may simultaneously utilize a deicing pad based on activity forecasts, peaking characteristics, and the future design day flight schedule, if available.



Sources: Ricondo & Associates, Inc.; FAA Advisory Circular 150/5300-14B, Design of Aircraft Deicing Facilities, February 5, 2008.

Figure 4-12. Deicing Pad Clearances.

- The aircraft fleet occupying a deicing pad can vary substantially over the course of a day or peak hour, requiring consideration of overall flexibility when planning/designing a deicing pad facility.
- Allow a minimum 12.5 feet around the entire aircraft for vehicle movement areas.
- Recognize that operational procedures (pad access, priority, etc.) can significantly influence overall facility capacity.

Additional Guidance

FAA Advisory Circular 150/5300-14B, *Design of Aircraft Deicing Facilities,* February 5, 2008.

Apron Vehicle Service Roads

Vehicle service roads on the apron should be located with consideration for the operational requirements and FAA-dictated clearances (e.g., OFAs) to minimize the potential for aircraft interactions. The proper layout of apron roadways enhances safety by restricting vehicle traffic to identified corridors to reduce the potential for aircraft and vehicle conflicts.

Vehicle roadways on the apron should be capable of accommodating the largest airport vehicles anticipated to use the roadways, in terms of both physical size and weight. It is not uncommon for the weight of airport vehicles, such as ARFF equipment, cargo loaders, aircraft tugs, and fuel trucks, to reach or exceed 100,000 pounds gross vehicle weight rating. Although most apron roads are located on pavement designed for aircraft, roadways connected to an apron on pavement not used by aircraft must be capable of accommodating sustained use by this type of equipment without damage or deterioration. In conjunction with terminal planning, planners of head-of-stand roads must consider the required height clearances for the type of vehicles operating on these roadways to prevent damage to the PLB segments that span the roadway.

The minimum width of apron vehicle service roads is typically the same as that defined by American Association of State Highway and Transportation Officials guidelines, which identify a minimum width of 12 feet per lane. Apron roadway widths may be increased to accommodate GSE that exceeds this width or vehicles that require larger turning radii, such as fuel trucks, semi-trailer trucks, or buses. During the planning process, planners should coordinate with airport operators and tenants to understand the type, size, and frequency of vehicles operating on the aprons.

It is critical to maintain adequate clearance between all parts of a parked aircraft and the nearest edge of an apron service road. Some airports, particularly those with constrained apron areas that cannot be significantly expanded or reconfigured, are challenged to accommodate both parked aircraft and the service road without some limited overlap, as shown on Figure 4-13. In coordination with airlines and the airport operator, it may be possible to configure some aircraft apron parking positions so that limited overhang of the tail of the parked aircraft is acceptable. In this case, specific analysis is required to ensure that ground vehicle heights and aircraft tail heights are appropriately considered. While this apron service road configuration is not desirable, it may present a viable option at airports where space constraints prevent other solutions or aircraft parking configurations.

In all cases, a high degree of caution must be exercised by all airfield drivers when operating a vehicle in the vicinity of parked aircraft. All vehicle service roads should be clearly marked with the FAA-recommended "zipper roadway marking" to ensure that vehicle operators understand and can identify the defined limits of the service road.

Non-aircraft servicing vehicles that use the apron may require on-apron parking. These vehicles include delivery vehicles, trash removal vehicles, tractor trailers for delivery or snow melting, federal agency (TSA, CBP) vehicles, airport security and operations vehicles, and other contractor vehicles. Coordination with airport staff and apron users is recommended to determine the quantity and preferred location for parking spaces to accommodate these vehicles if they are

Source: A.S.S.E.T., LLC.

Figure 4-13. Tail overhang of apron vehicle service road.

required to remain in the apron area. Locating these parking spaces close to the terminal building is often preferred, as such location maintains greater distances between the vehicles and maneuvering aircraft, and increases safety and convenience for users of the vehicles by limiting their need to walk in the apron environment to access their vehicles.

For aprons that accommodate passenger or employee busing operations, specific dropoff areas should be provided as close as possible to the terminal building to minimize the distance that passengers or personnel have to walk in the apron environment. Bus stops serving secure passengers should be located where direct access to the security area complies with TSA rules, regulations, and procedures. Bus stops for employees allowed access to the secure apron environment should be located such that disembarking employees do not interfere with vehicle or aircraft movements.

Roadways for emergency vehicles should be provided where needed. Firefighting personnel may require dedicated roadways to directly access the apron environment in an emergency; parking may be prohibited in the vicinity of apron fire hydrants.

Key Points:

- Design roadways to accommodate the largest vehicles to utilize roadways in terms of weight and width.
- As much as possible, avoid service road configurations that require vehicles to pass under any portion of an aircraft.
- Consider emergency vehicle access requirements in apron service road planning/design.

PLBs

Planning for PLBs requires consideration of many variables, including maximum bridge slope limits in accordance with ADA requirements, PLB operating ranges, aircraft parking positions (location of aircraft and door sill on the apron), and the use of multiple passenger loading bridges.

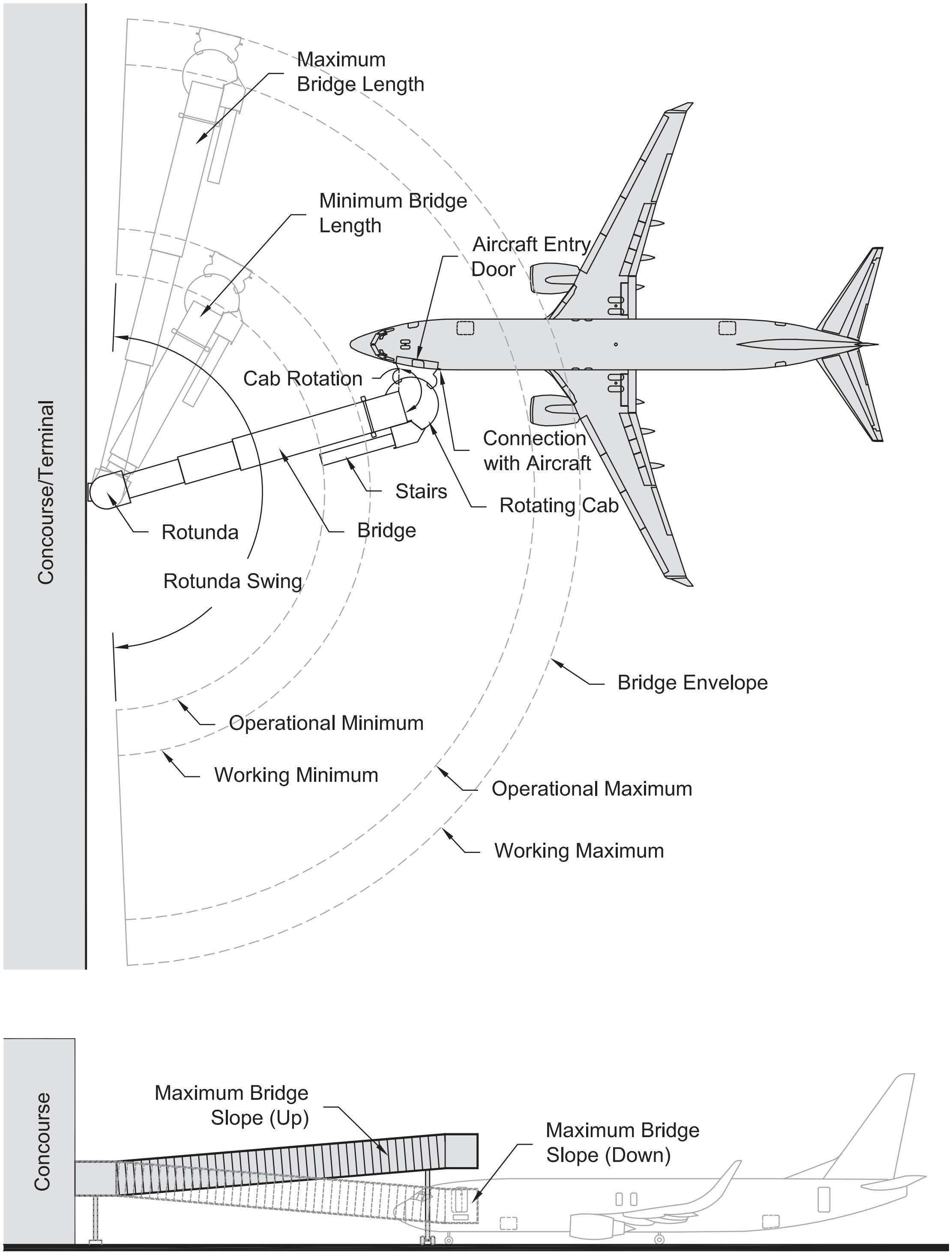
ADA Requirements

PLBs must comply with ADA requirements, which limit the maximum slope to 1:12 (8.33 percent) for the segment of the PLB spanning between the terminal and the PLB cab. For planning purposes, this span is typically measured from the tunnel hinge point at the rotunda closest to the building to the center point of the cab where the sloped tunnel section ends. ADA slope limits can be one of the biggest challenges in PLB planning, particularly in planning for aircraft that have relatively low loading door sill heights and apron depths that limit how far back the aircraft can be positioned without extending beyond the parking limit line.

Operating Ranges

Several models of PLBs are manufactured, and they provide varying operating ranges to accommodate a range of aircraft sizes and apron layouts. Fixed PLBs can generally move in two directions, with a tunneled section that can be extended and retracted as well as raised and lowered. Apron drive PLBs are capable of the same vertical and horizontal movements, but can also be rotated about a rotunda near the building face and have a rotating cab at the far end of the PLB. Apron drive PLBs are able to accommodate a larger range of aircraft by providing a greater range of movement.

PLB operating ranges vary with the bridge model, most notably relating to whether it is a two-tunnel or three-tunnel version. As shown on Figure 4-14, apron drive PLBs are typically



Source: Ricondo & Associates, Inc.

Figure 4-14. PLB operating ranges.

configured with two or three telescoping tunnels that have minimum and maximum operating ranges. The PLB operating range reflects the difference between the fully extended PLB and the fully retracted PLB.

The range of swing for the rotunda is limited and the cab has rotational limits. The operating range of a PLB can be electronically or mechanically limited to prevent the equipment from being used in a manner or configuration that could cause damage. Many airports in areas prone to hurricanes require apron drive PLBs to be stowed against the face of the building as part of hurricane preparations. Alternatively, anchors can be installed in the apron pavement to secure PLBs during these events. Fixed PLBs typically have a horizontal operating range reflecting the extension of a tunnel and a vertical operating range reflecting the raising or lowering of the tunnel.

Typically, the PLB rotunda is attached to a terminal or concourse building by a short fixed segment. The PLB rotunda can also be attached to a long fixed PLB segment if the aircraft parking position is located reasonably far from the building. Fixed PLB segments can also be used to raise or lower the rotunda floor height to help meet ADA slope criteria.

If the PLB is already installed, the operating ranges and slope limits are used to define possible aircraft parking layouts. If a PLB has not yet been installed, the aircraft parking position on the apron will be limited by the operating ranges of the PLB models under consideration, the door sill heights of aircraft that may occupy the parking position, and general pavement slopes in the apron area.

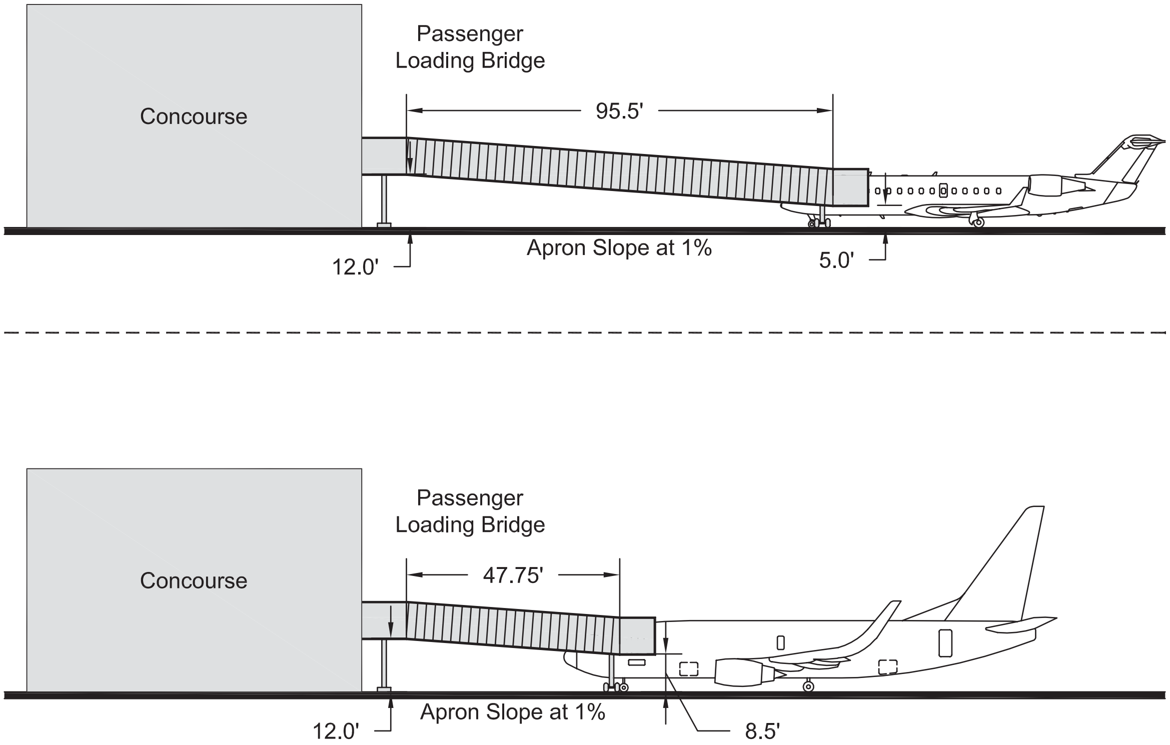
Aircraft Parking Positions

Planning for PLBs on an apron also requires consideration of the aircraft fleet mix to be accommodated at the parking position. Fleet mix data can be obtained from airport staff, the airline occupying the gate, or other relevant stakeholders. Consideration of aircraft types that may use specific parking positions or aprons in the future should be incorporated into planning for PLB equipment on an apron.

Aircraft with low door sill heights, such as regional jets, usually need to be parked farther away from the rotunda so the bridge can slope downward and stay within ADA slope limit requirements. Conversely, aircraft with high door sill heights may also need to be parked away from the rotunda so the bridge can slope upward and remain in compliance with ADA requirements. Generally, the retracted (i.e., minimum) length of a bridge is slightly greater than one-half or one-third of its fully extended length depending on whether the bridge consists of two or three telescoping tunnel segments. Planning for PLBs should also consider any special ramps needed for regional jets, turboprop aircraft or aircraft that require PLBs to be positioned lower than the aircraft door sill.

To plan for accommodating a wide range of aircraft, the needs of the smallest aircraft must be balanced with the needs of large aircraft that typically have higher door sill heights and need to be parked closer to the terminal building to avoid the tail extending beyond the apron parking limit. The greatest flexibility in accommodating a range of aircraft is achieved by increasing apron depth if space is available. Greater apron depth typically allows longer and larger aircraft to occupy a gate while also providing sufficient space for smaller aircraft to be positioned farther from the gate to meet ADA slope limit requirements for the PLB, assuming that the aircraft is positioned within the operating limits of the PLB.

Figure 4-15 provides a simplified example to plan for an apron drive PLB. Using AutoCAD or a similar program allows planners to test the capability of a particular PLB to serve multiple aircraft at a given parking position. Specialized computer programs are also available to assist with PLB planning.



Source: Ricondo & Associates, Inc.

Figure 4-15. PLB planning example.

Assuming that an apron adjacent to a terminal that has a second-level floor height 12.0 feet above the apron needs to accommodate four aircraft with the corresponding door sill heights:

- Boeing 737-700: 8.50 feet
- MD-80: 7.30 feet
- CRJ-900: 6.28 feet
- CRJ-200: 5.00 feet

The range of PLB capability needed to accommodate these aircraft must be calculated.

To determine the length of the PLB needed to accommodate the door sill height for the range of aircraft listed, use the following calculation:

$$\textit{Required Bridge Length} = \frac{\textit{Building Floor Height} - \textit{Aircraft Door Sill Height}}{\textit{Required Maximum Slope Percentage} - \textit{Apron Slope}}$$

The required maximum slope is 8.33 percent (1:12) to comply with the ADA.

A terminal apron typically slopes away from the terminal building at a minimum of 1 percent for the first 50 feet and at a minimum of 0.5 percent beyond 50 feet to meet National Fire Protection Association (NFPA) requirements (see Section 4.2.1). For the example below, a 1 percent consistent apron slope was assumed.

$$\textit{Required Bridge Length for Boeing 737-700} = \frac{12.0 - 8.50}{8.33\% - 1\%} = 47.75 \textit{ feet}$$

$$\textit{Required Bridge Length for Boeing MD-80} = \frac{12.0 - 7.30}{8.33\% - 1\%} = 64.12 \textit{ feet}$$

$$\textit{Required Bridge Length for CRJ-900} = \frac{12.0 - 6.280}{8.33\% - 1\%} = 78.04 \textit{ feet}$$

$$\textit{Required Bridge Length for CRJ-200} = \frac{12.0 - 5.00}{8.33\% - 1\%} = 95.50 \textit{ feet}$$

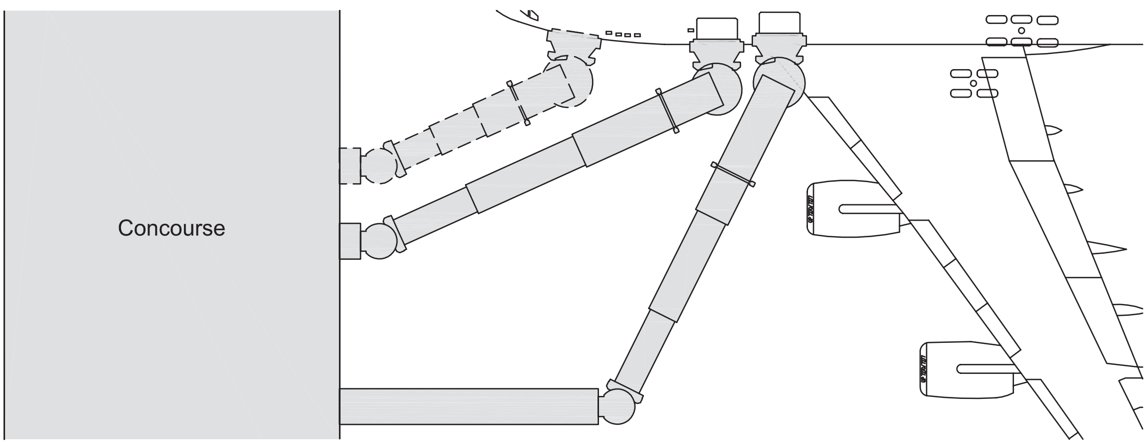
The required PLB length ranges from 47.75 feet to 95.50 feet. After determining the necessary operating lengths, the aircraft parking plan should be configured to ensure that the apron depth is sufficient to accommodate the aircraft tail farthest from the gate at the same time that the loading door is positioned at the point used to analyze PLB length requirements. Using the calculated operating ranges, a PLB model can be selected to achieve the aircraft parking and servicing requirements.

Multiple PLBs

The use of multiple PLBs to serve a single aircraft, as shown on Figure 4-16, requires consideration in planning the apron area and the interior of the terminal/concourse to ensure that the PLB attachment points and supporting holdrooms are appropriately located in relation to the aircraft parking position. Multiple bridges can be used to serve a single widebody aircraft or to serve two narrowbody aircraft within approximately the same gate envelope. Consideration must be given to accommodating the PLB operating ranges for both aircraft parking configurations. The methodology for determining the required PLB length is the same as if the position was served by a single PLB except that the length requirements must be calculated from the rotunda location and assumed elevation (which may differ from the terminal floor elevation), and which may be some distance from the terminal face if a fixed bridge segment is used.

Key Points:

- Identify types of PLBs to be utilized for specific airlines and aircraft operations.
- Planning/design must take into account loading and unloading of new generation large aircraft.
- PLBs can have a significant influence on apron/gate planning, particularly around the ends of pier concourses and along concourses.
- As much as possible, incorporate flexibility into PLB/apron planning to enhance the likelihood of accommodating fleet changes.



Source: Ricondo & Associates, Inc.

Figure 4-16. Multiple PLBs.

GSE Staging and Storage

Planning to accommodate the staging and storage of GSE contributes to a safer apron environment by ensuring that equipment not in use is positioned in areas that reduce the potential for aircraft and vehicle interaction. GSE staging areas are used to pre-position equipment in advance of an aircraft arrival. These areas are generally located adjacent to each apron parking position.

GSE storage areas are used to park GSE when not in use. These areas are often located on the apron in close proximity to aircraft parking positions, but outside the aircraft service 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. An apron can be configured with additional depth or wingspan clearance to increase the area for GSE storage and maneuvering. It is important to recognize that the GSE storage areas configured in proximity to the aircraft parking positions often have a shape and size (narrow and deep) that may not allow efficient access to stored/parked equipment/vehicles. In these cases, available gate-area GSE storage area may not be used as effectively as storage areas remote from the gate environment that are less limited by the aircraft service envelope, PLB operating zones, and building clearances/access.

Larger aggregate GSE storage requirements are usually accommodated in a separate area in close proximity to the apron. It is not unusual for GSE storage requirements to exceed the available area around parked aircraft. In such cases, GSE may have to be stored in areas that, while not immediately adjacent to the aircraft gates, are sufficiently close that operating efficiency is not significantly affected.

In assessing the amount of GSE storage space that may be required, an inventory of mobile equipment is necessary. Depending on the use of that equipment (number of flights served per day/night), it is possible that some GSE will always remain in service or be staged at gates awaiting arriving aircraft. Airports with a notable fleet of electric-powered vehicles (e.g., baggage tugs) may utilize space on the apron for charging stations for these vehicles, although these stations are also accommodated in lower level terminal/concourse space so that they are under cover. This space may occupy a large footprint to accommodate multiple charging stations and the ability to independently maneuver GSE into and out of the station. Stakeholder input is important in sizing GSE storage areas to ensure an understanding of the operational characteristics that may influence GSE use.

Many aircraft parking positions rely on a combination of fixed and mobile GSE. Examples of fixed GSE include mounted preconditioned air units, GPUs, and potable water supply cabinets. The use of fixed equipment reduces congestion around the aircraft parking position by eliminating additional stand-alone carts or vehicles. The following subsections describe the methods used in planning for GSE staging and storage areas for air carrier, cargo, and general aviation aircraft operations on the apron.

Key Points:

- Recognize that GSE storage can impose significant space demands in the apron environment.
- Understand the types and sizes of GSE that are in use at a particular facility when planning/designing an apron.
- Communicate with airlines and airport users to identify the types and amount of GSE that is required in the vicinity of the gates to support operations.

Air Carrier Aircraft

Air carrier aircraft are typically serviced while parked on an apron. Air carrier aircraft generally require baggage handling, refueling, galley servicing, lavatory servicing, and cabin cleaning.

Many GSE vehicles and fixed equipment may be used to service an aircraft simultaneously, as shown on Figure 4-17. All or some of these vehicles may be used depending on available fixed equipment, such as PCA units, GPUs, and existing hydrant fueling systems, and whether or not the APUs on aircraft are used.

When a gate or parking position is unoccupied, GSE staging areas should be provided around each aircraft parking position where possible. The staging areas allow for the pre-positioning of necessary GSE so that the aircraft can be promptly serviced upon arrival at the gate. As shown on Figure 4-18, GSE staging areas are typically provided outside of aircraft safety envelopes to be clear of aircraft appurtenances, such as wing-mounted engines and wingtips/wingtip devices. Some equipment may be safely staged within the safety envelope if it remains clear of aircraft during maneuvers into or out of the parking position. For example, Figure 4-18 shows a hydrant fueling cart staged within the aircraft safety envelope. The height of this equipment is sufficiently low and with it being secured to the apron, an aircraft can taxi into position without contacting the cart; however, personnel would not be allowed inside the aircraft safety envelope during the aircraft entry maneuver. Spatial requirements for GSE staging depend on the quantities and types of GSE needed, which can vary according to the size of aircraft and type of operation (domestic or international), passenger loading method, and airline operating preferences.

During nonpeak times or when certain types of mobile GSE are not required, it may be more practical and safer to store the mobile equipment away from the gate staging areas. Storage areas should be provided for airline GSE that is not in use or less frequently used. It may be possible to have a shared storage area for a group of gates shared by one airline, instead of individual storage

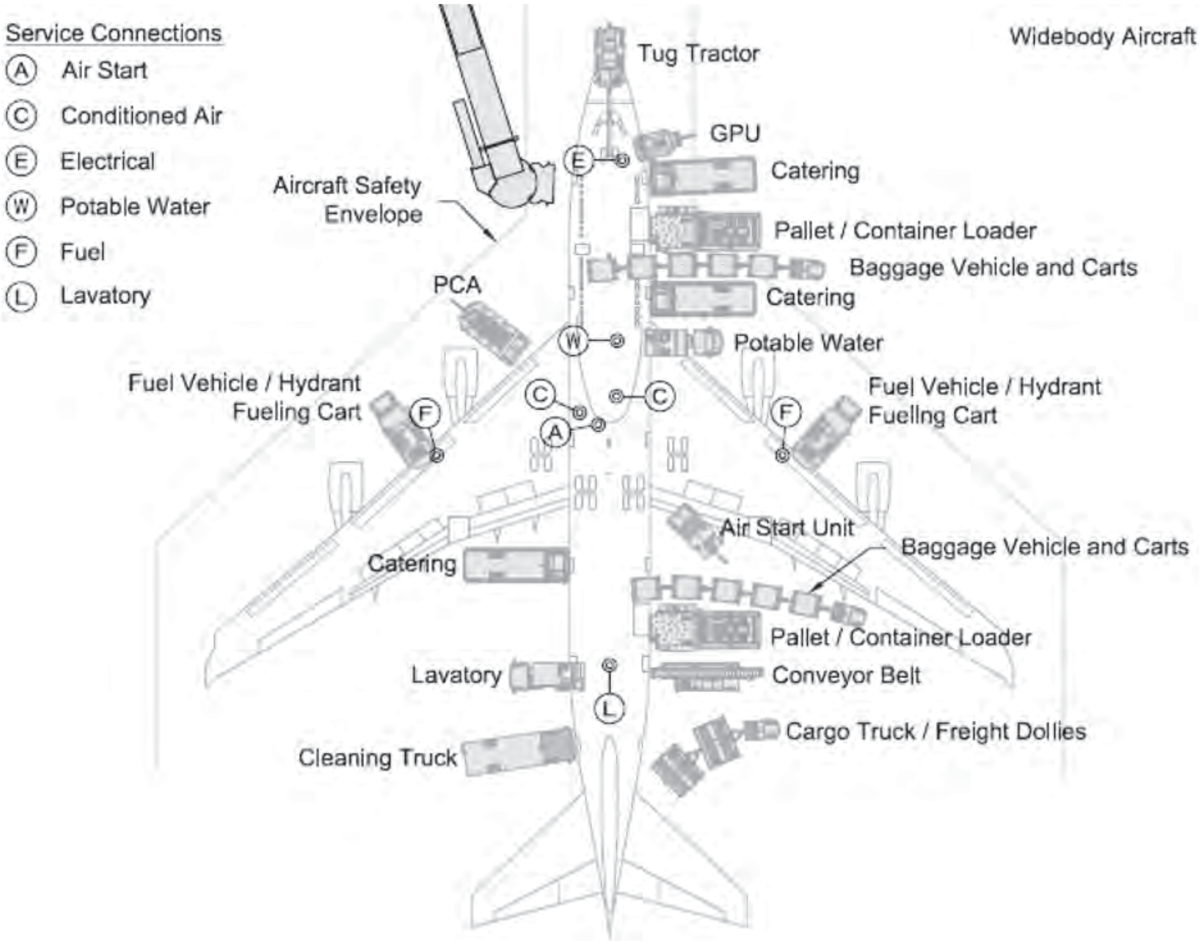


Figure 4-17. Representative aircraft servicing equipment.

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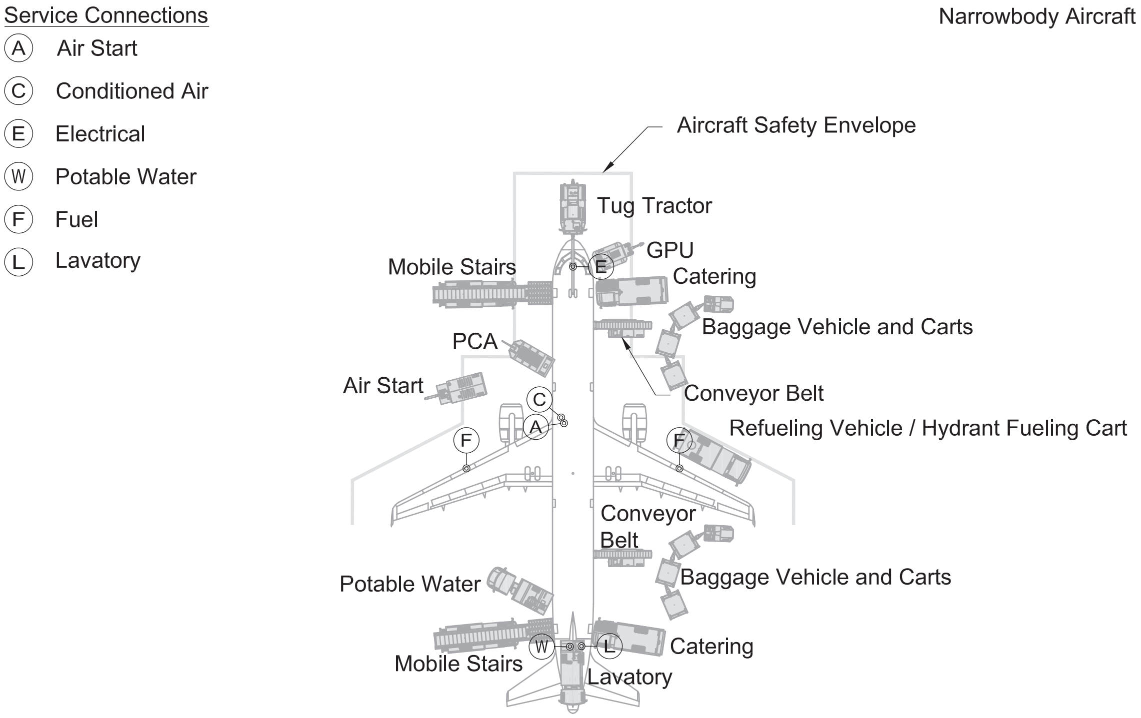
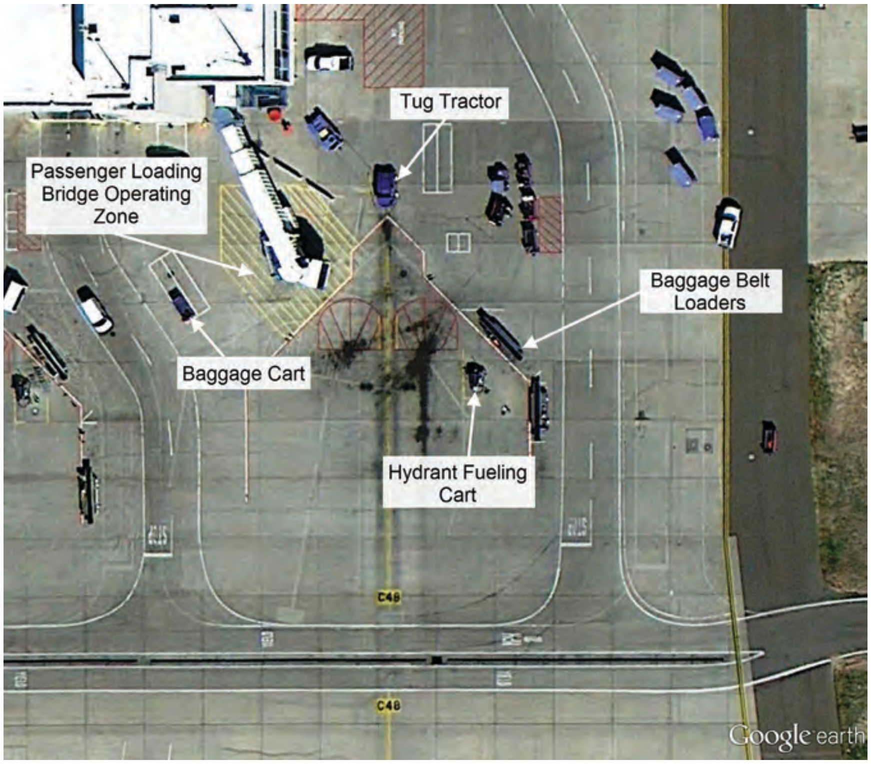


Source: Ricondo & Associates, Inc.; The Boeing Company, 747-400 Airplane Characteristics for Airport Planning, December 2002; Airbus S.A.S., A321 Aircraft Characteristics Airport and Maintenance Planning, June 1, 2012.

Figure 4-17. (Continued)



Source: Google Earth Pro.

Figure 4-18. GSE staging areas.

areas for each gate. As shown on Figure 4-19, these areas can be located adjacent to gates or in a separate area in close proximity to the apron. Remote storage locations help to keep the apron locations free of clutter, but these locations should not be so remote that it takes excessive time to reach the parking positions. In planning for these storage areas, the installation of physical barriers should be considered to prevent stored equipment from rolling away and to protect the equipment from jet blast exposure. The size of the storage areas is also dependent on the types and quantities of equipment to be stored, which should reflect airline input.

Source: Google Earth Pro.

Figure 4-19. GSE storage areas.

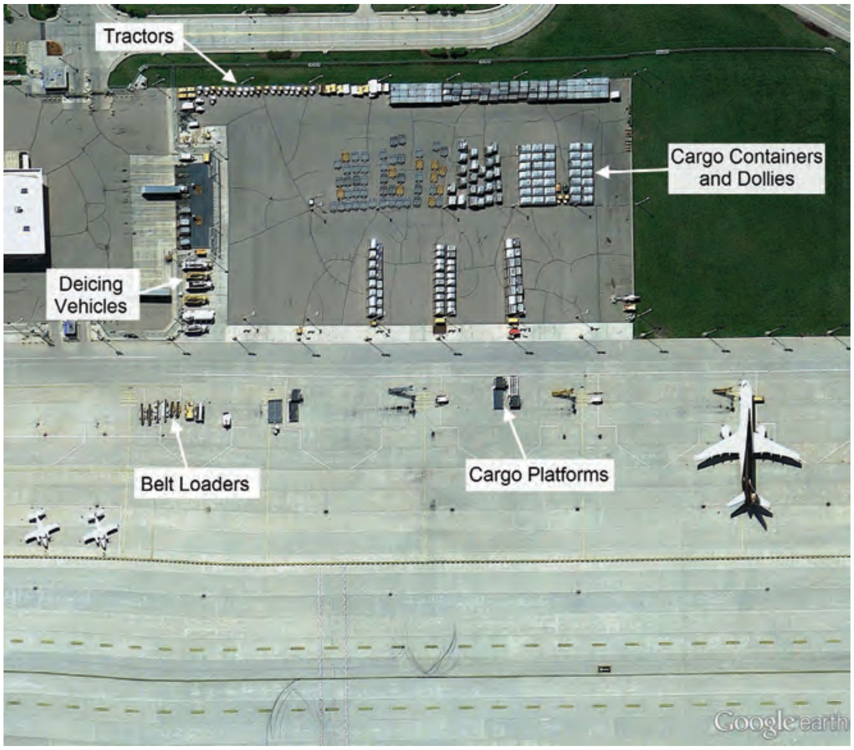
As planning for apron GSE staging and storage is largely driven by the equipment used by individual airlines, an inventory of GSE should be prepared through coordination with the operating airlines. Information on the aircraft service methods used on the apron is helpful. An inventory checklist outlining the items that should be considered for air carrier aircraft GSE staging is provided in Appendix A. Use of this checklist allows planners to conduct a detailed analysis of the GSE and aircraft service methods to be used, if warranted by the specific project. After this inventory is completed, the apron can be drawn with proper locations for staging and storage of GSE. Many GSE staging and storage areas are marked (on the pavement) to keep the apron organized and maximize the utility of the parking/storage area.

Key Points:

- GSE in use may vary significantly among airlines. Gather as much airline-specific information on GSE as possible when planning/designing equipment storage areas.
- Ensure that adequate GSE storage areas are included to support apron facilities to minimize the potential for equipment to be parked or stored in areas that may create safety or operational impacts.

Cargo Aircraft

Much of the GSE used to service cargo aircraft is similar to that used to service passenger air carrier aircraft, with the addition of cargo-specific loading equipment. Mobile stairs, GPUs, and cargo loading platforms are usually static and are not moved between parking positions. Cargo container loading vehicles, container tugs, and dollies are used to support all parking positions and usually staged near the parking area, as shown on Figure 4-20.



Source: Google Earth Pro.

Figure 4-20. Cargo GSE staging and storage.

Cargo operators also have a large amount of transport and loading equipment that is not in use throughout the day. Storage areas on and adjacent to cargo aircraft aprons should be provided for this equipment when not in use. The most space-intensive demand for cargo GSE storage is for cargo containers and dollies. This equipment is used upon aircraft arrival, during unloading and unpacking, and prior to aircraft departure for container packing and loading.

Similar to planning air carrier aprons, the cargo apron planning process should include an inventory of GSE used in the specific user's cargo operation as detailed as warranted by the specific project, including determination of the aircraft fleet and cargo container sizes, types, and quantities. An inventory checklist outlining the items that should be considered for cargo GSE storage is provided in Appendix A1. This information can be used for apron layout, identification of proper storage locations, and appropriate markings. It is important to consider space for maneuvering by container lift vehicles and cargo dolly trains. Storage areas need to be configured for personnel to walk among equipment, maneuver in and out of position, and be protected from jet blast.

Key Points:

- Recognize that all cargo aircraft operations generally require different types of ground service equipment and often require a greater quantity of equipment depending on cargo airlines' procedures for collecting, sorting, and staging outbound cargo.
- Due to the peaked nature of many all-cargo operations, it is critical to ensure that there is adequate GSE storage and staging areas, as well as service roads that support GSE movements in and around the cargo area.

General Aviation Aircraft

General aviation facilities are typically operated by FBOs that provide ground support services, commonly referred to as line services, which are generally the same types of services required for air carrier aircraft, but typically on a smaller scale. However, it is important to recognize that even widebody aircraft can be considered general aviation aircraft depending on the operator/operation.

As most general aviation aprons do not have marked parking positions to allow for flexible parking layouts (the fleet mix can vary substantially at a general aviation facility), GSE staging and storage do not typically occur adjacent to aircraft parking positions. It is not common for GSE to be pre-staged in advance of the arrival of a general aviation aircraft, except in the case of large aircraft (e.g., sports team charter, dignitaries). As shown on Figure 4-21, GSE storage areas on general aviation aprons are most often delineated areas at the edge of the apron, close to the terminal or maintenance buildings. This location provides servicing technicians with quick access to equipment, such as tow tractors, GPUs, fuel trucks, and follow-me vehicles. Follow-me vehicles are used by FBOs to guide general aviation aircraft to aprons. The staging area should be located to avoid obstructing passengers and pilots that may be walking to/from the terminal. The GSE can then be driven or towed, as needed, to the aircraft that requires ground support services. Usually, one co-located staging and storage location is used given the relatively small size of general aviation aprons.

An inventory checklist outlining the items that should be considered for general aviation GSE staging and storage is provided in Appendix A. Similar to planning for other aprons, the planning process for general aviation aprons should include an inventory of GSE required by apron users, including vehicles, and an inventory of the services provided by an FBO operating a general aviation apron. This information can be used to configure the apron, identifying appropriate storage and staging locations and marking them or identifying the general areas accordingly.

Source: Google Earth Pro.

Figure 4-21. General aviation GSE storage area.

Key Points:

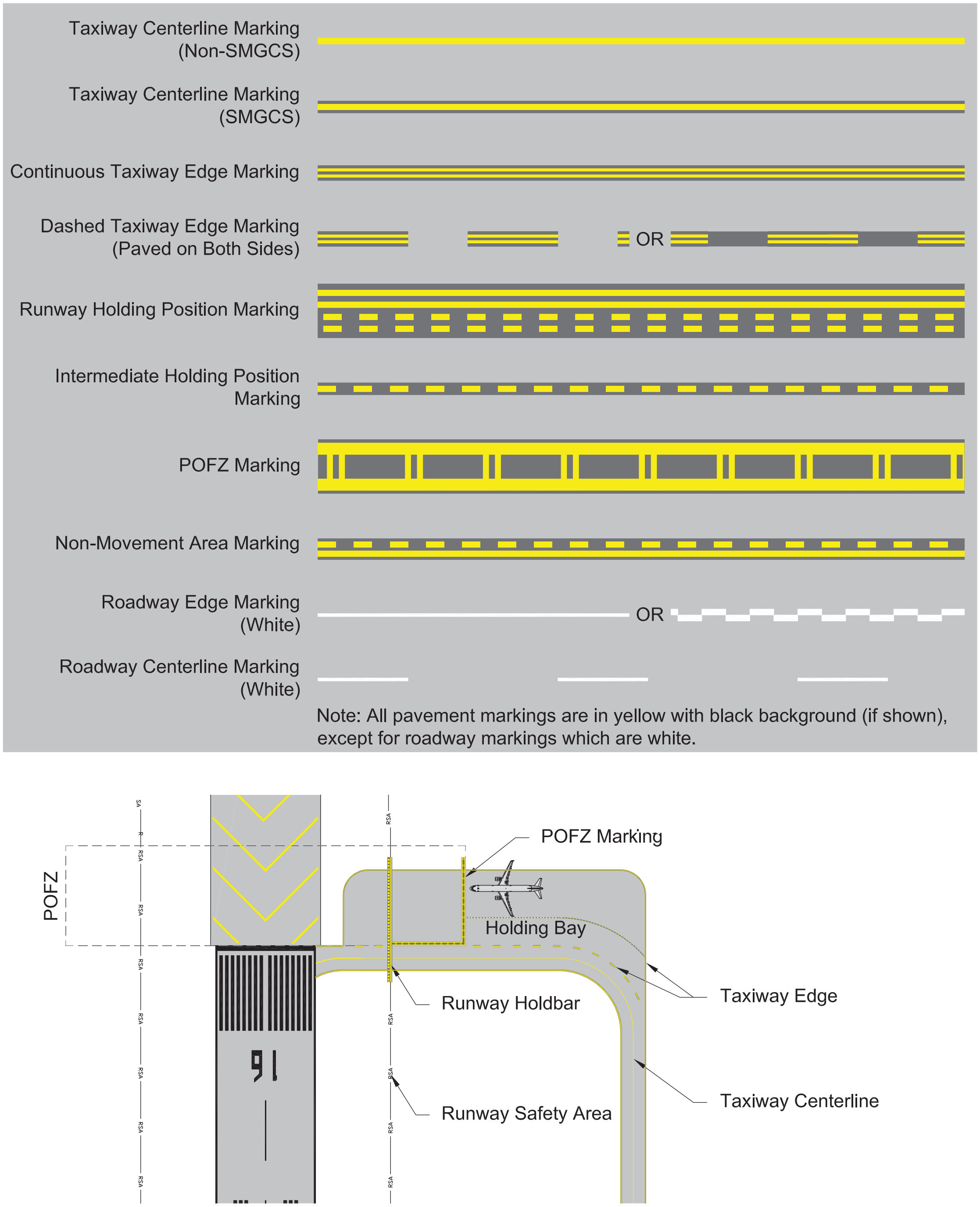
- It is critical to understand the specific line services offered by FBOs or other GA apron operators in order to plan for the necessary equipment.
- GA aprons can accommodate an extensive range of aircraft, which can have widely varying GSE/line service needs.

Pavement Markings/In-Pavement Lighting

Pavement markings and in-pavement lighting provide visual guidance to pilots maneuvering in apron areas, as well as into and out of specific parking positions or gates. The markings also aid ground crew personnel in accurately positioning aircraft for servicing and in enhancing safety by demarcating areas that must remain clear of personnel and equipment to avoid conflict with aircraft operations or servicing and to protect the safety of personnel, equipment, and aircraft. The following subsections describe apron-related FAA airfield markings and apron markings.

Apron-Related Airfield Markings

The FAA publishes marking guidelines for airfield elements, including those associated with or adjacent to aprons: taxiways and taxilanes, holding positions, nonmovement area boundaries, and roadways. Figure 4-22 identifies markings standardized by the FAA for airfield components, as discussed in the text that follows.



Note: All pavement markings are in yellow with black background (if shown), except for roadway markings which are white.

Sources: Ricondo & Associates, Inc.; FAA Advisory Circular 150/5340-1K, Standards for Airport Marking, September 3, 2010.

Figure 4-22. Apron-related airfield markings.

Taxilanes and Taxiways. All taxilanes and taxiways have a centerline marking that provides pilots with continuous visual guidance along a designated path. A taxilane/taxiway centerline marking consists of a yellow line, which is bordered in black when the taxiway is part of a Surface Movement Guidance and Control System (SMGCS) route. At some airports, a color marking may be added adjacent to a taxilane marking to help aircraft operators more easily identify specific taxilanes on aprons with multiple apron taxiways and taxilanes.

Taxiway centerline lights provide enhanced visual guidance to pilots in the area between a runway and an apron area and operating on the apron. Taxiway lights are not required, but are installed where other lighting may cause confusion for pilots taxiing or parking aircraft or to improve guidance to aircraft parking positions. These lights are green and offset from the centerline by approximately 2 feet.

Holding Positions. Holding position markings are used on taxiways and aprons to identify critical areas associated with runways, navigational aids, and RPZs. Different types of holding position markings are used for different purposes. Runway holding position markings are used on taxiways to hold aircraft short of an active runway and are placed at or beyond the RSA. These markings consist of two solid lines parallel with two sets of dashed lines. ILS holding position markings are used on taxiways to delineate the edges of critical areas and the POFZ that aircraft must remain clear of until directed otherwise. Intermediate holding position markings are most typically used by ATC to hold aircraft at taxiway-taxiway intersections in congested areas or on aprons in movement areas. The markings are yellow and consist of the pattern shown on Figure 4-22.

Nonmovement Area Boundaries. Nonmovement area boundaries are used to delineate movement areas under the control of the ATCT controller from nonmovement areas that are not under ATCT control (although aircraft may be under the control of ramp tower controllers when in nonmovement areas). The FAA recommends that a letter of agreement should be formalized between the airport operator and FAA ATC to specify the location of these markings.

Roadways. Vehicle roadway markings are used to delineate roadways located on or crossing aprons or airfield components. The markings are intended to reduce the risk of aircraft and vehicle interactions by channelizing vehicle movements, providing traffic guidance (signed or painted on pavement), and facilitating driver awareness of aircraft operating areas. Vehicle roadway markings consist of three components: roadway edge lines, centerlines, and stop lines. Roadway edge markings can be either solid white lines or zipper-style markings where roadway edges would benefit from enhanced delineation. Zipper-style markings enhance visual awareness for both vehicle operators and aircraft pilots. A dashed line is used to delineate the centerline separating the roadway lanes. Stop lines or stop bars are used at junctions with other roadways and at the fixed or movable object line when the roadway crosses a taxiway or taxilane. Vehicle roadway markings and stop bars are typically painted white. Supplemental markings that identify stop bars with the letters "STOP" or other roadway functions, such as a fire lane or restricted roads, may also be used.

Apron Markings

Consideration must be given to the clarity and density of apron markings in terminal and cargo areas to avoid visual confusion for both ground crews and pilots. The efficiency of apron areas can be greatly influenced by the amount of and type of markings. Given that the FAA usually does not control aircraft activity on aprons and does not currently publish guidance related to markings in the leased portions of the apron, planning for apron markings, other than airfield markings that are required by the FAA, is a site-specific activity. The Airports Council International (ACI), International Air Transport Association (IATA), ICAO, and Airlines for America (A4A, formerly known as the Air Transport Association of America) all publish apron marking guidelines; however, the application of these guidelines should reflect strong coordination with users, particularly at air carrier gates.

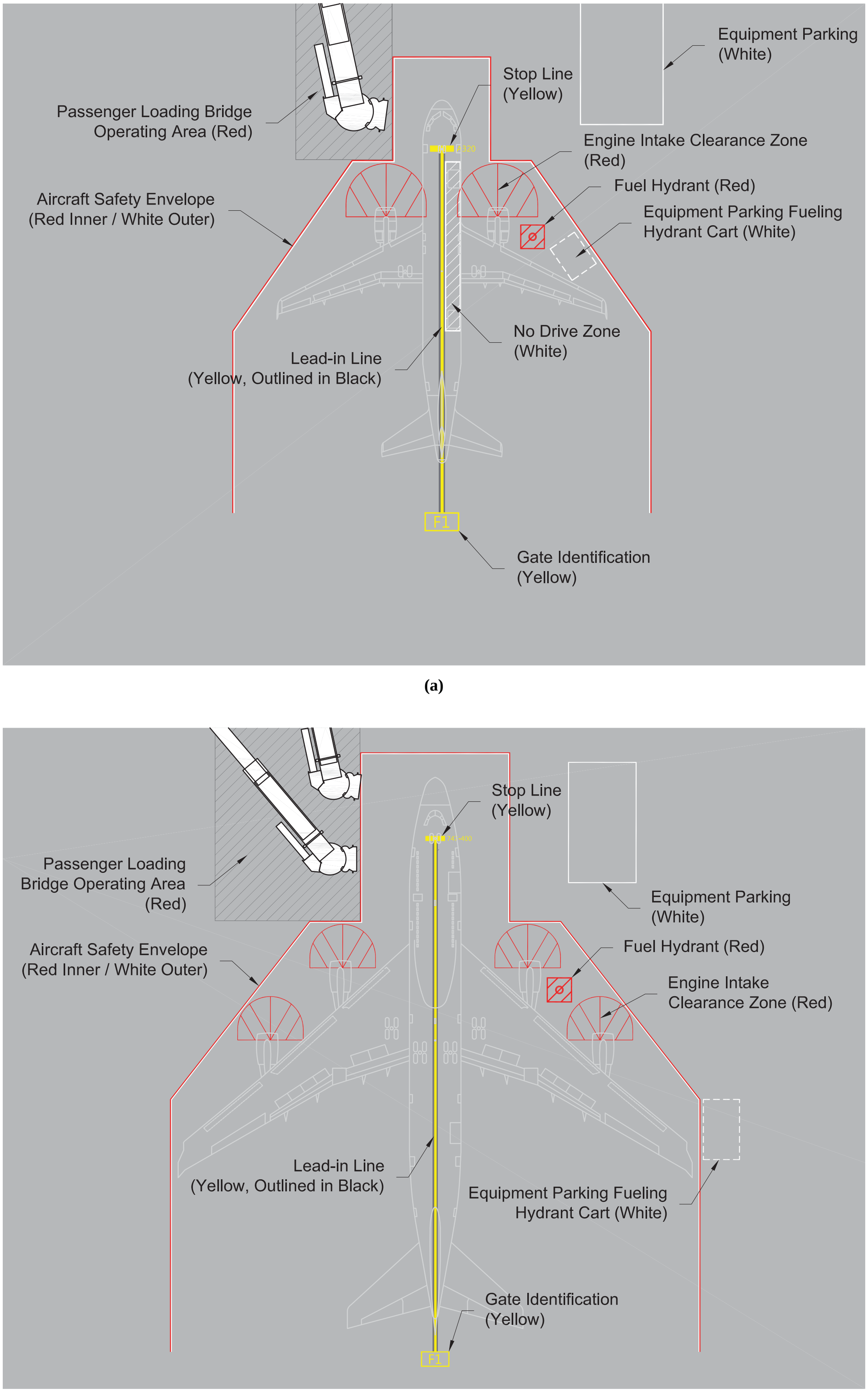
Apron markings can vary greatly among airports and can even vary among aprons and parking positions at a single airport. Contributing to this is that airports typically have responsibility for marking the areas of the ramp that are commonly used by operators (e.g., taxiways, taxilanes, vehicle service roads, air traffic hand-off points, etc.) to ensure that appropriate FAA standards are incorporated. However, the FAA does not have marking standards for the leased, nonmovement portions of aprons.

The operator or airline exclusively leasing an apron area or parking position(s) often uses its own marking standards that were developed and implemented to support its specific operations and practices. The application of an airline's specific marking standards allows that airline to maximize the utility and efficiency of the leased area, consistent with the safety priorities of that airline. This can be of particular benefit for airlines that have a hub operation or substantial activity at a particular airport, and/or at terminal facilities that are notably dated relative to current planning criteria. As aircraft have evolved and as airlines have changed the aircraft in their collective fleets, airlines have been challenged at some airports to efficiently accommodate those changes within the limits of existing airfield elements, aprons, and terminals/gates. Optimized use of an airline's apron, particularly when it cannot be expanded or significantly altered, can require that airline to configure aircraft parking differently than would occur if additional area/depth were available. In these cases, the marking plans reflect the apron-specific aircraft parking and servicing challenges and may differ from those in use by that airline at other airports and from those in use by other airlines at that airport. Apron markings in exclusively leased areas may not be standardized among airports, but rather reflect the airport-specific challenges and constraints, as well as the operational requirements of the airline.

Facilities shared by multiple users are often marked in a more standardized manner, typically following standards developed by the airport operator. These standards may result in a less efficient apron operation due to the need to operationally accommodate a more diverse group of users/equipment and to provide an acceptable level of safety (i.e., clearances, service envelopes, etc.) for the largest aircraft that could occupy the facility. For example, an aircraft gate exclusively leased to an airline may reflect that airline's own marking standards while a common-use aircraft gate, available to multiple airlines, will be marked according to airport operator standards to provide commonality and consistency among gate markings, irrespective of which gate an airline would be assigned to use. The level of responsibility by airport operators for marking aprons ranges from allowing lessees full control of apron marking to enforcing airport-generated marking standards. At a minimum, airport operators will require approval of marking plans for parking positions between leaseholds. It is recommended that when an apron lease expires, the apron markings are revised to reflect airport marking standards in case the apron is needed while not leased. In instances in which a leased gate is returned to the airport operator and not immediately leased to another airline, the apron markings utilized by the prior tenant should be reviewed in the context of potential uses and fleet. An airport-controlled gate may be used as temporary overflow aircraft parking, utilized to accommodate irregular or diverted operations, store GSE, and other potential uses. At the time the gate is returned, a determination should be made whether remarking is required to ensure that the apron area can safely accommodate anticipated or potential uses.

The types of markings used on aprons also vary depending on the type of operation and the size of the apron available. On general aviation aprons, fewer aircraft-specific markings are generally required to preserve the flexibility of the apron. Similarly, the more diverse the uses of a particular apron (overnight parking, aircraft deicing, hold pads, remote hardstand/ground loading), the more challenging it is to define a marking plan that accommodates the desired flexibility but does not become sufficiently prescriptive that operational efficiency or effectiveness is compromised. In these cases, the best marking plan is achieved with input from the users, the airport, and the FAA (particularly for facilities in the movement area).

The following paragraphs describe the markings and in-pavement lighting typically present on aprons and the locations where in-pavement lighting is frequently used. The different types of markings and variations used on aprons are presented for informational purposes; prior to developing an apron marking plan, planners should coordinate with airport users and management and consider the operational environment at the airport. Figures 4-23 through 4-25 illustrate various configurations of the markings.

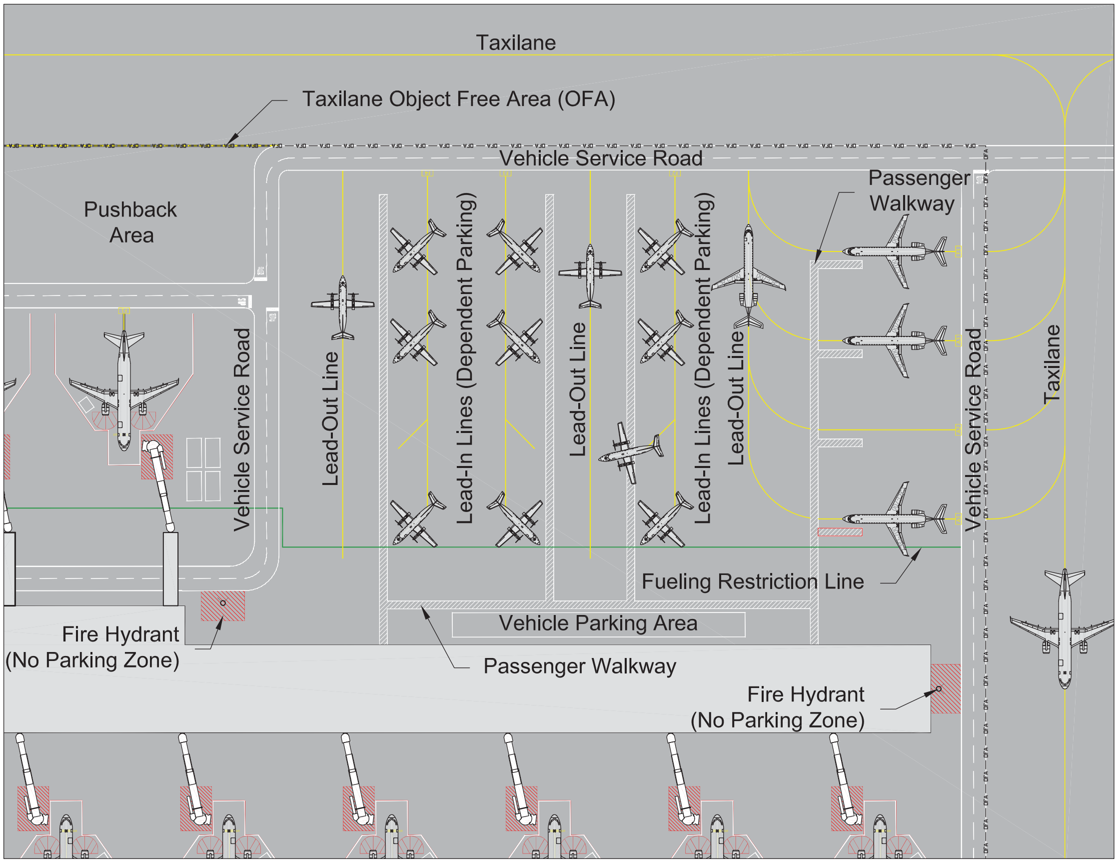


(a)

(b)

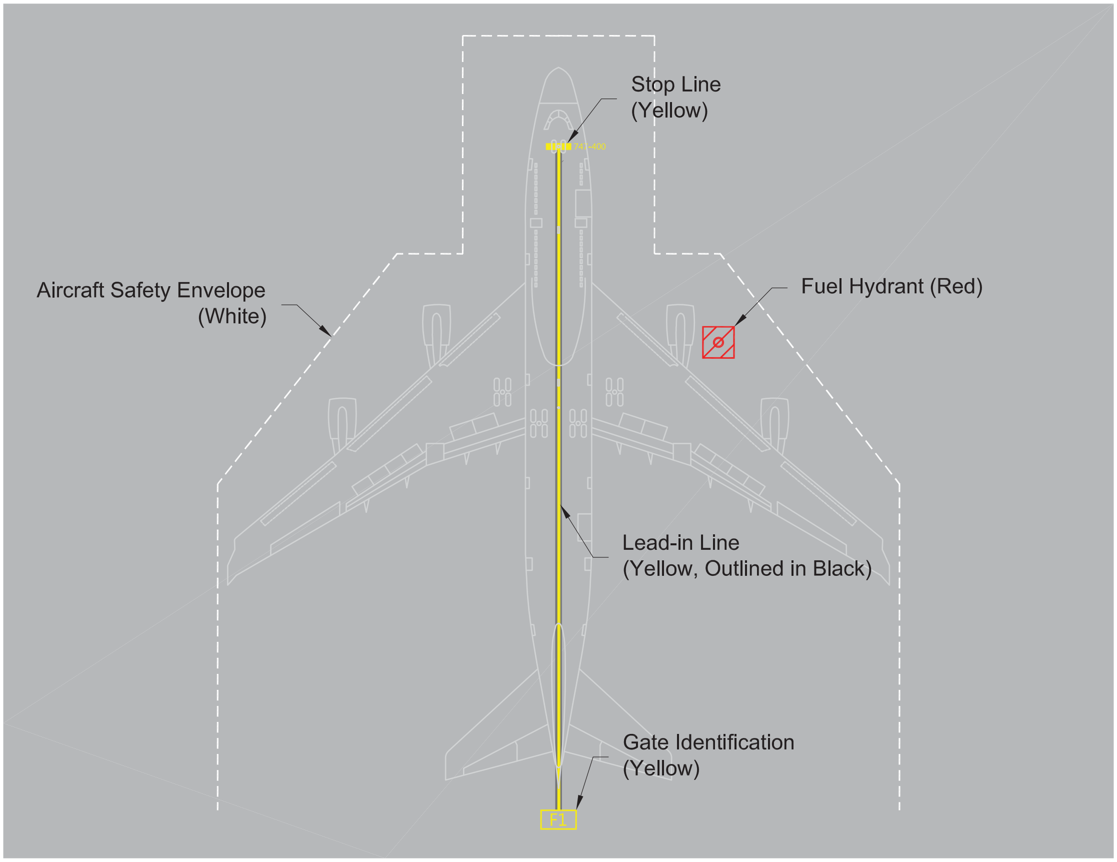
Source: Ricondo & Associates, Inc.

Figure 4-23. ***Terminal area markings: (a) narrowbody aircraft and (b) widebody aircraft.***



Source: Ricondo & Associates, Inc.

Figure 4-24. Terminal gate markings.



Source: Ricondo & Associates, Inc.

Figure 4-25. Cargo apron markings.

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 to be towed into a gate or aircraft parking position. When used in combination with aircraft safety envelopes, these lines provide necessary clearances from vehicles and equipment in the gate area. These lines are typically yellow and the same width as the taxiway/taxilane centerlines, but in certain instances, a lead-in line for a specific aircraft is identified by a different color. Lead-in/lead-out lines are outlined in black when necessary to provide contrast for light-colored pavement, such as concrete. More than a single lead-in line is possible at a parking position to accommodate a wider range of aircraft. In these cases, the centerlines are labeled to identify gate or position numbers (e.g., 29 and 29A), maximum wing span (e.g., MAX SPAN 118 FEET), or specific aircraft models (e.g., 747). A4A recommends that 24-inch letters be used to identify parking position or gate numbers.

Stop Lines. Nosewheel stopping points along a parking centerline are typically labeled by aircraft type (B-737, DC-9, etc.) and are provided to aid aircraft marshallers and aircraft tug drivers in positioning aircraft so that PLBs can accurately approach and be connected to the aircraft. Some airport operators implement a marking system in which stop lines are labeled with letters or numbers (e.g., A, B, C, D or 1, 2, 3, 4) that correspond with signage at the head of the gate that identifies the corresponding aircraft for each stop (e.g., A: 737, B: 757, C: A320). A4A recommends that 12-inch letters be used to identify nosewheel stopping positions. Deicing, holding, and RON aprons with lead-in lines often incorporate stop lines to ensure that the aircraft remains outside of any critical areas, such as OFAs.

Aircraft Safety Envelopes. 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. The area outside of the aircraft parking and service envelopes and outside of the PLB operational ranges, up to the building face, can be used for GSE parking and storage and other apron activities. The envelopes should accommodate a safety zone around jet engine intakes to avoid adverse engine suction on personnel and equipment. Aircraft manufacturers provide information on the recommended safety zones around engines when idling. These markings are typically solid red bordered in white to provide additional contrast between the marking and the pavement. Many cargo operators use only white markings to identify the aircraft safety envelope. A4A recommends 10 feet as the minimum distance that the safety envelopes should protect from any point on the aircraft.

Passenger Walkways. Markings are used on aprons to identify designated passenger walkways between ground-loaded aircraft and a terminal or concourse building. These markings are typically outlined in white with a white cross hatch. Passenger walkways should be configured to protect passengers from maneuvering/moving aircraft, aircraft engine intake zones/propeller safety areas, and ground vehicle movements, while also ensuring that ground personnel are able to effectively monitor and direct passengers to the intended aircraft without compromising safety or security. Passenger walkway marking plans should be reviewed with users to ensure that the proposed walkway configurations meet all safety and security needs.

Equipment Parking. At many airports, although not all, equipment parking lines are used to identify areas outside of the aircraft safety envelopes and the loading bridge operating ranges that can be used to stage or store GSE. These markings consist of a solid white outline that is usually rectangular and sized either for one piece of equipment or that may consist of one outline for parking multiple pieces of GSE. The only equipment that is typically allowed to park inside of the aircraft safety envelope is fuel hydrant carts.

PLB Operating Area. The area under and around passenger loading bridges must be kept free of vehicles, GSE, other equipment, material storage, and any other obstacles that could impede the range and safe maneuvering of PLBs. The markings should define the full operational range of the PLB necessary to accommodate the aircraft fleet serviced at the PLB. The operating area should also encompass all bridge appurtenances, such as baggage slides or elevators or attached equipment. This operating area is considered a no parking zone and is marked as such, by a red outline and red crosshatching oriented 45 degrees to the lead-in line. A solid white circle, outlined in red, is often used to identify a "home" position where a PLB is stored when not in use.

Fuel Hydrants. Fuel hydrant markings identify fuel system connections located on the apron. The markings for these vary, with airport operators using red or yellow boxes, centered on the in-pavement hydrant fuel pit connection, to identify their locations. The same markings can also be used to identify underground fuel ports for GPU and PCA connections. Text painted on the pavement may accompany these markings with the words "Fuel" or "No Parking."

Engine Inlet/Propeller Hazard Zones. In addition to engine exhaust jet blast, consideration and recognition of engine inlet and propeller hazard zones are critical to the safety of apron operations. Running aircraft engines generate sufficient suction to ingest unsecured equipment, materials, or people if not kept clear of the engine intake/ingestion areas. Propeller aircraft also create suction that can pull people or equipment into the propellers. Pavement markings can be used to define these hazards zones, which must be maintained clear of personnel, equipment, and materials. Pavement markings can also be used to define the area within which it is safe to approach a stationary aircraft that has engines running. Aircraft and engine manufacturers are the most accurate sources of dimensional information on engine inlet and propeller hazard zones. These areas can have a radius of up to 30 feet for some aircraft and engine models.

No Parking/No Driving Zones. No parking and no driving zones prohibit the parking or operation of vehicles and equipment in the marked areas. The markings encompass the no parking/no driving zones by a red line with red crosshatching within that is oriented 45 degrees to the aircraft lead-in line. This type of marking is used for multiple purposes, all of which are intended to keep vehicles, personnel, and equipment clear of specific areas, including PLB operating areas and engine intake and propeller hazard zones, and to provide building emergency access. No parking zones provide clear and expedient emergency access to fire hydrants and building firefighting systems and controls. Some aircraft and airport operators use no driving zones parallel to lead-in lines to keep GSE vehicles from driving under aircraft. These no drive zones are often painted white to minimize pilot confusion. No drive zones for PLB operating areas should be placed so that all equipment on the PLB (e.g., stairways, baggage slides and lifts) is contained in this area.

Engine Startup Positions. Apron markings are sometimes used to identify locations or boundaries that aircraft must be pulled to by an aircraft tow tractor before engine start can be initiated or breakaway thrust can be used.

Fueling Restriction Lines. Fueling restriction lines are used to identify areas adjacent to a building where fueling activities are not permitted in accordance with NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways.* These markings may be used on aprons without hydrant fueling systems to ensure that fueling activities do not occur near buildings. There is currently no industry guidance related to marking fuel restriction lines.

Some aprons may include markings that designate smoking areas for apron workers. Providing for these areas may enhance safety by ensuring that smoking does not occur near fueling activities or in other inappropriate areas.

Additional Guidance

FAA Advisory Circular 150/5340-1K, *Standards for Airport Marking,* September 3, 2010.

Airlines for America, SG 908: *Recommended Apron Markings and Identifications,* 2010.

ACI, *Apron Markings and Signs Handbook*, 2007.

Key Points:

- Incorporate specific types, designs, and colors of apron markings considering the specific user of the apron or gate area.
- Clearly identify all critical aircraft hazard locations that could endanger personnel or equipment.
- Coordinate all proposed apron/gate markings and labels with the ultimate user of the specific gate or apron area.
- Recognize the potential for confusion when there is significant density and types of apron markings.
- Clearly depict all areas that must remain clear of all equipment and vehicles for safety reasons and/or to ensure unencumbered access by emergency vehicles and equipment.

Signage

Apron signage is an important means by which information and instructions can be communicated to pilots and others on the airfield. The FAA requires airport operators to develop signage plans that incorporate mandatory instructions, location, boundary, direction, destination, roadways, and information signs (e.g., radio frequencies, noise abatement procedures). These plans can extend to apron areas, particularly the movement area that extends into a portion of the apron.

Elevated airfield signs are limited on aprons (generally fitting only on-apron entrances and exits) because parked aircraft limit visibility of the signage, aircraft movements on aprons are not channeled as much as they are on taxiways/taxilanes, and flexibility in aircraft movements and parking is critical. Many of these signs are used at the apron edges to identify taxiways or taxilanes, holding positions, safety areas, OFZs, ILS critical areas, and runway approaches. Signage may also be used to identify apron entrances, apron destinations (such as hold and deicing areas), passenger and FBO terminals, engine run-up areas, compass calibration pads, and fueling facilities. In addition, signs that warn pilots of the end of a taxilane or edge of pavement are used.

In the terminal area, gate signage assists pilots in locating gates and is often located on the terminal/concourse face or on the cab of a PLB. Internally lighted gate signage is recommended as it increases visibility during nighttime hours or low visibility conditions. Airport operators or hub airlines often use dynamic signage on terminal aprons, known as ramp information display systems that provide information to airline and ramp personnel. These systems often display flight numbers, destinations, scheduled times, and time remaining for aircraft departure and arrival.

Building-mounted signs typically define the function of a building or identify the entrances to a building, such as FBO and CBP facilities. On general aviation aprons, building signage is used to identify service operators and advertise their business name and services available. Fueling areas are often signed with the fuel vendor's brand, type, and cost. Figure 4-26 shows several examples of signs used on-apron facilities.

Surface-painted or thermoplastic-applied signs are used where elevated signs are prohibited or not practical and to reinforce elevated signs at critical locations. On aprons, these are generally limited to defining parking spots in conjunction with apron markings.

Truck-mounted signs are often used for follow-me vehicles used during SMGCS operations or by FBOs to guide unfamiliar pilots to their facilities.

(a) (b)

(c) (d)

Source: Ricondo & Associates, Inc.

Figure 4-26. Apron signage: (a) informational sign; (b) runway approach sign; (c) no entry sign; and (d) gate signage.

Key Points:

- Due to the expansive and flexible nature of aprons, it is often difficult to install apron-level signage, emphasizing the need for clear and unambiguous pavement markings.
- Apron signage to be designed for adequate visibility from numerous locations around an apron area.

Additional Guidance

FAA Advisory Circular 150/5340-18F, *Standards for Airport Sign Systems,* August 16, 2010.

Lines of Sight

Aprons are often controlled by personnel in either an ATCT or a ramp tower. Where these towers are used, it is critical to ensure a clear line-of-sight to aprons.

ATCT

The FAA advises that controllers in an ATCT cab must have an unobstructed view of all controlled movement areas. Although it is desirable to have the ability to view all pavement surfaces (edge to edge), it may be sufficient to view only pavement centerlines where a clear view of an aircraft on that centerline is possible. The FAA also sets visibility requirements for object discrimination, which is a quantitative assessment based on observation range, ATCT height, and atmospheric and surface conditions. Angle of incidence is another criterion used by the FAA to assess an observer's viewing perspective of movement areas. For general planning purposes, the angle of incidence for line-of-sight (or the angle of the sight line to the ground at the location of the airfield component) should be equal to or greater than 0.80 degree.

ATCT controllers should have the ability to clearly view aircraft entering movement areas or aircraft pushing back into movement areas from aprons. Many aprons are located in or adjacent to movement areas, making it necessary to consider line-of-sight when planning apron facilities. Such consideration includes ensuring that aircraft parked on a new apron will not cause line-of-sight shadows to movement areas, particularly when considering tail heights.

Key Points:

- Design of apron areas must permit unobstructed visibility from the ATCT or airline ramp tower.
- FAA air traffic controllers must have unobstructed visibility of any hand-off points at which aircraft exiting an apron area transition to the movement area.

Additional Guidance

FAA, *FAA Order 6480.4A Airport Traffic Control Tower Siting Process*, April 10, 2006.

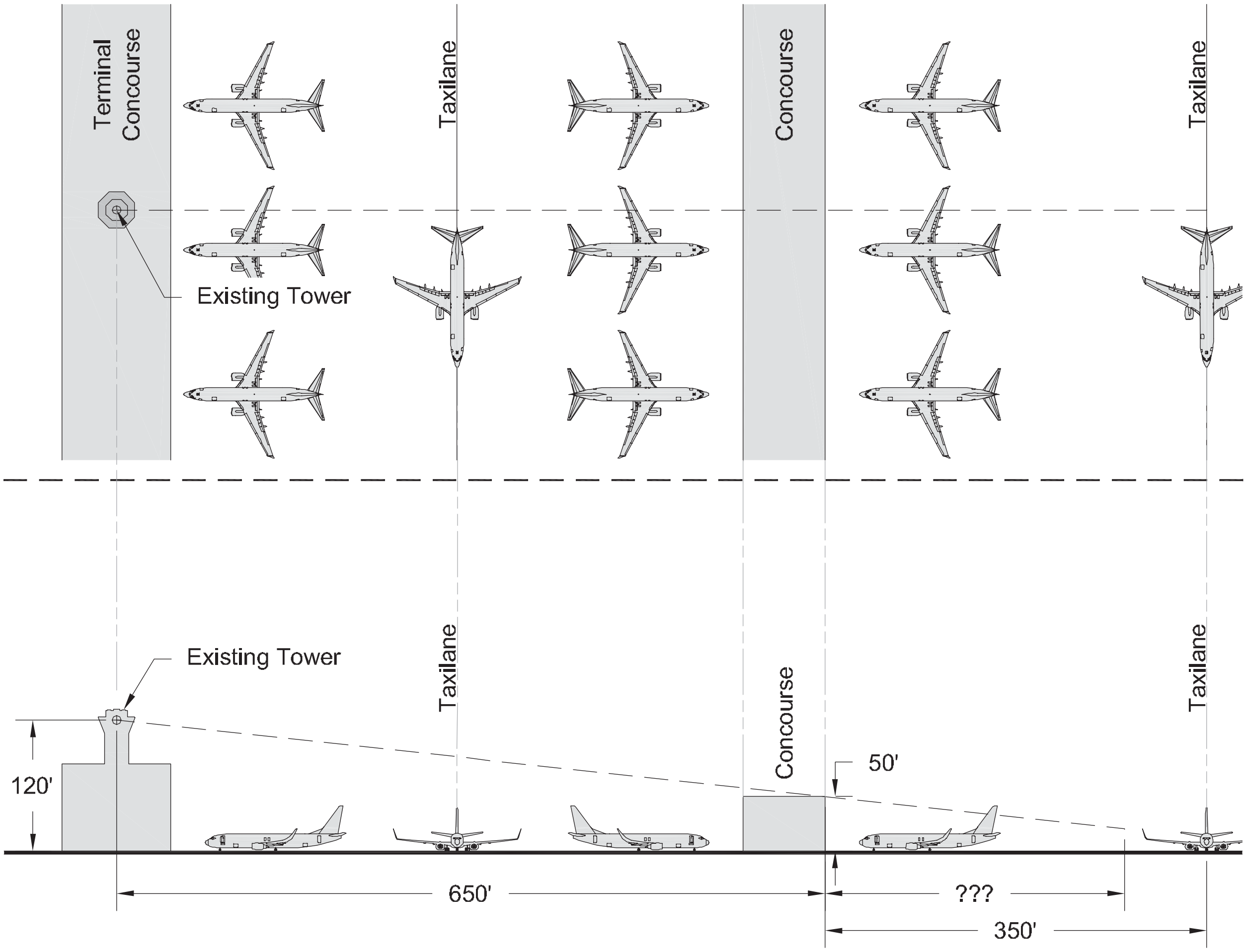
Ramp Tower

Maintaining a clear line-of-sight from a ramp tower is desirable to ensure that aircraft can be moved safely into and out of aprons, including gates and deicing positions. A clear line-of-sight is especially desirable for terminal gates where many aircraft and vehicle movements occur simultaneously. In areas where the unobstructed view of an apron from a ramp tower is not possible, CCTV has been used to provide supplemental viewing from the ramp tower when coordinated and approved by all tower users and aircraft operators.

The FAA has not published specific criteria for the siting (location) or height of ramp towers. In a terminal area, ramp towers should be sufficiently tall to provide an unobstructed view over the tails of aircraft parked on the terminal or cargo ramps to enable identification of any aircraft taxiing on the most inboard taxilane. Although it is most desirable to view all areas of an apron or taxilane, in cases where this is not possible, the ability to view the fuselage of an aircraft should be maintained at a minimum. Given the range of aircraft sizes, understanding the aircraft fleet projected to use the apron is critical. Planning for a ramp tower or apron should provide for the ability to view the smallest aircraft in the projected fleet over the tails of the largest aircraft in the fleet. Figures 4-27 and 4-28 illustrate the general calculations used to determine the necessary eye height for a tower or to determine if a tower provides an unobstructed view of a planned apron. Eye height is usually assumed to be approximately 5 feet above the floor of the tower. The tower structure would be taller than eye height to accommodate the roof structure plus any utilities or navigational equipment.

An important factor in the planning of ramp towers or aprons to be controlled by a ramp tower is ensuring that all stakeholders agree with the proposed ramp tower location, height, and apron layouts. The operators of ramp towers vary, but often include airport or airline personnel or third-party contractors.

As shown in Figure 4-27, an existing ramp tower is located some distance from a proposed concourse building that would have a taxilane located on the far side. The eye height for the existing ramp tower is 120 feet above ground level (AGL). The proposed concourse building (including appurtenances, such as air handling units) is 50 feet AGL with the same base elevation as the existing concourse. The far edge of the proposed concourse building is 650 feet from the ramp tower and the taxilane is 350 feet from the building. Will a controller in the existing ramp tower be able to view the centerline of the proposed taxilane?



Source: Ricondo & Associates, Inc.

Figure 4-27. Ramp tower planning example – determining apron visibility from existing tower.

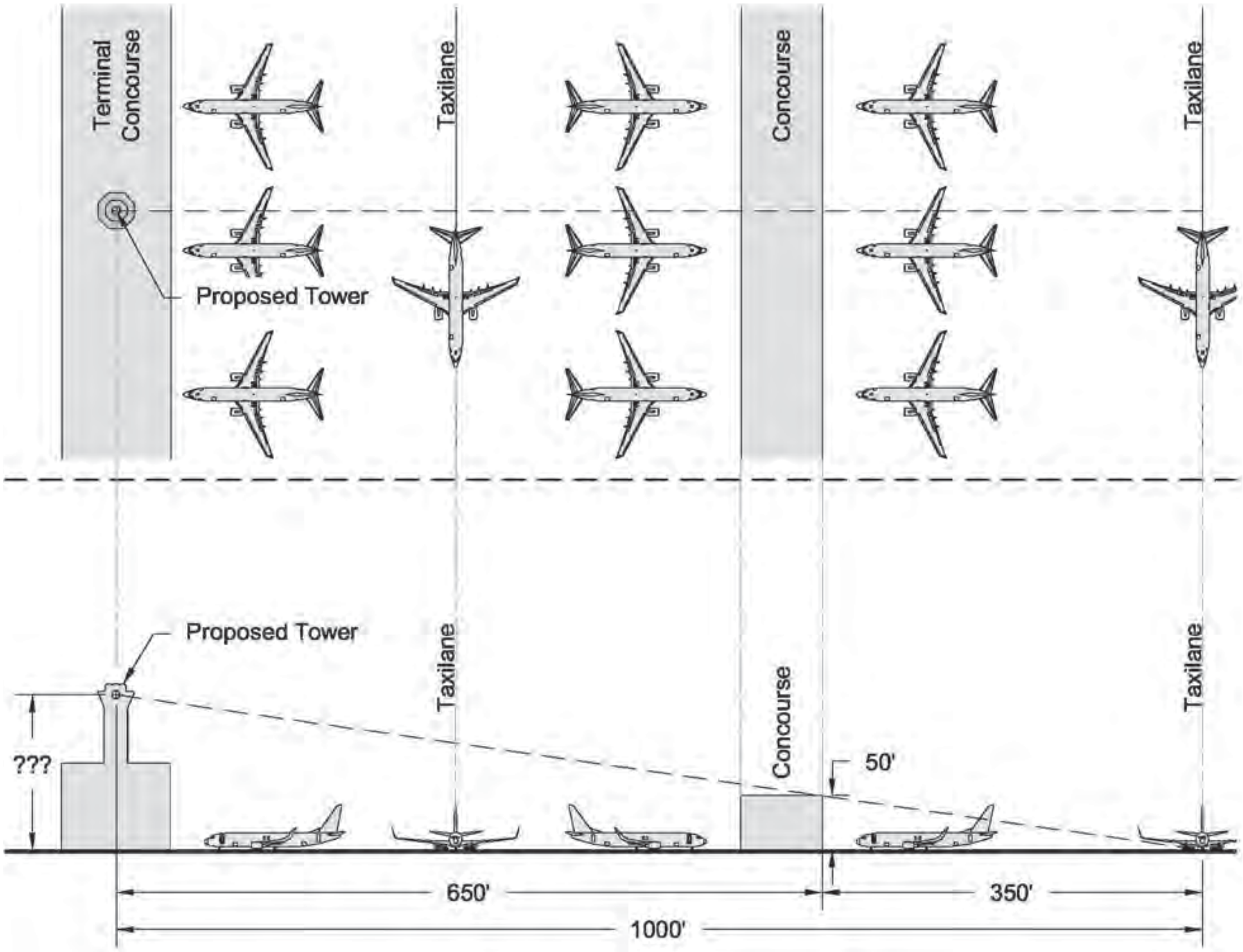
To determine the length of the line-of-sight shadow created by the proposed concourse, compare the rise and run for these two similar triangles:

$$\frac{\textit{Height of tower eye height over proposed building}}{\textit{Distance between ramp tower and far side of proposed building}}$$

$$= \frac{\textit{Height of proposed building over taxilane centerline}}{\textit{Length of shadow}}$$

$$\frac{120' - 50'}{650'} = \frac{50'}{\textit{Length of shadow}} \rightarrow \textit{Length of shadow} = \frac{50' \times 650'}{(120' - 50')} = 464.3'$$

As the length of the shadow was calculated to be 464.3 feet, which exceeds the distance between the proposed concourse building and the taxilane, the centerline of the taxilane would not be visible from the ramp tower (the shadow would extend over the taxilane, obstructing the view of the centerline). It should be noted that this is a simplified example for illustration purposes only; the slope, both latitudinal and longitudinal, and the elevation of the apron at several locations along the building must be verified.



Source: Ricondo & Associates, Inc.

Figure 4-28. Ramp tower planning example – determining ramp tower height.

In the example shown on Figure 4-28, a ramp tower is being proposed to view the taxilane on the far side of a proposed concourse. What eye height is required to provide unobstructed line-of-sight to the centerline of the taxilane?

To determine the eye height necessary to view the taxilane, compare the rise and run for these two similar triangles:

$$\frac{Eye\ height\ of\ ramp\ tower}{Distance\ between\ proposed\ ramp\ tower\ and\ taxilane}$$

$$= \frac{Height\ of\ concourse\ building\ over\ taxilane\ centerline}{Distance\ between\ concourse\ building\ and\ taxilane\ centerline}$$

$$\frac{Eye\ height\ of\ proposed\ tower - 50'}{1000'} = \frac{50'}{350'} \rightarrow Eye\ height\ of\ proposed\ ramp\ tower$$

$$= \frac{50' \times 1000'}{350'} = 142.9'\ AGL$$

The proposed ramp tower would need to have an eye height of 142.9 feet AGL to view the taxilane centerline. It should be noted that this is a simplified example for illustration purposes only; the slope, both latitudinal and longitudinal, and the elevation of the apron at several locations along the building must be verified.

Key Points:

- Design of apron areas should permit for unobstructed visibility from the ATCT or airline ramp tower.
- There may be opportunities to provide visibility coverage to limited apron areas through the use of CCTV when these areas are not in the movement area.
- Ramp tower controllers can be crucial in the efficient and safe movement in and around the apron area, particularly during periods of high activity.

Jet Blast and Propeller Wash

Jet blast and propeller wash from aircraft maneuvering in the apron/gate area can create a safety concern given the density of activity, personnel, and equipment in a tight area. Jet blast is the thrust-producing exhaust from a running jet engine and propeller wash is the air mass from the thrust of an aircraft propeller. Jet blast and propeller wash velocities and temperatures vary with engine type, aircraft type, amount of thrust applied, and the engine height above ground. Velocity and temperature dissipate with increasing distance behind the aircraft. The effect of jet blast is more pronounced for engines mounted under the wing of an aircraft than for tail-mounted engines because of their height above apron-level personnel and equipment. However, the effects of jet blast from tail-mounted engines can be material for terminals/concourses if the facilities are configured so that aircraft engines direct exhaust against the building surfaces. Blast velocities and temperatures increase with increasing engine size and power. While takeoff engine power is not experienced on aprons, idle engine power is typical and breakaway engine power is likely. Breakaway engine power is the power applied to transition the aircraft from a still (idle) position to taxiing movement (initiate roll).

Aircraft are often maneuvered in close proximity to other aircraft, ground crews, GSE, and ground-loaded passengers when arriving at or departing from a parking position. Consideration of the potential for jet blast and propeller wash exposure is necessary to ensure that an appropriate level of safety is provided in the apron/gate area, given the possibility for airborne foreign object debris.

During the planning phases, it is important to consider the characteristics of the aircraft that will use or transit the apron. Aircraft manufacturers provide information on aircraft characteristics, including jet blast and propeller wash, specific to each aircraft type and model for airport planning manuals. Using these characteristics, the potential effects of jet blast and propeller wash can be evaluated for each aircraft type. Planning for the safe accommodation of, or protection from, jet blast and propeller wash starts with having a clear understanding of the specific characteristics of aircraft using the apron, as well as the standard operating procedures at each airport.

Information on jet blast and propeller wash velocities and temperatures is depicted as contours, typically contained in airplane characteristics for airport planning manuals provided by manufacturers for each aircraft and engine model. Contours are typically provided for ground idle, breakaway, and takeoff power operations under specific conditions, including sea level, zero wind, and standard day conditions.

Jet blast or propeller wash velocities over 30 miles per hour (mph) are considered to be excessive, given the potential for loose objects (foreign object debris, ground equipment, stored materials, etc.) to become airborne, which can lead to personnel injuries or damage to equipment or buildings. Jet blast and propeller wash velocities are irregular, can introduce vibrations, and should be considered when planning structures near an apron. FAA guidance recommends using the National Weather Service Beaufort Scale to determine maximum jet blast or propeller wash velocities. The following velocities are appropriate for use in apron planning or evaluation.

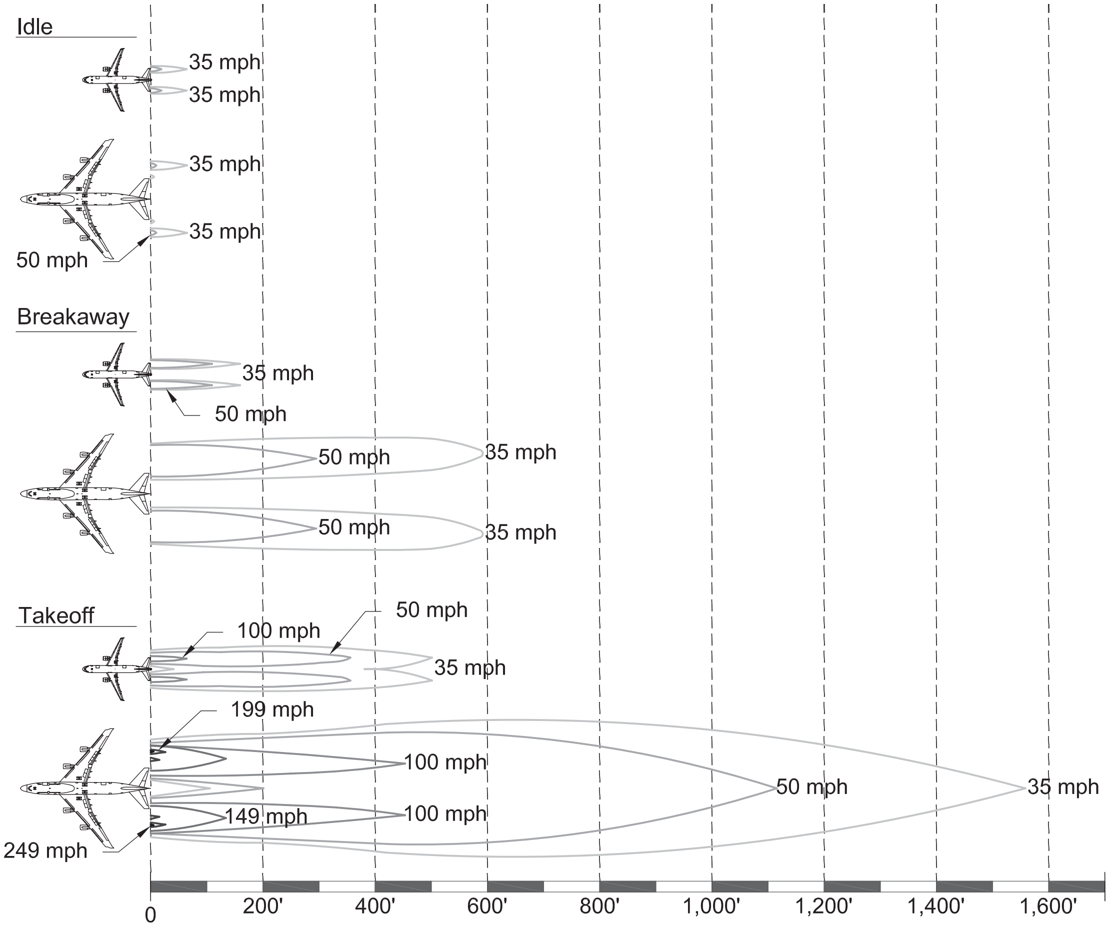
- Terminal tail-to-tail parking – 35 mph (56 kilometers per hour, km/h).
- Terminal parking where parallel or skewed terminals (e.g., V-configuration) face each other:
  - 50 mph (80 km/h) maximum to determine the "reach" of initial jet blast from aircraft taxiing in and out and its effects on the facing terminal and associated service road.
  - 35 mph (56 km/h) maximum under breakaway thrust conditions to locate the facing terminal gate parking and associated service roads assuming ramp personnel are trained, there is no general aviation parking, and parked commuter aircraft (defined by the FAA as propeller-driven, multiengine airplanes with seating of 19 or less and a maximum certificated takeoff weight of 19,000 pounds or less) do not ground load.
- General aviation/commuter aircraft parked next to turbojet aircraft:
  - 24 mph (38 km/h) maximum under idle and breakaway thrust conditions assuming ramp personnel are trained and aware of jet blast and propeller wash conditions.
- Hardstands (focus is on mitigating the effects of turning movements while taxiing):
  - 24 mph (38 km/h) maximum under idle thrust conditions for placement of adjacent hardstand where passengers are being ground loaded.
  - 35 mph (56 km/h) maximum under idle conditions when aircraft arriving/departing from the hardstand if the airline's written ramp management plan prescribes that all passengers in the adjacent hardstand locations are boarded or escorted away from the active hardstand by trained ramp personnel.
  - 39 mph (62 km/h) maximum under breakaway thrust conditions for the location of service roadways behind the aircraft.
  - 35 mph (56 km/h) for service roads next to a hardstand

This guidance should be used to determine the possible effects of jet blast and propeller wash from aircraft parked on aprons on or adjacent to facilities (buildings, roadways), as well as activities on the aprons (passenger ground loading, ramp personnel/servicing, other aircraft on the apron, especially light general aviation or commuter aircraft). Figure 4-29 shows jet blast velocity contours for a narrowbody aircraft and a widebody aircraft at idle, breakaway, and takeoff power conditions. This figure demonstrates that jet blast velocities at breakaway power can be 50 mph at 300 feet behind a widebody aircraft.

Once the jet blast or propeller wash profiles for specific aircraft using apron facilities are evaluated, physical and operational means to mitigate the potential conflicts can be identified. The characteristics and resulting effects on fixed and movable objects should be evaluated for all aircraft movements, including entry/exit maneuvers, taxiing, and turning, as each movement produces a different jet blast or propeller wash profile. Software programs are available that simulate jet blast and propeller wash effects for both parked and taxiing aircraft.

Key Points:

- Jet blast can have significant safety impacts and must be considered in apron planning/design.
- Consider reasonably expected aircraft maneuvers in assessing areas potentially exposed to jet blast.
- As an "invisible" threat, it is critical that apron planning adequately consider jet blast impacts.



Sources: Ricondo & Associates, Inc.; Simtra AeroTech AB, PathPlanner A5.

Figure 4-29. Jet blast contours at varying power.

Physical Protection

Physical barriers can be used to provide protection from jet blast in and around the apron/gate area. A physical barrier, typically referred to as a blast deflector or blast fence, as shown on Figure 4-30, deflects and attenuates the aircraft engine blast to minimize exposure to personnel and equipment. Blast fences are typically constructed of metal or concrete barriers and can have either perforated corrugated, louvered, or smooth surfaces. Where space exists, earthen berms can be built to protect adjacent facilities or operations from jet blast or propeller wash.

Source: Kimley-Horn and Associates, Inc.

Figure 4-30. Blast deflector.

When locating a physical barrier, planners must consider the anticipated aircraft orientation during movements, the location of personnel and equipment, and the type of aircraft that will be operating in the terminal apron/gate area. It is critical that a jet blast barrier does not pose a risk to aircraft taxiing in, out, or through the protected area. A physical barrier must extend to a height that provides the desired level of protection. At some airports and jet engine service centers, jet blast deflectors can be combined with sound-deadening walls to form a ground run-up enclosure within which a jet aircraft engine can safely and more quietly be tested at near full thrust. Generally speaking, a blast fence should be located as close to the source of the blast as possible and should be located outside of any runway or taxiway safety areas or OFAs.

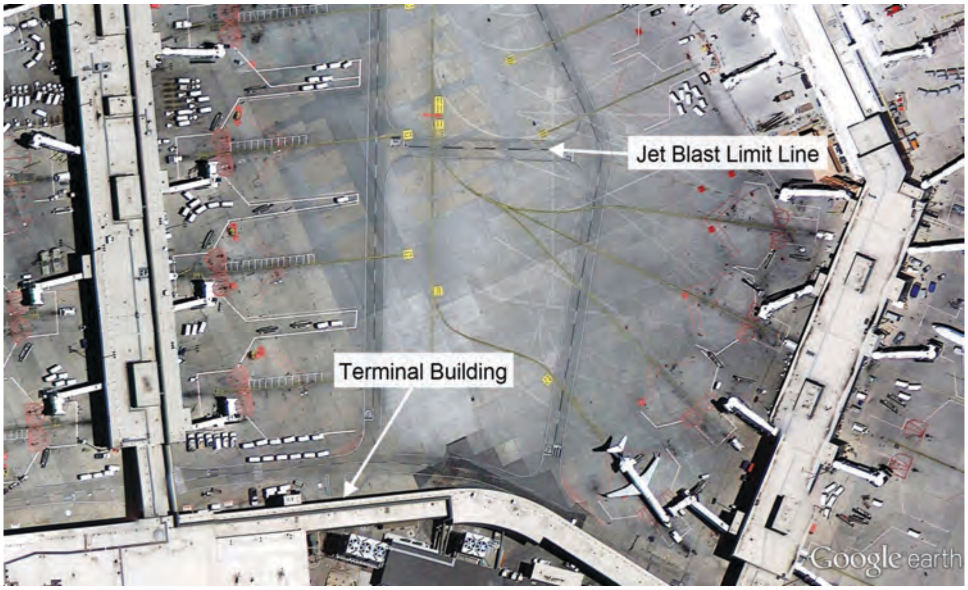
Key Points:

- While physical barriers can provide effective protection from jet blast, these can impact the apron flexibility due to the space that they require.
- Physical blast protectors can obstruct line-of-sight from the ATCT and/or the ramp control tower.

Operational Procedures

In some cases, protection from excessive jet blast velocities and temperatures can be provided by implementing operational procedures and supporting visual cues. These visual cues identify the location and aircraft orientation where it is appropriate to apply power to the aircraft engines without creating excessive blast exposure to personnel, equipment, or facilities. The visual definition of a point on the apron or taxilane, sometimes referred to as a “start block” or “tug release point” can be identified, to which the aircraft must be towed to before taxiing under its own power when departing from the gate.

Figure 4-31 depicts an example of an operational procedure and supporting visual cues used to mitigate jet blast. At Salt Lake City International Airport, aircraft parked at the gates at the



Sources: Google Earth Pro; Ricondo & Associates, Inc.

Figure 4-31. Jet blast operational procedure – visual cues.

end of the alley located between Concourses B and C be must pulled forward to a marking on the apron before thrust in excess of idle power is applied to avoid adverse jet blast effects on the terminal building.

Alternatively, operational procedures that do not rely on visual cues can be used. For example, when blast effects are a concern, procedures can require that an aircraft initiating a turn into a specific parking position from a taxiway or taxilane must not come to a complete stop until it is in the final position. This avoids the application of breakaway engine thrust and protects personnel or equipment from unacceptable levels of jet blast or propeller wash. In this case, the aircraft would have to be towed into the final gate position if, for any reason, it came to a complete stop during the gate entry maneuver. To be effective, operational procedures must be agreed upon by aircraft operators and be documented in a manner that makes the information readily accessible for those unfamiliar with operations at a particular airport.

Key Points:

- Operational procedures must be consistently adhered to in order to be effective in providing protection from jet blast damage or injury.
- The development of effective procedures to protect against jet blast involves working with air traffic control representatives and affected stakeholders.

Additional Guidance

FAA Advisory Circular 150/5300-13A. *Airport Design* (Appendix 3, The Effects and Treatment of Jet Blast), September 28, 2012.

SMGCS

A SMGCS facilitates the safe movement of aircraft and vehicles by establishing more rigorous control procedures and requiring enhanced visual aids at U.S. airports where scheduled airlines are authorized to conduct operations in low-visibility conditions.

The FAA recognizes two categories of SMGCS based on visibility: operations less than 1,200 feet runway visual range (RVR) down to and including 600 feet RVR and operations below 600 feet RVR. Requirements for operations less than 600 feet RVR are more stringent than for operations from 600 feet to 1,200 feet RVR. While SMGCS plans approved by the FAA generally focus on the movement area, the FAA also provides guidance for nonmovement areas, including aprons.

SMGCS Working Group

Prior to implementation of any SMGCS plan, the FAA strongly recommends that an airport operator establish an SMGCS working group consisting of airport stakeholders. Such stakeholders should include airport staff involved with airfield operations and lighting; ARFF representatives; FAA representatives from ATC, the Airports District Office, Flight Standards, and Airway Facilities; airline representatives; A4A representatives; airline union or other pilot representatives; and any appropriate 14 CFR 91 (*General Operating and Flight Rules)* operators. At many airports with an existing SMGCS plan, an SMGCS working group already exists. Consultation with the current SMGCS working group, if applicable, is recommended prior to beginning any apron SMGCS planning.

Taxiway and Taxilane Centerline Lighting

The FAA recommends the installation of centerline lights or centerline reflectors to provide improved guidance to pilots taxiing in reduced visibility. For operations below 1,200 feet RVR, down to and including 600 feet RVR, in-pavement centerline lighting or centerline reflectors are not required in nonmovement areas. For operations below 600 feet RVR, the FAA requires in-pavement taxiway centerline lights or provisions for taxiing assistance in the form of a follow-me vehicle, tug towing, or ground marshaling.

Taxiway Guidance Signing and Marking Requirements

For SMGCS operations, surface-painted location and directional signs should be positioned on apron pavement where they will enhance taxiing operations for pilots. Additionally, geographic position markings, or spot markings, can also be used for positioning information, or where location verification or additional guidance may be needed. All markings added for the purpose of SMGCS operations should be located where they enhance low-visibility operations, as determined by the SMGCS working group.

Finally, gate lead-in lines and markings should be painted so that they are easily discernible to a pilot taxiing from a taxilane centerline to the gate environment. To benefit pilots in low-visibility conditions, markings included in the SMGCS plan should be visually conspicuous and provide good contrast from the pavement. Markings along SMGCS and low-visibility taxiing routes should receive special attention and be repainted when the visual clarity of the markings is degraded through wear and tear. Taxiway and taxilane centerline markings, outlined with black borders, should be painted on light-colored pavements. In addition, reflective or glass-beaded paint should be used for geographic position markings, but should not be added to black paint.

Operational Considerations

An SMGCS plan approved by the FAA may provide for certain operational restrictions or special procedures to be followed for low-visibility operations in the apron area. Some of these restrictions may include, but are not limited to:

- A surface movement radar
- Specialized training for apron ground personnel involved in low-visibility operations
- A requirement for vehicles to have specific equipment to aid in their detection by ATC staff during low visibility conditions
- Driving restrictions for certain types of vehicular traffic
- A requirement for follow-me vehicles, ground tugs, or ground marshaling to assist aircraft in reaching the gate

Because of the unique nature of low-visibility SMGCS operations and the vast differences among airports, it is advisable to form or consult with the existing airport SMGCS working group prior to planning any apron areas expected to be used in low-visibility conditions.

Additional Guidance

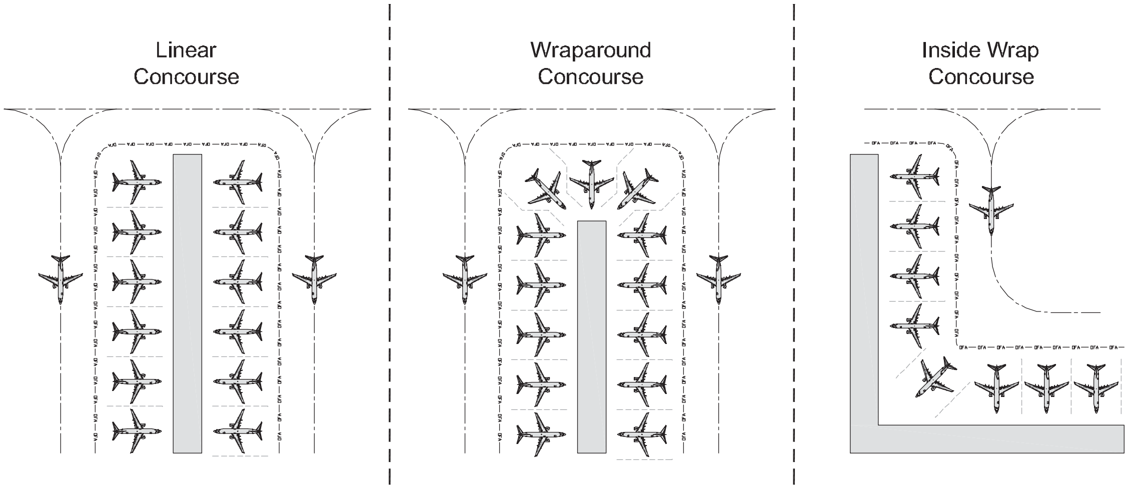
FAA Advisory Circular 120-57A, *Surface Movement Guidance and Control System,* December 19, 1996.

Key Points:

- Determine if SMGCS is or will be an established procedure at the airport.
- Identify requirements or limitations that will apply to the apron design.

Terminal Building Configurations

The terminal apron and gate area is the area in which the transfer of passengers, baggage, and light cargo occurs in a safe, efficient, and controlled manner. The terminal building, in which passengers and their baggage are collected or dispersed, is a fixed facility that has programmed spaces to accommodate the functions that typically occur (and are projected to occur) in the building. The apron and gate area is linked to the planning/design of the terminal building to efficiently connect passengers to the aircraft.



Source: Ricondo & Associates, Inc.

Figure 4-32. Terminal configurations and associated implications.

The terminal building configuration significantly influences apron and gate area planning. Several general types of terminal/concourse configurations exist, all of which have different implications for parking, accessing, and servicing of aircraft. These representative terminal configurations are depicted on Figure 4-32.

In general, the terminal configuration and the relationship between the terminal/concourse and the apron and gate area influence the achievement of planning objectives. The various terminal configurations provide different levels of operational efficiency and flexibility, and impose different limitations on functional capacities. In other words, depending on the specific site constraints, user priorities, and operational considerations (e.g., GSE equipment staging, hydrant fuel pit placement), certain terminal configurations will better meet the specific planning objectives.

Another important planning aspect for terminal buildings is the elevation of the floor to which PLBs are connected to the building (often referred to as floor height). The planning of PLBs must consider various factors, including maximum bridge slope limits, in accordance with ADA requirements, PLB operating ranges (horizontal, vertical, and rotational), and aircraft parking positions (location of aircraft and door sill on the apron and the aircraft door sill height). Airports with a wide range of aircraft with varying door sill heights should plan for a terminal floor height that provides the greatest flexibility while balancing the necessary apron depth to accommodate the airport's existing and projected fleet. As the controlling terminal floor elevation increases, an increasing apron depth may result when equipping gates with PLBs due to the need to comply with ADA requirements for maximum slope and given the operating ranges of the bridges. Terminal building planning will often have to balance intended uses of the space below the terminal boarding level (e.g., airline operations or employee functions) with the desire to keep the terminal floor height as low as possible to provide flexibility in accommodating aircraft without disproportionately increasing apron dimensions.

Linear Configurations

Linear terminal/concourse configurations typically result in aircraft being parked approximately parallel to each other, essentially perpendicular to the building face. In this configuration, aircraft gate positions extend up to, but not around, the end of the concourse. Aircraft are parked wingtip-to-wingtip with the appropriate horizontal separation. This terminal/concourse configuration provides the most consistently defined and most flexible apron area for the parking, pre-positioning, storage, and maneuvering of GSE and other apron functions that occur outside the terminal/concourse building. Linear concourses result in loading bridges and aircraft parking positions being evenly spaced and are typically operationally efficient as there is minimal need for segmented aircraft push-back maneuvers. A linear configuration includes pier concourses, linear concourses (connected to the terminal building), linear satellite concourses (surrounded on both sides by aircraft movement areas or other site constraints and not connected to the terminal building at grade), or "X"-satellites, where two linear segments intersect approximately perpendicularly. Linear concourse configurations can be single-loaded (aircraft parking only on one side of the concourse) or double-loaded (aircraft parking on both sides of the concourse). One of the main advantages of linear configurations is the ability to expand incrementally with demand.

Wrap-Around Configurations

Terminal/concourse configurations in which aircraft parking positions wrap radially around the end of the terminal/concourse in a continuous manner are defined as wrap-around configurations. Aircraft are parked approximately parallel to each other up to the end of the concourse, at which point the aircraft parking positions wrap around the end of the building at various angles to each other and the building face. The resulting aircraft parking envelope associated with each of the wrap-around gates is somewhat pie shaped (i.e., narrower at the building/nose and wider at the apron edge/tail). This apron configuration more intensely uses interior terminal space at the end(s) of the concourse, as the aircraft noses are closer together, while wingtip clearances are maintained. However, the amount of space available on the apron to support the movement and operation of GSE and other apron equipment is more constrained ahead of the aircraft wing in this configuration. GSE parking and storage areas at the end of the concourse are more limited in this configuration which can present challenges if these gates are individually leased. Additionally, the allocation of space within the terminal building can be more challenging as the ratio of terminal space to apron area and aircraft size is lower, creating concourse size and programming challenges.

The parking areas that wrap around the end of the terminal/concourse generally achieve the same aircraft parking capability as a linear terminal configuration, but are more efficient in terms of the square footage of apron area per aircraft or linear footage of terminal frontage per aircraft. The planning of PLBs for the end of wrap-around concourses can be challenging, given the limited building face, and require left-side loading of the aircraft, which reduces the area available for interfacing with the aircraft and the space available for PLB maneuvering. Aircraft movements into and out of the end gates can be more challenging, especially if a movement area exists adjacent to the gates. A wrap-around terminal configuration generally provides maximum apron flexibility in terms of absorbing an increase in the aircraft fleet, although apron depth can become a limitation.

Inside-Wrap Configurations

Terminal/concourse configurations that require aircraft to be parked across an "inside" (concave) curve or geometric equivalent along the building face are defined as inside-wrap configurations. With this terminal configuration, aircraft are parked generally perpendicular to the building face, but not parallel to each other. The resulting aircraft parking envelope associated with inside-wrap gates is generally an inverted pie shape (i.e., wider at the building/nose, and narrower at the apron edge/tail). An apron layout with inside-wrap gates provides the largest apron area available for the parking, storage, pre-positioning, and maneuvering of GSE and other front-of-the-wing apron functions because the noses of the parked aircraft fan apart, creating larger spaces between the noses of the parked aircraft, while wingtip separations are maintained. The movement of aircraft into and out of gates near the inside corner may create operational challenges by blocking adjacent gates.

The inside-wrap configuration with parking areas along the inside curve(s) of a terminal/concourse generally achieve the same aircraft parking capability as a linear configuration, but are less efficient in terms of the square footage of apron area per aircraft or linear footage of terminal frontage per aircraft. Additionally, the apron flexibility with an inside-wrap configuration is less than with other configurations, as the ability to accommodate significant growth in the aircraft fleet is typically more limited because of the required wingtip clearances.

Key Points:

- Linear terminal design typically allows for the most unobstructed and efficient movement of aircraft.
- Wrap-around terminal design may have end gates from which aircraft must push back into the AOA when departing from these gates, potentially causing operational impacts.
- Inside wrap concourses tend to provide more GSE storage and staging area than other configurations, although push-back maneuvers can be more complex from some aircraft gates.

Cargo

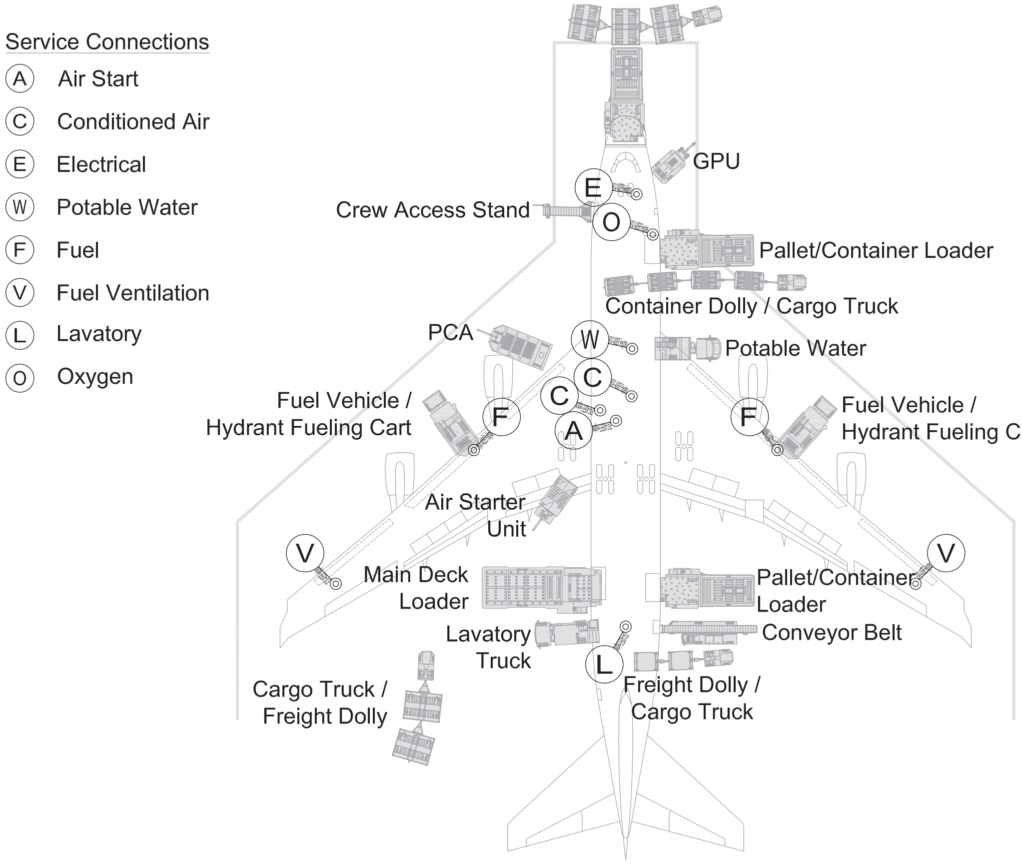
Many factors influence the operational efficiency of cargo operators. Airport facilities must be designed to accommodate the aircraft, sorting facilities, and ancillary operations required to move cargo efficiently. Design considerations include the size of the cargo apron facilities, the apron layout, and operational safety.

Apron Size and Layout

The required size and geometric layout of a cargo apron are a function of the number of aircraft parking positions needed and the size of the sort facility required for the cargo operator. These needs are based on a number of critical elements, including the aircraft fleet mix, number of operations, and cargo tonnage. The number of parking positions also affects the number of interior taxiways that need to be provided to accommodate the necessary aircraft movements. The size of parking positions and taxiway widths are determined based on the design parameters of the critical aircraft using the facility and the space required for GSE operations around the aircraft, including cargo loading/unloading.

While the number of aircraft to be accommodated on the apron and the required taxiways have a significant impact on the size of the apron, planners should also carefully consider the necessary space required for the tenant to operate safely, effectively, and efficiently. Requirements include interior access roads for vehicles and tugs, parking locations for GSE, loading positions on the aircraft (nose, belly, side, or back), fueling operations, aircraft servicing, and storage locations for cargo bins upon removal from the aircraft and prior to transfer to the sorting facility.

While standard recommendations are available for sizing aircraft parking envelopes, the additional space required to accommodate loading and unloading of cargo aircraft is generally determined by the individual operators. Figure 4-33 illustrates the location of cargo loading equipment and GSE. All or some of the cargo loading doors will be used, depending on available equipment and the cargo operator's preference. The space forward of and behind the aircraft wing is usually sufficient to position and operate this equipment. Sufficient clearance must be provided for aircraft tow vehicles as well as loaders for aircraft with nose-loading capabilities.



Source: Ricondo & Associates, Inc.

Figure 4-33. Typical cargo aircraft servicing.

Additionally, sufficient wingtip clearance must be provided for vehicles entering and exiting the apron. Widebody aircraft may hold up to 50 containers, requiring several trips by cargo container tractors and trailers to fully load and unload the aircraft.

To achieve the proper weight and balance, cargo loading has to be completed in an organized and strategic manner. Some cargo operators use tiedowns and tail stands to mitigate the potential imbalance. Sufficient space should be provided for nose tiedowns and/or tail stands when planning cargo parking positions for those operators that use this equipment to accommodate more flexible cargo loading. The accommodation of additional aircraft equipment, including mobile stairs, fueling trucks or carts, GPU, and lavatory service vehicles, must also be planned. Cargo apron planning must provide for sufficient apron or other paved areas for staging and storage of GSE, either as part of the apron or in a proximate location.

Operational Safety

Operational safety on a cargo apron includes not only the safe operation of aircraft movements, but also the safe operation of the GSE supporting cargo operations. Generally, similar operational safety considerations must be evaluated during the planning and design of cargo aprons as during the planning and design of other aprons. Published separation standards for parked and moving aircraft are critical. Vertical grade requirements, including maximum/minimum slopes, are important to allow aircraft to safely maneuver around the apron as well as to create positive drainage of the pavement areas.

Additional operational safety concerns on cargo aprons include the potential for fuel spills and foreign object debris. It is important to design a drainage system to contain potential fuel spills. When possible, drainage structures should be located behind aircraft parking positions to minimize the potential damage to aircraft should fuel spill onto the apron and ignite.

Key Points:

- Cargo apron design should incorporate added space for physical staging/placement of cargo as well as GSE.
- There are unique servicing and operational activities associated with all-cargo operations that can influence apron planning and design.

General Aviation

Given the wide variety of aircraft that can be categorized as general aviation, the planning of general aviation aprons is largely dependent on aircraft parking and the movement of aircraft between aprons, hangars, and any buildings (e.g., FBO terminals, fueling facilities). General aviation aprons range in size and can be as basic as tiedown positions operated by an airport owner or as complex as an FBO facility providing multiple services to a wide range of aviation users. Planning for general aviation aprons requires collaboration with the airport operator or tenant.

The following subsections describe planning guidance for general aviation aprons. This planning guidance applies to both general aviation airports as well as general aviation facilities at commercial service airports.

Design Aircraft

As a wide variety of aircraft operate on general aviation aprons, these aprons need to be planned for an identified design aircraft or the anticipated aggregate fleet of aircraft using the apron. Planning for a new apron requires the planner to determine the anticipated aircraft fleet by coordinating with the airport operator or tenant to determine the based aircraft expected to use the apron regularly and any itinerant aircraft anticipated to use the apron intermittently. The type of aircraft using the apron will drive the sizing of parking positions, the general parking area, and taxilanes and the determination of whether or not tiedowns are necessary. Identifying a design aircraft ADG or determining the number of parking positions required for each ADG drives the sizing and layout of general aviation aprons. Assessing the percentage of itinerant aircraft is also important as they only use the apron for short periods (from hours to days or weeks). Understanding the split between itinerant activity, which typically needs more convenient access, and based aircraft is an important driver for apron layout.

Key Points:

- Although there can be significant fleet diversity within general aviation activity at an airport, the planner should focus on defining a reasonable fleet mix for planning purposes and incorporate as much flexibility in the apron size and configuration as one means of accommodating GA aircraft/activity outside of that fleet (larger or smaller).
- The based aircraft fleet can differ notably from the itinerant aircraft fleet that is forecast to use a facility.

Apron Layout

In developing the layout of general aviation aprons, planners should take into account the existing or planned location of FBO terminal buildings, fueling facilities, other aviation-related facilities, and drainage systems. The layout should be based on the number and size of aircraft that will use the apron and the provision of efficient aircraft taxiing flows.

There are generally two types of general aviation aprons: those that accommodate itinerant aircraft and those that accommodate aircraft based at the airport. Transient aircraft aprons, used by aircraft not based at the airport, tend to have short-term aircraft parking needs. If space permits, transient aprons should be configured to provide easy access by the aircraft and the ability to drop off passengers/cargo near the FBO terminal. The type and size of itinerant aircraft that need to use the apron can vary from day to day. These aprons are often configured with taxilanes and parking positions (or tiedowns) to accommodate the largest ADG expected at the airport or on the apron.

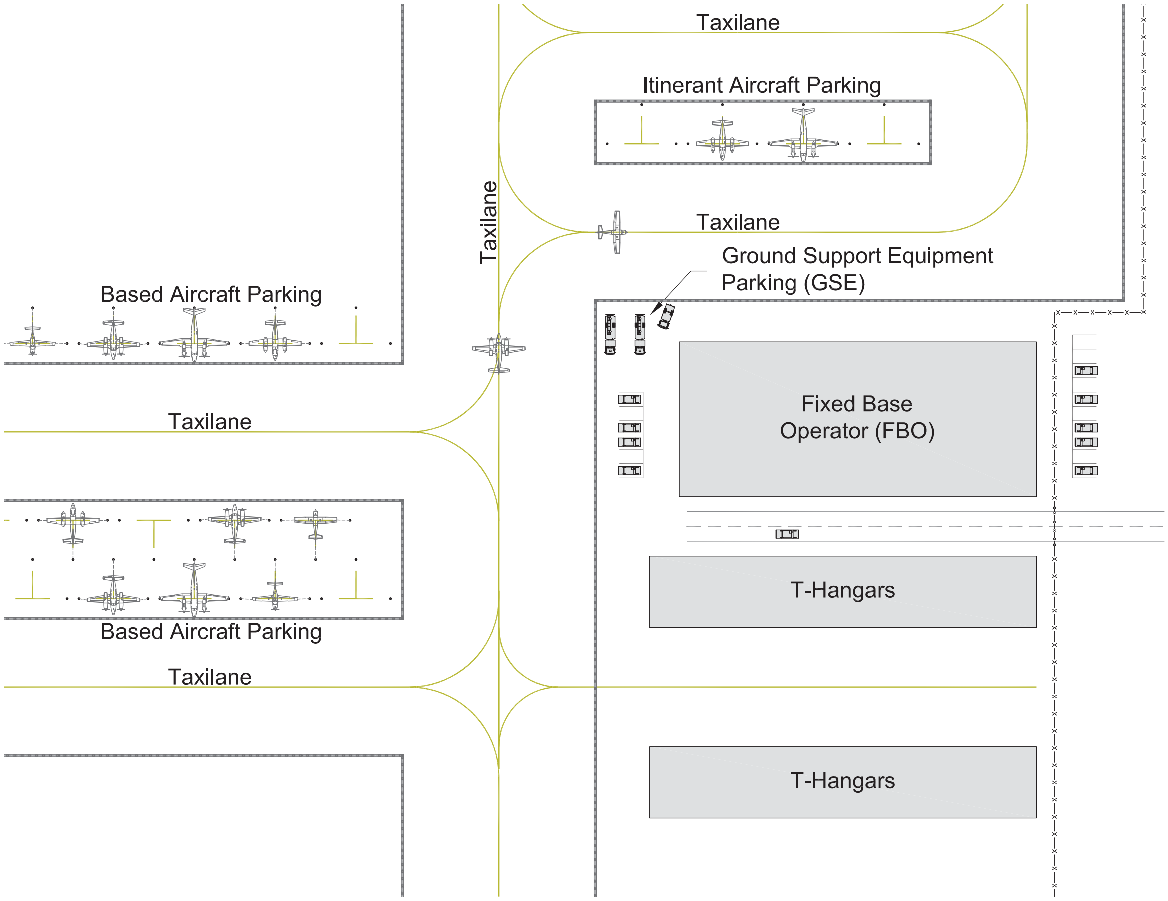
Based aircraft aprons are used for aircraft that are parked at the airport on a consistent basis. These aprons are often designed to prioritize the number of aircraft accommodated, with the flexibility to use the aprons as efficiently as possible being secondary. Aprons and associated taxilanes for based aircraft should be planned for the owners of aircraft leasing parking positions at the airport. Efforts should be made to group together aircraft with similar wingspans to reduce the potential for inadvertent strikes and maximize the use of apron areas. The resulting apron configuration may accommodate different sizes of aircraft. For example, a main taxilane entering the apron may be planned to provide clearances for ADG II aircraft, but taxilanes accessible from this main taxilane may only accommodate ADG I aircraft.

Where possible, aprons should be configured to provide separate parking areas for based aircraft and itinerant aircraft. Taxilanes on aprons are required to provide taxilane OFA clearances and a minimum wingtip clearance of 10 feet should be used for small aircraft. Aprons should also be designed to account for jet blast and propeller wash and sufficient space for aircraft maneuvering. Figure 4-34 illustrates a layout for a general aviation apron configured to accommodate both itinerant and based aircraft parking.

Traffic flows into and out of aprons are enhanced by multiple taxiways linking the parking area to the airfield. At least two apron connector taxiways are recommended to avoid nose-to-nose taxiing conflicts. Additionally, when planning or designing apron layouts, the placement of apron lighting, self-service fuel systems, and other potential obstacles that can impede aircraft movements and safety should be considered. When planning for jet aircraft on general aviation aprons, the effects of jet blast must be considered. Planners of general aviation aprons must also consider controlled access by aircraft operators, proximity to automobile parking, and distance from security-sensitive areas, such as commercial airline passenger enplaning and deplaning. General aviation facilities that accommodate arriving international flights may require a portion of an apron to be identified for CBP use to accommodate searches of arriving aircraft and cargo.

Where possible, the layout and orientation of general aviation aprons should accommodate expansion without major modifications to existing pavements or drainage systems and without significantly affecting airport operations during construction. The potential for future expansion of an apron should be considered during the planning and design processes. The ability to extend taxilanes and expand rows of parking positions for future needs should be preserved. Also, the drain design and the elevation of the surrounding terrain should be considered to ensure that future apron expansions will drain properly.

Aprons for small aircraft are recommended to have a maximum gradient of 2 percent; for larger aircraft, a maximum gradient of 1 percent is recommended. Hangar entrances must have shallow slopes for the hand maneuvering of aircraft. Drainage can be a challenge to plan for with



Source: Ricondo & Associates, Inc.

Figure 4-34. Conceptual general aviation apron layout.

such shallow gradients. Therefore, subsurface drainage infrastructure is common for aprons, including slotted drains, trench drains, and pipes with inlet systems.

Key Points:

- Effective facility planning/design tends to segregate based and itinerant aircraft so that maximum capacity can be prioritized in the configuration of the based aircraft apron, while flexibility can be prioritized in the configuration of the itinerant aircraft apron.

Additional Guidance

FAA Advisory Circular 150/5300-13A, *Airport Design* (Appendix 5, General Aviation Aprons and Hangars), September 28, 2012.

Apron Size

Apron size is determined by the number and size of aircraft anticipated to use the apron at peak planning periods over the planning horizon, as well as the incorporation of taxilanes. Small airports serving ADG I and ADG II aircraft can typically provide approximately 1,000 square feet and 1,500 square feet, respectively, of apron per aircraft when an adjacent taxilane is included. General aviation aprons serving ADG III or larger aircraft are usually sized for the width and length of the aircraft fleet using the airport. These aprons may be separated from aprons used by ADG I and ADG II aircraft to reduce pavement thickness and costs for the parking areas that support the larger aircraft.

Additional Guidance

FAA General Aviation Apron Design Spreadsheet, available at http://www.faa.gov/airports/central/planning_capacity/

Vehicles and equipment used on the apron must also be considered. Fuel trucks, which can be large, may be used on general aviation aprons lacking self-fueling facilities. The need to accommodate specific operational functions must also be considered. For example, agricultural operations may require the use of large semi-trailer trucks that supply chemicals to the aircraft. Firefighting aircraft may require loading of water or fire retardants by large trucks or hoses. As necessary, vehicular access and maneuvering can increase general aviation apron size and, if necessary, must be considered in planning and designing the apron configuration.

Tiedowns

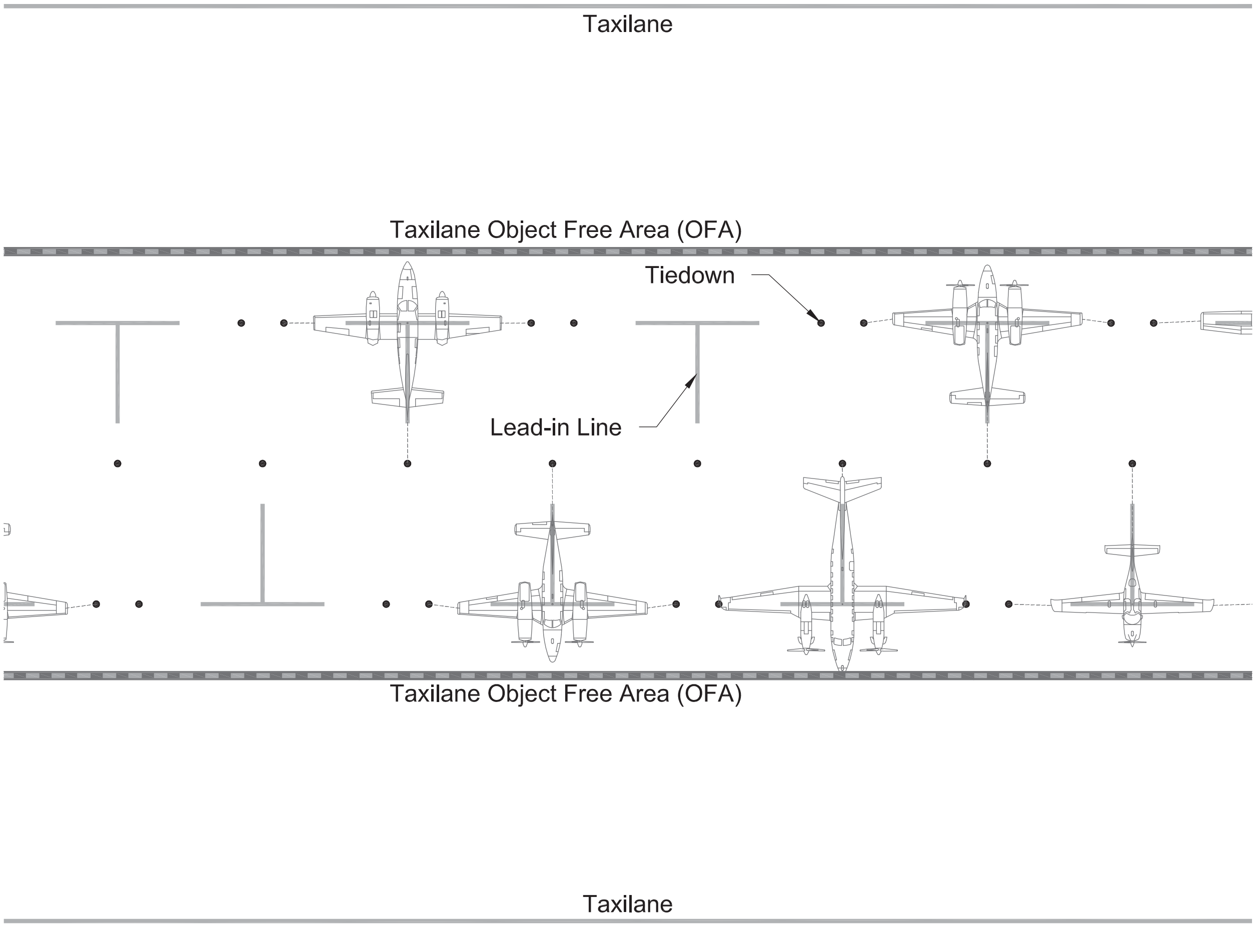
Tiedowns are required to anchor general aviation aircraft in place to protect against unwanted movement caused by high winds, jet blast, or apron surface gradients. Configured most commonly in a "T" layout with ground anchors for each wingtip and the aircraft tail, tiedowns are designed to accommodate a restraining rope, chain, or strap. Manufacturers make different sizes of tiedown anchors depending on the apron pavement type (asphalt or concrete) and the size and weight of the anticipated aircraft that will use them. These anchors are typically installed flush with the surface of the apron to avoid damage to or by snow removal equipment. In addition, tiedowns can be used to secure helicopters.

Tiedowns can also consist of two parallel cables that run along the top of the apron surface, secured to multiple ground anchors. The cables allow flexibility to attach anchor ropes along the cables that can be adjusted to more easily accommodate different sizes of aircraft. Although more convenient, the cable systems introduce challenges when removing snow and during pavement sweeping.

Tiedown anchors must have sufficient hold-down strength to keep an aircraft stationary in anticipated wind and weather conditions. Tiedown anchor designs must consider the hold-down strength required for the aircraft and the type of attachment and anchor for the material (e.g., concrete, asphalt). Tiedowns can also serve as static grounding points. Ideally, the wing tiedowns will be positioned outside the attachment points on the wings and the tail tiedown will be located beyond the rear attachment point. This configuration provides stronger anchorage for lateral forces. Small aircraft are particularly vulnerable to overturning from a strong rear-quartering tailwind. Therefore, at airports with extreme wind conditions, apron planning/design should accommodate tiedowns oriented so that aircraft face into the prevailing winds when possible.

Apron-wide tiedown patterns can vary significantly. Placement of a tiedown must be compatible with the overall apron layout and consider the overhang of parked aircraft engines in front of the tiedowns while not allowing penetration of the OFA for an adjacent taxilane. Single-row tiedowns for aircraft parked wingtip-to-wingtip are best suited for the edge of an apron or for transient aircraft parking positions with a taxilane available on both sides of the parking area (along the noses and tails of parked aircraft). The use of fuel dispensing trucks in front of aircraft may require additional setback to ensure that taxilanes/taxiways are not blocked. A minimum of 10 feet of clearance is required between the wingtips of parked and anchored aircraft and all aircraft must be clear of all OFAs. Single-row tiedowns require the most apron space for a given number of parked aircraft.

Two single-row tiedowns in a back-to-back configuration with aircraft tails placed between opposing side aircraft tails provides the highest-capacity use of available apron space, especially for small general aviation aircraft that are easy to ground maneuver and are approximately the same size. The FAA recommends a minimum clearance of 6 feet between aircraft tails in all directions when aircraft are parked in this configuration. Figure 4-35 illustrates a general tiedown configuration for a general aviation apron.



Source: Ricondo & Associates, Inc.; FAA Advisory Circular 20-35C, Tiedown Sense, July 12, 1983.

Figure 4-35. Tiedown layout.

Key Points:

- Identify the variety of GA aircraft that operate on or will utilize an apron area.
- Design GA aprons for the largest aircraft that may park on the apron on a regular basis, but plan the apron to accommodate infrequent operations by larger aircraft.
- Identify the need for and size of itinerant parking areas.
- Accommodate efficient aircraft circulation within the apron tiedown area to maximize the utility of the facility.

Additional Guidance

FAA Advisory Circular 150/5300-13A, *Airport Design* (Appendix 5, General Aviation Aprons and Hangars), September 28, 2012.

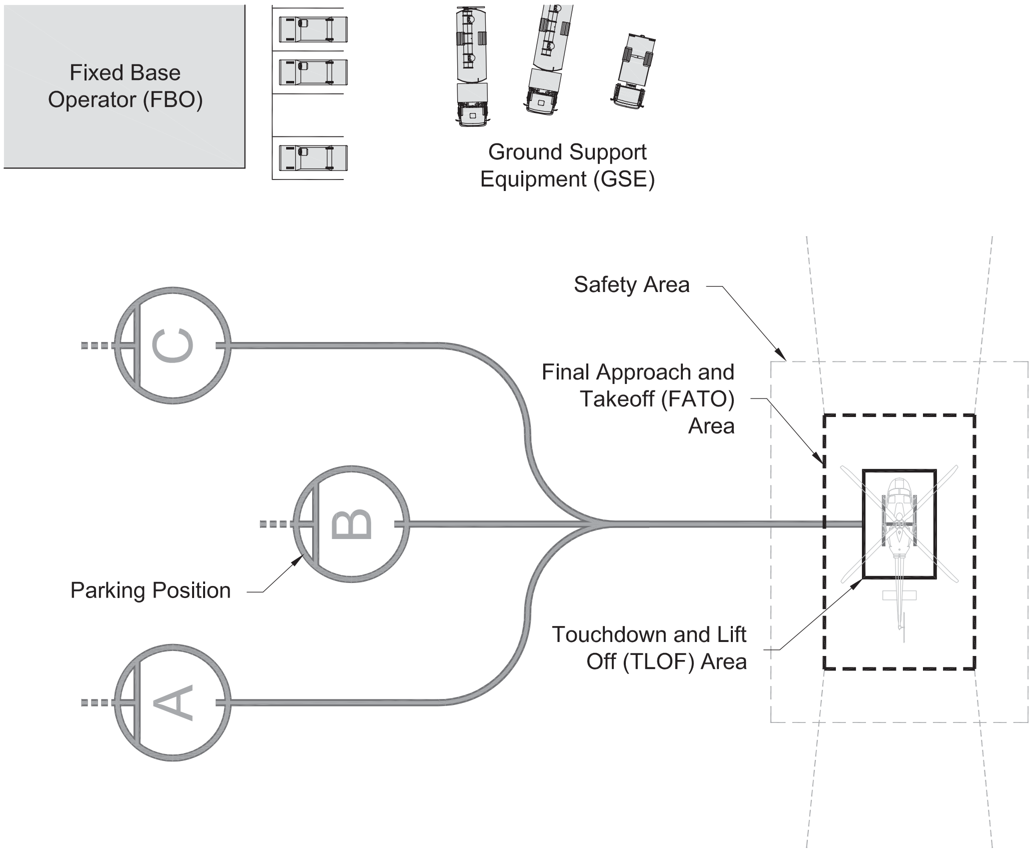
FAA Advisory Circular 20-35C, *Tiedown Sense,* July 12, 1983.

Helipads

Helipads accommodate helicopter landings and takeoffs at airports, serving as clearly marked landing and takeoff areas away from any obstacles. Helipads at airports are either identified on an aircraft apron or as part of a helicopter-specific facility. Apron planning and design for helicopter facilities is heavily contingent on the fleet mix. The types and sizes of helicopters operating at an airport affect the dimensional size of an overall helipad(s) and the related parking positions, while the level of helicopter activity affects the number of helipads and parking positions required at an airport or helicopter facility. Planners and designers should coordinate with stakeholders to determine the helicopter fleet mix at the airport to assess critical dimensions and weight.

As shown on Figure 4-36, helipads consist of the following components:

- **Approach/Departure Paths:** Heliports typically have two approach/departure paths. In planning the orientation of these paths, planners should consider wind direction, obstructions, and noise and environmental impacts (see FAA Orders 5050.4B, and 1050.1, *Environmental Impacts: Policies and Procedures*).
- **Final Approach and Takeoff (FATO) Area:** A defined area over which a helicopter pilot lands or takes off. This area is either circular or rectangular with a minimum dimension of 1.5 times the critical helicopter's overall length. The FATO area is expanded for helipads at elevations above 1,000 feet above mean sea level. The FATO area is usually marked with a dashed white outline.
- **Touchdown and Liftoff (TLOF) Area:** A load-bearing area usually centered in the FATO area on which the helicopter lands and takes off. The TLOF area is either circular or rectangular with a minimum dimension equal to the critical helicopter's overall length. The TLOF area is usually marked with a white outline and is usually paved or consists of an aggregate-turf surface designed to support the dynamic loads of a helicopter. Paved surfaces should be concrete where feasible; asphalt is less desirable because of the potential for rutting.
- **Heliport Identification Marking:** An "H" marking placed at the center of a TLOF area and oriented with the preferred approach/departure path. A bar is placed under the "H" when it is necessary to distinguish the preferred approach/departure direction. Some helipads also



Source: Ricondo & Associates, Inc.

Figure 4-36. Conceptual helipad layout.

include a touchdown/positioning circle marking, which is a circular marking at the center of the TLOF area to identify that the area is clear of any obstacle.

- **Safety Area:** An area surrounding the FATO area intended to reduce the risk of damage to helicopters accidently diverging from the FATO area.
- **Helicopter Protection Zone:** Similar to a RPZ, a helicopter protection zone is intended to enhance the protection of the people and property on the ground under helicopter approaches and departures.

If the helipad is planned to support more than one helicopter at a time, it is advisable to provide helicopter parking positions. The number of parking positions is dependent on the number of helicopters expected on the ground at any time. Planners should coordinate with airport operators or tenants to determine the number of required parking positions. Helipads may also incorporate taxiways used for the movement of helicopters from the TLOF area to helicopter parking positions.

Helipad markings are used to draw attention to the facilities and communicate information to the pilot, such as the location of areas designated for landing, landing orientations, and allowable landing and takeoff weights and lengths. Markings also provide guidance to ground personnel, pedestrians, and vehicles.

Helicopter operations can be dangerous, especially when pedestrians are exposed to rotors and rotor downwash. Pedestrian walkways should be clearly marked to identify appropriate routes to follow when permission is granted to enter areas where helicopters are operating. Walkways are usually marked with white bars or cross hatching.

Lighting should be provided at helipads that support nighttime operations. These helipads should be designed with lighting that communicates information to the pilot, such as the location of areas designated for landing, landing orientations, the location of structural components, and route identification. Markings also provide guidance to ground personnel, pedestrians, and vehicles. If possible, landing area lighting should be flush mounted with the helipad pavement. If flush-mounted lights cannot be installed, raised lights are permitted so long as they do not exceed a horizontal plane 2 inches above the FATO area. The perimeter of the TLOF area is delineated with a minimum of eight equally spaced green lights. Green lights are also used to define the perimeter of load-bearing FATO areas. Lighting is not required on the perimeter of FATO areas if any portion of the FATO area is not load-bearing. As an option, landing direction and flight path alignment lights may be installed to draw attention to preferred landing directions and approach/departure paths. Taxiway edges should be marked with blue lights.

Lighting is recommended at landing and parking areas to illuminate surface markings. These lights should be installed so that they will not create a hazard to helicopter operations. Flood lights should be installed on adjacent buildings or on poles that are clear of protected imaginary surfaces associated with 14 CFR 77. Imaginary surfaces include, but are not limited to, the approach/departure surface, transitional surface, and any safety areas. Where it is not possible to install flood lighting on adjacent buildings or poles, the lighting may be installed at grade, preferably outside of the safety area. Flood lights should also be angled down to minimize the potential for interfering with a pilot's vision. The designer and the end user should coordinate to determine specific needs.

Helipads should also include safety/security barriers around the perimeter of the apron, such as chain-link-fencing or landscaping, to protect the general public from inadvertently accessing the apron area. Similarly, the barriers should protect aircraft and private property from theft or vandalism. Ancillary apron components include windsocks, lighting for nighttime operations, and a heliport beacon.

It may be difficult for pilots to see some unmarked/unlit structures and objects even in the daytime. These structures/objects include, but are not limited to, wires, antennas, poles, and towers. These items should be reviewed on an individual basis to determine if additional marking/lighting is necessary to draw more attention to their locations.

Guidance signage at apron helipads should be provided in accordance with the standard FAA guidance sign system. These signs include typical airfield designation of pavements, route identification, location of mandatory holding positions, identification of approach and other boundaries, and navigational aids. In addition to guidance signage, best practices for signage system design should also include signage for safety considerations. The intent of safety-related signage is to communicate information regarding helicopter operations to the general public. Cautionary signage should be installed at all entrances to, and along the perimeter of, areas where helicopters operate. Beyond the entrance, pedestrian routes should be clearly marked and signed.

Although not ideal, it is common for helipad approaches/departures to traverse roadways, parking areas, and other public infrastructure. It is recommended that signage, identifying helicopter operations, be placed at locations where helicopters are operating in close proximity to the public. Security signage is also recommended to inform the general public that helicopter landing area access is limited to authorized personnel only. Recommended signage includes "No Trespassing," "Restricted Access," or similar verbiage.

The FAA requires notification for any construction, activation, deactivation, or alteration of a helipad or heliport facility by submitting Form 7480-1, *Notice of Landing Area Proposal* to the appropriate FAA Airports Regional or District Office.

Key Points:

- Identify the types and sizes of rotorcraft to use a facility or park in apron areas.
- Ensure adequate marking and lighting for helipad facilities, providing guidance for both the rotorcraft and for passengers that need to approach and depart from the rotorcraft.
- Approach and departure paths should not interfere with fixed-wing aircraft operations.
- Consider rotorcraft taxi movements in configuring the apron and access to it.

Additional Guidance

FAA Advisory Circular 150/5390-2C, *Heliport Design,* April 24, 2012.

Technology/Planning Tools

Computer software programs can assist with aspects of apron planning and design.

Computer-Aided Design

The use of CAD software allows apron planners and designers to create, modify, and analyze different apron configurations using scaled drawings of aircraft and the overall layout of an airport. Most aircraft manufacturers provide scaled drawings of their aircraft on their websites. Electronic files of existing ALPs and facilities can usually be obtained from airport operators. Furthermore, many templates for GSE are available on the Internet. As CAD files are typically references to a geographic coordinate system, they allow planners to lay out apron facilities and ensure that sufficient space is available to accommodate the range of aircraft in the fleet, GSE, and necessary clearances. CAD files also promote the ability to more easily develop and evaluate apron layout alternatives.

Aircraft/Vehicle Maneuvering Simulation Software

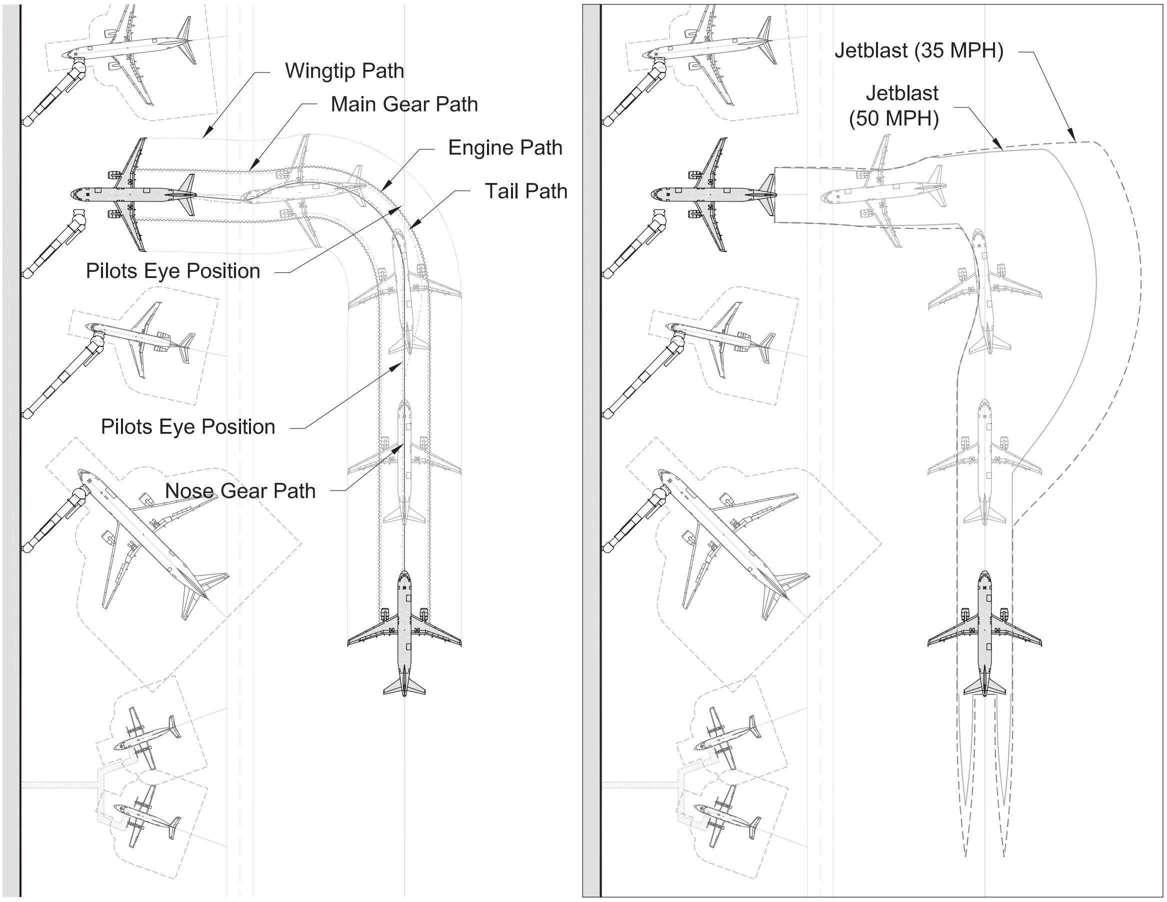
Several CAD-based software add-ons are available to assist with apron planning and design through the simulation and analysis of aircraft and vehicle movements. Simulation software offers an extensive library of both commercial and military aircraft, as well as a wide variety of airside vehicles, aircraft-specific vehicles, and landside vehicles. Available software includes, but is not limited to:

- Transoft Solutions – AeroTURN
- Simtra AeroTech – PathPlanner Series
- Savoy Computing Services – AutoTrack Airports

In general, the software capabilities can be divided into two categories: movement and servicing.

Movement. One of the primary purposes of simulation software is to replicate the realistic movements of aircraft and vehicles. Performance parameters provided by the manufacturer, such as maximum steering angle, wheel base, and wheel span, are used to recreate the movements. Simulation software can maneuver the object forward or backward, all while using arc, dynamic arc, direct, and oversteer turning maneuvers. The software also accounts for object speed and steering rate. The path of the object is determined by following pre-existing linework, such as defined taxiways, or manually specifying targets within the user interface.

There are standards/recommendations for distances that aircraft must remain clear of fixed objects, other aircraft, and pavement limits, among others, as they move about an airport. As shown in Figure 4-37, the simulation software provides the ability to track the swept path of



Sources: Ricondo & Associates, Inc.; PathPlanner A5.

Figure 4-37. ***Aircraft and vehicle simulation software.***

various object components as they perform a range of movements, including outer engine, nose tip, nose gear, tail tip, main gear, cockpit, and wingtip. The software also is able to track pilot eye position, the extent of different jet blast categories (idle, breakaway, and takeoff), and FAA and ICAO clearances.

Similar to the movement of aircraft, the simulation software also tracks the movement of vehicles and GSE used on the apron. These tracks include driven path, swept surface, and wheels. Additionally, multiple objects, such as a baggage tug and trailers or tug and aircraft, can be linked together to simulate complex movements that would correspond with the movement of luggage trains, aircraft towing, and aircraft pushbacks.

Servicing. When an aircraft reaches its parking area, the simulation software provides a variety of capabilities to evaluate and optimize servicing. Within the servicing category, the software can provide assistance with remote hardstand and gate design.

The software provides the location of aircraft service connections, stopbars, lead-in lines, aircraft clearance boxes and suggested positioning of service vehicles. Gate design includes all of the features associated with remote hardstand design, but the software also provides a powerful set of docking and gate features that make it possible to optimize gate layouts. Operating data for specific jet bridge models are included with the software and limit the simulated movement of the PLB to conform to specific bridge capabilities. Site-specific factors, such as apron slope and rotunda elevation, can also be accounted for in the software to increase the accuracy of the analysis. Possible uses of the software include analyzing whether an existing PLB will accommodate aircraft or if an aircraft with a much lower sill height at a specific gate/position will be serviceable based on bridge slope requirements.

Pavement Strength Software

The design of apron pavements is a complex engineering challenge that involves a large number of interacting variables. The FAA has developed software to assist with the design of airfield pavement according to FAA requirements. The FAA Rigid and Flexible Iterative Elastic Layer Design (FAARFIELD) is a computer-based thickness design procedure for designing airport pavements. FAARFIELD can be used for designing new pavement, strengthening existing pavement, and evaluating existing pavement.

It is important that apron planning include the data needed by pavement designers to determine pavement requirements. FAARFIELD requires information on the pavement, including the anticipated aircraft fleet mix using the apron to determine aircraft loading. The required data include aircraft type, gross aircraft weight, and number of annual departures. Consideration of the types of GSE operating on the apron is also critical, as GSE vehicles may account for the heaviest loads on general aviation aprons. Pavement designers will also need to include information on the depth of frost penetration, soil boring information, and type of pavement (typically asphalt or concrete). The software provides a recommended pavement design, including all layers of materials. The project design engineer can then adjust the various layers to suit local conditions and materials.

Additional Guidance

FAA Airport Design Software, available at http://www.faa.gov/airports/engineering/design_software/

Key Points:

- There are multiple tools available for the planning and design of apron facilities.
- Simulation tools can assist in evaluating alternative apron configurations to identify potential operational or safety issues associated with alternatives.

Management/Operational Policies

Planning of apron facilities must recognize the management and operational policies that are in place at an airport. Management policies often reflect the priorities of the airport organization and can include, but are not limited to, the following types of examples:

- Restrictions/requirements in leases (e.g., development standards, minimum gate equipage, restrictions on APU usage due to noise and emissions concerns, etc.).
- Approval processes (e.g., aircraft parking and marking plans, ramp operations plan).
- Exclusive use/preferential use/common use facility leases.
- Inclusion of sustainability measures on development projects.
- Facility access priority (e.g., deice pad access during peak periods).

Management policies can have a direct influence on the planning of apron facilities (new, reconfigured/modified, replacement) and may influence the justification/timing of apron projects. Asset management and return on investment approaches to facility expansions and modifications can drive more focus on facility optimization as a condition of future project approvals. In other words, an airport's management policies may require there to be a documented and demonstrated optimization of existing apron facilities (measured by gate occupancy, daily average turns at existing gates, etc.) before future apron expansion or reconfiguration projects are considered. Clearly understanding airport management policies is critical during the planning process to ensure that each apron project is appropriately tailored to the requirements and expectations of each airport and its stakeholders. Management policies can also cover communication protocols in the event of unplanned events or incidents (aircraft contact/damage), observed compromises in safety, and other issues that should be brought to the attention of the airport operator.

Similarly, operational policies in place at an airport can influence the planning of apron facilities, including the size, configuration, and infrastructure needed. Examples include, but are not limited to:

- Minimum wingtip clearances.
- Fueling restrictions.
- Required use of centralized preconditioned air and ground power systems, rather than point-of-use equipment.

Clearly understanding and documenting operational policies implemented by the airport, tenant airlines, FBOs, and other relevant parties is important in planning apron facilities that will receive stakeholder support.

Design Implications and Considerations

Pavement

Adequate design of an apron pavement system, including pavement type and cross-section, is imperative for the long-term performance and serviceability of the apron. A number of items require consideration when selecting the appropriate pavement design, such as anticipated aircraft fleet mix, material properties, subgrade support conditions, local material availability, and pavement design life, among others.

Apron pavement design should entail an evaluation of the design and durability of existing pavement, in-place soils, and subsurface conditions in order to identify or verify potentially problematic issues that may result in premature pavement failure, accelerated deterioration, increased maintenance requirements, unexpected electrical system outages or reduced reliability, pilot/user refusals to operate in specific apron areas (e.g., due to roughness or unevenness), or other consequences. This includes, but is not limited to, the prevalence of concrete materials that are alkali-silca reactive, a history of ground water seepage and/or erosion of base materials, permafrost (cold climates), and clay-based expansive soils causing pavement heaving. This evaluation could influence pavement design and possibly reduce or eliminate causes of pavement deterioration in and around apron areas.

As with any investment in infrastructure, it is necessary to maintain the pavement by implementing cost-effective preventative maintenance measures that will result in a long-life pavement. The appropriate timing of pavement maintenance and rehabilitation alternatives can be determined through the development and use of a pavement management system.

Drainage System

The objective of an apron storm drainage system is to provide for the safe passage of vehicles and aircraft and operation of the apron during a storm event. The storm drainage system must provide for the rapid removal of storm water from the airfield pavement and the pavement base or subbase by use of an underdrain system. The drainage system will vary depending on the size of the facility, location of the facility within the United States, local storm intensity, frequency patterns, soil type, and the water table.

When planning and designing an apron, it is generally recommended to keep the surface gradient as flat as possible for ease of aircraft towing and taxiing, but also promote positive drainage. The maximum allowable grade for aprons depends on the Aircraft Approach Categories to be accommodated. According to the FAA, the maximum allowable grade in any direction is 2.0 percent for Aircraft Approach Categories A and B, and 1.0 percent for Aircraft Approach Categories C, D, and E. All grades for aprons adjacent to buildings or structures should be designed to direct drainage away from the structures. The NFPA provides guidelines on surface gradients for aprons where aircraft fueling occurs, requiring that the aprons slope away from all buildings or structures at a minimum of 1.0 percent for the first 50 feet, reducing to a minimum of 0.5 percent beyond that point, extending to the drainage inlets. All materials used in the drainage system should be noncombustible and inert to fuel. With the potential for fuel or oil spills to occur on the apron, oil/water separators or other appropriate treatment systems may need to be incorporated into the drainage system. A maximum pavement cross slope from aircraft wingtip-to-wingtip should be between 0.5 percent and 0.75 percent, as greater slopes may inhibit proper aircraft wing tank fueling.

Additional Guidance

FAA Advisory Circular 150/5320-5, *Surface Drainage Design,* September 29, 2006.

FAA Advisory Circular 150/5320-6E, *Airport Pavement Design and Evaluation,* September 30, 2009.

NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways*, 2013.

Drainage around aircraft parking areas should always be directed away from buildings and away from aircraft. Aircraft should not be parked where any portion of the aircraft is over an open trench drain so as not to endanger an aircraft if a fuel spill occurs. Trench drains are required not to exceed a length of 125 feet and incorporate a minimum surface break of 6 feet to act as a fire stop in case of a fuel spill fire.

As aprons are usually large expansive areas of pavement with minimal slopes, it is often easier to use trench drains or slotted drains to effectively collect runoff. Catch basins can be used to collect runoff, but it may be more difficult to maintain the allowable design grades mentioned above and promote positive drainage of the apron using catch basins.

The design of the drainage system should conform to FAA Advisory Circular 150/5320-5, *Surface Drainage Design;* National Pollution Discharge Elimination System (NPDES), state, and local permit requirements; local engineering practice; and NFPA 415.

Fuel Pits/Fuel Lines

In-ground fueling systems are typically installed at larger commercial service airports with high volume use. Fuel system distribution should strictly adhere to all regulatory and industry safety standards and those standards should be incorporated in all designs for aprons to be equipped with fueling capability. Standards to be followed include, but are not limited to, those included in FAA Advisory Circulars and guidelines published by the NFPA, American Petroleum Institute, and A4A.

Critical apron/ramp design parameters include surface gradients away from buildings, location and spacing of drainage infrastructure, locations of potential fuel spill points, distances of features from building faces, and the placement of aircraft within these critical parameters. These industry standards represent minimum standards and are subject to the requirements of the local authority having jurisdiction. Coordination with affected airlines is also required. The ground handling procedures for each airline and aircraft model should be reflected in each layout.

Placement. Fuel distribution piping should be routed along infield areas where practical, and not beneath pavement. The main gear configurations of larger aircraft transmit pavement loading into subgrade depths that may affect piping design and installation techniques. Piping ranges in size based on system design capacity and are generally 10 to 20 inches in diameter and are typically embedded between 8 and 12 feet below final pavement surface elevations. The depth of transfer piping should be consistent with American Petroleum Institute and owner/operator requirements. Piping profiles should be sloped at a minimum of 0.5 percent to 1.0 percent and should be reviewed for potential utility interference. Pipe alignment should minimize aircraft main gear crossings as much as possible. At aircraft gates, pipe routing should be between the main gear and the terminal building to minimize surface loading on the piping caused by aircraft maneuvers. All piping systems are coated to provide corrosion protection. Systems can also include cathodic protection, which includes corrosion control test stations, dielectric insulation, and galvanic anodes.

An in-ground hydrant fueling pit is shown in Figure 4-38 and provides a point for hose connections that allows the fueling cart to transfer fuel to the aircraft fuel port. Aircraft fuel ports are generally located near the right wingtip of the aircraft. Aircraft refueling is generally completed on the right wing of the aircraft. Some larger aircraft are fueled on both wings simultaneously, requiring a left side placement of an additional hydrant pit. Fuel hydrant pits should be located within 30 feet of an aircraft fuel port. The placement of a hydrant fuel pit and operational range of a PLB are the primary drivers for planning an aircraft parking layout.

Hydrant pits should be located a minimum of 50 feet from any terminal, concourse, PLB (stationary or mobile), cargo, or hangar building face. Fueling pits should be located where apron surface drainage is directed away from the facilities and should not be located under any portion

Source: Kimley-Horn and Associates, Inc.

Figure 4-38. Hydrant fuel pit.

of building overhangs. All requirements in NFPA 415 should be addressed in hydrant fueling system planning and design.

Each fueling position is required to have an emergency fuel shutoff location that shuts off fuel flow to all hydrants that have a common exposure. Visibility and signage for the emergency shutoff shall be in accordance with NFPA 407, *Standard for Aircraft Fuel Servicing.* Signage is required to be a minimum of 7 feet above grade and visible within 25 feet of the refueling point.

Apron design considerations should include fuel tanker wheel loading on pavement design, load transfer for transitions between asphalt and concrete pavements, and the use of fuel resistant pavement materials, including joint sealants. High polymer bituminous mixes, coal tar sealants, and micro surfacing should be considered in asphalt pavement design.

Building Considerations. Aircraft fuel servicing on aprons near terminal buildings should follow the industry criteria discussed above. Elements affecting building design include separation distance from aircraft, separation distance from potential fuel spill point to the building envelope, positive surface sloping away from the building, and proximity to building ventilation systems and fuel vapor (fueling, spills, vents). Potential fuel spill points include points around an aircraft or airport ramp where fuel can be released (e.g., fuel ports, fuel hydrants, fueling vehicles, fuel tank connections, and fuel vents).

Deluge Systems/Fire Suppression. The requirements for a deluge system on a terminal building are indicated in NFPA 415. A terminal building with a potential fuel spill point within 100 feet of a building glazing material (glass) typically requires an automatically activated fire suppression system. Specific requirements are outlined in NFPA 415.

Additional Guidance

NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways,* 2013.

NFPA 407, *Standard for Aircraft Fuel Servicing,* 2012.

A4A (formerly ATA) Specification 103, *Standard for Jet Fuel Quality Control at Airports,* 2009.

FAA Advisory Circular 150/5230-4B, *Aircraft Fuel Storage, Handling, Training, and Dispensing on Airports*, September 28, 2012.

Key Points:

- Apron infrastructure planning is critical to a safe and efficient facility.
- Effective hydrant fuel system design can influence the safety, efficiency, and flexibility of aircraft aprons.

Maintenance and Rehabilitation

The replacement of apron pavements often requires parking positions or taxilanes/taxiways to be closed, causing operation impacts. Applying timely preventative maintenance and rehabilitation of apron pavements can reduce the need for premature apron pavement replacement. Pavements following FAA standards are intended to have a design life of at least 20 years with appropriate maintenance, although a longer structural life can be achieved. Airfield pavements typically consists of several layers or courses, with a surface course on top and base and subbase courses underneath to provide additional structure support. There are generally two types of pavements used to construct aprons: rigid and flexible.

Rigid pavements use Portland cement concrete as the main structural component. Concrete is generally the preferred material for apron pavement for those facilities that frequently accommodate large aircraft due to the heavy static loads that the material can accommodate. In general, the following maintenance requirements can be anticipated for concrete pavement:

- Joint sealing at approximately 5 years.
- Regular pavement inspection for signs of deterioration, including alkali silica reaction, durability cracking, and structural failure (shattered slabs); these types of deterioration could require total replacement of the concrete pavement or isolated slab replacements.

- Regular inspection for signs of common failure modes, such as edge spalling at slab joints or corners, which, in addition to contributing to pavement deterioration, can become a source of foreign object debris at an airport.

Flexible pavements use hot mix asphalt as the main surface component. Generally asphalt pavements have a shorter structural life as compared to concrete pavements. In general, the following maintenance requirements can be anticipated for asphalt pavement:

- Crack sealing at approximately 5 years.
- Regular pavement inspection for signs of deterioration, including cracking, disintegration (weathering, potholes) and distortion (rutting, corrugation, depression); these types of deterioration could require surface treatment, patching, resurfacing, and mill and overlay.

The best way to limit impact to operations is to design a pavement section that is long-lasting given the design inputs (forecast fleet and operations, wheel loads, soil type) and make certain that the contractor adheres to plans and specifications during construction.

Prior to rehabilitation and maintenance, operational plans may need to be developed to park aircraft at other parking positions or to route aircraft around construction areas. This may include gate planning, aircraft movement simulations, or coordination with ramp or ATCT staff to avoid these areas.

Additional Guidance

FAA Advisory Circular 150/5380-6B, *Guidelines and Procedures for Maintenance of Airport Pavements,* September 28, 2007.

ACRP Synthesis 22: Common Airport Pavement Maintenance Practices, 2011.

Key Points:

- Pavement management systems are recommended for new apron areas to maximize the useful life of new pavements.
- Apron design is often influenced by existing site conditions and the local availability of construction materials.

Marking Materials

Several types of materials are used to apply apron markings. Paint is the most common material used for airfield and apron markings. The types of paints used on aprons may be waterborne, solvent-based, epoxy, or methacrylate. Waterborne paint is available in three different types. Type I paint is for use under normal conditions. Type II paint is for use under adverse conditions, such as high humidity or low application temperatures. Type III paint is for use where higher durability is required and under conditions similar to those for Type II paint. The curing time for waterborne paints is largely dependent on paint and pavement temperature, humidity, wind speed, and paint thickness.

Solvent-based (oil-based) paint are categorized into two types. Type I is a "standard dry" that has a dry time of 30 minutes. Type II is a "fast dry" with a dry time of 10 minutes. Solvent-based paints may be used in cool, humid environments. Waterborne paints are generally preferred over solvent-based paints because of the potential environmental impacts stemming from the use of solvents in the solvent-based paint.

There are three marking materials that have a tendency to be more durable than waterborne and solvent-based paints. Epoxy paint is a two-component system consisting of pigment and binder. While this type of paint is more durable than waterborne and solvent-based paints, it is more expensive and requires a considerably longer drying time. Epoxy paints may also be difficult to remove and may shear off when subjected to snow plows. Methacrylate is another durable material that is a two-component system. The first component consists of a methyl methacrylate monomer, pigments, fillers, glass beads, and silica. The second component consists of benzoyl peroxide that has been dissolved in a plasticizer. The components are mixed immediately prior to the application. While methacrylate paint is very durable, it is susceptible to edge chipping and has a greater initial cost compared to waterborne paint.

The third durable material is preformed thermoplastic. These markings consist of colored solid panels that are heated to form a bond with the pavement surface. While this type of marking is more durable than the other types, its cost is substantially greater than the cost of a waterborne paint system. Preformed thermoplastics are most commonly used on taxiways, applied as the surface-painted hold markings, taxiway/taxilane centerlines, zipper roads, nonmovement boundary markings, gate designations and other apron markings.

Painted markings must be visible for both daytime and nighttime operations. To enhance visibility for daytime operations, waterborne or solvent-based black paint can be used to outline a border around markings on light-colored pavement, such as concrete or weathered asphalt. Preformed thermoplastic markings, which are prefabricated tape markings applied to pavement, should have a non-reflectorized black border integrated with the marking.

To maintain visibility for nighttime operations or reduced visibility weather conditions, reflective materials are used. Round spheres of recycled or new glass, known as glass beads, are applied onto or within a marking material. There are three types of glass beads that are approved by the FAA and meet the requirements of Federal Specification TT-B-1325D. Type I is a low-index recycled glass bead for drop-on application. Type III is a high-index glass bead made from new material that provides a greater concentration of returned light as compared to Type I and IV. Type IV consists of larger glass beads that can be used with waterborne or solvent-based based paint if applied at a thicker application rate in order to properly anchor to the material. Climate is not a major factor in the selection of glass bead type. Each type will perform adequately in both warm and cool climates. However, for airports that receive large amounts of snowfall that may be removed by plow, it should be noted that larger glass beads, such as Type IV are more susceptible to damage during snow removal operations because the larger beads stand higher than smaller beads.

Additional Guidance

FAA Advisory Circular 150/5340-1K, *Standards for Airport Marking,* September 3, 2010.

Innovative Pavement Research Foundation, Report IPRF 01-G-002-05-1, *Airfield Marking Handbook,* September 2008.

Key Points:

- Weigh the benefits of newer generation painting materials relative to the more frequent painting of apron pavements with current materials.
- Effective pavement markings are critical to the safe and efficient utilization of aircraft aprons, in supporting both aircraft movements and ground service vehicle activity.

Lighting

Apron lighting enables nighttime operations at airports, complementing other airfield lighting. By providing illumination of the ground handling, aircraft parking, and terminal areas, safety and security are enhanced during low-visibility conditions. Multiple zones of illumination can be achieved by the installation of both fixed and portable lighting equipment.

Placement

Aprons are primarily lit from the landside edge to prevent the placement of floodlight poles in the vicinity of aircraft operations. This placement limits their ability to illuminate deep aprons without potential glare to pilots. In some cases, particularly at airports with deep aprons or those with a need to provide other services on the apron (such as electrical power for GPUs), the installation of floodlights within the apron may be reasonable, but such lights reduce apron efficiency and increase the potential for interaction by aircraft and ground vehicles.

Floodlights can illuminate areas about three times their mounting height with acceptable uniformity. Spacing of the lights along the apron edge is a function of the interruptions of the edge by buildings, access points, equipment storage areas, etc. An ideal spacing is rarely achieved because of these interruptions of a uniform layout. As the apron function varies, altering the illumination requirement by intensity or by shape, light pole spacing may also vary. The arrangement and aiming of floodlights should also minimize glare to pilots of aircraft in flight and in the air and also to the ATCT, if present.

The function of the apron means that shadow reduction is an important design criterion. Providing illumination from two sources is usually an effective means of shadow reduction. For larger aircraft and high activity areas, a shadow study may be reasonable.

Lights carts and light stands are typically the responsibility of the party engaging in the activity requiring enhanced illumination. Portable lights allow increased illumination for tasks requiring greater visual acuity and color rendition, such as aircraft maintenance or construction activities. The number and placement of the lights will vary by the task and the provider.

While trying to achieve the greatest cost effectiveness from the use of floodlights, fewer, taller poles generally provide greater illumination of the apron and can improve uniformity. However, practical limitations exist. Planners and designers need to consider critical aeronautical surfaces that may be penetrated by lighting. Lights penetrating 14 CFR 77 surfaces require FAA review and, if allowed, an L-801 obstruction light must also be mounted. An additional concern is the ability to maintain the lights. The reach limit of high-lift trucks may restrict lamp replacement and general maintenance.

Illumination

The Illuminating Engineering Society (IES) is the recognized technical authority on illumination. IES publishes various technical publications, and works cooperatively with related organizations on a variety of programs and in producing jointly published documents that provide guidelines and standards for illumination. The FAA recommends that apron lighting guidance developed by IES be utilized. Illumination requirements for aprons vary by apron function. The following outlines the illumination intensity recommended by IES for aprons:

- Terminal Building Parking Area – 0.5-foot candles (~5 lux)
- Terminal Building Loading Area – 2-foot candles (~20 lux)
- Hangar Apron – 1-foot candles (~10 lux)

High activity areas, such as passenger walkways for aircraft ground loading may require additional lighting up to 10-foot candles (~100 lux). ICAO Annex 14 recommends that aircraft stands have an illuminance of 20 lux (~2-foot candles) with a uniformity ratio (average to minimum) of not more than 4:1. This level of illuminance is needed for color perception and is the minimum for tasks typically carried out on aircraft stands. ICAO also recommends that the area between aircraft stands and the apron limit should be illuminated to an average illuminance of 10 lux (~1-foot candle).

These functions may be defined by time of day as well as location. Use of timers and remote activation of lighting systems can provide an economical installation that meets multiple requirements. Color rendition is an important part of lighting design. Low pressure sodium lamps are very monochromatic and are not recommended for aircraft parking aprons. High pressure sodium lamps have an amber color and provide adequate color rendition for low and medium activity areas and areas where color-sensitive tasks are not performed. Metal halide lamps provide a blue-white light and are preferable for any area where color rendition is important. Portable lights may also use quartz lamps, which provide an instant on response and excellent color rendition. Glare reduction is another important design element. The use of asymmetrical forward-throw luminaries and cutoff louvers enable floodlights to serve a greater distance from the light pole while limiting glare.

Key Points:

- Lighting should be positioned so it does not visually impede taxiing aircraft or the ATCT.
- Design standards must address the height of exterior lighting to avoid interfering with Part 77 surfaces.
- Adequate and effective lighting of the apron area is critical to safe activity on the apron, considering aircraft movements, personnel activities in the vicinity, and ground vehicles and equipment.

Additional Guidance

Illuminating Engineering Society of North America, *Recommended Practice for Airport Service Area Lighting, 1987.*

Illuminating Engineering Society of North America, *The Lighting Handbook,* 2011.

International Civil Aviation Organization, *Annex 14, Volume I, Aerodrome Design and Operations,* July 2009.

International Civil Aviation Organization, *Document 9157, Aerodrome Design Manual,* 2004.

Constructibility/Phasing

The constructibility or phasing of the construction of an airport apron will vary greatly depending on whether it is a new development, expansion, modification, or rehabilitation of an existing apron. Depending on the location of the new apron on the airport, the complexity of the phasing will vary significantly. Impacts to the airport operations while constructing a new or expanding an existing apron are dependent on the location. Aprons located on the perimeter of the airfield may have minimal impacts as compared to aprons located in the middle of the airfield or near high activity areas such as terminal or cargo facilities.

Consideration of construction phasing planning, particularly for apron pavement replacement or rehabilitation, during the planning and design process is recommended. Construction phasing must consider weather-related limitations. In colder climates, this requires work to be divided into appropriate phases to minimize the risk of a project being affected by weather. Conversely, concrete poured in high temperatures may be adversely affected by the heat, requiring that pours occur during nighttime when cooler temperatures occur. Other factors that can influence the assessment of constructibility and the phasing of a project include but are not limited to material availability, material recycling requirements, utility disruptions, site access and security, operational/activity demands of users, and other factors. The preliminary design of apron facilities should explore constructibility and phasing in sufficient detail to demonstrate (and be able to communicate) project feasibility. This process may yield design changes (revised pavement sections to construct within the schedule and operational constraints imposed on the project) and should be engaged early enough that design changes can be incorporated without endangering the project schedule.

Usually the effect of new apron construction on airport operations is minimal. When rehabilitating an existing apron, airport operations, impacts to tenants, and construction costs all need to be considered. Typical apron rehabilitations around passenger terminals are completed in small phases to limit the impacts on airport tenants (gate closures, taxi restrictions, etc.). Large-scale apron rehabilitation projects at large-hub airports can take several years to complete. During pavement rehabilitation there is a need to protect existing systems such as hydrant fueling, underground utilities, and lighting. Also, pavement rehabilitation must consider effects on adjacent parking positions, taxiways, or taxilanes. This may require temporary lead-in lines to route aircraft around construction activities. With either new development or rehabilitation of an existing apron, it is always important to involve all stakeholders early in the process.

Key Points:

- Constructibility is a key consideration in the construction or rehabilitation of apron pavement in an operational environment.
- Phased construction is often desirable or necessary in order to minimize the operational impacts of the construction on current activity. Temporary apron positions may be necessary to accommodate planned construction while keeping aircraft, personnel, and equipment safe.

Additional Guidance

FAA Advisory Circular 150/5370-2F, *Operational Safety on Airports During Construction,* September 29, 2011.

Navigational Aids

A navigational aid is electronic or visual equipment used to assist pilots with navigating an aircraft during takeoff, landing, and during flight in the terminal airspace. Other navigational aids are used to identify the location of aircraft and vehicles on runways and taxiways. During apron planning, the potential for interference caused by aircraft and equipment to any existing or planned navigational aids must be considered.

Most navigational aids have associated critical areas that are outlined in FAA orders and standards. These critical areas ensure that electronic or light signals are not affected. A notice of proposed construction or alteration (FAA Form 7460-1) must be submitted to the FAA for the construction of any aprons. This process allows the FAA to evaluate the potential impact to any navigational aids. During the planning process, planners and designers are advised to coordinate with the appropriate FAA Air Traffic Organization service center and technical operations field office before finalizing plans to ensure that proposed facilities do not affect any navigational aids.

The following provides a summary of navigational aids that tend to have the greatest impact on the planning and design of aprons. Other navigational aids may be affected by apron construction and FAA guidance should be reviewed during the planning process.

ILS

An ILS is a ground-based navigational system that provides guidance using several pieces of equipment. An ILS provides lateral guidance (aligned, right, or left) through use of a localizer. Vertical guidance along the descent angle is provided by a glide slope antenna.

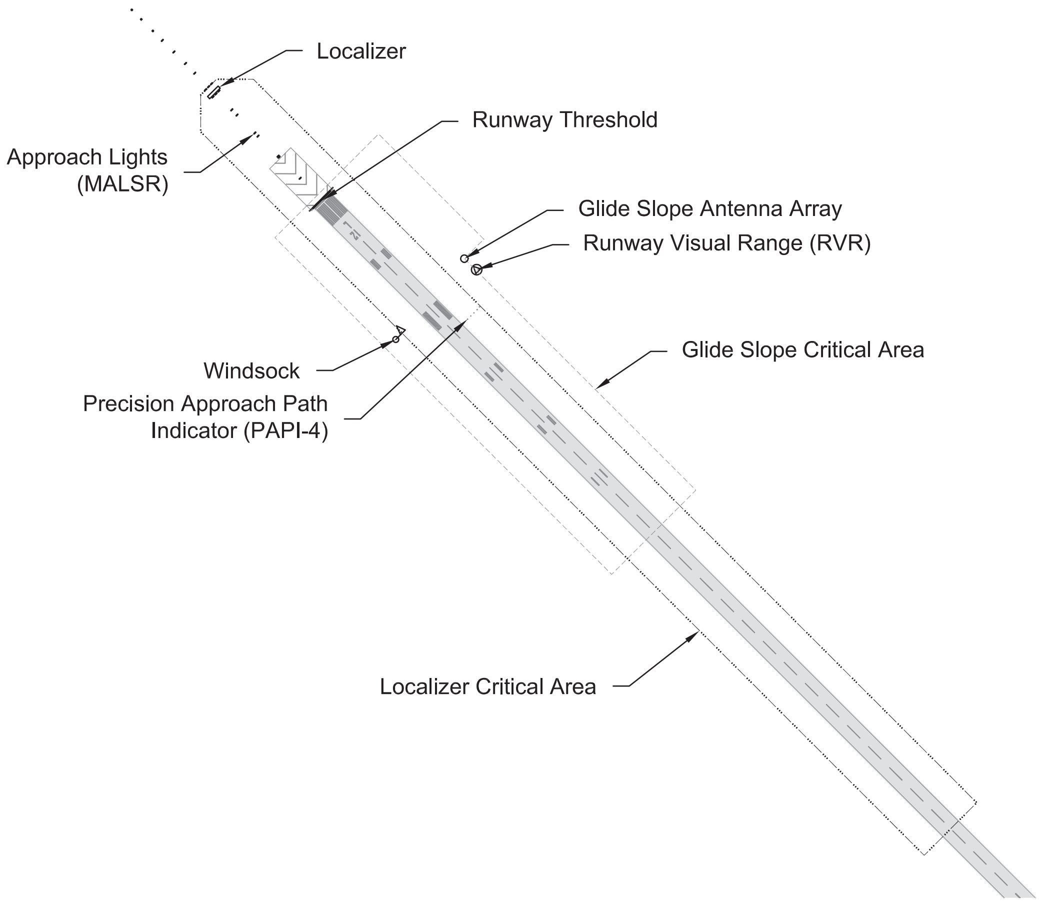
The localizer is typically placed at the far end of the runway on which the aircraft is landing. Glide slope equipment is located near the arrival end of the runway, approximately 1,000 feet down the runway (depending upon the slope of the runway, glide slope angle, and threshold crossing height).

Planners of aprons to be located near a runway must consider the location of the glide slope antenna or other navigational equipment. Both glide slopes and localizers have critical areas that must be clear of obstructions, including aircraft that can cause degradation to signals. Figure 4-39 illustrates the general components and location of ILS facilities, including critical areas, relative to a runway.

FAA Order 6750.16D, *Siting Criteria for Instrument Landing Systems*, February 14, 2005.

Airport Surface Detection Equipment

Airport surface detection equipment (ASDE) provides ATC staff with location information for aircraft and vehicles on an airfield during reduced visibility conditions or for areas where



Source: Ricondo & Associates, Inc.

Figure 4-39. Components and critical areas of an ILS.

there is limited or no unobstructed line-of-sight from the ATCT. The ASDE usually consists of an antenna or radar on the roof of the ATCT or on a stand-alone tower. ASDE is supplemented by transmitters and receivers that are placed throughout the airfield and near runways and taxiways. Planners of apron facilities should ensure ASDE coverage for apron areas is coordinated with the FAA if the airport has this equipment.

Airport Surveillance Radar

Airport surveillance radar (ASR) provides ATC staff with the location of aircraft operating within the terminal airspace. ASR consists of a large antenna, usually placed on top of a tower. Although this equipment is not used to control the movement of aircraft on the ground, apron planners must consider required clearances for this equipment if an airport is equipped with an ASR.

Key Points:

- While navigational aids are not frequently constraints to the planning and design of apron facilities, it is critical that apron locations, configurations, and operation reflect the presence of any proximate navigational aid.
- Airport navigational aids can enhance security of operations in and around the apron area, particularly during nighttime and low visibility conditions.

Additional Guidance

FAA Order 6310.6, *Primary/Secondary Terminal Radar Siting Handbook*, July 20, 1976.

Related Regulations/Guidance/References

FAA

The FAA produces advisory circulars to inform and guide airport planning and design in order to achieve acceptable levels of safety and operational efficiency and to generally standardize facilities that accommodate similar sizes and types of aircraft and passenger activity. Advisory circulars describe actions or advice that the FAA expects to be implemented or followed and links the approval of federal funding to compliance with these documents. They are intended to be informative/advisory but not regulatory. FAA orders prescribe programs, policies, methods, and procedures to meet FAA requirements. These documents provide the basis for airport and apron planning and design. Since the aviation industry is continually changing, FAA advisory circulars and orders are continually being revised, replaced, or cancelled. Likewise, the FAA prepared program guidance letters (PGLs) that add to or revise specific program guidance [e.g., AIP (Airport Improvement Program)]. PGLs can influence the planning and design of facilities and should be reviewed for applicability during apron planning and design.

Safety Management Systems

The FAA has proposed amending the airport certification standards in 14 CFR 139 by establishing minimum standards for the training of personnel who access the airport nonmovement areas (ramp and apron) to help prevent accidents and incidents in those areas. The Notice of Proposed Rulemaking would require the operators of all 14 CFR 139 airports to deliver recurring training to all individuals accessing the ramp or apron. It is proposed that, at a minimum, individuals would receive training in familiarization with airport markings, signs, and lighting; procedures for operating in the nonmovement areas; and duties required by the airport certification manual or regulations. Given the FAA's prioritization of and focus on maintaining a safety culture in all aspects of airport operations, along with its planned update of the Advisory Circular on safety management systems and the anticipated final rulemaking, considering aspects of safety in the planning of apron areas is consistent with the longer range needs of airport operators and the FAA.

Key Points:

- Given the intensity and diversity of activity on many aprons, special attention should be focused on the safety aspects of all planned apron facilities.
- As SMS requirements and guidance mature, it is possible that safety management systems will become part of the apron planning process, particularly at the points where the apron interfaces with the movement area.

Additional Guidance

FAA Advisory Circular 150/5200-37, *Introduction to Safety Management Systems for Airport Operators*, February 28, 2007.

Sustainability

A 1987 report titled *Our Common Future,* typically referred to as the Brundtland Report, from the United Nations World Commission on Environment and Development, provides an often-cited definition of sustainability: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This report identified three fundamental components to sustainable development: environmental protection, economic growth, and social equality. These three components of sustainability are commonly referred to as the triple bottom line. A fourth operational efficiency component is often considered in the aviation industry, in a concept referred to as EONS, which stands for economic viability, operational efficiency, natural resource conservation, and social responsibility.

No single definition of sustainability or quantification of being "sustainable" applies to all airports. Therefore, airport operators have responded to the need to be more sustainable with a variety of sustainability planning initiatives. The aviation industry and national and global institutions have also responded with the provision of guidance and rating systems. A few guidelines and rating systems common in aviation include the following:

- In 2008, a coalition of aviation interests, known as the Sustainable Aviation Guidance Alliance (SAGA) was formed to assist airport operators in planning, implementing, and maintaining a sustainability program by consolidating existing guidelines and practices. Airport operators planning and designing aprons can consult the SAGA database, a tool that can be searched and filtered based on general project types and sustainability priorities, to identify sustainable guidelines and practices to consider.
- The FAA implemented a Sustainable Master Plan Pilot Program in 2009, with the intent of incorporating sustainability principles into the master planning process, such as reduced energy consumption, reduced air emissions, and improved water quality. Through this process, an airport operator could receive funding to develop a sustainable master plan or a sustainable management plan, which could guide sustainability considerations for airport projects, such as apron pavement planning and design along with other airport development projects and operations.
- Several sustainability rating systems have been developed and applied at airports (e.g., the U.S. Green Building Council's Leadership in Energy and Environmental Design [LEED™], which defines design guidelines for green buildings, and the internationally developed Global Reporting Initiative, which provides for a standardized sustainability reporting structure). A sustainable infrastructure rating system, Envision™, was developed and released through a joint collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure. Envision™ provides a framework for evaluating and rating the community, environmental, and economic benefits of all types of infrastructure projects.

The planning/design of aprons can incorporate sustainability initiatives that support goals established by an airport operator or by the developer of a facility (particularly if the apron is developed by an FBO or other party). The inclusion of sustainability initiatives can facilitate enhancements, such as energy reduction, the capture and recycling of deicing fluids, and other elements that mitigate a facility's environmental impacts, while potentially balancing with social (airport connectivity, workplace health and safety, etc.) and financial initiatives (life cycle cost analyses, return on investment analyses, etc.).

Additional Guidance

ACRP Synthesis 10: Airport Sustainability Practices, 2008.

FAA, *Interim Guidance for FAA's Sustainable Master Plan Pilot Program* and *Lessons Learned from the Sustainable Master Plan Pilot Program,* available at: http://www.faa.gov/airports/environmental/sustainability/

Institute for Sustainable Infrastructure, *Envision Sustainable Infrastructure Rating System:* http://www.sustainableinfrastructure.org/rating/index.cfm

SAGA: http://www.airportsustainability.org/

Key Points:

- With increasing focus on sustainability in the planning and design process, aprons are anticipated to continue to focus on the social, environmental, and financial aspects of this type of facility and its relationship to other aspects of the airport.

VALE Program

The VALE Program was established by the U.S. Congress in 2004, as part of the Vision 100 legislation. Through the VALE Program, airport operators have access to funds, either through passenger facility charges (PFCs) or AIP grants, for projects that improve air quality. The program is available to commercial service airports located in areas that are in non-attainment or maintenance of NAAQS, which are air quality standards set by the U.S. EPA pursuant to the Clean Air Act.

To determine project eligibility for VALE Program funding, airport operators must discuss a proposed project with the FAA Airports Regional Office or Airports District Office to review project eligibility prior to the airport operator preparing a VALE Program application. Types of projects eligible for VALE Program funding that relate specifically to apron planning and design include:

- Underground fuel hydrant systems, which reduce or eliminate the use of diesel- or gasoline-powered refueling vehicles.
- Gate electrification projects, including supporting electrical infrastructure upgrades, as point-of-use or centralized PCA and ground power converter units, which can significantly reduce emissions in comparison with aircraft APU use.
- Remote ground power and supporting electrical infrastructure upgrades for RON, cargo, and maintenance operations to reduce APU emissions.
- Geothermal heating systems that use the earth's underground temperature.

In addition to the VALE Program, the FAA Modernization and Reform Act of 2012 created the Zero Emissions Airport Vehicles and Infrastructure Pilot Program that allows the FAA to award AIP funds for the acquisition of zero emissions vehicles and for making infrastructure changes to facilitate the delivery of energy necessary for the use of these vehicles. Any public-use airport in the NPIAS is eligible to receive grants under this program.

Additional Guidance

U.S. Department of Transportation, Federal Aviation Administration, *Voluntary Airport Low Emissions Program, Technical Report,* Version 7, December 2, 2010.

U.S. Department of Transportation, Federal Aviation Administration, *Zero Emissions Airport Vehicles and Infrastructure Pilot Program, Technical Guidance,* Version 1, 2012.

Key Points:

- Apron planning and design can contribute to reducing overall emissions associated with activities in and around the apron area.

Environmental Regulations

NEPA

NEPA requires federal agencies to disclose to decision makers and the interested public a clear, accurate description of potential environmental impacts of proposed federal actions and reasonable alternatives to those actions. Although airport operators are responsible for deciding when and where airport development is needed, the NEPA process is triggered when an airport operator seeks FAA approval or funding, which constitutes a "federal action." Examples of federal actions relevant to apron planning and design include approval for changes to an ALP or for use of AIP funds or PFCs to implement a project.

The FAA has issued guidance on complying with the NEPA process in FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures;* FAA Order 5050.4B, *NEPA Implementing Instructions for Airport Actions;* and the *Environmental Desk Reference for Airport Actions.* Three levels of NEPA review are defined in Order 1050.1E, tailored to the anticipated significance of a project's impacts on the environmental resource categories defined in NEPA:

- **Categorical Exclusion (CATEX):** Actions eligible to be categorically excluded are typically small, routine actions that do not individually or cumulatively have a significant effect on the environment. FAA guidance lists actions that are typically categorically excluded so long as the action does not involve extraordinary circumstances (e.g., affect a resource covered by a special purpose law).

- **Environmental Assessment (EA):** Actions requiring an EA are those that do not meet the criteria for a CATEX, and those for which the environmental effects are anticipated to either not be significant or the airport operator anticipates that the effects may be avoided, minimized, or mitigated to a less than significant level. EAs are also undertaken to determine whether an action would have a significant effect on the environment and would, therefore, require preparation of an environmental impact statement (EIS).
- **Environmental Impact Statement:** Actions requiring an EIS are those that are anticipated to have a significant impact on an environmental resource category that cannot be mitigated below the level of significance.

Additional Guidance

FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures,* June 8, 2004.

FAA Order 5050.4B, *NEPA Implementing Instructions for Airport Actions,* April 28, 2006.

FAA, Environmental Desk Reference for Airport Actions, October 2007.

State Environmental Planning Requirements

Several states have environmental planning laws, regulations, or executive orders that are similar to NEPA. The state environmental planning requirements may involve additional or separate documentation from that prepared for compliance with NEPA.

Key Points:

- Apron planning and design must reflect an effort to avoid and minimize the environmental consequences of proposed new or modified facilities.

NFPA

The NFPA publishes codes and standards designed to help minimize the risks and effects of fire by establishing criteria for building, processing, design, service, and installation. The purpose of these codes and standards is to provide a reasonable degree of protection for life and property from a fire at airports. The standards applicable to this guidebook are:

• NFPA 407	Standard for Aircraft Fuel Servicing
• NFPA 409	Standard on Aircraft Hangars
• NFPA 415	Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways
• NFPA 418	Standard for Heliports

Key Points:

- Fire safety and protection are critical in the apron environment, for the benefit of personnel, equipment, and facilities.
- Adherence to appropriate standards and guidance will minimize the potential safety and/or fueling issues in the apron environment.

ICAO

ICAO is a specialized agency of the United Nations with a mandate to ensure the safe, efficient, and orderly evolution of international civil aviation. One of ICAO's priorities is the development of international standards and recommended practices, including those that address aerodrome (airport) planning and design. Copies of relevant annexes, manuals, and circulars are available from ICAO.

Key Points:

- As the FAA and ICAO pursue increasing harmonization in aviation facility planning and design, apron planning and design guidance published by ICAO is anticipated to be increasingly reflected in apron facilities.

Glossary of Acronyms

100LL	100 Octane Low-Lead
A4A	Airlines for America
AGL	Above Ground Level
AIP	Airport Improvement Program
ALS	Approach Lighting System
APU	Auxiliary Power Unit
ARFF	Aircraft Rescue and Fire Fighting
ASDE	Airport Surface Detection Equipment
ASP	Airport Security Program
ASR	Airport Surveillance Radar
ATADS	Air Traffic Activity Data System
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
CAD	Computer-Aided Design
CAT	Category
CATEX	Categorical Exclusion
CBP	Customs and Border Protection
CCTV	Closed-Circuit Television
CFR	Code of Federal Regulations
DC	Direct Current
EA	Environmental Assessment
EIS	Environmental Impact Statement
ETMSC	Enhanced Traffic Management System Counts
FAARFIELD	FAA Rigid and Flexible Iterative Elastic Layer Design
FATO	Final Approach and Takeoff
FBO	Fixed-Base Operator
FDA	Food and Drug Administration
GPA	Glide Path Angle
GPS	Global Positioning System
GPU	Ground Power Unit
GSE	Ground Support Equipment
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IES	Illuminating Engineering Society
ILS	Instrument Landing System
MOS	Modification of Standard
MPH	Miles per Hour
MRO	Maintenance, Repair, and Overhaul

NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NLA	New Large Aircraft
NPDES	National Pollutant Discharge Elimination System
NPIAS	National Plan of Integrated Airport Systems
OAG	Official Airline Guide
OCS	Obstacle Clearance Surface
OFA	Object Free Area
OPSNET	Operations Network
PCA	Preconditioned Air
PFC	Passenger Facility Charge
PGL	Program Guidance Letter
PLB	Passenger Loading Bridge
POFZ	Precision Object Free Zone
ROC	Require Obstacle Clearance
ROFA	Runway Object Free Area
RON	Remain Overnight
RPZ	Runway Protection Zone
RSA	Runway Safety Area
RVR	Runway Visual Range
RVZ	Runway Visibility Zone
SAGA	Sustainable Aviation Guidance Alliance
SMGCS	Surface Movement Guidance and Control System
TAF	Terminal Area Forecast
TERPS	Terminal Instrument Procedures
TLOF	Touchdown and Liftoff
VALE	Voluntary Airport Low Emissions
VMA	Vehicle Maneuvering Area
VSZ	Vehicle Safety Zone

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FAA, Advisory Circular 150/5070-6B, *Airport Master Plans,* May 1, 2007.

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FAA, Advisory Circular 150/5220-21C, *Aircraft Boarding Equipment,* June 29, 2012.

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FAA, Advisory Circular 150/5340-18F, *Standards for Airport Sign Systems,* August 16, 2010.

FAA, Advisory Circular 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities,* August 16, 2010.

FAA, Advisory Circular 150/5370-2F, *Operational Safety on Airports During Construction,* September 29, 2011.

FAA, Advisory Circular 150/5370-17, *Airside Use of Heated Pavement Systems,* March 29, 2011.

FAA Advisory Circular 150/5380-6B, *Guidelines and Procedures for Maintenance of Airport Pavements,* September 28, 2007.

FAA, Advisory Circular 150/5390-2C, *Heliport Design,* April 24, 2012.
FAA, *Environmental Desk Reference for Airport Actions,* October 2007.
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APPENDIX A

Planning and Design Checklists

Ground Support Equipment Inventory

Terminal Apron

Passenger Loading
- ☐ Passenger loading bridge
- ☐ Mobile stairs
- ☐ Boarding ramp

Fueling
- ☐ Refueling truck
- ☐ Hydrant cart
- ☐ Hydrant truck

Ground Power Units
- ☐ Mobile cart
- ☐ PLB mounted
- ☐ Apron mounted
- ☐ Centralized

Preconditioned Air Units
- ☐ Mobile cargo
- ☐ PLB mounted
- ☐ Apron mounted
- ☐ Centralized

Lavatory
- ☐ Mobile cart
- ☐ Lavatory servicing vehicle

Potable Water Service Method
- ☐ Mobile cart
- ☐ Water cabinet
- ☐ Water truck

Baggage
- ☐ Baggage tractor
- ☐ Baggage cart
- ☐ Conveyor belt loader
- ☐ Container loader
- ☐ Pre-positioned baggage cart (regional jets and propeller aircraft)

Aircraft Maneuvering
- ☐ Push-back tractor
- ☐ Towbars
- ☐ Towbarless tractor

Other Aircraft Servicing
- ☐ Cabin cleaning/galley service
- ☐ Aircraft deicing
- ☐ Air start vehicle
- ☐ Air start cart
- ☐ Aircraft maintenance
- ☐ Automobiles/trucks

Cargo

Loading/Unloading
- ☐ Main deck platform loader
- ☐ Lower lobe platform loader
- ☐ Ball bearing floor

Cargo Transport
- ☐ Tractor
- ☐ Cargo Container Dolly
- ☐ Cargo Containers
- ☐ Forklift

Aircraft Tilt Prevention
- ☐ Tail stand
- ☐ Nosewheel tether

Fueling
- ☐ Refueling truck
- ☐ Hydrant cart
- ☐ Hydrant truck

Other Aircraft Servicing
- ☐ Mobile stairs
- ☐ GPU mobile cart
- ☐ GPU apron mounted
- ☐ PCA mobile cart
- ☐ PCA apron mounted
- ☐ Fueling
- ☐ Aircraft deicing
- ☐ Air start vehicle
- ☐ Air start cart
- ☐ Lavatory mobile cart
- ☐ Lavatory servicing vehicle
- ☐ Maintenance vehicle
- ☐ Automobiles/trucks

General Aviation

Passenger Loading
- ☐ Mobile stairs
- ☐ Boarding ramp

Fueling
- ☐ Refueling truck
- ☐ Self-service fueling area

Aircraft Servicing
- ☐ GPU mobile cart
- ☐ PCA mobile cargo
- ☐ Lavatory mobile cart
- ☐ Lavatory servicing vehicle
- ☐ Potable water mobile cart
- ☐ Potable water truck

Aircraft Maneuvering
- ☐ Push-back tractor
- ☐ Towbars
- ☐ Towbarless tractor

Other Aircraft Servicing
- ☐ Aircraft deicing
- ☐ Air start vehicle
- ☐ Air start cart
- ☐ Aircraft maintenance
- ☐ Automobiles/trucks
- ☐ Follow-me vehicles

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
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