Guidebook for Preparing and Using Airport Design Day Flight Schedules

DETAILS

158 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-44595-5 | DOI 10.17226/23692

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP RESEARCH REPORT 163

Guidebook for Preparing and Using Airport Design Day Flight Schedules

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Subscriber Categories
Aviation • Design • Planning and Forecasting

Research sponsored by the Federal Aviation Administration

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2016

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.

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ACRP RESEARCH REPORT 163

Project 03-32
ISSN 1935-9802
ISBN 978-0-309-44595-5
Library of Congress Control Number 2016954530

Published research reports of the

AIRPORT COOPERATIVE RESEARCH PROGRAM

are available from

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet by going to

http://www.national-academies.org

and then searching for TRB

Printed in the United States of America

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C O O P E R A T I V E   R E S E A R C H   P R O G R A M S

AUTHOR ACKNOWLEDGMENT

The authors wish to express their gratitude and appreciation to the leadership and staff of the airports and consulting firms that took the time to provide detailed reviews and critiques of the draft guidebook. Their insight and recommendations greatly improved this document. The airports and firms included:

- San Diego County Regional Airport Authority
- Memphis-Shelby County Airport Authority
- Minneapolis-St. Paul Metropolitan Airports Commission
- Port Authority of New York and New Jersey
- Ricondo & Associates, Inc.
- Landrum & Brown
- LeighFisher, Inc.

The authors would also like to gratefully acknowledge the assistance of Greg Albjerg, Kim Hughes, Yue Xu, Ken Reed, and Audrey Wald of HNTB for their contributions to the research underpinning much of this guidebook.

We also wish to thank the members of the project panel for their vital support and guidance during the conception, preparation, and completion of this document.

FOREWORD

By Marci A. Greenberger
Staff Officer
Transportation Research Board

ACRP Research Report 163: Guidebook for Preparing and Using Airport Design Day Flight Schedules is designed to provide airport leaders an understanding of design day flight schedules (DDFS) and their uses, while at the same time provide airport staff and consultants with detailed information on how to prepare one. By understanding the assumptions incorporated into and the information generated from a DDFS, airport decision makers can communicate more effectively with the person or persons preparing the DDFS, the scope, and the results. This guidebook discusses the many different projects where a DDFS can best achieve the objective in planning and simulation modeling.

DDFS are used at airports for a number of different purposes, including the planning and programming of airport operations and facilities, airfield and landside modeling, and construction phasing, among others. In addition to a number of inputs, the assumptions that are also used must be well understood by users to fully understand the analysis from the results. Also, like any forecast, uncertainty is inherent in DDFS, and this uncertainty must be recognized and managed. While DDFS are used routinely in the industry, there aren't consistent methods for the development and use of them. One of the purposes of this guidebook is to ensure that users and preparers are fully aware of the advantages and potential pitfalls associated with DDFS.

HNTB and their team, as part of ACRP Project 03-32, were selected to develop a guidebook to assist aviation practitioners in the preparation and use of airport DDFS for operations, planning, and development. Part of their research efforts consisted of a literature review, surveys, and interviews with airports, airlines, and consulting firms. The guidebook is written with two audiences in mind: those that use the results and the analysis from a DDFS, and those who have to prepare one. This guidebook will be useful to airport directors, those in operations and planning, as well as those directly responsible for preparing a DDFS.

CONTENTS

SUMMARY

Guidebook for Preparing and Using Airport Design Day Flight Schedules

Airports are called upon to serve an ever-changing passenger market and airline industry against a backdrop of increasing security, logistical, environmental and fiscal challenges. The planning and operational issues airports face frequently defy simple solutions or even simple descriptions. Detailed modeling is often required to diagnose and address the more complex airport issues and these models require equally detailed inputs, including design day flight schedules (DDFSs). A DDFS is essentially a detailed snapshot of existing or forecast activity at an airport during a defined busy day (design day) or critical daily demand period. The DDFS shows individual aircraft arrivals and departures by time of day and, if needed, can also show airline, origin/destination, and the number of passengers associated with each flight.

DDFS users, mainly airport leaders and decision makers, need to have a basic understanding of a DDFS and should be able to determine when a DDFS is needed, how it should be scoped, and how the results should be communicated. DDFSs are needed in the following instances:

- Assessment of complex airside development and improvements including capacity/delay analyses, gate allocation, Remain Overnight (RON) parking, and incursion and safety mitigation;
- Evaluation of major terminal development and improvements including ticket counter and queue, passenger and baggage security screening, baggage handling systems and baggage claim areas, U.S. Customs and Border Protection (CBP) processing, and passenger conveyance systems;
- Application of the FAA's Aviation Environmental Design Tool (AEDT) for airspace noise and airside air emission analysis; and
- Gate allocation and gate management models.

DDFSs are essential for any airside or terminal simulation modeling, and are useful, but not essential, for less-detailed airfield and terminal planning, landside planning, landside noise and dispersion analysis, and staffing. Chapter 3 in this guidebook provides more detailed direction on when DDFSs should be used and identifies alternatives to DDFSs when appropriate.

DDFS users also are encouraged to review Chapters 1 and 2 for additional background on DDFSs, Chapters 4 and 5 for guidance on what to include and how to scope a DDFS, and Chapter 8 for guidance on how to manage the uncertainty inherent in any forecast, including a DDFS. The communication of DDFS results (Chapter 9) is especially important, in particular engaging key stakeholders throughout the process and relaying the point-in-time nature of a DDFS within the context of the risks and uncertainties associated with a dynamic aviation industry.

DDFS preparers, mainly airport staff and consultants, need to have a detailed understanding of a DDFS and should also know when a DDFS is needed, how it should be scoped, and how the results should be communicated. Since a preparer's main focus is constructing a DDFS and applying the results, he or she needs to be familiar with the many intricacies and nuances involved in preparing a DDFS and how they may affect the projects or issues that the DDFS will be used to evaluate.

Chapter 6 in this guidebook provides detailed step-by-step guidance on preparing a DDFS, including defining key parameters, estimating future nonstop markets, fleet mix, flight times, gate assignments, passengers by flight, and nonscheduled operations. Chapter 7 provides direction on how to modify DDFS output, if necessary, for application in airfield, terminal, landside, and environmental planning and operations and management. DDFSs are inherently very detailed and their preparation involves substantial individual judgment in the selection of new markets, flight times, and other elements. Consequently, there is a risk for error or bias and measures are needed, as detailed in Chapter 6 and Appendix E, to maintain quality assurance.

The nine chapters in this guidebook are supported by appendices that include a DDFS case study, additional discussion of methods for dealing with uncertainty, formalized quality control checks, a list of data sources, and a glossary.

CHAPTER 1

Introduction and Overview

This chapter introduces and defines DDFSs, discusses their benefits, and describes the organization of the guidebook.

The intent of this guidebook is to provide airport planners and operators with a ready reference for effectively preparing and using DDFS for their analysis of future airport activity and its effects. The guidebook is designed to help aviation professionals exploit the advantages and mitigate the disadvantages of DDFSs to help them prepare DDFSs accurately and efficiently, use them effectively and to their full potential, and identify alternatives to a DDFS when appropriate.

1.1 Definitions

A DDFS is essentially a detailed snapshot of existing or forecast activity at an airport or in an airport system and can serve many roles. It can be a **market assessment** that illustrates passenger flows to other communities. It can be an **airline business plan** that demonstrates the role of an airport in an airline's route system, and how the airline moves passengers within its system. It can also be an **airport facility planning tool** that provides a mechanism for planning and managing runways, gates, terminals, roadways, and other airport facilities by level of activity and time of day. A DDFS provides an unparalleled degree of detail essential to analyzing complex issues and developing solutions for those issues.

A DDFS provides unparalleled detail essential to analyzing problems and developing solutions for complex airport issues.

DDFSs are referred to by many names, including event files, gated flight schedules, planning day schedules, or hypothetical design day activity. They can be designed in several ways depending on the type of analysis, but are distinguished in that they discretely represent each flight in a day, indicating type of operation (arrival/departure) and specific time of operation. Many DDFSs also include equipment type, gate assignment, origin and destination (O&D), and arrival/departure pairings. Some DDFSs also include ground movements, such as the use of airfield penalty boxes and towing from a gate to a RON hardstand. When used for passenger facility analysis, DDFSs can include the number of passengers assigned to each flight, potentially identifying O&D and connecting passengers.

In this guidebook, a **DDFS is defined as a constructed schedule showing individual aircraft arrivals and departures by time of day and aircraft type that can also show airline, O&D, and the number of passengers associated with each flight, depending on the level of detail required**. Although a DDFS typically includes an entire design day, it can be restricted to a peak period of interest if a full day is not required for a particular project. It may be used by airport staff, or by consultants on behalf of airport operators, for operational or facilities planning analyses or for simulation modeling purposes.

A DDFS is defined as a constructed schedule showing individual aircraft arrivals and departures by time of day and aircraft type that can also show airline, origin/destination, and passengers associated with each flight, depending on the level of detail required.

A DDFS is contingent on selection of a **design day**. The definition of the design day depends on the purpose of the analysis. For most planning, the design day is intended to represent a busy day that characterizes the ability of a facility to provide adequate capacity and service levels most of the year while avoiding the cost of building for the single busiest day of the year. The trade-off between capacity/service level and cost may vary by facility. For most environmental analyses, the design day is defined as an average annual day.

1.2 Guidebook Audience

There are two main audiences for this guidebook, **users of the DDFS and preparers of the DDFS**. Users need to have a basic understanding of a DDFS, including its advantages and limitations. Users should be able to determine when a DDFS is needed, how it should be scoped, and how the results should be communicated, but do not need to immerse themselves in the details of DDFS preparation. Preparers of the DDFS should also be knowledgeable of DDFS uses, but their main focus is on constructing the DDFS. Preparers need to be familiar with the many intricacies and nuances involved in preparing a DDFS and how they may affect the projects or issues that the DDFS will be used to evaluate. Later in this overview and at the beginning of each chapter, readers are informed as to whether the material is directed to the user audience or the preparer audience.

There are two main audiences for this guidebook, **users and preparers.**

1.3 Guidebook Organization and Summary

To the extent possible, this guidebook features a modular organization. The guidebook is organized to enable quick navigation to the area of interest. The chapters of the guidebook are organized as follows.

Chapter 2: What Is a DDFS (users and preparers) describes the DDFS, its key elements, and current uses. Some DDFS elements are common to all DDFSs, whereas others are optional depending on the intended DDFS use. Key elements are listed in Table 1.1.

Table 1.1. Elements of a DDFS.

Reference Number/Record Identifier
Arrival/Departure Designation
Arrival/Departure Pairing
Activity Category
Flight Time
Day of Week
Airline
Flight Number
Gate Assignment
Remain Overnight Status
Domestic/International/Precleared Designation
Origin/Destination
Aircraft Equipment Type
Seats
Load Factor
Enplaned/Deplaned Passengers
O&D Percentage
Originations/Terminations/Connections
Runway Use Designation
Arrival/Departure Fixes

The key elements will vary depending on the intended use of the DDFS. For example, airfield analyses will not require passenger loading information, such as enplaning and O&D passengers by flight.

In general, DDFSs are used when detailed analysis is required for: (1) planning, design, and operation of airports when complex master planning alternatives and facilities need to be evaluated; (2) decision support to resolve airport issues and formulate strategies; and/or (3) programming, design, and environmental analysis of new large projects. Often these analyses involve airfield or terminal building simulation modeling that requires inputs at an individual flight level of detail. Airport operators are also increasingly using real-time or short-term DDFSs to address operational and management issues, such as gate allocation, staffing, and noise monitoring. For more detail, click to access Chapter 2.

Chapter 3: When Should a DDFSs Be Used (primarily users) provides guidance on when to apply a DDFS, with a focus on the type of issue being analyzed, the size and role of the airport, available resources, and alternative analytical approaches. The decision regarding whether or not to prepare and use a DDFS will depend on the factors listed in Table 1.2.

In general, DDFSs are used extensively to assist in the planning of major airfield and terminal capacity projects. To a lesser extent, they are used in landside and environmental planning. Short-term DDFSs are increasingly being used in managing airport and airport-related operations. For more detail, click to access Chapter 3.

Chapter 4: Which Elements Need to Be Included in a DDFS (primarily users) provides guidance on the recommended level of DDFS detail, specifically airline, aircraft, market, gate assignment, and passenger load information, which depends on the type of facility being analyzed, as well as the audience and stakeholders, the purpose of the analysis, and the available resources (see Table 1.3).

Under some limited circumstances, a partial DDFS that includes the anticipated peak period and the times immediately preceding and following the peak period can be used instead of a DDFS for a full design day. Partial DDFSs may be appropriate at small uncongested airports where the peak activity period is clearly defined and carryover delay and recovery times are not an issue. Partial DDFSs are best used to examine requirements for facilities closely tied to peak passenger or aircraft flows. Some facilities, such as curbsides, accommodate activity peaks that are offset significantly from the at-gate peaks and may be influenced by off-peak activity flows in

Table 1.2. Factors determining the need for a DDFS.

Airport Size
Airport Role
Airline Hub Role
Airport Constraints
Patterns of Scheduled Activity
Type of Project
Capacity Issues
Likelihood of Detailed Follow-on Planning
Complexity of Project
Planning Tools to Be Used
Competing Demands within Airport
Degree of Scrutiny
Project Cost
Available Resources
Expected Controversy

Table 1.3. DDFS elements needed by type of analysis.

Type of Analysis	DDFS Elements Needed
Airside Planning	The most important elements are flight times, aircraft types, and arrival/departure designations. Passenger-related information, such as the number of passengers per flight, is not required.
Terminal Planning	Terminal planning, especially planning for facilities related to passenger processing, usually requires the most DDFS detail. In addition to flight times and aircraft types, the numbers of passengers associated with each flight and segmentation by O&D or connecting status are required.
Landside Planning	Landside planning typically focuses on vehicle flows, which are derived from passenger flows. Therefore, the DDFS passenger data typically used for terminal planning is required, but aircraft details are not required.
Environmental Planning	Environmental planning mostly involves noise and air quality analyses, although the modeling tools used for these analyses may differ depending on the focus of the analysis: airfield planning or landside planning. A DDFS level of detail is often not required. If the environmental analysis is related to aircraft operations, the DDFS level of detail required for airside planning is sufficient. If the environmental analysis is focused on vehicular traffic, the level of detail required for landside analysis is more appropriate.
Operations and Management	DDFSs used for operations and management tend to be real-time or short-term (1 to 2 years out at most) and are sometimes prepared and updated using automated methods or third-party vendors. When DDFSs are used for airfield or gate management, the most important elements are flight times, aircraft types, and arrival/departure designations. When DDFSs are used for terminal facility management, estimates of the numbers of passengers associated with each flight are also required.

ways not readily apparent. The requirements for other facilities, such as gates, may be greatest at off-peak times, such as late at night. In these instances, partial DDFSs are not appropriate. For more detail, click to access Chapter 4.

Chapter 5: How to Scope a DDFS (users and preparers) provides guidance on determining the scope of the effort, if a DDFS is useful or appropriate, which DDFS elements should be included, and appropriate time horizons. As illustrated in Exhibit 1.1, it is the first step in preparing a DDFS. For more detail, click to access Chapter 5.

Chapter 6: How to Prepare a DDFS for Base Year and Future Conditions (primarily preparers) provides guidance on preparing a DDFS, including defining key parameters, describing the steps involved in the preparation, and applying the results. Exhibit 1.1 shows a generalized schematic diagram of the DDFS process.

Parameters that will govern preparation of the DDFS need to be defined, as they help determine the required data inputs. Among the most important of these is the **design day definition**. If the DDFS is being prepared for future conditions, assumptions regarding future operating policies and physical constraints should be determined. These can include noise curfews; demand management policies, such as slot restrictions; and physical gate, airspace, or airfield capacity constraints that cannot or are not expected to be mitigated. In addition, if the DDFS is intended to be used to model a future airport layout, pertinent information, such as gate and concourse locations and capabilities, should be determined.

Construction of a DDFS involves **market and fleet mix projections** assembled to generate a design day estimate of arrivals and departures by aircraft types. The market and fleet mix projections are sometimes available from an annual activity forecast, but often need to be independently

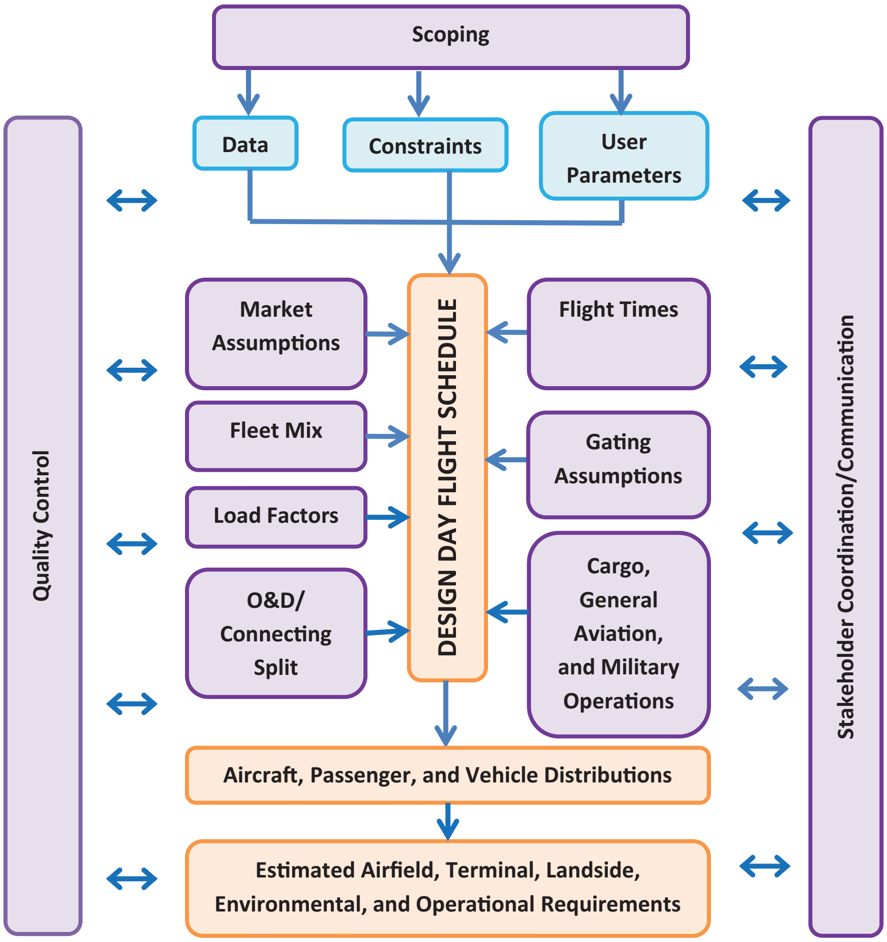


Exhibit 1.1. General DDFS preparation process.

calculated. **Flight times** are estimated for each aircraft arrival and departure and arrivals and departures are paired or matched. Once flight times are estimated, **passenger loads, gates, and flight tracks** can be assigned if necessary.

For many airfield simulation analyses and for terminal planning, arriving **aircraft need to be assigned to gates**. Factors that should be considered include existing and planned gate layouts, gate capabilities for accommodating different types of aircraft, gate assignment policies (exclusive, preferential or common-use), buffer time between a departure and arrival at the same gate, and balancing of operations among gates. When DDFSs are used for terminal and landside planning, they must be translated into **passenger flows**. This requires estimating enplaned passenger loads and O&D/connecting passenger splits for each flight. At spoke airports, a generic O&D/connecting passenger split may be sufficient, but at airline hubs, the O&D/connecting passenger split will be markedly different for the hubbing airline.

DDFSs prepared for large airports tend to be focused on scheduled passenger airline aircraft operations because they often represent the largest category and affect critical facilities, such as the terminals, gates, and curbsides. However, if intended to address airfield issues, a DDFS should include nonscheduled aircraft categories, such as charter, air taxi, all-cargo, general aviation (GA), and military operations. In a DDFS, these operations are typically represented by a selected sample of daily activity representing a normal distribution of operations activity.

DDFSs are inherently detailed and their preparation involves substantial individual judgment in the selection of new markets, flight times, arrival/departure pairings, and other elements. As a result, there is a potential for both error and bias and **quality assurance** is an important consideration. For more detail, click to access Chapter 6.

Chapter 7: How to Apply DDFS Outputs (primarily preparers) provides guidance on how to modify DDFS output, if necessary, for application in airfield, terminal, landside, and environmental planning and operations and management (see Table 1.4). For more detail, click to access Chapter 7.

Chapter 8: How to Address Risk and Uncertainty with DDFSs (users and preparers) provides recommendations on how to evaluate and manage the uncertainty inherent in all future DDFSs. Sources of uncertainty in future DDFS and the annual activity forecasts upon which they are based include:

- Inputs such as projections of economic growth or fuel and other costs;
- Assumptions on future industry changes, such as those related to airfares, types of air service, and competitive factors;
- Statistical modeling error; and
- Disruptive events, such as the September 11, 2001, terrorist attacks.

Statistical methods for quantifying uncertainty are used to estimate how an actual future value of a forecast metric (for example, passengers) is likely to deviate from the predicted value. By measuring historical variations in activity from the long-term average, the most likely distributions of activity around the long-term average can be estimated and applied to forecast values. These distributions are often described as **confidence intervals**, discussed further in Chapter 7. Some methods of addressing DDFS uncertainty are listed on Table 1.5. For more detail, click to access Chapter 8.

Table 1.4. Application of DDFS output.

Type of Analysis	Application
Airside Planning	DDFSs can be directly incorporated into airfield and airspace simulation and spreadsheet models. They can be used to identify new runway or taxiway/holding pad requirements, estimate capacity or delay, or identify hot spots that could represent safety concerns. DDFSs can also be aggregated into hourly aircraft distributions for input into spreadsheet models to estimate capacity and delay.
Terminal Planning	DDFSs can be directly incorporated into terminal simulation models or aggregated into hourly passenger distributions that can be customized to reflect alternative design day definitions or peak period activity levels for use in spreadsheet models.
Landside Planning	DDFSs can be aggregated into O&D passenger distributions for conversion to vehicle distributions using modal split and lead and lag time assumptions. The vehicle distributions can then be used as input to landside simulation models or simpler landside spreadsheet models.
Environmental Planning	DDFSs can be incorporated directly into the AEDT or aggregated into day/night and stage length categories for AEDT processing. DDFSs can also be directly incorporated into the AEDT for aircraft-related air quality dispersion analysis or used indirectly to estimate ground vehicle emissions.
Operations and Management	DDFSs are used directly to assist in airline and airport operations and gate management. If staffing requirements are related to airfield or terminal building operations, intermediate aircraft or passenger distributions developed from DDFSs can be used to generate staffing requirements.

Table 1.5. Methods of addressing DDFS uncertainty.

Randomly adjust DDFS elements, such as arrival or departure times, to test the sensitivity of planning outcomes.
Develop forecast scenarios for DDFSs, which could generate a wealth of detail, but could also be cost prohibitive.
Calculate confidence intervals for aggregate DDFS results to estimate the uncertainty associated with measures of airfield capacity, gate requirements, and peak passenger flows.
Prepare Monte Carlo simulations in which probability distributions are identified for forecast input factors and parameters, and multiple iterations are then run with the inputs and parameters randomly generated based on the probability distributions.
Prepare risk registers to address low-frequency, high-magnitude risks that are difficult to define using probability distributions.

Chapter 9: How and When to Communicate DDFS Results (primarily users) provides guidance on how to best communicate the assumptions, results, and uncertainty associated with DDFSs and when and how often to engage stakeholders in the process.

Coordination and communication are important to a successful DDFS: defining the problem to be solved, obtaining meaningful input and reviews by stakeholders, and identifying critical elements. This coordination and communication process becomes most critical once DDFS results are produced and applied.

In most instances, reporting and coordination of DDFS results have two distinct target audiences: (1) senior airport management and stakeholders and (2) technical airport staff and consultants.

Senior airport management and stakeholders will make decisions based on analysis results. They need to be involved in the definition of the issue/problem and the reason for preparing the DDFS and they need to understand the:

- Rationale for the DDFS preparation approach used;
- Key assumptions that will likely influence the results; and
- Areas of uncertainty and risk in the DDFS results.

Documentation provided to senior management and stakeholders should be straightforward, nontechnical, and as concise as an executive summary.

Technical airport staff and consultants need additional detail to fully understand the results, assumptions, and decisions so that a documentation trail is available to use in follow-on studies and analyses, both in the near term and for future updates. While the level of detail and documentation will vary from airport to airport and project to project, at a minimum, assumptions regarding critical DDFS factors need to be transparent.

One of the most important messages that needs to be relayed to all audiences is the "point-in-time" nature of the DDFS preparation process and the inherent uncertainties and related risks of a dynamic aviation industry. This issue is one of the challenges of the DDFS process and needs to be clearly explained to establish the credibility of the DDFS results, which would be used for various facility analyses. For more detail, click to access Chapter 9.

The appendices include a DDFS case study (Appendix A) with examples, more detailed discussion of the stability and predictability of DDFS factors (Appendix B), additional discussion of uncertainty (Appendix C and Appendix D), quality control recommendations (Appendix E), a list of data sources (Appendix F), and a glossary (Appendix G).

One of the most important messages that needs to be relayed to all audiences is the point-in-time nature of the DDFS preparation process and the inherent uncertainties and related risks of a dynamic aviation industry.

Several other ACRP publications supplement the guidance herein. In particular, the reader is encouraged to refer to:

- *ACRP Report 25: Airport Passenger Terminal Planning and Design*, Volumes 1 and 2 (2010), provides guidance on applying DDFS inputs for terminal planning. http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_025v1.pdf and http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_025v2.pdf
- *ACRP Report 40: Airport Curbside and Terminal Area Roadway Operations* (2010), provides guidance in applying DDFS-derived inputs to evaluate airport roadway and curbside operations. http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_040.pdf
- *ACRP Report 76: Addressing Uncertainty about Future Airport Activity Levels in Airport Decision Making* (2012), provides in-depth guidance for incorporating uncertainty into airport forecasting and planning. http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf
- *ACRP Report 79: Evaluating Airfield Capacity* (2012), provides guidance on applying DDFS inputs for airfield planning. http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_079.pdf
- *ACRP Report 82: Preparing Peak Period and Operational Profiles—Guidebook* (2013), provides alternatives to DDFSs for estimating peak activity levels. http://onlinepubs.trb.org/online pubs/acrp/acrp_rpt_082.pdf

CHAPTER 2

What Is a DDFS

This chapter describes DDFSs, their key elements, and current uses. It is directed to both users and preparers.

A DDFS is a constructed schedule showing individual aircraft arrivals and departures by time of day and aircraft type, which can also include several other elements depending on available information and intended use. Section 2.1 provides additional background information on DDFSs, Section 2.2 describes the key DDFS elements in more detail, and Section 2.3 describes some common DDFS uses.

2.1 Background

The core of a DDFS is a set of airline schedules. For the base year, the schedules represent airline plans to provide service, including markets served, aircraft equipment, and scheduled flight times. For future DDFSs, the schedule represents the preparer's estimate of how airlines would plan to provide service. As not all flights are scheduled, a representative sample of nonscheduled passenger and cargo, air taxi, GA, and military aircraft operations is added. Many DDFS uses require estimates of passenger flows. In those instances, estimates of total passengers and passenger characteristics (O&D or connecting, etc.) must be added. Finally, the relationship between the DDFS and specific airport facilities must be defined. This often includes gate or parking assignments and can also include runway assignments.

2.2 Key Elements

The layout and format of a DDFS can vary depending on the preparer and the requirements of the analysis. Exhibit 2.1 shows a section of a sample DDFS. Some DDFS elements are common to all DDFSs, whereas others are optional depending on the intended DDFS use. Key elements include the following and are designated by an alphabetical character on Exhibit 2.1.

Reference Number/Record Identifier (A): This is a unique identifier applied to each record or row in the DDFS. It is useful for sorting and for pairing arrivals and departures when they appear on separate records.

Arrival/Departure Designation (B): Although the left or right placement within a DDFS can often be used to determine whether a flight is an arrival or a departure, a separate field specifying a flight's arrival or departure status is often used to prevent confusion among new users.

Arrival/Departure Pairing or Matching: Most DDFSs pair or match an arriving flight with a succeeding departing flight. The pairing is typically denoted by placing the arriving

		Arrivals														Departures												
Rec. No.	Cat	Gate	RON	Type D/I	Origin	Arr. Hour	Arr. Min.	Air-line	Flt. No.	Equip-ment	Seats	Arr. L.F.	Arr. OD %	Depl	Term	RON	Type D/I	Dest.	Dept. Hour	Dept. Min.	Air-line	Flt. No.	Equip-ment	Seats	Dept. L.F.	Dept. OD %	Enp	Orig
1074	PAX	D09		D	PHF	17	25	FL	900	73G	137	97%	41%	133	54		D	LAS	18	30	FL	764	73G	137	100%	62%	137	84
[illegible]	PAX	D09		D	ICT	19	35	FL	686	717	117	74%	35%	87	30		D	DTW	20	10	FL	132	717	117	78%	50%	91	46
[illegible]	PAX	D09		D	FLL	20	50	NK	142	319	138	83%	100%	114	114	Y					NK		'319	138				
1077	PAX	D10	Y					[illegible]		735	104						D	EWR	8	15	CO	1154	'735	104	59%	81%	61	49
1078	PAX	D10		D	EWR	10	33	[illegible]	1167	735	104	74%	79%	77	61		D	EWR	11	15	CO	1148	'735	[illegible]	84%	81%	87	71
1079	[illegible]	D10		D	EWR	13	28	CO	1149	735	104	[illegible]	79%	92	73		D	EWR	14	5	CO	1160	'735	[illegible]	95%	81%	99	80
[illegible]	[illegible]	D10		D	EWR	16	40	CO	[illegible]	735	104	[illegible]	79%	97	77		D	EWR	17	30	CO	1152	'735	104	96%	81%	100	81
[illegible]	[illegible]	D10		D	IAH	[illegible]	[illegible]	CO	[illegible]	735	104	[illegible]	79%	85	68		D	EWR	[illegible]	[illegible]	CO	1158	'735	104	84%	81%	87	71
1082	PAX	D10		D	EWR	[illegible]	[illegible]	CO	[illegible]	735	104	79%	79%	82	65	Y			[illegible]	[illegible]	CO		'735	104				
1083	PAX	D11	Y					AC		CRJ	50						I	YYZ	[illegible]	0	AC	[illegible]	'CRJ	50	60%	100%	30	30
1084	PAX	[illegible]	Y					NW		[illegible]	125						D	MEM	7	40	NW	[illegible]	'D95	125	54%	86%	67	58
1085	PAX	[illegible]	Y					FL		[illegible]	[illegible]						[illegible]	CAK	8	24	FL	[illegible]	717	117	[illegible]	63%	66	42
1086	PAX	[illegible]		D	[illegible]	8	35	FL	342	[illegible]	137	58%	26%	80	21		[illegible]	PHL	9	15	FL	342	73G	137	[illegible]	52%	103	54
1087	PAX	D11		I	[illegible]	9	45	AC	1000	E75	73	64%	100%	47	47		[illegible]	YYZ	10	[illegible]	[illegible]	1003	'E75	73	[illegible]	100%	52	52
1088	PAX	D11		I	YYZ	12	35	AC	8622	[illegible]	[illegible]	80%	[illegible]	40	40		[illegible]	YYZ	13	[illegible]	[illegible]	8625	'CRJ	50	86%	100%	43	43
1089	PAX	D11		I	YYZ	16	10	AC	1004	[illegible]	[illegible]	88%	[illegible]	64	64		I	YYZ	16	45	[illegible]	1007	'E75	73	91%	100%	67	[illegible]
1090	PAX	D11		D	PIT	16	58	FL	997	717	[illegible]	91%	[illegible]	107	34		D	[illegible]	17	36	FL	857	717	117	96%	[illegible]	113	[illegible]
1091	PAX	D11	[illegible]	I	YYZ	19	30	AC	1006	E75	73	78%	100%	57	57		I	[illegible]	20	5	AC	1009	'E75	73	77%	[illegible]	56	[illegible]
1092	PAX	D11	[illegible]	D	DAY	20	33	FL	709	717	117	74%	41%	86	[illegible]		D	[illegible]	21	20	FL	709	717	117	82%	[illegible]	96	1
1093	PAX	D11		I	YYZ	23	0	AC	8628	CRJ	50	65%	100%	33	[illegible]	Y					AC		[illegible]	50				
1094	PAX	D12	Y					CO		735	104						D	IAH	7	0	CO	1621	[illegible]	104	57%	81%	59	48
1095	PAX	D12		D	EWR	9	1	CO	1169	735	104	70%	79%	72	57		D	EWR	9	45	CO	1164	[illegible]	104	73%	81%	76	62
1096	PAX	D12		D	EWR	11	50	CO	1165	733	124	79%	79%	98	78		D	EWR	12	30	CO	84	'733	124	90%	81%	112	91
1097	PAX	D12		[illegible]	EWR	14	55	CO	1159	735	104	91%	79%	[illegible]	76		D	EWR	15	45	CO	1150	'735	104	97%	81%	[illegible]	81
1098	PAX	D12		[illegible]	EWR	18	14	CO	1151	733	124	92%	79%	[illegible]	91		D	EWR	19	0	CO	1156	'733	124	88%	81%	[illegible]	88
1099	PAX	D12		[illegible]	EWR	22	27	CO	1155	735	104	71%	100%	[illegible]	73	Y					CO		'735	104				
1100	PAX	D13	Y					NW		D95	125						D	DTW	9	0	NW	476	'D95	125	72%	86%	90	77
1101	PAX	D13		D	MEM	11	39	NW	818	D95	125	73%	87%	91	79		D	DTW	12	22	NW	466	'D95	125	89%	86%	112	96

A – Reference Number/Record Identifier	B – Arrival/ Departure Designation	C – Activity Category
D – Flight Time	E - Airline	F – Flight Number
G –Gate Assignment	H – Remain Overnight Status	I – Domestic/International/Precleared Designation
J – Origin/Destination	K –Aircraft Equipment Type	L - Seats
M – Load Factor	N – Enplaned/Deplaned Passengers	O – O&D Percentage
P – Originations/Terminations		

Exhibit 2.1. Example of a design day flight schedule.

and departing flights on the same record. However, this is not required; sometimes arrival/departure pairings are identified by adding an extra field to the arrival record that denotes the record number associated with the departure record with which it is paired. In Exhibit 2.1, the pairing is indicated by showing the arrival and departure on the same record.

Activity Category (C): This element designates the general activity category of the aircraft operation, such as scheduled or nonscheduled passenger, cargo, air taxi, GA, or military. In some instances, the required level of detail, flight time definitions, or simulation rules may vary depending on the activity category. If a DDFS is limited to a single category (e.g., passenger aircraft), as may be the case for terminal building analysis, the activity category designation becomes redundant.

Flight Time (D): This is the scheduled time of arrival for aircraft arrivals and the time of departure for aircraft departures. This element typically refers to gate time for passenger flights, as that is how flight times are listed in published airline schedules. For other, nonscheduled flights, flight time is often defined as the time of runway contact. In some instances, arrival flight time is defined as the time a flight enters the local airspace. It is essential that the flight time be accurately defined in the DDFS so that the analyst can make the appropriate adjustments in the analysis or simulation.

Day of Week: In some instances, DDFSs are prepared for an entire week, and a specific field is used to indicate which days of the week each flight operates. The example in Exhibit 2.1 represents a DDFS prepared for a single day and therefore does not include a day of the week indicator. DDFSs prepared for multiple days include an additional column indicating whether the flight in the record operates in a given day of the week.

Airline (E): Identifying the airline operating the flight helps when estimating gate assignments, load factors, connecting percentages, and new flight times.

Flight Number (F): Although not essential, airline flight numbers can help tie a DDFS flight to an existing flight schedule.

Gate Assignment (G): In many DDFSs, individual arrival/departure flight pairs are assigned to gates. When the DDFS is used for airfield analyses and gate assignments are not critical, flights are assigned to super gates, which can encompass a given area within an airport, such as a terminal concourse. In some instances, DDFSs are used in conjunction with gating models, which determine gate assignments and requirements as outputs.

Remain Overnight Status (H): When an aircraft departs for the first time during a day, an indicator is often used to show that it was parked overnight at either a contact gate or RON parking position. Likewise, when an aircraft arrives for the last time during the day, an indicator is used to show that it will be parked overnight at a gate or RON position. In some instances, flights are paired with arrivals or departures from the previous or succeeding day.

Domestic/International/Precleared Designation (I): Not all gates are equipped with the secure environments required for U.S. CBP; therefore, a flight's domestic, international, or precleared status helps determine its gate assignment or requirement.

Origin/Destination (J): In a DDFS, the origin and/or destination designations help determine runway use, arrival/departure routes, and sometimes load factors and originating/connecting passenger distributions.

Aircraft Equipment Type (K): Aircraft equipment type is very important in determining which gates can be used, numbers of passengers and their requirements, and runway and airspace use. In some instances, general aircraft size categories are substituted for specific aircraft types.

Seats (L): The number of seats associated with each aircraft determines the maximum number of passengers per flight and, coupled with load factor, determines the number of enplaned or deplaned passengers.

Load Factor (M): Load factor, coupled with aircraft seats, determines enplaned or deplaned passengers on each flight. Depending on the level of detail needed, airport average load factors can be used, or they can be segmented by any combination of airline, market, and time of day. As the load factor is an intermediate element used to generate numbers of enplaned or deplaned passengers that are then used to determine many terminal building requirements, it does not need to be listed in a DDFS. However, it is often included for reference.

Enplaned/Deplaned Passengers (N): Enplaned and deplaned passengers are associated with each departing and arriving flight, and are typically estimated using the number of seats per aircraft and load factor. The enplaned and deplaned passenger estimates are typically used to determine post-security terminal requirements. Pre-security terminal requirements are dependent on originations and terminations.

O&D Percentage (O): The O&D percentage is used to determine the share of enplaned and deplaned passengers that consists of local passengers, as distinguished from connecting passengers. This percentage helps determine most nonsecure terminal building requirements. At airports without significant connecting activity, the same O&D percentage is sometimes used for all flights. At major connecting hub airports, O&D percentages are usually differentiated by airline because, typically, a single airline accounts for most of the connecting activity at an airport. As the O&D percentage is an intermediate element used to generate numbers of originating and terminating passengers, it does not need to be listed in a DDFS. However, similar to load factor, it is often included for reference.

Originations/Terminations (P): Numbers of originating passengers on departing flights and terminating passengers on arriving flights are estimated by applying the O&D percentage to the enplaned and deplaned passenger estimates. The originating and terminating passenger estimates are used to estimate most security screening checkpoint and pre-security terminal and landside requirements. In detailed analyses where passenger movements between concourses and terminals need to be estimated, numbers of connecting passengers are further disaggregated by terminal/concourse destination.

Runway Use Designation: Preferred runway use is sometimes listed in a DDFS, but it is generally more practical to make runway use determinations during the airfield modeling phase of the analysis.

Arrival/Departure Fixes: Similar to preferred runway use, arrival/departure fixes are sometimes listed in the DDFS, but are usually determined during the airfield/airspace modeling phase of the analysis.

The key elements will vary depending on the intended use of the DDFS. For example, airfield analyses will not require passenger loading information, such as enplaned and O&D passengers by flight.

2.3 Current Uses

In general, DDFSs are used when detailed analysis is required for: (1) planning, design, and operation of airports when complex master planning and facility alternatives need to be evaluated; (2) decision-making support to resolve airport facility or operational issues and formulate strategies; and/or (3) programming and design of new large projects. Often these analyses involve airfield or terminal building simulation models that require input at an individual flight level of detail and therefore a DDFS. DDFSs are typically prepared sporadically on an as-needed basis, and are prepared for longer-term planning horizons, such as five, 10, or 20 years. In many instances, DDFSs prepared for one purpose are used for multiple additional purposes that were not envisioned at the outset.

DDFSs are often used at large and rapidly growing airports that need to address expensive or controversial capacity issues. DDFSs are much less commonly used at small or slow-growing airports, or for less detailed planning based on annual or peak hour forecasts. These airports often do not have capacity issues and, therefore, do not need DDFS levels of detail to plan and justify facility modifications or expansion.

Airport operators are also increasingly using real-time or short-term DDFSs to address operational and management issues, such as gate allocation, staffing, and noise monitoring. More detailed guidance on when to prepare and apply DDFSs is provided in Chapter 3.

Current DDFS uses include:

- Detailed analysis of complex master planning and facility alternatives
- Decision-making support to resolve airport issues and formulate strategies
- Detailed project programming and design

CHAPTER 3

When Should DDFSs Be Used

This chapter provides guidance on when to apply DDFSs. The chapter initially provides general guidance and then more specific guidance on when it is appropriate to prepare a DDFS to address airfield, terminal, landside, environmental, and operational and management issues. It is primarily directed to users.

DDFSs require much effort and data to prepare. Although they are indispensable for resolving some problems, in some instances they are excessive or more cost-effective alternatives are available. The decision regarding whether or not to prepare and use a DDFS depends on the size of the airport, the available time and resources, the planning approach being used, the type of problem or issue being addressed, and the expense and potential consequences of the problem or issue being addressed. In some cases, DDFSs do not need to be prepared for the entire design day. These cases are described in more detail in Section 6.2.

3.1 General Guidance

Table 3.1 provides a general summary of the circumstances under which a DDFS is likely to be useful. Later tables in this chapter provide more detailed guidance on the appropriate use of DDFSs in addressing specific problems or issues.

Although DDFSs are indispensable for resolving some problems, in certain instances they are excessive or more cost-effective alternatives are available.

What is the Airport Size? DDFSs are seldom prepared or used at non-hub or GA airports. Factors that favor the use of DDFSs, such as airport role, the pattern of aircraft activity, project complexity and degree of stakeholder scrutiny, type and cost of the project, expected amount of controversy, likelihood of competing airport activity demands, and available analytical resources, are more likely to apply to large airports than small airports. Often, small airports have a clearly apparent activity peak. If the facilities being analyzed are dependent on peak passenger or aircraft flows and delay is not a significant issue, the DDFS may be truncated to encompass just the peak period and the times immediately preceding and following the peak period.

What is the Airport Role? If an airport serves a large number of scheduled aircraft operations, its activity profile can be more effectively described and modeled with a DDFS. If the airport serves mostly unscheduled operations, such as GA operations, hourly distribution profiles may be more appropriate. A DDFS can be prepared using a daily sample of unscheduled operations, but the additional detail may imply a degree of precision that does not exist.

What is the Airline Hub Role? Airports that serve as a connecting hub for one or more airlines may have a greater need for a DDFS than spoke airports. The efficient operation of

Table 3.1. When should DDFSs be used: general guidance.

	DDFSs Are More Likely to Be Needed or Useful	DDFSs Are Less Likely to Be Needed or Useful
Airport Size	Large or Medium Hub	Non-hub or GA
Airport Role	High Percentage of Scheduled Operations	Low Percentage of Scheduled Operations
Airline Hub Role	Connecting Hub Airport	Spoke Airport
Pattern of Aircraft Activity	Complex/Changing	Simple/Stable
Constraints on Aircraft Activity	Constraints	No constraints
Type of Project	Capacity	Non-capacity
Project Category	Terminal/Airfield	GA/Landside
Project Complexity	Complex	Simple
Detailed Follow-on Work	Yes	No
Competing Airport Activity Demands	High	Low
Planning Tool(s)	Complex	Simple
Project Cost	High	Low
Degree of Stakeholder Scrutiny	High	Low
Expected Amount of Controversy	High	Low
Available Analytical Resources	High	Low

airline connecting banks imposes specific requirements on gates and runway capacity that often necessitate a detailed schedule to fully evaluate. In addition, the O&D versus connecting passenger split is very different for hubbing airlines versus airlines providing point-to-point service. O&D and connecting passengers have very different effects on terminal building and landside facilities. Therefore, activity profiles need to be developed by airline to accurately define passenger peaks and facility requirements at connecting hub airports.

What is the Pattern of Scheduled Activity? At small airports, scheduled activity generally consists of an early morning departure peak and a late evening arrival peak. Identifying the future fleet mix, number of hubs served, and average load factor is often sufficient to identify the peak period passenger flows that drive terminal requirements. At larger airports, with changing market and airline shares and multiple terminals and concourses, a DDFS may be required to describe the changes in sufficient detail to be used for facility planning.

Are Airport Constraints Involved? In some instances, an airport has physical or policy constraints that cannot be feasibly remediated (e.g., slot or gate restrictions) and the effect of these constraints is realized primarily during peak periods. The effect of aircraft and passenger flows at these airports is more accurately modeled using DDFSs than using top-down approaches where peak flows are derived from annual forecasts.

Are Capacity Issues Involved? If the planning issue involves adding airfield or terminal building capacity, DDFSs are more likely to be suitable than if the planning issue involves meeting standards, addressing safety, or replacing facilities. DDFSs can provide the level of detail necessary to identify the peak flows that need to be accommodated by a variety of facilities at a number of different locations.

What Type of Project Is Involved? In general, airfield and passenger terminal projects are well-suited for DDFS analysis, whereas other types of projects, such as GA or landside projects, DDFSs are best suited for complex airfield and terminal projects that required detailed analyses of competing needs within a limited airport footprint.

are less suited. Sections 3.2 through 3.6 provide additional guidance on the use of DDFSs for specific types of planning analyses.

How Complex Is the Project? Generally, the more complex a project is in terms of size, number of functions, number of users, interaction with other facilities, and phasing, the more likely it is to benefit from the detailed information provided by DDFSs and associated planning and simulation models.

Will There Be Detailed Follow-on Planning? Immediate planning issue may be of moderate complexity and a DDFS may be advisable but not required. In those instances, the likelihood of follow-on planning should be considered. If the follow-on work is likely to require a DDFS, a DDFS should be considered in the first instance to ensure that the results of each planning phase are consistent.

Are There Competing Airport Activity Demands? Often, at busy airports, various functions must operate within a small building or area footprint. Reconciling competing demands by multiple users for limited airfield, ramp, and other airport space requires a detailed understanding of demand by these users by time of day, which is usually best provided by a DDFS.

What Type(s) of Planning Tool(s) Will Be Used? Planning tools can range from tables in a planning manual to complex simulation models. Most simulation models require a DDFS level of detail as input.

What Is the Project Cost? Expensive airport projects tend to be complex and, therefore, more likely to require analyses that entail DDFS inputs. In addition, higher project costs tend to demand more detailed justification and invite closer stakeholder scrutiny.

What Is the Degree of Stakeholder Scrutiny? High profile, high cost airport projects become the focus of much stakeholder scrutiny, especially by the airlines. The level of detail provided by a DDFS can help identify each user's specific anticipated operation and effect on facility requirements and thereby assist in validation and justification. The simulation models supported by DDFSs can also provide a view of current and future airport operations that is difficult to convey with tables and charts.

What Is the Expected Amount of Controversy? The advantages of DDFSs in withstanding stakeholder scrutiny can also help with public controversy. The ability to describe airport activity in a way that nontechnical people can understand and to support simulation models helps convey a project's purpose and need more directly than tables and charts.

What Resources Are Available? DDFSs are labor intensive and can require up to 80–120 person-hours per schedule for a large-hub airport, not counting data collection and up-front modifications of annual forecasts, or subsequent documentation and coordination. As a result, DDFSs are expensive and time-consuming to prepare. This sometimes comes as a surprise to those without prior DDFS experience. Resources required to prepare DDFSs may not be available and, in some circumstances, an answer to a planning problem may be needed before a DDFS and associated planning tools can be applied. Users need to be aware of these resource requirements when determining funding, scheduling, and whether to do the work in-house or retain an outside consultant.

Is the Issue an Immediate Issue or a Long-Term Issue? This question does not determine whether or not a DDFS should be used, but it does determine whether a DDFS should represent existing conditions or future conditions. If the DDFS is only needed to represent existing conditions, preparation steps are much simpler. See Chapter 5 for additional guidance.

3.2 Specific Guidance for Airside Planning

The airside is defined as the runway, taxiway, and apron areas, along with facilities that directly support the airfield, such as aircraft rescue and firefighting and deicing facilities. Table 3.2 summarizes when a DDFS should be used for airside planning, including types of airport facilities, types of tools that can be used to analyze or plan these facilities, whether or not a DDFS is required to support these tools, and the alternatives to a DDFS that can be used.

Airfield Facility Planning

Airfield facility planning involves an assessment of the ability of the existing or proposed airfield to accommodate aircraft movements under a variety of circumstances and often involves

Table 3.2. When should a DDFS be used: airside.

	Planning Issue	Approach	DDFS Role	Alternatives to DDFS
Airfield Facility Planning	Capacity/Delay	Simulation Model	Required	None
		Spreadsheet Models	Not Required	Peak Period/Fleet Mix Forecasts
	Operations and Efficiency	Simulation Model	Required	None
		Airfield Layout Analysis	Not Required	Peak Period/Fleet Mix Forecasts
	Runway Length	Spreadsheet Models	Not Required	Fleet Mix Forecasts
	Deicing	Simulation Model	Required	None
		Spreadsheet Models	Not Required	Peak Period/Fleet Mix Forecasts
Aircraft Parking	At Gate	Gate Allocation Model	Required	None
		Spreadsheet Models	Not Required	Operations/Passenger Forecasts
		Airline Input	Not Required	Not applicable
	Remain Overnight	Gate Allocation Model	Required	None
		Spreadsheet Models	Not Required	Operations/Passenger Forecasts
		Airline Input	Not Required	Not applicable
Airfield Safety	Aircraft Rescue and Firefighting	Airfield Layout Analysis	Not Required	Operations/Fleet Mix Forecasts
	Safety Areas and Zones	Airfield Layout Analysis	Not Required	Operations/Fleet Mix Forecasts
	Incursion Analysis	Simulation Model	Required	None
		Airfield Layout Analysis	Not Required	Operations/Fleet Mix Forecasts
Standards	Meeting FAA Standards	Airfield Layout Analysis	Not Required	Operations/Fleet Mix Forecasts

Legend	
(green)	Approach that requires a DDFS
(orange)	Approach in which a DDFS is not required

quantifying the efficiency of the airfield, using metrics such as delay. At many large airports, simulation models are used to evaluate airfield needs and proposed solutions. The decision regarding whether or not to use a DDFS for airfield planning will be influenced by the following considerations:

- New runways or runway extensions usually require FAA funding and extensive environmental review, which then typically warrant the use of simulation modeling and a DDFS.
- Runway closure for reconstruction will significantly reduce capacity, albeit temporarily. Detailed simulation modeling and a DDFS are often needed to determine the best phasing and the most effective way to use the runways that remain open.
- Runway length analysis is dependent on the critical aircraft types; therefore, an annual fleet mix forecast is sufficient.
- If only initial screening of airfield development concepts is required, as in master planning, forecasts of annual and peak period aircraft operations, along with a fleet mix forecast, are sufficient.
- For master planning, which will not lead to design or construction without additional planning at a time closer to the implementation date, peak period activity estimates are often sufficient.
- At most small airports, airfield capacity is not an issue. The need for new runways, if any, is driven by issues such as wind coverage or redundancy rather than capacity, and DDFSs are generally not necessary.

Aircraft Parking

Airline aircraft parking requirements are very closely related to gate requirements. At-gate or RON aircraft parking needs can be evaluated at a high level of detail using a DDFS in conjunction with gate allocation models. If less detail is required, ratio methods that directly relate the number of parking positions to annual enplaned passengers or passenger aircraft operations can be used.

The use of a DDFS and gate allocation model is appropriate under the following circumstances:

- Significant increases in activity that would affect apron use, such as international flights, are anticipated.
- Changes in gate-use agreements are anticipated or contemplated. This could involve a change from exclusive-use agreements, under which an airline has sole rights to a gate/parking position, to common-use agreements, under which airlines share gates and parking positions.
- New gates or parking positions that would be costly are anticipated. Additional analysis may be warranted to avoid overbuilding.

ACRP Report 25: Airport Passenger Terminal Planning and Design, Volumes 1 and 2 http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_025v1.pdf provides guidance on estimating passenger aircraft parking requirements at a non-DDFS level of detail.

Airlines possess knowledge about their future schedules and their ability to increase aircraft parking utilization (aircraft departures per gate). As this information is generally unavailable to airport planners, input from airlines can also be useful in determining future gate requirements at an airport.

Airfield Safety

Planning for airfield safety involves applying knowledge of airfield risk factors and FAA standards. DDFSs and simulation models are useful in some instances, such as incursion analysis, but not necessary in most safety assessments.

Standards

FAA standards for runway and taxiway design are based on annual measures of airport activity such as total operations and operations by aircraft design group. Therefore, planning to meet FAA airfield standards does not require simulation modeling or preparation of a DDFS.

3.3 Specific Guidance for Terminal Planning

The terminal area is defined as the terminal building plus all concourses and gates. Table 3.3 summarizes when DDFSs should be used for terminal area planning, including the types of terminal facilities, the tools typically used to analyze and plan for these facilities, whether a DDFS is required or useful for supporting these tools, and what alternatives to a DDFS can be used.

Table 3.3. When should DDFSs be used: terminal area.

	Planning Issue	Approach	DDFS Role	Alternatives to DDFS
Gates	Gate Quantity	Gate Allocation Model	Required	None
		Spreadsheet Models	Not Required	Operations/Passenger Forecasts
		Airline Input	Not Required	Not Applicable
	Gate Sizing	Gate Allocation Model	Required	None
		Spreadsheet Models	Not Required	Operations/Fleet Mix Forecasts
		Airline Input	Not Required	Not Applicable
Departing Passenger Facilities	Ticket Counter	Simulation Model	Required	None
		Mini-Queuing Model	Useful	Peak Period Forecasts (O&D)
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Ticket Queue	Simulation Model	Required	None
		Mini-Queuing Model	Useful	Peak Period Forecasts (O&D)
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Passenger Security Screening	Simulation Model	Required	None
		Mini-Queuing Model	Useful	Peak Period Forecasts (O&D)
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Baggage Security Screening	Simulation Model	Required	None
		Detailed Planning Analysis	Useful	Design Day Profile (O&D)
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Baggage Handling Systems	Simulation Model	Required	None
		Spreadsheet Models	Useful	Peak Period Forecasts (Passengers)
	Baggage Make-Up Area	Baggage Make-Up Model	Not Required	Equivalent Aircraft
		Ratio Methods	Not Required	Equivalent Aircraft
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Departure Lounges	Spreadsheet Models	Not Required	Gate Requirements Forecasts

Legend	
(green)	Approach that requires a DDFS
(light)	Approach in which a DDFS is useful but not essential to provide the necessary inputs
(orange)	Approach in which a DDFS is not required

(continued on next page)

Table 3.3. (Continued).

	Planning Issue	Approach	DDFS Role	Alternatives to DDFS
Arriving Passenger Facilities	U.S. CBP	Simulation Model	Required	None
		Mini-Queuing Model	Useful	Peak Period Forecasts (O&D)
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Meeter/Greeter Area	Simulation Model	Required	None
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Baggage Claim	Simulation Model	Required	None
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
Other Terminal Facilities	International Re-check	Simulation Model	Required	None
		Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Passenger Conveyance Systems (people movers, escalators & elevators)	Simulation Model	Required	None
		Spreadsheet Models	Useful	Peak Period Forecasts (Passengers)
	Concourse Circulation	Terminal Layout Analysis	Not Required	Gate Requirements Forecasts
	Terminal Circulation	Terminal Layout Analysis	Not Required	Terminal Layout
	Restrooms - Terminal	Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
	Restrooms - Concourse	Simulation Model	Required	None
		Spreadsheet Models	Useful	Peak Period Forecasts (enplaned/deplaned passengers)
	Concessions	Detailed Retail Location Planning	Useful	Design Day Profile
		Spreadsheet Models	Not Required	Annual Passenger Forecasts
	Rental Car Counter and Offices	Spreadsheet Models	Useful	Peak Period Forecasts (O&D)
		Tenant Input	Not Required	Not Applicable
	Airline Offices and Operations and Maintenance	Airline Input	Not Required	Not Applicable

Legend	
(green)	Approach that requires a DDFS
(light green)	Approach in which a DDFS is useful but not essential to provide the necessary inputs
(orange)	Approach in which a DDFS is not required

There are four main categories listed in the table, including gates, departing passenger facilities, arriving passenger facilities, and other terminal facilities. *ACRP Report 25: Airport Passenger Terminal Planning and Design*, Volumes 1 and 2 http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_025v1.pdf provides additional guidance on planning tools for determining terminal facility requirements. The approaches in *ACRP Report 25* do not require DDFS inputs, but DDFSs are useful in characterizing and defining the peak periods.

Gates

The planning techniques used to identify gate requirements are similar to those used to determine passenger aircraft apron requirements (see Section 3.2). Specifically, more detailed analysis involving a DDFS should be considered if new activity is expected that would affect the intensity of gate use, if changes in lease terms would affect how airlines share gates, or if expansion would be costly.

Departing Passenger Facilities

Departing passenger facilities consist of ticketing facilities, security screening, baggage make-up areas, and holdrooms that serve departing passengers. Except for holdrooms, the demand for these facilities is determined by numbers of originating passengers. Holdrooms accommodate both originating and connecting passengers.

DDFSs should be used when terminal simulation or gate allocation models are involved. Mini-queuing models and spreadsheet analyses require peak period originating passenger forecasts. DDFSs are useful in characterizing and defining peak period originating passengers, but peak period forecasts are often generated without using a DDFS.

Arriving Passenger Facilities

Arriving passenger facilities include U.S. CBP facilities, meeter/greeter areas, and baggage claim facilities. The factors that determine if the planning of arriving passenger facilities requires a DDFS are similar to those for departing passenger facilities. One exception is that peak passenger flows are determined by deplaning passengers, especially those that are terminating their trips at the airport. Therefore, the timing of the effect on arriving passenger facilities lags the deplaning peak period defined in a DDFS.

Other Terminal Facilities

International re-check facilities serve international to domestic connecting passengers. The DDFS should be modified to include fields for domestic and international connecting passengers if simulation is used to determine re-check requirements.

Some terminal facilities, including concourse and terminal circulation space, passenger conveyance systems, and rental car counters, serve both arriving and departing passengers. The demand for these facilities is usually estimated using annual numbers of passengers or the configuration of other facilities, such as gates. Other facilities, such as airline offices, are not directly affected by peak passenger activity. DDFSs can be useful for estimating the demand for restrooms, which is determined by a combination of peak period arriving and departing passengers. Some airport operators have also used the passenger data segmentations provided by DDFSs to help optimize the location of retail concessions.

In addition, the following factors should be considered when determining whether or not a DDFS is required for terminal planning:

- At large airports that accommodate a wide variety of airlines and passenger characteristics (domestic/international, originating/connecting), determining the appropriate passenger distributions for each departing passenger facility becomes increasingly complex and a terminal simulation model requiring a DDFS may be appropriate.
- For detailed analysis that will lead to the design and construction of terminal facilities, and that involves the evaluation of multiple configuration alternatives and alternative phasing options, DDFS-generated daily passenger profiles segmented by category (domestic/international, originating/connecting, or other relevant characteristics) and airline are preferred.
- Analyses of the re-use or repurposing of redundant terminal facilities may require a DDFS level of detail to ensure that retained facilities continue to meet airport needs.

- For conceptual long-term planning, which will not lead to design or construction without additional planning closer to the implementation date, DDFSs are not required and peak period forecasts are usually sufficient.

3.4 Specific Guidance for Landside Planning

The landside area is defined as the portion of the airport that provides ground access to the terminal building and airfield. The landside area encompasses the terminal curbsides, access roads, parking facilities, and all other on-airport ground access facilities, such as mass transit. Table 3.4 summarizes when DDFSs should be used for landside planning, including the types of landside facilities, the tools typically used to analyze and plan for these facilities depending on the level of detail needed, and whether or not a DDFS is required or useful in applying these tools.

Roadways and Curbsides

Access roads provide access to the curbsides and automobile parking facilities at the airport, and the majority of these facilities are affected by O&D passenger activity. The requirements for the departures curbside and access roads to parking facilities are determined by numbers of originating passengers and their vehicles. Requirements for the arrivals curbside and roads that provide egress from parking facilities are determined by numbers of terminating passengers and their

Table 3.4. When should DDFSs be used: landside analysis.

	Planning Problem	Approach	DDFS Role	Alternatives to DDFS
Roads and Curbsides	Access Roads	Simulation Model	Useful	Design Day Profile (O&D)
		Roadway Layout Analysis	Not Required	Peak Period Forecasts (O&D)
	Curbside Capacity - Private Automobile	Simulation Model	Useful	Design Day Profile (O&D)
		Spreadsheet Models	Not Required	Peak Period Forecasts (O&D)
	Curbside Capacity – Commercial Vehicles	Simulation Model	Useful	Design Day Profile (O&D)
		Spreadsheet Models	Not Required	Peak Period Forecasts (O&D)
Parking	Parking - Hourly	Simulation Model	Useful	Design Day Profile (O&D)
	Parking -Daily	Spreadsheet Models	Not Required	Design Day Forecasts (O&D)
	Parking - Long Term	Spreadsheet Models	Not Required	Design Day Forecasts (O&D)
	Rental Car	Spreadsheet Models	Not Required	Design Day Forecasts (O&D)
	Entry/Exit Plazas	Simulation Model	Useful	Design Day Profile (O&D)
		Roadway Layout Analysis	Not Required	Peak Period Forecasts (O&D)
	Parking-Taxicab Hold	Queuing Models	Useful	Design Day Profile (O&D)
		Spreadsheet Models	Not Required	Peak Period Forecasts (O&D)
	Parking - Cell Phone Lot	Queuing Models	Useful	Design Day Profile (O&D)
	Parking - Employee	Spreadsheet Models	Not Required	Design Day Profiles (employees)
		Spreadsheet Models	Not Required	Annual Forecasts (employees)

Legend	
(light green)	Approach in which a DDFS is useful but not essential to provide the necessary inputs
(orange)	Approach in which a DDFS is not required

vehicles. Many airports serve both arriving and departing passengers at the same curbside; in this case, demand is determined by a combination of arriving and departing passenger numbers. Curbside and roadway requirements are highly sensitive to the configuration of the airport, the separation of different types of demand (e.g., passengers versus employees), and separation by vehicle type (e.g., private automobile versus commercial vehicle). Therefore, simulation models using design day vehicle profiles are often used to simulate these more complex interactions. DDFSs are not directly used as inputs to these traffic simulation models, but they can be used to generate originating and terminating passenger profiles, which are then used to generate design day vehicle profiles to be used as inputs to the traffic models.

DDFSs can be used to generate originating and terminating passenger profiles, which are then used to generate design day vehicle profiles to be used as inputs to the traffic models.

As is the case with terminal facilities, curbside peaks are displaced from enplaning and deplaning passenger peaks in a DDFS, although lead times for departing passengers and lag times for arriving passengers are greater. Therefore, the connection between enplaning/deplaning passenger peaks and curbside and roadway peaks tends to be more tenuous than those seen in the terminal. In addition, the demand on roadways and curbsides will depend on the airport-specific passenger transportation mode. Transportation mode is sensitive to whether the passenger is a resident or a nonresident, which, in turn, is sensitive to time of day. See the *ACRP Web Only Document (WOD) 14: Guidelines for Preparing Peak Period and Operational Profiles* (Appendix K) http://onlinepubs.trb.org/onlinepubs/acrp/acrp_w014.pdf for more discussion.

When choosing whether or not to use a DDFS for access roadway or curbside analysis, the following should be considered:

- At a multiple terminal airport, where loads at curbside may depend on which airlines are assigned to which terminals, terminal-specific design day vehicle profiles based on a DDFS may be required.
- For conceptual long-term planning, peak period forecasts derived from design day profiles should be sufficient. Alternatively, an empirical analysis based on identifying the current distribution of vehicle traffic by time of day and scaling up based on increases in numbers of originating passengers may be more cost-effective.

Automobile Parking

Automobile parking can be categorized as short-term, daily, and long-term. The short-term parking category includes hourly parking, cell phone lots, and taxicab hold areas. Planning for these facilities typically relies on design day vehicle profiles, which can be indirectly generated by DDFSs. As is the case with curbside facilities, short-term parking peaks are displaced from the enplaning and deplaning passenger peaks in DDFSs. Longer-term parking demand is dependent on the accumulation of demand rather than peak demand flows. Therefore, for these types of parking facilities, design day forecasts of O&D traffic are sufficient to forecast requirements and a DDFS is not required.

The sizing of entry and exit parking plazas is dependent on peak traffic flows. More detailed analyses use simulation, similar to the more detailed roadway and curbside analyses.

3.5 Specific Guidance for Environmental Planning

Most quantitative airport activity-related environmental planning involves noise and air quality analyses. The tools used to conduct these analyses may differ depending on if the focus is the airside or the landside. Table 3.5 summarizes when DDFSs should be used for environmental

Table 3.5. When should DDFSs be used: environmental analysis.

	Planning Issue	Approach	DDFS Role	Alternatives to DDFS
Noise	Noise - Landside	TNM	Useful	Design Day Profile (O&D)
	Noise - Airside	AEDT	Useful	Day/Night and Stage Length Profiles
		AEM	Not Required	Day/Night Profile
	Noise - Airspace	AEDT	Required	None
		AEST	Useful	Anticipated Change in Aircraft Operations Profile
Air Quality	Inventory	AEDT/MOVES2014	Not Required	Average Annual Day Fleet Mix
	Dispersion - Airside	AEDT/MOVES2014	Required	None
	Dispersion - Landside	AEDT/MOVES2014	Useful	Design Day Profile (O&D)

Legend	
(green)	Approach that requires a DDFS
(light green)	Approach in which a DDFS is useful but not essential to provide the necessary inputs
(orange)	Approach in which a DDFS is not required

Definitions:
AEDT – Aviation Environmental Design Tool
AEM – Area Equivalent Model (spreadsheet model)
AEST – Aviation Environmental Screening Tool
MOVES2014 – Motor Vehicle Emissions Simulator
TNM – Traffic Noise Model

planning, including the types of environmental impacts, the tools typically used to analyze the types of environmental impacts depending on the level of detail needed, and whether or not a DDFS is useful or required to use these tools. There are many additional environmental impact categories, such as historic and archaeological resources, fish and wildlife, endangered species, socioeconomic impacts, and hazardous materials, but their analyses are not dependent on measures of passenger or aircraft activity and, therefore, a DDFS is not required.

Noise Analysis

In most instances, noise analysis is governed by Title 14 of the Code of Federal Regulations Part 150 (14 CFR Part 150) and FAA National Environmental Policy Act (NEPA) guidance in FAA Order 1050.1F, *Policies and Procedures for Considering Environmental Impacts*, and FAA Order 5050.4B, *National Environmental Policy Act (NEPA) Implementing Instructions for Airport Actions*. Therefore, there is less flexibility in choosing analytical tools in environmental planning than in facility planning.

The FAA now requires use of the AEDT to calculate aircraft and airspace noise impacts as well as airside and landside air quality impacts. In effect, AEDT has replaced the Integrated Noise Model (INM), the Noise Integrated Routing System (NIRS), and the Emissions and Dispersion Modeling System (EDMS), but the same inputs are used depending on the specific analysis required.

Using AEDT to evaluate airspace related noise impacts, especially in multi-airport areas, generally requires a DDFS to provide the proper level of detail to model complex routes. For a single airport, the AEDT can be used to estimate aircraft noise impacts using average annual day aircraft operations segmented by day/night split, stage length, and aircraft type; therefore, a DDFS is not required. However, a DDFS can be used in conjunction with an airfield simulation model to estimate future aircraft delays that may affect noise results, which cannot be evaluated using a day/night split.

The AEM is a simpler spreadsheet analysis, but it is limited to use as a screening tool to determine if a change in aircraft fleet mix will create a significant change in noise exposure.

Airports generate noise from vehicular traffic as well as aircraft operations. These landside noise impacts can be estimated using models such as the Traffic Noise Model (TNM), which requires an average annual day profile of vehicle movements, which as noted earlier, can be estimated using a DDFS.

The effect of small, incremental changes to airspace use and related noise can be evaluated using the Aviation Environmental Screening Tool (AEST) and the AEDT Plug-in within the Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS) tool for environmental screening.

Air Quality Analysis

Similar to noise analysis, air quality analysis is directed by FAA and U.S. EPA regulations and the FAA now requires use of the AEDT in conjunction with other air quality analysis models. The AEDT is currently used to prepare air quality inventories and to conduct air quality dispersion analysis related to airport activity. The inventory analysis requires a fleet mix for the average annual day; therefore, a DDFS is not needed. The dispersion analysis information needs are more detailed and require output from an airfield simulation model; therefore, a DDFS is required as an initial forecast input. In addition, the AEDT needs to be supplemented with inputs from the Motor Vehicle Emissions Simulator (MOVES2014) to assess ground vehicle emissions and emissions from off-road mobile sources, such as ground support equipment (GSE).

3.6 Specific Guidance for Operations and Management

The operators of airports and airport tenants are increasingly relying on DDFSs to help manage their operations. The characteristics of DDFSs used for operations and management differ somewhat from those used for planning purposes. DDFSs used to assist with operations tend to be real-time or short-term (1 to 2 years out at most), whereas those used for planning often extend 10 or 20 years. Table 3.6 summarizes when DDFSs should be used for operations and management, including the types of operations and management issues, the tools typically used to manage these types of issues, and whether or not a DDFS is useful or required to employ these tools.

Some airport operators use proprietary gate management software or hire vendors to help optimize the use of their gates in real-time to account for deviations in aircraft arrivals and departures from their scheduled times. The gate management models incorporate information from the Aircraft Communications Addressing and Reporting System (ACARS), the Aircraft Situation Display to Industry (ASDI), and screen captures from airport Flight Information Display Systems (FIDS) to update estimated arrival and departure times and optimally balance gate availability and needs on an ongoing basis.

DDFSs prepared using available published future airline schedules are used to help determine medium-term gate requirements and allocate common-use gates over the next 6 to 24 months. DDFSs can also be used in scenario planning to evaluate terminal facility effects resulting from

Table 3.6. When should DDFSs be used: operations and management.

	Operations/ Management Issue	Approach	Is a DDFS Required?	Alternatives to DDFS
Operations and Management	Gate Management - Short-Term	Gate Management Models	Required	None
	Gate Management - Medium Term	Gate Allocation Models	Required	None
		Airline Input	Not Required	Not Applicable
	Staffing	Staffing Models	Useful	Design Day Profile
	Irregular Operations	Gate Management Models	Required	None

Legend	
(green)	Approach that requires a DDFS
(light green)	Approach in which a DDFS is useful but not essential to provide the necessary inputs
(orange)	Approach in which a DDFS is not required

reassigning airline gates and concourses. Alternatively, gate requirements and allocations can be based on airline input, in which case a DDFS is not needed.

Airport noise monitoring systems combine data from a variety of sources, including ASDI, airline schedules, radar data, and flight plans, to automatically assemble a profile of activity similar to a DDFS. However, aside from airline schedules, these systems do not require a separately prepared DDFS as input.

Some airport operators, airport tenants, and government agencies use short-term and medium-term DDFSs to help determine staffing levels by time and location. At times, DDFSs are also used to assign resources to eliminate potential passenger bottlenecks before they occur.

Gate management models can also be used to help match aircraft to gates and aircraft parking positions, including hardstands, in case of irregular operations from adverse weather conditions or other disruptions.

3.7 Future Considerations for DDFS Use

DDFS uses listed on Tables 3.1 through 3.6 are not exhaustive. Some airport operators are contemplating using DDFSs for utility and energy management, peak pricing of facilities and services, GSE needs, and concessions planning. Others are considering using DDFS-generated passenger flows to design and manage interfaces with non-airport functions, such as rail transit and truck cargo. Irregular operations planning can also be enhanced by the use of DDFSs that are modified to represent operations disrupted by adverse weather conditions or security breaches.

CHAPTER 4

Which Elements Need to Be Included in a DDFS

This chapter provides guidance on the recommended level of DDFS detail, specifically regarding the airline, aircraft, market, gate assignment, and passenger load elements. These elements depend on the type of airport facility being analyzed, the planning tools used, and the likelihood of follow-on DDFS analysis. This chapter is primarily intended to help users appropriately scope a DDFS effort.

As noted in Chapter 2, a DDFS consists of many elements, not all of which are required to address a specific problem or issue. Chapter 3 provides guidance on how to determine if a DDFS is required. This chapter provides guidance on which elements are needed to address airfield, terminal, landside, environmental, or operations and management issues once the decision is made to that a DDFS should be prepared.

4.1 Level of Effort

Much of the content on the exhibits and tables presented in this chapter is based on independent research performed as part of the guidebook development regarding the sensitivity of planning results to changes in the individual DDFS elements. Part of the research involved a survey of DDFS preparers to determine approximately how much of the total effort was required for each DDFS element. Exhibit 4.1 provides a summary of the results of that survey.

Estimating flight times and then reconciling arrival and departure times when pairing flights are typically expected to account for more than half the effort. Other elements, including passenger load factors and O&D percentage, markets (origins for arrivals and destinations for departures), equipment type, and gate assignments account for the remainder of the DDFS effort. Note that the chart represents an estimate that can vary widely depending on the airport and available data, the focus of the analysis, and the approach used.

4.2 DDFS Requirements by Type of Analysis

The importance of individual DDFS elements will depend on the type of analysis being conducted.

The **airside** includes runway, taxiway, and apron areas, as well as facilities that directly support the airfield, such as aircraft rescue and firefighting facilities. Elements related to aircraft movements are much more important for airside analysis than elements related to passenger movements.

The **terminal building area** includes the terminal building and all concourses and gates. Most terminal building requirements are determined by passenger flows; therefore, the DDFS

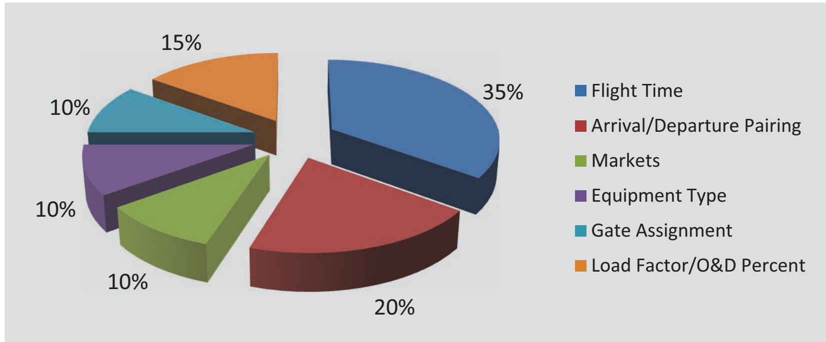


Exhibit 4.1. Survey results regarding estimated level of effort required for DDFS elements.

passenger elements are critical. However, aircraft movements are also important for determining gate requirements.

The **landside area** is the portion of the airport that provides for ground access to the terminal building and airfield, and includes the terminal curbsides, access roads, parking facilities, and the airport portion of all other facilities, such as mass transit, used to access the airport. As noted in Chapter 3, DDFSs are not used for landside analysis as often as for airside and terminal building analysis. When DDFSs are used for landside analysis, passenger elements are the most important.

Most quantitative airport activity-related **environmental planning** involves noise and air quality analyses, although the tools used for these analyses may differ depending on whether the focus is on the airfield or on the landside. Both aircraft and passengers can generate environmental impacts. Therefore, DDFS aircraft and passenger characteristics are both important.

The characteristics of DDFSs used for **operations and management** tend to be real-time or short-term (1 to 2 years out at most) and are sometimes prepared and updated using automated methods and/or third-party vendors. Depending on the type of facility being analyzed, DDFS aircraft and passenger characteristics can be important.

It should be noted that, once prepared, DDFSs are often used for more than their original purpose. For example, a DDFS could initially be prepared to address an airfield issue, but later could be applied to analyze a terminal building issue. When scoping a DDFS, the user and preparer should consider additional uses beyond the original purpose. From the standpoint of consistency and quality control, it is most effective to prepare all elements of a DDFS concurrently, rather than adding elements incrementally as needed later on.

4.3 Application of Individual DDFS Elements by Type of Analysis

When scoping a DDFS, consider additional uses beyond the original purpose.

Tables 4.1 through 4.6 and the narrative in this section provide guidance on the specific DDFS elements that would be required or useful for the various types of planning and analysis. (Readers using the pdf version of this guidebook may click below to navigate to the appropriate table.)

- Table 4.1 Required DDFS Elements: Airside Analysis
- Table 4.2 Required DDFS Elements: Terminal Building Analysis—Gates and Passenger Departure Facilities

Table 4.1. Required DDFS elements: airside planning.

	Type of Planning Analysis					
	Airfield			Aircraft Parking		Safety
DDFS Element	Capacity/ Delay	Operations and Efficiency	Deicing	At Gate	RON	Incursion Analysis
Arrival/Departure Designation	Required	Required	Required	Required	Required	Required
Arrival/Departure Pairing	Useful	Useful	Useful	Required	Required	Useful
Activity Category	Useful	Useful	Useful	Useful	Useful	Useful
Flight Time	Required	Required	Required	Required	Required	Required
Day of Week	Useful	Useful	Useful	Useful	Useful	Useful
Airline Designation	Useful	Useful	Useful	Useful	Useful	Useful
Flight Number	Useful	Useful	Useful	Useful	Useful	Useful
Domestic/ International Designation	Not Required	Not Required	Not Required	Useful	Useful	Not Required
Gate Assignment	Useful	Useful	Useful	Useful*	Useful*	Useful
RON Status	Useful	Useful	Useful	Required	Required	Useful
Origin/Destination	Useful	Useful	Useful	Useful	Useful	Useful
Equipment Type/Category	Required	Required	Required	Required	Required	Required
Aircraft Seats	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Enplaned/Deplaned Passengers	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
O&D/Connecting Passengers	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Runway Use Designation	Useful	Useful	Useful	Not Required	Not Required	Useful
Arrival/Departure Fixes	Useful	Useful	Useful	Not Required	Not Required	Useful

*In some instances, gate assignments are outputs of the DDFS rather than inputs.

- Table 4.3 Required DDFS Elements: Terminal Building Analysis—Passenger Arrival Facilities and Other Facilities
- Table 4.4 Required DDFS Elements: Landside Analysis
- Table 4.5 Required DDFS Elements: Environmental Analysis
- Table 4.6 Required DDFS Elements: Operations and Management

More detail on the application of individual DDFS elements (first described in Chapter 2) and depicted on Exhibit 2.1: to airside, terminal, landside, and environmental analyses, as well as operations and management, is provided below.

Arrival/Departure Designation: The arrival or departure designation is a core element required for any DDFS.

Arrival/Departure Pairing or Matching: The pairing or matching of aircraft arrivals with departures is essential for any aircraft parking analysis. Arrival delays can translate to departure delays if the initial delay is long and the turnaround time is short. At congested airports, arrival delays are more likely to translate to departure delays and careful aircraft pairing becomes

Table 4.2. Required DDFS elements: terminal building analysis – gates and passenger departure facilities.

	Type of Planning Analysis						
	Gates		Passenger Departure Facilities				
DDFS Element	Quantity	Sizing	Ticket Counter	Ticket Queue	Passenger Security Screening	Baggage Security Screening	Baggage Handling Systems
Arrival/ Departure Designation	Required	Required	Required	Required	Required	Required	Required
Arrival/ Departure Pairing	Required	Required	Useful	Useful	Useful	Useful	Useful
Activity Category	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Flight Time	Required	Required	Required	Required	Required	Required	Required
Day of Week	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Airline Designation	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Flight Number	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Domestic/ International Designation	Required	Required	Required	Required	Required	Required	Required
Gate Assignment	Useful*	Useful*	Useful*	Useful*	Useful*	Useful*	Useful*
RON Status	Required	Required	Useful	Useful	Useful	Useful	Useful
Origin/ Destination	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Equipment Type/ Category	Required	Required	Useful	Useful	Useful	Useful	Useful
Aircraft Seats	Not Required	Useful	Useful	Useful	Useful	Useful	Useful
Enplaned/ Deplaned Passengers	Not Required	Useful	Useful	Useful	Useful	Useful	Required
O&D/Connecting Passengers	Not Required	Not Required	Required	Required	Required	Required	Required
Runway Use Designation	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Arrival/Departure Fixes	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required

*In some instances, gate assignments are outputs of the DDFS rather than inputs.

essential. Some flights will represent the first departure or last arrival of the day and the aircraft will remain overnight at a gate or remote hardstand. These flights do not need to be paired if the DDFS is being prepared for a single day, but should be designated as remaining at gate or towed to a remote hardstand.

Aircraft pairing helps ensure that the real world characteristics of passenger flows by gate and concourse are accurately represented when planning other terminal facilities. For landside analyses, aircraft pairing also helps ensure that the real world characteristics of passenger flows by concourse and at curbsides are accurately represented.

Pairing of aircraft arrivals with aircraft departures is useful for environmental noise and air quality analysis since arrival delays can translate to departure delays if the initial delay is high

Table 4.3. Required DDFS elements: terminal building analysis – passenger arrival facilities and other facilities.

	Type of Planning Analysis				
	Passenger Arrival Facilities			Other Terminal Facilities	
DDFS Element	CBP	Meeter/ Greeter Area	Baggage Claim	Passenger Conveyance Systems	Concessions
Arrival/Departure Designation	Required	Required	Required	Required	Required
Arrival/Departure Pairing	Useful	Useful	Useful	Useful	Useful
Activity Category	Useful	Useful	Useful	Useful	Useful
Flight Time	Required	Required	Required	Required	Required
Day of Week	Useful	Useful	Useful	Useful	Useful
Airline Designation	Useful	Useful	Useful	Useful	Useful
Flight Number	Useful	Useful	Useful	Useful	Useful
Domestic/ International Designation	Required	Required	Required	Useful	Useful
Gate Assignment	Useful	Useful	Useful	Useful	Useful
RON Status	Not Required	Not Required	Not Required	Not Required	Useful
Origin/ Destination	Useful	Useful	Useful	Not Required	Useful
Equipment Type/ Category	Useful	Useful	Useful	Useful	Useful
Aircraft Seats	Useful	Useful	Useful	Useful	Useful
Enplaned/ Deplaned Passengers	Required	Useful	Useful	Required	Required
O&D/Connecting Passengers	Required	Required	Required	Required	Useful
Runway Use Designation	Not Required	Not Required	Not Required	Not Required	Not Required
Arrival/Departure Fixes	Not Required	Not Required	Not Required	Not Required	Not Required

and the turnaround time is low. At congested airports, arrivals delays are likely to translate to departure delays and aircraft pairing becomes essential.

Any operations or management process involving gates or gate management requires aircraft arrival and departure pairing. Flight pairing can be useful for staffing when multiple concourses or terminals are involved as it ensures consistency between the locations of aircraft arrivals and departures.

Activity Category: The activity category (passenger, cargo, etc.) is useful for aircraft parking, gating, and RON analyses to ensure that the demand for and location of aircraft parking positions are accurately represented. If there is no other way to determine the activity category, such as airline name, the designation becomes essential. The activity category designation is essential for gate management and can be useful for allocating staff. The designation is not essential for other planning analyses not related to aircraft parking, but can be useful for organizing and sorting results.

Table 4.4. Required DDFS elements: landside analysis.

	Type of Planning Analysis						
	Roads and Curbsides			Parking			
DDFS Element	Access Roads	Curb - Private Auto	Curb - Com-mercial Vehicles	Hourly	Entry/ Exit Plaza	Taxicab Hold	Cell Phone Lot
Arrival/Departure Designation	Required	Required	Required	Required	Required	Required	Required
Arrival/ Departure Pairing	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Activity Category	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Flight Time	Required	Required	Required	Required	Required	Required	Required
Day of Week	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Airline Designation	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Flight Number	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Domestic/ International Designation	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Gate Assignment	Useful	Useful	Useful	Useful	Useful	Useful	Useful
RON Status	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Origin/ Destination	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Equipment Type/ Category	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Aircraft Seats	Useful	Useful	Useful	Useful	Useful	Useful	Useful
Enplaned/ Deplaned Passengers	Useful	Useful	Useful	Useful	Useful	Useful	Useful
O&D/Connecting Passengers	Required	Required	Required	Required	Required	Required	Required
Runway Use Designation	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Arrival/Departure Fixes	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required

Flight Time: Flight time is a core element of any DDFS and is a required element.

Day of Week: Some DDFS applications are run for multiple days and require the day of the week associated with each flight. When a DDFS is prepared for a single design day, the selected day is typically a weekday. It should be noted that load factors can vary by the day of the week. This variation can affect passenger flows in the terminal and vehicular traffic flows even when airline schedules are similar. *ACRP Report 82: Preparing Peak Period and Operational Profiles—Guidebook* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf provides additional information on these day of the week variations.

When used for noise analysis, the design day is intended to represent an average annual day and may be a composite of multiple days. Depending on local needs, air quality analysis may be based on a busy day, which is typically a weekday.

Table 4.5. Required DDFS elements: environmental analysis.

	Type of Planning Analysis				
	Noise			Air Quality	
DDFS Element	Airfield	Landside	Airspace	Dispersion - Airside	Dispersion - Landside
Arrival/Departure Designation	Required	Required	Required	Required	Required
Arrival/Departure Pairing	Useful	Useful	Useful	Useful	Useful
Activity Category	Useful	Useful	Useful	Useful	Useful
Flight Time	Required	Required	Required	Required	Required
Day of Week	Useful	Useful	Useful	Useful	Useful
Airline Designation	Useful	Useful	Useful	Useful	Useful
Flight Number	Useful	Useful	Useful	Useful	Useful
Domestic/International Designation	Not Required	Not Required	Not Required	Not Required	Not Required
Gate Assignment	Not Required	Not Required	Not Required	Required	Not Required
RON Status	Not Required	Not Required	Not Required	Required	Not Required
Origin/Destination	Useful	Useful	Useful	Useful	Useful
Equipment Type/Category	Required	Not Required	Required	Required	Not Required
Aircraft Seats	Not Required	Useful	Not Required	Not Required	Useful
Enplaned/Deplaned Passengers	Not Required	Useful	Not Required	Not Required	Useful
O&D/Connecting Passengers	Not Required	Required	Not Required	Not Required	Required
Runway Use Designation	Required	Not Required	Required	Required	Not Required
Arrival/Departure Fixes	Required	Not Required	Required	Required	Not Required

Gate requirements and staffing requirements vary by day of the week and therefore the day of the week associated with each flight is required.

Airline Designation: An airline designation is not essential, but can be useful for organizing and sorting results and for determining gate or parking assignments. In addition, the information can be used to help refine load factors and O&D percentages for each flight, which, in turn, makes estimating passenger and vehicular flows more accurate for terminal, landside, and environmental analyses, as well as staffing. For noise analysis, airline designation can also be useful in identifying aircraft engine types with multi-engine configurations.

Flight Number: Flight numbers are not essential, but are useful for organizing and pairing flights to existing schedules and across multiple DDFSs.

Domestic/International Designation: Identifying a flight as domestic or international is useful for analyzing aircraft parking because the CBP facilities required for nonprecleared international arrivals are often restricted to certain areas or gates. Some terminal facilities, such as international re-check and CBP are only used by international passengers. In addition, international passengers have longer lead and lag times than domestic passengers and therefore show different arrival

Table 4.6. Required DDFS elements: operations and management.

	Type of Operations and Management			
DDFS Element	Gate Management - Short-Term	Gate Management - Medium Term	Staffing	Irregular Operations
Arrival/Departure Designation	Required	Required	Required	Required
Arrival/Departure Pairing	Required	Required	Useful	Required
Activity Category	Useful	Useful	Useful	Useful
Flight Time	Required	Required	Required	Required
Day of Week	Required	Useful	Required	Useful
Airline Designation	Required	Required	Useful	Required
Flight Number	Required	Useful	Useful	Required
Domestic/ International Designation	Required	Required	Required	Required
Gate Assignment*	Required	Useful	Required	Required
RON Status	Required	Required	Useful	Required
Origin/ Destination	Useful	Useful	Useful	Useful
Equipment Type/Category	Required	Required	Useful	Required
Aircraft Seats	Not Required	Not Required	Useful	Not Required
Enplaned/De-planed Passengers	Not Required	Not Required	Required	Not Required
O&D/Connecting Passengers	Not Required	Not Required	Required	Not Required
Runway Use Designation	Useful	Not Required	Not Required	Useful
Arrival/Departure Fixes	Not Required	Not Required	Not Required	Not Required

*In some instances, gate assignments are outputs of the DDFS rather than inputs.

profiles. These differing profiles can also affect the sizing of terminal and landside facilities used by both domestic and international passengers. Identifying a flight as domestic or international is essential in gate management and staffing because nonprecleared international flights require special gate facilities and staffing.

Gate Assignment: Gate assignments are useful for detailed airside and terminal building analyses as they allow aircraft paths to be more precisely defined in simulation modeling among other activities. At larger airports with multiple terminals or concourses, international gates, or multiple points of ingress and egress, some kind of locational identification (e.g., concourse) is necessary to ensure that passenger flows are modeled with reasonable accuracy. Gate assignments are also useful for detailed air quality dispersion analyses as they enable the identification of source point locations for aircraft and GSE emissions, but they are not necessary for noise analysis. Gate assignments are also essential for short-term gate management and some staff planning, such as for the TSA.

DDFSs are sometimes used in conjunction with gate allocation models to determine gate assignments. In those instances, gate assignments are an output of the DDFS rather than an input.

RON Designation: A RON designation indicates whether a gated aircraft departs to or arrives from a remote hardstand. This information is essential for gate or RON analysis as it determines which of the two aircraft parking alternatives will be required for the aircraft. For airside analysis, this information is also essential to distinguish between aircraft that leave a gate for a RON position versus an aircraft that leaves a gate to take-off. Except for gates, most terminal and landside facilities are affected by passenger flows; therefore, as long as enplaned or deplaned passengers are modeled correctly, RON status is not needed. RON assignments are useful for detailed air quality dispersion analyses because they enable the identification of point source locations for GSE emissions. RON status is not necessary for noise analysis.

A RON designation is essential for gate management as it determines whether a gate can be made available for another arriving or departing flight. Some airline staffing (tow crews, etc.) will also be affected by RON needs.

As with gate assignments, RON assignments may sometimes be an output of a DDFS rather than an input.

Origin/Destination: For airside and environmental analyses, identifying the origin of an arriving flight and the destination of a departing flight can help determine runway use and arrival/departure fixes. It adds accuracy and precision to the DDFS planning results, but has less effect on ultimate delay or capacity results than the number or timing of flights.

For terminal and landside analyses, flight origins and destinations may have a significant effect on load factors, O&D/connecting passenger ratios, and gate assignments for efficient access to preferred runways and flight paths. Providing that load factors and O&D/connecting passenger ratios are differentiated by market, O&D information can be very useful in planning most terminal building and landside facilities.

Flight origins and destinations may affect optimal gating for efficient access to preferred runways and flight paths and are essential inputs for gate management. O&D information can also have a significant effect on load factors and O&D/connecting passenger ratios, which can affect staffing requirements at some terminal building facilities.

Equipment Type/Category: Identification of aircraft equipment type or, at a minimum, size and performance category, is essential for airside analysis because it determines separation distances and the types of runway an aircraft can use, thereby significantly affecting capacity and delay analyses. It also determines which gates or RON parking positions an aircraft can use. It is indirectly useful for categories of terminal facility and landside planning and staffing that are dependent on passenger flows because the information is used to estimate numbers of aircraft seats, which helps determine the number of enplaned and deplaned passengers. Identification of aircraft equipment type is also essential for airside noise and air quality analyses, but is not required to estimate landside environmental impacts.

Aircraft Seats: The number of seats on an aircraft, along with the aircraft equipment type, is often used to determine holdroom size. Seat information also can be used to help determine the numbers of enplaned and deplaned passengers to assist in planning other terminal building and landside facilities. Aircraft seat information can also be indirectly useful to estimate O&D passenger flows and resultant ground vehicle flows for environmental analysis.

Enplaned/Deplaned Passengers: It is not necessary to identify the numbers of enplaned or deplaned passengers on each flight for airside analysis unless the delay costs to passengers are being calculated. Post-security concession requirements are generally dependent on passengers enplaning and deplaning, while U.S. CBP facilities are dependent on deplaned international passengers. Landside facilities are affected by originating and terminating passengers instead of enplaned and deplaned passengers. However, numbers of enplaned and deplaned passengers are still useful as an intermediate step in calculating O&D traffic. Numbers of enplaning or deplaning passengers on each flight do not need to be identified for environmental analysis, but the information can be indirectly useful to estimate O&D passenger flows and resultant ground vehicle flows. Enplaned/deplaned passenger information is necessary for some terminal staffing facilities, such as restrooms and post-security retail concessions, and can be indirectly useful in estimating other terminal staffing requirements because the information can be used to help determine O&D passenger flows.

O&D/Connecting Passengers: The numbers of O&D or connecting passengers by flight is essential for planning ticket counter, ticket queuing, passenger and baggage security screening, U.S. CBP, meeter/greeter, and baggage claim facilities. Similarly, O&D passenger estimates are required for just about all landside facilities as these facilities are dependent on O&D passenger flows. Numbers of O&D or connecting passengers by flight are not needed for airside environmental analysis, but the information is required to estimate resultant ground vehicle flows for landside environmental analysis. O&D passenger estimates are not needed for gate management. However, the information is essential for staffing ticket counter, passenger and baggage security screening, U.S. CBP, and baggage handling facilities.

Runway Use Designation: Most DDFSs do not include runway use designations. The information is often determined within an airfield simulation model based on rules defined by the airside planner. Runway use designations are also essential for airside noise and air quality analyses, but this information is often added subsequent to the DDFS preparation process. These designations can be useful for optimizing short-term gate assignments, but are not needed for staffing.

Arrival/Departure Fixes: Most DDFSs do not include arrival or departure fixes. However, the information can be helpful in developing the internal rules to identify runway use priorities within airfield simulation models. Arrival and departure fix information is not needed for terminal building or landside planning. This information is essential for airside noise and air quality analyses, but is often added subsequent to the DDFS preparation process. Arrival and departure fix information is not needed for gate management or staffing.

CHAPTER 5

How to Scope a DDFS

This chapter provides a process for scoping a DDFS. It integrates the information provided in Chapters 3 and 4 to help define the issue, determine if a DDFS is needed or feasible, and determine the extent of the effort. It is intended for both users and preparers.

This chapter and Exhibit 5.1 describe the process involved in preparing a DDFS for base year and future conditions. The step in the exhibit that is in bold type and **ALL CAPS** is needed only for DDFSs prepared for future conditions. If the steps are not in bold type and all caps, they apply to DDFSs prepared both for base year and future conditions.

5.1 Identify the Problem/Issue

The first step is to identify the problem or issue that needs to be resolved. It may involve a long-term parking garage or roadway signage, facilities for which DDFSs are not useful. Also, the specific problem/issue should be screened to determine whether it is important enough to warrant the expense of DDFS preparation. Stakeholders are also important. Are they willing to provide information if needed, will they accept the results, and will they accept the necessary expenditure of resources? If stakeholders are brought into the DDFS decision early and given the opportunity to provide input, they are more likely to accept the results.

5.2 Determine If a DDFS Is Useful or Appropriate

Chapter 3 provides more detail on when a DDFS is likely to be useful or appropriate. In addition, if a DDFS is determined not to be useful, Chapter 3 provides alternative non-DDFS approaches that can be used to address the problem or issue. These can include spreadsheet models and other analytical techniques with less intensive data input requirements. Click here to access Chapter 3.

> If stakeholders are brought into the DDFS decision early and given the opportunity to provide input, they are more likely to buy into the results.

5.3 Determine Which DDFS Elements Should Be Included

If the initial screening determines that a DDFS may be appropriate, the DDFS elements that need to be included should be determined. Chapter 4 provides guidance on which DDFS elements are appropriate, depending on the problem or issue being addressed. Once the required DDFS elements are determined, the user and preparer need to determine whether a DDFS is feasible. Click here to access Chapter 4.

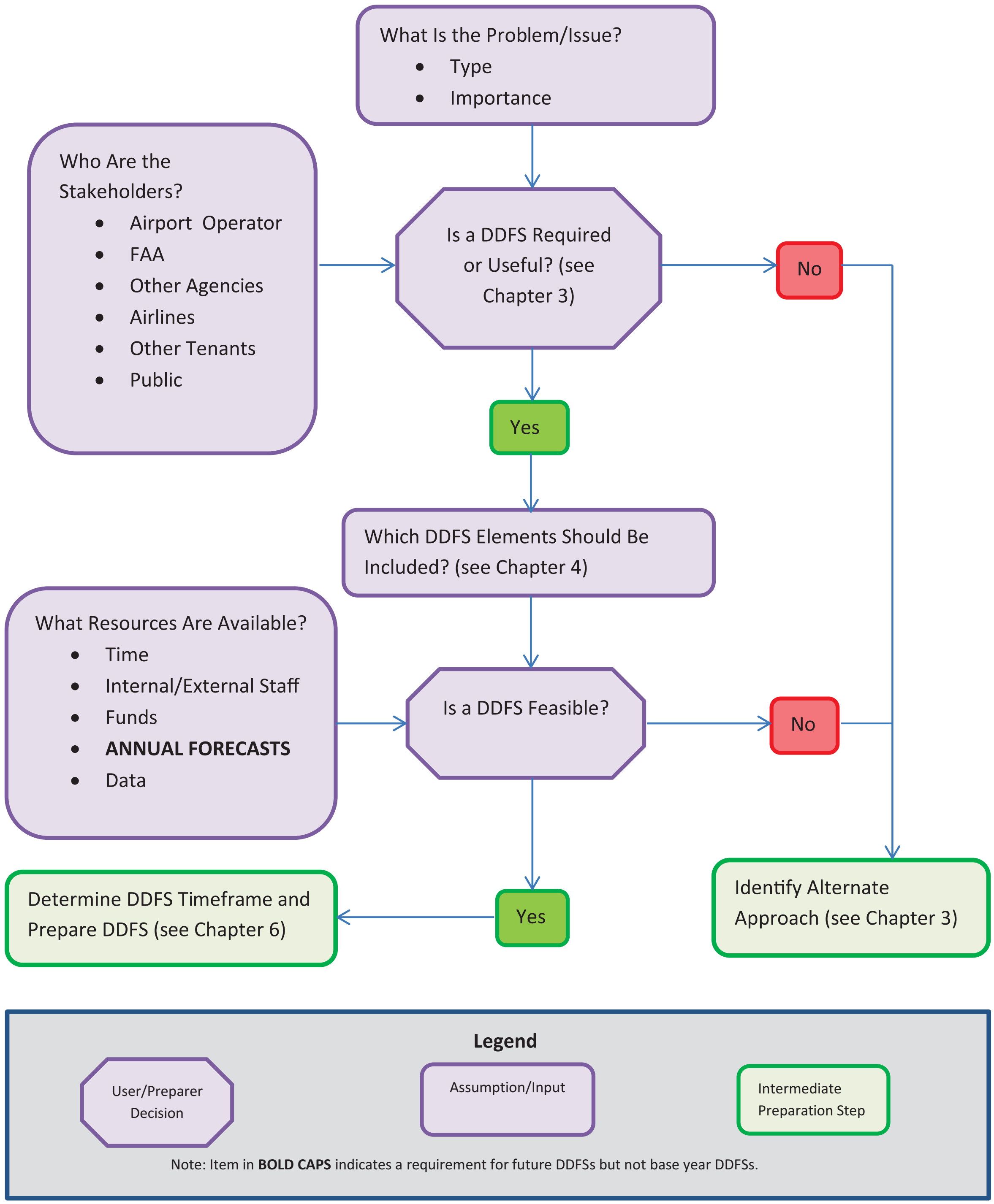


Exhibit 5.1. Scoping a DDFS.

Several factors are involved in the decision on feasibility:

- **Is there sufficient time to prepare the DDFS?** If an answer is needed tomorrow, a DDFS is not the appropriate tool.
- **Are sufficient qualified internal or external (consulting) staff available to perform the task?** If so, can they be engaged in time?
- **Is funding available to conduct the analysis?** If funding for DDFS analysis is not available, simpler alternatives (see Chapter 3) will be required.

- **Are updated annual forecasts available in sufficient detail to provide the necessary DDFS inputs?** If not, do staff members have the capability to conduct additional analysis to generate the necessary annual forecast data?
- **Are the necessary input data (schedules, activity statistics, etc.) available or obtainable at the required level of accuracy?** If the necessary data are not available and cannot be obtained, the DDFS will be too inaccurate to be useful.

If the answer to any of the above questions is no, a DDFS is not feasible or will likely be too flawed to be useful. Alternative approaches, as described in Chapter 3, would then be recommended.

5.4 Determine DDFS Timeframe

Once a DDFS is determined to be feasible, the DDFS timeframe should be identified as that will affect the preparation approach.

If a DDFS is being prepared to represent base year conditions, the forecast elements are unnecessary. An existing schedule can be used without modification and estimates of flight time, fleet mix, and market changes are not needed. Pairing of flights, gate assignments, and passenger load estimates may still be required, but the process is simpler and more accurate as existing data can be applied.

If a DDFS is being prepared for the near-term future (i.e., less than 12 months out), published airline schedules for commercial passenger aircraft operations are often available and can be used as the basis of the forecast DDFS without relying on annual forecasts, as the flight time, fleet mix, and market information is embedded in the schedule. Most DDFSs prepared for operations and management are focused on this near-term timeframe. A DDFS prepared for the medium term, say 5 years out, is much more reliant on annual forecasts. In some instances, the dominant airline at an airport is able to provide an internally developed schedule that provides many of the benefits of a published schedule and simplifies the process of estimating future flight times, fleet mix, and markets.

If the forecast horizon is 10, 20, or more years out, a full DDFS forecast will be required. Even on the rare occasions that a dominant airline can provide a schedule for that many years into the future, the economic and industry assumptions upon which it would be based are unlikely to be consistent with the annual airport forecasts.

The number of future DDFSs should also be determined. Each additional DDFS adds significant cost. Therefore, the decisions on which forecast years and how many forecast years are to be modeled should be carefully considered. If the purpose of the DDFS is to analyze a new or expanded facility, useful DDFS forecast years would include the anticipated year of completion and a long-term out-year to ensure that the facility would be in operation long enough to justify the investment. If complex phasing is involved, intermediate DDFS forecast years would also be appropriate.

An example of the scoping process used to prepare a DDFS can be found in Appendix A. Click here to access Section A.1. Scoping.

CHAPTER 6

How to Prepare a DDFS for Base Year and Future Conditions

This chapter provides detailed guidance on preparing a DDFS. Key steps include defining parameters and estimating markets, fleet mix, flight times, gate/RON assignments, and passengers per flight. Guidance is also provided for non-passenger aircraft operations and quality assurance and control. Preparing a DDFS is a complex effort and the associated guidance is necessarily detailed. As this chapter is primarily directed toward preparers, users interested in a high-level overview may wish to review the summary in Chapter 1 instead.

This chapter and the associated exhibits describe the process involved in preparing a DDFS for base year and future conditions. It begins with a general overview of DDFS preparation and follows with step-by-step processes for estimating markets, fleet mix, flight times, gate assignments, passenger loads, and non-passenger aircraft operations. The chapter concludes with guidance on applying constraints, updating DDFSs, and quality control checks.

Each of the main sections in this chapter discusses a specific element of DDFS preparation and includes background, detailed step-by-step instructions, and observations and cautions. Preparation steps are accompanied by flow charts in most instances.

Steps shown in purple indicate that a decision or assumption is required. Steps shown in blue indicate a data input, typically from annual forecasts or airport/industry sources. Steps in green indicate an intermediate preparation step, usually an internal calculation. Intermediate or final outputs are shown in orange. In addition, steps shown on the exhibits that are in bold type and **ALL CAPS** are needed only for DDFSs prepared for future conditions. If the steps are not in bold and all caps, they apply to DDFSs prepared both for base year and future conditions.

As noted in Chapters 3 and 4, not all planning/operational issues require a DDFS, and not all potential elements of a DDFS are necessary to address each planning/operational issue. **Many of approaches in this chapter involve a significant amount of work that, in many instances, may not be necessary. Please refer to Chapter 4 to identify the DDFS elements that should be included**.

The following DDFS preparation steps are discussed in this chapter. Click to directly access the section.

6.1 General Steps for Preparing a DDFS

This section describes the initial steps required prior to preparing a DDFS and the general processes required to prepare a DDFS. Key initial steps include obtaining stakeholder input on assumptions and setting the stage (see Section 6.2) by determining parameters and collecting pertinent data. The main steps involved in preparing a DDFS are outlined on Exhibit 6.1. First, once the annual forecasts are obtained, market and fleet mix forecasts are then assembled to generate a design day estimate of arrivals and departures by aircraft type, as discussed in more detail in Section 6.3. Next, flight times are estimated for each arrival and departure and arrivals and departures are paired (see Section 6.4 for more detail). Once flight times are estimated, passenger loads, gate assignments, and flight tracks can be assigned if necessary. These steps are discussed in more detail in Sections 6.5 and 6.6.

Stakeholder Input

To help ensure the accuracy and credibility of DDFS assumptions, input and buy-in should be obtained early from DDFS users and other key stakeholders, especially the airlines. Key players to engage in this process are corporate airline real estate staff who, in turn, can approach the airline's route planners to obtain realistic, applicable input. Included should be perspectives on:

> To help ensure the accuracy and credibility of DDFS assumptions, input and buy-in should be obtained early from DDFS users and other key stakeholders.

- Future fleet mix
- Trade-off between cost and passenger service when assigning new flight times
- Target aircraft turnaround times by general aircraft category
- Target tow-on and tow-off times by general aircraft category
- Average gate utilization targets
- Airline perspective on the service/cost trade-off between contact gates and hardstands
- Gate buffer times by aircraft and flight category (short-haul, long-haul, domestic, international)
- Policy on spare gates, if any
- Willingness to use common-use gates at peak times
- Contingency plans/priorities during irregular operations

When making assumptions regarding facility use (i.e., gate or runway assignments), it is particularly important to obtain input from the stakeholders that manage those facilities.

Under some circumstances, airlines may be able and willing to provide a future schedule. Note that airline schedules are subject to frequent change depending on changes in business philosophies, aircraft orders, aircraft retirement plans, and competitive factors. In addition, their input may reflect strategies for minimizing the cost and maximizing the control of airport facilities.

Discussions with the user of the DDFS (typically the airport operator) should address whether or not the purpose of the DDFS justifies the additional effort involved in assigning specific flights to specific gates. The answer may be yes if the purpose is detailed terminal simulation or concessions planning at an airport with multiple terminals or concourses. At smaller airports with centrally located terminal processing facilities, the effort may not be justified.

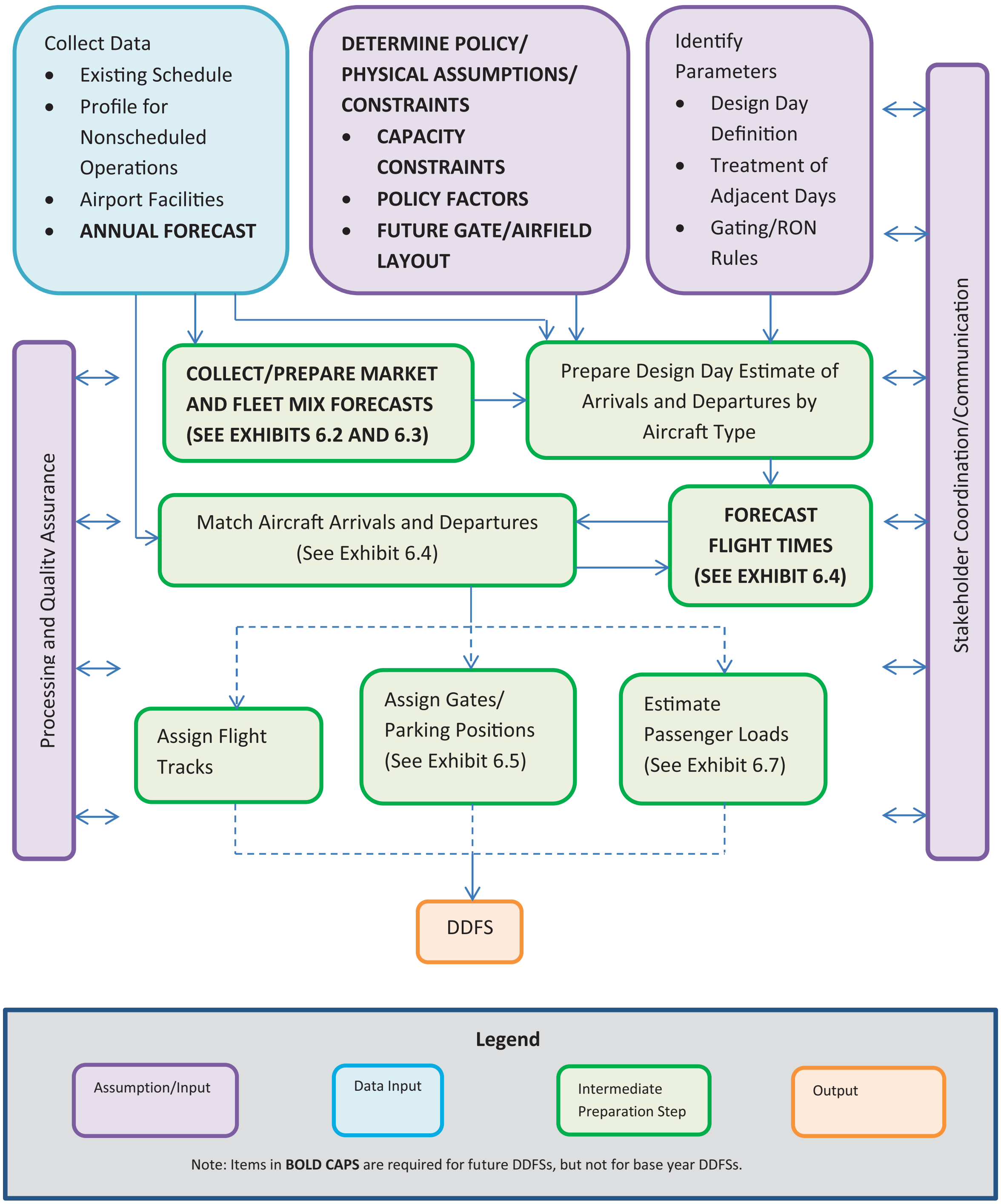


Exhibit 6.1. Preparing a DDFS.

6.2 Setting the Stage

Once stakeholder input has been obtained, staging steps, including the formulation of policy and facility assumptions, parameters, and data collection can be finalized.

Determine Assumptions on Policies, Physical Constraints, and Future Airport Layouts

If the DDFS is being prepared for future conditions, assumptions on future operating policies and physical constraints should be determined at this point. These can include nighttime operating restrictions, such as noise curfews; demand management policies, such as slot restrictions; and physical gate or airfield capacity constraints that cannot or are not expected to be mitigated. These factors can all affect the estimates of future flight times.

In addition, if the DDFS is intended for use in modeling a planned future airport layout, pertinent information such as gate and concourse locations and capabilities should be determined. Gating, hardstand, and RON use rules should also be established at an early stage as they can require airline input. Gating, hardstand, and RON rules are discussed in more detail in Section 6.5.

Parameters

The parameters that will govern DDFS preparation help determine the required data inputs and should be determined by the DDFS preparer in coordination with the DDFS user. Among the most important of these is the **design day definition**. For most facility planning, the design day is a typical busy day that best represents the trade-off between achieving acceptable service levels most of the time and avoiding the cost of overbuilding. In many instances, this is defined as an average day or an average weekday during the busiest month. Design days can also be defined as percentiles, for example, the 10th percentile would represent the 36th busiest day of the year, so that 10 percent of the days of the year would be busier and 90 percent would be less busy. For some environmental analyses, the design day is defined as an average annual day. *ACRP Report 82: Preparing Peak Period and Operational Profiles-Guidebook* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf and *ACRP Report 25: Airport Passenger Terminal Planning and Design, Volumes 1 and 2* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_025v1.pdf provide guidance to help select representative design days.

> For most facility planning, the **design day** is a typical busy day that best represents the trade-off between achieving acceptable service levels most of the time and avoiding the cost of overbuilding.

In some instances, it may be desirable to select more than one design day. At some airports, such as Minneapolis-St. Paul International Airport, numbers of originating passengers peak in a different season than enplaned passengers and aircraft operations. Therefore, a DDFS prepared to examine landside requirements may entail a different design day than a DDFS prepared to examine airfield capacity. An alternative to preparing two different DDFSs is to adjust the DDFS output to account for seasonality. Chapter 7 provides guidance on making these adjustments. Click here to access Chapter 7.

At this stage, the preparer and user should determine whether a single day or multiple adjacent days should be modeled. Although preparing a design week flight schedule requires significantly more effort, it helps avoid some of the problems involved in selecting a single design day and provides better fidelity in the following circumstances.

Day of the week variations: In the past, airlines tended to operate the same schedule during each weekday, despite demand being higher on Mondays and Fridays and lower on Tuesdays and Wednesdays. Now, airlines are increasingly matching service to demand, resulting in a less homogeneous weekday schedule.

Asynchronous peaks: At some airports, international demand peaks on Saturdays, when domestic demand is low and airlines use the available aircraft capacity to offer international service to leisure markets. In these circumstances, using a traditional design day definition could result in the understatement of international demand and international facility requirements.

Nighttime Operations: Some airports, especially those with significant international or all-cargo aircraft operations, stay busy through the midnight hour. Demand on some facilities, such as RON parking, may peak at that time. A midnight cutoff for the design day may significantly reduce the effectiveness of a DDFS in those instances.

Under some limited circumstances, a partial DDFS that encompasses the anticipated peak period and the times immediately preceding and following can be used instead of a DDFS for a full design day. Partial DDFSs may be appropriate at small uncongested airports where the peak activity period is clearly defined and carryover delay and recovery times are not an issue. Partial DDFSs are best used to examine requirements for facilities closely tied to peak passenger or aircraft operation flows. The activity peaks at some facilities, such as terminal curbsides, are offset significantly from the at-gate peaks, and may be influenced by off-peak activity flows in ways that are not readily apparent. Requirements for other facilities, such as gates, may be greatest at off-peak times, such as late at night. In these instances, partial DDFSs are not appropriate.

Data Inputs

Data used to prepare a DDFS can include the following, depending on which DDFS elements are incorporated:

- An existing passenger airline flight schedule representing the design day.
- An existing all-cargo airline flight schedule if available. U.S.-flag airlines typically no longer publish their schedules, but may make them available to airport operators for ramp management.
- Daily activity profiles for nonscheduled operations. Estimates of nonscheduled operations can be obtained from the FAA's Distributed Operations Network (OPSNET) database or vendors that process data from the ASDI system. In addition, some airport traffic control towers (ATCTs) collect data on operations by hour.
- Airport noise monitoring data, if available. These data can also be used to identify flight times for nonscheduled operations.
- U.S. DOT T-100 data on passengers and load factors by market and airline.
- U.S. DOT O&D Survey data for O&D and connecting passenger segmentations by market and airline.
- Airport information on existing and future gate and aircraft parking layouts.
- Archived FIDS and airfield surface tracking data, if available.

A more extensive description of potential data sources is provided in Appendix F.

Airline schedules can be filed up to 12 months in advance, but their accuracy and reliability tend to be less accurate the further in the future they go. In some cases, airlines overschedule in their advance schedules and then trim flights to match booking demand. In other instances, it is uncertain which aircraft would be most appropriate to serve each route, and some airlines use place-holder aircraft in their advance schedules to be later replaced with right-sized aircraft when advance bookings provide a better gauge of demand.

Therefore, when an advance schedule is used as the basis for a DDFS (e.g., a July peak month schedule is used as the basis for a DDFS being prepared in March), some adjustments for these factors may be required. These adjustments include scaling back future seat capacity in the advance schedule to match current year-to-year growth, or adjusting the fleet mix in the advance schedule to match the airlines' current fleet mix.

Some DDFS preparers use airline schedules without adjustment and others make adjustments to match daily aircraft operations. Because of cancellations, not all scheduled operations actually occur. Therefore, many DDFSs contain slightly more aircraft operations than are actually flown. These differences are subtle, but may significantly alter results at highly constrained airports where a slight change in operational levels can result in a significant change in average delay. Therefore, it is essential to document whether a DDFS represents scheduled operations or completed operations.

Perhaps the most important input to a DDFS is the annual activity forecast. These forecasts may be master plan forecasts, forecasts prepared for other purposes, such as determining financial feasibility, or FAA Terminal Area Forecasts (TAF).

The TAFs lack the necessary fleet mix detail to be used directly for DDFS preparation without significant additional work on the part of the preparer. Note, however, that a DDFS that is based on an annual forecast that is not consistent with the TAF (defined as within 10 percent over the first five years or 15 percent over the first 10 years), additional discussion with the FAA will be required to obtain FAA agreement necessary for FAA funding and environmental approval (FAA 2008).

The assumptions underlying the annual and DDFS forecasts should be consistent. For example, if the annual forecasts include assumptions regarding new nonstop markets or a future fleet mix, those forecast assumptions are typically incorporated in the DDFS to save time and effort in addition to maintaining consistency.

The assumptions underlying annual and DDFS forecasts should be consistent.

Appendix A provides an example of some of the activities involved in setting the stage. Click here to access Section A.2. Setting the Stage.

6.3 Forecasting Future Passenger Markets and Fleet Mix

O&D markets are a major determinant of aircraft type and passenger characteristics. However, there is no single industry standard for forecasting new markets and the fleet mix associated with each market. Two options for forecasting markets and fleet mix are presented here. The first option, described in Exhibit 6.2, is a detailed bottom-up passenger-focused approach, whereas the second option, shown in Exhibit 6.3, is a less-detailed top-down operations-focused approach. In some instances, markets may not need to be identified (see Chapter 4).

Background/Considerations

Regardless of the option selected, the following should be considered when forecasting future markets and fleet mix.

Airline market share is very difficult to predict because of mergers, bankruptcies, changes in alliances, and changes in business plans. For airport planning that does not involve a DDFS, aircraft operations and passengers are usually not differentiated by airline and the issue is avoided. In a DDFS, aircraft need to be assigned to gates and markets. As gates and markets are often airline-specific (especially if the gates are not common use), the airline designation becomes more important. At most connecting hub airports, one airline serves most of the connecting traffic and has very different ratios of O&D to connecting passengers than the other airlines.

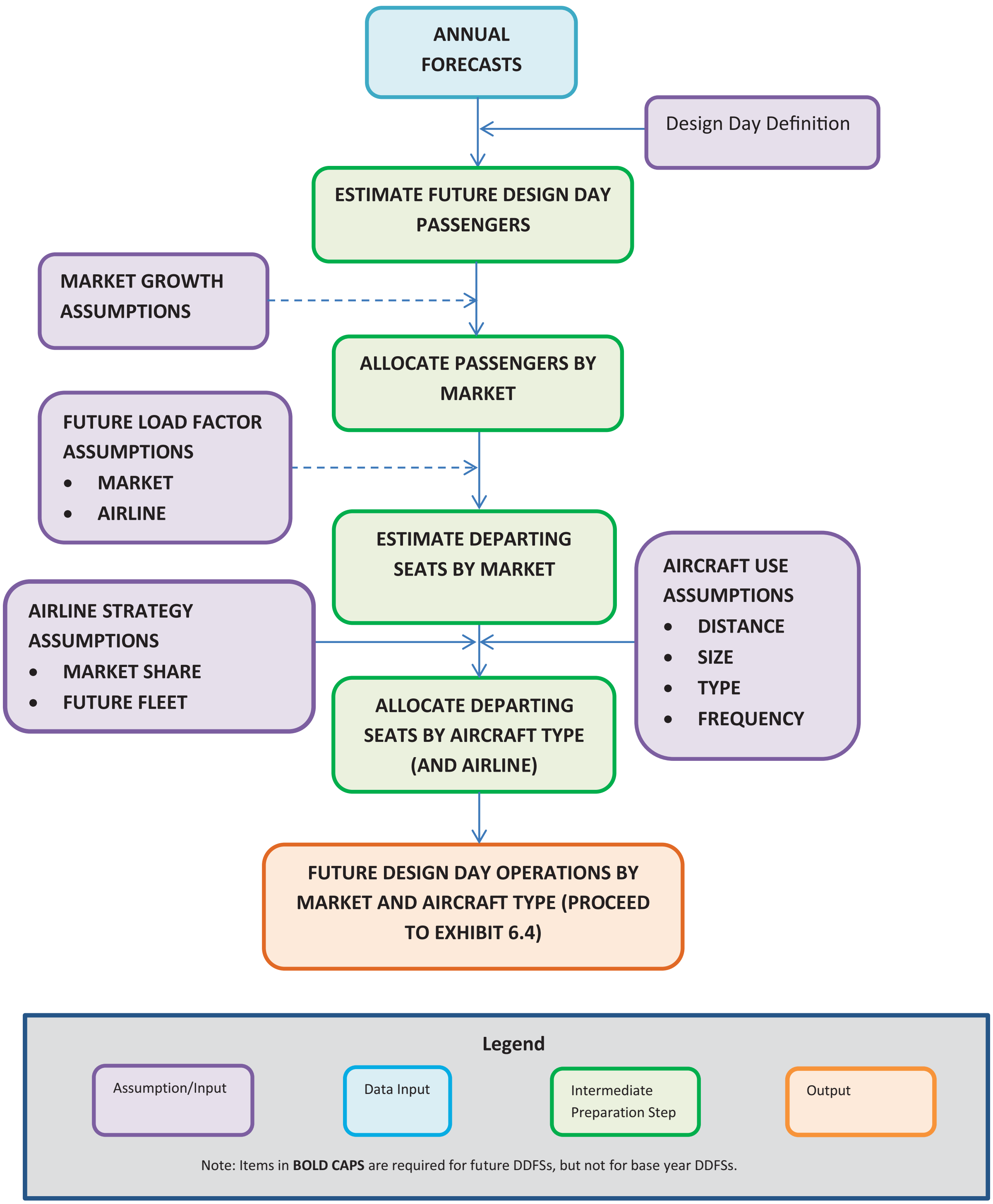


Exhibit 6.2. Forecasting future markets and fleet mix for DDFS (Option 1).

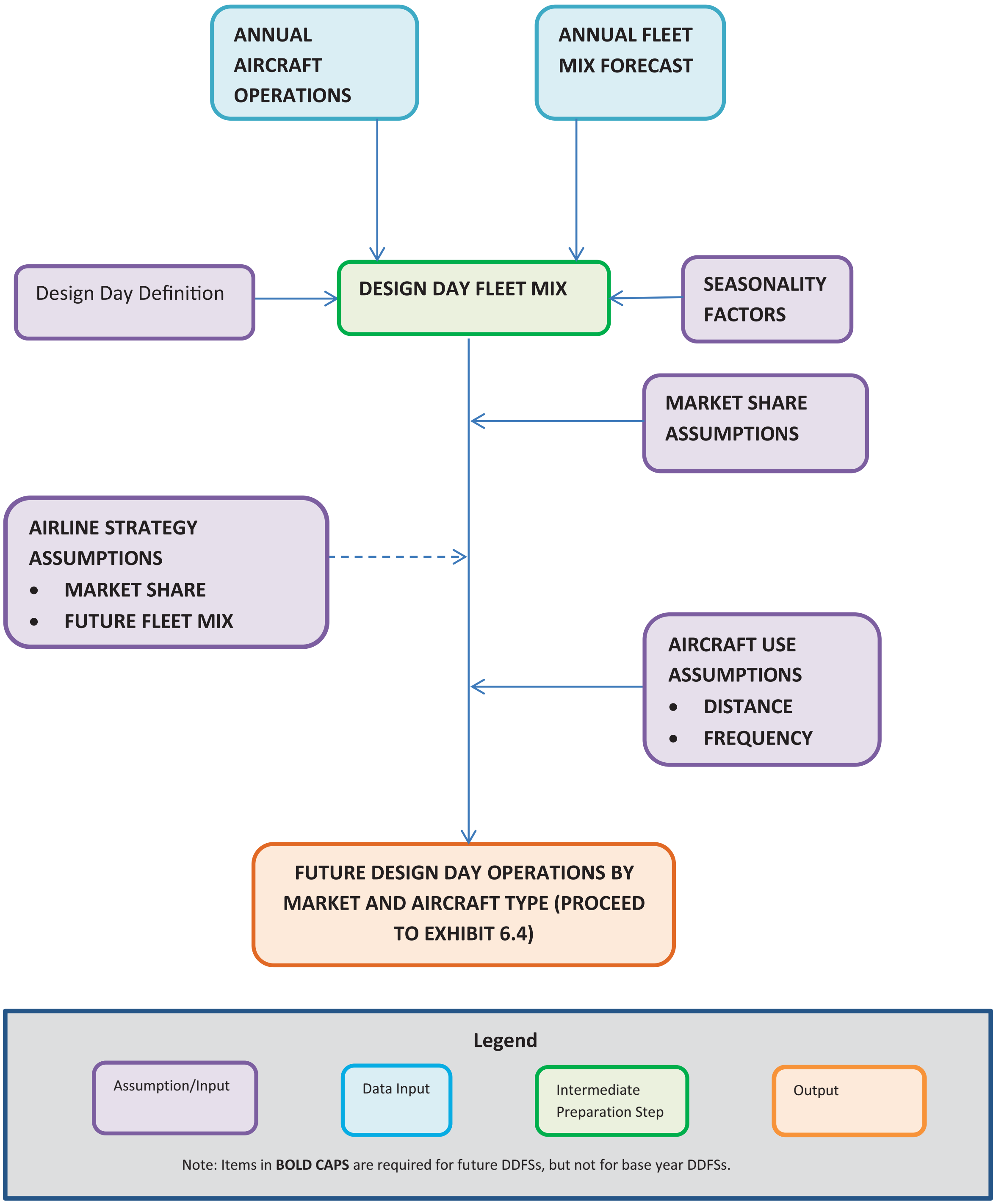


Exhibit 6.3. Forecasting future markets and fleet mix for DDFS (Option 2).

At most connecting hub airports, one airline serves most of the connecting traffic and has very different ratios of O&D and connecting passengers than the other airlines.

Identifying the airline then becomes important in determining O&D flows. Some nonstop markets may be viable for some airlines but not others. For example, a hubbing airline would be able to supplement O&D passengers with connecting passengers, which often determines whether there is a sufficient amount of traffic to sustain service.

Approaches to **estimating the growth of existing nonstop markets** can range from assuming a constant market share to tying market growth to economic factors such as income, or even to developing separate forecast equations for each market. Sometimes, growth factors are applied directly to aircraft operations; sometimes, they are applied to scheduled departing seats that are then converted to aircraft operations; and other times they are applied to passenger traffic that is then converted to departing seats and aircraft operations. The growth may be accommodated with larger aircraft, higher load factors, more flights, or a combination of those factors.

Approaches to **identifying new nonstop markets** are equally varied. They include:

Defining certain flights as operating to and from new markets without specifying the market: This approach has the virtue of simplicity, but some flight characteristics, such as aircraft type and flight time, are dependent on the market served. Segmenting new markets by category (i.e., short-haul domestic, long-haul domestic, international) can mitigate some of the shortcomings of this approach.

Judgment-based analysis: In this approach, the preparer uses his or her knowledge of airline behavior and existing nonstop markets to anticipate the markets in which airlines are likely to add new nonstop service. This approach is difficult to document, which may be a shortcoming in highly controversial projects.

Using historical airline service as a guide to future airline service: In this approach, it is assumed that airlines are most likely to reintroduce nonstop service in markets that have been served nonstop in the past. An inherent assumption is that the factors leading to the future introduction of new nonstop service will be similar to the underlying factors in the past. However, many markets have lost nonstop service because of the evolution of the aviation industry. For example, many small short-haul markets have lost service because airlines no longer operate the 19-seat aircraft that are optimal for those markets and/or travel by automobile is a viable alternative. This trend is unlikely to be reversed.

Using O&D passenger or airline revenue thresholds: In this approach, the current minimum threshold (measured in numbers of O&D passengers or airline revenue) needed to justify nonstop service is calculated within each distance band from the airport under analysis (500 miles, 1,000 miles, etc.). As demand increases, consistent with the annual forecasts, more and more unserved markets exceed the minimum threshold and are, therefore, assumed to gain nonstop service. This approach is more resource-intensive than the others. This approach has theoretical appeal, but has not been empirically validated. Also, the thresholds will likely differ for hubbing airlines that can rely on additional connecting traffic compared to nonhubbing airlines.

Air service analysis: In this approach, a detailed air service analysis, addressing potential airline revenue, demographic characteristics, potential feed traffic, and other factors that airlines consider in their route analyses, is conducted for each potential nonstop market. This is a very costly undertaking, but, in some cases, the airport operator may have already undertaken air service analyses as part of its airline route development and marketing efforts, which can be applied to the DDFS.

It is also important to **identify which existing nonstop markets may be lost**. As noted earlier, many short-haul markets are losing service because the optimal aircraft for serving those markets are no longer in operation. This suggests that the thresholds for nonstop service may be shifting upwards.

Fleet mix will vary by market. Generally, short-haul markets are served with small aircraft at high frequency, and long-haul markets are served with large aircraft at low frequency. Competitive markets (those served by more than one airline) tend to be served by smaller aircraft with greater frequency than noncompetitive markets of similar size and segment distance. Business markets tend to be served with smaller aircraft at greater frequency than leisure markets because business travelers select flights largely on the basis of schedule. Operating a greater number of smaller aircraft costs the airlines more on a seat-mile basis, but they are able to recoup those costs because of the premium fares paid by time-sensitive business travelers.

Steps for Forecasting Passenger Markets—Option 1 (Passenger Based)

Exhibit 6.2 shows a top-down passenger-based approach for forecasting and distributing future design day activity among markets (Option 1). The result is a fleet mix forecast showing airline, aircraft type, and daily service frequency in each market. The approach involves the following steps:

Steps for Estimating Passenger Markets and Fleet Mix—Option 1

1. Estimate future design day passengers if not available from the annual forecasts. *ACRP Report 82: Preparing Peak Period and Operational Profiles—Guidebook* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf provides options for estimating design day passengers based on the user's criteria.
2. Allocate passengers among markets. Some detailed annual forecasts include distribution of passengers by market. If annual market forecasts are not available, potential allocation methodologies are listed below, ranked in order of least complex to most complex:
   a. Allocate passengers according to existing shares.
   b. Grow passengers in each market according to recent trends and then normalize (proportionally adjust) results to sum to original design day total.
   c. Grow passengers in each market according to the anticipated growth in a market-demand proxy, such as income in the destination market, and then normalize results to sum to original design day total.
   d. Grow passengers in each existing market in accordance with 2.c. above, identify new nonstop markets using one of the approaches discussed earlier in this section, and then normalize results to sum to original design day total.
   e. Prepare a separate forecast for each market, including new nonstop markets, and then normalize results to sum to original design day total.
3. Estimate future load factor for each market and then divide the passenger forecasts for each market prepared in Step 2 above by the estimated load factors to generate a departing seat forecast for each market.
4. Estimate the fleet mix most likely to account for daily departing seats to each market. This will involve some judgment and should include the following considerations:
   a. Existing service patterns to the market.
   b. Current airline route strategies.
   c. Degree of competition in the market. Markets in which airlines compete tend to have more service frequencies using smaller aircraft than monopoly markets of similar size and distance.
   d. Known planned aircraft orders and retirements for each airline.

e. Relationship among market size, average aircraft size, and flight frequency. This relationship tends to change with increased distance; long-haul markets tend to be served by larger aircraft with fewer frequencies compared to short-haul markets of similar size (measured in departing seats).
f. Adjust as necessary so that the sum of aircraft types serving each market is consistent with the annual fleet mix forecast.

Some preparers use a variation of Option 1, in which, after passengers are allocated among markets (Step 2), it is assumed that the airline(s) will attempt to maximize average load factors in the market before adding service. The maximum load factor is defined as the maximum load factor in other similar markets. Once load factor is maximized, the airline(s) are assumed to increase equipment gauge (aircraft size), to the extent possible. Maximum realistic aircraft size is again defined by experience in other, similar markets. Flight frequencies are added only after load factor and aircraft gauge are increased to the maximum realistic levels.

Steps for Forecasting Passenger Markets—Option 2 (Operations Based)

Exhibit 6.3 shows a simpler, top-down operations-based approach for estimating and distributing future design day activity among markets (Option 2). This approach involves the following steps.

Steps for Forecasting Passenger Markets and Fleet Mix—Option 2

1. Assemble a design day fleet mix from the annual fleet mix. At some airports, the fleet mix during the busy season differs from the annual fleet mix. However, the design day fleet mix trends should be consistent with annual trends. For example, if the annual forecasts show a phase-out of 50-seat regional jets, this phase-out should be reflected in the design day fleet mix.
2. Estimate the percentage of flights to existing nonstop markets and new nonstop markets. Methods for forecasting new markets are discussed earlier in this section.
3. Allocate the existing market share of flights among existing markets according to existing distributions.
4. Adjust the fleet mix in each market in a manner consistent with the assumed fleet mix changes for the primary airlines serving the market and the range of characteristics of the aircraft types. Adjust as necessary so that the sum of aircraft types serving each market matches the annual fleet mix.

Estimating Future Passenger Markets and Fleet Mix—Observations and Cautions

As a general caution, it is not a given that new nonstop markets will be served. Some airports, especially smaller airports, have been losing rather than gaining nonstop markets.

As each aircraft that lands must take-off again, the distribution of aircraft types and airlines is symmetrical between arrivals and departures in the long term. There are some exceptions during transition days, such as Fridays, Saturdays, Sundays, and Mondays, as airlines ramp their operations up or down to adjust for lower or higher weekend demand. When the selected design day is in the middle of the week, this is typically not an issue, but it must be considered when preparing multiple DDFSs representing several adjacent days.

Typically there is a rough symmetry in the distribution of aircraft types and airlines between arrivals and departures within a given market pair, but the symmetry is not exact. Slight differences in aircraft types between arrivals and departures are not unusual and, in some cases, the total number of aircraft arrivals and departures does not match in a given market pair.

For an actual example of how some of these approaches to forecasting markets and fleet mixes were applied, see Appendix A. Click here to access Section A.3. Future Markets and Fleet Mix.

6.4 Forecasting DDFS Flight Times

Forecasting future flight times is a key part of preparing a DDFS. This section provides general background, a detailed step-by-step process for forecasting flight times, and some observations and cautions.

Background/Considerations

There is no standard approach to forecasting future flight times, but based on the research conducted as part of the development of this guidebook, several general observations and principles should be considered.

- In general, the hourly pattern of arrivals and departures tended to be consistent during the past 10 years at most airports. That is, the peaks and valleys in the daily profile of activity at the airport tend to occur around the same time over the years as a result of geographic location and airline route network strategies. This is not to say that the profiles are absolutely rigid. Variations of 5 to 10 percent in each hour's share of design day scheduled operations or scheduled seats are not unusual. Airport size is positively correlated with the stability of schedules (e.g., large hubs have more stable schedules than medium hubs and so on).
- Total operating schedules are more stable than separate arrival and departure schedules.
- The stability of domestic operations schedules is similar to that of total operations, while international operations schedules are more variable.
- Individual airline schedules are less stable than total airport schedules.
- There is no discernible trend in airline-specific schedule stability; the scale of individual airline operations at an airport is a more important driver than the specific airline. For example, there is no evidence that, given an equal number of operations, a low-cost carrier's schedule is more or less stable than a legacy carrier's schedule.
- Approaches to determining flight times for new service will vary by airline. Network airlines focus on providing flights at peak times to and from their hubs. Other airlines focus on the peaks as well, but also on maximizing gate utilization to provide operating cost efficiencies.
- International schedule profiles tend to be less stable than domestic schedule profiles. Flights to specific international regions (e.g., Europe, northeast Asia, and southern Latin America) tend to operate within specific schedule windows, but if the mix of flights to each region changes, the overall profile of international operations may change significantly. See Appendix N in *ACRP WOD 14* (Technical Report accompanying ACRP Report 82) http://onlinepubs.trb.org/onlinepubs/acrp/acrp_w014.pdf for additional detail on international profiles.
- Major structural changes to an airline schedule, such as an increase or decrease in the number of connecting banks, a transition to a rolling hub, or de-hubbing, will cause more significant changes to schedule profiles.
- Although airports exhibit certain tendencies regarding the timing of the peak hour within the day, shifts in the timing of the peak of 2 or 3 hours can still occur.
- Over time, the peak hour share of daily operations can range from three percent to almost 20 percent above or below the long-term trend, depending on the size of the airport.

Existing Flight times are much more likely to change if an airline adds or deletes a flight to a market.

- Even when daily flight frequencies remain constant, flight times to individual markets change often. These changes most often are within 10 to 15 minutes of the prior scheduled time, but can be longer.
- Existing flight times are much more likely to change if an airline adds or deletes a flight to a market. If there is a change in frequency, airlines will reschedule remaining flights to maximize service coverage during the day. Under these circumstances, flight times can vary by several hours, especially if the flight is not the first or last flight of the day. Appendix Q in *ACRP WOD 14* (Technical Report accompanying ACRP Report 82) http://onlinepubs.trb.org/onlinepubs/acrp/acrp_w014.pdf provides more background information.

These observations are discussed in more detail in Appendix B. Click here to access Appendix B: Stability and Predictability of Critical DDFS Factors.

Steps for Forecasting DDFS Flight Times

Exhibit 6.4 shows a general approach for forecasting flight times for passenger aircraft operations. This approach involves the following steps.

Steps for Forecasting DDFS Flight Times

1. Begin with the market forecast of aircraft operations by airline, aircraft type, and flight frequency and an existing schedule of passenger aircraft arrivals and departures (see Section 6.2).
2. For each destination (departure) market, update each existing flight to reflect changes in equipment, if any, and add new service frequencies. When forecasting scheduled times for new flights to existing markets, consider the following factors:
   a. Avoid scheduling two flights to the same market by the same airline at the same time. Airlines try to avoid wingtip-to-wingtip flights when possible.
   b. If the airport being analyzed serves as a connecting hub for an airline, add new flight frequencies to those connecting banks that currently have no service to the destination market. Check to see that scheduled arrivals at the destination market would occur at a reasonable time (see 2.d. below).
   c. If the airline operates a connecting hub at the destination airport, schedule flights so that the arrival times at the destination airport occur in connecting banks that currently have no service from the airport being analyzed.
   d. Schedule flights to avoid arriving during nighttime hours (2300–0600) at U.S. destination airports. Note, however, that some U.S. and non-U.S. airports with major international service can be very busy during nighttime hours.
   e. Determine whether or not to adjust existing flight times in markets where new flights are added. For example, an airline may currently schedule two departures to a market, one in the morning and one in the late afternoon. If a flight is added, the new schedule may include one flight in the morning, one in the early afternoon, and one in the evening. Thus, the original late afternoon flight time would be eliminated and replaced by two new flight times.
   f. A graph of existing departing flight times by market time zone or distance can serve as a quick reference of realistic times for new flights.
3. Estimate times for service to new markets, taking into consideration the factors described in Step 2. Use similar markets (in terms of size, distance, and time zone) with existing service as a guide to likely service times.
4. Repeat Steps 2 and 3 for origin (arrival) markets.
5. As each aircraft that lands must take-off, arriving flights must be paired or matched with departing flights, unless the flight is the first departure or last arrival of the day. (At busy airports, pairings may change as a result of operational considerations. For example, if an

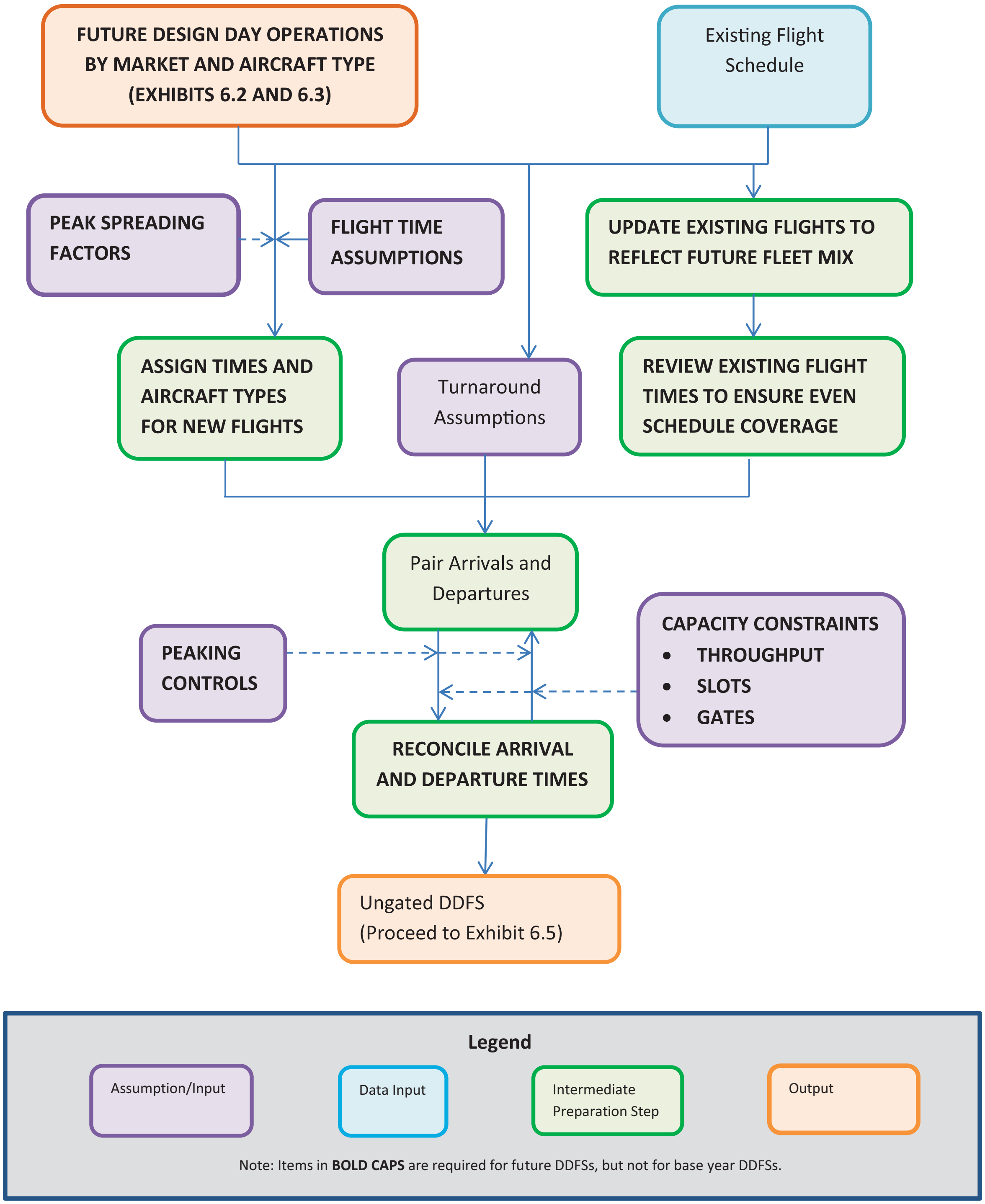


Exhibit 6.4. Forecasting DDFS flight times for scheduled aircraft operations.

arriving flight is delayed, a different aircraft than originally planned may be substituted for a scheduled departure. As a practical matter, this is difficult to model in a planning DDFS.) The time difference between the arrival and subsequent departure must be long enough to allow the offloading and loading of passengers, cargo, and fuel and short enough to allow the aircraft to be fully utilized during the day. In general, turnaround times are determined by the structure of the connecting banks and aircraft size although brake and tire cooldown times are sometimes factors. Small regional aircraft can often turn around in 20 to 30 minutes. Mainline aircraft generally take at least 45 minutes or more, unless they are operated by Southwest Airlines, in which case they can turn around in as little as 30 to 35 minutes. Widebody aircraft in domestic service, including Alaska and Hawaii, usually require at least an hour and widebody aircraft in overseas international service often require a 2-hour turnaround time.

6. Many preparers use the first-in/first-out approach to pair flights. This involves sorting arrivals and departures by airline and aircraft type, and then pairing each arrival with the first departure that meets the turnaround criteria in Step 5.
7. In some instances, airlines will hold a few aircraft departures back to provide some contingency in the schedule in case of delayed arriving aircraft or mechanical breakdowns or to serve a market at a more competitive time. The existing schedule should provide a good guide as to how often airlines plan for these contingencies. For example, if a midday departure cannot be paired using the approach in Step 6, it may be an aircraft that has been held over since the previous night.
8. Generally, after all apparent pairings of arriving and departing aircraft have been completed in a future DDFS, there will be a few remaining flights for which there are no obvious pairs. From a demand standpoint, the best times to add new arriving flights do not always correspond to the best times to add new departing flights. For example, at East Coast airports, there may be a late morning schedule gap for departures to West Coast airports. Adding long-haul aircraft departures at that time may not be feasible, however, as the availability of long-haul aircraft arriving during that period may be insufficient because those arriving aircraft would have departed their West Coast airport of origin sometime between midnight and 0600. If the number of unmatched pairs is too high to be reasonably explained by airline contingency planning, it will be necessary to iteratively adjust flight times, while adhering to the considerations in Steps 2 and 3, until the remaining arriving and departing aircraft can be paired.
9. Additional adjustments may be required to ensure that the schedule complies with policy constraints, such as slot restrictions, or physical constraints, such as gate or airfield throughput capacity. See Section 6.8 for additional discussion of constraints.

Forecasting DDFS Flight Times—Observations and Cautions

When airport activity increases, peak activity also increases, but usually at a lower rate.

When airport activity increases, peak activity also increases, but usually at a lower rate. Therefore, the peak percentage tends to decrease as an airport becomes busier. *ACRP Report 82: Preparing Peak Period and Operational Profiles—Guidebook* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf provides additional discussion of peak spreading and some approaches to forecasting the effects.

There are differing strategies for dealing with peak spreading in DDFSs. One top-down strategy is to pre-define the peak activity periods and use these predefined peak periods as controls for determining the distribution of flight times in the DDFS. The second, bottom-up strategy is to build the DDFS without peak controls and let the DDFS results define the peak period.

The advantage of the top-down strategy is that it helps mitigate conscious or unconscious biases that a DDFS preparer may have for or against certain flight times. In some instances, the reconciliation of arrival and departure links may unintentionally cause the migration of operations or aircraft equipment to times not representative of real world operations.

The bottom-up strategy is advantageous when the airlines serving an airport are expected to change their strategies. For example, a change in the number of connecting banks will create a discrete change in the peak hour percentage. The markets and number of operations in each forecast bank will depend on individual market characteristics and are difficult to determine using a top-down strategy. Another example would be a gateway airport currently serving European markets, with a characteristic late afternoon and evening international peak. If service at the airport is added to South American or Asian markets, existing peaks will be a poor guide for determining flight time distributions for the additional flights.

Based on the discussion above, imposing top-down controls on the distribution of DDFS flight times may be too rigid, and may generate results that fail to incorporate more subtle trends that can emerge from bottom-up DDFS preparation. A potential compromise may be to establish soft controls (see Section 6.10) to establish boundaries from which DDFS-generated profiles could not deviate without good cause. Regardless of the strategy used, the future profile of activity should be cross-checked with the existing profile to ensure that there are no deviations that cannot be readily explained by changes in service patterns, such as the mix of domestic and international flights.

Appendix A provides an example of how new flight times were forecast. Click here to access Section A.4 Flight Times.

6.5 Assigning Gates

For many airfield simulation analyses and for terminal planning, the aircraft arrival and departure pairs will need to be assigned to gates.

Background/Considerations

At most airports, airlines determine which flights use specific gates. Airlines begin the process of converting airline schedules to gate requirements with their airline schedule planning group generating a proposed flight schedule. Then, either the airline's schedule planning, operations planning, or corporate real estate (CRE) group converts the schedule to preliminary requirements, in some cases relying on commercial gate plot software and in other cases relying on internally developed software programs.

The next airline step depends on the complexity of the gating issues. Determining the gate requirements for three to four flights spread throughout the day may be a matter of the CRE group simply confirming that a single gate is available for lease or use from the airport operator and on what terms. On the other hand, optimizing the number of gates required for a large number of originating flights followed by a much smaller number of flights throughout the day usually requires further analysis and discussion between the CRE group, station managers, schedule planning, and, in some cases, finance. The question is often whether or not the originating flights can be towed to and from the gate to avoid the need to lease gates that will not be needed after the peak. There is a trade-off between customer service (aircraft at gate when needed) and cost control (aircraft towed to or from the gate until needed). Other areas of internal discussion in determining gate requirements are the effect of weather, the need to add more buffers between flights if the schedule is tight, and the availability of common-use or other gates on a per-use basis to accommodate peaks. In balancing customer schedule preferences with airport costs, the relative prioritization depends on the business model of each airline and may change over time.

Gate assignment decisions are usually made by airline station managers. Sometimes, there is additional coordination with airport operations, especially for common-use gates, and U.S. CBP when international services are required. In allocating flights to particular gates, the critical factor is the ability to accommodate particular aircraft in terms of length and wingspan. Beyond that, airlines consider multiple factors when assigning flights to particular gates, with different airlines taking different approaches. The following is a composite list of the airline considerations involved in assigning flights to specific gates:

- Park aircraft reasonably close to their usual departure and arrival runways.
- If a high proportion of deplaning passengers are connecting to a single destination, use a nearby gate for the connecting flight.
- Evenly distribute workload among available station personnel.
- When possible, assign the same flights to the same gates, especially for business markets.
- Separate the boarding areas for business and leisure flights.
- Avoid overcrowding boarding areas with high-demand flights. Assign flights with high passenger loads to gates with larger holdrooms and avoid assigning two such flights to adjacent gates.
- Increase buffer times between flights as much as possible.
- Minimize congestion in taxiways adjacent to concourses.
- Locate the last arriving flights in a bank near the center of the hubbing airline's gates rather than on the periphery to avoid passengers having to run from the end gate.
- Assign flights from the same bad weather/delay destinations to the same gates (as the delays tend to affect multiple flights in a similar manner).
- Coordinate with airport operators to assign flights to gates near concessions that best serve particular passenger characteristics, especially for business travelers.

Another factor to consider is that some large airports have stand-alone terminal buildings. Moving connecting passengers between terminal buildings is inconvenient for passengers, airlines, and airport staff. Therefore, to the extent possible, airlines and airline alliances should be assigned gates within the same terminal building.

Steps for Assigning Gates

To the extent possible, the above factors should be considered when assigning gates in a DDFS. In many instances, a DDFS preparer will not have access to airline gating policies or the resources to model each aspect. Exhibit 6.5 provides a more general approach for assigning gates in a DDFS. Many firms have proprietary models that automate the process. Whether the process is manual or automated, the following factors should be considered.

Steps for Assigning Gates

1. If the requirements of the analysis dictate that the DDFS be gated, a gate layout representing future terminal area conditions is required when existing gate capacity is not sufficient to fully accommodate forecast activity. If a future layout is not available, unaccommodated flights can be assigned to virtual gates. However, general locations must be assigned to those virtual gates if the DDFS is used as input to airfield simulation analysis or if the terminal and roadway analysis is subdivided by terminal building, concourse, or other segmentation.
2. Not all gates are configured to accommodate all aircraft types. Aircraft should be assigned only to gates that can, or are planned to, accommodate those aircraft categories.
3. Sufficient buffer time between a departing flight and the next arriving flight at a gate should be included. Current gate scheduling practices at the airport under analysis should be examined to determine the appropriate buffer times. At preferential- or exclusive-use gates, the buffer time is typically no less than 15 minutes for a domestic flight and no less than 30 minutes for an overseas international flight. Many airlines use buffer times of 30 minutes or more even for domestic flights. If common-use gates are contemplated, buffer times should be increased

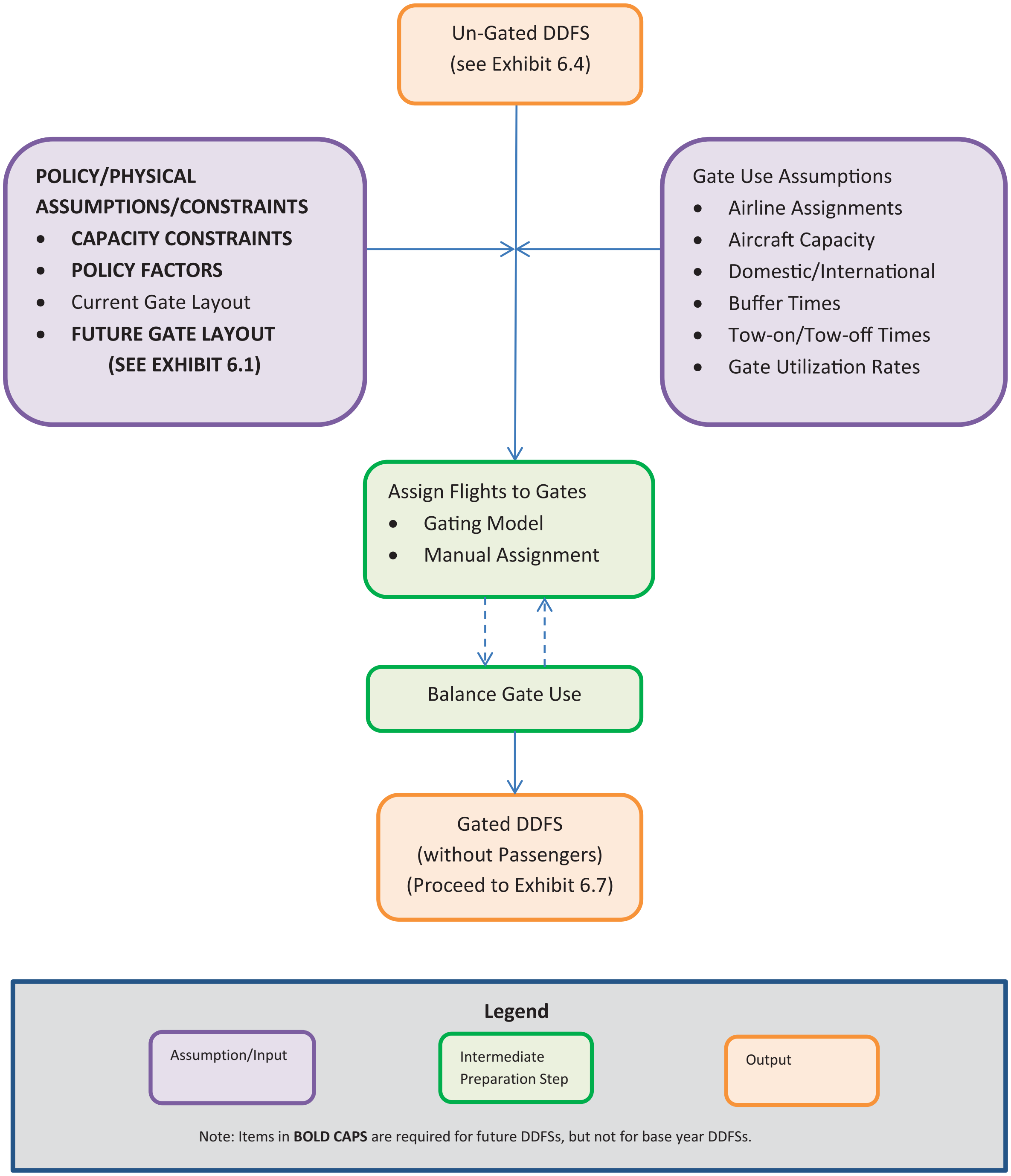


Exhibit 6.5. Assign gates for DDFS.

because individual airlines have less internal flexibility to optimize the distribution of their aircraft among gates to accommodate disrupted schedules. Long-haul flights, because of head-winds and other contingencies, tend to have more unpredictable arrival times than short-haul flights and may, therefore, warrant a longer buffer time. In addition, disrupted schedules are more likely at highly congested airports, and increased buffer times will be more appropriate in those instances.

4. Some airlines, especially those that operate connecting hubs, lease spare gates to accommodate disrupted schedules. Spare gates are not always obvious, and may change from hour

to hour, but at any given time, a certain percentage of an airline's gates will have no flights scheduled to provide for unexpected aircraft. There are no general rules regarding the need for spare gates. Historical estimates range from two percent to seven percent of gates at large-hub airports that are considered as spares. However, instead of designating certain gates as unscheduled spare gates, airlines are now more likely to schedule all gates, but with some additional buffer time to better accommodate irregular operations.

5. Buffer times and spare gates are intended to address the same issue: to provide additional gate capacity in case flight schedules are disrupted and off-schedule flights result in a higher demand for gates than anticipated under the original schedule. Therefore, it is not realistic to be too generous or too conservative with both buffer times and spare gates. If an airline has long buffer times, it can operate with fewer spare gates. If it has short buffer times, more spare gates will be required.
6. Some airlines have preferred runways for destinations in a given direction, and they assign gates to minimize taxiing time to those runways. Existing gate assignment patterns should be examined for these practices. If a gate assignment chart is not available from the airport operator or airline, gate assignments for individual flights can be determined in real-time from FIDS, which are often accessible using the Internet.
7. At large airports, gating models can theoretically schedule 15 to 20 daily flights at one gate (usually the first to be gated) and only one peak hour flight at another gate (usually the last to be gated). This scheduling does not occur in the real world. Airlines and airport operators will attempt to balance gate use to avoid overly stressing a given facility. Utilization across gates in the design day schedule should be balanced to match current use patterns. In general, airlines rarely exceed 8 to 10 daily turns per gate.
8. At many airports, RON demand exceeds gate demand. In those instances, arriving RON aircraft must be towed from a gate to a remote parking area to free the gate for the next arriving aircraft. The following morning, the aircraft is towed back to a gate to depart once the gate has been vacated by a previous aircraft departure. Aircraft dwell times before tow-off and after tow-on must be assigned to these aircraft to allow passengers sufficient time to deplane or enplane. These times can vary from 20 minutes or 30 minutes for small aircraft to 45 minutes or more for large aircraft.

Assigning Gates—Observations and Cautions

Users should be aware that gating models or approaches may yield different results depending on the algorithms used. A model that gates aircraft in order of size may generate fewer large aircraft gate requirements but more overall gate requirements. A model that gates aircraft in order of arrival/departure time (from first in the morning to last in the evening) may generate fewer overall gate requirements but a greater number of large gate requirements.

Exhibit 6.6 provides a simple example. Case 1 and Case 2 show alternative gating approaches to an identical four-flight schedule. In Case 1, widebody aircraft are gated first. Once they are gated, the two narrowbody aircraft cannot share a gate and, therefore, two additional gates are required. In Case 2, all aircraft are gated in order of arrival flight time. In this approach, only two gates are required, but they must both accommodate widebody aircraft.

Once all flights are gated, the schedule is ready for airfield planning or simulation modeling. Additional steps, outlined in the next section, will be necessary to use the schedule for terminal or landside planning.

Appendix A provides a description of the gating process, including a Gantt chart. Click here to access Section A.5 Gate Assignments.

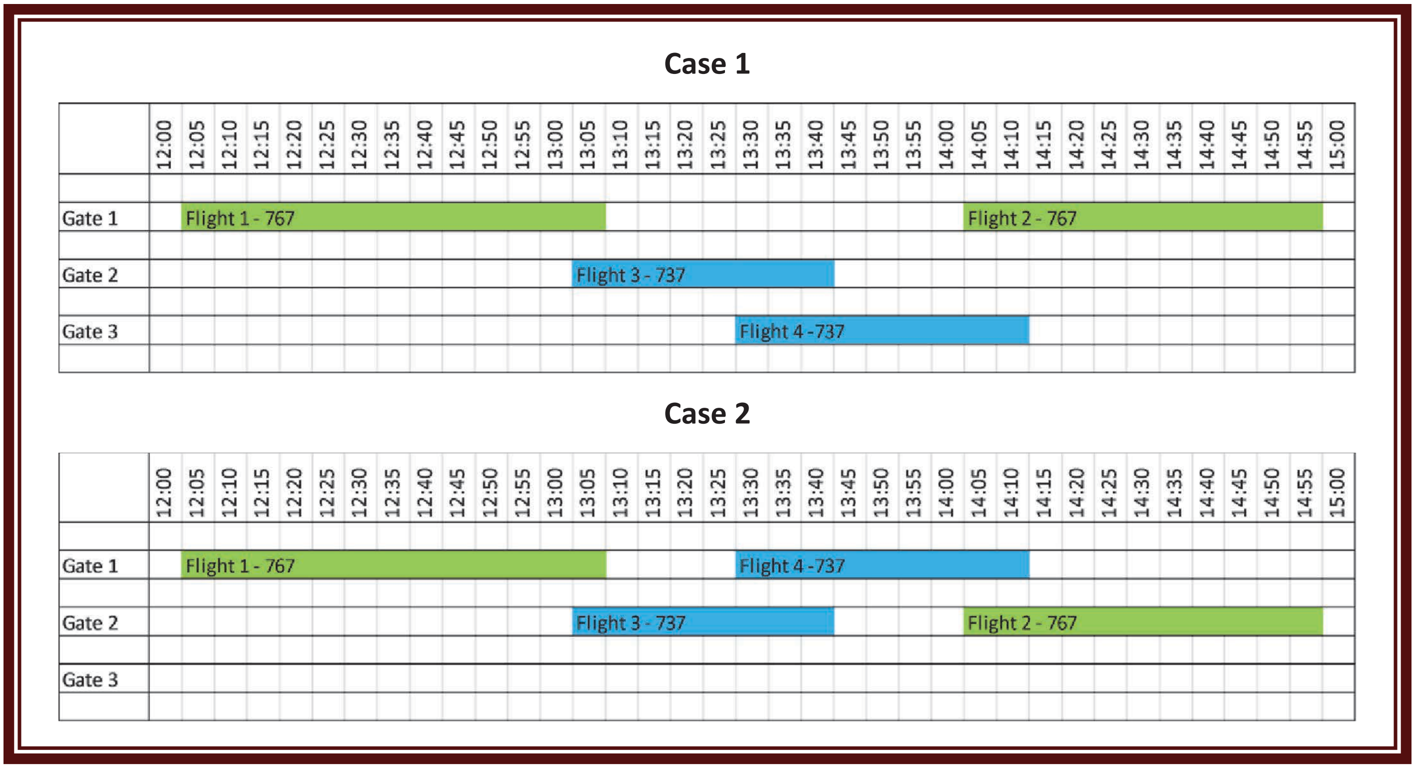


Exhibit 6.6. Impact of gating algorithm on gating requirements.

6.6 Forecasting Passengers by Flight

When DDFSs are used for terminal and landside planning, they must be translated into passenger flows. This requires forecasting passenger loads from enplaning load factors and O&D/connecting passenger splits for each flight.

Background/Considerations

Enplaning Load Factor: The simplest approach for assigning load factors is to assume the same airport average load factor for all flights. This approach is used when analysis resources are limited and the degree of precision is not critical. Several approaches can be used when more detail is required. One approach is to assume that enplaning load factors in each market will increase at the same rate as the overall forecast airport load factor. Another approach is to assume that market load factors will converge toward a common mean. The assumption underlying the second approach is that airlines will view high load factors as a signal to add more service, and low load factors as a signal to reduce service. Research conducted during the development of this guidebook suggests that load factors are, in fact, converging toward a common mean. Load factors are increasing in general, but mostly as a result of significant increases in load factors on flights to markets that previously had low load factors.

O&D/Connecting Passenger Split: When DDFSs are used for terminal or landside planning at a connecting hub airport, an estimate of the split between O&D (local) and connecting passengers on each flight is recommended as such split affects facilities differently and their relative importance may change over the course of the day. This estimate can be complicated for individual flights for two reasons.

First, because of fares and schedules, not all passengers take the most direct route to their destinations. For example, not all passengers traveling from San Francisco International Airport

(SFO) to John F. Kennedy International Airport (JFK) in New York will board a nonstop New York flight. Some may connect through another airport to take advantage of a lower fare.

Secondly, the definition of a local (O&D) passenger for airport planning differs from the definition used by the U.S. DOT, which collects O&D statistics. Using the SFO–JFK–Berlin passenger example, that passenger would be an originating passenger for the San Francisco–New York flight for airport planning purposes, but the U.S. DOT would classify that passenger as a San Francisco–Berlin O&D passenger. From the perspective of the SFO–JFK flight, the SFO–Berlin passenger counts as a beyond O&D passenger.

When resources are available, detailed O&D data segmented by itinerary can be used to separately identify these different O&D categories (nonstop O&D, O&D with a connecting stop, and beyond O&D). In addition, some database vendors use the itinerary data to generate beyond O&D estimates for each market pair. A reduced level of effort may entail some simplifying assumptions, such as:

- All O&D passengers to short-haul destinations fly nonstop if nonstop service is available.
- The ratio of O&D passengers to total enplaned passengers to long-haul destinations is capped to ensure that it does not exceed 1.00. This could happen because the sum of O&D passengers (flying nonstop or connecting through another airport) can exceed the sum of enplaned passengers flying nonstop to the same destination.
- All excess originating passengers (passengers traveling to markets without nonstop service and to long-haul markets in excess of the number of enplaned passengers) are assumed to be funneled through other airline hubs.

The easiest method is to assume that each airline's originating passengers to enplaned passengers ratio is the same for all markets. This method is appropriate for spoke airports with minimal connecting activity.

Steps for Estimating Passengers by Flight

Exhibit 6.7 shows a step-by-step approach for assigning passengers to a DDFS for a large connecting hub airport. This approach involves the following steps and can be applied to both base year and future DDFSs.

Steps for Estimating Passengers by Flight

1. Obtain load factors by airline for each market for the existing design day month. These data are available from the U.S. DOT's T-100 database.
2. If the design day is intended to represent a specific day of the week, adjust the load factors collected in Step 1 to represent the design day of the week, if daily airport or airline data are available.
3. If airline or airport data are available, adjust the load factors in Step 2 for the time of day for both arrivals and departures.
4. Apply the load factors calculated in Steps 1, 2, and 3 to the available seats on each flight in the DDFS.
5. Normalize the results to ensure that the average load factor across the day (total daily enplaned passengers divided by total daily departing seats in the market) matches the daily average calculated in Step 2. Steps 3, 4, and 5 can be skipped if an airline operates only one daily flight to a market, which is often the case for international markets.
6. Estimate the existing ratio of originating passengers to enplaned passengers (ratio of terminating passengers to deplaned passengers should be similar) for each market and airline. These data are available from the U.S. DOT's O&D Survey and T-100 data on a quarterly

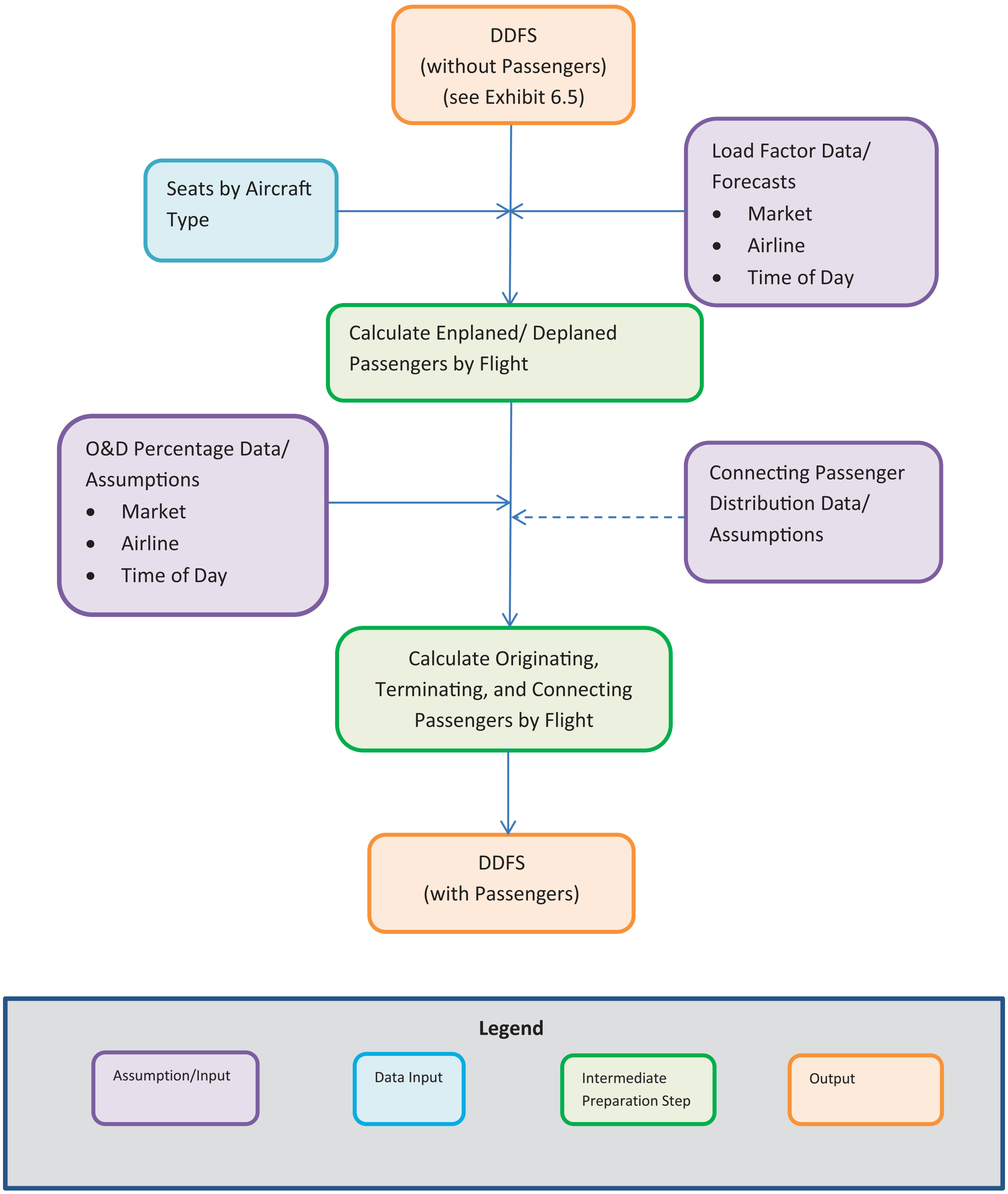


Exhibit 6.7. Estimating passengers by flight for DDFS.

and annual basis for U.S.-flag airlines. Some considerations are necessary when using these ratios because originating passengers to enplaned passengers ratios for a given flight will not always match market originating passengers to enplaned passengers ratios:

a. Airlines flying to other hubs will often be carrying O&D passengers to beyond markets and a market originating passengers to enplaned passengers ratio will understate the on-board ratio. For example, an American Airlines flight leaving from Hartsfield-Jackson Atlanta International Airport (ATL) to Dallas Fort Worth International Airport (DFW) will be carrying O&D passengers from ATL to Phoenix Sky Harbor International Airport, ATL to

Tucson International Airport, and ATL to Albuquerque International Sunport, and so on, not just O&D passengers from ATL to DFW. For this reason, beyond O&D passengers need to be considered. Beyond O&D passenger data are available from some vendors, but for airlines that do not operate a hub at the airport under analysis, it is often simpler to apply an airport-wide originating passengers to enplaned passengers ratio rather than an individual market originating passengers to enplaned passengers ratio.

b. Even for a hub airline, some flight itineraries include multiple stops. In these instances, the number of originating passengers for the one-stop market would have to be added to the non-stop market to estimate true on-board originating passengers to enplaned passengers ratios.
c. In many long-haul markets, the market originating passengers to enplaned passengers ratio exceeds 1.00, which is mathematically impossible for a given flight. This occurs for various reasons, usually associated with price or schedule. Passengers will take an alternative connecting flight rather than the nonstop flight to reach their destination. In these instances, it will be necessary to adjust the on-board originating passengers to enplaned passengers ratios to 1.00 or less.
d. If resources permit, examine the full routing O&D passenger data to refine the on-board originating passengers to enplaned passengers ratios by market pair. If resources do not permit, it will be necessary to make an across-the-board adjustment to the individual on-board originating passengers to enplaned passengers ratios to ensure that the aggregate originating passengers to enplaned passengers ratio matches the overall airport originating passengers to enplaned passengers ratio.
e. The O&D Survey database does not provide O&D passenger information for foreign-flag airlines. Those airlines would need to be surveyed to obtain information on their originating passengers to enplaned passengers ratios. In general, some connecting passenger activity is associated with all international overseas flights. The connecting percentage is much higher for foreign-flag airlines that code-share or are in an alliance with a domestic airline, if any, that uses the airport under analysis as a connecting hub.

7. Apply any forecast changes in the originating passengers to enplaned passengers ratio from the annual forecasts to existing ratios calculated in Step 6 to estimate future originating passengers to enplaned passengers and terminating passengers to deplaned passengers ratios for each market and airline combination.
8. Some judgment will be required to adjust the originating passengers to enplaned passengers and terminating passengers to deplaned passengers ratios by time of day and the factors following should be considered:
   a. Unless red-eye flights are operated from South America, or from the West Coast, to East Coast airports, flights that depart prior to the first arrival bank will carry virtually no connecting passengers. Likewise, flights that arrive after the last departing bank will have virtually no connecting passengers.
   b. There should be a rough correlation between deplaning connecting passengers in a given arrival bank and enplaning connecting passengers in the succeeding departure bank. At no time should the number of cumulative daily enplaning connecting passengers exceed the cumulative number of deplaning connecting passengers.
   c. At international gateway airports, the connecting passenger percentage of total passengers typically peaks during the overseas international arrival and departure peaks as that is when the connecting opportunities peak.

Estimating Passengers by Flight—Observations and Cautions

The steps and guidance provided earlier apply mainly to U.S. airports and access to data such as the U.S. DOT's T-100 database and O&D Survey data. At a few non-U.S. airports, more detailed data are collected from the airlines, which allows load factors and originating passengers to enplaned passengers ratios to be more precisely defined by day of week and time of day. However, at many airports, especially those in the developing world, this type of data is not available. In those instances, the preparer must rely on airline and passenger surveys, field observations, and professional judgment to estimate the number and segmentation of passengers on each flight.

The U.S. DOT O&D Survey data provide a segmentation of originating passengers by point of origin for round trips. This information can be used to segment O&D information by resident and nonresident passengers. This segmentation has little effect on terminal requirements, but can have a major effect on landside requirements. As an example, almost all automobile parking demand is generated by resident passengers and almost all rental car demand is generated by nonresident passengers. If landside analysis is one of the purposes of the DDFS, an additional flight-by-flight segmentation of O&D passengers into resident and nonresident categories can be included. Note that this information will vary by market (which is available from the O&D Survey) and by time of day (which is only available from a passenger survey).

Appendix A provides an example of how originating passengers to enplaned passengers ratios were estimated for an actual DDFS. Click here to access Section A.6 Passengers by Flight.

6.7 Nonscheduled Aircraft Operations

DDFSs prepared for large airports tend to focus on scheduled passenger airline aircraft operations because they often represent the largest category of operations and they affect critical facilities, such as the terminal building, gates, and curbsides. However, if intended to address airfield issues, the DDFS is incomplete if it does not address nonscheduled operations, including **charter airline passenger, all-cargo airline, air taxi, GA, and military aircraft operations**.

Except for some all-cargo airline flights, these categories are nonscheduled by definition. In a DDFS, these categories are typically represented by a sample of daily activity that represents a typical distribution of operations.

Irregular operations are scheduled operations that have been disrupted because of bad weather or other reasons. Step 4 in Section 6.5 discusses the use of buffer times or spare gates to account for these operations. Another option is to prepare a DDFS based on a past example of a significantly disrupted day at an airport, and use it to evaluate impacts on facilities and contingency plans.

Charter Airline Passenger Aircraft Operations

Data on charter airline passenger aircraft operations are typically available from airport sources or the U.S. DOT's T-100 database, and can include airline, aircraft type, and market. If not available from airport sources, information on flight times can be obtained by interviewing the operators or accessing ASDI data.

Without information provided by the operators, most preparers of DDFSs assume that the future distribution of charter operations will be similar to the current distribution. Load factors can be obtained from the U.S. DOT's T-100 database, and passengers are almost always 100 percent O&D.

All-Cargo Airline Aircraft Operations

As discussed earlier regarding passenger data, approaches to developing the cargo elements of a DDFS have not been standardized. Exhibit 6.8 provides one approach for preparing DDFS cargo elements. The steps include the following.

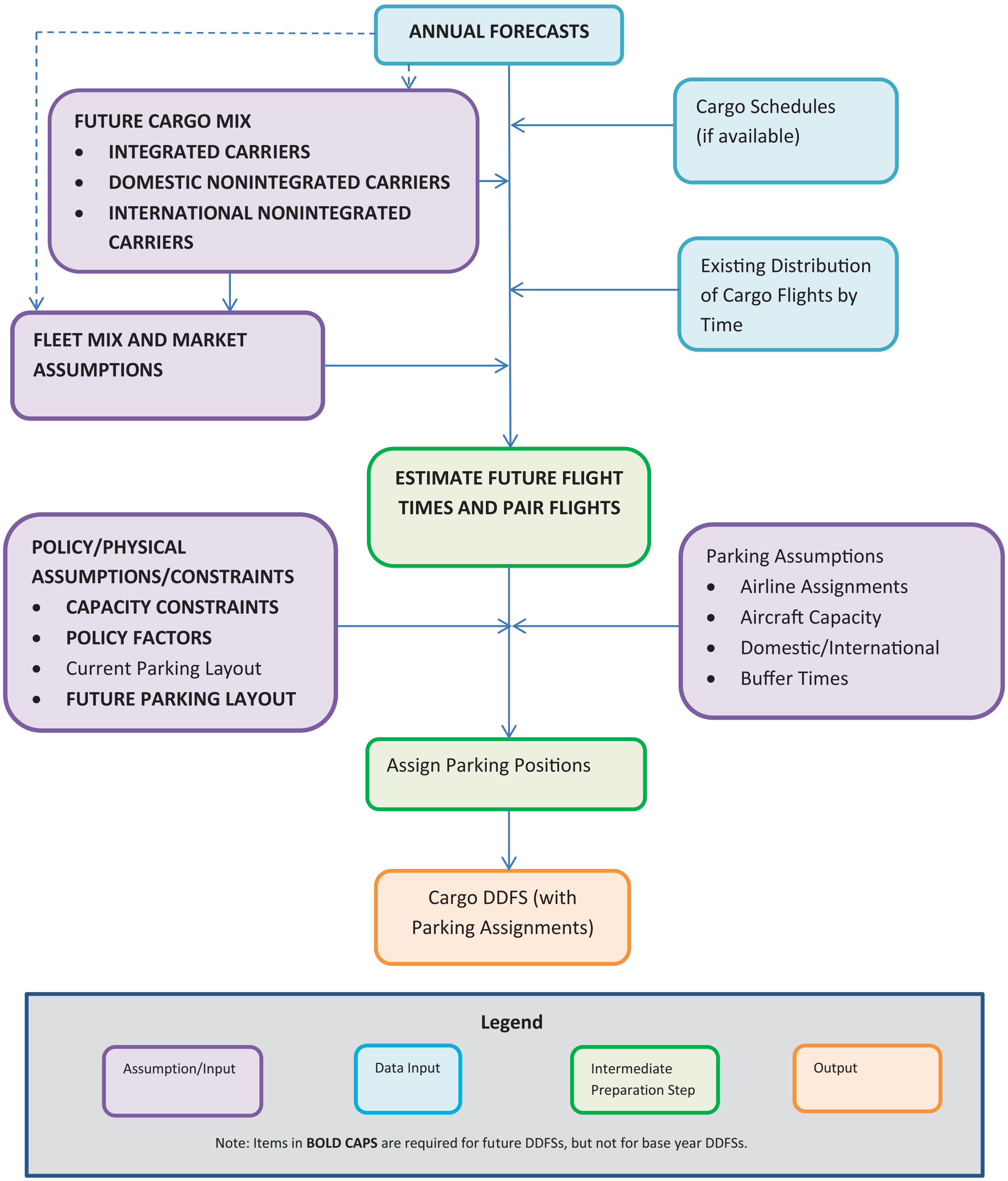


Exhibit 6.8. Forecasting all-cargo airline aircraft flights for DDFS.

Steps for Adding All-Cargo Airline Aircraft Operations to a DDFS

1. Collect relevant data. Some scheduled all-cargo aircraft operations data are still available on published schedule databases (but should be verified because wet-lease cargo operations, where one airline's aircraft and crew are leased to another airline, are sometimes missed). These data can be supplemented with data from the U.S. DOT's T-100 database and ASDI data for existing flight times. For a DDFS, interviews with the all-cargo airline's local or headquarters planning staff can be used to identify the airline's plans for the specific airport, related strategies for moving cargo across the airline's network, and the airline's "window" of operations at its hubs.
2. Note that seasonal peaking characteristics for cargo are different than for passengers. Cargo demand tends to peak in the fall, often in October or December, in response to holiday retail sales demand. If the focus of the DDFS analysis is cargo, the design day should be adjusted accordingly.
3. Segment cargo operations by category, if not available from the annual forecasts. This is important because integrated (express) carriers, other U.S.-flag airlines, and other foreign-flag airlines have differing characteristics that affect flight times, markets served, and fleet mix.
4. Determine new markets and growth in existing markets. Unless the annual forecasts contain a detailed market forecast or the airlines provide information, this will largely be a matter of judgment.
5. New flight times for express carrier operations should be selected with care. These carriers need to schedule to their sort hub operations at a centralized facility, which means there is little opportunity for peak spreading or other adjustments. Non-express all-cargo airlines have much more leeway in selecting flight times and, therefore, they tend to operate on a much less regular schedule. Overseas international airlines often experience nighttime curfews at destination airports, which can constrain their windows of operation.
6. At major sort hubs, turnaround times are determined by the sort time required. At outstations, turnaround time minimums may be determined by brake cooling time, as widebody aircraft carry substantial loads and a cooldown period for tires and brakes of up to 45 minutes may be required.
7. Assigning parking positions to cargo airlines is similar to the passenger airline gating approaches. If cargo facilities are not the focus of the analysis, assigning cargo aircraft to general parking locations, rather than specific parking positions, is adequate.

Other Nonscheduled Aircraft Activity

Exhibit 6.9 provides a general approach to forecasting the air taxi, GA, and military elements of a DDFS.

Air Taxi Aircraft Operations

Air taxi aircraft operations are conducted by small for-hire commercial aircraft governed by 14 CFR Part 135. The fleet mix is similar to GA aircraft. Detailed information on air taxi operations is scarce and typically available only through interview with air taxi operators or from ASDI databases.

Similar to charter operations, without information provided by the operators, most preparers of DDFSs assume that the future distribution of air taxi operations will be similar to the current distribution. FAA ATCT counts include scheduled regional airline operations using aircraft with fewer than 60 seats and some air cargo feeder flights with air taxi counts, so the two categories need to be distinguished when preparing a DDFS.

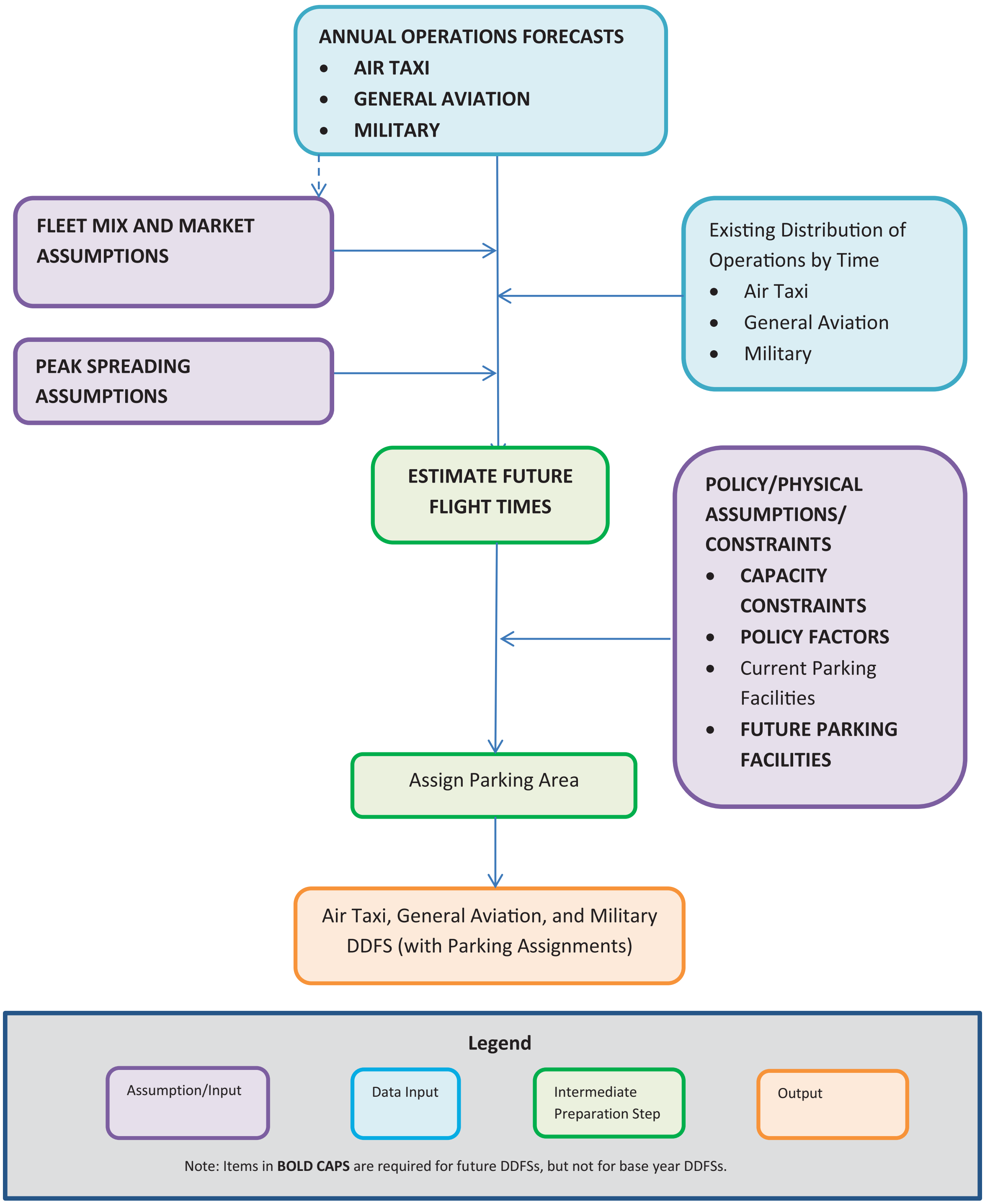


Exhibit 6.9. Forecasting DDFS air taxi, GA, and military aircraft activity.

GA Aircraft Operations

The available data for GA activity differ depending on whether the operators are flying under instrument flight rules (IFR) or visual flight rules (VFR). Most IFR operations appear in the ASDI database, but VFR operations do not. The FAA's Distributed OPSNET database provides hourly estimates of all GA aircraft operations, but it is assumed in the estimates that the hourly distribution of VFR operations is the same as for the distribution of IFR operations. Information on the true hourly distribution of VFR operations is typically available only through ATCT counts or through independent counts or surveys.

As a practical matter, DDFSs are very seldom needed or prepared for airports that primarily serve GA. Most DDFSs are prepared for large commercial-service airports, where GA accounts for a small percentage of activity. When DDFSs are prepared for airfield analysis, it is important to account for the GA component. However, most GA aircraft at large commercial-service airports operate under IFR flight plans, and are, therefore, captured in the ASDI databases.

Without information provided by GA aircraft operators, most preparers of DDFSs assume that the future distribution of GA aircraft operations will be similar to the current distribution.

Military Aircraft Operations

Secondary information on military aircraft operations is probably less reliable than such information on any other category of aircraft operations because vital information is often deleted from the ASDI-sourced databases. The FAA's Distributed OPSNET database provides hourly counts of military aircraft operations for airports with an ATCT, but because flight times are removed for many flights, they default to 0 and appear as a spike in the hour between midnight and 0100. Before using the FAA's Distributed OPSNET data, preparers should make an adjustment for this spike to avoid over forecasting nighttime operations.

Most preparers of DDFSs assume that the future distribution of military operations will be similar to the current distribution. However, if military activity accounts for a significant portion of an airport's operations, the military commander should be consulted to determine if there are any upcoming changes in mission, as such changes often significantly alter the number of operations, fleet mix, and main hours of operation.

6.8 Application of Constraints

One of the purposes of DDFS analysis is to determine future facility requirements. Therefore, in many cases, a DDFS is based on an unconstrained forecast to ensure that demand is properly modeled. In other cases, however, constraints cannot be realistically eliminated because of limits in physical space, lack of funding, policy restrictions, or political opposition. If that is the case, the DDFS must incorporate the constraint. Airport constraints can take many forms, including:

- Airfield constraints, such as the lack of runways, taxiways, or queuing space
- Terminal building constraints, such as the lack of gates or other passenger processing facilities
- Landside constraints, such as the lack of curb space, access roads, or parking
- Policy constraints, such as slot restrictions or nighttime noise restrictions

Typically, the constraint on overall activity is addressed in the annual forecasts. However, as the effect of constraints is most evident during peak periods, constraints must be specifically addressed in the DDFS. The approach used to incorporate constraints into DDFSs depends on whether the constraint is physical, financial, policy-related, or other.

As the effect of constraints is most evident during peak periods, constraints must be specifically addressed in the DDFS.

Airspace/Airfield Constraints

The effects of airspace/airfield constraints are often measured in terms of hourly throughput capacity. *ACRP Report 79: Evaluating Airfield Capacity* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_079.pdf provides guidance on ways to measure throughput capacity. Chen and Gulding identified a relationship between scheduled demand and throughput capacity in which it was recognized that scheduled demand can exceed capacity over short periods of time, but not over longer periods of time. This relationship is summarized in Table 6.1 and discussed in more detail in the Chen and Gulding paper, as well as in ACRP Report 82: *Preparing Peak Period and Operational Profiles – Guidebook* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf.

These relationships can be used as controls when preparing a DDFS. If the estimated number of flights exceeds capacity during the first DDFS pass, preparers should move or eliminate flights consistent with airline strategies. Generally, airlines prioritize their high-revenue operations, typically international or long-haul domestic flights, at the expense of low-revenue operations, typically short-haul commuter flights.

Terminal Building Constraints

The effect of a terminal building constraint on a DDFS will differ depending on if the constraint affects aircraft (gates) or passengers (passenger processing facilities).

The number of aircraft departures per gate often increases with airport size. Large airports serving large markets can support more flight frequencies that generate higher gate utilization. Very large airports such as ATL and Chicago O'Hare International Airport accommodate up to eight departures per gate per day. Most other busy airports accommodate six departures per gate per day, and smaller commercial airports accommodate three to four turns per gate per day. Maximum turns per gate will also depend on the airline. Gate utilization by network airlines will often be constrained by their connecting bank structure at either the origin or destination airport. Low-fare airlines have more flexibility and can sometimes average up to 10 departures per gate per day or more. If the DDFS needs to be adjusted to accommodate gate constraints, the adjustment should reflect airline priorities (i.e., low-revenue flights should be moved or eliminated first).

Non-gate terminal constraints affect passengers directly and airlines indirectly. Passengers will usually adjust to potential terminal bottlenecks by increasing lead times, and airlines generally are not compelled to modify their schedules. If non-gate terminal constraints become extremely onerous, passengers will either fly less or use another airport, but this factor is ideally addressed in the annual forecasts rather than the DDFS.

Table 6.1. Maximum scheduled demand by peak period definition.

Peak Period Definition	Maximum Demand/Capacity Ratio (Aircraft Operations)
15 Minutes	1.41
1 Hour	1.21
2 Hours	1.14
3 Hours	1.06

Source: *ACRP Report 82, Preparing Peak Period and Operational Profiles - Guidebook* Exhibit 9.1 "Maximum demand/capacity ratio by peak period definition" (2013). http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf

Landside Constraints

The effect of landside constraints on DDFS preparation is similar to the effect of non-gate terminal building constraints. These constraints directly affect passengers and passengers adjust, to a point, by increasing lead times or changing to a ground transportation mode. If the landside constraints become extremely onerous, passengers will either fly less or use another airport, but again, this factor is ideally addressed in the annual forecasts rather than the DDFS.

Policy Constraints

As practiced in the United States, policy constrains, such as slot restrictions, perimeter rules, or nighttime noise restrictions, essentially dictate the number, type, and timing of aircraft operations at a given airport. Some of these policies, such as the slot controls at the three main New York airports and Washington Reagan National Airport are imposed by the FAA, whereas others, such as the Perimeter Rule at New York LaGuardia Airport, are locally imposed. DDFS preparers must estimate the composition (markets and fleet mix) of these aircraft operations. Examination of constrained airports indicates that airlines will take the following actions, in order or priority, when faced with a constraint (Kennon et al. 2013):

1. Increase fares to take advantage of reduced competition and to cover increased operating costs.
2. Reschedule some flights to off-peak hours, subject to market constraints.
3. Increase the size of the aircraft serving a market, provided the right-sized aircraft is in the airline's fleet.
4. Eliminate or reduce service to some markets.

In general, load factors are not higher at constrained airports than at unconstrained airports. When slots are subject to a use or lose it provision, some airlines will operate unprofitable flights to retain a slot in anticipation of preserving it for a profitable flight in the future.

6.9 DDFS Updates

Updating a DDFS and retaining the original level of detail and fidelity are not simple. Even when the change just involves the entry of a new airline or addition of a new market, competitive responses and adjustments by existing airlines mean that the changes may reverberate throughout a significant portion of the schedule. Often, a new DDFS must be prepared to represent the changed conditions.

As an alternative to preparing a new DDFS, tools are built into a number of simulation models that provide user input for rule-based, randomized cloning of activity. These models are used by several airport operators and consultants analyzing near-term issues or conducting sensitivity analyses. Cloning also can be used to provide a sensitivity analysis of DDFS-based modeling results. However, these approaches lack fidelity and granularity and are limited in certain areas, such as determining gate assignments.

Appendix A includes discussion of how some elements of a DDFS were updated as project requirements changed. Click here to access Section A.9 DDFS Updates.

6.10 Quality Assurance and Control

DDFSs are inherently detailed and their preparation involves substantial individual judgment in the selection of new markets, flight times, arrival/departure links, and other elements, which are all inter-related. As a result, there is a potential for both error and bias and quality assurance is an important consideration.

Table 6.2. Tolerance bounds for DDFS peak hour operation results.

FAA Hub Category		Lower Bound	Peak Hour Target	Upper Bound
Large Hubs		95% of target	100%	105% of target
Medium Hubs		92% of target	100%	108% of target
Small Hubs		89% of target	100%	111% of target
Non-hubs		87% of target	100%	113% of target

Sources: Oliver Wyman and HNTB analyses of Official Airline Guide schedule data.

Some consultants use proprietary spreadsheet programs to help reduce and analyze the data, check DDFS control totals, ensure that numbers of arriving and departing connecting passengers are balanced, and help the gate assignment process. Some consultants also have internal broad guidelines for preparing DDFSs, such as assumptions regarding load factor triggers for up-gauging aircraft or adding flights. For these consultants, it is critical that the rules used to prepare future schedules are checked at every stage, including physical and other constraints.

Exhibit 6.4 in *ACRP Report 82: Preparing Peak Period and Operational Profiles—Guidebook* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf provides a detailed checklist of recommended quality control checks for DDFSs, which is reproduced and supplemented as Appendix E in this guidebook. This micro-checklist should be coupled with a macro-checklist to ensure that the passenger and aircraft operation distributions resulting from the DDFS are reasonable. At the same time, care must be taken to ensure that insights resulting from the bottom-up DDFS approach are not suppressed by the imposition of strict control totals.

One way to achieve this balance would be to adopt an approach similar to the FAA's approach for determining consistency between an airport operator's forecast and the TAF. With the TAF, a deviation of more than 10 or 15 percent does not result in automatic rejection; instead, it triggers a more in-depth investigation into the differences. With this strategy, if a DDFS bottom-up approach results in hourly distributions that differ significantly from existing distributions, it would trigger a detailed review, but not an automatic rejection. Table 6.2 lists suggested tolerance bounds for DDFS peak hour operation results based on historical deviations of peak hour percentages at a sample of airports of differing sizes.

The percentages should be applied to the peak hour operations from the annual forecasts. For example, if the peak hour forecast was 120 operations for a large-hub airport, the lower bound would be 114 operations (95 percent × 120) and the upper bound would be 126 operations (105 percent × 120).

Appendix A provides an example of the application of quality controls in the preparation of a DDFS. Click here to access Section A.10 Quality Assurance and Control.

CHAPTER 7

How to Apply DDFS Outputs

This chapter describes how to apply DDFS outputs to assist in airside, terminal, and landside planning, in environmental analysis, and for operations and management. It is intended primarily for DDFS users.

As noted in Chapter 3, DDFSs have many uses. Some uses incorporate DDFSs directly as inputs while other uses require some post-processing. Exhibit 7.1 provides a general schematic of how DDFS outputs are used for airport planning and operations.

7.1 Airfield and Airspace Planning

DDFSs, with some minor changes in format, are often used as direct inputs for airfield and airspace simulation and spreadsheet models. Runway preferences and arrival/departure fixes for each flight may be set as part of the DDFS or later, when establishing rules for the simulation runs. The results may be used to identify new runway or taxiway/holding pad requirements, estimate capacity or delay, or identify hot spots that could represent safety concerns.

DDFS results may also be aggregated into aircraft distributions or design day profiles. These are hourly listings of airport operations, segmented by arrivals and departures, which can be used as inputs for simpler spreadsheet models to estimate capacity and delay.

Once converted, design day profiles can be modified using tools such as the *ACRP Report 82* Operations Toolbox to represent alternative design day definitions or even different activity levels. These adjustments are appropriate if there is reason to believe that the general distribution of activity throughout the day (the shape of the profile) will not change significantly.

ACRP Report 79: Evaluating Airfield Capacity http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_079.pdf provides comprehensive guidance on how and when to use DDFS output in capacity and delay analyses.

7.2 Terminal Building Planning

The flight-by-flight passenger information in a DDFS can be directly entered into terminal simulation models. More often, the results are aggregated into passenger profiles, segmented by time of day and in accordance with the facility being analyzed (terminal, concourse, etc.). In these instances, software such as the *ACRP Report 82* Passenger Toolbox can be used to process DDFSs into user-defined design day distributions or peak period activity levels and can also be used to adjust the results to represent alternative definitions of the design day or different forecast activity levels. Again, these adjustments are appropriate only if there is reason to believe that the general distribution of activity throughout the day will not change significantly.

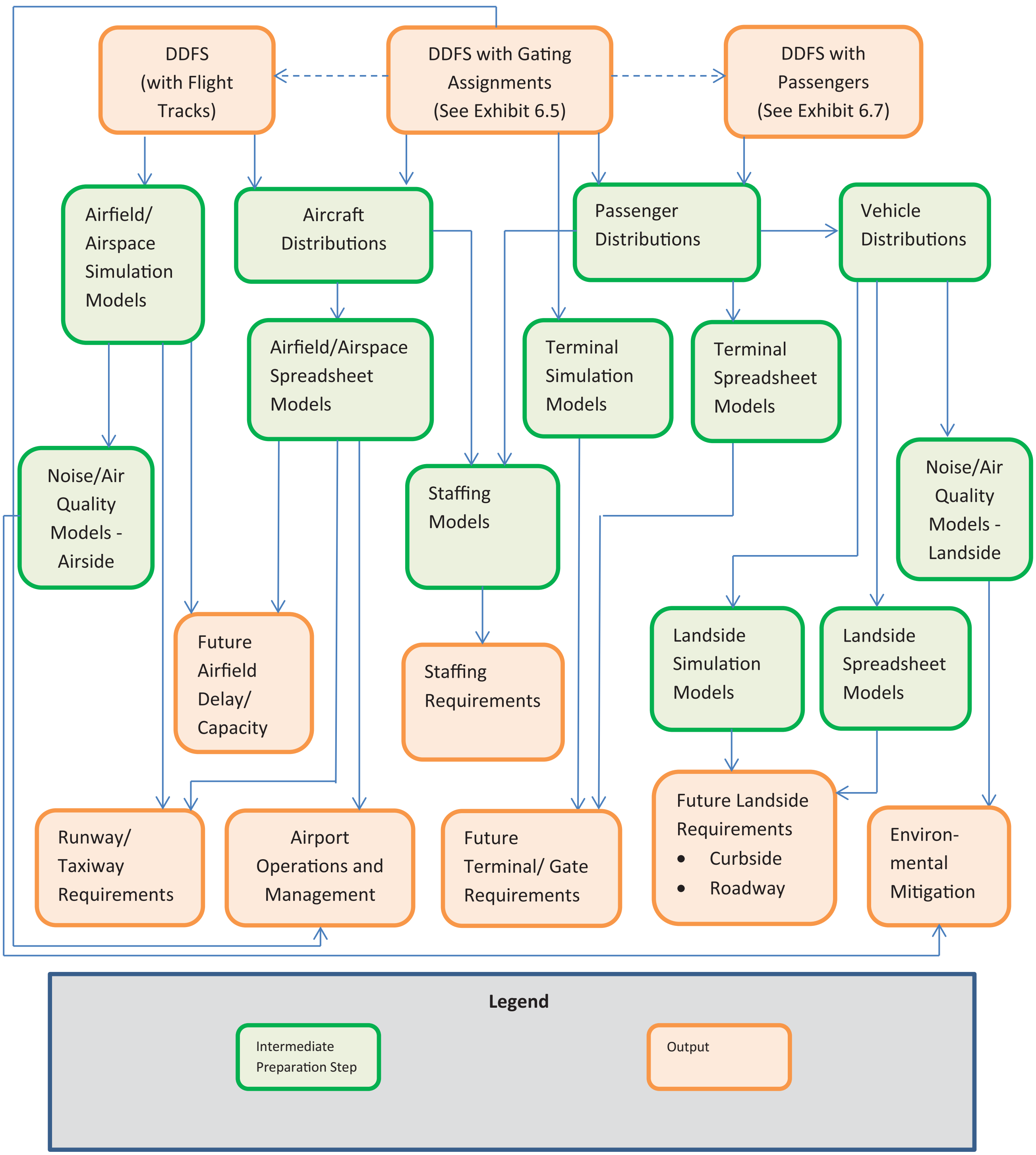


Exhibit 7.1. Use of design day flight schedules.

Most DDFSs tie enplaning passenger activity to scheduled gate departure times of the flights with which they are associated. However, departing passengers require time to check in, pass through security, and navigate through the airport. Therefore, peak flows at departing passenger facilities occur in advance of the enplaning peak measured in a DDFS. The extent of this lead time (sometimes described as show-up time) will depend on the configuration of the airport, the queues at the various departing passenger facilities, security restrictions, whether the flight is domestic or international, airline policies such as cutoff times, and the extent to which passengers build in a buffer time to allow for unforeseen delays. The lead time is not constant; it varies by time of day and by type of passenger. It also varies by airport: passengers at large airports tend to allow longer lead times than those at small airports. The lead time is often described as a probability function where y percentage of passengers show up at the terminal x minutes before scheduled departure time (see Exhibit 7.2). As a result of the combination of the lead time and probability distribution, the timing and intensity of the peak period flow at a given departing passenger facility may not exactly match the enplaning peak.

Peak flows at departing passenger facilities occur in advance of the departures peak measured in a DDFS.

A similar phenomenon occurs with arriving passengers. They need time to deplane, in some cases go through Customs or to baggage claim, and then proceed to their selected ground transportation mode. These lag times trail the scheduled arrival times in the DDFS. Again, because of this lag, the timing and intensity of the peak period flow at a given arriving passenger facility may not exactly match the deplaning peak.

The *ACRP Report 82* Passenger Toolbox http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf provides a method of adjusting DDFS output for lead and lag times. However, the user must provide the lead and lag time distribution curves, which are typically only available from passenger surveys. *ACRP Report 26: Guidebook for Conducting Passenger User Surveys* provides guidance on collecting this type of data. An example of how lead distribution curves were used to modify DDFS results can be found in Appendix A. Click here to access Section A.11 Application of Results.

Once the DDFS outputs have been processed into design day profiles or peak period activity levels with appropriate lead and lag time distributions, the data can be entered into the model described in *ACRP Report 25: Airport Passenger Terminal Planning and Design*, Volumes 1 and 2, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_025v1.pdf to generate requirements for ticketing, security screening, baggage make-up, and baggage claim facilities.

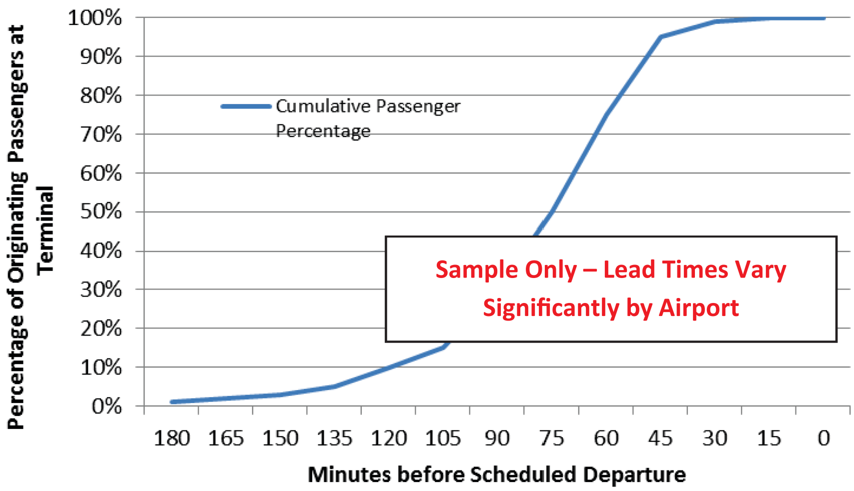


Exhibit 7.2. Example of lead time distribution.

7.3 Landside Planning

Once lead or lag time factors have been applied, DDFS passenger distributions or, more specifically, O&D passenger distributions can be converted into vehicle distributions using modal split and lead and lag time assumptions. The vehicle distributions are used as inputs to landside simulation models or simpler landside spreadsheet models. *ACRP Report 40: Airport Curbside and Terminal Area Roadway Operations* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_040.pdf provides detailed guidance on ways to apply DDFS outputs to resolve landside planning issues.

7.4 Environmental Planning

As noted in Chapter 3, the FAA requires the use of the AEDT model to calculate aircraft and airspace noise impacts, as well as airfield and landside air quality impacts. Two major adjustments are required before DDFS outputs can be applied to noise analysis. First, as the DDFS design day is typically a busy day, it must be scaled down to represent an average annual day. Next, the times in a DDFS reflect gate times rather than runway take-off and touchdown times, which are more appropriate for noise analysis. The difference can be significant at large, congested airports with extensive taxiing times and delays. Therefore, if a DDFS is used for noise analysis, it should be used in conjunction with an airfield simulation model to ensure that the output incorporates the effects of taxiing time and delay. Air quality dispersion analysis also requires that a DDFS be used in conjunction with an airfield simulation model.

Before a DDFS can be used to estimate noise impacts, the O&D passenger output must be converted to vehicle movements. Once vehicle movements are estimated, TNMs can be used to estimate noise impacts from vehicles. Again, please note that the DDFS output needs to be converted to an average annual day format. DDFS output can be used to estimate ground vehicle emissions, but the output needs to be processed through models such as MOVES2014.

Additional guidance on the application of DDFS output to airport environmental analysis is provided in the FAA's *AEDT Version 2b User Guide* (FAA 2015).

7.5 Airport/Airline Operations and Management

Near-term or real-time DDFSs are used to assist in airline and airport operations and management related to gate management and noise monitoring. Depending on its intended use, DDFS output can be entered directly into gate optimization or other facility management models, or processed through intermediate models for use in noise monitoring and other activities.

7.6 Staffing

Depending on whether staffing requirements are related to airfield or terminal building operations, intermediate aircraft or passenger distributions developed from DDFSs can be used to generate staffing requirements. As is the case with airport or airline management and operations, staffing requirements are based on near-term or real-time DDFSs.

CHAPTER 8

How to Address Risk and Uncertainty in DDFSs

This chapter provides recommendations on how to evaluate and manage the uncertainty inherent in all DDFS forecasts. It is intended for both users and preparers.

There is an element of uncertainty associated with all forecasts, and DDFS forecasts are no exception. This chapter describes the factors that generate forecast uncertainty, methods of evaluating the uncertainty, and methods of managing the uncertainty.

8.1 Sources of Uncertainty

Exhibit 8.1 diagrams many, but not all, of the factors that generate uncertainty in DDFS forecasts. In most instances, DDFS forecasts are directly related to annual forecasts, and any uncertainties associated with the annual forecasts are carried over to the DDFS forecasts.

Sources of uncertainty in annual and DDFS forecasts can be categorized in several broad categories:

- Forecast inputs such as projections of economic growth or fuel and other costs
- Forecast assumptions on industry changes, such as airfares, type of air service, and competitive factors
- Airport operator policy or infrastructure decisions
- Airline business and marketing decisions
- Forecast modeling factors
- Disruptive events, such as the September 11, 2001, terrorist attacks

Most airport forecasters rely on secondary sources for projections of future economic growth or fuel prices, either from private economic firms or local and national government sources. Uncertainty is associated with these economic forecasts, even in the short-term, as forecasting organizations tend to have more difficulty predicting the peaks and valleys of business cycles than forecasting long-term growth.

Aviation industry forecasting assumptions are another source of uncertainty. Airline costs are mostly a function of fuel, labor, aircraft maintenance, and aircraft acquisition costs, but how much of these costs are passed on to passengers in the form of airfares depends on the degree of competition among the airlines, or lack thereof.

Airport operator and FAA policy and infrastructure decisions will affect an airport's ability to accommodate demand. Many of the political, environmental, and financial resolutions required to advance large capacity projects at airports are inherently difficult to predict.

Accurate forecasts of airline factors—such as the degree of hubbing, fleet plans, and other air service elements—are largely dependent on correctly assessing future airline behavior.

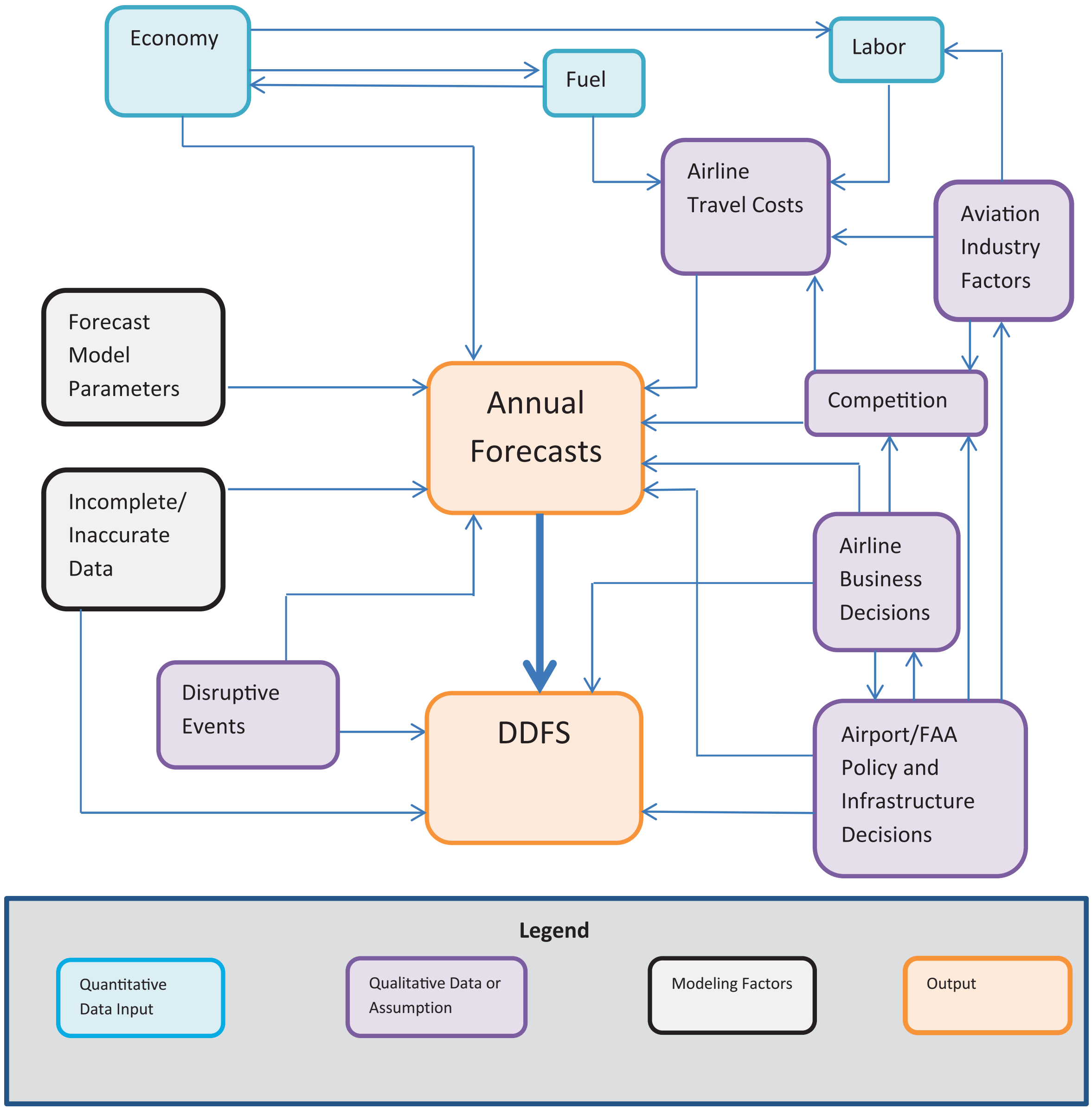


Exhibit 8.1. Sources of uncertainty.

Uncertainty will remain even if the DDFS preparer obtains full airline input and cooperation, as airline business plans contain their own uncertainty and the useful life of the business plan tends to be much shorter than the 20-year planning horizon of a typical master plan and is often affected by the strategies of competing airlines.

Many annual forecasts are based on one or more quantitative forecasting equations, which convert inputs such as income and fare levels into passenger forecasts. The coefficients associated with these equations are normally estimated using regression analysis, which is a statistical method of finding the best fit between forecast drivers (e.g., income, fares) and forecast output (e.g., passengers). These equations are subject to uncertainty because the coefficients are estimated using a small sample size. Also, a key variable may be omitted from the equation or an inappropriate variable may be incorrectly included.

Historical measures of both economic data and airport activity data may be inaccurate. If so, these inaccuracies will be carried forward into any forecasts from which they were developed.

Even when accurate, relevant data are not always available on a timely basis, and the outdated information can result in inaccurate forecasts.

Finally, unforeseen events, such as the September 11, 2001, attacks or the Severe Acute Respiratory Syndrome outbreak, or at a more local level, airline exit from or entry into a market, are major sources of uncertainty.

ACRP Report 76: Addressing Uncertainty about Future Airport Activity Levels in Airport Decision Making http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf provides comprehensive guidance on ways to incorporate risk and uncertainty into annual activity forecasts.

8.2 Evaluation of Uncertainty

Statistical methods for quantifying uncertainty are described in detail in *ACRP Report 76* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf. In general, they provide a method for estimating how an actual future value of a forecast metric—e.g., passengers—is likely to deviate from the predicted value. By measuring historical variations in activity from the long-term average, the most likely distributions of activity around the long-term average can be estimated and applied to forecast values. These distributions are often described as confidence intervals.

A confidence interval represents the probability that an actual activity level will fall within a specified forecast range. For example, if 85 peak hour operations are forecast, and the 90 percent confidence interval encompasses plus or minus five operations, it means that there is a 90 percent chance that actual peak hour operations will be between 80 and 90 operations. Another way of describing the confidence interval is that there is at least a 95 percent chance that peak hour operations will number 80 or more (5 percent chance that peak hour operations will be less than 80), and a 5 percent chance that peak hour operations will number more than 90 (95 percent chance that they will be less than 90). More detail on confidence intervals is presented in *ACRP Report 76:* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf and in Appendix C of this guidebook.

> A confidence interval represents the probability that an actual activity level will fall within a specified forecast range.

A critical question when evaluating uncertainty is how much of the uncertainty is directly attributable to the DDFS and how much is attributable to the annual forecasts upon which the DDFS is based. The analysis in Appendix C suggests that the majority of the uncertainty associated with DDFS forecasts results from the annual forecasts and, if the confidence intervals associated with the annual forecasts are accurately estimated, those same confidence intervals can be applied to the DDFS.

8.3 Management of Uncertainty

This section describes three methods of incorporating uncertainty into DDFS forecasts to better manage the planning results. DDFSs are currently used mostly to assess requirements and effects under baseline forecast conditions and few attempts have been made to assess the effects of forecasting risk and uncertainty on DDFSs and resultant planning recommendations. The primary reason for this is the level of effort involved in either preparing alternative DDFSs or manipulating existing DDFSs to represent the potential range of outcomes. Three methods of assessing DDFS uncertainty are listed below.

***Ad Hoc* Adjustments:** Some DDFS elements, such as aircraft arrival and departure times, can be randomly adjusted to test the sensitivity of planning outcomes. This approach can be applied to airfield simulation models, gate requirement models, or terminal facility requirements that are dependent on peak passenger flows. The random adjustments should be tied to a probability distribution based on historical data if confidence levels are to be associated with the results.

Table 8.1. Example of confidence intervals for curbside requirements by airport size.

90 percent confidence interval

	Calculated Requirement (length in feet)	Variation in Curbside Length Requirements by Confidence Interval								
		98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		92%	93%	95%	97%	100%	103%	105%	107%	108%
Medium Hubs		90%	91%	93%	96%	100%	104%	107%	109%	110%
Small Hubs		85%	87%	90%	95%	100%	105%	110%	113%	115%
Non-Hubs		77%	81%	85%	92%	100%	108%	115%	119%	123%
Curbside Requirement at each Confidence Level										
Large Hubs	3,000	2,754	2,795	2,841	2,917	3,000	3,083	3,159	3,205	3,246
Medium Hubs	1,500	1,343	1,369	1,398	1,447	1,500	1,553	1,602	1,631	1,657
Small Hubs	1,000	850	875	903	949	1,000	1,051	1,097	1,125	1,150
Non-Hubs	500	384	403	425	461	500	539	575	597	616

Note: Based on peak 60 minute O&D passengers.

Source: Appendix D

Forecast Scenarios: Forecast scenarios can range from simple high and low scenarios to more complex scenarios involving potential airline changes, including air service, peaking/distribution characteristics, and bankruptcies and mergers. Preparing a DDFS for each forecast scenario can generate a wealth of detail. However, preparing alternative DDFSs to match each forecast scenario can also be cost prohibitive.

Incorporating Uncertainty to Aggregate DDFS Results: Much airport planning is based on aggregate DDFS results, including measures of airfield capacity, gate requirements, and peak passenger flows. When planning is based on aggregate DDFS results, establishing confidence intervals becomes a simpler process. Appendix B provides some default confidence intervals for various DDFS elements for large, medium, small, and non-hub airports. **Note that these confidence intervals can only be applied to evaluate DDFS uncertainty, and do not include uncertainty associated with the annual forecasts, which can be much greater**.

Table 8.1 provides an example of how confidence intervals can be applied to curbside requirements. In this medium-hub airport example, the calculated required curbside length was assumed to be 1,500 feet. As the curbside length requirement is based on the 60-minute peak, the confidence interval is based on the variation in numbers of peak hour O&D passengers for medium-hub airports. The table indicates that there is a 90 percent (95% minus 5%) degree of confidence that the requirement will be more than 1,369 feet and less than 1,631 feet, once uncertainty regarding the future peak hour percentage of O&D passengers is taken into account.

Monte Carlo Analysis

ACRP Report 76: Addressing Uncertainty about Future Airport Activity Levels in Airport Decision Making http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf describes Monte Carlo analysis in detail and how to use Monte Carlo simulations to generate probability distributions for annual forecast outputs. In that report, probability distributions are identified for forecast input factors (income, airfares, etc.) and forecast parameters (income and fare elasticities). Every Monte Carlo iteration involves generating a forecast with the inputs and parameters randomly calculated based on the probability distributions identified for each input and parameter. The process is repeated multiple times to generate a distribution of forecast outcomes that can be aggregated to provide a probability distribution for the activity forecast that incorporates all of the probability distributions associated with the inputs and parameters.

Monte Carlo analysis can be applied to DDFS outputs in two ways, independently or in combination with annual forecasts. Table 8.2 provides an example of the inputs and parameters that would be involved in each type of Monte Carlo analysis. Note that the input box under the independent DDFS analysis case is empty. It is empty because DDFSs are derived from annual forecasts and, in this particular example, the variability of annual forecasts is not addressed.

As noted earlier, Appendix D provides confidence intervals for DDFS critical factors. Once developed, these confidence intervals can be used to run Monte Carlo models of DDFS metrics (average delay, peak period passengers, etc.) without requiring a new DDFS for each Monte Carlo simulation. This method does not offer the same degree of precision that would result from multiple DDFS and simulation runs, but it is more cost-effective and practical. Appendix C provides examples of independent or combined Monte Carlo simulations.

It is not realistic to ignore the variability associated with annual forecasts in most real world planning. Monte Carlo analysis can be applied more comprehensively in a combined analysis by assembling the probability distributions associated with annual forecast inputs and parameters, and then adding probability distributions associated with peak period percentages and load factors. The combined annual and peak period probability distributions can be used to generate more comprehensive probability distributions for facility requirements that incorporate both annual and peak period variability.

A Monte Carlo approach to DDFS uncertainty would be less resource-intensive than developing separate DDFS scenarios. Nevertheless, the effort is not trivial. Time is required to quantify the linkages between the annual forecast inputs and parameters and the DDFS-related parameters and each associated probability distribution.

The analysis provided in Appendix C suggests that the majority of uncertainty is in the annual forecasts rather than the DDFS forecasts. Therefore, if resources are limited, it is recommended that confidence intervals be developed for the annual forecasts and then applied to the facility planning requirements resulting from the DDFS analysis.

In some instances, airport forecasts and plans are tied to activity levels instead of specific forecast horizon years. This approach mitigates some but not all of the uncertainty associated with annual forecasts. For example, if total passengers are used to define a specific activity level, forecast elements such as aircraft operations and peak hour passengers may still be off. Consequently, there will still be some uncertainty associated with the DDFS and an independent DDFS Monte Carlo analysis may be warranted.

Table 8.2. Types of Monte Carlo analysis as applied to DDFSs.

Type of Monte Carlo Analysis	Type of Inputs	Type of Parameters
1. Independent DDFS Monte Carlo Analysis		Peak hour percentage, peak load factor, O&D ratio
2. Combined DDFS and Annual Forecasts Monte Carlo Analysis	Income, employment, population, airfares	Income elasticity, fare elasticity, peak hour percentage, peak load factor, peak O&D ratio

Risk registers are especially useful for addressing low-frequency, high-magnitude risks that are difficult to define using probability distributions.

Risk Registers

ACRP Report 76: Addressing Uncertainty about Future Airport Activity Levels in Airport Decision Making http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf also identifies risk registers as an effective way of identifying and quantifying risk and uncertainty in airport activity forecasting. Risk registers are especially useful in addressing low-frequency, high-magnitude risks that are difficult to define using probability distributions.

Risk register factors are grouped within two general categories. The first category, **risk identification**, includes:

- Risk ID
- Risk name and brief description
- Risk status: active, dormant, or retired
- Risk category
- Date the risk was first identified

The second category, **risk evaluation**, considers:

- Probability of occurrence
- Description of the impact
- Metrics affected, such as passengers or aircraft operations
- Magnitude of impact, which can defined as a single variable or a probability distribution
- Duration of impact
- Recovery

Table 8.3 provides an example of a risk register focused on risks that are more likely to apply to DDFSs than to annual forecasts. The first example in the table relates to the potential of an increase in connecting banks at an airline hub. This type of change occurs at the discretion of the hubbing airline, and airport operators are generally given short notice. Nevertheless, an increase in the number of connecting banks can reduce peak hour activity and lower the requirements for most terminal facilities, including gates. However, an increase in the number of connecting banks may result in one or more banks occurring between 10 p.m. and 7 a.m., which is defined as nighttime. Therefore, this contingency would also present a risk related to an airport's noise program.

Another example is irregular operations, which are most often the result of adverse weather conditions and, therefore, provide relatively short notice to airport operators. Aircraft are unable to depart and the demand for gate and hardstand facilities increases as a result. Passengers are likewise unable to depart and, therefore, the demand for concessions, restrooms, and other airport facilities greatly increases.

The probability or likelihood of a certain risk category occurring during the planning period is a matter of judgment. For example, over a 20-year planning period, it is almost certain that irregular operations will occur at some point. On the other hand, technological developments, such as supersonic aircraft, are considerably less likely to occur. One of the key features of a risk register is that it can be easily updated. Therefore, as information relevant to the probability of an occurrence becomes available, it can be readily incorporated into the risk register. Also, the risk register can be used to prepare contingency plans should any of the events in the listed risk category occur.

Appendix A shows one of the ways in which risk and uncertainty can be incorporated into a DDFS. Please click to access Section A.12 Dealing with Uncertainty.

Table 8.3. Example DDFS risk register.

Risk Identification				Risk Evaluation							
							Magnitude of Impacts				
Risk ID	Risk Category	Status	Threat or Opportunity	Probability/ Likelihood	Description of Impact	Impact on	Low	Mid	High	Expected Duration	Expected Recovery
1	Airline Strategy		Increase in number of connecting banks	30%	Increase in number of connecting banks resulting in passengers and operations spread more evenly throughout the day with reduced peaks and increased nighttime operations	Aircraft Operations, Passengers			X	Medium to Long term	Uncertain
2	Airline Strategy		Decrease in aircraft turnaround time	40%	Decrease in gate requirements; reduced ability to recover from disrupted operations	Aircraft Operations, Passengers		X		Long term	None
3	Technology		Supersonic aircraft	5%	Change in international flight times/windows, U.S. CBP requirements	International Aircraft Operations, Passengers		X		Long term	None
4	Airport Facilities		Runway Reconstruction	50%	Reduced capacity; change in throughput, reduced peak activity	Aircraft Operations, Passengers			X	Medium term	Full
5	Irregular Operations		Disruption in Schedule	99%	Delay in Operations	Aircraft Operations, Passengers			X	Short-term	Full

CBP = U.S. Customs and Border Protection

CHAPTER 9

How and When to Communicate DDFS Results

It is important to have a continuing buy-in, understanding, and support of the DDFS process by airport leadership and staff, especially regarding the reason for undertaking the DDFS process, key assumptions, and the uncertainties associated with the results.

This chapter provides guidance on how and when to engage stakeholders in the process and how to best communicate the assumptions, results, and uncertainty associated with DDFSs. It is intended primarily for DDFS users.

As noted throughout this document, coordination and communication are important to the successful process of DDFS formulation: defining the problem to be solved, receiving stakeholder input and reviews, and identifying critical elements. This coordination and communication process becomes most critical once results are produced and subsequent applications of the DDFS are used. It is important to have a continuing buy-in, understanding, and support of the DDFS process by airport leadership and staff.

9.1 Target Audiences and Level of Detail

In most instances, reporting and coordination of DDFS results have two distinct target audiences:

(1) Senior airport management and stakeholders
(2) Technical airport staff and consultants

Education of audiences that are unfamiliar with DDFSs is necessary. At all levels, the audience needs to understand that DDFSs are only an educated approximation of the future. Both audience groups need to appreciate that the complexity of DDFSs implies a level of precision that may not exist.

Senior Airport Management and Stakeholders

Senior airport management and stakeholders make decisions based on analysis results. It is important that they understand the following:

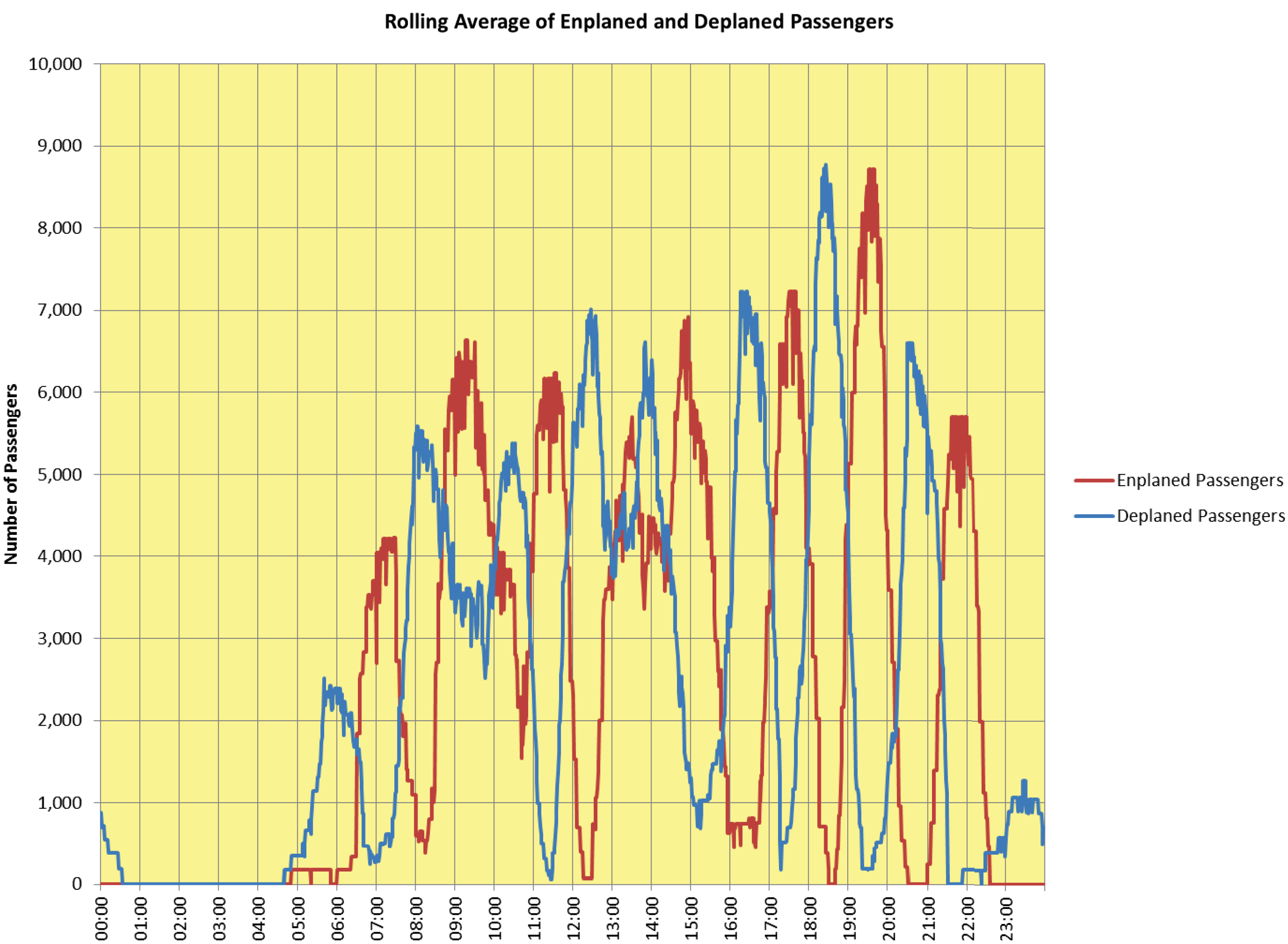
- Definition of the problem and reason for preparing the DDFS (senior airport management typically provides input to the decision and has a basic understanding of the DDFS process)
- Rationale for the DDFS preparation approach used
- Key assumptions that will likely influence the DDFS results
- Areas of uncertainty and risk in the DDFS results

Management also needs to appreciate the point-in-time nature of the DDFS process. In addition, any potential issues, challenges, and possible implications of future aviation demand need to be identified. Upon receiving the results, management may request further analysis and/or refinement of the DDFS, budget and time permitting.

It is recommended that documentation provided to senior airport management and stakeholders be straightforward, nontechnical, and as concise as an executive summary. It is important to realize that meaningful reviews of DDFSs may be difficult because of the level of detail and complexity.

It is also recommended that the documentation presented to senior airport management and stakeholders include a very brief tabulation or sample (such as shown on Exhibit 9.1) of the DDFS results during the design day(s) and/or peak periods, as appropriate for the airport and/or project. Key information presented in the tabulations/exhibits is dependent on the project, but typically includes:

- Listing of major overarching assumptions:
- Numbers of aircraft arrivals and departures and/or enplaning/deplaning passengers per hour (and by terminal or concourse, if pertinent); and
- Any implication of the results on facilities (such as need for gates) and related constraints.



Source: HNTB analysis of DDFS data from Minneapolis-St. Paul International Airport Long-Term Comprehensive Plan (2015).

Exhibit 9.1. Sample hourly passenger distributions from DDFS.

Technical Airport Staff and Consultants

Technical airport staff and consultants typically need additional detail to fully understand the results, assumptions, and decisions to have a documentation trail for use in follow-on studies and analyses, both in the near term and for future updates and as a retrospective history. While the level of detail and documentation will vary from airport to airport and project to project, at a minimum, assumptions regarding critical DDFS factors discussed in Chapter 6 and earlier chapters need to address:

- Design day selection/peak period for analysis;
- Parameters (if any) used to control passenger/operational peaking and related constraints;
- Gate assignments;
- Average seats per aircraft; and
- Market identification and frequency of service.

In some cases where different terminals and/or concourses are involved in the analysis, assumptions regarding individual airline activity may be necessary.

Tables 4.1 through 4.6 in Chapter 4 provide a summary of required or useful DDFS components by type of analysis that should be considered for the various elements to be included in a DDFS.

> **How to Communicate**
>
> Consider presenting information to senior airport management and stakeholders in **executive summary** format, while providing **spreadsheet data** to technical airport staff and consultants. A technical documentation trail is beneficial for future reference.

The technical documentation provided to technical airport staff and consultants should also include sources and contacts, and pertinent input and guidance received during the DDFS preparation process.

One of the key uses of this background documentation is for potential DDFS updates. It is important to maintain DDFS files and backup as airport staff members change to retain the institutional knowledge of the DDFS preparation and analysis.

Present the results in a technical, but understandable, format. DDFS results (or peak period flight schedules) are typically provided in a well-documented spreadsheet format, such as the example table shown on Exhibit 2.1. The spreadsheet(s) can then be formatted for input into subsequent facility analysis, either by the preparer or others. Gantt charts are also useful for conveying estimated gate requirements generated by DDFSs.

> **When to Communicate**
>
> Preparers should report progress to technical airport staff and the project manager throughout the DDFS preparation process. Ongoing progress reports enable the project manager to:
>
> - Continually assess strategies for appropriate stakeholder involvement.
> - Obtain relevant inputs so that the DDFS can be developed as accurately as possible without minimal rework.
> - Provide regular status updates and changes to senior management.

9.2 Timing of Reporting

Ideally, progress is reported to the airport project manager, including input and review of major assumptions by the DDFS preparer, as the preparation process proceeds. Also, when possible and appropriate, include stakeholder technical personnel (at the airport operator's project manager's discretion) throughout the process to achieve consensus and two-way communication. Input and concurrence with input assumptions should be obtained as early as possible to avoid major changes or the introduction of new input later in the process.

Likewise, the project manager should coordinate any reporting to senior management.

Regarding outreach to stakeholders, DDFS preparers should understand potential challenges in obtaining data and long-range planning assumptions from airlines because of the uncertainty and highly competitive nature of the industry. In some cases, airlines may require a confidentiality agreement regarding their input. Likewise, there may be some unknowns regarding information to be obtained from the FAA (such as runway use and assignments) and other important stakeholders. In these situations, the preparer (and airport project manager) needs to weigh available information, determine whether or not any agreements are needed, and make best guess assumptions. Note that when communicating results, it will be sometimes challenging to obtain a meaningful review of a DDFS from clients and stakeholders given DDFS complexity

When the DDFS preparation process is nearing completion and prior to its use for facility planning and design-related analysis, senior airport management should be briefed. The focus of this briefing is to ensure that management concurs with the work performed and that there are no surprises as the DDFS preparation process ends and the follow-on applications of the DDFS results begin.

9.3 Explaining Uncertainty

One of the most important messages that needs to be related to all audiences is the "point-in-time" nature of the DDFS preparation process and the inherent uncertainties and related risks of a very dynamic aviation industry. This issue is one of the challenges of the DDFS process and needs to be clearly explained to establish the credibility of the DDFS results that will be used for various facility analyses. Every effort should be made to recognize, address, and mitigate these risks in the DDFS preparation process, as noted in Chapter 8.

The risks and uncertainties of the DDFS preparation process need to be clearly explained to establish the credibility of the DDFS results.

The public often expects certainty from forecasts, including DDFSs. Therefore, when reporting and documenting their work, airport technical staff or the consultants preparing the DDFS need to be transparent and address and explain the uncertainties and related risks that were considered, whether through the use of Monte Carlo analysis, risk registers, or alternative scenarios.

Appendix A provides an example of the communication process in an actual DDFS study. Click here to access Section A.13 Communication of Results.

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APPENDIX A

Case Study Examples from MSP DDFSs

The purpose of this appendix is to provide real world examples of the application of the guidance in the main guidebook. The examples are a set of DDFS prepared for Minneapolis-St. Paul International Airport (MSP) on behalf of the Metropolitan Airports Commission (MAC). (At the time of guidebook publication, the completion of the LTCP document was still pending. However, the DDFS analysis associated with the LTCP has been completed.) The DDFSs were prepared in late 2014 by HNTB Corporation (one of the authors of this guidebook) in support of the Airport's Long-Term Comprehensive Plan (LTCP) update (the LTCP is the MAC's equivalent to an Airport Master Plan). Instead of recapitulating the entire DDFS process, this appendix follows the guidance in Chapters 5 through 9 and highlights key elements from the LTCP DDFSs to show how the guidance can be applied.

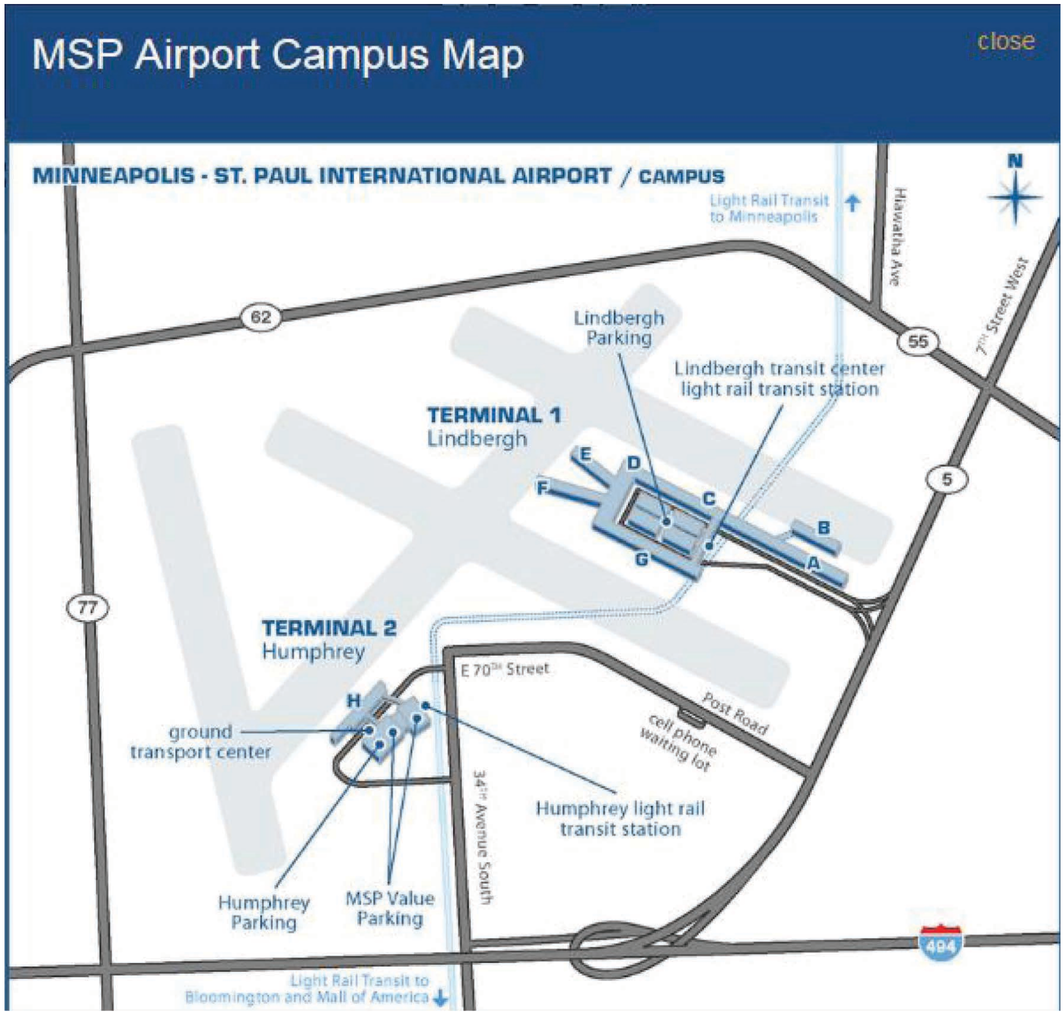
A.1 Scoping

Early in the LTCP scoping process, it was determined that the key issues were related to the terminal buildings, gate capacity, and associated landside facilities. One major question was whether to expand at Terminal 1, where the hub carrier and legacy carriers were located, or at Terminal 2, where the principal low-fare carriers were located (see Exhibit A.1). Since aircraft operations had declined significantly from their previous peak, airfield capacity was not considered an urgent issue.

The terminal analysis was expected to involve complex phasing issues, in which gate requirements by airline and aircraft type would be needed. In addition, security processing capacity was a major issue so detailed estimates of originating traffic by time of day would be needed. Consequently, it was determined that DDFSs would be useful and appropriate for this study.

Airfield capacity was not expected to be an issue, and the analysis of cargo, GA, and military facilities was not anticipated to require a DDFS level of detail. Therefore, the DDFS scope only included scheduled passenger aircraft operations. In addition, no runway use designations and arrival/departure fixes were included. There was sufficient time in the LTCP schedule to prepare a set of DDFSs, so the effort was deemed feasible.

The effort was scoped to include the base year (2014) and two forecast years, 2020 (correlates to a planning activity level of approximately 38 million annual passengers) and 2030 (correlates to a planning activity level of approximately 48 million annual passengers). The base year was needed for calibration and to serve as a staging point for the two forecast schedules. The year 2020 was considered the earliest year that any substantial terminal improvements could be completed and 2030 was considered a reasonable out-year for determining longer-term requirements.



Source: Metropolitan Airports Commission

Exhibit A.1. Locations of Terminal 1 and Terminal 2 at MSP

A.2 Setting the Stage

Delta Air Lines is a major stakeholder at MSP. A meeting was held with Delta Corporate Real Estate and route planning staff at the beginning of the study to review and discuss key LTCP and forecast assumptions, including those relevant to the DDFS such as fleet mix, gate utilization, and gate buffer times. In addition, Delta staff, along with other stakeholders, had the opportunity to review and comment on draft products as they were developed. Two other consulting teams were involved in the LTCP, and they also provided input, particularly regarding the type of DDFS output that would be required for their analyses. Finally, MAC staff were deeply involved and led biweekly working group conference calls to review results and determine subsequent steps.

The study was approached from an unconstrained perspective; therefore, no slot controls or other demand management policies were assumed. Two gating alternatives were initially developed: the first assumed the existing airline distribution among terminal buildings would continue (Airlines Remain Scenario); the second assumed that all carriers that were not part of the Delta network would move to Terminal 2 (Airlines Relocate Scenario). A third (Incremental Airlines Relocate Scenario) was developed later in the study (see Section A.9).

The design day was defined as an average weekday during July, the usual peak month for enplanements and operations at MSP. Several of the Terminal 2 carriers, however, peak in March. In addition, the international arrival peak occurs during Saturdays in March. Therefore, partial DDFSs were prepared for Terminal 2 carriers for an average weekday in March and for international operations for an average Saturday in March. Since late night operations at MSP are minimal, multiple day or weekly DDFSs were not considered necessary. In contrast to enplanements, MSP passenger originations peak in March instead of July. The adjustments used to estimate this originations peak are discussed further in Section A.11.

In addition to the Delta Air Lines input, the following data was collected:

- Monthly and annual statistics and current gate layouts from the MAC;
- A base year airline schedule from the Official Airline Guide;
- USDOT T-100 data for market-by-market enplanements, fleet mix, and load factor information; and
- USDOT O&D Survey data for market-by-market originations.

A.3 Future Markets and Fleet Mix

Discussions with Delta Air Lines, along with an analysis of recent trends, indicated that Delta activity would grow more slowly than the MSP market and that Delta's market share would therefore gradually decline. Based on recent trends, the market shares of the other legacy carriers—American and United—were also projected to decline, and the market shares of low-fare carriers, such as Southwest, Sun Country, and Spirit, were projected to increase.

Market growth in existing markets was measured in terms of seat departures. The approach was similar to Option 1 (see Section 6.3 in the guidebook) except that seat departures by market were estimated directly instead of first estimating passengers by market. The markets were organized into four categories: (1) large, medium, and small hubs; (2) non-hubs; (3) Dakotas and Rocky Mountain states; and (4) Southwest Airlines markets based on historical growth trends that were projected to increase in accordance with those trends. New nonstop markets were estimated using a revenue threshold analysis. Candidate markets for nonstop domestic air carrier service were determined by identifying the current thresholds of total revenue (passengers multiplied by average fare) that justified nonstop service to MSP. Thresholds were lower for nearby markets than more distant markets because service can be offered with smaller aircraft and because there is less competition from connecting hubs between the two markets. Revenue thresholds necessary to justify nonstop service were estimated using the average of revenue in the smallest market with nonstop service and the largest market without nonstop service in each mileage band (0–300 miles, 301–500 miles, 501–700 miles, etc.). Exhibit A.2 shows the calculation of the domestic revenue thresholds and Exhibit A.3 shows their application to estimate new nonstop markets. It was assumed that revenue in each market would increase at the same rate as the forecast of total MSP domestic originations. Nonstop service was assumed to be initiated after the revenue in the market grew to exceed the threshold. In Exhibit A.3 the year in which the threshold is forecast to be exceeded is shaded in light green, and the year in which nonstop service is assumed to be initiated is shaded in darker green. Once the initial individual market seat departure forecasts were prepared, they were proportionately adjusted as necessary so that the individual market seat departure forecasts would add up to the forecast of total domestic scheduled seat departures. The same approach was used to estimate new nonstop international markets.

Revenue Thresholds for Domestic Nonstop Service at MSP: 2013

Geographic Category	Revenue (10 percent sample) (a)				
	Lowest With (b)		Highest Without (c)		Average (d)
Domestic					
0-300 Miles	TVF	452,030	MQT	9,839,070	5,145,550
301-500 Miles	MBS	25,754,290	CMI	16,687,570	21,220,930
501-700 Miles (east/South)	LEX	91,971,300	SGF	65,977,320	78,974,310
501-700 Miles (West)	HLN	20,901,150	CPR	19,713,780	20,307,465
701-1000 Miles (East/South)	TYS	145,799,270	LIT	181,408,350	163,603,810
701-1000 Miles (West)	HLN	20,901,150	COS	114,090,570	67,495,860
1001-1300 Miles (East/South)	ORF	260,409,380	CHS	238,465,230	249,437,305
1001-1300 Miles (West)	FCA	43,798,090	COS	114,090,570	78,944,330
1301-1800 Miles (East/South)	RSW	568,904,770	PBI	446,959,020	507,931,895
1301-1800 Miles (West)	SJC	645,208,400	OAK	602,416,030	623,812,215
1801 + Miles (Alaska)	FAI	89,356,230	JNU	47,559,220	68,457,725
1801 + Miles (Hawaii/Carib.)		*1,308,692,746* (e)	HNL	1,142,666,600	1,225,679,673

(a) USDOT O&D data. Includes all domestic revenue in market. 10 percent sample of airline revenue for entire market in 2013.
(b) Lowest revenue market in geographic category with non-stop service to MSP.
(c) Highest revenue market in geographic category without non-stop service to MSP.
(d) Average revenue of lowest revenue market with non-stop service and highest revenue market without non-stop service.
(e) HNL revenue level multiplied by average ratio of "lowest with" to "highest without" revenue levels in other geographic categories.

Source: Table D.3 from MSP Forecast Technical Memorandum, 2015.

Exhibit A.2. Example of calculation of revenue thresholds.

Exhibit A.4 shows an example of how the fleet mix was estimated in each market. The seat targets to destination (shaded in light green) were based on the annual seat departure forecast by market. The fleet mix was then estimated using the seat targets as a control total. Professional judgment (incorporating airline input, published fleet acquisition, and retirement plans) and current service patterns were used to estimate the fleet mix within each market. The fleet mix forecasts in Exhibit A.4 determined the number of flights by airline and aircraft type that were included in the DDFSs.

A.4 Flight Times

Albuquerque (see Exhibit A.4) was projected to gain an additional daily arrival and departure flight frequency between 2014 and 2030. Therefore, flight times for the new frequencies were required. The existing flight times provide good schedule coverage for the morning and afternoon. Therefore, it was assumed that with a new frequency Delta would choose to fill the midday gap in the schedule, while remaining consistent with its connecting bank structure (Exhibit A.5). Exhibits A.6 and A.7 graphically depict Delta's existing connecting bank structure at the airport. The new selected arrival time (13:59) fits in one of Delta's arrival peaks and the new

Estimated New Domestic Non-Stop Markets at MSP

Geographic Category		2013	2015	2020	2025	2030	2035
MSP Domestic Originations (a)		7,506,520	8,293,726	8,909,272	9,998,486	11,226,675	12,655,356
Domestic							
0-300 Miles	threshold (b)	5,145,550	5,145,550	5,145,550	5,145,550	5,145,550	5,145,550
		(no new non-stop markets assumed)					
301-500 Miles	threshold (b)	21,220,930	21,220,930	21,220,930	21,220,930	21,220,930	21,220,930
CMI	(c)	16,687,570	18,437,589	19,805,995	22,227,402	24,957,760	28,133,827
MHK	(c)	12,766,560	14,105,384	15,152,261	17,004,721	19,093,537	21,523,337
SPI	(c)	12,678,840	14,008,465	15,048,149	16,887,880	18,962,344	21,375,449
501-700 Miles (east/South)	threshold (b)	78,974,310	78,974,310	78,974,310	78,974,310	78,974,310	78,974,310
SGF	(c)	65,977,320	72,896,337	78,306,576	87,880,048	98,675,009	111,232,165
EVV	(c)	34,602,440	38,231,185	41,068,637	46,089,536	51,751,057	58,336,779
501-700 Miles (West)	threshold (b)	20,307,465	20,307,465	20,307,465	20,307,465	20,307,465	20,307,465
CPR	(c)	19,713,780	21,781,157	23,397,716	26,258,234	29,483,729	33,235,761
GCC	(c)	6,747,150	7,454,721	8,007,997	8,987,026	10,090,969	11,375,123
701-1000 Miles (East/South)	threshold (b)	163,603,810	163,603,810	163,603,810	163,603,810	163,603,810	163,603,810
LIT	(c)	181,408,350	200,432,577	215,308,332	241,631,131	271,312,483	305,839,089
GSP	(c)	146,359,330	161,707,979	173,709,662	194,946,762	218,893,525	246,749,415
GSO	(c)	144,579,750	159,741,775	171,597,530	192,576,408	216,232,003	243,749,194
MDT	(c)	120,527,640	133,167,329	143,050,775	160,539,633	180,259,912	203,199,377
JAN	(c)	113,494,190	125,396,284	134,702,977	151,171,263	169,740,756	191,341,577
HSV	(c)	109,349,500	120,816,942	129,783,764	145,650,646	163,542,000	184,353,981
BTV	(c)	108,210,950	119,558,993	128,432,452	144,134,127	161,839,196	182,434,482
CAE	(c)	96,328,500	106,430,434	114,329,515	128,307,018	144,067,925	162,401,680
701-1000 Miles (West)	threshold (b)	67,495,860	67,495,860	67,495,860	67,495,860	67,495,860	67,495,860
COS	(c)	114,090,570	126,055,206	135,410,803	151,965,626	170,632,696	192,347,023
ASE	(c)	54,554,120	60,275,191	64,748,710	72,664,647	81,590,587	91,973,619
GJT	(c)	41,192,640	45,512,497	48,890,355	54,867,508	61,607,293	69,447,297
DRO	(c)	36,836,680	40,699,729	43,720,392	49,065,485	55,092,564	62,103,518
1001-1300 Miles (East/South)	threshold (b)	249,437,305	249,437,305	249,437,305	249,437,305	249,437,305	249,437,305
HOU	(c)	606,263,120	669,841,711	719,556,190	807,526,463	906,720,954	1,022,108,191
CHS	(c)	238,465,230	263,472,991	283,027,495	317,629,388	356,646,172	402,032,149
ELP	(c)	227,654,350	251,528,378	270,196,374	303,229,581	340,477,530	383,805,922
MHT	(c)	185,342,840	204,779,676	219,978,065	246,871,768	277,196,866	312,472,306
SAV	(c)	149,903,320	165,623,626	177,915,922	199,667,263	224,193,880	252,724,281
PWM	(c)	146,893,780	162,298,477	174,343,986	195,658,635	219,692,843	247,650,452
1001-1300 Miles (West)	threshold (b)	78,944,330	78,944,330	78,944,330	78,944,330	78,944,330	78,944,330
FLG	(c)	12,141,810	13,415,117	14,410,764	16,172,570	18,159,168	20,470,062
1301-1800 Miles (East/South)	threshold (b)	507,931,895	507,931,895	507,931,895	507,931,895	507,931,895	507,931,895
PBI	(c)	446,959,020	493,831,449	530,482,754	595,337,609	668,467,363	753,534,992
SRQ	(c)	96,396,740	106,505,831	114,410,507	128,397,912	144,169,984	162,516,726
1301-1800 Miles (West)	threshold (b)	623,812,215	623,812,215	623,812,215	623,812,215	623,812,215	623,812,215
OAK	(c)	602,416,030	665,591,178	714,990,190	802,402,241	900,967,286	1,015,622,324
ONT	(c)	311,530,530	344,200,622	369,746,590	414,950,438	465,921,891	525,214,047
1801 + Miles (Alaska)	threshold (b)	68,457,725	68,457,725	68,457,725	68,457,725	68,457,725	68,457,725
JNU	(c)	47,559,220	52,546,738	56,446,665	63,347,625	71,129,086	80,180,811
1801 + Miles (HI/CR)	threshold (b)	1,225,679,673	1,225,679,673	1,225,679,673	1,225,679,673	1,225,679,673	1,225,679,673
HNL	(c)	1,142,666,600	1,262,497,627	1,356,197,991	1,522,001,731	1,708,960,542	1,926,438,956
SJU	(c)	569,484,840	629,206,506	675,905,112	758,538,765	851,715,733	960,103,131

(a) Table 5.
(b) Table D.3.
(c) Base year revenue from USDOT O&D Survey. Assumed to grow at same rate as MSP revenue. New non-stop service assumed to occur five years after threshold is reached.

Source: Table D.4 from MSP Forecast Technical Memorandum, 2015.

Exhibit A.3. Example of use of revenue thresholds to estimate new nonstop markets.

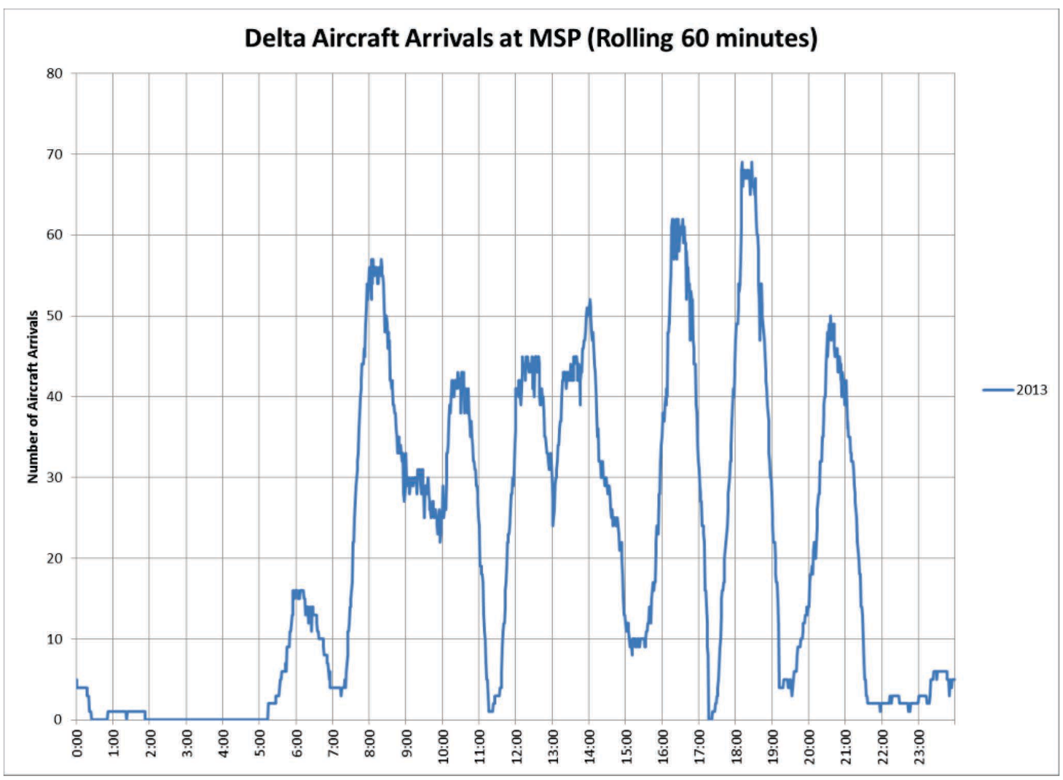
Market	Domestic/ International	Distance	Published Carrier	Equipment	Seats per Aircraft	July: Aircraft Departures Jul-13	Jul-14	Jul-15	Jul-20	Jul-25	Jul-30	Jul-35	July: Seat Departures Jul-13	Jul-14	Jul-15	Jul-20	Jul-25	Jul-30	Jul-35
ABQ	Albuquerque, NM: Albuquerque International								Seat Targets to Destination						306	321	352	389	432
ABQ	D	981	DL	319	126							2	0	0	0	0	0	0	252
ABQ	D	981	DL	320	150	2							300	0	0	0	0	0	0
ABQ	D	981	DL	738	160						1		0	0	0	0	0	160	0
ABQ	D	981	DL	739	180					2		1	0	0	0	0	360	0	180
ABQ	D	981	DL	717	110						2		0	0	0	0	0	220	0
ABQ	D	981	DL	E95E2	110								0	0	0	0	0	0	0
ABQ	D	981	DL	M90	160		2	2	2				0	320	320	320	0	0	0
						2	2	2	2	2	3	3	300	320	320	320	360	380	432
ABR	Aberdeen, SD: Aberdeen Regional								Seat Targets to Destination						107	131	157	188	228
ABR	D	257	DL	CRJ	50	2	2	2	1	2	1		100	100	100	50	100	50	0
ABR	D	257	DL	CR9	76				1		2	3	0	0	0	76	0	152	228
ABR	D	257	DL	CR7	65					1			0	0	0	0	65	0	0
						2	2	2	2	3	3	3	100	100	100	126	165	202	228

Source: Modified from Table D.8 from MSP Forecast Technical Memorandum, 2015

Exhibit A.4. Example of design day fleet mix estimates by market.

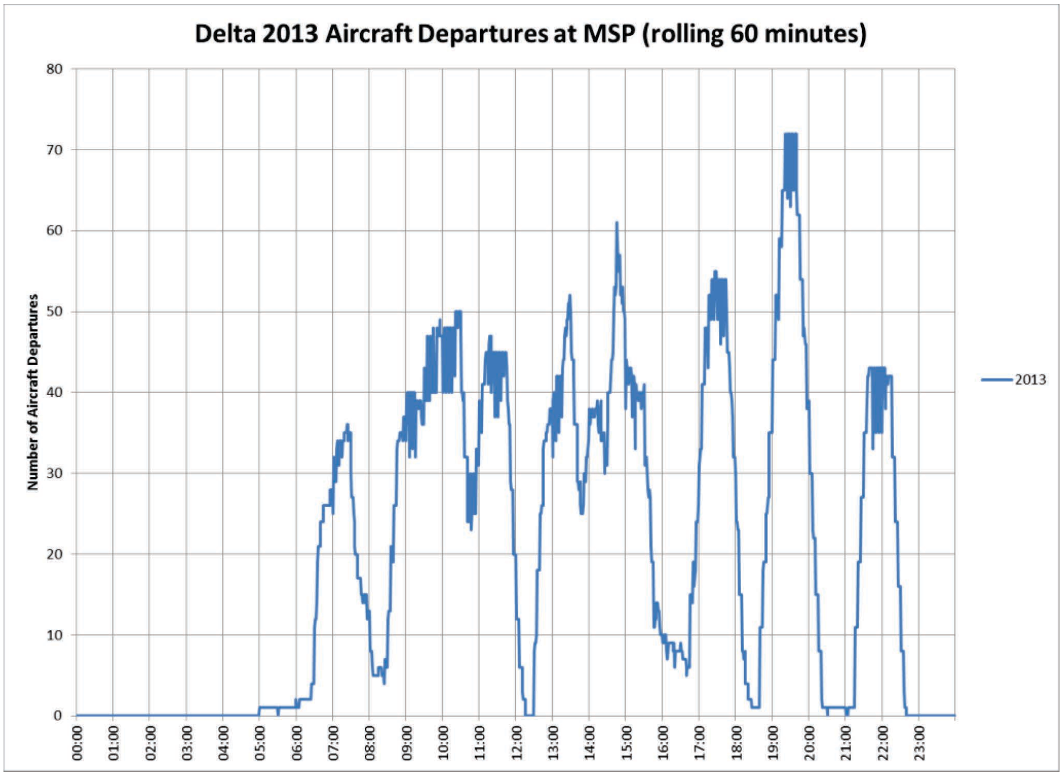
2013 (Existing)		2030	
Arrivals	**Departures**	**Arrivals**	**Departures**
9:29	11:45	9:29	11:45
		13:59	15:05
18:15	21:35	18:15	21:35

Exhibit A.5. Existing and projected flight times for Albuquerque.



Source: Official Airline Guide and HNTB analysis.

Exhibit A.6. Delta existing (2013) aircraft arrival banks at MSP.



Source: Official Airline Guide and HNTB analysis.

Exhibit A.7. Delta existing (2013) aircraft departure banks at MSP.

selected departure time (15:05) fits in one of Delta's departure peaks. An early morning departure fitting within Delta's first departure bank was considered, but that time would have allowed no opportunity to collect connecting passengers from the East Coast, so it was not considered a likely choice for Delta.

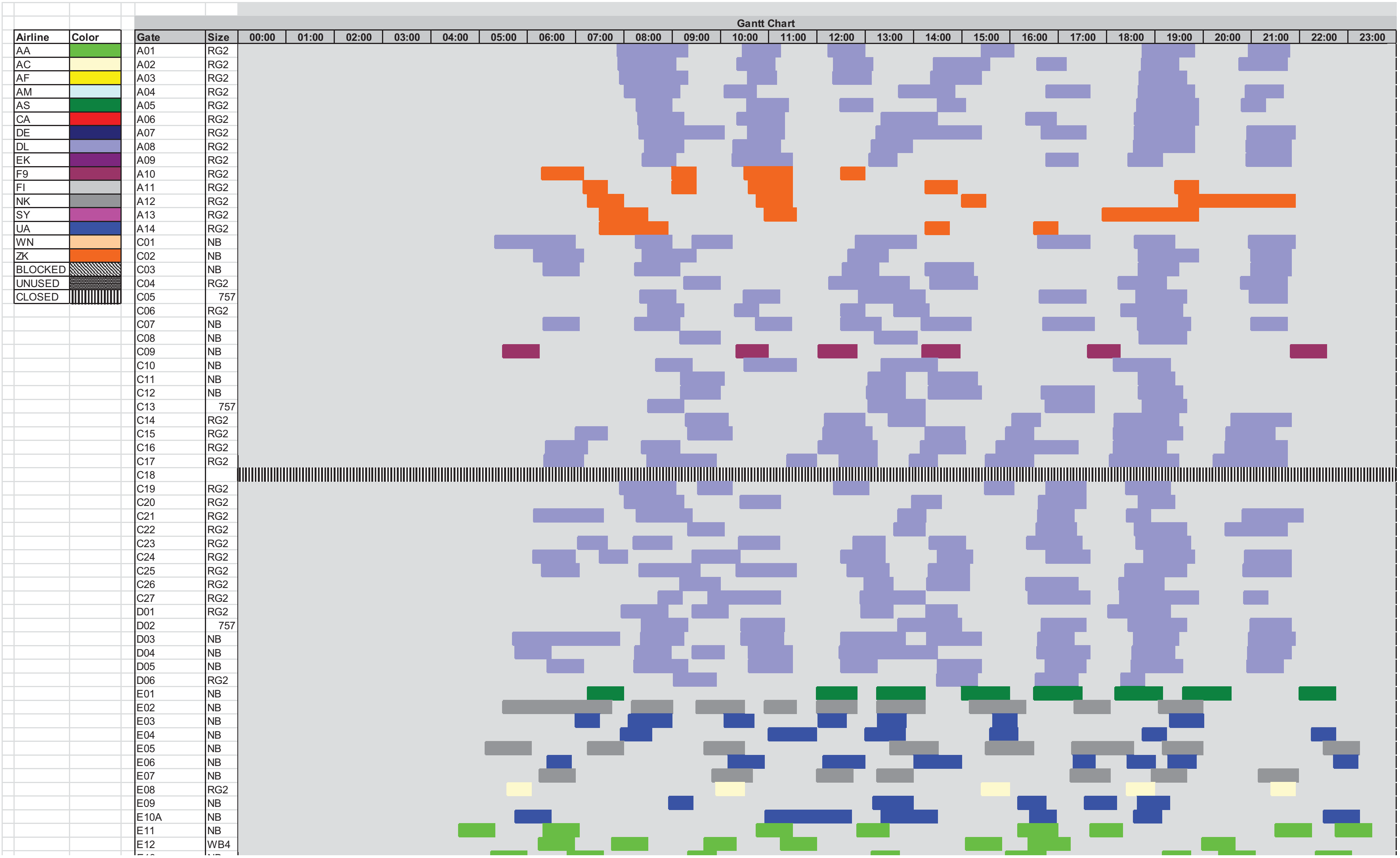
A.5 Gate Assignments

A gating model was used to assign gates to the flights in the DDFS for each of the terminal expansion alternatives. The model incorporated initial assumptions about which airlines would be assigned to which existing gates. These assumptions were adjusted, as necessary, if some airlines needed additional gates or had an excess number of gates. Flights were gated according to two sets of buffer time/spare gate assumptions: (1) 15 minute buffer and spare gates equal to 8 percent of the total, and (2) 25 minute buffer time and no spare gates. The results were presented in Gantt charts (see Exhibit A.8 for an example).

A.6 Passengers by Flight

USDOT T-100 data was used to estimate base year July load factor by airline for each nonstop market to estimate base year enplanements and deplanements by flight. These load factors were then increased in accordance with the load factor projections in the annual forecast to arrive at 2020 and 2030 load factors by market and airline. The future load factors were then used to estimate 2020 and 2030 enplanements and deplanements by flight.

Estimates of peak month passenger originations and terminations by flight took into account (1) market, (2) airline, and (3) time of day. USDOT O&D Survey data is available by quarter



Sources: MSP Forecast Technical Memorandum and HNTB analysis.

Exhibit A.8. Gantt chart showing estimated gate use by time of day.

Published Carrier	Air Carrier Name	Total Deplanements	Terminations	OD Pct
AA	American Airlines Inc.	127,858	117,620	91.99%
AF	Air France	16,308	4,892	30.00%
AS	Alaska Airlines Inc.	25,394	21,740	85.61%
UA	United Air Lines Inc.	177,376	139,950	78.90%
F9	Frontier Airlines Inc.	43,970	43,970	100.00%
FI	Icelandair	12,987	11,688	90.00%
WN	Southwest Airlines Co.	250,703	243,320	97.06%
NK	Spirit Air Lines	77,306	72,460	93.73%
AC	Air Canada	12,454	11,209	90.00%
SY	Sun Country Airlines	183,809	145,987	79.42%
US	US Airways Inc.	157,095	151,510	96.44%
ZK	Great Lakes Airlines	6,796	160	2.35%
DL	Delta Air Lines Inc.	3,430,278	1,172,416	34.18%

Sources: USDOT T100 data and Origin-Destination Survey.

Exhibit A.9. Terminating to deplaning ratio by airline – third quarter 2013.

but not by month. Consequently, ratios of originations to enplanements and terminations to deplanements were calculated from data for the third quarter of 2013. Foreign-flag carriers do not file O&D data and their origination to enplanement ratios were therefore estimated based on judgment. Exhibit A.9 shows an example of the calculations. Non-Delta carriers have very little connecting traffic; therefore, each carrier's average ratio of originating to enplanement traffic was used across all markets.

Since Delta operates a connecting hub at MSP, individual originating to enplanement and terminating to deplaning passengers were prepared for **each nonstop market** using third quarter 2013 T-100 and O&D Survey data. Some markets with limited nonstop service had more originations than enplanements. Others with no nonstop service had originations but no enplanements. These excess originations would reach their ultimate destination by connecting through another hub, most likely a Delta hub. Therefore, the originations to enplanement ratios to other Delta hubs (Atlanta, Detroit, Cincinnati, Salt Lake City, New York JFK, and Seattle) were increased proportionately to account for these excess originations.

The potential for connecting activity is very limited prior to the first arrival bank of the day or after the last departure bank of the day at MSP. Consequently, early morning enplaning connections and late night deplaning connections were capped to not exceed the available deplaning connections in the morning or the available enplaning connections in the late evening. Midday originating to enplaning ratios were adjusted downwards to offset the higher ratios in the beginning and end of the day.

Ideally, the aggregate bottom-up calculations of design day enplanements and originations would sum exactly to the top-down calculation of average weekday peak month originations and enplanements. Typically, however the two sets of numbers are off by 1 to 2 percent. Therefore, a final proportionate adjustment was made to the enplanement/deplanements and origination/termination numbers in the DDFS so that they would conform to the base year and forecast totals.

A.7 Nonscheduled Operations

As noted in Section A.1, nonscheduled operations were not included in the MSP DDFSs.

A.8 Application of Constraints

As noted in Section A.2, no physical or policy constraints were assumed to impact demand over the forecast period.

A.9 DDFS Updates

During the course of the LTCP study, a new gating alternative was developed (Incremental Airlines Relocate Scenario), which moved some but not all of the non-Delta carriers from Terminal 1 to Terminal 2. The gating model was operated with gate assignments conforming to the new alternative and revised gate requirements were calculated. This revision did not require an update of the number of flights or flight times.

DDFSs have been prepared on behalf of the MAC on several occasions, each time incorporating a new base year schedule and applying a new annual forecast. Since the most recent DDFSs were prepared using new data, it was not possible to bypass any of the DDFS preparation steps. However, institutional knowledge acquired in prior efforts, particularly with regard to airline service patterns, helped speed the DDFS development process.

A.10 Quality Assurance and Control

The checklist in Appendix E of this guidebook was used to assist in quality control of the MSP DDFSs. Since DDFSs consist of very detailed spreadsheets, pivot tables are very useful for organizing the data so that it can be more easily checked against control totals and for internal consistency. Exhibit A.10 illustrates part of a pivot table of the DDFS that was used to verify that the number and type of Delta aircraft were consistent between arrivals and departures and with the original departure projections (see Exhibit A.4).

A.11 Application of Results

As noted in Section A.1 the primary objective of the MSP DDFSs was to assist in terminal and landside planning.

Row Labels	Count of D/I	Row Labels	Count of D/I2	Category Match	Number Match
DL	**487**	**DL**	**487**		
D	**455**	**D**	**455**		
SAT	3	SAT	3	TRUE	TRUE
738	1	738	1	TRUE	TRUE
E70	2	E70	2	TRUE	TRUE
ABQ	3	ABQ	3	TRUE	TRUE
717	2	717	2	TRUE	TRUE
738	1	738	1	TRUE	TRUE
ABR	3	ABR	3	TRUE	TRUE
CR9	2	CR9	2	TRUE	TRUE
CRJ	1	CRJ	1	TRUE	TRUE

Sources: MSP Forecast Technical Memorandum and HNTB analysis.

Exhibit A.10. Pivot table cross-check of DDFS arrivals and departures in 2030.

When future gate requirements were estimated (see Section A.5) and matched to currently available gates it was determined that there would be a shortage of some types of gates (narrow body aircraft gates) and a surplus of other types of gates (turboprop and small regional jet). This information was used to develop a plan to reconfigure the gates at the existing Terminal 1 to better match the anticipated fleet mix. It was also used to fine tune the phasing of the Incremental Airlines Relocate Scenario so that no new gates were added at Terminal 2 before they were warranted based on existing gate capacity at Terminal 1.

Curbside capacity is a significant issue at Terminal 1. Two adjustments were required before the DDFS outputs could be applied to the curbside analysis. First, since the MSP originations peak occurs in March, the originations profile from the July DDFSs had to be adjusted for seasonality. Secondly, since departing passengers show up at the curb well before scheduled aircraft take-off, and arriving passengers show up at the curb after aircraft arrival, lead and lag factors had to be applied.

The Passenger Toolbox from *ACRP Report 82: Preparing Peak Period and Operational Profiles—Guidebook* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf was used to make both sets of adjustments. Exhibit A.11 shows an example of the output showing departing passengers (originations) for March 2030 by hour with a lead time (show-up time) factor applied. Since the 2030 DDFS was used to develop the profile, no base year data was required, and therefore the base year columns are blank.

A.12 Dealing with Uncertainty

The annual forecast included three scenarios, a High Scenario which assumed high economic growth and low fuel prices, a Low Scenario which assumed low economic growth and high fuel prices, and a Low Connecting Percentage Scenario which assumed a downsized connecting passenger operation at MSP. Additional DDFSs corresponding to each forecast scenario were not prepared. However, as noted in Appendix B, the majority of forecast uncertainty resides in annual forecasts rather than DDFSs. Gate requirements for each scenario were therefore estimated by adjusting passenger aircraft operations (an output of the annual forecast) in accordance with the forecast scenarios, and keeping gate utilization (an output of the DDFSs) constant.

A.13 Communication of Results

During the active phase of the LTCP preparation, MAC staff led biweekly working group meetings (in person for local participants and by telephone for non-local participants) to review results and determine subsequent steps. In addition to key stakeholders, DDFS preparers and users were involved in the meetings, and this provided an opportunity to collect input and direction, ask and answer questions, and share results. In addition, a SharePoint site was established in which DDFSs and DDFS-related planning analyses were downloaded.

The biweekly working group meetings were very detailed and technical and primarily involved participants who were active in the development of the LTCP. Communication to senior MAC decision makers and the public was primarily the responsibility of MAC staff and involved a higher-level summary of the DDFS results.

AIRPORT COOPERATIVE RESEARCH PROGRAM
Peak Period and Operational Profile Toolbox
Passenger Module

DESIGN DAY DERIVATIVE PROFILE ESTIMATES
(Assumes no Peak Spreading)

MSP 2030 T1 Hybrid Alternative
Departing Passenger Count - Origin-Destination Passengers

Base Year				Forecast Year		
Design Day Derivative Profile				**Future Design Day Derivative Profile**		
Hour	Passengers by Hour	Percent		Hour	Passengers by Hour	Percent
00:00-00:59				00:00-00:59	-	0.0%
01:00-01:59				01:00-01:59	43	0.2%
02:00-02:59				02:00-02:59	227	0.8%
03:00-03:59				03:00-03:59	376	1.4%
04:00-04:59				04:00-04:59	586	2.1%
05:00-05:59				05:00-05:59	2,400	8.7%
06:00-06:59				06:00-06:59	1,373	5.0%
07:00-07:59				07:00-07:59	2,332	8.5%
08:00-08:59				08:00-08:59	1,656	6.0%
09:00-09:59				09:00-09:59	2,008	7.3%
10:00-10:59				10:00-10:59	1,295	4.7%
11:00-11:59				11:00-11:59	1,673	6.1%
12:00-12:59				12:00-12:59	1,806	6.6%
13:00-13:59				13:00-13:59	2,212	8.0%
14:00-14:59				14:00-14:59	937	3.4%
15:00-15:59				15:00-15:59	2,221	8.1%
16:00-16:59				16:00-16:59	1,485	5.4%
17:00-17:59				17:00-17:59	1,983	7.2%
18:00-18:59				18:00-18:59	1,536	5.6%
19:00-19:59				19:00-19:59	433	1.6%
20:00-20:59				20:00-20:59	861	3.1%
21:00-21:59				21:00-21:59	77	0.3%
22:00-22:59				22:00-22:59	-	0.0%
23:00-23:59				23:00-23:59	-	0.0%
Total:				Total:	27,520	100.0%

Peak Value:				Peak Value:	2,400	5:00
Peak Hour:				Peak Hour:	05:00-05:59	8.72%

Source: *ACRP Report 82: Preparing Peak Period and Operational Profiles – Guidebook* (2013) and HNTB analysis.

Exhibit A.11. Application of ACRP Report 82 passenger toolbox – March 2030 originating passenger curbside profile.

APPENDIX B

Stability and Predictability of Critical DDFS Factors

To date, little attention has been devoted to how the various elements of DDFSs vary over time. In general, it has been assumed that DDFS elements will grow or decline in step with annual activity, sometimes with allowances for peak spreading.

The research conducted to help develop this guidebook rigorously evaluated the various elements that comprise DDFSs and their variability and predictability over time independent of variations in annual activity. More specifically, it involved the analysis of a 10-year sample of historical OAG schedule and US DOT T-100 data, including a sample of five large-hub, five medium-hub, five small-hub and five non-hub airports, to assess the following DDFS elements:

- Stability of airport schedule profiles over time;
- Stability of the peak hour, both in terms of percentage of daily activity and timing;
- Stability of individual flight times to specific markets;
- Stability of the nonstop markets served;
- Stability of fleet mix; and
- Stability of load factors for each market and airline.

There were several purposes to this research effort. First, to determine whether the current practice of using existing flight schedules as the foundation for future flight schedules is appropriate. Second, to determine whether cloning (which implicitly assumes a continuation of existing daily schedule profiles) is a reasonable alternative to manually identifying and adding new flights. The third purpose was to provide guidance on selecting new flight times to new or existing markets. The fourth purpose was to provide guidance on selecting new nonstop markets, adjusting equipment types, and adjusting load factors. The final purpose was to provide a quantitative basis for establishing confidence intervals around each element to assist in the evaluation of risk and uncertainty (see Appendix D).

B.1 Stability of Schedule Profiles Over Time

The analysis determined that, in general, the hourly pattern of arriving and departing operations tended to be consistent at most airports. That is, the peaks and valleys in the daily profile of activity tended to occur around the same time across the 10-year period of analysis. This is not to say profiles are absolutely rigid. Variations in each hour's share of design day scheduled operations or scheduled seats of five or 10 percent were not unusual. Other findings from the analysis included:

- Airport size is positively correlated with the stability of schedules (e.g., large hubs have more stable schedules than medium-hubs and so on).
- Total operation schedules are more stable than separate arrival and departure schedules.

- Total operation schedules are more stable than arriving/departing seat schedules; however, the gap in variability between scheduled operations and scheduled seats decreases as airport size decreases. This is because the type of aircraft and number of seats per aircraft become more uniform as airport size decreases.
- The stability of domestic operation schedules holds very close to that of total operations, while international operation schedules are more variable.
- Individual carrier schedules are less stable than total airport schedules.
- There is no discernible trend for carrier-specific schedule stability; the scale of individual carrier operations at an airport is a more important driver than the specific carrier. For example, there is no evidence that, given an equal number of operations, a low cost carrier's schedule is more stable than a legacy carrier's schedule.

As noted, international schedule profiles tend to be less stable than domestic schedule profiles. Flights to specific international regions (e.g., Europe, Northeast Asia, and southern Latin America) tend to operate within specific schedule windows, but if the mix of flights to each region changes, the overall profile of international operations may change significantly. See Appendix N in *ACRP Web Only Document (WOD) 14: Guidelines for Preparing Peak Period and Operational Profiles* (technical report accompanying *ACRP Report 82*) for additional detail on international profiles.

In addition, major structural changes to an airline schedule, such as an increase or decrease in the number of connecting banks, or a transition to a rolling hub, will cause changes to the schedule profiles over and above those suggested earlier.

The research findings suggest that imposing top-down controls on the distribution of DDFS flight times may be too rigid and may generate results that fail to incorporate more subtle trends that can emerge from bottom-up DDFS development. A potential compromise may be to establish soft controls to establish bounds from which DDFS-generated profiles could not deviate from without good cause.

B.2 Stability of Peak Period Over Time

The guidebook research analysis also examined the stability of the peak hour over time, both in terms of the hour of occurrence and the magnitude as a percentage of daily activity. The analysis determined the following:

- Large-hub airports tend to peak earlier in the morning than other airports, with the peak time occurring around 9:00 or 10:00 am.
- Medium-hub, small-hub, and non-hub airports all tend to peak later in the afternoon with the peak time tending to occur around 2:00 to 4:00 in the afternoon.
- With respect to the stability of the time that the peak hour occurs, there is no discernible difference between airport size groups.
- The percentage of daily activity that the peak hour represents tends to be negatively correlated with airport size, indicating that larger airports typically have a more even distribution of activity across the time of day while smaller airports have higher peaks of activity.
- Larger airports tend to have more stability in the percentage of daily activity represented by the peak hour, relative to the airports of smaller size.

The analysis indicated that although airports exhibit certain tendencies regarding the timing of the peak hour within the day, shifts in the timing of the peak of 2 or 3 hours can still occur. This has implications for air quality analysis, where average meteorological conditions can change depending on the time of day, and also for many terminal and landside facility requirements that are dependent on passenger O&D traffic. An early morning departing peak is likely to have more originating passengers than a mid-morning peak with the same number of scheduled seat departures. Likewise, a late evening arriving peak is likely to have more terminating passengers than an afternoon arriving peak with the same number of scheduled seat arrivals.

Like the schedule profile analysis, the peak hour analysis indicated variations in the peak hour share of daily activity ranging from three to almost 20 percent, depending on the size of the airport. Again, this suggests that imposing top-down controls on the distribution of DDFS flight times may be too rigid, and may generate results that fail to incorporate more subtle trends that can emerge from bottom-up DDFS development.

B.3 Stability of Scheduled Flight Times to Individual Markets

A key task in the preparation of a DDFS for future conditions is the adjustment of existing flight times or the estimation of new flight times. The guidebook research analysis examined how scheduled flight times to individual markets varied over the period of analysis. To make it manageable, the study was limited to markets where daily flight frequency did not change and focused on the first and last flights of the day. The analysis generated the following observations:

- The average schedule change between sequential months is significant, with changes of 10 to 15 minutes or more where frequencies stay constant.
- The standard deviation for scheduled flight time changes between periods is very high, suggesting that changes in flight times are variable and difficult to predict.
- The last flight of the day has a greater average change in scheduled flight time than the first flight of the day.
- Scheduled flight times for medium- and small-hub airports generally have greater inter-period change than for large-hub airports; however, non-hub airports have relatively simple operation profiles and their scheduled flight times have more stability as a result.

Connecting banks have a significant effect on flight times at airline connecting hubs and at small airports where much of the service consists of flights to a connecting airport. The scheduled flight time analysis suggests that the first and last flights, and intermediate flights by inference, tend to remain within the same connecting bank. Within the bounds of that connecting bank, however, there is a tremendous amount of variability. This suggests that the selection of DDFS flight times at a connecting airport could be a two-step process, with the first step involving the selection of the connecting bank(s) and the second step randomly selecting times that fit within that bank.

Appendix Q in *ACRP Web Only Document 14* contains a complementary analysis that looked at the impact of changes in flight frequency upon scheduled flight times. The analysis found that, when the initial flight(s) were in the early morning or late evening, their schedule times were relatively unaffected by the addition of a new flight frequency. However, if the initial flight(s) were in the afternoon, the addition of a new frequency caused the initial flight time to shift by more than an hour almost 50 percent of the time. This suggests that midday flight times from an existing schedule are poor guides for a future DDFS in instances where flight frequencies to an existing market are expected to change.

B.4 Stability of Nonstop Markets

Depending on the ultimate use, market selection can be an important element of a DDFS. It affects directional headings for airspace analysis and can affect load factors and O&D connecting splits on individual flights. The guidebook research analysis looked at the stability in the number of flights to individual markets and the number of nonstop markets served by airport category. The analysis determined:

- Large airports were more stable than medium or small airports in terms of the number of markets served.
- The frequency of flights to individual markets was also more stable at large airports than at small airports.
- The number of nonstop markets served appears to be increasing at large-hub airports but declining at all other airports.

The 10-year study period encompassed a challenging time for the airline industry, during which the overall number of scheduled departures was dropping. Therefore, the guidance above may not apply to potential changes in nonstop markets during times of growth.

B.5 Stability of Aircraft Equipment Types

Equipment type can be an important consideration for DDFSs, as they affect aircraft delay, gate requirements and passenger loads. The guidebook research involved an analysis of the stability of general equipment types (widebody, narrowbody, regional jet, and turboprop) by airport category and determined that:

- The mix of equipment types is more stable at large airports than small airports.
- Equipment types that account for a large portion of an airport's activity tend to be more stable (in percentage terms) than those that account for a smaller portion.
- Airlines at large-hub and medium-hub airports predominantly use narrow bodies, followed by regional jets.
- Airlines at small-hub airports predominantly operate regional jets, followed by narrow bodies.
- Airlines at non-hub airports generally fly regional jets, followed by turboprops.

The 10-year period of analysis encompassed a time when many carriers were shifting service away from turboprops and small regional jets, resulting in elimination of service to small communities and shifting to larger aircraft with less frequency at other markets. This secular change in equipment use suggests that the variation in equipment type might be less in more stable times for the industry.

B.6 Stability of Load Factors

One of the key drivers of passenger loads is the enplaning or deplaning load factor. Applying specific load factors to each market, as opposed to using an airport average, can generate greater precision but at the cost of additional effort. One of the guidebook research tasks was to determine how stable market load factors were over time, and whether the additional precision associated with assessing load factors by market could be confounded by variations over time. The general findings of the analysis were:

- There is a clear positive correlation between airport size and average load factor, with larger airports having higher load factors.
- There is a negative correlation between airport size and load factor variability, with larger airports having more stable load factors than small airports.
- Load factor stability is consistently higher when measured on a carrier basis than a market basis, regardless of airport size.
- Load factors have become more stable over time for all airport groups.

A likely reason for the difference in market and carrier load factor stability is that while market demand may have seasonality, resulting in lower load factors in certain months and higher overall variability, carriers can compensate for this seasonality on a system-wide basis by reallocating their capacity to other markets.

Load factors tend to be increasing at the same time that the standard deviation associated with load factors is decreasing. This is consistent with the ongoing industry trend in which airlines are increasingly matching capacity to demand, and service to markets with low load factors is being reduced. This suggests that differentiating load factors by market for DDFSs may become less of an issue in the future, as the differences between markets decline. It also suggests that if a DDFS preparer does differentiate load factor by market, they should consider increasing load factors at markets with low factors at a higher rate than at markets with high load factors.

B.7 Summary

The analysis of the stability of DDFS critical factors indicates that there is material variation in these factors over time, and that the degree of variation follows rational and predictable trends. This predictability can in turn be used to establish confidence intervals to help quantify the uncertainty associated with DDFSs. See Appendix D for more discussion of confidence intervals.

APPENDIX C

Evaluation of DDFS Uncertainty

The purpose of this appendix is to supplement the information provided in Chapter 6 with more background information on some key issues related to the evaluation of uncertainty with respect to DDFSs. In particular, the concept of confidence intervals will be explained in more detail, along with the distribution of uncertainty between annual forecasts and DDFS forecasts.

C.1 Confidence Intervals

Confidence intervals are described in detail in *ACRP Report 76: Addressing Uncertainty about Future Airport Activity Levels in Airport Decision Making* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf. In general, they provide a method for describing and quantifying how an actual future value of an activity measure, such as aircraft operations, is likely to deviate from the predicted value. By measuring historical variations in activity from the long-term average, the most likely distributions of activity around the long-term average can be measured and applied to forecast values. These distributions are often described as confidence intervals.

A confidence interval represents the probability that an actual activity measure will fall within a given range. For example, if there is a forecast of 85 peak hour operations and there is a 90 percent confidence interval of plus or minus five operations, it means that there is a 90 percent chance that forecast peak hour operations will be between 80 and 90 operations. Another way of describing the confidence interval in this example is that there is at least a 95 percent chance that peak hour operations will be 80 operations or higher (five percent chance that peak hour operations will be lower than 80), and a five percent chance that peak hour operations will be higher than 90 operations (95 percent chance that they will be lower than 90).

Exhibit C.1 provides an example of confidence intervals associated with a normal probability distribution curve (sometimes described as a bell curve). The mean represents the projected activity level, and the area beneath the curve represents the expected distribution of outcomes (actual activity levels). As shown, outcomes are most likely to cluster near the mean, but outliers should also be expected but much less frequently. The vertical bars representing the 90 percent confidence level encompass 90 percent of the graph (measured in area).

The x-axis in Exhibit C.1 represents the standard deviation. The standard deviation is the square root of the variance of the population around the mean. When only a sample of the population is being evaluated, which is usually the case in forecasting, an additional adjustment is made for degrees of freedom, which serves to slightly increase the effective standard deviation. (The degrees of freedom are equal to the sample size minus one. When calculating the variance of a sample and applying it to the population, the sum of the deviations in the sample is divided by $(n-1)$ rather than (n), where (n) represents the sample size.) The part of the curve that is encompassed by 1 standard deviation on either side accounts for approximately 68 percent of

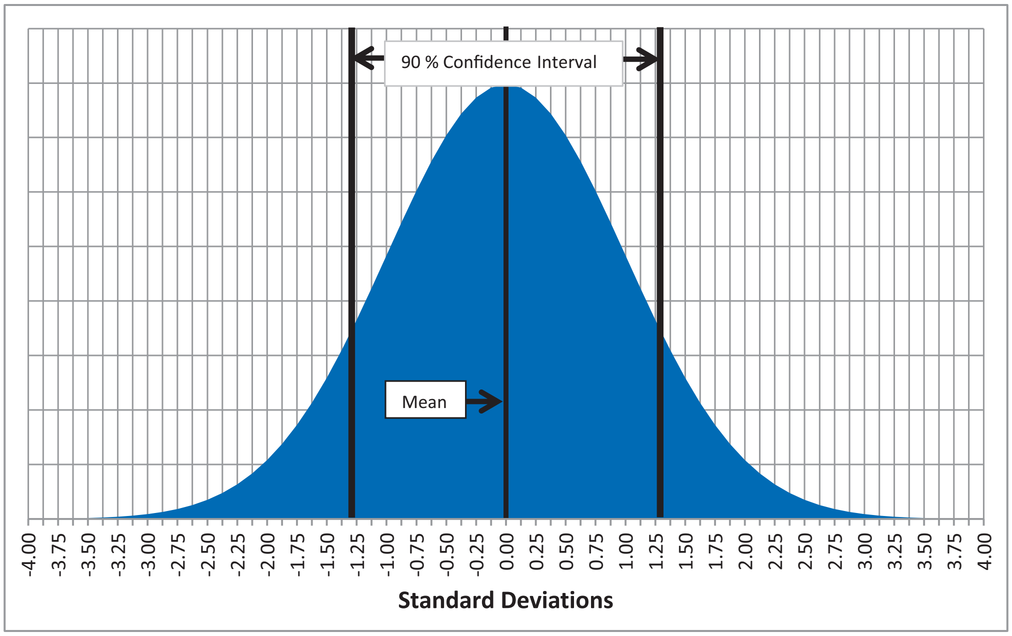


Exhibit C.1. Normal probability distribution curves and confidence intervals.

occurrences, the part encompassed by 2 standard deviations accounts for about 95 percent of occurrences, and the part encompassed by 3 standard deviations accounts for 99.7 percent of occurrences. When the spread is equal to approximately 1.25 standard deviations, 90 percent of the area under the curve is encompassed.

The distribution shown in Exhibit C.1 is a normal distribution which means that deviations around the mean are symmetric. This is not always the case. For example, if one were to estimate the distribution of average seats per aircraft in the world commercial passenger fleet, the average would be about 150 seats per aircraft. The low extreme would be about 19 seats per aircraft for small turboprops but the high range would be an Airbus A380 that would have 500 seats or more. Therefore, the outliers on the upper end of the distribution are more extreme than those on the lower end, and the probability distribution becomes skewed. Normal distributions are typically assumed as a matter of analytical convenience, but they sometimes break down with real world data, especially at high or low extremes.

C.2 Share of Uncertainty between Annual and DDFS Forecasts

A critical question when evaluating uncertainty is how much of the uncertainty is directly attributable to the DDFS and how much is attributable to the annual forecasts upon which it is based. One way of examining this issue is a Monte Carlo analysis. Monte Carlo analysis is briefly described in Chapter 8. *ACRP Report 76: Addressing Uncertainty about Future Airport Activity Levels in Airport Decision Making* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_076.pdf also describes Monte Carlo analysis in more detail and how to use Monte Carlo simulation to generate probability distributions for annual forecast outputs.

In a Monte Carlo analysis, probability distributions are identified for forecast input factors and forecast parameters. Using these probability distributions, the inputs and parameters are randomized and integrated within the forecast equations to generate multiple forecast outcomes. The forecast outcomes are then aggregated to provide a general forecast probability distribution that incorporates all the probability distributions associated with the inputs and parameters.

Separate Monte Carlo tests were performed on an example large-hub airport to estimate confidence intervals based on DDFS forecast factors by themselves, based on annual forecast factors by themselves, and based on annual and DDFS factors in combination. Peak hour originations were evaluated.

Exhibit C.2 shows the confidence intervals based solely on variations in DDFS factors, namely the peak hour percentage. For the purpose of this test, no variation was assumed in the annual forecast factors. As shown, the distributions around the mean are very symmetric and relatively small.

Exhibit C.3 is similar to Exhibit C.2 except that is holds the peak hour percentage constant and allows the uncertainty in the annual forecast factors to generate the confidence intervals. In this instance, the annual forecast factors were projected regional income and average air fares, along with a random Black Swan variable representing infrequent disruptive events.

In comparison with Exhibit C.2, the confidence intervals are much broader, indicating that there is much more uncertainty associated with the annual forecasts than with the DDFS forecast. Also, both the mean and the median of the Monte Carlo distribution are lower than the base forecast. This is because disruptive events represented by the Black Swan variable almost always have a negative impact on aviation activity. Typically, base planning forecasts do not include a future Black Swan variable.

Exhibit C.4 is similar to Exhibits C.2 and C.3 except that it combines annual and DDFS uncertainty in a single Monte Carlo test. Although the confidence intervals are slightly wider in

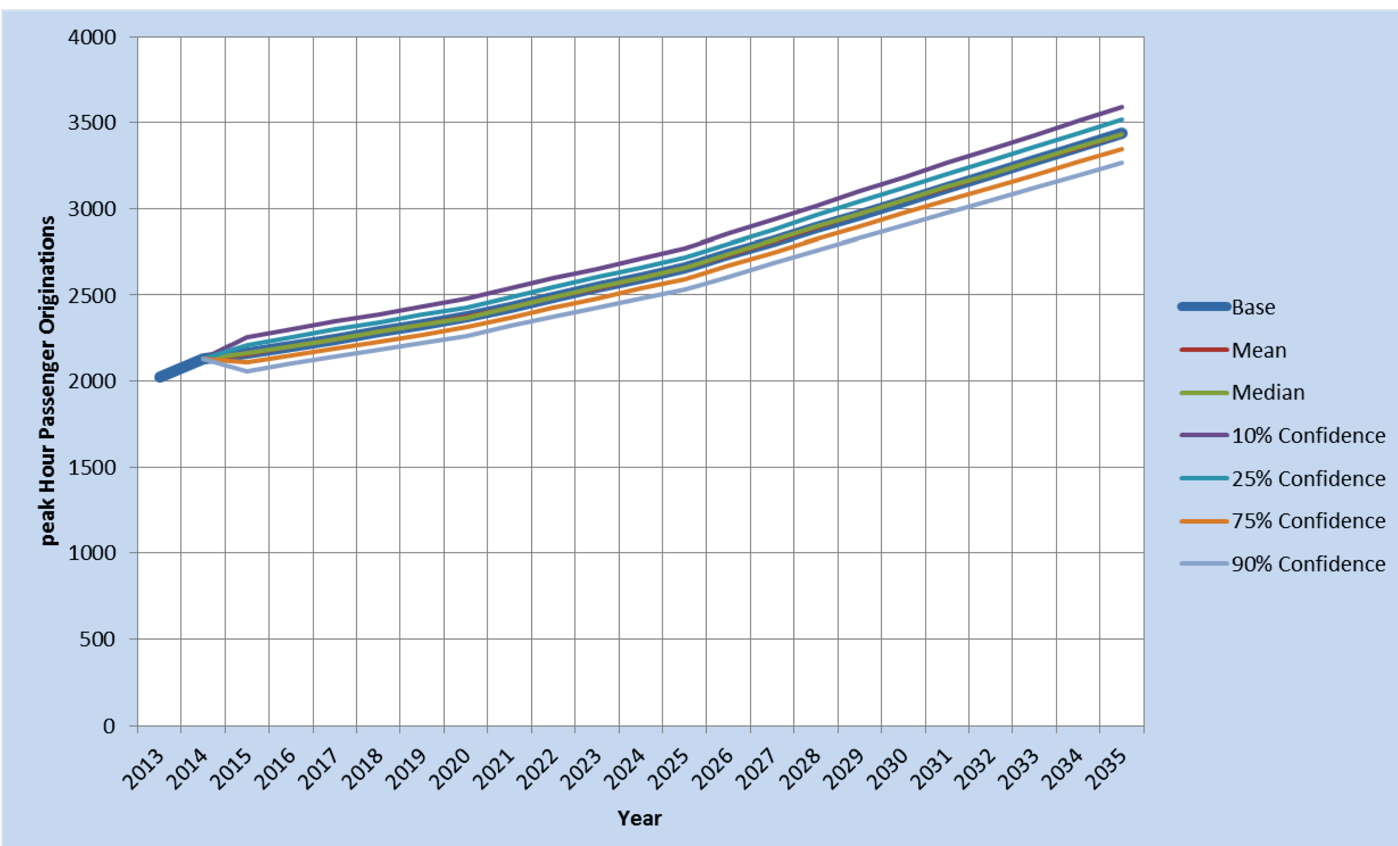


Exhibit C.2. Monte Carlo example: peak hour uncertainty independent of annual forecasting uncertainty.

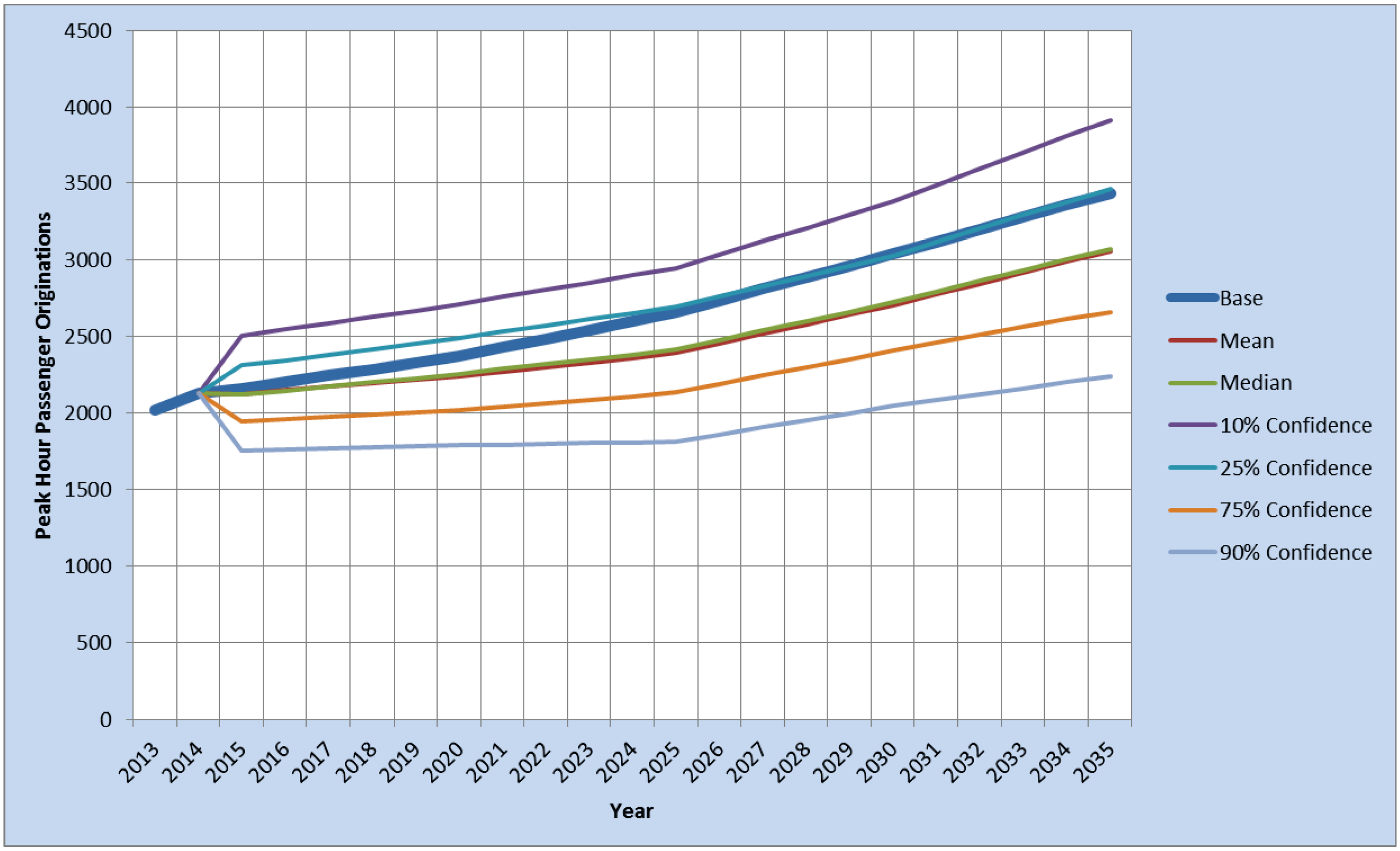


Exhibit C.3. Monte Carlo example: peak hour uncertainty based on annual forecasting uncertainty.

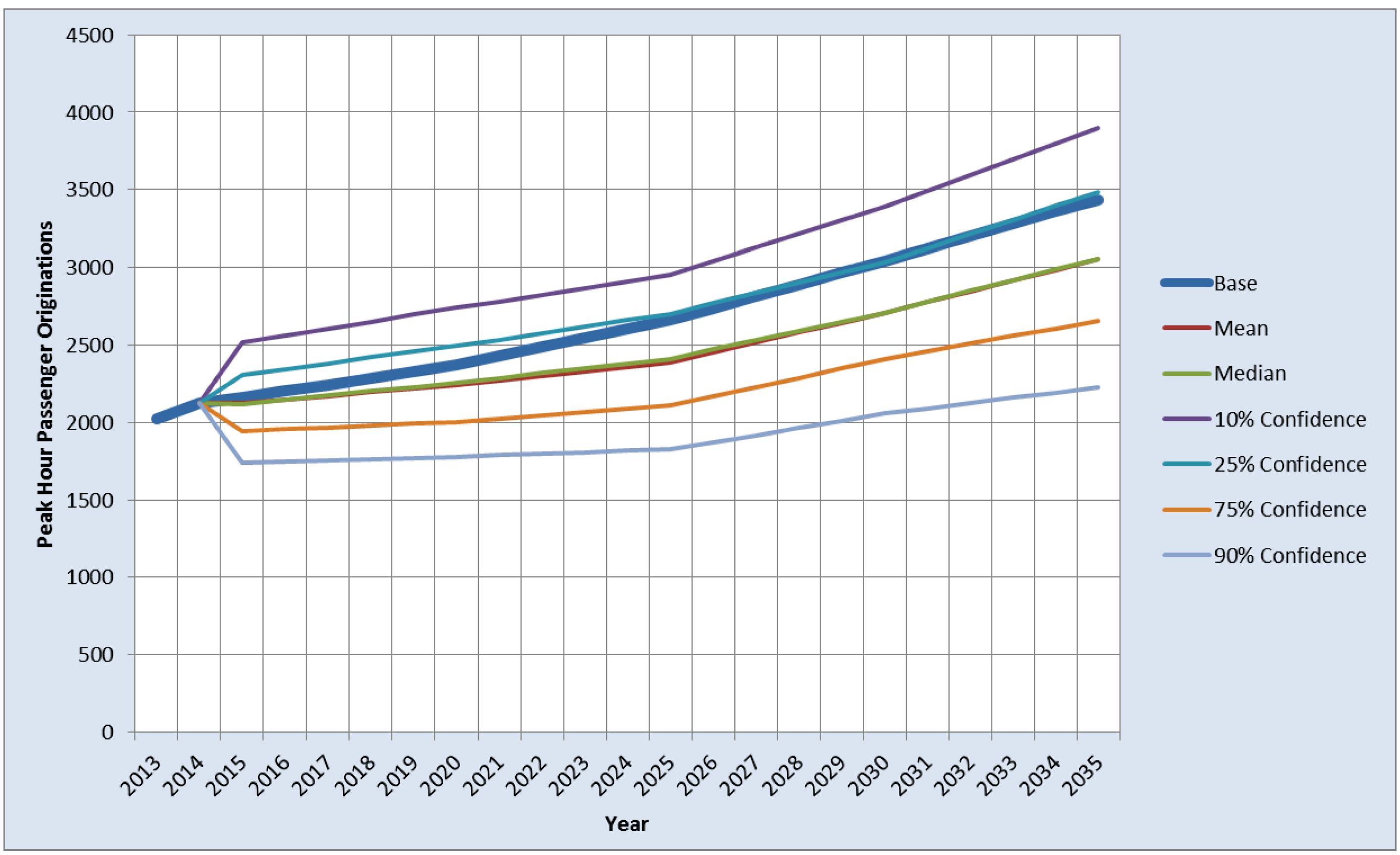


Exhibit C.4. Monte Carlo example: peak hour uncertainty based on annual and DDFS forecasting uncertainty.

Exhibit C.4 than in Exhibit C.3, the differences are not readily detectable when looking at the graphs. It should be noted that the confidence intervals associated with DDFS uncertainty are not additive to the confidence intervals associated with annual forecasting uncertainty. Within a Monte Carlo framework, there are many instances when a negative deviation in an annual forecast factor will be offset by a positive deviation in a DDFS forecast factor and vice versa. In general, adding uncertainty to a system will generate broader confidence intervals, but the increase will not be linear.

Ideally, the analysis would be performed for a large sample of airports. However, this test does suggest that it is more important to accurately assess the uncertainty associated with the annual forecasts than with the DDFS forecasts. Exceptions would be instances in which planning was based on annual activity levels. Since the annual activity level would essentially be defined as constant, an analysis of DDFS uncertainty would be appropriate to capture variations that occur even when annual activity levels do not change.

APPENDIX D

Confidence Intervals for DDFS Elements

A key challenge to addressing uncertainty in DDFSs is the level of resources required to first prepare and then apply each DDFS. This makes many traditional methods of evaluating uncertainty (alternative scenarios, sensitivity tests, Monte Carlo analyses applied directly to DDFSs) identified in Chapter 8 very costly. The objective of this appendix is to apply the research results from the development of this guidebook to estimate general confidence intervals for each DDFS element. These confidence intervals can be used to run Monte Carlo models of DDFS metrics (average delay, peak period passengers, etc.) without generating a new DDFS for each Monte Carlo simulation. This method does not offer quite the same degree of precision that would result from multiple DDFS and simulation runs but has the virtue of being more cost-effective and practical.

This appendix includes an assessment of confidence intervals associated with an analysis of historical schedule data and application of these confidence intervals estimates of facility. As part of the background research to this guidebook, the confidence intervals were calculated from an analysis of historical airline schedule data, in conjunction with planning factors from *ACRP Report 25: Airport Passenger Terminal Planning and Design,* Volumes 1 and 2 http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_025v1.pdf and airfield simulation analyses.

D.1 Confidence Intervals Associated with DDFS Elements

Historical airport activity information was used to quantify how much factors such as peak hour percentages, flight times, flight frequency, number of nonstop markets, and load factor were likely to fluctuate from the long-term trend.

Peak Periods

Table D.1 presents confidence intervals for peak hour passenger aircraft operations, aircraft arrivals, and aircraft departures at large, medium, small, and non-hub airports. The table indicates that, at large-hub airports, there is a 98 percent chance that the peak hour operations percentage will be at least 94 percent of the long-term peak hour percentage.

For example, at a large-hub airport that currently has 1000 daily passenger operations and 80 peak hour passenger operations, the peak hour percentage would be 8 percent (80/1000). If the 10 year forecast projects 1200 daily operations, and no peak spreading is assumed, the peak hour passenger operations forecast would be 96 (1200 × 8 percent). However, there is some uncertainty associated with this projection since the peak hour percentage varies from year to year. The intent of Table D.1 and subsequent tables is to quantify this uncertainty.

Table D.1. Peak hour operations by confidence interval.

	Variation in Peak Hour Operations by Confidence Interval								
	98%	95%	90%	75%	50%	25%	10%	5%	2%
				Peak Hour Aircraft Operations					
Large Hubs	94%	95%	96%	98%	100%	102%	104%	105%	106%
Medium Hubs	91%	92%	94%	97%	100%	103%	106%	108%	109%
Small Hubs	87%	89%	91%	96%	100%	104%	109%	111%	113%
Non-Hubs	79%	83%	87%	93%	100%	107%	113%	117%	121%
				Peak Hour Aircraft Arrivals					
Large Hubs	92%	93%	95%	97%	100%	103%	105%	107%	108%
Medium Hubs	88%	90%	92%	96%	100%	104%	108%	110%	112%
Small Hubs	84%	87%	90%	95%	100%	105%	110%	113%	116%
Non-Hubs	70%	75%	80%	90%	100%	110%	120%	125%	130%
				Peak Hour Aircraft Departures					
Large Hubs	92%	94%	95%	97%	100%	103%	105%	106%	108%
Medium Hubs	89%	91%	93%	96%	100%	104%	107%	109%	111%
Small Hubs	90%	92%	94%	97%	100%	103%	106%	108%	110%
Non-Hubs	85%	87%	90%	95%	100%	105%	110%	113%	115%

Continuing with the example, the large-hub row in Table D.1 indicates that there is a 98 percent chance that there will be at least 90 future peak hour operations (96 × 94 percent = 90). There is a 90 percent chance that there will be at least 92 peak hour operations (96 × 96 percent = 92). As would be expected with a normal probability distribution, there is a 50 percent chance that peak hour operations will be as high as the baseline peak hour forecast (96 × 100 percent). There is a two percent chance that there will be 102 peak hour operations or more (96 × 106 percent).

Note that, in this example, it is assumed that the annual forecasts are accurate. As noted earlier, the annual forecasts also carry some uncertainty. Therefore, the true peak hour confidence interval is a combination of the probability distribution associated with the annual forecasts and the probability distribution associated with the peak hour percentage.

As shown in Table D.1, the probability distribution decreases with airport size. At a large-hub airport, there is an 80 percent degree of confidence (90 percent minus 10 percent, highlighted in green) that the variation in the peak hour will be within plus/minus four percent (96 to 104 percent). At a non-hub airport, the same 80 degree of confidence, highlighted in blue, encompasses a variation of plus/minus 13 percent (87 to 113 percent).

Tables D.2 and D.3 are similar to Table D.1 except that they show the confidence intervals for the 30 minute and 15 minute peak instead of the 60 minute peak. The 30 minute and 15 minute peak distributions were derived from the 60 minute distributions by performing a Monte Carlo distribution of an existing DDFS and generating ratios of the 15 and 30 minute mean and standard deviations to the 60 minute mean and standard deviations. Activity levels during small time intervals tend to be more volatile than activity levels during larger time intervals. Therefore, the confidence intervals for the 30 minute and 15 minute peaks tend to be wider than for the 60 minute peaks.

Tables D.4 through D.6 are similar to Tables D.1 through D.3 but show scheduled seat arrivals and departures instead of aircraft operations. Seat arrival and departure distributions are useful because

Table D.2. Peak 30 minute operations by confidence interval.

	Variation in Peak 30 Minute Operations by Confidence Interval								
	98%	**95%**	**90%**	**75%**	**50%**	**25%**	**10%**	**5%**	**2%**
Peak 30 Minute Aircraft Operations									
Large Hubs	92%	93%	95%	97%	100%	103%	105%	107%	108%
Medium Hubs	87%	89%	91%	95%	100%	105%	109%	111%	113%
Small Hubs	81%	84%	88%	94%	100%	106%	112%	116%	119%
Non-Hubs	70%	75%	81%	90%	100%	110%	119%	125%	130%
Peak 30 Minute Aircraft Arrivals									
Large Hubs	91%	92%	94%	97%	100%	103%	106%	108%	109%
Medium Hubs	86%	88%	91%	95%	100%	105%	109%	112%	114%
Small Hubs	81%	85%	88%	94%	100%	106%	112%	115%	119%
Non-Hubs	65%	71%	77%	88%	100%	112%	123%	129%	135%
Peak 30 Minute Aircraft Departures									
Large Hubs	86%	88%	91%	95%	100%	105%	109%	112%	114%
Medium Hubs	80%	84%	87%	93%	100%	107%	113%	116%	120%
Small Hubs	83%	85%	89%	94%	100%	106%	111%	115%	117%
Non-Hubs	72%	77%	82%	91%	100%	109%	118%	123%	128%

Table D.3. Peak 15 minute operations by confidence interval.

	Variation in Peak 15 Minute Operations by Confidence Interval								
	98%	**95%**	**90%**	**75%**	**50%**	**25%**	**10%**	**5%**	**2%**
Peak 15 Minute Aircraft Operations									
Large Hubs	87%	90%	92%	96%	100%	104%	108%	110%	113%
Medium Hubs	79%	83%	87%	93%	100%	107%	113%	117%	121%
Small Hubs	70%	75%	81%	90%	100%	110%	119%	125%	130%
Non-Hubs	53%	61%	70%	84%	100%	116%	130%	139%	147%
Peak 15 Minute Aircraft Arrivals									
Large Hubs	86%	89%	91%	95%	100%	105%	109%	111%	114%
Medium Hubs	79%	82%	86%	93%	100%	107%	114%	118%	121%
Small Hubs	72%	77%	82%	91%	100%	109%	118%	123%	128%
Non-Hubs	47%	56%	66%	82%	100%	118%	134%	144%	153%
Peak 15 Minute Aircraft Departures									
Large Hubs	78%	81%	85%	92%	100%	108%	115%	119%	122%
Medium Hubs	68%	73%	79%	89%	100%	111%	121%	127%	132%
Small Hubs	72%	76%	82%	90%	100%	110%	118%	124%	128%
Non-Hubs	55%	62%	71%	85%	100%	115%	129%	138%	145%

Table D.4. Peak hour scheduled seats by confidence interval.

	Variation in Peak Hour Scheduled Seats by Confidence Interval								
	98%	**95%**	**90%**	**75%**	**50%**	**25%**	**10%**	**5%**	**2%**
Peak Hour Scheduled Seats									
Large Hubs	92%	93%	95%	97%	100%	103%	105%	107%	108%
Medium Hubs	90%	91%	93%	96%	100%	104%	107%	109%	110%
Small Hubs	85%	87%	90%	95%	100%	105%	110%	113%	115%
Non-Hubs	77%	81%	85%	92%	100%	108%	115%	119%	123%
Peak Hour Scheduled Seat Arrivals									
Large Hubs	92%	94%	95%	97%	100%	103%	105%	106%	108%
Medium Hubs	87%	89%	91%	95%	100%	105%	109%	111%	113%
Small Hubs	81%	85%	88%	94%	100%	106%	112%	115%	119%
Non-Hubs	66%	71%	78%	88%	100%	112%	122%	129%	134%
Peak Hour Scheduled Seat Departures									
Large Hubs	93%	94%	95%	98%	100%	102%	105%	106%	107%
Medium Hubs	88%	90%	92%	96%	100%	104%	108%	110%	112%
Small Hubs	89%	91%	93%	96%	100%	104%	107%	109%	111%
Non-Hubs	83%	86%	89%	94%	100%	106%	111%	114%	117%

Table D.5. Peak 30 minute seats by confidence interval.

	Variation in Peak 30 Minute Scheduled Seats by Confidence Interval								
	98%	**95%**	**90%**	**75%**	**50%**	**25%**	**10%**	**5%**	**2%**
Peak 30 Minute Scheduled Seats									
Large Hubs	88%	90%	92%	96%	100%	104%	108%	110%	112%
Medium Hubs	85%	87%	90%	95%	100%	105%	110%	113%	115%
Small Hubs	78%	82%	86%	93%	100%	107%	114%	118%	122%
Non-Hubs	66%	72%	78%	89%	100%	111%	122%	128%	134%
Peak 30 Minute Scheduled Seat Arrivals									
Large Hubs	91%	93%	94%	97%	100%	103%	106%	107%	109%
Medium Hubs	84%	87%	90%	95%	100%	105%	110%	113%	116%
Small Hubs	78%	82%	86%	93%	100%	107%	114%	118%	122%
Non-Hubs	60%	67%	74%	86%	100%	114%	126%	133%	140%
Peak 30 Minute Scheduled Seat Departures									
Large Hubs	87%	89%	91%	95%	100%	105%	109%	111%	113%
Medium Hubs	79%	82%	86%	93%	100%	107%	114%	118%	121%
Small Hubs	80%	83%	87%	93%	100%	107%	113%	117%	120%
Non-Hubs	69%	74%	80%	90%	100%	110%	120%	126%	131%

Table D.6. Peak 15 minute seats by confidence interval.

	Variation in 15 Minute Scheduled Seats by Confidence Interval								
	98%	95%	90%	75%	50%	25%	10%	5%	2%
Peak 15 Minute Scheduled Seats									
Large Hubs	81%	84%	88%	94%	100%	106%	112%	116%	119%
Medium Hubs	76%	80%	85%	92%	100%	108%	115%	120%	124%
Small Hubs	66%	72%	78%	88%	100%	112%	122%	128%	134%
Non-Hubs	47%	56%	66%	82%	100%	118%	134%	144%	153%
Peak 15 Minute Scheduled Seat Arrivals									
Large Hubs	87%	89%	91%	96%	100%	104%	109%	111%	113%
Medium Hubs	77%	81%	85%	92%	100%	108%	115%	119%	123%
Small Hubs	68%	73%	79%	89%	100%	111%	121%	127%	132%
Non-Hubs	40%	50%	61%	80%	100%	120%	139%	150%	160%
Peak 15 Minute Scheduled Seat Departures									
Large Hubs	78%	82%	86%	93%	100%	107%	114%	118%	122%
Medium Hubs	65%	71%	78%	88%	100%	112%	122%	129%	135%
Small Hubs	67%	73%	79%	89%	100%	111%	121%	127%	133%
Non-Hubs	50%	58%	67%	83%	100%	117%	133%	142%	150%

they can serve as proxy for passenger distributions. Empirical data on passenger peaks are generally not available, and therefore cannot be used to directly estimate peak hour passenger distributions.

The scheduled seat distributions have patterns that are similar to the passenger operations distributions but with slightly broader confidence intervals. This suggests that scheduled seat peaks, and associated passenger peaks, are slightly more volatile than passenger aircraft operation peaks.

Flight Times

Table D.7 is based on flight time analyses from historical airline schedule data. The Table shows the degree to which flight times to individual markets are likely to vary over time. The analysis was

Table D.7. Change in flight times by confidence interval.

	Variation of Change in Flight Time by Confidence Interval (min.)				
	50%	25%	10%	5%	2.5%
Atlanta - First Flight	9.5	14.9	19.8	22.7	25.2
Atlanta - Last Flight	9.0	14.4	19.3	22.2	24.7
PDX - First Flight	12.0	22.8	32.6	38.5	43.7
PDX - Last Flight	9.0	19.2	28.3	33.9	38.7
PVD- First Flight	18.0	30.9	42.5	49.5	55.6
PVD- Last Flight	15.0	26.5	36.9	43.2	48.7
SGF-First Flight	9.0	13.1	16.9	19.2	21.4
SGF-Last Flight	8.0	12.8	17.2	20.0	22.4

limited to the first and last flight of the day to markets in which the number of daily flights did not change. Flight times to markets where the number of flights do change are likely to vary more significantly. Appendix Q: New Flight Analysis in *ACRP WOD 14* (technical report accompanying *ACRP Report 82*) http://onlinepubs.trb.org/onlinepubs/acrp/acrp_w014.pdf provides more detail of the impact of new additional frequencies on flight times.

As shown from the examples in Table D.7, there appears to be at least a 50 percent chance that flight times to specific markets will vary by 8 minutes or more, and there is a 10 percent chance that they could vary as much 40 minutes depending on the airport.

The variation of flight times is important to the construction of DDFSs. Often, flight times in future DDFSs need to be changed to accommodate greater turnaround times (when the aircraft gauge increases) or a new flight pairing. The ranges in Table D.7 can provide a rough guide as to how much these times can be changed and still be consistent with current airport scheduling patterns.

Flight Frequency

The confidence intervals in Table D.8 are based on a flight frequency analysis of historical airline schedule data. The table shows the extent to which the number of daily flights to individual markets is likely to change over a 10 year period. The confidence intervals are quite broad, suggesting substantial volatility in flight frequency especially at non-hub airports. Note that the analysis was performed on data from 2005 to 2014, when there was substantial aircraft up-gauging accompanied by reduced flight frequency, in many small markets. Therefore, the data in Table D.8 may represent a secular trend rather than true random variation. It is possible that, had the analysis been performed during a more stable period in the airline industry, the confidence intervals would not be as broad.

Like the variation in flight times, the frequency of flights by market is important to the construction of DDFSs. When adding flights, the DDFS preparer must choose a balance between increasing frequencies to existing markets and introducing flights from new nonstop markets. The distributions in Table D.8 provide rough controls on the extent to which frequencies in existing markets can be changed.

Load Factor

Table D.9 provides confidence intervals for average load factors by market for large, medium, small, and non-hubs. The confidence intervals are relatively broad even for large airports. Two factors should be considered prior to applying these confidence intervals in the preparation or evaluation of DDFSs.

Table D.8. Flights per market by confidence interval.

	Variation in Individual Market Flight Frequencies by Confidence Interval								
	98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs	73%	78%	83%	91%	100%	109%	117%	122%	127%
Medium Hubs	51%	59%	68%	83%	100%	117%	132%	141%	149%
Small Hubs	54%	62%	70%	85%	100%	115%	130%	138%	146%
Non-Hubs	22%	35%	50%	74%	100%	126%	150%	165%	178%

Table D.9. Average load factor by confidence interval (markets).

	Variation in Individual Market Load Factors by Confidence Interval								
	98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs	69.4%	71.4%	73.6%	77.3%	81.4%	85.5%	89.2%	91.4%	93.4%
Medium Hubs	64.6%	66.8%	69.3%	73.6%	78.3%	83.0%	87.3%	89.8%	92.0%
Small Hubs	62.6%	64.9%	67.5%	71.8%	76.7%	81.6%	85.9%	88.5%	90.8%
Non-Hubs	59.9%	62.4%	65.3%	70.2%	75.6%	81.0%	85.9%	88.8%	91.3%

First the ranges include month-by-month variation in addition to year-by-year variation. If a future DDFS is based on a peak month that doesn't change, a more appropriate confidence interval would be based on data from just that month, which would be expected to exhibit less variation. Also, the variation in load factor has decreased over the last 10 years as airlines have reduced or eliminated service to low performing markets. Consequently, it is probable that load factor confidence intervals developed in future years will show less variation than those exhibited in Table C.9.

Table D.10 is similar to Table D.9 except that it shows load factor confidence intervals by airline rather than by market. As with the Table D.9 analysis, the cautions regarding seasonal variations and long-term reductions in the degree of variation apply.

D.2 Impact of DDFS Elements on Facility Requirements

This section examines the application of the confidence intervals earlier in this appendix upon facility requirements. Impacts on airfield and terminal/landside requirements are described.

Airfield Analysis

Table D.11 combines the peak hour confidence interval developed in Table C.1 together with the evaluation of the peak hour impact on delay performed as part of the research for this guidebook. The table shows that, in this instance, there is a 96 percent chance (98 percent – 2 percent) that the average aircraft delay per operation would vary plus/minus 0.07 minutes (4 seconds) or less from the baseline estimate as a result of a variation in the peak hour estimate. Note that these results are specific to the single airport that was tested, and that other airports may exhibit a different degree of variation.

Table D.10. Average load factor by confidence interval (airlines).

	Variation in Individual Carrier Load Factors by Confidence Interval								
	98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs	70.4%	72.2%	74.2%	77.6%	81.4%	85.2%	88.6%	90.6%	92.4%
Medium Hubs	65.6%	67.6%	70.0%	73.9%	78.3%	82.7%	86.6%	89.0%	91.0%
Small Hubs	63.4%	65.5%	68.0%	72.1%	76.7%	81.3%	85.4%	87.9%	90.0%
Non-Hubs	60.7%	63.1%	65.9%	70.5%	75.6%	80.7%	85.3%	88.1%	90.5%

Table D.11. Impact of peak hour operations on delay estimates.

	Variation in Peak Hour Operations by Confidence Interval								
	98%	95%	90%	75%	50%	25%	10%	5%	2%
Peak Hour Confidence Interval	94%	95%	96%	98%	100%	102%	104%	105%	106%
Estimated Variation in Delay (min.)									
Total	(0.07)	(0.06)	(0.05)	(0.03)	-	0.03	0.05	0.06	0.07

Sources: Table D.1.

Terminal and Landside Analysis

Tables D.12 through D.19 show how the terminal and landside facility requirements are likely to vary depending on the confidence intervals developed earlier in this appendix.

Table D.12 provides the confidence intervals for ticket position counters for large, medium, small, and non-hub airports. Included are examples of ticket counter requirements. In this instance, the table shows that if a large-hub airport has a requirement for 25 ticket counters, based on the variation in peak 30-minute departing seats (proxy for passenger originations) there is a 10 percent chance that the airport would need at least 27 ticket counter positions and a 5 percent chance that it would need at least 28 ticket counter positions.

Note that the planning factors used to develop facilities requirements are often based on long-term empirical observations of what works. Most airport users or operators would not consider a facility that meets demand only 50 percent of time as working. Therefore, it is likely that most planning factors implicitly include a safety margin that accounts for some of the variation detailed in these tables. To continue with the example, if a planner takes the baseline facility requirement (25 counter positions), assumes it accounts for none of the variation in peaking, and then increases the requirement to 28 to ensure that the facility operates effectively 95 percent of the time during peak periods, the facility would likely be overdesigned.

Table D.12. Variation in counter position requirements by airport size.

		Variation in Counter Position Requirements by Confidence Interval								
	Example Requirement	98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		87%	89%	91%	95%	100%	105%	109%	111%	113%
Medium Hubs		79%	82%	86%	93%	100%	107%	114%	118%	121%
Small Hubs		80%	83%	87%	93%	100%	107%	113%	117%	120%
Non-Hubs		69%	74%	80%	90%	100%	110%	120%	126%	131%
Sample Counter Requirements										
Large Hubs	25	22	22	23	24	25	26	27	28	28
Medium Hubs	15	12	12	13	14	15	16	17	18	18
Small Hubs	7	6	6	6	7	7	7	8	8	8
Non-Hubs	3	2	2	2	3	3	3	4	4	4

Note: Based on peak 30 minute originations.

Sources: Table D.5.

Table D.13. Variation in kiosk requirements by airport size.

		Variation in Kiosk Counter Requirements by Confidence Interval								
	Example Requirement	98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		87%	89%	91%	95%	100%	105%	109%	111%	113%
Medium Hubs		79%	82%	86%	93%	100%	107%	114%	118%	121%
Small Hubs		80%	83%	87%	93%	100%	107%	113%	117%	120%
Non-Hubs		69%	74%	80%	90%	100%	110%	120%	126%	131%
Sample Kiosk Requirements										
Large Hubs	20	17	18	18	19	20	21	22	22	23
Medium Hubs	12	9	10	10	11	12	13	14	14	15
Small Hubs	6	5	5	5	6	6	6	7	7	7
Non-Hubs	3	2	2	2	3	3	3	4	4	4

Note: Based on peak 30 minute originations.

Sources: Table D.5.

Table D.14. Variation in curbside counter positions by airport size.

		Variation in Curbside Counter Requirements by Confidence Interval								
	Example Requirement	98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		87%	89%	91%	95%	100%	105%	109%	111%	113%
Medium Hubs		79%	82%	86%	93%	100%	107%	114%	118%	121%
Small Hubs		80%	83%	87%	93%	100%	107%	113%	117%	120%
Non-Hubs		69%	74%	80%	90%	100%	110%	120%	126%	131%
Sample Curbside Counter Requirements										
Large Hubs	6	5	5	5	6	6	6	7	7	7
Medium Hubs	4	3	3	3	4	4	4	5	5	5
Small Hubs	3	2	2	3	3	3	3	3	4	4
Non-Hubs	2	1	1	2	2	2	2	2	3	3

Note: Based on peak 30 minute originations.

Sources: Table D.5.

Table D.15. Variation in baggage screening space requirements by airport size.

	Example Requirement (square feet)	Variation in Baggage Screening Space Requirements by Confidence Interval								
		98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		93%	94%	95%	98%	100%	102%	105%	106%	107%
Medium Hubs		88%	90%	92%	96%	100%	104%	108%	110%	112%
Small Hubs		89%	91%	93%	96%	100%	104%	107%	109%	111%
Non-Hubs		83%	86%	89%	94%	100%	106%	111%	114%	117%
Sample Baggage Screening Space Requirements										
Large Hubs	10000	9,265	9,387	9,525	9,751	10,000	10,249	10,475	10,613	10,735
Medium Hubs	6000	5,297	5,413	5,545	5,762	6,000	6,238	6,455	6,587	6,704
Small Hubs	3000	2,669	2,724	2,786	2,888	3,000	3,112	3,214	3,276	3,331
Non-Hubs	1500	1,245	1,287	1,335	1,414	1,500	1,586	1,665	1,713	1,755

Note: Based on peak 60 minute originations.

Sources: Table D.4.

Table D.16. Variation in required screening lanes by airport size.

	Example Requirement	Variation in Required Screening Lanes by Confidence Interval								
		98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		87%	89%	91%	95%	100%	105%	109%	111%	113%
Medium Hubs		79%	82%	86%	93%	100%	107%	114%	118%	121%
Small Hubs		80%	83%	87%	93%	100%	107%	113%	117%	120%
Non-Hubs		69%	74%	80%	90%	100%	110%	120%	126%	131%
Sample Required Screening lanes										
Large Hubs	10	9	9	9	10	10	10	11	11	11
Medium Hubs	7	6	6	6	6	7	8	8	8	8
Small Hubs	3	2	2	3	3	3	3	3	4	4
Non-Hubs	2	1	1	2	2	2	2	2	3	3

Note: Based on peak 30 minute originations.

Sources: Table D.5.

Table D.17. Variation in screening space requirements by airport size.

	Example Requirement (square feet)	Variation in Screening Space Requirement by Confidence Interval								
		98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		87%	89%	91%	95%	100%	105%	109%	111%	113%
Medium Hubs		79%	82%	86%	93%	100%	107%	114%	118%	121%
Small Hubs		80%	83%	87%	93%	100%	107%	113%	117%	120%
Non-Hubs		69%	74%	80%	90%	100%	110%	120%	126%	131%
Sample Required Screening lanes										
Large Hubs	10000	8,662	8,883	9,134	9,547	10,000	10,453	10,866	11,117	11,338
Medium Hubs	7000	5,505	5,753	6,033	6,494	7,000	7,506	7,967	8,247	8,495
Small Hubs	3000	2,398	2,497	2,610	2,796	3,000	3,204	3,390	3,503	3,602
Non-Hubs	2000	1,381	1,483	1,600	1,791	2,000	2,209	2,400	2,517	2,619

Note: Based on peak 30 minute originations.

Sources: Table D.5.

Table D.18. Variation in baggage claim frontage requirements by airport size.

	Example Requirement (feet)	Variation in Baggage Claim Frontage Requirements by Confidence Interval								
		98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		87%	89%	91%	96%	100%	104%	109%	111%	113%
Medium Hubs		77%	81%	85%	92%	100%	108%	115%	119%	123%
Small Hubs		68%	73%	79%	89%	100%	111%	121%	127%	132%
Non-Hubs		40%	50%	61%	80%	100%	120%	139%	150%	160%
Sample Required Screening lanes										
Large Hubs	1000	867	889	914	955	1,000	1,045	1,086	1,111	1,133
Medium Hubs	600	461	484	510	553	600	647	690	716	739
Small Hubs	300	203	219	238	267	300	333	362	381	397
Non-Hubs	150	61	75	92	120	150	180	208	225	239

Note: Based on peak 15 minute terminations.

Sources: Table D.6.

Table D.19. Variation in curbside requirements by airport size.

	Example Requirement (length in feet)	Variation in Curbside Length Requirements by Confidence Interval								
		98%	95%	90%	75%	50%	25%	10%	5%	2%
Large Hubs		92%	93%	95%	97%	100%	103%	105%	107%	108%
Medium Hubs		90%	91%	93%	96%	100%	104%	107%	109%	110%
Small Hubs		85%	87%	90%	95%	100%	105%	110%	113%	115%
Non-Hubs		77%	81%	85%	92%	100%	108%	115%	119%	123%
Sample Curbside Requirement										
Large Hubs	3000	2,754	2,795	2,841	2,917	3,000	3,083	3,159	3,205	3,246
Medium Hubs	1500	1,343	1,369	1,398	1,447	1,500	1,553	1,602	1,631	1,657
Small Hubs	1000	850	875	903	949	1,000	1,051	1,097	1,125	1,150
Non-Hubs	500	384	403	425	461	500	539	575	597	616

Note: Based on peak 60 minute originations and terminations.

Sources: Table D.4.

APPENDIX E

DDFS Quality Control Checks

A bottom-up preparation of a design day gated flight schedule can be a laborious and tedious process and, as such, is subject to error. The following list of QC checks is recommended prior to using the schedule for any simulation or analysis. Although time-consuming, debugging the schedule at this stage is much less expensive than after simulation modeling or environmental analysis is undertaken.

☐ **Arrivals/Departures Match Check:**

Does the number of aircraft arrivals match the number of aircraft departures by airline and by equipment type for each airline? *An exception may be made if the purpose is to model a specific day of the week rather than a more general design day.*

☐ **Pairing Match Check:**

At a gate, do all aircraft remain the same equipment type between arrival and departure? *This is obvious but sometimes overlooked.*

☐ **Gate Overlap Check:**

Are all gates occupied by only ONE aircraft at all times?

☐ **Passenger Match Check:**

Does the sum of passengers in the design day schedule match the design day estimate?

☐ **O&D Match Check:**

Does the sum of origin-destination passengers in the design day schedule match the design day estimate?

☐ **Connecting Passenger Check:**

Is the sum of connecting enplaning passengers in a departure bank equal to the sum of connecting deplaning passengers in the previous arrival bank estimate?

☐ **Turnaround Time Check:**

Is there a sufficient interval for loading and unloading passengers and cargo, as well as taking on fuel and supplies? *Large aircraft on long-haul flights generally require more time than small aircraft on short-haul flights. This can vary by airline; for example Southwest Airlines routinely turns flights around in 30 to 35 minutes whereas most mainline operators require fifty minutes or more. Long-haul international flights often require two hours. For wide-body aircraft making technical stops to refuel or relieve crews, brake cooling time can limit the minimum turnaround time. Turnaround times can be a potential pitfall if a future design day schedule is prepared by up-gauging from an existing schedule. For example, if a regional flight is up-gauged to a mainline flight, the arrival time may have to be advanced or the departure time delayed to maintain a reasonable turnaround time.*

☐ **Buffer Time Check:**

Has buffer time been provided between the scheduled departure time and the next arriving flight? *15 minutes is usually the minimum practical buffer time, although many airlines use 20-30 minutes. Since the reliability of arrival times is less with long-haul flights, the buffer times at international gates tend to be greater than at domestic gates.*

☐ **Origin/Destination Time Check:**

Do new flight times abide by all compatible airport curfews, and do arriving times at destination airports and departing times at origin airports correspond to when passengers are willing to fly and airlines are willing to provide service? *For example, it is very unusual for an East Coast market to see an arrival from the West Coast prior to 2-3 PM, since such a flight would have to depart prior to 6 AM local time. Likewise, there is a dearth of departures for the East Coast at West Coast airports between 4 PM and 11 PM (Flights between these times would arrive past midnight but not late enough to be a reasonable "red eye" flight arriving early in the morning).*

☐ **Schedule Coverage Check:**

Are scheduled flights realistic with origin/destination times, with as much coverage as possible through the day and with focus on the morning and afternoon peaks?

☐ **Consistency with Connecting Banks Check:**

Are new flight times for carriers with hub-and-spoke networks consistent with the connecting bank structure at their hub airports? *One source of guidance is the flight times from the same market and airline to other airports with similar distances and time zones.*

APPENDIX F

Data Sources

This appendix was adapted from Appendix B in *ACRP Report 82* http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_082.pdf and modified for DDFS preparation. It provides a listing of data that is useful for the preparation of DDFS. Included are potential sources for the data, a description of the type of data and the level of detail that is provided, and any costs or restrictions that are associated. In some instances, examples of the data interface or output are provided.

F.1 Aircraft Operations Data

Each aircraft take-off and landing is counted as an aircraft operation. The primary source of aircraft operations data is ATCT counts, which can be provided at varying levels of detail as shown in the following text. Additional sources such as the Official Airline Guides and U.S. DOT Form 41 data are also available. Small airports without ATCTs typically do not record operations data. In those instances, operations data can be supplemented with acoustical counters, either year round or for representative periods, to assemble estimates of annual, busy, and peak period activity. Following are descriptions of potential secondary sources of aircraft operations data.

Published Airline Schedules

Sources An Internet search of airline schedule data will show several private vendors who can provide this data.

Types of Data Published commercial airline schedule information including the published airline, operating airline (which may differ from the published airline under code-sharing agreements), flight number, aircraft type, O&D, flight itinerary, scheduled time of flight (departing and arriving at gate), and frequency during the week.

Level of Detail Disaggregated to the individual flight level.

Costs/Restrictions Includes no data for aircraft operators that do not publish a schedule. Vendors charge a fee to provide data.

Bureau of Transportation Statistics – Airline On-Time Statistics

Sources http://apps.bts.gov/xml/ontimesummarystatistics/src/index.xml

Types of Data Historical commercial airline schedule information including the operating airline, flight number, aircraft tail number, O&D, scheduled time of flight (departing and arriving at gate), actual time of flight, wheels-off time, and delay.

Level of Detail Disaggregated to the individual flight level.

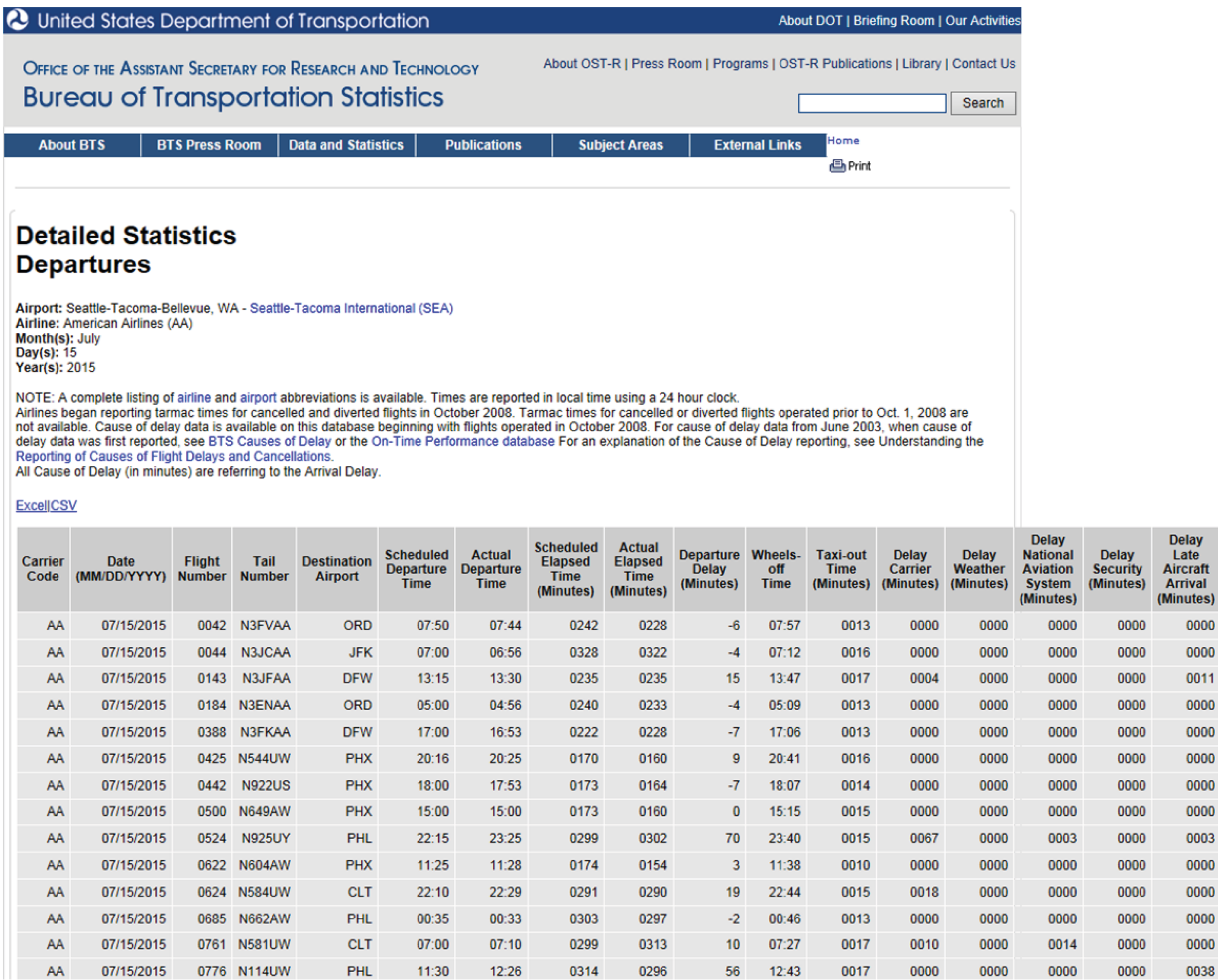
Costs/Restrictions Includes no data for aircraft operators that do not publish a schedule. There is a lag of several months before becoming publicly available.

Exhibit F.1 shows data for Seattle-Tacoma International Airport departures. Much of the data is related to delay, but original scheduled flight, airline, flight number, and destination airport are provided as well. The aircraft tail number can also be used to identify the aircraft type.

FAA Operations Network (OPSNET)

Sources FAA Operations and Performance website http://aspm.faa.gov/

Types of Data Provides data on operations for all FAA and FAA-contracted towered airports in the United States. Operations are organized according to six categories: air carrier, air taxi, itinerant GA, local GA, itinerant military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Airport: Seattle-Tacoma-Bellevue, WA - Seattle-Tacoma International (SEA)
Airline: American Airlines (AA)
Month(s): July
Day(s): 15
Year(s): 2015

NOTE: A complete listing of airline and airport abbreviations is available. Times are reported in local time using a 24 hour clock.
Airlines began reporting tarmac times for cancelled and diverted flights in October 2008. Tarmac times for cancelled or diverted flights operated prior to Oct. 1, 2008 are not available. Cause of delay data is available on this database beginning with flights operated in October 2008. For cause of delay data from June 2003, when cause of delay data was first reported, see BTS Causes of Delay or the On-Time Performance database For an explanation of the Cause of Delay reporting, see Understanding the Reporting of Causes of Flight Delays and Cancellations.
All Cause of Delay (in minutes) are referring to the Arrival Delay.

Excel|CSV

Carrier Code	Date (MM/DD/YYYY)	Flight Number	Tail Number	Destination Airport	Scheduled Departure Time	Actual Departure Time	Scheduled Elapsed Time (Minutes)	Actual Elapsed Time (Minutes)	Departure Delay (Minutes)	Wheels-off Time	Taxi-out Time (Minutes)	Delay Carrier (Minutes)	Delay Weather (Minutes)	Delay National Aviation System (Minutes)	Delay Security (Minutes)	Delay Late Aircraft Arrival (Minutes)
AA	07/15/2015	0042	N3FVAA	ORD	07:50	07:44	0242	0228	-6	07:57	0013	0000	0000	0000	0000	0000
AA	07/15/2015	0044	N3JCAA	JFK	07:00	06:56	0328	0322	-4	07:12	0016	0000	0000	0000	0000	0000
AA	07/15/2015	0143	N3JFAA	DFW	13:15	13:30	0235	0235	15	13:47	0017	0004	0000	0000	0000	0011
AA	07/15/2015	0184	N3ENAA	ORD	05:00	04:56	0240	0233	-4	05:09	0013	0000	0000	0000	0000	0000
AA	07/15/2015	0388	N3FKAA	DFW	17:00	16:53	0222	0228	-7	17:06	0013	0000	0000	0000	0000	0000
AA	07/15/2015	0425	N544UW	PHX	20:16	20:25	0170	0160	9	20:41	0016	0000	0000	0000	0000	0000
AA	07/15/2015	0442	N922US	PHX	18:00	17:53	0173	0164	-7	18:07	0014	0000	0000	0000	0000	0000
AA	07/15/2015	0500	N649AW	PHX	15:00	15:00	0173	0160	0	15:15	0015	0000	0000	0000	0000	0000
AA	07/15/2015	0524	N925UY	PHL	22:15	23:25	0299	0302	70	23:40	0015	0067	0000	0003	0000	0003
AA	07/15/2015	0622	N604AW	PHX	11:25	11:28	0174	0154	3	11:38	0010	0000	0000	0000	0000	0000
AA	07/15/2015	0624	N584UW	CLT	22:10	22:29	0291	0290	19	22:44	0015	0018	0000	0000	0000	0000
AA	07/15/2015	0685	N662AW	PHL	00:35	00:33	0303	0297	-2	00:46	0013	0000	0000	0000	0000	0000
AA	07/15/2015	0761	N581UW	CLT	07:00	07:10	0299	0313	10	07:27	0017	0010	0000	0014	0000	0000
AA	07/15/2015	0776	N114UW	PHL	11:30	12:26	0314	0296	56	12:43	0017	0000	0000	0000	0000	0038

Exhibit F.1. Sample of BTS airline on-time statistics.

and local military. IFR and VFR operations are included. Detailed delay data is also included.

Level of Detail Available on a daily, monthly or annual basis, but not on an hourly basis.

Costs/Restrictions None.

Exhibit F.2 shows 2015 monthly data for Omaha Eppley Airfield. The data can also be downloaded by day or by year.

Traffic Flow Management System (TFMS)

Sources FAA Air Traffic Airspace Lab

Types of Data ETMS contains individual flight information such as the date, time, aircraft identity (flight number or N-number)

Level of Detail Disaggregated to the individual flight level.

Costs/Restrictions Not generally available to the public. Requires special request from the FAA.

Traffic Flow Management System Counts (TFMSC) - Airport

Sources FAA Operations and Performance website http://aspm.faa.gov/

Types of Data Airport summary that includes counts by day, month, or year including aircraft type, and user group at towered airports.

Level of Detail Available on a daily, monthly or annual basis, but not on an hourly basis.

Costs/Restrictions None.

OPSNET: Airport Operations: Standard Report

From 01/2015 To 12/2015 | Facility=OMA

	Itinerant					Local			
Date	Air Carrier	Air Taxi	General Aviation	Military	Total	Civil	Military	Total	Total Operations
Jan-15	3,219	2,079	1,272	94	6,664	401	64	465	7,129
Feb-15	2,915	1,882	1,267	99	6,163	376	96	472	6,635
Mar-15	3,600	2,142	1,786	150	7,678	611	126	737	8,415
Apr-15	3,489	2,148	1,496	147	7,280	548	94	642	7,922
May-15	3,660	2,222	1,951	191	8,024	558	152	710	8,734
Jun-15	3,950	1,856	2,181	285	8,272	538	233	771	9,043
Jul-15	3,885	1,885	1,727	315	7,812	596	182	778	8,590
Aug-15	3,764	1,774	1,780	413	7,731	564	267	831	8,562
Sep-15	3,500	1,777	1,612	246	7,135	454	104	558	7,693
Oct-15	3,744	1,839	1,682	351	7,616	474	208	682	8,298
Nov-15	3,603	1,786	1,263	128	6,780	422	36	458	7,238
Dec-15	3,429	1,960	1,235	160	6,784	450	102	552	7,336
Total:	**42,758**	**23,350**	**19,252**	**2,579**	**87,939**	**5,992**	**1,664**	**7,656**	**95,595**

Report created on Mon Mar 28 08:58:14 EDT 2016
Sources: The OperationsNetwork (OPSNET)

Exhibit F.2. Sample of OPSNET data.

Exhibit F.3 provides a partial sample of TFMSC data for Omaha Eppley Airfield. Full samples include similar data for cargo, air taxi, and GA operations. Aircraft flying on VFR (VMC) are not included.

Traffic Flow Management System Counts (TFMSC) – Distributed OPSNET

Sources FAA Operations and Performance website http://aspm.faa.gov/

Types of Data OPSNET operations by arrival, departure, and hour at towered airports. Includes commercial (combined air carrier and air taxi), GA, and military.

Level of Detail Available on an hourly, daily, monthly or annual basis.

Costs/Restrictions None.

The hourly distributions in the Distributed OPSNET data are based on TFMS data, again for Omaha/Eppley Airfield (Exhibit F.4). They are then scaled up by category to match OPSNET data. Therefore, the hourly distribution of VMC operations is implicitly assumed to be the same as for IMC operations.

TFMSC Report (Airport)

From 7/15/2015 To 7/15/2015 I Airport=OMA

#	User Class	Aircraft	Departures	Arrivals	Total Operations	Departure Seats	Average Departure Seats	Arrival Seats	Average Arrival Seats
1	Air Carrier	A319 - Airbus A319	7	7	14	880	125	880	125
2	Air Carrier	A320 - Airbus A320 All Series	3	3	6	438	146	438	146
3	Air Carrier	AC50 - Aero Commander 500	2	2	4	8	4	8	4
4	Air Carrier	B190 - Beech 1900/C-12J	1	1	2	19	19	19	19
5	Air Carrier	B712 - Boeing 717-200	1	1	2	116	116	116	116
6	Air Carrier	B733 - Boeing 737-300	2	2	4	260	130	260	130
7	Air Carrier	B737 - Boeing 737-700	16	16	32	2,080	130	2,080	130
8	Air Carrier	B738 - Boeing 737-800	4	5	9	642	160	802	160
9	Air Carrier	BE40 - Raytheon/Beech Beechjet 400	2	2	4	10	5	10	5
10	Air Carrier	C208 - Cessna 208 Caravan	5	4	9	70	14	56	14
11	Air Carrier	C56X - Cessna Excel/XLS	1	0	1	15	15	0	0
12	Air Carrier	C750 - Cessna Citation X	1	0	1	14	14	0	0
13	Air Carrier	CL30 - Bombardier (Canadair) Challen	1	0	1	8	8	0	0
14	Air Carrier	CRJ2 - Bombardier CRJ-200	1	1	2	50	50	50	50
15	Air Carrier	CRJ7 - Bombardier CRJ-700	6	5	11	420	70	350	70
16	Air Carrier	CRJ9 - Bombardier CRJ-900	3	3	6	270	90	270	90
17	Air Carrier	DH8D - Bombardier Q-400	2	2	4	140	70	140	70
18	Air Carrier	E145 - Embraer ERJ-145	2	3	5	100	50	150	50
19	Air Carrier	E170 - Embraer 170	6	5	11	420	70	350	70
20	Air Carrier	E45X - Embraer ERJ 145 EX	4	6	10	200	50	300	50
21	Air Carrier	H25B - BAe HS 125/700-800/Hawker	0	2	2	0	0	24	12
22	Air Carrier	LJ40 - Learjet 40; Gates Learjet	1	0	1	10	10	0	0
23	Air Carrier	LJ45 - Bombardier Learjet 45	1	0	1	10	10	0	0
24	Air Carrier	LJ70 - Learjet 70	2	0	2	0	0	0	0
25	Air Carrier	LJ75 - Learjet 75	1	0	1	0	0	0	0
26	Air Carrier	MD83 Boeing (Douglas) MD 83	3	3	6	435	145	435	145

Exhibit F.3. Sample of TFMSC Airport data.

OPSNET Operations Prorated By TFMS Report

From 7/15/2015 To 7/15/2015 | Airport=OMA

#	Hour	Departure				Arrival				Total Operations
		AC+AT	GA	MIL	Total	AC+AT	GA	MIL	Total	
1	0	1	1	1	3	3	1	1	5	8
2	1	0	1	0	1	1	0	0	1	2
3	2	0	0	0	0	1	0	0	1	1
4	4	0	0	0	0	1	0	0	1	1
5	5	4	0	0	4	2	0	0	2	6
6	6	11	1	0	12	1	0	0	1	13
7	7	13	5	0	18	1	0	0	1	19
8	8	5	0	0	5	3	2	0	5	10
9	9	5	2	0	7	9	5	0	14	21
10	10	7	1	0	8	3	1	0	4	12
11	11	3	1	0	4	2	5	0	7	11
12	12	5	3	0	8	6	4	0	10	18
13	13	9	4	0	13	7	1	0	8	21
14	14	4	4	0	8	5	2	0	7	15
15	15	4	4	0	8	3	1	0	4	12
16	16	4	1	0	5	7	2	0	9	14
17	17	8	3	0	11	6	5	0	11	22
18	18	3	1	0	4	5	3	0	8	12
19	19	5	2	0	7	4	0	0	4	11
20	20	5	0	0	5	12	0	0	12	17
21	21	3	0	0	3	3	0	0	3	6
22	22	2	0	0	2	4	2	0	6	8
23	23	2	1	0	3	13	0	0	13	16
OPSNET Total :		**103**	**35**	**1**	**139**	**102**	**34**	**1**	**137**	**276**
TFMS Total * :		**104**	**26**	**0**	**130**	**96**	**21**	**0**	**117**	**247**
TFMS % Of OPSNET * :		**100.97**	**74.29**	**0**	**93.53**	**94.12**	**61.76**	**0**	**85.4**	**89.49**

* - Does not include TFMS records if Userclass = O-Other or is missing and does not include TFMS records missing specific times (hour = NA).

Report created on Mon Mar 28 09:24:34 EDT 2016
Sources: Traffic Flow Management System Counts (TFMSC), Aviation System Performance Metrics (ASPM)

Exhibit F.4. Sample of distributed OPSNET data.

Performance Data Analysis and Reporting System (PDARS)

Sources FAA Office of System Capacity and NASA Aviation Safety Program

Types of Data PDARS contains individual flight information such as the date, time, aircraft identity (flight number or N-number) and origin/destination.

Level of Detail Disaggregated to the individual flight level.

Costs/Restrictions Not generally available to the public. Requires special request that the FAA must approve.

Airport Noise and Operations Monitoring System (ANOMS)

Sources	Individual airports that have had the system installed.
Types of Data	Individual flight information such as the date, time, aircraft identity (flight number or N-number).
Level of Detail	Disaggregated to the individual flight level.
Costs/Restrictions	Varies by airport.

Exhibit F.5 shows a small sample from the Denver International Airport ANOMS database. These databases are often customized for individual airports, so the format may vary.

Archived Flight Information Display System (FIDS) Data

Sources	Individual airports that archive FIDS data.
Types of Data	Individual flight information such as the date, actual time, flight number, and gate assignment.
Level of Detail	Disaggregated to the individual flight level.
Costs/Restrictions	Varies by airport.

Exhibit F.6 shows a screen capture showing the type of data that is available from FIDS. The format and individual data elements may vary by airport.

Passenger Data

Passenger data can be segmented in many ways, by arrival (deplaning) or departure (enplaning), by local (O&D) or connecting, and by domestic or international O&D. A listing of potential sources of passenger data follows.

Airline Origin and Destination Survey (DB1B, O&D Survey)

Sources	Bureau of Transportation Statistics, Research and Innovative Technology Administration (RITA). http://transtats.bts.gov/ In addition, several private vendors provide this data in customized formats.
Types of Data	10 percent survey that contains the full routing for each passenger, including the origin, destination, and any connecting airports.
Level of Detail	Airport, airline, and destination market by quarter and year.
Costs/Restrictions	Available at no cost from RITA, vendors charge a fee. Only available for US-flag airlines. To access international data requires special permission from USDOT.

Exhibit F.7 shows the RITA interface for displaying and downloading origin-destination data. Several private vendors also provide the same data but with additional sort and display options.

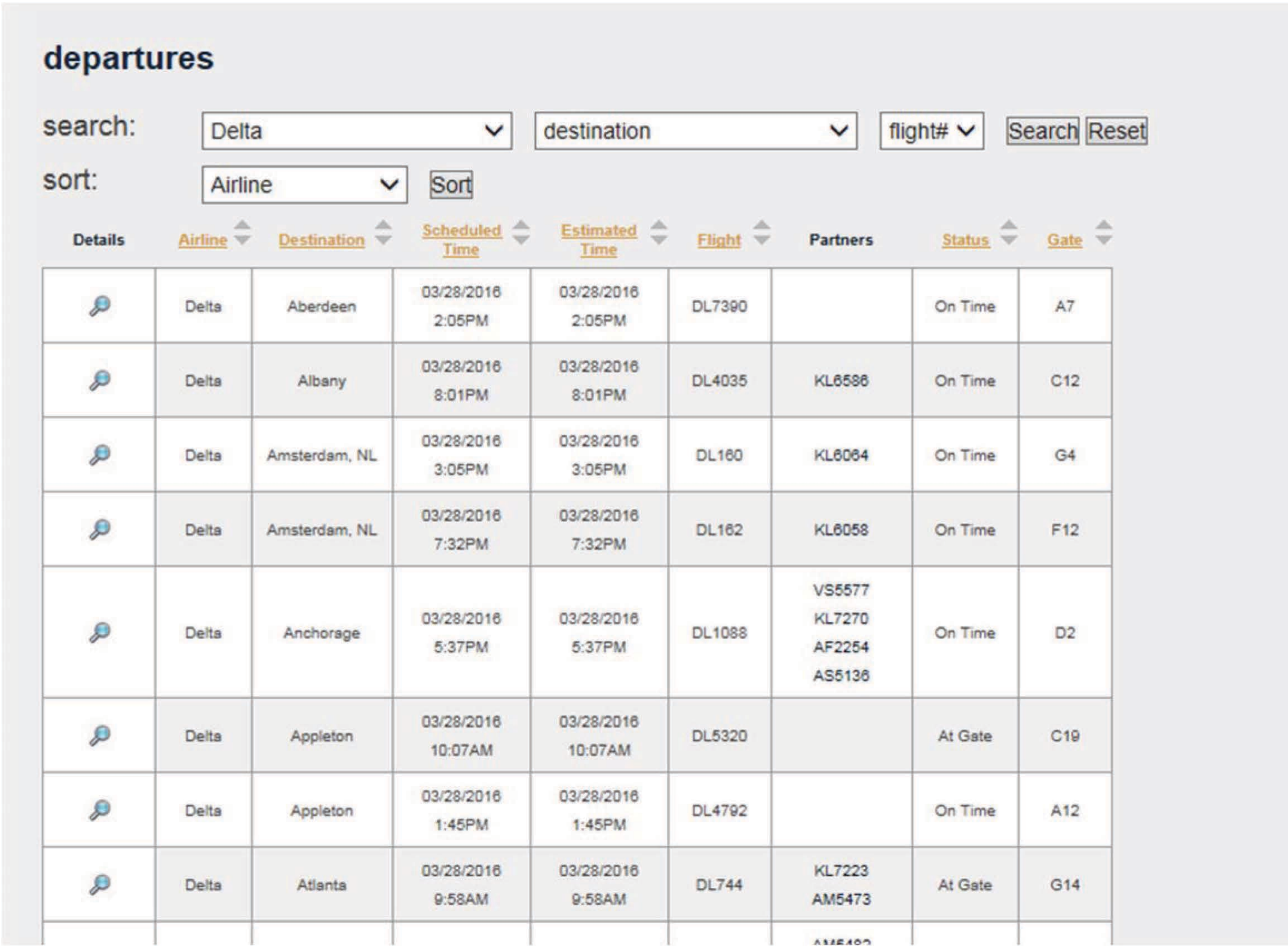
Form 41 Traffic Statistics (T-100 Reports)

Sources	Bureau of Transportation Statistics, RITA http://transtats.bts.gov/ In addition, several private vendors provide this data in customized formats.

PCA Timestamp	Operation No	Corr ID	Actual Date/Time	Flight No	Tail No	Airline	Aircraft Type	Runway Name	Other Port	AC Categ.	Airport ID	Beacon	Operation Type	Way Point	Operator Categ.	Path Name	PCA Alt (ft)	PCA Dist (mi)	PCA Range (mi)	PCA Slant (deg)	PCA Speed (m/s)	PCA Origin (lat)	PCA Origin (long)
1/1/13 0:05	13008066	17764567	1/1/2013	AAL1460	-	AAL	B738	8	KMIA	C	DEN	1467	D	-	-	-	5850.948	22.85059	22.8237	2.779636	0	39.86275	-105.049
1/1/13 0:11	13008067	17765542	1/1/2013	JBU490	-	JBU	A320	8	KBOS	C	DEN	1441	D	-	-	-	5463.808	22.36881	22.34486	2.651529	0	39.86275	-105.049
1/1/13 0:31	13008068	0	1/1/2013	AWE1531	-	AWE	A320	16L	KCLT	C	DEN	3136	A	-	-	-	5362.102	19.34063	19.31395	3.009907	72	39.86275	-105.049
1/1/13 1:07	13008075	17768110	1/1/2013	EGF3677	-	EGF	CRJ7	16L	KLAX	U	DEN	7232	A	-	UNK	-	10224.31	11.26639	11.09873	9.896914	117	39.86275	-105.049
1/1/13 5:54	13008086	17766910	1/1/2013	AAL328	-	AAL	MD83	17R	KDFW	C	DEN	1456	D	-	COM	-	5608.165	20.74874	20.72154	2.93432	0	39.86275	-105.049
1/1/13 6:05	13008088	17768111	1/1/2013	UAL810	-	UAL	B752	16L	PHNL	C	DEN	1372	A	-	COM	-	11638.35	2.611973	1.401342	57.55382	168	39.86275	-105.049
1/1/13 6:19	13008089	0	1/1/2013	AWE641	-	AWE	A319	17R	KPHX	C	DEN	1444	D	-	COM	-	5621.289	20.7321	20.70474	2.943557	95	39.86275	-105.049
1/1/13 6:21	13008090	17767611	1/1/2013	UAL532	-	UAL	A320	8	KORD	C	DEN	1411	D	-	COM	-	5516.302	22.10012	22.07542	2.709592	0	39.86275	-105.049
1/1/13 6:27	13008091	17767612	1/1/2013	AAL1210	-	AAL	MD83	8	KORD	C	DEN	1474	D	-	COM	-	5575.357	22.52522	22.50046	2.6869	0	39.86275	-105.049
1/1/13 6:32	13008093	17767613	1/1/2013	UAL103	-	UAL	B739	8	KIAD	U	DEN	1477	D	-	UNK	-	5719.714	22.75125	22.72545	2.729116	0	39.86275	-105.049
1/1/13 6:32	13008094	0	1/1/2013	UAL397	-	UAL	A320	17R	KIAH	C	DEN	1435	D	-	UNK	-	5955.934	20.73833	20.70763	3.118022	0	39.86275	-105.049
1/1/13 6:36	13008096	0	1/1/2013	SKW6245	-	SKW	CRJ7	17R	COS	U	DEN	5132	A	-	UNK	-	5457.247	20.67627	20.65042	2.865307	65	39.86275	-105.049
1/1/13 6:45	13008098	0	1/1/2013	UAL224	-	UAL	A320	17R	KLAX	C	DEN	1460	D	-	COM	-	16434.94	12.93682	12.55677	13.92232	178	39.86275	-105.049
1/1/13 6:45	13008099	0	1/1/2013	SKW5518	-	SKW	CRJ7	16L	KFSD	U	DEN	2443	A	-	UNK	-	5440.843	19.35239	19.32494	3.052289	67	39.86275	-105.049
1/1/13 6:45	13008100	17767614	1/1/2013	DAL1516	-	DAL	B752	8	KATL	C	DEN	1427	D	-	UNK	-	5627.85	22.3682	22.34279	2.731271	0	39.86275	-105.049
1/1/13 6:47	13008101	17767010	1/1/2013	TCF3466	-	TCF	E170	16L	KDFW	U	DEN	2265	A	-	UNK	-	5440.843	19.35615	19.32871	3.051695	72	39.86275	-105.049
1/1/13 6:50	13008102	0	1/1/2013	ASQ5965	-	ASQ	E45X	16L	KFAR	U	DEN	3601	A	-	UNK	-	5362.102	19.34	19.31332	3.010005	72	39.86275	-105.049
1/1/13 6:54	13008103	0	1/1/2013	SKW3275	-	SKW	CRJ7	17R	KASE	U	DEN	5131	D	-	UNK	-	15896.88	5.396885	4.47902	33.90878	164	39.86275	-105.049
1/1/13 6:52	13008104	17767011	1/1/2013	UAL797	-	UAL	A320	16L	KMSP	C	DEN	2423	A	-	UNK	-	5440.843	19.351	19.32355	3.052508	66	39.86275	-105.049
1/1/13 6:54	13008105	0	1/1/2013	TCF3503	-	TCF	E170	26	KOMA	U	DEN	2450	A	-	UNK	-	5440.843	22.57498	22.55145	2.616245	59	39.86275	-105.049
1/1/13 6:58	13008107	0	1/1/2013	GLA233	-	GLA	B190	26	PIR	T	DEN	2661	A	-	COM	-	5440.843	22.03068	22.00657	2.68093	71	39.86275	-105.049
1/1/13 6:58	13008108	0	1/1/2013	SKW6468	-	SKW	CRJ2	16L	KBIS	U	DEN	3675	A	-	UNK	-	5440.843	19.34525	19.31778	3.053417	65	39.86275	-105.049
1/1/13 7:01	13008109	0	1/1/2013	FFT211	-	FFT	A319	26	KAUS	C	DEN	2503	A	-	UNK	-	5440.843	22.45844	22.43479	2.62983	66	39.86275	-105.049
1/1/13 7:03	13008110	0	1/1/2013	SKW6228	-	SKW	CRJ7	26	KTUL	U	DEN	1140	A	-	UNK	-	5440.843	21.81322	21.78887	2.707676	64	39.86275	-105.049
1/1/13 7:03	13008111	17767013	1/1/2013	UAL429	-	UAL	A319	16L	KDSM	C	DEN	2645	A	-	UNK	-	5440.843	19.36203	19.33459	3.050769	64	39.86275	-105.049
1/1/13 7:05	13008112	0	1/1/2013	ASQ5926	-	ASQ	E45X	16L	KMOT	U	DEN	2472	A	-	UNK	-	5362.102	19.29581	19.26907	3.016904	15	39.86275	-105.049
1/1/13 7:00	13008113	17767012	1/1/2013	ASQ6002	-	ASQ	E45X	16L	KLNK	U	DEN	3666	A	-	UNK	-	5440.843	19.36482	19.33738	3.050328	71	39.86275	-105.049
1/1/13 7:06	13008114	0	1/1/2013	SKW5499	-	SKW	CRJ2	26	KGFK	U	DEN	2411	A	-	UNK	-	5362.102	22.38097	22.35792	2.600723	69	39.86275	-105.049
1/1/13 7:04	13008115	0	1/1/2013	GJS3680	-	GJS	CRJ7	26	KSTL	U	DEN	1131	A	-	UNK	-	5440.843	22.33257	22.30879	2.644663	70	39.86275	-105.049
1/1/13 7:11	13008116	17767810	1/1/2013	EGF3672	-	EGF	CRJ7	25	KLAX	U	DEN	1423	D	-	UNK	-	12130.48	3.992142	3.264809	35.13396	169	39.86275	-105.049
1/1/13 7:09	13008117	0	1/1/2013	FFT384	-	FFT	A319	17R	KFLL	C	DEN	1440	D	-	UNK	-	5772.207	20.74621	20.71739	3.020598	0	39.86275	-105.049
1/1/13 7:12	13008118	0	1/1/2013	FFT127	-	FFT	A319	26	KDFW	C	DEN	2305	A	-	UNK	-	5440.843	22.38157	22.35784	2.638869	68	39.86275	-105.049
1/1/13 7:13	13008119	17768310	1/1/2013	AWE1530	-	AWE	A320	17L	KCLT	C	DEN	1410	D	-	UNK	-	5906.722	21.74102	21.71222	2.949492	97	39.86275	-105.049
1/1/13 7:07	13008122	0	1/1/2013	SKW5544	-	SKW	CRJ7	26	KDRO	U	DEN	5147	A	-	UNK	-	12986.77	13.94403	13.72539	10.15968	154	39.86275	-105.049
1/1/13 7:17	13008123	17767014	1/1/2013	RPA1549	-	RPA	E190	16L	KFSD	U	DEN	3654	A	-	UNK	-	5440.843	19.28954	19.262	3.062244	44	39.86275	-105.049
1/1/13 7:06	13008125	0	1/1/2013	ASQ6153	-	ASQ	E45X	16L	KMTJ	U	DEN	5124	A	-	UNK	-	11021.55	11.27396	11.07903	10.67009	138	39.86275	-105.049
1/1/13 7:13	13008127	17767015	1/1/2013	SKW5626	-	SKW	CRJ7	16L	GJT	U	DEN	5113	A	-	UNK	-	11028.11	11.28514	11.09017	10.66582	123	39.86275	-105.049
1/1/13 7:25	13008129	0	1/1/2013	AAL664	-	AAL	MD83	17R	KDFW	C	DEN	1461	D	-	COM	-	5585.199	20.7734	20.74645	2.918823	0	39.86275	-105.049
1/1/13 7:25	13008130	17767016	1/1/2013	RPA1333	-	RPA	E190	16L	KOMA	U	DEN	2623	A	-	UNK	-	5362.102	19.35365	19.32699	3.00788	71	39.86275	-105.049
1/1/13 7:25	13008131	0	1/1/2013	SKW5337	-	SKW	CRJ2	26	KMAF	U	DEN	2322	A	-	UNK	-	5440.843	22.32393	22.30013	2.645688	66	39.86275	-105.049
1/1/13 7:26	13008132	0	1/1/2013	FFT670	-	FFT	A319	17R	KMCO	C	DEN	1430	D	-	UNK	-	5568.795	20.74206	20.71523	2.914643	0	39.86275	-105.049
1/1/13 7:27	13008134	0	1/1/2013	RPA4936	-	RPA	DH8D	26	KICT	T	DEN	1146	A	-	COM	-	5362.102	21.75729	21.73358	2.675326	61	39.86275	-105.049
1/1/13 7:27	13008135	17767017	1/1/2013	RPA1791	-	RPA	E190	16L	KMSP	U	DEN	3676	A	-	UNK	-	5440.843	19.34739	19.31993	3.053079	71	39.86275	-105.049

Source: Denver International Airport.

Exhibit F.5. Sample of ANOMS data.



departures

search: Delta | destination | flight# | Search | Reset

sort: Airline | Sort

Details	Airline	Destination	Scheduled Time	Estimated Time	Flight	Partners	Status	Gate
	Delta	Aberdeen	03/28/2016 2:05PM	03/28/2016 2:05PM	DL7390		On Time	A7
	Delta	Albany	03/28/2016 8:01PM	03/28/2016 8:01PM	DL4035	KL6586	On Time	C12
	Delta	Amsterdam, NL	03/28/2016 3:05PM	03/28/2016 3:05PM	DL160	KL6064	On Time	G4
	Delta	Amsterdam, NL	03/28/2016 7:32PM	03/28/2016 7:32PM	DL162	KL6058	On Time	F12
	Delta	Anchorage	03/28/2016 5:37PM	03/28/2016 5:37PM	DL1088	VS5577 KL7270 AF2254 AS5136	On Time	D2
	Delta	Appleton	03/28/2016 10:07AM	03/28/2016 10:07AM	DL5320		At Gate	C19
	Delta	Appleton	03/28/2016 1:45PM	03/28/2016 1:45PM	DL4792		On Time	A12
	Delta	Atlanta	03/28/2016 9:58AM	03/28/2016 9:58AM	DL744	KL7223 AM5473	At Gate	G14

Exhibit F.6. Sample of FIDS data.

Types of Data Data on all passengers and cargo on U.S. and foreign-flag airlines who are traveling on flight segments within the United States, and flight segments between the United States and foreign points provided by airport, airline, and equipment type.

Level of Detail Monthly and annual basis.

Costs/Restrictions Available at no cost from RITA, vendors charge a fee.

Exhibit F.8 shows the RITA interface for displaying and downloading T-100 traffic statistics.

Marketing Information Data Transfer (MIDT) (Travel Agency booking data)

Sources The data is available for purchase through several different vendors

Types of Data Booking data collected by flight coupon (flight segment, or boarding of an aircraft) so that the full routing is provided for each passenger, including the origin, destination, and any connecting airports

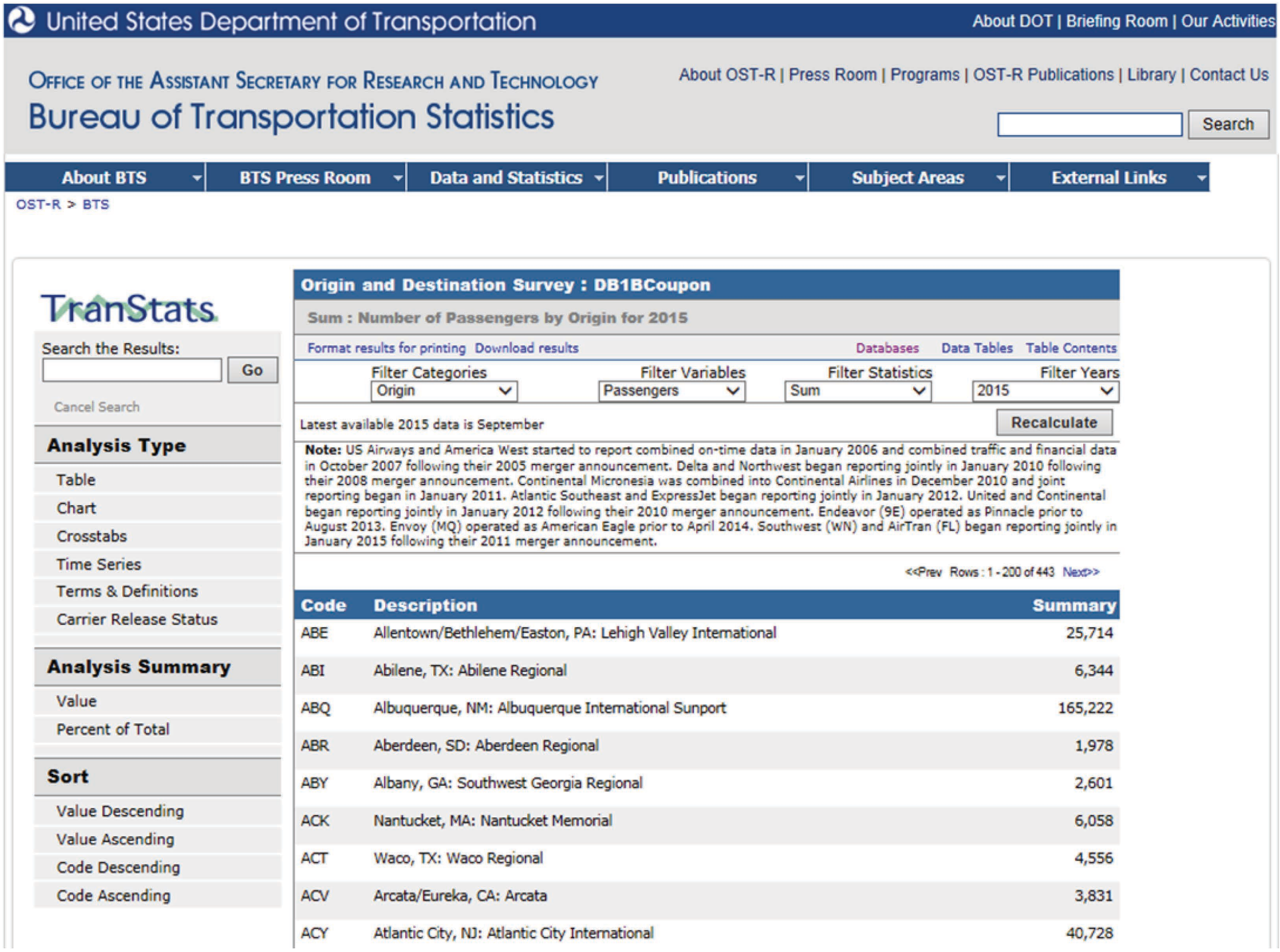


Exhibit F.7. Sample of RITA origin-destination data.

Level of Detail Monthly and annual basis

Costs/Restrictions Prices vary depending on the data requested.

IATA Billing and Settlement Plan (BSP) Data (Foreign Point-of-Sale Travel Agency ticketing data)

Sources Available for purchase through an IATA-designated vendor.

Types of Data Ticketing data is collected by flight coupon (flight segment, or boarding of an aircraft) so that the full routing is provided for each passenger, including the origin, destination, and any connecting airports used.

Level of Detail Monthly and annual basis.

Costs/Restrictions Prices vary depending on the data requested.

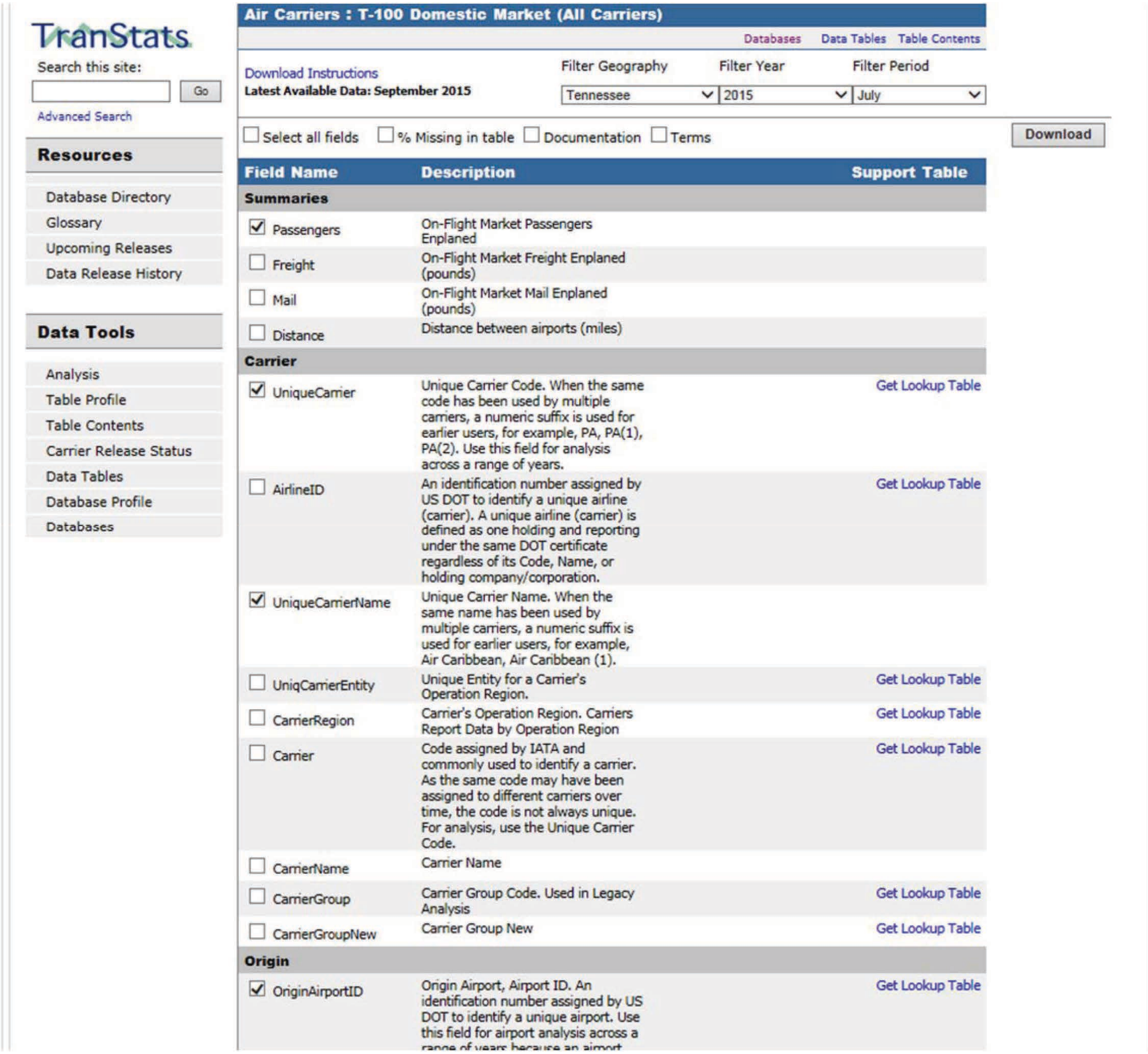


Exhibit F.8. Sample of RITA T-100 data.

Airline Reporting Corporation (ARC) Data (U.S. Point-of-Sale Travel Agency ticketing data)

Sources Airline Reporting Corporation
http://arctravelcard.com/solutions/industry-analysis.jsp

Types of Data Ticketing data organized by flight coupon (flight segment, or boarding of an aircraft) so that the full routing is provided for each passenger, including the origin, destination, and any connecting airports used.

Level of Detail Available for specific travel dates and specific flight numbers,

Costs/Restrictions Prices vary depending on the data requested.

F.2 Annual Forecasts

In addition to the TAF detailed below (Exhibit F.9), annual forecasts can be obtained from airport master plans or other planning studies, regional or state system plans, and private vendors.

APO TAF Quick Data Summary Report - Facility

For National Forecast 2015 -- 2015 Scenario

Region State: ASO-NC | LOCID: RDU Radar Towers

City: RALEIGH/DURHAM | Airport: RALEIGH-DURHAM INTL

2014 Based Aircraft: 162

	-- ENPLANEMENTS --			-- AIRPORT OPERATIONS --									-- TRACON --
				-- Itinerant Operations --					-- Local Operations --				
Fiscal Year	Air Carrier	Commuter	Total	Air Carrier	AT & Comm	GA	Military	Total	Civil	Military	Total	Total OPS	Total OPS
2011	3,060,123	1,411,702	4,471,825	88,408	56,153	41,082	5,712	191,355	64	50	114	191,469	244,407
2012	3,055,647	1,432,968	4,488,615	85,826	55,565	44,577	5,387	191,355	40	14	54	191,409	243,588
2013	3,114,632	1,354,612	4,469,244	84,906	50,055	44,364	4,894	184,219	240	63	303	184,522	234,722
2014	3,246,942	1,369,412	4,616,354	94,043	41,656	43,698	4,178	183,575	458	230	688	184,263	234,973
2015	* 3,321,489	1,443,885	4,765,374	100,827	31,665	43,408	4,148	180,048	815	127	942	180,990	231,008
2016	* 3,770,936	1,286,447	5,057,383	102,384	31,562	42,464	4,148	180,558	815	127	942	181,500	231,335
2017	* 3,871,023	1,320,328	5,191,351	106,182	30,582	42,694	4,148	183,606	815	127	942	184,548	234,810
2018	* 3,965,867	1,351,084	5,316,951	110,436	28,680	42,925	4,148	186,189	815	127	942	187,131	237,737
2019	* 4,063,821	1,383,959	5,447,780	115,071	26,410	43,158	4,148	188,787	815	127	942	189,729	240,659
2020	* 4,182,523	1,423,007	5,605,530	120,400	23,995	43,392	4,148	191,935	815	127	942	192,877	244,169
2021	* 4,297,004	1,462,621	5,759,625	126,236	20,847	43,626	4,148	194,857	815	127	942	195,799	247,414
2022	* 4,399,412	1,497,170	5,896,582	132,380	16,677	43,861	4,148	197,066	815	127	942	198,008	249,856
2023	* 4,495,409	1,529,926	6,025,335	137,307	13,971	44,098	4,148	199,524	815	127	942	200,466	252,615
2024	* 4,592,684	1,563,157	6,155,841	140,599	13,610	44,336	4,148	202,693	815	127	942	203,635	256,231
2025	* 4,687,697	1,595,333	6,283,030	143,484	13,734	44,575	4,148	205,941	815	127	942	206,883	259,952
2026	* 4,788,356	1,627,816	6,416,172	146,465	13,851	44,816	4,148	209,280	815	127	942	210,222	263,779
2027	* 4,887,359	1,660,333	6,547,692	149,434	13,972	45,058	4,148	212,612	815	127	942	213,554	267,605
2028	* 4,986,191	1,693,059	6,679,250	152,405	14,095	45,301	4,148	215,949	815	127	942	216,891	271,433
2029	* 5,086,641	1,725,708	6,812,349	155,405	14,222	45,546	4,148	219,321	815	127	942	220,263	275,296
2030	* 5,190,789	1,760,067	6,950,856	158,530	14,350	45,792	4,148	222,820	815	127	942	223,762	279,287
2031	* 5,297,247	1,793,692	7,090,939	161,667	14,478	46,039	4,148	226,332	815	127	942	227,274	283,294
2032	* 5,407,163	1,830,331	7,237,494	164,978	14,607	46,288	4,148	230,021	815	127	942	230,963	287,492
2033	* 5,521,367	1,868,572	7,389,939	168,452	14,740	46,538	4,148	233,878	815	127	942	234,820	291,871
2034	* 5,637,276	1,906,846	7,544,122	171,929	14,870	46,789	4,148	237,736	815	127	942	238,678	296,268
2035	* 5,756,219	1,945,789	7,702,008	175,490	15,011	47,042	4,148	241,691	815	127	942	242,633	300,771
2036	* 5,871,046	1,983,959	7,855,005	178,991	15,139	47,296	4,148	245,574	815	127	942	246,516	305,205
2037	* 5,986,804	2,021,913	8,008,717	182,468	15,273	47,552	4,148	249,441	815	127	942	250,383	309,618
2038	* 6,100,625	2,059,786	8,160,411	185,904	15,411	47,809	4,148	253,272	815	127	942	254,214	314,001
2039	* 6,212,255	2,096,590	8,308,845	189,264	15,556	48,067	4,148	257,035	815	127	942	257,977	318,314
2040	* 6,322,910	2,132,052	8,454,962	192,549	15,694	48,327	4,148	260,718	815	127	942	261,660	322,547
GR1	2.59	1.71	2.35	2.79	-3.68	0.38	-0.02	1.35	2.24	-2.25	1.21	1.35	1.22
GR2	2.6	1.57	2.32	2.62	-2.76	0.43	0	1.49	0	0	0	1.48	1.34

GR1: Growth Rate from 2014 to 2040 GR2: Growth Rate from 2015 to 2040

Report created 3/28/2016 09:47

Exhibit F.9. Example of TAF for Raleigh-Durham International Airport.

FAA Terminal Area Forecast (TAF)

Sources FAA Operations and Performance website http://aspm.faa.gov/

Types of Data Air Carrier and Regional Carrier enplanements. Operations by Air Carrier, Commuter/Air Taxi, and Itinerant and Local GA and Military

Level of Detail Annual

Costs/Restrictions None

F.3 Summary of Applicable Data Sources

Exhibits F.10 through F.16 provide a summary of the data sources that are likely to be useful in the preparation of DDFS.

Activity Category	Airline Schedule	T-100	OPSNET	TFMSC	Airport
Scheduled Passenger Carrier	F	F	T*	F*	I
Nonscheduled Passenger Carrier		F	T*	F*	I
All-Cargo Carrier		F	T*	F*	I
Air Taxi			T*	F*	I
GA			T*	F*	I
Military			T*	F*	I

F = Fleet mix detail
F*= Fleet mix detail for instrument operations at towered airports.
T* = Total operations at towered airports.
I = Intermittent – available at airports that compile radar data as part of their noise monitoring operations

Exhibit F.10. Annual and monthly aircraft operations.

Activity Category	Airline Schedule	T-100	OPSNET	TFMSC	Airport
Scheduled Passenger Carrier	F		T*	T*	I
Nonscheduled Passenger Carrier			T*	T*	I
All-Cargo Carrier			T*	T*	I
Air Taxi			T*	T*	I
GA			T*	T*	I
Military			T*	T*	I

F = Fleet mix detail
F*= Fleet mix detail for instrument operations at towered airports.
T* = Total operations at towered airports.
I = Intermittent – available at airports that compile radar data as part of their noise monitoring operations

Exhibit F.11. Daily aircraft operations.

Activity Category	Airline Schedule	T-100	OPSNET	TFMSC	Airport
Scheduled Passenger Carrier	F			T*	I
Nonscheduled Passenger Carrier				T*	I
All-Cargo Carrier				T*	I
Air Taxi				T*	I
GA				T*	I
Military				T*	I

F = Fleet mix detail
F*= Fleet mix detail for instrument operations at towered airports.
T* = Total operations at towered airports.
I = Intermittent–available at airports that compile radar data as part of their noise monitoring operations

Exhibit F.12. Hourly aircraft operations.

Activity Category	Airline Schedule	T-100	OPSNET	TFMSC	Airport
Scheduled Passenger Carrier	F	F		F*	I
Nonscheduled Passenger Carrier		F		F*	I
All-Cargo Carrier		F		F*	I
Air Taxi				F*	I
GA				F*	I
Military				F*	I

F = Fleet mix detail
F*= Fleet mix detail for instrument operations at towered airports. Seats and payload capacity for each aircraft would need to be obtained from alternate sources.
T* = Total operations at towered airports.
I = Intermittent – available at airports that compile radar data as part of their noise monitoring operations. Seats and payload capacity for each aircraft would need to be obtained from alternate sources.

Exhibit F.13. Annual and monthly capacity (seats for passenger/payload capacity for cargo).

Activity Category	Airline Schedule	T-100	OPSNET	TFMSC	Airport
Scheduled Passenger Carrier	F				I
Nonscheduled Passenger Carrier					I
All-Cargo Carrier					I
Air Taxi					I
GA					I
Military					I

F = Fleet mix detail
F*= Fleet mix detail for instrument operations at towered airports.
T* = Total operations at towered airports.
I = Intermittent – available at airports that compile radar data as part of their noise monitoring operations

Exhibit F.14. Daily aircraft capacity (seats for passenger/payload capacity for cargo).

Activity Category	Airline Schedule	T-100	OPSNET	TFMSC	Airport
Scheduled Passenger Carrier	F				I
Nonscheduled Passenger Carrier					I
All-Cargo Carrier					I
Air Taxi					I
GA					I
Military					I

F = Fleet mix detail
F*= Fleet mix detail for instrument operations at towered airports.
T* = Total operations at towered airports.
I = Intermittent – available at airports that compile radar data as part of their noise monitoring operations

Exhibit F.15. Hourly aircraft capacity (seats for passenger/payload capacity for cargo).

Activity Category	Airline Schedule	T-100	OPSNET	TFMSC	Airport
Scheduled Passenger Carrier		F			I
Nonscheduled Passenger Carrier		F			I
All-Cargo Carrier		F			I
Air Taxi					I
GA					I
Military					I

F = Fleet mix detail
F*= Fleet mix detail for instrument operations at towered airports.
T* = Total operations at towered airports.
I = Intermittent – available at airports that compile passenger and cargo statistics.

Exhibit F.16. Annual and monthly passengers/cargo.

APPENDIX G

Glossary

Air Carrier: The FAA definition for operations counts is an aircraft with seating capacity of more than 60 seats or a maximum payload capacity of more than 18,000 pounds carrying passengers or cargo for-hire or compensation. The FAA definition for passenger counts is an airline which flies the majority of their available seat miles on aircraft with more than 70 seats.

Air Taxi: The FAA definition for operations counts is an aircraft designed to have a maximum seating capacity of 60 seats or less or a maximum payload capacity of 18,000 pounds or less carrying passengers or cargo for-hire or compensation. Small regional jets and turboprop aircraft in scheduled service are considered air taxi in FAA statistics. The FAA definition for passenger counts is an airline which flies the majority of their available seat miles on aircraft with 70 seats or less.

Aircraft Operation: An aircraft take-off or landing.

Aircraft Situation Display to Industry (ASDI): A data stream available through the USDOT's Volpe Transportation Center based on radar and flight plan data that shows location, altitude, airspeed, destination, estimated arrival time and aircraft designator of aircraft flying on IFR flight plans within the United States.

Aviation Environmental Design Tool (AEDT): An environmental analysis tool for noise and air quality being developed for the FAA that will replace the INM and EDMS models.

Airport Cooperative Research Program (ACRP): Program authorized by Congress and sponsored by the FAA with the goal of developing near-term, practical solutions to problems faced by airport operators.

Airport Traffic Control Tower (ATCT): A structure from which air traffic control personnel control the movement of aircraft on or around the airport.

Area Equivalent Model (AEM): Spreadsheet model used to estimate aircraft noise.

Average Day in the Peak Month (ADPM): Defined as peak month passengers or operations divided by the number of days in the month.

Average Weekday in the Peak Month (AWDPM): Defined as the number of weekday passengers or operations in the peak month divided by the number of weekdays in the peak month.

Aviation Environmental Screening Tool (AEST): Tool used to estimate impact of small incremental changes to airspace use and noise.

Bag Claim Device: Typically a mechanical device designed to hold and display checked luggage for passengers to claim upon arriving at their destination airport.

Buffer time: At a gate, the scheduled time between a departing aircraft and the next arriving aircraft.

Clock Hour: A 60 minute period that begins at the beginning of the hour. For example 1:00 pm through 1:59 pm represents a clock hour; 1:35 pm through 2:34 pm does not.

Cloning: A process of expanding a design day schedule by duplicating flights, usually including a small random adjustment to the flight time to avoid exact duplication.

Connecting Bank: A group of aircraft, operated by a single airline system, which arrives at an airport within a narrow time interval, exchanges passengers, and then departs, also within a narrow time interval.

Contact Gate: Gate with an attached loading bridge, which provides passengers with a direct connection between the aircraft and terminal building.

Corporate Real Estate (CRE): The department at an airline that is responsible for managing the leasing of facilities, such as gates, at airports.

Customs and Border Protection (CBP), U.S.: Agency under the U.S. Department of Homeland Security (DHS) with the priority mission of keeping terrorists and their weapons out of the United States. It also has a responsibility for securing and facilitating trade and travel while enforcing U.S. regulations, including immigration and drug laws.

Day/Night Split: Distribution of aircraft operations between daytime (7 am to 10 pm) and night-time (10 pm to 7 am).

Departure Lounge: Interior area within an airport terminal where passengers wait just prior to boarding aircraft.

Deplane: Act of getting off an aircraft; passenger getting off an aircraft.

Derivative Operational Profiles: Operational profiles that are derived from the traditional passenger and aircraft operation profiles, usually by applying a lead or lag factor, to assess loads on specific terminal or landside facilities.

Design Day: A representative busy day selected for planning, intended to strike a balance between providing capacity for most periods without incurring the cost of designing for the single busiest day of the year.

Design Day Flight Schedule: A constructed schedule showing individual aircraft arrivals and departures by time of day and aircraft type, which can also show airline, origin/destination, and passengers associated with each flight, depending on the level of detail required.

Domestic Travel: Typically, air travel within the borders of a particular country; may also include travel from precleared origins within Canada and the Caribbean.

Emissions and Dispersion Modeling System (EDMS): Model used prior to AEDT to estimate airport air quality impacts.

Enplane: Act of boarding an aircraft; passenger getting on an aircraft.

EPA: Environmental Protection Agency.

Fare Class: Typically, premium or first class tickets and less expensive coach tickets.

Federal Aviation Administration (FAA): Agency under the U.S. Department of Transportation, responsible for both ensuring safety of and promoting aviation industry.

Federal Inspection Services (FIS): Facility operated by U.S. CBP, designed to process arriving international passengers and their luggage.

Gate: Passageway through which passengers embark or disembark from an aircraft.

General Aviation: The FAA defines general aviation as take-offs and landings of all civil aircraft, except those classified as air carriers or air taxis.

Hub Airport: General industry definition is an airport at which a significant amount of connecting passenger activity occurs. Also an FAA classification of airports according to what percentage of national enplanements they accommodate annually.

IFR Flights: Fights operated under instrument flight rules which indicate that the pilot is authorized to fly by instruments under conditions where visibility is impaired.

Integrated Carrier: All-cargo airlines, such as FedEx and UPS, which provide door-to-door service including freight forwarding and ground transportation.

Integrated Noise Model (INM): Model used to estimate airport noise impacts prior to AEDT.

International Travel: Typically, that portion of air travel outside the borders of a particular country.

Lag Time: The interval between the time an aircraft arrives at a gate and the average time a deplaning passenger arrives at a given airport facility.

Large-Hub Airport: An airport that accounts for 1 percent or more of annual passenger enplanements at U.S. airports. In 2014 this included airports with more than 7,612,884 enplanements.

Lead Time: The interval between the time an enplaning passenger arrives at a given facility, such as a ticketing kiosk, and the time his or her flight departs the gate.

Level of Service (LOS): A measure of the quality of service provided by a facility. For example, as it relates to terminals, LOS A would be defined as no congestion, free-flow and excellent level of comfort, and LOS F would be defined as extreme congestion, unstable flow with unacceptable delays, near system breakdown and unacceptable level of comfort.

Master Plan: Document outlining the general, long-term development strategy for a facility to meet projected activity.

Medium-Hub Airport: An airport that accounts for at least 0.25 percent but less than 1 percent of annual passenger enplanements at U.S. airports. In 2014 this included airports with between 1,903,221 and 7,612.884 enplanements.

Monte Carlo Analysis: A method of evaluating uncertainty that involves repeated sampling from probability distributions associated with multiple inputs and/or parameters to generate a single, composite probability distribution.

MOVES2014: Air quality model used to assess ground vehicle emissions.

Nautical Mile: A unit of measure equal to 1.15078 statute miles.

Non-hub Airport: An airport that accounts for more than 10,000 enplanements but less than 0.05 percent of annual passenger enplanements at U.S. airports. In 2014 this included airports with between 10,000 and 380,644 enplanements.

Nonrevenue Passenger: Typically, airline passenger working for the airline industry or family member flying at no cost. Frequent flier passengers flying on award tickets are classified as revenue passengers in U.S. DOT statistics.

Operational Profile: The distribution of arriving and departing passengers or aircraft operations by time of day during the design day. It can be a design day profile, a design schedule, or a day/night stage length distribution.

Operations Network (OPSNET): FAA source of data that provides information on operations for all FAA and FAA-contracted towered airports in the United States.

Origin and Destination (O&D) Passenger Traffic: See definitions of originations and terminations.

Originations: Passengers who are beginning their air travel at an airport, having arrived by some form of ground transportation.

Noise Integrated Routing System (NIRS): A noise evaluation system designed to provide an analysis of air traffic changes over large regions.

Passenger Security Screening Checkpoint (PSSCP): Operated by the TSA, a screening checkpoint examines both passengers and their carry-on belongings for items that are banned from the passenger compartment of a commercial aircraft.

Peak Period: A period of time, often called the peak hour, representing the typical high flow of passenger or aircraft operations activity that must be accommodated by a given airport facility. Like the design day, it is intended to strike a balance between providing capacity for most periods without incurring the cost of designing for the single busiest period of the year.

Peak Spreading: The tendency of peaks of passengers and aircraft operations, to decline as a percentage of daily activity, as an airport becomes busier.

Performance Data Analysis and Reporting System (PDARS): Joint FAA/NASA program for tracking flight data to measure facility performance.

Precleared Airport: An international airport where passengers headed for the United States can go through the CBP process, thereby avoiding processing upon landing at their U.S. destination.

Processing Rate: Number of entities that a single resource can process in a given unit of time (e.g., passengers though a security checkpoint).

Processing Time: Time interval between the beginning of a process on one entity and the beginning of a process on the next entity, assuming a constant rate of demand and a queue.

Regional Airline: Airline that operates small aircraft, usually under contract or a code-sharing with a larger air carrier. Historically, regional airlines have operated aircraft with fewer than 60 seats, but they are increasingly operating aircraft with 70 or more seats.

Remain Overnight (RON): Typically refers to parking position(s) used to accommodate aircraft that are not unloading or loading passengers and cargo, between their last arrival in the evening and their first departure the following morning.

Revenue Passenger: Passenger paying a fare on a flight; includes passengers traveling on redeemed frequent flier miles.

Risk Register: A central repository of risks identified by an organization, including information including description, likelihood of occurrence, threat/opportunity assessment, potential mitigation measures, and other factors.

Scaling: A process by which a mix of aircraft operations or passengers is increased or decreased proportionately to match a target level.

Scheduled Seat Arrivals: The sum of the seats in each scheduled arriving passenger flight over a given period of time.

Scheduled Seat Departures: The sum of the seats in each scheduled departing passenger flight over a given period of time.

Seat Factors: Also known as enplaning or deplaning load factors. They are calculated by dividing passenger enplanements by aircraft departing seats or dividing passenger deplanements by aircraft seat arrivals. Seat factors differ slightly from load factors which are calculated by dividing revenue passenger miles by available seat miles.

Small-Hub Airport: An airport that accounts for at least 0.05 percent but less than 0.25 percent of annual passenger enplanements at U.S. airports. In 2014 this included airports with between 380,644 and 1,903,221 enplanements.

Spoke Airport: An airport where almost all passenger traffic is O&D.

Stage Length: The distance an aircraft travels between take-off and landing.

Standard Deviation: The standard deviation is the square root of the variance of the population around the mean. It is a measure of the amount of variation in a given sample or population, such as annual enplanements.

Standard Instrument Departure (SID): Published flight procedures for aircraft on an IFR flight plan immediately after take-off.

Standard Terminal Arrival Route (STAR): Published flight procedures for aircraft on an IFR flight plan immediately preceding landing.

Supergate: An aggregation of gates used in airfield simulation, to simplify the gate assignment process when the terminal area is not the focus of the analysis.

TARGETS: FAA's Terminal Area Route Generation, Evaluation, and Traffic Simulation tool.

Terminal Area Forecast (TAF): Annual FAA forecast of passenger and operations activity at approximately 3000 airports in the United States.

Terminations: Passengers who are ending their air travel at an airport and are leaving by some form of ground transportation. (Also, *destinations.*)

Throughput Capacity: The maximum number of units (passengers or aircraft operations) that an airport facility can process within a specified time interval.

Ticket Counter/Check-in Counter: Portion of airport terminal where departing passengers purchase tickets, check in for flights, change itineraries, etc.

Tow-on/tow-off time: For aircraft towed on to a gate, the interval between the time an aircraft is towed on to a gate and the time it departs the gate for take-off. For aircraft towed off a gate, the interval between the time an aircraft arrives at a gate and the time it is towed to another location.

Traffic Flow Management System (TFMS): FAA database of instrument flight operations that includes airline, aircraft type, and time and location of O&D.

Traffic Flow Management System Counts (TFMSC): Publicly available summary of TFMS data.

Traffic Noise Model (TNM): Model used to estimate ground traffic noise impacts.

Transportation Research Board (TRB): Part of the nonprofit National Research Council; provides leadership in transportation innovation and progress through research and information exchange.

Transportation Security Administration (TSA): Responsible for protecting the U.S. transportation system; operates under the DHS.

Turnaround time: The time interval between an aircraft's arrival at the gate and its departure. Typically refers to the minimum time needed to prepare an arriving aircraft for its outbound flight.

VFR flights: Flights operated under visual flight rules, which indicate that visibility and weather conditions are such that the pilot can see where the aircraft is going.

Visual meteorological conditions (VMC): Weather conditions under which VFR flights are permitted.

Wingtip-to-wingtip flights: Multiple flights scheduled by a single airline between a single market pair within a few minutes of each other, typically within the same connecting bank.

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
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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ISBN 978-0-309-44595-5
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