

Airport Passenger Terminal Planning and Design, Volume 2: Spreadsheet Models and User's Guide

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ACRP REPORT 25

**Airport Passenger Terminal
Planning and Design**

***Volume 2:
Spreadsheet Models and User's Guide***

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AIRPORT COOPERATIVE RESEARCH PROGRAM

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

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

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

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

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

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

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

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Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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Matthew Lee of Landrum & Brown and Joel Hirsh of Hirsh Associates served as co-principal investigators for the research and spreadsheet model development. Brian Poe of Landrum & Brown performed the major portion of the detailed spreadsheet model development and the initial drafting of the User's Guide. Shane Wirth of Landrum & Brown provided initial model testing and critiques for all of the individual models and documentation. Jerry Roberts of Planning Technology prepared the interactive CD-ROM, integrating the spreadsheet files with the electronic versions of the User's Guide and the Guidebook.

The authors are very grateful for the guidance by the panel for ACRP Project 07-04 and for the guidance and help provided by the panel for ACRP Project 07-05.

The research team would also like to acknowledge the invaluable contribution of the research team for ACRP Project 07-05 led by Bruce Anderson of Landrum & Brown. Mr. Anderson provided overall leadership of the contractor team for both ACRP projects 07-05 and 07-04. His quality control and guidance assured that the content of both projects will provide consistent guidance.

Finally, the authors are grateful for the time and dedication of numerous Landrum & Brown staff members in the overall production of the Spreadsheet Models and the User's Guide.



FOREWORD

By **Theresia H. Schatz**

Staff Officer

Transportation Research Board

ACRP Report 25: Airport Passenger Terminal Planning and Design comprises a Guidebook, Spreadsheet Models, and a User's Guide in two volumes and a CD-ROM to provide guidance in planning and developing airport passenger terminals and assist users in analyzing common issues related to airport terminal planning and design. Volume 1 describes the passenger terminal planning process and provides, in a single reference document, the important criteria and requirements needed to address emerging trends and create solutions for airport passenger terminals. This comprehensive Guidebook addresses the airside, terminal building, and landside components of the terminal complex. Volume 2 consists of (1) a CD containing 11 spreadsheet models, which include practical learning exercises and several airport-specific sample data sets to assist users in determining appropriate model inputs for their situations, and (2) a User's Guide to assist the user in the correct use of each model. The models on the CD include such aspects of terminal planning as design hour determination, gate demand, check-in and passenger and baggage screening, which require complex analyses to support planning decisions.

The Guidebook and Spreadsheet Models will be beneficial for airport operators, planners, designers, and other stakeholders involved in planning functional and cost-effective airport passenger terminals by providing tools that can be used immediately.

Planners and designers for all sizes of airports are struggling with how to design passenger terminals that provide good value and level-of-service efficiency that meet the criteria of many aspects of airport terminals, from security requirements and procedures to the needs of low-cost carriers and concessionaires. Practical information is needed not only to address current issues but also to provide the flexibility to accommodate emerging trends and issues. Airport passenger terminal planners and designers need up-to-date information on how to provide good value and efficiency to meet the needs of stakeholders and accommodate changing technologies, materials, regulations, and operational factors for both large and small airports.

ACRP Report 25 is the result of two separate research projects—ACRP 07-04, “Spreadsheet Models for Terminal Planning and Design,” and ACRP 07-05, “Airport Passenger Terminal Planning Guidebook.” Both projects were performed by Landrum & Brown as the prime contractor with the assistance of a variety of subcontractors: Hirsh Associates, Ltd.; Kimley-Horn and Associates, Inc.; Jacobs Consultancy; The S-A-P Group; TranSecure, Inc.; Steven Winter Associates, Inc.; Star Systems, LLC—A Subsidiary of Five Star Airport Alliance; Planning Technology, Inc.; and Presentation & Design, Inc.

ACRP Report 25 provides a foundation for understanding and using the results of related ACRP research projects on airport terminal planning. For a list of related projects and published reports, see Appendix B of Volume 1.



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Introduction

This User's Guide and the Terminal Planning Spreadsheet Models on the CD-ROM bound into this volume of *ACRP Report 25* are companions to *Volume 1: Guidebook*. The models provide practical learning exercises, which provide users with knowledge from the industry's top planning consultants.

The CD contains three primary files: the Terminal Planning Spreadsheet Model workbook file, the Design Hour Determination workbook file, and an electronic copy of this User's Guide. The CD also contains an installation procedure and a Quick Reference Guide. The installation procedure allows the user to copy the contents of the CD to a specified directory on the user's local disk drive or network. Starting work in the Terminal Planning Spreadsheet Models requires opening the file: `Terminal_Planning_Spreadsheet_Model.xls`.

The Terminal Planning Spreadsheet Models require the user to enable macros in Microsoft® Excel. Enabling macros allows all of the models' features to function properly. The User's Guide also has an Excel Help section, which includes directions on how to enable macros in Excel.

The Terminal Planning Spreadsheet Models have been developed and tested in Excel 2003. Additional testing was also conducted with Excel 2000 and Excel 2007. Other versions of Excel were not tested.

The User's Guide is a reference manual that provides guidance to assist the user in the correct use of each model. While the models provide comments, diagrams, and guidance that describe the contents of various cells in each spreadsheet, the models also require decisions from the user about input values, analysis techniques, and data sources. Making these decisions provides a means to learn and understand the major issues that drive the layout and size of various airport passenger terminal facilities. All of the models have buttons (which invoke macros) that open an electronic copy of the appropriate section of the User's Guide to provide additional information and guidance. In addition, the User's Guide also incorporates most of the related material covered by the Guidebook. Where appropriate, the Terminal Planning Spreadsheet Models CD contains sample data sets that provide an airport-specific example for each model. These airport-specific examples may help users make more informed decisions about appropriate model inputs that match their unique situations.

The User's Guide has one section for each of the main tabs in the Spreadsheet Models workbook. Each model section has information and exhibits from the Guidebook and excerpts and exhibits from the model with process explanations and commentary to help the user understand the reasoning behind the models' methodology.

The models on the CD do not address every single aspect of terminal planning. Many aspects of terminal planning can be assessed by applying simple multipliers or ratios to the number of passengers or aircraft using a terminal, or by allocating a percentage of the total terminal space

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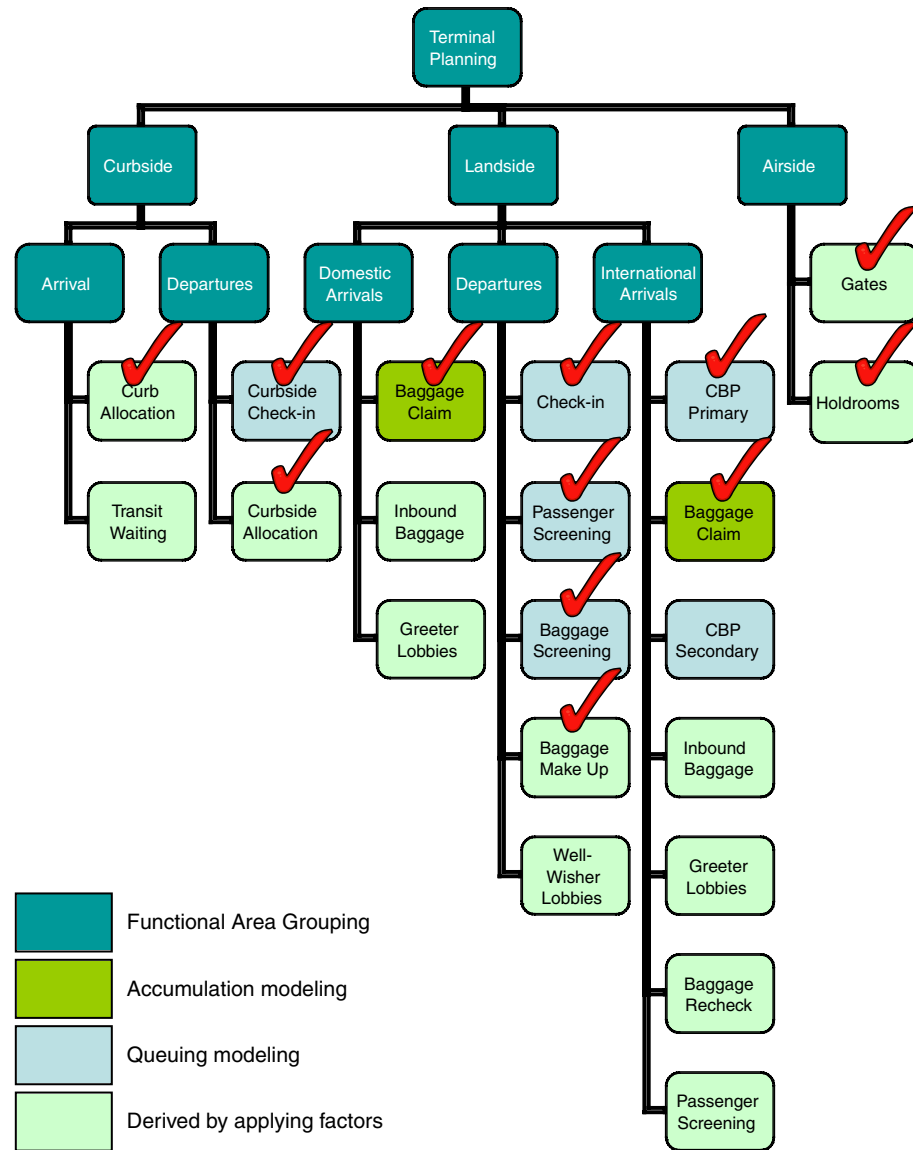


Figure 1. Terminal planning functions.

to a particular function. The models on the CD include those areas that require more complex analyses to support planning decisions. Figure 1 provides an overview of the functional areas in terminal planning. Check marks indicate the areas covered by the spreadsheet models.

Model Overview and Format

Model Uses

The Spreadsheet Models are set up to be used as exercises with the knowledge gained from the Guidebook and User's Guide. The exercises are intended to provide understanding as to why terminal planners use certain ratios and planning factors; it is not intended as a "cookbook" of specific recipes for demand requirements. The models were developed with the goal to enhance learning. With a strong understanding of the process and methods discussed in the Guidebook and models, users should be more prepared to develop some of their own terminal space program components.

The process flow of the models is to gather data about a terminal's physical components (space utilization and availability) and determine the design hour passenger traffic. With this inventory in hand, along with the design hour determined from a base schedule or from estimation factors, the user can go through each model exercise, starting with the Gate Demand model, following the typical path of departing passengers and baggage through the airport, and ending with arriving passengers retrieving their bags at baggage claim in the Baggage Claim model.

The spreadsheets are password protected to protect them from accidental overwrite of key information. However, the password is provided for the power users who may wish to make changes for specific needs. THE PASSWORD IS *TRBModels*. Additional help on unlocking or locking a protected workbook is provided in the Excel Help section.

Model Explanations

Queuing models are used within the Spreadsheet Models to better determine the processing requirements while considering passenger delays. These queuing models are referred to as “mini-queue” models in the text of the Guidebook as well as in the models. In the Check-in and Security models, an initial value is calculated for the number of check-in positions or lanes based on average processing times, desired maximum waiting time, and the assumption that passengers arrive at the processing areas at a constant rate during the entire peak period. This optimal, yet unrealistic, condition would make use of all available processing capacity and, therefore, would create a steady flow of passengers to and from the processing areas. Therefore, the initial value for positions is always lower than what is truly needed. This initial number of positions is then used as a starting point to analyze the sensitivity of expected wait times and required queuing area to variances in the number of counters or lanes.

However, passengers will more likely arrive at Check-in and Security areas at varying rates. The two mini-queue models show the difference between assuming an even distribution of passengers arriving at a steady flow during the peak period and assuming a normal (bell curve) distribution of passengers, which better reflects real-world arrivals, with a peak in the middle of a generic period. The mini-queue models include this peaking effect and the resulting wait times are therefore based on a more likely scenario. When the model uses the initial number of processing positions, the estimated maximum wait time will be higher than the target level of service (LOS) wait time because the expected passenger arrival pattern has been assigned a peaked distribution. The user can then adjust the model input for counters or lanes until the desired wait time is reached and observe the effects on the time and space parameters based on the number of counters or lanes.

Modeling Conventions and Symbols

All of the models are formatted using a color-coded cell system (Figure 2). Only the white input cells are left unlocked; the blue or light green cells are locked specifically to preserve the calculations and formulae. The formulae are visible when the user places the Excel cursor on each cell.

The first step after initiating the Spreadsheet Models workbook is to review the Table of Contents (opening tab), and to make note of the color-coded format and the use of cell comments marked with a red triangle in the upper right corner of the associated cell. These comments will

Input Data Values	White
Calculated Values	Lt. Green
Linked or Predetermined Values	Lt. Blue

Figure 2. Color coding of spreadsheet cells.

give suggestions, possible input ranges, and explanations to the input or output cells' connections to each other, as well as formula descriptions. They are used throughout each of the individual models as a quick reference to better understanding each step within the models' process.

The models contain some conditional formatting that may prompt the user to enter a different value, one that is more in line with a typical range of values, or to change the input format to match what a calculation in the model needs to work properly.

As previously noted, macros are used in the models to facilitate the navigation through the Spreadsheet Models as a complete set of individual models. In addition, macros used within certain model tabs provide a way to minimize some repetitive work for the user and also to perform some larger tasks much faster. Those users that wish to see what the macros are doing behind the scenes can check the Visual Basic (VBA) code that is stored within the spreadsheet by pressing the Alt key and the F11 key together to launch the Microsoft® VBA program. The code should be easily understood by those with a moderate level of proficiency.

Each workbook tab has links to sections of the User's Guide and to the workbook's Table of Contents tab. As there are many tabs in this model, and they may not all fit on the bottom of the screen, depending on the size of the user's computer monitor, the "Return to Table of Contents" tab makes it simple to get back to the main page and follow the process through each of the models.

The overall modeling approach is for the user to review the data checklist, determine the design hour, and then step through each of the models while referring to the User's Guide for additional help and information related to each of the specific areas of terminal planning. It is recommended that the user proceed in the order (left to right, and top to bottom) illustrated in Figure 3. This order will allow for demand values, determined in the initial steps, to flow into dependent calculations in later steps.

Summary of Terminal Planning Spreadsheet Models

- **Design Hour Determination:** This model takes the user from data sourcing and collection through determining the peak month, choosing an average day of the peak month, and finally determining the design hour and the associated peak planning factors.

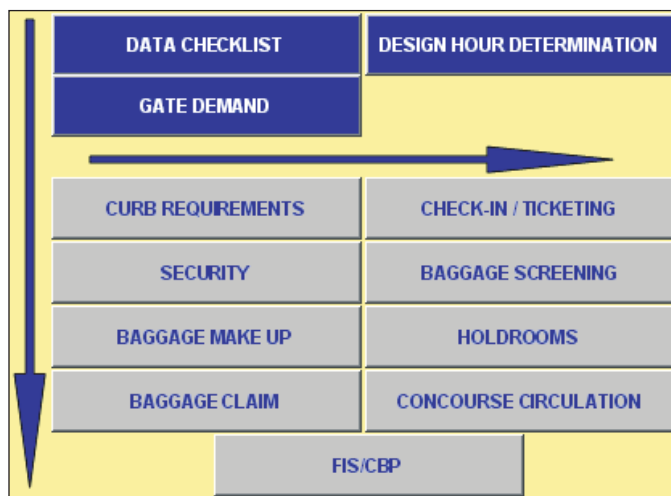


Figure 3. Model selection buttons in the workbook Table of Contents.

- **Gate Demand:** This model lets the user estimate future gate demand through two common approaches. The user can determine the Narrowbody Equivalent Gate and Equivalent Aircraft through the use of gate equivalency tables for the current or future gate mix.
- **Curb Requirements:** This model estimates the length of terminal curb frontage required for arrival and departure curbs for private cars and various types of public vehicles.
- **Check-in/Ticketing:** This model allows the user to select the number of check-in positions among the Counter, Kiosk, and Curbside areas and adjust the processing conditions to see the effect on the processing time and required space. Mini-queue models are used to show estimated delays.
- **Security Screening:** This model determines the necessary number of TSA passenger screening lanes and space required for TSA screening operations. The model includes a mini-queue model to see the effect of processing and queuing variances on the passenger delay and unit requirements.
- **Baggage Screening:** This model helps to determine the Transportation Security Administration (TSA) Surge hourly rate of outbound baggage and estimates the required number of Electronic Detection System (EDS) and Explosive Trace Detection (ETD) units, as well as the basic spatial requirements for operation and handling.
- **Baggage Make-up:** This model estimates the make-up space and number of containers/carts required to adequately stage and prepare outbound baggage for delivery to the aircraft.
- **Holdrooms:** This model looks at a single holdroom and allows the user to adjust usage parameters to determine the current LOS or estimate the necessary holdroom conditions to achieve a desired LOS.
- **Baggage Claim:** This model determines the overall claim frontage that is necessary, based on the user-defined peak period demand. The user can then size an individual claim unit and determine how many units are required for his/her unique aircraft fleet mix.
- **Concourse Circulation:** This model allows the user to describe a single concourse design and determine the necessary circulation width (including space for moving walkways), the suggested concourse length, and the total circulation area within the concourse.
- **Federal Inspection Services (FIS)/U.S. Customs and Border Protection (CBP):** This model provides the user with CBP standards in the main functional areas of passenger processing. A mini-queue model helps the user to determine the required number of primary processing stations and size the baggage claim frontage based on the design hour international demand.

Excel Help

Enabling Macros in Excel

Macros are functions and actions that are running behind the scenes of a spreadsheet. They are commonly triggered by keyboard inputs, buttons, or tabs that link the keyboard action to instructions that perform many routine operations that are sometimes very complex. Macros are useful in data preparation and analysis when the same set of instructions needs to be repeated over and over again; they can help to simplify the process. Macros can also be useful in providing navigation assistance in the use of spreadsheets when there is a pattern to how operations should proceed and in what order.

The Terminal Planning Spreadsheet Models use simple macros that should not pose any threats to the user's computer. With a trusted source and the absence of complex code, lower security settings can be safely used to allow the Spreadsheet Models' macros to function properly and safely.

During the initial launch of the Spreadsheet Models, there should be either a Security Warning window requesting the user to disable or enable macros, or a window stating that macros are

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already disabled because of the current security-level setting. Figure 4 shows examples of Excel macro security warnings.

If the Enable Macros option was not selected during startup, or the Security Level window appeared, the command buttons will not function and the operational macros will not work. Fortunately, there are a couple of easy steps to get the spreadsheet running properly with macros.

If the Enable Macros option was available and not selected, close Excel, restart Excel, select the Enable Macros option, and finally reopen the Terminal_Planning_Spreadsheet_Model.xls file. The macros should be operational.

If the Security Level setting window appeared, close the file, restart Excel, change the macro security level to Medium, and finally reopen the Terminal_Planning_Spreadsheet_Model.xls file. Figure 5 shows the process of changing the Excel macro security level.

From the Tools menu, select Macro and then Security. These selections will launch the Security window where the Medium setting should be chosen. Click OK. When the file is reopened, the Enable Macros option will be available to choose.

Protecting and Unprotecting Excel Spreadsheets

Microsoft provides authors of Excel files the option of protecting spreadsheets at various levels of security. The author can lock cells to keep them from being selected or allow the user to select the cell to see the formula or lock some cells with formulas and unlock input cells for changing user data. A knowledgeable user of Excel is able to make custom changes to a spreadsheet; the password can be provided so that the sheet can be unlocked and the ability to make changes is granted.

Figure 6 explains the process of unlocking the sheet to gain access to changing the functionality or look of the spreadsheet.

From the Tools menu, select Protection and then Unprotect Sheet. These actions will launch the Unprotect Sheet window that requires a password. Enter the password and click OK. The spreadsheet will be unprotected and open to changes. Be cautious when making changes to another author's work. In most cases it is recommended to back up the work before making changes, to retain a record of the original formulas and formatting that were used.

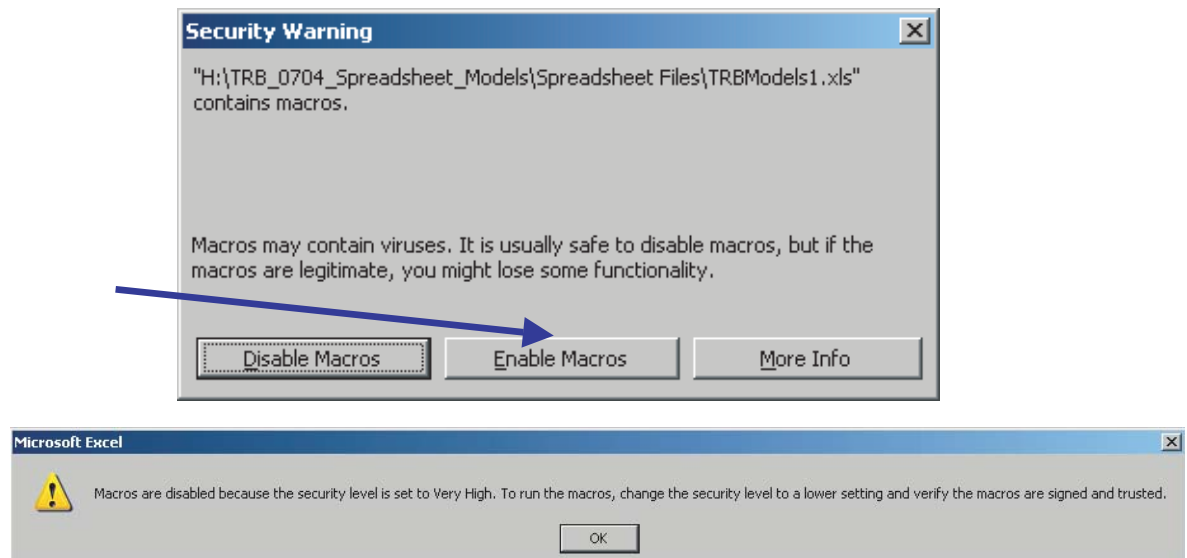


Figure 4. Examples of Excel macro security warning messages.

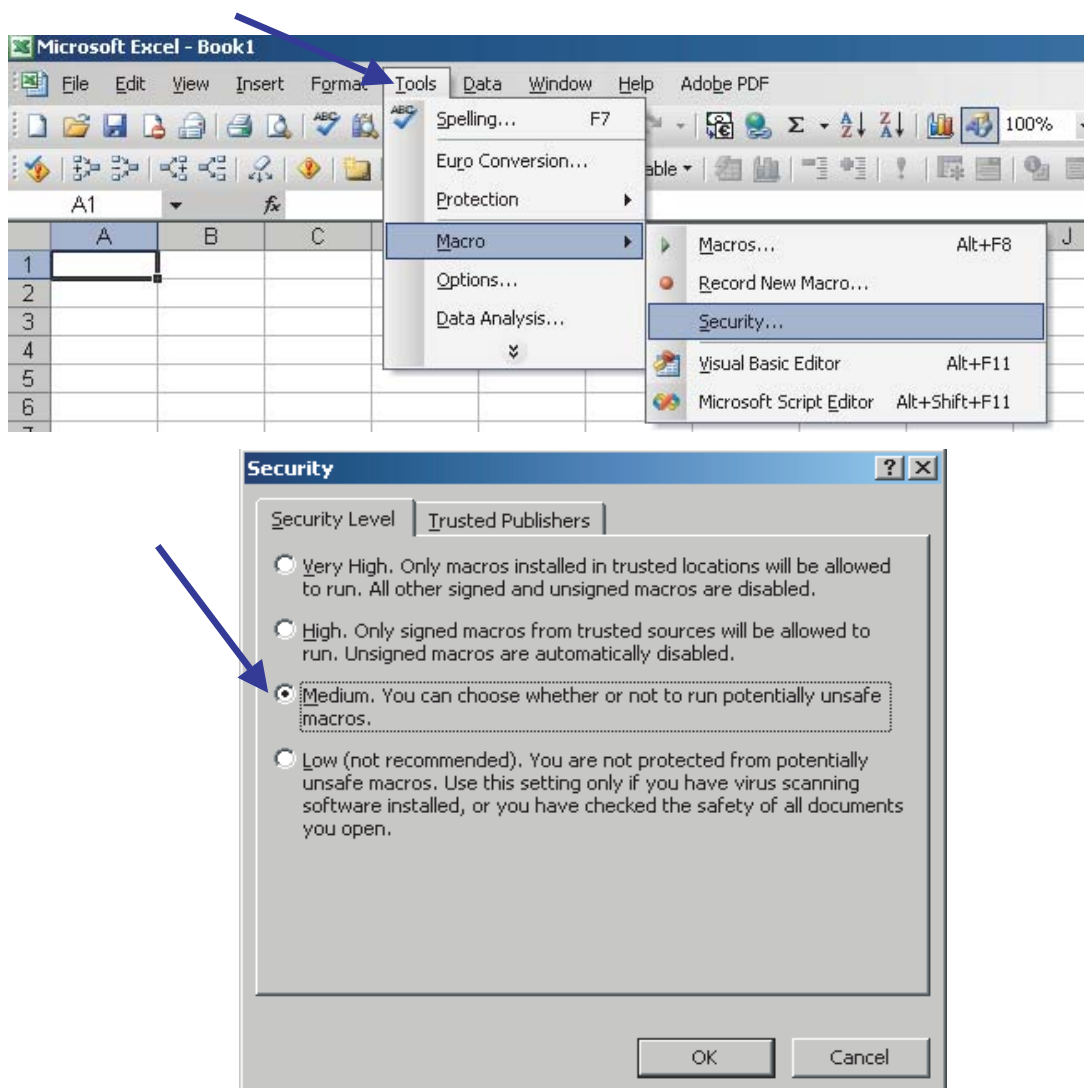


Figure 5. Resetting Excel macro security levels.

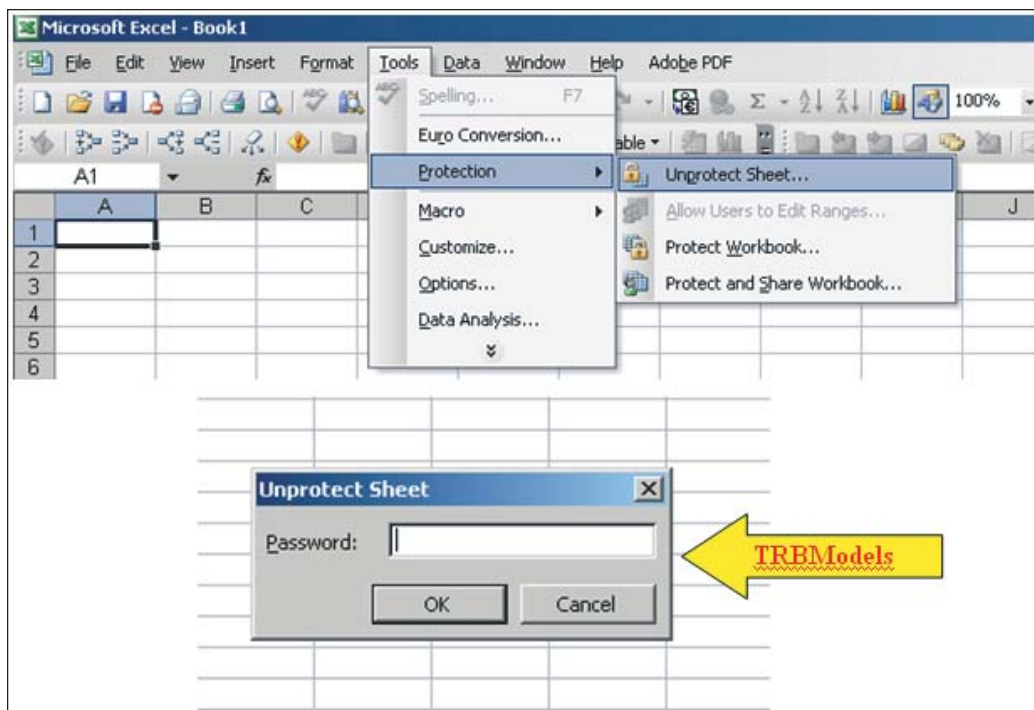


Figure 6. Unprotect sheets to access formulae.



Design Hour Determination Model

Analysis Techniques

The design hour for passengers historically has had a number of definitions. One approach is to define the design hour as the 90th (or 95th) percentile busiest hour of the year. Determining this hour requires keeping track of all of the enplaning and deplaning passengers for every flight during the year, and then ranking these by hour (usually a clock hour) to find the level of activity that accounts for 90% of the annual traffic. While used by some non-U.S. airports, it is a very data-intensive approach for which data is not available for the vast majority of U.S. airports.

In the United States, peak hour passengers are typically defined as peak hour–average day–peak month passengers and are also often referred to as the “design hour passengers.” This User’s Guide will use the term “design hour passengers” for consistency. The design hour measures the number of enplaned and deplaned passengers departing or arriving on aircraft in an elapsed hour of a typically busy (design) day. The design hour typically does not correspond exactly to a clock hour such as 7:00–7:59 but usually overlaps two clock hours (e.g., 7:20–8:19), reflecting airline scheduling patterns.

Design Hour Demand

The design hour is not the absolute peak level of activity, nor is it equal to the number of persons occupying the terminal at a given time. It is, however, a level of activity, which the industry has traditionally used to size many terminal facilities. The total number of people in the terminal during peak periods, including visitors and employees, is also typically related to design hour passengers.

The focus of the Design Hour Determination model is on scheduled seats. These can easily be converted to passengers with the use of an assumed average load factor (percentage of seats filled). The model sets up the determination of the design hour in such a way that most segments of interest can be determined at the same time (i.e., Domestic/International, Air Carrier/Regional, and Arriving/Departing/Total).

The peak month is described in the model as a percentage of annual passengers based on historical patterns. This percentage may be modified for future years based on local trends and/or anticipated changes in air service patterns. The peak month may be different for enplaned and deplaned passengers, domestic and international, and so forth. Depending on the number of days in the month, an average day is calculated.

An alternative to using the average day of the month is to use an average weekday. This is often done at airports where domestic service is the predominant activity and weekend activity is less

than weekday activity. Airport records on monthly and daily passenger volumes (as recorded by the airlines) is the best source for determining whether an average day or an average weekday is the appropriate (design) day for the design hour.

If a flight schedule is not being developed, the design hour is estimated as a percentage of daily activity. These percentages (enplaned and deplaned) should be based on actual passenger activity data collected from the airlines for a typical week. As with the peak month, percentages may be modified for the future based on local trends and/or anticipated changes in air service patterns.

The Design Hour Determination model is driven by actual passenger traffic data to systematically calculate the planning factors that could be used later, in the absence of a design day schedule, to estimate design hour activity. The model's structure takes the user through each required step with simple instructions and directions for when to go to the next step. Each tab of the spreadsheet has a blue instruction box with step numbers corresponding to the numbered areas requiring an action in the worksheet. The user must still gather the necessary data for each step, but the process should be simple to follow by doing the actions in the right order.

Figure 7 shows the tab structure for the Design Hour Determination model. The user has command buttons in each tab that when clicked will jump to the next tab in the right order or the user can just click on the worksheet tabs at the bottom of the screen and follow them in order from 1 to 7.

Figure 8 is a screen print of the first tab of the Design Hour Determination spreadsheet. The user gathers monthly enplanement data and enters it into the input cells, and the normal peak month is determined. The spreadsheet functions can be seen in the light green calculated cells to observe the processes that are being used. The process is not difficult, and the spreadsheet is doing some of the work automatically for the user. Once the peak month is determined, an average week from Sunday to Saturday needs to be selected. The user should select a week that does **not** contain holidays or other anomalies.

Operations and scheduled seats data from the average week of the peak month is then gathered and entered into the input cells on Tab 2 (Figure 9), which helps determine an average day during the peak month. The user must determine the actual day of the month for the selected average week, typically choosing Sunday as the start of the week. Enter that day into cell B9. All of the steps for Tab 2 are again listed in the blue instruction box and the action areas are highlighted with corresponding numbers. The user can observe the percent difference or variation in Step 4 to help in choosing the design day, which will provide the data for the peak hour determination in the following steps. Although the model is set up to use scheduled seats, actual passenger and operations data for the week would be preferable if it is available.

After determining a design day (normally a Wednesday or Thursday) that most closely resembles the peak month average week's daily average, a complete schedule of arriving and departing seats for the design day during the peak month is needed for the next step, which will generate 10-minute buckets that will be used to create rolling hours throughout the day. The actual design rolling hour is then determined automatically and traffic charts are generated on TAB 6 with the corresponding data to better describe the chart activity. The complete schedule can be acquired from recent airport data or from the Official Airline Guide (OAG). The OAG data will be actual seats flown or scheduled seats to be flown if the peak month average day is very near in the future.



Figure 7. Tab structure of the Design Hour Determination model.

USE THIS WORKSHEET TO DETERMINE THE PEAK MONTH

REQUIRED DATA: Historical Enplanement data from the last 5 complete calendar years

Total Commercial Passenger Enplanements **1**

Year	January	February	March	April	May	June	July	August	September	October	November	December
2004	339,212	335,431	380,372	383,986	384,009	412,229	433,519	438,881	359,801	392,988	389,683	390,748
2005	351,751	343,331	410,799	410,089	417,314	431,319	448,310	453,798	381,840	396,737	390,193	386,018
2006	346,250	345,682	406,676	412,639	410,434	430,066	437,895	446,311	373,111	401,655	395,973	407,416
2007	371,721	365,513	432,975	433,370	436,341	452,244	456,592	478,329	388,735	414,229	390,115	366,854
2008	350,450	350,533	408,656	392,136	385,109	398,749	411,909	419,764	342,455	362,867	325,972	344,026

2 **3**

Year	Total	Monthly Average	Maximum Value	Peak Month	PM % of Year
2004	4,640,859	386,738	438,881	August	9.5%
2005	4,821,499	401,792	453,798	August	9.4%
2006	4,814,108	401,176	446,311	August	9.3%
2007	4,989,018	415,752	478,329	August	9.6%
2008	4,492,626	374,386	419,764	August	9.3%
Average Peak Month				AUGUST	9.4%

You have determined AUGUST to be the Peak Month

Data Input Cells	
Calculated Values	
Linked/Shared Values	

4

(1) Click the 'RESET ALL INPUTS' button to begin.

(2) Input the most recent full calendar year into Cell A11 (i.e. 2008)

(3) Input monthly enplanements data from one of the following sources: Airport records, U.S. DOT (T-100), FAA (Air Traffic data), or OAG(using Scheduled Seats).

(4) Review the Peak Month results in Cells E14:E18 and Select the most common month, giving more weight to more recent years, in Cell E19.

-->The Peak Months should be consistent; if not, specific knowledge of the conditions affecting the variation should be investigated. If the variation is due to the similarity between certain months, data from earlier years may be gathered to help confirm the most common peak month.

Figure 8. Tab 1 example of the Design Hour Determination model.

USE THIS WORKSHEET TO DETERMINE THE PEAK MONTH AVERAGE DAY

REQUIRED DATA: Peak Month Operations & Seats data

Peak Month AUGUST **1**

2

Day of Week	Daily Operations		Daily Scheduled Seats		%Diff. (Ops)	%Diff. (Seats)	%Diff. (Total)
	Arrivals	Departures	Arriving	Departing			
10 3 Sunday	142	142	11826	11699	0.08	0.09	0.17
11 Monday	155	155	12744	12705	0.09	0.07	0.16
12 Tuesday	153	153	12657	12618	0.07	0.05	0.12
13 Wednesday	153	153	12657	12618	0.07	0.05	0.12
14 Thursday	156	156	12922	12883	0.11	0.10	0.21
15 Friday	156	156	12922	12883	0.11	0.10	0.21
16 Saturday	122	120	10597	10471	0.36	0.29	0.65
4 Average	148	148	12332	12268			

Figure 9. Tab 2 example of the Design Hour Determination model.

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Tabs 3 and 4 are set up to be simple for the user to input the airport or OAG data into the input blocks starting at Row 5 in Column A. Copy and paste the schedule data, as is, into these columns and then update the Pivot Table, if there are international markets that need to be identified. The instructions for these tabs stress the need for the time of departure or arrival to be in the 24-hour format. This format is normally the default time setting, but if not, it will need to be adjusted for the model to work properly.

The determination of international and domestic markets was not automated so that in the cases of preclearance efforts, those markets could be treated as each individual airport sees fit. If no markets are selected as international, then there will be no design hour international segment identified. In Tabs 3 and 4, there is a section that is titled “Designation Table for Dom/Int”; this section has a built-in Excel Pivot Table. The section will become populated with a summary of each destination or origin airport when the Update Pivot Table button is clicked. This button was added so that when the international and domestic segments were truly desired, the user would only have to select each international market once instead of going through what may be a lengthy list and checking for multiple listings. Figure 10 shows Step 5 where “D” or “I” will be selected from a drop down list, and Figure 11 shows the populated table from when Step 3 is completed.

Certain airport markets may have a unique mix of regional aircraft, and the appropriate designation as either air carrier or regional may not always follow the FAA guidelines, which use 60 seats as the threshold between air carrier and regional. Cell F3 uses 60 seats as the default, which resets when all the inputs are reset, but allows the user to choose the level that best fits the mix of local aircraft and how that mix is interpreted. By adjusting the Regional Level Factor (Step 4) as pointed out in Figure 12, the user can control which aircraft will be considered regional and air carrier.

The arrival and departure data that is entered into Tabs 3 and 4 will automatically be organized into 10-minute buckets and rolling hours on Tab 5, which is basically an organized summary sheet that displays the design hour for arriving, departing, and total seats, as shown in Figure 13. With specific knowledge of the operations at local airports, the determined design hours should be within the expected range based on personal experience of the user.

The model highlights the peak bucket and rolling hour period in each section with yellow and red markings (Figure 14). In addition, the percentage of the design day that the design hour represents is also calculated within this tab and will be displayed on Tab 7, Design Hour Forecast.

Figure 14 also shows the top of the table on Tab 5 where Row 7 contains the percentage of daily activity that the design hour—for arriving, departing, and total seats—represents.

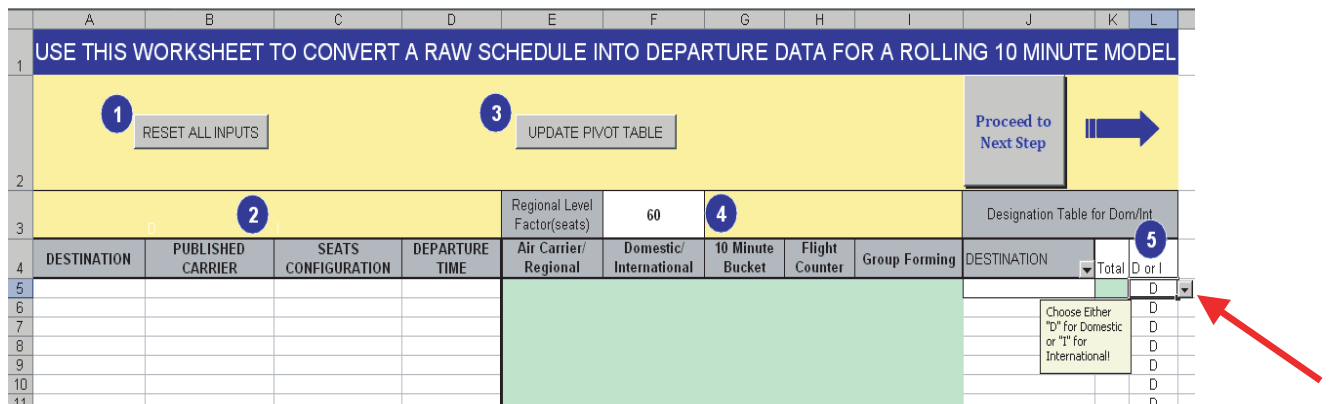


Figure 10. Tab 3, Step 5, example of the Design Hour Determination model.

USE THIS WORKSHEET TO CONVERT A RAW DEPARTURE SCHEDULE INTO DATA FOR 10 MINUTE BUCKETS														
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 5px;">1 RESET ALL INPUTS</div> <div style="border: 1px solid black; padding: 5px;">3 UPDATE PIVOT TABLE</div> <div style="border: 1px solid black; padding: 5px; display: flex; align-items: center;"> Proceed to Next Step </div> </div>														
2											3			
4											5			
DESTINATION	PUBLISHED CARRIER	SEATS CONFIGURATION	DEPARTURE TIME	Air Carrier/Regional	Domestic/International	10 Minute Bucket	Flight Counter	Group Forming	DESTINATION	Total	D or I			
5	ATL	DL	183	8:45	Air Carrier	D	41	1	D/Air Carrier41	ATL	5	D		
6	ATL	DL	183	8:55	Air Carrier	D	54	1	D/Air Carrier54	EWR	3	D		
7	ATL	DL	183	11:52	Air Carrier	D	72	1	D/Air Carrier72	CVG	1	D		
8	ATL	DL	183	14:05	Air Carrier	D	85	1	D/Air Carrier85	DEN	9	D		
9	ATL	DL	124	21:35	Air Carrier	D	130	1	D/Air Carrier130	DFW	10	D		
10	AUS	AA	148	17:55	Air Carrier	D	108	1	D/Air Carrier108	IAH	6	D		
11	CVG	DL							D/Air Carrier69	MSP	3	D		
12	DEN	UA							D/Air Carrier41	ORD	8	D		
13	DEN	UA							D/Air Carrier47	STL	1	D		
14	DEN	UA							D/Air Carrier63	AUS	1	D		
15	DEN	UA							D/Air Carrier66	LAS	11	D		
16	DEN	UA							D/Air Carrier105	OAK	9	D		
17	DEN	F9							D/Air Carrier41	PDX	4	D		
18	DEN	F9							D/Air Carrier64	PHX	16	D		
19	DEN	F9							D/Air Carrier65	SEA	9	D		
20	DEN	F9							D/Air Carrier121	SFO	11	D		
21	DFW	AA							D/Air Carrier41	SJC	16	D		
22	DFW	AA							D/Air Carrier51	SLC	6	D		
23	DFW	AA							D/Air Carrier57	SMF	7	D		
24	DFW	AA							D/Air Carrier65			D		
25	DFW	AA							D/Air Carrier71			D		
26	DFW	AA							D/Air Carrier79			D		
27	DFW	AA							D/Air Carrier83			D		
28	DFW	AA							D/Air Carrier94			D		
29	DFW	AA							D/Air Carrier103			D		
30	DFW	AA							D/Air Carrier113			D		
31	EWR	CO							D/Air Carrier45			D		
32	EWR	CO							D/Air Carrier95			D		
33	EWR	CO							D/Air Carrier128			D		
34	IAH	CO							D/Air Carrier41			D		
35	IAH	CO							D/Air Carrier50			D		
36	IAH	CO							D/Air Carrier53			D		
37	IAH	CO							D/Air Carrier70			D		
38	IAH	CO							D/Air Carrier77			D		
39	IAH	CO							D/Air Carrier89			D		

(1) Click the 'RESET ALL INPUTS' button to begin.

(2) Access either OAG, Airport or another source of data for the most recent or nearest Peak Month Average Day, and input the departure schedule data starting in Cell A5.

(3) Click the 'UPDATE PIVOT TABLE' button to populate the summary of destinations table starting in Cell J5.

(4) Adjust the Regional Level Factor to the level most appropriate to the market. (60 is the FAA default)

(5) Review the destinations and Change any international destinations to an 'I', if desired, using the drop down list. (The default is set as 'D' for Domestic)

-->The required departure schedule data consists of Destination, Departure Time, Seats Configuration, and Published Carrier.

--> Time should be in the 24 hour format. (e.g. 8:30, 12:01, 18:35)

The data prepared in this worksheet drives the Peak Hour worksheet which will show the rolling Peak Hour based on 10 Minute buckets.

Figure 11. Tab 3, Step 3, example of the Design Hour Determination model.

USE THIS WORKSHEET TO CONVERT A RAW SCHEDULE INTO ARRIVAL DATA FOR A ROLLING 10 MINUTE MODEL													
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 5px;">1 RESET ALL INPUTS</div> <div style="border: 1px solid black; padding: 5px;">3 UPDATE PIVOT TABLE</div> <div style="border: 1px solid black; padding: 5px; display: flex; align-items: center;"> Proceed to Next Step </div> </div>													
2											3		
4											5		
ORIGIN	PUBLISHED CARRIER	SEATS CONFIGURATION	ARRIVAL TIME	Air Carrier/Regional	Domestic/International	10 Minute Bucket	Flight Counter	Group Forming	ORIGIN	Total	D or I		
5	ATL	DL	11:02	Air Carrier	D	67	1	D/Air Carrier67	ATL	5	D		
6	ATL	DL	13:12	Air Carrier	D	80	1	D/Air Carrier80	AUS	1	D		
7	ATL	DL	18:06	Air Carrier	D	109	1	D/Air Carrier109	CVG	1	D		
8	ATL	DL	20:38	Air Carrier	D	124	1	D/Air Carrier124	DEN	9	D		
9	ATL	DL	22:11	Air Carrier	D	134	1	D/Air Carrier134	DFW	10	D		
10	AUS	AA	9:15	Air Carrier	D	56	1	D/Air Carrier56	EWR	3	D		
11	CVG	DL	18:33	Air Carrier	D	64	1	D/Air Carrier64	IAH	6	D		

Figure 12. Tab 4 example of the Design Hour Determination model.

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THIS WORKSHEET CONVERTS SCHEDULE DATA TO 10 MINUTE BUCKETS AND ROLLING HOURS																				Proceed to Next Step									
Scheduled Seats																													
Design Day																													
Rolling 10 Minute Bucket Method 1																													
Total		17504	484	17988	0	0	0	17988	17504	484	17988	0	0	0	17988	35976													
Peak		762	44	762	N/A	N/A	N/A	2258	1644	44	1688	N/A	N/A	N/A	2764	3219													
% of Average Day								12.6%							15.4%	8.9%													
Arriving Seats										Departing Seats																			
AC		Reg.		Total		AC		Reg.		Total		AC		Reg.		Total		AC		Reg.		Total		Rolling TOTAL		Arriving Seats Peak Hour 60 Min Period (from/to)			
Hour	10 Minute Bucket	AC	Reg.	Total	AC	Reg.	Total	Rolling Arr Total	AC	Reg.	Total	AC	Reg.	Total	AC	Reg.	Total	Rolling Dep Total	Rolling TOTAL					21:50		22:49			
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					6:50		7:49			
12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					Total Seats Peak Hour 60 Min Period (from/to)		10:00		10:59	
13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
16	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
17	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
18	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
19	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
21	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
22	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
23	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
24	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
25	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
26	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
27	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
28	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
29	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										

Figure 13. Tab 5 example of the Design Hour Determination model.

Tab 6, as shown in Figure 15, graphically illustrates the rolling hour data from Tab 5. The data included in Tab 6 charts is for total activity (domestic, international, air carrier, and regional) but can be modified by the user to illustrate any subset of data from Tab 5. As shown, the design hour usually does not occur within a clock hour, but across two clock hours.

The final tab in the Design Hour Determination model allows the user to see the calculated planning factors for peak month, average day, and design hour, and the effect that these factors can have on the design hours used in future planning levels. Knowledge of these average values for planning factors and understanding their impact can allow the user to make valid use of them in the absence of a design day schedule. The planning factors from the design hour exercise are boxed in red on Figure 16, which is a screen print of Tab 7.

Factor Analyses

Generally, historic data on aircraft activity at the airport in question or a comparable facility can be used to derive planning factors that are used to divide annual demand into average day of the peak month (ADPM) and average day peak hour (ADPH) values. Analysis of U.S. Department of Transportation (U.S.DOT) databases on origin and destination (O&D) travel (10% ticket

THIS WORKSHEET CONVERTS SCHEDULE DATA TO 10 MINUTE BUCKETS AND ROLLING HOURS																			
Scheduled Seats																			
Design Day																			
Rolling 10 Minute Bucket Method 1																			
Total		17504	484	17988	0	0	0	17988	17504	484	17988	0	0	0	17988	35976			
Peak		762	44	762	N/A	N/A	N/A	2258	1644	44	1688	N/A	N/A	N/A	2764	3219			
% of Daily								12.6%							15.4%	8.9%			
123	113	310	44	354	0	0	0	1169	148	0	148	0	0	0	927	2096			
124	114	124	0	124	0	0	0	1137	137	0	137	0	0	0	916	2053			
125	115	261	0	261	0	0	0	1384	137	0	137	0	0	0	980	2364			
126	116	157	0	157	0	0	0	1291	248	0	248	0	0	0	979	2270			
127	117	273	0	273	0	0	0	1391	0	0	0	0	0	0	868	2259			
128	118	0	0	0	0	0	0	1118	257	0	257	0	0	0	954	2072			
129	119	322	0	322	0	0	0	1503	137	0	137	0	0	0	878	2381			
130	120	371	0	371	0	0	0	1442	157	44	201	0	0	0	741	2183			
131	121	124	44	168	0	0	0	1208	136	0	136	0	0	0	677	1885			

Figure 14. Example of peak buckets.

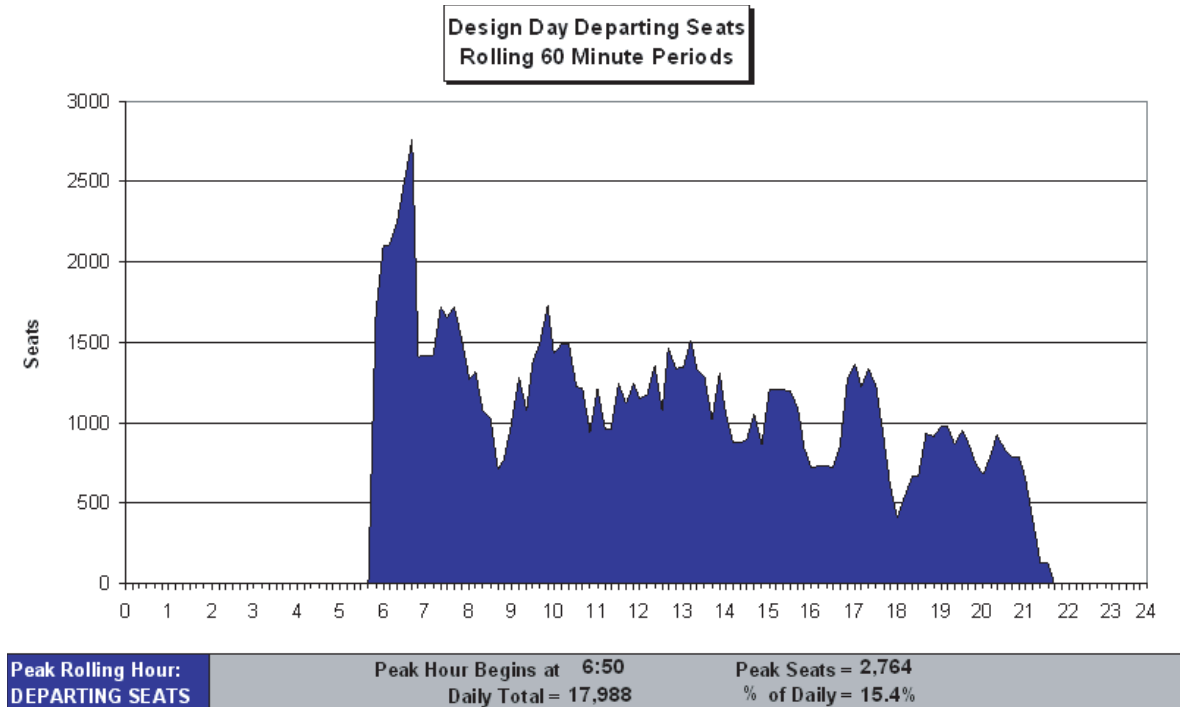


Figure 15. Design Hour for departing passengers.

survey) and connecting travel can be used to derive factors that calculate connecting versus O&D traffic flows. Factor analysis at airline connecting hubs can yield poor results, if the factors are not calibrated with other locally available data.

Regardless of the analysis method used to derive the design hour volumes of passenger and aircraft activity, the method used to create the analysis must be calibrated against data or observations that describe actual operations at the airport.

Passengers: Originating versus Connecting

After determining the total number of passengers from the design hour seating capacity of the aircraft, it is usually appropriate to divide this volume into O&D passengers and connecting passengers. Connecting passengers usually stay on the airside area of the terminal while the O&D passengers make use of both the airside and the landside areas of the terminal. The only time connecting passengers make use of the landside facilities is when they change airlines and the second airline's gates are located in a different concourse and there is no airside passageway connecting the two concourses.

Connecting passenger volumes tend to vary considerably from airline to airline. In general, the larger volume of flight activity the airline has at an airport, the greater the likelihood that connecting passengers will be part of their total passenger volume. Information on connecting passenger volumes should be collected from the airlines.

2	REQUIRED: RECENT FORECAST DATA				
3					
4					
5	1 <input type="button" value="RESET INPUTS"/>				
6					
7	Calendar				Total
8	Year				Enplanements
9	ANNUAL				
10	<u>Base</u>				
11	2008				4,492,626
12	<u>Forecast</u>				
13	2010				4,168,100
14	2015				4,732,800
15	2020				5,381,300
16	2025				6,104,700
17	2030				6,925,300
18	PEAK MONTH				
19	<u>Base</u>	9.4%	Peak Month Factor		
20	2008		419,764		~from Peak Month Tab
21	<u>Forecast</u>	Peak Month Factor			
22	2010	9.4%	391,800		
23	2015	9.4%	444,900		
24	2020	9.4%	505,800		
25	2025	9.4%	573,800		
26	2030	9.4%	651,000		
27	PEAK MONTH AVERAGE DAY				
28	<u>Base</u>	31	# of Days in Peak Month		
29	2008				13,540
30	<u>Forecast</u>				
31	2010				12,640
32	2015				14,350
33	2020				16,320
34	2025				18,510
35	2030				21,000
36	DESIGN HOUR				
37					
38					
39	<u>Base</u>	% of Average Day	Enplaned	% of Average Day	Deplaned
40	2008	15.4%	2,080	12.6%	1,700
41	<u>Forecast</u>				
42	2010	15.4%	1,950	12.6%	1,590
43	2015	15.0%	2,150	12.2%	1,750
44	2020	14.7%	2,400	12.0%	1,960
45	2025	14.0%	2,590	11.7%	2,170
46	2030	13.5%	2,840	11.5%	2,420
47					
48					

Figure 16. Peak factors.



Gate Demand Model

Estimating gate demand requires an understanding of the current capacity and future requirements based on forecast activity. There are two basic ways to determine the number of gates required: by developing and using a design day flight schedule (DDFS), or by using current and forecast enplanements and departures to estimate the future trends.

If a DDFS has been developed for a forecast year (or annual activity level), it can allow a relatively detailed study of gate demand. Typically a DDFS is developed when airside simulation modeling is done for an airport.

In many cases, a DDFS is produced as separate lists of flight arrivals and departures (records) in a spreadsheet format. To use the DDFS to determine gate demand, arrivals and departures must be matched up. This matched schedule can then be analyzed by various proprietary models to determine the number of gates required during the course of the day. The output is typically a Gantt-type gate chart, and/or a histogram of gate demand by 5- or 10-minute periods. While this type of analysis can be very detailed, it is dependent on the assumptions used to add flights by specific airlines or aircraft types over time.

Methodologies without Design Day Flight Schedules

When a DDFS is not available, two other approaches can be used: enplaned passengers by gate or departures per gate. These approaches also allow the terminal planner to easily do “what if?” sensitivity checks on basic assumptions, including those which may underlie a DDFS.

The Gate Demand model is set up like the other Spreadsheet Models with links to the Table of Contents and the User’s Guide, and uses color-coded cells for consistency (see Figure 17). The two methods of determining gate demand without a DDFS are used in the model as outlined in Section V.3.9 of the Guidebook.

Annual Enplaned Passengers per Gate Approach

The first approach, as shown in Figure 18, uses the current ratio of annual enplaned passengers per gate, adjusted for forecast changes in fleet mix and annual load factors. This methodology assumes that the pattern of gate utilization will remain relatively stable over the forecast period. The changes in passengers per gate would be due to changes in enplanements per departure (due to fleet seating capacity and/or passenger load factors), as opposed to increasing (or decreasing) numbers of departures per gate.

The basis for the existing factor is the number of gates in use. This number may be less than the number of gates available at an airport. In rare cases of over-crowded terminals, aircraft may

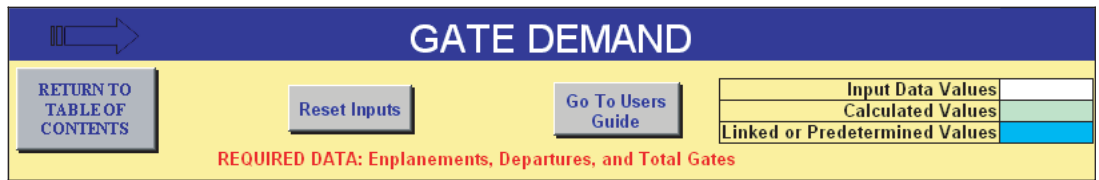


Figure 17. Gate Demand model.

be double parked at existing gates, so it is important to determine the true demand for active aircraft parking. From the existing passenger activity and annual departures, the current ratios of annual passengers per gate and enplanements per departure are calculated. Similar calculations can be based on total annual passengers, airline operations, or a combination of these, depending on how the airport keeps its statistics and develops its forecasts.

Forecasts for annual enplaned passengers and aircraft departures (or total passengers and aircraft operations) are usually forecast separately. Annual departures are typically forecast based on assumptions for fleet size and load factors that are applied to the passenger forecasts.

In the model example in Figure 18, the ratio of enplaned passengers per gate for each forecast year is calculated by multiplying the current (2008 in this example) factor by the percentage increase in enplaned passengers per aircraft departure. For example, enplaned passengers per departure increases from 54 in 2008 (actual) to 56 in 2010 (forecast), thus the factor would increase from 94,400 enplaned passengers per gate (2008 data when 36 gates were in use) to 97,500 for 2010, and 102,600 enplaned passengers per gate by the end of the forecast period without any further increase in the number of daily departures per gate.

Future gate requirements are then estimated by dividing annual forecast passengers by the estimated passengers per gate factor for that forecast period. For example, in 2010, 4,429,000 enplanements divided by 97,500 enplanements per gate results in a demand for 45 gates. This approach results in a forecast demand for 69 gates by the end of the forecast period.

Departures per Gate Approach

The first methodology has as an underlying assumption that the future pattern of air service will be stable and will resemble existing conditions. While this may be true at many airports and for some airlines at a given airport, it is often likely that gate utilization will change to some extent for other airlines. With a forecast reduction in mainline jets, for example, additional flights by

8	Enplaned Passengers per Gate Approach					
9		Annual		#	Enplaned	Enplaned
10		Enplaned	Annual	of	Passengers	Passengers
11	Year	Passengers	Departures	Gates	per Gate	per Dept.
12	2006	3,462,920	62,670	36	96,200	55
13	2007	3,336,027	63,808	36	92,700	52
14	2008	3,399,000	63,000	36	94,400	54
16	2010	4,429,000	79,500	45	97,500	56
17	2015	5,287,000	91,500	52	101,100	58
18	2020	6,240,000	106,500	61	102,500	59
19	2025	7,096,000	121,000	69	102,600	59

Figure 18. Example of enplaned passengers per gate approach to determine gate demand.

Departures per Gate Approach						
Year	Annual Enplaned Passengers	Annual Departures	# of Gates	Annual Departures per Gate	Daily Departures per Gate	
2006	3,462,920	62,670	36	1,740	5.0	
2007	3,336,027	63,808	36	1,770	5.1	
2008	3,399,000	63,000	36	1,750	5.0	
2010	4,429,000	79,500	44	1,820	5.2	
2015	5,287,000	91,500	47	1,930	5.5	
2020	6,240,000	106,500	50	2,110	6.0	
2025	7,096,000	121,000	53	2,290	6.5	

Figure 19. Example of departures per gate approach.

regional aircraft may be scheduled as demand grows. Similarly, airlines may add flights to their hubs from spoke cities. This typically results in higher average gate utilization.

However, if an airport attracts service by new entrant airlines, it is often likely that these carriers would initially follow scheduling patterns similar to existing carriers. This could result, for example, in a demand for more gates during the morning departure peak, and a reduction in average daily gate utilization.

For the departures per gate approach from the model (example shown in Figure 19), the ratio of annual departures per gate for each forecast year is calculated by multiplying the current (2008) factor by the percentage change in assumed daily departures per gate. In this example, it was assumed that average daily gate utilization would increase from 5.0 departures per gate in 2008, to 5.2 departures per gate by 2010, and gradually increase to 6.5 departures per gate by 2025. Thus, the annual gate utilization factor would increase from 1,750 annual departures per gate (2008) to 2,290 by 2025.

Future gate requirements are estimated by dividing annual forecast departures by the estimated departures per gate factor for that forecast period. For example, in 2010, 79,500 departures divided by 1,820 departures per gate results in a demand for 44 gates. This approach results in a forecast demand for only 53 gates by the end of the forecast period.

For most airports that assume increasing gate utilization, the departures per gate approach will result in a demand for fewer gates than the annual enplaned passengers per gate approach.

The model also provides an average of the two methods. The planner then needs to examine the range of values provided and determine the most reasonable and likely outcome. See Figure 20.

Once the gate requirements have been determined, the other ground requirements can be further quantified by relating the future DDFS to available gates. If the flight schedule suggests more aircraft than available gates or for early morning high turnover gates due to airline schedules, then additional aircraft parking spots will be required.

Average of Both Methods			
Year	Passengers per Gate	Departures per Gate	GATES
2010	45	44	45
2015	52	47	50
2020	61	50	56
2025	69	53	61

Figure 20. Comparison of gate analysis approaches.

Remain Overnight Aircraft Parking

At many airports, the pattern of airline service results in more aircraft being on the ground overnight than number of active gates. This situation is more pronounced at “spoke airports” where an airline may have, for example, hourly service to its hub for the first few hours of the day. Because it may take until mid-morning before aircraft begin to arrive, a single gate may accommodate two to three aircraft departures for which the aircraft must be parked overnight. These remain overnight (RON) aircraft are usually parked remotely or, in some cases, double parked on contact gates where the apron geometry allows. If RON aircraft are parked remotely, the aircraft are typically towed to a contact gate for departure, and towed off a contact gate to the RON parking area after the evening arrival.

Estimating the number of RON positions should take into account the airport’s air service pattern, the forecasts for cities to be served in the future, whether these are hubs or direct destination flights, and the relative utilization of gates.

Gate Equivalents

Airport comparisons are also frequently made on the basis of passengers per gate or terminal area per gate, but these comparisons lack a consistent definition of the term “gate.” To standardize the definition of “gate” when evaluating aircraft utilization and requirements, two metrics have been developed: narrowbody equivalent gate (NBEG) and equivalent aircraft (EQA).

The model includes a Gate Equivalencies Table (see Figure 21) to serve as a gate inventory during the gate demand process, showing available leased or forecast gates. This inventory is useful to other model segments where the EQA or NBEG values may be needed as factors that help determine other space requirements. The user needs to input the number of gates for each design group, and the total and equivalent values will be calculated. The calculated values are the cumulative sum product of the gate share and the index values.

Narrowbody Equivalent Gate

This metric is used to normalize the apron frontage demand and capacity to that of a typical narrowbody aircraft gate. The amount of space each aircraft requires is based on the *maximum* wingspan of aircraft in its respective aircraft group. FAA Airplane Design Groups used to define runway/taxiway dimensional criteria have been used to classify the aircraft as shown in Figure 22.

Group IIIa has been added to more accurately reflect the B757, which has a wider wingspan than Group III but is substantially narrower than a typical Group IV aircraft. A wingspan comparison is illustrated in Figure 23.






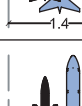

Gate Equivalencies Table							
Design Group	Class and Aircraft	# of Gates	NBEG		EQA		% Share by Group
			Maximum Wingspan	Index	Typical Seats	Index	
I.	Small Regional (Metro, B99, J31)	-	49	0.4	25	0.2	0.0%
II.	Medium Regional (SF340, CRJ)	1	79	0.7	50	0.4	2.8%
III.	Large Regional (DHC8, E175)	8	118	1.0	75	0.5	22.2%
III.	Narrowbody (A320, B737, MD80)	15	118	1.0	145	1.0	41.7%
IV.	757(B757, B757 w/Winglets)	5	135	1.1	185	1.3	13.9%
IV.	Widebody(MD-11, B767)	4	171	1.4	280	1.9	11.1%
V.	Jumbo (B747, B777, B787, A330, A340)	3	214	1.8	400	2.8	8.3%
VI.	A380 (A380, B747-8)	-	262	2.2	525	3.6	0.0%
Total		36	NBEG	40.2	EQA	41.9	

Figure 21. Computing EQA and NBEG gate equivalents.

FAA Airplane Design Group	Maximum Wingspan		Typical Aircraft	NBEG Index
	Feet	Meters		
I. Small Regional	49	15	Metro	0.4
II. Medium Regional	79	24	SF340/CRJ	0.7
III. Narrowbody/Lrg. Regional	118	36	A320/B737/DHC8/E175	1.0
IIIa. B757(winglets)	135	41	B757	1.1
IV. Widebody	171	52	B767/MD11	1.4
V. Jumbo	214	65	B747,777,787/A330,340	1.8
VI. A380	262	80	A380/B747-8	2.2

Source: Hirsh Associates

Figure 22. NBEG index.

Airplane Design Group (ADG)	Maximum Wingspan		NBEG	
	Feet	Meters		
I. Small Regional	49	15	0.4	 <p>No. of Narrowbody Aircraft in wingspan of ADG I Aircraft = 0.4</p>
II. Medium Regional	79	24	0.7	 <p>No. of Narrowbody Aircraft in wingspan of ADG II Aircraft = 0.7</p>
III. Narrowbody	118	36	1.0	 <p>No. of Narrowbody Aircraft in wingspan of ADG III Aircraft = 1.0</p>
IIIa. B757	135	41	1.1	 <p>No. of Narrowbody Aircraft in wingspan of ADG IIIa Aircraft = 1.1</p>
IV. Widebody	171	52	1.4	 <p>No. of Narrowbody Aircraft in wingspan of ADG IV Aircraft = 1.4</p>
V. Jumbo	214	65	1.8	 <p>No. of Narrowbody Aircraft in wingspan of ADG V Aircraft = 1.8</p>
VI. A380	262	80	2.2	 <p>No. of Narrowbody Aircraft in wingspan of ADG VI Aircraft = 2.2</p>

Source: Hirsh Associates and Landrum & Brown

Figure 23. Wingspan comparison.

In developing terminal facilities requirements, the apron frontage of the terminal, as expressed in NBEG, is a good determinant for some facilities, such as secure circulation. Terminal concepts can also be more easily compared by normalizing different gate mixes.

Equivalent Aircraft

The concept of EQA is similar to that of NBEG, i.e., a way to look at the capacity of a gate. EQA, however, normalizes each gate based on the seating capacity of the aircraft that can be accommodated. The EQA measure was originally developed in the early to mid-1970s as a technique for sizing terminal facilities.

The EQA measure was originally included in *The Apron & Terminal Building Planning Manual*, for U.S.DOT, FAA, by The Ralph M. Parsons Company, July 1975. When the Manual was developed, the majority of jet aircraft had 80 to 110 seats, thus the EQA measure centered on the 80- to 110-seat range with an EQA of 1.0. Smaller aircraft had an EQA of 0.6, and larger aircraft fell into seating ranges with the center of the range determining the EQA of that range. One hundred seats was equal to 1.0 EQA, aircraft in the 211- to 280-seat range had an EQA of 2.4, etc.

In considering the modern fleet mix of regional and jet aircraft, and in order to have some relationship with the physical parameters associated with the NBEG, the basis of EQA has been revised from the 1970s definition. The current EQA is also a Group III narrowbody jet. Most of the larger aircraft in this class typically have 140 to 150 seats. This establishes a basis of 1.0 EQA = 145 seats. As with the concept of NBEG, smaller aircraft may use a gate, but the EQA capacity is based on the largest aircraft and seating configuration typically in use.

While most terminal facility requirements are a function of design hour passenger volumes, some airline facilities are more closely related to the capacity of the aircraft. For example, while the total number of baggage carts required for a flight are a function of design hour passengers (and their bags), the number of carts staged at any one time are generally based on the size of the aircraft. Thus, the EQA capacity of the terminal can represent a better indicator of demand for these facilities.

The number of seats in each design group, as shown in Figure 24, can vary considerably from the basic definitions. For example, larger “regional jets” in Group III can be in the 100- to 110-seat range, while a Group III A321 narrowbody can have over 180 seats. Similarly, as fuel economy and range becomes more important, most new widebody aircraft are being designed with wider Group V wingspans than the Group IV aircraft they replace, but may have less than 250 seats. For a given airport, it may be appropriate to modify the EQA metrics to better match the fleet mix expected when using EQA to determine some terminal facilities.

FAA Airplane Design Group	Typical Seats	Typical Aircraft	EQA Index
I. Small Regional	25	Metro	0.2
II. Medium Regional	50	SF340/CRJ	0.4
III. Large Regional	75	DHC8/E175	0.5
III. Narrowbody	145	A320/B737/MD80	1.0
IIIa. B757 (winglets)	185	B757	1.3
IV. Widebody	280	B767/MD11	1.9
V. Jumbo	400	B747,777,787/A330,340	2.8
VI. A380	525	A380/B747-8	3.6

Source: *The Apron & Terminal Building Planning Manual*, for U.S. Department of Transportation FAA, by The Ralph M. Parsons Company, July 1975.

Figure 24. EQA index.



Curb Requirements Model

The Curb Requirements model is a peak demand–driven process that estimates the terminal curb frontage requirement and utilization based on current use and allocation. The model is set up in the same manner as the other spreadsheet models with links to the Table of Contents and User’s Guide, and color-coded cells for consistency as seen in Figure 25.

The terminal curbside on an airport is a complex operating environment. There are many types of vehicles that approach and stop at the curb. These include private automobiles, taxis, limousines, parking lot buses, rental car buses, regional buses, and shuttles and shuttle buses for hotels and motels. Significant curbside capacity is required to accommodate the maneuvering necessary for vehicles to pull to the curb, stop to load and unload passengers and luggage, and pull away from the curb to merge back into the traffic stream. The curbside area can be divided into two sections: pedestrian facilities and vehicle facilities.

Many airports have a pedestrian island between vehicle travel lanes, particularly at the arrivals curbside, but occasionally at the departures curbside as well. This island separates the curb lanes into two traffic streams and enables the airport to provide two parallel curbsides for passenger pick-up or drop-off, in an equivalent length of terminal building. The curbside areas are usually separated into passenger car and commercial vehicle (parking shuttles, rental car shuttles, hotel/motel shuttles, etc.) areas.

Figure 26 shows an example curbside with a pedestrian island. In this example, the inner curbside (closest to the terminal building) is designated for commercial vehicles, while the outer curbside serves private vehicles. Crosswalks are provided between the terminal building and the pedestrian island. The orientation of the commercial and passenger vehicle lanes varies by airport.

Curb Vehicle Facilities

The curbside provides access to the terminal buildings for pedestrians by way of private vehicles, as well as commercial vehicles such as shuttle buses, taxis, etc. The innermost lane (closest to the terminals) is essentially a short-term parking lane, dedicated to vehicles stopping to drop-off/pick-up passengers. Vehicles pull into an empty space at the curb, load or unload, and then pull out. At all but the smallest, low activity terminals, the second lane is used by both double-parked vehicles, as well as a transition lane, used by vehicles pulling in and out of the curbside. The third lane is a transition/weaving lane. The fourth lane (and fifth, if one exists at very large airports with multiple unit terminals) is used by vehicles driving past the curb. Therefore, at all but the smallest airports, the minimum number of curbside lanes is recommended to be four, because it is expected that the second lane may be partially blocked during peak drop-off/pick-up times.

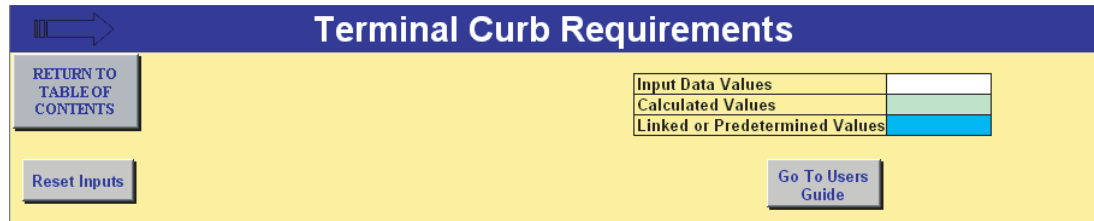


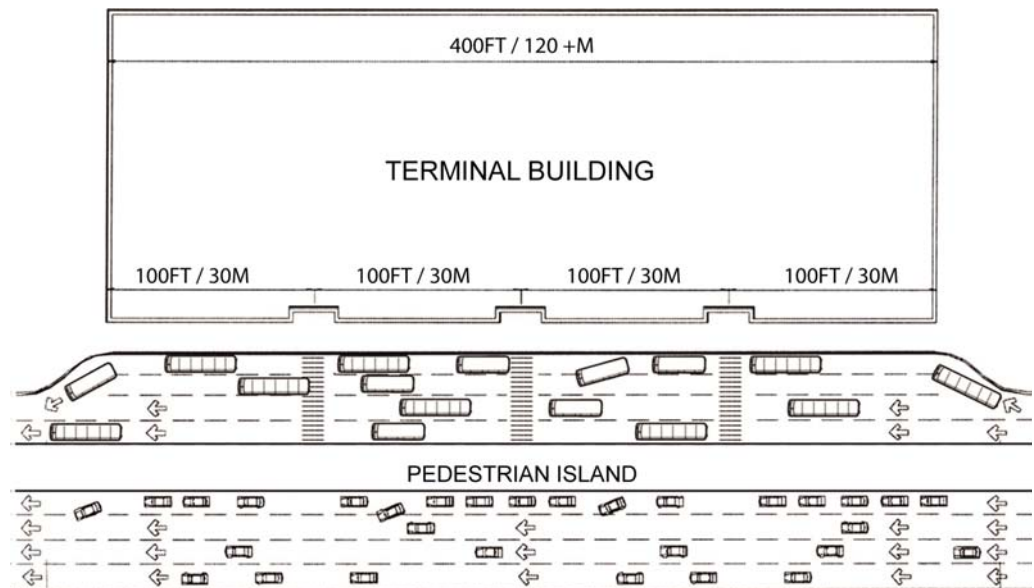
Figure 25. Terminal Curb Requirements model.

Because of the nature of curbside facilities, throughput per lane is greatly reduced compared to typical roadway facilities with the same number of lanes. Therefore, there is a need to provide additional curbside lanes to handle peak loads. Ideally, the roadway will provide enough capacity to accommodate expected traffic volumes even if a through lane is blocked due to maneuvering vehicles and double or triple parking.

Curbside facilities work most efficiently if the curbside is divided into sections that each serves a different vehicle type. This division limits conflict between different types and sizes of vehicles, as well as spreading the vehicle load throughout the entire curbside. The curbside is typically allocated among private vehicles, buses/shuttles, and taxis/limousines. The bus/shuttle section of curbside may be further allocated into separate areas for rental car shuttles, hotel/motel shuttles, parking shuttles, etc. This is particularly useful at the arrivals curbside, so that patrons waiting for a particular shuttle know where to stand to wait for the shuttle's arrival.

The curb typically runs the length of the terminal building. Passengers tend not to use any curbside area beyond the end doors of the building. However, some of the vehicle drop offs (such as commercial vehicles) can be located beyond the end doors. For shorter terminals, pedestrian islands may be necessary in order to achieve the curbside capacity needed.

Another important component of curbside capacity comes in the form of dwell times. At the arrivals curbside, vehicles will often stop to wait for arriving passengers if sufficient curbside



Source: Silverman, Fred. "Terminal Groundside Access Systems," FAA White Paper

Figure 26. Curbside with pedestrian island.

enforcement is not present. Most airports today enforce a policy of not allowing vehicles to stop at the curbside unless the driver can see their arriving passenger waiting at the curb. Long dwell times are less of a problem at the departure curbside, where most drivers drop off their passengers and depart immediately.

Figure 27 shows the Curb Requirements model and illustrates the basic flow that yields the outputs of required curbside frontage from the peak 15 minutes of demand and the comparison to existing curbside length with the percentage utilized.

Process for Estimating Curb Length

The Curb Requirements model uses the following approach in estimating frontage demand.

Passenger survey data is used to find the modal splits and vehicle occupancies for passenger traffic to and from the airport. The factors are used with the design hour passenger volume to generate demand for autos, taxis, limousines, and some other commercial vehicles. Bus and some shuttle schedules should be consulted to determine their peak frequencies. The peak 15 minutes of the design hour can be determined through a design day analysis or by observations. If data at the 15-minute detail level is not available, design hour or peak hour data can also be used with a peak 15-minute percentage. If traffic is considered to be evenly distributed during the design hour, the peak 15 minutes would equal 25% of hourly activity. Other inputs include dwell times, vehicle lengths, and multiple stop factors. These inputs will generate the associated frontage demand for each vehicle type and the total curbside frontage required.

A primary element of curbside LOS is the ability to find a space for loading or unloading. The probability of finding an empty curbside space or having to double park is typically used to describe LOS. The curbside capacity is considered to be the double parking capacity of the curbside, assuming a four-lane roadway with double parking allowed. LOS is then based on the percentage of the double parking capacity as follows:

- A—Parking demand equal to or less than 50% of double parking capacity.
- B—Parking demand is between 50% and 55% of double parking capacity.
- C—Parking demand is between 55% and 65% of double parking capacity.
- D—Parking demand is between 65% and 85% of double parking capacity.
- E—Parking demand is between 85% and 100% of double parking capacity.
- F—Parking demand exceeds 100% of double parking capacity.

Vehicle Type	Design Hour Demand in Vehicles	Peak 15 Minutes as % of Demand	Vehicle Dwell Time (min.)	Multiple Stop Factor	Peak 15 Min. Demand in Minutes	Vehicle Length (ft)	Peak 15 Min. Demand (ft*min.)	Peak 15 Min. Demand (ft)
Private Auto	500	30%	3.0	1.0	450	22	9,900	660
Rental Car Shuttle*	50	15	2.0	1.0	30	50	1,500	100
Taxis	200	60	1.5	1.0	90	22	1,980	132
Limousines	100	30	2.0	1.0	60	50	3,000	200
Hotel Shuttles*	30	9	2.0	1.0	18	50	900	60
Airport Shuttles*	30	9	2.0	1.0	18	40	720	48
Buses*	30	9	2.0	1.0	18	50	900	60
Other	30	9	2.0	1.0	18	30	540	36
Total	970	291						1,296

Existing Curbside Length	1,200	ft	Existing Capacity Ratio	0.54	
Effective Double Parking Capacity**	2,400	ft	Existing Level of Service (LOS)	B	
Required LOS 'C' Curbside Range = from			997	ft	
			to	1157	ft

* Consult the schedules to determine the maximum frequency of each vehicle
 ** Assumes a 4 lane curbside roadway where double parking is allowed

Figure 27. Example of curb requirements.

Travel Classification	General Headway Times (minutes)
Rental Car Shuttles (individual companies)	2 - 4
Rental Car Shuttles (consolidated)	3 - 5
Hotel Shuttles	5 - 10
Other Shuttles	5 - 15 (varies by type)
Buses	30 - 60

Source: Kimley-Horn and Associates, Inc., All rights reserved.

Figure 28. General headway times by travel classification.

Further Explanation of the Process for Estimating Curb Length

Traffic volumes by travel classification are airport specific and are based on the operations of the airport. Typically, travel classifications such as private automobiles, taxis, limousines, and various shuttles serve the curbside. These design hour volumes will need to be determined to calculate the curbside capacity at each location. These volumes can be determined three ways:

- Collect existing data at the location
- Collect data at similar airport facility
- Estimate the traffic volumes by multiplying *Originating Passengers × % Departures or % Arrivals × Curbfront Mode Split*

Curbfront mode split can be determined by passenger survey on mode of arrival to the airport (which is typically how they will also leave the airport) and party size. To determine the number of shuttles or other buses, the type of rental car facilities, number of local hotels providing airport shuttles, and number of bus or shuttle services providing service to the airport must be established. Furthermore, there will be fewer shuttle trips if a consolidated rental car campus is planned rather than rental car companies running individual shuttles. If no specific headway data is available, the general headway data shown in Figure 28 can be used.

To determine the curbside traffic volume for one of these modes, multiply the number of companies servicing the airport by the headway and convert to vehicles per hour.

Dwell times should be collected during the design hour to determine the maximum utilization of the curbside. A main component of dwell time is enforcement. Where there is strict enforcement of the curbside, dwell times are typically shorter than where enforcement is not as strict. If existing data is available, that would be best, however, data can be collected at a similar airport facility or the following dwell times may be used. The dwell times listed in Figure 29 are presented by travel classification with the assumption of relatively strict enforcement.

Travel Classification	Dwell Time (minutes)
Private Auto	2 - 4
Taxis	1 - 3
Limousines	1 - 3
Rental Car Shuttles	2 - 5
Hotel Shuttles	2 - 4
Other	varies

Source: Kimley-Horn and Associates, Inc., All rights reserved.

Figure 29. Dwell time by travel classification.

Travel Classification	Length
Private Auto	22FT / 7M
Taxis	22FT / 7M
Limousines	50FT / 15M
Rental Car Shuttles	50FT / 15M
Hotel Shuttles	40FT / 12M
Other	varies

Source: Kimley-Horn and Associates, Inc., All rights reserved.

Figure 30. Vehicle length by travel classification.

One thing to consider is that arriving and departing vehicles of the same travel classification may not have the same dwell times.

Vehicle length helps determine the amount of room on the curbside that the vehicles use when parked. Figure 30 provides general lengths to be used in the analysis. These lengths include additional room to compensate for the space between vehicles on the curbside.

These values can be used in the analysis instead of measuring specific lengths at the airport. However, if the airport has other travel classifications at the curbside, then specific lengths may need to be determined for that travel classification.

Another factor to consider is whether a multiple stop factor is appropriate for the curbside. A multiple stop factor should be applied when a vehicle, typically shuttles, would stop multiple times along one curbside. This occurrence is most common at airports having a shared curbside between multiple terminals and the walking distance is too far to expect passengers to travel to a central location with their luggage.

Considering all of these factors, the desired curbside utilization can be determined. Once this has been established, the required size of the curbside can be determined by summing the demand of all modes of travel. Demand can be calculated by multiplying $Volume \times Dwell Time \times Vehicle Length$, then converting it to demand by hour or 15-minute peak within the peak hour for each mode. Total demand compared to the desired curbside utilization will result in required curbside length.



Check-in/Ticketing Model

The departures process has traditionally begun at the ticket, or check-in counter, of the terminal, which is referred to as the Airport Ticket Office (ATO) counter. With the increasing use of automated, self-service, and remote check-in systems, the role of the ATO counter and the terminal check-in lobby has changed and continues to evolve.

There are five major types of check-in facilities:

- **Staffed check-in counters:** Many legacy carriers, depending on the location of the airport, can require a certain service level for their customers by requiring staffed ATO counters. These may be additionally divided among dedicated international, first/business class, elite-level frequent flyers, and coach domestic ticket counters. Some international carriers may require ticket purchasing positions either within the ATO counter or remotely.
- **Self-service check-in kiosks:** Self-service devices are commonly referred to as kiosks and are typically the size of an Automatic Teller Machine (ATM). These can be designed as stand-alone units that print passenger boarding passes and receipts and also allow passengers to make changes in their reservations, depending on the airline. These types of kiosks can be located remote from the ATO counter in the check-in lobby or throughout the terminal. Kiosks usually do not provide the ability to print bag tags because they are not staffed. When kiosks are located at the ATO ticket counter, they are typically configured in pairs with a bag well, which often includes a baggage scale between pairs. These combined ATO/kiosk positions provide bag tag printing and bag acceptance by airline or ground handling agents who usually support multiple kiosk positions.
- **Bag drop counters:** If passengers checking in remotely have bags to check and the airline does not allow self-tagging of baggage, bag drop counters are typically provided. These bag drop counters have configurations that are similar to regular ATO counters, but are dedicated to a bag drop function.
- **Self-tagging stations:** Self-tagging stations can incorporate bag tag printers, as well as boarding pass printers into self-service kiosks. Passengers would attach the bag tag to their luggage and deliver it to an originating input conveyor for loading into the baggage system. A self-tagging station could also be a stand-alone device that only scans the passenger's boarding pass and prints out the number of previously approved bag tags for application. These stations may require some minimal staffing requirements to handle customer service issues.
- **Curbside check-in:** Most airports allow for curbside check-in. Typically, curbside check-in facilities are equipped with conveyor belts located at these check-in podiums for direct input of bags into the outbound baggage system. At smaller airports (or for airlines who do not wish to pay for conveyors), checked bags may be placed on carts and taken into the check-in lobby to be transferred to the ATO counter bag conveyor.

Whether for passenger convenience or airline staffing economics, the proportion of passengers using non-traditional check-in methods has grown significantly, and is likely to serve the majority

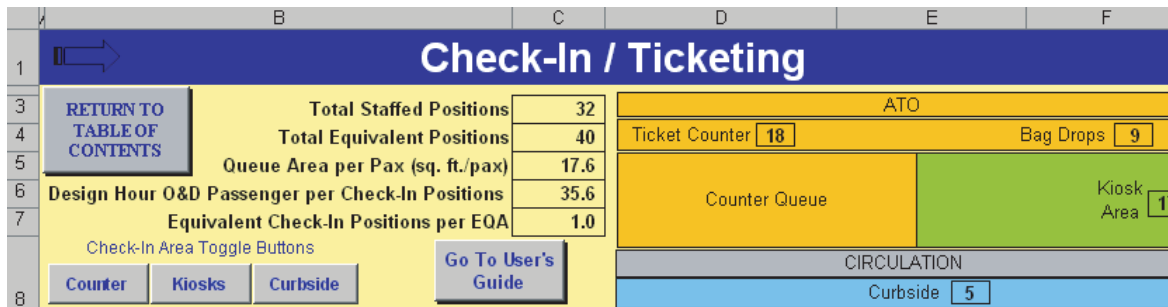


Figure 31. Example of Check-in/Ticketing model dashboard.

of passengers at most airports. Because there are different ways a passenger can check-in, or check a bag after checking in remotely (by Internet, remote kiosk, or other means), the ticket lobby may accommodate the different types of facilities described above and possibly others which may be developed in the future.

Model Overview

The Check-in/Ticketing model is formatted like all of the other models and uses a color-coded cell system to differentiate types of cells.

The top of the model is a dashboard of current settings and status for the inputs and conditions that the user is entering. In Figure 31 the dashboard shows the status summary, as well as some ratios such as check-in positions per EQA that can be compared to other similar airports.

The Check-In/Ticketing model incorporates models for the Staffed Counter, Kiosk, and Curbside check-in areas. However, the three basic models can be used for any type of future check-in procedure, such as self-tagging, with the appropriate inputs. Use the toggle buttons as seen in Figure 32 to auto scroll the screen to work on one area at a time.

In most of the input cells, a small red triangle will be in the upper right corner, signifying that a comment has been attached to give more explanation to the input requirements and/or more information on the general ranges. Some inputs and their title lines are conditionally formatted to alert the user to the possibility of an input error. The user can either keep the entered value if it is truly correct, or make a change to fall within the expected range, and the highlighted areas will return to the normal appearance. See Figure 33.

The terminal planner should be aware of the various systems and procedures in use, or expected to be used, as the check-in lobby and related spaces are planned. Flexibility in configuration and design is especially important for this evolving passenger-processing function.

The Design Hour Forecast Worksheet should have been completed before doing this step or an estimated design hour value will need to be used. If an estimate is used, enter the value into cell C11 in the Staffed Counter section; this will break the link to the Design Hour Forecast Worksheet and the other dependant cells will use this value as well.

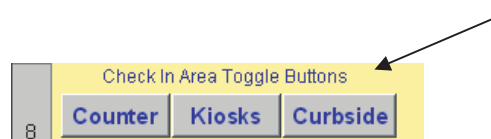


Figure 32. Toggle buttons for check-in areas.

Staffed Counter Positions		
DEMAND	INPUTS	OUTPUTS
Design Hour Departing Passengers (example year)	1,500	(Use Design Hour Worksheet Value)
% Connecting Traffic	5%	
Adjust Input for % of Passengers in Peak 30 min. Period	60%	
% of Passengers Using this Facility	50%	
Peak 30 min. Originating Passengers		428
Processing time per passenger (min.)	2	Starting Value ↓
Desired Maximum Wait Time (min.)	9	
Required # of Available Counter Positions		22

Figure 33. Example of Staffed Counter model.

The user should work on one section at a time and, when all of the inputs have been entered, check over the sections again to see if there are any errors or alerts. When all the inputs have been made, the user can make adjustments to the queue model inputs for the Staffed Counters and Kiosks to achieve the desired wait times and passenger queue spacing. Figures 34, 35, and 36 show the way common inputs are linked.

Figure 37 illustrates how the user may use suggestion boxes to achieve the desired results for wait times and passenger spacing by adjusting the queue model's number of service positions.

Although demand can be estimated if sufficient information is available, the number of ATO counter positions can often be as much an issue of airline back wall "billboard" space as actual demand, and/or staffing. Thus, some airlines will prefer to locate self-service kiosks in-line with the ATO counter, effectively replacing staffed counters, while others will prefer to locate kiosks in free-standing clusters or other configurations away from the ATO counter.

Analysis Technique

The Check-in model is designed to approach the issue of determining the required number of positions from a single-airline or common-use perspective. The model's approach can then be adjusted for additional airlines and the results of each airline can later be summed.

Staffed Counter Positions		
DEMAND	INPUTS	OUTPUTS
Design Hour Departing Passengers (example year)	1,500	(Use Design Hour Worksheet Value)
% Connecting Traffic	5%	
% of Passengers in Peak 30 min. Period	45%	
% of Passengers Using this Facility	50%	
Peak 30 min. Originating Passengers		321
Processing time per passenger (min.)	2	Starting Value ↓
Desired Maximum Wait Time (min.)	9	
Required # of Available Counter Positions		17

Figure 34. Inputs to Staffed Counter model will link to models of other check-in areas.

Kiosks		
DEMAND	INPUTS	OUTPUTS
Design Hour Departing Passengers	1,500	
% Connecting Traffic	5%	
% of Passengers in Peak 30 Min. Period	45%	
% of Passengers Using this Facility	40%	
Peak 30 Minute Originating Passengers		257
Processing time per passenger (min.)	1.5	
Desired Maximum Wait Time (min.)	2	
Required # of Available Counter Positions		13

Figure 35. Inputs to Staffed Counter model appear in Kiosk model.

Curbside			
DEMAND		INPUTS	OUTPUTS
67	Design Hour Departing Passengers	1,500	
68	% Connecting Traffic	5%	
69	% of Passengers in Peak 30 Min. Period	45%	
70	% of Passengers Using this Facility	10%	
71	Peak 30 Minute Originating Passengers		64
72	Processing time per passenger (min.)	2	
73	Desired Maximum Wait Time (min.)	5	
74	Required # of Available Counter Positions		4

Figure 36. Inputs to Staffed Counter model appear in Curbside model.

Regardless of the mix of facilities, the approach to determining the facilities for check-in requires essentially the same information:

- The number of design hour enplaning O&D passengers
- The number of airlines
- The time distribution of passengers arriving at the terminal
- Average service times and maximum waiting time targets
- The percentage of passengers using each type of facility in the ticket lobby versus other locations or going directly to the gate
- Use of curbside bag check-in or fully remote bag check-in

The model must have all of the above data in order to produce an accurate estimate of check-in facility demand.

To get the basic understanding of a queuing model without having to create a full-scale design day queuing model, a mini-queue model has been created to show delays at check-in during the peak 30-minute period within a peak period of the design day. This 30-minute slice of the design day can be used more generically to show the position requirements based on processing times and desired maximum wait periods. The mini-queue model uses an adjusted normal distribution curve around the center of the peak 30 minutes, with the average flow rates during the design hour as the leading and trailing arrival rates, to establish a stand-alone delay model. Design hour enplanements can be converted to the peak 30 minutes by prior knowledge of the passenger arrivals time distribution. Figure 38 gives the overall process of a queue model, while Figure 39 is the mini-queue model used to determine the flow conditions for ATO check-in.

The approach that is used in the spreadsheet model allows the user to determine the design hour O&D passengers departing during the peak 30 minutes, based on the arrivals distribution. That number is split into the three main areas of check-in by profile data gathered through surveys; then the 30-minute model is run for each area; and the totals are summed by airline or for the entire airport as a common-use facility.

One advantage of this approach is that it allows the planner to include LOS assumptions for waiting time. However, it also requires data (or estimates) for average processing times and the arrival time distribution. It must also be done separately for each airline or group of airlines (assuming the design hour occurs at a similar time for the airlines, or some type of common-use facility). Otherwise adjustments must be made for exclusive-use check-in positions, which may not be in use by airlines during the terminal's peak.

19	QUEUE MODEL (PROCESSING)		
20	Modeled # of Available Service Positions	20	More Needed
21	AVG. Queue Wait Time using Model Inputs (min.)	13.9	
22	MAX. Queue Wait Time using Model Inputs (min.)	20.8	Too Long
23	MAX. # of Passengers waiting in Queue	208	

Figure 37. Suggestion boxes.

32 Airport Passenger Terminal Planning and Design

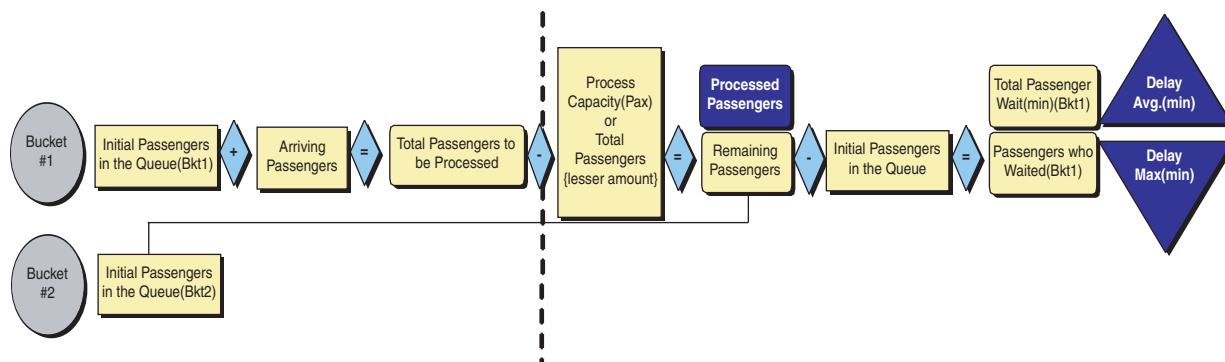


Figure 38. Queue process flowchart.

The standard staffed counter check-in queue is normally the major source of check-in delay, but with more travelers using self-service check-in options, the queue for using the Kiosks may be the queue to focus on. Both Staffed Counter and Kiosk portions of the Check-in/Ticketing model have mini-queue models that measure the passengers in queue and the maximum wait times based on the passenger and position inputs. The model will help determine the current LOS conditions and, by adjusting the position inputs for the mini-queue models, the user will see the time and space effects from position allocation.

When obtaining data on processing times for staffed or self-service check-in facilities, the user should exercise caution with airline-furnished data. Typically these service times only reflect the time an agent or kiosk is in use for a transaction (from log-in to delivery of boarding passes) and thus underestimates the full time taken by each passenger to complete the check-in process and walk away, making the position available for the next passenger.

Depending on the type of flight (domestic or international) and time of day (flights departing before or after 9 a.m.), the percentage of a flight's passengers who arrive for check-in during the

TICKETING QUEUE MODEL															
Ex. 1 Even Distribution				Optimized but Unrealistic				Ex. 2 Normal Distribution				More Realistic and less efficient			
				Would call for too few positions								Requires more positions, correctly			
Peak 30 Min. PAX		399		Peak 30 Min. PAX		399		RETURN TO TABLE OF CONTENTS		Peak 30 Min. PAX		399			
Process Time (min)		2		Process Time (min)		2				Process Time (min)		2			
# of Active Counters		20		Processed per 1 min		10.0				# of Active Counters		20		Processed per 1 min	
				99 Max # in Queue								128 Max Pax in Queue			
				2275 Total Group Wait								2963 Total Group Wait			
				5.7 Avg. Wait Time								7.4 Avg. Pax Wait Time			
				9.9 Max Wait Time								12.8 Max Wait Time			
<p>Passenger Arrival Distribution</p> <p>Peak 30 min.</p> <p># of Passengers</p> <p>Time in Model (min)</p>				<p>These two mini queue models have been added to show the difference in assuming an even distribution of passengers arriving at a steady flow during the peak period compared to a normal distribution of passengers arriving slowly at first and then more rapidly towards the average early arrival time before the peak departures time. The general process equation determines the number of required counter positions according to the even distribution method and underestimates the requirement because it is an optimized method with no process time lost. The normal distribution curve better suggests real world arrivals as a peak in the middle of a generic period. This model is only an example of a peak period at some point during the days demand. Early arrival profiles are commonly used together to predict when the real peak of arrivals will occur.</p>				<p>Passenger Arrival Distribution</p> <p>Peak 30 min.</p> <p># of Passengers</p> <p>Time in Model (min)</p>							
Real Time	Arriving	Total Pax	Processed	Remaining	Cummulative Wait Time	Probability	Frequencies	Real Time	Arriving	Total Pax	Processed	Remaining	Cummulative Wait Time		
0	7	7	7	0	0			0	7	7	7	0	0		
1	7	7	7	0	0			1	7	7	7	0	0		
2	7	7	7	0	0			2	7	7	7	0	0		

Figure 39. Mini-queue model for staffed counters.

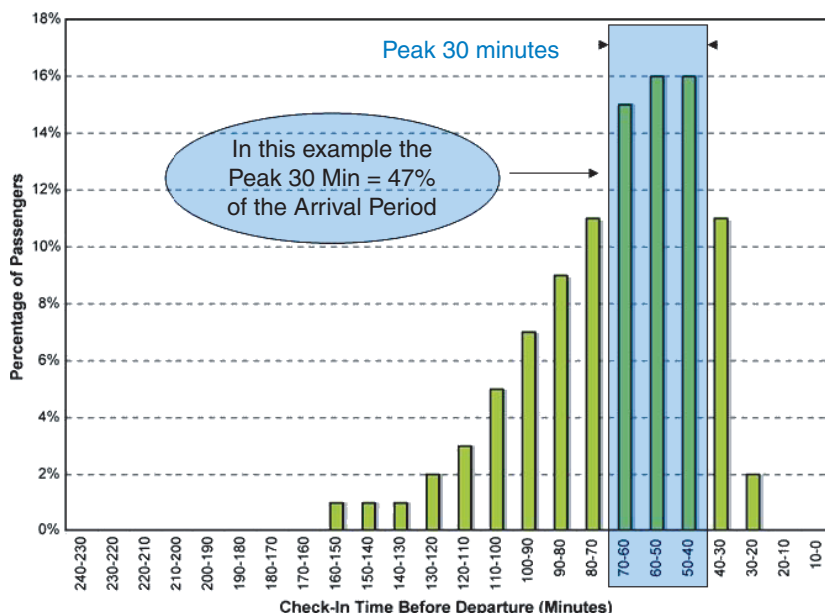


Figure 40. Example of an early arrival distribution chart.

peak 30 minutes can range from 30% to 50% of the flight’s load. The range for the peak 30 minutes comes from the early arrival distribution that passengers typically follow. Domestic passengers typically have an arrival distribution that spans up to two hours, whereas international passengers may arrive up to four hours before departure. The peak-hour originating passengers are, therefore, spread out over two to four hours and not just a one-hour period. Figure 40 is an early arrival distribution example of domestic passengers where the peak 30 minutes represents 47% of the entire flight’s passengers.

Other Analysis Techniques

One alternative to the method used in the Check-in model is the ratio approach, where existing ratios of check-in positions to design hour O&D passengers and/or EQA are used as a basis for future planning. These ratios should be based on actual peak period staffing of ATO positions (rather than leased counters) and numbers of available kiosks and should account for observed levels of service.

The ratio approach can combine conventional staffed positions and kiosks as Equivalent Check-in Positions (ECP). Each airline’s ECP is the number of conventional positions in use, plus the number of kiosks. The current ratio of Design Hour Enplaned Passengers per ECP is determined and then either held constant for the forecast years or changed, based on the existing LOS. The ratio of staffed counters to kiosks can then be varied depending on the current utilization of kiosks at the airport and the trends in kiosk use identified.

The Check-in model displays the results of both ratios in the dashboard (Figure 31) as Design Hour Originating Passengers per Check-in Position and ECP per EQA. These results can also be a measure for comparison to a benchmark level or another airport. The ratio approaches are incorporated on a separate tab that can be accessed by the command button as seen in Figure 41. The Ratio Approach Examples button is located just beneath the Staffed Counter Positions section in the Check-in model.

The Design Hour Originating Passengers per ECP method is shown in Figure 42. An advantage of using a design hour to ECP ratio is that it requires less detailed data than the 30-minute service

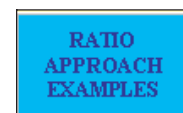


Figure 41. Ratio Approach command button.

9 Ratio Approach Using Design Hour Originating Passengers			
10 EXISTING CONDITIONS		INPUTS	OUTPUTS
11	# of Staffed Counters in use	11	
12	# of Self-service Kiosks in use	10	
13	Total # of Equivalent Check-In Positions (ECP)		21
14	Current # of Design Hour Originating Passengers	180	
15	Current ratio of Originating Passengers per ECP		8.6 (Pax/ECP)
16	Percentage using Staffed Positions		52%
17	Percentage using Kiosks		48%
18 FORECAST CONDITIONS			
19	Design Hour Originating Passengers	340	
20	Percentage using Staffed Positions	30%	
21	Percentage using Kiosks		70%
22	# of ECPs required		40
23	# of Staffed Positions		12
24	# of Kiosks		28

Figure 42. Example of ratio approach using design hour originating passengers.

model. The disadvantage can be that it assumes a continuation of existing staffing assumptions and the approximate number of airlines.

Another variation on this approach is to use a ratio of gate capacity (EQA) to ECP as shown in Figure 43. This may be appropriate when the airport is expecting new airlines and larger increases in gates versus growth in design hour passengers due to load factors and/or aircraft size growth within an aircraft group.

Other factors that can affect the number of ECPs include the following:

- Curbside check-in. The use of curbside, skycap check-in (although limited to domestic flights) is very popular among many passengers and airlines, especially when skycaps have the ability to issue boarding passes. While removing some passengers with checked bags from the ticket lobby, it relocates the queue to the curb, and has its own facility impacts. Recent trends in charging for curbside check-in may reduce utilization unless passengers believe they are getting a higher LOS.
- Common-use counters using Common Use Terminal Equipment (CUTE) technology. This allows airlines to share counters based on schedule compatibility (one airline’s schedule peaks coinciding with another’s schedule valleys). These types of systems are often administered by

27 Ratio Approach Using Gate Capacity (EQA)			
28 EXISTING CONDITIONS		INPUTS	OUTPUTS
29	Staffed counters in use	11	
30	Self-service kiosks in use	10	
31	Total equivalent check-in positions (ECP)		21
32	Current gate capacity (EQA)	3.3	
33	Current ratio of ECP per EQA		6.4 (ECP/EQA)
34	Percentage using Staffed Positions		52%
35	Percentage using kiosks		48%
36 FORECAST CONDITIONS			
37	Forecast gate demand (EQA)	5.3	
38	Percentage using Staffed Positions	30%	
39	Percentage using Kiosks		70%
40	# of ECPs required		34
41	# of Staffed Positions		10
42	# of Kiosks		24

Figure 43. Example of ratio approach using EQA.

airport authorities or joint airline operating companies. New standards incorporating both CUTE counters and Common Use Self-Service (CUSS) kiosks are in development by the International Air Transport Association (IATA) and should be in place in late 2009. These Common Use Passenger Processing System (CUPPS) standards will resolve some commonality issues which have increased the costs and complexity of introducing common use equipment at many airports.

- Dedicated ticket sales positions for foreign flag carriers. Many foreign carriers require separate counters for ticket sales because of internal training/accounting procedures and/or the use of non-airline personnel (handling agents) for the actual passenger check-in process.

Space Allocation

The number of forecast ECPs can be converted to conventional linear positions to establish the length of the ATO counter. As noted, locations for kiosks are a combination of airline preference and the physical constraints of the ticket lobby. To determine the length of an ATO counter for future activity, assumptions are made as to the ratio of in-line kiosks as compared to those located elsewhere in the ticket lobby. The resulting number of in-line and staffed ATO positions determine the length of the counter.

A Space Summary (Figure 44) is provided at the bottom of the spreadsheet model and will appear with the Curbside section. The dimensions that have been observed as normal or acceptable are described in the following paragraphs and although they are a good measure of what should work and be sufficient, careful observations of each individual airport are necessary to make adjustments on the use and allocation of space in the terminal.

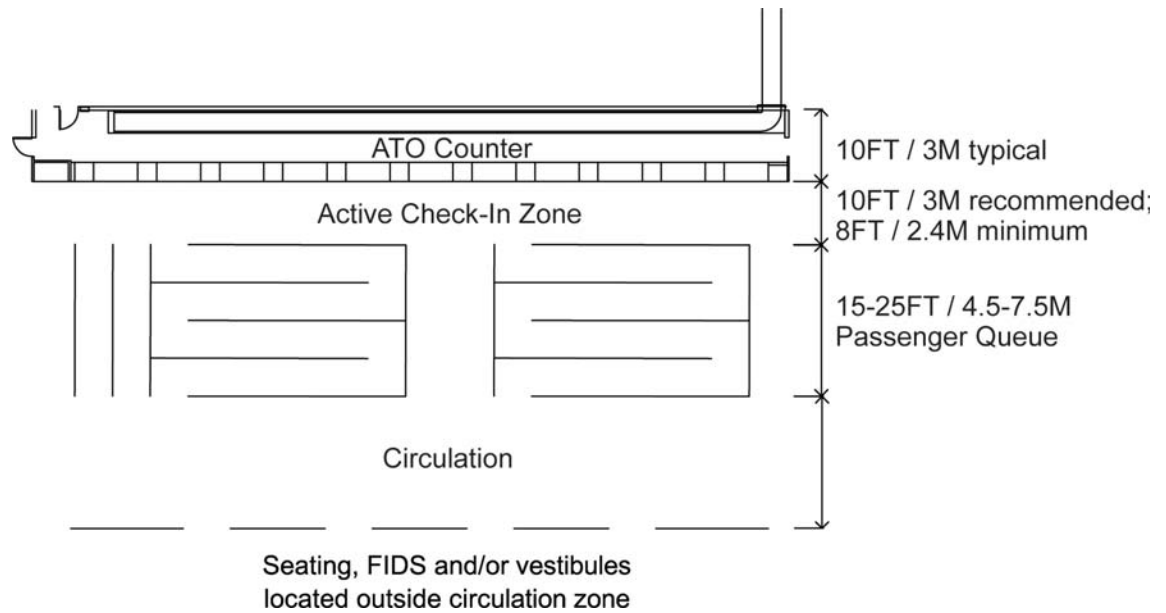
Typical Dimensions of the ATO Counter

The ATO counter consists of the actual counter, agent work space, and the baggage conveyors. In most domestic and smaller airports, the conveyor is arranged parallel to the counter and the bags are taken from the counter bag well to the conveyor manually. The overall depth of this configuration is typically 10 feet from back wall to face of counter.

The average width per agent varies from 4 to 5 feet depending on counter design and whether bag wells or bag scales are shared. Most domestic carriers can use a 6-foot double counter plus a shared 30-inch bag well for an average of 4.25 feet per agent. There are also typically breaks in the ATO counter to allow personnel access to individual ATO office areas, and end counters typically do not have bag wells. This increases the average ATO counter length for planning to approximately 5.0 to 5.5 linear feet per position for most terminals. The width of an in-line kiosk can be less than that of a staffed counter, but is highly dependent on individual airlines' equipment. For planning, all in-line positions are often assumed to require the same width. See Figure 45.

Space Summary				
83	ATO Airline Office Space	depth (ft)	20	2,000 sq. ft
84	ATO Counter Area	depth (ft)	10	1,000 sq. ft
85	Active Check In Zone	depth (ft)	10	
86	Active Check In Zone Area			1,000 sq. ft
87	Counter Queue			2,500 sq. ft
88	Kiosk Area			900 sq. ft
89	Curbside Area			525 sq. ft
90	Cross Circulation	depth (ft)	20	2,720 sq. ft
91	Total Check-in/Ticketing Area			10,645 sq. ft

Figure 44. Space Summary section.



Source: Hirsh Associates

Figure 45. Typical linear ticket lobby.

In many international terminals where bags are heavier, powered take-back belts (typically 24 inches wide) for each agent are used. The overall depth of this configuration is typically 12 to 15 feet including a parallel baggage conveyor. The average width per agent varies from 6 to 7 feet depending on counter design. This configuration has also been required by some larger domestic airlines.

Typical Dimensions of Check-in/Ticket Lobby

The ticket lobby includes the passenger queuing area for the ATO counter and the cross-circulation zone at the main entrance of the terminal building. Self-service kiosks can also be located within the passenger queuing area.

Active Check-in Zone

In front of the counter is space for the passengers who are being checked in and for circulation to and from the check-in positions. This space is recommended to be 10 feet deep, with 8 feet as a minimum.

Passenger Queuing Area

The total amount of passenger queuing area is ultimately determined by the number of passengers expected to be in the queue and the width of the ticket lobby (number of check-in positions). It has been found that 15 feet is typically the minimum depth for passenger queuing and is adequate for lower activity terminals. Medium and higher activity terminals typically require 20 to 25 feet for queuing, respectively. The model includes a LOS table with IATA-recommended areas per passenger which vary with the use of bag carts, etc.

Queues may be a combination of single queues (one per check-in position) or multi-server serpentine queues. The minimum width of a queue is recommended to be 4.5 to 5.0 feet. At terminals with larger checked bags, heavy use of bag carts, and/or larger traveling parties, wider queues are appropriate. Queue ropes should be spaced to provide more space at turns, with 5 feet as the minimum and 6 feet recommended when bag carts are used.

For stand-alone kiosks, 8 feet for the passengers and circulation is recommended. See Figure 46 for an illustration of check-in queuing dimensions.

Cross-Circulation Zone

A cross-circulation zone is needed behind the passenger queue. This zone should be free of obstructions and separate from seating areas, the Flight Information Display System (FIDS), advertising displays, and/or entrance vestibules. The width of this zone is recommended to be a minimum of 10 feet at lower activity terminals, increasing to 20 feet at higher activity terminals.

Total Dimensions

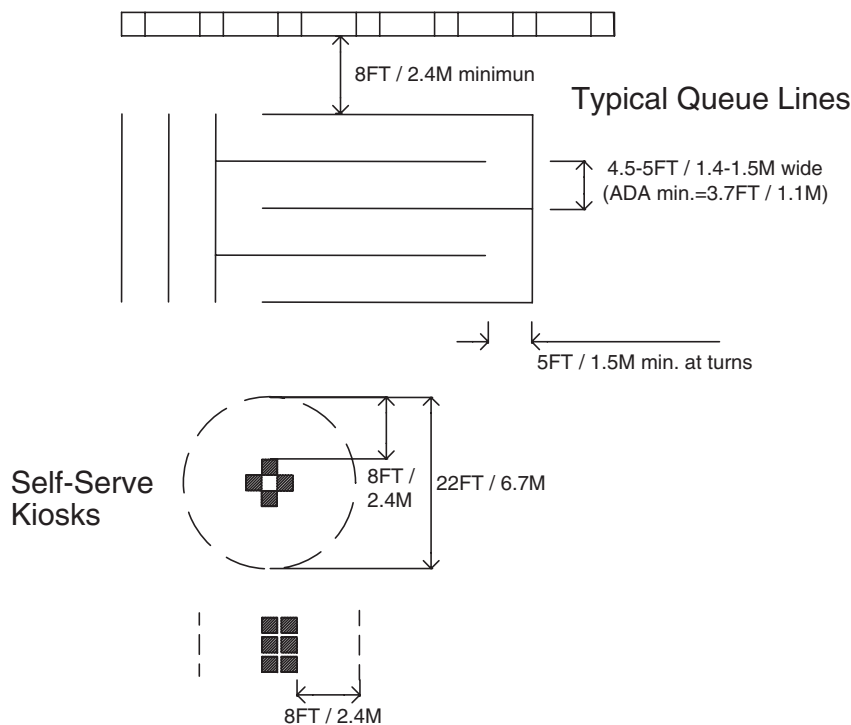
The combination of these three functions results in the following typical dimensions for the ticket lobby:

- Low Activity Terminals: 35 feet
- Medium Activity Terminals: 45 feet
- High Activity Domestic Terminals (minimum): 55 feet
- High Activity International Terminals: 50 to 70 feet

Terminals with unusual conditions resulting in large surges of passengers such as charters, cruise ship activity, etc. may require deeper lobbies. In all cases, the ticket lobby should be as barrier free as possible, with enough space provided for cross-circulation flows so they do not trigger automatic openers for curb doors.

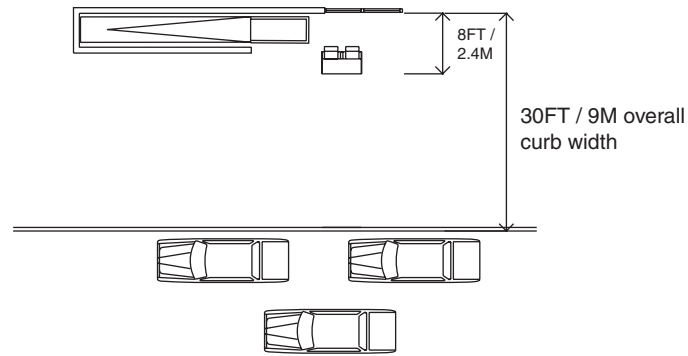
Seating areas, entrance vestibules, and other functions would be in addition to these and typically add a minimum of 5 feet to the overall depth of most lobbies.

The linear/frontal configuration is the most common for domestic terminals, as well as many terminals handling international passengers with limited numbers of airlines. This configuration provides the most frontage as compared to the number of check-in positions. Pier



Source: Hirsh Associates

Figure 46. Typical queue dimensions.



Source: Hirsh Associates

Figure 47. Typical curbside bag check area.

or island configurations typically provide more check-in positions for similar frontage than linear configurations.

Curbside Check-in Dimensions

Curbside baggage check-in is popular at many airports. The dimensions for these facilities are similar to that of typical check-in counters. Figure 47 illustrates a two-position check-in podium with a bag belt to the side. This configuration minimizes the depth of the podium (8 feet). Depth can also be limited by locating the bag conveyor within the terminal front wall to allow a more conventional counter configuration.

Passenger queuing and cross-circulation space is recommended to be a minimum of 12 feet, with greater depth for higher activity terminals where there may be more circulation along the curb edge. It is normally anticipated that queues will form parallel to the curb rather than toward the vehicle lanes. This results in a 30-foot recommended depth.

The curb depth is also influenced by the presence of vehicle barricades that may be required at some airports for blast protection considerations unrelated to passenger processing.



Security Screening Model

Security screening requirements for passengers are subject to FAA/TSA regulations and the level of security may be changed by FAA directive if unusual levels of threat are perceived. When specific direction or counsel is needed, requests must be made directly to TSA.

The Security Screening model is designed to provide a view of the passenger experience in the queue in relation to wait times and queue area. The user defines the processing rates and number of lanes, and inputs the existing or desired screening lane dimensions and queue dimensions. Figure 48 is a screenshot of the model. The cells are color-coded in the same manner as the other models in the spreadsheet. The user makes the inputs into the white cells and can perform a sensitivity analysis of the screening process by adjusting the inputs and observing the changes to the wait times and passenger space values.

Additional information about the inputs or calculations in the user cells is provided by way of cell comments that will pop up when the user's cursor is placed over the cell.

Estimating Demand

Processing rates for security screening checkpoints (SSCP) have been observed to vary significantly at different sized airports with rates ranging from approximately 100 passengers per hour per lane to over 200 passengers per hour per lane. A lane is typically a walk-through metal detector (WTMD) plus an X-ray machine for carry-on bags. Based on current TSA procedures requiring passengers to remove computers and some other electronics from passenger bags, to remove their shoes, etc., the bag X-ray machine usually determines the capacity of the SSCP. A combination of two X-ray machines paired with a single WTMD for better TSA staff utilization is currently the preferred configuration.

Passenger characteristics typically determine the SSCP throughput, with less frequent travelers (who are unfamiliar with TSA rules and procedures) taking longer than frequent flyers. Changing TSA rules (such as the ban on liquids and gels) can also slow down processing rates until all passengers become familiar with new procedures. It is very important that each airport measure its average processing rates during different seasons and times of day to determine a reasonable range of rates to use for planning. It is also recommended that actual throughputs be observed rather than relying on TSA hourly WTMD counts. These counts will overstate the passenger throughput as it counts each person who passes through the WTMD, including TSA officers and passengers who set off the alarm and are allowed to take off probable metal items and walk through again. The TSA also collects alarm rates for each WTMD. These alarm rates tend to vary depending upon the mix of passengers at the checkpoint.

	A	B	C	D	E	F
1	Security Screening					
2						
3	RETURN TO TABLE OF CONTENTS	Go To User's Guide				
4					Input Data Values	
5					Calculated Values	
6					Linked or Predetermined Values	
7	DEMAND	INPUTS	OUTPUTS			
8	<i>Use throughput value from Check-In Model</i>	750				
9	Peak 30 min Originating Passengers from Check-In	641	linked to Check In/ Ticketing			
10	% Additional Traffic (non-passenger, employees, crew)	15%				
11	Total Peak Period Security Traffic (passengers)		737			
12	Throughput Rate (Passengers/Hour per lane)	175				
13	# of Passengers Processed/minute per lane		2.9			
14	Maximum Target Wait Time (in Queue)	8				
15	Minimum Required # of Screening Lanes		7		Starting Value	
16	QUEUE MODEL FOR REQUIRED SCREENING LANES					
17	# of Screening Lanes for Queue Model Input	9			Decision Value	
18	Max. Wait Time in Queue (Min.)		8.1	Adequate # of Lanes		
19	EXISTING CONDITIONS					
20	Depth of Security Queue (ft)	20				
21	Width of Scanning Lane Module (2 Lanes) (ft.)	25				
22	Overall Length of Check Point Area (ft)	40				
23	Reconciliation Area Depth (ft)	10				
24	SPACE REQUIREMENTS					
25	Security Queue Area (sq. ft)		2,250			
26	Passengers in Queue based on Queue Wait Time		212			
27	Passenger Space Required for LOS Input (sq. ft/pax)	10.8 (Review the IATA Table)				
28	Required Security Queue Area for LOS Input (sq. ft)		2,294			
29	Passenger Space with Current Dimensions (sq. ft/pax)		10.6	More Queue Needed		
30	Total Checkpoint Area -tables, equipment, search area (sq. ft)		5,625			
31	Total Security Screening Area (sq. ft)		7,875			
32						

Figure 48. Example of Security Screening model.

The Demand portion of the Security Screening model is broken out in Figure 49 where the user determines the percentage of additional traffic at the airport in question, the throughput in passengers/hour/lane and the desired maximum waiting time. These inputs will provide a starting point for the required number of screening lanes. The linked mini-queue model uses a normal peaked distribution, which allows for lags and surges in the flow, to estimate a required number of screening lanes that is more likely to achieve the desired maximum waiting time. This mini-queue model is similar to that used in the Check-in model.

Typical Equipment

Passenger checkpoints have changed since the creation of the TSA, becoming larger than previous installations. As TSA procedures and equipment continue to evolve, it is expected that the configuration and size of the SSCPs will change as well.

	DEMAND	INPUTS	OUTPUTS
8	<i>Use throughput value from Check-In Model</i>	750	
9	Peak 30 min Originating Passengers from Check-In	641	linked to Check In/ Ticketing
10	% Additional Traffic (non-passenger, employees, crew)	15%	
11	Total Peak Period Security Traffic (passengers)		737
12	Throughput Rate (Passengers/Hour per lane)	175	
13	# of Passengers Processed/minute per lane		2.9
14	Maximum Target Wait Time (in Queue)	8	
15	Minimum Required # of Screening Lanes		7 Starting Value

Figure 49. Example of Security Demand entry.

As of this writing (2009), a standard SSCP contains five major components (See Figure 50):

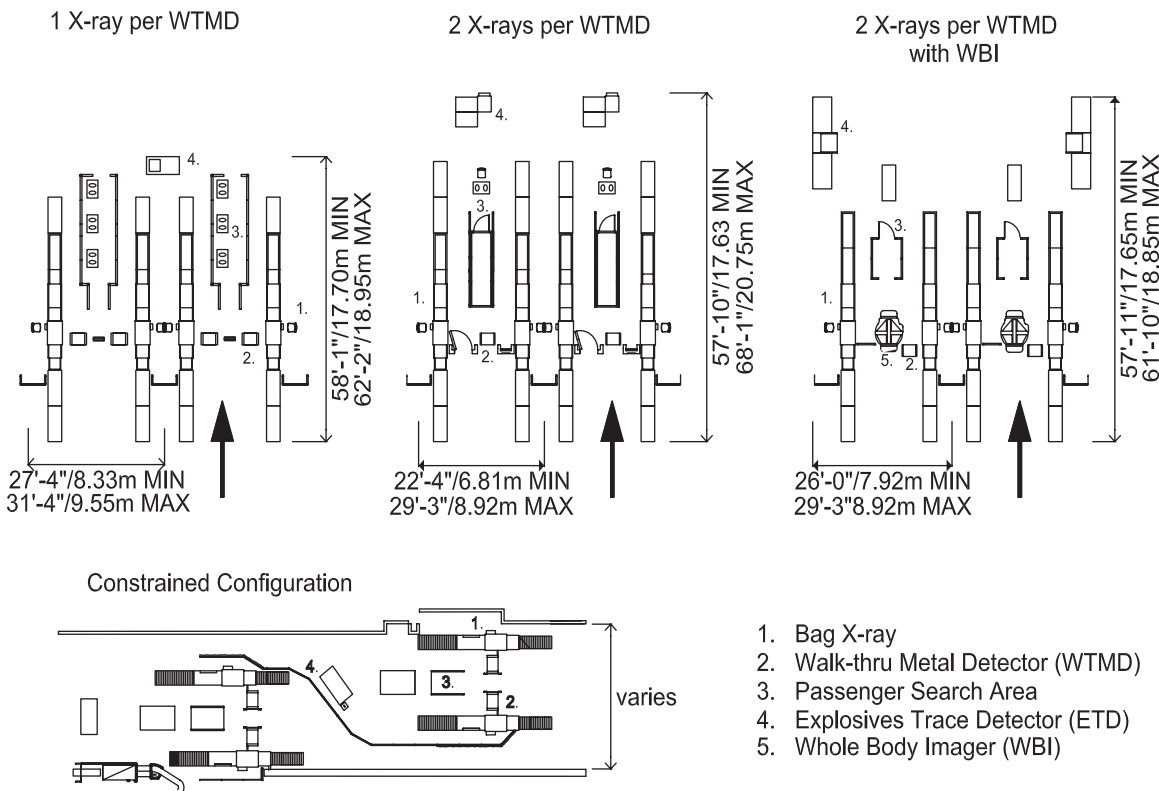
- X-ray for carry-on bags
- Walk-through metal detector (WTMD)
- A search area for passengers who set off the WTMD
- Explosives Trace Detection (ETD) for checking bags
- Whole Body Image (WBI)

Additional equipment that has been tested in the recent past includes a separate X-ray for shoes, passenger ETD portals (“puffers”), WBI, and other equipment currently undergoing testing. The TSA’s ultimate goal is to have fewer pieces of equipment with better capabilities to speed up passenger processing. However, it is also likely that SSCP’s will become larger and slower before they reduce in size and become faster.

A typical standard configuration has one X-ray for each WTMD and is approximately 25 feet wide for a pair of lanes. At some airports, a different configuration consisting of two X-rays for one WTMD has been installed. This can result in a slightly narrower footprint. Non-standard configurations are also used where physical constraints do not allow a typical line of inspection lanes.

Additional width may be associated with Americans with Disabilities Act (ADA) accessible lanes.

The length of the SSCP varies depending on a number of factors, but is primarily related to the length of the divestment tables prior to the X-ray for passengers to unpack laptop computers, take off jackets and shoes, and remove metal objects from pockets. Similarly the length of roller beds and collection tables and seats after the SSCP, to put clothing back on, and re-pack bags can vary. Airports are experimenting with these functions and there is no standard for these tables at present. Forty feet is considered an absolute minimum length for an SSCP. TSA recommends a 60-foot length since the longer length increases checkpoint throughput.



Source: Checkpoint Design Guide (CDG), Revision 1, February 11, 2009, Transportation Security Administration

Figure 50. SSCP equipment configurations.

16	QUEUE MODEL FOR REQUIRED SCREENING LANES		
17	# of Screening Lanes for Queue Model Input	<input type="text" value="9"/>	Decision Value
18	Max. Wait Time in Queue (Min.)		8.1 Adequate # of Lanes
19	EXISTING CONDITIONS		
20	Depth of Security Queue (ft)	<input type="text" value="20"/>	
21	Width of Scanning Lane Module (2 Lanes) (ft.)	<input type="text" value="25"/>	
22	Overall Length of Check Point Area (ft)	<input type="text" value="40"/>	
23	Reconciliation Area Depth (ft)	<input type="text" value="10"/>	

Figure 51. Existing Conditions and Queue model.

It is recommended that planners coordinate with the TSA on current equipment and procedures at the time of design. However, flexibility to re-configure SSCPs should be a goal.

In the next section of the model, the user selects and inputs the current configuration and dimensions of the security screening and queuing area. Figure 51 is taken from the model and shows how the user can adjust the number of screening lanes being used in the mini-queue model to see the impact on the maximum waiting time in the queue. The preliminary calculation for the number of required screening lanes in Row 15 (as shown in Figure 49) was determined by optimizing the process potential, and thus the real number of screening lanes must be greater, with time lost during periods of flow that are below the process capability.

Queuing

The size of the passenger queue area prior to the inspection lanes will be determined by the number of passengers anticipated to be in the queue at peak times. Serpentine queues are recommended. The width of the queue lines is recommended to be a minimum of 4 feet, with 5 feet to allow traveling parties to stand next to each other.

The last section of the model (as represented in Figure 52) looks at the queuing area and determines the passenger space within the queue. A pop-up IATA Table (Figure 53) is included for the user to adjust the area per passenger LOS and see the required changes to the dimension of the queue. By making adjustments and performing a sensitivity analysis, the user can better understand how to use the space and configuration available to provide their passengers with the LOS that is desired. Total checkpoint area and total security screening area are also calculated for future comparison of space/passenger values with other airports.

24	SPACE REQUIREMENTS		
25	Security Queue Area (sq. ft)	<input type="text" value="2,250"/>	
26	Passengers in Queue based on Queue Wait Time	<input type="text" value="212"/>	
27	Passenger Space Required for LOS Input (sq. ft/pax)	<input type="text" value="10.8"/> (Review the IATA Table)	
28	Required Security Queue Area for LOS Input (sq. ft)	<input type="text" value="2,294"/>	
29	Passenger Space with Current Dimensions (sq. ft/pax)	<input type="text" value="10.6"/>	More Queue Needed
30	Total Checkpoint Area -tables, equipment, search area (sq. ft)	<input type="text" value="5,625"/>	
31	Total Security Screening Area (sq. ft)	<input type="text" value="7,875"/>	

Figure 52. Example of queuing area in model.

Review the IATA Table for typical Areas/Passenger...

IATA Space Standards		LOS					m ² ft ²
		A	B	C	D	E	
Passport Control	Queue	1.4	1.2	1	0.8	0.6	
		15.1	12.9	10.8	8.6	6.5	

Figure 53. Pop-up of IATA space standards.



Baggage Screening Model

As a result of the Aviation and Transportation Security Act (ATSA), all checked baggage is subject to screening for explosives. Depending on the size of the airport, available space, and budget, two types of systems may be deployed:

- The smallest airports have used ETD units, typically located in the check-in lobby as the primary form of baggage screening. These are fully manual systems with the slowest throughput rate. Typically a single ETD unit shared by two screeners can process up to 66 bags/hour. ETD units also are used for checking oversized bags which cannot fit through EDS equipment, and for more detailed examination of bags alarmed by EDS units.
- EDS are capable of automatically detecting explosives and then providing a three-dimensional view of the bag's contents to TSA screeners for further analysis. Most of the currently deployed EDS technology was developed prior to the passage of ATSA, based on standards set forth by Congress in the Aviation Security Improvement Act of 1990. After large-scale deployment of EDS in 2002 and 2003, equipment manufacturers have incrementally improved performance in terms of false alarm rates and throughput capabilities. In addition, new EDS equipment has been certified. Most of the currently deployed EDS machines operate with throughput rates between 100 and 550 bags/hour.

EDS units have widely varying capacities and are configured in different ways:

- Stand-alone EDS are the simplest EDS installations, typically located either in the check-in lobby or immediately behind the ATO counter. Screeners manually load the bags into the EDS unit and then move the screened bags to a bag conveyor into the baggage make-up room. Typical throughput rates are in the range of 100 to 200 bags/hour.
- Mini in-line systems have a single (or possibly two) EDS units on a feed conveyor from the ATO counter to the make-up area. This configuration requires the least in the way of bag sortation. EDS units for these simple in-line systems typically have capacities of 100 to 400 bags/hour.
- Medium- and high-volume systems are highly integrated, highly automated, and low labor-intensive systems with multiple EDS units arranged in a screening matrix which requires sophisticated baggage sortation and tracking. Current EDS units for these systems have capacities of 400 bags/hour. Expected upgrades to these EDS units are estimated to increase throughput to the range of 500 to 700 bags/hour. Future EDS units in development are expected to have capacities of up to 1,000 bags/hour. Thus, the baggage handling systems supporting the EDS screening matrix should consider possible increases in EDS capacity during the life of the system. More detailed information can be found in the TSA's *Planning Guideline and Design Standards for Checked Baggage Inspection Systems* (release date October 10, 2007. Planners should check for updates).

The spreadsheet model for Baggage Screening is set up in the same manner as the other models where there is a link back to the Table of Contents and the User's Guide and all the cells are color coded for consistency as seen in Figure 54.

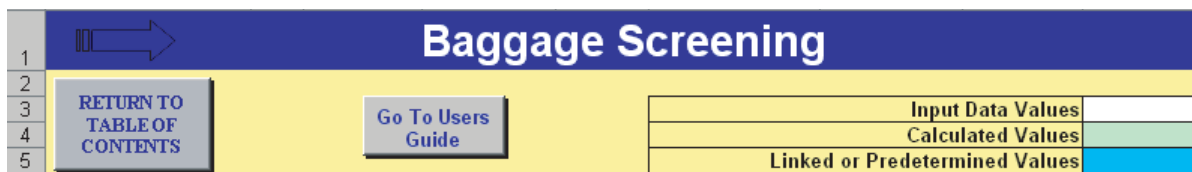


Figure 54. Example of Baggage Screening model.

Airports of varying sizes and traffic levels will require different screening systems.

A full analysis methodology for sizing a checked baggage screening system is beyond the scope of this planning guide. However, an initial estimate of baggage volumes and EDS equipment can be made given certain basic assumptions and design hour passenger volumes.

The spreadsheet model allows for preliminary estimates of the major equipment necessary for EDS system programming and follows the standard three-level TSA protocols for checked baggage inspection systems (CBIS). Figure 55 demonstrates the basic process used to estimate baggage screening requirements.

The first step in the model is to determine bag load, which is driven by the design hour check-in passengers. Line 8 lets the user choose to use the flow of design hour passengers checking in from the Check-in model, or to select a different user-specified input. Lines 9 and 10 in the model will request information from the user in relation to bag checking preferences. This data along with the surge factor developed by TSA provides the system demand that will drive the estimates for equipment and space. The surge factor should be used, but the user can turn the application on and off in Line 13 to see the actual effect on the equivalent bag rate. The demand segment is titled Design Hour Bag Load in the model as illustrated in Figure 56.

To segment the model inputs for the next section, the estimated percentage of over-/odd-sized bags is needed. This process assumes that most systems will be EDS for Level 1 screening; for smaller airports with only ETD systems, those selections are made in the next section.

The preferred TSA screening protocol involves three different screening levels. Level 1 screening is performed with EDS units for all bags that can physically fit in an EDS. All bags that alarm at Level 1 are automatically subject to Level 2 screening. During Level 2 screening, TSA personnel view alarmed baggage images captured during the Level 1 EDS scan, and clear any bags whose status can be resolved visually. This process is referred to as on-screen resolution (OSR), which, for in-line systems, allows the continuous flow of bags through the system until a decision is made. All bags that cannot be resolved at Level 2, and all bags that cannot use EDS

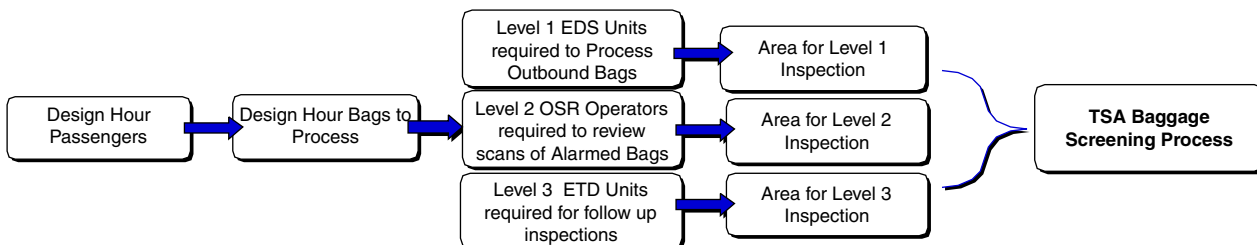


Figure 55. Baggage Screening process flow diagram.

7	DESIGN HOUR BAG LOAD		INPUTS	OUTPUTS
8	Design Hour Passengers Checking In	<i>User Input</i> 1500	1,500	linked to Check-In / Ticketing
9	% of Passengers Checking Bags		60%	
10	Average # of Bags per Passenger		1.5	
11	Total # of Bags to process in Peak Hour			1,350
12	10 minute Baggage flow rate			225
13	TSA Surge Factor (based on a 10 minute baggage flow rate)		<i>Applied</i>	1.13
14	Equivalent Baggage Surge Rate (bags/hour)			1,530
15	% of Total bags that are over-odd/sized bags & too large for EDS		3%	
16	# of over-odd/sized bags requiring ETD inspections			46
17	Total # of Bags to process through Level 1 EDS Units			1,484

Figure 56. Example of Design Hour Bag Load model.

for Level 1 because of size restrictions, are sent to Level 3. Level 3 screening is performed manually and involves opening the bag and using ETD technology. The small percentage of bags that do not pass Level 3 screening are either resolved or disposed of by a local law enforcement officer.

The model follows this three-step procedure and estimates the equipment quantities for either ETD or EDS or both. The user selects the existing or desired system parameters, and inputs the estimated process rates from records or using TSA suggestions. The outputs from the model are the number of EDS and ETD units required. See Figure 57.

After determining an estimate for unit quantities, the last section of the model, as shown in Figure 58, estimates the space necessary in the lobby or back-of-wall screening area for the units and personnel to operate and function efficiently. These area calculations do not include the full baggage conveyor or sortation systems that may be required but are provided to give an indication of the minimum areas necessary for the TSA screening process.

18	EDS/ETD EQUIPMENT REQUIREMENTS	
19	Level 1 EDS Screening - Process Rate(bags/hour)	150
20	# of Level 1 EDS Units required	10
21		
22	% of Scanned Bags requiring Level 2 Screening (Alarm Rate)	25%
23	# of bags requiring Level 2 OSR	371
24	Level 2 OSR rate (bags/hour per operator)	120
25	# of Level 2 OSR Stations required(1 operator/station)	4
26	% of Resolved OSR Bag Reviews (Clear Rate)	80%
27	Total # of Bags needing Level 3 Screening in Peak Hour	121
28		
29	Level 3 ETD Screening - Process Rate(bags/hour)	24 <small>TSA suggests 24 bags/hr/screener</small>
30	# of Level 3 ETD Units required (2 screeners/unit)	3

Figure 57. Example of EDS/ETD equipment requirement screen.

31	BAGGAGE SCREENING SPACE REQUIREMENTS	
32	Level 1 Area per EDS Screening Unit (sq. ft.)	800 ~ 800 sq. ft per Unit
33	# of Required EDS Units	10
34	Level 2 Area per OSR Station (sq. ft.)	40 ~ 40 sq. ft per Unit
35	# of OSR Stations required	4
36	Area per ETD Screening Unit (sq. ft.)	100 ~ 100 sq. ft per Unit
37	# of required ETD Units	3
38	Total Area requirements for Baggage Screening (sq. ft.)	8,460

Figure 58. Example of baggage screening space requirements.



Baggage Make-up Model

Baggage make-up includes manual or automated make-up units, the cart/container staging areas, and baggage tug/cart (baggage train) maneuvering lanes. The type of system selected for a terminal depends on a number of factors including the number of airlines, the terminal configuration, operating policies (common use, exclusive use), and size of the terminal complex.

Although checked baggage ratios are a consideration, especially when designing more complicated automated sortation systems, these ratios generally affect the total number of baggage carts/containers in use rather than the size of the make-up area. The number of carts/containers per flight staged at any one time, however, is generally based on the size of the aircraft. For most terminals, one cart or container is typically staged for each 50 to 75 seats of aircraft capacity; this would be equivalent to approximately two to three carts/containers per EQA (1 EQA = 145 seats). A cart or LD3 container is usually assumed to have the capacity for 40 to 50 bags. The number of staged carts/containers can also vary based on individual airline policies for pre-sorting baggage at the spoke airport for more efficient transfer at the hub. An airline may start moving carts/containers to the gate as they fill up when more than two or three are used for a flight.

The total number of staged carts or containers also is related to the passenger arrival time distributions and how early an airline staffs the make-up area. Typically, domestic flights begin staging carts two hours before scheduled time of departure (STD). International flights typically begin at three hours for early departing flights (between 4 and 9 a.m.), and four hours for other departure times. For passengers who check in before these normal time periods, some type of early bag storage may be required. The baggage make-up process is typically finished 30 minutes prior to STD, but can extend closer to STD for smaller airports.

To determine the number of staged carts or containers, the planner should estimate the peak number of departures during the two-, three-, or four-hour period (as appropriate for the terminal's type of service) and apply the appropriate aircraft size mix (or use EQA).

The Baggage Make-Up model estimates the make-up requirement based on the total EQA of gates in use, the average number of departures per nominal gate (not normalized to EQA) in the make-up period, and the likely number of staged carts/containers required per EQA. The EQA value can be linked to the Gate Demand model, but can also be entered manually.

The user will then estimate the expected number of departures per nominal gate during the make-up period. The make-up period for domestic flights is typically around two hours and may be up to four hours for an international flight. The average make-up period will depend on the type of service provided at the airport and the mix of markets that are served. The estimated value to be entered should reflect the number of departures per gate that will require baggage staging for those flights during the make-up period. Once the period and expected departure rate is determined, the user will need to choose how many carts/containers are likely to be staged for each flight, as described above.

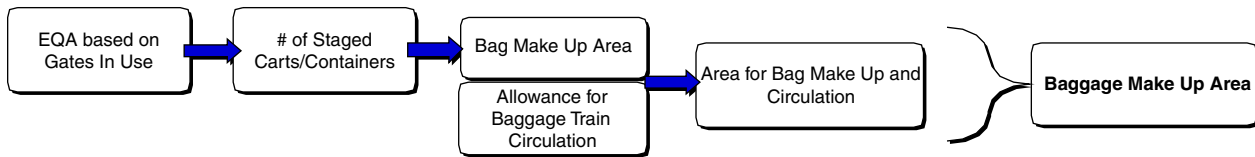


Figure 59. Baggage make-up area modeling methodology.

The size of the baggage make-up area will vary depending on the type of make-up units (index belts, re-circulating make-up units, sort piers, etc.) and whether the systems are exclusive or common use for typical configurations and dimensions. For preliminary planning purposes, the area per staged cart/container typically varies from 600 square feet/cart for individual airline make-up areas with re-circulating make-up units to 300 square feet/cart for larger pier make-up areas. These areas exclude conveyor tunnels or extensive sortation systems. In addition to the area for baggage make-up and bag claim off-loading, most terminals need additional lanes and other common-use maneuvering areas that link the inbound and outbound baggage handling areas to the apron. For programming, a 10% to 15% allowance of all baggage handling areas will generally be sufficient for tug circulation in a two-level terminal, provided the terminal configuration is reasonably efficient.

Figure 59 shows the overall method used to determine the baggage make-up area.

The alternative ratio method uses a general rule-of-thumb approach based on the average make-up area in relation to total EQA. Generally, 1,500 to 2,200 square feet per EQA of overall make-up area is the range at airports that have been studied. By using actual current space allocation and physical dimensions, the user can calculate the current ratio at a specific airport, which may then be used to project future requirements. This result is also a good measure for comparing to the results from the first method.

Figure 60 is a screen print from the model showing the linked EQA cell and the five required input cells for the first method, and only one required input cell for the alternative ratio method.

	A	B	C	D	E	F	G	H	I
1	Baggage Make Up								
2	RETURN TO TABLE OF CONTENTS		Go To User's Guide		Input Data Values				
3						Calculated Values			
4						Linked or Predetermined Values			
5									
6									
7	BAGGAGE MAKE UP SPACE REQUIREMENTS								
8	EQA (In Use)	User Specified Input	30.0	30	linked to Gate Demand				
9	Expected # of departures per Gate (within 2-4 hour staging period)			1.3					
10	Staged carts/containers per EQA			2	range: 2 - 3 per EQA				
11	Area required per cart/container (sq. ft.)			600					
12	Make Up Area (sq. ft.)						46,800		
13									
14	Additional Allowance for Baggage Train Circulation			10%			4,700		
15	Total Make Up Area (sq. ft.)						51,500		
16									
17	ALTERNATE RATIO METHOD								
18	EQA (In Use)			30					
19	Actual Average Area per EQA (sq. ft.)			1800	1500 - 2200 sq. ft.				
20	Total Make Up Area (sq. ft.)						54,000	Comparison	
21									

Figure 60. Baggage Make-up model.



Holdrooms Model

Holdroom sizing is typically based on the average seating capacity of the largest aircraft expected to use each gate. Holdrooms are typically sized for LOS C, with some airports choosing to provide a higher LOS. However, LOS in holdrooms does not, at this time, have a formally accepted definition. LOS parameters have been derived from generally accepted industry practices and are a combination of the following three factors:

- Load factor for the aircraft typically expected to use the gate: Typical ranges are 80% (LOS B/C) to 90% (LOS A). The design load factor may be reduced, however, if a significant number of passengers are expected to be using close-by concessions or waiting in airline clubs and/or premium class lounges (international flights).
- Percentage of passengers to be seated in the holdroom versus standing: This percentage can range from 50% seated (LOS C) to 80% (LOS B), or even 100% (LOS A). Again, these are typical ranges and should take into consideration the same factors as the load factor discussed above.
- Area per seated and standing passenger: Area per passenger is typically 15 square feet seated and 10 square feet standing (LOS B/C). This guideline can be increased to 17 square feet seated and 12 square feet standing (LOS A) to provide wider aisles, and/or more flexible seating configurations.

These factors that determine the total seating/standing lounge area of the holdroom are used in the Holdrooms model, where the user sets the LOS conditions and determines the suggested holdroom size.

The area for gate check-in podium(s) and queue(s) should be added to the passenger seating area. The gate podium provides facilities for airline agents to check passengers in, change seat assignments, and provide other passenger services. The number of agent positions is a function of aircraft size and airline staffing policies, but are typically as follows: one for commuter aircraft, two for narrowbody (up to 150 seats), three for widebody and B757 aircraft, and four for jumbo aircraft (over 300 seats).

In addition to the passenger seating area and check-in area, a boarding/deplaning corridor should be added to the lounge area which effectively acts as an extension of the loading bridge door. If a gate has multiple loading bridges, each bridge should have a separate boarding corridor. Depending on the configuration of the holdroom and the proximity of the check-in podium queue to the loading bridge entrance, some additional queuing may be provided for the boarding process. However, few airports or airlines have seen a need for this additional queuing area.

The Holdrooms model is organized like the other spreadsheet models with the same color-coded user cells and links to the Table of Contents and to the User's Guide as seen in Figure 61.

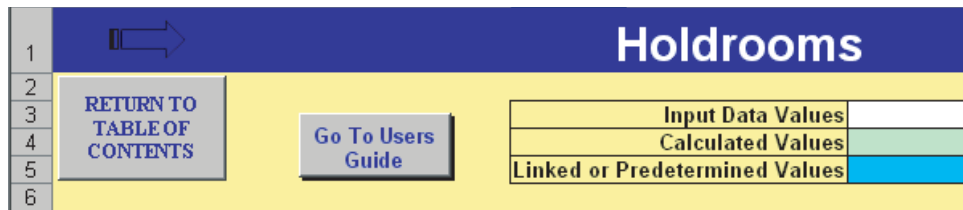


Figure 61. Holdrooms model.

Single Holdroom Approach

The Holdrooms model shown in Figure 62 requires that the user input aircraft and load factor information and, by using the LOS guidance in the cell comments, select the percentages and criteria that will determine the holdroom areas. By adjusting the factors that increase or decrease the suggested holdroom area, the user can observe the effects that properly accounting for the amenities, utilization, and sharing factors can have.

Holdrooms are recommended to be paired or grouped to allow better flexibility of use. Grouping makes it possible to reduce the total amount of holdroom space at many airports. One rule of thumb is to reduce the holdroom seating area by 5% for each gate in a common holdroom group. The amount of area reduction (for the passenger seating/standing area only) should be related to differences in departure times for adjacent gates, the estimated passenger arrival time distribution at the holdroom, and boarding time prior to departure. Thus, a reduction in seating area might not be recommended when near-simultaneous departures are expected. Examples would include a connecting hub airport, and some spoke airports, when all of the carriers schedule departures at the same time. If departure times are very well spaced, the area reduction may be greater than the rule of thumb.

7	SINGLE HOLDROOM APPROACH	INPUTS	OUTPUTS
8	# of Seats on Design Aircraft	145	
9	Load Factor	85%	
10	# of Design Passengers		123
11			
12	Percent Seated	80%	
13	Percent Standing		20%
14	Seated Passenger Space Requirement (sq. ft.)	15	
15	Standing Passenger Space Requirement (sq. ft.)	10	
16	Seated & Standing area (sq. ft.)		1,726
17	Allowance for Amenities (Increase)	5%	
18	High Utilization Factor (Increase)	20%	
19	Holdroom Sharing Factor (Decrease)	10%	
20	Adjusted Seated and Standing Area (sq. ft.)		1,960
21			
22	Podium Width/Position (ft)	4.0	
23	Depth of Podium to back wall (ft)	8	
24	Podium Queue Depth (ft)	15	
25	Area per Podium Position (sq. ft.)		92
26	Number of Podium Positions	1	
27	Total Podium and Queue Area (sq. ft.)		92
28	Boarding/Egress Corridor Width (ft)	6	
29	Depth of Holdroom (ft)	25	
30	Boarding/Egress Corridor per Bridge (sq. ft.)		150
31	Number of Bridges/ Doors	1	
32	Boarding Corridor Area (sq. ft.)		150
33			
34	Total Holdroom Area (sq. ft.)		2,200

Figure 62. Example of single holdroom approach.

16	Seated & Standing area		1,958
17	Allowance for Amenities (Increase)	5%	
18	High Utilization Factor (Increase)	20%	
19	Holdroom Sharing Factor (Decrease)	10%	
20	Adjusted Seated and Standing Area (sq. ft.)		2,260

Figure 63. Example of factors that affect holdroom size.

This model is referred to as a “single holdroom approach.” However, the number of podium positions and boarding bridges or doors is variable. This allows the model to be used for a holdroom that may serve multiple gates, and therefore, serve different aircraft classes.

Other Functions

In addition to passenger seating and departure processing, some airports and airlines have added other amenities to holdrooms, such as work counters or desks, laptop/cell phone recharging areas, play areas for children, and Internet stations. Providing these amenities can take varying amounts of space and must be planned on a case-by-case basis. A general allowance, in the range of 5%, for amenities should be included where relevant.

When gates have a high turnover rate, it is possible to have passengers from several flights waiting in the holdroom at about the same time. These cases are unique and only certain airports will have a need to apply this factor. If this is not an obvious case, this number should be entered as 0%, but in instances where the turnover is unusually high, such as with many of Southwest Airlines markets, this factor could be between 10% and 30%.

Figure 63 shows that the high utilization factor will increase the suggested holdroom size as does the allowance for amenities factor.

A table of holdrooms for single aircraft (without sharing reductions) is shown at the bottom of the spreadsheet. See Figure 64. These reflect the basic parameters selected by the user in terms of LOS, amenities, and utilization.

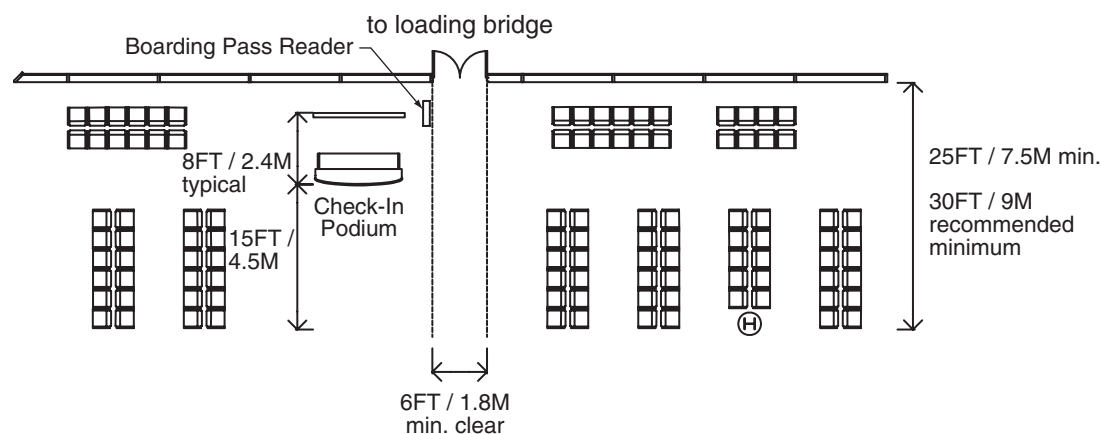
Typical Dimensions of Holdroom Areas

Seating Area

Seating configurations are driven by the LOS factors discussed above, as well as the overall proportions of the holdroom. The distance between rows of seats is recommended to be a min-

39	EXAMPLES OF TYPICAL SINGLE GATE HOLDROOMS (using the parameters entered above, except Seats, Podiums & Exits are all fixed)								
40	Gate/Aircraft Relationships	Seats	# of Podiums	# of Exits/Bridges	sq. ft. Sitting	sq. ft. Standing	sq. ft. Podiums	sq. ft. Exits	Total sq. ft. Holdroom
41									
42	Small Regional (Metro)	25	1	1	260	40	92	150	680
43	Medium Regional (SF340, CRJ)	50	1	1	480	80	92	150	1,010
44	Large Regional (DHC8, E175)	75	1	1	720	120	92	150	1,360
45	Narrowbody (A320, B737, MD80)	145	2	1	1,390	230	184	150	2,460
46	757 (B757, B757 w/ Winglets)	185	3	1	1,780	300	276	150	3,160
47	Widebody (MD-11, B767)	280	3	1	2,690	450	276	150	4,490
48	Jumbo (B747, B777, B787, A330, A340)	400	4	2	3,840	640	368	300	6,490
49	A380 (A380, B747-8)	525	4	3	5,040	840	368	450	8,440

Figure 64. Example of typical single gate holdrooms.



Source: Hirsh Associates

Figure 65. Typical holdroom configuration.

imum of 5 feet to allow free movement of passengers when seats are occupied. The separation can be increased for higher LOS and/or when large numbers of carry-on bags are expected.

Figure 65 illustrates a typical holdroom in a linear configuration along a concourse. The depth of the holdroom should be a minimum of 25 feet to allow some flexibility in seating arrangements. However, a 3-foot depth is recommended for most terminals to increase this flexibility and to allow circulation between seating and the loading bridge boarding corridor. For holdrooms serving multiple gates located in a “corner” of a concourse, additional depth is recommended.

Gate Check-in Podiums

A typical two-position gate check-in podium is 8 to 10 feet wide. The depth of the podium counter and back wall is typically 8 feet, but can be deeper if storage or other equipment is housed in the back wall.

An area should be provided in front of the podium to contain the queue within the holdroom and not block the adjacent corridor. A 15-foot depth is generally adequate.

Boarding/Deplaning Corridor

The corridor should provide as direct a path as possible from the loading bridge to the main concourse corridor. A minimum 6-foot width is recommended for deplaning.

Most airlines have installed boarding pass readers at the entry to the loading bridge, which increases the required width at the loading bridge door. These readers can either be a simple stand-alone reader (as shown in Figure 65) or include a small work podium for agents. A wider area, or multiple queue paths, are generally required for enplaning due to the crowd of passengers which usually forms when an aircraft boards. For example, in Figure 65 the check-in podium queue and the internal circulation aisles supplement the boarding/deplaning corridor for enplaning activity. If the configuration does not allow such shared use of circulation, an 8-foot wide boarding/deplaning corridor is recommended.



Baggage Claim Model

Baggage claim facilities are required for both domestic and international passengers. The following sizing methodology is primarily focused on domestic passengers; however, many of the principles apply to international baggage claim as well.

Domestic baggage claim requirements are typically based on design hour deplaned O&D passengers; the concentration of these arriving passengers within a 20-minute time period; and, to a lesser extent, on checked baggage per passenger ratios. Observations at most U.S. airports indicate that the majority of domestic passengers arrive at the baggage claim area before their bags are unloaded onto the claim units. The result is that the claim unit frontage should be sized for the estimated number of passengers waiting for baggage, because most bags are claimed on the first revolution of the claim unit. The number of passengers actively engaged in claiming bags is also related to the average traveling party size, because with larger family groups, not all of the party will actually be at the claim unit picking off bags.

Industry consensus is that all passengers actively claiming bags should be either adjacent to the claim unit (LOS A & B), or no more than one person away from the claim unit and able to reach in/around to the claim unit when his/her bag is presented (LOS C). This guideline results in a claim frontage of 2 to 3 feet per person (LOS A & B) to 1.0 to 1.5 feet per person (LOS C) for those actively claiming bags.

For international baggage claims, bags may be unloaded to the claim units before passengers arrive, if adequate passport inspection (CBP primary) processing is not available. Such an event will increase the time a claim unit is occupied by a flight and may require claim units to be sized to accommodate nearly 100% of the number of bags on the flight. The FIS/CBP spreadsheet model also includes a Baggage Claim model that provides a tool for assessing the timing of passenger and baggage arrival at the claim unit.

The Baggage Claim model takes the user through two standard approaches to size total bag claim frontage and the claim units for individual flights. The spreadsheet model is arranged in the same manner as the other models with color-coded cells and links to both the Table of Contents for the whole spreadsheet model and the User's Guide as seen in Figure 66.

Total Design Hour Demand

Figure 67 shows the section of the model that calculates the overall frontage demand based on the peak period of terminating passengers. This number can then be compared to the existing frontage and a first hand observation of the use and adequacy of the baggage claim area. The Baggage Claim model follows the method described above. The user must determine and input the passenger and baggage relationships for the design hour. The cell comments will help to make a general or default decision when specific data can not be found.



Figure 66. Example of Baggage Claim model.

The following factors are required for estimating the total claim unit capacity for the design hour:

- The number of design hour deplaned passengers.
- The concentration of passengers arriving within a 20-minute period.
- Percentage of passengers terminating at this airport. For international airports this is typically 100% because all passengers (except those in-transit) must clear CBP inspection at their first point in the United States. Connecting passengers then re-check their bags to their final destination.
- Percentage of passengers with checked bags. This number does not include carry-on gate-checked bags for regional aircraft which are claimed plane side.
- Average traveling party size. It has been observed that not all members of a traveling party (especially families with children) will actually be at the claim unit. Typically one member will claim the bags with most of the other members waiting in the peripheral area.
 - The spreadsheet model estimates this by calculating the number of traveling parties, taking one member to actively claim bags, and then adding in a percentage of the “extra” passengers who may accompany the active claimer at the claim unit. These factors would be based on passenger survey data (party size) and observations.
- The active claim frontage per passenger to achieve the desired LOS.

The total claim frontage combined with claim size for individual flights (Figure 68) can be used by the planner to determine the number and sizes of claim units needed for the current mix of design hour aircraft.

Single Aircraft Arrival

The same basic approach is used to estimate the amount of claim frontage for a single aircraft arrival. In this method, aircraft seat and load factor assumptions of an individual flight are substituted for the design hour deplaning passengers and the percentage of arrivals in the peak 20 minutes. See Figure 68. Once the total frontage is estimated, the size and number of claim units should be determined based on the expected number of flights and aircraft sizes during the design hour(s), and airport operating policies regarding exclusive or preferential use of claim units.

7	DEMAND			INPUTS	OUTPUTS
8	Peak Hour Deplaning Passengers	<i>User Specified Input</i>	1,500	1,500	link to Design Hour
9	Percent Deplaning in Peak 20 Min.			50%	
10	Percent Terminating Passengers			90%	
11	Peak 20 Min. Terminating Passengers				675
12	Percentage of Passengers Checking Bags			90%	
13	Passengers Checking Bags				608
14	Average Traveling Party Size			1.3	
15	Number of Parties				467
16	Percent Additional Passengers at Claim			30%	
17	Total People at Claim				509
18	Claim Frontage per Person (ft)			1.5	
19	Total Claim Frontage Required (ft)				764

Figure 67. Example of demand input.

21	TYPICAL SINGLE AIRCRAFT CLAIM UNIT SIZE		
22	Typical Aircraft Seating Capacity	145	
23	Design Hour Load Factor	90%	
24	Typical Aircraft Passenger Load		131
25	Percent Terminating Passengers	90%	
26	Peak 20 Min. Terminating Passengers		117
27	Percentage of Passengers Checking Bags	90%	
28	Passengers Checking Bags		106
29	Average Traveling Party Size	1.3	
30	Number of Parties		81
31	Percent Additional Passengers at Claim	30%	
32	Total People at Claim		89
33	Claim Frontage per Person (ft)	1.5	
34	Claim Frontage Required per Flight		133

Figure 68. Example of typical single aircraft claim unit sizing.

Baggage Claim Time in Use

The minimum time a claim unit would be in use for an individual flight helps establish the turnover of claim units. Turnover is more significant for widebody aircraft.

The following factors are required for estimating the time a claim unit is in use for an individual flight:

- Aircraft seating capacity
- Design hour load factor
- Percentage of passengers terminating at this airport
- Percentage of passengers with checked bags
- The average number of bags/passenger
- The average bag unloading rate. This rate varies depending on the size of the bags and the number of feed conveyors per claim unit

In addition to the time needed to unload the checked bags, additional time is added for bags that are not claimed on the first rotation of the claim unit because passengers either fail to see them or arrive late (add up to 10 minutes, unless there are unusual conditions).

As shown in the example in Figure 69, narrowbody domestic flights typically occupy a claim unit for 20 minutes or less (which results in the typical approach of sizing domestic baggage claim for a peak 20-minute period). Widebody flights can occupy a claim unit for significantly longer periods, which is why units sized for large aircraft typically are configured with two feed conveyors.

Baggage Claim Unit Types

The two basic types of claim units are flat plate and sloped bed. See Figure 70.

Flat plate units can be designed in various configurations; “L,” “T,” “U,” and variations of these are most common. Direct-feed, flat plate units are simpler to maintain and are generally

35	BAGGAGE CLAIM USE TIME (domestic only)		
36	Average # of bags per passenger checking bags	1.5	
37	Total # bags to unload at Baggage Claim		159
38	Flight Buffer to allow for late pick up of bags (min)	10	
39	Unload Rate of bags at Claim (bags/min)	20	
40	Claim Use Time estimate (min)		17.9

Figure 69. Example of Baggage Claim Use Time

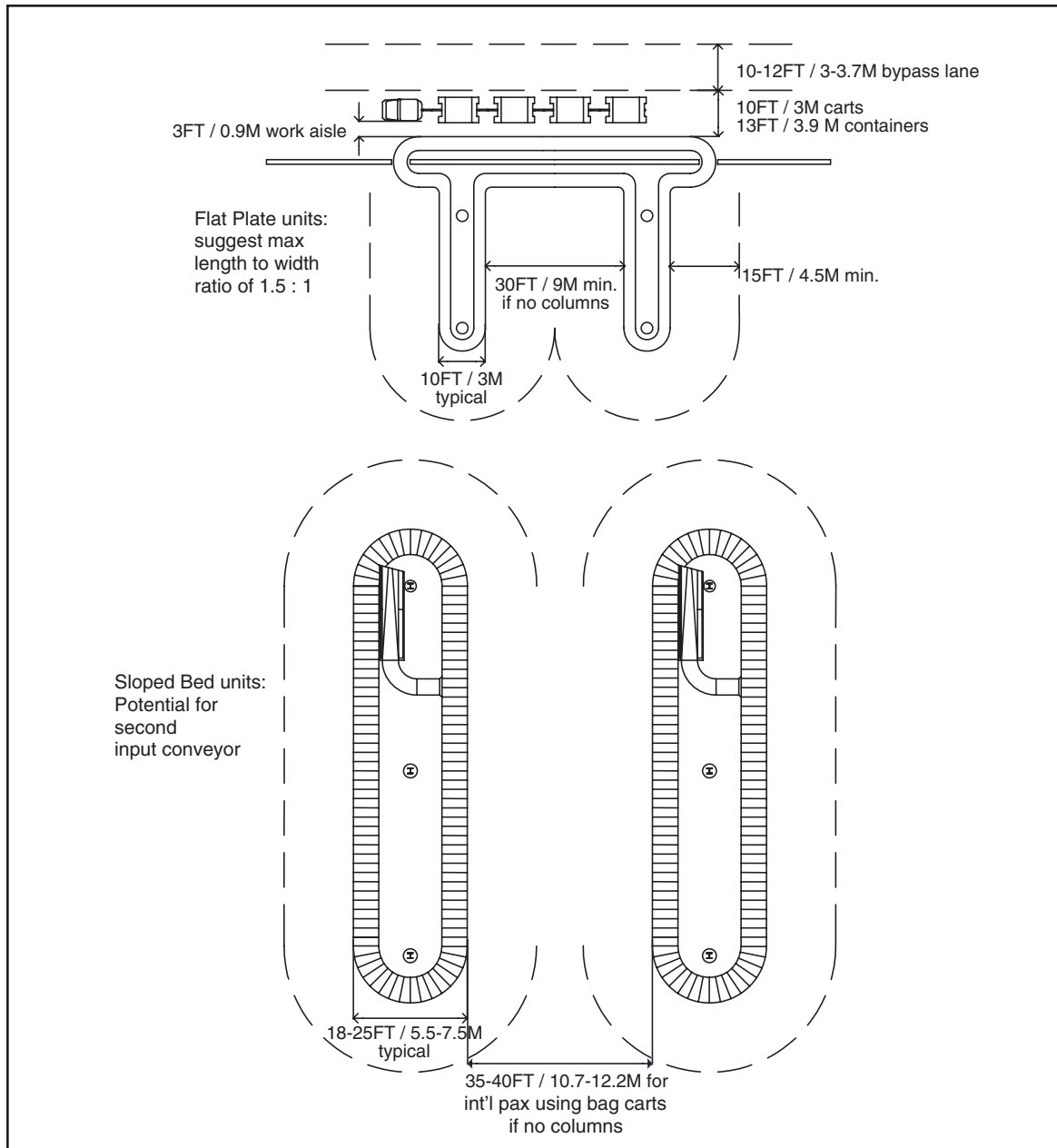


Figure 70. Typical baggage claim units.

preferred if the baggage off-load area is on the same level as the claim area. Bags are loaded on the secure side, pass through fire/security shutters (which are closed when the claim unit is not in use), and are claimed by passengers in the (typically) non-secure baggage claim lobby. Unclaimed bags will circulate back through the loading area.

The minimum outside radius is typically 5 feet resulting in a 10-foot wide unit. It is recommended that the ratio of clear length of the “arms” to the width of the unit be no greater than 1.5:1. This ratio will limit deep, narrow bays, which can cause passenger congestion.

Sloped bed units (often referred to generically as “carousels”) are almost always configured as ovals. Sloped bed units are fed from one or two conveyors, with larger international terminals typically preferring two conveyors because of the time required to deliver the larger number of

bags. Feed conveyors can be located on a different floor level, or from some distance, and may feed the claim unit from either above or below. This capability provides flexibility in location; but, with separate feed conveyors, there is the possibility of jams if oversized bags or bags with loose straps are accidentally loaded.

The minimum width of these units is 18 to 25 feet, depending on the manufacturer, but is often wider due to the location of structures and the feed conveyors. Sloped bed units can also be configured to allow flow-through passenger circulation, which may be advantageous in some terminal configurations, especially for larger claim units. Although sloped bed units have more baggage storage capacity, the effective amount of this capacity is often less than expected unless airline/airport personnel manually reposition bags to optimize bag capacity.

Odd-Sized or Oversized Baggage

Facilities should also be provided for odd-sized or oversized baggage, such as golf clubs, skis, and packages that are too large to fit on the baggage claim units or may cause jams on feed conveyors.

Odd-/Over-sized Baggage is usually handled in one of three ways:

- **Oversized Belt:** An extra wide conveyor, anywhere from 45 to 65 inches in width, transports odd-sized bags from the baggage off-load area to the baggage claim hall generally between two claim units or against an exterior wall of the claim area. This conveyor system can be flat, incline, or decline before entering the claim area, but it is recommended that no turns be used in the odd-sized system.
- **Oversized Slide:** Roll-up doors, between 6 to 10 feet wide and at least 5 feet high with a stainless steel slide, can be used to deliver oversized bags to the claim area. This system usually functions effectively only when the cart is unloaded at the same level as the claim area similar to the flat plate claim arrangement.
- **Manual Lay Down:** When it is not practical to include either a slide or belt system, airline employees can take odd-sized luggage from the secured side to the non-secured side by using an airport access door usually adjacent to the claim area for passenger retrieval.

Retrieval and Peripheral Areas

The total amount of the retrieval and peripheral areas is ultimately determined by the number of passengers expected to be near the claim unit and the desired LOS. These areas include the active claim depth along the unit (retrieval area), the depth for others in the traveling party, plus a circulation zone to and away from the claim unit peripheral area. It has been found, however, that 15 feet is typically the minimum recommended depth for the retrieval and adjacent peripheral areas at all but the smallest airports.

This minimum depth results in a minimum separation of 30 feet between adjacent claim units or the “arms” of a flat plate claim. For international claim areas where there is a high percentage of passengers using bag trolleys, a 35- to 40-foot minimum separation is recommended. These dimensions assume an obstruction-free area to allow ease of circulation. Columns, bag cart racks, and other structures should not be within the retrieval area. Objects located within the peripheral area usually will require additional separation. A minimum separation between the claim unit and walls, or bag trolley racks is recommended to be 15 to 20 feet for domestic claim units and 20 to 25 feet for international claim units.

At airports having “positive claim,” that is, a railing or wall around the claim units so that a security guard can check if a person has the correct bag, may require additional circulation for queuing at the controlled claim area exits.

Additional area, outside of the peripheral claim area, needs to be provided for access to the claim area, circulation to ground transportation counters (rental cars, public transportation, commercial vans, etc.), seating for meeters/greeters and passengers waiting for transportation pick-up, etc. The dimensions of this circulation zone are dependent on projected passenger volumes and functions adjacent to the claim units, such as rental car counters.



Concourse Circulation Model

Circulation elements provide the necessary public, non-public, and sterile links to tie the functional elements of the terminal together.

Secure Circulation

Secure circulation typically consists of the main corridor of the concourses, plus the security checkpoints. Concourses are typically either single loaded (gates on one side) or double loaded (gates on both sides). Single-loaded concourses can also have concessions and other uses on the non-gate side which may cause them to function more like double-loaded concourses. Corridor width is a function of single/double loading, the presence of moving walkways, passenger volumes, and hubbing activity.

As shown in Figure 71, ancillary uses (such as telephones, water fountains, vending machines, or advertizing displays), and some adjacent activities (FIDS monitors), can effectively reduce the width of a corridor. It is recommended that these uses be recessed into the corridor walls (as shown in Figure 72) to minimize the impact on passenger flow, or their presence taken into account when programming circulation space.

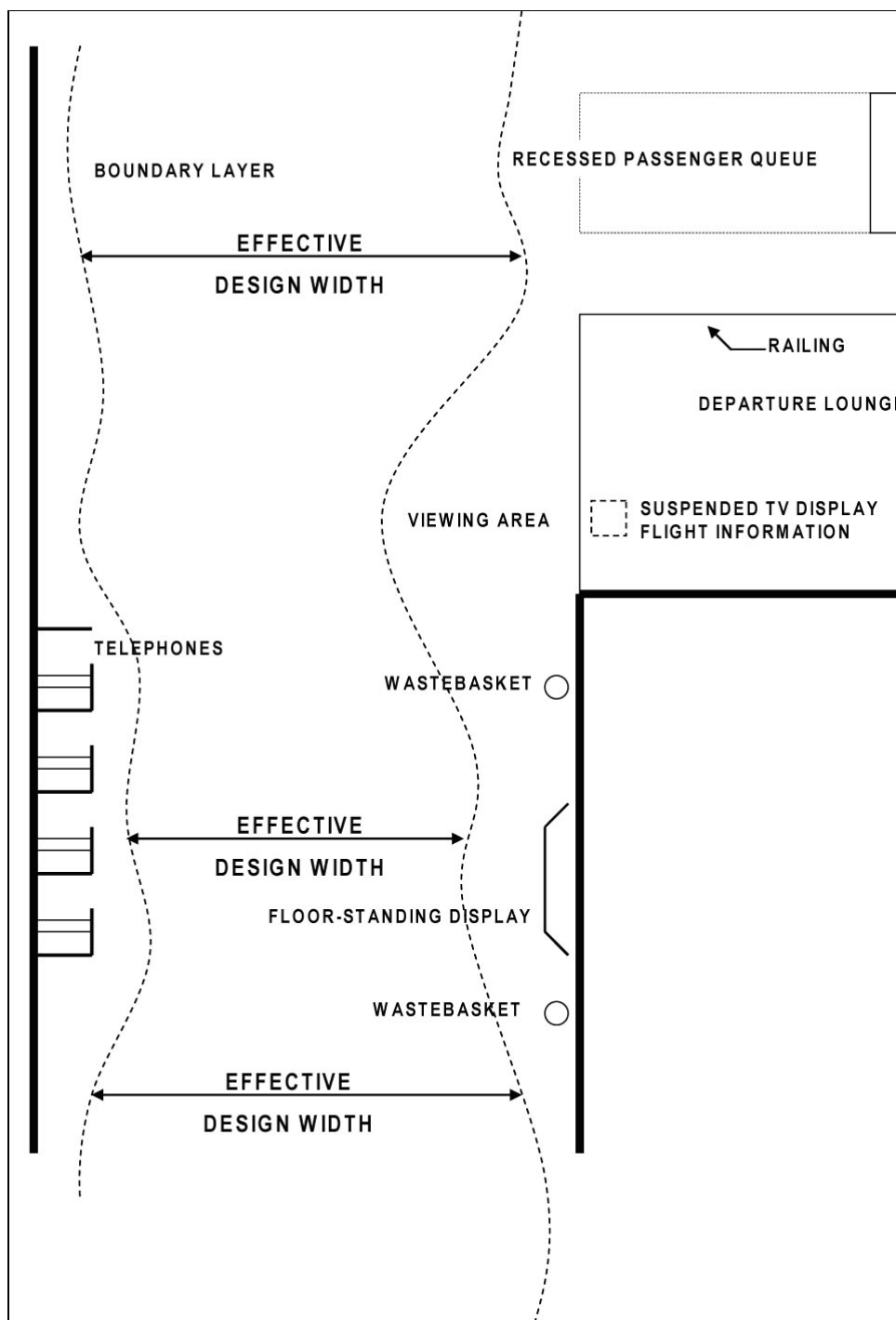
The following are recommended minimum clear circulation widths:

- For concourses without moving walkways, a corridor 20 feet wide for single-loaded concourses and 30 feet wide for double-loaded concourses is recommended. This width is generally adequate for most medium- to high-volume concourses used primarily for O&D flights, or for shorter hub concourses.
- For concourses with moving walkways, a 15-foot corridor is recommended on each side of the moving walkway. This width generally allows for bidirectional movement on both sides. Wider corridors may be required for high-volume hubbing terminals. If a significant number of electric carts are in use, this width would also require a wider clear circulation aisle.

FIS Sterile Arrivals Circulation

Sterile circulation consists of the corridors and vertical circulation elements that connect the international arrivals gates to the FIS facilities. In some terminals a portion of the sterile corridor system may involve “edge” corridors that connect multiple gates to a vertical circulation core or directly to the FIS. These edge corridors must have controlled isolation doors to prevent international arriving passengers from mixing with departing passengers.

Because sterile corridors have single-direction passenger flow, they can be narrower than the main concourse corridors. Typically, a 15- to 20-foot-wide corridor will allow a single-direction



Source: *The Apron & Terminal Building Planning Manual*, The Ralph M. Parsons Company, pg. 3-17.

Figure 71. Effects of ancillary uses on effective concourse width.

moving walkway for most terminals depending on the number of gates and peak period arrivals. Edge sterile corridors are typically 8 to 10 feet wide (clear width). The program area must also include vertical circulation from the holdroom level to the sterile corridor, if it is on a separate level.

The total circulation area can be based on an area per equivalent concourse length. This length is determined by gates as expressed in NBEG. The actual amount of secure circulation required will depend on the terminal configuration and should consider whether gates are

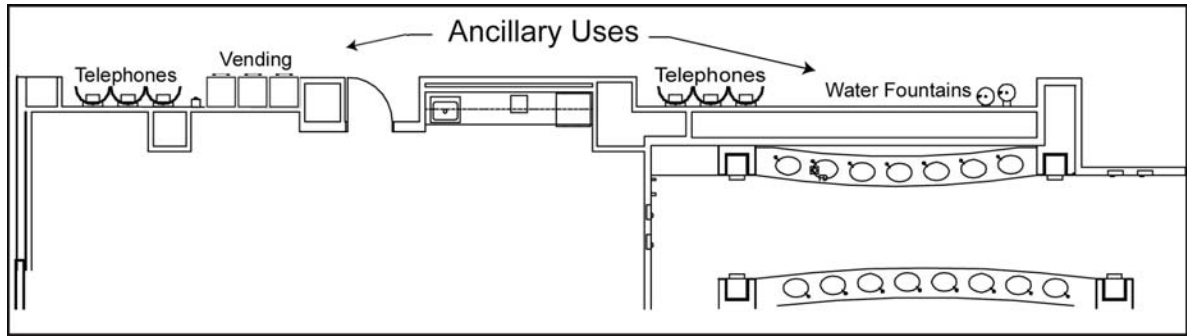


Figure 72. Example of recessing ancillary facilities.

single or double loaded. Exit and service stairs to the apron level should be included in the secure circulation area.

The spreadsheet model was developed to estimate the circulation dimensions using the NBEG approach. This model will function in the same manner as the other spreadsheet models with links to the Table of Contents and the User’s Guide, and the use of color-coded cells for consistency as seen in Figure 73.

The approach used in the model is based on estimating the length of a concourse using the planned gate mix as expressed in NBEG. The NBEG gate mix is converted to a gate frontage by assuming typical wingtip clearances. The user then makes assumptions as to concourse configuration to estimate the gross circulation areas.

There are a number of different circulation areas that can be addressed. The single-concourse estimate is used in the model to show the basic approach and the lessons learned can then be adapted to other areas of circulation that are more dependent on local design and use.

The model has three basic functions: to determine the suggested circulation corridor width, to determine the NBEG of the concourse to estimate frontage and overall length, and then to calculate and compare the existing circulation area. Figure 74 is a screen print of the model, showing that the comparison of existing width and area in this example are “Less than Suggested” based on the model inputs.

On line 8 of the model, as seen in Figure 75, the user is asked to input a percentage factor for concourses that support an airline hub. The comment for this input suggests a small 5% to 10% range that will add to the suggested corridor width. In most cases this factor can be left at 0%. However, at the largest and busiest airports, the sheer volume of passengers that may enplane or deplane during the peak periods, or the major cross-flows that may occur during the peak transfer times at large hubs, may require more than the normally suggested corridor width.

	A	B	C	D	E												
1	Concourse Circulation																
2	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; text-align: center; vertical-align: middle;">RETURN TO TABLE OF CONTENTS</td> <td style="width: 30%; text-align: center; vertical-align: middle;">Go To User's Guide</td> <td style="width: 20%; text-align: center; vertical-align: middle;">Input Data Values</td> <td style="width: 20%;"></td> </tr> <tr> <td></td> <td></td> <td style="text-align: center; vertical-align: middle;">Linked or predetermined Values</td> <td style="background-color: #add8e6;"></td> </tr> <tr> <td></td> <td></td> <td style="text-align: center; vertical-align: middle;">Calculated Values</td> <td style="background-color: #c8e6c9;"></td> </tr> </table>					RETURN TO TABLE OF CONTENTS	Go To User's Guide	Input Data Values				Linked or predetermined Values				Calculated Values	
RETURN TO TABLE OF CONTENTS						Go To User's Guide	Input Data Values										
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							Calculated Values										
3																	
4																	
5																	
6																	

Figure 73. Concourse Circulation model.

7	Secure Circulation-Single Concourse		INPUTS	OUTPUTS
8	Airport Hubbing Activity Factor		0%	
9	Type of Concourse Design		Double Loaded	
10	Are Moving Walkways used in this Concourse		Yes	
11	--> if Yes, What Type of Design is used		Wide Width	
12	Suggested Minimum Clear Width (ft.)			45
13				
14	Concourse NBEG (Do NBEG Exercise below)			31.0
15	Percentage of Usable Concourse Length		85%	
16	Wing Tip Separation (ft)		25	25 ft. is suggested
17	Total Aircraft Frontage (ft.)			4,433
18	Length of Concourse (ft.)			2,217
19	Area of Concourse Circulation (sq. ft.)		rounded	84,800
20				
21	Existing Concourse Circulation Width (ft)		40	
22	Existing Concourse Length (ft.)		1,500	
23	Existing Concourse Circulation Area (sq. ft.)			60,000
24	Comparison to Existing Corridor Width			Less than Suggested
25	Comparison to Existing Area			Less than Suggested
26				
27	Average Circulation Area/ NBEG (sq.ft.)			2,735

Figure 74. Example of comparison of suggested and existing width and area.

The model asks the user to select inputs that describe the concourse in question. On Line 10, the input is whether or not moving walkways are used. If the user selects Yes from the drop down list, the next input on Line 11 must be either Narrow Width or Wide Width. If the dash is selected, a Choice Error message will appear to prompt a correction. Inversely, if No is selected from the list on Line 10 and then Narrow Width or Wide Width is selected on Line 11, the Choice Error message will also appear until the dash is selected, as seen in Figure 76.

The model prompts the user to move down to Line 31 and input the number of gates that exist on the concourse for specific design aircraft classes in order to compute the NBEG. The NBEG will be calculated in cell E40 which is linked back to cell C14 as seen in Figure 77.

The next inputs that the user needs to make in the model are on Lines 15 and 16. A usage percentage is requested to describe the allocation of the end space on the concourse. If the concourse circulation runs to the end of the concourse with no space used for holdrooms or amenities, then

7	SECURE CIRCULATION - SINGLE CONCOURSE		INPUTS	OUTPUTS
8	Airport Hubbing Activity Factor		0%	
9	Type of Concourse Design		Double Loaded	
10	Are Moving Walkways used in this Concourse		Yes	
11	--> if Yes, What Type of Design is used		Wide Width	
12	Suggested Minimum Clear Width (ft.)			45
13				
14	Concourse NBEG (Do NBEG Exercise below)			31.0
15	Percentage of Usable Concourse Length		85%	
16	Wing Tip Separation (ft)		25	25 ft. is suggested
17	Total Aircraft Frontage (ft.)			4,433
18	Length of Concourse (ft.)			2,217
19	Area of Concourse Circulation (sq. ft.)		rounded	84,800
20				
21	Existing Circulation Corridor Width (ft)		55	
22	Existing Concourse Length (ft.)		2,300	
23	Existing Concourse Circulation Area (sq. ft.)			126,500
24	Comparison to Existing Corridor Width			Adequate
25	Comparison to Existing Concourse Length			Adequate

Figure 75. Example of Secure Circulation tab.

10	Are Moving Walkways used in this Concourse	No	
11	--> if Yes, What Type of Design is used	Wide Width	Choice Error!

Figure 76. Example of Choice Error message.

the usage percentage should be 100%. Depending on how the end space is used and how much area is taken away from circulation for holdrooms, the usage percentage may be as low as 80%. An assessment of the concourse gate allocation and loading structure will help determine what percentage to use. Typically 85% is a good starting point for linear pier concourse design.

Moving Walkways

Moving walks transport passengers and their baggage on a moving platform horizontally or at slight inclines. This system can either be manufactured as a pallet or moving belt style. A series of continuous flat metal plates jointed together in a horizontal manner to form the walkway describes the pallet system. The moving belt style consists of a series of metal rollers over which a rubber walking surface is placed, sometimes resulting in a bouncy feel when walking over the surface.

As a general planning standard, moving walkways are typically recommended when walking distances exceed approximately 1,000 feet between the major functions of the terminal complex. These walkways may be utilized from parking facilities to ticketing/baggage claim areas, as access to ground transportation stations, in connectors between concourse/terminal to terminal, and security screening checkpoints to major concourse nodes and/or the furthest concourse gate. When planning for moving walkways, factors that influence the layout consist of the volume of passengers to be transported, whether concourses are single or double loaded, and locations of major concessions nodes. Moving walkways are typically installed in pairs traveling in opposite directions and designated by pallet widths or the area the passenger travels on. Depending on the manufacturer, a pallet range for an airport moving walkway is 40 inches to as much as 56 inches,

14	Concourse NBEG (Do NBEG Exercise below)			31.0
15	Percentage of Usable Concourse Length	85%		
16	Wing Tip Separation (ft.)	25	25 ft. is suggested	
17	Total Aircraft Frontage (ft.)			4,433
18	Length of Concourse (ft.)			2,217
19	Area of Concourse Circulation (sq. ft.)		rounded	84,800

28	SINGLE CONCOURSE NBEG EXERCISE			
29				
30	Aircraft Group/Class	# of Gates	NBEG	Aircraft Frontage (Direct Method)
31	I. Small Regional (Metro)	-	49	0.4
32	II. Medium Regional (SF340, CRJ)	-	79	0.7
33	III. Large Regional (DHC8, E175)	5	118	1.0
34	III. Narrowbody (A320, B737, MD80)	10	118	1.0
35	IIIa. 757(B757, B757 w/Winglets)	12	135	1.1
36	IV. Widebody(MD-11, B767)	2	171	1.4
37	V. Jumbo (B747, B777, B787, A330, A340)	-	214	1.8
38	VI. A380 (A380, B747-8)	-	262	2.2
39	Total	29	Total	1.1
40	Source: Hirsh Associates		NBEG	31.0
				4,457

Figure 77. NBEG calculation matrix.

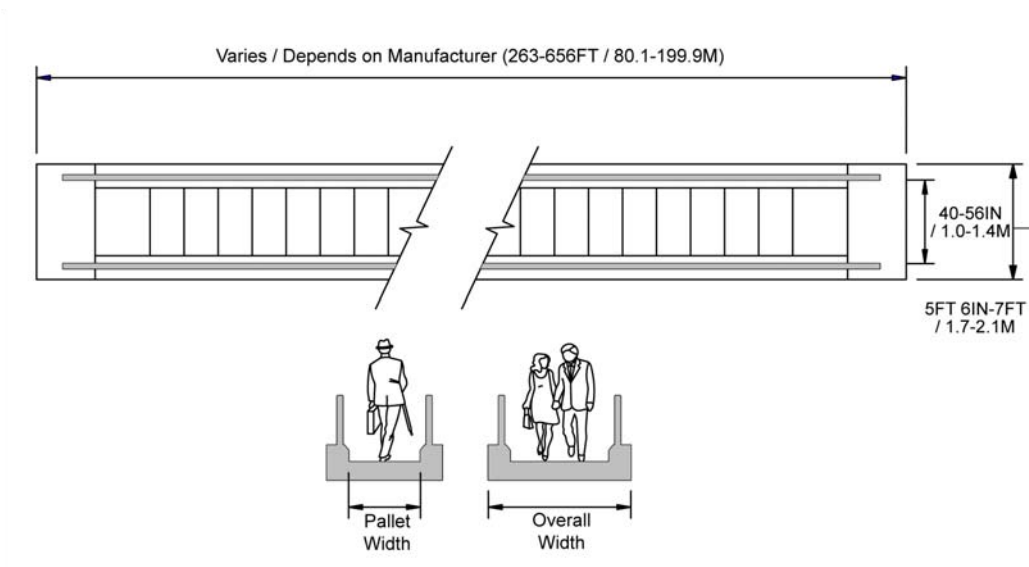


Figure 78. Dimensional example of a moving walkway.

which allows fast moving passengers to easily pass those standing with little to no interference. The overall required width for the moving walkway ranges from 5 feet 6 inches to 7 feet, and lengths vary between manufacturers. Figure 78 represents a typical moving walkway with common dimensional criteria.

The default widths used for double moving walkways are 12 feet and 15 feet, which allows for an additional 1-foot buffer between the two walkways.



Federal Inspection Services/ U.S. Customs and Border Protection Model

Federal Inspection Services (FIS) facilities are required at all airports with international flights. The exception is many flights from Canada, and a limited number of other airports that also have U.S. pre-clearance facilities. These passengers are considered the same as domestic arrivals because they went through FIS procedures at their airport of departure.

On March 1, 2003, the Immigration and Naturalization Service (INS), the U.S. Customs Service, and the Agricultural and Plant Health Inspection Service were consolidated to establish U.S. Customs and Border Protection (CBP). CBP is responsible for inspecting all passengers, baggage, and air cargo. By consolidating the three major agencies, CBP is attempting to unify the inspection procedures. At some airports, the Public Health Service and/or the U.S. Fish and Wildlife Service may also have offices.

Although the inspection process has varied over time, FIS procedures now call for all passengers to be processed through the primary inspection counters (formerly operated by INS). There are a limited number of foreign airports that have U.S. INS personnel to conduct pre-inspection. Passengers from these airports (Ireland and some Caribbean islands) bypass local CBP primary inspection but are still subject to baggage inspection. It is anticipated that these locations will eventually have full CBP pre-clearance facilities similar to those at most large Canadian airports.

Secondary baggage inspection is based on more selective procedures using computer-based lists of passengers, roving agents, designations of “high-risk” and “low-risk” flights, and other selection techniques. CBP procedures and facility requirements are described in *Airport Technical Design Standards—Passenger Processing Facilities*, August 2006. Although there is a national policy, implementation may vary at each gateway based on local conditions, and coordination is required with CBP for reviews and approvals of plans. Thus, it is essential to involve the FIS agencies in the planning process early. Planners should also request updates to standards from CBP during the planning process, as these are likely to change and evolve over time.

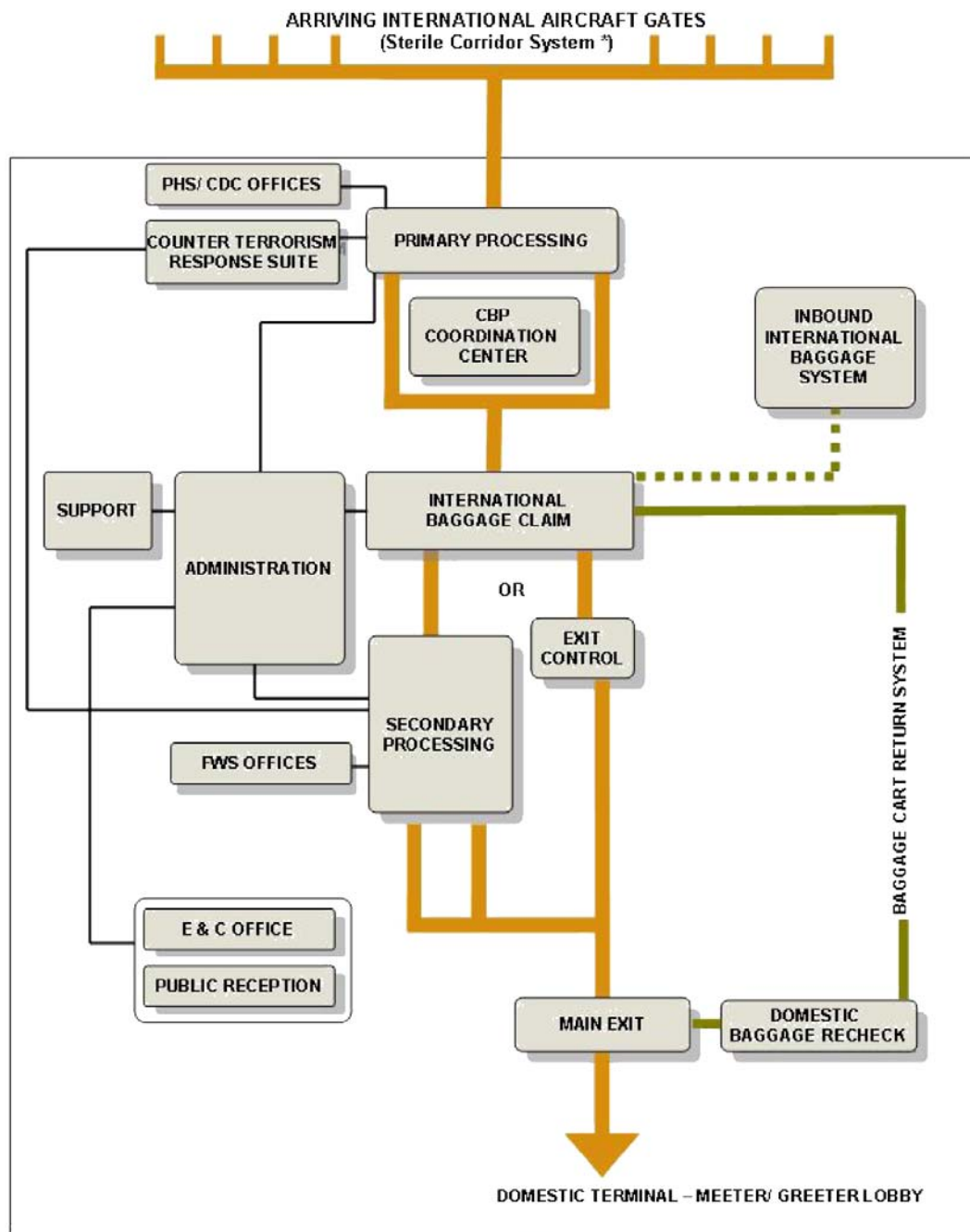
A terminal for international arrivals has facilities in addition to the actual FIS processing area. These consist of the following major elements: sterile corridor system, CBP primary inspection, baggage claim, CBP secondary inspection, and processing and transfer passenger recheck. Figure 79 shows the CBP inspection process.

Sterile Corridor System

Arriving international passengers must be kept separate from other passengers, visitors, or unauthorized airline employees until they have cleared all FIS inspections. Therefore, a separate corridor system from the aircraft gate to primary inspection is required. The corridors should be sized for single-direction passenger flow. Depending on the distance from gate to primary



Customs and Border Protection



* In-Transit Lounge and VIP Lounge located in the Sterile Corridor system where applicable

INTERNATIONAL PASSENGER TRAFFIC (solid orange line)
INTERNATIONAL BAGGAGE TRAFFIC (dashed green line)

Source: FAA White Paper, *Airport Technical Design Standards Passenger Processing Facilities*, U.S. Customs & Border Protection, Washington D.C., August 2006, pg. 2-15

Figure 79. CBP inspection process (single level).

inspection, moving walkways or an automated people mover may be appropriate. Because the departing passengers use the same gates as international arrivals, control doors and monitoring of the corridor system is required to prevent mixing of arriving and departing passengers. See Section VI.3.10, Circulation, of the Guidebook for guidance on corridor sizes.

CBP Primary

Because all passengers are subject to CBP primary inspection, the capacity of primary inspection generally dictates the overall capacity of the FIS. Under current guidelines, one double primary inspection booth (two agents, also referred to as a “piggy back counter”) is officially rated at an average of 100 passengers per hour. There are usually separate queues for U.S. citizens and foreign nationals, each of which will have a different average processing rate.

CBP primary facilities are sized for a capacity stated in terms of passengers per hour. This capacity rating is “steady state,” assuming a relatively well-distributed pattern of arriving flights. For such a rating to be correct, a design hour volume of 900 passengers, for example, would need to consist of six flights, arriving every 10 minutes, with 150 passengers each, rather than two flights of 450 passengers arriving within a few minutes of one another. Even in airports that have shorter-haul international flights, the idea that they will be of uniform size and evenly spaced is difficult to accept as a typical or reasonable planning standard.

However, there are factors which “spread” or dilute the impact of arriving passengers, notably the distance between aircraft gate and the government inspection booths, combined with the metering of passengers out of aircraft and variations in the speed they walk. It should be noted that speeds are more divergent in terminals where moving walkways are provided.

The number of booths required for primary facilities is typically prescribed by CBP based on the design hour passenger volume and, as such, consideration of dynamic issues will not usually impact that aspect of the facility. However, while agencies may specify minimum queue depth provision, they may not be sufficient depending on the likely distribution of design hour passengers amongst flights and the relative timing of those flights. Examining demand in a smaller time frame, 15 or 30 minutes, is often helpful in understanding the maximum length of queue to be accommodated. One other key area to consider in arrivals facilities is the impact of off-time (i.e., early or late) flights. In addition to a base analysis, if off-time data is available, a number of sensitivity tests should be performed to fully understand the dynamics of the facility.

The spreadsheet model for primary inspection has a tool for illustrating how variable arrival times for the same number and size of flights can impact passenger arrival rates and queue sizes in the primary area.

The FIS/CBP model is designed to estimate the passenger queue lengths, space requirements, and passenger delay time for primary processing; baggage claim requirements; and the time baggage claim devices will be in use. This model functions in the same manner as the other spreadsheet models with links to the Table of Contents and the User’s Guide, and the use of color-coded cells as seen in Figure 80.

The first section in this model is a random flight arrival time example that adjusts a group of five flights by as much as 15 minutes early or late and runs a mini-queue model on each of 10 iterations to determine (1) a range and average for the maximum number of queued passengers and (2) the minimum, maximum, and average wait times in the primary processing queue. This model is separate from the preliminary data used later in this section and acts as a stand-alone example (see Figure 81) with a dedicated randomizing queue model. From this example, users can see the influence and possible effects that arrival variability can have on

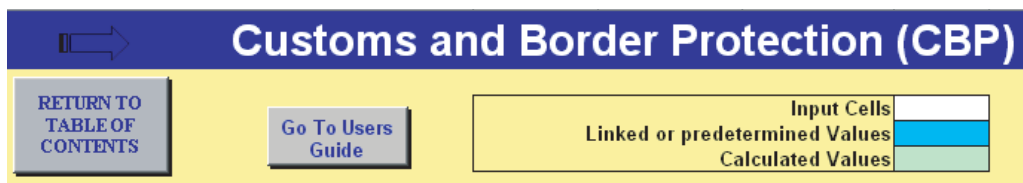


Figure 80. FIS/CBP model.

primary processing, which would then have an impact on the use of baggage claim. Users can enter their own flight arrival times and aircraft seating capacities to test various flight arrival scenarios. In addition, the model allows users to vary aircraft passenger load factor, the number of primary inspection booths, and the rate at which passengers disembark (unload) from the aircraft.

Users can add five flights in the one-hour example window of 1,600 to 1,659, or less if they so desire. The queue model assigned to this bank of flights randomly adjusts the arrival time by up to 15 minutes early or late for each of the input flights. With the load factor and unload rate entered, the queue model will determine when and how fast the passengers disembark from the flights and proceed to primary processing. The last function of the queue model uses the number of staffed inspection booths and the processing rates that the user entered to estimate the average and maximum wait times likely to be experienced by the passengers. This is useful in studying the effects of possible understaffing by CBP. The maximum number of passengers in the queue is also estimated and can be used to determine the size of the queue needed. A chart showing the passengers arriving at primary processing and how many passengers are in the queue, based on the original schedule and one of the random variations, is illustrated in Figure 82. Each time the randomizer button is clicked a different random variation is generated and the chart will depict a new scenario.

8 ARRIVAL TIME VARIANCE ON PRIMARY PROCESSING		INPUTS	OUTPUTS	EXAMPLE #1
9 ARRIVAL RANGE OF 15 MINUTES EARLY OR LATE FOR 5 FLIGHTS				
10	Average Load Factor for all example flights	80%		
11	Common Unload Rate (Passengers/min)	20		
12	Enter data for the sample hour of [1600 - 1659]	# of Seats	Schd. Arrival Time	
13	Sample International Flight #1 (seats), (arrival time)-->	180	1600	Click the Randomizer Button to Run
14	Sample International Flight #2 (seats), (arrival time)-->	180	1605	
15	Sample International Flight #3 (seats), (arrival time)-->	250	1630	
16	Sample International Flight #4 (seats), (arrival time)-->	200	1635	
17	Sample International Flight #5 (seats), (arrival time)-->	240	1655	
18				Randomizer
19	Sample Hour Arriving International Passengers		840	
20	Primary Processing Rate (Passengers/Double Booth/Hr)	100	CBP suggests 100 pax/double booth/hr	
21	Width of Double Booth (ft.)	11.5	11.5 ft is standard	
22	# of Double Booths required at input Processing Rate		9	
23	Actual # of existing Double Booths available	10	The actual value will determine the Queue Area	
24	# of Double Booths to use in the Queue Model Example	6		
25				
26	RANDOMIZED ARRIVAL TIME QUEUE MODEL	Avg.	Minimum	Maximum
27	Max Wait Time in Queue (min.)	25.4	16.6	33.8
28	Max # of Passengers in Queue	254	166	338
29				
30	Desired Passenger Space in Queue (sq. ft/ pax)	15.0		
31	Passenger Queue Area @ 15 sq. ft/pax (sq. ft.)	3,804	2,490	5,070
32	Queue Depth required using width of existing booths (ft.)	33.1	21.7	44.1

Figure 81. Example of random flight arrival time model.

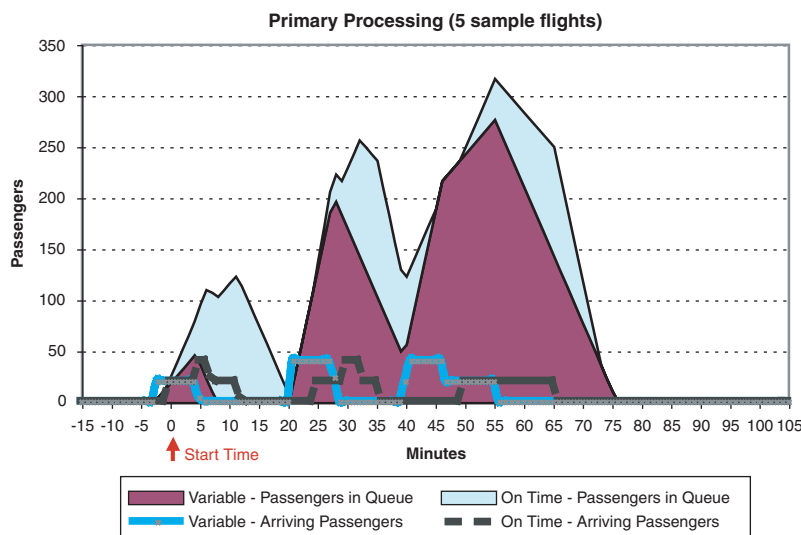


Figure 82. Example of random flights and initial flights queuing chart.

The example in Figure 81 gives a range of wait times that may be experienced by passengers in a scenario similar to the five-flight example period. The maximum wait time based on 10 iterations or runs in the queue model yielded a range of 17 to 34 minutes, and a maximum required queue depth of 44 feet. The minimum queue depth at any U.S. airport with international service is required to be at least 50 feet (75 feet normally); so, under the input conditions in this example the existing queue depth is satisfactory.

The next section in this model allows the user to look at a single sample international flight arrival and run a queue model to estimate wait times and queue size requirements. The demand in this case will be the estimated seat configuration of a likely international flight of a desired aircraft. The user can specify the number of double booths to be used in passenger processing and at what rate. One hundred passengers/per hour/per double booth is the CBP standard and should be used unless there is better local data that supports using a different known processing rate. This value can also be varied to do a sensitivity check on the overall process.

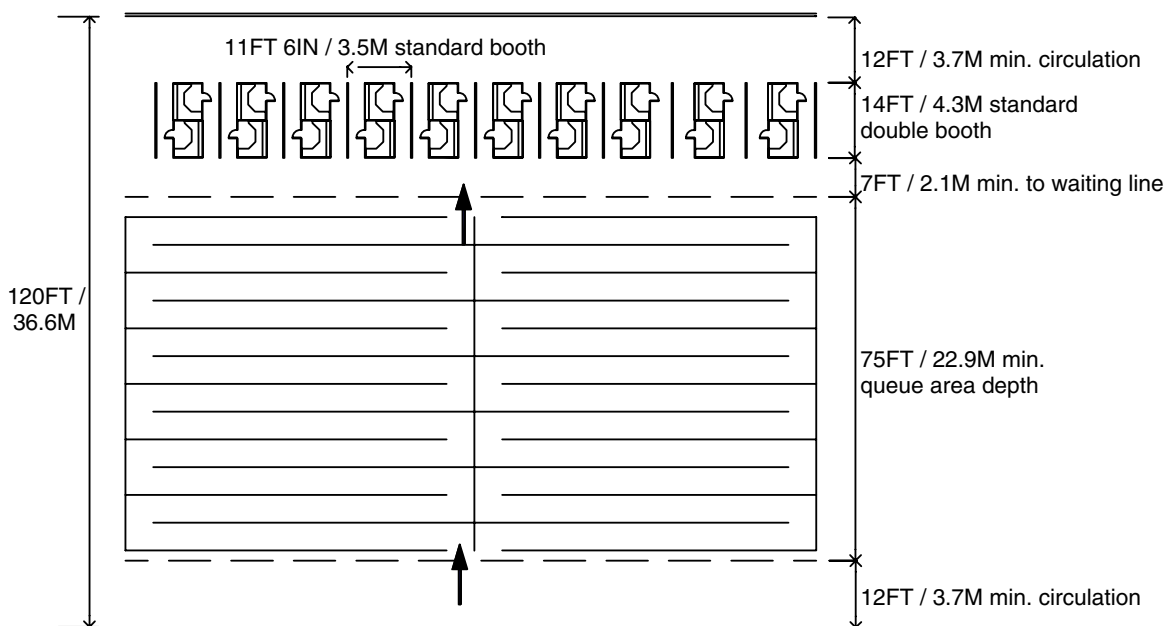
Among the many CBP facility requirements is the number of double inspection booths and the minimum passenger queue depth and width for primary inspection. This spreadsheet model allows the user to evaluate a CBP-recommended passenger flow rate and booth count, or user-selected values. Figure 83 shows the input section where the user makes these decisions.

The process in the single-arrival example will follow the same methods used in the multi-flight example except there is no random variability. The user enters the number of seats, load factor, and unload rate to determine the demand on primary processing. After the user next enters the number of double booths and processing rate, the queue model will estimate the maximum wait time and maximum number of passengers in the queue. To see the effects that bucket size has on a queue model example, the user can select either a 1-minute or 5-minute bucket size to observe minor variances. As in the first example with multiple flights, the output from the queue model will also estimate the required queue depth based on the existing number of double booths and desired LOS area for the passengers. In Example #2, shown in Figure 83, the user's entries have determined that if 15 square feet per passenger is the desired LOS area/passenger then the queue depth would need to be at least 43 feet.

34	SINGLE ARRIVAL- PRIMARY PROCESSING EXAMPLE	INPUTS	OUTPUTS	EXAMPLE #2
35	# of Seats on Arriving International Flight	400		
36	Load Factor of Arriving Flight	80%		
37	# of Arriving Passengers on sample flight		320	
38	Existing # of Double Booths	6		
39	User Specified # of Double Booths	4		
40	Total Primary Processing Positions		8	
41	Unload Rate (Passengers/min)	20		
42	Primary Processing Rate (Passengers/Hr/Double Booth)	100	CBP suggests 100 Pax/Hr/Double Booth	
43	Choose the bucket size for the Mini Queue Model to use	5 Minute	←--MAKE SELECTION	
44	Max # of Passengers in Queue		200	
45	Average wait time in Queue (min.)		15.9	
46	Max wait time in Queue (min.)		30.0	
47	Throughput Rate to Baggage Claim (Passengers/min)		6.7	
48	Width of Double Booth (ft.)	11.5	11.5 ft is standard	
49	Desired Passenger Space in Queue (sq. ft/ pax)	15.0		
50	Queue Model - Queue Area for Primary Processing (sq. ft)		3,000	
51	Queue Model - Queue Depth (ft.)		43	

Figure 83. Example of single arrival for primary processing.

The standard double inspector booth is approximately 14 feet deep and, with the passenger standing areas on either side, 11 feet 6 inches wide. The CBP requires a 7-foot minimum distance from the booths to the holding line for waiting passengers. CBP recommends a 50-foot minimum queue depth for smaller airports, and a 75-foot queue depth for larger airports, but the actual depth should be a function of the peak number of passengers forecast to be in the queue and the LOS assumed. Separate queues are required for U.S. residents and for foreign citizens. Although Figure 84 shows equal queuing areas, the division of the queues would be determined by the nationality mix of the passengers. The width of the queue lines is recommended to be 5 feet as most international passengers are traveling with others.



Source: Hirsh Associates

Figure 84. Primary inspection lanes with CBP standard dimensions.

53 Baggage Claim Example for Single Arrival		INPUTS	OUTPUTS
54	Arriving International Passengers at Baggage Claim		320
55	Average # of Bags per Passenger	2.0	
56	Claim Frontage required per Bag (ft.)	3.0	
57	Bag Dump Rate (Bags/min)	20	
58	Claim Frontage required per Passengers (ft.)	1.5	Typically 1.5 -3.0 ft
59	Passenger Delay to Claim (min.)	5.0	
60	Bag Delay to Claim (min.)	2.0	
61	Active Claim Area per Passenger (sq. ft)	12.0	
62	Time the Claim Unit is in Use (min.)		34
63	Total Linear Claim Frontage required (ft.)		559
64	Total Claim Area @ 35 sq. ft./LF of Frontage (sq. ft.)		19,578



Figure 85. Passengers and bags at Baggage Claim model.

Figure 84 illustrates a typical primary inspection area with the standard dimensions as published by CBP.

Baggage Claim

Following the primary processing step, the passengers move to baggage claim to retrieve their checked bags. Because of delays that may occur during primary processing, checked bags are often at the claim unit before the passengers arrive. In Figure 85, the next section in the model uses a probability bag-matching model to estimate the time a claim unit will be in use and how much linear frontage will be required for a specific demand load. The user must input average or specific information in relation to passengers and bags, as well as the likely bag delivery (dump) rate and delays. From these inputs the included bag-match model will estimate the desired outputs and generate a graph to show a possible flow pattern for the passengers and bags. The key outputs are also highlighted on the graph in Figure 86.

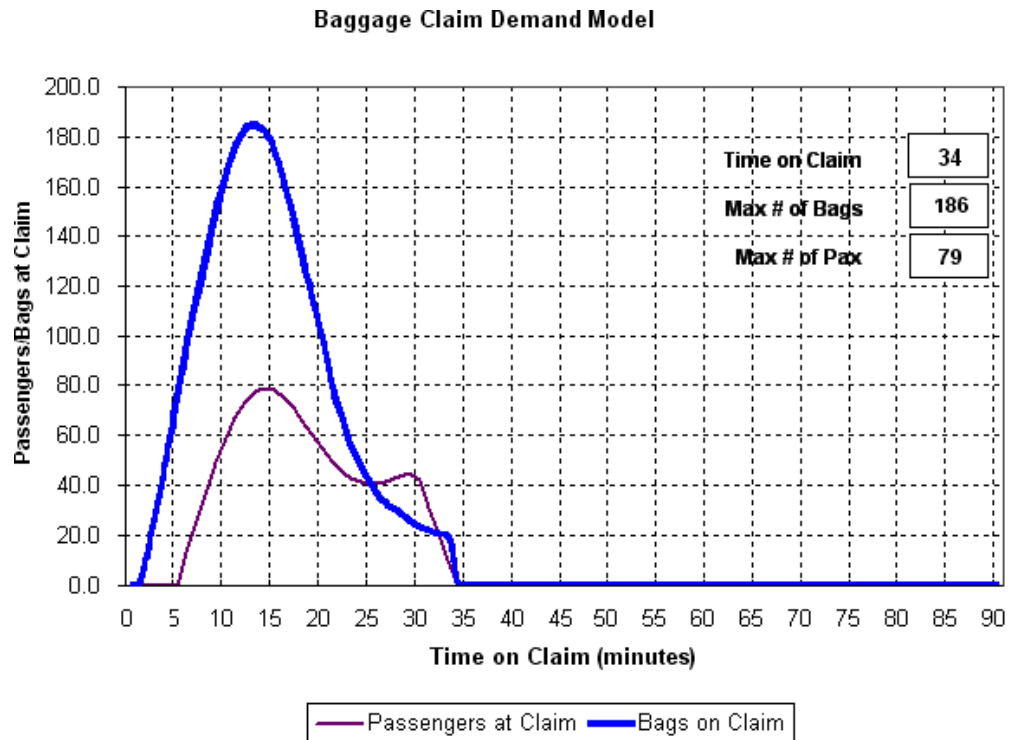


Figure 86. Chart of passengers and bags at baggage claim.

After primary inspection, passengers proceed to international baggage claim. The approach in sizing baggage claim for an FIS is similar to that for a domestic baggage claim. However, the time a claim unit is in use is typically longer for two reasons:

- Checked baggage ratios and the percentage of passengers with checked bags are typically higher than for domestic flights, thus requiring more time to unload. All passengers entering the United States must also have CBP baggage inspection at their first point of entry (except those in-transit). Connecting passengers then re-check bags to their final destination.
- Passengers must clear CBP primary before entering the baggage claim area, which normally allows bags to accumulate on the claim unit before passengers arrive. This delay can require a claim unit with greater capacity for baggage storage than is required for domestic flights with similar passenger characteristics. Thus, an international claim unit may be sized more for baggage storage than for active claim frontage, although both aspects should be considered. If sufficient storage isn't available (or passengers are delayed at CBP primary longer than anticipated), airline employees may have to unload bags from the claim unit and place them on the floor for passengers to pick up.



Compendium of Available Simulation Models

Recent research associated with the production of the Terminal Planning Spreadsheet Models has found substantial documentation on the availability of simulation models and model-making systems for passenger terminal planners. Several of the simulation models available for use are based on these model-making systems. When a more detailed level of estimation is required, a simulation model may provide the planner with more specific information and greater detail but will also require more time and a greater financial cost to the planner.

The following models are commercially available for use by passenger terminal planners and designers to support terminal space programs or validate alternative plans and designs:

- **PAXSIM**, Boeing (Preston Group), Melbourne, Victoria, Australia—a continuous simulation model for the movements of passengers and baggage within the passenger terminal building.
- **EDS-SIM**, Jacobs Consultancy, San Francisco, California—a continuous simulation model focused on automated baggage screening systems.
- **Flow-Model**, Jacobs Consultancy, San Francisco, California—an analytical model focused on the movement of passengers and baggage from ticketing through passenger and baggage security screening.
- **TRACS (Terminal, Roadway and Curbside Simulation)**, Transolutions, Inc. Ft. Worth, Texas—a continuous flow simulation model that covers all passenger and baggage movements inside the terminal building and covers vehicle movements on the terminal curbside.
- **Total AirportSim (TASM)**, Transolutions, Inc. Ft. Worth, Texas—a single-package continuous simulation model that covers all aspects of airport operations (aircraft, passengers, baggage, vehicles) within a single simulation model.
- **ARCport ALT**, Aviation Research Corporation, Point Roberts, Washington—a discrete event simulation model that models aircraft gate movements, passenger movements inside the terminal building, and baggage handling.
- **ServiceModel**, Ricondo & Associates, Chicago, Illinois—a discrete event simulation model that evaluates the movement of inbound and outbound passengers and baggage in the passenger terminal building.
- **TAS**, International Air Transport Association—a mathematical algorithm that evaluates aircraft, passenger, baggage, and vehicle movements on aircraft aprons and within terminal buildings.
- **Baggage—Systems**, Transolutions, Ft. Worth, Texas—a continuous simulation model for outbound baggage make-up (Automod model).
- **CAST Terminal, Airport Research Center**, GmbH, Aachen, Germany—a dynamic multi-agent simulation tool.

In addition to the preceding simulation models, the following modeling systems provide pre-made modules that represent passenger terminal facilities and provide tools to assemble these modules into custom simulations:

- **ARENA (SIMAN) Professional**, Rockwell Systems, Pittsburgh, Pennsylvania
- **WITNESS**, Lanner Group, Inc., Houston, Texas
- **Automod**, Applied Materials, Inc., Santa Clara, California



Acronym Guide

ADA	Americans with Disabilities Act
ADPH	Average Day Peak Hour
ADPM	Average Day of the Peak Month
ATO	Airport Ticket Office
ATSA	Aviation and Transportation Security Act
CBIS	Checked Baggage Inspection System
CBP	U.S. Customs and Border Protection
CUPPS	Common Use Passenger Processing System
CUSS	Common Use Self Service (~Kiosks)
CUTE	Common Use Terminal Equipment
DDFS	Design Day Flight Schedule
ECP	Equivalent Check-in Position
EDS	Explosives Detection System
EQA	Equivalent Aircraft
ETD	Explosives Trace Detection
FAA	Federal Aviation Administration
FIDS	Flight Information Display Systems
FIS	Federal Inspection Services
IATA	International Air Transport Association
INS	Immigration and Naturalization Service
LOS	Level of Service
NBEG	Narrowbody Equivalent Gate
O&D	Origin/Destination
OAG	Official Airline Guide
OSR	On-Screen Resolution (image reviewing)
PMAD	Peak Month Average Day
RON	Remain Overnight
SSCP	Security Screening Checkpoint
STD	Scheduled Time of Departure
TSA	Transportation Security Administration
WBI	Whole Body Image
WTMD	Walk Through Metal Detector

Abbreviations and acronyms used without definitions in TRB publications:

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	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
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
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation