

ACRP

REPORT 25

AIRPORT
COOPERATIVE
RESEARCH
PROGRAM

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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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, or the Federal Aviation Administration of the U.S. Department of Transportation.

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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.

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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

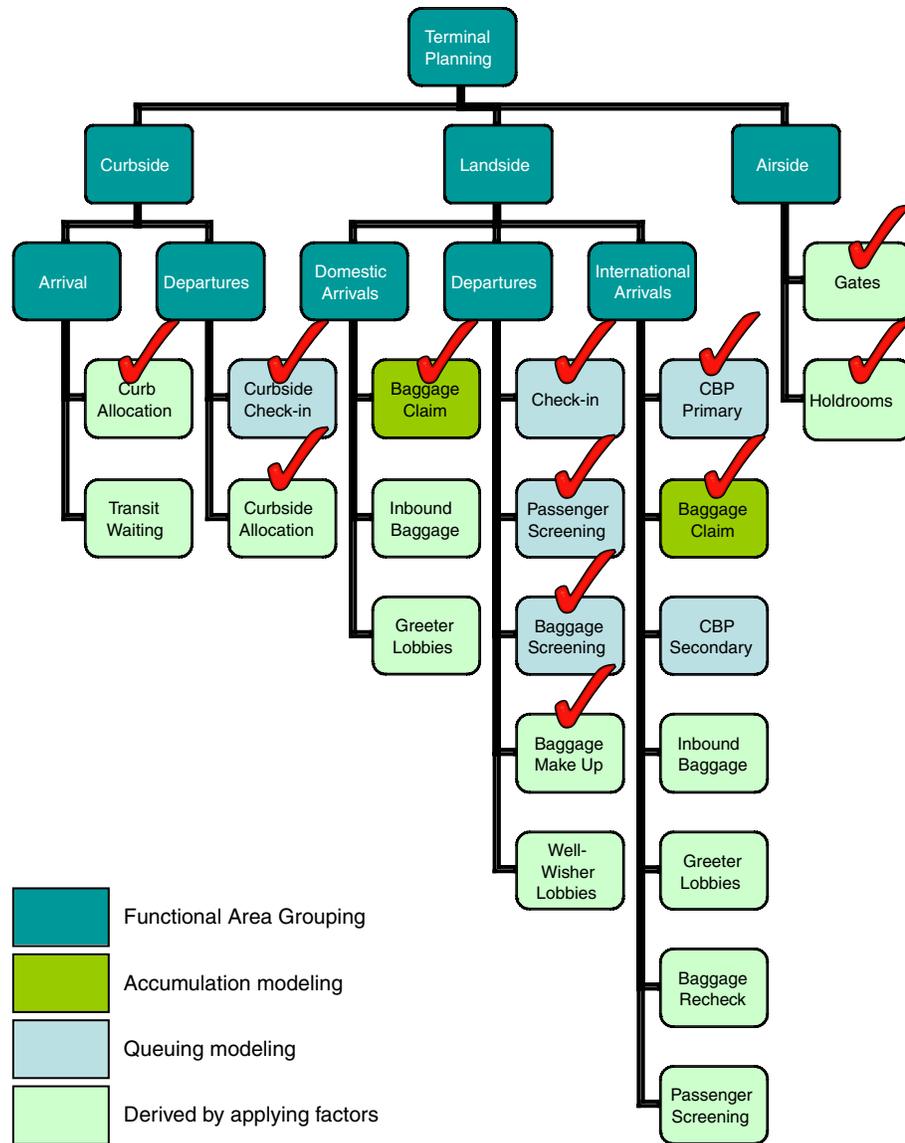


Figure 1. Terminal planning functions.

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

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.

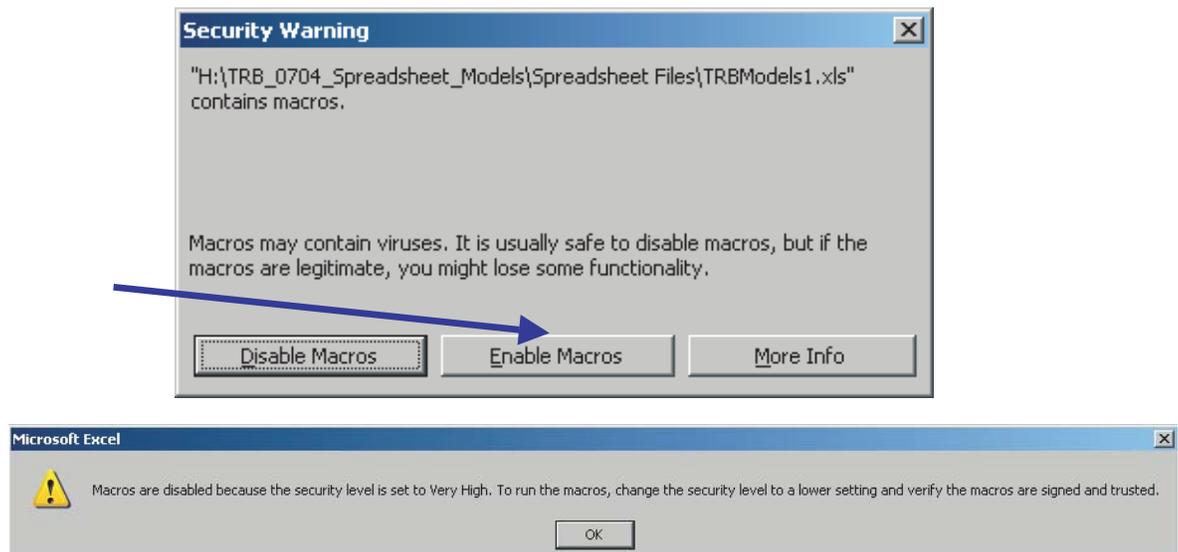


Figure 4. Examples of Excel macro security warning messages.