Modeling Measures to Improve Intermodal Connectivity at Airports

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ABSTRACT
The motivation to improve intermodal connectivity at airports results from a growing interest in reducing the volume of highway traffic generated by airport access and egress trips and facilitating the ability of airport travelers to use high-occupancy modes. However, there is a lack of standardized analysis tools for evaluating the viability and impact of different strategies to improve intermodal access to airports. This paper describes the development of a modeling framework to analyze alternative measures to improve intermodal connectivity at California airports that has been undertaken as part of a study for the California Department of Transportation. The modeling framework, termed the Intermodal Airport Ground Access Planning Tool, provides users with a structured and standardized way to organize and manage the data necessary to evaluate a large number of alternative potential projects and to analyze the impact of each project on the performance of the airport ground transportation system. A key feature of the analysis approach is the combination of a mode choice model that predicts how airport users will change their access and egress modes in response to changes in the ground transportation system with a formal model of the behavior of the transportation service providers in response to changes in use of the different modes. The focus of the paper is on the data management issues addressed by the modeling framework rather than the technical details of the underlying mode choice and transportation provider behavior models.
INTRODUCTION

The motivation to improve intermodal connectivity at airports results from growing pressures to reduce the volume of highway traffic generated by airport access and egress trips and to facilitate the ability of airport travelers to use high-occupancy modes (1). Continuing growth in air travel and air freight is generating increasing volumes of surface traffic traveling to and from airports, particularly major airports. This traffic arises primarily from air passenger trips, but airport employees and air cargo movement also contribute significant volumes of traffic at large airports. These vehicle trips contribute to congestion on the regional highway network and the local street system in the vicinity of the airport, as well as adversely impact air quality through increased vehicle emissions. The goal of improved intermodal connectivity is to encourage greater use of high-occupancy transportation modes for airport trips, particularly rail modes that do not involve use of the highway system (other than for access and egress trips to the rail stations) and in many cases use electrical power, thereby potentially reducing emissions in the area served by the airport. Strategies to improve intermodal connectivity could include shuttle bus or people-mover links to regional rail systems or express bus services to dedicated off-airport terminals some distance from the airport (1).

The growing interest in intermodal approaches to airport ground transportation led to two workshops in 1994 on ground access to airports that were organized by the Institute of Transportation Studies at the University of California at Berkeley for the Federal Aviation Administration (FAA) and that examined the role of off-airport terminals and institutional and funding issues in developing improved airport ground access services and systems (2). Subsequently the FAA in association with the Federal Highway Administration (FHWA) developed a planning guide for intermodal access to airports (3) and then in 1998 together with the Federal Transit Administration and FHWA requested the Transit Cooperative Research Program (TCRP) to undertake a comprehensive study of strategies for improving public transport access to large airports that led to two TCRP reports (4, 5). At about the same time, as part of the growing interest in developing intermodal strategies to address airport ground access, the Texas Department of Transportation sponsored an extensive study on the topic that undertook a comprehensive review of the literature, identified best practices and developed case studies, and performed an assessment of alternative strategies (6), while another comprehensive study in California (7) assembled information on the ground access conditions and needs at a large number of airports in the state and examined the roles and responsibilities of different agencies. More recently, the U.S. Government Accountability Office (GAO) undertook a major study on potential strategies that would redefine the Federal role in developing airport intermodal transportation capabilities (8).

However, in spite of the growing interest in these issues, there is a lack of standardized analysis tools for evaluating the viability and impact of different strategies to improve intermodal access to airports. Although there are a number of existing analysis tools that have been used to address various aspects of airport ground access planning (9), many of these are proprietary or require considerable effort to adapt to the needs of a given study.

In order to pursue these issues further, a current study for the California Department of Transportation (Caltrans) is developing a combined qualitative and quantitative approach to analyze the effectiveness of alternative strategies for improving intermodal connectivity at airports (10, 11). The qualitative approach involves a case study analysis of a selection of representative airports to identify and evaluate the potential effectiveness of alternative projects to improve the connectivity between the airports and the rest of the intermodal transportation
system, supplemented by a more detailed quantitative analysis of selected projects at case study airports using formal models of airport user mode choice.

Due to the lack of established public domain analytical tools to perform the quantitative analysis of the selected case study projects, it was decided to develop an analytical model, termed the Intermodal Airport Ground Access Planning Tool (IAPT), as part of the research. The IAPT is designed to provide an analytical environment that integrates existing data sources with models of air passenger and airport employee travel choice behavior, as well as goods movement decisions that involve airport trips, in order to evaluate the costs and benefits of proposed projects to improve intermodal connectivity at airports. The intent in developing the IAPT is to ensure a consistent approach to analyzing alternative projects and simplify the complicated modeling and computational aspects by providing decision makers and planners with a user-friendly interface to a standard set of analysis modules.

This paper describes the initial version of the IAPT, which has focused on air passenger travel to and from airports, leaving the other aspects of airport ground transportation trips to be addressed in a future stage of the research. The objective of the paper is to describe the architecture of the IAPT and the data management issues addressed by the design of the IAPT rather than present the technical details of the underlying modeling components. This is partly because these components are likely to evolve over time as better data and models become available, and partly because they will have to be tailored to the specific circumstances of each airport to which the IAPT is applied. The details of the initial modeling components developed for the current study will be presented elsewhere in the technical reports on the research project and future papers.

DESIGN OF THE INTERMODAL ACCESS PLANNING TOOL

A key feature of the IAPT that has not been addressed explicitly in prior modeling approaches is to incorporate into the analysis the expected response of transportation service providers to changes in competing services. Since many of the airport ground transportation services are in direct competition with each other, any shift in mode use that results from changes in one mode is likely to trigger a competitive response from the other modes. Failure to account for this response in any analysis is likely to overestimate the effect of improvements in intermodal connectivity on the use of high-occupancy modes.

Functional Design

The current implementation of the IAPT has been developed to allow a user to analyze the impact on air passenger ground access travel patterns of the introduction of a new mode or service or a change in the service characteristics of an existing mode. Because users may wish to compare several different alternatives, the IAPT provides the capability to define a set of project alternatives and estimate the effect on ground access travel patterns of each of these alternatives compared to a baseline alternative. Typically the baseline alternative will be the current system. The definition of a given project alternative comprises a complete description of the ground access system, including all available ground access services and their associated service characteristics (fares, frequencies, travel times, etc.).

Since the use of the different ground access services (or modes) for a given project alternative will depend on the total level of originating air passenger traffic at the airport, it will generally be necessary to analyze the system at different levels of air passenger traffic, corresponding to estimated future growth of traffic at the airport. Thus the IAPT allows the user to define a set of analysis scenarios consisting of a given project alternative and a given level of
air passenger traffic. For each analysis scenario the IAPT estimates the number of air parties using each ground access service, uses these estimates to compute other measures of system performance, such as fare revenue or vehicle trips, and allows the user to display, print or save this information in a format that can be used by other programs or for later analysis.

**Analysis Functionality**

In order to estimate the number of air parties using each ground access service for any analysis scenario, the IAPT applies an air passenger ground access mode choice model to a representative sample of air party trips using the appropriate service characteristics for each ground access service. Typically the representative sample of air party trips will be obtained from the results of an air passenger survey and will be provided as an input file. Any adjustments needed to correspond to the anticipated composition of the air passenger traffic in a future analysis scenario will have to be done externally to the IAPT analysis.

The response of the transportation providers to the changes in the use of the various ground access modes is explicitly modeled in the IAPT through a feedback loop between the mode choice model and a transportation provider behavior model, illustrated in Figure 1. The figure also shows the relationship between this analysis cycle and the other components of the analysis.

**FIGURE 1 Functional Structure of the Analysis**

Once the model has generated a set of air party trips by each mode, it is a fairly straightforward calculation to estimate the number of vehicle trips as well as other system performance measures that depend on person-trips or vehicle-trips, such as the total revenue for each service. Other system performance measures that depend on the distance traveled to the
airport, such as vehicle-miles of travel or vehicle emissions, can be calculated from the trip
origins of each air party and the service pattern for scheduled services. The output of an IAPT
run includes a file of estimated vehicle trips from each traffic analysis zone. These trips can be
added to a trip table for the non-airport traffic and used in a separate highway network traffic
flow analysis to explore the effect of changes in the volume and pattern of airport ground access
vehicle trips on traffic levels on the individual links of the local street and highway network near
the airport.

Model Components and Interfaces
As indicated in Figure 1, there are five basic components to the IAPT:

1. The graphical user interface
2. The analysis control program
3. The mode choice model
4. The transportation provider behavior model
5. The scenario performance measurement module.

Each of these components interacts through the IAPT database, a set of data tables with a
defined structure that contains both the input data for each analysis scenario and the output data
from each analysis run. The graphical user interface allows the user to enter the necessary data
to define a set of analysis scenarios, specify the measures of performance, initiate the analysis,
and control the display and output of the analysis results. The analysis control program
manages the interaction between the mode choice model and the transportation provider behavior
model to calculate the mode use and change in transportation service characteristics for each
analysis scenario. In essence this consists of two iteration loops. The outer loop processes each
analysis scenario in turn. The inner loop begins by calling the mode choice model with the
initial values of the transportation service characteristics for the given analysis scenario. The
mode choice model calculates the use of each mode for the sample of air party trips defined for
the given analysis scenario. The analysis control program then expands this mode use pattern to
the total usage of each mode for the associated airport traffic level and calls the transportation
provider behavior model to determine what adjustments, if any, to make to the transportation
service characteristics in the light of the mode use. The analysis control program then calls the
mode choice model and transportation provider behavior model in turn until a solution is
obtained in which the change in mode use on two successive iterations is less than a defined
threshold. Finally, the analysis control program calls the scenario performance measurement
module to calculate the defined performance measures for the calculated mode use. This
completes the analysis sequence for a given analysis scenario and the graphical user interface
provides the functionality to view, print, or export the results.

Each analysis module reads its input data from the IAPT database and writes its output to
the database. The graphical user interface obtains its input from user entries or external files and
transfers this data to the database. During the iteration between the mode choice model and the
transportation provider behavior model, the intermediate values of the transportation service
characteristics and resulting mode use can be stored in the database to permit subsequent analysis
of the convergence process.

Given the complexity of the issues to be addressed by the IAPT, it can be expected that
the analytical capabilities of the various components will be enhanced over time and that
additional capabilities will be incorporated in the future. Therefore the main model framework and the associated interface links have been designed to separate the analytical functions and underlying data structures so that the analysis modules can be easily modified and improved in the future.

Data Management
The design of the IAPT database provides a consistent framework for managing the large amount of airport- and project-specific data that is required for airport ground transportation analysis. While the basic unit of analysis for the IAPT is the project, there is a large amount of contextual information that is common to multiple projects, including data specific to the airport at which the project is located and the region within which the airport is located. Organizing these data in a hierarchical structure avoids the needs to redefine common data for each project or common data for multiple airports in the same region.

The underlying data that is required to support the IAPT consists of the following categories:

- Regional data describing the surface transportation system and other common characteristics of the region within which a specific airport is located;
- Airport data common to all projects at a specific airport, such as air passenger survey data and forecast traffic levels;
- Project data, including available ground access modes and associated service characteristics;
- Parameter values and structural information for the component models of the IAPT;
- Results of model analysis runs.

The two key data tables that are required to run the mode choice model are a table of air party characteristics for a representative sample of air parties, typically derived from an air passenger survey, and a corresponding table of the transportation service data (fares, travel times, etc.) for each ground access mode that would be experienced by each air party in the sample.

Graphical User Interface
The graphical user interface (GUI) is the key to the effective use of the software and is designed to insulate the user from many of the underlying details of the data management and analysis. It provides the functionality to manage the interfaces between the analytical components and the associated data flows, as well as allowing the user to define the problem to be analyzed, to input needed data in a straightforward and consistent way, and to view the results of the analysis. While users will need to have an understanding of the underlying modeling approach and satisfy themselves of the validity of the various analytical components incorporated in the IAPT, once these components have been configured and validated for a specific airport, subsequent use of the IAPT to evaluate specific projects does not require the user to directly manage the data flows between the model components. This not only simplifies the analysis process but also reduces the risk of errors resulting from the incorrect use of intermediate data.
The GUI is organized as a sequence of screen displays that perform specific functions and provide the user with a logical framework to enter the necessary data. Screen displays make use of data that has been already entered into the database to control the entry of additional data, thereby maintaining consistency of the underlying data. Checks are performed for completeness of the required data before initiating an analysis run. Each screen display contains a set of top-level navigation controls that allow the user to move between different data entry and model analysis functions, as well as a context-sensitive help feature that provides guidance on entering the required information for the current screen.

The first control option displays a descriptive overview of the IAPT and defines the terminology used in the tool. Selecting one of the other controls initiates a sequence of screens that guide the user through the relevant data entry or analysis tasks:

- Defining the projects to be analyzed
- Data entry
- Defining measures of performance
- Performing analysis runs
- Viewing, printing or exporting analysis results.

The following discussion does not attempt to describe every screen, but is intended to illustrate the functionality of the IAPT with reference to representative screens from the initial design of the GUI presented in the First Year Report for the project (11).

**Project Definition**

The IAPT analysis is based on defining a set of project alternatives at a given airport, where each project alternative (referred to simply as a project) represents a specified combination of ground access modes and associated service levels. The first step in any analysis is to assign a name to each project and provide a description of the project for later reference. The data for these projects are then entered later using the defined name.

The project definition screen allows the user to define a new project or modify the description of an existing project. Projects are defined in a hierarchical structure for a specific airport. At each level of the hierarchy a project inherits the characteristics of its parent project in order to reduce data entry requirements and simplify analysis of project variants. Once a project has been defined it can be selected for subsequent data entry or analysis steps from a list of defined projects using a pull-down menu. In order to define a new project, an existing project is selected as its parent in the hierarchy or the new project is designated as a top-level project, termed a baseline project. In the case of a new variant of an existing project, the name and description of the existing project are displayed and can be edited to define the new project, as illustrated by Figure 2.

**Data Entry**

The Data Entry control provides the user with access to a sequence of screens that are used to enter data for a region, airport or specific project. Regional Data screens allow the user to define a new region or select an existing region and enter or edit regional characteristics (currently limited to the number of analysis zones in the region, although this could be expanded
to support future capabilities) and import regional highway or transit network data from external files.

**FIGURE 2 Project Definition**

![Project Definition Diagram]

**Airport Data** screens allow the user to define or edit an analysis time frame with associated air traffic growth factors, to import representative air passenger data, and to define the existing ground access modes and their associated utility functions and service data. **Project Data** screens allow the user to define the available ground access modes for a selected project and enter or edit the modal service and cost data.

Some data is entered or edited directly on the screens, while more complex data can be imported from external files, as illustrated in Figure 3.

**Defining Measures of Performance**

Measures of system performance are key to the comparative analysis of project alternatives. The IAPT allows users to define measures of performance (MOPs) that are based on a selected output measure applied to a set of ground access modes. The available output measures are limited by the information that can be calculated from the IAPT mode choice input and output data, but provide a fairly comprehensive set of potential analysis results, including air passenger trips, total travel time, transportation provider revenue, vehicle-miles of travel, and vehicle emissions. For the current implementation of the IAPT, the categorical vehicle emissions (carbon monoxide, hydrocarbons, and oxides of nitrogen) are calculated on the basis of vehicle-miles of travel and average travel speed. This is consistent with the methodology used in the Federal Aviation Administration Emissions and Dispersion Modeling System (12). More
sophisticated analysis would be possible in future enhancements of the IAPT that could take into account traffic conditions on individual links of the regional highway system.

FIGURE 3 Regional Data Management

The process of defining a MOP is illustrated in Figure 4. The applicable output measure (emissions in this case) is selected from a pull-down menu and the modes to be included in this MOP are indicated by the use of check boxes. This allows the user to define MOPs that apply to a single mode, to several modes, or (as in this case) to all modes.

Perform Analysis

Once the data entry is completed and the MOPs have been defined, the analysis is performed from the Run Model control. This allows the user to select an airport, one or more projects, and one or more analysis years, and initiate the analysis. The IAPT analysis control module assigns a sequential number to the analysis run and then performs the analysis for each project and analysis year in order.

Display or Export Analysis Results

Finally, the View Output control allows the user to select a set of projects and analysis scenarios and display the resulting values of the measures of performance that have been defined for those projects, as illustrated in Figure 5. The tables with the resulting measures of performance can be exported for use in other applications.
FIGURE 4 Defining Measures of Performance

Intermodal Airport Ground Access Planning Tool

Airport: OAK Oakland International Airport

Project: 1.1 BART Connector - $5 fare

MOP: 6 Ground Access Vehicle Emissions

Output Measure: Emissions

Select menu to change output measure

MOP Description:
Categorical emissions from all ground access vehicle trips

Modes:
- Auto drop X
- Auto park X
- Rental car X
- Hotel courtesy van X
- Taxi X
- Limousine X
- Door-to-door van X
- Scheduled bus X
- BART (Connector) X
- AC Transit X

Edit text and mode selections and press OK to save changes or Cancel to return to previous screen

Enter New MOP Definition

FIGURE 5 Displaying Model Output

Intermodal Airport Ground Access Planning Tool

Airport: OAK Oakland International Airport

Project: 1 BART Connector - baseline

Measure of Performance

<table>
<thead>
<tr>
<th>Measure of Performance</th>
<th>Baseline 2001</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>BART Connector Ridership (annual)</td>
<td>733,600</td>
<td>1,426,000</td>
<td>1,972,000</td>
</tr>
<tr>
<td>BART Connector Revenue ($)</td>
<td>1,426,000</td>
<td>2,767,000</td>
<td>3,613,000</td>
</tr>
<tr>
<td>Other HOV Ridership (annual)</td>
<td>612,300</td>
<td>405,600</td>
<td>512,700</td>
</tr>
</tbody>
</table>

Press Print to print results or Cancel to return to previous screen
Press Export to export table in CSV format

Display Results
MODE CHOICE MODEL

The modeling of air passenger ground access mode choice forms the primary analytical component of the initial implementation of the Intermodal Access Planning Tool (IAPT). The choice of ground transportation mode by air passengers and airport employees for their airport access and egress trips determine the traffic volumes on airport roadways and the use of airport parking facilities, as well as the ridership on public modes serving the airports and the use of other airport ground transportation facilities. Airport ground access mode choice models (strictly airport ground access/egress mode choice models) therefore provide an essential analytical tool to support airport ground transportation planning, and a key component of the IAPT. There is a substantial literature on the development of air passenger mode choice models, although there are also unresolved concerns about their reliability. Much less research has been done on airport employee mode choice, and the current version of the IAPT does not address airport employee travel.

The IAPT is designed to allow users to specify the functional form and parameters of the mode choice model used in the analysis. Thus this component can be updated as better models become available and of course it will be necessary to revise the mode choice model if the IAPT is applied at a different airport. The initial version of the IAPT incorporates a set of mode choice models that are being developed for the San Francisco Bay Area airports as part of the current study. These models use a conventional nested logit structure with linear utility functions. However, the details of the functional form and estimated parameter values are beyond the scope of the current paper and will be reported in a future paper.

TRANSPORTATION PROVIDER BEHAVIOR

The second important aspect of the modeling framework incorporated in the IAPT is the modeling of transportation provider behavior. In contrast to the approach followed in most conventional analysis of airport ground transportation systems, where the service levels of other modes are assumed to remain unchanged when evaluating the impact of proposed service enhancements, the IAPT incorporates an explicit feedback process in which the transportation service providers can vary their fares or rates, schedules and other service characteristics in response to the changes in mode use resulting from a given project or other action.

The approach adopted in the IAPT recognizes that the ability of some transportation providers to adjust their service and prices may be constrained by regulations, contractual agreements or agency policies. For example taxi rates are generally regulated by local jurisdictions and cannot be varied by the operators (at least in the short run). However, a private sector transportation provider has to be able to cover its costs or it will simply go out of business. No regulation or contractual agreement can force a private sector transportation provider to continue to provide service at a loss. On the other hand, public transportation agencies (or the airport itself) may well be willing to subsidize services that do not cover their costs from their operating revenues. Thus users need to be able to specify the types of service and price adjustments that different transportation providers can implement. Initial modeling of transportation provider behavior has focused on price adjustments, but subsequent enhancements will allow users to include other service level adjustments in a transparent way.

Two different approaches to modeling transportation provider behavior are being explored as part of the current research project. In the first approach the providers in each mode are assumed to make price and service adjustments based on their perceived demand elasticity. These adjustments are made incrementally as patronage levels change in response to service decisions by other modes. The second approach is to model the competition between
transportation providers as a Nash game, using a formal mathematical optimization approach, as described in the First Year Report of the study (11).

The transportation provider behavior module of the IAPT interacts with the output of the mode choice model in an iterative cycle to move toward an equilibrium in which no private sector provider can improve its profitability by changing its service offerings. In the case of public transit agencies, where profitability as such is not a concern, the user needs to specify the service objective such as maximizing ridership subject to a subsidy constraint. However, for many public transit agencies where airport travelers use the same services as other travelers, it is not feasible to change the service levels offered to airport travelers as such, limiting the potential response options for those agencies. Airport authorities often find themselves with conflicting goals that place them somewhere between a private sector provider and public transit agencies. Airport-operated parking facilities provide a major source of airport revenue, and airports are often anxious to maximize the net revenue from these facilities. On the other hand, many airports also operate shuttle bus or other links to nearby rail stations, or in some cases express bus services to off-airport terminals. Many of these services operate on a subsidized or break-even basis, and the objective is often to maximize ridership (or at least satisfy the demand) rather than fully recover operating costs.

IMPLEMENTATION CONSIDERATIONS
The IAPT has been designed to be applicable to any airport. However, like any analytical tool, its use at any given airport requires some configuration to the local circumstances as well as the availability of necessary data.

Data Requirements
The data required to use the IAPT for a given airport consist of four components: (1) an air passenger survey with sufficient information to be able to estimate a mode choice model; (2) highway travel times and transit travel times and fares from the analysis zones used in the study to the airport; (3) parking rates, fares, service frequencies and travel times for each of the ground transportation modes serving the airport; and (4) capital and operating cost data for any airport ground transportation projects being evaluated using the IAPT. While this can be an extensive amount of data, the second component is generally available from the relevant local regional transportation planning agency and much of the third component is often available from the ground transportation information pages on the airport website. Many airports routinely perform air passenger surveys for other purposes than ground transportation planning, but where a suitable survey has not been performed recently this will have to be done as part of any study using the IAPT, as would be true for the use of any ground transportation analysis techniques.

The extent to which local capital and operating cost data for existing ground transportation modes is required to tailor the transportation provider behavior model to local circumstances is an issue for further study, and will depend in part on the specific implementation of the module. The current representation of this behavior is based on generic economic principles that should be applicable anywhere. While unit costs may vary from region to region, these are already reflected in the prices charged for transportation services and thus will be reflected in any percentage change in prices or service levels.

Transferability Issues
The underlying analysis framework of the IAPT is designed to be independent of the particular mode choice model used for a particular airport or even the implementation of the transportation
provider behavior model. Airport ground access mode choice models typically contain features that are specific to a given airport or group of airports (such as the available modes and their respective service areas), while their parameters reflect local socioeconomic and travel market conditions. Thus a mode choice model for one airport will not generally be transferable to another airport, and it may well be necessary to estimate a separate model for each airport being analyzed. It is not the intent of the IAPT to provide a universal airport ground access mode choice model that can be applied anywhere, but rather to provide a consistent data management framework to simplify the use of models that have been calibrated to local conditions. Indeed, the parameters and even the functional form for mode choice models for a given airport are likely to evolve over time as better data become available and analysts develop a better understanding of the factors influencing mode choice. Thus it is desirable to be able to modify that component of the IAPT without having to change other aspects of the tool, and this has been a key consideration in the development of the IAPT.

STATUS OF TOOL DEVELOPMENT
A prototype version of the IAPT has been developed for use in the San Francisco Bay Area and is currently being tested by applying it to the evaluation of a number of potential projects to enhance intermodal connectivity at the Bay Area airports. The implementation of the graphical user interface of the prototype tool differs in appearance from the initial design presented in some of the figures in this paper, in order to take advantage of standardized software features to reduce the development effort. However, the underlying functionality is essentially the same. It is envisaged that the graphical user interface appearance will be enhanced as part of the development of a production version of the software for use by Caltrans and others.

CONCLUSIONS
The design of the IAPT has been developed to address the immediate need in the current research project for an efficient way of analyzing a large number of proposed airport ground transportation improvements at multiple California airports. However, in doing so it has had to address a larger issue of effectively managing the extensive amount of data that is required to perform airport ground transportation modeling and do so in a consistent way across multiple projects. Furthermore, although the current project has been addressing the needs of California airports, the structure of the IAPT is sufficiently general to be applicable at any other airport.

The development of the IAPT has required that considerable thought be given to structuring the underlying data in a way that is sufficiently general to be applicable in a wide range of circumstances while at the same time following a consistent format so that the software can interact with these data without having to be customized for every application. The design of the graphical user interface has also required careful attention to how information is presented to the user and input is requested, so that users do not need to have a detailed understanding of the internal data flows or structure of the underlying databases. The current version of the IAPT therefore represents an initial attempt to rectify the absence of a standard set of modeling tools for addressing airport ground transportation analysis needs. Future enhancements, as more experience is gained applying the IAPT, can be expected to both broaden the range of issues that it can be used to address as well as implement improvements to the analysis components of the tool.
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