Evaluation of Opportunities to Improve Intermodal Connectivity at California Airports

Geoffrey D. Gosling
Principal
Aviation System Consulting, LLC
805 Colusa Avenue
Berkeley, CA 94707-1838
tel: (510) 528-8741
e-mail: gdgosling@aol.com

and

Xiao-Yun Lu
California Partners for Advanced Transit and Highways
University of California at Berkeley
Richmond Field Station, Bldg. 452
1357 S. 46th Street
Richmond, CA 94804-4648
tel: (510) 665-3644
e-mail: xylu@path.Berkeley.edu
Abstract

This paper describes the scope and initial findings of a study undertaken for the California Department of Transportation that is exploring opportunities to improve intermodal connectivity at California airports. It summarizes the findings of case studies of 13 airports in the state that examined opportunities to improve intermodal connectivity at those airports and discusses the issues involved in evaluating the feasibility of specific projects. The paper describes the role and structure of an analysis tool termed the Intermodal Airport Ground Access Planning Tool that has been developed to evaluate the potential impacts and feasibility of proposed projects.
INTRODUCTION

Continuing growth in air travel and air freight is generating ever increasing volumes of surface traffic traveling to and from airports. These vehicle trips contribute to congestion on the regional highway network and local street system in the vicinity of the airport, as well as adversely impact air quality through increased vehicle emissions. At large airports, particularly in metropolitan areas that do not meet ambient air quality standards, this has led to a growing interest in ways to reduce the number of ground access and egress vehicle trips generated by the airport activity (Gosling, 1997). Enhanced intermodal connectivity offers opportunities to encourage greater use of high-occupancy modes for airport access and egress trips, particularly rail modes that do not involve the use of the highway system (other than for access and egress trips to the rail stations) and in many cases use electrical power. Improving the connectivity to rail modes leverages the public investments that have been made in these modes, and to the extent that these modes are operating below capacity makes use of excess capacity at little additional cost.

This paper presents the scope and results of a study undertaken for the California Department of Transportation (Caltrans) that has explored a combined quantitative and qualitative approach to planning for improved intermodal connectivity at California airports. It describes the objectives of the study and discusses opportunities to improve intermodal connectivity at airports in general as well as the findings of case studies of 13 airports in the state. In order to evaluate these opportunities in more detail, the study developed an analysis tool termed the Intermodal Airport Ground Access Planning Tool (IAPT) that can be used to predict the likely impact of a given project to improve intermodal connectivity on the vehicle traffic generated by the airport, as well as study the financial feasibility of a proposed project. Since the
design and implementation of such projects involve a large number of trade-offs between the service level provided to users and the cost of the project, the IAPT provides a consistent evaluation approach for examining a large number of projects in an efficient way.

The remainder of this paper consists of five sections. The next section provides a brief review of recent studies directed at planning for improved intermodal connectivity at airports and describes the scope of the current study for Caltrans. The following section discusses possible strategies for improving intermodal connectivity at airports and summarizes the results of a series of case studies that examined potential opportunities for improved intermodal connectivity at 13 California airports. The fourth section addresses the analysis needs for evaluating the feasibility and effectiveness of proposed projects to improve intermodal connectivity. The fifth section describes the development of the IAPT to address these analysis needs. Finally, the last section presents some conclusions from the research.

PLANNING FOR IMPROVED INTERMODAL CONNECTIVITY AT AIRPORTS

In response to a growing interest in intermodal approaches to airport ground transportation, in 1994 the Federal Aviation Administration (FAA) asked the Institute of Transportation Studies at the University of California at Berkeley to organize two workshops on ground access to airports. These examined the role of off-airport terminals and institutional and funding issues in developing improved airport ground access services and systems (Gosling, 1994). Subsequently the FAA in association with the Federal Highway Administration (FHWA) developed a planning guide for intermodal access to airports (Shapiro et al., 1996) 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 (Leigh Fisher
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 (Mahmassani et al., 2002), while another comprehensive study in California (Landrum & Brown, 2001) 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 (GAO, 2005).

However, in spite of the growing interest in these issues, there is a lack of standardized analysis methodology and 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 (Gosling, 1999), 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, in 2004 Caltrans initiated a research study by the Partnership for Advanced Transit and Highways (PATH) at the University of California at Berkeley to develop a combined qualitative and quantitative approach to analyze the effectiveness of alternative strategies for improving intermodal connectivity at airports (Lu et al., 2005; Lu et al., 2006). 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, while the quantitative approach involves a more detailed analysis of selected projects at case study airports using formal models of airport user mode choice.

Based on the findings of the two approaches, the research project will develop policy recommendations for actions that can be taken by Caltrans or other agencies in the state to enhance intermodal connectivity at California airports.

**OPPORTUNITIES FOR IMPROVED INTERMODAL CONNECTIVITY**

In the broadest sense all airport ground transportation services are intermodal, in that they provide the connectivity between the air transport and surface transportation system. However, for the purposes of the current project, intermodal connectivity was defined more narrowly to address strategies to increase the use of high occupancy public transport modes for airport trips. These modes include regional and intercity rail systems as well as dedicated express bus services, whether operated by the public or private sector. With this context, there are three principal strategies to improve intermodal connectivity at airports:

- Direct rail service to the airport
- Improved links to nearby rail stations
- Express bus service to off-airport terminals or regional intermodal terminals.

In the special case of airports located adjacent to a large body of water, such as the San Francisco Bay, there may also be opportunities for ferry service.

Although direct rail service to an airport station has been proposed or implemented at an increasing number of large airports worldwide, it is typically a very expensive solution. Except in rare cases where an existing rail line runs within close proximity to an airport terminal, the engineering required to bring a rail line into a station in the airport terminal complex requires
substantial capital investment. There is also the question of train frequency. Operating a dedicated line at high frequency can incur significant operating costs. While such an approach may be justified at the very largest airports, where the volume of air passengers and airport employees may be enough to make such a service economically viable, in general this is not an appropriate strategy for most airports.

Improving links to nearby rail stations is generally a much less expensive strategy and more appropriate for smaller airports. These links may take the form of a dedicated shuttle bus service or an automated people-mover. The later may provide a higher level of service to the user, and eliminates the vehicle trips associated with a shuttle bus service, but is generally more expensive to construct and operate. The attractiveness of such links will depend on the frequency of service of both the link itself and the rail service to which it connects, as well as the fares charged for the use of the link and the rail service. While there is no need to operate the link at a higher frequency than the rail service, it is important for less frequent rail services that the connecting link is coordinated with the rail service schedule, so that the users do not incur a long wait twice.

The provision of express bus services to off-airport terminals located close to the trip ends of airport users provides another strategy to reduce the volume of vehicle trips to and from the airport. Such off-airport terminals typically provide parking at lower rates than at the airport, as well as waiting facilities for bus passengers or those waiting to pick up bus passengers. Larger facilities may also provide ancillary services, such as a newsstand or food and beverage, and some have provided airline ticketing or check-in. While the ability to check baggage at a remote location has often been proposed as a feature of off-airport terminals, it is unclear whether this is a significant factor in the attraction of such a facility and justifies the logistical
complexities involved. The principal advantages of an off-airport terminal to the users are the reduction in the driving time and distance, particularly for passengers being dropped off or picked up, compared to driving to and from the airport, and any saving in parking costs. For those using taxi to get from their trip origin or to their local destination, there are also typically significant cost savings compared to taking a taxi all the way to or from the airport. Locating an off-airport terminal at a major transit hub allows airport travelers to use transit to get to and from the terminal, and will generally provide better service than taking transit all the way to or from the airport. Similarly, providing express bus links between the airport and regional intermodal terminals, such as a central rail station, can allow airport travelers to utilize the better rail or transit service at those locations to travel to and from their ultimate trip end, while increasing the ease of travel between the airport and those facilities.

California Case Studies

There are already a number of examples of different types of intermodal connection at several California airports.

The extension of the Bay Area Rapid Transit (BART) system to San Francisco International Airport (SFO) that opened in June 2003 provides direct rail service to the second largest airport in the state. The BART system provides an extensive and frequent region-wide network with 43 stations serving Alameda, Contra Costa, San Francisco, and northern San Mateo counties. In addition, the Millbrae BART station provides an interchange with the Caltrain rail line that serves the Bayshore corridor of eastern San Mateo County and northern Santa Clara County. There is also direct rail service at Burbank/Bob Hope Airport, where the Burbank Airport Station is located adjacent to the airport within an easy walk of the airport terminal. This station is served by both Metrolink and Amtrak trains that provide service between Union Station
in downtown Los Angeles and communities in the San Fernando Valley and along the coast in Ventura and Santa Barbara counties. However, trains are relatively infrequent outside of weekday commute hours (Metrolink is primarily a commuter rail service) and to and from stations beyond Moorpark in the San Fernando Valley.

Several California airports have dedicated shuttle bus service to nearby stations. At Los Angeles International Airport (LAX) there is a shuttle bus operated by Los Angeles World Airports to the nearby Green Line Metro station. In the San Francisco Bay Area, the AirBART bus operated by the Port of Oakland connects Oakland International Airport (OAK) with the nearby Coliseum BART station and the adjacent Oakland Coliseum Amtrak station that serves the Capitol Corridor route between San Jose and Sacramento. At San José International Airport (SJC) the Route 10 Airport Flyer bus operated by the Santa Clara Valley Transportation Authority (VTA) connects the airport terminals with the Metro/Airport station on the Alum Rock-Santa Teresa Light Rail line and the Santa Clara Caltrain station. The Port of Oakland and BART are currently pursuing a joint project to construct an automated people-mover to link OAK to the Coliseum BART and Amtrak stations (U.S. Federal Transit Administration and San Francisco Bay Area Rapid Transit District, 2002) and San José International Airport is pursuing an automated people-mover link between the airport and the VTA light rail line, with a possible future extension to the Caltrain line (Lea+Elliott, 1999, San José International Airport, 2003).

Two California airports currently have express bus service to off-airport terminals. The Los Angeles World Airports (LAWA) operates the Van Nuys FlyAway service between LAX and an off-airport terminal adjacent to the Van Nuys airport in the San Fernando Valley. This terminal provides long-term parking and waiting facilities. LAWCA has recently modernized the terminal building and provided additional parking in an adjacent structure. In March 2006
LAWA opened a second FlyAway service between LAX and a terminal at the transit plaza adjacent to Union Station. Parking is available in an adjacent garage and the Union Station terminal has excellent transit and regional and long-distance rail links. From September 2006 passengers on domestic flights using the Van Nuys and Union Station FlyAway services could check baggage at the FlyAway terminals for a fee of $5 per person. In the Bay Area, Marin Airporter operates a scheduled bus service between SFO and two off-airport terminals in Marin County, at Larkspur and Ignacio near Novato (North Hamilton Parkway). Both terminals provide long-term parking and waiting facilities.

Scheduled airport bus service is also available to regional transit centers at a number of airports. Marin Airporter buses to and from the Hamilton terminal stop at the Central San Rafael Transit Center, as do Sonoma County Airport Express buses serving both SFO and OAK. In Southern California, Airport Bus of Anaheim provides scheduled bus service between the Anaheim Bus Terminal and LAX and John Wayne Orange County Airport.

In order to identify potential opportunities to enhance intermodal connectivity at other airports, or additional opportunities at the foregoing airports, a series of case study analyses were undertaken for thirteen California airports. These case studies examined existing ground access services at the airport and the proximity of nearby rail links and the nature of the service on those links. The analysis also reviewed a number of proposed ground access enhancements that had been proposed in an earlier study on ground access to airports in the state that had been performed for Caltrans (Landrum & Brown, 2001).

The potential opportunities identified in the case study analyses are documented in detail in Lu et al. (2005). Some of the more promising opportunities are as follows:
• **Burbank/Bob Hope Airport**  A shuttle bus link to the North Hollywood Station on the Los Angeles Metro Red Line about 4 miles from the airport would serve communities between North Hollywood and downtown Los Angeles, as well as communities in the San Fernando Valley served by the Orange Line from North Hollywood.

• **Long Beach Airport**  A shuttle bus link to the Willow station on the Los Angeles Metro Blue Line a mile and a half west of the airport would serve communities between downtown Long Beach and downtown Los Angeles, with connections in downtown Los Angeles to the larger regional transit system.

• **Ontario International Airport**  Shuttle bus links to the Rancho Cucamonga station on the Metrolink San Bernadino Line about 2 miles to the north of the airport and the East Ontario station on the Metrolink Riverside County line about a mile to the south of the airport would serve communities throughout the Inland Empire as well as large parts of the Los Angeles basin through connections to the Los Angeles Metro at Union Station.

• **Sacramento International Airport**  Extension of the Sacramento light rail system to the airport has been planned in conjunction with the development of the Metro AirPark business park to the east of the airport and new residential communities further east and southeast of the airport in the Natomas Basin. Planning studies for the project have been undertaken by the Sacramento Regional Transit District and an alternatives analysis has been completed (Parsons Brickerhoff Quade & Douglas, 2003).
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- **San Diego International Airport**  The Blue Line of the San Diego Trolley light rail system runs immediately to the north of the airport but there is currently no shuttle bus link between the airport terminal on the south side of the airport and the Blue Line Middletown station adjacent to the airport, although there is a frequent transit bus service to downtown San Diego. A shuttle bus link to the Middletown station would improve service to communities served by the Blue Line to the north of the airport.

- **Santa Barbara Municipal Airport**  Adjustments to the route of the Santa Barbara Metropolitan Transit District Route 11 bus, which currently provides half-hour service between downtown Santa Barbara and the campus of the University of California at Santa Barbara via the airport, to serve both the Goleta and Santa Barbara Amtrak stations would improve connections to trains serving Central Coast communities from San Luis Obispo to Ventura County.

In addition, the proposed people-mover projects at Oakland International and San José International airports mentioned above would improve connectivity between those airports and the Bay Area rail transit systems.

With each of these potential improvements, there are difficult project implementation and system planning questions to which the answers may not be intuitively obvious. For example:

- Is it better to charge a higher fare and thus be able to afford to run a service more frequently?

- Is it better to use larger vehicles that have lower operating costs per passenger or smaller vehicles that can serve more discrete locations more frequently?
To what extent does adding service at a new location attract new users compared to simply shifting existing users from other locations?

Thus the evaluation of any proposed project requires an understanding of the implications of these design trade-offs. Implementing a poorly conceived project not only reduces its likelihood of success, but may also compromise the viability of other projects that might have been able to make a greater contribution to improving the performance of the airport ground transportation system.

ANALYSIS NEEDS FOR EVALUATING POTENTIAL OPPORTUNITIES

Although the review of opportunities to improve intermodal connectivity at a sample of California airports identified a number of possible projects or actions that could be pursued, a more detailed evaluation of the feasibility and potential contribution of these projects requires a more formal quantitative analysis that would estimate the likely usage of the proposed facilities or services, the resulting revenues and costs involved in implementing the proposed improvements, the economic impacts on other ground access services at the airport, and changes in the environmental impacts of the ground access system. These estimates are required for detailed planning of the proposed improvements, assessing their financial feasibility, and developing the necessary environmental documentation that will be required in many cases before a project can proceed. They are also likely to be of considerable interest to both the airport operator and other ground transportation providers serving the airport due to the anticipated effect on the economics and operation of the airport and other ground transportation services.
Developing these estimates will generally require some form of mathematical modeling of the likely use that each potential improvement would attract. The circumstances at each airport are sufficiently distinct that the experience at one airport is not readily transferable to another without extensive adjustments to account for the different situations. Since it is typically not obvious how to determine a priori what are appropriate adjustments, this is usually addressed by developing a mathematical model of the system and using this model to predict the effect of changes to the system. Such models also have the advantage that they can be designed to readily generate the large amount of situation-specific data that is required to perform related analyses, such as estimating changes in highway traffic conditions and vehicular emissions for the purpose of air quality analysis.

The central component of these analytical activities is the modeling of airport traveler mode choice behavior. The ability to predict the changes in the use of the different components of the airport ground access system in response to any given change in the system obviously depends on the ability to predict how those traveler choices will change. However, as discussed in the following section, it is also necessary to be able to model the resulting decision process of the various transportation providers as they also respond to changes in the system. The nature and extent of these choices and decisions are not usually self-evident, and an important purpose of developing formal models of how the system will respond to any given change is to help decision makers better understand these complex and interacting factors.

At the same time it is important that the modeling activities are not viewed (or used) as a “black box” that produces numerical results in a way that the decision makers do not or cannot understand. A situation in which decisions are being made on the basis of the results of a model that nobody really understands is not only unsatisfactory for the decision makers, since they do
not know how much they should trust the results, but prevents any validity checking of the model itself. This is critically important in any complex situation such as an airport ground access system, where any analysis is very dependent on a large number of assumptions that are often deeply buried within the models. It is therefore essential to be able to understand how changes in the assumptions affect the results. If the results are largely insensitive to a particular assumption, then decision makers do not need to worry too much about whether the assumption is reasonable. However, if the results of the analysis turn out to be highly sensitive to a particular assumption, then those using these results need to satisfy themselves that the assumption is appropriate and to understand how changes in the assumption would affect the results.

This in turn implies that the modeling process needs to be able to analyze a large number of different scenarios and allow its users to easily perform sensitivity tests by varying the input assumptions and seeing what effect this has on the results. The more complex it is to reconfigure the analysis process to explore different assumptions or the more work that is required to perform any one analysis run, the less likely it is that an appropriate range of assumptions will be explored. In the present study, and for similar applications involving potential projects at a number of different airports, it is also critical that the analysis process can be easily reconfigured for use at different airports and that the analysis is performed in a consistent way for each airport. The use of airport-specific models that have been developed independently at different points in time makes it difficult to know whether differences in performance of similar projects at different airports are due to the differences in the situation at each airport or differences in the analysis tools being used.
ROLE OF THE INTERMODAL AIRPORT GROUND ACCESS PLANNING TOOL

Due to the lack of established public domain analytical tools that could be applied to evaluate the feasibility and effectiveness of a wide range of different projects at many different airports, it was decided to develop a new 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 airport ground access travel choice behavior in order to evaluate the costs and benefits of proposed projects to improve intermodal connectivity at airports. The design of the IAPT is intended to ensure a consistent approach to analyzing alternative projects and simplify the modeling and computational aspects by providing decision makers and planners with a user-friendly interface to a standard set of analysis modules.

The current implementation of the IAPT allows 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. The IAPT provides the capability for users 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 current system. The definition of a given project alternative comprises a complete description of the ground access system implied by that alternative, including all available ground access services and their associated service characteristics (fares, frequencies, travel times, etc.). In order to simplify the data preparation involved, the IAPT is designed to allow users to define a given project as a variant of a previously defined project or the existing system and for the new project to inherit the characteristics of its parent project, thereby limiting the required data to the differences from the parent project.
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 perform analysis for different levels of air passenger traffic, corresponding to estimated future growth of traffic at the airport. 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 and uses these estimates to compute other measures of system performance, such as fare revenue or vehicle trips.

The choice of ground transportation mode by air passengers and airport employees determines 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, as discussed by Gosling et al. (2003), although there are also unresolved concerns about their reliability (Gosling, 2006). Much less research has been done on airport employee mode choice, and the current version of the IAPT only addresses air passenger ground access travel.

An important aspect of the IAPT analysis is consideration of the likely response by other transportation providers to the introduction of a new mode or service. The airport ground access system consists of a large number of different modes operated by an even larger number of both public sector and private providers, most of which are in competition with each other. In such an environment, it can be expected that the introduction of a new mode or service that diverts
patronage from existing modes will prompt a competitive response from the other transportation providers, even if only to reduce service, which will influence the attractiveness of the new mode or service.

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, and this in turn affects the resulting pattern of mode use.

**Modeling Approach**

The basic structure of the IAPT and the associated data flows is shown in Figure 1.

**FIGURE 1 Functional Structure of the Analysis**
A graphical user interface (GUI) provides users with a consistent way to enter and manage the required data on the configuration of the ground access system, including the available modes and their service characteristics, and the composition of the air parties using the airport. The GUI also allows the user to interact with the analysis control program that manages the operation of three separate analysis modules: a mode choice model, a transportation provider behavior model, and a scenario performance measurement module.

As shown in Figure 1, the mode choice model interacts with the transportation provider behavior model through two intermediate datasets: one containing the current service characteristics of each ground access mode and the other containing the resulting use of each mode. For any given analysis scenario, the analysis proceeds iteratively, alternating between the mode choice model and the transportation provider behavior model. In each iteration, the transportation provider behavior model adjusts the service characteristics of those modes that are allowed to vary their service offerings in response to the current pattern of ground access mode use, and then the mode choice model recalculates the pattern of mode use to account for the changed service levels.

This process continues until an equilibrium state is reached in which the change in service characteristics and resulting mode use patterns is less than a defined threshold. The scenario performance measurement module then calculates a set of system performance measures for that particular analysis scenario, using the final pattern of mode use and transportation service characteristics.

Once this analysis has determined the number of air party trips using 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 can include a file of estimated vehicle trips from each traffic analysis zone. These trips can
be added to a trip table for non-airport traffic and used in a separate highway network traffic
flow analysis to explore the effect of changes in the airport ground access mode use on traffic
levels on the individual links of the local street and highway network near the airport.

Model Implementation

Because of the need to be able to configure the IAPT for a large number of airports, the
implementation of the tool has been designed to keep the analytical components as separate
software modules that interact through an underlying database. This allows users to modify each
component to reflect the particular application without affecting the overall functionality of the
tool. In particular, separation of the mode choice model from the transportation provider
behavior model allows users to change the functional form and parameters of the mode choice
model used in the analysis without affecting the overall analysis process. Thus this component
can be updated as better models become available and of course it will generally be necessary to
estimate a different mode choice model if the IAPT is applied at a different airport.

A more detailed discussion of the initial implementation of the analytical components of
the IAPT is presented in a companion paper (Lu & Gosling, 2007).

Once the development of the IAPT has been completed and experience has been gained
in applying it to evaluating airport ground transportation projects, the extent of the benefits of
using the tool will become clearer. These benefits are expected to fall into two broad categories:
a reduction in the required level of effort to evaluate a given set of airport ground access projects,
and an improvement in the consistency of the evaluation process across multiple projects. A reduction in the level of effort required to define and analyze a given set of projects will also encourage users to examine more alternatives, which should result in better project selection and design decisions.

CONCLUSIONS

Although it is increasingly recognized that improved intermodal connections at airports are the key to increased use of public transit and high-occupancy modes for airport access and egress trips, there is less agreement on how to achieve this or which projects are worth doing. The problem is not identifying potential projects, but determining whether their cost is justified by their contribution to improved airport accessibility. Running empty buses or simply shifting passengers from one high-occupancy mode to another serves no useful purpose.

The review of potential opportunities to improve intermodal connectivity at California airports discussed in this paper has identified a large number of possible projects or actions, many of which appear fairly straightforward to implement and perhaps long overdue. However, none are costless to implement and their contribution to the overall performance of the airport ground access system is not intuitively obvious. There is clearly a need for a robust analysis methodology that can be easily adapted to the situation at different airports and that can be used to determine the best implementation arrangements for a particular project as well as to evaluate its contribution to the performance of the airport ground transportation system.

The Intermodal Airport Ground Access Planning Tool (IAPT) being developed as part of the current research project has been designed to perform this role. The application of this tool to the evaluation of selected opportunities to improve intermodal connectivity at specific airports during the remainder of the project should shed useful light not only on the viability of those
individual projects, but also through evaluating a large number of diverse projects in a consistent way on the influence of local circumstances on the likely viability of any particular strategy to improve intermodal connectivity.
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