UC Berkeley
Research Reports

Title

Thinking Outside the Bus: Understanding User Perceptions of Waiting and Transferring in Order to Increase Transit Use

Permalink
https://escholarship.org/uc/item/4d75d18n

Authors
Taylor, Brian D.
Iseki, Hiroyuki
Miller, Mark A.
et al.

Publication Date
2009-01-16

eScholarship.org Powered by the California Digital Library
University of California

CALIFORNIA PATH PROGRAM
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY

Thinking Outside the Bus: Understanding User Perceptions of Waiting and Transferring in Order to Increase Transit Use

Brian D. Taylor, Hiroyuki Iseki,
Mark A. Miller, Michael Smart

California PATH Research Report
UCB-ITS-PRR-2009-8

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation, and the United States Department of Transportation, Federal Highway Administration.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

Report for RTA-65A0194-15762

January 2009

ISSN 1055-1425

CALIFORNIA PARTNERS FOR ADVANCED TRANSIT AND HIGHWAYS

Thinking Outside the Bus: Understanding User Perceptions of Waiting and Transferring in Order to Increase Transit Use

Brian D. Taylor
Hiroyuki Iseki
Mark A. Miller
Michael Smart

Final Report for RTA-65A0194-15762

January 16, 2009

Preface

This document is the Final Report for the Research Technical Agreement (RTA) between the California Department of Transportation (Caltrans) and the University of California at Los Angeles (UCLA). The RTA is entitled "Tool Development to Evaluate the Performance of Intermodal Connectivity (EPIC) to Improve Public Transportation". Caltrans' primary interest in this research was interconnectivity among transportation modes in California and the development of a methodology to evaluate connectivity performance, which could provide a new and needed tool to improve passenger transit trips.

This project was a collaborative effort between UCLA and the University of California at Berkeley (UC Berkeley). The overall project Principal Investigator was Professor Brian Taylor at UCLA, and Professor Samer Madanat served as the Principal Investigator for UC Berkeley. Mr. Mark Miller was the Project Manager working with Dr. Hiroyuki Iseki of the University of Toledo; at the start of the project Dr. Iseki was a Post-Doctoral Researcher at UCLA. Additionally, two Graduate Research Students at UCLA, Mr. Michael Smart and Ms. Adina Ringler, were members of the project team. Professor Taylor provided overall technical guidance and support to the project team for all project tasks. In addition to managing the project, Mr. Miller conducted research in the areas of reviewing the literature, designing and administering both project surveys and the institutional interview guide, and documenting research findings. Dr. Iseki developed the transfer penalties/travel behavior conceptual framework as part of his review of the literature; he also worked on designing the transit passenger survey and analyzing its responses as well as documenting its findings. Mr. Smart worked on designing and administering both project surveys and the institutional interview guide, analyzing responses to the transit operators survey and the institutional interview guide, and documenting their findings. Ms. Ringler worked on designing and administering the transit passenger survey, analyzing its responses, and documenting its findings. Additional information about the four authors of this report is provided in the "About the Authors" section of this report.

The two key products of this research are:

-The transfer penalties/travel behavior conceptual framework, which was based on our review of the state-of-the-practice for evaluating intermodal and intramodal connectivity, and
-The preliminary transit connectivity assessment tool

The framework allowed us to consider various attributes of transit stops, stations, and transfer facilities and guide us in our subsequent analysis of user perceptions of walking, waiting, and transferring experiences. Our research findings, especially the preliminary Assessment Tool, have taken substantive steps toward determining the connectivity of transit systems, its influences on travelers' satisfaction with transit services, and ways that public transit systems can reduce the burdens of out-of-vehicle "travel" times to help make public transit more attractive resulting in ridership increases.

This Final Report has integrated each of our project's components into a cohesive product documenting the significance of transit connectivity's contribution toward increasing transit

usage.

In this report, we describe transit trips made with transfers, the types of transfer venues, and transit connectivity. We follow this with a discussion of our transfer burdens/travel behavior conceptual framework. After this we discuss the three types of stakeholders we focused on in our assessment of transit stops, stations, and transfer facilities; next we present the methodological approach we employed in this assessment. We then discuss our findings together with presentation of our Attribute Assessment Tool. Finally, we discuss next steps for this line of research.

Acknowledgements

This work was performed under the sponsorship of the State of California Business, Transportation and Housing Agency, Department of Transportation (Caltrans), Division of Research and Innovation (DR&I) (Interagency Agreement #65A0194). The contents of this paper reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. The authors thank Mr. Bruce Chapman of DR&I who managed this project for Caltrans. The authors also thank Ms. Adina Ringler, a former Graduate Student Researcher for this project at the University of California, Los Angeles, for her significant contributions to this research. The authors would also like to thank former UCLA student Mr. Ting Sit who helped design and administer the survey, and collate and analyze the data; UCLA students Mr. Syed-Abrar Ahmed, Ms. Lanka Ranasinghe, and Ms. Karla Vasquez who helped administer the survey; UCLA student Ms. Vanessa Fernandez who translated the survey from English into Spanish; Los Angeles County Metropolitan Transportation Authority (Metro), Metrolink, Santa Monica Big Blue Bus, and Culver CityBus for allowing us to survey their passengers; the nearly 750 Los Angeles County transit riders and nearly 200 transit managers representing agencies around the U.S. who took time out of their busy schedules to give us their thoughts and views on how to make waiting for transit a less onerous experience; Ms. Michelle Tse and Ms. Rowena Barlow in the Business Office of the UCLA School of Public Affairs and Mr. Ken Castro-Oistad and Ms. Virginia Anders of the UCLA Office of Contracts and Grants Administration for their administrative support of this project.

ABSTRACT

This report presents the results of its research of interconnectivity among transportation modes in California and the development of a methodology to evaluate connectivity performance, which could provide a new and needed tool to improve passenger transit trips. The two key products of this research are the transfer penalties/travel behavior conceptual framework, which was based on our review of the state-of-the-practice for evaluating intermodal and intramodal connectivity, and a preliminary transit connectivity assessment tool. The framework allowed us to consider various attributes of transit stops, stations, and transfer facilities and guide us in our subsequent analysis of user perceptions of walking, waiting, and transferring experiences. Our research findings have taken substantive steps toward determining the connectivity of transit systems, its influences on travelers' satisfaction with transit services, and ways that public transit systems can reduce the burdens of out-of-vehicle "travel" times to help make public transit more attractive resulting in ridership increases. In our research to learn more about how wait times at stations and stops are perceived, and how they can be made better, we surveyed approximately 750 passengers at stops and stations in Los Angeles County, as well as 175 transit operators nationwide. From our analysis of the passengers/users perspective, one principal finding stands out clearly:

The most important determinant of user satisfaction with a transit stop or station is frequent, reliable service in an environment of personal safety, and only indirectly the physical characteristics of that stop or station.

Our principal finding from our analysis of transit managers perspective precisely matches that of the transit user investigation:

> ***For operators, safety- and security-related factors far outweighed other attribute factors at transit stops, stations, and transfer facilities.***

This report further develops a Preliminary Assessment Tool that transit operators can use to guide their efforts at improving existing transit stops and stations, or in developing plans for new facilities. The Preliminary Assessment Tool, sketched briefly, guides the operator in:

1. Determining the priority of improvements to stops and stations
2. Devising a user perception survey for stations and stops of particular interest, and
3. Analyzing the survey results to produce a ratings matrix using Importance-Satisfaction Analysis

Key Words: transit connectivity, intermodal, intramodal, stops, stations, transfer facilities, transit managers, attributes, safety, security

EXECUTIVE SUMMARY

Transit travelers expend a great deal of their time, energy, and patience outside of buses and trains – but the in-vehicle experience captures the lion's share of attention from transit managers.

A typical door-to-door trip involves walking from one's origin to a bus stop or train station, waiting for a vehicle to arrive, boarding the vehicle, traveling in the vehicle, alighting from the vehicle, and then walking to one's final destination. In many cases, the trip also involves transfers, contributing to both their actual and perceived burden of transit travel. This research examines ways to increase the attractiveness and reduce the perceived burden of the time spent outside of vehicles during transit trips.

In order to learn more about how wait times at stations and stops are perceived, and how they can be made better, we surveyed approximately 750 transit passengers in metropolitan Los Angeles, as well as 175 transit operators nationwide.

We surveyed passengers at stops and stations and asked them to assign a level of importance to each of a list of attributes, and then to tell us how satisfied they were with each attribute. We combined these two scores using Importance-Satisfaction Analysis to identify which attributes passengers found most important and which needed the most improvement.

We surveyed transit operators, asking them to do two things: to rate by importance a series of objectives for transit stops and stations, and also to guess how their operators would respond to a user perception survey (described above). We used the former to construct a rank-ordered list of transit operators' priorities for stops and stations, and the latter to see just how accurately operators understand their riders' priorities.

From our analysis of the passengers/users perspective, one principal finding stands out clearly:

The most important determinant of user satisfaction with a transit stop or station is frequent, reliable service in an environment of personal safety, and only indirectly the physical characteristics of that stop or station.

From the sixteen attributes we examined, users ranked safety and on-time performance most important, and amenities least important:

Most Important

1. I feel safe here at night
2. I feel safe here during the day
3. My bus/train is usually on time

14. It is easy to get around this stop/station
15. There are enough places to sit
16. There are places for me to buy food or drinks nearby

Least Important

A companion part of our analysis compared how transit managers and neighboring communities viewed transit stops and stations. Perhaps reassuringly, our principal finding precisely matches that of the transit user investigation:

> ***For operators, safety- and security-related factors far outweighed other attribute factors at transit stops, stations, and transfer facilities.***

Telephone interviews confirmed this finding, with most interviewees stressing the importance of safety and security. One interviewee told us that "safety trumps all" other concerns. Following safety and security, operators rated the following attributes as most important:

2. Reducing pedestrian/vehicle conflicts
3. Schedule coordination
4. Minimizing operating costs

We also compared transit managers' views of what was important to their riders with riders' own views from our analysis of Los Angeles County transit riders. While transit operators appear to have a fairly accurate understanding of what attributes are important to their, there are several points of disparity:

- The transit managers surveyed correctly assumed that safety and security were very important to riders, but they tended to underestimate the importance of specific safety-related factors, such as the presence of security guards and emergency assistance.
- It also appears that, controlling for other factors, transit managers overestimate the importance of station cleanliness and schedule information to their riders.

This report further develops a Preliminary Assessment Tool that transit operators can use to guide their efforts at improving existing transit stops and stations, or in developing plans for new facilities. The Preliminary Assessment Tool, sketched briefly, guides the operator in:

4. Determining the priority of improvements to stops and stations
5. Devising a user perception survey for stations and stops of particular interest, and
6. Analyzing the survey results to produce a ratings matrix using Importance-Satisfaction Analysis

Table of Contents

LIST OF TABLES PAGE

LIST OF FIGURES PAGE

1.0 Thinking Outside the Bus: Waits and Transfers in Transit Travel

A typical door-to-door transit trip involves walking from one's origin to a bus stop or train station, waiting for the vehicle to arrive, boarding the vehicle, traveling in the vehicle, alighting from the vehicle, and then walking to one's final destination. In many cases, the trip involves transfers; travelers alight from one transit vehicle, move to a new stop or platform, wait for another transit vehicle, board that vehicle and continue this process until they reach their last stop or station at which they walk to their final destination. Figure 1 shows a schematic diagram of the major components involved in a transit trip involving a transfer.

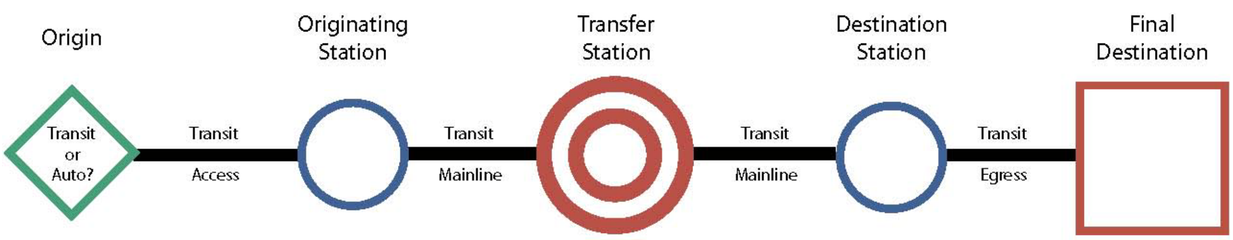


FIGURE 1 A Transit Transfer Trip

Source: Metropolitan Transportation Commission, Transit Connectivity Study, March 2006.

Transit stops and transfer facilities are obviously not all the same and can differ relative to numerous factors, for example with respect to:

- Physical size of the station or facility
- Travel modes serving the location
- Number of lines per transit operator
- Number of operators, and
- Amenities offered to travelers there.

At one extreme, we can have the bare minimum of attributes: An on-street bus stop that serves two lines of the same transit agency with only posted time-point schedules, no real-time bus arrival times, and not even a bench for waiting passengers to sit on (Figure 2 Simple Bus Stop: Downtown Los Angeles).

At the other end consider Union Station in downtown Los Angeles, which, as an off-street facility, accommodates both intermodal and intra-modal (bus, shuttles, light rail, heavy rail, commuter rail, and inter-city rail) transfers among different transit agencies and different lines of the same agency (Figure 3 Los Angeles Union Station).

.

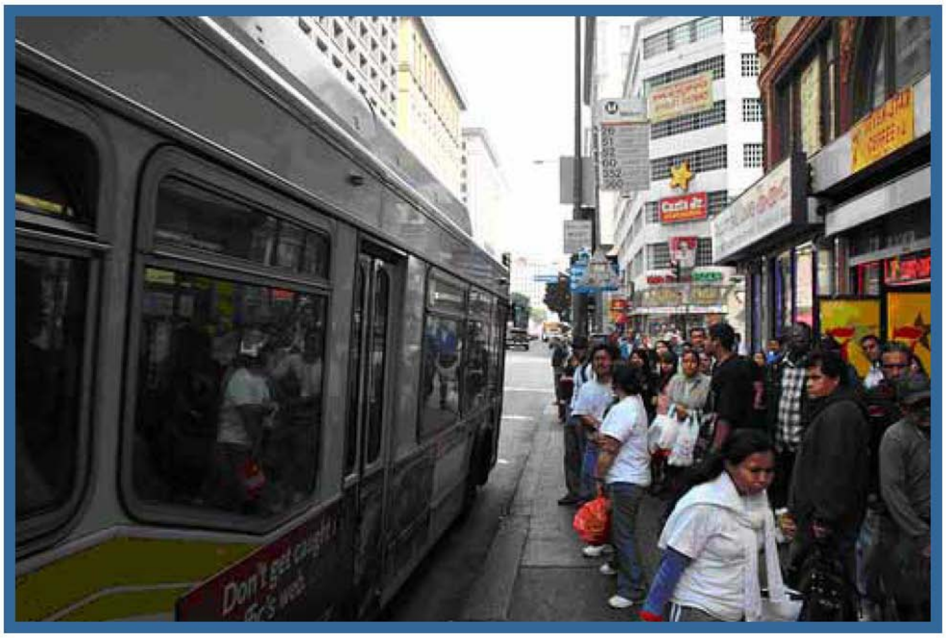


FIGURE 2 Simple Bus Stop: Downtown Los Angeles

FIGURE 3 Los Angeles Union Station

We describe in Table 1 how transit stops, stations, and transfer facilities may be grouped by the following set of factors in which wait and transfer locations can differ:

- Volume of passengers and activities
- Number of interfacing routes
- Number of interfacing modes
- Physical configuration
- Investment in facilities
- Transit center type (community, regional, or other), and
- Whether or not it is a joint development with commercial use of facility.

TABLE 1 Classification of Transit Stops, Stations, and Transfer Facilities

Descriptor	Attributes
I. Local stop serving a single transit mode	On-street curb loading area serving 1 or 2 bus routes or a station with a grade-level platform for rail
II. Slightly upgraded form from Classification I	On-street bus turnout serving two or more routes with loading bays separated from regular traffic lanes, or a passenger-car level, raised platform rail station, which may have auto parking and vehicle interface facility.
III. Completely off-street	A bus transfer facility at this level is an off-street turnout with loading platforms serving multiple routes. A rail station is an at-grade but raised platform station with a possible pedestrian overpass or underpass, auto parking, and bus transfer facilities.
IV. An urban grade-separated multi-modal transit facility	With exclusive bus access provisions and elevated or subway rail access; it may have large parking areas, and a level 2 or 3 bus-transfer facility. This level facility could be incorporated into a major activity center with joint development by others.
V. A major center-city, regional, grade-separated, multi-modal, multi-level bus or rail-transfer facility.	The significant capital investment is spent in pedestrian circulation elements, waiting room, ticket selling and other passenger processing facilities, and concession spaces. An example is the San Francisco Trans-Bay Bus Terminal.

Source: Fruin. John J. 1985. Passenger Information Systems for Transit Transfer Facilities. In Synthesis

Source: Fruin, John J. 1985. Passenger Information Systems for Transit Transfer Facilities, In Synthesis of Transit Practice, 7, edited by N.C.T.R.D. P. (U.S.). Washington, D.C.: Transportation Research Board National Research Council.

Thus, transit stops and transfer facilities vary greatly. For example, there are

- Bus stops
- Light rail stations
- Heavy rail stations
- Commuter rail stations
- Ferry docks, and
- Terminals

In general, the more transit users at stops and transfer facilities, the more complex a transfer facility is. We highlight the following three types of transit stop/transfer facilities:

> A ***transit mall*** is a special street set aside for exclusive use of buses and/or light rail vehicles in a city center or other high activity center that focus on pedestrian movement and activities, and include design components that are related to both transit and urban design, such as waiting shelters, the use of landscaping, street furniture, shopping and other civic activities. Transit malls are often combined with a development of adjacent property, which consists of shopping and office activities as well as transit-related retail and services.
>
> A ***transfer center*** is a facility whose primary purpose is to facilitate easy transferring between transit modes and routes and can be combined with transit-related developments, concessions to accommodate users with convenience shopping, (e.g. newsstands, snacks, flowers, and teller machines) or coordinated with a full scale shopping center. Such centers are usually located entirely or partially off-street. They also incorporate a more elaborate and extensive shelter and more passenger amenities than ordinary bus stops. These centers are typically located in suburban or edge-of-city locations in the metropolitan area with sufficient area to allow access and circulation of multiple travel modes as well as automobile parking.
>
> An ***intermodal terminal*** is a facility that provides key transfers among transit modes, which may include local bus, bus rapid transit, intercity bus, light rail, heavy rail, intercity passenger rail, ferry, or automated guideway transit. Such facilities may also have a variety of other services and connections, including parking, drop-off, ticket vending, and information booths. These facilities are a fixed location where passengers interchange from one route or vehicle to another that has infrastructure, normally only shelters and/or benches.

2.0 Transit Connectivity: The Key to the Wait/Transfer Experience

Public transit passengers typically must wait for and transfer between buses and trains during their journeys, and this constitutes the connectivity between distinct parts of a passenger's transit trip from origin to destination. Thus, the travel time spent outside of transit vehicles while waiting and transferring plays a significant role in the passenger's overall transit trip experience.

But what exactly is transit connectivity? How does one define, measure, and evaluate connectivity? Although the importance of transit transfer connectivity has been recognized for several decades, surprisingly little of what researchers have learned about out-of-vehicle travel behavior today explicitly informs transit planning practice. Efforts to improve connectivity at stops and stations have proven to be less effective than expected for the following reasons:

- Both practitioners and researchers tend to pay more attention to quantity and quality of in-vehicle travel for its more intuitively obvious effects on ridership.
- Stops and stations vary in size, modes served, location, and amenities; they are hard to analyze comprehensively using uniform criteria
- Most of the literature on stops and stations is descriptive in nature and lacks a theoretical framework to explain how improvements of transfer facilities affect people's travel behavior and, in turn, overall transit ridership.

Most previous studies of transit stops, stations, and transfer facilities have compiled laundry lists of out-of-vehicle trip attributes that contribute to or detract from travelers' transfer experiences; however, they have largely failed to consider the relative importance of each of these attributes — positive and negative — or whether and how these attributes influence ridership separately or in concert with another. As a result, we know little about which attributes are most important, under which circumstances, and in what combinations with other factors. In other words, we know very little about the effects of stops, stations, and transfer facilities on transit ridership and network performance. This state of knowledge based on past studies of the subject is incomplete because it fails to guide transit agencies toward planning practices that effectively improve the quality of transfers at transit centers that actually result in a ridership increase.

In our research on transit stops, stations, and transfer facilities we have addressed these shortcomings by developing a theoretical framework for understanding the relationship between transfer-facility attributes and travel behavior, which we discuss below.

3.0 Transfer Penalties/Travel Behavior Conceptual Framework

The concept of the transfer penalty represents generalized costs — including monetary costs, time, labor, discomfort, inconvenience, etc. — involved in transferring from one vehicle to another, between the same mode, or different transportation modes (e.g. bus to train, walk to bus, etc.). We use the term transfer penalties in two ways. Viewed broadly, transfer penalties are used to represent all of the monetary, time, and labor expenditures involved in waiting and walking, experiencing discomfort, worrying about safety, and any other inconvenience and emotional stress involved in waiting and transferring, and thus can generally be viewed as an impedance to travel.

Viewed more narrowly, transfer penalties are the impedance in transferring, excluding easily quantified factors, such as waiting time, walking time, and transfer fares. In other words, a narrow definition of transfer penalties considers costs beyond the monetary and time costs associated with transferring.

For the more easily quantified transfer penalties, such as walking and waiting times, there are differences between actual and perceived values for these times. People perceive time differently depending on the circumstances. While actual waiting time is the difference between a passenger's and his/her vehicle's arrival at a boarding location, perceived waiting time can be considerably longer depending on waiting conditions such as vehicle arrival time uncertainty, comfort, security, and safety. Thus the generalized cost of waiting can greatly increase beyond the cost of actual waiting time.

Traveler's perceived walking distance and time can also be substantially greater than their actual walking distance and time. Physical conditions and adequate information are both important in determining both actual and perceived walking distance and time. The shortest walking time is determined by the most direct path and a traveler's walking speed. When a traveler is familiar with a stop location or transfer facility, walking paths can be direct and walking times minimized. However, unfamiliar stops or facilities and/or poor information lead to wandering, stress, and uncertainty about how and where to make the connection. Thus, the location, layout, and information at transfer stops and stations can significantly influence the perceived transfer experience as well as actual walking distance/time and waiting time, and both affect the likelihood of using transit in the future.

Differences in actual and perceived travel, waiting, and transfer times can be viewed as different valuations of time for different activities, and such different valuations of time for different trip attributes are weighted differently. In choosing a travel mode, travelers make decisions based on their perceived total generalized cost of taking a trip by various modes, which can depend substantially on their perceptions of travel (including transfer) attributes, such as time, labor, comfort, and safety.

The perceived burdens of waiting time, walking time, and transferring suggests the following three broad categories of factors contribute to transfer penalties:

A common rule of thumb is that walking and waiting time are considered by transit users to be two to three times as onerous as in-vehicle travel time.

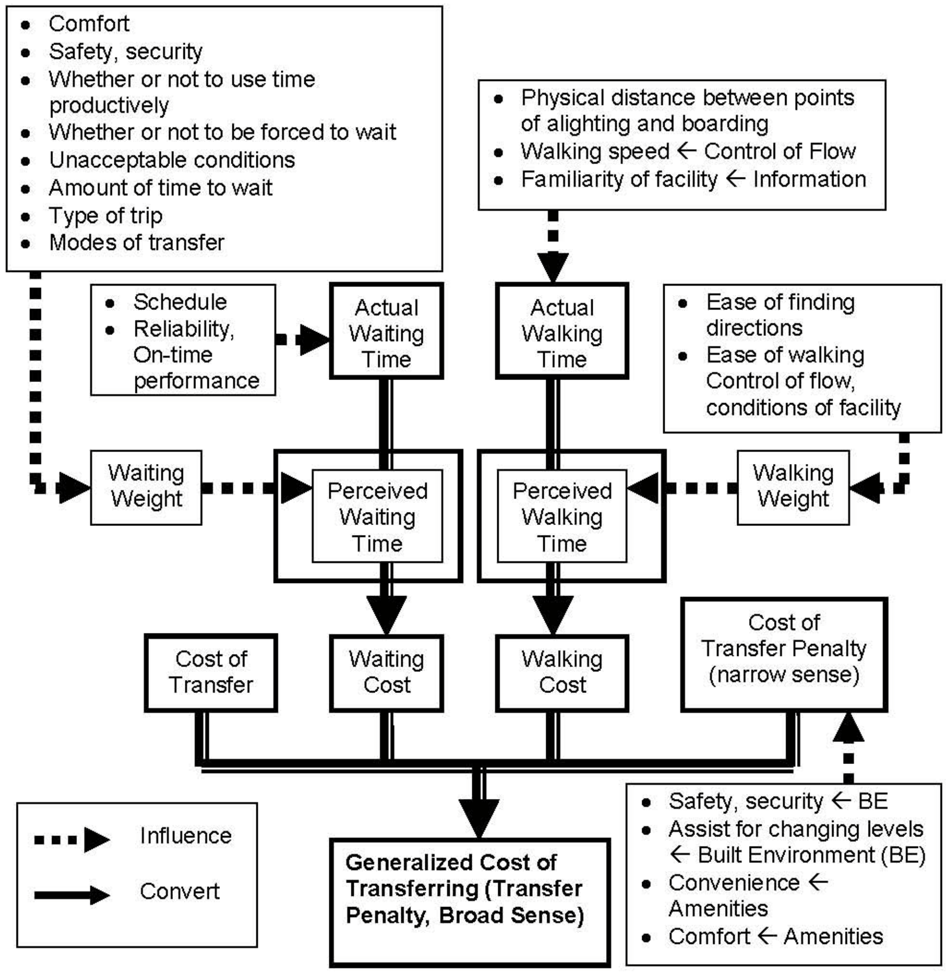
- Operational factors, such as headways, reliability, on-time performance of service and availability of adequate information.
- Physical environmental factors at facilities related to safety, security, comfort, and convenience
- Passenger options, such as whether they are forced to wait or whether they can be productive while waiting.

Given this, transit managers can take various measures to lower the burden (or generalized cost) of waiting, walking, and transferring by addressing both actual and perceived waiting time, perceived walking time, transfer burdens, and fares paid. Figure 4 presents our conceptual framework for determining the generalized cost of transferring in the overall context of transit travel. Perceived waiting and walking time are determined by actual time plus the weights that travelers assign to waiting and walking, which vary by the attributes, conditions, and environments of stops, stations, and transfer facilities.

We group the factors listed above into four groups:

1. The monetary cost of a transfer (fare);
2. Factors that affect the actual transfer time and distance;
3. Factors that influence people's perception of waiting and walking (e.g. the weights users assign to waiting and walking), and
4. Other factors that affect perceptions of transferring that are not taken into account by the first three groups.

The matrix at the bottom of Figure 4 notes which aspects of three factors – transfer fare, time schedule and operation, and transfer facilities – affect four aspects of traveler impedance: (1) monetary cost, (2) actual travel time and distance, (3) perceived travel time and distance, and (4) other penalties. This is discussed further below.



Factors affecting:	Monetary	Actual		Perceived		Other penalties
		Time	Distance	Waiting	Walking	
Transfer fare	O					
Time schedule						
Vehicle scheduling		O				
Reliability/On-time		O		O		
Real-time schedule		O		O		
Transfer Facilities						
1) Access			O		O	
2) Connection and reliability		O		O		
3) Information			O	O	O	O
4) Amenities				O	O	O
5) Security and Safety				O	O	O

FIGURE 4 Conceptual Wait/Walk/Transfer Impedance Framework for Public Transit

Transfer fares
In the context of the total costs of a transit trip, the penalty of a transfer fare is typically relatively small. It is often free or quite low for most intra-urban transit services, For short trips, however, transfer fares can be relatively large on a per-mile-traveled basis, and may disproportionally affect the burden of short trips with transfers.

Schedule and operation
Service frequency, schedule adherence, and schedule information (both posted and real time) affect both actual and perceived waiting time. Obviously, increasing service frequency reduces average waiting and transferring times. Poor coordination between lines, modes, and systems, and lack of schedule adherence can significantly increase transfer wait times; not surprisingly, improved coordination has been shown to increase transfer rates.

As noted above, frequent service can substantially (and nonlinearly) reduce the perceived burden of waiting. And frequent, reliable service has been shown to substantially reduce transfer burdens because travelers can count on short average wait times and can reliably time their arrival at stops and stations to minimize waiting.

Transfer facilities
Physical attributes of transfer facilities likely affect walking time and effort, waiting time and effort, convenience, comfort, safety, and indeed many other components of transfer burdens. In general, "passenger friendly" and "user friendly" transfer facility attributes can be grouped into the following five categories:

1. Facility design can affect access by defining the distance between alighting and boarding locations, improving off-vehicle passenger flow, and providing clear and comprehensible directions. Perimeter-oriented bus depots, for example, have been shown to increase transfer walk distances and inhibit pedestrian flows. Further, confusing or incomplete signage, or poorly located ticket machines and information kiosks can significantly increase both the actual and perceived distances walked in stations and transfer facilities.
2. Connection and reliability are determined by time schedules and schedule adherence, and have been repeatedly shown to strongly influence transfer burdens and transit use.
3. Complete, concise, and easy-to-understand information has been shown to reduce the actual (by reducing wandering) and perceived burden of transferring, especially for new or occasional transit users.
4. Amenities, such as benches, shades, water fountains, and rest rooms, affect comfort and convenience while passengers are waiting and transferring. Through increased comfort and convenience, these amenities can affect perception of waiting and walking time as well as other burdens of transferring.
5. Security and safety also influence perception of waiting, walking, and transfer burdens. Safety and security can be a "deal breaker" for travelers if levels of perceived risk exceed thresholds over which they will no longer consider traveling by transit, and will instead travel by other modes or forgo the trip entirely.

Even though the passenger perspective regarding transit connectivity is of utmost importance, we have found many references in the literature to transit connectivity from the transit operator and the neighboring community's perspective. Looking at these three aspects has provided us with a complete picture of assessing transit connectivity. We begin to explore these additional perspectives together with continuing our in depth examination of the passenger perspective in the next section.

4.0 Three Perspectives on Transit Stops and Stations – Users, Managers, and Neighbors

In assessing how effectively stops, stations, and transfer facilities operate, we identified three primary stakeholder groups from whose perspectives such evaluations have been performed. These are:

- Passengers/users
- Transit Operators
- Neighboring Communities/Businesses & Residents

Passengers/Users

Passengers/users are the clients who use stops, stations, and transit transfer facilities and who have specific desires and expectations for such facilities. Previous travel behavior research suggests that transit users' principal concerns are with quickly and easily boarding their desired vehicle. Toward that end, users desire:

- Minimum transfer time and distance,
- Convenience,
- Comfort, and
- Safety and security.

Which of these is most important under what circumstances, however, is less well known. However, when transfer facilities are designed and/or renovated to make transferring more safe and secure, pleasant, faster, and less problematic, people accept facilities more favorably and are more likely to accept the necessity of transferring in their transit trips.

Transit Operators

When a transit operator owns the property under which a stop or transfer facility sits, it can largely control the design and operation of the stop or facility. In most cases, however, transit operators do not own the land under their stops and stations and must therefore work and negotiate with a wide variety of public and private stakeholders.

Neighboring Communities/Businesses & Residents

Any transit stop or transfer facility ─ whether it is located in an urban or suburban environment, or whether it hosts intra-modal or intermodal transfers ─ does not exist in a vacuum. It and its users necessarily interact with adjacent neighborhoods and districts. As such, the people who live and/or work near the stop or facility, and the people who own and operate commercial establishments in the vicinity of the stop or facility have a stake in the facility that may be largely unrelated to its utility to transit users. These include:

- Community image and pride ─ architectural, cultural, and historic preservation

- Joint development and partnerships
- Safety and security
- Environmental impacts on surrounding neighborhood
- Neighborhood economy / local employment
- Physical and social impacts on neighboring land uses

Accordingly, the research described below sought explicitly to examine perceptions of transit stops and transfer facilities from the differing perspectives of these three groups. And it is to this research we now turn.

5.0 Methods of Investigation

In our investigation of each of the three stakeholder perspectives, we employed a variety of research methods:

Passengers/Users

We designed and administered a user survey based on the five principal transit stop and station attribute categories thought in the literature to affect transfer penalties:

- Access: Management of passenger flow control and directional information
- Connection and Reliability: Distance and time to make connections; on-time performance/frequency of bus/train
- Information: What, where, and how passengers acquire information
- Amenities: Comfort, service, weather protection, and cleanliness of station/stop
- Security and Safety: Station/stop equipment, infrastructure, or personnel that provide passengers with a safe and secure environment

Our objective was to provide an accurate portrait of transit riders at the system-wide level, by service-type, by time of day and day of week, and by location. This portrait included the following information:

◦ Demographic characteristics of riders at every transit transfer facility in terms of:
  - Age
  - Gender
  - Income
  - Ethnicity
  - Car availability
  - Modal preference

◦ Trip characteristics, including
  - Trip purpose
  - Pre- and post-trip mode
  - Transfer rate
  - Time of day and day of week
  - Service type;

◦ Frequency of use, and

◦ Evaluation of transit services and amenities

For each of the five attribute categories, the research team crafted a series of specific questions. The resulting survey, which was made available in English and Spanish, consisted of 29 questions and was self-administered to 749 transit users at 12 transit stops and stations around metropolitan Los Angeles. In total we approached 1,023 transit users and 274 of them refused to participate in the survey yielding a 73% response rate. Moreover, the 749 surveys were not entirely completed as some users had to stop providing responses to catch their bus or train. The survey was designed to assess the importance of and satisfaction with various aspects of transit stops, stations, and transfer facilities from the transit rider's perspective. The dozen transit stop and transfer sites were selected to secure the widest possible variation in the following:

- Transfer facility types (See Table 1)
- Available modes (bus, rail)
- Type of passenger loading (on- or off-street)
- Time of day
- Weather

A significant component of the survey was soliciting respondents' views on their satisfaction with, and level of importance of, various stop/station attributes (listed in Table 2). A copy of the User Survey Instrument may be found in Appendix C of this report, which consists of a copy of our interim deliverable documenting our evaluation of transit stops and stations from the perspective of transit users.

Transit Operators

We designed a transit system manager survey to collect the following information from respondents:

- Operators' estimation of how important various evaluation factors are to their own passengers
- Operators' views of what evaluation factors are important from their own perspective

The survey was administered by means of a web-based online nationwide survey of transit managers. The survey instrument (which is available in Appendix C) was designed to both mirror many of the questions in our user survey, and to ask about political and operational concerns not directly related to passenger use of stops or stations. From the Federal Transit Administration's 2005 National Transit Database we selected all 400 transit operators with at least one fixed-route/fixed-schedule transit line in service in the United States. We sent the general manager of each an electronic invitation to either respond to our survey or to designate a member of his/her staff to do so. We received a total of 175 completed responses, for a 43% response rate.

Neighboring Communities/Businesses & Residents

Finally, we developed a set of questions that were used during telephone interviews with a representative sample of transit operators in the United States in order to gain further insight into the transit operators' perspective, as well as to gather illustrative anecdotes about transit stops and stations. Twenty agencies were selected by a weighted sampling methodology, with the probability of inclusion in our sample weighted by the agency's annual ridership figures. Of these, 8 agencies participated, for an effective response rate of 40%. During these interviews, we also gathered data on the role of stop and station neighbors – both private and commercial – in shaping the design, location, and operation of transit stops and stations. These interviews focused in particular on community advocacy for and against the location, re-location, and/or expansion of transit stops and stations. Due to budget limitations, however, we did not survey or interview stop- or station-adjacent stakeholders directly.

TABLE 2 Survey Questions on User Importance and Satisfaction

Stop/Station Attributes	Criteria Category
This station/stop area is clean	Amenities
There are enough places to sit	Amenities
There are places for me to buy food or drinks nearby	Amenities
There is a public restroom nearby	Amenities
There is a shelter here to protect me from the sun or rain	Amenities
The signs here are helpful	Information
It is easy to get schedule and route information at this stop/station	Information
It is easy to find my stop or platform	Access
It is easy to get around this stop/station	Access
I usually have a short wait to catch my bus/train	Connection and Reliability
My bus/train is usually on time	Connection and Reliability
I feel safe here during the day	Safety and Security
I feel safe here at night	Safety and Security
There is a way for me to get help in an emergency	Safety and Security
This stop/station is well lit at night	Safety and Security
Having security guards here makes me feel safer	Safety and Security

6.0 Primary Findings

From our analysis of the passengers/users perspective, one principal finding stands out quite clearly:

> ***The most important determinant of user satisfaction with a transit stop or station is frequent, reliable service in an environment of personal safety, and only indirectly the physical characteristics of that stop or station.***

In other words, most transit users would prefer short, predictable waits for buses and trains in a safe, if simple or even dreary, environment, over long waits for late-running vehicles. This is true even if such long waits occur in the most elaborate and attractive transit stations and especially so if users fear for their safety. While this finding will come as no surprise to those familiar with past research on the perceptions of transit users, it does present a contrast to much of the descriptive and design-focused research on transit stops and stations.

In total, we examined sixteen stop and station attributes (listed in Table 2), using a technique known as the *Importance-Satisfaction Analysis* method, which seeks to identify those attributes passengers find most important (importance level) and those attributes in need of the most improvement (satisfaction level). Respondents' level of satisfaction with each attribute under current conditions at the 12 survey sites in the Los Angeles metropolitan area indicates that users are least happy with factors related to access, followed by some factors related to security and safety and connection and reliability. When we considered the level of satisfaction and importance ratings in tandem, factors that require improvement pertain most to security and safety and connection and reliability, and least to amenities. Of the sixteen attributes, users ranked safety and service quality factors as most important (the top six of the sixteen attributes) as shown in the following list:

Most Important

1. I feel safe here at night (78%)
2. I feel safe here during the day (77%)
3. My bus/train is usually on time (76%)
4. There is a way for me to get help in an emergency (74%)
5. This stop/station is well lit at night (73%)
6. I usually have a short wait to catch my bus/train (70%)

In contrast, stop and station-area amenities were ranked as least important by users:

Least Important

11. It is easy to get route and schedule information at this stop/station (62%)
12. There is a public restroom nearby (59%)
13. This stop/station is clean (58%)
14. It is easy to get around this stop/station (57%)
15. There are enough places to sit (50%)
16. There are places for me to buy food or drinks nearby (34%).

However, when we statistically related users' satisfaction with various stop/station attributes with their overall satisfaction with their wait/transfer experiences, we got similar, though not identical, results:

Most Important

1. It is easy to get around this stop/station.
2. I feel safe here during the day.
3. Having security guards here makes me feel safer.
4. it's easy to find my stop or platform.
5. The stop/station is well lit at night.
6. My bus/train is usually on time.

In contrast, the following stop and station-area attributes were ranked as least important (bottom six of the sixteen attributes):

Least Important

11. This stop/station is clean.
12. There is shelter here to protect me from the sun or rain.
13. There is a way for me to get help in an emergency.
14. There are enough places to sit.
15. There are places to buy food or drinks nearby.
16. There is a public restroom nearby.

Informative, rank-ordered lists like these can be problematic if users "split their votes" among similar, yet important factors, such as "I feel safe here at night" and "This stop/station is well-lit at night." To correct for this problem, we employed an ordered-logit regression model to measure the independent influence of each of 16 wait/transfer attributes on overall user satisfaction. This analysis tends to eliminate all but one of closely related factors, while elevating presumably less-important factors that independently influence users' overall levels of satisfaction. The results of this modeling exercise are telling:

Most Important

1. My bus/train is usually on time.
2. Having a security guard here makes me feel safer.
3. This stop/station is well lit at night.
4. I feel safe here during the day.
5. It is easy to get around this station/stop.
6. The signs here are helpful.

Of the 16 stop and station attributes that we evaluated, transit users assigned the highest importance to factors related to security and safety, and then to factors related to connection and reliability. In contrast, stop and station-area amenities were ranked as least important by users. We do not claim that amenities are not important to travelers; more than half ranked information, the presence of public restrooms, cleanliness, and ease of navigation as important attributes. However, travelers definitely prefer safe, frequent, and reliable service over these other factors.

Based on this analysis we have identified a simple hierarchy of transfer burdens perceived by users, shown in Figure 5. This figure summarizes the findings from our transit user investigation succinctly.

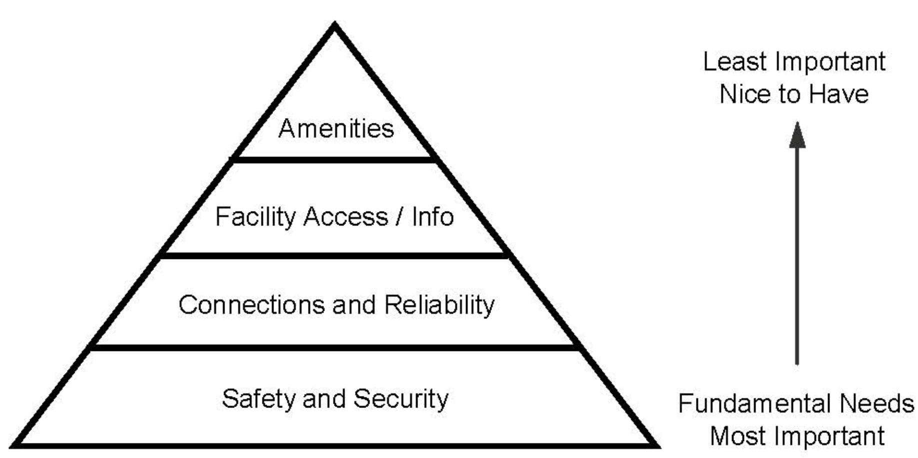


Figure 5 Hierarchy of Traveler Wait/Transfer Needs

In addition to surveying transit users, we conducted an nationwide online survey of transit operators, asking them about their objectives at transit stops, as well as about their perceptions of users' and neighboring communities' priorities for stops and stations. From our analysis of the survey results, we find that transit operators' top priority is precisely the same as that of the users of their systems:

> ***Safety and security related factors far outweighed other attribute factors at transit stops, stations, and transfer facilities.***

Following safety and security (#1), ten other factors cluster relatively closely as important factors in the views of the transit managers surveyed. We list them in order of priority:

2. Pedestrian/vehicle conflicts
3. Schedule coordination
4. Operating costs
5. Stop/station equipment reliability
6. Comfortable environment
7. Adequate stop/station space
8. Inter-agency coordination
9. Facilitate passenger flows
10. Accommodate vehicle movements
11. Protect passengers from weather.

The survey results further suggest that transit operators value user-oriented attributes such as physical comfort and seamless transferring higher than other, non-user oriented, attributes. This may be due to the immediacy and constancy of user-related factors such as the provision of clean and comfortable transfer stops and stations, while non-user attributes such as joint development typically occurs infrequently.

Our online survey results show that, while transit operators appear to have a fairly accurate understanding of what attributes are important to their riders at transit stops and transfer stations, there are several points of disparity. While operators correctly assumed that safety and security were very important to riders, they tended to underestimate the importance of specific safety-related amenities, such as the presence of security guards and emergency assistance. It also appears that, controlling for other factors, operators overestimate the importance of station cleanliness and schedule information to their riders. We note, however, that there was a mismatch in geographical coverage for this comparison; our riders' survey collected data from Los Angeles County transit riders, while our operators' survey collected data nationwide. It is likely that this mismatch has overemphasized some disparities, while downplaying others. These findings should be considered preliminary and further research should examine both subgroups that cover the same general location. Next steps and follow-on research are discussed in a later section of this report.

Our telephone interviews served to highlight these findings. Interviewees relayed to us many anecdotes in which safety and security concerns "trumped" all other concerns. For example, comfort concerns (ample and comfortable seating) often defer to security concerns (benches that are not conducive to sleeping). Another telephone interviewee told us of a station redesign that resulted in a safer environment for pedestrians, but which was far less aesthetically pleasing. Yet another interviewee from a city with a "very high murder rate" told us that city police are present at station design meetings, and that personal safety and security concerns always outweigh aesthetic, design, and passenger comfort concerns. Less obvious and more nuanced tradeoffs are made throughout the set of objectives; our ranking describes the propensity of transit operators to value one attribute more highly than others, and assigns estimates of the magnitude of these propensities.

Additionally, we talked to transit operators about the role of the community in planning, operating, and maintaining transit stops and transfer facilities. We heard from many respondents that the community often serves as opposition, and that its input usually comes indirectly through politicians and community leaders. Furthermore, we heard that community concerns are typically voiced in response to planned changes, rather than during initial planning stages.

We also determined that other stakeholders (specifically local government entities) control the design and location of most transit stops and stations. We also found that adjacent businesses and residents exert significant influence over the location, design, and operation of stops and stations. Often, transit agencies have surprisingly limited control over the siting and design of stations and stops.

7.0 Preliminary Assessment Tool: Putting Research into Practice

Based on the findings reported above we have developed a 3-step process (synthesized in Figures 6 & 7) that transit operators can employ as a tool to guide them as they consider making improvements to already existing transfer facilities or developing initial plans for new facilities.

Step 1: Use the Hierarchy of Traveler Wait/Transfer Needs (Figure 5 above) to determine the priority of improvements to any stop or station. We endeavored in this research to produce generalizable findings from our analysis by surveying a large number of transit users at a wide variety of facilities.2

Step 2: For transit stops and stations serving particular user populations (children, immigrants, the elderly, etc.) or for stops/stations in unique environments (adjacent to airports, amusement parks, hospitals, etc.), the user perception survey instrument developed and tested in this study can be used to survey the perceptions of passengers.

Step 3: Use the survey results to conduct an Importance-Satisfaction (I-S) Analysis (documented in detail in Appendix C) to produce an I-S Ratings matrix showing Average Importance and Satisfaction ratings for the users and/or stops surveyed as shown schematically in Figure 6 below.

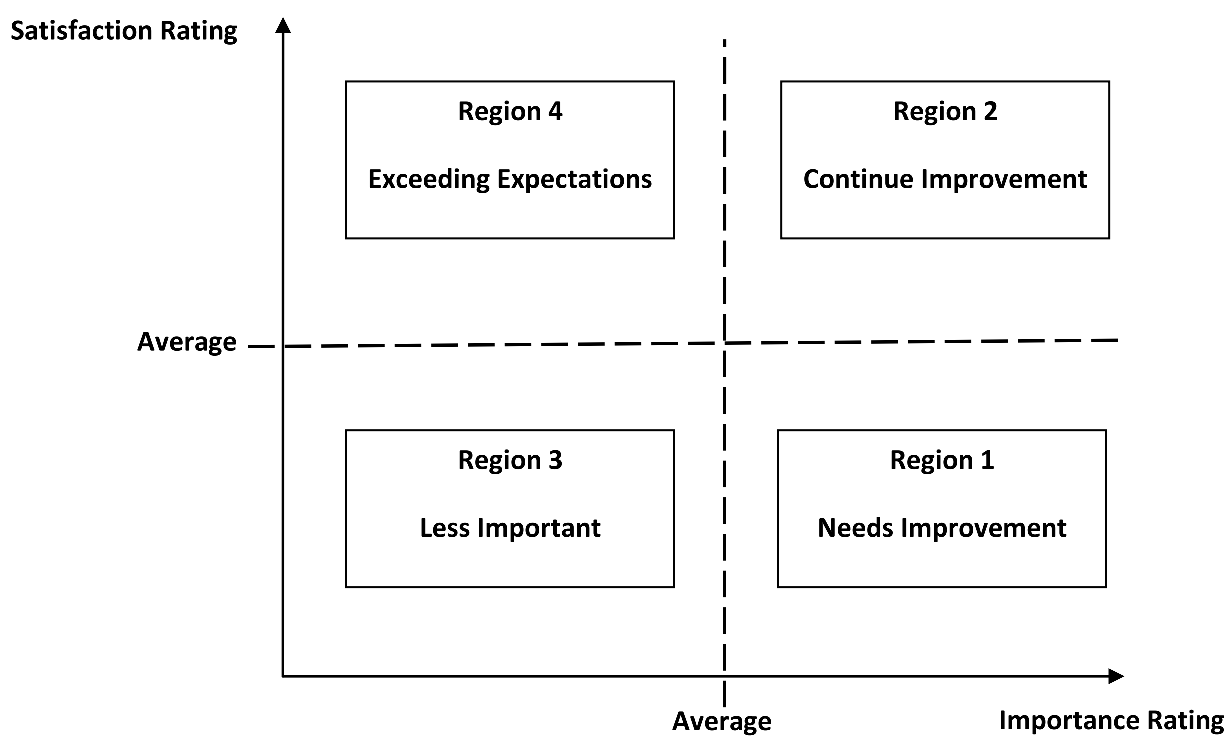


FIGURE 6 *I-S* Ratings Graph Template

- **Region 1** is an area where – for the surveyed users or stops – facility attributes have above-average importance but a less than average level of satisfaction, meaning that **these attributes should be high priorities for improvement**.
- **Region 2** is an area where attributes have above-average importance and above-average level of satisfaction, meaning that **priority should be given to maintaining the quality of these attributes**.
- **Region 3** is an area where attributes have less than average satisfaction levels but also less than average importance ratings; improvement to such attributes are **warranted only at low cost or if all of the attributes in Regions 1 and 2 have been fully addressed**.
- **Region 4** is an area where attributes have above average levels of satisfaction and importance ratings less than average; **such attributes exceed expectations and warrant no further attention**.

We suggest that transit operators employ this 3-step process in successive stages using the flow chart below (Figure 7). This chart guides users in identifying the order – consistent with our research findings – in which to improve a targeted transit stop or station. We have thus structured the flow chart so users' priorities in the Hierarchy of Traveler Wait/Transfer Needs (Figure 3 above) are addressed in order of importance: first with Safety and Security attributes, second with Connections and Reliability attributes, third with Access and Information attributes, and lastly with Amenities-related attributes.

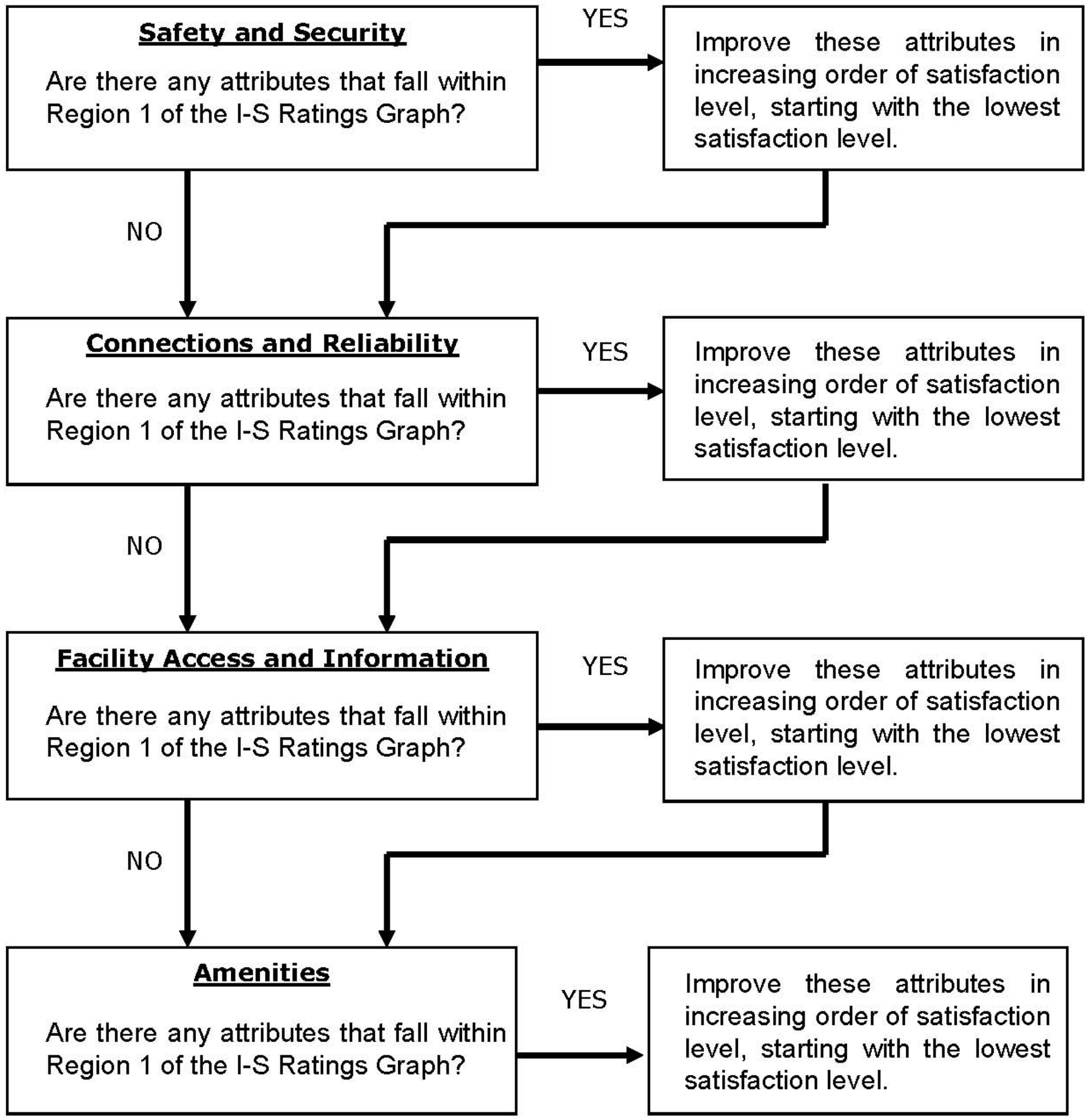


Figure 7 Stop/Station Evaluation Flow Chart

8.0 Next Steps / Future Research

The major milestone of this project was the development of a conceptual behavioral framework of the passenger's wait/transfer experience based on our review of the state-of-the-research of travel behavior. We used this framework to capture both transit user and manager perceptions of transfer burdens, which allowed us to advance considerably the body of research on transit stops and stations that to-date has been largely descriptive.

The findings of our research, together with the development of our preliminary assessment tool, have taken substantive steps toward:

- Determining the connectivity of transit systems and how this connectivity (as well as other service attributes) influences travelers' satisfaction with transit services, and
- Examining how public transit systems can reduce the burdens of out-of-vehicle "travel" times in order to help make public transit more attractive resulting in ridership increases.

There are, however, limitations to our research conducted to date. In this project, we surveyed over 700 transit users to determine the factors affecting their perceptions of waiting, walking, and transferring during a trip. Within each category of attributes, the users' satisfaction level was correlated with data from a detailed inventory of 12 stops and transfer facilities in Los Angeles County to identify significant linkage between users' perceptions of transit services and the built environment at stops, stations, and transfer facilities. While we secured a large number of surveys of users' perceptions, the fact that these were collected at just a dozen, locations – though diverse for Los Angeles County – did not give us sufficient variability in the facilities data inventories to statistically link the physical and operational characteristics of transit stops and stations with users' perceptions of them. In other words, we were unable to evaluate the relative importance of facility attributes in directly determining users' overall satisfaction levels.

Nonetheless, our evaluation framework has provided us with a strong theoretical foundation to expand our study of transit users and facilities beyond Los Angeles County. Accordingly, we are working with Caltrans to develop a follow-on scope of work to the research reported here, specifically, to:

- Evaluate user perceptions across a wider cross-section of users and a much wider array of transit systems;
- Expand our stop/station Assessment Tool to apply to a broader range of transit user populations and operating environments;
- Embark on a field implementation phase; and
- Expand our stakeholder analysis to include the perceptions and motivations of local governments that control the location of development of most transit stops and stations.

We aim in our next phase of this research to expand our inventory of stops and stations from 12 to 50 across California, with a goal of surveying approximately 2,000 users. This expanded approach will help make the findings of this effort considerably more generalizable to cities and transit operators in large and small cities around California. Moreover, by field testing the findings of our Phase I and II work at specific transit stops and stations, we can conduct before and after testing to determine if, indeed, this research can help transit operators attract more riders by cost-effectively addressing the specific aspects of waiting for and transferring among transit vehicles that transit users find most burdensome.

9.0 About the Authors

Brian D. Taylor, University of California, Los Angeles
Brian Taylor is a Professor of Urban Planning, and Director of the Institute of Transportation Studies at UCLA. His research centers on both transportation finance and travel demographics. He has examined the politics of transportation finance, including the influence of finance on the development of metropolitan freeway systems and the effect of public transit subsidy programs on both system performance and social equity. His research on the demographics of travel behavior has emphasized access-deprived populations, including women, racial-ethnic minorities, the disabled, and the poor. His work in this area has also explored the relationships between transportation and urban form, with a focus on commuting and employment access for low-wage workers. Professor Taylor teaches courses in transportation policy and planning and research design. Prior to coming to UCLA in 1994, he was an Assistant Professor in the Department of City and Regional Planning at the University of North Carolina at Chapel Hill, and before that a Transportation Analyst with the Metropolitan Transportation Commission in Oakland, California.

Hiroyuki Iseki, University of Toledo
Hiroyuki (Hiro) Iseki is an Assistant Professor in the Department of Geography and Planning at the University of Toledo. He received his Ph.D. in Urban Planning at UCLA. He specializes in transportation, land use, environmental planning and policy analysis, and the application of quantitative analysis methods (econometrics and GIS) to planning. His work focuses on balancing efficiency, effectiveness, and equity in urban planning and policy. He has published extensively on transit planning, management, and finance, and is an active member of the Committee on Public Transportation Planning and Development of the Transportation Research Board. His recent research projects have examined subjects such as: 1) privatization of public transit service, 2) a policy framework design for an interoperable transit smart card system, 3) an evaluation of the effects of transit transfers on travel behavior, and 4) a public-private partnership as a new strategy for highway financing.

Mark A. Miller, University of California, Berkeley and Los Angeles
Mark Miller is a Research Specialist at the California PATH (Partners for Advanced Transit and Highways) Program at the University of California, Berkeley where he has worked for eighteen years. During this time his research has focused on developing evaluation frameworks and methodologies and performing impact assessments of intelligent transportation systems (ITS) technologies in the setting of field tests and case studies. His work experience has been well balanced between quantitative and qualitative investigations covering both technical and non-technical (deployment, societal, and institutional issues) aspects of ITS. Mr. Miller has significant work experience in the areas of transit operations research and policy and behavioral research, including bus rapid transit, and commercial vehicle operations.

Since 2003, Mr. Miller has also been a Visiting Scholar at the Institute of Transportation Studies (ITS) within the School of Public Affairs at the University of California, Los Angeles. Since arriving at UCLA, Mr. Miller has worked to expand PATH's visibility and presence in southern California and to forge and strengthen ties between the Los Angeles and Berkeley campuses of the Institute of Transportation Studies, worked closely with graduate students on PATH projects, and given lectures on Intelligent Transportation Systems.

Michael Smart, University of California, Los Angeles
Michael Smart is a second-year doctoral student at UCLA. His research interests include transportation and social equity, access to the labor market, and travel behavior. He has recently completed an analysis of the SAFETEA-LU earmarking process and is currently working on a detailed look at carpooling among immigrant communities. He graduated with a Master's degree in City Planning from the University of Pennsylvania in Philadelphia and has previously worked with Professor Myron Orfield at the University of Minnesota Law School's Institute on Race and Poverty.

10.0 Bibliography of Project Documentation

Interim Project Deliverables

1. Iseki, H., B.D. Taylor, and M.A. Miller, *The Effects of Out-of-Vehicle Time on Travel Behavior: Implications for Transit Transfers*, January 2006.

2. Iseki, H., M. A. Miller, A. Ringler, M. Smart, and B.D. Taylor, *Evaluating Connectivity Performance at Transit Transfer Facilities*, February 2007.

3. Iseki, H., A. Ringler, B.D. Taylor, M.A. Miller, and M. Smart, *Evaluating Transit Stops and Stations from the Perspective of Transit Users*, August 2007.

4. Smart, M., M. A. Miller, and B. D. Taylor, *Evaluating Transit Stops and Stations from the Perspective of Transit Managers (Draft)*, September 2007.

Conference Compendiums & Proceedings and Journal Articles

1. Iseki, H. and B. D. Taylor, “Not All Transfers Are Created Equal: Toward a Framework Relating Transfer Connectivity to Travel Behavior”, 86th Annual Meeting of the Transportation Research Board CD-ROM Compendium of Papers, Transportation Research Board, Washington D.C., January 2007.

2. Taylor, B.D., H. Iseki, A. Ringler, M. J. Smart, and M. A. Miller, “Hate to Wait: Relating the Wait/Transfer Experience to Perceived Burdens of Transit Travel”, Accepted for Presentation and Publication at 48th Annual Conference of the Association of Collegiate Schools of Planning, Milwaukee, Wisconsin, October 2007.

3. Iseki, H. and B. D. Taylor, “Style versus Service”, Submitted for Presentation and Publication to 87th Annual Meeting of the Transportation Research Board, Transportation Research Board, Washington D.C., January 2008.

4. Smart, M., M. A. Miller, and B. D. Taylor, “Transit Stops, Stations, and Transfer Facilities: Evaluating Performance from the Perspective of Transit System Managers”, Submitted for Presentation and Publication to 87th Annual Meeting of the Transportation Research Board, Transportation Research Board, Washington D.C., January 2008.

11.0 Appendices of Interim Deliverables

Appendix A

The Effects of Out-of-Vehicle Time on Travel Behavior: Implications for Transit Transfers

Appendix B

Evaluating Connectivity Performance at Transit Transfer Facilities

Appendix C

Evaluating Transit Stops and Stations from the Perspective of Transit Users

Appendix D

Evaluating Transit Stops and Stations from the Perspective of Transit Managers

APPENDIX A

Appendix A

The Effects of Out-of-Vehicle Time on Travel Behavior: Implications for Transit Transfers (Deliverable #1)

Under Contract 65A0194 for Project
Tool Development to Evaluate the Performance of
Intermodal Connectivity (EPIC) to Improve Public Transportation

Submitted to:

Bruce Chapman
California Department of Transportation
Division of Research and Innovation
1227 'O' Street, 5th Floor
Sacramento, CA 94273-0001

Prepared by:

Hiroyuki Iseki,[1] Brian D. Taylor[1], and Mark Miller[1,2]

[1]Institute of Transportation Studies
University of California, Los Angeles
School of Public Affairs
3250 Public Policy Building, Box 951656
Los Angeles, CA 90095-1656

[2]California PATH Program
Institute of Transportation Studies
University of California, Berkeley
Richmond Field Station, Bldg. 452
1357 S. 46th Street
Richmond, CA 94804

January 18, 2006

EXECUTIVE SUMMARY

This report constitutes an interim deliverable for the Project "Tool Development to Evaluate the Performance of Intermodal Connectivity (EPIC) to Improve Public Transportation" under Contract 65A0194 with Caltrans. Our primary objective in this project is to develop an evaluation tool that transit agencies can use to assess the quality of service at transit transfer facilities and use the findings of such evaluations to improve travel connectivity. Such improvements, can, in turn, help the overall transportation system operate more smoothly and can make transit a more attractive travel option and thus can eventually contribute to increases in ridership. This report focuses on a review of the literature in the area transit transfer facilities with particular emphasis on studies of the perceived burdens of transferring by passengers and their travel behavior as this is potentially a rich source of information to be used as input in the design of the evaluation tool.

Many factors affect travel choices, including time, labor, cost, security, convenience, and comfort of the entire trip. As such, privately-owned automobiles have many advantages over traditional fixed-route public transit in providing higher levels of accessibility, flexibility, convenience, comfort, and safety against crime. The relative burdens of public transit service vis-à-vis private automobiles help to explain why the majority of personal travel in metropolitan areas is in private vehicles, which poses a daunting challenge to transit managers. Given that travelers tend to consider out-of-vehicle travel time (walking, waiting, transferring, etc.) to be substantially more burdensome than in-vehicle travel time, attracting travelers to public transit in significant numbers requires transit agencies to focus increasingly on improving transit users' experience *outside* of their vehicles – walking, waiting, and transferring.

As cities have grown more dispersed and auto-oriented, the relative burdens of out-of-vehicle transit travel have increased. In an effort to accommodate increasingly dispersed patterns of trip-making, transit systems in many U.S. metropolitan areas have adapted "hub-and-spoke" route systems, which require transit users to frequently make transfers among lines and systems. In larger metropolitan areas with many transit operators, where the number of transferring passengers can be very high, transfer centers to facilitate passenger transfers are central parts of transit networks. Given the importance of out-of-vehicle times on travel choices, intermodal connectivity at such transfer facilities is a critical part of overall transportation network effectiveness. Transfer facilities that integrate various transportation modes in one location encourage people to use transit service by reducing the burdens of transfers.

What aspects of walking, waiting, and transferring do travelers find to be more burdensome, and what can transit managers do to cost-effectively increase the attractiveness of transit travel? This report examines this question by carefully reviewing the literature on the perceived burdens of transit travel.

We find that, despite its importance, efforts to increase connectivity at transfer facilities have proven less effective than expected for the following reasons: 1) not enough attention has been given to the effects of out-of vehicle travel on ridership; 2) it is difficult to comprehensively analyze transfer facilities using uniform criteria due to a large variation in size, modes served, location, and amenities of transfer facilities; and 3) there is a lack of a framework to theorize the effects of transfer facility improvements on people's travel behavior and transit ridership. In particular, the lack of causal clarity in the research on transit transfer facilities is an enormous drawback. Most previous studies of transit stops, stations, and transfer facilities have compiled laundry lists of positive and negative attributes, but have largely failed to consider the relative importance of each of these attributes, or whether they influence ridership differently alone or in concert with other factors. As a result, we know little about which attributes are most important, under which circumstances, and in what combinations. Past studies on the subject have failed to lead transit agencies to implement planning practices that can effectively improve the quality of transfers at transit centers. Bridging this knowledge gap can lead to improvements of transfer facilities that will result in a ridership increase.

In this literature review, we identify the gaps in the current literature on factors influencing transit ridership, transfer penalties, and transfer facility improvements. We address the lack of a theoretical basis for understanding the relationship between transfer facility attributes and travel behavior and provide a brief review of determinants that affect transit ridership. This framework situates transfer penalties within the total cost of a transit trip. Finally, we examine the attributes of transfer facilities that influence transit transfers.

We situate the literature of travel behavior and valuation of time in the *transfer penalties* framework. Transfer penalties is a concept that represents *generalized cost*s—including monetary costs, time, labor, discomfort, inconvenience, etc.—involved in transferring from one vehicle to another between the same or different transportation modes, and is well-established theory in the travel behavior literature. When a traveler finds the total generalized cost of her/his trip by transit lowest among different means of transportation, she or he chooses to travel by transit. Value of time is another important concept in examining the relative importance of factors that influence people's travel behavior, particularly in mode choice. The *transfer penalties* framework provides the theoretical backbone for the importance of improvements pertinent to transit transfers.

According to previous studies on transfer facilities, we found that within a typical transit trip, a transfer accounts for approximately one quarter of total generalized costs (or time). The shorter the trip is, the more significant the impact of the transfer. Among several factors associated with a transit transfer, waiting time is generally the most important component to determine total generalized costs (and time) as long as safety and security are ensured. Time schedule and certainty of arrival time are two important factors to determine *actual* waiting time. In comparison to *actual* waiting time, *perceived* waiting time is very important in determining whether or not a traveler uses transit service. Perceived waiting time is affected by factors, such as safety, security, comfort, whether waiting is forced or not, and acquired knowledge about the arrival of the next vehicle.

In the examination of various attributes of transfer facilities that are thought to particularly influence transit transfers, we make a clear connection between improvements at transfer facilities and changes in people's travel behavior due to a reduction in transfer penalties. In other words, we distinguish two categories of improvements that are related to transit transfers: 1) those that affect *actual* time and costs of making a transfer, and 2) those that affect people's *perception* of transfer penalties. From this perspective, we identify the connection of transfer costs, time scheduling, and five evaluation criteria associated with transfer facility attributes that affect transfer penalties: 1) access, 2) connection and reliability, 3) information, 4) amenities, and 5) security and safety. The effectiveness of transit agencies' efforts to improve attributes of transfer facilities can be understood in terms of the effectiveness to improve travelers' experience at these facilities, reduce transfer penalties, influence travelers' behavior in mode choice, and eventually contribute to an increase in transit ridership.

We find that in order to improve the quality of transit transfers, transit agencies can work on the operational aspects that influence transfers (such as time schedule, on-time arrival, and transfer fare) and the physical aspects of transfer facilities (such as distance to make a transfer, lighting, seating, signage, streamlining, circulation lines, protections from weather, visibility). It is also an option for facility management to provide amenities at transfer facilities, such as commercial establishments including news stands, coffee shops, convenience stores, and dry cleaning stores. Physical aspects of transfer facilities can also affect walking time to travel between locations where people alight and board vehicles for transferring. Such aspects can also influence travelers' experiences at facilities, and therefore their perceptions of waiting time, walking time, and transfer penalties.

Because few studies have examined how the effects of physical improvements on transfer facilities affect travelers' choices to use transit service, it is important to investigate this issue in greater detail. At the same time, it is important to recognize that improvements of service operation are likely to have more significant impacts than physical improvements in facilities alone will have.

We conclude from this review that there are three ways to enhance the scope of study from our proposal: 1) as most transit transfers are intra-modal, these should be examined in addition to intermodal transfers, 2) operational and managerial attributes of transfer facilities should be examined in addition to the physical attributes of such facilities, and 3) steps need to be taken to begin to develop more systematic, quantitative tools for evaluating transit transfer facilities. Finally, it is important to examine the relative effectiveness of improvements on physical attributes of transfer facilities as well as service operation whenever possible.

Key words: transfer facilities, travel behavior, transfer penalties, generalized costs, value of time

LIST OF TABLES   PAGE

LIST OF FIGURES PAGE

TABLE OF CONTENTS

SECTION **PAGE**

PREFACE

While private automobiles provide door-to-door travel, public transit requires people to walk to bus stops and rail stations, wait for services, and often make transfers from one vehicle or mode to another. Good interconnectivity in the transit system is essential to reduce the burden of walking, waiting, and transferring and to provide a high quality of service for transit trips. However, the transit system in California lacks interconnectivity between transportation modes and often fails to efficiently serve the public that travel by public transit. To improve interconnectivity in the transportation system, it is important to develop a methodology to evaluate the quality of transferring in order to improve transfer facilities. Such improvements at transfer facilities lead to a provision of seamless travel for transit users.

The research project, *Tool Development to Evaluate the Performance of Intermodal Connectivity (EPIC) to Improve Public Transportation*, will assist the California Department of Transportation (Caltrans), regional and local transportation related entities, transit operators, and other stakeholders in evaluating interconnectivity issues pertaining to travel and in identifying opportunities and solutions for improving transportation systems. This project contributes to Caltrans' goals of *Flexibility* and *Productivity* by assisting it in providing the appropriate tools to contribute to a transportation system ─ with both intermodal and intra-modal components ─ that maximizes safety, security, reliability, mobility, and access.

The larger scope of our research addresses the following three questions: First, what factors at transfer facilities are important from the transit users' perspective relative to determining their travel behavior? Second, what factors at transfer facilities are important from the operators' perspective relative to improving efficiency in transit service operation? Third, what factors at transfer facilities are important from the neighboring community perspective that allow the community to benefit from the presence of and services provided by such facilities?

In this literature review, we address the first question and investigate factors at transfer facilities from the users' perspective in relation to their travel behavior. This is the first step to develop a tool to evaluate the performance of connectivity to improve public transportation. We found it essential to: 1) understand where to improve the quality of transfers positioned within a group of factors that affect transit ridership, 2) establish a conceptual framework to relate improvements at transfer facilities to people's travel behavior, and 3) identify a systematic classification of transfer facility attributes in relation to the developed conceptual framework. By understanding these factors, we will be able to identify improvements at transfer facilities that will effectively lead to a transit ridership increase. While this literature review is theoretical in developing a conceptual framework to relate improvements at transfer facilities to travel behavior, we are producing a second literature review that examines the current practice of evaluating connectivity based on attributes of transit facilities from the traveler, operator, and community perspectives.

1. INTRODUCTION

When people choose to travel by foot, bike, bus, rail, or private automobile, they consider many factors, such as time, labor, cost, security, convenience, and comfort for the entire trip—from door to door. Needless to say, private automobiles have significant advantages in most aspects, which helps to explain why over 86 percent of all metropolitan person trips in 2001 were in private vehicles (Hu and Reuscher 2004). Private vehicles – cars, trucks, vans, and motorcycles – once owned, provide many benefits over public transit, including greater mobility, accessibility, flexibility, convenience, comfort, and safety against crime. This poses a daunting challenge to public transit agencies aiming to improve their transit service to compete with private vehicles. Given that travelers tend to consider out-of-vehicle time (walking, waiting, transferring, etc.) to be substantially more burdensome than in-vehicle time, attracting travelers away from private vehicles in significant numbers will require transit agencies to focus increasingly on improving transit users' experience outside of vehicles – walking to and from stops, waiting for vehicles, and transferring between vehicles.

The importance of intermodal connectivity has been recognized for a long time. The Committee on Intermodal Transfer Facilities of the Transportation Research Board in 1974 emphasized the importance of identifying factors to measure and be used to optimize total transportation network effectiveness:

> "*The intermodal transfer facility determines total transportation network effectiveness. As a connecting node, the facility integrates the various transportation modes to maximize the number of users. A poor connector would discourage potential users or cause them to be diverted to other modes. Poor transportation system operating practices sometimes introduce crowding and delay, which can be attributed wrongly to inadequacy of the transfer facility. There is a need to establish factors that optimize total transportation network effectiveness. More information is required on the effect of system operating practices on modal transfer efficiency and space use, and procedures should be developed to improve efficiency and reduce space requirements, passenger inconvenience, and delay* (Committee on Intermodal Transfer Facilities 1974)."

Attention to improving the connectivity of transit – between lines and systems – has been increasing for some time. The ongoing suburbanization of U.S. metropolitan areas puts traditional fixed-route transit service at a growing competitive disadvantage with private vehicles, and makes serving increasingly far-flung trip origins and destinations increasingly costly. In response, many cities, such as Boise (Idaho), Sacramento (California), and Seattle (Washington) (Pratt and Evans 2004), have adapted so-called "hub-and-spoke" route systems to serve growing service areas, increasing transfers in the process. A hub-and-spoke model derives its name from a bicycle wheel, which consists of a number of spokes jutting outward from a central hub. In the abstract sense, a location is selected to be a hub, and the paths that lead from points of origin and destination are considered spokes. This transit model requires that people be routed through a transfer station and make transfers among lines and systems before reaching their destination. In larger metropolitan areas with many transit operators, the number of transferring passengers can be very high. In such places, transfer centers are used to facilitate passenger transfers from one line to another, from one mode to another (car to/from bus, bus to/from rail, etc.), or from one system to another and are central parts of transit networks.

Despite long-time recognition of its importance, efforts to address connectivity at transfer facilities have proven less effective than expected. First, although connectivity at transfer facilities is very important, both practitioners and researchers generally pay more attention to quantity and quality of *transit vehicle services* (in-vehicle travel) for their more intuitively obvious effects on ridership. Second, because transfer facilities vary in size, modes served, location, and amenities, it is hard to comprehensively analyze transfer facilities using uniform criteria (ITE Technical Council Committee 5C-1A 1992). Third, most of the literature on transfer facilities lacks a theoretical framework for how improvements of transfer facilities affect people's travel behavior and, subsequently, the overall ridership of the transit system. This lack of causal clarity in the research on transit transfer facilities is an enormous drawback that this research seeks to overcome.

Most previous studies of transit stops, stations, and transfer facilities have compiled laundry lists of attributes that contribute to or detract from travelers' transfer experiences, but have largely failed to consider the relative importance of each of these attributes, or whether and how they influence ridership separately or in concert with other factors (Rabinowitz et al. 1989; Fruin 1985; Kittelson & Associates 2003; Vuchic and Kikuchi 1974; Evans 2004). As a result, we know little about which attributes are most important, under which circumstances, and in what combinations with other factors. In other words, we know very little about the effects of transfer facilities on transit ridership and network performance. This state of knowledge based on past studies on the subject is incomplete because it fails to guide transit agencies toward planning practices that effectively improve the quality of transfers at transit centers that actually result in a ridership increase.

This literature review addresses the lack of a theoretical basis for understanding the relationship between transfer-facility attributes and travel behavior. We do this by placing the literature in a *transfer penalties* framework. The concept of transfer penalties refers to *generalized costs* — including monetary costs, time, labor, discomfort, inconvenience, etc.— that is, those costs involved in transferring from one vehicle to another and, between the same or different transportation modes, and is well-established theory in travel behavior literature (Ortuzar and Willumsen 2004).

The implications of intermodal transit systems and the factors that affect transit ridership are discussed at three levels in this report. First, reviewing past studies on determinants of transit ridership, we find that policies and programs that transit agencies use to increase ridership have had only limited effectiveness. We have found that transit use is determined largely by factors outside the control of transit agencies, such as patterns of urbanization, regional economy, and demographic factors. Second, we introduce a framework that places transfer penalties within the context of total travel costs of a transit trip. The concept of travel costs is drawn from travel behavior modeling, and has been examined extensively in transportation economics, engineering, and planning literature. Value of time is another important concept in examining the relative importance of factors that influence people's travel behavior, particularly in mode choice. This section provides the theoretical backbone for the importance of improvements pertinent to transit transfers. Third, we examine factors thought to particularly influence transit transfers. In doing so, we make a clear connection between improvements at transfer facilities and changes in people's travel behavior through reduction in transfer penalties, so that we will have in turn a clear connection between transit agencies' efforts to reduce transfer penalties and increased ridership. From this perspective, we identify the relationship among transfer costs, time scheduling, and five evaluation criteria of transfer facilities which affect transfer penalties: 1) access, 2) connection and reliability, 3) information, 4) amenities, and 5) security and safety. The final section summarizes the gaps in the current literature by clearly defining the objective of this study, establishing a foundation for research on transit transfer facilities, and proposing an agenda for further research on transit transfers.[1]

2. FACTORS INFLUENCING TRANSIT RIDERSHIP

According to economic theory, transit ridership is determined by the level of service supplied in the system and travel demand in the service area. Transit systems operate in diverse urban

---

[1] Our second deliverable — a continuation of the review of the literature — focuses on reviewing aspects of transfer facility evaluation and directly addresses the project's research questions and explains the next steps in our research that leads to the project deliverables.

environments where a variety of factors have been shown to influence service operation and travel demand. While aggregate travel demand is subject to people's socio-economic status, residential and work locations, and the state of the regional economy, transit agencies determine the level of service supply by taking into account their operating and financial conditions. Thus, actual consumption of transit services (i.e. transit ridership) can be considered a function of a set of factors that affect transit demand and a second set of factors that affect transit service supply.

Factors that affect transit ridership, according to criteria by Taylor and Haas (2002) and Transport and Travel Research Limited and European Commission (TTRL & EC) (1996), can be grouped into three categories. 1) *External factors*, such as physical geography and population demographics; 2) *Indirect measures,* which include policy factors external to public transit agencies — such as land use freeway plans; and 3) *Direct measures,* which include policy factors internal to public transit agencies—such as service frequencies and fare levels (See Table 1).

External factors directly affect transit travel demand and are not easily influenced by local governments or transit agencies.[2] *External factors* include factors such as population and employment growth, the regional economy, salary scales, residential and workplace locations, and migration of people.

Indirect policy measures can be influenced by regional governmental actors (TTRL & EC 1996). Local governments may be able to implement *indirect measures* to increase the relative attractiveness of public transit services and influence peoples' decisions about whether to take a trip and on which mode (TTRL & EC 1996). These measures include regulation, taxation, and pricing for automobile use, land use planning, measures to reduce travel demand, and enhancement of non-motorized modes. While *indirect policy measures* can strongly influence transit use, they are usually outside of the control or influence of transit systems from the perspective of transit agency managers (Taylor et al. 2002).

Direct measures are under the control of transit agencies, according to the framework of the study by Taylor et al. (2002). These measures enhance the advantages of public transit in absolute terms, and make public transit more attractive as a mode of transportation. These measures are related to the level of service provided, fare structure, service frequency and schedules, route design, and service information.

Although transit agencies have a variety of measures to take, their effectiveness is limited, compared to the impact of external factors. Direct policy instruments (or *direct measures*) have little influence on changes in people's choice over transportation modes for travel (TTRL & EC 1996; Taylor et al. 2002). TTRL & EC (1996) recommends that the most effective strategy is to "combine direct and indirect measures through a combination of physical, flow control and relative pricing measures." Despite their relatively low effectiveness, continuous efforts to incrementally improve service by transit agencies are important by helping to provide mobility and accessibility to transit dependents, reduce traffic congestion, improve air quality, and other issues related to automobile use.

---

[2] Here we distinguish *travel demand* that arises to meet people's needs to travel to conduct other activities and *consumption of service* that reveals actual movement of people by driving and taking public transit. In other words, travel demand exists even though it may not be met due to the insufficient level of supply, as treated in general consumer theory.

TABLE 1 Direct and Indirect Factors Influencing Transit Ridership

INDIRECT MEASURES Improving the competitive position of public transport	CAR OWNERSHIP Taxation of car ownership Restrictions on car ownership Road pricing CAR USE (AREA SPECIFIC) Traffic calming Access restrictions Car vehicle specification CAR USE (GENERAL) Fuel tax Restrictions on car use OTHER Information on traffic conditions Land-use planning Tele-communications / tele-shopping Flexible working hours Increase in road capacity Improvements to non-motorized modes
DIRECT MEASURES How to improve the offer of public transport	PRICING Fare levels Ticketing regimes/fare structure Ticketing technology Subsidy regime Fleet size SERVICE PATTERN Extensiveness of routes Distance to/from stops Service frequency/travel time Operating hours SERVICE QUALITY Vehicle characteristics Bus/rail stop quality Interchange quality Quality/Number of staff PRIORITY MEASURES Link priority/right-of-way Junction priority Quality regulations REGULATORY REGIME Market regulation Operational regulations INFORMATION Information provisions Publicity/promotion OTHER Park-and-ride Integrated approach

Source: Taylor et al (2002) and TTRC & EC (1996)

2.1 Relative Effects of Factors Internal to Transit Agencies on People's Travel Behavior

Transit agencies can use *direct measures* to increase the relative attractiveness of transit service to encourage people to choose transit among various modal options. In this section, we review the effects of these measures that transit agencies can control, and carefully examine what aspects of a trip are influenced by these measures.

Many studies on the subject prior to 1990 examined the impacts of various measures on transit ridership or modal shift to transit service at an aggregated level. Subsequently, the focus shifted to a disaggregated analysis using discrete choice models, which can take into account various characteristics of individual travelers and trips. Since the impacts of various measures are likely to vary by socio-demographic characteristics of travelers (e.g. age, income, auto access) as well as by trip characteristics (e.g. trip purpose, travel time of day, trip length), it is necessary to examine the impacts of various direct measures on people's choice of travel mode by different market segments (Cervero 1990; TTRL & EC 1996). Past studies have reported that changes in service quality, such as frequency of service and schedule reliability, have more significant impacts on ridership than fare changes. However, few studies have examined how improving transit facilities affects ridership (Cervero 1990; TTRL & EC 1996; Paine et al. 1967; Wachs 1981).

Table 2 presents an array of approaches available to transit agencies to increase ridership, some of which are drawn from a list of *direct* measures in the TTRL & EC study (1996). In this table, italicized items are related to transferring. The concept of elasticity is often used to examine the effect of some measure on transit ridership. In this case, elasticity is defined as the ratio of a percent change in ridership to a percent change for that measure. For example, when transit ridership decreases by 10 percent with a fare increase of 20 percent, fare elasticity is -0.5 (=-0.1/0.2).[3] Since it is an algebraic calculation, it requires numerically quantifying a change in some measure. For this reason past studies have primarily focused on measurements that can be easily quantified, such as fare, service output, and headway, and less on other measures that can be only qualitatively evaluated.

Fare and subsidy

Of all measures, fare elasticity has been examined the most in past studies. Cervero (1990) reviewed studies up to 1988 with a focus of transit pricing and found that fare changes have relatively small effects compared to changes in service quality, such as average headway and speed. Most studies Cervero reviewed reported estimated fare elasticities between -0.1 and -0.5. Similarly, the review of TTRL & EC (1996) reports fare elasticities in the range of -0.2 to -0.5. In general, fare elasticities are approximately half of elasticities of changes in service quality. Gaudry (1974) has found similar conclusions in his regression study that compares relative effects of factors on transit ridership.

Studies on the effect of transit subsidies report a range of elasticities from +0.2 to +0.4 based on a review of 11 international cases (Bly, Webster, and Pounds 1980; TTRL & EC 1996). However, the mechanism of the effect of transit subsidies on ridership is complex. While transit

---

[3] When elasticity is between negative infinity and negative one, demand is elastic, which means the percentage change in quantity is greater than that in price. When elasticity is between negative one and zero, demand is inelastic, which means the percentage change in quantity is smaller than that in price. The negative sign indicates that an increase in price leads to a decrease in demand, and vise versa.

subsidies certainly help to keep fares lower and increase service supply more than without subsidies, it is not clear which of these two factors is a main cause for an increase in ridership increase. Since part of the subsidies is often used to increase labor compensation, subsidies do not increase service output in the same proportion (Lave 1985), which, in turn, reduces the effects of subsidies on ridership.

A fare structure is likely to significantly influence ridership especially when it varies by time of day and trip distance, since it influences people's mode choice of travel differently for different socio-demographic groups and for different trip purposes. However, there has not been much study done in this field. Smartcard technology is also related to fare structure, but is still very new with little, if any, evidence of its impacts on ridership (TTRL & EC 1996).

TABLE 2 Measures Available to Transit Agencies[4]

Group	Factor	Elasticity
Fare and subsidy	fare level	-0.5~-0.1(half of that of service quality)
	subsidy regime	+0.2~0.4 (its effect is not clear)
	ticketing regime/fare structures,	-
	ticketing technology (smart card)	-
Service supply:	(vehicle-km of bus service)	+0.2~0.7
	route, stops	-
	station distance	-0.57~-0.49
	operating hours	-
Service quality	twice as much effects on ridership as fare changes)	
	service frequency/scheduled journey time	-
	waiting time	-0.54
	Reliability	-
	vehicle speed (in-vehicle travel time)	-1.16~-0.59
	vehicle speed (in-transit time)	-0.54
	link priority/segregated right of way	-
	junction priority	-
	vehicle characteristics	-
	fleet size	-
Transit facilities	bus/rail stop quality	-
	station facilities	-
	bus stop quality, station facilities	-
	terminal/interchange quality	-
	park and ride	-
	information provision	-
Others	safety/security	-
	publicity/promotion	-
	market regulation	-
	number and quality of staff	-
	operational regulations/quality regulations	-

Service supply: route, stops, and operating hours

Since ridership is determined by service supply and travel demand, the level of service supply certainly influences ridership. Elasticities of ridership to service supply measured by vehicle-kilometers of bus services are in the range of +0.2 and +0.7 (TTRL & EC 1996).

[4] Vehicle speed is the only factor in this table that is estimated by a discrete choice model study. Other factors are estimated by aggregate models or not specified at all in the literature.

Routing and the degree of route extension influence a transit system's coverage area, and therefore potentially influence ridership. The effect of these factors on ridership significantly varies by area. Some scholars critique the expansion of transit service into suburban areas as having the effects of lowering productivity, efficiency, and therefore effectiveness of transit service (Lave 1985; Garrett and Taylor 1999).

In contrast, the number or density of stops shows a relatively large impact on ridership, because it affects access distance and walking time for transit users. Transit service demand with respect to walk time is very sensitive (Cervero 1990). TTRL & EC (1996) cites a study by Gordon and Wilson (1985) to report that demand for light and heavy rail have elasticities of -0.568 and -0.485 respectively with respect to walking distance. Station distance also determines distance that rail users may have to walk to access and therefore affects walking time, which is perceived to be very onerous by travelers.

While some users may have a preference for longer operating hours, there has been no careful study to separate the effects of longer operating hours from the effects of an increased total service supply due to longer operating hours. In other words, is it the earlier and later hours that attract riders, or simply the greater number of vehicle runs?

Service quality: service frequency/scheduled journey time, vehicle speed, link priority/segregated right of way, junction priority, vehicle characteristics, fleet size

From TTRL & EC (1996), service frequency "refers to average frequency, length of operating day/week, and reliability." The most important objectives of scheduling and frequency adjustment in service quality are to reduce overall travel time and improve convenience for passengers (Evans 2004).[5] Scheduling changes can be made to improve the reliability of service that results in both actual and perceived waiting time for passengers and less anxiety (Evans 2004). While frequency of service, headway, and reliability influence opportunities for waiting time at stops/stations, vehicle speed is a main factor to determine travel time (or in-vehicle time). In general, changes in service quality, such as average headways and speeds, have twice as much effect on ridership as fare changes (Cervero 1990).

It is very difficult to reliably measure service elasticities in response to multiple service changes that often occur simultaneously – such as schedule changes that accompany a fare increase. Further, most transit ridership data are in terms of unlinked trips, while travelers make linked trips (*walk – wait – ride – walk*, or *walk – wait – ride – walk – wait – ride – walk* in the case of a trip with a transfer), where the out-of-vehicle aspects of the links have the largest influence of perceived travel burdens. Such methodological challenges notwithstanding, Evans (2004) reports an elasticity of 0.5 in response to service frequency changes. When changes in service hours and frequency were accompanied by aggressive marketing, such as direct mail campaigns, free ride coupons, and image building by new bus paint designs in Santa Clarita and Santa Monica, California, each transit system experienced significant ridership increases with elasticities of +1.14 and +0.82 respectively (Evans 2004; Mass Transportation Commission 1964).

[5] In the TCRP report 95, Evans (2004) list the following types of scheduling and frequency changes for discussion: 1) frequency changes, 2) service hours changes, 3) frequency changes with fare changes, 4) combined service frequencies, 5) regularized schedules, and 6) reliability changes. Combined service frequencies is the approach to offer a combination of different transit services on the same corridors to accommodate diverse trips taken by different groups of transit users.

In general, higher values of elasticity are achievable when frequency changes are made to transit lines with previous service schedules with 60 minute or 30 minute headways and when riders are mainly in middle and upper income groups (Evans 2004). On the other hand, elasticity tends to be relatively low when previous service already has short headways and the majority of patrons are from lower income groups (Evans 2004). In addition, different groups of transit users have different responses to frequency changes. Off-peak riders are often more sensitive to frequency changes than peak period riders (Evans 2004). Since transit dependents are likely to use transit service even though service quality may not be satisfactory, an increase in ridership due to frequency changes is often attributed to an increase in new discretionary (choice) riders who are likely to be in middle and upper income groups (Holland 1974).

Scheduled journey time and vehicle speeds affect in-vehicle travel time. Cervero (1990) reports in-vehicle travel time elasticities in the range of -0.59 and -1.16 from two mode choice studies (McGillivrary 1969; Domencich, Kraft, and Valette 1968), in which the high end represents an elasticity in the peak period. Gaudry (1974) reports elasticity of 0.27 for in-transit time, compared to fare elasticity of -0.15.

Service frequency and reliability determine travelers' waiting time at transit facilities. Transit riders are found to be very sensitive to out-of-vehicle time, and among various types of out-of-vehicle time, waiting time is the most onerous factor to transit users (Cervero 1990). Gaudry (1974) reports elasticity of -0.54 for waiting time.

Reliability is one of the most important factors to attract transit ridership. Commuters in attitudinal studies conducted in Baltimore and Philadelphia considered "arrival at intended time" as the second most important for work trips, following "arrival without accident (Evans 2004)." Similar results were shown in a survey in Boston and Chicago; "arrival at intended time" is more important than travel time, waiting time, and cost measures (Evans 2004). Improvement in reliability and speed in urban bus services in Britain in the 1970s significantly increased ridership (TTRL & EC 1996). In the study conducted by Horowitz and Thompson (Horowitz and Thompson 1995), time-scheduling and reliability are the second most important attribute at transfer facilities following safety and security. Douglas (1991) found in a study in New Zealand that the value of *expected* delay was 8 times as much as that of walk time for rail users (TTRL & EC 1996). Waiting time with uncertainty of arrival of the next vehicle increases the value of waiting time by a factor of two (Webster 1977).

Link priority, segregated right of way, and junction priority generally influence ridership through their impacts on variability of travel time and in-vehicle travel time. The effect of bus lanes has been found to be less than expected in the studies reviewed by (TTRL & EC 1996). While one study reports that the reduction of travel time by increased speed of a light rail line using junction priority from 33 minutes to 22 minutes increased ridership by 10 percent, the measure of junction priority is not developed enough and it is still difficult to evaluate its effect (TTRL & EC 1996).

It is also difficult to quantify vehicle characteristics, and there is no hard evidence to support particular vehicle characteristics, although people generally prefer comfortable rides by rail vehicles to those by buses.

Transit facilities: Bus/rail stop quality, station facilities, terminal/interchange quality, park and ride, information provision

The quality of transit facilities can have significant impacts on attracting ridership to transit systems in several different ways. Since one of the main functions of transit facilities is to accommodate users' waiting time, factors such as comfort, security, safety, and convenience, influence people's experience in taking public transit service, and therefore increase their likelihood of choosing transit service over other modes. However, past studies provide little evidence that clearly indicates a *direct* connection between qualities of transit facilities and ridership. As we discuss in later sections of this report, qualities of transit facilities can *indirectly* affect transit demand and ridership by improving travelers' experience at facilities.[6]

Some studies examined the values transit users placed on components of terminals (e.g. including waiting facilities, lifts/escalators, catering facilities, and information displays), terminal/interchange quality, and park-and-ride facilities. Survey respondents in the study by Douglas (1991) value improvements on stations as much as those on trains (TTRL & EC 1996).[7] However, the effects on transit demand are unknown (TTRL & EC 1996).[8] The only study that took into account a component of transit facilities in a discrete choice model is the study by Guo and Wilson (2004), which showed that the presence of escalators to assist level changes for transferring at subway stations could reduce transfer penalties.

At the same time, it is not difficult to think that a small change in transit facilities will not dramatically change people's travel behavior. A study in Lima, Peru, showed that bicycle storage and easier access for the handicapped by replacing stairways did not have a statistically significant impact on people's choice of travel mode in the stated preference survey, while increase in feeder service to rails and in bus rapid transit service to downtown were found important (Martinez 2003).

Travel time interconnectivity at transfer facilities is very important. This is determined mainly by vehicle scheduling: "Specific benefits from adjusting frequencies so that services interconnect efficiently. Values of waiting time on transferring (or interchange) and delays are high (TTRL & EC 1996)." Several studies in recent years developed models to minimize the uneasiness, inconvenience, and other costs associated with transit transfers.[9] These studies used a modeling approach to optimize time-related functions such as time tables and vehicle dispatching to reduce waiting time (Shayer 2004).

In the survey study by Douglas (1991), respondents placed a value of seven New Zealand cents on at-stop (rail) information in addition to having leaflets, and also placed a similar value on a telephone inquiry system, and real-time information (TTRL & EC 1996). However, no

---

[6] One of the main problems in past studies that evaluated the qualities of transit facilities is a lack of a conceptual framework that explains how facility improvements can affect transit demand and ridership and how cost effective those improvements are. For example, although almost all transit users would like to have shelters and benches at bus stops, the presence of shelters and benches does not necessarily increase ridership, as the presence of refrigerators and laundry machines at bus stops, for an extreme example, does not necessarily increase ridership. This lack of causal clarity in the research on transit transfer facilities is an enormous drawback when transit agencies implement transit facility improvements in order to increase the overall ridership in the transit system.

[7] Network Southeast have values for station appearance, station facilities (including catering) and information, although there is some debate about the plausibility of some of these values (See Cuthbertson et al., 1993).

[8] London Underground and British Rail have determined the values passengers place on terminals (Case study 2.5). A look-up table of interchange (or transfer) penalties has been developed based on distance and connection time, to take into account that certain interchanges are more onerous than others. Evidence from Thameslink suggests that this method may have underestimated the penalty of cross London interchanges, which has implications for other rail schemes.

[9] These studies include Bookhinder and Desilets (1992), Chowdhury and Chien (2001), Chowdhury (2001), and Boile (2002).

study has been found that provides evidence of a significant effect of route-specific service information on an increase in ridership.

There are other measures listed by TTRL & EC (1996). These include publicity/promotion, market regulation, number and quality of staff, and operational regulations/quality regulations. These measures, however, lack hard evidence of their effects on transit demand.

Safety and Security

While it may not necessarily attract new ridership, improving the built environment to reduce overall crime may have a significant impact on regaining transit users' confidence. Transit security is a serious concern in most metropolitan areas of the United States. Studies that examined the relationship between transit facilities and crime show certain built environment attributes contribute to higher and lower crime rates. Crime rates were higher for bus stops near alleys, multi-family housing, liquor stores and check-cashing establishments, vacant buildings, and graffiti and litter (Loukaitou-Sideris et al. 2001; Liggett, Loukaitou-Sideris, and Iseki 2001). In contrast, good visibility of the bus stop from its surroundings, large numbers of pedestrians, and the existence of bus shelters contributed to lower crime rates (Loukaitou-Sideris et al. 2001; Liggett, Loukaitou-Sideris, and Iseki 2001).

While the studies found that the most important predictor of crime is the location of bus stops, appropriate design and layout of the physical characteristics around transit facilities at the micro level can affect opportunities for and likelihood of criminal activity (Liggett, Loukaitou-Sideris, and Iseki 2001). In the case of the light rail system that runs through the median of the Century Freeway (I-105) in Los Angeles, the study found a high crime rate at park-and-ride facilities adjacent to stations. While these parking lots are partially fenced and adequately lit, a lack of pedestrian activity reduces the level of ambient surveillance and may facilitate criminal activities (Loukaitou-Sideris, Liggett, and Iseki 2002). Platforms of five stations with high crime rates are located in the middle of the freeway median and isolated from surrounding neighborhoods (Loukaitou-Sideris, Liggett, and Iseki 2002). These stations are likely to suffer from little visibility and natural surveillance as well as several hiding places (under stairs and behind pillars), and result in higher crime rates. There is certainly correlation between the built environment at and around transit facilities and the incidence of crime. The sense of security is so important in people's choice of travel mode, time of travel, and route that it may completely deter taking transit. Therefore, transit agencies should maintain a certain minimum level of security, taking measures of policing and improving the built environment.

Overall, measures available to transit agencies have only limited effects to increase ridership in comparison to the effects of external factors and indirect measures in policy options that are outside the control of transit agencies. Past studies provide more information on the effects of factors that are easily quantified, such as fare, service output, and headway, on ridership, and have resulted in an understudy of other measures that can be only qualitatively evaluated. There is no clear theoretical framework to relate qualities of transit facilities to transit demand, ridership, and travel mode choice. The majority of past studies that examined the effects of various factors used aggregated analyses that are not capable of examining the effects of qualities of *individual* transit facilities. Although disaggregated analyses using discrete choice models are capable of such examinations, only few studies actually took into account qualities and components of transit facilities. All of these contribute to a lack of evidence to evaluate the effects of qualities of transit facilities on transit ridership.

In addition, it is also important to take into account cost effectiveness as well as political feasibility of adopting various policies and programs, including improvements of transit facilities, so that policy makers and planners can choose the best strategies to increase transit ridership.

3. THE FRAMEWORK OF TRANSFER PENALTIES WITHIN TOTAL TRAVEL COSTS OF TRANSIT TRIPS

> "*Understanding what affects the transfer penalty can have significant implications for a transit authority. It can help identify which types of improvement to the system can most cost-effectively reduce this penalty, thus attracting new customers, and helping determine the value of improvements to key transfer facilities* (Guo and Wilson 2004)."

The concept of *transfer penalty* represents *generalized costs* — including monetary costs, time, labor, discomfort, inconvenience, etc. — involved in transferring from one vehicle to another between the same or different transportation modes, and is well-established theory in the travel behavior literature (Ortuzar and Willumsen 2004). The concept of travel costs is drawn from travel behavior modeling, and has been examined extensively in transportation economics, engineering, and planning literature. In the transportation literature, the term "transfer penalties" is used in two different definitions. In a broader definition, transfer penalties is a general term to represent all of the monetary costs, time, labor, inconvenience, and emotional distress pertinent to making a transfer, and generally work as an impedance factor for travel. In this broader definition, transfer penalties consist of factors, such as transfer fare, walking time and labor, waiting time and labor, comfort, safety, and convenience (Liu, Pendyala, and Polzin 1997).[10] In contrast, in a narrower definition, transfer penalties are an impedance factor in transferring after excluding factors that we can easily quantify, such as waiting time, walking time, and transfer fare. In other words, transfer penalties in the more narrow definition are the penalties beyond the monetary and time costs associated with making transfers (Liu, Pendyala, and Polzin 1997).

3.1 Example of Transfer Penalties in a Typical Transit Trip

In the following example, we will use a description from Currie's article (Currie 2005). A typical one-way transit trip consists of the following attributes (minutes in parentheses are numbers that we chose for this example):[11]

1) access by walking from a trip origin to a bus stop (8 minutes),
2) wait at a bus stop (4 minutes),
3) travel in vehicle from a bus stop to a rail station (20 minutes),
4) transfer from a bus stop to a rail station, involving walking (6 minutes), waiting (10 minutes), and other transfer penalties,

---

10 Other attributes of transfers are: seamlessness, flexibility, safety, security, comfort, convenience of both transferring and taking care of errands (e.g. buying a cup of coffee, magazine, and newspaper), ease of payment, ease of vehicle access/egress, in-vehicle time, seat availability, staff friendliness/helpfulness, familiarity of service, ease of comprehension, ease of finding out information, and image of public transport.

11 Liu, Pendyala, and Polzin (1997) also states that "a typical transit user in New York-New Jersey area in their study would walk to a transit station, board a bus or the subway system, make one or more transfers, and finally walk to the destination."

5) travel in vehicle from a rail station to another (30 minutes), and
6) egress from a rail station to a trip destination (6 minutes).

Assuming we can convert all of time, fare, and qualities of travel into generalized cost, a formula to compute the total generalized cost (TGC) for this trip looks like:

$$TGC = \{(Walk_t * Walk_w) + (Wait_t * Wait_w) + (IVT_t * IVT_w) + (NT * TP_b) + MSC_m\} * VOT + Fare \qquad \text{----- Eq. (1)}$$

Where:

- $Walk_t$: time in minutes walking to and from the transit service
- $Walk_w$: passenger valuation of walk time to and from transit stops
- $Wait_t$: time waiting for transit vehicle to arrive at the transit stop
- $Wait_w$: passenger valuation of wait time at transit stops
- IVT_t: travel time in transit vehicles
- IVT_w: passenger valuation of in-vehicle travel time
- NT: number of transfers
- TP_b: transfer penalty, including transfer walking and waiting in a broader sense[12]
- MSC_m: mode specific constant for transit mode m
- VOT: value of travel time
- $Fare$: average fare per trip

Following the definition of transfer penalties in both the broad and narrow senses, we can further decompose TP_b:

$$TP_b = (Walk_{tt} * Walk_w) + (Wait_{tt} * Wait_w) + TP_n \qquad \text{----- Eq.(2)}$$

Where:

- $Walk_{tt}$: time in minutes walking to make a transfer
- $Wait_{tt}$: time waiting for transit vehicle to make a transfer
- TP_n: transfer penalty, including transfer walking and waiting in a narrow sense

In Eq. (2), weights represent different valuations of time for different attributes. Weights, in this context, can be interpreted as the differences between *actual* travel time and the time *perceived* by a traveler. In a mode choice, travelers make their travel decisions based on the total generalized cost of the trip in their calculation, which partly depends on their perception of transfer attributes, such as time and other burdens associated with different segments in transit trips.

Table 3 shows time and costs associated with components of a typical transit trip. Walking in Eq. (1) is further divided into different segments of a trip: 1) ingress, 2) transfer, and 3) egress.

---

[12] TP_n and TP_b are equivalent to *Interchange I* and *Interchange II* respectively in Wardman's study (2001), which will be reviewed in a later section.

This example includes two kinds of waiting time: 1) waiting at a bus stop for the initial segment of trip and 2) waiting for making a transfer. It also has two types of in-vehicle time and two types of fare for bus and train. This example does not include *mode specific constant* in Eq. (1).

We assume the monetary value of in-vehicle time is $7.50 per hour—half of an assumed wage rate of $15 per hour. We use average valuation of walking time, waiting time, and other transfer penalties according to a study by Wardman (2001). Monetary value of walking time, waiting time, and other transfer penalties are computed to be $12.45 per hour, $11.03 per hour, and $1.32 per transfer respectively based on our assumptions. We have intentionally made costs associated with other transfer penalties comparable to other costs in this example—and $1.32 for "Other transfer penalties" in Table 3.

In this example, transfer penalties, including transfer walking and waiting time, account for 26 percent of the total generalized cost of the trip. In the fourth column which assumes that people can make a transfer without waiting, the total travel cost decreases by 11 percent. In the fifth column, which assumes no waiting time for transferring, the total travel cost decreases by 7 percent. In the sixth column which assumes no waiting and walking time (for example, a timed-transfer across a platform), the total travel costs significantly decreases by 18 percent. The proportion of costs associated with transfer penalties in total costs can be reduced from 26 percent to 9 percent in the case that transit users have to spend for neither waiting nor walking. Thus, the significant portion of the total generalized cost of a trip can be attributed to transfer penalties, and can be reduced by providing timed-transfers which do not require transit users to wait or walk long distance to transfer. We will extensively review these transfer penalties in a later section.

TABLE 3 Typical Transit Trip and Its Associated Time and Costs

		Typical	**No transfer waiting**	**No transfer walking**	**No transfer walking & waitin**
	Time (min.)	Cost	Cost	Cost	Cost
Access by walk from trip origin to bus stop	8	$1.66	$1.66	$1.66	$1.66
Wait at a bus stop	4	$0.74	$0.74	$0.74	$0.74
Bus fare ($1.35)	-	$1.35	$1.35	$1.35	$1.35
Travel in vehicle from a bus stop to a rail station	20	$2.50	$2.50	$2.50	$2.50
Transfer Penalities					
Transfer from a bus stop to a rail station: walking	***6***	**$1.25**	**$1.25**	**$0.00**	**$0.00**
waiting	***10***	**$1.84**	**$0.00**	**$1.84**	**$0.00**
Other transfer penalties*	-	**$1.32**	**$1.32**	**$1.32**	**$1.32**
Travel in vehicle from rail station to another	30	$3.75	$3.75	$3.75	$3.75
Train fare ($1.35)	-	$1.35	$1.35	$1.35	$1.35
Egress from a rail station to a trip destination	6	$1.25	$1.25	$1.25	$1.25
Total	84	$16.99	$15.16	$15.75	$13.91
Reduction in total costs		**-**	**11%**	**7%**	**18%**
% of transfer penalties in TOC		**26%**	**17%**	**20%**	**9%**

	Weight	Hour	Minute
Wage	2.00	$15	$0.25
In-vehicle travel	1.00	$7.50	$0.13
Walking**	***1.66***	$12.45	$0.21
Waiting**	***1.47***	$11.03	$0.18
Other transfer penalties**	***17.61***	$132.08	-

*: Other transfer penalties is further weighted by 0.01 to make its cost comparable to other costs.

**: The ratio relative to in-vehicle time is taken from Wardman (2001).

In the above example, we assumed that weights (or valuation of time) for different attributes are constant. However, weights for different attributes vary by differences between *perceived* time and *actual* time.

People perceive time differently under different circumstances. A traveler's *perceived* waiting time can be much more onerous than his *actual* waiting time (Moreau 1992; Hess, Brown, and Shoup 2005). Waiting time is perceived especially burdensome when travelers have to wait in difficult environments, such as in cold, hot, or rainy weather, or in a seemingly unsafe or insecure condition. Safety and security are particularly important, since it can increase *perceived* costs related to waiting infinitely; if travelers feel a waiting location is so insecure that he or she may get mugged, most of them do not take a risk to take public transit (ITE Technical Council Committee 5C-1A 1992).

There are other examples of factors that differentiate *perceived* time/costs from *actual* time/costs, such as whether or not waiting is productive, whether or not a wait is forced, and whether or not a traveler knows an arrival time of the next bus.[13] Thus, although *actual* waiting time is determined by the difference in arrival time of a user and a vehicle at a boarding location, *perceived* waiting time can be substantially longer depending on waiting conditions, and therefore the generalized cost of waiting time can also become higher.

Perceived walking distance and time also can be longer than *actual* walking distance and time. Physical conditions as well as other attributes at transfer facilities, such as availability of adequate information, are very important in two ways: 1) in determining *actual* walking distance for transferring and 2) in affecting *perceived* walking distance and time.

At first glance, we may think walking distance is determined simply by distance between two points where a traveler alights one vehicle and boards another for his/her transfer, and walking time is determined by this distance and a traveler's walking speed. But it is again not always this simple. When a traveler is familiar with a transfer facility and direction to a point where he/she rides on the next bus or train, it does not require him/her much time and energy to transfer. However, when a traveler does not have good sense of a facility without sufficient information, walking distance can be much longer since he needs to perform additional activities including where to go to board his next bus or train, where to exchange a bill into coins, and where to buy a ticket. While this traveler looks for these places and information, he/she needs significantly longer time to walk the longer *actual* distance. Furthermore, the burden and frustration that arise in looking for a place to board, ticket vending machine, etc. makes this traveler's *perceived* walking distance and time longer than *actual*. A layout of transfer facilities that is not intuitive and not easy to figure out can significantly make a traveler's experience of transferring unpleasant, and this raises the generalized cost associated with transferring.

Thus, conditions at facilities wherein travelers make a transfer can influence their *perceived* experience of transferring as well as *actual* walking distance/time and waiting time, and then affect their likelihood of taking the same transit trip in the future. If a transfer point is off-street, then the characteristics of the surrounding environment would also be relevant to the perceived walking time; for example, if the street provides a pleasant setting for walking, then perceived walking time might be less than if the transfer point were on a busy street.

---

[13] We will review the difference between *actual* time and *perceived* time more extensively in a later section. It should be noted that some of these factors may also be taken into account by transfer penalties beyond waiting time, walking time, and transit fare.

3.2 Valuation of Time Associated with Components of a Transit Trip

In the above example that examined the proportion of transfer penalties in the total generalized cost of a trip, we explained how *actual* time/cost and *perceived* time/cost could be very different. The difference in *actual* time and *perceived* time is also viewed as different valuations of time in different activities, and has been extensively examined in the transportation literature. Since value of time is used to convert *actual* time into a monetary value of generalized costs, it is a significant factor in people's mode choice. This section reviews what we know about value of time with a particular attention to waiting time, walking time, and other transfer penalties.

Table 4 summarizes valuations of waiting time, walking time, transferring time, and transfer penalties relative to in-vehicle time.

TABLE 4 Overall time valuations (relative to in-vehicle time = 1.0)

Study	Location/ Type	Factor	Mean	S.D.	Obs
Parsons Brinckerhoff Quade and Douglas Inc. (1998)	Houston	Wait time	2.58	-	-
Barton-Ashman Associates (1993)	Cleveland	Wait time	2.13	-	-
Parsons Brinckerhoff Quade and Douglas Inc. (1993)	Minneapolis-St. Paul	Wait time (first 7.5 minutes)	4.00-4.36	-	-
		Wait time (over 7.5 minutes)	0.88-10.78		
		Transfer wait time	1.58-4.36		
		Transfer penalty (extra)	17.27-121.05		
Parsons Brinckerhoff Quade and Douglas Inc. (1999)	Chicago	Wait time	3.41	-	-
Kim (1998)	Portland	Various out-of-vehicle time, work trips	1.25-2.46	-	-
		Out-of-vehicle time, non-work trips	2.67	-	-
US Environmental Protect Agency (2000)	Review of 50 US studies	Walk time	2.0-2.72	-	-
Wardman (2001)	Review of British studies from 1980 to 1996	Walk time	1.66	0.71	140
		Wait time	1.47	0.52	34
		Walk and wait time	1.46	0.79	64
		Headway	0.80	0.46	145
		Interchange 1	17.61	10.93	8
		Interchange II	34.59	25.88	16
		Interchange III	33.08	22.73	23

Transit riders are very sensitive to out-of-vehicle time. Among various types of out-of-vehicle time, waiting time is the most onerous factor for transit users (Cervero 1990). In practice, the rule of thumb is that walking and waiting time are valued twice as much as in-vehicle time for non-business trips. This rule of thumb (or slightly higher values of walking and waiting time) is supported by several studies reviewed by Wardman (2001), while the relative value of walking, waiting, and in-vehicle time varies by conditions (MVA Consultancy 1987; Bruzelius 1979; Transport and Road Research Laboratory 1980). A few studies report a higher value of waiting time than that of walking time (Transport and Road Research Laboratory 1980; Steer Davies Gleave 1997). Several studies, including those reviewed by Bly, Webster, and Pounds (1980), show two or three times as much disutility of walk time as that of in-vehicle time. Recent modeling studies show that the value of walk time, compared to in-vehicle time, ranges between 2.0 and 4.5 — 2.58 in the case in Houston (Parsons Brinckerhoff Quade and Douglas Inc. 1998), 2.13 in Cleveland (Barton-Ashman Associates 1993), 4.0 to 4.36 in Minneapolis-St. Paul (Parsons Brinckerhoff Quade and Douglas Inc. 1993), and 3.41 in Chicago (bus and rapid transit) (Parsons Brinckerhoff Quade and Douglas Inc. 1999). In Minneapolis-St. Paul, the value of wait time over 7.5 minutes varies significantly by types of trip, such as home-to-work, home-to-other, non-home based-work related and non-home based-non-work related.

In contrast, the average values of walking time, waiting time, combined walking and waiting time are found less than two — 1.66, 1.47, and 1.46 respectively—in Wardman's review and meta-analysis of British studies from 1980 to 1996 on values of travel time and service quality (TABLE 4) (Wardman 2001). In the U.S. cases, Kim (1998) reports 1.25 to 2.46 for various types of out-of-vehicle time for work trips, and 2.67 for non-work trips in the case of Portland. In its review of travel demand modeling studies in the U.S., the U.S. Environmental Protection Agency (2000) also reports 2.12, ranging from an average of 2.72 for urban areas under 750,000 population to roughly 2.0 for large cities, and from average of 2.48 for 1990s models to about 2.0 for older models.

3.3 Weighting of Time Associated with Elements of a Transit Trip

The value of walking and waiting time is higher under certain circumstances. When a person is taking a trip on business, values of travel time are expected to be higher; the average values of walking and waiting times relative to in-vehicle time in 13 studies was found to be 1.80 (Wardman 2001). Wardman (1998) explains that a high value of time on business may reflect employers' willingness to pay for taxis to save time. Waiting in congested conditions, unacceptable waiting, and walking up stairs can have higher values (London Transport 1996).

In addition, waiting time with uncertainty of arrival of the next vehicle increases the value of waiting time by a factor of two (Webster 1977). Reliability is one of the most important characteristics of transit service known to both academia and practitioners in the transportation field, but is not achieved at a satisfying level in most transit systems — especially for U.S. bus systems. Transit users perceive less amount of waiting time when they feel less anxious, given the information on expected waiting time (Evans 2004). A study in New Zealand found that the value of *expected* delay was 8 times as much as that of walk time for rail users (TTRL & EC 1996). The literature review by Reed {, 1995 #1} reports that travelers perceive waiting time 1.5 to 12 times as long as in-vehicle time. In addition, the study conducted in Minneapolis-St. Paul found that commuters, who know the schedule and adjust their arrival time at the bus stop, did not view waiting time over the initial 7.5 minutes onerous at all, while people who make other trips less repetitively and more discretionary particularly consider longer waits very onerous (Parsons Brinckerhoff Quade and Douglas Inc. 1993).

As previously mentioned, the perception of length of waiting time varies significantly depending on the circumstances in which people wait. People are likely to overestimate waiting time when people experience time drag in a tiresome situation (Moreau 1992). Time drag is a condition that makes people feel that time is passing more slowly than it actually does. People tend to overestimate unfilled time and underestimate time filled by a compelling job (Moreau 1992). In the case of transit, time drag may arise when passengers think time spent for waiting is unproductive and/or burdensome — when people are not engaged in any activities, are anxious about something, such as being late for work, are not informed about delays of arrival or departure, feel poorly served, and travel alone (Hess, Brown, and Shoup 2005; Moreau 1992; Reed 1995).

The value of waiting time also varies by whether people are forced to wait or choose to wait. Hess, Brown, and Shoup (2005) examined value of waiting time in a natural experimental condition. In this situation, traveling students can choose either to pay the 75-cent fare and take a "Green" bus that arrives first at a bus stop or wait for the next "Blue" bus and take a free ride on the University Fare program. Hess, Brown, and Shoup (2005) found that waiting time estimated by people who decided to wait for the "Blue" bus was lower and much closer to the actual time (only 19 percent more than the actual time) while people who just wait for the next bus estimated waiting time much longer than actual waiting time (91 percent more than actual time).[14] This indicates it is important to reduce headway and uncertainty of arrival time, so that waiting time *perceived* by people does not become much longer than actual waiting time.

In Wardman's review (2001), service headway (or interval between services), which is related to unreliability of transfer through waiting time, is treated differently (TABLE 4). The value of service headway[15] relative to in-vehicle time is 0.80, while it increases to about 1.6 when arrival times of vehicles are uncertain. Transit riders are more sensitive to unexpected and unpredictable delays than expected and predicted waiting time (Evans 2004). When service is unreliable, people need to have a larger time margin to catch a bus to reduce the risk of missing the service. So the convenience of journey planning and risk reduction add value to reliable headway (Wardman 2001). The value of headway is also affected by the level of headway itself, since people do not care about waiting for a few minutes of headway while they do care about a few more minutes in addition to 10 minutes. It is also higher for a shorter distance trip and a business trip (Wardman 2001).

The value of making a transfer is significantly high. In Minneapolis-St. Paul, the value of additional transfer penalty varies significantly from 17.27 for home-other trips to 121.05 for non-home-based-non-work-related trips (Parsons Brinckerhoff Quade and Douglas Inc. 1993).

Interchange in Wardman's review refers to a transfer between trains, and have three different measures. *Interchange I* refers to an interchange penalty which reflects the disutility of making a transfer, excluding the disutility of time spent for waiting or transferring (or walking) for a transfer.[16] The average value of *Interchange I* is about 18 minutes of in-vehicle time, reflecting

---

[14] They found the value of waiting time is $8.50 (paying 75 cent to avoid the average of 5.3 minutes of waiting).

[15] Headway represents the interval between public transport services and is a measure of how frequent the services are.

[16] This is transfer penalties in a narrow sense discussed earlier.

both travelers' unfamiliarity with a given transfer and the risks associated with lower service frequencies (Wardman 2001).

Interchange II includes *Interchange I* penalties, plus a premium valuation of waiting and walking time. The value of *Interchange II*, according to Wardman, is approximately 35 minutes. Using the value of walking and waiting time of approximately 1.6 times in-vehicle time and the value of *Interchange I*, Wardman concludes that the value of *Interchange II* is both consistent and plausible.

Interchange III represents the combination of the pure interchange penalty and the connection time. *Interchange III* has a value of 33, which is lower than expected. Thus, in the studies reviewed by Wardman (2001), transfer penalties are substantially more burdensome than both wait/walk time and in-vehicle time. While Wardman's nomenclature is perhaps awkward, the point is clear: travelers strongly dislike transferring, and some aspects of transferring (e.g. uncertainty, fear) are substantially more burdensome than others (such as walking and waiting).

The value of the need to transfer varies by type of modal transfer among different combinations of transportation modes (Currie 2005; Liu, Pendyala, and Polzin 1997). Table 5 presents the valuation of transfer penalties for six studies using discrete choice models that were reviewed by Guo and Wilson (2004) as well as for their own study.

A reduction in the costs of interchange will lead to increasingly *seamless journeys* and such benefits which must be quantified. It should be noted that it is difficult to compare values in different studies in Table 5 because of differing sets of data. For international cases, conditions of a transfer and variables used in discrete choice modeling can differ widely as shown in Table 5 as well.

TABLE 5 Valuation of Transfer Penalties

Studies	Variables in the Utility Function	Transfer Types (Modal Structure)	Transfer Penalty Equivalence *
Alger et al, 1971 Stockholm	Walking time to stop Initial waiting time Transit in-vehicle time Transit cost	Subway-to-Subway Rail-to-Rail Bus-to-Rail Bus-to-Bus	4.4 14.8 23 49.5
Han, 1987 Taipei, Taiwan	Initial waiting time Walking time to stop In-vehicle time Bus fare Transfer constant	Bus-to-Bus (Path choice)	30 10 IWT 5 WT
Hunt, 1990 Edmonton, Canada	Transfer constant Walking distance Total in-vehicle time Waiting time Number of transfers	Bus-to-Light Rail (Path choice)	17.9
Liu, Pendyala, and Polzin, 1997 New Jersey, NJ	Transfer constant In-vehicle time Out-of-vehicle time One way cost Number of transfers	Auto-to-Rail Rail-to-Rail (Modal choice)	15 5**
CTPS, 1997 Boston, MA	Transfer constant In-vehicle time Walking time Initial waiting time Transfer waiting time Out-of-vehicle time Transit fare	All modes combined (Path and Mode Choice)	12 to 15
Wardman, Hine and Stradling, 2001 Edinburgh, Glasgow, UK	Utility function not specified	Bus-to-Bus Auto-to-Bus Rail-to-Rail	4.5 8.3 8
Guo and Wilson, 2003	Details in Table 6	Subway-to-Subway	1.6 to 31.8

*: minutes in-vehicle time except IWT (initial wait time) and WT (walk time)

**: Guo and Wilson had a value of 1.4, but it is corrected by checking the original article by Liu, Pendyala, and Polzin (1997)

Source: (Guo and Wilson 2004)

Algers, Hansen, and Tegner (1975) show a large variation of transfer penalty for different combinations of transit modes. The transfer penalty between subways (4.4 minutes in-vehicle time) is the lowest followed by the penalty between other forms of rail transit (14.8 minutes in-vehicle time). The significantly lower value of transfer penalty between subways can be explained by several factors, such as short walking distance, short headway, reliable schedule, and protected environment for the subway system. When a transfer involves bus transit, transfer penalty generally has a higher value; transfer penalty between bus and rail has the value of 23 minutes in-vehicle time. A bus-to-bus transfer has a significantly higher value (49.5 minutes in-vehicle time). This may reflect, in contrast to a transfer between subways, uncertainty of vehicle arrival time and a less protected environment at bus stops or terminals. A study by Alger et al. emphasized variables related to comfort and convenience that are measured by variables such as waiting time, the number of transfers, and seat availability (Guo and Wilson 2004).

A study by Han (1987) finds average transfer penalties equal to approximately 30 minutes in-vehicle time, about the same magnitude estimated for *Interchange III* by Wardman in his review (2001). Han estimated bus-to-bus penalties of about 10 minutes of in-vehicle time for the initial bus stop wait time, and 5 minutes walk time. A penalty estimated for a bus-to-light rail transfer was 17.9 minutes in a study by Hunt (1990). Liu, Pendyala, and Polzin (1997) examined transfer penalties and their effects on mode choice using discrete choice models with stated preference data; they estimated transfer penalties between automobiles and rail (15 minutes) to be substantially higher than between two trains (5 minutes). Liu, Pendyala, and Polzin (1997) speculate that the much higher intermodal transfer penalty is likely due to the fact that a transfer from automobile to a train is more cumbersome than between two trains because in the former the traveler must 1) find a parking spot, 2) traverse the parking lot/structure, 3) possibly purchase a ticket, 4) find the proper platform, and 5) then wait for the train. A similar study by the Central Transportation Planning Staff (CTPS) estimates transfer penalties of 12 to 15 minutes in-vehicle time for transfers among all types of modes (1997). Finally, Wardman, Hine, and Sradling (2001) presents relatively smaller values of transfer penalties: 4.5 minutes in-vehicle time for a bus-to-bus transfer, 8.3 minutes for an auto-to-bus transfer, and 8 minutes for a rail-to-rail transfer. Collectively, while these studies all find substantial penalties associated with transferring, the variance of these penalty estimates is substantial. While this is surely due in part to different types of data analyzed and methods used, it more likely reflects the enormous variance in the transfer experience from city to city, mode to mode, line to line, and trip to trip.

While these studies give a general idea of the valuation of transfer penalties on public transit in general, they do not offer much insight into how the variation in conditions at transfer facilities/locations affects transfer penalties. For example, it is likely that transfer penalties vary substantially among stops and stations within the transit system. To address this point, (Guo and Wilson 2004) conducted a substantially more detailed study of transfer penalties than had previously been conducted, parsing transferring time into walking time, waiting time, other transfer penalties, and the need to use stairs and escalators at different transfer stations in the Massachusetts Bay Transportation Authority (MBTA) subway system. TABLE 6 shows their results: the valuation of transfer penalty in terms of transfer walking time in the Massachusetts Bay Transportation Authority subway system.

TABLE 6 Estimated Subway-to-Subway Transfer Penalties at the MBTA

<table>
<tr><th colspan="2">Varriable number and name</th><th>Underlying factors</th><th>The range of the penalty</th></tr>
<tr><td>1</td><td>Transfer constant</td><td rowspan="2">Model B: 7</td><td rowspan="2">4.8 - 9.7 WT</td></tr>
<tr><td>2</td><td>Walking time</td></tr>
<tr><td>3</td><td>In-vehicle time</td><td rowspan="3">Model C: 1, 4, 5, 6</td><td rowspan="3">4.3 - 15.2 WT</td></tr>
<tr><td>4</td><td>Transfer walking time</td></tr>
<tr><td>5</td><td>Transfer waiting time</td></tr>
<tr><td>6</td><td>Assisted level change</td><td rowspan="3">Model D: 1, 4, 5, 6, 7</td><td rowspan="3">4.4 - 19.4 WT (peak)
2.3 - 21.4 WT (off-peak)</td></tr>
<tr><td>7</td><td>Station dummies</td></tr>
<tr><td>8</td><td>Pedetrian environment dummies</td></tr>
</table>

Note: WT means walking time. Source: (Guo and Wilson 2004)

Guo and Wilson develop different models (labeled B, C, and D in Table 6) using different variables to estimate the penalties of different components of transfers, compared to walking time savings between a subway station and a final destination. They estimate overall transfer penalties of 4.8 to 9.7 minutes of walking time saving depending on the station analyzed (Model B). When they parsed transfers into walking time, waiting time, level changes (escalator, etc.), and other transfer penalties for all stations (Model C), the total transfer penalty is estimated to range from 4.3 to 15.2 minutes of walking time saving, depending on the station. Their results also suggest that the range of transfer penalties perceived by travelers varies more for off-peak trips than for peak trips, probably reflecting the greater variation in the value of time perceived by off-peak travelers compared to peak travelers (Model D). When the estimated value in Table 6 is converted to a relative unit of in-vehicle travel time, the value of transfer penalties ranges from 1.6 to 31.8, and falls within the range of values in the past studies that estimated the value at a particular transfer facility or for the entire system. In short, transit travelers don't like to wait for buses or trains, and they like transferring among buses and trains even less.

In this section, we introduced the concept of transfer penalties that theoretically relate improvements on transit transfers to changes in people's choice of travel mode. We also presented total generalized costs of a typical transit trip that consists of costs of walking time, waiting time, in-vehicle travel time, transfer penalties, mode specific constant, and fare. We showed that approximately 26 percent of the total generalized costs are incurred by transferring for a typical trip, and that a significant reduction of costs can be achieved by reducing waiting and walking time — 18 percent of cost reduction can be achieved if passengers can make a transfer across a platform with no waiting and walking time.

We then reviewed past studies on value of time and the difference between *perceived* time and *actual* time. In short, walking time and waiting time are considered more onerous than in-vehicle travel time, and have values of approximately 1.4 to 1.7 relative to in-vehicle time. The difference between *perceived* time and *actual* time, particularly on waiting and walking, can vary by conditions and environments of the transfer facility. These conditions and environment includes; 1) operational factors, such as headways, reliability, on-time performance of service, and availability of adequate information, 2) physical environmental factors at facilities that are related to safety, security, comfort, and convenience, and 3) conditions on passengers, such as whether they are forced to wait or choose to wait, or whether they can be productive while waiting (Figure 1). Past studies show that transfer penalties have significant costs, and that those costs vary by each transfer facility, by a combination of modes of transferring, and by time of day.

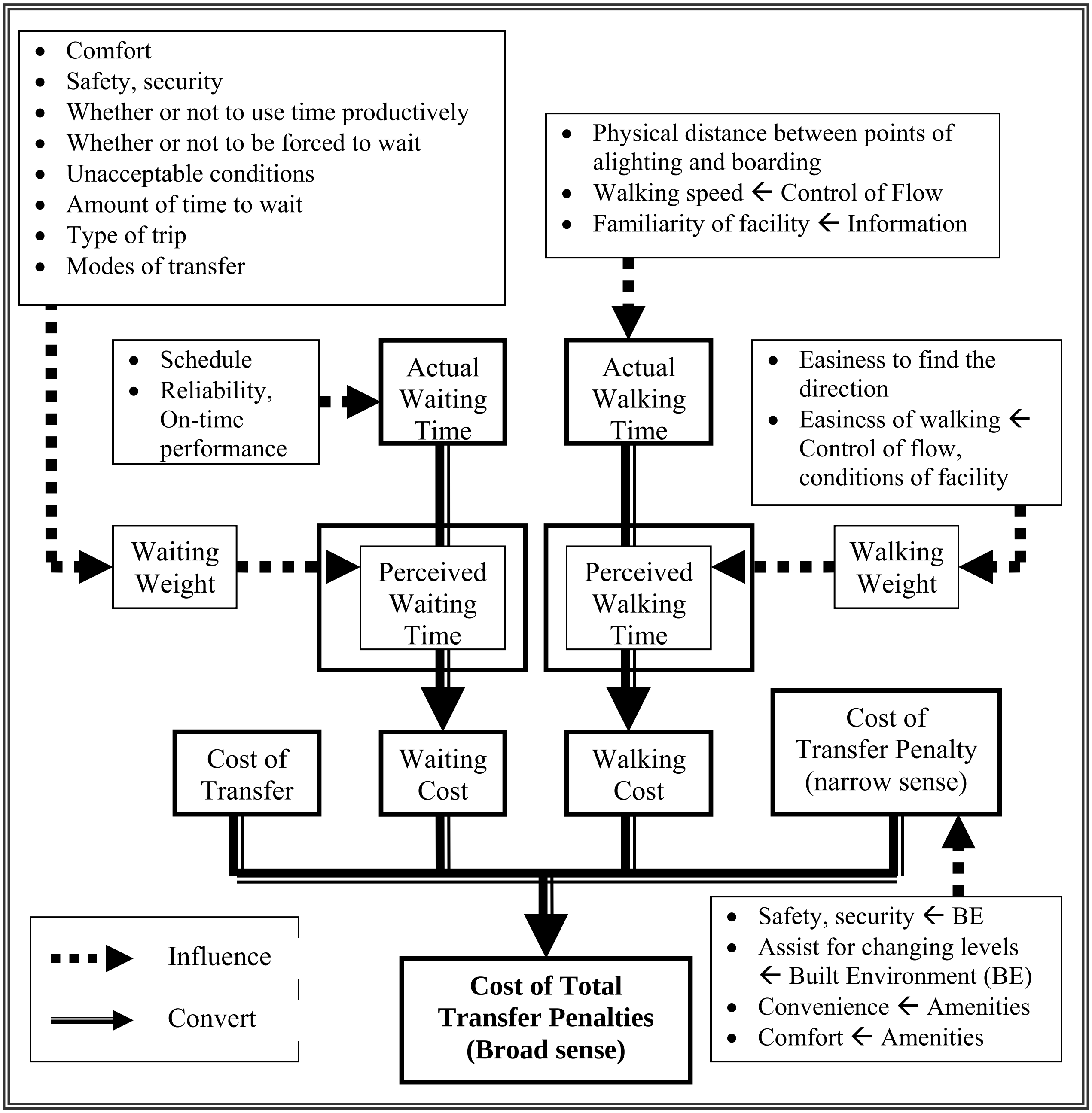
Transit agencies can reduce either *actual* or *perceived* time or both for transferring, and reduce costs associated with transfer penalties. This reduction in costs associated with transfer penalties increases attractiveness of transit trips compared to trips in other modes. In the next section, we review factors that influence transfer penalties in more detail to seek what transit agencies can do to reduce costs associated with transfer penalties.

4. FACTORS INFLUENCING TRANSFER PENALTIES

We have identified conditions and environments that influence generalized costs associated with waiting time, walking time, and transfer penalties. These are: 1) operational factors, such as headways, reliability, on-time performance of service, and availability of adequate information, 2) physical environmental factors at facilities that are related to safety, security, comfort, and convenience, and 3) conditions on passengers, such as whether they are forced to wait or choose to wait, or whether they can be productive while waiting.

Transit agencies can take various measures to lower the generalized cost of transferring that consists of costs associated with perceived waiting time, perceived walking time, transfer penalties, and transfer fare. Figure 1 shows a conceptual framework to determine the generalized cost of transferring or the cost of transfer penalties in a broad sense. Perceived waiting and walking time are determined by actual time and weights of waiting and walking. These components of the generalized cost of transferring are influenced by many factors—attributes, conditions, and environments of transfer facilities. We can group these factors into four groups depending on which component of the generalized cost of transferring each factor influence: 1) monetary cost of a transfer (transfer fare), 2) those that mainly affect the actual time and distance, 3) those that influence people's perception of waiting and walking (or weights of waiting and walking), and 4) those that affect perception of other transfer penalties (in a narrow sense) that are not taken into account by monetary cost, waiting, and walking. Transit agencies can effectively improve these factors to reduce the costs of transferring for transit riders, and this cost reduction in transferring leads to an increase in attractiveness of transit trips compared to trips in other modes.

FIGURE 1 Conceptual Framework to Determine the Cost of Total Transfer Penalties



According to the survey study conducted by Horowitz (Horowitz and Thompson 1995), the first priority at transfer facilities is security and safety. The survey by Shayer (2004) also reveals that transit users consider safety essential and they would not take a trip if they think the security level is inadequate. This is understandable; if travelers have to worry about being mugged or falling from a platform, they would not travel even if a transfer time is only one minute. A certain minimum level of security and safety has to be ensured.

Making a transfer can be more burdensome to users who are not familiar with the transit system and transfer facility. Travelers who are not regular users of a transit facility need to figure out "how to make a transfer, where to transfer, on which corner or bus stop or platform to wait, and so forth" (Reynolds and Hixson 1992). Bad conditions in terms of comfort, security, and safety also make travelers' experience of transit service unpleasant. Among these conditions, uncertainty in schedule and associated long waiting times are the worst to prevent potential transit users from using and re-using the transit service (Reynolds and Hixson 1992).

Table 7 lists factors that can influence either *actual* time or *perceived* time pertinent to transfer penalties and shows the major categories of factors that transit agencies can change and/or improve — transfer fare, time schedule and operation, and attributes of transfer facilities — and their relation to the grouping of factors affecting different components of the transferring cost. Each category is elaborated below.

TABLE 7 Factors Affecting Attributes of Transfer Penalties

	1) Monetary cost of a transfer	2) Factors affecting actual		3) Factors influencing perception of		4) Factors affecting other transfer penalties
		Time	Distance	Waiting	Walking	
Transfer fare	O					
Time schedule						
Vehicle scheduling		O				
Reliability/On-time performance		O		O		
Real-time schedule information		O		O		
Transfer Facilities						
1) Access: Station design to determine distance, control flow, and improve easiness of comprehension			O		O	
2) Connection and reliability: Time Schedule to determine time for transferring		O		O		
3) Information: Information for schedule, facility, and system			O	O	O	O
4) Amenities: Various amenities to enhance comfort and convenience				O	O	O
5) Security and Safety				O	O	O

4.1 Transfer Fare

Taking into account the total costs of a transit trip, a transfer penalty in terms of fare, which is usually less than $2, is not an important component as shown in the hypothetical case in Section

2. However, for a short trip, the fare may comprise a large portion of total costs, and significantly influence whether or not a traveler takes pubic transit. Because of this reason, low-income people may forego taking transit to travel short distances, and choose to walk instead.

4.2 Time Schedule of Transit Service

> "*[T]ime spent waiting, especially the traveler-perceived uncertainty in waiting, intuitively plays an important role in determining travelers' perception of transportation service quality, and, therefore, is an important determinant of transit–customer satisfaction* (Reed 1995)."

Transfer waiting time is determined by *actual* time schedules of vehicles before and after making a transfer. While a rail system generally has very good time schedule reliability with high certainty, a bus system's schedule is not as reliable because buses typically operate in mixed flow traffic and are subject to traffic congestion; however, the operation of exclusive busways dedicated to bus-only travel has much better schedule reliability than conventional bus travel.[17]

In some transit systems, time scheduling sometimes lacks coordination between modes, and significantly increases waiting time for transit users (Parsons Brinckerhoff 2002). Therefore, scheduling and frequency changes are made to reduce overall travel time, especially waiting time, and improve convenience for passengers, so that the overall service quality increases (Evans 2004). While transit users generally avoid transfers, they may not mind transferring when service schedule is certain and reliable. In a study in England, half of transit users chose the transfer service, compared to alternating direct service on the same line, when departure and arrival times for transfer buses were coordinated very well. On the other hand, only 24 percent of passengers used the service with a transfer without transfer service coordination (Tebb 1977).

Vehicle scheduling to coordinate transfers have been examined in the transportation engineering field (Abkowitz 1987; Charles River Associates 1981; Clever 1997; Dessouky 1999; Newman et al. 1983; Sacramento Regional Area Planning Commission. 1978; Sullivan 1975; Systan Inc. 1983; Vuchic et al. 1983). Timed transfers and timed-connections between vehicles are implemented at a point where two transit lines merge with each other in order to minimize waiting time and irregularity associated with transferring (Evans 2004).

Timed transfers reduce transfer time for passengers and improves service levels compared to unscheduled transferring (Abkowitz 1987). Two of the most common types of timed transfers are: 1) multiple vehicles converging at a transfer center or "focal point" to allow passengers from all vehicles to switch from any vehicle to any other vehicle before all vehicles' departures from the center,[18] and 2) coordinating arrival and departure times to allow passengers from both vehicles to switch to the other vehicle by keeping the first arriving bus waiting for a sufficient amount time (Abkowitz 1987; Reynolds and Hixson 1992). In addition, local suburban timed-

---

17 While transfers are unavoidable in most transit systems, the level of needs in transfers depends partially on the type of transit system—a grid system, a hub-and-spoke system, and a combination of both. In general, a hub-and-spoke system requires transfer facilities to a larger degree than in a grid system, and therefore becomes more capital intensive. Availability of capital subsidy often gives transit agencies an incentive to more capital incentive projects, such as such as rail systems, transit malls, and transfer facilities, and conversion of a transit system to a hub-and-spoke system requires alternation of service routes and scheduling. However, their effects on the improvements of service quality and on ridership are unknown due to a lack of study.

18 "Timed transfer points have a many-to-many transferring pattern (Reynolds and Hixson 1992). It means that some traveler must walk a distance to make a transfer, and may have to cross streets."

transfer lines at a transfer center combined with a trunk line that serves downtown eliminate bus trips that directly connect suburbs to downtown, and may save substantial operating costs for an operator (Evans 2004).

A timed-transfer system at two transit centers was introduced to Oregon's Westside community in 1979. Its high service reliability and schedule efficiency contributed to a significant increase in ridership both in the peak and off-peak periods, while it should be noted that the 1979 gas shortage occurred during the changes (Kyte, Stanley, and Gleason 1982; Charles River Associates 1997). In a survey study of the Tidewater region in Norfolk, Virginia, the majority of users showed positive responses to service changes after an operator implemented an elaborate multiple hub system, in which trips with transfers shared 40 to 45 percent of bus trips, to reduce the operating subsidy (Charles River Associates 1997). This shows timed-transfers can significantly improve users' perceptions about service quality while its effect is hard to quantify.

When service is frequent enough, people may not perceive waiting as so much of a burden. When people know the service schedule with a high degree of certainty, they can adjust their arrival to a transit facility to reduce waiting time (Reed 1995; Evans 2004). Because of its readily available schedules and dependable service, people generally perceive waiting time for commuter trains less burdensome than for irregular bus service (Evans 2004). Therefore, reduction in the uncertainty (or increase in reliability) in waiting time is likely to reduce the disutility (or increase the utility) of transit service (Reed 1995).

Even if it is difficult to have on-time operation of transit service, people's perception of waiting time becomes significantly better when they have information on the arrival of the next bus. Therefore, real-time schedule information has the potential to significantly reduce the burden of waiting time for travelers by reducing the uncertainty of wait time for the next bus (Reed 1995).

In addition, schedules that are systematic and easy for transit users to remember may have positive effects on transit usage (Pratt and Bevis 1977). While any quantitative evidence is not available to support this argument, Webster and Bly (1980) provide anecdotal evidence. They state that ridership increased when bus arrival schedules are set at simple "clockface" times, such as 10 minutes, 30 minutes, and 50 minutes after each hour. The "clockface" scheduling practice was one of the service changes made by Omnitrans in Riverside, California, whose ridership increased by 20.4 percent between 1995 and 1996.

4.3 Transfer Facilities

Physical attributes of transfer facilities can potentially affect walking time, walking effort, waiting time, waiting effort, convenience, comfort, safety, and indeed many other components of transfer burdens. (Guo and Wilson 2004) found that transfer penalties were lower where escalators allowed passengers to change levels at transfer stations. In general, "passenger friendly" and "user friendly" transfer facility attributes (Parsons Brinckerhoff 2002) can be grouped into five categories described below.

First, facility design can affect *access* by defining the distance between alighting and boarding locations, improving off-vehicle passenger flow, and providing clear and comprehensible direction. Perimeter-oriented bus depots, for example, have been shown to transfer walk distances and inhibit pedestrian flows (Parsons Brinckerhoff 2002). Further, confusing or incomplete signage, poorly located ticket machines and information kiosks can significantly increase both the actual and perceived distances walked in transfer facilities.

Connection and reliability are determined by time schedules and schedule adherence, and have been repeatedly shown to have a strong influence on transfer burdens and transit use. Complete, concise, and easy-to-understand *information* has been shown to reduce the actual (by reducing wandering) and perceived burden of transferring, especially for new or occasional transit users (Parsons Brinckerhoff 2002).

Amenities, such as benches, shades, water fountains, and rest rooms, affect comfort and convenience while passengers are waiting and transferring. Through increased comfort and convenience, these amenities can affect perception of waiting and walking time as well as other burdens of transferring.

Lastly, *security and safety* also influence perception of waiting, walking, and transfer burdens. Safety and security can be a "deal breaker;" levels of perceived risk exceed thresholds over which travelers will no longer consider traveling by transit, and will instead travel by other modes or forgo the trip entirely.

Thus, we can systematically link various transit stop and station attributes to travel behavior by using a transfer penalties framework. These five types of stop and station attributes, plus wait, walk and transfer time and fares can all increase or decrease the perceived burdens of transit travel. Unfortunately, few studies have systematically examined these factors and, importantly, their relative importance; it is still difficult to make any statement on *how important* improvements of transfer facilities are in increasing ridership compared to other measures that transit agencies can take.

In addition, it should be noted that increasing ridership is not necessarily a main objective of transfer facilities. Only three transit agencies out of ten indicated that increasing ridership was a primary objective of the facility in the survey conducted by the Institute of Transportation Engineers (Hocking 1990). The survey reveals that common objectives of transfer facilities are to: 1) provide a rest area for operators, 2) enhance the public's image of transit, 3) provide a civic facility, 4) aid downtown development or revitalization, and 5) enhance passenger convenience by providing riders with protection from weather, facilitating a better waiting environment, and reducing the potential for accidents (Hocking 1990). Taking into account these multiple objectives of transfer facilities, even after the strong relationship is identified between improvements of transfer facilities and ridership, it might be difficult to allocate scarce resources to improve transfer facilities that are significant enough to positively affect people's travel behavior and result in an actual ridership increase.

5. SUMMARY AND CONCLUSIONS

In this initial report, we have drawn from the travel behavior literature to propose a *transfer penalties* framework within total travel costs of transit trips and *value of time* in order to more systematically evaluate how attributes of transit wait/walk times and transfers influence people's travel behavior. In doing so we have suggested a classification of factors relating to out-of-vehicle travel time (waiting, walking, transferring, etc) to show which aspect of transfer penalties would likely be affected by various improvements to transit service, stops, and stations. In doing so, we have offered a basis for developing methods to systematically evaluate the connectivity performance of transit stops and stations. Using this conceptual framework, we can systematically implement improvements to both the operation and physical environment of transit stops and stations to reduce the *total generalized cost* of transit trips and subsequently improve such facilities' overall connectivity. When the total generalized cost of a trip by transit is lower than that by car, a traveler will choose transit over driving. Finally, and more substantively, the merits of focusing more on improving perceived out-of-vehicle travel times are compelling, and that the potential to cost-effectively increase transit use may be substantial.

Our travel behavior framework suggests that there are three areas where transit agencies can reduce wait/walk/transfer burdens: (1) transfer fares, (2) operational aspects of service that influence transfers, such as headways and on-time arrival, and (3) the physical attributes of stops and stations, such as transfer walking distance, lighting, seating, signage at stops and stations, streamlining pedestrian flows at crowded stations, protection from the elements, and visibility. Such attributes may be classified into five categories: 1) access, 2) connection and reliability, 3) information, 4) amenities, and 5) security and safety. In particular, the literature suggests that improved schedule-adherence (or on-time performance) is one of the most effective ways that transit systems can reduce wait/walk/transfer burdens and cost-effectively increase ridership.

Other major findings from this literature review are summarized below.

1. External factors have the strongest influence on transit ridership. However, *indirect* and *direct policy measures* have only limited impact on attracting more transit riders. Incremental improvements in factors internal to transit agencies are still important to make a difference in transit ridership in the overall objective to publicly provide transit service.

2. Within a typical transit trip, a transfer involves about one quarter of total generalized costs (or time). Obviously, the shorter the trip, the more significant the impact of the transfer.

3. Among several factors associated with a transit transfer, waiting time is generally the most important component to determine total generalized costs (and time) as long as safety and security are ensured. The time schedule and certainty of vehicle arrival time are two important factors to determine *actual* waiting time.

4. In comparison to *actual* waiting time, *perceived* waiting time is very important to determine whether or not a traveler uses transit service. Perceived waiting time is affected by factors, such as safety, security, comfort, whether a wait is forced or not, acquired knowledge about the arrival of the next vehicle, and so on.

5. To improve the quality of transit transfers, transit agencies can work on: 1) operational aspects that influence transfers, such as time schedule, on-time vehicle arrival, and transfer fare, and 2) physical aspects of transfer facilities, such as distance to make a transfer, lighting, seating, signage, streamlining circulation lines, protection from weather, and visibility. It is also an option for facility management to provide various shops, such as news stands, coffee shops, convenience stores, and other commercial establishments as amenities at transfer facilities.

6. Physical aspects of transfer facilities can affect the walking time to travel between locations where people alight and board vehicles for a transfer. They can also influence people's experience at facilities, and therefore people's perception of waiting time, walking time, and transfer penalties.

While what transit agencies can do to increase ridership is limited, incremental improvements of transit service is still important to address many issues, such as provision of mobility and accessibility of transit dependents and reduction of traffic congestion and air pollution. While there is a substantial body of research on how walking and waiting affect transit patronage, the research on the physical aspects of transit stops and stations tends to be far less rigorous, more anecdotal, and more descriptive. More careful empirical research in this area is clearly needed, particularly regarding the *relative importance* of various attributes of transit stops and stations – though it is unlikely that physical improvements to transit facilities, no matter how adroit, could have the same magnitude of effects on transfer penalties and, hence, ridership as service improvements such as reduced headways or improved schedule adherence. In addition, transit agencies may not have jurisdictional authority at transfer points, and it may require tremendous effort to change the physical aspects of transfer facilities.

6.0 BIBLIOGRAPHY

Abkowitz, Mark David. 1987. Operational feasibility of timed transfer in transit systems. *Journal of transportation engineering* 113 (2):168-177.

Algers, Staffan, Stein Hansen, and Goran Tegner. 1975. Role of Waiting time, comfort, and convenience in model choice for work trip. *Transportation research record* 534:38-51.

Barton-Ashman Associates, Inc. 1993. Estimation, Calibration, and Validation of the Houston Mode Choice Model. Technical Report. In *Prepared for Metropolitan Transit Authority of Harris County*. Houston, TX.

Bly, P. H., F. V. Webster, and Susan Pounds. 1980. Subsidisation of urban public transport. Crowthorne, Eng.: Transport and Road Research Laboratory.

Boile, Maria P., and James G. Gaspard. 2002. Evaluating the Efficiency of Transportation Services on Intermodal Commuter Networks. *Journal of Transportation Research Forum. Published in Transportation Quarterly* 56 (1).

Bookbinder, James H., and Alain Desilets. 1992. Transfer Optimization in a Transit Network. *Transportation Science* 26 (2):22.

Bruzelius, Nils. 1979. *The value of travel time: theory and measurement*. London: Croom Helm.

Central Transportation Planning Staff (CTPS). 1997. Transfer penalties in urban mode choice modeling. In *Report prepared for the travel model improvement program*: FTS, U.S. Department of Transportation.

Cervero, Robert. 1990. Transit pricing research: a review and synthesis. [117]-139.

Charles River Associates, Inc. 1981. Use and consequences of timed transfer on U.S. transit properties. Boston, Mass.

———. 1997. Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies That Influence It. In *TCRP Report 27*. Washington, D.C.: Transportation Research Board.

Chowdhury, Shoaib, and Steven Chien. 2001. Dynamic Vehicle Dispatching at Intermodal Transfer Station. Paper read at Transportation Research Board Annual Meeting, at Washington, D.C.

———. 2001. Optimization of Transfer Coordination for Intermodal Transit Network. Paper read at Transportation Research Board Annual Meeting, at Washington, D.C.

Clever, Reinhard. 1997. Integrated timed transfer: a European perspective. *Transportation research record* 1571:109-115.

Committee on Intermodal Transfer Facilities, Transportation Research Board. 1974. Intermodal Transfer Facilities Research Needs. *Transportation Research Record* 505:43-46.

Currie, Graham. 2005. The Demand Performance of Bus Rapid Transit. *Journal of Public Transportation* 8 (1):41-55.

Dessouky, Maged. 1999. Bus dispatching at timed transfer stations using bus tracking technology. *Transportation research. Part C, Emerging technologies* 7C (4): [187]-208.

Domencich, T. A., F. Kraft, and J. Valette. 1968. Estimation of urban passenger travel behavior: An economic demand model. *Highway Research Record* 238:64-78.

Evans, John E. 2004. Chapter 9 - Transit Scheduling and Frequency. In *Traveler Response to Transportation System Changes*. Washington D.C.: Transportation Research Board.

Fruin, John J. 1985. Passenger Information Systems for Transit Transfer Facilities. In *Synthesis of Transit Practice, 7*, edited by N. C. T. R. D. P. (U.S.). Washington, D.C.: Transportation Research Board National Research Council.

Garrett, Mark, and Brian D. Taylor. 1999. Reconsidering Social Equity in Public Transit. *Berkeley Planning Journal* 13:6-27.

Gaudry, Marc. 1974. An Aggregate Time-Series Analysis of Urban Transit Demand: The Montreal Case. *Transportation Research* 9:249-258.

Guo, Zhan, and Nigel H.M. Wilson. 2004. Assessment of the Transfer Penalty for Transit Trips: Geographic Information System-Based Disaggregate Modeling Approach. *Transportation Research Record* 1872:10-18.

Han, Anthony F. 1987. Assessment of Transfer Penalty to Bus Riders in Taipei: A Disaggregate Demand Modeling Approach. *Transportation research record* 1139:8-14.

Hess, Daniel, Jeffery Brown, and Donald Shoup. 2005. Waiting for the Bus. *Journal of Public Transportation* 7 (4):67-84.

Hocking, R. J. 1990. Effectiveness of Downtown Transit Centers. *ITE Journal*.

Holland, D.K. 1974. A Review of Reports Relating to the Effects of Fare and Service Changes in Metropolitan Public Transportation Systems. St. Louis, MO: Center for Urban Programs, St. Louis University.

Horowitz, Alan J., and Nick A. Thompson. 1995. Generic objectives for evaluation of intermodal passenger transfer facilities. *Transportation research record* 1503:104-110.

Hu, Pat S., and Timothy R. Reuscher. 2004. Summary of Travel Trends: 2001 National Household Travel Survey, edited by U. S. D. o. Transportation and F. H. Administration. Washington, D.C.: Center for Transportation Analysis Oak Ridge National Laboratory

MacroSys Research and Technology.

Hunt, John D. 1990. A logit model of public transportation route choice. *ITE Journal* 60 (2):26-30.

ITE Technical Council Committee 5C-1A. 1992. The Location and Design of Bus Transfer Facilities. *ITE Journal*:33-37.

Kim, K.H. 1998. Technical Specifications for the March 1998 Travel Demand Model. Portland, OR: Metro Transportation Department.

Kittelson & Associates, Inc., et al.,. 2003. Transit Capacity and Quality of Service Manual - 2nd Edition - Part 3 Quality of Service and Part 7 Stop, Station, and Terminal Capacity. In *TCRP Report 100*, edited by T. R. Board. Washington, D.C., 2003.: National Academic Press.

Kyte, M., K. Stanley, and E. Gleason. 1982. Planning, Implementation, and Evaluation of a Timed-Transfer System in Portland, Oregon's suburban Westside. Paper read at Annual Meeting of the Transportation Research Board, at Washington D.C.

Lave, Charles A. 1985. *Urban transit : the private challenge to public transportation*, *Pacific studies in public policy*. San Francisco, Calif., Cambridge, Mass.: Pacific Institute for Public Policy Research; Ballinger Pub. Co.

Liggett, Robin, Anastasia Loukaitou-Sideris, and Hiroyuki Iseki. 2001. Bus stop-environment connection : do characteristics of the built environment correlate with bus stop crime? *Journal of the Transportation Research Board* 1760:20-27.

Liu, Rongfang, Ram M. Pendyala, and Steven Polzin. 1997. Assessment of intermodal transfer penalties using stated preference data. *Transportation research record* 1607:74-80.

London Transport. 1996. The value of time. In *Research Note M(96)01*. London.

Loukaitou-Sideris, A., R. Liggett, and H. Iseki. 2002. The geography of transit crime - Documentation and evaluation of crime incidence on and around the green line stations in Los Angeles. *Journal of Planning Education and Research* 22 (2):135-151.

Loukaitou-Sideris, A., R. Liggett, H. Iseki, and W. Thurlow. 2001. Measuring the effects of built environment on bus stop crime. *Environment and Planning B-Planning & Design* 28 (2):255-280.

Martinez, Manuel J. 2003. Value of Facilities and Attributes of New Heavy Rail and Bus Rapid Transit Projects in a Developing City. The Case of Lima, Peru. Paper read at Transportation Research Board Annual Meeting, at Washington, D.C.

Mass Transportation Commission, McKinsey & Co., Systems Analysis and Research Corp., and Joseph Napolitan & Assoc.,. 1964. Mass Transportation in Massachusetts. Massachusetts.

McGillivrary, R.G. 1969. Binary choice of transport mode in the San Francisco Bay Area. Ph.D. Dissertation, University of California, Berkeley, Berkeley.

Moreau, Agnès. 1992. Public transport waiting times as experienced by customers : marketing research involving the Grenoble system. *Public transport international* 41 (3):52-68.

MVA Consultancy, ITS University of Leeds, TSU University of Oxford. 1987. Value of travel time savings. In *Policy Journals*. Newbury, Berks.

Newman, Debra A., Juliet McNally, Marlies Bebendorf, United States. Urban Mass Transportation Administration. Office of Service and Management Demonstrations., Transportation Systems Center., and Systan Inc. 1983. Timed transfer : an evaluation of its structure, performance and cost : final report. In *UMTA/TSC project evaluation series*. Washington, DC: Urban Mass Transportation Administration Office of Service and Management Demonstration : For sale by the Supt. of Docs. U.S. G.P.O.

Ortuzar, Juan de Dios, and Luis G. Willumsen. 2004. *Introduction" in Modeling Transport, Third Edition*. West Sussex, England: John Wiley & Sons, LTD.

Paine, F.T., A. N. Nash, S. J. Hille, and G.A. Brunner. 1967. Consumer Conceived Attributes of Transportation: Attitued Study. College Park: University of Maryland.

Parsons Brinckerhoff. 2002. Intermodal Facilities. *PB network*, May 2002.

Parsons Brinckerhoff Quade and Douglas Inc. 1993. Calibration of the Mode Choice Models for the Minneapolis-St. Paul Region. In *Prepared for the Metropolitan Council*.

———. 1998. Cleveland Regional Travel Demand Forecasting Model Documentation Report. In *Prepared for the Greater Cleveland Regional Transit Authority and the Northeast Ohio Areawide Coordinating Agency*.

———. 1999. Travel Demand Model Development Methodology Report. In *North Illinois Regional Commuter Railroad Corporation (METRA)*.

Pratt, R.H., and H.W. Bevis. 1977. An Initial Chicago North Suburban Transit Improvement Program 1971-1975 - Vol. I: Report and Exhibits - Vol II: Technical Supplement: Urban Mass Transit Administration, U.S. Department of Transportation.

Pratt, Richard H., and John E. Evans. 2004. Chapter 10 - Bus Routing and Coverage. In *Traveler Response to Transportation System Changes*. Washington D.C.: Transportation Research Board.

Rabinowitz, H. Z., Edward A. Beimborn, Peter S. Lindquist, and Donna M. Opper. 1989. Market Based Transit Facility Design, edited by U.S. Department of Transportation. Washington, D.C.: Urban Mass Transportation Administration.

Reed, Thomas B. 1995. Reduction in the burden of waiting for public transit due to real-time schedule information : a conjoint analysis study. Paper read at Vehicle Navigation and Information Systems Conference (6th : 1995 : Seattle, Wash.). at Piscataway, N.J.

Reynolds, Marilyn M., and Charles D. Hixson. 1992. Transit vehicle meets system : a method for measuring transfer times between transit routes. *Transportation research record* 1349:35-41.

Sacramento Regional Area Planning Commission. 1978. Development of a multi-destination, timed transfer transit system in Sacramento (phase I) : technical supplement to the 1978 regional transit general plan. Sacramento, Calif.: The Commission.

Shayer, Yelena. 2004. Intermodal Transfer Comparison between the User and the Supplier Points of View. Paper read at Transportation Research Board Annual Meeting, at Washington, D.C.

Steer Davies Gleave. 1997. Transport quality and values of travel time. In *Prepared for TRENEN II STRAN*: Trinity College Dublin.

Sullivan, Brian E. 1975. The timed transfer focal point : a refinement in public transport service design. Vancouver, B.C.: Bureau of Transit Services Dept. of Municipal Affairs Province of British Columbia.

Systan Inc. 1983. Timed transfer: An evaluation of its structure, performance and cost. In *UMTA/TSC project evaluation series*. Washington, D.C.: U.S. Department of Transportation, Urban Mass Transportation Administration.

Taylor, Brian D, Peter Haas, Brent Boyd, Daniel B. Hess, Hiroyuki Iseki, and Allison (in alphabetical order for all but PIs) Yoh. 2002. Increasing Transit Ridership: Lessons from the Most Successful Transit Systems in the 1990s. San Jose, California: The Norman Y. Mineta International Institute for Surface Transportation Policy Studies, College of Business, San Jose State University.

Tebb, R.G.P. 1977. Passenger Resistance to a Rural Bus - Bus Interchange. Crowthorne, Berkshire, England: Transport and Road Research Laboratory.

Transport and Road Research Laboratory. 1980. The Demand for Public Transport. In *Report of the International Collaborative Study of the Factors Affecting Public Transport Patronage*. Crowthorne, Berkshire.

Transport and Travel Research Limited., and European Commission. Directorate-General Transport. 1996. *Transport research. effectiveness of measures influencing the levels of public transport use in urban areas*. Luxembourg, Lanham, Md.: Office for Official Publications of the European Communities; UNIPUB distributor.

U.S. Environmental Protection Agency. 2000. COMMUTER Model Coefficients. Washington, D.C.

Vuchic, Vukan R., Richard Clarke, Angel Molinero, United States. Urban Mass Transportation Administration. University Research and Training Program., Technology Sharing Program (U.S.), and University of Pennsylvania. Dept. of Civil and Urban Engineering. 1983. Timed transfer system planning, design, and operation : final report. Washington, D.C.: U.S. Dept. of Transportation.

Vuchic, Vukan R., and Shinya Kikuchi. 1974. Design of Outlying Rapid Transit Station Areas. *Transportation Research Record* 505:1-12.

Wachs, M. 1981. Pricing urban transportation: A critique of current policy. *Journal of the American Planning Association* 47:243-251.

Wardman, Mark. 1998. The value of travel time : a review of British evidence. *Journal of transport economics and policy* 32 (3):285-316.

———. 2001. A review of British evidence on time and service quality valuations. *Transportation research. Part E, Logistics and transportation review* 37E (2-3):107-128.

Wardman, Mark, Julian Hine, and Stephen Stradling. 2001. Interchange and travel choice volume 1: Scottish Executive Central Research Unit.

Webster, F. V., and P. H. Bly. 1980. The Demand for Public Transport. Crowthorne, Berkshire, England: Transport and Road Research Laboratory.

Webster, F.V. 1977. Some implication of the results of elasticity determinations. In *TRRL Supplementary Report*. Crowthorne: Transport and Road Research Laboratory.

APPENDIX B

Appendix B

Evaluating Connectivity Performance at Transit Transfer Facilities (Deliverable #2)

Under Contract 65A0194 for Project
Tool Development to Evaluate the Performance of
Intermodal Connectivity (EPIC) to Improve Public Transportation

Submitted to:

Bruce Chapman
California Department of Transportation
Division of Research and Innovation
1227 'O' Street, 5th Floor
Sacramento, CA 94273-0001

Prepared by:

Hiroyuki Iseki[1], Mark Miller[1,2], Adina Ringler[1], Michael Smart[1], and Brian D. Taylor[1]

[1]Institute of Transportation Studies
University of California, Los Angeles
School of Public Affairs
3250 Public Policy Building, Box 951656
Los Angeles, CA 90095-1656

[2]California PATH Program
Institute of Transportation Studies
University of California, Berkeley
Richmond Field Station, Bldg. 452
1357 S. 46th Street
Richmond, CA 94804

February 12, 2007

EXECUTIVE SUMMARY

This report constitutes the second deliverable for the Project "Tool Development to Evaluate the Performance of Intermodal Connectivity (EPIC) to Improve Public Transportation" under Contract 65A0194 with Caltrans. Our primary objective in this project is to develop an evaluation tool that transit agencies can use to assess the quality of service at transit transfer facilities and use the findings of such evaluations to improve travel connectivity. Such improvements, can, in turn, help the overall transportation system operate more smoothly and can make transit a more attractive travel option and thus can eventually contribute to increases in ridership. In this report we evaluate the performance of transit transfer facilities by identifying factors from the literature most relevant to transit connectivity.

We classify these factors from three perspectives: 1) passengers/users, 2) transit operators, and 3) neighboring communities. While all three of these perspectives are important we argue that passengers/users' factors should be given priority over other considerations in designing or renovating transfer facilities because users are the raison d'etre of public transit. Transit users' main requirements for transfer facilities are related to the ease in use of facilities for making transfers, including: 1) minimal transfer time and distance, 2) convenience, 3) comfort, and 4) safety and security. But while customers may be the priority, transit operators can have separate design and operational concerns as well. These include capacity, flexibility of operation, capital and operating costs, facility location, surrounding environment, demand and traffic volume by access mode, and operating requirements by mode. Third, all transit transfer facilities relate to and interact with the surrounding neighborhood and districts; that is, they interact with 1) people who live and/or work near the facility, and 2) business people who own and operate commercial establishments in the vicinity of the facility. A facility's presence in the surrounding community may be felt in positive terms by contributing to development of the surrounding neighborhood, enhancing community pride and facilitating cultural preservation, as well as the negative impacts of increased traffic congestion, additional noise and air pollution from buses and creating unsightly visual aspects.

For the passengers/users perspective, we focused on the facility's physical attributes, which we classified into five categories: 1) access, 2) connection and reliability, 3) information, 4) amenities, and 5) security and safety. For the *security/safety* category, criteria include having security personnel and video surveillance equipment, extent of visibility and lighting, means of communication for emergencies, and infrastructure such as police kiosks/sub-stations and guardrails. For *amenities*, criteria include comfort and convenience, service and commercial enterprises, weather protection, and having an aesthetically pleasing/clean environment. For *information*, the criteria are divided into what, where, and how the information is communicated to facility users. There are numerous types of information that can be communicated to passengers/users including station name, entrances and exits, maps, schedules, ticket purchases and fares, directions to gates, and arrival/departure times. Information can be provided to users either outside or inside the transfer facility and can be conveyed visually on television or computer monitors, posted signs, and paper, or orally by audio announcements of recorded or real-time information. *Access* is a function primarily of facility design consisting of the facility's physical infrastructure and its layout, the management of passenger flow, and directional information provided to facility users whether inside or outside the facility. Examples of physical infrastructure inside include stairways, elevators and escalators; while outside the facility include parking structures. Generally, passenger flow is managed through directional signs that efficiently and effectively guide people to various destinations within the facility. Examples of passenger flow management schemes include separation of pedestrians and vehicles outside the facility, and pedestrian pathways and circulation plans inside the facility. Examples of directional information include departure gate location, information kiosks, and ticket machines. For *connection and reliability*, the former deals with the distance and time needed for passengers to complete their transfer. Ideally, a transfer facility should be designed so that passengers who make a transfer do not have to walk long distances, especially in any type of unpleasant environment. Reliability deals with how well the schedule adherence of vehicles is maintained.

From the transit operators' perspective, we identified numerous criteria, which we organized into four groups: fiscal (costs & revenues), institutional and coordination, passenger processing, and environmental. The *fiscal* aspects of operating a transit transfer facility are clearly significant to the transit operator(s) running the facility. Some of these criteria are specifically listed in terms of minimizing component or total costs of facility operation including total cost, operating cost, maintenance, and investment cost. Other cost-related factors include minimizing wasted space, maximizing income from non-transport activities, and utilizing energy efficiently. Transit transfer facilities with multiple transit service providers, modes, and/or lines will involve *institutional and coordination* issues about which the transit operator(s) is concerned, especially about transfer fares, coordination of schedules, and provision of information to travelers. *Passenger processing* criteria refer to the functional facility components together with their arrangements within the facility including 1) internal pedestrian movement areas such as passageways and stairs, 2) line haul transit access areas, 3) components that facilitate movements between access modes and the transfer facility such as ramps and automatic doors, and 4) communications (information and directional graphics, public address system). The *environmental* quality of a transit transfer facility involves aspects with which facility users associate their comfort, convenience, safety, and security. Typical safety standards include fire prevention and accident reduction measures. Security provisions are used to protect against or in response to crime, vandalism, or terrorism. Amenity-related environmental aspects for comfort and convenience are not directly associated with the movement of people; rather these aspects concern the physical environment through which they move.

From the neighboring communities' perspective, we identified numerous criteria, which we grouped into six categories: community image and pride, joint development and partnerships, safety and security, environmental impacts, neighboring economy / local employment, and physical and social impacts on neighboring land uses. The *community image and pride* category deals with the cultural impacts of the transfer facility in the surrounding neighborhood, compliance of the facility with historic significance and preservation requirements, the quality of its architectural design and sense of place. *Joint development* involves the public and private sectors in the community brought together in the planning, design, and operation and maintenance of the facility by means of the establishment of community partnerships. *Safety and security* on a personal as well as on a group level is of prime importance when it comes to crime and vandalism if a transit transfer facility is to be regarded as a community asset. The e*nvironmental impacts to the surrounding neighborhood* deal with the levels of air pollution emissions, noise, unsightliness and energy consumption and how this affects community acceptance of the facility. The *neighborhood economy and local employment* criteria deal with business opportunities the facility helps to generate, especially for informal vending carts and vehicles that can move from place to place during facility construction, operations, and maintenance. The *physical and social impacts on neighboring land uses* criteria deal with flexibility for expansion of the facility, conflicts with surrounding land uses, land acquisition, urban renewal, and physical and social impacts of the facility to the surrounding neighborhood.

While the literature discusses numerous evaluation criteria from the passengers'/users', transit operators', and neighboring communities' perspectives, much of the literature provides only simple lists of such criteria with which to evaluate transfer facilities. Some of the reviewed studies have only criteria that tend to be broadly-worded and there are only a few studies that provide specifics of transfer facilities for evaluation. In addition, many studies provide evaluation criteria without clearly specifying from whose perspective these criteria should be used for an evaluation. As a result, the literature generally does not provide sufficient information on 1) what criteria should be used to perform a transfer facility evaluation, 2) how to use such criteria for evaluation purposes, and 3) from whose perspective do such criteria refer and matter.

Key words: transit transfer facilities, evaluation, users, transit operators, neighboring communities

TABLE OF CONTENTS

LIST OF TABLES PAGE

PREFACE / OVERVIEW

The research project, *Tool Development to Evaluate the Performance of Intermodal Connectivity (EPIC) to Improve Public Transportation*, is investigating the state of practice of evaluating transit connectivity at transfer facilities. This research, especially its final product deliverable, will assist the California Department of Transportation (Caltrans), regional and local transportation related entities, transit operators, and other stakeholders in evaluating interconnectivity issues pertaining to travel and in identifying opportunities and solutions for improving transportation systems. This project addresses Caltrans' 2005/2006 goals of *Flexibility* and *Productivity* by providing tools to improve multimodal and intermodal transportation systems that maximize safety, security, reliability, mobility, and access.

This report is the second deliverable for the project and expands considerably on the first deliverable, which was also a review of the literature. In the first deliverable, we focused on the travel behavior literature and proposed a transfer penalties framework within total travel costs of transit trips and value of time in order to more completely explain how attributes of transit wait/walk times and transfers influence people's travel behavior. From this framework we also suggested a classification of factors relating to out-of-vehicle travel time (waiting, walking, transferring, etc) to show which aspect of transfer penalties would likely be affected by various improvements to transit service, stops, and stations. This framework has provided a basis for developing methods to systematically evaluate the connectivity performance of transit stops and stations and from this framework, improvements to both the operation and physical environment of transit stops and stations can be implemented to reduce the total generalized cost of transit trips and thus contributing to changes in traveler behavior in favor of taking transit.

The travel behavior framework suggested that there are three areas where transit agencies can reduce wait/walk/transfer burdens: (1) transfer fares, (2) operational aspects of service that influence transfers, such as headways and on-time arrival, and (3) the physical attributes of stops and stations, such as transfer walking distance, lighting, seating, signage at stops and stations, streamlining pedestrian flows at crowded stations, protection from the elements, and visibility. While there is a substantial body of research on how walking and waiting affect transit patronage, the research on the physical aspects of transit stops and stations tends to be far less rigorous, more anecdotal, and more descriptive. We suggested that more careful empirical research in this area is needed, particularly regarding the *relative importance* of various attributes of transit stops and stations.

In this report, we focus our review of the literature on the evaluation of connectivity performance at transfer facilities by identifying those evaluatory criteria or factors that are relevant to understanding the achievement of transit connectivity. We formulated a three-way classification of such factors consisting of 1) passengers/users, 2) transit operator, and 3) neighboring community perspectives and our research investigates those factors at transfer facilities that are important from 1) transit users' perspective to determine what influences ─ and by how much ─ their travel behavior based on the transfer penalties framework, 2) operators' perspective to improve efficiency in transit service operation, and 3) community perspective to benefit from the presence and provided services of facilities.

This research is the next step in developing an evaluation tool to assess the performance of transit connectivity to improve public transportation. By identifying these factors, we have established the foundation with which to prepare for the next step in our analysis to determine the important attributes of transfer facilities that can ultimately contribute to ridership increases: Conducting transit facility-specific case studies.

1. INTRODUCTION

> "*Intermodal transfer facilities are interchanges between transportation subsystems. They range from relatively simple bus or rail platforms to multimodal regional transportation centers or large airport terminals. Because intermodal transfer facilities are expensive to construct and operate, it is important to optimize their functions"* (Committee on Intermodal Transfer Facilities 1974).

> *"Transfer facilities are also the connecting links of the transit network; their number and location determine both the range of trip opportunities that can be served and the utility of the system"* (Fruin 1985).

Planning and designing for transfer facilities requires the determination of many factors, such as location, size, configuration, equipment, information to be provided, and effects on the transportation network, the region, and the neighboring community. Transfer facilities play an important role in connecting multiple transportation systems — both *intermodal* and *intramodal*. The effectiveness of connectivity influences travelers' experience at transfer facilities because making a transfer is usually necessary to reach their final destination. When connections are poor, transfers become burdensome for transit users and discourage people from using transit service. (Committee on Intermodal Transfer Facilities 1974). Moreover, poor connectivity

> *"creates barriers that impede customers' ability to make efficient multi-operator trips. When connectivity is poor, multi-operator transit trips are frustrating, time-consuming, and costly, lowering service quality for users and making transit unattractive for new customers."* (MTC Transit Connectivity Study, 2006).

Whereas good connectivity is

> *"reflected in a convenient and 'seamless' transit system by reducing travel times, providing more reliable connections, making it easier to pay and ensuring that transfers are easy and safe."* (MTC Transit Connectivity Study, 2006)

Alternatively, private automobile trips typically consist of longer legs of driving and shorter segments of walking in which people do not perceive any disconnect for their trip unless they have to park their car very far from their destination. The disconnect between two segments of a transit trip produces *transfer penalties*, which we extensively discussed in the first component of the literature review (Iseki, et al, 2006). The perception of this disconnection (or *transfer penalty*) in a transit trip, causes the traveler to view the trip as burdensome. Therefore, it is important that transfer facilities not only increase accessibility to and from these facilities, but also increase accessibility between two locations at a single transfer facility where people board and alight vehicles for a transfer. The particular transportation modes guide the location, physical dimensions, and configuration of a facility, which affect the physical environment in the neighborhood. In short, transfer facilities should be designed and planned to enhance the utility of the transportation network by providing seamless transfers to users (Committee on Intermodal Transfer Facilities 1974).

In this literature review, we investigate the state of the practice of evaluating the quality of transfer facilities from three perspectives: 1) passengers/users, 2) transit system operators, and 3) neighboring communities (Vuchic and Kikuchi 1974; Committee on Intermodal Transfer Facilities 1974). We focus primarily on the <u>transit users' perspective</u> under the premise *that* *attributes at transfer facilities be planned and designed to accommodate transit users' travel needs, so that improvements at transfer facilities will eventually contribute to a ridership increase*. Another reason that this literature review primarily focuses on transit users' perspective is that extensive studies have been conducted in the engineering and architecture fields, which focus on improving transfer facilities from the operators' perspective. Transit agencies have been practicing these guidelines for some time now. From our review of the literature, we found that there are gaps in the discussion on transfer facilities from transit users' perspective and its relationship to determining users' travel behavior, given opportunities and services provided by public transit and other transportation modes. Therefore, one of our objectives in this literature review has been to identify any gaps between what operators' think is important and what users think important, or if there are any factors at transfer facilities that have not been implemented due to a limitation on transit operators' side, such as availability of funding and yet are important from users' perspective.

The remainder of this report is divided in 4 sections. In Section 2, we present a classification of transfer facilities. The variation in these classes of transfer facilities, for example, by size and functionality, requires different criteria to evaluate and so plays a role in determining the appropriate facility attributes to evaluate. In Section 3, we introduce the notion of our three perspectives from which transfer facility attributes can be evaluated: 1) passengers/users, 2) transit system operators, and 3) neighboring communities. Section 4 focuses on the evaluation criteria associated with each of the three stakeholder-perspective areas that were identified in the literature. The last section summarizes findings from the literature review and describes our project research agenda.

2. TYPES OF TRANSFER FACILITIES

Transfer facilities are obviously not all the same and can differ with respect to a multitude of factors. For example, consider the following simple transfer facility: An on-street bus stop that services two lines of the same transit agency with only time-point schedules posted and no real-time bus arrival times, and no bench for waiting passengers to sit on. This transfer facility has only the bare minimum of attributes. It is quite different from, for example, the Downtown Los Angeles Union Station, which, as an off-street facility, accommodates both intermodal and intra-modal (bus, shuttles, light rail, heavy rail, commuter rail, and inter-city rail) transfers among different transit agencies and different lines of the same agency. These two transfer facility examples differ relative to numerous attributes such as physical size, travel modes serving the facility, number of lines per transit agency, number of transit agencies, and amenities offered to travelers using the facility.

When transit transfer facilities are evaluated, it is likely that different evaluation criteria may be necessary depending on the specific attributes of the transfer facility; moreover, to better understand how transit transfer facilities may be and have been evaluated, it helps to first classify them according to different types. For example, the aforementioned attributes with which the on-street bus stop and Union Station were discussed may be used to create a typology with which to classify transfer facilities.

Another classification scheme of transfer facilities is based on an adaptation from the *National Cooperative Transit Research & Development Program 7 Synthesis of Transit Practice: Passenger Information Systems for Transit Transfer Facilities* (NCTRDP7) (Fruin

1985). While the main subject of this report focused on facility information systems, this classification is also applicable to physical components of transfer facilities. In general, the more transit users at transfer facilities, the more complex a transfer facility gets.

Transfer facilities have five levels of facility classifications based on the following factors: 1) volume of passengers and activities, 2) number of interfacing routes, 3) number of interfacing modes, 4) physical configuration, 5) investment in facilities, 6) transit center type (community, regional, or other), and 7) whether or not it is a joint development with commercial use of facility (Fruin 1985).

1. The simplest form of a transfer facility is a local stop serving a single transit mode — an on-street curb loading area that serves one to two bus routes or a station with a grade-level platform for rail.
2. A slightly upgraded form of facility — an on-street bus turnout serving two or more routes with loading bays separated from regular traffic lanes, or a passenger-car level, raised platform rail station, which may have auto parking and vehicle interface facility.
3. This level of transfer facility is completely off-street. A bus transfer facility at this level is an off-street turnout with loading platforms serving multiple routes. A rail station is an at-grade but raised platform station with a possible pedestrian overpass or underpass, auto parking, and bus transfer facilities.
4. An urban grade-separated multi-modal transit facility with exclusive bus access provisions and elevated or subway rail access. It may have large parking areas, and a level 2 or 3 bus-transfer facility. This level facility could be incorporated into a major activity center with joint development by others.
5. A major center-city, regional, grade-separated, multi-modal, multi-level bus or rail-transfer facility. The significant capital investment is spent in pedestrian circulation elements, waiting room, ticket selling and other passenger processing facilities, and concession spaces. An example is the San Francisco Trans-Bay Bus Terminal.

Thus, transfer facilities may be simple in nature such as bus stops, light rail stations, heavy rail stations, commuter rail stations, and ferry docks, and terminals. Alternatively, there are considerably more complex transfer facilities, as follows:

Transit mall is "a special street set aside for exclusive use of buses and/or light rail vehicles in a city center or other high activity center (Rabinowitz et al. 1989)." Transit malls emphasize pedestrian movement and activities, and include design components that are related to both transit and urban design, such as waiting shelters, the use of landscaping, street furniture, shopping and other civic activities. Transit malls are often combined with a development of adjacent property, which consists of shopping and office activities as well as transit-related retail and services.

Transfer center is a facility with the primary purpose "to facilitate easy transfer between transit modes and routes," and can be combined with transit-related developments or concessions to accommodate users with convenience shopping (*e.g.* newsstands, snacks, flowers, and teller machines). Transfer centers can also be a project coordinated with a full scale shopping center (Rabinowitz et al. 1989). Transfer centers are usually located entirely or partially off-street, and include a more elaborate and extensive shelter and more passenger amenities than ordinary bus stops (Kittelson & Associates 2003). At transfer centers, multiple transit routes meet to allow transit users to transfer from one line to another within the same mode or between different modes (Kittelson & Associates 2003). It is an important node with high accessibility, and is typically located in suburban or edge-of-city locations in the metropolitan area (Rabinowitz et al. 1989). Transfer centers often have sufficient area to allow access and circulation of multiple travel modes as well as automobile parking (Rabinowitz et al. 1989). Transit agencies with well-planned operation provide pulse schedules at transfer centers to coordinate arrivals and departures of vehicles and accommodate transit users with timed-transfers that minimize users' waiting time.

Intermodal terminals/centers are facilities that provide key transfers between transit modes, which may local bus, bus rapid transit, intercity bus, light rail, heavy rail, intercity passenger rail, ferry, or automated guideway transit. Such facilities may also have a variety of other services and connections, including parking, drop-off, ticket vending, and information booths. These facilities are a fixed location where passengers interchange from one route or vehicle to another that has infrastructure, normally only shelters and/or benches.

3. TRANSFER FACILITY STAKEHOLDERS: AN OVERVIEW OF THREE PERSPECTIVES

In assessing how effectively transfer facilities operate, we identified three primary stakeholder categories from whose perspectives such evaluations have been performed (Vuchic and Kikuchi 1974; Committee on Intermodal Transfer Facilities 1974). These groupings are

1. Passengers/users
2. Transit Operators
3. Neighboring Communities

3.1 Passengers/Users

Passengers/users are basically clients and customers who receive the services offered at transit transfer facilities and, as such, they will likely have specific requirements they would like to be satisfied when they use such facilities. Passengers/users' requirements should be given major attention and priority over other requirements in designing transfer facilities because such requirements are a significant contributor to and determinant of users' choice of travel mode (Committee on Intermodal Transfer Facilities 1974). Transit users' main requirements for transfer facilities are related to the ease in use of facilities for making transfers. Some of their major requirements include: 1) minimum transfer time and distance, 2) convenience, 3) comfort, and 4) safety and security (Table 1) (Vuchic and Kikuchi 1974).

TABLE 1 Passenger and Operator Requirements for Transfer Facilities

Passenger Requirements: Passengers approaching the station building have the following basic requirements for station design	• Minimum transfer time and distance: Short walks between modes and good schedule coordination • Convenience: Good information service, adequate circulation patterns and capacity, easy boarding and alighting, and provisions for disabled people • Comfort: Aesthetically pleasing design, weather protection, and small vertical climbs • Safety and security: Maximum protection from traffic accidents, safe surfaces, and good visibility and illumination to deter vandalism and to prevent crime
Operator Requirements that the design must satisfy:	• Minimum investment cost • Minimum operating cost • Adequate capacity • Flexibility of operation • Passenger attraction

Source: Vuchic and Kikuchi (1974)

It is important that transfer facilities are designed to accommodate transit users' needs at facilities. In accommodating transit users' needs, the *perception* of their experience at transfer facilities plays an important role and influences their travel behavior. The Committee on Intermodal Transfer Facilities states "[p]assenger perceptions of service efficiency, convenience, comfort, and security greatly influence their choices of transportation modes" (Committee on Intermodal Transfer Facilities 1974). According to the Committee, no analytical techniques were available to quantitatively evaluate the values that passengers/users place on waiting time, walking distances, and other activities at transfer facilities back in 1974. The Committee called for studies that examine "the relationship of human behavioral factors to facility design" and "evaluate alternative designs and their relationship to increased facility investment and improvements in service" (Committee on Intermodal Transfer Facilities 1974). The study gives an example of such a relationship and examines the factors affecting human tolerance for time delays and situations in transit trips, such as transit platform clearance times and delays in long headway versus short headway systems.

When transfer facilities are evaluated and designed to make transferring more pleasant, faster, and less problematic, people accept facilities more favorably and are more likely to accept the necessity of transferring in their transit trips (Reynolds and Hixson 1992). Liu, Pendyala, and Polzin (1997) particularly mention the following as important factors in the decision making process of travelers when making a trip involving a transfer:

- Routes

- Physical environment of the transfer location
- Service reliability
- Uncertainty of travel time
- Exposure to weather
- Implications of carrying packages, such as luggage
- Point of transfer in the context of the overall trip
- Nature of the fare system

Well-designed transfer facilities contribute to making public transit a more attractive travel option relative to driving alone and thus can increase the likelihood that people take public transit service, and contribute to a ridership increase.

In Japanese urban cities, where public transit systems have an important role in people's daily lives, many projects have been implemented to provide better space at transit stations. This improved space recognizes that transit stations should be easy and convenient for transit users to use as part of their daily lives, not only function as facilities for transportation system to efficiently operate (Kajima Institute Publishing Co. Ltd. 2002).

3.2 Transit Operators

When a transit operator owns the property for a transfer facility, it usually has full control of determining and designing certain attributes of the transfer facility from the operator's perspective to accommodate operational requirements, part of which also accommodate needs of transit users at the facility. These attributes include capacity, flexibility of operation, and passenger attraction, as well as capital and operating costs (Table 1) (Vuchic and Kikuchi 1974). These attributes are minimum requirements for operators to provide efficient and safe services to users, taking into account facility location, the surrounding environment, and demand and traffic volume by access mode, and operating requirements by mode.

It should be noted that the same attributes at transfer facilities can be evaluated from multiple perspectives. For example, queuing at ticket vending machines and turnstiles may be viewed from the operator's perspective in terms of the efficiency with which fares are collected and travelers flow through points of entry control, while it would be perceived from the users' perspective as waiting time. The operator views matters in terms of person throughput at the facility whereas the user views the situation primarily through the lens of time and cost that he/she has personally expended.

3.3 Neighboring Communities

Any transit transfer facility ─ whether it is located in an urban or suburban environment and whether it deals exclusively with intra-modal or intermodal transfers ─ does not exist in an environmental vacuum. It relates to and interacts with the outside 'world' of the surrounding neighborhood in which it is sited; that is, it interacts with 1) people who live, work, and/or use the facility to travel to, from, and through the community and 2) business people who own and operate commercial establishments in the vicinity of the facility. In essence then, its presence in the neighborhood is felt by and has a real impact on the surrounding community. The facility's impact may be immediate in terms of contributing to traffic congestion, noise and air pollution (from buses) and unsightly visual aspects. In the long term, the facility can impact the type and level of development that results from its location in particular communities (Vuchic and Kikuchi, 1974). In a survey of transit agencies concerning ten U.S. transfer facilities, the agencies identified provision of a civic facility and assistance of downtown development as common objectives of transfer facilities (Hocking 1990). In this sense, it is also important to consider the relationship between a transfer facility and its immediate surroundings in the facility design (Vuchic and Kikuchi 1974).

4. EVALUATION CRITERIA

The literature dealing with transfer facility evaluation criteria revealed a variety of findings across the three stakeholder perspectives. Much of this literature provides only simple lists of criteria with which to evaluate transfer facilities. Some of these studies have only several criteria that tend to be broadly-worded and there are only a few studies that provide specifics of transfer facilities for evaluation. In addition, many studies provide evaluation criteria without clearly specifying from whose perspective these criteria should be used for the evaluation. As a result, the literature does not provide sufficient information on 1) what criteria should be used to perform a transfer facility evaluation, 2) how to use such criteria for evaluation purposes, and 3) from whose perspective do such criteria refer and matter.

An example of evaluation criteria that provides broadly-stated factors without specifics is provided in Table 2, which lists eight criteria from the passengers/users and community perspectives to measure the effectiveness in developing an intermodal transfer facility.

TABLE 2 Criteria to Evaluate Effectiveness in Developing an Intermodal Transfer Facility

Evaluation Criteria	Stakeholder Perspective
Intermodal interaction is supported and safe	Passengers/Users
Facility type and size reflect community needs	Community
Amenities enhance the users' experiences	Passengers/Users
Facility is accessible to everyone (ADA compliant)	Passengers/Users
Transferability between modes is feasible and reliable	Passengers/Users
Reliable passenger information and service are provided	Passengers/Users
Community involvement is integrated in the planning and design	Community
Opportunities for community partnerships exist	Community

Source: Land et al. (2001)

Table 3 shows an example of evaluation criteria of transfer facilities from both the passengers'/users' and operators' perspectives; it also presents objectives, criteria, and performance measures from ITE Technical Council Committee 5C-1A (1992). This table provides more detailed criteria with clearer evaluation-related objectives than the previous example, and also more specific performance measures for each objective/criteria pair. It uses both qualitative and quantitative measures (*in the fourth column which has been added to the original table*). The fifth column, again, added to the original table, in Table 3 shows which perspective directs each objective. For example, Objective 3 — *minimum queues* — uses a quantitative performance measure — *aggregate waiting time* — and is directed by the operators' perspective. Objective 6 — *maximize safety* — uses a qualitative performance measure — *type and locations* — and is directed by both the users' and operators' perspectives. As we can see in this table, operators' perspective is more likely to be the basis of evaluation criteria, while both quantitative and qualitative performance measures are used to evaluate criteria.

TABLE 3 Objectives, Criteria, and Performance Measures

Objectives / Requirements	Criteria	Performance Measures	Quantitative (1) or Qualitative (2)	Perspective: Users (1) Operators (2)
Minimize travel impedances	Total walk time	Aggregate travel time	1	1
	Total time in system	Aggregate time	1	1 & 2
	Individual OD time	Unit journey time	1	1
Minimize crowding on links	Areas per person in the space associated w/ a link	Sq. Ft. / person on pathway	1	1
Minimize queues	Total delay time in queue	Aggregate waiting time	1	2
	Number in queue of node	Number of people	1	2
	Time in queue while traveling between nodes	Unit journey waiting time	1	1
Minimize pedestrian-vehicle conflicts	Measures of crossing flows	Relative volumes (major and minor flows)	1	2
Minimize disorientation	Connectivity from node-link network	Network connectivity measures	1 & 2	2
Maximize safety	Availability of directional information	Type and locations	2	1 & 2
	Safety features on mechanical facilities	Special safety features	2	2
Eliminate physical barriers	Difficulty in navigating fare collection/entrance control area	Type and width (turnstile, gate)	2	2
	Capability of users	----	2	1
Provide sufficient space	Facility size	Square feet	1	2
Provide a comfortable environment	Scale	Availability of seating	2	1 & 2
	Aesthetic quality	Landscaping features	2	1 & 2
	Noise	Noise levels	1	1 & 2

Objectives / Requirements	Criteria	Performance Measures	Quantitative (1) or Qualitative (2)	Perspective: Users (1) Operators (2)
Ensure adequate lighting	Passenger loading areas must be well lit	Illumination levels (ft-candles)	1 & 2	1 & 2
	Maintenance factors, brightness ratios, glare, reflectance, and emergency lighting	-----	1 & 2	2
Provide supplementary services	Advertising	Type, size, location	1 & 2	1 & 2
	Concessions Floor space allocated Percent of total space	Type, size, location Sq. ft. allocated Percent	1 & 2 1 1	1 & 2 2 2
Provide protection from weather	Terminal area exposed	Percent terminal area exposed	1	1 & 2
Provide adequate security	Visibility of loading areas by security, patrols, population presence, contiguous area	Sight distance	1	1 & 2
		Land use conditions	2	1 & 2
		Pedestrian volumes	1	1 & 2
Minimize maintenance, cleaning, and replacement needs	Maintenance effort	Size and cost of maintenance force	1	2
Account for total cost Initial Operation Security Other	Allocated funds Subsidy required Public investment Private investment -----	Dollars -----	1 1 1 1 -----	2 2 2 2 -----
Provide for joint development potential within off-street facility boundaries	Compatibility with community planning and land-use goals	Policy evaluation (a function of location)	2	2
	Special zoning	-----	2	2
	Percent area non-transportation	-----	1	2
Provide design flexibility	Expansion potential, vertical, horizontal, passenger processing, other activity, modular components	Floor space, local land costs, area around station, zoning ordinances	1 & 2	2
Ease of site access and egress	Street traffic volumes to cross (left-turn entry) and upon exit	Entry and exit delay per bus	1	2

Source: ITE Journal 5C-1A (1992)

Table 4 (Hoel, Demetsky, and Virkler (1976)) shows an example of evaluation criteria of transfer facilities from the operator perspective and, like Table 3, also shows objectives, and detailed criteria with specific performance measures for each objective/criteria pair.

TABLE 4 Operator Perspective Requirements, Criteria, and Performance Measures

Operator Requirements	Criteria	Performance Measures
Maximize equipment reliability	Back-up facilities in case of breakdown; Inspection procedures	Present or not present; Frequency and type
Efficiently collect fares and control entry	Attraction to robbery or vandalism; Inconvenience to traveler due to method; Technology used	Type of fare collection and safeguards provided; Time required for purchasing and waiting; Passenger processing rate and ability to keep non-payers out
Maximize safety	Safety features on mechanical and electrical systems	Special safety features
Efficiently process flows		Hourly flow rate of passengers
Provide adequate space	Station size	Square feet
Provide proper security	Size of security force; Number of facility levels; Means of escape; Number of exits; Accessibility to station agent's booth and major passenger paths; Surveillance and security patrols	Number of personnel; Number of levels; Type and number of directions for each destination; Number of exits; Distance of discrete areas from agent's booth Percentage of floor area that is part of 'paid area; Number of areas not subject to frequent security patrols or surveillance including parking lots
Minimize maintenance, cleaning, and replacement needs	Maintenance; Cleaning surfaces; Cleaning concessions	Size and cost of maintenance work force
Obtain an efficient return on incremental investment	Additional benefits or objectives met beyond base cost	Benefit-Cost ratio assuming that benefits are convertible to dollars
Receive adequate income from non-transport activities	Cost of facilities vs. income received	Break even or profit; loss must be avoided
Utilize energy efficiently	Total and incremental energy requirements	Kilowatt hours
Minimize total cost	Allocated funds; Subsidy required; Public and private investments	Dollars
Exploit joint development potential	Compatibility with community planning and land use goals; Special zoning; Percentage area for non-transport usage	Policy evaluation – a function of location
Provide opportunity for expansion	Expansion potential on ground floor and upward for higher floors	Floor space, local land costs, area around facility, and zoning ordinances

Source: Hoel, Demetsky, and Virkler (1976)

Horowitz and Thompson (1995) recognize that evaluation of transfer facilities requires judgment on many design elements, taking into account costs of individual elements. They also emphasize the need to incorporate the opinions of transit users, transit operators, government agencies, designers, and the community ─ from each of the three stakeholder perspectives. Factors, such as the external environment, operators, financial needs, and travel requirements affect the physical design of transfer facilities when objectives of the facility are clearly defined and used to determine the details in design.

Table 5 shows a list of 70 generic and broadly worded objectives from all three stakeholder perspectives that Horowitz and Thompson (1995) developed based on a literature review and interviews with individuals from Metropolitan Planning Organizations, transit users, planners at transit agencies, and experts in intermodal station design. Horowitz and Thompson define an objective as “a specific statement of a goal for a transit transfer facility”, in other words, a “desired-end-product”; moreover, each objective is worded in terms of ‘achieving’, ‘maximizing’, or ‘minimizing’ something. The first column shows ranks of individual objectives and fifth column shows the aggregate ratings of each objective based on input from the interviews where each interviewee was asked to rate objectives on a scale of 0 to 10; The authors classified each of these objectives using two classification schemes based on level of specificity, which are shown in columns three and four: the third column classifies each objective as one of ten types — transfer (T), safety/security (SS), access (A), efficiency (E), financial ($), modal enhancement (M), physical environment (PE), nonphysical environment (NE), space/site (#), architectural/building (AB), and coordination (C); the fourth column shows one of four generic objective categories: 1) system objectives related to the complete regional transportation system (SO); 2) internal objectives related to the design of the facility and its site (IO), 3) external objectives related to the environment and the surrounding community beyond the site (EO), and 4) mode interface objectives related to aspects of the facility directly affecting transfers (MIO).

A good evaluation procedure for an intermodal passenger transfer facility should have certain essential features. The evaluation procedure must: 1) be capable of generating and evaluating alternatives; 2) incorporate available expertise, including knowledge of modal operations; 3) foster the establishment of goals, objectives, and criteria for the project; 4) have sufficient staff support to accomplish necessary data collection, analyses, and reporting; 5) contain mechanism for fast and clear communication among the many participants in the process; 6) satisfy the many laws and regulations associated with implementing a large transportation project; and 7) have the ability and authority to choose an alternative. The process must be consistent with the style of planning that exists within the local community.

TABLE 5 Composite Ranking and Scores of Top-Rated Objectives

Rank	Objective	Type	Category	Rating
1	Max. reliability of transfers	T	MIO	9.0
2	Max. security	SS	IO	8.8
3	Max. safety and security of operations of modes	SS	MIO	8.7
4	Min. institutional barriers to transferring	T	MIO	8.6
5	Max. passenger information	T	IO	8.5
5	Achieve handicapped access	A	IO	8.5
7	Max. safety	SS	IO	8.4
7	Max. user benefits	T	SO	8.4
9	Max. reliability of facility services	E	IO	8.3
9	Max. system legibility	T	SO	8.3
11	Max. efficient access and egress	A	MIO	8.2
11	Min. disorientation and confusion	T	IO	8.2
11	Max. coordination of transfer scheduling	T	SO	8.2
14	Min. waiting	E	MIO	8.1
15	Min. physical barriers of transferring between modes	T	MIO	8.0
15	Min. physical barriers to handicapped	SS	IO	8.0
17	Min. queuing delays	E	IO	7.9
18	Min. difficulty of ticketing or fare payment	E	MIO	7.8
18	Max. ease of operations for modes	E	MIO	7.8
18	Max. passenger comfort	P	IO	7.8
18	Max. weather protection	P	IO	7.8
22	Max. system coordination of information and fares	T/C	SO	7.6
23	Max. directness of paths for modes	E	MIO	7.4
23	Max. ease of fare collection	E	IO	7.4
23	Max. amount of connections between routes	T	SO	7.4
23	Min. negative cultural impacts in surrounding neighborhood	NE	EO	7.4
27	Min. path conflicts between modes	A	MIO	7.3
27	Min. directness of path	E	MIO	7.3
29	Achieve elimination of hazardous materials	PE	MIO	7.2
29	Max. quality of waiting areas	P	MIO	7.2
31	Min. costs	$	SO	7.1
31	Max. joint development	$	EO	7.1
33	Min. barriers	A	IO	7.0
33	Min. exertion	P	IO	7.0
33	Max. market areas for each mode	M	SO	7.0

Rank	Objective	Type	Category	Rating
33	Max. community pride	NE	EO	7.0
33	Min. negative social impacts in surrounding neighborhood	NE	EO	7.0
33	Min. physical impacts to surrounding neighborhood	PE	EO	7.0
33	Max. flexibility for expansion	#	EO	7.0
40	Min. difficulty of baggage handling	P	MIO	6.9
40	Max. pedestrian assists	E	IO	6.9
40	Min. path length	E	IO	6.9
40	Min. crowding	P	IO	6.9
40	Achieve compliance with historic preservation requirements	PE	EO	6.9
45	Min. conflicting paths	E	IO	6.8
46	Min. maintenance requirements	AB	IO	6.7
46	Min. service duplication	E	SO	6.7
46	Achieve property rights	#	EO	6.7
46	Achieve same or lower air pollution emissions,	PE	EO	6.7
46	Min. conflict with surrounding land uses	PE	EO	6.7
51	Max. aesthetics	AB	IO	6.6
51	Max. quality of architectural design	AB	EO	6.6
53	Max. amenities	P	IO	6.5
53	Max. sense of place historic significance, community image	NE	EO	6.5
55	Min. regional air pollution emissions	PE	SO	6.4
56	Min. construction impacts	PE	EO	6.3
56	Min. disruptive land acquisition	NE	EO	6.3
58	Min. level changes	E	IO	6.1
59	Min. fare inconsistencies	$/C	SO	6.0
60	Max. urban renewal	#	EO	5.9
61	Max. reuse of existing building/infrastructure	#	EO	5.8
61	Max. positive cultural and social elements	NE	EO	5.8
61	Max. use of local employment	NE	EO	5.8
64	Max. alternative uses of time while waiting	P	IO	5.7
64	Max. openness of interior design	AB	IO	5.7
66	Min. regional energy consumption	PE	SO	5.6
67	Min. wasted space	AB	IO	5.5
67	Min. negative impact on existing transportation services	$/M	SO	5.5
69	Max. income from non-transport activities	$	SO	4.7
70	Max. informal vending	AB	EO	4.1

Note: Type: T-Transfer, SS-Safety/Security, A-Access, E-Efficiency, P-Passenger, $-Financial, M-Modal Enhancement, PE-Physical Environment, NE-Non-physical Environment, #-Space/Site, AB-Architectural/Building, C-Coordination; Objective category: MIO-Mode Interface Objectives, IO-Internal Objectives, SO-System Objectives, and EO-External Objectives.

The Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area has very recently completed a comprehensive investigation of transit connectivity primarily from the user perspective. Motivation for the study began with a series of state and regional political decisions acknowledging the significance of coordination among the Bay Area's more than two dozen transit agencies relative to the services they offer to the traveling public:

- California State legislation that required MTC to be the facilitator of promoting coordination among the Bay Area's more than two dozen transit agencies
- MTC passed its "Connectivity" Resolution that made multi-operator trips easier for transit riders a top priority
- In November 2004 Regional Measure 2 passed by Bay Area voters establishing that a Connectivity Plan be produced with the goal of synchronizing transit systems' routes, fares, schedules, and facilities.

The groundwork was thus laid for a comprehensive investigation of transit connectivity in the Bay Area. The Connectivity Plan was a two-part endeavor, which began in 2004 and concluded in early 2006. The initial part documented the current state of Bay Area connectivity, interagency transfers, barriers to connectivity, and recommendations for improvement. The second and final part built upon these preliminary findings to improve the quality of linkages between transit systems for transit customers. Specific improvements were identified to increase ridership and customer satisfaction with a focus on the user perspective.

In the second part, usually referred to as the *2005-2006 Transit Connectivity Study* (Metropolitan Transportation Commission 2006), Bay Area regional transit hubs were initially classified into four distinct types, as follows:

1. Urban hubs with buses loading on-street
2. Urban hubs with off-street bus loading
3. Bus only hubs
4. BART with off-street bus loading

Because of resource constraints, a single site-specific regional transit hub was selected from each of these classes ─ except for the fourth class in which two sites were selected ─ on which case study evaluations were subsequently performed. The four selected case study sites are as follows, respectively:

1. San Francisco Ferry Terminal / Embarcadero BART Station
2. San Jose Diridon Station (Caltrain commuter rail station)
3. San Rafael Transit Center
4. El Cerrito Del Norte and Dublin / Pleasanton BART Stations

Evaluations of these five case studies consisted of conducting on-site inventories to quantify current characteristics and the establishing stakeholder task forces to review current conditions, to identify problems, and to develop recommendations. The methodological approaches used were two-fold consisting of 1) focus groups of regular and frequent transit users and non-transit users using travel diaries and 2) transit operator and agency interviews to learn about procedures, practices, and policies relative to connectivity issues. The key connectivity issues that were identified were the following:

- Wayfinding (Signage)
- Customer use of transit information by various means such as the internet, print, phone, station agent, and vehicle operators
- Schedule coordination
- Real-time technology by means of the internet, dynamic message signs, phones, and kiosks
- 'Last Mile' connecting transit services from shuttles, taxis, walking, and bicycling
- Facility amenities including weather protection, availability of seating, audio announcements, restrooms, and security

Based on these case study evaluations, a 'Connectivity Toolbox' was developed that consists of 1) Checklists for wayfinding signage, 'last mile' connecting services, and facility amenities, and 2) Guidelines/recommendations for wayfinding, customer use of transit information, schedule coordination, real-time technology, 'last mile' connecting services, and facility amenities and infrastructure improvements.

The checklist statements are similar to the objectives developed by Horowitz and Thompson (1995) however they are phrased differently than the latter and not in terms of "Maximize"- or "Minimize"-type statements. Rather the checklist statements are written in a detailed fashion as preferred outcomes. For example, in Table 4 objective 53 is "Maximize Amenities", which is very generally and broadly stated; whereas in the 'Connectivity Toolbox' there is a list of specific amenity-related statements dealing with weather protection, seating areas, audio announcements, and availability of restrooms. Evaluating a transfer facility using this checklist simply means that the evaluator determines whether each checklist statement is true or not. If a checklist statement is true, then the evaluator proceeds to the next checklist statement. If a checklist statement is not true then a recommendation is given on how to satisfy the checklist item and guidelines on where the recommendation is applicable.

In Table 6, we list each of the broad categories for wayfinding signage, 'last mile' connecting services, and facility amenities as provided in the MTC study. While detailed checklist statements for each category may be found in (Metropolitan Transportation Commission, 2006), we show here two examples of the type of such detailed statements.

TABLE 6 Transit Connectivity Checklist Categories

Wayfinding Signage	Identification of station or transit operator
	Moving around or entering or exiting the station
	Identification of where to board or wait for transit
	Transit information for Pre-Trip and Enroute Planning
Last Mile Connecting Services	Overall approach
	Shuttle service standards and benchmarks
	Pedestrian access standards and benchmarks
	Bicycle access and parking standards and benchmarks
	Taxi service standards and benchmarks
	Alternative commute modes standards and benchmarks
Facility Amenities and Infrastructure Improvements	Connectivity
	Weather protection
	Seating areas
	Audio announcements / Information
	Restrooms
	Security

Source: Metropolitan Transportation Commission (2006)

For example, for the category "Identification of station or transit operator" for Wayfinding Signage, the following five specific checklist statements are to be evaluated ─ simply determining whether such statements are true or false ─ as part of the Connectivity Tool:

- The hub is clearly identified, visible from surrounding roadways by vehicular and pedestrian traffic
- Entrances into the hub are clearly identified, visible from approaches by vehicular and pedestrian traffic
- Transit operators serving the hub are clearly identified at the entrances with their logo and name
- Station identification reinforces information on printed maps and schedules
- Station name is identified on the entrance sign along with agency logo

For the "Seating Areas" category for Facility Amenities and Infrastructure Improvements, the following four specific checklist statements are to be evaluated as part of the Connectivity Tool:

- Ample seating is provided in close proximity to passenger loading areas
- Passenger seating is protected from wind and rain
- Passenger seating is clean and in good repair
- Lean-on railings are provided to supplement other passenger seating

There are similarities between the MTC Transit Connectivity project and our project in that both projects focus on transit connectivity in major metropolitan areas of California, focuses on the user perspective, and develops a connectivity tool for transit agencies to use as an evaluation tool. However, the methodology used by and the findings from the MTC Study confirms the weaknesses that we have observed in the literature and previously discussed: 1) a lack of comprehensiveness in the factors that are considered, 2) no strategy to deal with variation in values for the same factor at different locations of the same transfer facility, 3) only simple "Yes" or "No" answers that are part of the connectivity tool may not be appropriate for all factors, 4) lack of recognition of the importance of transit service reliability, and 5) lack of distinction for different perspectives with which to evaluate transfer facilities.

4.1 Passengers/Users Perspective

In Iseki, et al. ─ our initial deliverable ─ we focused on the travel behavior literature and developed a transfer penalties framework, which identified physical attributes of transfer facilities as one area where transit agencies can reduce wait, walk, and transfer penalties for facility passengers. Indeed, physical attributes of transfer facilities can potentially affect walking time, walking effort, waiting time, waiting effort, convenience, comfort, safety, and indeed many other attributes of transfer burdens. Such attributes may be classified into one or more of the following five impedance factor categories: 1) access, 2) connection and reliability, 3) information, 4) amenities, and 5) security and safety. Moreover, based on our review of the literature, these five categories are sufficient to explain a transfer facility's physical attributes. For example, in Table 7 we use this classification scheme to summarize the physical attributes identified and discussed in the literature that we have previously discussed (See Tables 2, 3, 5, and 6).

TABLE 7 A Summary of Physical Attribute Categories

Study Summarized in a Previous Table	Physical Attribute Categories
Table 2 Land et al. (2001)	Safety and Security
	Amenities
	Access
	Connection and Reliability
	Information
Table 3 ITE Journal 5C-1A (1992)	Safety and Security
	Amenities
	Access
Table 5 Horowitz and Thompson (1995)	Safety and Security
	Amenities
	Access
	Connection and Reliability
	Information
Table 6 Metropolitan Transportation Commission (2006)	Safety and Security
	Amenities
	Access
	Information

The development of these five categories for the physical attributes of transfer facilities originated with work at the Department of the Environment, Transport and the Regions (DETR) in the United Kingdom, which produced the "Guidance on the Methodology for Multi-Modal Studies (GOMMMS)" to provide an appraisal framework to evaluate the impacts of different transportation options (Department for Transport 2003). This guideline has five criteria – *environment* (built and natural), *safety/security*, *economy*, *accessibility*, and *integration*. The environmental criterion seeks to reduce impacts of transport policies and facilities on the built and natural environment of users and non-users. The safety/security criterion is for reducing the loss of life, injuries and damage to property resulting from transport incidents and crime. The economy criterion is concerned with the economic efficiency of transport for consumers, business users, transportation service providers, and intend to improve reliability and the wider economic impacts. Accessibility is related to the level at which people can reach different locations and facilities by different modes. The integration criterion "ensures that all decisions are taken in the context of the Government's integrated transport policy." Each criterion has factors and sub-factors to evaluate in detail. Among these criteria, the transport interchange factor in the integration criterion is the most relevant to our investigation of the evaluation of transfer facilities, while several other factors, namely, journey ambience in the environment criterion, security in the safety criterion, and value of time and reliability in economic criterion are also relevant.

The integration criterion in GOMMMS qualitatively evaluates attributes of transfer facilities under an assumption that all quantitative attributes, such as benefits relating to travel time changes are evaluated in the economic criterion. In particular, the passenger interchange assessment is to identify changes in indicators listed in Table 8 that affect passengers. This assessment includes both intermodal transfers between public transit modes and transfers between public and private modes (such as car and train). In the following review, we will use the *integration criterion* as a guideline, and incorporate other factors from GOMMMS and other studies in its framework.

TABLE 8 Range of Standards for Interchange Quality

Passenger Indicator	Poor Standard	Moderate Standard	High Standard
1) Access: Physical linkage for next stage of journey	Physical linkage impossible without use of more than one bridge or subway. Need to change to a physically separate terminal.	Physical linkage possible with use of a single bridge or subway. No need to change to a physically separate terminal.	Physical linkage possible without use of bridge, subway or changing to a physically separate terminal.
2) Connection and reliability: Reliability of connection	Timetable largely un-coordinated. High risk of missing connections.	Some timetable coordination but still a moderate risk of missing connections.	Timetable coordinated or guaranteed either within or between modes to minimize risk of missing connections.
3) Information: Level of information	No announcements, partial timetables, absence of automatic displays or information office.	Full timetables and announcements, no automatic displays or information office. Information level could be improved.	Frequent announcements, full timetables, automatic displays, information office.
4) Amenities I: Waiting environment	Old, uninviting, uncomfortable, non-existent or poorly-lit waiting room.	Some comfortable waiting rooms, but improvement or upgrades still needed.	New, inviting and comfortable well-lit waiting room.
Amenities II: Level of Facilities	Terminal old and needing upgrade. No or very poor buffet. No other facilities available.	Some good facilities, but others needing replacement or upgrade.	Modern terminal, good buffet and/or other facilities available.
5) Security: Visible staff presence	No visible staff presence for most of the time the terminal is open.	Staff presence visible at some times terminal is open.	Staff presence visible at all times the terminal is open.

Source: Department for Transport (2003)

In the remainder of this section, we review several past studies that actually examined and evaluated the quality of transfer facilities, including intermodal transfer facilities to identify factors and components that should be considered in the evaluation criteria.

Access

While the original GOMMMS category is "physical linkage for next stage of journey," it can be expanded to general accessibility of a transfer facility to passengers, including a variety of transportation modes to access the facility.

Since the level of accessibility affects facility productivity, it should be carefully evaluated and designed. While adequate access increases the operating capacity of a transfer facility, inadequate access can result in under use of the facility and lead to a waste in investment (Committee on Intermodal Transfer Facilities 1974). The supply of facility and equipment for access should match users' demand to maximize productivity and minimize passenger crowding and delay (Committee on Intermodal Transfer Facilities 1974). For example, taxi facilities may be provided to facilitate passengers' trips from a transfer facility (Parsons Brinckerhoff 2002). Equipment, such as bike storage for bicyclists and elevators and slopes for wheelchair persons, should also be provided (Vuchic and Kikuchi 1974).

Vuchic and Kikuchi (1974) discuss that the highest priority should be given to pedestrians among several access modes, such as bicycles, surface transit–feeder buses, taxis, kiss-and-ride modes, and park-and-ride, to transfer facilities.

> *"Walking should be favored over all other access modes. So it is important to provide a continuous network of pedestrian walkways throughout the station area. The network must connect all adjacent streets, residential areas, stores, and other locations that generate pedestrian trips, as well as the park-and-ride and kiss-and-ride areas. The walkways must be separated from automobile and other mechanized traffic as much as possible. Pedestrian crossings should be carefully designed, well marked, and, if necessary, controlled by signs or signals (Vuchic and Kikuchi 1974)."*

In addition, pedestrian paths should be sufficiently separated from other modes, particularly automobiles. Access modes should have adequate capacity, and direct and shortest distance to transit modes. It is important for all modes to have easy orientation and smooth and safe circulation to and within the facility (Vuchic and Kikuchi 1974).

Connection and Reliability

The level of connection between vehicles is particularly important to passengers. The connection can be measured in two ways: distance and time. Ideally, a transfer facility should be designed so that passengers who make a transfer do not have to walk long distances, especially in any type of unpleasant environment. Queuing at locations at a transfer facility, such as exits, entrances, and stairs, should be minimized, following technical guidelines.

To accommodate users' mobility at a transfer facility, an agency needs to determine the human factors, traffic capacity, and costs that govern the use of vertical movement systems (elevators, escalators, and walks). For example, operators need to take into account the volume of users, and estimate the need for higher speed escalators and moving walkways, using actual traffic flow capacities of mechanical movement systems, rather than manufacturers' claims (Committee on Intermodal Transfer Facilities 1974).[1]

In addition to the physical distance between vehicles to make a transfer, time to make a transfer should also be minimized. Furthermore, it is particularly important to have reliable vehicle schedules at transfer systems since passengers evaluate highly improvements of service punctuality (Hensher 1990).

In the *economic criterion*, which evaluates all benefits relating to travel time changes and the interchange penalty (the product of the value of time and travel time), GOMMMS recommends that the variability of lateness (for public transport) or of journey time (for private road vehicles) be estimated and subsequently be monetized (Department for Transport 2003). The following equation expresses the concept of the reliability ratio (changes in variability of lateness or of journey time):

$$\text{Reliability Ratio} = \frac{\text{Value of SD of travel time or lateness}}{\text{Value of travel time or lateness}}$$

SD = Standard Deviation

In order to monetize changes in average lateness in public transportation, the calculation requires value of lateness, which can be computed using value of travel time and a conversion factor:

Value of lateness = factor * value of travel time

The concept of this conversion factor is same as those for walking time and waiting time. People perceive time related to lateness more onerously than in-vehicle travel time.

In regard to reliability, scheduling adherence is very important, since irregular services significantly influence waiting time of transit users, who are "more sensitive to unpredictable delay than predictable time requirements" (Evans 2004). For users' convenience, it is recommended that operators use "clockface" times, such as 10, 30, or 50 minutes after each hour, which are easy for transit users to remember, to enhance a favorable perception by transit users toward waiting for low and medium frequency service lines (Evans 2004).

Transit operators can introduce intelligent transportation technologies to accommodate passengers' transfers at facilities. A transit system in Hamburg, Germany, adapted a guaranteed connection system to make sure that people transferring do not miss connecting buses just by a few minutes (Knobloch 1999). In this system, when on schedule, people usually have two to five minutes to make a transfer. However, when buses get delayed, people may lose this time margin, and see a connecting bus departing. The system was installed for 49 buses and 18 bus stops with 50 display units to inform a bus driver at the bus stop of the arrival of other buses in a few minutes, so that a bus driver can wait for up to four minutes. This is particularly important for passengers who travel during the time of day when there is infrequent service. The Hamburg transit system also provides a variety of information at transfer facilities, such as time tables,

[1] For all of these, there are a good number of technical manuals, guidebooks, and handbooks available.

network maps, fare information, maps of the immediate vicinity, and information and emergency telephones, as well as amenities, such as kiosks and public toilets. In order to increase safety and security, facilities have clever designs, transparent walls, good lighting, security guards, and video surveillance. It should be noted that although timed transfers reduce transit users' burden in transferring and is likely to increase their satisfaction, there is insufficient evidence to document the effects of timed transfer on ridership (Evans 2004).

When we evaluate elements and components of a transfer facility, it is very helpful to include factors related to the spatial or physical aspects of the transfer facility. According to the authors of *Station Revitalization* (Kajima Institute Publishing Co. Ltd. 2002), station space can be divided into four main components: 1) platform, 2) concourse inside fence, 3) concourse outside fence, and 4) public space and free paths. From a passenger's point of view, each of these four may have particular functions or services.

Platforms are a place where passengers board and alight trains. A platform should have a way to allow passengers to access to and egress from a concourse and wait for trains, and therefore may have stairs, elevators, escalators, and benches. Platforms should be designed to facilitate people's movement, and ensure that passengers are protected from trains. Stairs and escalators are basic to connect different levels at a station, and can have a large capacity for people's movement [connection and reliability and access]. Elevators are limited in their capacity, but are essential for some types of transit users, such as people in wheel chairs and those with baby strollers.

Concourses facilitate people's movement or provide services. A concourse provides services, such as ticket sales and checking, information and guidance, a space for waiting, kiosks, convenience stores, and restrooms, so that users can prepare for a train ride and spend such wait time with convenience and comfort. In the United States, many stations have free accessibility to platforms without tickets, and do not have boundaries between inside and outside of the concourse.

The structure and design of stations should facilitate people's movement and circulation to facilitate mass transit service (Kajima Institute Publishing Co. Ltd. 2002). For example, paths from platform to concourse should have sufficient capacity to allow a large number of people to traverse as they disembark a train [access].

It is also ideal that various services are provided to transit users as well as people in neighboring communities adjacent to a station as a public space (Kajima Institute Publishing Co. Ltd. 2002). A station has a public space inside the structure that leads transit users to surrounding areas. Some stations provide free access paths that go through the station and provide accessibility from one side of the station to the other, so that a station minimizes its disrupting effect to surrounding neighborhoods. Taking into account that transfers should be facilitated between trains at platform level and other transportation modes, such as cars and buses outside of a station building, transit agencies should coordinate with local governments to facilitate people's movement and activities in areas adjacent to a station (Kajima Institute Publishing Co. Ltd. 2002).

Information
Information and signage should be provided to users in public spaces and along unrestricted paths, so that users can find their way in and out of a station (Kajima Institute Publishing Co. Ltd. 2002). The quality of available information at transit facilities is quite important (Hensher 1990). A well-designed passenger information system at transfer facilities can improve passengers' experience of transit trips and encourage the use of transit by giving a clear understanding of transit services, facilitating the ease of transfers, increasing passenger processing speed, minimizing crowding, and enhancing safety and security (Fruin 1985).

In GOMMMS, the *journey ambience factor* within the environment criterion has three sub-factors; 1) traveler care, 2) traveler view, and 3) traveler stress (Table 8). One of the sub-factors of traveler care is information, and the rest are related to amenities (cleanliness, facilities, and environment) that are discussed in the next section. Traveler stress is also divided into frustration, fear of potential accidents, and route uncertainty.

Inside a facility, processing equipment, such as turnstiles, ticket dispensing devices, and passenger control systems, are also designed to facilitate operation and people's movement (Committee on Intermodal Transfer Facilities 1974). Information about the transportation system, transit operation lines and schedules, and fare information should be adequately provided to users. At the neighborhood level, transfer facilities not only provide accessibility for people in the community but also play a significant role as a center of the community for economic development in the surrounding neighborhood.

TABLE 9 Journey Ambience Factor and Related Sub-Factors

Factor	Sub-factor
Traveler Care	Cleanliness
	Facilities
	Information
	Environment
Travelers Views	-
Travelers Stress	Frustration
	Fear of potential accidents
	Route uncertainty

Source: Department for Transport (2003)

TCRP Synthesis Report 7 "Passenger Information Systems for Transit Transfer Facilities" (Fruin 1985) categorizes information aids for transit passengers into four groups: 1) visual communication, 2) oral communication, 3) distributed information, and 4) automatic passenger interactive systems. The principle of information as guidance for the user in a facility is that at any point in and around a transit facility, its physical layout, paths, walls and fences, lighting, and signage each have the potential to make movement (circulation) for users whether or not in queues very clear, instead of requiring them to figure the situation out by themselves and thus spend valuable time, and facilitate smooth intra- and intermodal transfers (Kajima Institute Publishing Co. Ltd. 2002). Table 10 provides concrete examples of information aides in each of these four categories.

TABLE 10 Information Aides

Visual Communication
External station or stop identification
Local guide signs
Internal directional signing
Route map and schedule (timetable) displays
You-are-here maps, directories, local community orientation and facility guide maps
Video displays of schedules, routes, gate assignments
Oral Communication
Telephone information (operator assisted, manual or computer-assisted data retrieval)
Passenger assistance telephones
Special information personnel, information agents, patron assistance aides
Transit system operating personnel — drivers, station agents, police
Public address system (recorded, real-time announcements)
Two-way closed-circuit television
Commercial and public service television and radio and cable television programming
Other passengers
Transit agency speakers bureau
Distributed information
Route maps and timetables
Rider kits, brochures
Media advertising, press releases
Newsletters and flyers
Information displays
Mobile information center
Telephone directory listing, maps, schedules
Automatic passenger interactive systems
Telephone--computer automated voice, recorded voice, geo-coded digital phone input
Electric light push-button route map
Computerized trip planner
Touch-sensitive CRT/Computerized map display

Source: Fruin (1985)

In addition, TCRP Report 7 (Fruin 1985) identifies five classification levels for information at transit transfer facilities: 1) rehearsals where passengers can learn about the service before using it; 2) simplicity of message content; 3) consistency of presentation, design, and technology, 4) continuity in progressively presenting multiple bits of information, and 5) use of repetition to reinforce the presentation of information (Fruin 1985).

The *rehearsal* level is based on the premise that prior introduction to a subject significantly improves the retention of information by confirming and reinforcing subsequent, more detailed information in later communications (Fruin 1985). Passengers can have a simple form of rehearsal to become familiar with the transit system by the media, such as news events or marketing efforts. Examples of this "rehearsal" information at transfer facilities are system maps, "you-are-here" plans, and directories at strategic locations, such as near entrances and critical decision points.

Message content should be *simple* and direct and use well understood and familiar terms to enhance communications without the use of transit jargon. Station, routes, and other relevant terms should have names with commonly used words with information about orientation, direction, and location.

For consistency, it is important to have uniform methods of presentation, design, and terminology to facilitate communication.[2] Transit users can easily get confused and disoriented by unusual or unexpected plan configurations, non-uniform designs for signs, or variations in terminology contrary to expectations.

A progressive and *continuous* compilation of information can enhance the quality of communication. "A sequence or series of visual cues or signs without gaps – numbering and lettering systems that incrementally increase or decrease – provides continuing confirmation to users that they are on the 'right track'" (Fruin 1985).

Trip information that is *repeatedly* (and redundantly) presented by different methods confirms and reinforces to the passenger. The methods include: a) the use of the same presentation format and sequential messages on successive signs to lead passengers, b) the use of color to name transit routes and repeat the same color on maps and signs for each route, and c) the use of geometric shapes for signage.

Different transfer facilities have different needs for information aids; the size and complexity of the facility influences the types and numbers of aids needed at facilities. For example, an on-street bus stop on a single route may need only an identifying logo and a route marker, while a full range of aids, possibly including special personnel, is often required for a multi-modal, multi-route facility. Therefore, it is important for transit operators to examine characteristics of a facility, establish design and service standards, evaluate alternatives, and select types and quality of information provided to transit users (Fruin 1985).

---

[2] Behavioral research has established that wayfinding through an environmental setting involve a process called "cognitive mapping," in which the wayfinder draws on past experiences for orientation, direction, and movement within a new setting.

Amenities

Amenities have impacts on behavior and perceptions of customers, and may directly or indirectly affect ridership. Many transit agencies work to improve amenities since they feel that it affects long-term viability of the transit system (Project for Public Spaces 1999 and TCRP Research Results Digest, 1995).

In the *TCRP Report 46*, the authors argue that new provision or improvement of amenities promotes transit ridership (Project for Public Spaces 1999). "In addition to foregoing a fare reduction, a high percentage of riders surveyed indicated that they would increase their transit use if selected amenities were provided" (Project for Public Spaces 1999). In the *Transit Design Game*, the authors found that spending at the 18 point level for amenities would lead to a 1.5 to 3 percent ridership increase in the case study cities. The 18 points in this survey was equivalent to approximately "$450,000 in annualized costs for a typical 300-bus transit system (Project for Public Spaces 1999)." In addition, many riders stated they would take public transit more if the selected amenities were provided. The more expensive and elaborate amenities would induce more additional riders (Project for Public Spaces 1999).

This study also found that a majority of riders actually prefer improvements in amenities to a fare reduction. For the 12-point survey, 53 percent and 70 percent of passengers in Rochester and Aspen, respectively, stated that they prefer the improvements of <u>all</u> amenities in their selection to a 10 cent fare reduction with no improvement of these amenities (Project for Public Spaces 1999). Only 23 percent and 14 percent of those in these cities, respectively valued a 10 cent fare reduction more important than all amenities that they selected. In the 18-point survey, there were fewer passengers whose preference toward amenity improvement exceeded a fare reduction. Many riders with an 18-point budget stated that they wanted to spend only 12 points for amenity improvements and reduce the fare by 5 cents (Project for Public Spaces 1999). This means that transit users would pay for modest amenity improvements, but prefer a fare reduction to luxurious amenity improvements, which is likely to have a larger effect to increase ridership. Since the relative importance of amenities to fares depends on riders' socio-economic characteristics as well as the unique physical environment for each transit system, it is desirable that transit agencies examine their users' preferences toward amenities, fare, and other service attributes.

Transit rider surveys and focus group research in *TCRP Report 46* shows that "passengers expect transit to be efficient, safe, and comprehensive, as well as comfortable (Project for Public Spaces 1999)." Transit users are highly concerned about "wait quality" which is evaluated in terms of the length of time, reliability of the bus arrival time relative to the scheduled arrival time, and the availability of a place to sit down (Hensher 1990). Passengers value shelters at stops, even if seats are not provided. Other qualities associated with the transit trip that concerns passengers include: 1) "vehicle quality" measured by the interior cleanliness and age of the buses, and 2) "trip quality" measured by the opportunity to have a seat, efficient boarding, a smooth ride, and express service.

Amenities can influence security and passengers' perception of security. (Security is discussed in the next section.) Amenities directly improve security by providing adequate lighting at and around bus stops, telephones at or near stops, location of stops near active land uses, and a map of the surrounding area (Project for Public Spaces 1999). Amenities significantly influence transit users' perception of security; good amenities at a facility indicate a certain level of care-taking and surveillance, which increases a sense of security. The *broken window theory* explains that people may perceive a facility to be more dangerous than it actually is when a low quality of appearance, lack of maintenance, or signs of deterioration implies a low level of care-taking at such a facility. An anecdotal example of this is that improvements on the built environment at subway stations in the City of New York increased a sense of safety perceived by transit users, regardless of actual crime patterns (Project for Public Spaces 1999).

Security

Security and safety are fundamental needs for users of transfer facilities. Without ensuring a certain level of security, it is impossible to increase ridership. Table 11 lists examples of security indicators from GOMMMS both for the security of users against crimes and terrorists', and safety of users from accidents, disaster, and other emergencies. This table also presents how each indicator has been evaluated in terms of three levels of quality.

TABLE 11 Security Indicators for Public Transport Passengers

Security Indicator	Poor	Moderate	High
Site perimeters, entrances and exits	Unmarked or poorly marked site perimeters, exits etc. Use of solid walls or similar.	Attention to boundary and exit marking, but otherwise unfavorable use of materials.	Clearly marked site perimeters/exits. Use of open fencing rather than solid walls.
Formal surveillance	No CCTV system in place. Design discourages staff surveillance and isolates passengers.	CCTV system in place, but number, location of system not optimal. Poor design which discourages staff surveillance.	Effective CCTV system in place. Design to encourage staff surveillance and group passengers.
Informal surveillance	Poor use of materials (fencing etc) and design. Poor visibility from site surrounds. Very isolated from retailers or other human activity.	Unfavorable use of materials (fencing etc) but reasonable proximity of retailers or other activity.	Positive use of materials (fencing etc) and design to encourage open visibility from site surrounds. Encouragement or proximity of retailers or other activity.
Landscaping	Landscaping features (design, plants etc) inhibits visibility and encourages intruders.	Evidence of some positive use of landscaping features (design, plants etc), but more measures needed to contribute to visibility and deter intruders.	Positive use of landscaping features (design, plants etc) to contribute to visibility and deter intruders.
Lighting and visibility	Poor design including recesses, pillars, obstructions etc which hinder camera/monitor view. Poor or no lighting in passenger areas at night when facility open. No or poor lighting on any signing, information or help points.	Design includes some recesses but not problematical to camera/monitor view. Lighting in passenger areas at some, but not all times when facility open. Lighting not to daylight standard. Attention to lighting on signing, information and help points.	Good design to avoid recesses and facilitate camera/monitor view. Lighting to daylight standard in passenger areas when facility open. Attention to lighting on signing, information and help points.

Emergency call	No or very poor provision of emergency phones, help points and public telephones. Little provision or information on emergency help procedures.	Basic provision of emergency phones, help points and public telephones. Improvements to these and on emergency help procedures needed.	Good provision of emergency phones, help points, public telephones and information on emergency help procedure.

Source: Department for Transport (2003)

A facility should be well maintained, and material used for facilities should be carefully chosen for maintenance. Ill-maintained facilities not only give an uncomfortable feeling to users, but also send signs of insufficient surveillance and may attract misconduct or illegal and criminal activities, according to the *broken window theory* (Kajima Institute Publishing Co. Ltd. 2002).

4.2 Transit Operators Perspective

Over the course of the past thirty years, the transit transfer facility literature focused mainly on the physical or geometric design of facilities and their operations, as well as on user attributes. The body of research in the mid-to-late 1970s investigated and developed a formalized and comprehensive approach for transit station design as prior to this time only a 'rule of thumb' approach had been used to address facility design (Hoel, Demetsky, and Virkler 1976). Hoel and Rozner (1976), in their National Science Foundation-sponsored research, reviewed the literature of transit facility design as it existed then and conducted a seminar on transit facility design that brought together representatives from the architecture, engineering, and transit communities with academic researchers in the transportation field. Concurrent research sponsored by the U.S. Department of Transportation (Hoel, Demetsky, and Virkler 1976), (Demetsky, Hoel, and Virkler 1976) and (Demetsky, Hoel, and Virkler 1977) involved the development of an interface facility design methodology, which added structure to the conventional 'rule of thumb' approach employed at the time by using a systems analysis approach to develop a methodology for planning, designing, and evaluating urban transportation interface facilities, in other words, public transit transfer facilities. In essence, this new methodology developed an approach with which to assess connectivity at transit transfer facilities. While this early research focused on the planning and design of transit transfer facilities as new facilities, the findings from this research have also been applicable to renovation of existing facilities as well (Demetsky, Hoel, and Virkler 1976).

The newly-developed methodology recognized that perspectives from different stakeholders needed to be acknowledged and included in the development of an interface facility design methodology. The early research considered the perspectives of the 1) conventional traveler, 2) special traveler, that is, the elderly or disabled, and 3) the operator. Vuchic and Kikuchi (1974) developed a variation of this classification and suggested considering the perspectives of the 1) traveler, 2) operator, and 3) community. Because this research was conducted prior to enactment of the Americans with Disabilities Act (ADA, 1990), it was reasonable in the mid-1970s to underscore or give special treatment to the disabled community. There appears to be less of a need to do this now because the ADA has been law for over sixteen years and so accommodating the disabled community has in essence become part of the normal design process. Moreover since the Baby Boom generation is poised to retire resulting in an expansion of the elderly segment of the general population, accommodating the elderly as a *special* group apart from non-elderly travelers also appears to be less necessary than it was previously.

The information gathered from previous research, especially shown previously in Tables 1, 2, 4, and 5, are essentially just lists of factors with no explanatory structure or ability to help understand 1) how and why these operator-perspective requirements contribute to transit transfer connectivity, 2) how they interact with each other and their tradeoffs, and 3) their relative importance. To begin adding structure to these lists of factors, we have organized the transit operator-related factors repeatedly identified in the literature into the following four categories:

- Fiscal / Costs and Revenues
- Institutional and Coordination
- Passenger Processing
- Environment

Fiscal/ Costs and Revenues

The fiscal aspects of operating a transit transfer facility are clearly and crucially significant to the transit operator(s) running the facility. A few of the individual fiscal-related factors or objectives identified from the literature are specifically listed in terms of minimizing component or total costs associated with operating the facility, for example 1) total cost, 2) operating cost, 3) maintenance (cleaning and replacement), and 4) investment cost (obtaining an efficient return on incremental investment). Other factors, shown in Table 12, are stated in less cost-explicit terms, yet, nonetheless, are very much cost-related (Horowitz and Thompson 1995), (Vuchic and Kikuchi 1974), (Hoel, Demetsky, and Virkler 1976), (Demetsky, Hoel, and Virkler 1976), and (ITE Technical Council Committee 5C-1A, 1992).

TABLE 12 Fiscal Objectives of Transit Operators

Transit Operator Fiscal/Cost Objectives	Linkage to Fiscal Matters
Achieve elimination of hazardous materials	If the facility contains hazardous materials (such as asbestos) they must be removed prior to new construction or renovation. Occupancy by operator employees and the traveling public cannot be allowed until this has been accomplished, thus contributing to the overall total facility cost.
Minimize wasted space	Unused or un-needed space increases construction and/or renovation costs, increases maintenance costs during operation and requires additional security and environmental controls. All of these are cost drivers for a project.
Maximize income from non-transport activities	Non-transport income could include income from advertising, leases of retail space, concessions, and joint development. These non-transport sources could offset some portion of the cost of operations.
Minimize negative impact on existing transportation services	A facility could have a cost impact on operators that cannot participate or on operators whose routes are disrupted or whose routes face additional competition.
Maximize joint development	Joint development involves the public and private sectors sharing the facility as well as its costs and revenues.
Achieve property rights	For a new facility, required property must be purchased and rights of use and access must be obtained. This contributes to the overall total facility cost.
Maximize flexibility for expansion	Costs may be saved when the facility is designed to just handle anticipated travel demand, yet provision is made for facility expansion in the case of increases in demand or addition of new modes.
Minimize fare inconsistencies	Fare inconsistencies include different rates among operators or inconsistent rates among like modes; such inconsistencies can impact revenues.
Maximize ease of operations of modes	Generally, the more difficult it is for the operator to perform its customary modal operations the more likely will it result in additional expenditure of resources and associated costs.
Utilize energy efficiently	The use of energy for heating and cooling the facility must be paid for and their efficient use will help reduce overall energy costs.
Maximize flexibility of operation	The ability to adapt to operational changes, whether necessary and unexpected or desirable can contribute to lower total costs.

Sources: Horowitz and Thompson (1995), Vuchic and Kikuchi (1974), Hoel, Demetsky, and Virkler (1976), Demetsky, Hoel, and Virkler (1976), and ITE Technical Council Committee 5C-1A (1992).

Institutional and Coordination

Transit transfer facilities with multiple transit service providers, modes, and/or lines will involve institutional ─ inter- or intra-organizational ─ and coordination issues about which the transit operator(s) is concerned, especially about transfer fares, coordination of schedules, and provision of information to travelers. Each of the four combinations of (single or multiple) transit service providers and (single or multiple) transit modes allow for the consideration of institutional issues. Examples of these four combinations are shown as follows:

1. Multiple transit service providers for multiple modes, e.g., Bay Area Rapid Transit (BART) and Alameda-Contra Costa County (AC) Transit in the San Francisco Bay Area
2. Multiple transit service providers for the same mode, e.g., the Metropolitan Transportation Authority and the Santa Monica Big Blue Bus in Los Angeles County
3. Multiple modes for a single transit service provider, e.g., Los Angeles County Metropolitan Transportation Authority (MTA/Metro) rail and bus services
4. Multiple lines/routes of a single mode for a single transit service provider (BART Richmond and Daly City Lines).

Generally, there is only one source from the literature ─ Horowitz and Thompson (1995) ─ that explicitly lists institutional issues as objectives from the transit operator perspective. These objectives are listed in Table 4 and they are "minimize institutional barriers to transferring" and "maximize coordination of transfer scheduling", which are, respectively, listed as the 4^{th} and 11^{th} ranked objectives (out of 70) with average ratings of 8.6 and 8.2 (out of 10.0). Thus, these objectives are very highly ranked and rated, in fact, higher than issues over costs at least according to this research. However, the "joint development" objective, which we have listed under the *Fiscal / Costs and Revenues* category, may also be listed under the Institutional Barriers and Coordination Aspects category.

Passenger Processing

Passenger processing objectives, listed below, refer to the *functional facility* components together with their *arrangements within the facility*. Basic functional facility components consist of 1) internal pedestrian movement facilities and areas (passageways, stairs, ramps, escalators, elevators, moving walkways, etc.), 2) line haul transit access area (entry control and fare collection; loading and unloading of passengers), 3) components that facilitate movements between access modes and the transfer facility such as ramps and automatic doors, and 4) communications (information and directional graphics, public address system). Corresponding criteria and performance measure information for each of these objectives are described in Tables 3 and 4 [Hoel, Demetsky, and Virkler (1976), Demetsky, Hoel, and Virkler (1976), and ITE Technical Council Committee 5C-1A, (1992)].

- Maximize equipment reliability
- Efficiently collect fares and control entry
- Maximize safety
- Efficiently process flows

- Provide adequate space
- Minimize queues
- Minimize pedestrian-vehicle conflicts
- Eliminate physical barriers

Environment

The *environmental* quality of a transit transfer facility involves aspects with which facility users associate their comfort, convenience, safety, and security [Hoel, Demetsky, and Virkler (1976), Demetsky, Hoel, and Virkler (1976)]. Nonetheless, these are also relevant ─ at least to some minimum degree ─ from the transit operator perspective since without an acceptable environment, at least those users with alternative means of travel will reconsider using the facility. There are also transit agency staff working in the facility and their comfort, safety, and security would be of concern to the transit operator. Typical safety standards include fire prevention and accident reduction measures. Security provisions are used to protect against or in response to crime, vandalism, or terrorism. Amenity-related environmental aspects for comfort and convenience are not directly associated with the movement of people; rather these aspects concern the physical environment through which they move. Basic amenity-related environmental components include the following. It is interesting to note in the list below that inclusion of "public telephones" is presently quite dated with the nearly ubiquitous use of cell phones.

- The physical environment (lighting, air quality, temperature, aesthetics, cleanliness)
- Non-transport businesses and services
- Restrooms and lounges; first-aid stations, public telephones
- Weather protection

4.3 Neighboring Communities Perspective

Over the course of the past thirty years, the transit transfer facility literature has focused mainly on the physical or geometric design of facilities together with their operations, as well as on user attributes. Research dealing with the relationship between transit transfer facilities and their neighboring communities has, at best, been sparse; moreover, there are notable differences between the existing body of research prior to and since the mid-1990s and we thus treat these time periods separately. As an example for bus transfer facilities, the Institute of Transportation Engineers (1992) state that the literature has focused mainly on the "physical or geometric design of bus lanes, and bus maneuvering areas, traffic flow relationships, the position of on-street bus stops, and the planning of off-street facilities" used as transportation centers. These authors addressed some of the shortcomings of the state of bus transfer facilities research at the time, especially its lack of a community perspective; however, according to Volinski and Page (2004), this work did not "adequately address the potential impacts and interrelationships between bus transfer centers and the communities where they were located" and "there was relatively little information on the subject of how transit transfer centers could contribute to positive development in the areas surrounding them".

Research prior to mid-1990s

For the body of research that does exist, prior to the mid-1990s community-perspective factors were examined and documented only in broad terms; Moreover, such research generally did not discuss any priority or ranking of community-perspective factors. It appears as though such factors were presented only to raise the level of awareness of this topic among researchers and practitioners. We provide the following three examples to illustrate typical literature before the mid-1990s:

1. In Vuchic and Kikuchi (1974), the authors state in general terms below community-perspective objectives. Since there was no reference to interviews, surveys, or focus groups to explain these objectives were ascertained, we assume it is based on the authors' experiences and expertise.

"The [transit transfer] station should be both attractive to passengers and efficient for the operator. But the community also is interested in both the immediate and long-range effect of the station on its surroundings. The immediate effects include environmental impact, visual aspects, noise, and possible traffic congestion. Long-range effects include the type of developments in the vicinity that may be stimulated or discouraged by the design of the station."

2. The authors of the Transportation Research Board Committee on Intermodal Transfer Facilities (1974) are representatives from both the research and practitioner communities, e.g., transit agencies, and thus, the view expressed below is based on their experiences and expertise. No mention of any interviews, surveys, or focus groups was made to explain how the community-perspective objectives in the quotation below, however broadly-stated, was ascertained.

"The transfer facility can provide a nucleus for community development; it can be the center for governmental, cultural, commercial or other development. The relationship of the facility to community development should be determined. This includes considerations of land use strategy and control near terminals, facility expansion and change, zoning techniques, joint development programs, institutional and financial arrangements, jurisdictions, and commercial development within and surrounding the facility."

3. The Institute of Transportation Engineers Technical Council Committee (1990) list two factors based on responses to a survey of ten U.S. transit operators running transfer centers. It should be noted that these community-related factors were obtained from the operator perspective. In addition to being stated broadly, the first factor does not specifically refer to transit transfer facilities or even public transit facilities.
    a. Provide a civic facility for which the community can be proud
    b. Aid downtown development and revitalization

Research since the mid-1990s

By the mid-1990s, while some research continued to be performed rather broadly, generally the research took on a more comprehensive approach with the performance of numerous site-specific case studies in the U.S. by means of site visits and interviews with local stakeholders. In addition, research during this period occasionally included prioritization and ranking of community-perspective factors. This approach was motivated by the Federal Transit Administration's (FTA) *Livable Communities Initiative* (FTA, 1994) and (National Academy Press and the Transportation Research Board, 1997). In reaction to what the FTA viewed at the time as a combination of technological advances in transportation and communication together with urban sprawl, increased traffic congestion, adverse environmental effects and the isolation of many residents from their communities, the FTA viewed transportation options as becoming increasingly limited especially for individuals who were unable to drive, preferred not to drive or had no automobile. Such negative factors, in FTA's view, had created renewed interest in compact communities with user-friendly transit linked to related development (FTA, 1994). In this context the FTA initiated its *Livable Communities Initiative*, which provided funding for eligible projects to strengthen the connections between public transportation and surrounding communities. Overall, FTA's goal was to support "transit facilities and services that promote more livable communities" (FTA, 1999) where such transit facilities are ones "which are customer-friendly, community-oriented and well designed resulting from a planning and design process with active community involvement" (FTA, 1999). The Initiative's objectives were to improve mobility and the quality of services available to residents of neighborhoods by:

- Strengthening the link between transit planning and community planning, including land use policies and urban design supporting the use of transit and ultimately providing physical assets that better meet community needs
- Stimulating increased participation by community organizations and residents, minority and low-income residents, small and minority businesses, persons with disabilities and the elderly in the planning and design process
- Increasing access to employment, education facilities and other community destinations through high quality, community-oriented, technologically innovative transit services and facilities
- Leveraging resources available through other Federal, State and local programs

FTA's above-stated goal when it embarked on its *Livable Communities Initiative* highlighted two elements directly linked to the relationship between a transit transfer facility and its surrounding community and which the sparse literature since the mid-1990s consistently refers to:

- Community-perspective factors of the transit facility that neighboring communities deem important and beneficial, e.g., 'customer-friendly', 'community-oriented', and 'well designed' as stated above.
- The process that the transit agency needs to employ to satisfactorily reach a community-supportive transfer facility, e.g., 'resulting from a planning and design process with active community involvement' as stated above.

Numerous community perspective factors repeatedly run through the research literature since the mid-1990s and we have organized these factors into the following six categories:

- Community image and pride ─ architectural, cultural, and historic preservation
- Joint development and partnerships

- Safety and security
- Environmental impacts on surrounding neighborhood
- Neighborhood economy / local employment
- Physical and social impacts on neighboring land uses

Community Image/Pride: Architectural, Cultural, and Historic Preservation

In Table 4 the following community-perspective objectives are listed, which cover community image and community pride relative to the transit transfer facility (Horowitz and Thompson, 1995). These objectives are listed below with both their individual ranking (out of 70 objectives) and their aggregate interviewee ratings (on a 0-to-10 scale) given in parentheses; the rankings indicate that most of these objectives were not give top priority by participants as they have been ranked in the lower half of the entire listing of 70 objectives.

- Minimize negative cultural impacts in surrounding neighborhood (23, 7.4)
- Maximize community pride (33, 7.0)
- Achieve compliance with historic preservation requirements (40, 6.9)
- Maximize quality of architectural design (51, 6.6)
- Maximize sense of place, historic significance, community image (53, 6.5)
- Maximize reuse of existing buildings and infrastructure (61, 5.8)
- Maximize positive cultural and social elements (61, 5.8)

Volinski and Page (2004 and 2006) focused on intra-modal bus transfer facilities and reported on how four transit agencies in four distinct regions of the U.S. used their bus transfer centers to improve their individual image and community relations as well as to serve as catalysts for positive development in the surrounding areas. The authors assert more broadly that transfer facilities can accommodate non-traditional and non-transit services and "should strongly consider including them if they help gain community acceptance and if they help the prosperity of the surrounding area" and that a bus transfer facility should be consistent with "a comprehensive [community] plan and help the surrounding community accomplish its broader development goals." Yet, these authors also state that architectural design of the facility and how it integrates local cultural characteristics of the surrounding neighborhood to enhance acceptance of the transfer facility are important; moreover, the transfer facility needs to serve as a "gateway to the community that people will feel proud of" and that "when completed, the facility should look as though it has always belonged there". National Academy Press and the Transportation Research Board (1997) stated that transit facilities should focus on how they "can act as catalysts for regenerating surrounding communities as well as on how they can serve as centers of community life," culturally. To achieve these goals, the authors recommend design-oriented strategies to enhance the comfort and convenience of transit users, "while having a positive impact on the surrounding area." Land and Foreman (2001) conducted a review of existing small-scale intermodal transfer facilities to determine common characteristics required to successfully establish such facilities on a neighborhood scale. The authors asserted that the facility "should be a recognizable feature of the neighborhood through informative signage and have public art and landscaping to enhance its attractiveness"; moreover, the authors assert that community-driven development helps the community "buy-in to the presence of the facility and generate pride of ownership in the facility."

Joint Development/Partnerships

In Table 4, "maximize joint development" is listed as the 31st ranked objective (out of 70) with an average rating of 7.1 out of a maximum 10.0 where the authors (Horowitz and Thompson, 1995) define "joint development" as the involvement of "the public and private sectors sharing the facility and its costs and revenues." In National Academy Press and the Transportation Board (1997), the contribution of transit agencies to the establishment of community-supportive transfer facilities is considered; moreover, the authors recommend that community involvement be integrated in the planning, design, and operation of the facility through the formation and maintenance of community partnerships. Volinski and Page (2004 and 2006) assert that "[c]omplete community involvement in the planning of a new transit center is vital to ensure it includes functions deemed important and beneficial by the community and to help ensure community support for the facility."

Regarding partnerships, Volinski and Page (2004 and 2006) asserted that transit transfer centers "can be more beneficial to surrounding communities when done in partnership with a broad array of public and private partners who are concerned with and help generate support for the facility" and "additional partners can bring more resources to access grants that can help pay for improvements and spur new development." Land and Foreman (2001) stated that "partnerships were integral in each of the case studies" and that partnerships should be encouraged "to instill a team approach to the facility's success" and that "opportunities for community partnerships exist."

Safety and Security

One of the community-perspective factors that is emphasized and given high priority in the literature is safety and security, both actual and perceived. In Horowitz and Thompson (1995), security and safety are ranked, respectively, as numbers 2 and 7 out of 70 and rated, respectively, 8.8 and 8.4 out of 10. National Academy Press and the Transportation Research Board (1997) stated that "In focus groups conducted for this study, [personal safety and security] was almost always the first issue mentioned". Volinski and Page (2004 and 2006) asserted that "there needs to be a no-tolerance policy taken when it comes to crime and vandalism if the [transit] center is to be regarded as a community asset. The transit center will not be a community asset unless it invests whatever is necessary to provide a high level of security."

Environmental Impacts to Surrounding Neighborhood

In Table 4 the following community-perspective objectives are listed, which cover environmental impacts to the facility's surrounding neighborhood (Horowitz and Thompson, 1995) with rankings and aggregate ratings given in parentheses.

- Achieve same or lower air pollution emissions (46, 6.7)
- Minimize regional air pollution emissions (55, 6.4)
- Minimize regional energy consumption (66, 5.6)

Volinski and Page (2004 and 2006) asserted that "the transit agency should take steps as quickly as possible to address the issues of bus noise and exhaust. Minimizing such pollutants will help gain community acceptance."

Neighborhood Economy/Local Employment

In Table 4 the following community-perspective objectives are listed, which cover the neighborhood economy and local-area employment opportunities (Horowitz and Thompson, 1995) with rankings and aggregate ratings given in parentheses.

- Maximize use of local employment during construction, operations, and maintenance of the facility (61, 5.8)
- Maximize informal vending, which includes sales from carts and vehicles that can move from place to place, street musicians, and occasional sales events, such as art shows, antique fairs, and charity fund-raisers (70, 4.1)

National Academy Press and the Transportation Research Board (1997) stated that transit facilities should focus on how they "can act" economically "as catalysts for regenerating surrounding communities as well as on how they can serve as centers of community life." To achieve these goals, the authors recommend design-oriented strategies to enhance the comfort and convenience of transit users, "while having a positive impact on the surrounding area."

Physical and Social Impacts on Neighboring Land Uses

In Table 4 the following community-perspective objectives are listed, which cover physical and social impacts on the community and its neighboring land uses (Horowitz and Thompson, 1995) with rankings and aggregate ratings given in parentheses.

- Minimize physical impacts to surrounding neighborhood (33, 7.0)
- Minimize negative social impacts in surrounding neighborhood (33, 7.0)
- Maximize flexibility for expansion (33, 7.0)
- Minimize conflict with surrounding land uses (46, 6.7)
- Minimize disruptive land acquisition (56, 6.3)
- Maximize urban renewal (60, 5.9)

To more completely and comprehensively examine community-perspective factors, it is very important to have prioritization of and ranking among the community-perspective factors that we have identified from the literature. We have identified only a couple examples of such prioritization and ranking in the post mid-1990s literature suggesting that safety and security, environmental impacts, and architectural design's integration with cultural characteristics are the three most important community-perspective factors, listed in order of priority. However, such prioritization is based on a sparse body of research, thus making inferences and drawing conclusions from such slim evidence is problematic. There is clearly, then, a gap in the research that our subsequent project tasks will attempt to fill.

Community Opposition to Siting of Facilities

The public transit research literature ─ especially since the mid-1990s ─ identifies various community-participatory/supportive actions that transit agencies can take toward the successful establishment and operation of transit transfer facilities; however the transit transfer literature does not address an essential intermediate component, that of any discussion of community opposition to these types of facilities and we view this as a gap in the literature even though anecdotal information regarding such opposition abounds from both personal professional experience as well as informal discussions with transit managers.

This gap in the research notwithstanding, there is a large body of documented research in the planning and geography fields that deals with community opposition to the siting of public or private facilities, a subject that customarily comes under the rubric 'NIMBY[3]-ism' or 'NIMBY Syndrome', and is more generally stated as locally unwanted land uses (LULUs). Such facilities can be classified into two primary types: human service or industrial, where the former provide services of one kind or another to particular segments of the population and may be entirely non-transportation related (Takahashi, 1998) and (Takahashi and Dear, 1997).

- Human Service Facilities
    - Alcohol rehabilitation facilities
    - Day care centers
    - Drug treatment centers
    - Homeless shelters
    - Hospitals
    - Outpatient mental health clinics
    - Nursing homes
    - Schools
    - Hospitals
    - Prisons
    - Specialized housing development for
        - Low-income families
        - Persons with AIDS
        - Individuals who suffer from depression, are mentally disabled or retarded
- Industrial
    - Hazardous/toxic material disposal or storage facilities
    - Factories
    - Landfills

Typical reasons given to explain the growth of neighborhood NIMBY-type organizations and their opposition to the siting of such facilities include their potential negative impacts (Jacobson, 2004), (Takahashi, 1998), (National Law Center of Homelessness and Poverty, 1997). As stated in (Takahashi, 1998), ". . . while studies have indicated that such facility types do not create these negative externality effects, the fear of these potential impacts continues to linger."

Common explanations given for community opposition to the siting of facilities include the following:

- Decreasing property values and depressing the housing or commercial building markets

[3] Not In My Backyard

- Resulting in negative fiscal impact on businesses
- Increasing crime
- Increasing traffic flow and overall traffic congestion
- Attracting the 'wrong' type of people or the 'wrong element' that leads to dangerous or criminal activity, e.g., drug dealers, inside and in the vicinity of the facility especially when adjacent land use is residential or commercial.
- Increasing air pollution, noise, and other adverse environmental impacts
- Having an unsightly or unattractive facility
- Changing other neighborhood amenities that the presence of facilities and clients might foster

To address such community opposition and more successfully manage facility siting, local governments are engaging in community participation to help justify the siting process, to represent multiple views, and to prevent opposition from taking hold (Takahashi and Dear, 1997). These methods are analogous to the process used by transit operators and neighboring communities participating in FTA's *Livable Communities Initiative* (FTA, 1994). While the focus of this community-opposition literature is on the siting of human service and industrial facilities, there are documented examples of community opposition to transit projects in general if not transit transfer facility projects in particular. For example, as part of the Environmental Impact Statement's public comment period for a project in Boulder, Colorado in 2005 to site commuter rail maintenance yards along U.S. Highway 36, there was great opposition to the siting of these yards. Concerns were expressed by both individuals such as private property owners and organizations such environmental advocacy groups and universities. Among the concerns expressed are the following, which are similar to issues previously listed, though include concerns that reflect the more rural nature of the corridor (US 36 Corridor Environmental Impact Statement, 2005) than issues cited above:

- Negative environmental impacts
    - Noise and need for sound walls
    - Loss of wetlands, walking trails open space, and bike paths
- Traffic
- Loss of community resources such as community centers, houses of worship, and elder housing
- Loss of small businesses and associated jobs and tax base

Another example involves the attempt by BART in the San Francisco Bay Area in the early 1990s to construct a multi-layered parking facility next to the Fruitvale BART Station. Although the community agreed that new parking was necessary, the design and location of the facility generated opposition among residents and business owners in the Fruitvale Station neighborhood. Members of the community were concerned that the proposed structure would increase traffic and pollution and further separate the Fruitvale neighborhood from the BART station. Neighborhood opposition to the parking structure design and location was well-organized and strong and convinced BART that any development around the BART station should be guided by a broad-based community planning process; BART eventually withdrew its proposal and agreed to work with the Unity Council on a plan for the area (FHWA, 2000).

As shown from these two examples, reasons given for community opposition to non-transportation facility sitings are generally also applicable to transportation-related facilities and, we hypothesize, transit transfer facilities; so this larger field of community opposition to the siting of facilities and its documented literature is relevant for our current study; however, objective and systematic research is absent and needs to be conducted to specifically investigate community opposition to transit transfer facilities, corroborate our hypothesis, and fill this gap in the research and associated literature.

5.0 SUMMARY AND NEXT STEPS

Throughout our review of the transit transfer literature, a multitude of evaluation criteria were identified for each of the components of the three-way stakeholder perspective framework we developed and used: Passenger/User, Transit Operator, and Neighboring Community. Much of the literature provides only lists of criteria with no structure or organization with which to assist in evaluating the transfer facilities. To begin to remedy this situation, for each of the three stakeholder perspectives, we have organized the evaluation criteria into categories and summarize them in this section (Tables 13, 15, and 16). It should also be noted that the same criteria associated with transit transfer facilities may be evaluated from multiple perspectives (See Section 3.2). Identifying these common cross-perspective attributes is important because it will enable the project team to understand the relative importance of attributes not only for each perspective category but also across perspective categories.

5.1 Passengers/Users Perspective

From the transfer facility literature, we identified numerous criteria from the passengers/users perspective and developed a five-way classification scheme to organize these criteria. For each of the five categories ─ security/safety, amenities, information, access, and connection/reliability ─ we examined the evaluation criteria from the literature and produced, after removing redundant listings, a reduced set of five lists (Table 13). As we previously discussed, some criteria are listed in the literature in very broadly-worded terms, such as “Maximize security and safety” and “Maximize amenities” while others are very narrowly-worded, such as “Security personnel” and “Video surveillance equipment”.

While the five categories encompass all physical attribute evaluation criteria, they are not mutually exclusive as they overlap in certain areas. Table 14 indicates by an “X” which passenger/user perspective evaluation criteria categories overlap with other such categories. For example, Security and Safety and Amenities overlap in the following ways:

- Promotion of retail and other activities
- Design and layout of retailer stores/human activity
- Landscaping features and its relationship to visibility and presence of intruders

Security and Safety and Information categories overlap because unmarked or poorly marked site perimeters and exits are part of the Information category while they could impact security.

Security and Safety and Access overlap through the use of stop signs, crosswalks, traffic control signals. Amenities and Information overlap with respect to signage for commercial or retail stores. Information and Access categories overlap vis-à-vis the directional information that guides facility users to get to their final facility destination.

TABLE 13 Passengers/Users Perspective Evaluation Criteria

Physical Attribute Category	Evaluation Criteria
Security and Safety	Security personnel
	Video surveillance equipment
	Extent of visibility and lighting
	Means of communication for emergencies
	Infrastructure
	Maximize safety & security
Amenities	Comfort / Convenience
	Service/commercial enterprises
	Weather protection
	Aesthetically pleasing/clean environment
	Maximize amenities
Information	What information is provided
	Where the information is provided
	How the information is conveyed
Access	Passenger flow management
	Physical infrastructure
	Directional information
Connection and Reliability	Schedule adherence/Reliability of vehicle
	Connection/Completing transfer (Distance and Time)

TABLE 14 Overlapping of Evaluation Criteria Categories

	Security & Safety	Amenities	Information	Access	Connection & Reliability
Security & Safety		X	X	X	
Amenities			X		
Information				X	
Access					
Connection & Reliability					

5.2 Transit Operators Perspective

From the transfer facility literature, we identified numerous criteria from the transit operators perspective and organized these criteria into four groups. For each of these four groups ─ fiscal / costs & revenues, institutional and coordination, passenger processing, and environmental ─ we examined the evaluation criteria from the literature and produced, after removing redundant listings, a reduced set of four lists (Table 15). Some criteria are listed in the literature in very broadly-worded terms, such as “Achieve property rights” and “Maximize safety” while others are more specific, such as “Minimize operations and maintenance costs” and “Provide restrooms”.

TABLE 15 Transit Operators Perspective Evaluation Criteria

Evaluation Criteria Categories	Evaluation Criteria
Fiscal / Costs & Revenues	Minimize total, operating, maintenance, and investment costs
	Achieve elimination of hazardous materials
	Minimize wasted space
	Maximize income from non-transport activities
	Minimize negative impact on existing transportation services
	Maximize joint development
	Achieve property rights
	Maximize flexibility for expansion
	Minimize fare inconsistencies
	Maximize ease of operations of modes
	Utilize energy efficiently
	Maximize flexibility of operation
Institutional and Coordination	Minimize institutional barriers to transferring
	Maximize coordination of transfer scheduling
Passenger Processing	Maximize equipment reliability
	Efficiently collect fares and control entry
	Maximize safety
	Efficiently process flows
	Provide adequate space
	Minimize queues
	Minimize pedestrian-vehicle conflicts
	Eliminate physical barriers
Environment	Provide a safe and secure environment
	Provide proper physical environment (lighting, air quality, temperature, aesthetics, and cleanliness)
	Provide restrooms, first-aid stations, public telephones
	Provide protection from the weather

5.3 Neighboring Communities Perspective

From the transfer facility literature, we identified numerous criteria from the neighboring community perspective and organized these criteria into six categories. For each of these six groups ─ community image and pride, joint development and partnerships, safety and security, environmental impacts, neighboring economy / local employment, and physical and social impacts on neighboring land uses — we examined the evaluation criteria from the literature and produced, after removing redundant listings, a reduced set of six lists (Table 16). Some criteria are listed in the literature in very broadly-worded terms, such as “Maximize community pride” and “Maximize urban renewal” while others are more specific, such as “Achieve same or lower air pollution emissions”.

TABLE 16 Neighboring Communities Perspective Evaluation Criteria

Evaluation Criteria Categories	Evaluation Criteria
Community Image and Pride	Minimize negative cultural impacts in surrounding neighborhood
	Maximize community pride
	Achieve compliance with historic preservation requirements
	Maximize quality of architectural design
	Maximize sense of place, historic significance, community image
	Maximize reuse of existing buildings and infrastructure
	Maximize positive cultural and social elements
Joint Development and Partnerships	Maximize joint development
	Establish inter-organizational partnerships
Safety and Security	Provide a safe and secure environment
Environmental Impacts	Achieve same or lower air pollution emissions
	Minimize regional air pollution emissions
	Minimize regional energy consumption
Neighboring Economy / Local Employment	Maximize use of local employment during construction, operations, and maintenance of the facility
	Maximize informal vending, which includes sales from carts and vehicles that can move from place to place, street musicians, and occasional sales events, such as art shows, antique fairs, and charity fund-raisers
Physical and Social Impacts on Neighboring Land Uses	Minimize physical impacts to surrounding neighborhood
	Minimize negative social impacts in surrounding neighborhood
	Maximize flexibility for expansion
	Minimize conflict with surrounding land uses
	Minimize disruptive land acquisition
	Maximize urban renewal

5.4 Next Steps

The next phase of the project involves extensive field work to collect data for subsequent analysis relative to the passengers/users, transit operators, and neighboring communities stakeholders' perspectives. This work will contribute to the development of the transit connectivity tool.

For the passengers/users stakeholders, our methodological approach consists of designing and administering a survey to users at numerous transit transfer facilities in southern California. Criteria for the selection of specific facilities include time of day, transfer facility type, available travel modes, means of passenger loading, etc. The survey will have questions to ascertain user perceptions regarding the passengers/users evaluation criteria (Table 13): security & safety, amenities, information, and access. At each of the selected sites, we will also make note of the physical attributes associated with these evaluation criteria. The relationship between our site observations and survey responses, especially the perceptions of users, will be studied as part of the data analysis phase of our work.

For the transit operators and neighboring communities stakeholders groups, our methodological approach involves developing a set of questions with which to discuss with representatives of various transit operators and community groups associated with the previously-selected transit transfer facilities at which user surveys were administered. This phase of our work has three objectives: 1) To update the evaluation criteria that were identified from the literature so that these criteria reflect current circumstances as some of the research forming the basis of the literature is now thirty years old; 2) To prioritize and/or rank the evaluation criteria; and 3) To investigate community opposition to transit transfer facilities.

BIBLIOGRAPHY

American Association of State Highway and Transportation Officials. 1983. *Guide for the Design of High Occupancy Vehicle and Public Transfer Facilities*. Washington, D.C.: American Association of State Highway and Transportation Officials.

Committee on Intermodal Transfer Facilities, Transportation Research Board. 1974. Intermodal Transfer Facilities Research Needs. *Transportation Research Record* 505:43-46.

Department for Transport. 2003. *Transport Analysis Guidance* 2003 [cited Nov. 09. 2005]. Available from http://www.webtag.org.uk/index.htm.

Evans, John E. et al. 2004. Chapter 9 - Transit Scheduling and Frequency. In *TCRP Report 95 Traveler Response to Transportation System Changes*. Washington, D.C.: Transportation Research Board.

Federal Highway Administration, Federal Transit Administration, December 2000, Transportation and Environmental Justice Case Studies, Publication No. FHWA-EP-01-010

Federal Transit Administration, http://ntl.bts.gov/DOCS/livbro.html Date accessed: April 12, 2006 (FTA, 1994)

Federal Transit Administration, Livable Communities Initiative. Building Livable Communities with Transit, September 1999, http://safety.fhwa.dot.gov/fourthlevel/pdf/livable.pdf

Fruin, John J. 1985. Passenger Information Systems for Transit Transfer Facilities. In *Synthesis of Transit Practice, 7*, edited by N.C.T.R.D. P. (U.S.). Washington, D.C.: Transportation Research Board National Research Council.

Hensher, David. 1990. Hierarchical Stated Response Designs - An Application to Bus User Preferences. *Logistics and Transportation Review* 26:299.

Hocking, R. J. 1990. Effectiveness of Downtown Transit Centers. *ITE Journal*.

Horowitz, Alan J., and Nick A. Thompson. 1995. Generic objectives for evaluation of intermodal passenger transfer facilities. *Transportation research record* 1503:104-110.

ITE Technical Council Committee 5C-1A. 1992. The Location and Design of Bus Transfer Facilities. *ITE Journal*: 33-37.

ITE Technical Council Committee 6A-40, "Effectiveness of Downtown Transit Transfer Centers", Institute of Transportation Engineers Journal, September 1990.

Jacobson, J.O., *The Ecological Context of Substance Abuse Treatment Outcomes Implications for NIMBY Disputes and Client Placement Decisions*, June 2004, Pardee RAND Graduate School Dissertation.

Kajima Institute Publishing Co. Ltd. 2002. *Station Revitalization*. Edited by K. I. P. C. Ltd. Tokyo, Japan: Kajima Institute Publishing Co. Ltd.

Kittelson & Associates, Inc., et al.,. 2003. Transit Capacity and Quality of Service Manual - 2nd Edition - Part 3 Quality of Service and Part 7 Stop, Station, and Terminal Capacity. In *TCRP Report 100*. Washington, D.C.: Transportation Research Board.

Knobloch, Axel von. 1999. The Importance of Multimodal Transfer Facilities in Hamburg. *Public Transport International* 1:30-32.

Land, L. and Foreman, C., "Neighborhood Intermodal Transfer Facilities", Report Number NCTR-392-16, Research & Special Programs Administration, U.S. Department of Transportation, Florida Department of Transportation and University of South Florida, Center for Urban Transportation Research, National Center for Transit Research, Tampa, Florida, October 2001.

Liu, Rongfang, Ram M. Pendyala, and Steven Polzin. 1997. Assessment of intermodal transfer penalties using stated preference data. *Transportation research record* 1607:74-80.

Metropolitan Transportation Commission, *Transit Connectivity Study*, 2006.

National Academy Press and the Transportation Research Board, *The Role of Transit in Creating Livable Metropolitan Communities*, Transit Cooperative Research Program Report 22, http://gulliver.trb.org/publications/tcrp/tcrp_rpt_22-b.pdf. 1997

National Law Center on Homelessness & Poverty, *Access Delayed, Access Denied: Local Opposition to Housing and Service for Homeless People Across the United States*, December 1997.

Parsons Brinckerhoff. 2002. Intermodal Facilities. *PB network*, May 2002.

Partnerships, Enhancements and Public Involvement http://www.fhwa.dot.gov/environment/ejustice/case/index.htm

Project for Public Spaces, Inc. with Multisystems Inc. 1999. The role of transit amenities and vehicle characteristics in building transit ridership: Amenities for transit handbook and the Transit design game workbook. In *US Federal Transit Administration, Transit Cooperative Research Program, TCRP Report 46*. Washington, D.C.: Transit Development Corporation, National Research Council (U.S.). Transportation Research Board, National Academy Press. Original edition, Project for Public Spaces.

Rabinowitz, H. Z., Edward A. Beimborn, Peter S. Lindquist, and Donna M. Opper. 1989. Market Based Transit Facility Design, edited by U.S. Department of Transportation. Washington, D.C.: Urban Mass Transportation Administration.

Reynolds, Marilyn M., and Charles D. Hixson. 1992. Transit vehicle meets system : a method for measuring transfer times between transit routes. *Transportation research record* 1349:35-41.

Takahashi, L., Homelessness, AIDS, and Stigmatization: The NIMBY Syndrome in the United States at the End of the Twentieth Century (Oxford Geographical and Environmental Studies Series), 1998.

Takahashi and Dear, M.J. (1997), The Changing Dynamics of Community Attitudes Toward Human Services, Journal of the American Planning Association, 63: 79-93.

The Project for Public Spaces, Inc. 1997. The Role of Transit in Creating Livable Metropolitan Communities. In *Transit Cooperative Research Program*, edited by T. R. Board. Washington, D.C.: National Academy Press.

Thomsett, M.C., NIMBYism: Navigating the Politics of Local Opposition, CenterLine Publishing, Arlington, VA, 2004.

Transportation Research Board Committee on Intermodal Transfer Facilities, "Intermodal Transfer Facilities Research Needs", *Transportation Research Record, Number 505, Intermodal Transfer Facilities*, Transportation Research Board, National Research Council, Washington D.C., 1974.

Vuchic, Vukan R., and Shinya Kikuchi. 1974. "Design of Outlying Rapid Transit Station Areas", *Transportation Research Record* 505:1-12, Transportation Research Board, National Research Council.

Volinski, J. and O. Page, "Developing Bus Transfer Facilities for Maximum Transit Agency and Community Benefit", NCTR 527-13 / FDOT BC 137-53, National Center for Transit Research, University of South Florida, December 2004.

Volinski, J. and O. Page, "Developing Bus Transfer Facilities for Maximum Transit Agency and Community Benefit", 85th Annual Meeting of the Transportation Research Board, Washington D.C., January 2006.

Volinski, J., J. Rey, and V. Perk, "Security Issues Surrounding Transit Transfer Centers in or Near Residential Settings", Center for Urban Transportation Research, White Paper, 1999.

APPENDIX C

APPENDIX C

Evaluating Transit Stops and Stations from the Perspective of Transit Users

Under Contract 65A0194 (PS04):
Tool Development to Evaluate the Performance of
Intermodal Connectivity (EPIC) to Improve Public Transportation

Submitted to:

California Department of Transportation
Division of Research and Innovation
1227 O Street, 5th Floor
Sacramento, CA 94273-0001

Prepared by:

Hiroyuki Iseki[1] Adina Ringler, Brian D. Taylor, Mark Miller[2], and Michael Smart

Institute of Transportation Studies
University of California, Los Angeles
School of Public Affairs
3250 Public Policy Building, Box 951656
Los Angeles, CA 90095-1656

[2]California PATH Program
University of California, Berkeley
Institute of Transportation Studies
Richmond Field Station, Bldg. 452
1357 S. 46th Street
Richmond, CA 94804-4648

[1]Department of Geography and Planning
University of Toledo
College of Arts and Sciences
4200 University Hall, Mail Stop 932
2801 W. Bancroft Street
Toledo, OH 43606

August 10, 2007

Executive Summary

Travel by public transit involves much more than moving about on buses or trains. A typical door-to-door trip entails walking from one's origin to a bus stop or train station, waiting for one's vehicle to arrive, boarding the vehicle, traveling in the vehicle, alighting from the vehicle, and then walking to one's final destination. In many cases, the trip involves transfers; travelers frequently alight from one transit vehicle, move to a new stop or platform, wait for another transit vehicle, and board that vehicle. Transit travelers expend a great deal of time and energy on this out-of-vehicle walking and waiting, which plays greatly into their perceived burden of transit travel. Despite the importance of out-of-vehicle transit travel, the in-vehicle travel experience has tended to garner the lion's share of attention from transit managers and researchers. Accordingly, this study is concerned with the out-of-vehicle segments of transit travel and with ways to reduce the burdens of walking, waiting, and transferring.

What are the best ways to reduce these out-of-vehicle travel burdens? Are some approaches to improving the "interconnectivity" among transit lines, modes, and systems more cost-effective than others? Can improvements be made in a stand-alone fashion, or do they need to be implemented in concert with other improvements? Do different types of transit travelers tend to perceive the burdens of walking, waiting, and transferring differently? These are some of questions we aim to address in this research. To do so, we have developed a methodology based on travel behavior research, which we use to evaluate the components of the out-of-vehicle travel experience. Such information should help transit planners cost-effectively improve operations at transit stops and stations.

In this report, we focus on factors that are important from the passengers'/users' perspective. More specifically, the analysis presented in this report has sought to address the generally absent causal clarity that plagues most previous research on transit stops and stations. Accordingly, we have examined: (1) how passengers evaluate transit stops and stations, taking into account the level of importance passengers place on each factor, and (2) what factors influence passengers' evaluation of transit stops and stations using the five evaluation criteria developed from the transfer penalties causal framework developed in a previous report:

1) *access*,
2) *connection and reliability*,
3) *information*,
4) *amenities*, and
5) *security and safety*.

Using this framework we designed a survey to examine user perceptions of each of these five evaluation criteria and administered the survey to 749 transit passengers at twelve transit stops and stations (which ranged from adjacent corner bus stops to a large enclosed multi-modal transit center) around metropolitan Los Angeles. In particular, we asked transit passengers to assess the level of importance of multiple service features, and their level of satisfaction at the stop or station where the survey was administered under the current conditions on a four-point scale from "very important" to "not important", and "strongly agree" to "strongly disagree", respectively. The demographics and travel patterns of those surveyed generally mirror those of southern California transit users in general.

Drawing on the data collected from this survey, we conducted two types of analyses: First, we conducted an *Importance-Satisfaction Analysis* to identify which attributes passengers found most important (importance) and which needed the most improvement (satisfaction). Second, we used *chi-square tests*, *correlation tests*, and *multiple regression analyses* to determine the relative importance of the five-category attributes to users' satisfaction with the transit facility and to examine which transit stop and station attributes measured in the physical inventory were related to the satisfaction level of transit users.

From these analyses, one principal finding stands out loud and clear: the most important determinant of user satisfaction with a transit stop or station has nothing (directly) to do with physical characteristics of that stop or station – it is frequent, reliable service in an environment of personal safety. In other words, most transit users would prefer short, predictable waits for buses and trains in a safe, if simple or even dreary, environment, over long waits for late-running vehicles in even the most elaborate and attractive transit station, especially if they fear for their safety. While this finding will come as no surprise to those familiar with past research on the perceptions of transit users, it does present a contrast to much of the descriptive, design-focused research on transit stops and stations.

In total, we examined sixteen stop and station attributes and, of these, users ranked safety and service quality factors as most important:

<u>Most Important</u>

1. I feel safe here at night (78%)
2. I feel safe here during the day (77%)
3. My bus/train is usually on time (76%)
4. There is a way for me to get help in an emergency (74%)
5. This stop/station is well lit at night (73%)
6. I usually have a short wait to catch my bus/train (70%)

In contrast, stop and station-area amenities – the ostensible focus of this research – were ranked as least important by users:

<u>Least Important</u>

11. It is easy to get route and schedule information at this stop/station (62%)
12. There is a public restroom nearby (59%)
13. This stop/station is clean (58%)
14. It is easy to get around this stop/station (57%)
15. There are enough places to sit (50%)
16. There are places for me to buy food or drinks nearby (34%).

This is not to say that such amenities are not important to travelers – more than half ranked information, a public restroom, cleanliness, and ease of navigation – as important. Rather, *ceteris paribus*, travelers prefer safe, frequent, reliable service over these factors.

However, when we statistically related users' satisfaction with various stop/station attributes with their overall satisfaction with their wait/transfer experience, we got similar, though not identical, results:

Most Important

1. It is easy to get around this stop/station.
2. I feel safe here during the day.
3. Having security guards here makes me feel safer.
4. It's easy to find my stop or platform.
5. The stop/station is well lit at night.
6. My bus/train is usually on time.

Least Important

11. This stop/station is clean.
12. There is shelter here to protect me from the sun or rain.
13. There is a way for me to get help in an emergency.
14. There are enough places to sit.
15. There are places to buy food or drinks nearby.
16. There is a public restroom nearby.

Following this, we then employed a logistic regression model to measure the influence of each of 16 attributes on overall satisfaction, while simultaneously controlling for the effects of all other measured attributions on satisfaction. This sort of an analysis tends to eliminate all but one of closely related factors (such as "I feel safe here at night" and "This stop/station is well-lit at night") while elevating ostensibly less-important factors that independently influence users' overall levels of satisfaction:

Most Important

1. My bus/train is usually on time.
2. Having a security guard here makes me feel safer.
3. This stop/station is well lit at night.
4. I feel safe here during the day.
5. It is easy to get around this station/stop.
6. The signs here are helpful.

Finally, we performed an extended series of statistical tests in an attempt to relate the physical attributes of stops and stations (as collected in our station inventories) with the surveyed passengers' perceptions of these attributes. These results were largely as expected. While we were not able to draw firm conclusions regarding how these various attributes were related to overall user satisfaction levels, we did identify specific attributes that predict users' satisfaction levels. These attributes include graffiti, visibility, and the presence of seating area, restroom, and shelter. At the same time, we found the results of other variables, such as the availability of services, call boxes, protection from rain, utilization of the stop or station, and the presence of hiding areas, to be counter-intuitive. Many of this last set of findings, however, are best viewed as preliminary, and likely require further investigation.

While perhaps surprising to those interested in the influence of urban design on travel, these findings should be heartening to transit managers focused on delivering quality transit service to users. While comfortable, informative and attractive stops and stations can indeed make traveling by public transit more agreeable, all things being equal, what passengers want most is safe, frequent, and reliable service – plain and simple.

Key words: travel behavior, transit user perceptions, out-of-vehicle travel, wait/transfer burden, transit stops, transit stations, transfer facilities, user satisfaction survey, Importance-Satisfaction analysis, ordered logit analysis

TABLE OF CONTENTS

List of Tables

List of Figures

1. PREFACE

Travel by public transit involves much more than moving about on buses or trains. A typical door-to-door trip entails walking from one's origin to a bus stop or train station, waiting for one's vehicle to arrive, boarding the vehicle, traveling in the vehicle, alighting from the vehicle, and then walking to one's final destination. In many cases, the trip involves transfers; travelers frequently alight from one transit vehicle, move to a new stop or platform, wait for another transit vehicle, and board that vehicle. Transit travelers expend a great deal of time and energy on this out-of-vehicle walking and waiting, which plays greatly into their perceived burden of transit travel. Despite the importance of out-of-vehicle transit travel, the in-vehicle travel experience has tended to garner the lion's share of attention from transit managers and researchers. Accordingly, this study is concerned with the out-of-vehicle segments of transit travel, and with ways to reduce the burdens of walking, waiting, and transferring.

What are the best ways to reduce these out-of-vehicle travel burdens? Are some approaches to improving the "interconnectivity" among transit lines, modes, and systems more cost-effective than others? Can improvements be made in a stand-alone fashion, or do they need to be implemented in concert with other improvements? Do different types of transit travelers tend to perceive the burdens of walking, waiting, and transferring differently? These are some of questions we aim to address in this research. To do so we have developed a methodology based on travel behavior research, to evaluate the components of the out-of-vehicle travel experience. Such information should help transit planners cost-effectively improve operations at transit stops and stations.

The research project, *Tool Development to Evaluate the Performance of Intermodal Connectivity (EPIC) to Improve Public Transportation*, will assist the California Department of Transportation, regional and local transportation related entities, transit operators, and other stakeholders in understanding which attributes of transit stops and stations are important to users, operators, and communities. Our study evaluates interconnectivity issues pertaining to travel and identifies opportunities and solutions for improving transportation systems.

This report is the third deliverable of this effort; the first two deliverables documented our reviews of the literature. In the first deliverable, we focused on factors at transit stops and stations that influence transit users' experience in transit trips. Reviewing a large number of studies conducted on the subject of travel behavior, we developed a transfer penalties framework to relate transit waiting time, walking time, and transfers to people's generalized cost (or utility) in their transit trips. Based on this framework, we also suggested a classification of factors relating to out-of-vehicle travel time (waiting, walking, transferring, etc) to examine which part of transfer penalties would likely be affected by various improvements to transit service, stops, and stations. This framework provides a theoretical basis for developing methods to evaluate the connectivity performance of transit stops and stations systematically and meaningfully. This approach is very different from a vast majority of past studies, which have focused heavily on design aspects. In these design-focused studies, most of the suggested improvements have seemed intuitively correct, though the actual effects on travel behavior remain relatively ambiguous and unexamined.

Three important findings from the first deliverable are: 1) that we should include both *intermodal* and *intramodal* transfers in the study of transit stops and stations, 2) that we should include attributes in the operation and management aspects as well as attributes of the physical environment in our evaluation of transit stops and stations, and 3) that evaluation methods can be either qualitative or quantitative or both.

In the second deliverable, we focused on the evaluation of connectivity performance at transit stops and stations by identifying those evaluation criteria or factors that are relevant to understanding the achievement of transit connectivity. We formulated a three-branch classification system of such factors important to 1) passengers/users, 2) transit operators/managers, and 3) the neighboring communities' perspectives. This and subsequent project deliverables investigate those factors at transit stops and stations that are important from each of these perspectives.

In this third deliverable, we report o ur research on factors that are important from the passengers'/users' perspective. More specifically, we address questions on: 1) how passengers evaluate transit stops and stations, taking into account the level of importance passengers place on each factor, and 2) what factors influence passengers' evaluation of transit stops and stations. To collect data for this analysis, we conducted a survey of transit passengers in metropolitan Los Angeles, asking a series of questions about their experiences at transfer stops and stations.

This component of the research helps us to achieve the project's central goal of developing the means by which transit stakeholders may assess the performance of transit connectivity. The findings from this research form the basis for the project's continuing process in identifying and investigating the important factors of transit stops and stations influencing people's travel behavior and their contribution to growth in ridership.

2. INTRODUCTION

As cities have grown more dispersed and auto-oriented, the relative burdens of out-of-vehicle time in transit trips have increased. In an effort to accommodate increasingly dispersed patterns of trip-making, many transit systems in U.S. metropolitan areas now require transit users to make frequent transfers among lines, modes, and operators. In metropolitan areas with large transit systems, transit stops and stations are central parts of the transit network, playing an important role in connecting multiple transportation systems — both *intermodal* and *intramodal*. The effectiveness of connectivity influences travelers' experience at transit stops and stations, and, in turn, their choice of whether or not to take a particular transit trip. Given the importance of out-of-vehicle times on travel choices, good connectivity at such transit stops and stations is a critical part of overall transportation network effectiveness.

While many previous studies have investigated the improvements at transit stops and stations, this past research has, in general, lacked causal clarity of how such improvements can increase transit ridership. Most of these studies were conducted from a design perspective, and suggest improvements at transit stops and stations that are often obvious (e.g. providing more seats and shelters, improving lighting, keeping facilities clean). However, these studies do not show the relative importance of various stop/transfer factors in actually influencing people's travel behavior, or how they might work in concert (Rabinowitz et al. 1989; Fruin 1985; Kittelson & Associates 2003; Vuchic and Kikuchi 1974; Evans 2004). This lack of clarity or causality is a problem, making it difficult for transit managers to improve the quality of waiting and transfers at transit stops and stations cost-effectively.

The focus of this report is on the evaluation of the waiting and transfer experiences from the passengers' perspective. Specifically, we examine: 1) how passengers evaluate transit stops and stations, taking into account the level of importance passengers place on each factor, and 2) what factors influence passengers' evaluation of transit stops and stations. Throughout this report, we use the five evaluation criteria of transit stop and station attributes drawn from the transfer penalties causal framework developed in a previous report for this project:

1) *access*,
2) *connection and reliability*,
3) *information*,
4) *amenities*, and
5) *security and safety*.

This classification helps us identify how different *types* of improvements at transit stops and stations can affect people's travel behavior through transfer penalties and, thus, affect transit system use.

Our investigative method centers on the use of a survey instrument designed to collect data from passengers at transfer stops and stations in the metropolitan Los Angeles area. We also conducted an inventory of the quality of service and attributes at the same transfer stops and stations.

The analysis presented in this report has two parts. The first analytical method, *Importance-Satisfaction Analysis*, allows us to identify the priority that users place on improving the various facility attributes included in our study. *Importance-Satisfaction Analysis* allows us to make recommendations that will maximize the impact that new investments have on customer satisfaction by emphasizing improvements in those areas where the level of satisfaction is relatively low and the perceived importance of the issue is relatively high. In the second part of our analysis, we use the chi-square test, correlation test, and advanced regression analysis to examine which attributes at transit stops and stations measured in the inventory are related to the satisfaction level of transit users.

In summary, we find that improvements of (1) service quality (i.e. good *connection and reliability*) and (2) personal *safety and security* are much more important to transit users than physical conditions of transit stops and stations. In addition, while the analysis showed the highest need for improvement in the *amenities* category, transit agencies do not always have jurisdictional authority to change the physical aspects of the transit stations and stops.

We found in our regression analysis that the passenger's level of satisfaction with attributes in the categories of *connection and reliability* and *safety and security* significantly affect the passenger's overall satisfaction level with a transit stop or station. We also found satisfaction with attributes related to *access* and *information* were important determinants of overall satisfaction. On the other hand, none of the variables related to *amenities* were found to be important in determining overall satisfaction levels. While we were not able to draw firm conclusions regarding how these *amenity* attributes were related to overall user satisfaction levels, we did identify specific station inventory elements that predict users' satisfaction levels in intuitive ways. These attributes include graffiti (lower satisfaction), visibility, and the presence of seating areas, restroom, and shelter (higher satisfaction). At the same time, we found the results for other variables to be counter-intuitive, such as the availability of services, call boxes, protection from rain, utilization of the stop and station, and the presence of hiding areas. Many of these findings, however, are best viewed as preliminary, and require further investigation.

Following this introduction, we describe the design, administration, and implementation of the transit user perception survey and our researcher-identified inventory of attributes at transit stops and stations. We then report on our analysis of the demographics of survey respondents and the characteristics of their trips. Following this section, we report the results from our *Importance-Satisfaction (IS) Analysis* and other statistical analyses. Finally, we conclude with a summary of our findings.

3. TRANSIT USER PERCEPTION SURVEY AND FACILITY INVENTORY

Transit User Perception Survey

Transit stops and stations are an essential part of transit service. It is therefore important to consider these facilities from the point of view of the customer ─ both new and experienced riders. To gain this perspective, we designed a user survey to identify potential improvements to the transit transfer process. The questionnaire contained 29 self-administered questions to assess passenger perceptions of transit stops and stations, and was made available in English and Spanish. Appendix 1 contains a copy of the survey.

The development of the user survey was based on the travel behavior literature and transfer penalties framework, which identified the attributes of transit stops and stations where transit agencies can reduce wait, walk, and transfer penalties for facility passengers (Rabinowitz et al. 1989; Fruin 1985; Kittelson & Associates 2003; Vuchic and Kikuchi 1974; Evans 2004; Iseki and Taylor 2007). Such attributes can be classified into one or more of the following five impedance factor categories: 1) *access*, 2) *connection and reliability*, 3) *information*, 4) *amenities*, and 5) *security and safety*. The development of these five categories of transit stop attributes originated with work at the Department of the Environment, Transport and the Regions (DETR) in the United Kingdom, which produced the "Guidance on the Methodology for Multi-Modal Studies (GOMMMS)" to provide an appraisal framework to evaluate the impacts of different transportation options (Department for Transport 2003). After examining all references to these categories in the literature reviews (Iseki and Taylor 2007), we disaggregated each category into further sub-groupings and removed all duplicates. We also examined numerous existing onboard surveys conducted by transit agencies, and incorporated basic ideas of questions into our questionnaire in an effort to increase comparability with existing research.

Our objective in designing a survey instrument was to address one of the primary weaknesses of the literature ─ that existing studies have only provided simple unranked lists of transit stop and station attributes; there has been no mention of the relative importance or comparison across such factors from the users' perspective. Overall, there is little mention in the literature of facility evaluation factors from the users' perspective. Taking into account these objectives, we concluded that both a quantitative and qualitative approach was necessary to combine observational data of transit stop and station attributes with users' perceptional data for each of the five impedance categories. Observations alone would not suffice, as these do not tell the whole story of users' perceptions, which play a significant role in understanding travel behavior and the use of public transportation.

The survey is useful in assessing both the current state of passengers' feelings about transit stops and stations, as well as opportunities for facility improvements. By knowing the users' needs, a priority can be placed on improving those areas that are of most importance to the user. The survey included questions regarding trip purpose, available mode alternatives, station accessibility, and various demographic elements. It further provided respondents the opportunity to rate transit stop and station attributes according to satisfaction and importance. The user survey allowed us to gauge the relative importance of the five attributes from the users' perceptions and correlate it with our findings from the site visits.

Discussion of Treatment and Control Variables

The survey included both treatment and control variables. The treatment variables are independent variables based on the five criteria associated with transit stop and station attributes thought to affect transfer penalties. We identified five key control variables that were used to help analyze the relationship between other variables. The following list summarizes the treatment and control variables used in the creation of the survey.

Treatment Variables:

1) **Safety & Security**
    - **a.** Security personnel (guards, transit police)
    - **b.** Video surveillance equipment
    - **c.** Visibility/lighting
    - **d.** Emergency communication devices (telephones, call boxes)
    - **e.** Infrastructural safety (visible and/or tactile strips at edge of loading areas, guardrails to control circulation at points of crowding)
2) **Amenities**
    - **a.** Comfort (TV, benches, restrooms, telephones, lockers, water fountain, smoking room, etc.)
    - **b.** Service (commercial enterprises to purchase items such as food, photo shop, shoe shining, flowers, cigarettes, etc.)
    - **c.** Weather protection (shelters)
    - **d.** Aesthetics/cleanliness (absence of graffiti and litter)
3) **Access**
    - **a.** Outside:
        - **i.** Flow control management/Infrastructure (physical)
        - **ii.** Directional Information
    - **b.** Inside:
        - **i.** Flow control management/Infrastructure (physical)
        - **ii.** Directional Information
4) **Information**
    - **a.** What, where, and how do passengers access information?
5) **Connection & Reliability**
    - **a.** Connection (distance and time it takes to make connections)
    - **b.** Reliability (on-time performance/frequency-headway)

Control Variables:

1) **Transfer facility type** (Level 1 – 5)
    - *Level 1* is the simplest form of transfer facility, such as a local stop serving a single transit mode ─ an on-street curb loading area which serves any number of bus routes, and a station with a grade-level platform for rail.
    - *Level 2* is a slightly upgraded form of facility ─ an on-street bus turnout serving two or more routes with loading bays separated from regular traffic lanes, and a passenger-car level, raised platform rail station, which may have auto parking and vehicle interface facility.
    - *Level 3* is a transfer facility completely off-street. A bus transfer facility at this level is an off-street turnout and loading platforms serving multiple routes. A rail station is an at-grade but raised platform station with a possible pedestrian overpass or underpass, auto parking, and bus transfer facilities.
    - *Level 4* is an urban grade-separated multi-modal transit facility with exclusive bus access provisions and elevated or subway rail access. It may have large parking areas, and a level 2 or 3 bus-transfer facility. This level facility could be incorporated into a major activity center with joint development by others.
    - *Level 5* is a major center-city, regional, grade-separated, multi-modal, multi-level bus or rail-transfer facility. The significant capital investment is spent in pedestrian circulation elements, waiting room, ticket selling and other passenger processing facilities, and concession spaces. An example is the Trans-Bay Bus Terminal in San Francisco.
2) **Modes**
    - Bus only
    - Rail only
    - Bus & Rail
3) **Passenger loading**
    - On-street
    - Off-street
4) **Time of day**
    - Morning commute (before 9:00 AM)
    - Mid-day (9:00 AM- 4:00 PM)
    - Evening commute (4:00 PM- 7:00 PM)
5) **Weather**

Table 1 Passengers/Users Perspective Evaluation Criteria

Physical Attribute Category	Evaluation Criteria
Security and Safety	Security personnel
	Video surveillance equipment
	Extent of visibility and lighting
	Means of communication for emergencies
	Infrastructure
	Maximize safety & security
Amenities	Comfort/convenience
	Service/commercial enterprises
	Weather protection
	Aesthetically pleasing/clean environment
	Maximize amenities
Information	What information is provided
	Where the information is provided
	How the information is conveyed
Access	Passenger flow management
	Physical infrastructure
	Directional information
Connection and Reliability	Schedule adherence/reliability of vehicle
	Connection/completing transfer (Distance and Time)

Survey participants were asked to rate the importance of service features and their level of satisfaction with each feature on a four-point scale from "very important" to "not important" and "strongly agree" to "strongly disagree" (Appendix 1). The results from this section were used for the *Importance-Satisfaction (IS) Analysis* to illustrate which particular attributes passengers felt were most important and which needed the most improvement.

Selection of Sites

We selected twelve transfer facility sites in Los Angeles County to reflect varying degrees of station types, station levels, and facility amenities (Figure 1). The primary criteria we used to select these sites stemmed from a desire to examine a broad spectrum of site types: both rail and bus facilities; sites which included transit dependents and choice riders at the same or different facilities; and sites with varying levels of amenities. As described above, we classify transit stops and stations into five levels based on the following factors: 1) volume of passengers and activities, 2) number of interfacing routes, 3) number of interfacing modes, 4) physical configuration, 5) investment in facilities, 6) transit center type (community, regional, or other), and 7) whether or not it is a joint development with commercial use of facility (Fruin 1985).

Transit stops and stations are clearly not all equal and, and they may differ on a multitude of variables. For example, a transfer facility can be a simple on-street bus stop with no schedules posted and no bench for waiting passengers to sit on. This transfer facility has only the bare minimum of attributes. It is quite different from, for example, the Los Angeles Union Station, which, as an off-street facility, accommodates both intermodal and intramodal (bus, shuttles, light rail, heavy rail, commuter rail, and inter-city rail) transfers among different transit agencies and different lines of the same agency. These two examples of transfer facilities differ relative to numerous attributes such as physical size, travel modes serving the facility, number of lines per transit agency, number of transit agencies, and amenities offered to travelers using the facility.

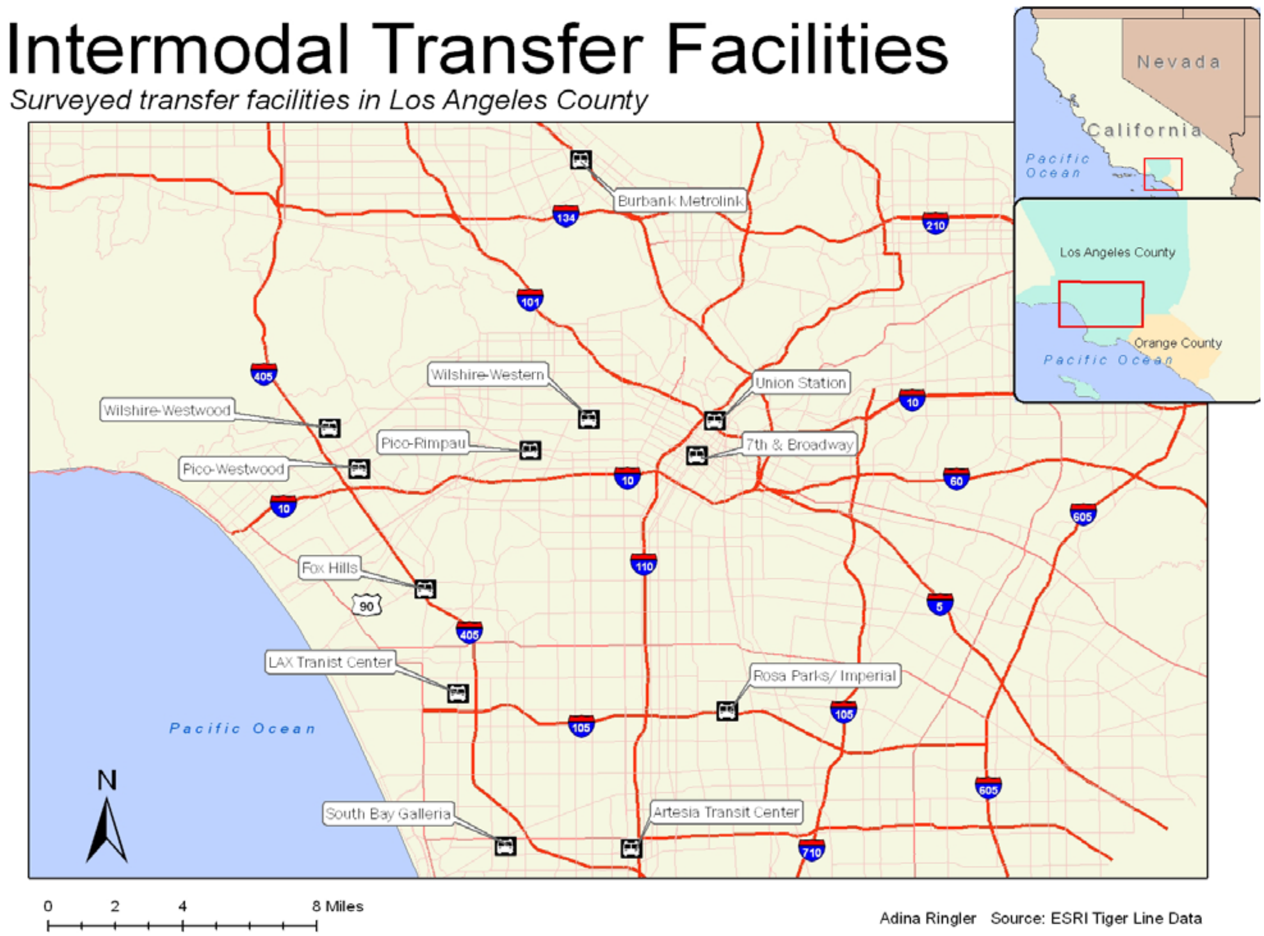


Figure 1 Location of Surveyed Transit Stops and Stations in Los Angeles County

Site Descriptions

1. **Wilshire/Western (WW):** Wilshire/Western (Figures 2 and 3) is a transfer point between heavy rail and bus, which are both operated by the Los Angeles County Metropolitan Transportation Authority (Metro). The heavy rail is Metro's Red Line

subway, which connects with Metro's light-rail Blue Line in downtown Los Angeles and provides service between Union Station, Hollywood, and the San Fernando Valley where it meets the Metro Orange Line Bus Rapid Transit (BRT). Bus service consists of Metro's local and Rapid services along Wilshire Boulevard and Western Avenue. The **Wilshire/Western** station (see picture below) is considered a *Level 4* facility because it is an urban grade-separated multi-modal transit facility with bus access provisions and subway rail access. The station is located in the Mid-Wilshire district near Koreatown.

Figure 2 Wilshire Western Metro Rail Station (Underground)

Figure 3 Wilshire Western Metro Rail Station (Street Level)

2. **L.A. Union Station (USR & USB):** Two separate areas of Union Station were surveyed ─ Union Station Rail (USR) (Figure 4) and Union Station Bus (USB) (Figure 5). **Union Station** in downtown Los Angeles, which opened in May 1939, is known as the 'Last of the Great Railway Stations' built in the United States, but even with its massive and ornate waiting room and adjacent ticket concourse, it is considered small in comparison to other major railway stations in the United States. Metro provides service to Union Station in the form of three rail lines (Red, Purple, and Gold); and eleven bus lines. Amtrak, Amtrak California, and Metrolink, a regional commuter rail service, serve the station as well. Furthermore, Los Angeles World Airports recently initiated service of an express bus service to Los Angeles International Airport called *FlyAway*. This station is considered a *Level 5* facility because it is a major center-city, regional, grade-separated, multi-modal, multi-level bus or rail-transfer facility. A significant capital investment was spent in pedestrian circulation elements, waiting room, ticket selling and other passenger processing facilities, and concession spaces.

Figure 4 Union Station Rail

Figure 5 Union Station Bus

3. **South Bay Galleria Transit Center (SBG):** South Bay Galleria Transit Center is a bus-only transfer facility with eight bus bays (Figure 6). The facility is horseshoe-shaped and lies adjacent to the parking structure for the South Bay Galleria Mall. The station is considered a *Level 3* facility because it is a transfer facility completely off-street with loading platforms serving multiple routes. This station is located near Redondo Beach and is on the western side of Mall's parking structure. Passengers need to either walk through the parking facility or go around it to access the Mall.

Figure 6 South Bay Galleria Bus Station

4. **LAX Bus Center (LAX):** LAX Bus Center is an off-street bus transfer facility with 14 bus bays (Figure 7). The facility is a horseshoe-shaped and adjacent to long-term parking lots for LAX. The station is considered a *Level 3* facility because it is a transfer facility completely off-street with loading platforms serving multiple routes. This station is located near LAX International Airport adjacent to a long-term airport parking lot.

Figure 7 LAX Bus Center

5. **Imperial/Wilmington (IW):** Imperial/Wilmington (also known as Rosa Parks Station) is a light rail station at the intersection of the Metro Blue and Green lines (Figure 8). The Metro Blue Line runs north and south between Long Beach and Los Angeles. The Metro Green Line, which crosses the Blue Line, runs east and west between Norwalk and Redondo Beach, curving south near the Los Angeles International Airport. This station is considered a *Level 4* facility because it is an urban grade-separated multi-modal transit facility. This station is located near Compton, Los Angeles. The picture below shows a Green Line train headed east toward Norwalk. The right-of-way of the Green Line between I-405 (San Diego Freeway) on the west and I-605 on the east in Norwalk is in the median of I-105 (See picture of Green Line below).

Figure 8 Imperial/Wilmington Metro Rail Station (Green Line)

6. **Fox Hills Transit Center (FH):** Fox Hills Transit Center is a bus-only facility with six bus bays that is horseshoe-shaped (Figure 9). Both the Culver City Bus and Los Angeles Metro transit agencies operate buses at this facility. There is a freeway overpass with parking immediately below that separates the Transit Center from the Fox Hills Mall. This station is considered a *Level 3* facility because it is completely off-street with loading platforms serving multiple routes. This station is located near the Marina Freeway (State Route 90) in Culver City.

Figure 9 Fox Hills Transit Center

7. **Pico/Rimpau Transit Center (PR):** The Pico/Rimpau Transit Center is an outside off-street bus-only facility with 11 bus bays (Figure 10). This station is considered a *Level 3* facility because it is completely off-street with loading platforms serving multiple routes. This station is located in Los Angeles.

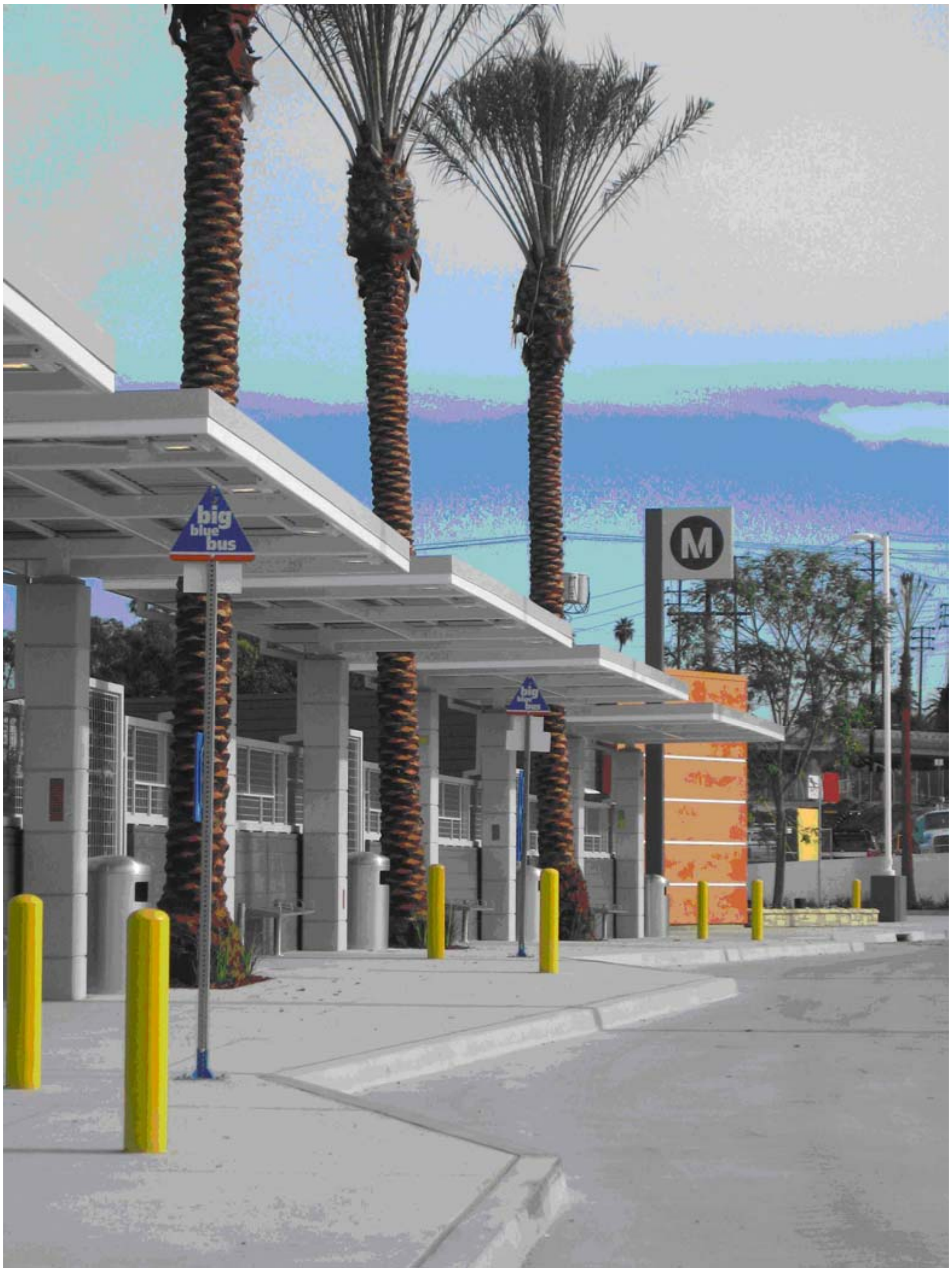


Figure 10 Pico/Rimpau Transit Center

8. **Artesia Transit Center (ATC):** Artesia Transit Center is an outside off-street bus-only facility with 12 bus bays (all Metro) (Figure 11). Artesia Transit Center is a large bus transfer station on Metro's Harbor Transitway. The station is located at the southwest corner of the interchange of Interstate 110 (Harbor Freeway) and California State Route 91 (Gardena Freeway). This station is considered a *Level 3* facility because it is completely off-street with loading platforms serving multiple routes. This station is located in the city of Artesia, near neighboring Carson.

Figure 11 Artesia Transit Center

9. **Burbank Metrolink Station (BUR):** The Burbank Metrolink Station, sometimes referred to as the Burbank Transportation Center, is a Metrolink commuter rail station (Figure 12). It is served by Metrolink's Antelope Valley Line to Lancaster and the Metrolink Ventura County Line to Montalvo; both have downtown terminals at Los Angeles Union Station. This station is also served by local bus lines and is considered a *Level 3* facility because it is a raised-platform rail station with pedestrian access, parking, and bus transfer facilities. This station is located near downtown Burbank, California.

Figure 12 Burbank Metrolink Station

10. **Pico & Westwood (PW):** Pico-Westwood is a bus-only transfer point. This stop can be considered a *Level 1* facility because it is the simplest form of a transfer facility ─ a local stop serving a single transit mode ─ an on-street curb loading area that serves three bus routes. This stop is located near the Westside Pavilion Mall, at the intersection of Pico Blvd. and Westwood Blvd. in West Los Angeles. Figure 13 below shows the south-east corner of the Pico/Westwood intersection with a Santa Monica Big Blue Bus, which is facing north, boarding and alighting passengers.

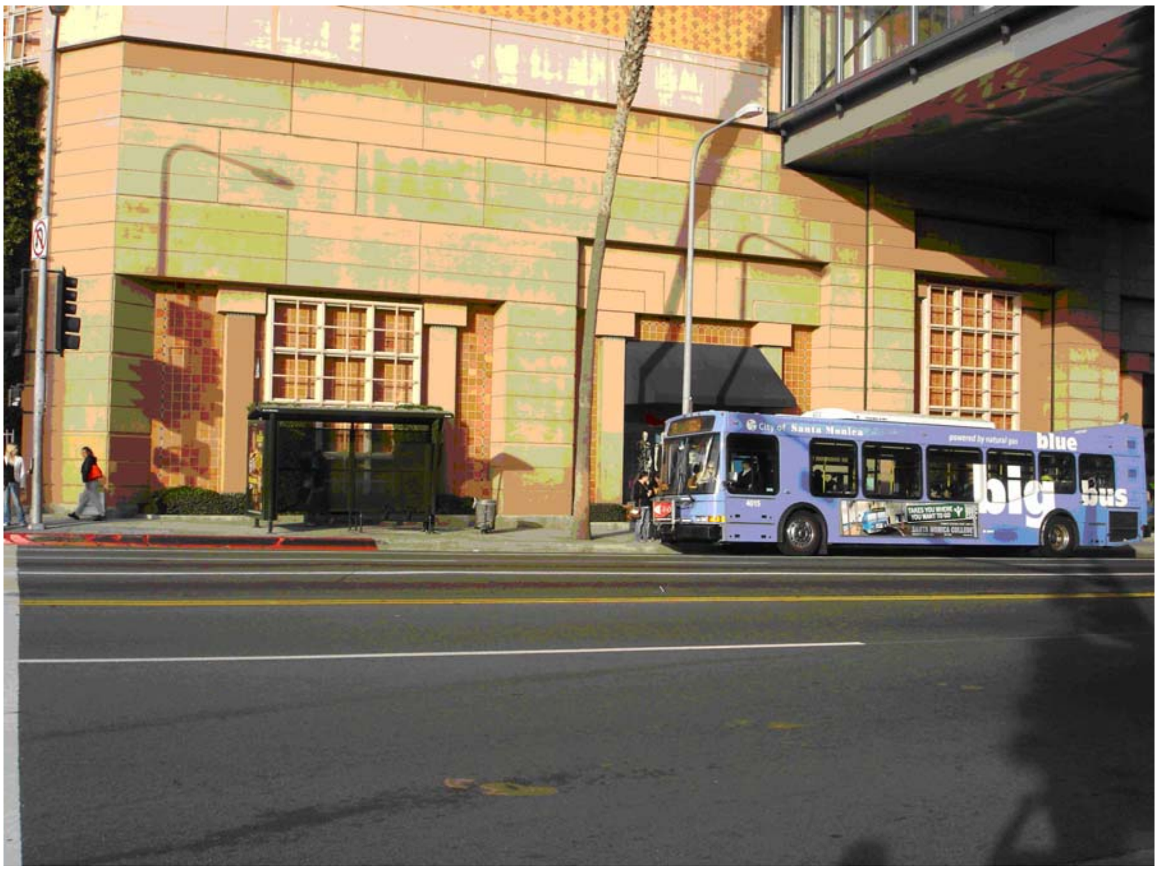


Figure 13 Intersection of Pico and Westwood Boulevards

11. **Wilshire & Westwood (WEST):** Wilshire and Westwood is a bus-only transfer point. This stop can be considered a *Level 1* facility because it is the simplest form of a transfer facility ─ a local stop serving a single transit mode ─ an on-street curb loading area that serves multiple bus routes. This stop is located in Westwood, near the UCLA campus and the Wilshire/Westwood business district. Figure 14 below shows one of Metro's new articulated Metro Rapid buses facing east on the south-east corner of the intersection.

Figure 14 Intersection of Wilshire and Westwood Boulevards

12. **Broadway & 7th Street (B7):** Broadway & 7th is a bus-only transfer point. This stop can be considered a *Level 1* facility because it is the simplest form of a transfer facility ─ a local stop serving a single transit mode ─ an on-street curb loading area that serves multiple bus routes. This stop is located near the Jewelry district in Downtown, Los Angeles. Figure 15 below shows passengers waiting for one of Metro's buses on the north-east corner of the Broadway and 7th Street intersection.

Figure 15 Intersection of Broadway and 7th Street (Downtown Los Angeles)

Table 2 summarizes these surveyed transit stops and stations in terms of station type and level of facility.

Table 2 Summary of Surveyed Transit Stops and Stations

Station Name	Station Type	Level
Wilshire/Western Metro Red/Rapid Station	Bus-Rail	4
L.A. Union Station	Bus-Rail-Commuter Rail	5
Galleria at South Bay Transit Center	Bus	3
LAX Bus Center	Bus	3
Imperial/Wilmington (Blue & Green LRTs)	Bus-Light Rail	4
Fox Hills Transit Center	Bus	3
Pico/Rimpau Transit Center	Bus	3
Artesia Transportation Center	Bus	3
Burbank MetroLink Station	Bus-Commuter Rail	3
Pico & Westwood	Bus	1
Wilshire & Westwood	Bus	1
Broadway & 7th (Metro Center)	Bus	1

Implementing the Survey

Our approach was to create a short passenger survey (roughly 5 minutes to complete) that could be conducted at various sites. The surveys were printed on one legal size page, contained 29 questions and were available in both English and Spanish. A team of surveyors from UCLA were given satchels containing survey materials including questionnaires in English and Spanish, pencils, badges with UCLA identification, and a UCLA hat. Surveyors approached passengers who had either just alighted from a bus or train or were waiting to catch their next bus or train. Patrons were asked if they were willing to participate in this voluntary study by filling out the questionnaire by hand. The research team emphasized that the survey was anonymous and no individual would be identified. If the patron agreed to participate, the questionnaire was handed to the respondent on a clipboard to be filled out immediately at the transit station/stop.

The main part of the passenger survey was conducted during the months of December 2006 and January 2007. Additional surveying was conducted on an as-needed basis during February-March of 2007 to increase the number of surveys collected on key sites or key sample times, particularly nighttime service. A total of 749 riders were surveyed. For each station, interviewing would begin at a randomly selected time and day of the week. Time categories included morning commute (before 9:00AM), mid-day (9:00 AM – 4:00 PM), and evening commute (4:00 PM – 7:00 PM). Researchers attempted to collect at least 50 surveys per site.

Facility Inventory

In conjunction with the administration of transit user perception surveys, the team of UCLA researchers conducted an inventory of the facility attributes at each location. The team of researchers noted the presence or absence of facility attributes, including lighting, security guards, video surveillance and/or an emergency call box, linkages to the street and ease of connecting to nearby bus/train, platform identification, litter and/or graffiti, restrooms, seating, shelter, as well as noting the clarity of existing signs, maps, and schedule information.

Surveyors numerically coded the observational data collected for the visited sites. For example, for *safety and security*, we have five sub-categories: security personnel, video surveillance equipment, visibility/lighting, emergency communication devices, and infrastructural safety measures. Each category was coded with a "0" or a "1", meaning that the site does not have or does have such components, respectively (Appendix 2). These observations were used in tandem with user perceptions to come up with an understanding of their relationship, that is, their correlation. This information will help assess user perceptions based on observations at other sites ─ not part of the data collection effort ─ in order to make recommendations on what transit agencies could do to improve user perceptions at those sites especially under circumstances of tight agency budgets.

4. BASIC DEMOGRAPHICS OF SURVEY RESPONDENTS AND TRIP CHARASTERISTICS

The purpose of the user survey was to provide an accurate portrait of transit riders at the system-wide level, by service-type, by time of day/time of week, and by location. This portrait includes the following information:

- *Demographic characteristics* of riders at every transit transfer facility in terms of age, sex, income, race, car availability, and modal preference;
- *Trip characteristics* such as trip purpose, pre- and post-trip mode, transfer rate, time of day/time of week, and service type;
- *Frequency of Use*;
- *Evaluation of Transit Services and Amenities*

Rider Demographics

The following section examines the demographics of transit riders from our 12 survey sites. We administered our survey to 749 transit users at these transit stops and stations; however in total we approached 1,023 transit users and 274 of them refused to participate in the survey yielding a 73% response rate. It must be noted, however, that the 749 surveys were not all completely filled out as some users had to stop providing responses to catch their bus or train. These characteristics include sex, ethnicity, age, household income, and other household and personal information.

<u>Sex</u>

Consistent with other mass transit studies, our survey indicated that women made up a greater proportion of transit ridership (51.4%). The female-male split of our survey responses is shown in Figure 16. According to the 2002 Metro On Board Passenger Survey, weekday Metro Bus riders are 57% female and 43% male, with little difference by Metro (geographic) service sector

(Los Angeles Metropolitan Transit Authority (LAMTA) 2002). Possible reasons for the greater number of women are the lower rates of access to and ownership of cars among low-income women than among low-income men (Blumenberg, 2004). Over half of the women surveyed (54.4%) were transit dependent riders, meaning they have no car, do not drive, or were not licensed drivers.

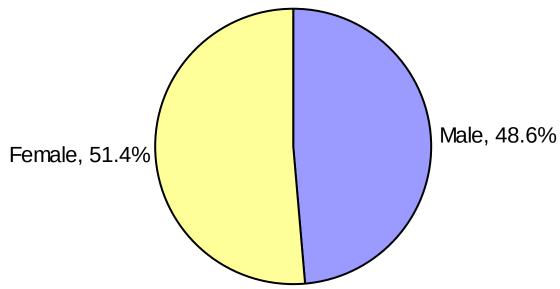


Figure 16 Sex

Age

The age distribution of our survey responses is shown in Figure 17. Approximately half (48.4%) of surveyed transit riders were within the age range of young adults (18 to 34). Overall, seniors comprise a relatively small proportion of surveyed transit riders (2.4%). About five percent of surveyed riders were of school age, and 44.2% were older adults (35-64). The vast majority of surveyed transit riders (92.6%) were of working age (18-64). The average age of the surveyed transit riders was 35.8 years old. The mean age of Los Angeles Metro weekday riders is 39.6 (Los Angeles Metropolitan Transit Authority (LAMTA) 2002).

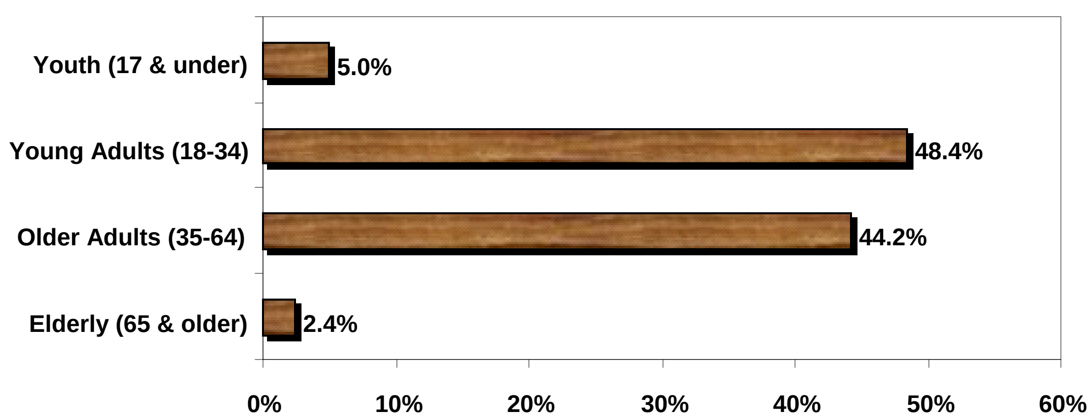


Figure 17 Age

Race and Ethnicity

The race and ethnicity distribution of our responses is shown in Figure 18. Forty percent of the surveyed transit riders were Hispanic/Latino, while Anglo/White and African-American/Black riders each comprise approximately one-fifth of the ridership (20% and 19.1% respectively). Twelve percent of riders were of Asian/Pacific Islander descent and 1.5% of riders were Native American Indian. Approximately 7% of surveyed transit riders indicated that they were of more than one race or ethnicity or "Other".

According to the 2002 MTA On Board Passenger Survey of weekday Metro Bus riders, Latinos were the largest ethnic group among weekday riders (58%). African-Americans were 20% of the ridership, and Whites and Asians are 12% and 8%, respectively (Los Angeles Metropolitan Transit Authority (LAMTA) 2002). Our findings showed a similar demographic for race and ethnicity, with Latinos as the highest percentage, followed by African-Americans. However, our sample contained a slightly higher percentage of Anglo/White riders (19% compared to 12% from the MTA). This could be attributed to the commuter rail and heavy rail stations we surveyed, which are more heavily patronized by Anglo/White riders. For example, 49% of surveyed riders in the Burbank Metrolink commuter rail station were Anglo/White.

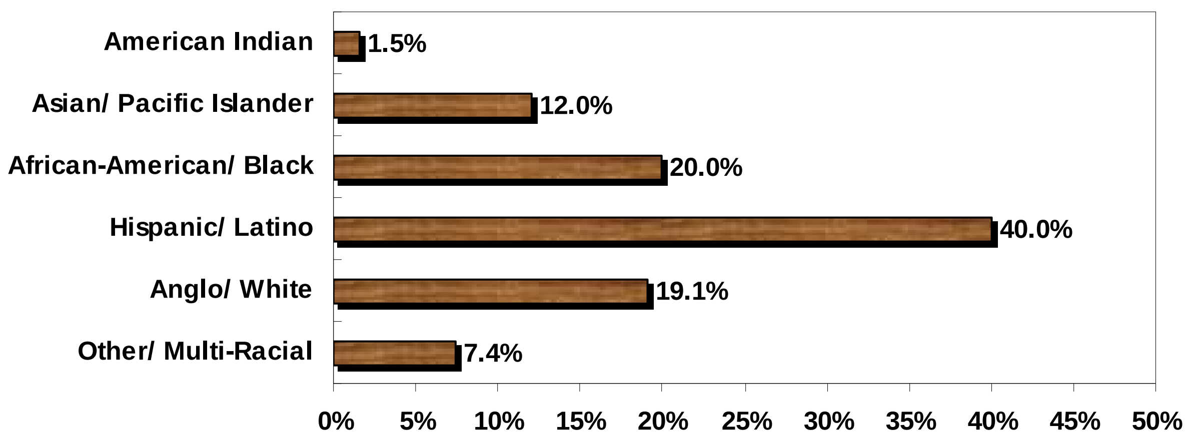


Figure 18 Race and Ethnicity

Language of Survey

While most surveys distributed were in English, 19% were in Spanish (Figure 19). It is not possible to determine what percent of transit riders were bilingual or have English as a second language, but the number of passengers requesting surveys in other languages suggests that many passengers may need transit information provided in Spanish.

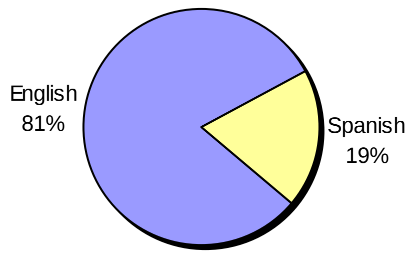


Figure 19 Survey Language

Household Income

More than half (53.8%) of surveyed transit riders reported an annual household income of less than $35,000, while almost two thirds (63.4%) of the ridership reported an annual household income of less than $50,000 (Figure 20). The relatively low household income among transit riders was consistent with the tendency of public transportation to serve lower income populations.

According to the MTA On Board Passenger Survey (2002), median annual household income for weekday bus riders was $12,000 per year, with little difference by service sector (Los Angeles Metropolitan Transit Authority (LAMTA) 2002). This amount is significantly lower than our survey sample because we surveyed passengers on commuter rail and heavy rail lines, which are generally patronized by more affluent passengers; the MTA surveyed only bus lines, which are generally patronized by lower income passengers. For example, the average annual household income for surveyed passengers at Union Station Rail (USR) was between $50,000 and $74,999, whereas the average annual household income for surveyed passengers at Pico-Rimpau was between $15,000 and $24,999.

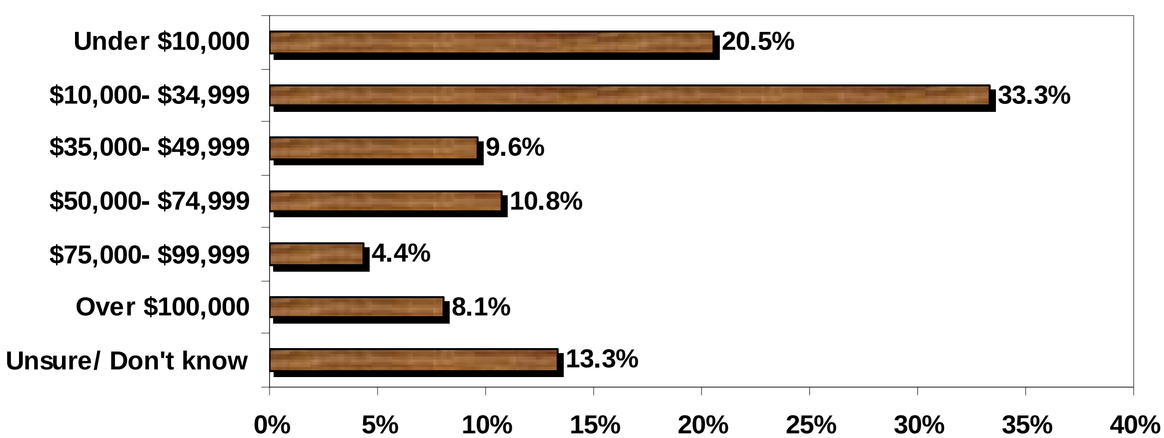


Figure 20 Household Income

Transit Dependency

Among surveyed transit riders, 25.8% were non-discretionary or transit dependent riders, meaning they reported that they have no access to a car, do not drive, or were not licensed drivers and 23.1% would have difficulty accessing a car (Figure 21). Transit dependent riders include riders with disabilities and elderly riders. Nearly half of the survey sample (48.9%) stated that they either had limited or no access to an automobile. The other half of the surveyed users could have had access to a car, but chose to ride transit instead. Patrons who choose to use transit instead of an available automobile are generally happier with the transit service – this follows logically because these riders made the conscious choice to forego their automobile to use public transit, indicating a preference for transit for that trip.

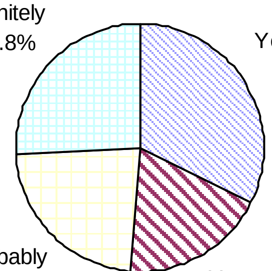


Figure 21 Transit Dependency

Trip Characteristics

The following section explores how surveyed transit riders were using the transit stop/station at the time they were surveyed, and how they used the facility in general for their transportation needs. Riders were asked to describe how often they rode the bus or train and for what purpose, how they got to and from stops, and how long they expected to wait for their next bus or train.

Trip Purpose ─ What is the purpose of your trip today?

Passengers were asked where they were coming from and where they were going to on this trip and results are shown in Figure 22. The majority of transit trips were to or from work (65.4%). The second most common trip purpose was shopping or errands (17.3%), followed by college or school (15.1%) and visiting family or friends (12.2%). Other trips not listed on the survey accounted for a very small portion of trips (8%) and included doctor's appointment, church, court house, museum, and the beach. Percents do not add up to 100% because some passengers had multiple trip purposes for their transit trip. This phenomenon shows that trip chaining is a large part of users' transit trips. Empirical evidence points to a secondary role for the work trip, which provides an opportunity to link non-work travel (McGuckin, 1995). The work trip is becoming more complex as workers incorporate personal, household, and child-care activities into their commutes.

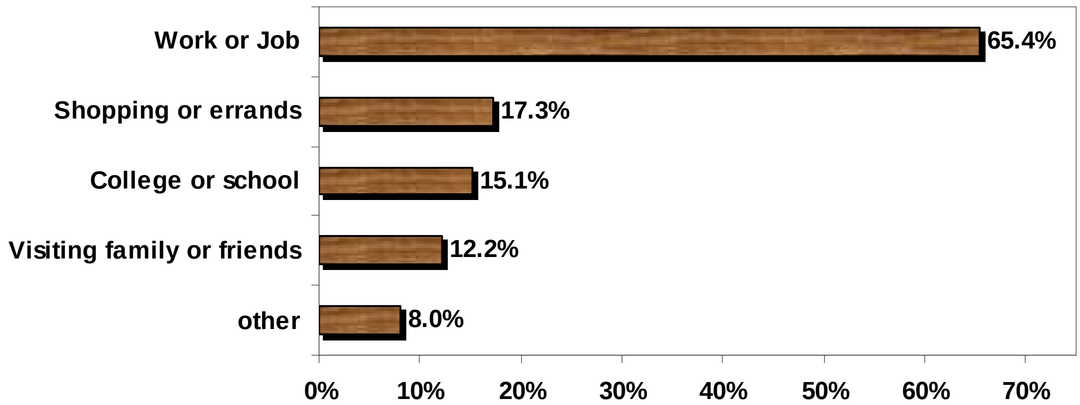


Figure 22 Trip Purpose

<u>Trip Frequency—How often do you make this trip?</u>

Trip frequency distribution is shown in Figure 23. The majority of surveyed riders made their trip regularly (79.4%). These findings are consistent with the MTA On Board Passenger Survey (2002), which found that most riders (82%) used MTA buses 5 or more days per week and were regular users (Los Angeles Metropolitan Transit Authority (LAMTA) 2002). The remaining riders (20.6%) were not regular users—10.4% made the trip 'sometimes;' 7.8% made the trip 'not often;' and 2.4% had never made the trip before. It is important, however, that the information available at these facilities accommodates these non-regular users.

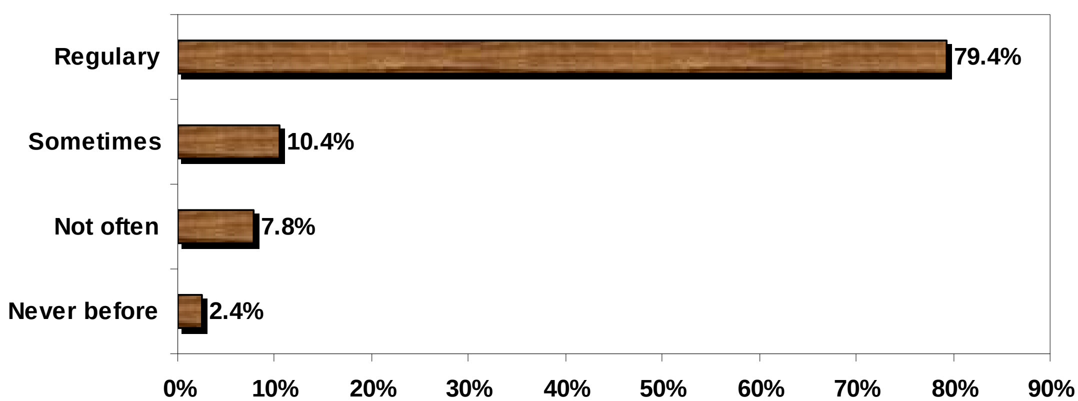


Figure 23 Trip Frequency

Mode of Travel To and From Transit Facility

Riders were asked to indicate how they arrived at the station/stop for their current trip, and how they would continue to their final destination from the stop/station where they would alight. The users' indicated mode of travel to and from stations helps to determine the transfer rate. The access mode is the way in which passengers travel to the bus/train on which they were surveyed. Access mode is important because it supports the planning of service improvements that increase the ease of access and potentially ridership levels. These two questions were important because it showed transferring plays are major role for all surveyed stations/stops. According to the MTA On Board Passenger Survey (2002), a large majority of weekday Metro Bus riders (74%) used more than one bus or train in the course of their one-way trip (Los Angeles Metropolitan Transit Authority (LAMTA) 2002).

Our findings were consistent with the MTA study and are shown in Figures 24 and 25. We found that the majority of users were using the station/stop as a transfer facility, indicating that they used more than one bus or train in the course of their trip. Sixty nine percent of the surveyed passengers accessed facility by bus or train. The next most frequent access mode was walking (12.7%), followed by driving alone (9.7%) and carpooling (4.3%). Overall, few riders used a private vehicle, either as driver or as passenger, to get to or from the facility (15%). Bicycling and taxi or shuttle/van service accounted for a very small percent of access mode (0.7% and 1% respectively). Other/multiple modes accounted for 2.4% of station access. For passengers who walked to the facility, their average reported walk time was 10 minutes.

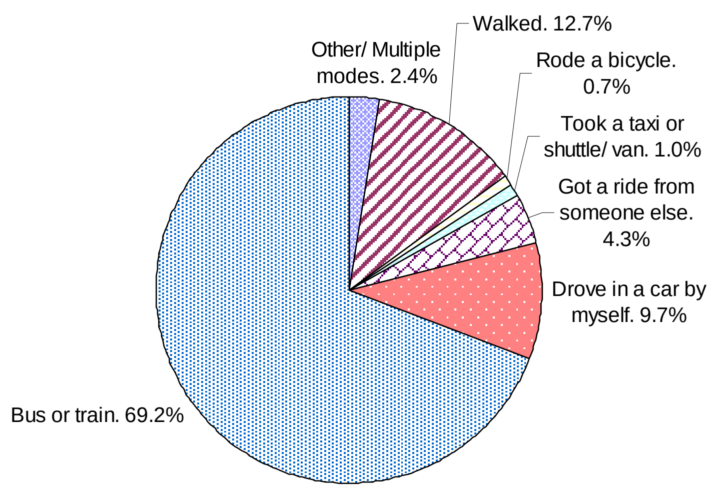


Figure 24 Transit Facility Access

When asked how they will reach their final destination, the majority of passengers responded that they would take a bus or train (81.1%). Walking was next most frequent mode of egress, at 11.8%. For those who walked, the average walk time was 8 minutes. The remaining modes comprised of a very small amount of station egress.

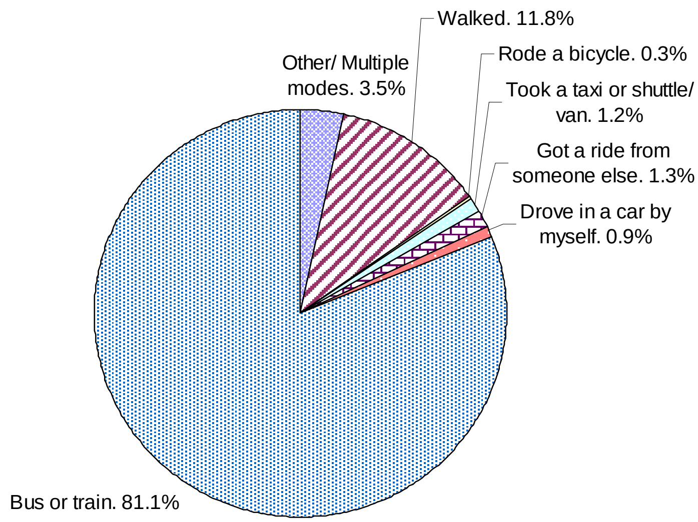


Figure 25 Transit Facility Egress

Mode Preference

Over a third of surveyed transit users would have strongly preferred to have made their trip using a private vehicle, rather than public transportation (Figure 26). A passenger's preferred choice of mode can reflect how satisfied the user is with the facility. A fifth of users strongly preferred to travel by bus or train. Overall there is nearly an equal split between users who strongly or usually prefer private auto and those who strongly or usually prefer bus or train.

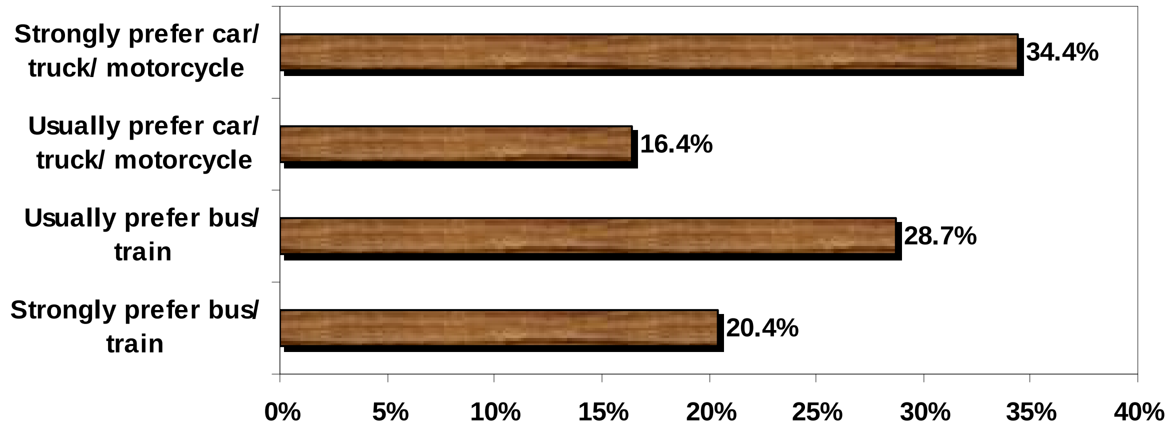


Figure 26 Mode Preference

5. ANALYSIS, FINDINGS, AND DISCUSSION

Importance-Satisfaction Analysis

*Importance-Satisfaction (IS) Analysis*s can be a valuable tool to help transportation planners and managers evaluate the relative priority that should be placed on various transportation issues (Tennessee Department of Transportation Office of Strategic Planning 2006). IS-Analysis maximizes the impact that new investments have on customer satisfaction by emphasizing improvements in areas where both the reported level of customer satisfaction is relatively low and where customers' perceived importance of the issue or factor is relatively high (Tennessee Department of Transportation Office of Strategic Planning 2006). Accordingly, we apply IS-Analysis here to evaluate transit policies, facilities, and services.

The user survey in this study asked travelers to assess the level of importance that they place on particular aspects of the facility and the level of satisfaction that they have under the present situation. Based on these two measures ─ importance and satisfaction ─ we use IS-Analysis to provide indices of improvement need (IS ranking), which are used to determine the order of priority to be given to each factor examined. The basic concept in IS-Analysis is that agencies should invest their resources on aspects of higher priority in order to maximize customer satisfaction.

We applied IS-Analysis to our study to assess the quality of various attributes at transit stops and stations in the Los Angeles regional transit system based on users' evaluation of the quality of service at these facilities. As previously described in the methodology section, we asked transit users to rate the level of importance and the level of satisfaction using a four-level scale. To obtain the importance rating, we calculated the proportion of survey respondents who placed the highest importance rating on an attribute ("Very important" in the survey) among the total number of respondents who answered a question on this particular attribute.[1] To obtain the

---

[1] The original importance-satisfaction analysis uses responses from a survey in which users are asked to *choose* a certain number of issues that they think most important and are most satisfied with among given options. For

satisfaction rating, we calculated the proportion of survey respondents who indicated a positive level of satisfaction on an attribute among the total number of respondents who answered a question on this particular attribute ("Strongly agree" or "Agree somewhat" in the survey). These ratings are expressed in percentages. Based on these ratings among 16 attributes, we determined the ranking for importance and satisfaction.

Then the Importance-Satisfaction (IS) rating is computed for each attribute by multiplying the importance rating by 1 minus the satisfaction rating.

IS = [Importance x (1-Satisfaction)]

= [Importance x Dissatisfaction] (Eq-1)

The maximum rating of 1.00 is obtained when all respondents consider an attribute "Very important" but no respondents are satisfied with the current quality of this attribute (in other words, no respondents chose "Strongly agree" or "Agree somewhat" in the survey). The minimum rating of 0.00 is obtained when *one of the following* occurs in the survey responses:

1. No respondents consider an attribute "Very important"
2. All respondents are at least somewhat satisfied with the current quality of this attribute; All respondents chose "Strongly agree" or "Agree somewhat" in the survey

The IS rating is an index used to assess the need for improvement. The higher the IS rating, the higher the improvement need. Therefore, an agency should prioritize the improvement of attributes with the highest IS ratings. After calculating the IS rating, we also ranked attributes from 1 through 15 based on the IS ratings.

Importance Rating and Ranking

Table 3 shows the proportion of respondents who placed the highest level of importance on each issue in the question on the survey (rating) and ranking from 1 to 16 based on the ratings.

---

example, Tennessee Department of Transportation asked respondents to choose what issue of highways, such as highway congestion level, high road surface condition, water drainage on highways, signs on highways, they think most important and are most satisfied with (Tennessee Department of Transportation Office of Strategic Planning 2006). Then the importance rating and the satisfaction rating are calculated by summing the percentage of respondents who selected an item as one of the most importance and the most satisfactory. In this sense, our I-S analysis is slightly different from the original IS analysis, although the basic concept is the same.

Table 3 Importance Rating and Ranking Table

Question on the Survey	Category	Importance	
		Rating	Ranking
This station /stop area is clean.	Amenities	58%	13
There are enough places to sit.	Amenities	50%	15
There are places for me to buy food or drinks nearby.	Amenities	34%	16
There is a public restroom nearby.	Amenities	59%	12
There is shelter here to protect me from the sun or rain.	Amenities	69%	8
The signs here are helpful.	Information	69%	9
It is easy to get schedule and route information at this station.	Information	62%	11
I usually have a short wait to catch my bus/train.	Connection & Reliability	70%	6
My bus/train is usually on time.	Connection & Reliability	76%	3
It's easy to find my stop or platform.	Access	70%	7
It is easy to get around this station/stop.	Access	57%	14
I feel safe here during the day.	Security & Safety	77%	2
I feel safe here at night.	Security & Safety	78%	1
There is a way for me to get help in an emergency.	Security & Safety	74%	4
This station is well lit at night.	Security & Safety	73%	5
Having security guards here makes me feel safer.	Security & Safety	67%	10
This is an easy place to transfer to another bus or train.	Overall	73%	-

Table 3 shows that 'safety at night' received the highest importance ranking (78%), followed by the 'safety during the day' (77%).[2] This indicates that, overall, passengers felt that safety and security is very important when making a transit trip. The third most important attribute indicated by passengers was under the category of *connection and reliability*, and had to do with schedule adherence (76%). Improving transit service quality, including travel reliability reduces unit travel time costs.

The importance level within categories of *amenities*, *information*, and *access* varies somewhat. For *access*, 70 percent of respondents who answered this question placed the highest level of importance on finding a way to a stop and/or platform, while 57 percent gave "getting around a station or stop" a very high importance rating. Within the category of *amenities*, shelter from the sun or rain received the highest importance rating (69%), while availability of places to buy food or drinks received the lowest importance (34%). Overall, two questions on *connection and reliability* received a relatively higher level of importance, following the *safety and security* issues.

[2] It should be noted that small differences in percentages in Table 3 and Table 4 may not be statistically significant.

Satisfaction Ratings and Ranking

Table 4 shows the proportion of respondents who placed the highest and second highest levels of satisfaction ("Strongly agree" or "Agree somewhat") on each issue ("rating") and ranking from 1 to 16 based on the ratings ("ranking"). This means that a ranking of "1" indicates that surveyed passengers were most satisfied with that particular attribute.

Table 4 Satisfaction Rating and Ranking Table

Question on the Survey	**Category**	**Importance**	
		Rating	**Ranking**
This station/stop area is clean.	Amenities	78%	6
There are enough places to sit.	Amenities	65%	12
There are places for me to buy food or drinks nearby.	Amenities	57%	14
There is a public restroom nearby.	Amenities	40%	16
There is shelter here to protect me from the sun or rain.	Amenities	69%	8
The signs here are helpful.	Information	81%	4
It is easy to get schedule and route information at this station.	Information	66%	11
I usually have a short wait to catch my bus/train.	Connection & Reliability	66%	9
My bus/train is usually on time.	Connection & Reliability	67%	10
It's easy to find my stop or platform.	Access	89%	2
It is easy to get around this station/stop.	Access	89%	1
I feel safe here during the day.	Security & Safety	85%	3
I feel safe here at night.	Security & Safety	57%	13
There is a way for me to get help in an emergency.	Security & Safety	55%	15
This station is well lit at night.	Security & Safety	74%	7
Having security guards here makes me feel safer.	Security & Safety	79%	5
This is an easy place to transfer to another bus or train.	Overall	88%	-

Most people who responded to the survey (88%) are at least somewhat satisfied with the overall quality of the stop or transit stops and stations where they were surveyed. Among the five categories examined, *access* received the highest satisfaction ratings (89%). Respondents were satisfied with the ease of navigating to, from, and within the facility. Within the *information* category, *signs* received a very high satisfaction rating, while *availability of schedule and route information* at the site had a lower rating. The category of *connection and reliability* received a relatively low rating, indicating that passengers were generally not satisfied with schedule adherence and wait times.

Within categories of *amenities* and *security and safety*, the ratings varied significantly. In the *amenities* category, the availability of public restroom received the lowest satisfaction rating (40%), which is also the lowest among all items. Not surprisingly, very few of the transit stops and stations that we surveyed had access to a public restroom. Passengers were generally satisfied with the cleanliness of the facility (78%). In the safety and security category, there was a large gap in the level of satisfaction between daytime and nighttime. Most respondents did not seem to have a problem with safety during the day (85%), while 43 percent of people did not feel safe at night. The surveyed transit users appear to be satisfied with lighting and the presence of security guards, but were concerned about the case of an emergency. Because of its high level of importance, nighttime safety should be improved by providing a way to get help in an emergency.

Importance-Satisfaction Ratings and Ranking

Table 5 shows the *importance-satisfaction (IS) rating,* which combines the level of importance that users placed on each facility attribute with the level of satisfaction users had. Codes in Table 5 are used in Figure 27.[3]

Table 5 Importance-Satisfaction Rating and Ranking

Question on the Survey	Category	Code	Importance	
			Rating	Ranking
This station/stop area is clean.	Amenities	A1	13.1%	13
There are enough places to sit.	Amenities	A2	17.5%	9
There are places for me to buy food or drinks nearby.	Amenities	A3	14.8%	10
There is a public restroom nearby.	Amenities	A4	35.5%	1
There is shelter here to protect me from the sun or rain.	Amenities	A5	21.2%	7
The signs here are helpful.	Information	I1	13.3%	12
It is easy to get schedule and route information at this station.	Information	I2	21.4%	6
I usually have a short wait to catch my bus/train.	Connection & Reliability	CR1	23.7%	5
My bus/train is usually on time.	Connection & Reliability	CR2	25.0%	4
It's easy to find my stop or platform.	Access	AC1	7.6%	15
It is easy to get around this station/stop.	Access	AC2	6.2%	16
I feel safe here during the day.	Security & Safety	SS1	11.3%	14
I feel safe here at night.	Security & Safety	SS2	33.1%	3
There is a way for me to get help in an emergency.	Security & Safety	SS3	33.7%	2
This station is well lit at night.	Security & Safety	SS4	18.9%	8
Having security guards here makes me feel safer.	Security & Safety	SS5	13.9%	11
This is an easy place to transfer to another bus or	Overall	-	8.6%	-

3 It should be noted that small differences in percentages in this table may not be statistically significant.

Based on the IS rating, availability of public restroom (35.5%), an emergency contact method (33.7%), and safety at night (33.1%) are the top three attributes which require improvement in the system. The high IS ranking for restrooms indicates that passengers felt public restrooms should be provided at transit stops and stations. An emergency communication device and general safety at night are also top concerns for transferring riders. Two items in the category of *connection and reliability* follow, regarding schedule adherence (25%) and wait time (23.7%). The reliability of transit service scheduling is very important to the customer, yet very little information is actually available as to how reliable the services at a given facility. Many customers plan their trips based on published (printed and online) schedule information, and can be greatly inconvenienced if the service does not arrive or depart at the expected time. Access to and within a facility received the two lowest priority items in the list, based on the IS rating.

Figure 27 shows the importance rating on the X-axis and the satisfaction rating on the Y-axis respectively (the codes in this figure relate to those presented in Table 5). This figure visually summarizes the relationship between the relative importance transit users attach to each service feature and the level of satisfaction they experience with each feature. By combining the importance and satisfaction ratings relative to their means, transfer facility attributes are classified into four categories.

Attributes that fall in the bottom-right box ("Needs Improvement") require substantial attention for improvement due to the lower satisfaction level relative to the high importance level. These attributes include an emergency communication device (SS3), overall safety at night (SS2), availability of a public restroom (A5), schedule adherence (CR1), and wait time (CR2).

The top-right portion of Figure 27, labeled "Continue Improvement" depicts attributes that surveyed users have rated as "very important". For this reason transit agencies need to continue to maintain them so that customers continue to be satisfied with these attributes. The attributes in this category fall under *safety & security*, *access*, and *information*, and include station lighting (SS4), presence of security guards (SS5), general safety during the day (SS1), ease of accessing schedule and route information(I1), and ease of locating the stop or platform (AC2).

Two attributes receive very high satisfaction ratings, while their importance ratings are lower than the average in the top-left box ("Exceeding Expectations"). Under the *access* category, passengers are most satisfied the ease of navigating around the station or stop (AC1); under the *amenities* category, passengers are satisfied with the cleanliness of the facility (A1). The transit facilities in the Los Angeles transit system are exceeding the users' expectations for the quality of these two attributes.

The last group of attributes located in the bottom-left box ("Less Important") was, on average, given a relatively lower importance level by surveyed transit users; these respondents also gave these attributes a lower than average satisfaction level. These attributes are seating (A2), places to buy food or drink (A3), shelter from the rain or sun (A4), and the helpfulness of the signs at the station/stop (I2).

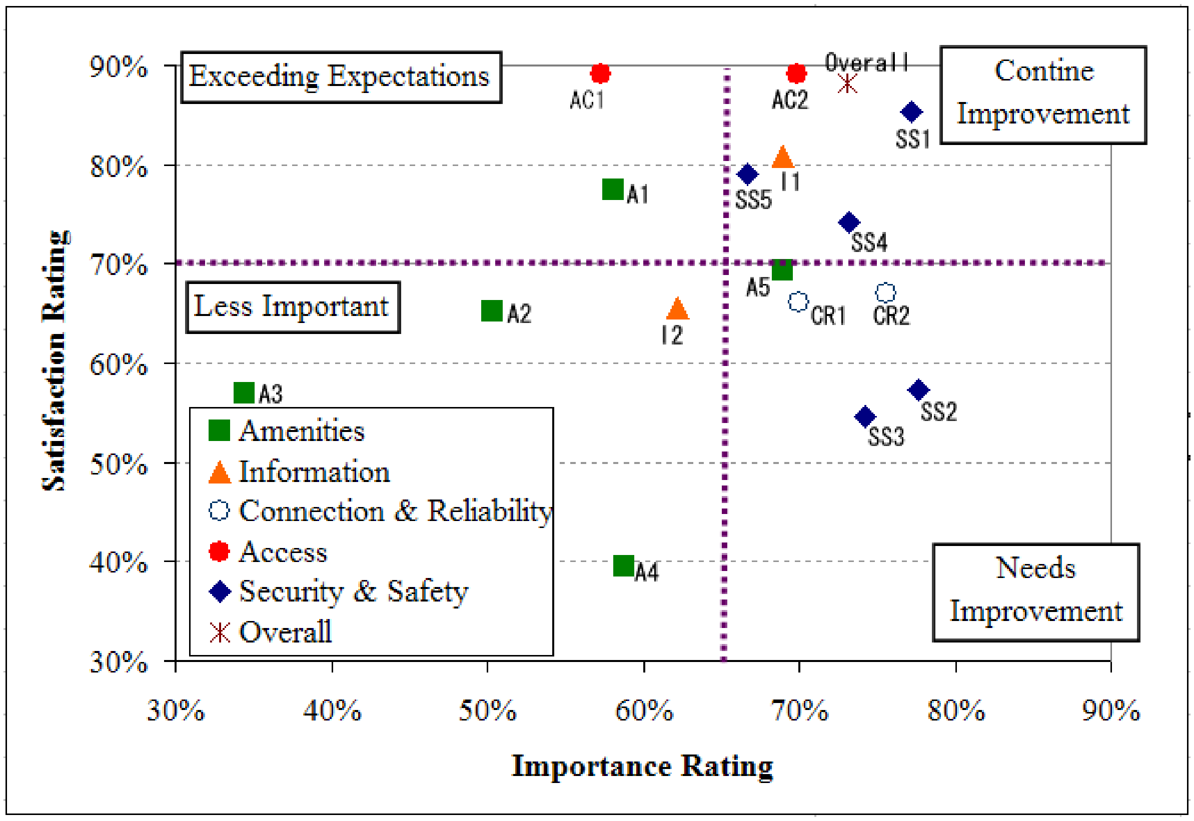


Figure 27 Four Categories of Importance and Satisfaction Levels

Comparison by Attribute Category

In order to make comparisons by category, the un-weighted means of importance ratings, satisfaction ratings, and IS ratings and rankings for each category are shown in Table 6. This table summarizes information from the IS-Analysis and shows the relative importance and satisfaction in each category.

As Table 6 shows, the IS rating by category suggests that, on average in our sample, *connection and reliability* requires the most improvement compared to the four other categories[4]. This IS rating results from the high importance rating and the relatively low satisfaction rating. We can thus expect that improvement of on-time performance and reducing transfer time by timed transfers would likely have significant impact on users' satisfaction. Although *safety and security* received the highest importance level, it had a moderate satisfaction rating, which placed *safety and security* as the second highest IS rating. *Safety and security* is the most important factor in our sample in determining whether travelers use transit and can increase perceived costs related to waiting infinitely; if travelers feel a waiting location is so unsafe that he or she may be mugged (or worse), most will not take the risk of using public transit (ITE Technical Council

[4] While we have attempted to include a wide array of transit stops and stations in our analysis, we are reporting on the experience of users of these facilities in Los Angeles County. Drawing general conclusions about the state of stops and stations generally is probably premature at this point.

Committee 5C-1A 1992). In this sense, respondents in this survey, who are *already* traveling by transit, may have a higher satisfaction level than the general population.

Table 6 Importance-Satisfaction Analysis by Attribute Category

	Importance		Satisfaction		I-S Rating (Index for improvement need)	
	Ave. Rate	Rank	Ave. Rate	Rank	Ave. Rate	Rank
Amenities	54.1%	12.8	61.7%	11.2	20.4%	8.2
Information	65.6%	10.0	73.2%	7.5	17.3%	9.0
Connection & Reliability	72.8%	4.5	66.6%	9.5	24.3%	4.5
Access	63.6%	10.5	89.1%	1.5	6.9%	15.5
Security & Safety	73.8%	4.4	70.1%	8.6	22.2%	7.4
Overall	73.1%		88.3%		8.6%	

Note: A smaller number for "Rank" in the "Importance" column represents the higher importance that users place on these attributes. A smaller number for "Rank" in the "Satisfaction" column represents the higher satisfaction level that users have. A smaller number for "Rank" in the "IS-Rating" column represents a higher improvement need.

While respondents did not generally consider *amenities* as important as other attributes at transit stops and stations, respondents did indicate a very low level of satisfaction with the amenities in place. This low satisfaction level placed the *amenities* category at third in the IS rating. Finally, the relatively high satisfaction level that survey respondents had with the level of access to and within the facilities gave the *access* category the lowest IS rating overall.

Importance-Satisfaction Analysis by Location

In this section we discuss our analysis for each of the five attribute categories by the facility sites that were surveyed and we illustrate how user perceptions of these facilities vary. While this analysis contributes to our understanding of the evaluation of transit stops and stations relative to the five attribute categories, its usefulness is likely to be more robust toward transit stops and stations in southern California than for other stops and stations outside the region.

Figure 28 shows the average IS rating by attribute category by location. Table 7 that follows Figure 28 lists the full name of facilities that are indicated by abbreviation in this figure. While the order based on IS rating varies by transit facility (or location), there are some clear patterns we can observe from this figure.

<u>Access and Information</u>

Access consistently received the lowest IS rating at all locations and *information* generally received the second lowest ratings among the five categories. Clear exceptions to this pattern are Burbank Metrolink (BUR) and Pico & Westwood (PW). Both BUR and PW have *information* as the highest ranked attribute according to IS ranking. At these facilities, surveyor-administered inventories indicate that the provision of signs and maps were not sufficient and schedule information was either moderate (BUR) or not available (PW). PW is a Level 1 on-street bus stop that does not have any significant infrastructure or signage. Because BUR is a commuter rail station that typically caters to regular users, there was also minimal signage present at this facility.

One way to improve the transferring experience is to provide better signage within the facility of the available transfer services. Information is necessary to direct passengers to connecting bus stops, shuttle stops, taxi stands or bicycle and pedestrian pathways in the surrounding community. In addition, signs are helpful to assist passengers in accessing elevators, escalators, station exits, fare machine or other services. Because the availability of signage was low at BUR and PW, first time users may have a hard time making connections or finding their platform.

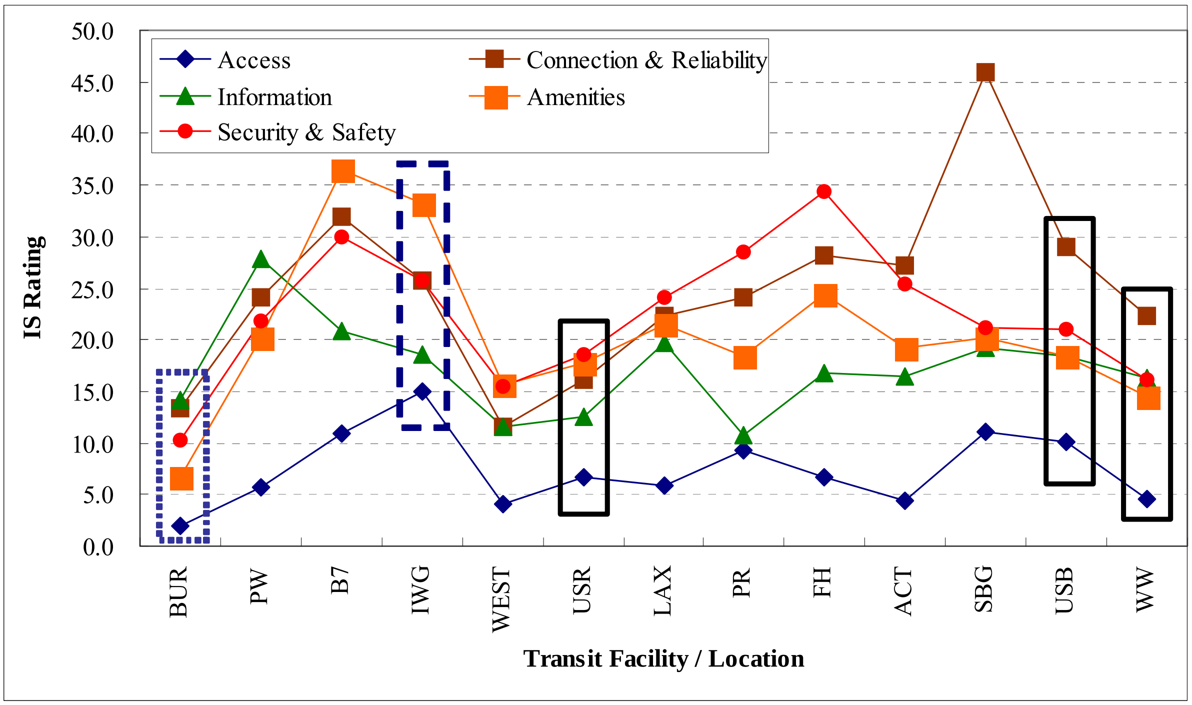


Figure 28 Importance-Satisfaction Analysis by Location

Note: BUR is marked by a dotted-line rectangular to indicate it as a commuter rail station. IWG is marked by a dashed-line rectangular to indicate it as a transfer station between two light rail lines: the Blue Line and Green Line. USR, USB, and WW are marked to indicate it as a station with rail lines.

Table 7 Importance-Satisfaction Analysis by Location

Abbreviation	BUR	PW	B7	IWG	WEST	USR	LAX	PR	FH	ACT	SBG	USB	WW	Average	Standard Deviation
Location	BUR Metrolink	Pico & Westwood	Broadway & 7th	Imp/Wilm (BlueXGreenLRT)	Wilshire&Westwood	Union Station (RAIL)	LAX City Bus Center	Pico & Rimpau	Fox Hills	Artesia Transit Center	So.Bay Gall	Union Station (BUS)	Wilshire/Western		
Type	Com. Rail	Bus	Bus	LR/ Bus	Bus	Bus/ Rail	Bus	Bus	Bus	Bus	Bus	Bus/ Rail	HR/ Bus		
Access	2.0	5.7	10.8	15.0	4.1	6.7	5.9	9.3	6.7	4.4	11.1	10.1	4.5	7.4	3.6
Connection & Reliability	13.3	24.2	31.9	25.7	11.6	16.1	22.3	24.2	28.2	27.1	46.0	28.9	22.2	24.8	8.8
Information	14.1	27.8	20.9	18.6	11.5	12.6	19.7	10.7	16.8	16.4	19.2	18.4	16.3	17.2	4.5
Amenities	6.6	20.2	36.6	33.3	15.6	17.8	21.5	18.4	24.4	19.3	20.2	18.4	14.4	20.5	7.7
Security & Safety	10.3	21.8	30.0	25.8	15.5	18.6	24.2	28.5	34.3	25.3	21.1	21.0	16.1	22.5	6.5
Mean	5.4	7.1	10.4	9.7	3.0	7.8	6.1	15.0	10.5	6.5	12.8	4.2	16.3	8.8	4.1
Standard Deviation	5.0	8.5	10.2	7.1	4.7	4.9	7.4	8.3	10.7	9.0	13.2	6.7	6.4	7.9	2.5
Access	5	5	5	5	5	5	5	5	5	5	5	5	5	5.0	0.0
Connection & Reliability	2	2	2	3	3	3	2	2	2	**1**	**1**	**1**	**1**	1.9	0.8
Information	**1**	**1**	4	4	4	4	4	4	4	4	4	3	3	3.4	1.1
Amenities	4	4	**1**	**1**	**1**	2	3	3	3	3	3	4	2	2.6	1.1
Security & Safety	3	3	3	2	2	**1**	**1**	**1**	**1**	2	2	2	4	2.1	1.0

The other three categories ─ *safety and security*, *connection and reliability*, and *amenities* ─ share the highest, second highest, and third highest IS ratings respectively. When we look more closely at the rankings (Table 7, bottom), we find that *safety and security* and *connection and reliability* have almost equal numbers of 1s and 2s (first and second highest IS rating), which are greater than the number of 1s and 2s that *amenities* have. This results in the overall higher IS ratings for *safety and security* and *connection and reliability* that we found in Table 7.

Safety & Security

LAX Transit Center (LAX), Pico-Rimpau (PR), Fox Hills Transit Center (FH), and Union Station Rail (USR) have *security and safety* as their highest IS rating, though the ratings at USR are very close among categories. USR differs from the other three facilities, given that it is a Level 5 major center-city, grade-separated, multi-modal transfer facility, as opposed to an off-street bus facility. The high concern for *safety and security* at USR could at least in part be attributed to post-9/11 security concerns. Although this station had security guards present throughout the facility, passengers were still concerned with their safety and security.

LAX, PR, and FH did not have security guards present at the time the survey was conducted. The presence of security guards, transit police or other security personnel is an important concern for passengers, especially during night hours. A security guard can make passengers feel more comfortable in making trips during the less-busy hours by discouraging inappropriate behavior by fellow- and non-passengers. Fox Hills (FH) had the highest IS rating for *safety and security*. Fox Hills is a bus terminal in Culver City where buses operated by Culver City, Santa Monica Big Blue Bus, and Metro converge. While the facility is located in the middle of the shopping mall parking lot, safety measures are insignificant at this location. LAX, PR, and FH are all bus-only, off-street stations, adjacent to large parking lots and a busy street and/or freeway nearby. Because there is not a lot of street life surrounding the facility, passengers may feel unsafe while waiting for their next bus. According to the surveyor-administered inventory, each station had adequate to good levels of lighting and high occupancy (ranging from 50-75%). For each facility, the inventory data reported presence of litter and graffiti. The level of cleanliness of the facility is an important factor, as it shows that the facility is well maintained.

At LAX and FH, distance from the parking lot to the facility was also an important issue. It took the longest time (roughly 5 minutes) to travel between the park & ride lot and the transit facility. Liggett, Loukaitou-Sideris, and Iseki (2002) found the number of crimes at park and ride facilities at light rail stations on the Metro Green Line is significantly higher than the number of crimes at the stations themselves (Loukaitou-Sideris, Liggett, and Iseki 2002). They conclude that this is because the environment at park and ride facilities is much worse than that of stations ─ lower lighting, fewer people, and no security guards. These attributes, together with the fact that park and ride facilities consist of parked vehicles with a multitude of hiding places, could account for why passengers feel the need for improvements in safety and security at these facilities.

Connection & Reliability

Artesia Transit Center (ATC), South Bay Galleria (SBG), Union Station Bus (USB), and Wilshire/Western (WW) have the highest IS rating for *connection and reliability*, while the ratings at ATC are very close among categories. These stations are used primarily as transfer facilities, not as origin/destination stations. This may account for why *connection and reliability* is ranked the highest according to the IS rating.

Long or uncertain wait times at these facilities can seem particularly onerous depending on whether or not waiting is productive, whether or not a wait is forced, and whether or not a traveler knows the arrival time of the next bus. Thus, although actual waiting time is determined by the difference in arrival time of a user and a vehicle at a boarding location, perceived waiting time can be substantially longer depending on waiting conditions, and therefore the generalized cost of waiting time can become higher in facilities which are not surrounded by a mixture of land uses (Iseki and Taylor 2007).

In addition, SBG's IS rating for *connection and reliability* is much higher than ratings for other categories. SBG is a bus terminal in Redondo Beach, where people make transfers among many buses operated by different municipal operators and Metro. It is a common problem that different transit operators do not work together for their time schedule to minimize transfer time for users. SBG was surveyed during night time hours when it was cold outside, which could have added to the perception of wait time. Wait time is perceived especially burdensome when travelers have to wait in difficult environments, such as in cold weather, or in a seemingly unsafe or insecure condition.

Amenities

The availability of *amenities*, such as weather protection, seating, restrooms, public telephones, audio announcements and the opportunity to purchase transit tickets, snacks, flowers, or newspapers, can enhance the passenger's experience. Broadway & 7th Street (B7) and Imperial

Wilmington (IW), had the highest IS ranking (indicating the highest improvement needs) for *amenities* among the attribute categories, while the IS rating for *amenities* was almost the same as that for *security and safety* at WEST. B7 is located in the middle of downtown Los Angeles. It is not a distinct transit facility with infrastructure beyond a sign, and the environment surrounding bus stops is not maintained by transit agencies. The location experiences a great deal of pedestrian activity, automobile traffic, and there are retail shops and fast food restaurants nearby. There is not any designated seating for people waiting for the bus, nor any weather protection from the sun or rain. The bus stops are not clearly marked and there are not any maps or schedule information present. This kind of environment significantly degrades the quality of *amenities* at this place.

The stations/stops at B7, IW, and WEST do not have public restrooms and have minimal to no available seating. WEST had the most favorable IS ranking for *amenities* despite not having available restrooms and few seats, which may be explained by the fact that the stop is located in a pleasant commercial neighborhood with coffee shops and restaurants (where restrooms are readily available) nearby. IW is a station where two light rail lines ─ Green Line and Blue Line ─ intersect with each other. It is located in central Los Angeles, and has a significant number of users. This station is located adjacent to a freeway, tends to be very noisy, and only minimal amenities nearby.

Table 7 and Figure 29 show the mean and the standard deviation of IS ratings by location. Wilshire and Westwood (WEST) and Union Station Bus Terminal (USB) received the lowest (most favorable) and second lowest IS rating. In addition, the standard deviation of IS ratings is high for South Bay Galleria (SBG), Fox Hills (FH) and Broadway & 7th St. (B7), and low for Wilshire and Westwood (WEST) and Union Station Rail Station (USR).

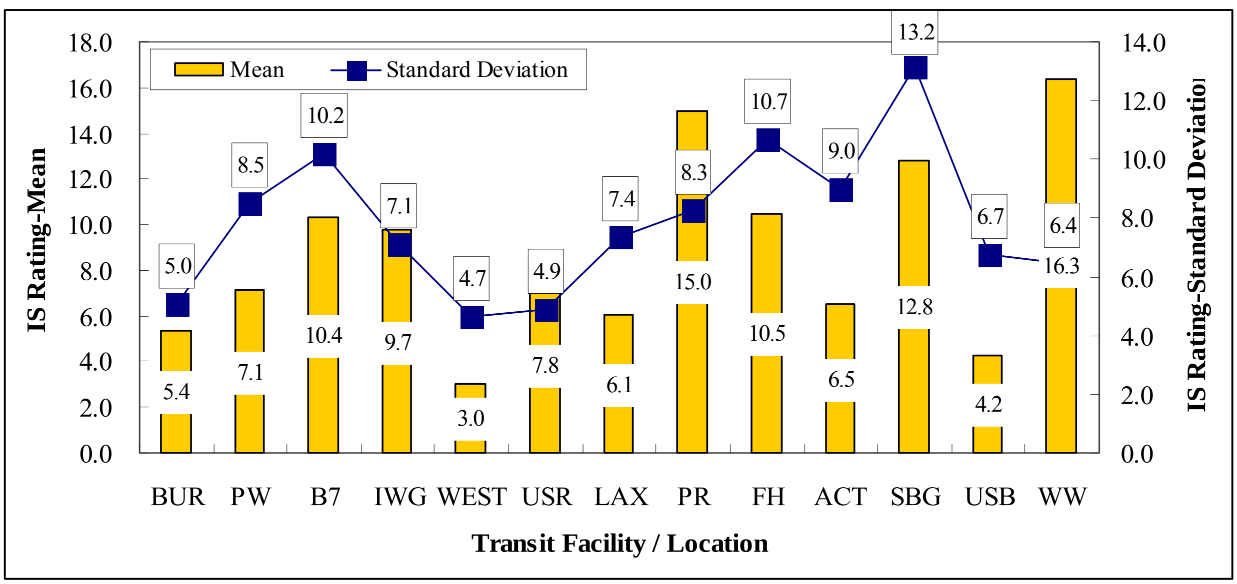


Figure 29 Mean and Standard Deviation of IS Rating by Transfer Facility

Our findings generally show that the facilities with a higher percentage of choice riders, such as USR, USB, BUR, and WEST, tend to be the most satisfied with the transfer facility and have the lowest mean IS rating. This may be because many users at these facilities chose to forego their car in order to use public transit. This finding could indicate that the attributes present at a transit facility do not play a significant role in influencing passenger satisfaction.

Relative Importance of Transfer Facility Attributes based on Satisfaction Ratings

One of the central questions motivating this research is which transit stop and station attributes most influence traveler's use of public transit. The more satisfied transit users are with their waiting and transferring experiences, the more likely they are to take transit.

In order to examine relative importance of transit stop and station attributes, we conducted chi-square tests and ordered logit regression (OLR) analyses, using the various satisfaction ratings described above.[5] In our survey, the dependant variable had four ordinal categories: strongly agree, agree, disagree, and strongly disagree.

First, we conducted chi-square tests to determine whether any of the answers by survey respondents in questions A through P (questions about the individual characteristics of the wait or transfer) influence the distribution of responses for question Q (which is their overall evaluation of the stop or station). Table 8 summarizes results from chi-square tests.[6]

---

5 The chi-square test is a method used to examine whether the distribution of observations among categories of a dependant variable is influenced by another categorical variable (Fox 1997; StataCorp LP 2005). Ordered logit regression is a method used to examine the relationships between a series of independent variables and an ordinal dependant variable. As in other logit regression models, the dependant variable is not continuous, but categorical. In an ordered logit, the particular order of values in the dependent variable is important, while differences between two consecutive values of a dependent variable are not. More details on the use of ordered logit model can be found in STATA manuals (2005) and other advanced statistics textbooks.

6 Note that the there were four possible responses to question Q, but this was reduced to three in our analysis, combining responses of "disagree" and "strongly disagree." This was done to prevent the number of observations in each cell of a bivariate table from being no less than five. As a result, the degrees of freedom (D of F) are six in all of these chi-square tests.

Table 8 Chi-square Test Results

	Survey Question	Category	No. of Obs	Pearson chi2	D of F	Prob
A	This station / stop area is clean.	Amenities	496	61.04	6	0.00
B	There are enough places to sit.	Amenities	496	46.80	6	0.00
C	There are places for me to buy food or drinks nearby.	Amenities	470	32.41	6	0.00
D	There is a public restroom nearby.	Amenities	462	24.67	6	0.00
E	There is shelter here to protect me from the sun or rain.	Amenities	468	54.21	6	0.00
F	The signs here are helpful.	Information	490	103.52	6	0.00
J	It is easy to get schedule and route information at this station.	Information	480	99.01	6	0.00
H	I usually have a short wait to catch my bus / train.	Connection & Reliability	481	79.22	6	0.00
I	My bus / train is usually on time.	Connection & Reliability	486	113.28	6	0.00
G	It's easy to find my stop or platform.	Access	486	117.92	6	0.00
K	It is easy to get around this station / stop.	Access	488	175.03	6	0.00
L	I feel safe here during the day.	Security & Safety	492	124.02	6	0.00
M	I feel safe here at night.	Security & Safety	475	78.29	6	0.00
N	There is a way for me to get help in an emergency.	Security & Safety	477	54.20	6	0.00
O	This station is well lit at night.	Security & Safety	485	115.12	6	0.00
P	Having security guards here makes me feel safer.	Security & Safety	494	121.81	6	0.00

As you can see in the "Prob" column, the probability that the distribution of responses to question Q is related to questions A through P is in all cases less than 0.05. While the chi-square test does not take into account the order of responses, we can conclude that responses to each of the questions about individual transit stop or station attributes influence the users overall satisfaction in a statistically significant sense.

Following these chi-square tests, we performed a series of a simple ordered logit regression analyses, including variables from one question at a time. Since the explanatory variables are also ordinal variables, three dummy (or dichotomous [0, 1]) variables were used to differentiate the four levels of responses. The results are shown in Table 9. In this table, positions of questions G and J are flipped so that questions in the same category are next to one another. "Pseudo R2" in this table is similar to R-squared in the Ordinary Least Regression (OLS) model; it compares the goodness of fit of different models.[7] Based on the results in Table 9, the variance of responses to the question about getting around the station /stop (K: Access) explains more of the variance of responses in the overall rating (question Q) than any other explanatory variable, having the highest pseudo R-squared value of 0.16. The questions about on-time performance (I: Connection & Reliability) and finding stop or platform (G: Access) have the second highest pseudo R-squared value of 0.12. On the other hand, the variance of questions about amenities (D, C, and B) does not explain much of variance of the overall ratings, having the three lowest pseudo R-squared values among 16 questions.

The columns labeled "probability" show which level of response is statistically significant in the ordered logit model. Here, the level of response means: 1-strongly disagree, 2-disagree, 3-agree, and 4-strongly agree with a statement that the user is satisfied with each attribute at the transit facility. For all individual attributes, the level 4 (strongly agree) response is statistically significant at the 95 percent confidence level. Questions H, L, and O also statistically significant at the 95 percent confidence level for level 3 (agree) responses. Questions I, K, and M are significant at the 95 percent confidence level for response levels 2 (disagree), 3 (agree), and 4

[7] The "log likelihood" with the same degrees of freedom would be technically the more appropriate statistic here.

(strongly agree). In addition to a variable that is statistically significant at the 95 percent confidence level, Questions A, F, and H have another variable statistically significant at the 90 percent confidence level (last column in Table 9).

Considered collectively, overall ease of navigation at the transfer center, personal safety, and service reliability are the most important factors in explaining a passenger's overall satisfaction with a stop or station. For example, "It's easy to get around this station/stop" (pseudo-R2 = 0.16, significant at 3 response levels) is most important overall, "I usually have a short wait to catch my bus/train" (pseudo-R2 = 0.12, significant at 3 response levels) is second, "It's easy to find my stop or platform" (pseudo-R2 = 0.12, significant at 1 response level) is third, "This station is well lit at night" (pseudo-R2 = 0.11, significant at 2 response levels) is fourth, and "Having security guards here makes me feel safer (pseudo-R2 = 0.10, significant at 1 response level) is fifth.[8] On the other hand, station amenities and cleanliness (public restrooms, food/drink sales, places to sit, shelter from sun/rain, and cleanliness) all ranked at the bottom of importance.

Table 9 Results of Simple Ordered Logit Regression Analysis

Survey Question	Category	No. of Obs	Pseudo R2	Probability 0.05-0.00	Probability 0.05-0.10
A This station / stop area is clean.	Amenities	496	0.06	4	3
B There are enough places to sit.	Amenities	496	0.04	4	-
C There are places for me to buy food or drinks nearby.	Amenities	470	0.03	4	-
D There is a public restroom nearby.	Amenities	462	0.02	4	-
E There is shelter here to protect me from the sun or rain.	Amenities	468	0.06	4	-
F The signs here are helpful.	Information	490	0.09	4	3
J It is easy to get schedule and route information at this station.	Information	480	0.09	4	-
H I usually have a short wait to catch my bus / train.	Connection & Reliability	481	0.08	3,4	2
I My bus / train is usually on time.	Connection & Reliability	486	0.12	2,3,4	-
G It's easy to find my stop or platform.	Access	486	0.12	4	-
K It is easy to get around this station / stop.	Access	488	0.16	2,3,4	-
L I feel safe here during the day.	Security & Safety	492	0.10	3,4	-
M I feel safe here at night.	Security & Safety	475	0.07	2,3,4	-
N There is a way for me to get help in an emergency.	Security & Safety	477	0.05	4	-
O This station is well lit at night.	Security & Safety	485	0.11	3,4	-
P Having security guards here makes me feel safer.	Security & Safety	494	0.10	4	-

Next, we conducted an ordered logit regression analysis including responses from more than one question for 512 observations. After numerous iterations where we sought to identify a set of statistically significant variables, while taking into account collinearity among variables, we obtained the results shown in Table 10, which lists the variables in the order of the scale of their coefficients.

The pseudo R-squared in this model indicates that approximately 27 percent of variance of an outcome (dependant) variable is explained by the variance of all variables included in the

[8] While most safety attributes were ranked as relatively important, "There is a way for me to get help in an emergency" did not. This is perhaps due to the ubiquity of mobile phones, even among low-income travelers, which may obviate the need for emergency phones and the like.

regression model. All variables included in this parsimonious model are statistically significant at the 95 percent confidence level.

Since all variables are dummy (dichotomous variables) to indicate whether the overall satisfaction response is something other than "strongly disagree," we can compare coefficients among variables directly.[9]

Table 10 Final Ordered Logit Model of Factors Predicting Users Overall Satisfaction Level with their Transit Stop or Station

Nnumber of observations: 512						
LR chi2(8) = 255.37		Prob > chi2 = 0.0000				
Log likelihood = -349.8149		Pseudo R2 = 0.2674				
	Survey Questions	**Category**	**Coef.**	**Std. Err.**	**z**	**P>|z|**
I-4	My bus / train is usually on time.	Connection & Reliability	1.270	0.397	3.20	0.00
P-4	Having security guards here makes me feel safer.	Security & Safety	1.244	0.228	5.45	0.00
O-4	This station is well lit at night.	Security & Safety	1.102	0.330	3.34	0.00
L-4	I feel safe here during the day.	Security & Safety	1.049	0.310	3.39	0.00
L-3			0.961	0.265	3.63	0.00
K-4	It is easy to get around this station / stop.	Access	0.934	0.282	3.31	0.00
F-4	The signs here are helpful.	Information	0.555	0.262	2.12	0.03
G-4	It's easy to find my stop or platform.	Access	0.516	0.256	2.02	0.04
Cut point between "strongly disagree and disagree" & "agree"			-0.175	0.235	(Ancillary parameters)	
Cut point between "agree" and "strongly agree"			2.262	0.265		

The penultimate row shows the cut point (threshold value) separating those who disagree and strongly disagree with a statement that they are satisfied overall with the transit stop or station (in other words, that they are unsatisfied or very unsatisfied with the stop or station overall), and those agree with the statement that they are satisfied with the stop or station. Likewise, the last row shows the cut point between those who are satisfied with the stop or station, and those who are very satisfied.[10] It should be noted that we obtained a similar result using the statement "I feel safe here at night" (M) instead the statement "I feel safe here during the day" (L). Due to the high correlation between these two variables, we decided to use variables for the statement "I feel safe here during the day" (L).

The difference between this logit analysis and the chi-square analysis presented earlier is that this analysis attempts to consider the influence of each of many stop or station attributes while controlling, to the extent possible, for the influence of other attributes. Thus, the scale of

---

[9] This is not a linear regression model, however, so interpretation of coefficients calls for caution. To see how these coefficients affect the probability of the overall satisfaction level, see Table 11 below.

[10] Cut point values are used to compute probabilities that each observation with certain values of independent values fall within each category of a dependant variable, taking into account the disturbance factor, which is assumed to be logistically distributed (StataCorp LP 2005). For example, when all independent values of the obtained regression model are zero, then probabilities for each of three categories (1&2, 3, and 4) are 0.456, 0.449, and 0.094 respectively.

coefficients in Table 10 indicates the relative importance of the explanatory variables examined. Significantly, the most important factor in determining users' overall satisfaction with a transit stop or station has nothing to do with the stop or station; it is the on-time performance of the transit service. This is an important finding, though it should not come as a surprise to anyone familiar with travel behavior research. In other words, the perceived burden of waiting for or transferring between transit vehicles is reduced substantially by reliable (and frequent) service. This finding is all the more reliable because the respondents of this survey were aware that the foci of our analysis were transit stops and stations.

Following schedule adherence, the next three most important stop or station attributes concern personal safety (security guards, lighting, and overall perceptions of security). And following perceptions of personal safety are three factors related to the navigatability of the stop or station (easy to get around, signs are helpful, easy to find stop or platform).

To see how a response to the quality of each attribute influences the overall satisfaction level for the facility, probabilities for the overall satisfaction level were calculated from the estimated coefficients in Table 10 using the mean values for all variables in the regression model (Table 11). In Table 11, the satisfaction level for each of the final model's attributes clearly influences the overall satisfaction level with the transit stop or station. For example, when a transit user is strongly satisfied with on-time performance (I), the probability that this person is strongly satisfied with the overall quality of the transit facility increases from 0.41 to 0.71. The same interpretation applies to all variables.

Table 11 Probability of the Overall Satisfaction Level for Transfer Facilities

	Survey Questions	Category	Response	Mean Probability of Responses #	Agree	Strongly Agree
I	My bus / train is usually on time.	Connection & Reliability	*	0.11	0.48	0.41
			Strongly Agree	0.03	0.25	0.71
P	Having security guards here makes me feel safer.	Security & Safety	*	0.13	0.50	0.37
			Strongly Agree	0.04	0.29	0.67
O	This station is well lit at night.	Security & Safety	*	0.11	0.48	0.41
			Strongly Agree	0.04	0.28	0.68
L	I feel safe here during the day.	Security & Safety	#	0.16	0.52	0.32
			Agree	0.07	0.38	0.55
			Strongly Agree	0.06	0.36	0.57
K	It is easy to get around this station / stop.	Access	*	0.12	0.49	0.39
			Strongly Agree	0.05	0.33	0.62
F	The signs here are helpful.	Information	*	0.11	0.47	0.42
			Strongly Agree	0.07	0.39	0.55
G	It's easy to find my stop or platform.	Access	*	0.11	0.47	0.42
			Strongly Agree	0.06	0.38	0.56

*: Strongly disagree, disagree, and agree combined; #: Strongly disagree and disagree combined.

Overall, the results of this ordered logit regression are consistent with our findings from the importance-satisfaction analysis. *Connection and reliability* factors are the most important, followed by *security and safety* factors. A few attributes in the access and information categories also significantly influence users' satisfaction levels, but amenities in general are not nearly as important as the other attributes tested.

Relationship between Facility Attribute Characteristics and Users' Perceptions

In the final stage of the analysis, we related our observed levels of quality from our facility inventory to the overall satisfaction ratings in our user survey.[11] First, we related each survey question to each of the facility attributes inventoried, and then we conducted chi-square and correlation tests to test whether the distribution of responses to the overall satisfaction question varies by the score we assigned in our facility attribute inventory. Tables 12 through 15 summarize our results for the four categories of transit stop and station attributes.[12]

The first column in each of the following tables indicates questions from the user survey. The second column indicates a transit facility attribute that is related to the question in the first column. The third through fifth columns show results from chi-square tests: the numbers in the third, fourth and fifth columns are the Pearson test statistic, degrees of freedom, and a chi-square probability respectively. Chi-square probabilities of less than 0.05 are shown in **bold** type. Since the number of seats is a continuous variable (unlike most of our other inventory variables), we obtained a correlation coefficient and a measure of its statistical significance for this variable.

For the stop and station amenities – except litter for question A and fast food and restaurant for question C – the inventory score is related to the satisfaction level in the user survey (Table 12). For the "information" variable, the results indicate that responses in overall satisfaction levels are independent from our inventory scores (Table 13). In other words, we could not establish a relationship between our visual survey of information quality at each of the stops and stations inventoried and users' reported levels of satisfaction with attributes related to information at those stops and stations.

---

[11] We initially sought to conduct regression analyses relating the transfer facility inventory data to users' reported overall levels of satisfaction. However, we did not find statistical significance in chi-square tests and correlation analysis between the overall rating and many variables from our stop/station inventory. This is almost certainly due to a lack variance in the inventory data, and not by the number of facilities in the survey. Thus, a lack of variance in the inventory data in relation to the overall rating prevented us from developing the hoped-for multiple regression model to allow us to compare a relative importance of transfer attributes from the facility inventory. In selecting our survey sites we sought to chose stops and stations that were as different from one another as possible, but unfortunately the scope and scale of our survey effort did not permit us to survey the vary large number of stops and stations that would have been necessary to achieve the needed inventory variables across all of the variables of interest. We hope to address this issue in a subsequent phase of this research.

[12] Unfortunately, we were not able to obtain objective measures of the connectivity and reliability of transit service at the stops and stations inventoried, since the attributes in this category required difficult-to-obtain schedule-adherence data for each line at each stop and station.

Table 12 Chi-square and Correlation Test Results of the Relationship between our Inventory of Stop/Station Inventory of Facility Attributes and Users' Perceptions of Amenities

Question		Chi-squared or Correlation*		
	Amenities	Pearson chi2	DoF	Prob
A: Cleanliness	Graffiti	17.96	6	**0.006**
	Litter	9.84	6	0.131
B: Seating	Seating	91.00	6	**0.000**
	Number of full seats*	0.36	-	**<0.05**
C: Food / drink services	Services (food/drinks/newspaper)	21.83	6	**0.001**
	Vending machines	10.67	3	**0.014**
	Kiosk	7.90	3	**0.048**
	Fast food/ restaurant	6.90	3	0.075
D: Public restroom	Restroom	51.44	3	**0.000**
	Restroom entrance visible	26.65	3	**0.000**
	Restroom well-lit	32.69	3	**0.000**
E: Protection	Shelter	45.46	6	**0.000**
	Protection from wind	10.46	3	**0.015**
	Protection from sun	27.34	3	**0.000**
	Protection from rain	60.67	3	**0.000**

Table 13 Chi-square Test Results of the Relationship between Stop/Station Inventory Attributes and Users' Perceptions of Information

Question		Chi-squared		
	Information	Pearson chi2	DoF	Prob
F: Signs	Signs/ maps	8.74	6	0.19
J: Information	Schedule info	13.57	9	0.14

For the group of access attributes, the distribution of responses for question G ─ facility identity ─ depends only on the level of stop/station visibility identified in the inventory (Table 14). The distribution of responses for question K ─ getting around ─ is related both linkage of the stop/station to the street network and linkage of the stop/station to connecting buses or trains.

For security and safety, there appear to be several attributes whose inventory scores influence the distribution of responses in the satisfaction levels with safety, both during day and at night (Table 15). The distribution of responses in the satisfaction with level of lighting is highly related to the inventory score. However, for emergency call boxes and security guards, Pearson test statistics are statistically significant at a 90% confidence level, but not at the stricter 95% confidence level.

Table 14 Chi-square Test Results of the Relationships between Stop/Station Inventory Attributes and Users' Perceptions of Access

Question	*Access*	Chi-squared		
		Pearson chi2	DoF	Prob
G: Facility identification (1&2, 3, 4)	Linkage to street (3)	2.14	4	0.710
	Visibility	6.09	2	**0.048**
	Platform ID	6.49	4	0.166
K: Getting around a facility (1&2, 3, 4)	Linkage to street	9.80	4	**0.044**
	Linkage to Connecting bus/train	15.26	6	**0.018**

Table 15 Chi-square Test Results of the Relationship between Stop/Station Inventory Attributes and Users' Perceptions of Security and Safety

Question	*Safety & Security*	Chi-squared		
		Pearson chi2	DoF	Prob
L: Safety during day (1&2, 3, 4)	Security guards	19.65	4	**0.001**
	Utilization of station	15.08	6	**0.020**
	Utilization of parking lot	31.81	6	**0.000**
	Call box	16.76	2	**0.000**
	Hidden Area	27.25	4	**0.000**
	Video Surveillance	1.56	2	0.459
	Graffiti	1.13	4	0.889
	Litter	2.20	4	0.698
M: Safety at night (1&2, 3, 4)	Lighting	7.90	4	0.095
	Security guards	9.03	4	0.060
	Utilization of station	15.75	6	**0.015**
	Utilization of parking lot	25.05	6	**0.000**
	Call box	27.30	2	**0.000**
	Video Surveillance	0.58	2	0.750
	Hidden Area	14.59	4	**0.006**
	Graffiti	9.01	4	0.061
	Litter	7.75	4	0.101
N: Help for Emergency	Call box	7.73	3	0.052
O: Lighting	Lighting	13.64	6	**0.034**
P: Security Guards	Security guards	12.34	6	0.055

For questions for which chi-square and correlation tests showed statistical significance at the 95 percent confidence interval, we conducted a series of ordered logit regression analyses using users' satisfaction with each factor as the dependant variable. These questions are on 1) cleanliness (A), seating (B), food/drink services (C), public restroom (D), and protection from the weather (E) in the amenities category, 2) facility identification (G) and getting around a facility (K) in the access category, and 3) questions safety during day (L), safety at night (M), and lighting (O) in the security and safety category, but do not include questions in the information category.

Tables 16, 17, and 18 show the results for each category tested. In these tables, the first column shows question of interest from the user survey. When the scales of satisfaction were reduced from four to three in the process of analysis, it is shown by the code "1 & 2, 3, 4", indicating the levels 1 ("Strongly disagree") and 2 ("Disagree") were combined together. The second column shows the related stop/station attribute from the inventory. The third, fourth, and fifth columns show the number of observations, log-likelihood, and pseudo R-squared. The sixth column shows the dummy variable used. For example, graffiti was scored using the following ordinal ranking: 0) none, 1) minimal, 2) moderate, and 3) a lot, though no stop or station in our sample was categorized as having a lot of graffiti.[13] In the regression analysis in this case, two separate dummy variables were created to indicate "1. minimal" and "2. moderate" different from "none". Columns seven through 11 show estimated coefficients, standard error, z-value, and probability that an estimated coefficient is not different from zero.

Table 16 Ordered Logit Regression Analysis on Satisfaction Scores in the Amenities Categories

		Ordered Logit Regression							
	Amenities	No.Obs	LL	PseudoR2	Var	Coeff	Std.Err.	Z	P>|Z|
A	Graffiti	596	-710.50	0.01	1	-0.517	0.204	-2.53	0.01
					2	-0.752	0.233	-3.22	0.00
B	Number of full seats	584	-741.57	0.05	no_seat	0.027	0.003	8.59	0.00
C	Services	542	-735.02	0.01	1	-1.3148	0.382	-3.44	0.00
					2	-0.647	0.250	-2.59	0.01
	Fast food/ restaurant				1	0.481	0.181	2.66	0.01
D	Restroom	521	-671.40	0.05	1	1.146	0.166	6.92	0.00
E	Shelter	528	-651.74	0.05	3	0.713	0.199	3.59	0.00
	Protection from rain				1	1.252	0.207	6.06	0.00

Table 16 shows that all five user queries about stop/station amenities in our survey have at least one associated variable from our stop/station inventory. The coefficients for graffiti with question A are negative, indicating that more graffiti leads to less satisfaction ─ an expected finding. The coefficients for services for question C are also negative, suggesting that the more services observed at the stop or station, the less satisfied users are with service ─ a decidedly counter-intuitive result. This *services* measure is a composite of more discrete attributes—vending machines, kiosks, and nearby fast food or restaurants with table service. Given that we

[13] See Appendix 3 for *Transit Transfer Stop/Station Characteristics' Template*.

do observe the expected relationship between fast food restaurants and satisfaction with stop and station services, it may be that combining various services into a single composite variable compounds too many factors, obscuring the results. The other estimated coefficients in Table 16 are both positive and expected, indicating that the higher the ranking of particular amenity attributes in our stop/station inventory, the more transit users tend to be satisfied with those attributes.

Table 17 shows the OLR analysis results for question G ─ facility identification. Although the chi-square test showed the dependency of responses in question K, no inventory variables were found to be statistically significant with user perceptions of identity at the 95 percent significance level. Further, and somewhat surprisingly, the estimated coefficient is negative, indicating that users are less satisfied with facility identification when visibility in our inventory was rated as adequate ─ the opposite of what we expected. However, when we examined the tabulation of the responses to question G with the visibility scores from our field inventory, we found that most respondents indicated that they either strongly agreed or agreed somewhat with question G while the few negative responses tended to be distributed somewhat randomly. Thus, combining these two responses ("strongly agree" and "agree somewhat") into a single category produced apparently counter-intuitive results. However, when we examined the distribution of "strongly agree" responses with the ratings of the facilities from our inventory, we found that "strongly agree" responses were much more common in the highest rated facilities in our inventory, and much less common in the lowest rated facilities in the inventory – exactly as we would expect.

Table 17 Ordered Logit Regression Analysis of User Satisfaction Scores in the Access Categories

		Ordered Logit Regression							
	Access	No.Obs	LL	PseudoR2	Var	Coeff	Std.Err.	Z	P>|Z|
G 1&2, 3, 4	Visibility	543	-513.54495	0.0044	3	-0.390	0.185	-2.11	0.04

Table 18 shows the OLR analysis results for questions L (safety during a day), M (safety at night), and O (lighting). The number of satisfaction levels for L and M were reduced down from four to three as indicated ("1&2"). For safety and security, regardless of whether respondents were traveling during the day or at night, the level of station utilization had a negative coefficient. Station utilization refers to how many patrons were surrounding the station/stop area at the time the survey was conducted. This suggests that travelers tend to feel less safe and secure when more people are around. These results are difficult to interpret; the presence of people is often considered to be a form of natural surveillance, which should increase perceptions of safety at more crowded stops. The coefficients for the presence of a call box and security guards are positive, as expected, while the coefficient for the presence of hiding spaces is positive, which is not as expected. While this result calls for further examination, perceptions of safety at a stop or station are related to a wide variety of factors, and it may be that those stops and stations more prone to crime in our small sample happen to have had few nooks and crannies to shelter nefarious activities. For question O ─ lighting ─ the positive estimated coefficient suggests that more lighting observed in our inventory is closely related to the level of satisfactions with lighting expressed by users in our survey – an expected result. Finally, we again treated the two *safety and security* survey questions (L and M) as composite indices, and again obtained mixed results. This suggests that a future iteration of this survey should disaggregate safety and security factors as discretely as possible.

Table 18 Ordered Logit Regression Analysis of Satisfaction Scores in the Safety and Security Categories

		Ordered Logit Regression							
	Safety and Security	No.Obs	LL	PseudoR2	Var	Coeff	Std.Err.	Z	P>|Z|
L 1& 2, 3, 4	Utilization of station	525	-507.47795	0.034	3	-0.407	0.189	-2.15	0.03
					4	-1.178	0.402	-2.93	0.00
	Security guards				2	0.417	0.239	1.74	0.08
	Call box				1	0.443	0.222	2.00	0.05
	Hide area				2	0.762	0.233	3.27	0.00
M 1& 2, 3, 4	Utilization of station	497	-514.55795	0.034	3	-0.449	0.191	-2.35	0.02
					4	-0.742	0.383	-1.94	0.05
	Call box				1	0.780	0.197	3.96	0.00
	Hide area				2	0.652	0.217	3.01	0.00
O	Lighting	495	-607.31173	0.0099	2	0.485	0.283	1.71	0.09

We examined the relationship between the overall satisfaction level and the inventory data on stop and station attributes. As noted in Footnote 9 above, however, very few variables were found to be statistically significant in either chi-square or correlation tests. The results are shown in Appendix 3.

6. CONCLUDING REMARKS

The analysis presented in this report has sought to address the general lack of causal clarity that plagues most previous research on transit stops and stations. Accordingly, we have examined: (1) how passengers evaluate transit stops and stations, taking into account the level of importance passengers place on each factor, and (2) what factors influence passengers' evaluation of transit stops and stations using the five evaluation criteria categories developed from the transfer penalties causal framework developed in a previous report:

1) *access*,
2) *connection and reliability*,
3) *information*,
4) *amenities*, and
5) *security and safety*.

Using this framework we designed and administered a survey to 749 transit users at twelve transit stops and stations (which ranged from adjacent corner bus stops to a large enclosed multi-modal transit center) around metropolitan Los Angeles. The demographics and travel patterns of those surveyed generally mirror those of southern California transit users in general.

Drawing on the data collected from this survey, we conducted two analyses: First, we conducted an *Importance-Satisfaction Analysis* to identify the priority that users in our sample place on improving transit stop and station attributes. Second, we used *chi-square tests*, *correlation tests*, and *multiple regression analyses* to examine which transit stop and station attributes measured in the inventory were related to the satisfaction level of transit users.

From these analyses, one principal finding stands out loud and clear: the most important determinant of user satisfaction with a transit stop or station has nothing (directly) to do with physical characteristics of that stop or station ─ it's frequent, reliable service in an environment of personal safety. In other words, most transit users would prefer short, predictable waits for buses and trains in a safe, if simple or even dreary, environment, over long waits for late-running vehicles in even the most elaborate and attractive transit facility, especially if they fear for their safety. While this finding will come as no surprise to those familiar with past research on the perceptions of transit users, it does present a contrast to much of the descriptive, design-focused research on transit transfer facilities.

Of our sixteen stop and station attributes, users ranked safety and service quality factors as most important:

<u>Most Important</u>

1) I feel safe here at night (78%)
2) I feel safe here during the day (77%)
3) My bus/train is usually on time (76%)
4) There is a way for me to get help in an emergency (74%)
5) This stop/station is well-lit at night (73%)
6) I usually have a short wait to catch my bus/train (70%)

In contrast, stop and station-area amenities ─ the ostensible focus of this research ─ were ranked as least important by users:

<u>Least Important</u>

1) It is easy to get route and schedule information at this stop/station (62%)
2) There is a public restroom nearby (59%)
3) This stop/station is clean (58%)
4) It is easy to get around this stop/station (57%)
5) There are enough places to sit (50%)
6) There are places for me to buy food or drinks nearby (34%).

This is not to say that such amenities are not important to travelers ─ more than half ranked information, a public restroom, cleanliness, and ease of navigation ─ as important. Rather, *ceteris paribus*, travelers prefer safe, frequent, reliable service over these factors.

When we statistically related users' satisfaction with various stop/station attributes with their overall satisfaction with their wait/transfer experience, we obtained similar, if not identical, results:

Most Important

1. It is easy to get around this stop/station
2. I feel safe here during the day
3. Having security guards here makes me feel safer
4. It's easy to find my stop or platform
5. The stop/station is well lit at night.
6. My bus/train is usually on time

Least Important

1. This stop/station is clean
2. There is shelter here to protect me from the sun or rain
3. There is a way for me to get help in an emergency
4. There are enough places to sit
5. There are places to buy food or drinks nearby
6. There is a public restroom nearby

We then employed a logistic regression model to measure the influence of each of 16 attributes on overall satisfaction, while simultaneously controlling for the effects of all other measured 'satisfaction' attributes. This sort of an analysis tends to eliminate all but one of closely related factors (such as "I feel safe here at night" and "This stop/station is well-lit at night") while elevating ostensibly less-important factors that independently influence users' overall levels of satisfaction:

Most Important

1. My bus/train is usually on time
2. Having a security guard here makes me feel safer
3. This stop/station is well-lit at night
4. I feel safe here during the day
5. It's easy to get around this station/stop
6. The signs here are helpful

Finally, we performed an extended series of statistical tests in an attempt to relate the physical attributes we inventoried at the stops and stations with the surveyed passengers' perceptions of these attributes. These results were largely as expected. While we were not able to draw firm conclusions regarding how these various attributes were related to overall user satisfaction levels, we did identify specific attributes that predict users' satisfaction levels. These attributes include graffiti, visibility, and the presence of seating area, restroom, and shelter. At the same time, we found the results of other variables, such as the availability of services, availability of call boxes, protection from rain, utilization of facility, and the presence of hide area, are counter-intuitive. Many of this last set of findings, however, are best viewed as preliminary, and likely require further investigation.

While perhaps surprising to some, these findings should be heartening to transit managers focused on delivering quality transit service to users. While comfortable, informative and attractive stops and stations can indeed make traveling by public transit more agreeable, what passengers *really* want most is safe, frequent, and reliable service ─ plain and simple.

7. ACKNOWLEDGMENT

This work was performed as part of the Institute of Transportation Studies at the University of California, Los Angeles and of the California PATH Program of the University of California in cooperation with the State of California Business, Transportation and Housing Agency, Department of Transportation (Caltrans). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. The authors acknowledge Bruce Chapman of Caltrans' Division of Research and Innovation for his support of this project. The authors wish to thank Ting Sit who helped in the design and administration of the survey, converted survey responses into an electronic database, and helped prepare preliminary descriptive statistics. The authors also thank UCLA students Syed-Abrar Ahmed, Lanka Ranasinghe, and Karla Vasquez who helped administer the survey and Vanessa Fernandez who translated the survey from English into Spanish. The authors also wish to thank Rowena Barlow and Michelle Tse of the UCLA School of Public Affairs Business Office for their administrative support of this project. Lastly, the authors thank the hundreds of Los Angeles area transit riders who voluntarily took their own time to answer our survey, which formed the basis of this work.

8. BIBLIOGRAPHY

Blumenberg, Evelyn. 2004. "En-gendering Effective Planning: Spatial Mismatch, Low-Income Women, and Transportation Policy," Journal of the American Planning Association, 70(3): 269-281.

Department for Transport. 2003. *Transport Analysis Guidance*, [cited Nov. 09. 2005]. Available from <http://www.webtag.org.uk/index.htm>.

Evans, John E. 2004. Chapter 9 - Transit Scheduling and Frequency. In *TCRP Report 95: Traveler Response to Transportation System Changes*. Washington D.C.: Transportation Research Board.

Fox, John. 1997. *Applied Regression Analysis, Linear Models, and Related Methods*. Thousand Oaks: Sage Publications.

Fruin, John J. 1985. Passenger Information Systems for Transit Transfer Facilities. Synthesis of Transit Practice, 7. Washington, D.C.: Transportation Research Board National Research Council.

Iseki, H., and Brian D Taylor. 2007. Not All Transfers Are Created Equal: Toward a Framework Relating Transfer Connectivity to Travel Behavior. Paper read at Transportation Research Board Annual Meeting, at Washington D.C.

ITE Technical Council Committee 5C-1A. 1992. The Location and Design of Bus Transfer Facilities. *ITE Journal*:33-37.

Kittelson & Associates, Inc., et al.,. 2003. Transit Capacity and Quality of Service Manual - 2nd Edition - Part 3 Quality of Service and Part 7 Stop, Station, and Terminal Capacity. In *TCRP Report 100*, edited by T. R. Board. Washington, D.C., 2003.: National Academic Press.

Los Angeles Metropolitan Transit Authority (LAMTA). 2002. On Board Bus Survey Weekday Passenger Report. Los Angeles, CA.

Loukaitou-Sideris, A., R. Liggett, and H. Iseki. 2002. The geography of transit crime - Documentation and evaluation of crime incidence on and around the green line stations in Los Angeles. *Journal of Planning Education and Research* 22 (2):135-151.

Rabinowitz, H. Z., Edward A. Beimborn, Peter S. Lindquist, and Donna M. Opper. 1989. Market Based Transit Facility Design. Washington, D.C.: Urban Mass Transportation Administration.

StataCorp LP. 2005. *STATA Base Reference Manual*. College Station, Texas: StataCorp LP.

Tennessee Department of Transportation Office of Strategic Planning. 2006. 2006 TDOT Statewide Customer Satisfaction Survey.

Vuchic, Vukan R., and Shinya Kikuchi. 1974. Design of Outlying Rapid Transit Station Areas. *Transportation Research Record* 505:1-12.

Appendix 1   User Survey Instrument

UCLA Transportation Survey - Tell us what you think!

UCLA researchers are assisting the State of California in improving transportation services. Part of this work includes asking people like you about your views on bus stops, train stations, and the like. This survey should take only a couple of minutes to complete and is completely voluntary. You are under no obligation to take this survey, or even to complete it once you have started. Further, the survey is anonymous and no individuals will be identified in any of the work produced from this research. Are you willing to participate in this survey?

_____ YES   _____ NO

1. How many days in a typical week do you ride a bus, train, or subway?

________ days per week

☐ less than once a week

2. What is the purpose of your trip today? *(check all that apply)*

☐ (1) work or job
☐ (2) shopping or errands
☐ (3) college or school
☐ (4) visiting family or friends
☐ (5) other: ___________________

3. How often do you make *this* trip?

☐ (1) regularly
☐ (2) sometimes
☐ (3) not often
☐ (4) never before

4. Could you have made this trip today by car / truck / motorcycle instead of by bus / train?

☐ (1) yes, easily
☐ (2) yes, with a little effort
☐ (3) no, probably not
☐ (4) no, definitely not

5. How did you get to this station / stop today?

☐ (1) bus or train
☐ (2) drove in a car by myself
☐ (3) got a ride from someone else
☐ (4) took a taxi or shuttle / van
☐ (5) rode a bicycle
☐ (6) walked ______ minutes
☐ (7) other: ___________________

6. From this station / stop, how will you reach your next destination?

☐ (1) bus or train
☐ (2) drive in a car by myself
☐ (3) get a ride from someone else
☐ (4) take a taxi or shuttle / van
☐ (5) ride a bicycle
☐ (6) walk ______ minutes
☐ (7) other: ___________________

7. How long do you expect to wait before leaving?

________ minutes   ☐ don't need to wait   ☐ unsure

8. Would you have preferred to make this trip by car / truck / motorcycle rather than by bus / train?

☐ (1) I strongly prefer car / truck / motorcycle
☐ (2) I usually prefer car / truck / motorcycle
☐ (3) I usually prefer bus / train
☐ (4) I strongly prefer bus / train

9. Are you: ☐ (1) male   ☐ (2) female

10. What is your background? *(check all that apply)*

☐ (1) American Indian
☐ (2) Asian / Pacific Islander
☐ (3) African-American / Black
☐ (4) Hispanic / Latino
☐ (5) Anglo / White
☐ (6) other: _________

11. In what year were you born?   1 9 __ __

12. About how much is your yearly household income?

☐ (1) Less than $10,000
☐ (2) $10,000 - $14,999
☐ (3) $15,000 - $24,999
☐ (4) $25,000 - $34,999
☐ (5) $35,000 - $49,999
☐ (6) $50,000 - $74,999
☐ (7) $75,000 - $99,999
☐ (8) $100,000 - $149,999
☐ (9) $150,000 - $199,999
☐ (10) $200,000 or more
☐ (11) unsure / don't know

		Do you agree or disagree?				How important is it to you?			
		Strongly Agree 4	Agree Somewhat 3	Disagree Somewhat 2	Strongly Disagree 1	Very Important 4	Important 3	Somewhat Important 2	Not Important 1
A	This station / stop area is clean.								
B	There are enough places to sit.								
C	There are places for me to buy food or drinks nearby.								
D	There is a public restroom nearby.								
E	There is shelter here to protect me from the sun or rain.								
F	The signs here are helpful.								
G	It's easy to find my stop or platform								
H	I usually have a short wait to catch my bus / train.								
I	My bus / train is usually on time.								
J	It is easy to get schedule and route information at this station.								
K	It is easy to get around this station / stop.								
L	I feel safe here during the day.								
M	I feel safe here at night.								
N	There is a way for me to get help in an emergency.								
O	This station is well lit at night.								
P	Having security guards here makes me feel safer.								
Q	This is an easy place to transfer to another bus or train.								

Thanks for helping us improve public transit!

Appendix 2 Transit Transfer Stop/Station Characteristics' Template

Station Name: ____

Date & Time: ____

Rules of Thumb

- Nominal or categorical variables will be coded by a set of dummy (0 or 1) variables to represent all categories
- Orderly variables, in which the order is important but differences among choices do not mean anything, will be coded either a set of dummy variables or numbers in order. In any case, I need to re-code after looking at the data.
- Scale variables will be coded using numbers, while a unit of numbers may not be clear.
- Continuous variables should be coded as numbers or percentages as much as possible. Avoid collecting them in other ways, which result in a loss of information.

For all variables, which require some subjective judgment (e.g. graffiti), the team initially defined as clearly as possible each level and the followed the definition (or standard) as much as possible regardless of survey location. Our objective in developing this inventory was to be as detailed as possible in our collection of site-specific information that could subsequently be aggregated later if necessary; subsequent coding of the data would be based on our definitions of each level; it was important to identify variability in measurements among the sample locations.

Control Variables

Station Type Bus only __0__ Rail only ____1_ Bus & Rail ___2__

Surrounding Environment Urban ___1__ Suburban ___0__

Transfer Facility Type Level 1-5 __1 through 5____

Passenger Loading On-street __0____ Off-street ___1____

Park-and-Ride Yes/ No ______ # of Spaces ___

Approximate Time to Walk between Park-and-Ride and Platform

Comments

____

____

Treatment Variables

I. Safety & Security:

Lighting

None____0__ _Minimal ____1___ Average ____2____Adequate ____3___

Security Guards/Police Officers

Always ___2___ Sometimes____1___ Never ____0_____

Comments

____

____

Utilization of Station Mostly empty _0__ 1/3 filled _1__ ½ filled _2__ ¾ filled __3_ Full __4___

In Percentage) _____________ %

Comments

____

____

Utilization of Parking Lot

Mostly empty _0__ 1/3 filled _1__ ½ filled _2__ ¾ filled __3_ Full __4___

In Percentage _____________ **%**

Comments

____

____

Emergency Communication Device

Call Box __Yes 1, No 0 Video Surveillance _ Yes 1, No 0   Both __ Not needed_______

Comments (location and relative distance)

____

____

II. Access:

Linkage to Street

Stairway _1__ Underpass __2_ Overpass _3__ Access to Sidewalk _4__ Elevator/ Escalator__5_

Other (explain) ______________________________

Comments (indicate how easy or difficult it is for pedestrians to access the station)

____

____

Linkage to Connecting Bus/Train

Stairway _1__ Underpass _2__ Overpass __3_ Sidewalk _4__ Elevator/ Escalator__5__

Other (explain) __________________________

Comments (indicate how easy or difficult it is for pedestrians to transfer to another bus or train)

____

____

Visibility from Surroundings

Minimal _1___ (hard to see surroundings)

Moderate __2__ (partial visibility)
Adequate _3___(open space)

Comments

____

____

Hidden Areas (under stairs, behind walls, nooks, bushes, etc.)

Count the number of hidden areas, in addition to qualitative observation

Comments

____

____

Platform Identification

Minimal ____1____ (loading area not identified)
Moderate ____2____ (not clearly identified)
Adequate ____3_____ (clearly marked)

Comments

____

____

III. Amenities:

Cleanliness/Presence of:

Graffiti	None __0_	Minimal __1__	Moderate __2_	A lot __3__
Litter	None __0_	Minimal __1__	Moderate __2_	A lot __3__

Comments

____

____

Restrooms (location of restrooms-if any- relative to platform)

Restroom	Yes 1, No 0
Entrance visible	Yes 1, No 0
Well-lit	Yes 1, No 0

Comments

____

____

Seating Minimal ___1_____ Moderate _____2____ Adequate ___3______

Seating Capacity

Full-seat # _____

Half-seat (those which you can sit on in a standing position) # ________

Comments

____

____

Services Minimal ____1____ Moderate _____2____ Adequate ___3______

Vending machines	Yes 1, No 0
Kiosk (can buy newspaper, drinks)	Yes 1, No 0
Fast food or regular restaurants with seating	Yes 1, No 0

Comments (location)

____

____

Shelter Minimal ________ Moderate _________ Adequate _________

Shelter from wind Yes 1, No 0

Shelter from sun Yes 1, No 0

Shelter from rain Yes 1, No 0

(It is important to check if you can see the next vehicle's arrival from the shelter.)

Comments

IV. Information:

Signs/ Maps

None __0__ (not posted)

Minimal ___1_____ (hard to find/not clearly marked)

Moderate ___2_____ (easy to identify)

Adequate ___3_____ (centrally located/clearly marked)

Comments

____

____

Schedule Information

None __0__ (not posted)

Minimal ___1_____ (present but hard to find)

Moderate ___2_____ (clearly posted in one area)

Adequate ___3_____ (clearly posted throughout the station)

Comments

____

____

Availability of Multiple Languages

Check multiple languages for some information that should be communicated through text

Spanish	Yes 1, No 0
Korean	Yes 1, No 0
Chinese	Yes 1, No 0

STATION NEIGHBORHOOD CHARACTERISTICS
(1/4 mile from station platform)

Station Name ____

Land Uses (check all that apply)

Residential Single Family ____
Residential Duplexes ____
Residential Multifamily ____
Mixed Use ____
Office (low rise) ____
Office (medium rise) ____
Office high rise ____
Retail neighborhood ____
Retail "Big Box" ____
Industrial light ____
Industrial heavy ____
Vacant Land ____
Parking lots ____
Parking garages ____
Open Space (e.g. parks) ____
Other (specify)

Comments (note the approximate proportion of each land use)

____

____

Density

Residential	High ___	Medium ___	Low ____
Commercial	High ___	Medium ___	Low ____

Comments

____

____

Street Traffic (adjacent to station)

Heavy ____	Moderate ____	Low _____
(busy street)	(moderate traffic flow)	(few cars passing)

Pedestrian Traffic (adjacent to station)

Heavy ____	Moderate ____	Low _____
(many people nearby)	(few passer-byes)	(little/ no pedestrians)

Comments

____

____

Specific Land Uses (note the existence and number of the following)

	Number
Parks	________________________
Schools	________________________
Restaurants	________________________
Cafes	________________________
Banks	________________________
Civic Buildings	________________________
ATMs	________________________
Check Cashing	_______________________
Pawn Shops	________________________
Alleys	________________________
Liquor Stores	________________________

Motels ___________________________

Abandoned Buildings ___________________________

Other ___________________________

Sense of Safety[14]

Good _____ Average _____ Poor ______

Comments (explain your answer)

____

____

[14] This is a rather subjective and impressionistic measure, but we want to know if based on what you see you feel safe in this neighborhood? Some things to consider include: Do you see other people in the neighborhood? Do you see fenced windows and doors? Are there homeless, beggars, or transients, etc.?

Appendix 3 Inventory Variables Affecting the Overall Satisfaction Rating

We examined the relationship between the overall satisfaction level and the inventory data on stop and station attributes. In Table A-1 below, however, very few variables (in bold type) were found to be statistically significant in either chi-square or correlation tests.

Table A-1 Chi-square and Correlation Tests to Examine the Relationship between Users' Overall Satisfaction Levels and the Stop/Station Attribute Inventory

Transfer Attribute Categories	Transfer Facility Attribute from the Inventory	Chi2 with Qeusetion Q (1&2, 3, 4)		
		Pearson chi2	**DoF**	**Prob**
Amenities	Graffiti	0.346	4	0.483
	Litter	1.290	4	0.863
	Restroom	1.350	2	0.509
	Restroom entrance visible	1.132	2	0.568
	Restroom well-lit	0.883	2	0.643
	Seating	3.846	4	0.427
	Number of full seats	0.070*	-	>0.10
	Services	**8.547**	**4**	**0.073**
	Vending machines	1.814	2	0.404
	Kiosk	3.976	2	0.137
	Fast food/ restaurant	1.568	2	0.457
	Shelter	**11.927**	**4**	**0.018**
	Protection from wind	1.730	2	0.421
	Protection from sun	**10.979**	**2**	**0.004**
	Protection from rain	**7.736**	**2**	**0.021**
Information	Signs/ maps	2.342	6	0.886
	Schedule info	4.503	6	0.609
Access	Linkage to street	8.680	8	0.370
	Linkage to Connecting bus/traing	1.613	6	0.952
	Visibility	3.737	2	0.154
	Platform ID	0.062	4	1.000
Safety & Security	Lighting	4.912	4	0.296
	Security guards	5.906	4	0.206
	Utilization of station	7.606	6	0.268
	Utilzation of parking lot	4.404	4	0.354
	Call box	2.430	2	0.297
	Hidden areas	1.317	4	0.859
	Video Surveillance	0.922	2	0.631

The variables that did prove statistically significantly related to overall satisfaction levels were services, shelter, protection from sun, and protection from rain. Unfortunately, shelter, protection from sun, and protection from rain all have a high degree of correlation with one other (0.42-0.75). These factors are, ironically, some of the least important factors identified in our more preliminary analyses reported above. Based on these chi-square and correlation tests, therefore, we expect that most of variables gathered for our inventory will not prove to be statistically significant in a regression analysis. And, indeed, this was the case. The reason, as discussed above, is almost certainly due to the high degree of correlation among the various inventory variables in our study sites. In other words, stops and stations with good signs tend to have lots of seats, plenty of shelter, and so on. It will take a much larger sample of stops and stations ─ perhaps in a later stage of this research ─ to meaningfully test overall user perceptions of the stop/transfer experience with the wide array of physical stop/station attributes simultaneously.

APPENDIX D

APPENDIX D

Evaluating Transit Stops and Stations from the Perspective of Transit Managers
Interim Deliverable #4

Under Contract 65A0194 for Project
Tool Development to Evaluate the Performance of
Intermodal Connectivity (EPIC) to Improve Public Transportation

Submitted to:

California Department of Transportation
Division of Research and Innovation
1227 O Street, 5th Floor
Sacramento, CA 94273-0001

Prepared by
Michael Smart[1], Mark A. Miller[1, 2], and Brian Taylor[1]

[1]Institute of Transportation Studies
University of California, Los Angeles
School of Public Affairs
3250 Public Policy Building, Box 951656
Los Angeles, CA 90095-1656

[2]California PATH Program
Institute of Transportation Studies
University of California, Berkeley
Building 452, Richmond Field Station
1357 S. 46th Street
Richmond, CA 94804

October 15, 2007

EXECUTIVE SUMMARY

What makes a good transit stop or transfer facility? The answer, naturally, depends on who you ask. Passengers, transit system managers, businesses and residents adjacent to stops and stations, and the local governments host to stops and stations can all have strong, and sometimes conflicting, ideas about what makes a good stop, station, or transit facility. Our previous Interim Deliverables for this project have examined the existing literature (Deliverables 1 and 2) and analyzed the transit user's perspective using an extensive passenger survey (Deliverable 3). This report examines this question from the transit system managers' perspective, as well as comments on transit operator's perception of the community's (nearby passenger and non-passenger) viewpoint. Additionally, we conducted telephone interviews with several transit agency employees to gain further insight into the operator's perspective, as well as to gather pertinent anecdotes.

Much of the previous literature on this topic is descriptive, often listing operator-related factors of a good stop/station with little explanatory analysis of (1) how listed factors contribute to transit service connectivity, (2) tradeoffs among factors, and (3) their relative importance. To address these shortcomings, we developed and administered a web-based online nationwide survey of U.S. transit agencies to identify factors that transit managers and planners believe are most important to them and to their riders, and the relative importance that transit operators place on these factors in their planning.

Overall, we found that survey respondents believe that safety, security, and the absence of movement conflicts between transit vehicles and pedestrians are the most important determinants of a good stop/station and transit transfer facility, with safety and security ranking 1st, and minimizing pedestrian conflicts ranking 2nd overall. Ranked just below this was ease of transferring, followed by the reduction of institutional barriers and cost minimization. These findings contribute to our understanding of the factors influencing transit users' "out-of-vehicle" travel experiences and other factors affecting the location and design of transit stops/stations and transfer facilities.

We found several preference patterns among respondent subgroups. For example, we found that survey respondents who identified as having "executive/administrative" occupations actually felt that cost minimization was *less* important than all other respondents in other occupational categories, controlling for the other objectives included in our research. For another respondent subgroup ─ service area population ─ we found that respondents from the smallest quarter of participating transit agencies rated "minimize institutional barriers to transferring such as transfer fares, lack of information or poor coordination of schedules" less important than did all other respondents. This is likely due to the relative lack of additional service providers with which to interact and coordinate in these smaller jurisdictions. In another respondent subgroup ─ agency fleet size ─ the data suggest that agencies with very large fleets rated the presence of amenities as less important than other agencies. Agencies with large fleets also tend to be located in denser urban areas and such dense areas also provide non-agency related, that is, private retail, amenities to satisfy riders' desires. For the respondent subgroup dealing with the percentage of fixed-route service, agencies with mostly fixed-route service, (largest quartile), generally rated "Maximize operational ease at the station or facility, e.g., vehicle maintenance and storage, ticketing, baggage handling, and/or accounting" much higher than other respondents. This is expected since operators with a large relative amount of fixed-route service have a greater need to coordinate an efficient system for mass vehicle maintenance and storage than other operators.

Our telephone interviews proved illuminating, highlighting foremost that safety and security concerns “trump all”, and that oftentimes other considerations must be foregone in order to achieve maximum safety and security. We further learned that large regional agencies and agencies operating in relative isolation tended to be less concerned with the reduction of institutional barriers than were agencies operating as an element of a larger regional transit system. Flexibility for expansion was important to some of our agencies – both those in fast-growing regions and our one state agency (which contained several fast-growing regions and rapidly increasing congestion), while for other agencies, both service supply and demand were seen as relatively static.

Through our telephone interviews with agency employees, we also learned about the neighboring community’s perspective. They told us that homeowners are often wary of new transit investment, fearing “the wrong element” and reduction in property values. Several interviewees commented that it is much easier to site a transit center during the planning phase of a new district than to insert it later; others commented that in neighborhoods with high residential turnover, it may be easier to site a new facility without attracting criticism. Several interviewees also stressed that certain groups strongly *support* new transit investment, including low-income individuals and communities, the disabled community, and businesses that employ large numbers of low-income individuals.

We learned a great deal about the influence of non-transportation goals in the planning process for transit stops and transfer facilities. Our interviewees commented at length on “political concerns” that often override engineering and transportation concerns. Some respondents told us that politicians often look for a project to “cut a ribbon” on, while other politicians and community advocacy groups look toward transit investment as a way to revitalize a distressed neighborhood or commercial center. Respondents universally expressed frustration at these incidents, though they tended to find them necessary and often useful.

Finally, our online survey results show that, while transit operators appear to have a fairly accurate understanding of what attributes are important to their riders at transit stops and transfer stations, there are several points of disparity. While operators correctly assumed that safety and security were very important to riders, they tended to *underestimate* the importance of specific safety-related amenities, such as security guards and emergency assistance. It also appears that, controlling for other factors, operators may *overestimate* the importance of station cleanliness and schedule information to their riders.

In sum, we learned that, by and large, safety and security are transit agencies’ primary concern at transit transfer facilities. Indeed, as one of our respondents commented, safety concerns tend to “trump” all other concerns, and tradeoffs are nearly always made in favor of safety and security concerns. At a more nuanced level, it is clear that many other tradeoffs are made; our ranking of concerns suggests a framework within which our respondents tend to make these tradeoffs. For example, one interviewee told us of a bus facility where aesthetic and comfort concerns (ranked 8th in our list of 23) were subjugated to the need to minimize pedestrian-vehicle conflicts (ranked 2nd). This ranking serves both to describe more accurately the prioritization of various objectives by transit operators, as well as to serve as a tool in considering transit stop and transfer facility siting, design, operation and maintenance.

Key Words: transit system managers, transit operators, transit stops, transit stations, transfer facilities, web-based survey, evaluation

TABLE OF CONTENTS

List of Tables

List of Figures

1. INTRODUCTION

Unlike door-to-door travel by foot, bicycle, taxi, or private vehicle, public transit passengers typically must wait for and transfer between buses and trains during journeys. As such, the travel time spent outside of transit vehicles waiting and transferring constitutes an important, and under-studied, part of transit travel. Understanding how travelers perceive waits and transfers can help transit managers reduce the burdens of transit travel, thereby increasing the attractiveness of public transit.

When connections are poor, waits and transfers become burdensome for transit users and can discourage transit use[1]. Moreover, poor stop and station connectivity

> *". . . creates barriers that impede customers' ability to make efficient multi-operator trips. When connectivity is poor, multi-operator transit trips are frustrating, time-consuming, and costly, lowering service quality for users and making transit unattractive for new customers."*[2]

Whereas good connectivity is

> *"reflected in a convenient and 'seamless' transit system by reducing travel times, providing more reliable connections, making it easier to pay and ensuring that transfers are easy and safe."*[2]

The scope and scale of wait/transfer sites vary significantly, from hundreds of thousands of simple bus stops around the U.S. marked by little more than a small sign on a pole, to elaborate and architecturally significant multi-modal commercial hubs, like Union Station in Washington D.C. The attributes of these wait/transfer facilities differ in many ways: physical size and configuration, number of lines, agencies, and modes served, traveler amenities, operating costs, and effects on neighboring communities. Systematically evaluating such heterogeneous places thus poses a significant analytical challenge.

Further, perceptions of the most relevant criteria to evaluate the performance of transit stops and stations can vary significantly depending on the stakeholders involved[1,3]. These include:

- Passengers/users,
- Transit operators, and
- Businesses and residents adjacent to stops and stations, and the local governments host to stops and stations.

Passengers/users are the *raison d'etre* of transit travel and their perceptions and needs are central[1]. Research on the burdens (or "penalties") of passenger waits and transfers includes: minimum transfer time and distance, convenience, comfort, and safety and security[3].

Beyond passenger needs, transit stops and stations must meet operational needs of transit systems as well. These include vehicle queuing and staging areas, adequate road/rail network access, adequate vehicle/passenger segregation, driver break facilities, and so on. When a transit operator directly controls property on which a stop or transfer facility sits, it can largely control stop/station attributes of the station or facility to accommodate operational requirements[3]. But more often, stops and stations are partially or fully controlled by other governmental agencies – most frequently local governments that control sidewalks – who may have interests different than, and sometimes at odds with, those of transit agencies[4].

No transit station or transfer facility ─ whether it is located in the city or suburbs, or whether it serves intra-modal or intermodal transfers ─ is truly a stand-alone facility. It relates to and interacts with adjacent businesses and homes, both in providing access to nearby parcels as well by generating traffic, noise, emissions, and other negative externalities. Over the longer term, the facility can affect the type and level of adjacent development, sometimes significantly[3]. In one survey of transit agencies, respondents named the provision of a civic facility and assistance with downtown development as common objectives of transit transfer facilities[5]. Thus, it is essential to consider the relationship between a station or facility and its immediate surroundings in the design process[3].

This research is part of a larger, ongoing project comparing and contrasting the perspectives of transit stops and stations among riders, transit managers, and other stakeholders. In this report, we explore the transit operators' perception of various attributes (and their relative importance) of transit stops, stations, and transfer facilities; a better understanding of how operators view their transfer stations and facilities will aid in the development of performance measures. Additionally, we attempted to ascertain the priorities of neighboring community residents and businesses by interviewing transit planners on this subject. Following this introduction, we offer background material based on our review of the transit connectivity literature focusing on the transit operator perspective. We follow this with a discussion ─ both of our methodology and of our findings ─ of a nationwide web-based survey of transit agencies that we have conducted to investigate these factors. Finally, the report offers concluding remarks about this research.

2. PREVIOUS WORK

The transit connectivity literature focuses primarily on the physical and geometric design of transfer facilities and their operations. Prior to the mid-1970s, a 'rule of thumb' approach was employed to address transit station design. This changed as a result of research sponsored by the National Science Foundation that reviewed the literature of transit facility design as it existed at the time and conducted a seminar on transit facility design that assembled representatives from the architecture, engineering, and transit communities with academic researchers in the transportation field[6]. This work resulted in the development of a more formalized and comprehensive approach for transit station design[7].

Concurrent research sponsored by the U.S. Department of Transportation[7, 8, 9] involved the development of a design methodology for interface facilities, which added structure to the conventional 'rule of thumb' approach by using a systems analysis approach to develop a methodology for planning, designing, and evaluating urban public transit transfer stations and facilities. In essence, this new methodology devised an approach with which to assess connectivity at transit transfer facilities. While this early research focused on the planning and design of transit transfer facilities as new facilities, the findings from this research have also been applicable to renovation of existing facilities as well[8].

This newly-developed methodology recognized that perspectives from different stakeholders needed to be acknowledged and included in the development of an interface facility design methodology. The early research considered the perspectives of the 1) conventional traveler, 2) special traveler, e.g., the elderly or disabled, and 3) the operator. Vuchic and Kikuchi[1] developed a variation of this classification and suggested considering the perspectives of the 1) traveler, 2) operator, and 3) community. Because this research was conducted prior to enactment of the Americans with Disabilities Act (ADA, 1990), it was reasonable in the mid-1970s to underscore the disabled community.

Most previous research simply listed factors or attributes considered important by various stakeholders, with little in the way of explanatory information to help understand 1) how and why operator-perspective factors contribute to transit transfer connectivity, 2) how such factors interact with each other and their tradeoffs, and 3) their relative importance. For example, Vuchic and Kikuchi[1] provide the following list of operator-related factors that the design of transfer facilities must satisfy:

- Minimum investment cost,
- Minimum operating cost,
- Adequate capacity,
- Flexibility of operation, and
- Passenger attraction.

Hoel, Demetsky, and Virkler[7] and ITE Technical Council Committee 5C-1A[10] each identify objectives and, for each objective, criteria against which an evaluation could be conducted together with specific performance measures. These two reports share some operator-related objectives as well as possessing some unique objectives (Table 1).

Horowitz and Thompson[11,12] recognize that evaluation of transfer facilities requires judgment on many design elements, taking into account costs of individual elements. They also emphasize the need to incorporate the opinions of transit users, transit operators, government agencies, designers, and the community ─ from each of the three stakeholder perspectives. This research is the only example that goes beyond a simple listing of factors by classifying operator-related factors and providing information about the relative importance of the operator-related factors in addition to passenger-related and community-related factors.

A list of 70 broadly worded objectives from all three stakeholder perspectives was developed by Horowitz and Thompson based on a review of the literature and interviews with Metropolitan Planning Organization staff, transit users, transit agency planners, and experts in intermodal station design. Horowitz and Thompson define an objective as "a specific statement of a goal for a transit transfer facility," or a "desired-end-product." Moreover, each objective is worded in terms of 'achieving,' 'maximizing, or 'minimizing' something; the 70 objectives were rank-ordered by their aggregate rating based on input from the interviews where each interviewee was asked to rate the objectives on a scale of 0 (Not Important) to 10 (Extremely Important).

Horowitz and Thompson classified each of these objectives using two schemes based on level of specificity. The first classifies each objective as one of ten types:

- transfer (T)
- safety/security (SS)
- access (A)
- efficiency (E)
- financial ($)
- modal enhancement (M)
- physical environment (PE)
- nonphysical environment (NE)
- space/site (#)
- architectural/building (AB) and
- coordination (C).

The second scheme classifies each objective as one of four generic objective categories:

1) system objectives related to the complete regional transportation system (SO);
2) internal objectives related to the design of the facility and its site (IO);
3) external objectives related to the environment and the surrounding community beyond the site (EO), and
4) mode interface objectives related to aspects of the facility directly affecting transfers (MIO).

Table 2 shows an abridged version of Horowitz's and Thompson's original list of 70 objectives, focusing on the highest-rated operator-related factors, where the highest possible rating is 10.0.

Table 1 Objectives, Criteria, and Performance Measures

Operator Objectives	Criteria	Performance Measures
Common to Both		
Maximize safety	Safety features on mechanical and electrical systems	Special safety features
Provide proper security	Size of security force; Number of facility levels; Means of escape; Number of exits; Accessibility to station agent's booth and major passenger paths; Surveillance and security patrols	Number of personnel; Number of levels; Type and number of directions for each destination; Number of exits; Distance of discrete areas from agent's booth Percentage of floor area that is part of 'paid area; Number of areas not subject to frequent security patrols or surveillance including parking lots
Minimize maintenance, cleaning, and replacement needs	Maintenance; Cleaning surfaces; Cleaning concessions	Size and cost of maintenance work force
Minimize total cost	Allocated funds; Subsidy required; Public and private investments	Dollars
Exploit joint development potential	Compatibility with community planning and land use goals; Special zoning; Percentage area for non-transport usage	Policy evaluation – a function of location
Unique to Hoel, Demetsky, and Virkler[6]		
Maximize equipment reliability	Back-up facilities in case of breakdown; Inspection procedures	Present or not present; Frequency and type
Efficiently collect fares and control entry	Attraction to robbery or vandalism; Inconvenience to traveler due to method; Technology used	Type of fare collection and safeguards provided; Time required for purchasing and waiting; Passenger processing rate and ability to keep non-payers out
Efficiently process flows	-----------	Hourly flow rate of passengers
Provide adequate space	Station size	Square feet
Obtain an efficient return on incremental investment	Additional benefits or objectives met beyond base cost	Benefit-Cost ratio assuming that benefits are convertible to dollars
Receive adequate income from non-transport activities	Cost of facilities vs. income received	Break even or profit; loss must be avoided
Utilize energy efficiently	Total and incremental energy requirements	Kilowatt hours
Provide opportunity for expansion	Expansion potential on ground floor and upward for higher floors	Floor space, local land costs, area around facility, and zoning ordinances
Unique to ITE Journal 5C-1A[9]		
Minimize pedestrian-vehicle conflicts	Measures of crossing flows	Relative volumes (major and minor flows)
Provide sufficient space	Facility size	Square feet
Ensure adequate lighting	Maintenance factors, brightness ratios, glare, reflectance, and emergency lighting	-----
Provide protection from weather	Terminal area exposed	Percent terminal area exposed
Provide design flexibility	Expansion potential, vertical, horizontal, passenger processing, other activity, modular components	Floor space, local land costs, area around station, zoning ordinances
Provide supplementary services	Advertising & Concessions Floor space allocated Percent of total space	Type, size, location Square feet allocated Percent

Source: Hoel, Demetsky, and Virkler (7) and ITE Journal 5C-1A (10)

Table 2 Composite Rankings and Ratings of Top-Rated Objectives

Objective	Type	Category	Average Rating
Maximize security	SS	IO	8.8
Minimize institutional barriers to transferring	T	MIO	8.6
Maximize safety	SS	IO	8.4
Maximize coordination of transfer scheduling	T	SO	8.2
Maximize system coordination of information and fares	T/C	SO	7.6
Maximize directness of paths for modes	E	MIO	7.4
Minimize path conflicts between modes	A	MIO	7.3
Achieve elimination of hazardous materials	PE	MIO	7.2
Minimize costs	$	SO	7.1
Maximize joint development	$	EO	7.1
Maximize market areas for each mode	M	SO	7.0
Maximize flexibility for expansion	#	EO	7.0

Note: Type: T-Transfer, SS-Safety/Security, A-Access, E-Efficiency, P-Passenger, $-Financial, M-Modal Enhancement, PE-Physical Environment, NE-Non-physical Environment, #-Space/Site, AB-Architectural/Building, C-Coordination; Objective category: MIO-Mode Interface Objectives, IO-Internal Objectives, SO-System Objectives, and EO-External Objectives.

Our review of the literature on transit stop/station design identified a set of operator-related factors that were repeated frequently from study to study. Accordingly we developed a generic set of factors in four general categories:

- Fiscal / Costs and Revenues
- Institutional and Coordination
- Passenger Processing
- Environment

We describe each of these in turn below.

Fiscal/ Costs and Revenues

The costs of operating a transit transfer facility are clearly important. A few of the individual fiscal-related factors or objectives identified from the literature include: 1) total cost, 2) operating cost, 3) maintenance (cleaning and replacement), and 4) investment cost (obtaining an efficient return on incremental investment). Other factors, shown in Table 3, are stated in less cost-explicit terms, yet, nonetheless, are very much cost-related[3, 7, 8, 10, 11, 12].

Table 3 Cost-Related Objectives

Transit Operator Fiscal / Cost Objectives	Linkage to Fiscal Matters
Achieve elimination of hazardous materials	If the facility contains hazardous materials (such as asbestos) they must be removed prior to new construction or renovation. Occupancy by operator employees and the traveling public cannot be allowed until this has been accomplished, thus contributing to the overall total facility cost.
Minimize wasted space	Unused or un-needed space increases construction and/or renovation costs, increases maintenance costs during operation and requires additional security and environmental controls. All of these are cost drivers for a project.
Maximize income from non-transport activities	Non-transport income could include income from advertising, leases of retail space, concessions, and joint development. These non-transport sources could offset some portion of the cost of operations.
Minimize negative impact on existing transportation services	A facility could have a cost impact on operators that cannot participate or on operators whose routes are disrupted or whose routes face additional competition.
Maximize joint development	Joint development involves the public and private sectors sharing the facility as well as its costs and revenues.
Achieve property rights	For a new facility, required property must be purchased and rights of use and access must be obtained. This contributes to the overall total facility cost.
Maximize flexibility for expansion	Costs may be saved when the facility is designed to just handle anticipated travel demand, yet provision is made for facility expansion in the case of increases in demand or addition of new modes.
Minimize fare inconsistencies	Fare inconsistencies include different rates among operators or inconsistent rates among like modes; such inconsistencies can impact revenues.
Maximize ease of operations of modes	Generally, the more difficult it is for the operator to perform its customary modal operations the more likely will it result in additional expenditure of resources and associated costs.
Utilize energy efficiently	The use of energy for heating and cooling the facility must be paid for and their efficient use will help reduce overall energy costs.
Maximize flexibility of operation	The ability to adapt to operational changes, whether necessary and unexpected or desirable can contribute to lower total costs.

Sources: Horowitz and Thompson[11,12]*, Vuchic and Kikuchi*[3]*, Hoel, Demetsky, and Virkler*[7]*, Demetsky, Hoel, and Virkler*[8]*, and ITE Technical Council Committee 5C-1A*[10].

Institutional and Coordination

Transit transfer facilities, which frequently have multiple lines, modes, and/or service providers, require coordination on many levels, including: transfer fares, schedules, and information dissemination. Generally, there is only one source from the literature ─ Horowitz and Thompson[11,12] ─ that explicitly identifies institutional issues as objectives from the transit operator perspective. These objectives are listed in Table 2; they are "minimize institutional barriers to transferring" and "maximize coordination of transfer scheduling," which are, respectively, the 4th and 11th ranked objectives (out of 70) with average ratings of 8.6 and 8.2

(out of 10.0). Thus, these objectives are very highly ranked and rated – in fact, *higher* than cost issues in this study.

Passenger Processing

Passenger processing objectives, listed below, refer to the *functional facility* components together with their *arrangements within the facility*. Basic functional facility components consist of 1) internal pedestrian movement facilities and areas (passageways, stairs, ramps, escalators, elevators, moving walkways, etc.), 2) line haul transit access area (entry control and fare collection; loading and unloading of passengers), 3) components that facilitate movement between access modes and the transfer facility such as ramps and automatic doors, and 4) communications (information and directional graphics, public address system). Corresponding criteria and performance measure information for each of these objectives are described in Table 2.

- Maximize equipment reliability
- Efficiently collect fares and control entry
- Efficiently process flows
- Provide adequate space
- Minimize queues
- Minimize pedestrian-vehicle conflicts
- Eliminate physical barriers

Environment

The *environmental* quality of a transit transfer facility involves aspects with which facility users associate their comfort, convenience, safety, and security[7,8]. There are also transit agency staff members working at larger facilities; their comfort, safety, and security are of concern to transit operators. Typical safety standards include fire prevention and accident reduction measures. Security provisions are used to protect against or in response to crime, vandalism, or terrorism. Amenity-related environmental aspects for comfort and convenience are not directly associated with the movement of people; rather these aspects concern the physical environment through which they move. Basic amenity-related environmental components include the following list; it is interesting to note in the list below that inclusion of "public telephones" is presently quite dated with the nearly ubiquitous use of cellular phones:

- The physical environment (lighting, air quality, temperature, aesthetics, cleanliness)
- Maximize safety
- Non-transport businesses and services
- Restrooms and lounges; first-aid stations, public telephones
- Weather protection

Table 4 presents a summary of the transit operator-related factors that we identified from the literature (after removing redundancies). These factors formed the basis of our design of a survey of managers of U.S. transit agencies to further explore the most important attributes of transit stops and stations. (Note that certain factors are listed in the literature in very broadly-worded terms, such as "achieve property rights" and "maximize safety," while others are more specific, such as "Minimize operations and maintenance costs" and "Provide restrooms").

Table 4 Transit Operators' Perspective Evaluation Objectives

Categories	Evaluation Objectives
Fiscal / Costs & Revenues	Minimize total, operating, maintenance, and investment costs
	Achieve elimination of hazardous materials
	Minimize wasted space
	Maximize income from non-transport activities
	Minimize negative impact on existing transportation services
	Maximize joint development
	Achieve property rights
	Maximize flexibility for expansion
	Minimize fare inconsistencies
	Maximize ease of operations of modes
	Utilize energy efficiently
	Maximize flexibility of operation
Institutional and Coordination	Minimize institutional barriers to transferring
	Maximize coordination of transfer scheduling
Passenger Processing	Maximize equipment reliability
	Efficiently collect fares and control entry
	Maximize safety
	Efficiently process flows
	Provide adequate space
	Minimize queues
	Minimize pedestrian-vehicle conflicts
	Eliminate physical barriers
Environment	Provide a safe and secure environment
	Provide proper physical environment (lighting, air quality, temperature, aesthetics, and cleanliness)
	Provide restrooms, first-aid stations, public telephones
	Provide protection from the weather

3. METHODOLOGY

Given the 26 stop/station evaluation factors identified from the literature and summarized in Table 4, we developed and administered a nationwide survey of U.S. transit agencies in order to 1) update the evaluation objectives identified in the literature so these factors reflect current circumstances, as some of the information in the literature is now thirty years old, 2) identify other factors important to transit operators not identified from the literature, 3) understand the priorities that transit operators place on these factors and their relative importance, and 4) evaluate whether transit operators understand their riders' priorities when it comes to transit stops and stations. The survey instrument is contained in Appendix A. Furthermore, we conducted telephone interviews with a representative sample of transit operators in the United States in order to gain further insight into the transit operators' perspective, as well as to gather illustrative anecdotes about transit stops and stations. Additionally, we used these telephone interviews to gather data on the role of the neighboring community in the design, implementation, and operation of transit stops and stations, with a particular focus on community advocacy for and opposition to projects. The interview guide is contained in Appendix B.

Designing the Survey Instrument

Our online survey was composed of three parts:

1. Information about the respondent, including respondent name, title and position at work, telephone number, email, and the name and location of the respondent's transit agency:

   This first section was used to ensure that no transit agency responded multiple times to the survey, as well as to link the respondents' answers with outside data on the transit agency and its service area (for example, number of routes and service area population).

2. Operators' estimation of how important various evaluation factors are to their passengers:

   This second section essentially asked operator-respondents to *guess* how important various transit stop and station attributes are to their riders. This section used the same survey design as we had previously administered to transit riders in Los Angeles (reported on in a previous deliverable for this project). The transit operators' responses were then compared with the answers of Los Angeles area transit users to illuminate possible misperceptions, disparities, as well as similarities between users and operators.

3. Operators' views of what evaluation factors are important from their own perspective:

   In designing this final section of the survey, we utilized a 4-point Likert scale methodology to inquire of transit operators their views on how important evaluation factors are: *Very Important*, *Important*, *Somewhat Important*, or *Not Important*. Respondents were also permitted to select *Not Applicable/Do Not Know*. The inventory of factors was based on those listed in Table 4. Some objectives appeared duplicative, and in these instances we collapsed objectives into one broadly-worded category. For example, the criteria "safety" and "security" were combined into one category. We then supplemented these with a few others based on research team discussions, including "Maximize vehicle maneuverability," "Maximize environmental friendliness of station/facility ("green" station/facility"), and "Provide a break area for vehicle operators." The survey also allowed respondents to type in other evaluation factors that they deemed to be important but that were not listed in the survey.

Identifying the Participants and Administering the Survey

We used the Federal Transit Administration's 2005 National Transit Database (NTD) to identify 406 potential participants, all of which operated at least one fixed-route/fixed-schedule transportation mode. The contact person provided by the NTD for each of these agencies was customarily the CEO or the General Manager of the agency. Invitations to participate in the survey were sent by e-mail to potential respondents along with a link to the survey website. The survey website provided a general overview of the project, the purpose of the survey, survey instructions, questions, and a statement assuring confidentiality of identity and individual responses. To gather as representative a sample of U.S. transit agencies with fixed route/fixed schedule as possible, we sent two e-mail reminders to agencies that had not completed the survey or had not even begun the survey. Respondents had had over five weeks to complete the survey.

4. ANALYSIS AND FINDINGS

At survey completion, one hundred ninety-seven (197) potential respondents accessed the survey website. Of these potential respondents, several response sets were excluded from analysis:

- Six (6) potential respondents opted out of participating in the survey after following the link to the survey site.
- Twelve (12) potential respondents agreed to participate in the survey but then provided no answers to questions.
- Four (4) respondents began the survey but did not provide answers to all questions considered in the first part of this report; these response sets *were,* however, retained for analysis of the user-operator comparison, discussed below.

Thus, one hundred seventy-five (175) response sets remained for analysis, for an effective response rate of 43% of invited agencies. Additionally, 20 agencies were contacted to participate in in-depth telephone interviews. These agencies were selected by a weighted sampling methodology, with the probability of inclusion in our sample weighted by the agency's annual ridership figures.[1] Of these, 8 agencies participated, for an effective response rate of 40%. These 8 agencies represent a wide spectrum of agency types, with small, medium and large agencies at the municipal, regional and state level. Additionally, one agency we interviewed operates bus transit service at a large state university. The telephone interviews lasted 39 minutes on average, with the shortest interview lasting 25 minutes and the longest just under an hour.

Table 5 shows the distribution of respondents to the online survey by occupation category. Respondents were overwhelmingly in executive/administration positions, with 104 respondents (60%) reporting this occupation category. The second-largest group were those respondents in planning occupations, with 23% of respondents in this category. The third-largest group were those reporting "other", which ranged from recent retirees working as consultants to one respondent working in "statistical analysis".

[1] We used this methodology to increase the likelihood of randomly selecting one of the nation's very few very large agencies, which we felt were important elements to this report. Ridership-weighted random sampling essentially creates a random sample by randomly selecting twenty transit trips from all transit trips nationally and then selecting the transit agency that provided the trip.

Table 5 Respondents' Title Categories

Respondent's Title Category	Frequency	Percent
Executive/Administrative	104	60%
Planning	40	23%
Other	16	9%
Operations or Logistics/Scheduling	8	5%
No Response	3	1%
Marketing	2	1%
Finance/Budgeting	2	1%
Total	***175***	***100***

Compared with the universe of transit agencies invited to participate in the survey, the survey respondents tended to hail from larger metropolitan areas. Figure 1 shows the distribution of transit agencies by service area population for both the full population of invitees and the set of respondents.

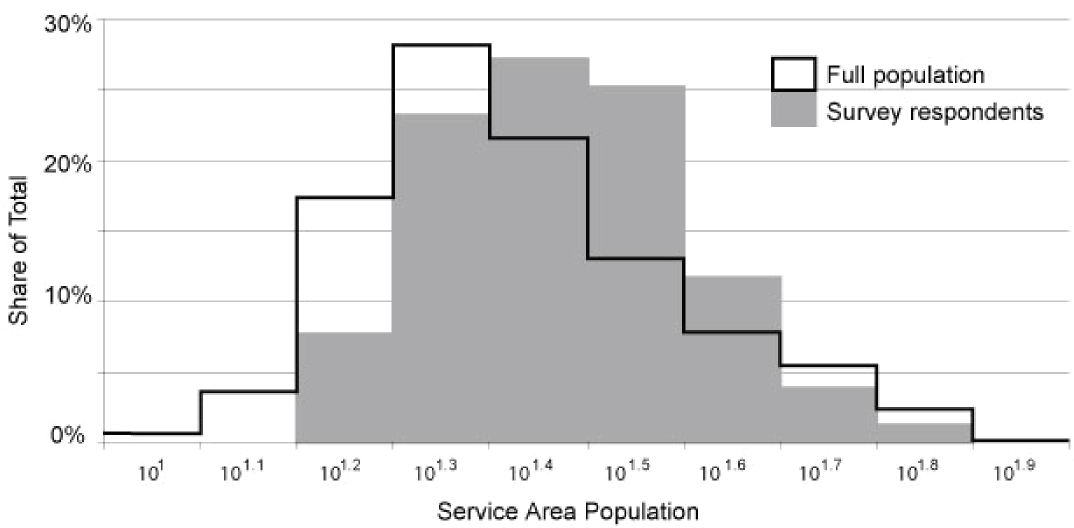


FIGURE 1 Distribution of Transit Agencies by Service Area Population (thousands)

The geographic distribution of respondents also differed somewhat from the survey universe. For example, within states where the research team invited more than five transit agencies to participate in the survey, response rates varied greatly; nine of Ohio's twelve agencies (75%) responded to the survey, while only one of New Jersey's fourteen invited agencies (7%) responded.

Participants were asked to rate 23 separate attributes connected with the planning, siting, operation or maintenance of transit stops and transfer facilities using a four-point Likert scale. Table 5 shows the mean attribute scores and standard deviations for all respondents. An average score of 1.00 would indicate that all respondents rated the attribute as "very important", and an average score of 4.00 would indicate that all respondents rated the attribute as “not important”. As is typical with Likert-scale measurement, significant response clustering is evident, with nearly all average scores falling within the one-point interval [1.40, 2.40].

The attribute SAFETY (“Provide a safe and secure environment”) was ranked most important by respondents, with an average score of 1.15 and a relatively small standard deviation of 0.39. This score is considerably lower (more important) than the second-most important attribute, PEDCON (“minimize pedestrian-vehicle conflicts”). The remaining attributes are all relatively closely clustered. With a scoring range of only 1.41 through 1.64, the 2nd through 11th ranked factors below were closely bunched:

- Pedestrian/vehicle conflicts,
- Schedule coordination,
- Operating costs,
- Stop/station equipment reliability,
- Comfortable environment,
- Adequate stop/station space
- Inter-agency coordination,
- Facilitate passenger flows,
- Accommodate vehicle movements, and
- Protect passengers from weather,

The remaining 12 factors are not as tightly bunched as the top dozen and, numerically, are all closer to 2.0 or 2.5 than 1.0 or 1.5.

Table 5 further divides the attributes measured in our survey into four groups: the top attribute with an average score near 1.0 (Group 1), and those attributes with average scores near 1.5, 2.0 and 2.5 on the Likert scale, respectively for Groups 2, 3, and 4. More precisely, Group 2 consists of the interval of average scores centered at 1.5 +/- 0.25 and similarly for Group 3 and 4, centered at 2.0 and 2.5, respectively. Group 1 consists of the interval centered at 1 +0.25. While it is not clear-cut, one may observe that lower-score (more important) attribute groups tend to contain more passenger-oriented attributes, while, further down the rank order, attributes tend to be more system- or operator-oriented or focus on facility externalities. For example, Group 2 contains attributes such as minimizing pedestrian/vehicle conflicts (passenger safety), coordinated transfers (passenger convenience), passenger comfort, and protection from the weather. In contrast, Group 3 contains few explicitly passenger-oriented attributes; more typical for this group are attributes that deal with station geometry, the ability for station expansion, the pursuit of joint development opportunities and the provision of an environmentally-friendly (“green”) facility. While there are certainly examples that are counter to this trend (the minimization of costs, an explicitly operator-oriented attribute, ranks 4th), the results of our survey suggest that transit operators value user-oriented attributes (the provision of a seamless and comfortable transfer experience for the passenger) higher than many non-passenger attributes.

Table 6 Average Objective Scores (using mean)

	CODE	OBJECTIVES	MEAN SCORE	STD DEV	
1	SAFETY	Provide a safe and secure environment.	1.15	0.39	GP 1
2	PEDCON	Minimize pedestrian-vehicle conflicts.	1.41	0.62	GROUP 2
3	TRANSF	Maximize coordination of scheduling to accommodate transfers.	1.48	0.61	
4	MNCOST	Minimize total cost of operations (including maintenance costs).	1.5	0.67	
5	RELIAB	Maximize reliability of station/stop equipment.	1.52	0.66	
6	COMFRT	Provide a comfortable physical environment with respect to lighting, temperature, and cleanliness.	1.54	0.63	
7	ASPACE	Provide adequate station/stop space.	1.54	0.62	
8	INSTBR	Minimize institutional barriers to transferring such as transfer fares, lack of information or poor coordination of schedules.	1.57	0.66	
9	PASFLW	Efficiently process rider flows.	1.63	0.63	
10	MANEUV	Maximize vehicle maneuverability (turning radii, etc).	1.64	0.77	
11	WEATHR	Provide protection from the weather.	1.64	0.72	
12	FARECT	Efficiently collect fares and control entry to station/stop/vehicle.	1.76	0.71	GROUP 3
13	OPEASE	Maximize operational ease at the station or facility, e.g., vehicle maintenance, vehicle storage, ticketing, baggage handling, and/or accounting.	1.87	0.79	
14	FLXINC	Maximize flexibility for expansion to handle an increase in demand or addition of new modes.	1.99	0.75	
15	BREAKS	Provide a break area for vehicle operators.	2.03	0.83	
16	FARESC	Minimize fare inconsistencies, i.e., different fare rates across operators or inconsistent rates across like modes.	2.12	0.94	
17	GREENS	Maximize environmental friendliness of station/facility ("green" station/facility).	2.17	0.79	
18	JOINTD	Maximize joint development, i.e., involving the public and private sectors in sharing the facility and its costs and revenues.	2.21	0.89	
19	TOITEL	Provide restrooms, first-aid supplies, and public telephones.	2.28	0.94	GROUP 4
20	QUEUES	Minimize queues.	2.30	0.9	
21	WASTSP	Minimize wasted space in station/stop design because large spaces increase construction costs and require more maintenance, security, and environmental controls.	2.31	0.86	
22	COMPET	Minimize negative impact on existing transportation services, i.e., on operators who cannot participate or on operators whose routes are disrupted or whose routes face additional competition.	2.37	0.91	
23	ADSVND	Maximize income from non-transport activities, such as advertising and vending.	2.56	0.99	

Respondents clearly believe safety and security to be more important factors than all others, with the most important (safety and security) and 2nd most important (minimize pedestrian conflicts) attributes relating this topic. Ease of transferring was also an important factor for respondents; the 3rd most highly-ranked attribute ranked was TRANSF ("maximize coordination of scheduling to accommodate transfers"). Cost-related factors (MNCOST) rated 4th most important, followed by considerations of equipment reliability (RELIAB) (though, again, the 2nd through 11th ranked factors are very closely bunched). It should be noted that some confusion may have arisen around the attribute RELIAB, with respondents perhaps uncertain whether rolling stock or station equipment (our intention) was meant.

Comfort considerations (COMFRT) and the provision of adequate space (ASPACE) received nearly equal ratings (1.55 and 1.56, respectively), followed closely by the absence of institutional barriers to transferring (INSTBR). Further down the list were the efficient processing of passenger flows (PASFLW), protection from the elements (WEATHR), and adequate space for vehicle maneuverability (MANEUV).

At the other end of the spectrum, ADSVND ("maximize income from non-transport activities, such as advertising and vending") ranked least important, with an average score of 2.51 and a very high standard deviation of 0.97; for some operators, this factor was "very important" (26 cases), while for many others this factor was "not important" (29 cases). This large degree of variation may be due, for example, to the variability in agency income derived from advertising. Indeed, of respondent agencies, the ratio of non-transport to transport revenue varies greatly, with an average of 0.11 and a standard deviation of 0.24 (National Transit Database, 2005). This likely reflects that oftentimes it is local governments that control advertising on bus benches, shelters, and even in off-street facilities; thus, it is these local governments that reap income from transit stops and stations, and not the transit operators. Thus, the disinterest of many respondents to the collection of non-transport revenues likely reflects that such revenues go to other entities *(4)*. Accordingly, respondents from agencies with high levels of non-transport income were slightly less likely to rate ADSVND as "not important" than did respondents from other agencies, though this correlation is minor (Pearson correlation=0.058) and insignificant.

Similarly, COMPET ("Minimize negative impact on existing transportation services, i.e., on operators who cannot participate or on operators whose routes are disrupted or whose routes face additional competition") ranked quite low among respondents, with an average score of 2.35 and a high standard deviation of 0.93. Further, the minimization of wasted space (WASTSP) and queues (QUEUES) as well as the provision of amenities such as restrooms and telephones (TOITEL) also ranked low on the list of attributes, at about 2.30 each.

Several questions elicited a large number "Not Applicable/Don't Know" responses or received no answer at all. Respondents skipped COMPET ("Minimize negative impact on existing transportation services, i.e., on operators who cannot participate or on operators whose routes are disrupted or whose routes face additional competition") 61 times (35% of respondents), while 34 (19%) skipped FARESC ("Minimize fare inconsistencies, i.e., different fare rates across operators or inconsistent rates across like modes"). Both of these questions pertain to operations that interface with other agencies; presumably many respondent agencies operate in relative isolation, and this may account for a significant number of non-responses here. However, the complex phrasing of COMPET may also have contributed to the large number of non-responses.

The preceding analysis used mean Likert scores. Perhaps another more suitable, though less straightforward, method of analysis is the non-parametric Friedman rank test. Developed by economist Milton Friedman, this method better accounts both for differential usage of the scale and for non-normal distributions across respondents, such as U-shaped distributions, where many respondents rate an attribute as either “very important” or “not important”, with few respondents selecting the middle two categories.

This method produces rank values for each respondent’s answers across categories; these individual rank scores are then aggregated to the full sample. The Friedman rank test essentially places each respondent’s response – say, a “very important” for SAFETY – in the context of that respondent’s propensity to select that response – in this case, his or her propensity to select “very important”. In cases where a respondent rates multiple attributes equally (for example, rating both nighttime safety and daytime safety as “very important”), a tie rank score (the midpoint of the tied rank range) is given to all tied attributes. Table 6 shows standardized Friedman rank scores for our operators’ response set. The table may be interpreted thusly: the most important attribute (in our case, SAFETY) is assigned a value of 1, and all other attributes’ Friedman rank scores are scaled in proportion to SAFETY.

While perhaps less intuitive, this methodology gives us a better understanding of the magnitude of differences between attributes and places them on an easily-understood scale. Again, we group objectives together by similar values; using this method, we find that our second-ranked attribute PEDCON (“Minimize pedestrian-vehicle conflicts”) advances in magnitude of importance relative to the third-ranked attribute, transfer coordination. For this reason, we place this objective in a group of its own. However, as this objective is intimately linked with the first-ranked attribute, SAFETY, one might also simply group these objectives together.

By and large, the rank order remains the same using this analytical method as it was using mean values. However, there are a few interesting exceptions. First, using this more nuanced method, we find that both of our objectives related to the interface with outside agencies become significantly more important. (This finding is in accord with Horowitz and Thompson’s findings, shown in Table 2 above.) The objective INSTBR (“Minimize institutional barriers to transferring, such as transfer fares, lack of information or poor coordination of schedules) rises from rank 8 to rank 4 using the Friedman test. Similarly, the objective FARESC (“Minimize fare inconsistencies, i.e. different fare rates across operators or inconsistent rates across like modes”) rose in rank from position 16 to position 14. These changes reflect the high relative importance of these two attributes to *some* of our respondents even given their low level of importance to others.

In addition to the rating of listed attributes, respondents were asked to provide additional attributes they felt were important to the siting, design, and operation of transit transfer facilities. Thirty-nine respondents (22%) provided additional input through this option. The most frequently mentioned attribute among these responses was easy pedestrian accessibility to the transfer facility (7 responses). The second-most frequently mentioned attribute was the provision of real-time information through “next bus” or “next train” electronic signs (6 responses). The third-most frequently mentioned attribute was the centrality of the transfer facility siting (4 responses), with respondents citing the need for “proximity to rider destinations” and location in “urban centers rather than in remote locations.” Another four respondents cited adherence to Americans with Disabilities Act provisions for station accessibility.

Table 7 Average Objective Scores (using standardized Friedman rank score)

	CODE	OBJECTIVE	STD. FRIEDMAN SCORE	
1	SAFETY	Provide a safe and secure environment.	1.00	Gp. 1
2	PEDCON	Minimize pedestrian-vehicle conflicts.	0.78	Gp. 2
3	TRANSF	Maximize coordination of scheduling to accommodate transfers.	0.71	GROUP 3
4	INSTBR	Minimize institutional barriers to transferring such as transfer fares, lack of information or poor coordination of schedules.	0.69	GROUP 3
5	MNCOST	Minimize total cost of operations (including maintenance costs).	0.67	GROUP 3
6	RELIAB	Maximize reliability of station/stop equipment.	0.65	GROUP 3
7	ASPACE	Provide adequate station/stop space.	0.64	GROUP 3
8	COMFRT	Provide a comfortable physical environment with respect to lighting, temperature, and cleanliness.	0.63	GROUP 3
9	PASFLW	Efficiently process rider flows.	0.62	GROUP 3
10	WEATHR	Provide protection from the weather.	0.61	GROUP 3
11	MANEUV	Maximize vehicle maneuverability (turning radii, etc).	0.60	GROUP 3
12	FARECT	Efficiently collect fares and control entry to station/stop/vehicle.	0.58	GROUP 3
13	OPEASE	Maximize operational ease at the station or facility, e.g., vehicle maintenance, vehicle storage, ticketing, baggage handling, and/or accounting.	0.50	GROUP 4
14	FARESC	Minimize fare inconsistencies, i.e., different fare rates across operators or inconsistent rates across like modes.	0.50	GROUP 4
15	BREAKS	Provide a break area for vehicle operators.	0.48	GROUP 4
16	FLXINC	Maximize flexibility for expansion to handle an increase in demand or addition of new modes.	0.47	GROUP 4
17	JOINTD	Maximize joint development, i.e., involving the public and private sectors in sharing the facility and its costs and revenues.	0.45	GROUP 4
18	GREENS	Maximize environmental friendliness of station/facility ("green" station/facility).	0.43	GROUP 4
19	WASTSP	Minimize wasted space in station/stop design because large spaces increase construction costs and require more maintenance, security, and environmental controls.	0.41	GROUP 4
20	COMPET	Minimize negative impact on existing transportation services, i.e., on operators who cannot participate or on operators whose routes are disrupted or whose routes face additional competition.	0.41	GROUP 4
21	QUEUES	Minimize queues.	0.41	GROUP 4
22	TOITEL	Provide restrooms, first-aid supplies, and public telephones.	0.40	GROUP 4
23	ADSVND	Maximize income from non-transport activities, such as advertising and vending.	0.39	GROUP 4

In addition, three respondents each identified the following factors: (1) schedule adherence in the operation of a transit transfer facility and the provision of "realistic schedules," (2) non-interference with the efficient flow of existing automobile traffic, (3) high-quality customer service (noting that the "quick" and "efficient" resolution of customer complaints and enquiries is desirable), and (4) providing parking areas at transit transfer centers, especially for "express" and BRT services. Finally, a number of other individual comments were made, including the provision of functioning clocks and support from local government officials.

Analysis by Subgroups

Certainly, not all kinds of respondents rated objectives in the same way. To some extent, variation in responses may be due to differential use of the Likert scale, random error, or even personal whim. There is, however, likely a sizeable amount of variation within the data that can explained by characteristics of the respondent and the respondent's transit agency. For example, respondents in temperate cities may value shelter from the elements *less* than respondents from very hot or very cold climates. Indeed, within respondents, several subgroups can be created, and these subgroups can be compared to one another.

Occupational Category

The first subgroups we analyze are the respondents' occupational categories. For example, we hypothesized that CEOs may value the objective of cost minimization more highly than his or her colleagues in the planning department. Indeed, when using the nonparametric Mann-Whitney U test (similar to the Friedman rank test), we discovered three statistically significant ($p<0.10$) differences between "Executive/Administrative"-respondents and all others. We report a "standardized Mann-Whitney rank ratio" – the inverse ratio of one subgroup's mean rank to that of the other group.

- MNCOST (standardized Mann-Whitney rank ratio = 0.86) "Minimize total cost of operations (including maintenance costs)." Controlling for all other objectives analyzed here, "executive/administrative" respondents, on average, felt that cost minimization was *less* important than did their colleagues in other occupational categories. The standardized Mann-Whitney score suggests that executive/administrative respondents felt this objective was approximately only 86% as important as all other respondents. This result is contrary to our expectation. Perhaps, however, it is project managers (and *not* CEOs) who feel most acutely the anxiety of budget adherence; these project managers may self-categorize as "planning" rather than "executive/administrative", explaining the observed result.
- WEATHR (1.15) "Provide protection from the weather." Controlling for all other objectives, "executive/administrative" respondents felt that protection from the weather was *more* important than did all other respondents. Similarly, in all further subgroup comparisons, the objective WEATHR was found to be significantly different at the $p<0.10$ level. It is likely that this is the product of regional climate and of chance, and not of a systematic difference of opinions. For this reason, WEATHR is excluded from further analysis by subgroupings.

- MANEUV (1.18) “Maximize vehicle maneuverability (turning radii, etc).” On average, executive/administrative respondents rated maneuverability significantly more important than other respondents.

In addition to analyzing the survey results by occupation category, we joined our response sets with attributes about the transit agencies from which respondents hailed. We obtained data on agency and service area size and the agency’s transportation offerings from the 2005 National Transit Database. Creating subgroups by quartile, we asked whether, for example, very small agencies had unique views on transit stops and stations, or whether those agencies with rail service felt that certain attributes were more important than did their counterparts at bus-only agencies. Our analysis again uses the nonparametric Mann-Whitney U test of equal distributions, and we report for all statistically significant objectives ($p<0.10$) the degree to which one subgroup’s average Mann-Whitney ranking differs from the other.

Service Area Size

The data suggest that agencies in service areas of different population sizes have differing opinions on various objectives at transit stops and stations:

- **Smallest service areas** (first quartile, fewer than 135,000 people): The smallest quarter of our survey participant agencies (by service area population) rated INSTBR (“Minimize institutional barriers to transferring such as transfer fares, lack of information or poor coordination of schedules”) less important than did all other respondents. Agencies within small service areas had a standardized average Mann-Whitney rank ratio of 0.80, suggesting that, controlling for other objectives included in the analysis, agencies in small service areas felt that the reduction of institutional barriers was about 80% as important as their counterparts in larger service areas. This is likely due to the relative lack of additional service providers with which to coordinate in small cities.
- **Largest service areas** (fourth quartile, greater than 790,000 people): the largest quarter of our survey participant agencies (by service area population) rated the following attributes *less* important than all other agencies:
    - TOITEL(standardized Mann-Whitney rank ratio of 0.74) “Provide restrooms, first-aid supplies, and public telephones.” Agencies in large service areas found the presence of such amenities to be *less* important than did agencies in smaller service areas. One possible explanation is that larger cities tend also to be denser, allowing for non-agency amenities (such as coffee shop bathrooms) to satisfy rider needs.
    - WASTSP (0.79) “Minimize wasted space in station/stop design because large spaces increase construction costs and require more maintenance, security, and environmental controls.” Controlling for all other objectives in the analysis, respondents from populous service areas rated this objective as less important than all other respondents.
    - GREENS (0.84) “Maximize environmental friendliness of station/facility ("green" station/facility).” Controlling for all other objectives studied here, respondents from transit agencies in large service areas tended to rate environmental

friendliness as *less* important than other respondents. One possible explanation for this finding is that larger service areas tend also to have older transit systems; these older systems may be more cumbersome to retrofit "green" than is the case for a new facility elsewhere.

    - FLXINC (0.84) "Maximize flexibility for expansion to handle an increase in demand or addition of new modes." Controlling for other objectives, respondents from large service areas tended to rate flexibility for expansion as *less* important than other respondents. Again, a possible explanation for this finding is that large service areas may tend to grow at a slower rate than do smaller service areas; thus, the need for expansion is less acute in these areas.
    - MANEUV (0.85) "Maximize vehicle maneuverability (turning radii, etc)." Again, respondents from agencies with populous service areas tended to rate this objective as *less* important than other respondents.

Agency Fleet Size

The data suggest that agencies with very large fleets (fourth quartile, more than 208 vehicles) rated, on average, the presence of amenities such as toilets, telephones, and first aid supplies (TOITEL) as *less* important than other agencies, with a standardized Mann-Whitney rank ratio of 0.80. Again, as above, we suggest that agencies with larger fleets may also be located in denser areas, and that these dense areas provide non-agency (private retail) amenities to satisfy rider needs.

Percent Fixed-Route

- Agencies with relatively little fixed-route service (first quartile, less than 63% fixed-route) had several statistically significant differences from other agencies:
    - ADSVND (standardized Mann-Whitney rank ratio of 1.20) "Maximize income from non-transport activities, such as advertising and vending." Controlling for all other objectives analyzed here, respondents from agencies with relatively little fixed-route service (that is, with a relatively large share of paratransit service) felt that income from advertising and vending was more important than other respondents. This is contrary to our expectation; one would expect that agencies with little fixed-route service would also have little advertising space from which to gain income. Again, we suggest that responses to ADSVND are related to unobserved factors, such as ownership of advertising space.
    - TRANSF (1.18) "Maximize coordination of scheduling to accommodate transfers." Respondents from paratransit-heavy agencies also tended to rate schedule coordination as *more* important than other respondents. While this may seem contrary to common sense, it seems likely that transit agencies with low levels of fixed-route transit may also run those routes with long headways; this low service frequency results in a greater need to ensure properly timed transfers.
- Agencies with mostly fixed-route service (fourth quartile, more than 86% fixed-route) had several statistically significant differences from other agencies:

- OPEASE (standardized Mann-Whitney rank ratio of 1.34) “Maximize operational ease at the station or facility, e.g., vehicle maintenance, vehicle storage, ticketing, baggage handling, and/or accounting.” Agencies with mostly fixed-route service tended to rate operational ease much higher than other respondents. This makes sense, since operators with a large amount of fixed-route service have a greater need to coordinate an efficient system for mass vehicle maintenance and storage, as well as to reap large efficiency gains even from small improvements across a large fleet.
- QUEUES (1.29) “Minimize queues.” Agencies with mostly fixed-route service felt, on average, that queue minimization was significantly *more* important than did their counterparts at other agencies. This finding meets our expectation, as paratransit requires no queues, but fixed-route service often does.

Presence of Fixed-Guideway Transit

- Agencies with fixed-guideway transit (rail) had several statistically significant differences from those agencies without:
    - TOITEL (standardized Mann-Whitney rank ratio of 0.76) “Provide restrooms, first-aid supplies, and public telephones.” Agencies with fixed-guideway service tended to rate these amenities as significantly less important than other respondents. Again we conjecture that the higher levels of density associated with rail transit also provide for significant non-transit (private retail) amenities to satisfy rider needs.
    - TRANSF (0.79) “Maximize coordination of scheduling to accommodate transfers.” Similarly, respondents from agencies with fixed-guideway rated transfer coordination as less important than their colleagues from agencies without fixed-guideway service. As above, we conjecture that the shorter headways often associated with rail rapid transit reduce the need to time transfers. Additionally, several respondents in this subcategory hailed from regional rail agencies; the hub-and-spoke nature of most American commuter rail systems (with few rail transfer points and many passengers arriving by automobile), likely reduces the sense of urgency for timed transfers in these systems.
    - RELIAB (1.29) “Maximize reliability of station/stop equipment.” Controlling for other objectives analyzed here, respondents from agencies with fixed-guideway service tended to rank station equipment reliability as far more important than their counterparts at other agencies. The greater reliance on station equipment at rail facilities (for example, fare vending machines and fare barriers) suggests an explanation for this greater concern for equipment reliability.

Telephone Interviews

Our telephone interviews provided further insight into the relative importance to transit operators of some of the objectives studied above. For several of the objectives we looked at, interviewees had little to say, and these objectives are not mentioned specifically below. The objectives that garnered the most attention were:

- **Safety and Security:** All interviewees agreed that safety was the primary concern. One interviewee from a medium-sized agency remarked that safety "trumps all", and this theme was repeated in nearly all interviews. Many interviewees related anecdotes in which safety and security concerns forced agency planners to design a station in such a way that other objectives were compromised. For example, one interviewee from a large transit agency told us of several bus stops that were relocated to locations that felt safer, but were less productive from a connectivity and accessibility standpoint. Another respondent from a city with a "very high murder rate" told us that city police are present at station design meetings, and that personal safety and security concerns always outweigh aesthetic, design, and passenger comfort concerns. Several respondents commented on security concerns, and all claimed that these concerns had grown in recent years since the terrorist attacks September 11, 2001. Our two agencies with extensive rail operations were particularly concerned with security, and both stated that they were working with federal agencies on this issue.
- **Pedestrian-vehicle conflicts and interference with existing transportation**: One interviewee related an anecdote in which a bus transit center was re-designed to reduce conflicts with pedestrians and automobiles. The result, she claimed, was a facility that functioned safer, but was less aesthetically pleasing and more cumbersome for passengers arriving on foot. No other interviewees commented extensively on this objective, other than to mention that it was very important, but a "sort of a given" and part of the standard engineering and design process.
- **Institutional barriers to transferring**: Several interviewees from large urban areas remarked that inter-agency cooperation was very important in order to provide the passenger with "seamless" service. Each of these interviewees remarked that interagency cooperation had improved in recent years. Other respondents from smaller urban areas remarked that, as one respondent noted, they were "the only game in town". One Sunbelt agency told us that, as its urban area continues to grow, it is slowly meeting up with another nearby urban area; this growing-together of cities has prompted initial meetings with the transit agency operating in the adjacent region.
- **Minimize cost**: Interviewees had very differing opinions on this topic; their views varied according to characteristics of their service area, but also by the interviewee's job title. For example, both of our engineer interviewees told us that they viewed cost considerations as negligible – that costs were fixed by the time they begin working on a project in earnest. Other interviewees told us that costs associated with transit stops and stations tended to be minimal compared to costs associated with vehicles and labor. Another interviewee mentioned that his agency had "fared well" in the most recent round of federal transportation earmarking, and that cost concerns were less important than they had been previously. Another two interviewees from rail-heavy agencies replied that cost considerations were enormous; both told us that the uncertainty associated with

maintaining and refurbishing historic train stations leads to frequent cost overruns. As one told us, "we inherited a 150-year old system, but only 50 years of records. The location of a lot of utilities is unknown."

- **Provide adequate space**: Only one respondent commented extensively on this objective. He commented that his agency (largely a bus-operating agency in a dense urban environment) "deals in imaginary space; the stop is created by the bodies that occupy that space [near the bus stop sign]. There's not much that we do to influence that." Another interviewee commented briefly that space concerns are not yet important to his agency, but that with population growth (and ridership growth), this will likely become a concern at some stations.
- **Comfort**: Most interviewees agreed that passenger comfort was very important, though how they described achieving this objective differed. Two interviewees discussed at great length the removal of graffiti and trash. Another commented that "all the five senses should be pleased," and that this is a very difficult task, especially with older shelters and stations that tend to attract more vandalism. One respondent told us that his transit agency was looking to engage in public-private partnerships at major transit agencies, and that it was looking to offload cleaning responsibilities to another party. Another interviewee told us that it was important to provide comfortable seating at most stops and stations, though "not every rider needs a seat." Further, he told us, security concerns led to small, uncomfortable seats that are not conducive to sleeping (for example, by homeless individuals) – but, he told us, these seats are also not conducive to sitting.
- **Weather**: Nearly all respondents mentioned protection from the weather. This objective was of particular concern to our two respondents from very hot climates, both of whom used "mushroom-shaped" canopies at bus stops; this design allows for shade, while permitting a breeze and blocking no sightlines – important for passengers' perception of safety. Another respondent told us of a rail station where aesthetic concerns had led to a rail station design that, though attractive, that does not protect adequately from rain storms.
- **Flexibility for expansion**: Expansion was an important topic for some interviewees, and for others it was unimportant. Our interviewees from regional and state agencies tended to find the need for expansion more important that our municipal and university-based transit agencies; at these large geographic scales, even static-population regions experience localized pockets of growth. One interviewee from a large state agency told us that increasing capacity on existing rail lines and adding additional service was the agency's top priority. Another interviewee from a medium-sized regional agency in a fast-growing area commented that bus stops were constructed in a modular fashion in order to accommodate future growth. He further commented that his agency often acquires extra land and constructs additional bus bays in anticipation of future growth. However, one respondent from a municipal transit agency in a large city commented that his agency did not anticipate the need for expansion of transit stops or stations, and that, for the most part, transit service was fixed.
- **Joint development**: Nearly all interviewees spoke at length about joint development, and those who did were of one mind – that joint development was highly desirable but extremely difficult. Indeed, though most commented that the pursuit of joint development

projects had become increasingly important in recent years, these same interviewees told us about failed or stalled projects and frustration. One interviewee went so far as to tell us that "joint development never works; developers want to move a lot faster than [the agency] is willing to move." Other interviewees told us how difficult it is for transit agencies to work within the relatively short time horizon of real estate development. One told us that her transit agency, in order to avoid this problem, has decided to build retail space "on speculation", thus avoiding the need to work on a developer's schedule – and that this space has typically found tenants. Another interviewee from a large public university told us that there could be a lot more of this kind of on-site retail development, telling us that "students don't take transit because they can't get Starbucks [coffee] on transit." A respondent from a smaller transit agency told us that joint development had not occurred yet in his region; instead, the transit agency is chasing breakneck development, accommodating new shopping mall growth, for example, by building new transit centers. Only one of our respondents told us of a success story; at his agency, the real estate development department had grown from a few employees to an entire division. However, he noted that the bulk of joint development is the result of political maneuverings by members of the board, some of whom are real estate developers themselves.

Additionally, interviewees provided us with some objectives that we had not included in our online survey:

- **Station/stop spacing**: Of particular interest to two of our respondents were station spacing concerns; these respondents felt that it was extremely important to maintain appropriate station spacing, and that planners should attempt to accommodate other concerns within these parameters.
- **Transit-Oriented Development:** Another interviewee told us that transit-oriented development (as distinct from joint development) was a growing objective for his transit agency, and that the agency was doing everything it could to assist this type of development. He noted that transit-oriented development was a stated goal of municipal and state governments in his region.
- **Legibility:** Beyond the need for clear signage, one respondent commented that a transit system should be "legible". She clarified by stating that the passenger should feel that all aspects of the transit system (station designs and corridor layouts as well as fare structures and routes) should make intuitive sense to the passenger, and should be kept as simple and straightforward as possible.

In addition to comments pertaining to the objectives analyzed above, telephone interviewees provided insight into many other aspects of siting, designing, operating and maintaining transit stops and stations. Of particular interest to us were obstacles to the implementation of a desired plan for a new or existing transit stop or station. Several themes emerged:

- **Undesirable element**: Six of our eight interviewees mentioned the perception of transit (especially bus transit) being a mode for "undesirable" people. This view, most interviewees agreed, came mostly from homeowners, both individually and as formal organizations. One interviewee commented that, especially at bus stops, it can appear that waiting passengers (particularly youths, he noted) may appear to be simply "hanging out", even when they are waiting for a bus. This perception can lead to fear in some nearby residents, he found.

- **Traffic**: Several respondents told us that community opposition often arises around the siting of new transit facilities (especially new train stations and multi-line bus transit centers) due to the perception that these facilities will cause an increase in road traffic.
- **"Citification"**: One interviewee commented that the presence of transit facilities often sparks opposition from residents who wish to maintain a suburban/rural character to their community. These opponents feel that transit is the beginning of a "citification" process that they find distasteful.
- **Pollution**: Though most interviewees commented that this was not a major concern, a few stated that at *specific* transit centers where buses tend to dwell for longer periods, both vibration and air pollution can be an issue for residents – particularly those residents who live directly adjacent to the facility. One agency re-timed its routes to accommodate residents who had complained of noise and vibration.
- **The approval process:** The process by which transit facilities are approved for construction varied greatly across agencies, with some requiring formal approval from many jurisdictions and agencies (municipalities, departments of transportation and environmental protection, and so forth), while other agencies only provided "courtesy briefings" to these stakeholders, but required no formal approval. Especially at one large regional agency in a highly fragmented metropolitan area, obtaining formal approval from multiple (often uncooperative) stakeholders proved to be perhaps the most important obstacle to project completion.
- **"Coming late":** Many of our respondents stressed that trying to add a transit stop or station to an existing neighborhood or commercial district was much harder than integrating a facility into the planning of a new area. Two important patterns emerged from our discussions:
    - First, two of our respondents commented that their agencies used the design review and planning approval process of local municipalities to incorporate bus stops and transit centers into the design of new shopping malls, subdivisions, and office parks. One transit agency was successful in obtaining "most" of its land for free by asking city planning officials to include transit "extractions" as part of the approvals process.
    - Second, transit operators in two rapidly-growing Sunbelt cities and one in a high-turnover university setting commented that siting a new transit center or making significant changes to existing facilities was less difficult in areas with high residential or commercial turnover (for example, in neighborhoods with many students or in neighborhoods composed of mostly young people). These interviewees commented that, in this way, transit may not have necessarily been there from the beginning of the neighborhood, but from the beginning of most current residents' knowledge of – *and sense of investment in* – the neighborhood.
- **"Political concerns":** This category encompasses a large and complex set of comments our interviewees made. In general, respondents expressed concern for the large number of non-transportation concerns that influence the planning process, such as:

- **Ribbon-cutting:** Some respondents perceived that a politician's desire to inaugurate a new facility led to the siting of a facility that made little sense from a strictly transportation-oriented perspective.
- **Ubiquity:** One respondent claimed that political desires for ubiquity of service over a large geographic area led to a thinning of resources that degraded system productivity.
- **Parity:** One respondent claimed that parity concerns – whereby politicians in one geographic area felt they deserved a rail line because another geographic area had seen one built – had led to a transportation system that would likely not have been built otherwise.
- **Local economic revitalization:** Several respondents mentioned that politicians had pressed for a new transit facility with the hope that this construction might spark the redevelopment of an economically depressed area. In some cases, these transit facilities appeared to our interviewees to make little transportation sense.
- **Personal feelings:** One interviewee told us how a Member of the Board at his transit agency cancelled a transit project because he believed that a landowner he disliked would benefit financially from the project.

While most comments involving the community pertained to community opposition to planned changes, several respondents did mention community *support* for new service or service improvements.

- **The poor:** One respondent from a large state agency commented that, especially in poor urban areas, community leaders often advocate for additional and improved transit service, as well as for investments in the appearance and comfort level of transit stops and stations.
- **The disabled:** Two respondents told us that the disabled community had been particularly active in advocating for transit improvements such as new stops and transfer stations in their regions.
- **Retailers**: Other respondents commented that some businesses see transit as a way to increase their customer base; a prime example of this was a group of local businesses served by the university transit agency we spoke to.
- **Social services**: Another interviewee told us that social service agencies in one region had been particularly adamant in getting transit service to service sites; however, this interviewee told us that social service agencies tended to be transient, and that they are often priced out of transit-accessible locations.
- **Large employers**: In two other interviews, we heard that large employers, especially of low-wage workers (such as discount superstores and large telemarketing firms), encouraged transit service to their locations in order to get workers to the jobsite.

We also asked interviewees to tell us about community involvement in the planning process for new stops and stations, rehabilitations, and ongoing operations and maintenance of facilities. Responses to these questions varied considerably. Most interviewees told us that their agencies included community input mostly during the later stages of planning, and several told us that the agency sought community involvement most actively during the architectural design phase, for example through design charettes. By and large, our respondents told us that community involvement was largely reactionary in nature, with residents and businesses responding to most proposed changes that the agency announces. Some responses come from individuals and businesses themselves, though the bulk of community input, most agreed, came through mediated sources, such as politicians and community leaders.

Operator ─ User Comparison

In addition to surveying transit operators on their perceptions of various attributes at transit transfer facilities, stops and stations, we sought to understand the degree to which transit operators understood their users' perceptions of transit stops and stations. Transit operators may find insight into any 'disconnect' between transit users and transit providers that is valuable in re-assessing assumptions about riders' expectations.

In pursuit of this goal, we asked operators nationwide to estimate the level of importance of various attributes from their riders' perspective. Using the same seventeen attributes included in the Los Angeles-based on-site user perception survey described in Deliverable Two of this project, operator-respondents were asked the question, "How important do you think the following stop and station attributes are to *your passengers*?" Responses were coded using the same four-point Likert scale of *not important* to *very important* used in the Los Angeles transit user questionnaire. All 406 invited survey participants were given the opportunity to respond to this question block. Of 197 responses to our online survey, all 175 response sets used above were retained, and 4 additional partially-completed response sets were re-introduced. (These response sets lacked answers to questions discussed above but did have answers to questions considered in this section.) Thus, 179 respondents provided answers to the question block pertinent to this analysis, for an effective response rate of 44%.

For all but one attribute (on-time performance), the operators' mean rating was consistently higher (less important) than the users' mean rating. (See Table 8) Lower-ranked attributes tended to have larger differences of means than did higher-ranked attributes. This suggests that operators may have been more willing to select "somewhat important" and "not important" than were transit users.

Table 8 Attribute Rankings and Average Rating Score, Operators and Users

Attribute	Operators Rank	Users Rank	Difference of Ranks	Operators Mean	Users Mean	Difference of Means
On-time	1	1	0	1.25	1.29	-0.04
Safety (night)	2	3	-1	1.40	1.31	0.09
Safety (day)	3	2	1	1.47	1.29	0.18
Find platform	4	6	-2	1.50	1.36	0.14
Easy to transfer	5	7	-2	1.52	1.37	0.15
Lighting	6	5	1	1.54	1.32	0.22
Signage	7	9	-2	1.66	1.42	0.24
Short wait	8	8	0	1.66	1.39	0.27
Shelter from weather	9	10	-1	1.66	1.42	0.24
Cleanliness	10	14	-4	1.71	1.57	0.14
Schedule and route info	11	11	0	1.72	1.49	0.22
Easy to get around	12	13	-1	1.76	1.54	0.22
Emergency help available	13	4	9	1.84	1.32	0.51
Places to sit	14	16	-2	2.20	1.78	0.42
Restrooms	15	15	0	2.40	1.68	0.72
Guards	16	12	4	2.50	1.50	0.99
Food and drink	17	17	0	3.22	2.29	0.92

The large and consistent gap between users' average ratings and operators' average ratings likely represents a differential understanding or implementation of the rating system itself. For example, the consistent differential may be evidence of "hypothesis guessing" by one or both of our survey groups. For example, transit users may believe that the research team will use the results of this survey to direct funding for facility upgrades toward specific stops and stations; thus, these users would feel it is in their interest to overstate the importance (and their dissatisfaction with) attributes at *their* stations, thereby skewing their answers upwards from the true mean. On the other hand, transit operators and planners may correctly believe that their input is being used to create a rank-order list by importance of transit stop and stations' attributes; thus, they may purposely "stretch out" their answers, attempting to use most or all of the Likert scale responses in their response set. This form of hypothesis guessing may skew operators' responses downward from the true (latent) mean.

In light of this possible differential understanding of the Likert scale itself, perhaps a better method of analysis is by comparing the relative rankings of attributes. Table 8 shows attributes, ranked by operators' average scores, as well as the users' ranking of that attribute and the difference of those ranks. By analyzing rankings instead of raw mean scores, the potential for distortion caused by differential understandings of the Likert scale is minimized. By and large, attributes are ranked in roughly the same order by both groups; most attributes have a difference of order of just one or two ranks. However, there are a few notable exceptions:

- **Cleanliness**: Transit operators ranked the attribute “the station/stop areas are clean” 10th-most important (of 17), while transit users ranked this attribute 14th, for a difference of ranks of 4. This suggests that transit operators may over-estimate the importance of station area cleanliness to their users, compared with the other 16 attributes analyzed here.
- **Emergency help available**: Transit operators ranked the attribute “there are ways for riders to get help in an emergency” 13th-most important, while transit users ranked this attribute 4th-most important, for a large difference of ranks of 9 ranks (of 17). This suggests that transit operators greatly underestimate the importance of emergency help to their users, compared with the other 16 attributes analyzed here.
- **Guards**: Transit operators ranked “riders are made to feel safer by the presence of security guards” 16th-most important, while transit users ranked this attribute 12th-most important, for a difference of ranks of 4. This suggests that transit operators may underestimate the importance of security presence at transit stops and stations, compared with the other 16 attributes analyzed here.

Our use of this methodology rests upon several assumptions. The first assumption is that Los Angeles transit users are a representative sample of national transit users. This assumption may hold for some attributes analyzed here, but for others, this may not be the case. For example, weather concerns may be less important in the relatively pleasant climate of Los Angeles than in, say, Minneapolis or Houston. Similarly, security-related attributes may be more important to transit riders in a major metropolitan area such as Los Angeles than they would be to, say, users of a small-town transit system. The second assumption, discussed above, is that all subgroups of respondents will, on average, use the Likert scale in the same fashion. As already discussed, this assumption may not hold for this study.

Again, we used the more nuanced non-parametric Friedman rank test to further analyze our results. Table 9 shows standardized Friedman rank scores for both operators and users. The table may be interpreted thusly: for each subgroup (operators and users), the most important attribute (in our case, nighttime safety for both subgroups) is assigned a value of 1, and all other attributes Friedman rank scores are scaled in proportion to the Friedman score of “nighttime safety”. Thus, transit operator respondents ranked, on average, the availability of food and drink only 39% as important as night-time safety and on-time performance.

Table 9 Ranking Using Standardized Friedman Non-Parametric Test: Operators and Users

Attribute	Operators Standardized Friedman Rank	Users Standardized Friedman Rank	Operators Rank	Users Rank	Difference of Ranks
Safety (night)	1.00	1.00	1	1	0
On-time	1.00	0.95	2	4	-2
Safety (day)	0.90	0.99	3	2	1
Lighting	0.89	0.95	4	5	-1
Easy to transfer	0.88	0.94	5	7	-2
Find platform	0.87	0.94	6	6	0
Signage	0.78	0.92	7	8	-1
Shelter from weather	0.77	0.91	8	10	-2
Schedule and route info	0.76	0.83	9	13	-4
Short wait	0.71	0.92	10	9	1
Cleanliness	0.71	0.85	11	12	-1
Easy to get around	0.69	0.82	12	14	-2
Emergency help available	0.68	0.96	13	3	10
Places to sit	0.54	0.76	14	16	-2
Restrooms	0.51	0.79	15	15	0
Guards	0.49	0.86	16	11	5
Food and drink	0.39	0.62	17	17	0

Again, the Friedman scores indicate that transit operator respondents were more willing to make use of the entire Likert scale; their Friedman rank scores have a much broader range (0.39 to 1.00) than do users' average Friedman scores (0.62 to 1.00). Again, both subgroups ranked attributes in roughly the same order, with differences of ranks of just one or two; however, there are again several notable exceptions:

- **Schedule and route information**: Nationwide, transit operators overestimated the relative importance of schedule and route information at transit stops, ranking this attribute 9th-most important, while Los Angeles transit users ranked this attribute 13th-most important, for a difference of ranks of 4.
- **Emergency help available**: Again, transit operator respondents far underestimated the importance of the availability of emergency assistance. Operators ranked this attribute, on average, 13th-most important, while Los Angeles transit users ranked this attribute third-most important, for a very large difference of ranks of 10.
- **Guards**: Using the Friedman methodology, transit operators ranked "riders are made to feel safer by the presence of security guards" on average as 16th-most important, while transit users ranked this attribute 11th-most important, for a difference of ranks of 5.

> Compared with the 16 other attributes analyzed here, transit operators may underestimate the importance of security guards at transit facilities.

As above, these results should be interpreted with caution. Los Angeles transit users are likely not a representative sample of transit users nationwide. For example, in a large city such as Los Angeles, transit users may rank the availability of guards and emergency call-boxes higher than in other cities in the United States. Further analysis should use a scale-free method of analysis, such as conjoint analysis. This methodology would correct for the possible differential perceptions of scale encountered in this analysis. Ideally, the geographic scale of users' and operators' surveys should match: both, for example, could be conducted statewide in California.

5. CONCLUSIONS

So what makes a good transit stop or station? While the literature provides numerous examples of attributes and evaluation factors, it collectively provides scant information on (1) the factors that transit managers believe to be most important to a good stop/station, (2) what stop/station attributes transit managers believe are most important to their riders, and (3) the relative importance that transit operators place on these various factors in their planning. The findings of this research contribute to our understanding of the factors influencing the "out-of-vehicle" travel experience of transit users as well as the many other factors affecting the location and design of transit stops and stations. This research is part of a larger, ongoing project comparing and contrasting the perspectives of transit stops and stations among riders, transit managers, and other stakeholders.

To address these shortcomings in the literature, we developed and administered a web-based online nationwide survey of 406 U.S. transit agencies obtaining a 43% response rate. We then conducted telephone interviews with a small representative sample of transit agencies. Our findings strongly suggest that transit operators believe that passenger safety and security are, by far, the most important determinants of a good stop/station. This primary finding coincides with a previous survey of transit passengers that our team conducted earlier in this study, who also felt that safety and security far outweighed other attributes at transit stops, stations, and transfer facilities.

Following safety and security, ten other factors cluster relatively closely as important factors in the views of the transit managers surveyed. They are (in order): (2) pedestrian/vehicle conflicts, (3) schedule coordination, (4) operating costs, (5) stop/station equipment reliability, (6) comfortable environment, (7) adequate stop/station space, (8), inter-agency coordination, (9) facilitate passenger flows, (10) accommodate vehicle movements, and (11) protect passengers from weather.

The survey results further suggest that transit operators value user-oriented attributes such as physical comfort and seamless transferring higher than other non-user-oriented attributes. This may be due to the immediacy and constancy of user-related factors; while joint development typically occurs infrequently, the provision of clean, comfortable transfer stops and stations is an ongoing concern for most transit operators.

Our telephone interviews served to highlight these findings. Interviewees relayed to us anecdotes where safety and security concerns "trumped" all other concerns. For example, comfort concerns (ample and comfortable seating) often defer to security concerns (benches that are not conducive to sleeping). Less obvious and more nuanced tradeoffs are made throughout the spectrum of objectives; our ranking serves to describe the propensity of transit operators to value one attribute more highly than others, and assigns estimates of the magnitude of these propensities.

Additionally, we talked to transit operators about the role of the community in planning, operating, and maintaining transit stops and transfer facilities. We heard from many respondents that the community serves often as opposition, and that its input comes indirectly through politicians and community leaders. Furthermore, we heard that community concerns are typically voiced in response to planned changes, rather than during initial planning stages.

Finally, our online survey results show that, while transit operators appear to have a fairly accurate understanding of what attributes are important to their riders at transit stops and transfer stations, there are several points of disparity. While operators correctly assumed that safety and security were very important to riders, they tended to *underestimate* the importance of specific safety-related amenities, such as security guards and emergency assistance. It also appears that, controlling for other factors, operators *overestimate* the importance of station cleanliness and schedule information to their riders. However, as noted above, our comparison suffers from a mismatch in geographical coverage; our riders' survey collected data from Los Angeles area transit riders, while our operators' survey collected data nationwide. It is likely that this mismatch has overemphasized some disparities, while downplaying others. Further research should examine both subgroups that cover the same general location.

Our research has clarified and quantified the prioritization (by both transit operators and passengers) of various objectives and attributes of transit stops and transfer stations. We have found that safety and security are, by far, the most important priorities for both groups. Our rankings, together with the findings from the transit rider survey, provide the rudiments of a tool for prioritizing improvements to existing transit stops and transfer stations, as well as for the design of new facilities. This tool, we hope, will help transportation planners leverage limited transportation funds for maximum benefit at transit stops and transfer stations.

ACKNOWLEDGEMENTS

This work was performed under the sponsorship of the State of California Business, Transportation and Housing Agency, Department of Transportation (Caltrans), Division of Research and Innovation (DR&I) (Interagency Agreement #65A0194). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. The authors thank Bruce Chapman of DR & I for his support of this research. The authors also thank Hiroyuki Iseki of the University of Toledo, and Adina Ringler, formerly of the University of California, Los Angeles, for their contributions to this research. Lastly, the authors thank the individuals from the 175 U.S. transit agencies who voluntarily took their own time to respond to our online survey and, to the individuals from the eight transit agencies who consented to participate in our in-depth interviews, both of which formed the basis of this work.

REFERENCES

1. Committee on Intermodal Transfer Facilities, "Intermodal Transfer Facilities Research Needs". *Transportation Research Record* 505:43-46, Transportation Research Board, National Research Council, 1974.
2. Metropolitan Transportation Commission, *Transit Connectivity Study*, 2006.
3. Vuchic, V. R., and S. Kikuchi. "Design of Outlying Rapid Transit Station Areas", *Transportation Research Record* 505:1-12, Transportation Research Board, National Research Council, 1974.
4. Law, P. and B. D. Taylor, "Shelter From the Storm: Optimizing the Distribution of Bus Stop Shelters in Los Angeles," *Journal of the Transportation Research Board*, 1753: 79-85, 2001.
5. Hocking, R. J. 1990. Effectiveness of Downtown Transit Centers, *ITE Journal*.
6. Hoel, L.A. and E.S. Rozner, Transportation Research Board. Transit Facility Operations. *Transportation Research Record* 614: 1-5, Transportation Research Board, National Research Council, 1976.
7. Hoel, L.A., M.J. Demetsky, and M.R. Virkler, *Criteria for Evaluating Alternative Transit Station Designs*, U.S. Department of Transportation, DOT-TST-76-68, February 1976.
8. Demetsky, M.J., L.A. Hoel, and M.R. Virkler, *Methodology for the Design of Urban Transportation Interface Facilities*, U.S. Department of Transportation, DOT-TST-77-46, December 1976.
9. Demetsky, M.J., L.A. Hoel, and M.R. Virkler, *A Procedural Guide for the Design of Transit Stations and Terminals*, U.S. Department of Transportation, DOT-TST-77-53, Washington D.C., July 1977.
10. ITE Technical Council Committee 5C-1A. 1992. The Location and Design of Bus Transfer Facilities. *ITE Journal*: 33-37.
11. Horowitz, A. J., and N. A. Thompson. 1995. Generic objectives for evaluation of intermodal passenger transfer facilities, *Transportation research record* 1503:104-110.
12. Horowitz, A. J. and N. A. Thompson. 1994. *Evaluation of Intermodal Passenger Transfer Facilities*, Federal Highway Administration, U.S. Department of Transportation, DOT-T-95-02, Washington D.C.

APPENDIX A

ONLINE SURVEY INSTRUMENT

About our Study

We are part of a team of researchers at the Institute of Transportation Studies at the Berkeley and Los Angeles campuses of the University of California under the direction of Professor Brian Taylor (UCLA) working on a project sponsored by the California Department of Transportation (Caltrans) that is evaluating connectivity performance at transit stops, stations, and transfer facilities. We are studying how transit users perceive transfers and we have already conducted a user survey of more than 700 rail and bus passengers at over a dozen sites in the greater metropolitan Los Angeles area. That survey asked passengers to evaluate transit stops and stations, taking into account the level of importance they place on various attributes.

We are also studying the extent to which particular attributes of transit stops, stations, and transfer facilities are of use to transit operators providing services at these facilities. For example, such attributes include those dealing with safety and security, access, information, and amenities. Our aim is to provide transit operators with a comprehensive and useful assessment of such attributes to help them increase the attractiveness of their services.

As part of this investigation, we are conducting this online survey of U.S. public transit operators to learn more about the attributes of stops, stations, and transfer facilities that they are familiar with.

About Your Informed Consent to Participate

This survey should take about 20 minutes to complete and because it is conducted online, if you do not complete the survey today, your responses may be saved and you can return later if you so choose. You will need to resume the survey on the same computer though. However, you are under no obligation to complete the survey once you have started it. Your participation in this survey is completely voluntary and you are free not to participate. You may refuse to answer any questions and may stop taking part in the survey at any time.

Individual responses by your agency will be viewed only by project researchers and will not be shared with Caltrans, or any other individuals or organizations. Further, none of your responses will be presented in any publications or other materials produced from this research in a way that identifies you or your transit agency without your explicit and previous authorization.

There are no foreseeable risks to you from participating in this research. There are, in fact, potentially direct benefits to your transit agency because our primary deliverable for this project will be a tool that transit agencies can use to help them evaluate how their transit transfer facilities are functioning. There will be no costs to you, other than your time to complete the survey.

All of the information that we obtain from you during the research will be kept confidential. Prior to starting the survey, we will request your name, work telephone number, and work e-mail address; this information will be stored in a database on a password-protected computer with access given only to our Project Manager and his Graduate Student Researcher. Your name or other identifying information will absolutely not be used in any reports stemming from this research. Moreover, this personal information (name, telephone number, e-mail address) will be deleted from the database once the survey has been administered. One final item: All information you provide is transmitted over a secure network with SSL encryption.

Professor Brian Taylor's contact information is provided below if you would like to contact him about this research. If you have questions regarding your rights as a research subject, you may contact the UCLA Office for Protection of Research Subjects at 310-825-8714.

Professor Brian D. Taylor, AICP
Principal Investigator, Transit Transfer Project
UCLA Institute of Transportation Studies
3250 School of Public Affairs Building
Los Angeles, CA 90095-1656
Telephone: (310) 903-3228
Email: btaylor@ucla.edu

If you want to participate, then please click "Yes" below. By clicking "Yes", you have given your informed consent to participate and you will then have the opportunity to complete this survey. If you do not want to participate, simply click "No". In either case, after providing your answer, click "Save and Go to Next Page >>".

Thank you very much.

◯ Yes ◯ No

Online Survey Instructions

Save your Responses -- To save your responses on any page of the survey, simply click on "Save and Go to Next Page >>" at the bottom of that page. So, if you do not complete the survey in a single session, click "Save and Go to Next Page >>" then click "EXIT THIS SURVEY >>" in the top right hand corner of the page. When you leave the survey you will be taken to the UCLA Institute of Transportation Studies web site.

Return at a Later Time -- To return to the survey later, simply click on the same link (on the same computer) you received in our e-mail message to you. Upon your return, you will be brought to the page immediately following the page you saved and you will need to click "<< Go Back" to pick up where you left off.

Edit your Responses -- You may go back and change your existing responses until you complete and submit the survey. Once you have hit the "Submit this Survey >>" button on the last page, you will not be able to re-enter the survey.

Answer your Questions -- If you have questions about the survey, please contact Mark Miller, the Project Manager, by phone at (415) 250-5415 or by e-mail at mamiller@path.berkeley.edu.

Information About You

Before you start the survey, we request some information about you.

What is your name?

What is your title at work?

What is your position at work?

- ◯ Planning
- ◯ Operations or Logistics/Scheduling
- ◯ Research
- ◯ Marketing
- ◯ Executive/Administrative
- ◯ Finance/Budgeting
- ◯ Other

If you checked "Other" in the question immediately above, please provide additional detail here; otherwise, proceed to the next question.

What is your telephone number at work?

What is your e-mail address at work?

Information About Your Transit Agency

Where is your transit agency located? Please make your selection from this drop-down menu.

Alabama Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Alaska Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Arizona Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Arkansas Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

California Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Colorado Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Connecticut Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Delaware Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Washington D.C. Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Florida Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Georgia Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Hawaii Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Idaho Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Illinois Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Indiana Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Iowa Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Kansas Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Kentucky Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Louisiana Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Maine Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Maryland Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Massachusetts Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Michigan Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Minnesota Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Mississippi Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Missouri Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Montana Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Nebraska Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Nevada Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

New Hampshire Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

New Jersey Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

New Mexico Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

New York Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

North Carolina Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

North Dakota Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Ohio Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Oklahoma Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Oregon Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Pennsylvania Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Puerto Rico Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Rhode Island Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

South Carolina Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

South Dakota Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Tennessee Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Texas Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Utah Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Vermont Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Virginia Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Washington State Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

West Virginia Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Wisconsin Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Wyoming Transit Agencies

What is the name of your transit agency? Please make your selection from this drop-down menu.

Your Passengers' Perspective

How important do you think the following stop and station attributes are to *your passengers*? For each attribute, please select one of the following: "Very Important", "Important", "Somewhat Important", "Not Important".

If you do not know how important a specific attribute is for your passengers or do not think the attribute applies to your passengers, please select the "Not applicable/Do not know" option.

If you need to exit the survey before making your selection for each item on this page, note that when you return to this page later the items on this list may appear in a different order.

	Very Important	Important	Somewhat Important	Not Important	Not Applicable/Do No Know
Riders usually have a short wait to catch buses/trains.	○	○	○	○	○
There are shelters at the stations/stops to protect riders from the weather, e.g., sun, rain, snow, etc.	○	○	○	○	○
The buses/trains are usually on time.	○	○	○	○	○
The signs at the stations/stops are helpful.	○	○	○	○	○
It is easy to get schedule and route information at the stations/stops.	○	○	○	○	○
Riders are made to feel safer by the presence of security guards.	○	○	○	○	○
It is easy for riders to find the platforms or stops.	○	○	○	○	○
Riders feel safe at the stations/stops at night.	○	○	○	○	○
There are places for riders to buy food or drinks nearby.	○	○	○	○	○
The stations are well lit at night.	○	○	○	○	○
The station/stop areas are clean.	○	○	○	○	○
There are enough places to sit.	○	○	○	○	○
It is easy to get around the stations/stops.	○	○	○	○	○
There are ways for riders to get help in an emergency.	○	○	○	○	○
Riders feel safe at the stations/stops during the day.	○	○	○	○	○
The stations/stops are easy places to transfer to other buses or trains.	○	○	○	○	○
There are public restrooms nearby.	○	○	○	○	○

Please use the space below if you would like to offer additional information regarding any of these attributes for any specific stop, station, or transfer facility you are familiar with.

Your Perspective as the Transit Operator

How important are the following statements from *your* perspective as the transit operator? For each statement, please select one of the following: "Very Important", "Important", "Somewhat Important", or "Not Important".

If you do not know how important a specific statement is from your perspective or do not think the statement is applicable, please select the "Not applicable/Do not know" option.

If you need to exit the survey before making your selection for each item on this page, note that when you return to this page later the items on this list may appear in a different order.

	Very Important	Important	Somewhat Important	Not Important	Not Applicable/Do Not Know
Minimize fare inconsistencies, i.e., different fare rates across operators or inconsistent rates across like modes.	○	○	○	○	○
Minimize pedestrian-vehicle conflicts	○	○	○	○	○

	Very Important	Important	Somewhat Important	Not Important	Not Applicable/Do Not Know
Minimize negative impact on existing transportation services, i.e, on operators who cannot participate or on operators whose routes are disrupted or whose routes face additional competition.	◯	◯	◯	◯	◯
Minimize queues	◯	◯	◯	◯	◯
Minimize total cost of operations (including maintenance costs)	◯	◯	◯	◯	◯
Minimize wasted space in station/stop design because large spaces increase construction costs and require more maintenance, security, and environmental controls.	◯	◯	◯	◯	◯
Minimize institutional barriers to transferring such as transfer fares, lack of information or poor coordination of schedules.	◯	◯	◯	◯	◯

We continue this question on the next page.

Your Perspective as the Transit Operator (continued)

How important are the following statements from *<u>your</u>* perspective as the transit operator? For each characteristic, please select <u>one</u> of the following: "Very Important", "Important", "Somewhat Important", or "Not Important".

If you do not know how important a specific statement is from your perspective or do not think the statement is applicable, please select the "Not applicable/Do not know" option.

If you need to exit the survey before making your selection for each item on this page, note that when you return to this page later the items on this list may appear in a <u>different</u> order.

	Very Important	Important	Somewhat Important	Not Important	Not Applicable/Do Not Know
Maximize reliability of station/stop equipment.	◯	◯	◯	◯	◯
Maximize income from non-transport activities, such as advertising and vending.	◯	◯	◯	◯	◯
Maximize flexibility for expansion to handle an increase in demand or addition of new modes.	◯	◯	◯	◯	◯
Maximize joint development, i.e., involving the public and private sectors in sharing the facility and its costs and revenues.	◯	◯	◯	◯	◯
Maximize vehicle maneuverability (turning radii, etc).	◯	◯	◯	◯	◯
Maximize environmental friendliness of station/facility ("green" station/facility).	◯	◯	◯	◯	◯
Maximize coordination of scheduling to accommodate transfers.	◯	◯	◯	◯	◯

	Very Important	Important	Somewhat Important	Not Important	Not Applicable/Do Not Know
Maximize operational ease at the station or facility, e.g., vehicle maintenance, vehicle storage, ticketing, baggage handling, and/or accounting.	○	○	○	○	○

We continue this question on the next page.

Your Perspective as the Transit Operator (continued)

How important are the following statements from *<u>your</u>* perspective as the transit operator? For each statement, please select <u>one</u> of the following: "Very Important", "Important", "Somewhat Important", or "Not Important".

If you do not know how important a specific statement is from your perspective or do not think the statement is applicable, please select the "Not applicable/Do not know" option.

If you need to exit the survey before making your selection for each item on this page, note that when you return to this page later the items on this list may appear in a <u>different</u> order.

	Very Important	Important	Somewhat Important	Not Important	Not Applicable/Do Not Know
Efficiently collect fares and control entry to station/stop/vehicle.	○	○	○	○	○
Provide a break area for vehicle operators.	○	○	○	○	○
Provide a comfortable physical environment with respect to lighting, temperature, and cleanliness.	○	○	○	○	○
Provide protection from the weather.	○	○	○	○	○
Provide restrooms, first-aid supplies, and public telephones.	○	○	○	○	○
Efficiently process rider flows.	○	○	○	○	○
Provide a safe and secure environment.	○	○	○	○	○
Provide adequate station/stop space.	○	○	○	○	○

Are there attributes that you think are important from *<u>your</u>* perspective as the transit operator but were not listed on the previous three pages? If so, please list up to five of them here and also identify whether they are "Very Important", "Important", or "Somewhat Important".

a.

b.

c.

d.

e.

Receiving the Findings of this Research

Given that you have taken the time to complete this survey, you likely have an interest in transit connectivity. If you or someone from your agency would like to receive a copy of the report on this research when it is completed, please tell us below to whom we should send it. This project will be completed in early Fall 2007.

Are you or is someone else in your agency interested in receiving a copy of the Final Report on this research?

◯ No

◯ Yes

If you answered "No" above, click "Save and Go to Next Page >>". If you answered "Yes" above, please provide the appropriate contact information here, then click "Save and Go to Next Page >>":

Name

Title

Agency

Address_1

Address_2

City

State

Zip

E-mail Address

Thank You!

On behalf of the entire Project Team, thank you for your time. To exit this survey, simply click on "EXIT THIS SURVEY >>" in the top right corner of this page and you will be returned to your web browser at the UCLA Institute of Transportation Studies website.

Brian Taylor
Principal Investigator, Transit Transfer Project
UCLA Institute of Transportation Studies

Thank You!

On behalf of the entire Project Team, thank you very much for participating in this survey and contributing to this research.

Brian Taylor
Principal Investigator, Transit Transfer Project
UCLA Institute of Transportation Studies

APPENDIX B

TELEPHONE INTERVIEW GUIDE

1. INTERVIEW GUIDE

Operator's Agency Name:
Transit Facility:
Contact Person Name:
Phone:
Fax:
E-mail:
Time of interview: ___/___/______ ____:____ AM/PM

Statement of Purpose

We are part of a team of researchers working on a project for the California Department of Transportation that evaluates the connectivity performance at transit stops, stations, and transfer facilities. Our goal is to better understand how transit users perceive transfers to help transit agencies increase the attractiveness of their services.

We have already conducted a user survey of more than 700 rail and bus passengers at over a dozen sites in the greater metropolitan Los Angeles area. This survey asked passengers to evaluate transit stops and stations, taking into account the level of importance they place on various factors.

In our conversation with you today, we want to ask you ─ the transit expert ─ what you think is most important about transit stops and stations your perspective as an operator of transit services and the perspectives of residents and businesses located adjacent to and near transit stops and stations, that is, from the neighboring community perspective.

Thank you for working with us in this important research investigation.

We'd like to speak with you first about your general experience with transit stops, stations, and transfer facilities from your perspective as the operator and then from the neighboring community perspective.

Operator's Perspective

Questions

1. What are the factors that play a significant role in the design, siting, operation, and maintenance of major stops, stations, and transfer facilities?

   DESIGN

   SITING

   OPERATION

   MAINTENANCE

   NOTE TO INTERVIEWER: Please bring up the following factors IF the interviewee does NOT mention them, but DO NOT mention them first as examples because that will lead the respondent:

   - Cost-related factors
   - Opportunities for joint development
   - Institutional barriers to transferring
   - Process of collecting fares and controlling entry to vehicle area
   - Pedestrian/vehicle conflicts
   - Providing a safe and secure environment.

2. What have been the major challenges or obstacles in the design, construction or improvement of major stops, stations, and transfer facilities?

NOTE TO INTERVIEWER: Please bring up the following factors IF the interviewee does NOT mention them, but DO NOT mention them first as examples because that leads the respondent on:

- Engineering issues
- Providing adequate vehicle and pedestrian circulation space
- Processing passenger flows efficiently
- Providing proper physical environment
    - Lighting
    - Temperature
    - Aesthetics
    - Cleanliness
- Existing and conflicting land uses or rights-of-way
- Funding: certainty / uncertainty
- Interagency coordination for facilities with multiple operators
    - Conversely, did the presence of another agency or agencies at the site provide your agency with additional options or resources in the implementation of this transfer facility?
- Joint development with the private sector and other members of public sector
    - Conversely, did joint development provide your agency with additional options or resources in the implementation of this facility?

3. Was the certainty or uncertainty of ridership estimates a concern in planning this facility?

Community Perspective

Now, we'd like to focus on neighboring communities' response to transfer facilities – during the planning stage, during siting or re-siting, the construction phase, or in the operations phase. We are interested in hearing about community and business groups – organized or unorganized – or even individual neighbors that in some way influenced the implementation of sites you are familiar with. We are interested in both opposition (e.g. NIMBY-type) to and support for such facilities.

Questions

1. How did community concerns influence the implementation of transfer facilities?

2. Do community concerns continue to play a significant role?

3. Which type of community groups played a significant role in the planning of this transfer facility?

4. Where does most of the opposition come from, the commercial sector – business groups or individual businesses – community groups, individual residents?

5. What reasons have been given for <u>opposing</u> stations and transfer facilities, especially during the planning stage?

<u>NOTE TO INTERVIEWER</u>: Please bring up the following factors IF the interviewee does NOT mention them, but DO NOT mention them first as examples because that will lead the respondent:

- Scale of facility
- Architectural quality or lack thereof
- Aesthetic quality or lack thereof
- Noise pollution
- Air pollution
- Light pollution
- Blocked sightlines
- Change for the worse in neighborhood's character
- Attraction of "wrong" element to the facility
- Long dwell times at the transfer facility

6. Where does most of the support come from, the commercial sector – business groups or individual businesses – community groups, individual residents?

7. What reasons have been given in <u>support</u> of stations and transfer facilities?

<u>NOTE TO INTERVIEWER</u>: Please bring up the following factors IF the interviewee does NOT mention them, but DO NOT mention them first as examples because that will lead the respondent:

- Source of community pride
- Architectural gem
- Helps provide a source of employment during construction and operation
- Urban renewal
- Offers opportunity for joint development or commercial tenancy

8. To what extent have community groups been involved in the planning process for facilities? In terms of its architectural or aesthetic qualities?

9. How did your agency support community participation?

NOTE TO INTERVIEWER: Please bring up the following factors IF the interviewee does NOT mention them, but DO NOT mention them first as examples because that will lead the respondent:

- Public meetings
- Hosting of design charettes
- Dissemination of information on internet, customary mailings

10. At this time, could you please choose a specific site and talk about it in terms of our previous discussion, that is, its operational and community perspectives?