# 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

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# 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

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## 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<br>• Convenience: Good information service, adequate circulation patterns and capacity, easy boarding and alighting, and provisions for disabled people<br>• Comfort: Aesthetically pleasing design, weather protection, and small vertical climbs<br>• 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<br>• Minimum operating cost<br>• Adequate capacity<br>• Flexibility of operation<br>• 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<br>Floor space allocated<br>Percent of total space | Type, size, location<br>Sq. ft. allocated<br>Percent | 1 & 2<br>1<br>1 | 1 & 2<br>2<br>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<br>Initial<br>Operation<br>Security<br>Other | Allocated funds<br>Subsidy required<br>Public investment<br>Private investment<br>----- | Dollars<br><br><br><br>----- | 1<br>1<br>1<br>1<br>----- | 2<br>2<br>2<br>2<br>----- |
| 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<br>Land et al. (2001) | Safety and Security |
| | Amenities |
| | Access |
| | Connection and Reliability |
| | Information |
| Table 3<br>ITE Journal 5C-1A (1992) | Safety and Security |
| | Amenities |
| | Access |
| Table 5<br>Horowitz and Thompson (1995) | Safety and Security |
| | Amenities |
| | Access |
| | Connection and Reliability |
| | Information |
| Table 6<br>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:*<br>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:*<br>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:*<br>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:*<br>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:*<br>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:*<br>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,

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[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).

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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 all 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 31$^{st}$ 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

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- 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.