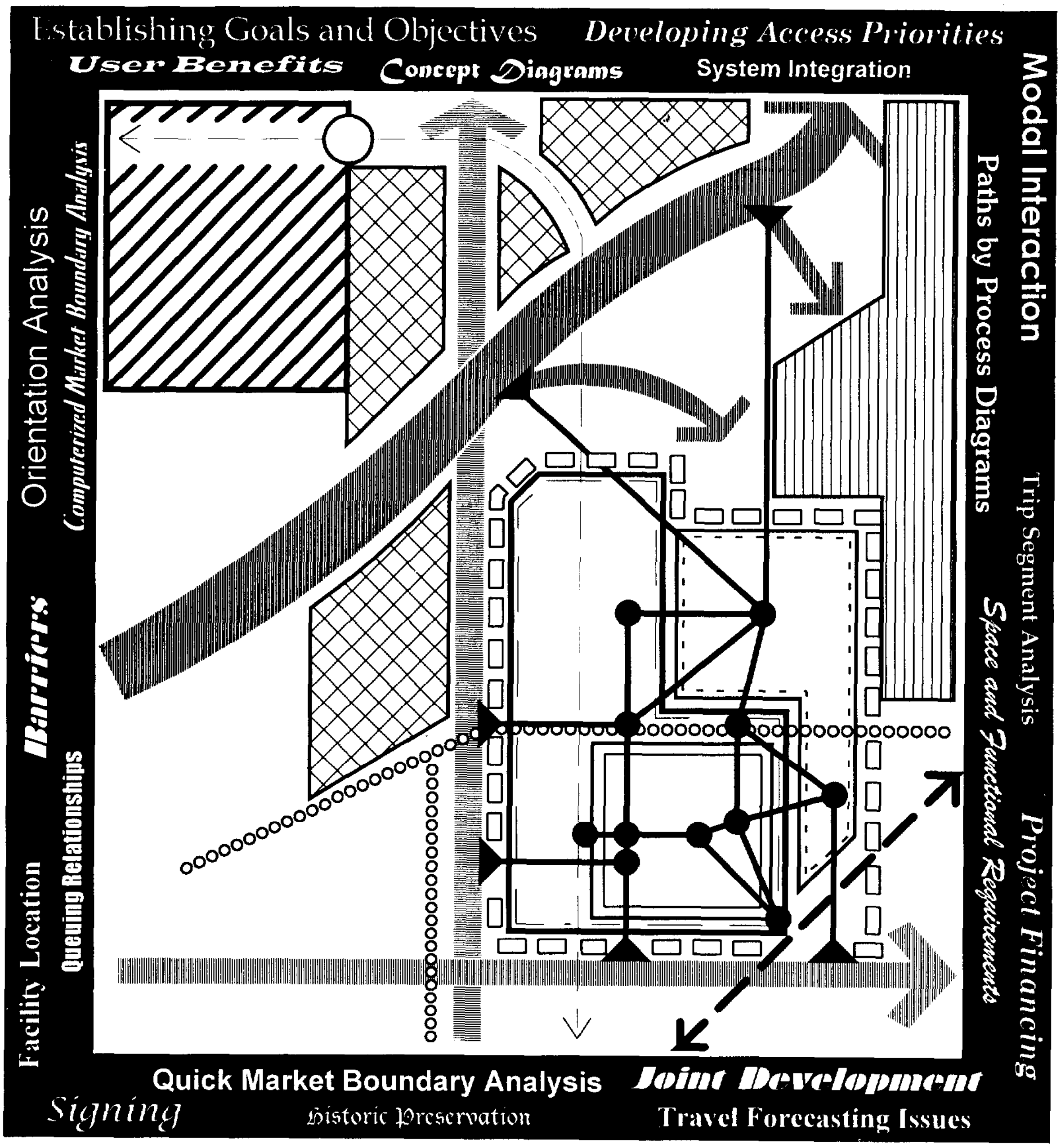
U.S. Department
of Transportation

Evaluation of Intermodal Passenger Transfer Facilities

September 1994



Evaluation of Intermodal Passenger Transfer Facilities

Final Report
September 1994

Prepared by

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Prepared for

Federal Highway Administration
U.S. Department of Transportation
Washington, D.C. 20590

Distributed in Cooperation with

Technology Sharing Program
U.S. Department of Transportation
Washington, D.C. 20590

DOT-T-95-02

Acknowledgments

This project was conducted under the sponsorship of the Federal Highway Administration of the US Department of Transportation. The authors gratefully acknowledge the Wisconsin Department of Transportation for providing the cooperative atmosphere that led to the successful completion of this study. Additional support was provided through the University of Wisconsin–Milwaukee. The opinions expressed are those of the authors and not necessarily those of the project sponsor.

Many organizations and people generously helped with this report. We would like to thank Dane Ismart, FHWA, and Michael Maierle, Wisconsin DOT, for project oversight; Lee Chimini, FHWA, for assistance with access to intermodal facilities and coordination with other Federal agencies; Marilyn Klein, FRA, and Joseph Ossi, FTA, for assistance with the historic preservation section; Effie Stallsmith, FTA, for assistance with the joint development section; Edward Beimborn, UW–Milwaukee, for assistance with market-based station design; Jerry Schneider, University of Washington, for a critique of the objectives list; John Cikota, FRA, for comments on an earlier draft; members of Transit List on the Internet for examples of good intermodal facilities and for responding to the objectives questionnaire; the numerous transportation planners who responded to the objectives questionnaire; the members of the Planning Advisory Group for the Milwaukee Intermodal Station Feasibility Study for responding to the objectives questionnaire; and Linda Rupp, UW–Milwaukee, for administrative assistance on the project.

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SUMMARY

The Wisconsin Department of Transportation has initiated a study into the feasibility of locating an intermodal passenger transportation facility in downtown Milwaukee. That feasibility study requires an evaluation of a very wide range of alternatives. The last concerted effort to develop evaluation criteria for intermodal passenger transfer facilities in the US dates to the 1970's. Since then issues, technologies, experiences and priorities have shifted and evolved. A new look at intermodal evaluation is appropriate.

This report is a distillation of opinion from a large number of transit system users, transportation planners and authors. However, opinion by itself is not very useful for intermodal station plans in Milwaukee or anywhere else. Taking the next logical step, this report presents a cafeteria of methods for preliminary design, location and evaluation of intermodal passenger transfer facilities. In some cases methods were adapted from previous station, terminal or airport studies. In other cases methods were adapted from multimodal transportation planning. But in all cases the methods address those factors most important to the choice of a project alternative.

The priorities attached to various methods was established by first creating a list of 70 generic objectives for the evaluation of an intermodal passenger transfer facility and then having a large panel of experts rate each generic objective. The generic objectives spanned all categories of system planning, internal design, external design and modal interfaces. An analysis of the ratings revealed that most important were objectives for assuring safety and security and objectives for improving transfers and transfer opportunities. Architectural and building considerations were least important. The twelve classes of objectives in order of importance were:

Safety/Security
The Transfer
Access
Efficiency
The Passenger
Coordination
Environment, Physical
Environment, Nonphysical
Finance
Space/Site
Modal Enhancement
Architecture/Building

A good evaluation of an intermodal passenger transfer facility is complicated; simple formulas do not exist. Of primary importance is the ability of facility to improve trip making. In order to ascertain levels of improvement for project alternatives, it is necessary to represent the facility and its modes as a network and to measure the

changes in the difficulty of travel across that network. Improvements in trip making can come from reductions in cost, in-vehicle time, out-of-vehicle time, barriers to transferring and from positive changes to the transfer environment.

All of the following questions must be affirmatively answered to justify public expenditures on an intermodal passenger transfer facility.

Have local agencies established objectives for the facility and have they demonstrated that those objectives can be met?

Do user benefits exceed the public cost of the facility?

Have all concerns about security and safety been addressed?

Does the alternative contain a sufficiently strong system integration plan to assure that the facility will be effectively and cooperatively used by modal operators?

Does the alternative fully exploit opportunities for joint development and private sector tenants?

Does the alternative contain a financial plan that assures there will be adequate funds to build, maintain and operate the facility?

Does the alternative achieve all legal requirements?

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Preface

Like many other cities in the United States, Milwaukee has become concerned about the ability of its transportation system to continue to provide a high level of mobility while still attaining its environmental objectives. To better meet these sometimes conflicting objectives, public officials, planners and citizens alike have started to place a greater emphasis on intermodal solutions to mobility problems. One effort in this direction is a study into the possible development of an intermodal station in Milwaukee's central business district.

Building an intermodal station in Milwaukee is both an opportunity and a challenge. The various transportation modes are widely dispersed throughout the downtown area and historically there has been little effort toward coordinating functions or facilities. Further complicating the picture are yet unfinished plans to implement high speed rail service from Chicago and to build a light rail line and a busway from the western suburban communities. In such an ambiguous planning environment, planners need to explore a wide range of alternatives, exercising careful judgment, to find the best possible intermodal station. How should those judgments be made? There are no pat answers.

The last concerted effort to develop evaluation criteria for intermodal stations in the US dates to the 1970's. Since then issues, technologies, experiences and priorities have shifted and evolved. Another look at intermodal evaluation seemed appropriate.

This report is largely a distillation of opinion from a large number of transit system users, transportation planners and authors. But opinion by itself is not very useful for intermodal station plans in Milwaukee or anywhere else. Taking the next logical step, this report presents a cafeteria of methods for preliminary design, location and evaluation of intermodal passenger transfer facilities. In some cases methods were adapted from previous station, terminal or airport studies. In other cases methods were adapted from multimodal transportation planning. But in all cases the methods address those factors most important to the choice of a project alternative.

Unlike most research reports, this one is not organized according to sequence of events during the research process. It might be useful to some readers to gain better understanding of the our actual sequence of tasks.

From the literature, we listed every issue anyone has mentioned as being important to the evaluation of stations and terminals. The list was organized and duplications were eliminated. At the same time, we reviewed evaluation methods that related to these issues.

To get users' opinions an international, electronic group interview was conducted with knowledgeable and frequent users of intermodal passenger transfer facilities. The interview took about one month to complete. Administered through the Internet's “transit list”, this group interview provided a good understanding of the issues most important to users. Some of the results of the interview are found in the appendix. In addition, meetings were held with persons representing agencies interested in intermodal station development in Milwaukee. They gave a sense of local concerns, expectations and constraints.

The literature review and the interviews resulted in a long list of issues that at least one person thought was important. It was still necessary to determine whether some issues were more important than others. Consequently, a tight list of 70 generic objectives was developed and planners from throughout the US were asked to rate them. Individuals from the Internet's “transit list” and representatives from local agencies also gave ratings. The generic objectives spanned all categories of system planning, internal design, external design and modal interfaces. Results are shown in Chapter 2. These ratings allowed for the drawing some strong conclusions as to the best ways of developing plans for intermodal passenger transfer facilities.

The methods presented in this report relate to the strongest generic objectives. Not all generic objectives are applicable in any given community, so not all methods are applicable either. Planners are encouraged to pick and choose. This report provides some guidance on the best methods for different situations, but it cannot replace the judgment and expertise of individuals most familiar with local circumstances.

Chapter 1. Introduction

A Framework for Evaluation

This report is concerned with transportation facilities that help people transfer between modes of travel. Most often, an intermodal passenger transfer facility is a bus or train station or an airport. Stations are places specifically designed for modal interchanges. However, this report is not limited just to stations. Intermodal transfer facilities can be much simpler and smaller than a station; they need not even have a precise location or physically aid a transfer.

Many communities are seeking ways of improving their intermodal transfer facilities. The cost of these improvements can range from inexpensive to very expensive, and their impacts can range from minor to profound. It is essential that each facility be efficiently designed in a manner that satisfies the community's transportation needs and makes the best use of available resources. Critical to the design process is evaluation. The evaluation of a proposal for a new or improved intermodal transfer facility is a way to ensure that transportation objectives are met, that funds are well spent and that the surrounding environment is protected.

The design and evaluation of an intermodal transfer facility are dictated by the nature of the transfers occurring there. Fundamentally, a transfer is perceived as an impediment to travel. Research has confirmed the conventional wisdom that a transfer is one of the most negative aspects of any trip. All trips involving more than one mode require a transfer, as do many trips on a single mode. Experience has shown that where the difficulty of transferring has been reduced, user satisfaction and the amount of travel have both increased. Since transfers cannot be entirely eliminated, it is essential to make them as quick and pleasant as possible. Transfers can be improved by several means, including better facilities, better operations and better institutional arrangements.

The design of transportation systems, including transfer facilities, usually involves the creation and evaluation of alternatives. For larger projects – those needing the preparation of environment impact statements – an analysis of alternatives is required. Although it is possible to build a successful intermodal transfer facility without ever considering more than one possibility, it is always good practice to evaluate a full range of alternatives.

Evaluation requires judgment. An intermodal transfer facility is among the most complicated of transportation system components, often composed of hundreds of different design elements. An effective design must carefully balance these elements to achieve the best facility at a given cost. Hence, evaluation is not a single step but a process that starts with the design of alternatives and ends with a decision incorporating the opinions of experts, potential users and the community at large.

Designers must be cognizant of evaluation criteria, just as evaluators must be knowledgeable of the details of an alternative design.

At the inception of the design process, it is difficult to know what the community expects from the facility. Without plans and drawings and models to serve as a focus for early discussions, decision makers are unlikely to be able to give specific advice for selecting and refining the design elements. However, decision makers should be capable of expressing a set of general goals for the facility. The statement of goals, when available, is very useful in defining the breadth of alternatives and in selecting a set of more specific design objectives.

The final design of an intermodal passenger transfer facility has inputs from a variety of people, many of whom can influence the choice of alternative, including the choice of doing nothing. A successful facility will require the cooperation of public and private operators, governmental agencies and community organizations. Many of these decision makers are business competitors; other decision makers compete for public funds or for private sector investment. They are of different sizes, have different missions and have different constituencies. There are potential winners and there are potential losers. Thus, it would be unreasonable to expect decision makers to provide a clear direction for the facility in the early stages of the design.

Some decision makers possess considerable technical expertise in their areas of interest. For example, a modal operator has knowledge of its own requirements for space and equipment. A facility could not be properly designed without that knowledge. The evaluation process must take advantage of the decision maker's second role of possible tenant.

An intermodal passenger transfer facility is part of a very large system of transportation services. Its design requires it to be integrated with existing modes, perhaps making fundamental changes to the operation of those modes. It is necessary to involve the expertise of transportation planners and managers, as well as engineers and architects, in the design. Even broader expertise might be needed to mitigate adverse impacts on the physical environment and on society.

The evaluation of a large transportation project is often started after the alternatives have been completely defined and at least partially detailed. At that point each alternative is tested to determine how well it meets the project objectives. This procedure is reasonably good for projects with few objectives and for projects with few design elements. However, intermodal passenger transfer facilities can be very complex. Each alternative in itself may require numerous design decisions and tradeoffs. As indicated in Figure 1.1, each physical design must be influenced by the external environment, modal operators, financial needs and travel requirements. This influence can only occur if the objectives are defined before the alternatives are defined and if the staff interprets those objectives as it creates the design details.

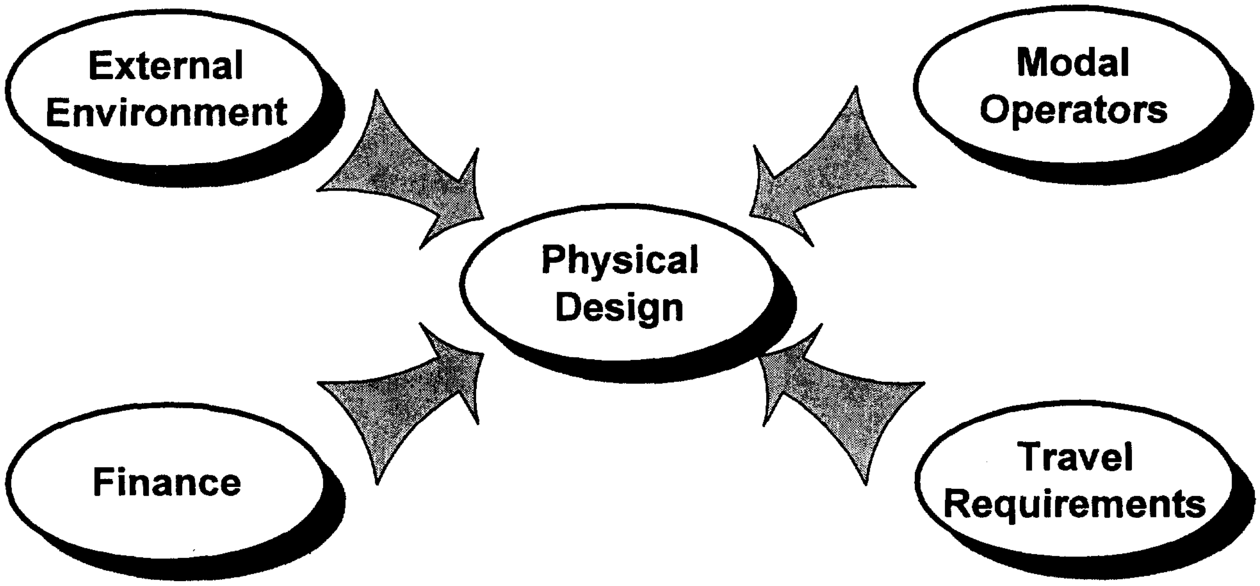

FIGURE 1.1. FACTORS AFFECTING PHYSICAL DESIGN

The flow of major steps in developing an intermodal transfer facility is illustrated in Figure 1.2. The implementation process starts with concept definition and ends with operations. In between are the major steps of planning and construction.

> *Concept Definition.* At the concept definition step, decisions are made as to the number of facilities and the nature of each facility, including its size and the selection of modes. Options for financing, joint development and historic preservation are also described. Concept diagrams are prepared for candidate sites. Scoping for environmental impact assessment is started. Goals, objects, criteria and standards are chosen.
>
> *Site Selection and System Design.* A site is found for each facility. The feasibility of modal connections and their access priorities are determined. The physical layout of each site is prepared. Demand is estimated. The adequacy of holding and waiting areas, pedestrian paths, paths of access, parking and other physical elements are assessed. Process diagrams and trip segment analysis are used to understand and refine the physical layouts.
>
> *System Integration Plan.* A plan for institutional, physical and operational integration is prepared. The plan details how the existing transportation operators and their services will respond to the intermodal facility. The plan will concentrate on ways to coordinate service at the facility, eliminate duplication and establish mechanisms for communication among operators and with the public.

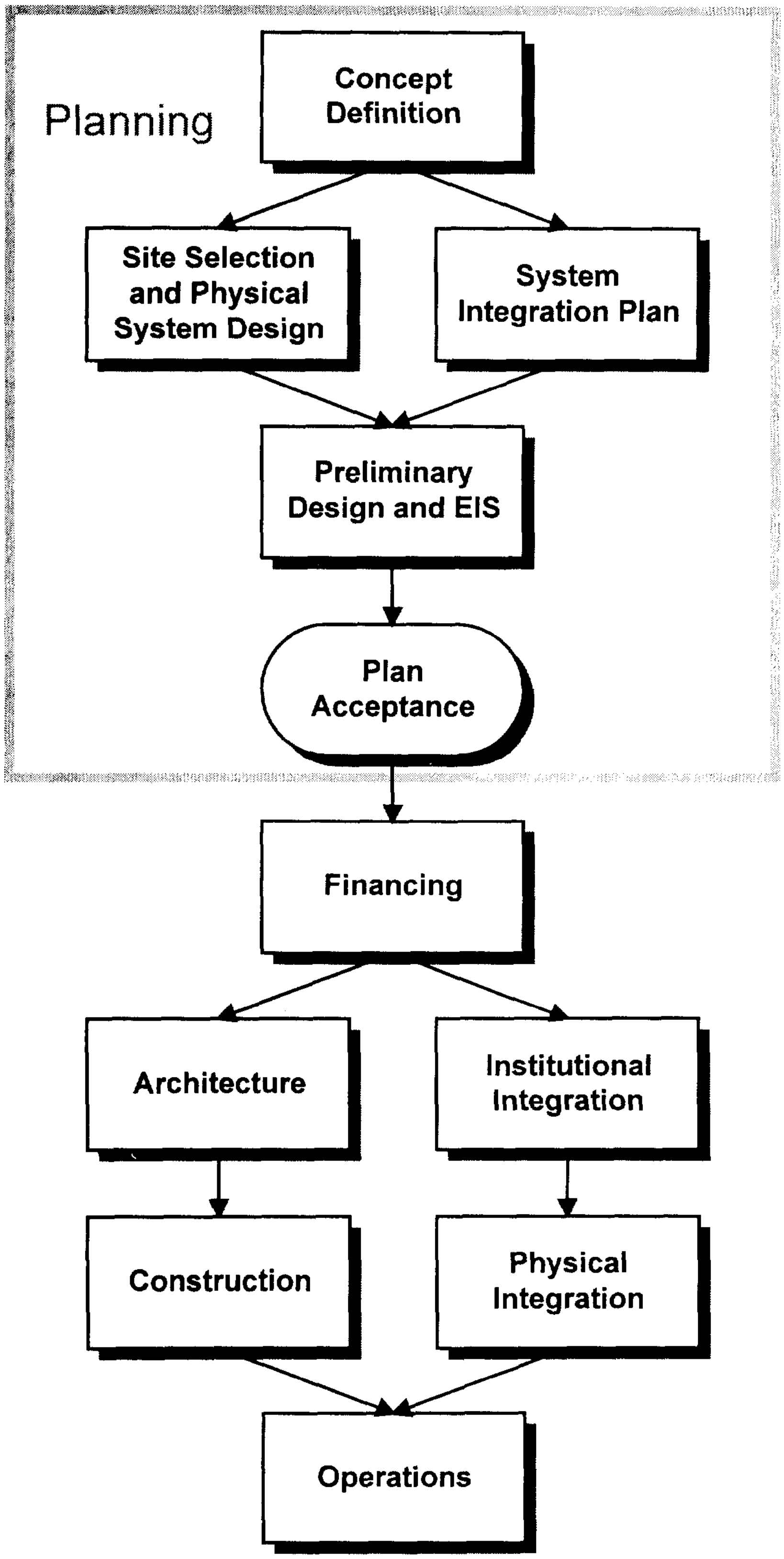

FIGURE 1.2. DEVELOPMENT OF AN INTERMODAL TRANSFER FACILITY

Preliminary Design and Environmental Impact Statement. The facilities are designed in sufficient detail to evaluate their impacts on the environment and on the community. Generalized floor plans, site layouts, and architectural renderings are prepared. Modal interaction, service interaction and sightline analyses are performed. An environmental assessment or a draft environmental impact statement is begun. Public comment is invited.

Plan Acceptance. Each alternative is evaluated, and the preferred alternative is chosen. The environmental assessment or the draft environmental impact statement is finished and circulated for comment. The detailed design is modified, as needed. Remaining tasks in the NEPA[1] process are completed.

Other Steps. Financing, Architecture, Construction, Institutional Integration, Physical Integration and *Operations.* The last steps in the process create the final design and execute the plan.

A Process for Evaluation

Consensus Building

Successful development of an intermodal passenger transfer facility cannot happen without the consensus of local leaders. An intermodal facility is a complicated and expensive transportation system component, with many individuals and groups directly and indirectly impacted by its development. These groups have their own agendas, priorities and points of view on how, and if, a facility should be built. The diversity of affected actors makes the process of satisfying everyone's demands difficult. However, the project cannot, and will not, proceed without a consensus of support from the influential actors. It is possible that a consensus building framework already exists within a local community. When possible it is desirable to use existing frameworks. Consensus building must begin early and continue throughout the planning and evaluation processes.

To begin building a consensus one must first identify all actors who will influence the evaluation and implementation of the project. The actors will come from the public and private sectors and the media, and include both decision makers and staff personnel. Once the actors have been identified, one or a few must step forward as primary advocates for the project. Advocates use their influence and standing in the community to sell the project to the other key actors.

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[1] National Environmental Policy Act of 1969. Preparation of an environmental assessment or an environmental impact statement is described in the Council on Environmental Quality Regulations, 40 CFR Parts 1500 to 1508.

All actors must become involved in the process from the beginning. Involvement occurs through formation of committees and public participation. Informational interviews with the actors and the media should be conducted to answer questions and identify issues. Meetings with community groups and businesses will initiate their involvement. Establishing an information clearinghouse will facilitate better interaction between members and groups and limit unsubstantiated claims from groups or individuals opposing the project. Consensus building requires that the project staff stay attuned to comments and coverage of the project. The staff should identify possibly contentious issues early in the process and actively attempt to resolve such issues as they arise.

A conducive evaluation procedure can also help consensus building. The next section presents a model evaluation procedure which attempts to reach a strong consensus as to the best alternative by directly involving key actors throughout the planning and evaluation process.

A Model Evaluation Procedure

There are many ways that an evaluation procedure may be implemented. However, a good evaluation procedure for an intermodal passenger transfer facility should have certain essential features. The evaluation procedure must:

A. Be capable of generating and evaluating alternatives;
B. Incorporate expertise, including knowledge of modal operations;
C. Establish goals, objectives and criteria for the project;
D. Have sufficient staff support to accomplish necessary data collection, analyses and reporting;
E. Contain mechanisms for fast and clear communication among the many participants in the process;
F. Satisfy the many laws and regulations associated with planning a large transportation project; and
G. Have the ability and authority to choose an alternative.

Furthermore, the process must be consistent with the style of planning that exists within the local community.

One evaluation procedure that meets these requirements of intermodal transfer facility design is illustrated in Figure 1.3. This example procedure establishes three formal bodies: a policy committee; a planning advisory group; and a staff.

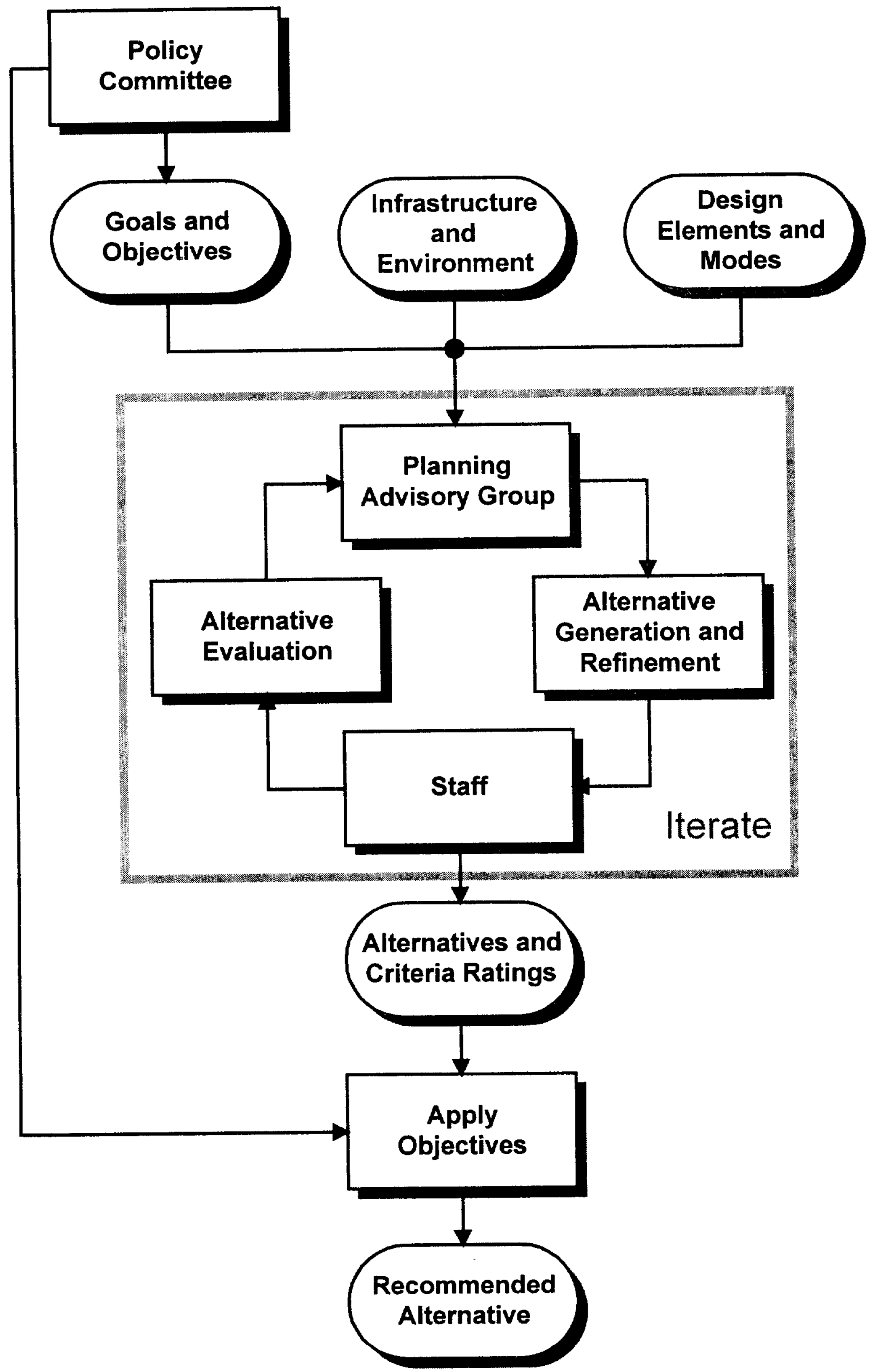


FIGURE 1.3. AN EVALUATION FRAMEWORK

Policy Committee. A policy committee is a group of individuals who either hold decision making authority or are highly respected in the community. As a whole, this committee would have had defacto control over the ultimate fate of the facility under any circumstances. The committee is primarily composed of political and business leaders. The committee's role is to guide the evaluation by articulating goals, balancing the needs of disparate interests and developing a consensus about the chosen alternative. It is essential that the policy committee, at least, meet at the beginning and end of the evaluation process. Other meetings may be desirable to follow the study progress and assure adherence to established goals. Since some members of the policy committee have representatives on the planning advisory group (PAG), they have the opportunity to further influence the alternatives.

Planning Advisory Group. The planning advisory group (PAG) is composed of individuals possessing relevant technical knowledge. The PAG can be large, but care is taken to avoid redundancies. The PAG meets often and works in close cooperation with the staff. The PAG selects and weights objectives consistently with the goals set forth by the policy committee. They assist in defining alternatives, provide design information, and assist in selecting criteria and standards. Some of the members of the PAG have close association with members of the policy committee. In addition, the PAG has members from relevant modal operators, planning agencies, community organizations and governmental bodies. Under some circumstances it may be desirable for a member of the Policy Committee to also serve on the PAG.

Staff. The staff consists a small number of paid individuals who are responsible for coordinating the project, collecting data, providing design details, calculating design criteria, handling public information and preparing presentations and reports. The staff works with the PAG in defining alternatives and selecting criteria and standards. The staff is composed of individuals on loan from organizations of the PAG or consultants.

These three groups may have different names, depending upon local institutions and planning history.

As illustrated in Figure 1.3, the policy committee provides one of three major inputs to the design process – the *goals* for the facility. Goals are general statements of expectations and requirements. Goals articulate community values, but are cast in terms of the specific project. Some example values and goals are illustrated in Figure 1.4. Goals may seem vague, but the policy committee is not expected to possess the necessary technical expertise to make them sufficiently specific for design purposes.

It is the responsibility of the staff and the PAG to translate goals into *objectives*. Each goal may have one or more objectives. An objective is something the project should maximize, minimize or achieve. There can be many objectives, and some objectives can be in direct conflict with each other. In defining objectives, it is helpful to look at those developed elsewhere. This report contains a list of *generic objectives* that cover the range of common goals for intermodal passenger transfer facilities.

Ultimately, the policy committee determines whether the objectives have been satisfied. The staff can help the policy committee by defining *criteria* for many of the objectives. Criteria are optional, quantitative measures of objectives. It is often useful to set a *standard* – an acceptable level – for a criterion. A criterion should not be defined unless it is a direct measure of its objective. Otherwise, descriptions or drawings may better communicate the achievement of an objective. There are risks associated with both too little and too much quantification. Where there is too little quantification, there may be difficulties in comparing alternatives. Where there is too much quantification, the decision makers may be unable to adequately comprehend the significance of the differences between alternatives. The staff and the PAG must satisfy themselves that the criteria directly measure the achievement of goals from the policy committee.

Most of the design work occurs through a structured interaction between the PAG and the staff. In Figure 1.3, this interaction is shown as a loop. The staff meets frequently with the PAG to generate, evaluate and refine alternatives. At any time during the design process, the staff may seek additional information from modal operators and the community. It is useful to set milestones for completion of tasks, but it is also important to allow the design process to unfold without being rushed.

Satisfying necessary environmental impact assessment regulations should be initiated by the staff in cooperation with the PAG. The scoping process, specifically, should be started at the earliest possible time.

The authority for selecting the best alternative rests with the policy committee. Although they may not have participated in the detailed design of each alternative, members have influenced the designs through their articulation of goals and through representatives on the PAG. Before its decision the policy committee, at its option, may want to receive additional formal public comments through hearings, questionnaires or referenda.

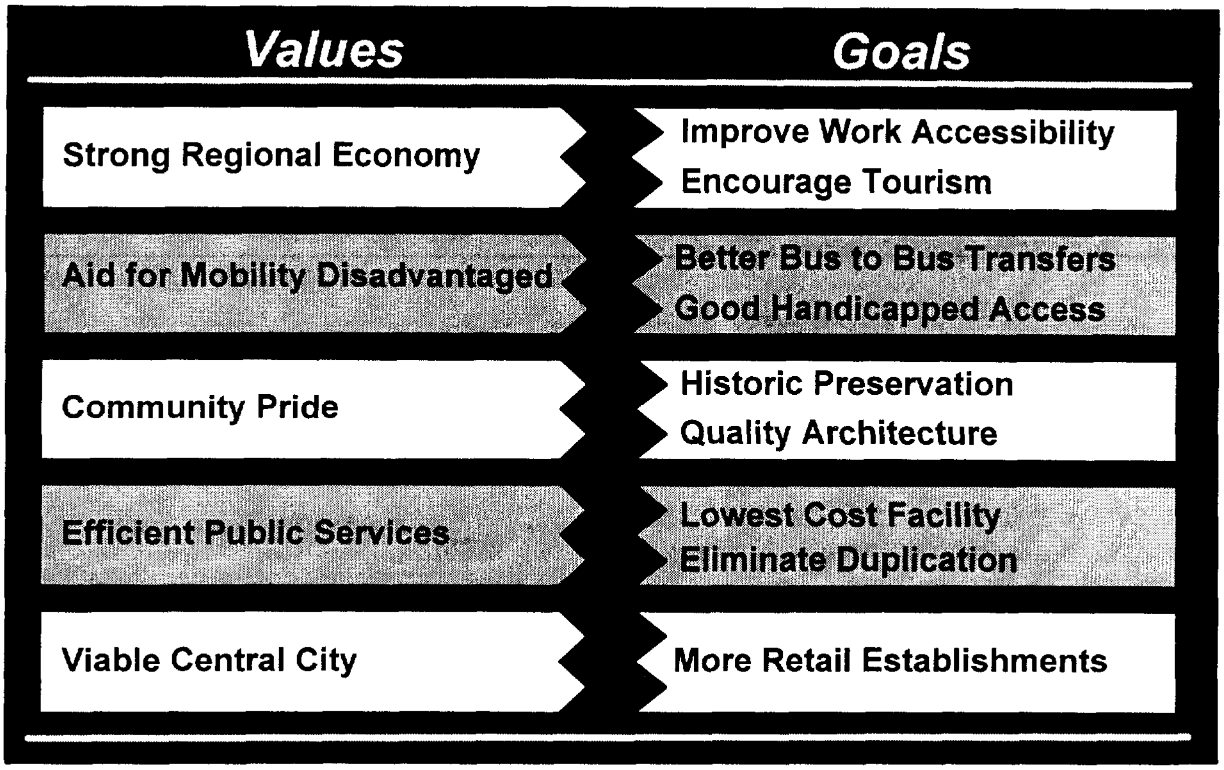


FIGURE 1.4. EXAMPLE GOALS AND VALUES

The Intermodal Transfer System

An intermodal passenger transfer facility is part of a large transportation system. The system extends over a vast area, and involves a large number of modes, services, and other transfer facilities. When designing an intermodal facility it is important to assure its good fit with the remainder of the transportation system and assure the transportation system's fit with the intermodal facility. This meshing of system components can encompass:

A. Properly locating a facility relative to other facilities and modes;
B. Relocating modes to better service the facility;
C. Realigning schedules to better coordinate transfers at the facility and throughout the system;
D. Integrating the system both physically and institutionally;
E. Introducing new modes and services to capitalize on the new facility and to accommodate new demand;
F. Establishing priorities of access to the facility;
G. Redefining the roles of existing transfer facilities to eliminate duplication and to develop specialization;
H. Upgrading the condition of modal equipment to match the new facility; and
I. Respecting business and community needs and environmental concerns.

As a practical matter, it is necessary to define reasonable system boundaries. It is suggested that boundaries be defined such that (a) they are distinct for each mode and (b) they extend as far as necessary from the transfer facility to accommodate a typical trip for the mode not involving another transfer with another vehicular mode or itself. The shape and placement of system boundaries greatly depend on the characteristics of the modes. As illustrated in Figure 1.5, pedestrian and highway boundaries can be compact, while transit and rail boundaries would extend along service corridors.

The choices of system boundaries are not innocuous. The boundaries affect ridership forecasts, estimates of environmental impacts, and the extent of required service changes beyond the intermodal facility. The system boundaries also affect the amount of data collection and analysis.

It is only necessary to consider modes that might directly connect to the facility or require only a short walk to the facility. Modes that indirectly connect by way of a transfer at a remote site are of lesser importance and can usually be ignored.

Table 1.1 is a list of modes that could be served by an intermodal transfer facility. Modes are differentiated here by their access characteristics and their passenger characteristics, as well as by technology. For example, automobile kiss-n-ride is listed separately from automobile park-n-ride. Freight modes have been included to the extent appropriate for a facility that principally serves passengers.

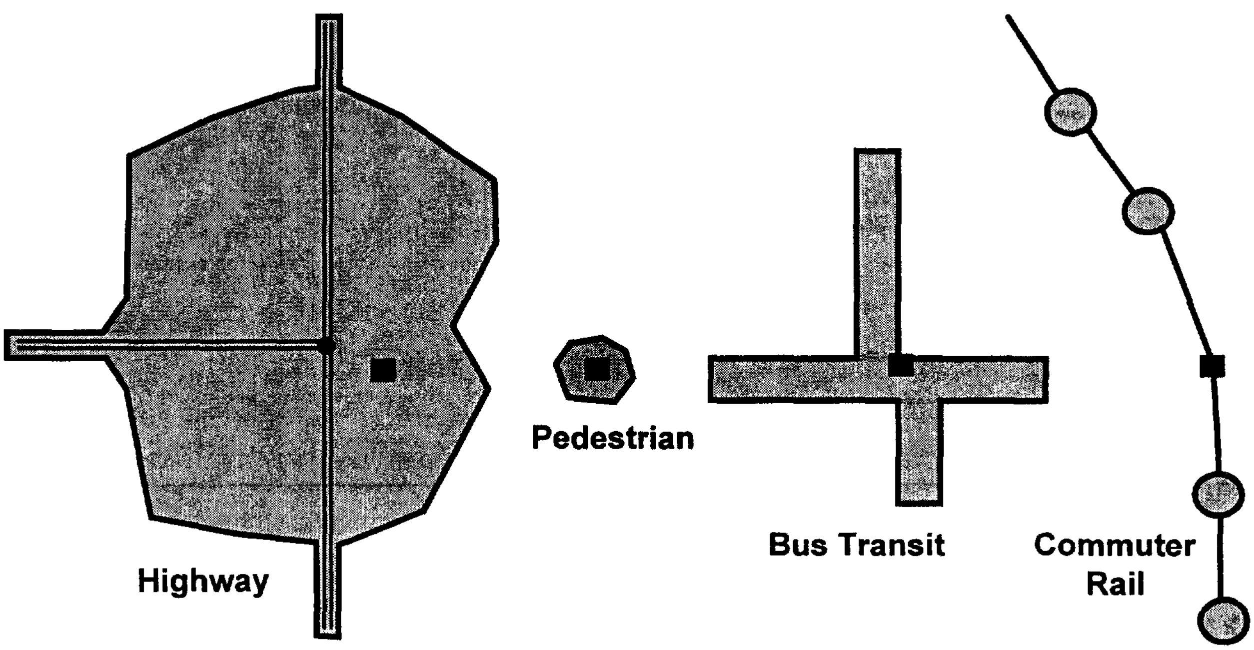


FIGURE 1.5. EXAMPLES OF SYSTEM BOUNDARIES

TABLE 1.1. DISTINCTIVE MODES OF ACCESS TO AN INTERMODAL PASSENGER TRANSFER FACILITY

Automobile: Kiss-n-Ride	Intercity Bus
Automobile: Park-n-Ride	Shuttles, Trams
Automobile: Private HOV	Tours, Limos, School Buses
Automobile: Package Drop Off	Taxis
Automobile: Disabled	Bicycles
Automobile: Rental	Motorcycle
Station Cars	Commuter Rail
Pedestrian: Abled	Intercity Rail: Conventional
Pedestrian: Disabled	Intercity Rail: High Speed
Light Rail Transit (LRT)	Handicapped Service
Metrorail	Delivery: Packages, Mail
Personal Rapid Transit (PRT)	Delivery: Freight
Pedestrian Assist Systems	Delivery: Baggage
Group Rapid Transit (Peoplemover)	Delivery: Roadrailer
Vertical Takeoff and Landing (VTOL)	Historic Vehicles
Short Takeoff and Landing (STOL)	Private Boats
Local Bus	Ferries
Express Bus	Water Taxi

Networks

Modal Networks. A convenient way of pictorially representing a mode is a *network*. Networks are an assemblage of various *nodes* and *links*. Typically, nodes are intersections or places where vehicles can change direction. Nodes are most often shown as dots of various shapes and sizes. Nodes can also represent places where trips can start and end. Links are trip segments between nodes. Links are most often drawn as straight lines. Depending upon the mode, a link could be a portion of a road, a transit route, a rail line or a walkway. Figure 1.6 is an example of a transit network in a small community where all routes converge upon a downtown transit center. Bends in routes and stops are shown by small nodes and the one transfer point is shown by a large node. The links in this figure are portions of routes.

A *path* is a sequence of nodes and links from the origin of a trip to its destination. Should the network show only a single mode, origins and destinations might be points of entry and exit from that mode.

Networks are much more than a way to depict modes. They can also be precise mathematical descriptions of modes. It is possible for any node or any link to have *attributes*. For example, an attribute of a transit link could be its route number or its running time or its headway. Once values for the attributes have been entered, it is possible to subject the network to various forms of analyses.

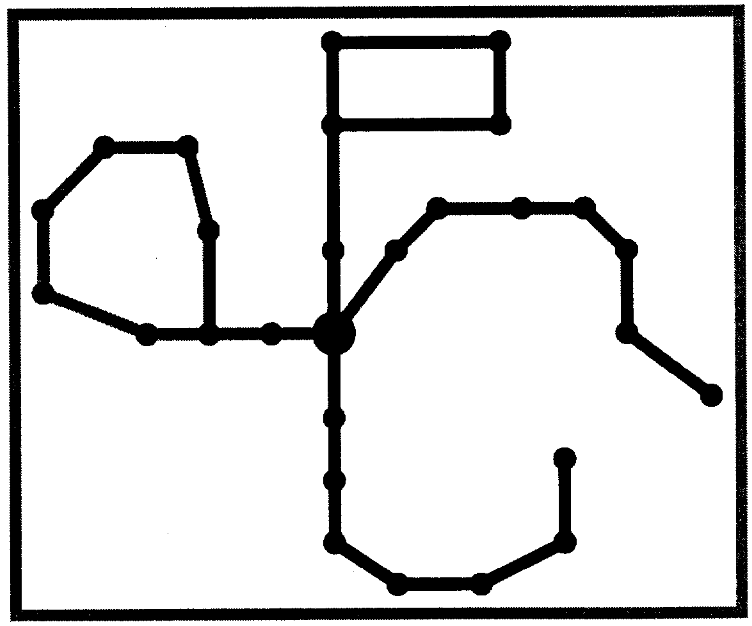


FIGURE 1.6. TRANSIT NETWORK FOR A SMALL TOWN

A particularly interesting mode for intermodal facility design is internal walking. A walk network would show all the paths from all points of access and egress for other modes. Important attributes of a walk link are its distance, its walking speed and its concentration of pedestrians. A partial example of a pedestrian network is the tunnel system for Los Angeles Union Station, shown in Figure 1.7. The tunnel network was helpful in determining whether the station had sufficient pedestrian capacity to handle future commuter rail service.

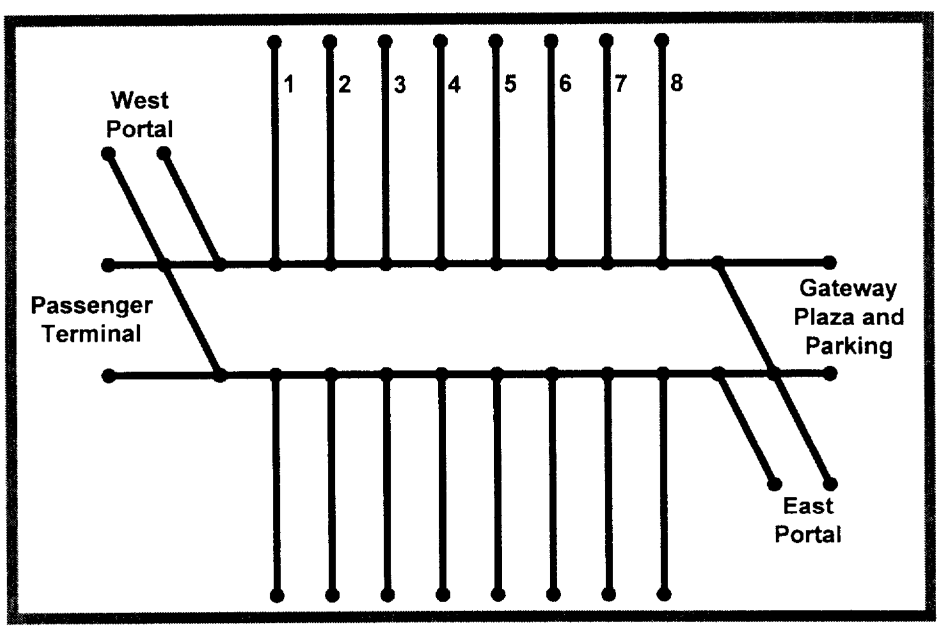


FIGURE 1.7. TUNNEL NETWORK FOR LOS ANGELES UNION STATION

Intermodal Networks. Many trips involve more than one mode, so an intermodal network can often provide valuable insights. In such a network connections between modes are explicitly shown as *transfer links*. There are many transfer links in an intermodal network. At each transfer point – at a station or on the street – there would as many transfer links as unique transfer possibilities. This number increases rapidly with the number of modes. A two-mode transfer point requires only one (two-way) transfer link; a three-mode transfer point requires just three transfer links; but a six-way transfer point could require up to 15 transfer links. Figure 1.8 shows part of an intermodal network near a station that is served by light-rail, commuter rail and park-n-ride automobile. Pedestrian access to the rail lines would require two more links.

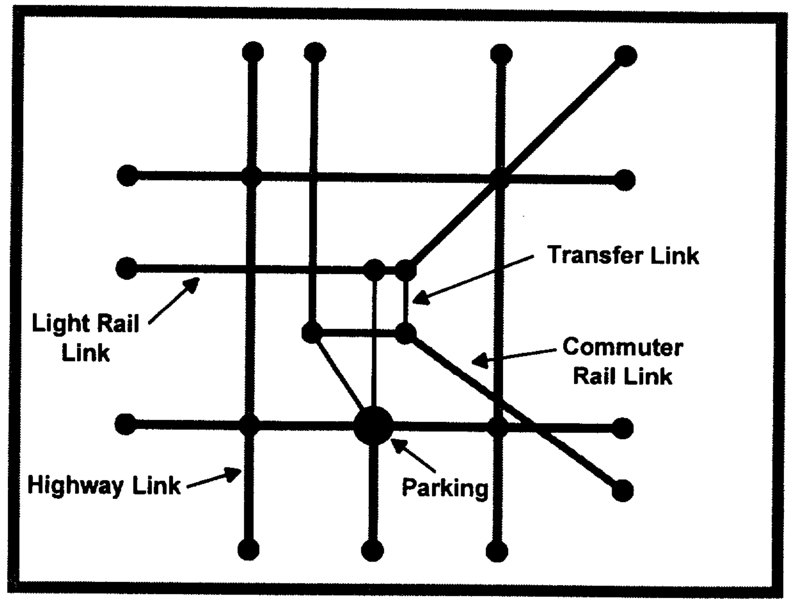


FIGURE 1.8. A SMALL INTERMODAL NETWORK

The Nature of a Transfer

Transfers are often necessary to complete trips; however, travelers perceive them as negative experiences. Travelers dislike the time and cost required for transferring, but they also dislike the need for added trip planning, the possibility of a missed connection, the uncertainty of arrival time at their destination, exposure to weather and crowding, the need to find the next vehicle, difficulty of baggage handling and waiting in unfamiliar or hostile surroundings. A good intermodal transfer facility can decrease the unpleasantness of the transfer by directly addressing the reasons why travelers avoid transfers.

The difficulty of making a trip is referred to as the trip's *disutility*. For the purpose of this report, it is assumed that disutility has units of riding time.[2] For example, a trip by automobile of 10 minutes in duration has a disutility of 10 minutes. It is known that the disutility of any trip can be influenced by the conditions of travel. Waiting and walking accrue greater amounts of disutility than riding the same amount of time. Poor weather, crowding and congestion can increase disutility, too. The requirement to spend money increases disutility.

[2] According to economic theory disutility has units of "utils", which have no special meaning. Disutility can be rescaled without loss of generality by multiplying by a constant. Research has shown that disutility of travel is almost linearly related to a trip's duration. Thus, disutility can be easily converted from utils to minutes of riding time by multiplying it by an appropriate factor.

A traveler is unable to place a number on a trip's disutility. Nonetheless, it is possible to estimate any given trip's disutility from analyzing how people have behaved in the past. Assuming travelers are rational, they tend to choose modes and paths that have the lowest disutility. By looking at a large number of such choices in a great variety of situations, it is possible to infer a set of *weights* and *penalties* for each component of a trip. Psychological scaling studies have also provided help in estimating disutility.

As indicated in Figure 1.9, travelers are most concerned with being able to make the trip at all. Time in travel – riding, waiting, walking and transferring – is also important. The convenience of a trip, particularly scheduling, can be important, too. For urban travel, cost, comfort and entertainment are of less concern. Style related issues are of little importance.

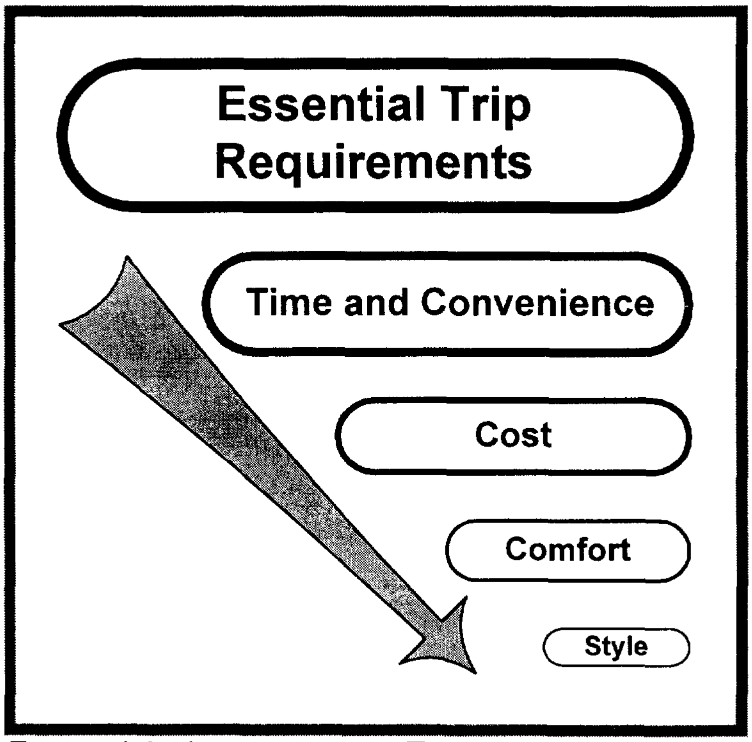


FIGURE 1.9. IMPORTANCE OF TRANSIT ATTITUDES

For example, in a study of dial-a-ride services General Motors Research Laboratories (GMRL) had potential riders rank 32 transit attributes. These attributes are shown in Table 1.2. It can be seen that travelers are most concerned about meeting minimum requirements of the travel experience (items ranked 1 to 7 and 9). Being able to make the trip with less expenditure of personal resources was next important (items ranked 8 to 11, except 9). Less important were attributes that make a trip physically easier (items ranked 13 to 20 and 23). Of lowest importance were items that help make a trip more comfortable or entertaining.

In the GMRL study weather protection ranked fifth among all attributes, even though it might be considered a comfort issue. This study was conducted in Michigan, where there are numerous days each year with subfreezing temperatures. The respondents placed a high importance on weather protection because they considered it essential for regular travel. Weather protection would be less important in more temperate climates.

The GMRL study was one of the most comprehensive analyses of attitudes toward transit system attributes, but many other less ambitious studies found consistent results. These general conclusions carry forward to transfer facilities. When planning

TABLE 1.2. A RANK ORDER OF TRANSIT ATTRIBUTES

1.	Arriving when planned
2.	Having a seat
3.	No transfer trip
4.	Calling without delay (demand responsive transit)
5.	Weather protection at pick-up
6.	Less wait time
7.	Choice of pick-up time
8.	Lower fares
9.	Longer service hours
10.	Less walk to pick-up
11.	Short travel time
	Direct route
13.	Easy fare paying
14.	Easy entry/exit from vehicle
15.	Dependable travel times
	No crowding on vehicle
17.	Space on packages
18.	Adjustable air, light, sound
19.	More phones in public places
20.	Adjustable seats
21.	Ability to meet friends on vehicle
22.	Vehicle size and appearance not detracting from neighborhood character
23.	Room for baby carriages, strollers, and wheelchairs
24.	More chance of riding in privacy
25.	More chance of rearranging seats to form talking groups
	Being able to ask questions of system representatives
	Less chance of meeting people that make you insecure or uncomfortable
28.	More pleasant or scenic routes
29.	More chance of riding with different kinds of people
30.	More chance of meeting people
31.	Availability of onboard coffee, newspapers and magazines
32.	Stylish vehicle exterior

Most Important — *Rank Order of Transit Attributes* — Least Important

Key

Attributes associated with meeting minimum requirements of travel
Attributes associated with being able to make the trip with less expenditure of personal resources
Attributes associated with making a trip physically easier
Attributes associated with making a trip more comfortable or entertaining

Source: Golob, Canty, Gustafson and Vitt, 1972.

and designing an intermodal transfer facility it is critical to place the greatest emphasis on attributes considered most important by a potential user. Hence, those attributes of a facility that improve connectivity and reduce disutility should dominate those attributes that improve its appearance or amenities.

In a second study conducted by GMRL, Horowitz (1979) found that disutility of travel was related to the trip's purpose, mode and environmental conditions. Some of the more interesting conditions of travel are shown in Figure 1.10. It is seen that

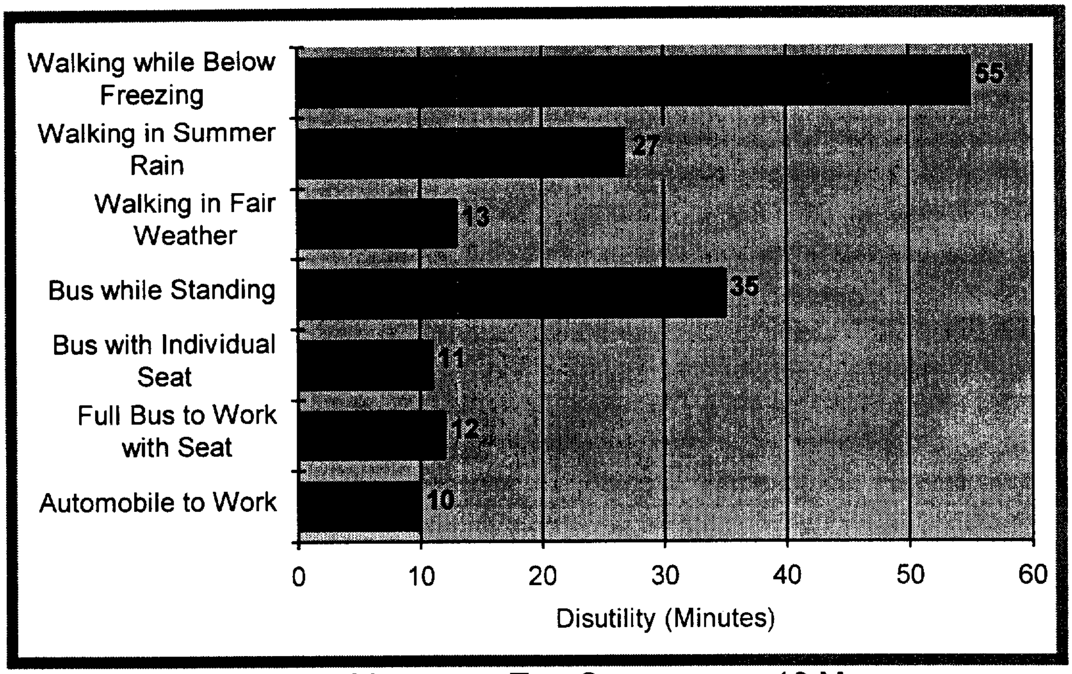


FIGURE 1.10. DISUTILITY VALUES ON TRIP SEGMENTS OF 10 MINUTES

standing while riding or walking in the rain or in below freezing weather have a particularly large impact on a trip's disutility. It would be reasonable to assume that poor weather has a similarly large influence on perceptions of any other unprotected portion of travel, such as waiting.

Furthermore, Horowitz (1981) identified a time-independent penalty associated with transferring. For bus-to-bus transfers, it was found that each transfer was equivalent to between 23 and 46 minutes of travel *before* accounting for transfer time and cost. Other studies (Han, 1987; Algers, Tegner and Hansen, 1975) measured the bus-to-bus transfer penalty at about 30 minutes. Algers and co-authors reported that the transfer penalty appears to be smaller for bus-to-rail and rail-to-rail transfers then for bus-to-bus transfers. None of these studies were able to clearly identify why the transfer penalty was so large. However, it appears that riders were being influenced by the uncertainty of making a connection, by the need for additional trip planning and by the lack of protection from the environment. With Metro-to-Metro connections, where transfers are protected and certain, Algers and co-authors found that the transfer penalty nearly vanishes.

Time while waiting, either initially or during a transfer, is perceived by travelers to be worse than while riding. Many planners have adopted a rule-of-thumb that says the value of time while waiting is twice the value of time while riding. This rule-of-thumb has been reconfirmed so often that it is now accepted without much question. A modal operator can achieve the same improvement in the disutility of a trip by eliminating 2 minutes of riding or by eliminating 1 minute of waiting. Waiting can be reduced by better schedule coordination, better passenger information, better on-time performance and by eliminating transfers wherever possible.

It is most often assumed in transportation analyses that waiting time is wasted time. This may be true for short waits. But, given a sufficiently large block of time and the necessary resources, some passengers can use waiting time productively. The ability to work, eat, socialize, learn and attend to personal needs can contribute to a more positive perception of waiting time.

Disutility Weights and Penalties

The disutility for any given trip is very difficult to determine empirically, consequently many transportation facilities are designed without formally considering the difficulty of travel. This need not be the case. Even if local disutility information is not available, it is still possible to synthetically build a relation for disutility from information obtained elsewhere.

Table 1.3 lists disutility weights, penalties and monetary values of time that can be used for intermodal station design. Particularly, these weights and penalties may be used in many of the procedures described later in this report – market boundary analysis, consumer surplus calculation and trip segment analysis.

Disutility may be estimated for any trip by adding the disutility of each of its components, properly weighted. For example, a good-weather work trip involving 30 minutes of riding, 10 minutes of unproductive waiting, 8 minutes of walking and a payment of $1.00 with a prevailing wage rate of $0.24/minute would have the following disutility components:

A. Access vehicle = 8
B. Walking time = 8 x 1.25 = 10
B. Riding time = 30 x 1.0 = 30
C. Waiting time = 10 x 2.0 = 20
D. Cost = 1.00/(0.333 x 0.24) = 12.5

The sum of these four components is 80.5 minutes. The disutility would have been larger had the traveler been subjected to standing or poor weather conditions.

Scope of this Report

This report is principally concerned with choices among alternatives. Thus, the greatest emphasis is placed on elements that would substantially differ across alternatives and have the greatest effect on costs and on existing modal operations. Those elements relate to the number and types of modes, the level of service provided by those modes, the ability to gain access to modes, the ability to transfer between modes, the number and location of the facilities, special site requirements, the gross arrangement of services within the facility, joint development, traveler's acceptance of the facility and environmental impact. Less emphasis is placed on those elements that would be decided after an alternative is selected. Many of those elements relate to

TABLE 1.3. SUGGESTED WEIGHTS, PENALTIES AND TIME VALUES

Time Component	Weight
Riding	1.0
Walking	1.25
Walking with Baggage	3.0
Unproductive Waiting	2.0
Productive Waiting	1.0
Queue Time	3.0
Traveling while Seated	1.0
Traveling while Standing	3.0
Weather Condition	**Weight Adjustment**
Rain	+1.25
Below Freezing	+4.25
Action	**Penalty**
Unprotected Vehicle to Vehicle	32 minutes
Protected Vehicle to Vehicle	16 minutes
Unprotected Timed Vehicle to Vehicle	8 minutes
Protected Timed Vehicle to Vehicle	4 minutes
Walk to Vehicle	8 minutes
Vehicle to Walk	0 minutes
Trip Purpose	**Time Values**
Travel to/from Work	0.333 of wage rate
Work Related Travel	2.000 of wage rate
Nonwork Travel	0.167 of wage rate

architectural design, the specific needs of modal operators, space for pedestrians and the size and locations of services.

The report is organized into stand-alone sections within chapters. Most of the sections provide step-by-step instructions for accomplishing a planning or evaluation task. Not every section applies to every facility, so it is necessary to browse through the provided techniques and to choose those that apply.

Throughout the report a distinction is made between planning and implementation, as indicated in Figure 1.2. This report is concerned almost entirely with those planning tasks that are outlined by the gray box.

Chapter 2. Establishing Project Objectives

Overview

Project objectives are derived from project goals and comprise the heart of an evaluation. The design of an intermodal passenger transfer facility should not even be started without first establishing objectives. This chapter presents procedures for developing and rating project objectives. Also presented is a list of generic objectives that can be employed in the evaluation of any intermodal passenger transfer facility. The generic objectives cover all aspects of system-wide design elements, interior design, exterior design and modal interfaces. The generic objectives were ranked by an expert panel of transportation officials and experienced users according to their importance. Because objectives play a large part in all phases of the evaluation, each following chapter is accompanied by a list of the objectives that relate to its topics.

Procedure: Evaluating Generic Objectives

Purpose

To define objectives for the intermodal transfer facility, so that they may be used as a basis for evaluating alternatives.

Requirement

A planning advisory group (PAG) or similar committee that understands the technical aspects of intermodal passenger transfer facilities and can translate project goals into specific objectives.

Background

Objectives are specific statements of goals for an intermodal facility. Different projects would have different sets of objectives. The *generic objectives* contained in this section are those objectives that might possibly be of interest to any given facility.

Each objective has a direction. In some cases, the objective is to maximize an element or an impact. In other cases, the objective is to minimize an element or an impact. In a few cases, the objective is to achieve a specific level of impact. This specific level may require increasing or decreasing an impact. But, once such a specific impact has been achieved, there is little to be gained by doing more.

There are many objectives and not all will be relevant or interesting. Furthermore, some objectives may be redundant. Establishing a final set of objectives requires a systematic sifting of all generic objectives to determine which to keep.

The list of generic objectives with definitions and explanations is shown below. These objectives were compiled by reviewing many case studies of station and terminal design. Each generic objective was important to the design of someone's facility. Too many objectives can overburden the design and evaluation processes, so it may be necessary to eliminate worthwhile objectives that are not critical to the choice of alternatives or that are of lower priority.

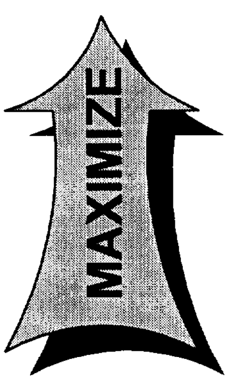
It is desirable that each objective have an accompanying set of criteria – measures to determine when an objective has been met. Criteria come in three forms:

A. Numerical indexes of the forecasted state of the facility, its users or its environment;
B. Descriptions of the facility; and
C. Results of a series of self-evaluation questions.

Some suggested criteria are included within the descriptions of the generic objectives. Many of these criteria are discussed later in this report.

Generic Objectives

Systemwide Objectives



User Benefits

User benefits consist primarily of savings in travel time and travel cost. Improvements in comfort and convenience, when they affect perceptions of travel time can also be user benefits. Additionally, user benefits include the ability to travel to destinations at different locations and the ability to make entirely new trips. Criterion: Consumer surplus.

Spatial Connectivity

Spatial connectivity refers to the quantity and quality of connections between routes and modes.

Temporal Connectivity

Temporal connectivity consists of coordination of schedules to improve transfers between modes.

System Legibility

Legibility relates to a passenger's ability to understand system connections and plan trips involving two or more modes.

System Coordination: Information and Fares

Coordination includes an unified fare structure and elimination of duplicate information and services.

Income from Nontransport Activities

Nontransport income could include income from advertising, leases of retail space, concessions and joint development. Criterion: Expected financial contribution.

Modal Market Areas

Market areas are the physical extent of the places, people and activities that are competitively served by a given mode. Criteria: Physical size of market areas.

Service Duplication

Service duplication includes redundant or competing routes. Criterion: Number of daily riders on redundant service.

Cost

Costs include both capital and operating expenditures. Criterion: Net present value of facility costs.

Regional Energy Consumption

The principal issue of regional energy consumption is the amount of petroleum-based fuels consumed by motor vehicles. Criteria: Percentage reduction in BTU's or gallons of fuel.

Regional Air Pollution Emissions

Air pollutant emissions are important in ozone nonattainment areas. Ozone is not emitted, but is formed in a chemical reaction of sunlight, organic gases (often unburned hydrocarbons from motor vehicle exhaust) and oxides of nitrogen. Under a given emission control technology, emissions can be most effectively reduced by reducing motor vehicle miles traveled (VMT). Criteria: Percentage reduction in hydrocarbons or oxides of nitrogen.

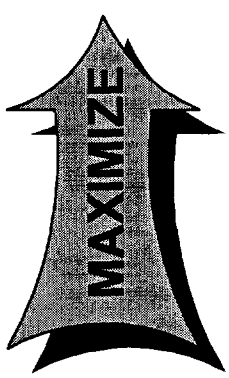
Negative Impact on Existing Transportation Services

A facility could have undesirable effects on operators that cannot participate or on operators whose routes are disrupted or whose routes face additional competition. Criteria: Number and size of affected operators.

Fare Inconsistencies

Fare inconsistencies include different rates among operators or inconsistent rates among like modes. Criterion: List of inconsistencies.

Internal Objectives



Security

Security can be enhanced by separating users from nonusers, by shutting down unused areas of the facility, by maintaining a high level of activity throughout periods of operation and by having visible security personnel, emergency phones and surveillance equipment.

Safety

Safety can be provided to pedestrians by reducing possible exposure to vehicles and modal operations, by eliminating hazards (including exposure to severe weather) and by proper maintenance.

Passenger Information

Passenger information can be provided by facility personnel, signs, pictograms, color codes, maps, computer terminals, floor markings and a public address system.

Reliability

Reliability relates to the dependability of the services and the physical plant.

Ease of Fare Collection

Automated methods of fare payment and collection may be easier for certain modes; however, automated systems vary in complexity.

Amenities

Amenities are services (restaurants, personal services, news stands, game rooms, etc.) that make the time spent at the facility more useful or more pleasant.

Aesthetics

Aesthetics relates to the sensory (usually visual) quality of the internal environment, including cleanliness.

Passenger Comfort

Elements affecting passenger comfort include seating, lighting and environmental controls.

Alternative Uses of Time

Alternate uses of time include recreation, eating, socializing, listening, working and attending to personal needs.

Weather Protection

Weather protection is the maintenance of an acceptably comfortable environment, free of wind, rain, ice, snow, sun and temperature extremes. Outdoor areas can also be partially protected from severe weather.

Pedestrian Assists

Pedestrian assists include elevators, escalators, shuttle vehicles, trams and moving sidewalks.
Criterion: Trip Segment Analysis.

Quality of Waiting Areas

Quality of waiting areas relates to comfort, size, available amenities, ease of access to appropriate modes and the proximity to services.

Openness of Interior Design

An open design would involve large, airy and unobstructed spaces.

Directness of Path

The most direct paths for walking are nearly straight lines between places within the facility.
Criteria: Percentage deviation from straight lines; Trip Segment Analysis.

Queuing Delays

Queuing delays are times spent waiting in line while traveling within the facility, while accessing modes and while obtaining services. Criteria: Mean waiting times for specific services.

Path Length

Path length relates to the distance traveled between points within the facility by following available pedestrian routes. Criteria: Trip Segment Analysis.

Conflicting Paths

Where pedestrian paths cross, interference between paths may result in delay, crowding and bumping.

Crowding

Crowding occurs whenever there is insufficient space for walking and waiting. Criteria: *Highway Capacity Manual* levels-of-service.

Exertion

Exertion is the physical effort required to reach a vehicle.

Disorientation and Confusion

Cluttered and disorganized spaces that are poorly signed contribute to passenger disorientation and confusion. Criterion: Orientation Index.

Barriers

Barriers include anything that disrupts a direct path between two points. Criterion: Barrier Checklist.

Level Changes

Level changes are any instances where passengers are required to go up or down to reach their destination. Level changes can be slight (e.g., climbing a platform) or major (e.g., going to another floor). Level changes require stairs, ramps, elevators, inclined moving sidewalks or escalators. Criteria: Numbers of assisted and unassisted level changes on sample trip segments.

Physical Barriers to Handicapped

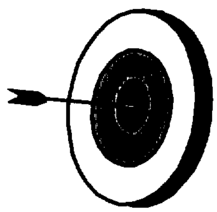
Certain characteristics of a facility and its site may make handicapped travel difficult without technically prohibiting it. Examples are poorly drained sidewalks, narrow and crowded doorways and unlevel pavement.

Maintenance Requirements

Materials can be selected and architectural elements can be designed and arranged to reduce maintenance requirements.

Wasted Space or Volume

Large spaces increase construction costs and require more maintenance, security and environmental controls.



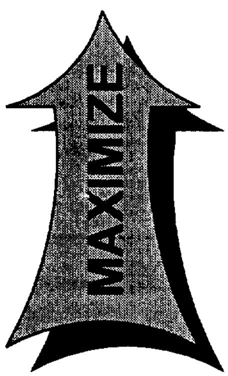
Handicapped Access

Handicapped access is required by the Americans with Disabilities Act. Criterion: Yes/No.

Hazardous Materials

The site and previous building might contain hazardous materials, such as asbestos, which must be removed prior to new construction and occupancy. Criterion: Yes/No.

Modal Interface Objectives



Efficient Access and Egress

Passengers should be allowed to gain entrance and exit from vehicles with little difficulty by placing gates close to waiting areas, providing vehicle-level platforms and by eliminating barriers.

Ease of Modal Operations

Operations at the facility include vehicle maintenance, vehicle storage, ticketing, baggage handling and accounting.

Safety and Security of Modal Operations

Modal operations (such as moving vehicles around the facility, performing maintenance, fuel dispensing and cash handling) should be safe and secure.

Directness of Modal Paths

Direct paths go from origin to destination without jogs, loops, bends or other deviations. Criteria: Deviations from straight lines.

Reliability of Transfers

Passengers should be able to consistently make connections, having sufficient time for walking, baggage handling and attending to personal needs.

Waiting

Many passengers perceive time while waiting to be more unpleasant than time while riding. Reductions in waiting have positive effects on passenger satisfaction and numbers of riders. Criterion: Average waiting time.

Difficulty of Ticketing or Fare Payment

Automated systems of fare payment are often preferred for routine trips, although some automated systems are difficult to understand. The difficulty of fare payment also relates to the type of ticket (e.g., farecard or token) and to the number and locations of ticket vendors.

Difficulty of Baggage Handling

Baggage can include packages and shopping bags, as well as luggage. The difficulty of handling baggage relates to the availability of carrying devices and storage, including the ease of accessing storage locations.

Physical Barriers to Transferring

Physical barriers include long or circuitous walks, lack of visual clues, need to claim and recheck baggage and high volumes of cross traffic.

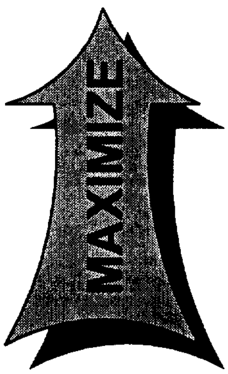
Institutional Barriers to Transferring

Institutional barriers include transfer fares, lack of information and poor coordination of schedules.

Modal Path Conflicts

Conflicts arise when vehicular paths cross and interfere with the flow of traffic. Criterion: Number of conflicts that must be resolved by assigning priority.

External Objectives



Joint Development

Joint development involves the public and private sectors sharing the facility and its costs and revenues.

Informal Vending

Informal vending 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.

Flexibility for Expansion

Costs may be saved when the facility is designed to just handle anticipated travel demand, but provision is made for facility expansion should travel demand increase or new modes added.

Sense of Place, Historic Significance, and Community Image

Should the facility involve historic structures or be located in a historic district, there are advantages in emphasizing historic elements of the design. Facilities tend to be large, so they should be designed as landmarks. An attempt should be made to promote a favorable community image and to attach significance to the neighborhood.

Quality of Architectural Design

The exterior design of the facility should be pleasing and well integrated with its neighborhood.

Reuse of Existing Buildings and Infrastructure

Existing buildings, roads, parking lots and utilities may be reused as part of the facility. Reuse of an older building is principally a way to save money, but it can also help achieve architectural consistency with other buildings in the immediate neighborhood. Criterion: GFA of reused structures.

Positive Cultural and Social Elements

Positive elements include art, displays, assembly areas and meeting places, reduced crime and casual contact between racial and ethnic groups.

Urban Renewal

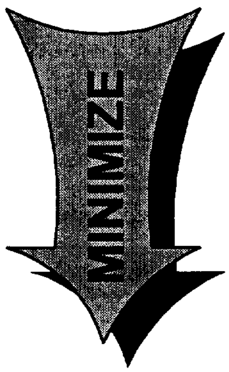
The facility and any associated development may make better use of land and existing structures. The facility may encourage redevelopment of the neighborhood.

Local Employment

Construction of the facility will result in a temporary increase in local employment. The facility needs permanent staff. Modal operators would need additional employees to run new or upgraded services. Criterion: Number of temporary jobs; number of permanent jobs.

Community Pride

Many communities are proud of the quality of their passenger transportation systems.



Construction Impacts

Construction impacts include noise, particulate emissions and traffic disruption.

Disruptive Land Acquisition

Land acquisition can become disruptive when the property is already serving a useful purpose or when households are displaced. Criteria: Value of commercial and industrial property displaced; number of locally owned businesses displaced; number of households displaced.

Conflict with Proposed Land Uses

The facility may contradict existing land use plans.

Physical Neighborhood Environmental Impacts

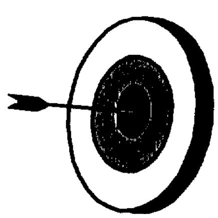
Physical impacts include air pollution, noise pollution, erosion, change in flood plains, taking of park land, the alteration of vistas and wetland destruction.

Negative Social Neighborhood Environmental Impacts

Negative social impacts include increased presence of strangers in the neighborhood and loss of part of an ethnic neighborhood.

Cultural Neighborhood Environmental Impacts

Cultural impacts include the relocation of churches, community centers and cemeteries and the removal of historic structures and culturally significant buildings, sites and landmarks.



Same or Lower Air Pollution Emissions

Nonattainment areas must demonstrate a reduction in air pollution emissions across all sources. Criterion: Yes/No.

Property Rights

Required property must be purchased and rights of use and access must be obtained. Criterion: Yes/No.

Historic Preservation Requirements

Community designated historic and culturally significant resources must be protected. Criterion: Yes/No.

Steps

Step 1. List goals. Obtain a list of goals for the intermodal facility. The list of goals should be developed by a policy committee (or similarly constituted group). The goals should properly reflect community values. See Chapter 1 for example values and goals.

Step 2. Establish a panel. Determine who will be doing the selection of objectives. People should be chosen who (a) are familiar with the project, (b) have sufficient technical expertise to interpret the goals and (c) have knowledge of the local environment and community. A good set of individuals for selecting objectives is the Planning Advisory Group, as discussed in Chapter 1.

Step 3. Create a questionnaire. A questionnaire can be used to obtain importance ratings of each generic objective. Although a questionnaire can be written in many different ways, it is suggested that each objective be rated on a category scale from 0 (not important) to 10 (extremely important). A sample question is shown below.

Objective		Not Important										Extremely Important
Minimize Disorientation and Confusion	N	0	1	2	3	4	5	6	7	8	9	10

In this type of question, the panel member has the capability of circling an "N" to indicate no opinion. Jargon should be avoided. Technical terms, when absolutely necessary, must be defined. The questionnaire should contain a list of goals and compete instructions, including a filled-out example question. A complete questionnaire is reproduced in Appendix A.

Panel members should be told to reference the list of goals when evaluating the generic objectives. To get a high rating a generic objective must help satisfy one or more goals. Panel members should be encouraged to give low ratings to any objective that is irrelevant to an intermodal facility, regardless of the objective's intrinsic worth. Ideally, the selection of objectives should be independent of proposed alternatives.

Step 4. Develop a procedure for administering the questionnaire. The questionnaire may be filled out individually or as a group exercise. If there is sufficient time, consider a consensus building technique. A proven way of working toward a consensus is the Delphi Method. The Delphi Method involves administering the questionnaire to the panel a multiple number of times. With the second and later questionnaires, panel members are also given the results of the previous questionnaire. Members whose ratings differ from the norm and who have strong feelings are permitted to explain their reasoning to the whole panel.

Step 5. Tabulate the results. Average the ratings for each generic objective and rank them.

Expected Ratings of Generic Objectives

Background

A questionnaire for rating generic objectives was completed by an expert panel. The questionnaire, reproduced in Appendix A, was based on the preceding set of generic objectives. The results reflect the opinions of those with expert knowledge of intermodal passenger transfer facilities.

Selection of Expert Panel

The expert panel selected to complete the Generic Objectives Questionnaire was composed of three subgroups. The first subgroup (TPA) consisted of individuals from Metropolitan Planning Organizations (MPO's), Regional Transit Authorities (RTA's) and local governments who had been, or were currently involved in, an intermodal passenger transfer facility project. Several of the MPO's and RTA's had also been involved in intermodal facility projects. Attempts were made to incorporate panel members from regions and cities of all sizes and locations.

Agencies were contacted before distributing the questionnaires. At that point they were questioned about their willingness to participate and were asked for the name of the staff member most capable of responding to the questionnaire. A few agencies expressed reservations about their ability to answer the questionnaire due to a lack of prior involvement with intermodal facility projects. In these instances the agencies were not sent questionnaires. Agencies were contacted until a predetermined sample size of 50 was reached. Panel statistics are shown in Table 2.1.

The second subgroup (PAG) was composed of members of the Planning Advisory Group from the Intermodal Station Feasibility Study for Milwaukee, Wisconsin. Nine members of the group were sent questionnaires. The small sample was a result of both a small Planning Advisory Group and the fact that only one questionnaire was allowed from each agency. The Planning Advisory Group had many agencies represented by more than one individual. In order to avoid the chance that agency biases become reflected in the results, each agency was limited to one questionnaire.

TABLE 2.1. SUMMARY OF EXPERT PANEL MEMBERS

Expert Panel Statistics

Transportation Planning Agencies (TPA)
- 50 questionnaires distributed
- 38 questionnaires returned completed
- 2 questionnaires returned uncompleted
- **80.0%** response rate

Planning Advisory Group (PAG)
- 9 questionnaires distributed
- 7 questionnaires returned completed
- **77.8%** response rate

Experienced Users Group (USR)
- Questionnaire posted to a transit issues discussion group on the Internet with approximately 300 subscribed members
- 22 questionnaires returned completed
- **7.3%** response rate *

* The low response rate is to be expected because the questionnaire was not sent directly to individuals. Several members of the discussion group do not regularly participate in discussions and may have missed the questionnaire during the period that it was posted.

The third subgroup (USR) consisted of members of the Transit List on the Internet. Individuals in this discussion group are involved in the transportation field, either as consultants, transit agency personnel, professors, students or hobbyists.

Questionnaire Process

The ranking of objectives is fundamental to intermodal facility planning. The responses from the questionnaire shapes all phases of the process. How panel members respond to the questionnaire depends, in part, upon the format of the questionnaire and the way in which it is presented to the panel. Careful consideration should go into all phases of the questionnaire's administration to ensure ratings that truly reflect the opinions of the group. Several "Do's and Don'ts" of the questionnaire process are included in Figure 2.1.

Although the panel members were asked to rate objectives on a scale of 0 to 10, most members rated the objectives fairly high. The average score of all objectives was 7.1. It should be noted that above average ratings were expected because of the care taken in only including objectives that were determined to have importance to somebody. Furthermore, the panel members showed considerable enthusiasm for the subject.

Results

Overall, the Mode Interface objectives were rated highest (average score of 7.98), with Internal objectives second (7.24), System objectives third (6.84) and External objectives scoring the lowest (6.45). (See Figure 2.2) This order was preserved among the panel subgroups, with the exception of the Planning Advisory Group who ranked System objectives (6.80) – slightly higher than Internal objectives (6.74). *Note: Caution should be exercised in gauging the significance of results from the Planning Advisory Group because of its small sample size.*

All Mode Interface objectives scored at or above 6.9, while all External objective scored at or below 7.4. Eighteen of the 21 highest rated objectives were Mode Interface or Internal objectives, whereas 14 of the 20 lowest rated objectives were System or External objectives. Table 2.3 shows this generally high rating of the Mode Interface and Internal objectives as compared to the System and External objectives.

Among the three subgroups, the Transportation Planning Agencies (TPA) panel members rated on average all objectives the highest, while the Planning Advisory Group (PAG) generally rated all objectives the lowest. Only a few objectives differed substantially in rating from one subgroup to another. Table 2.2 lists these objectives and the rank they received within their category.

Do's and Don'ts of the Questionnaire Process

Do's

- ***Do run a pretest of the questionnaire to identify problems with content and format.*** Have the testers be as critical as possible. Have testers pay particular attention to the format and understandability of the questionnaire. Solicit their thoughts and criticisms, then make any necessary changes.
- ***Do contact panel members before sending the questionnaire.*** Inform panel members that they will be receiving the questionnaire, explain its purpose and emphasize its importance.
- ***Do a follow-up mailing and a follow-up phone call to panel members.*** Ask if panel members have any questions and remind them to complete and return their questionnaire. There must be total involvement if the panel size is small.
- ***Do minimize time needed to complete the survey.*** The questionnaire will be long, so instructions must be short and direct. The questionnaire's format should be self explanatory.
- ***Do include a voice phone number and encourage respondents to call if they have any questions.***
- ***Do include a self-address stamped returned envelope and a fax number.*** Every attempt must be made to make the process as simple as possible in order to receive responses. Review the format of questionnaire to assure that it can be easily faxed.
- ***Do have a rating scale large enough to bring out differences among objectives.*** The scale should be no smaller than 0 to 10. A smaller scale will not allow for differentiation among objectives, particularly if the panel is small.

Don'ts

- ***Don't wait until the last minute to prepare and distribute the questionnaire.*** The entire process, beginning with questionnaire design and pretesting and ending with the compilation of the results, will take several weeks.
- ***Don't expect complete agreement on rating of objectives.*** Each person will approach the questionnaire with different opinions and agendas. The panel members will have a wide range of backgrounds. Consensus building will be difficult. Remind each person that the objectives should reflect the goals that have been established for the project.
- ***Don't organize questionnaire in a manner that conveys importance upon certain objectives.*** Before the questionnaire is even developed, it will be obvious that some objectives will receive high ratings regardless of the panel. Keep the questionnaire logically organized, but at the same time order the objectives randomly. If the panel is large, develop a second questionnaire that reverses the order of the objectives.
- ***Don't omit any relevant objectives.*** Although the time required to complete the survey should be minimized, this requirement must not be met at the expense of omitting relevant objectives.
- ***Don't fill questionnaire with jargon.*** Some jargon will obviously be necessary. If required include a brief definition of the objective. The definition must be confined to one or two concise sentences.

FIGURE 2.1. TIPS FOR SUCCESSFUL ADMINISTRATION OF OBJECTIVES QUESTIONNAIRE

The results based on the original four objective categories (External, Internal, System and Mode Interface) did not reveal many interesting patterns in the data. Consequently, the objectives were regrouped and reanalyzed based upon facility attributes, services or impacts. The objectives were regrouped under 12 new classes: *Safety and Security, Transfer, Passenger, Access, Efficiency, Coordination, Physical Environment, Nonphysical Environment, Finance, Space and Site, Modal Enhancement* and *Architecture and Building.* A few objectives were placed into two classes. The questionnaire (see Appendix A) did not make reference to these particular classes.

Table 2.3 shows the average ratings of each class. Safety and Security objectives were rated highest with an average score of 8.63. Transfer objectives were rated second highest with an average score of 8.22. No other class rated above 8.0. It should be noted that the Transfer class had three times the number of objectives as the Safety and Security class, which tended to lower the Transfer's final rating. Transfer objectives accounted for 3 of the top 5 objectives, including the highest rated objective. Furthermore, 5 of the 10 highest rated objectives were from the Transfer class. Table 2.3 shows the minimal importance given to the Architecture and Building objectives. Of this class' 5 objectives, 3 were rated among 6 lowest rated objectives, including the overall lowest rated objective.

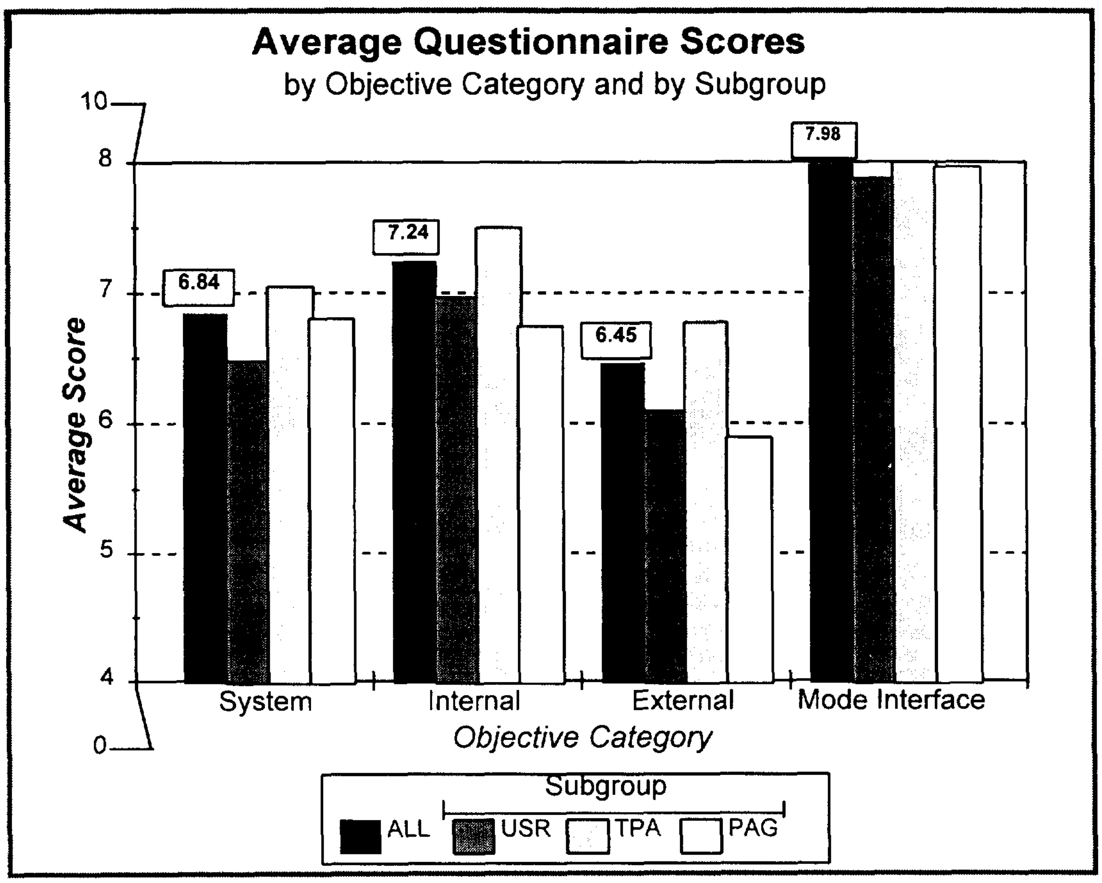


FIGURE 2.2. AVERAGE SCORES ON QUESTIONNAIRE

TABLE 2.2. OBJECTIVES RECEIVING SIGNIFICANTLY DIFFERENT RATINGS AMONG SUBGROUPS

Objectives Receiving Substantially Different Rankings Among Subgroups

Bold number indicates subgroup that varied substantially from other subgroups.
Rank value reflects ranking within the objective category and not overall rank.

Subgroups: TPA: Transportation Planning Agency Group
USR: the Internet Group
PAG: Planning Advisory Group

Objective Category	*Objective* *Subgroup:*	*Rank in Category:* TPA	USR	PAG
EXTERNAL (Range: 1 to 19)	Maximize use of local employment	17	18	**1**
	Minimize negative cultural impacts on surrounding neighborhood	2	**12**	3
	Achieve same or lower air pollution emissions	**3**	12	16
	Achieve compliance with historic preservation requirements	7	2	**15**
INTERNAL (Range: 1 to 27)	Maximize safety 3	4	**17**	
	Achieve handicapped access	**1**	**10**	3
	Achieve elimination of hazardous materials	**6**	26	26

The five highest rated classes (Safety and Security; Transfer; Passenger; Access; and Efficiency) contributed 27 of the 28 highest rated objectives, and 30 of the 39 objectives with an average score of 7.0 or higher. The five lowest rated classes (Nonphysical Environment; Finance; Space and Site; Modal Enhancement; and Architecture and Building) accounted for 9 of the 11 objectives that received an average rating below 6.0.

The detailed results of the questionnaire are displayed in Table 2.4. The ranking and scores reflect a compilation of all subgroups. Table 2.4 lists both the original category and the class of the objective, its ranking among all objectives and the average rating it received. The results are further broken down by objective category in Tables 2.5, 2.6, 2.7 and 2.8. *Note: In Tables 2.5-2.8 the final ranking reflects comparisons among objectives within that category only.*

TABLE 2.3. OBJECTIVE RATINGS BY CLASS

Objective Classes	Average Score	Number of Objectives
Safety/Security	8.63	3
Transfer	8.22	10
Access	7.80	8
Efficiency	7.34	5
Passenger	6.98	13
Coordination	6.80	2
Environment, Physical	6.60	8
Environment, Nonphysical	6.54	7
Space/Site	6.35	4
Modal Enhancement	6.25	2
Finance	6.08	5
Architecture/Building	5.87	6

TABLE 2.4. COMPOSITE RANKING AND SCORES OF OBJECTIVES

Composite Ranking and Scores of Facility Objectives

OBJECTIVE CLASSIFICATION KEY

■	Transfer	⌘	Modal Enhancement
◆	Safety/Security	♣	Physical Environment
●	Access	♥	Nonphysical Environment
✱	Efficiency	◻	Space/Site
★	Passenger	⊙	Architectural/Building
$	Financial	✪	Coordination

OBJECTIVE CATEGORY KEY

Mode Interface Objectives
Internal Objectives
System Objectives
External Objectives

Rank	Objective	Type	Rating
1	Maximize reliability of transfers	■	9.0
2	Maximize security	◆	8.8
3	Maximize safety and security of operations of modes	◆	8.7
4	Minimize institutional barriers to transferring	■	8.6
5	Maximize passenger information	■	8.5
5	Achieve handicapped access	●	8.5
7	Maximize safety	◆	8.4
7	Maximize user benefits	■	8.4
9	Maximize reliability of facility services	✱	8.3
9	Maximize system legibility	■	8.3
11	Maximize efficient access and egress	●	8.2
11	Minimize disorientation and confusion	■	8.2
11	Maximize coordination of transfer scheduling	■	8.2
14	Minimize waiting	✱	8.1
15	Minimize physical barriers to transferring between modes	■	8.0
15	Minimize physical barriers to handicapped	●	8.0
17	Minimize queuing delays	✱	7.9
18	Minimize difficulty of ticketing or fare payment	✱	7.8
18	Maximize ease of operations for modes	✱	7.8
18	Maximize passenger comfort	★	7.8
18	Maximize weather protection	★	7.8
22	Maximize system coordination of information and fares	■ ✪	7.6
23	Maximize directness of paths for modes	✱	7.4
23	Maximize ease of fare collection	✱	7.4
23	Maximize amount of connections between routes	■	7.4
23	Minimize negative cultural impacts in surrounding neighborhood	♥	7.4
27	Minimize path conflicts between modes	●	7.3
27	Maximize directness of path	✱	7.3
29	Achieve elimination of hazardous materials	♣	7.2
29	Maximize quality of waiting areas	★	7.2
31	Minimize costs	$	7.1
31	Maximize joint development	$	7.1

TABLE 2.4 (CONT.). COMPOSITE RANKING AND SCORES OF OBJECTIVES

OBJECTIVE CLASSIFICATION KEY

■	Transfer	⌘	Modal Enhancement
◆	Safety/Security	♣	Physical Environment
●	Access	♥	Nonphysical Environment
✸	Efficiency	◻	Space/Site
★	Passenger	⊙	Architectural/Building
$	Financial	✪	Coordination

OBJECTIVE CATEGORY KEY

Mode Interface Objectives
Internal Objectives
System Objectives
External Objectives

Rank	Objective	Type	Rating
33	Minimize barriers	●	7.0
33	Minimize exertion	★	7.0
33	Maximize market areas for each mode	⌘	7.0
33	Maximize community pride	♥	7.0
33	Minimize negative social impacts in surrounding neighborhood	♥	7.0
33	Minimize physical impacts to surrounding neighborhood	♣	7.0
33	Maximize flexibility for expansion	◻	7.0
40	Minimize difficulty of baggage handling	★	6.9
40	Maximize pedestrian assists	✸	6.9
40	Minimize path length	✸	6.9
40	Minimize crowding	★	6.9
40	Achieve compliance with historic preservation requirements	♣	6.9
45	Minimize conflicting paths	✸	6.8
46	Minimize maintenance requirements	⊙	6.7
46	Minimize service duplication	✸	6.7
46	Achieve property rights	◻	6.7
46	Achieve same or lower air pollution emissions	♣	6.7
46	Minimize conflict with surrounding land uses, existing & proposed	♣	6.7
51	Maximize aesthetics	⊙	6.6
51	Maximize quality of architectural design	⊙	6.6
53	Maximize amenities	★	6.5
53	Maximize sense of place, historic significance, community image	♥	6.5
55	Minimize regional air pollution emissions	♣	6.4
56	Minimize construction impacts	♣	6.3
56	Minimize disruptive land acquisition	♥	6.3
58	Minimize level changes	✸	6.1
59	Minimize fare inconsistencies	$ ✪	6.0
60	Maximize urban renewal	◻	5.9
61	Maximize reuse of existing buildings/infrastructure	◻	5.8
61	Maximize positive cultural and social elements	♥	5.8
61	Maximize use of local employment	♥	5.8
64	Maximize alternative uses of time while waiting	★	5.7
64	Maximize openness of interior design	⊙	5.7
66	Minimize regional energy consumption	♣	5.6
67	Minimize wasted space	⊙	5.5
67	Minimize negative impact on existing transportation services	$ ⌘	5.5
69	Maximize income from nontransport activities	$	4.7
70	Maximize informal vending	⊙	4.1

TABLE 2.5. RANKING AND SCORES OF SYSTEM OBJECTIVES

Rank	System Objectives	Score
1	Maximize user benefits	8.4
2	Maximize system legibility	8.3
3	Maximize coordination of transfer scheduling	8.2
4	Maximize system coordination of information and fares	7.6
5	Maximize amount of connections between routes	7.4
6	Minimize costs	7.1
7	Maximize market areas for each mode	7.0
8	Minimize service duplication	6.7
9	Minimize regional air pollution emissions	6.4
10	Minimize fare inconsistencies	6.0
11	Minimize regional energy consumption	5.6
12	Minimize negative impact on existing transportation services	5.5
13	Maximize income from nontransport activities	4.7
	Average	6.84

TABLE 2.6. RANKING AND SCORES OF MODE INTERFACE OBJECTIVES

Rank	Mode Interface Objectives	Score
1	Maximize reliability of transfers	9.0
2	Maximize safety and security of operations of modes	8.7
3	Minimize institutional barriers to transferring	8.6
4	Maximize efficient access and egress	8.2
5	Minimize waiting	8.1
6	Minimize physical barriers to transferring between modes	8.0
7	Minimize difficulty of ticketing or fare payment	7.8
7	Maximize ease of operations for modes	7.8
9	Maximize directness of paths for modes	7.4
10	Minimize path conflicts between modes	7.3
11	Minimize difficulty of baggage handling	6.9
	Average	7.98

TABLE 2.7. RANKING AND SCORES OF INTERNAL OBJECTIVES

Rank	Internal Objectives	Score
1	Maximize security	8.8
2	Maximize passenger information	8.5
2	Achieve handicapped access	8.5
4	Maximize safety	8.4
5	Maximize reliability of facility services	8.3
6	Minimize disorientation and confusion	8.2
7	Minimize physical barriers to handicapped	8.0
8	Minimize queuing delays	7.9
9	Maximize passenger comfort	7.8
9	Maximize weather protection	7.8
11	Maximize ease of fare collection	7.4
12	Maximize directness of path	7.3
13	Achieve elimination of hazardous materials	7.2
13	Maximize quality of waiting areas	7.2
15	Minimize barriers	7.0
15	Minimize exertion	7.0
17	Maximize pedestrian assists	6.9
17	Minimize path length	6.9
17	Minimize crowding	6.9
20	Minimize conflicting paths	6.8
21	Minimize maintenance requirements	6.7
22	Maximize aesthetics	6.6
23	Maximize amenities	6.5
24	Minimize level changes	6.1
25	Maximize alternative uses of time while waiting	5.7
25	Maximize openness of interior design	5.7
27	Minimize wasted space	5.5
	Average	7.24

TABLE 2.8. RANKING AND SCORES OF EXTERNAL OBJECTIVES

Rank	External Objectives	Score
1	Minimize negative cultural impacts in surrounding neighborhood	7.4
2	Maximize joint development	7.1
3	Maximize community pride	7.0
3	Minimize negative social impacts in surrounding neighborhood	7.0
3	Minimize physical impacts to surrounding neighborhood	7.0
3	Maximize flexibility for expansion	7.0
7	Achieve compliance with historic preservation requirements	6.9
8	Achieve property rights	6.7
8	Achieve same or lower air pollution emissions	6.7
8	Minimize conflict with surrounding land uses, existing/proposed	6.7
11	Maximize quality of architectural design	6.6
12	Maximize sense of place, historic significance, community image	6.5
13	Minimize construction impacts	6.3
13	Minimize disruptive land acquisition	6.3
15	Maximize urban renewal	5.9
16	Maximize reuse of existing buildings and infrastructure	5.8
16	Maximize positive cultural and social elements	5.8
16	Maximize use of local employment	5.8
19	Maximize informal vending	4.1
	Average	*6.45*

Chapter 3. Principles of Facility Location

Overview

Location Criteria

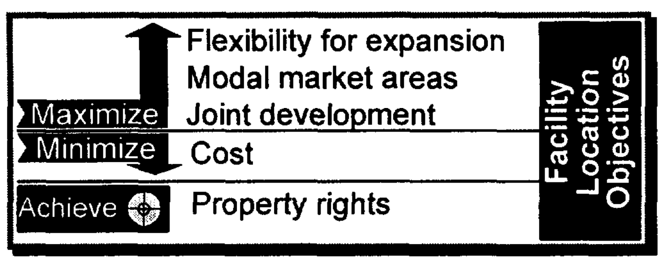
The art and science of locating a transfer facility can be summarized by just two rules:

Rule One	Rule Two
Maximize ease of access from modal markets	*Maximize potential transfers between modes*

Obviously, there are other considerations. Cost, environmental impact, site availability and opportunities for joint development and historic preservation all relate to location. In fact, most of the generic objectives are affected in some way or another by the choice of site. *However, an intermodal facility ultimately will be judged by its ability to serve passengers, and its location is critical to the quality of that service.*

Since determining the location of an intermodal facility is a large job in itself, there are advantages to writing and scoring a series of location criteria prior to evaluating generic objectives.

Example Location Criteria. Table 3.1 lists the seven location criteria for the Jacksonville intermodal facility. Each location criteria was rated by a local panel for importance on a 1 (unimportant) to 5 (important) scale. Only one criterion related to site suitability, with the remaining 6 criteria related to modal access. The panel consisted of 20 people, about half representing modal operators and the remainder representing public agencies and community groups.



Location criteria should be fair to all possible sites. Consequently, it is important for criteria be created and scored without reference to a preferred site. The Jacksonville panel gave a large score to good highway access but did not consider pedestrian or bicycle access to be especially important. The low score for pedestrian

TABLE 3.1. SITING CRITERIA FOR JACKSONVILLE INTERMODAL FACILITY

Siting Criteria	Score*
Locate the terminal to have direct access to one or more existing, improved or planned roadways which are either an interstate or state principal arterial	4.50
Locate the terminal on existing rail lines and/or railroad rights-of-way to minimize or eliminate the acquisition of significant new rail rights-of-way or new trackage	4.50
Locate terminal to accommodate within the site the present and future program requirement of all modes proposed to be served	4.47
Locate the terminal to complement the peoplemover which will in the future be the primary traffic circulation system serving the downtown area	3.95
Locate the terminal to be compatible with the existing and proposed traffic circulation on regional and local roads	4.05
Locate the terminal to have a good visibility from major approach roadways	3.95
Locate the terminal to be accessible for safe bicycle and pedestrian traffic access and circulation	3.00

**Note: Average ratings on a scale of 1 (unimportant) to 5 (very important).*

access has two possible explanations: (1) pedestrian access is truly unimportant or (2) the panel members were showing strong preference for a particular site without good pedestrian access. It is not possible to eliminate bias toward certain sites. However, bias can be reduced by choosing panel members without vested interests in a specific site, by phrasing the criteria to be general for all possible sites and by having sufficient criteria to cover all possible modes and site considerations.

Modal Access

Figure 3.1 is a modal access worksheet. The worksheet is a tool for quickly screening sites for their accessibility by all possible modes. The worksheet provides space for rating the ease of serving a site and rating the expected traffic volume from each mode. Ease of service is rated between 0 (no access possible) and 4 (access readily available). Traffic volume is rated between 0 (no traffic) and 4 (high traffic volume, measured in persons per day). When access is not possible or when the mode is technically infeasible, there can be no traffic.

In general, intermodal transfer facilities are better when there are many transfer opportunities and many travelers are using the facility. Thus, a rough measure of modal access for a site is the sum across all modes of the traffic rating multiplied by the ease rating. With this scoring system, the best possible score of a mode is 16.

An example modal access evaluation is illustrated in Figure 3.2. In this example Site 3 had the best accessibility. For each site it was assumed that access was possible for all modes and that all modes were technically feasible.

Modal Access Worksheet

Site________________

Mode	Ease	Traffic	Ease x Traffic
Automobile: Kiss-n-Ride	0 1 2 3 4	0 1 2 3 4	
Automobile: Park-n-Ride	0 1 2 3 4	0 1 2 3 4	
Automobile: Private HOV	0 1 2 3 4	0 1 2 3 4	
Automobile: Package Drop Off	0 1 2 3 4	0 1 2 3 4	
Automobile: Disabled	0 1 2 3 4	0 1 2 3 4	
Automobile: Rental	0 1 2 3 4	0 1 2 3 4	
Station Cars	0 1 2 3 4	0 1 2 3 4	
Pedestrian: Abled	0 1 2 3 4	0 1 2 3 4	
Pedestrian: Disabled	0 1 2 3 4	0 1 2 3 4	
Light Rail Transit (LRT)	0 1 2 3 4	0 1 2 3 4	
Metrorail	0 1 2 3 4	0 1 2 3 4	
Personal Rapid Transit (PRT)	0 1 2 3 4	0 1 2 3 4	
Pedestrian Assist Systems	0 1 2 3 4	0 1 2 3 4	
Group Rapid Transit (Peoplemover)	0 1 2 3 4	0 1 2 3 4	
Vertical Takeoff and Landing (VTOL)	0 1 2 3 4	0 1 2 3 4	
Short Takeoff and Landing (STOL)	0 1 2 3 4	0 1 2 3 4	
Local Bus	0 1 2 3 4	0 1 2 3 4	
Express Bus	0 1 2 3 4	0 1 2 3 4	
Intercity Bus	0 1 2 3 4	0 1 2 3 4	
Shuttles, Trams	0 1 2 3 4	0 1 2 3 4	
Tours, Limos, School Buses	0 1 2 3 4	0 1 2 3 4	
Taxis	0 1 2 3 4	0 1 2 3 4	
Bicycles	0 1 2 3 4	0 1 2 3 4	
Motorcycles	0 1 2 3 4	0 1 2 3 4	
Commuter Rail	0 1 2 3 4	0 1 2 3 4	
Intercity Rail: Conventional	0 1 2 3 4	0 1 2 3 4	
Intercity Rail: High Speed	0 1 2 3 4	0 1 2 3 4	
Handicapped Service	0 1 2 3 4	0 1 2 3 4	
Historic Vehicles	0 1 2 3 4	0 1 2 3 4	
Private Boats	0 1 2 3 4	0 1 2 3 4	
Water Taxi	0 1 2 3 4	0 1 2 3 4	
		Total	

Instructions:

1. Rate ease of serving the site. Ease of service is rated between 0 (no access possible) and 4 (access readily available).
2. Rate expected traffic volume from each mode. Traffic volume is rated between 0 (no traffic) and 4 (high traffic volume). Traffic volume is measured in persons per day.
3. **Multiply traffic rating by ease rating. Sum totals for each mode.**

FIGURE 3.1. MODAL ACCESS WORKSHEET

Modal Access Worksheet — Site: #1

Mode	Ease	Traffic	Ease x Traffic
Automobile: Kiss-n-Ride	0 1 2 3	0 1 2 3	2
Automobile: Park-n-Ride	0 1 2 3	0 1 2 3	1
Light Rail Transit (LRT)	0 1 2 3	0 1 2 3	6
Local Bus	0 1 2 3	0 1 2 3	8
Intercity Bus	0 1 2 3	0 1 2 3	6
Taxis	0 1 2 3	0 1 2 3	2
Bicycles	0 1 2 3	0 1 2 3	4
Motorcycles	0 1 2 3	0 1 2 3	2
Pedestrian	0 1 2 3	0 1 2 3	6
Intercity Rail	0 1 2 3	0 1 2 3	6
		Total	43

Modal Access Worksheet — Site: #2

Mode	Ease	Traffic	Ease x Traffic
Automobile: Kiss-n-Ride	0 1 2 3	0 1 2 3	12
Automobile: Park-n-Ride	0 1 2 3	0 1 2 3	1
Light Rail Transit (LRT)	0 1 2 3	0 1 2 3	9
Local Bus	0 1 2 3	0 1 2 3	8
Intercity Bus	0 1 2 3	0 1 2 3	6
Taxis	0 1 2 3	0 1 2 3	2
Bicycles	0 1 2 3	0 1 2 3	4
Motorcycles	0 1 2 3	0 1 2 3	3
Pedestrian	0 1 2 3	0 1 2 3	8
Intercity Rail	0 1 2 3	0 1 2 3	6
		Total	59

Modal Access Worksheet — Site: #3

Mode	Ease	Traffic	Ease x Traffic
Automobile: Kiss-n-Ride	0 1 2 3	0 1 2 3	4
Automobile: Park-n-Ride	0 1 2 3	0 1 2 3	2
Light Rail Transit (LRT)	0 1 2 3	0 1 2 3	12
Local Bus	0 1 2 3	0 1 2 3	16
Intercity Bus	0 1 2 3	0 1 2 3	9
Taxis	0 1 2 3	0 1 2 3	6
Bicycles	0 1 2 3	0 1 2 3	2
Motorcycles	0 1 2 3	0 1 2 3	3
Pedestrian	0 1 2 3	0 1 2 3	4
Intercity Rail	0 1 2 3	0 1 2 3	8
		Total	66

Instructions

1. Rate ease of serving the site. Ease of service is rated between 0 (no access possible) and 4 (access readily available).
2. Rate expected traffic volume from each mode. Traffic volume is rated between 0 (no traffic) and 4 (high traffic volume). Traffic volume is measured in persons per day.
3. Multiply traffic rating by ease rating. Sum totals for each mode.

FIGURE 3.2. EXAMPLE MODAL ACCESS ANALYSIS

Procedure: Quick Market Boundary Analysis

Purpose

To roughly determine the extent of the market area for the facility, relative to other facilities in the region. Market areas will vary depending upon the access mode.

Steps

Step 1. Obtain scaled maps. Obtain a scaled map of the region containing transfer facilities. The map should be sufficiently large for accurate measurement of distances between facilities. Obtain scaled maps of each applicable mode.

Step 2. Locate other facilities. Determine the location of all competing facilities and find the airline distance (miles or km) between all pairs of facilities. Over-the-road distance is not used in this procedure.

Step 3. Select a line-haul mode and a single final destination. Market boundaries cannot be drawn without knowing the final destination and mode of travel between the facility and the final destination. The different fares and travel times to the final destination can greatly influence the size of market boundaries.

Step 4. Determine line-haul mode data. For the selected line-haul mode at each facility, determine:

A. Fare ($);
B. Travel time (minutes); and
C. A value of time during line-haul travel ($/minute).

If the fare is the same at all stations, then it may be ignored.

Step 5. List and describe each major access mode. Access is typically by automobile and walking, but it is important to be more precise. Market boundaries can differ greatly depending upon how an automobile is used to gain access. For example, kiss-n-ride automobile will result in a much different market boundary than park-n-ride automobile.

Step 6. Determine access mode data. For each access mode, determine:

A. Perceived vehicle operating costs per mile ($/mile or $/km);
B. Parking charges (attributable to a single one-way trip, $);
C. Average speed of access from all possible origins (mph or k/h);
D. A value of time during access ($/minute); and
E. Time necessary to transfer from the access mode to the line-haul mode (minutes).

Remember that kiss-n-ride access usually involves much more travel time than park-n-ride access. If either the parking charges or the transfer time is the same at all stations, it may be ignored. It would be appropriate to find a weighted time for the transfer, considering all segments (see the Chapter 1 for appropriate disutility weights and penalties).

Step 7. Calculate line-haul costs. Determine generalized line-haul cost to the final destination for all facilities and for all access modes from this formula.

> line-haul cost =
> (line-haul time + transfer time)(line-haul value of time) +
> (fare) + (parking)

Step 8. Calculate costs per unit distance. Determine generalized access cost per unit distance (mile or km) during access from this formula.

> access cost per unit distance =
> (operating costs per unit distance) +
> (access value of time)(60)/(access speed)

Step 9. Calculate airline costs. Determine airline cost per unit distance (mile or km) with a circuity factor. Circuity factors are usually taken to be approximately 1.2.

> airline cost per unit distance =
> (access cost per unit distance)(circuity factor)

Step 10. Determine distance advantage. For each pair of facilities, determine the airline distance advantage of the lower cost station.

> distance advantage =
> [(higher line-haul cost) - (lower line-haul cost)]
> /(airline cost per unit distance)

Should the distance advantage be greater than the actual airline distance between stations, the lower cost station *dominates* the higher cost station. That is, it would never be advantageous to go to the higher cost station, regardless of origin. No market boundary exists.

Step 11. Determine shortest distance to market boundary. For each pair of stations, determine the point where the market boundary intersects the line between the two facilities.

distance to MB from lower cost facility =
[(airline distance) + (distance advantage)]/2

distance to MB from higher cost facility =
[(airline distance) - (distance advantage)]/2

Step 12. Sketch market boundary. For each pair of stations, sketch the market boundary. Should the two facilities have equal costs, then the market boundary is the perpendicular bisector of the line between the two facilities. Otherwise, the market boundary is a hyperbola with the following properties: (a) it will be symmetrical about the line between the two stations; (b) it will be closer to the higher cost facility; and (c) it will bend around the higher cost facility.

The market boundary is the curve that will satisfy the following relation.

(distance to lower cost facility) - (distance to higher cost facility) =
distance advantage

The method for plotting a boundary is illustrated in Figure 3.3. Select arbitrary values of d_L and d_H such that their difference is the distance advantage. Use a compass to locate points on the boundaries.

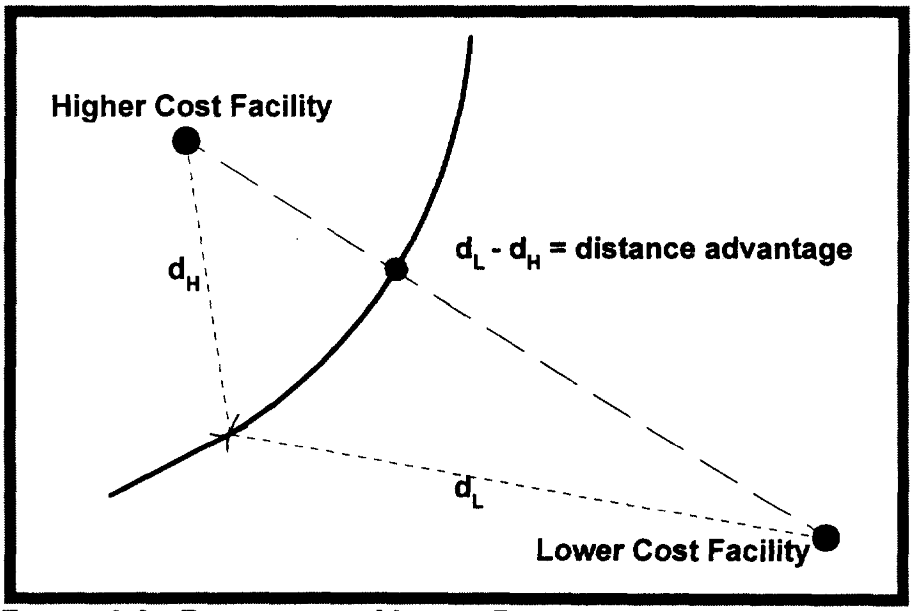


FIGURE 3.3. PLOTTING THE MARKET BOUNDARY

Step 13. Build market areas. Assign all places on the map to the market area of one and only one facility. If more than two facilities are being analyzed, there may be places that could be assigned to more than one facility. For each such ambiguous place, assign it to the facility with the lowest total cost (access plus line-haul). In most cases, this assignment can be made by inspection.

Example: High Speed Rail Station Location

Steps 1-6. Prepare data. Three stations are being considered for high-speed rail: Airport, Downtown and Westside. These locations are shown in Figure 3.4.

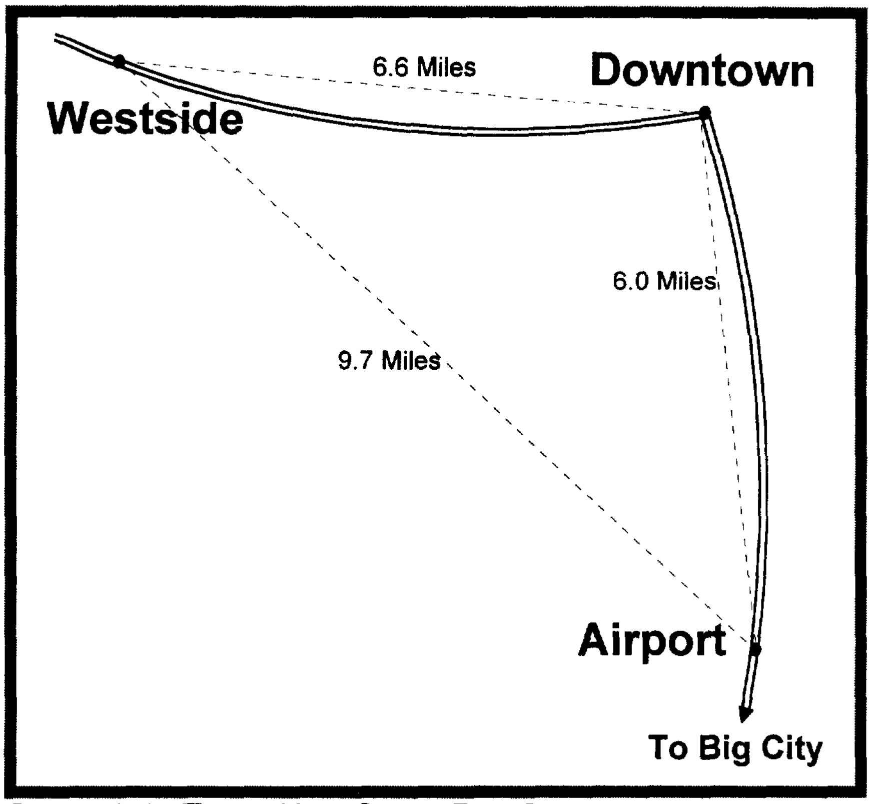


FIGURE 3.4. THREE HIGH SPEED RAIL STATIONS

Table 3.2 shows the travel time and costs for each station. There are three access modes: park-n-ride, kiss-n-ride and taxi. Table 3.3 provides the necessary access mode data. Note that the value of time is higher for kiss-n-ride because of the need to account for the time of both driver and passenger. Only park-n-ride vehicles require parking and only taxi has a per mile monetary charge.

TABLE 3.2. TRAVEL TIMES AND COSTS FOR EACH STATION

	Time to Big City	Daily Parking	One-Way Fare
Airport	45 min	$4.00	$10.00
Downtown	52 min	$3.00	$11.00
Westside	61 min	$1.00	$12.00

TABLE 3.3. ACCESS MODE DATA

	Value of Time	Cost per Mile	Parking Required
Park-n-Ride	$0.10/min	$0.00/mile	Yes
Kiss-n-Ride	$0.20/min	$0.00/mile	No
Taxi	$0.10/min	$1.50/mile	No

In addition, transfer times are the same at all stations; the line-haul value of time is $0.10/minute; the average speed is 36 mph; and the circuity factor is 1.2.

Step 7. Generalize line-haul costs. Line-haul costs are estimated by the previously presented equation. The calculations and answers are presented in Table 3.4. In this example, transfer time is the same everywhere and is ignored. For each access mode, the highest cost station is Westside and the lowest cost station is Airport.

TABLE 3.4. ACCESS MODE COSTS

	Cost for Each Access Mode ($)		
	Park-n-Ride	Kiss-n-Ride	Taxi
Airport	45*0.1+10+4/2=16.5	45*0.1+10+0=14.5	45*0.1+10+0=14.5
Downtown	52*0.1+11+3/2=17.7	52*0.1+11+0=16.2	52*0.1+11+0=16.2
Westside	61*0.1+12+1/2=18.6	61*0.1+12+0=18.1	61*0.1+12+0=18.1

Steps 8-9. Generalize access costs and airline costs. Generalized costs are shown in Table 3.5. The taxi is much more expensive than the other two modes, so its airline costs will have a larger effect on the placement of market boundaries.

TABLE 3.5. GENERALIZED COSTS

	Access Cost per Mile	Airline Cost per Mile
Park-n-Ride	0+0.1*60/36=0.167	0.167*1.2=0.20
Kiss-n-Ride	0+0.2*60/36=0.333	0.333*1.2=0.40
Taxi	1.50+0.1*60/36=1.667	1.667*1.2=2.00

Step 10. Distance advantage. The distance advantages, measured in miles, are calculated in Table 3.6. When using the distance advantage to plot market boundaries, it is necessary to know which station is the highest cost. In this example, the highest cost station is always Westside and the lowest cost station is always Airport.

TABLE 3.6. DISTANCE ADVANTAGES

	Distance Advantage (Miles)		
	Park-n-Ride	Kiss-n-Ride	Taxi
Downtown-Airport	(17.7-16.5)/0.2=6	(16.2-14.5)/0.4=4.25	(16.2-14.5)/2.0=0.85
Westside-Airport	(18.6-16.5)/0.2=10.5	(18.1-14.5)/0.4=9	(18.1-14.5)/2.0=1.8
Westside-Downtown	(18.6-17.7)/0.2=4.5	(18.1-16.2)/0.4=4.75	(18.1-16.2)/2.0=0.95

Step 11. Calculate shortest distance to market boundary. Calculation of the shortest distance to the market boundary is shown on Table 3.7. For the park-n-ride access mode, Airport dominates. The distance advantage of Airport over Downtown and Airport over Westside is greater than the respective distances between stations. Thus, no market boundary exists.

TABLE 3.7. DISTANCE TO MARKET BOUNDARY

	Distance to Market Boundary (Miles)		
	Park-n-Ride	**Kiss-n-Ride**	**Taxi**
Downtown-Airport	No Boundary*	(4.25+6)/2=5.125	(0.85+6)/2=3.4
Westside-Airport	No Boundary*	(9+9.7)/2=9.4	(1.8+9.7)/2=5.8
Westside-Downtown	(4.5+6.6)/2=5.6	(4.75+6.6)/2=5.7	(0.95+6.6)/2=3.8

Step 12-13. Sketch market boundaries and areas. Because Airport dominates both Downtown and Westside, the market boundary between Westside and Downtown is irrelevant. All park-n-ride trips should go to Airport, and no sketch is necessary. The kiss-n-ride and taxi market boundaries are more interesting. For kiss-n-ride it is first necessary to develop a table of arbitrary values of d_L and d_H whose difference is the distance advantage. For the Downtown to Airport boundary, the table would look like Table 3.8.

TABLE 3.8. SHORTEST DISTANCES TO MARKET BOUNDARY

Point	d_L	d_H	Difference
0	5.125	0.875	4.25
1	5.625	1.375	4.25
2	6.125	1.875	4.25
3	6.625	2.375	4.25

Point 0 is on the direct line between the two stations, and points 1 to 3 are arbitrary. The market boundaries are illustrated in Figure 3.5.

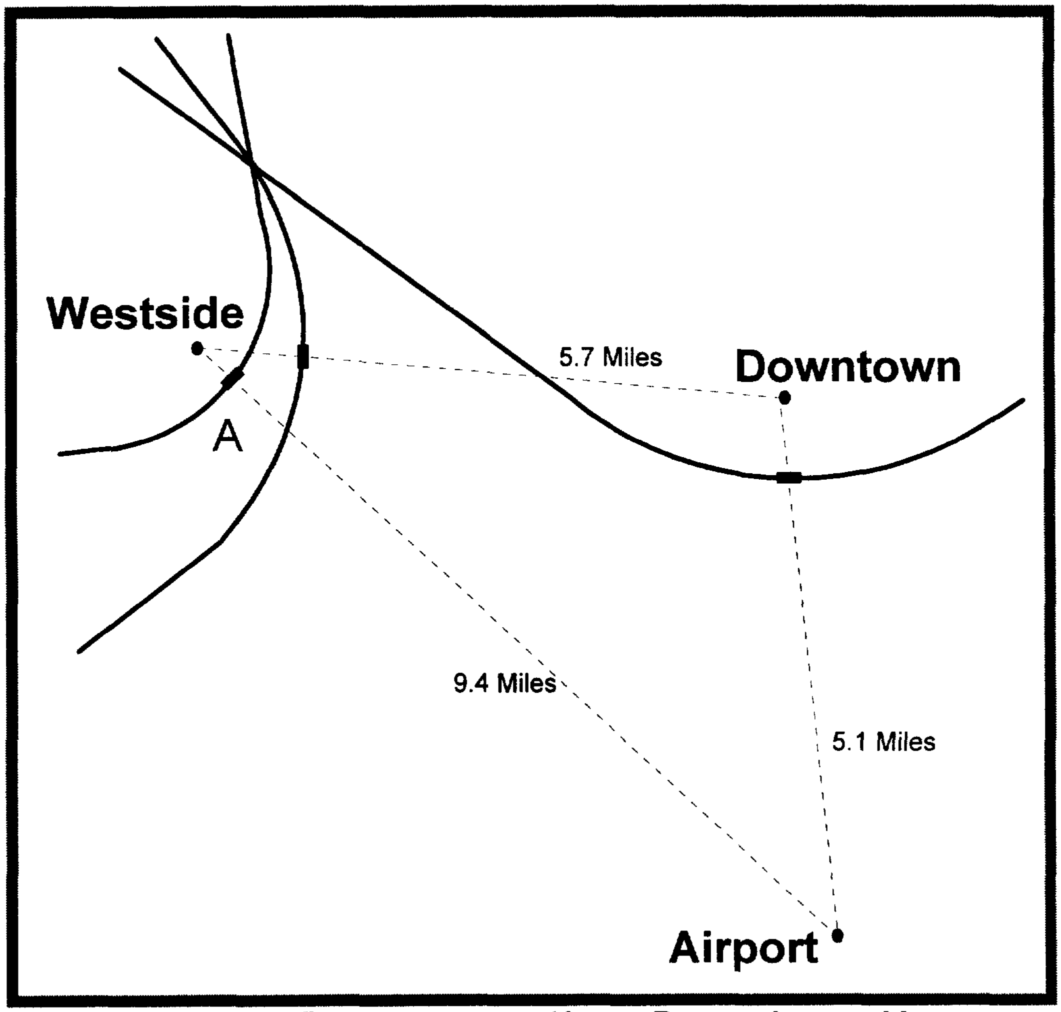


FIGURE 3.5. MARKET BOUNDARIES WITH KISS-N-RIDE AS ACCESS MODE

The places within each market area are evident from Figure 3.5. The places designated as "A" are part of Airport's market area; at those places Westside is preferred to Downtown, but Airport is preferred to Westside. Figure 3.5 shows that all three market boundaries intersect at a point. This intersection is a typical result and it can be used as an aid to determine whether the market boundaries have been drawn properly.

The market boundaries for taxi are illustrated in Figure 3.6. The places within each market area are evident from this sketch. The places designated as "A" are part of Airport's market area; here Downtown is preferred to Westside, but Airport is preferred to Downtown.

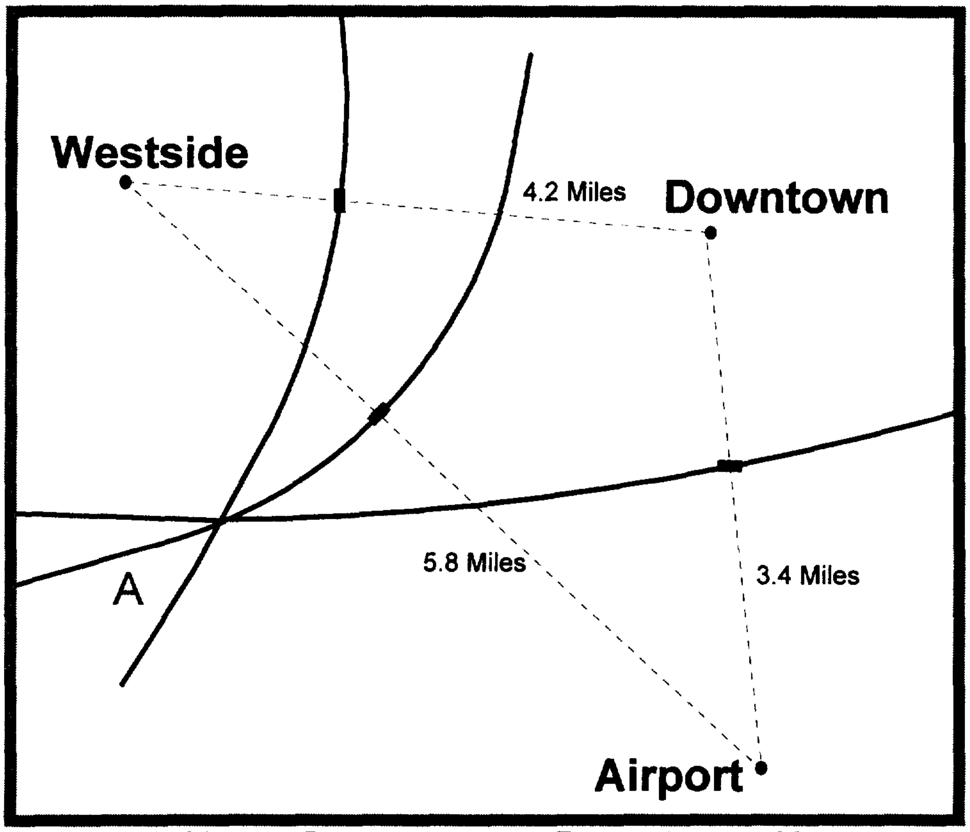


FIGURE 3.6. MARKET BOUNDARIES WITH TAXI AS ACCESS MODE

Discussion

The market boundaries are only as accurate as the airline distance assumption and the constant speed assumption. For the purposes of roughly siting facilities, these assumptions are usually good enough. More accurate sketching of market boundaries requires a separate network for each access mode.

Procedure: Computerized Market Boundary Analysis

Purpose

To determine precisely the extent of the market area for the facility, relative to other facilities in the region. Market areas will vary depending upon the access mode.

Requirements

- Network editing or building software.
- A computer program capable of finding a shortest path through a network.

Steps

Step 1. Conduct Quick Market Boundary Analysis. Complete the Quick Market Boundary Analysis to get a rough idea of the final results.

Step 2. Build network. Using suitable network-building software, for each access mode prepare a separate access network to all transfer facilities. As appropriate for that access mode, provide link times, node delays, waiting times, transfer times and transfer penalties. Link times should include (suitably weighted) monetary costs of travel, including fares and operating costs. Computer programs for network building are typically supplied with travel forecasting packages. The examples in this chapter were prepared with QRS II and the General Network Editor, but any of the major travel forecasting packages would have sufficed.

As a way of simplifying local bus access networks, it is recommended that bus-to-bus transfers at some distance from the transfer facility be omitted. In effect, most routes that do not directly connect to a transfer facility should be eliminated from the access network. Figure 3.7a shows a local bus network near an intermodal transfer facility. Its simplified representation is illustrated in Figure 3.7b.

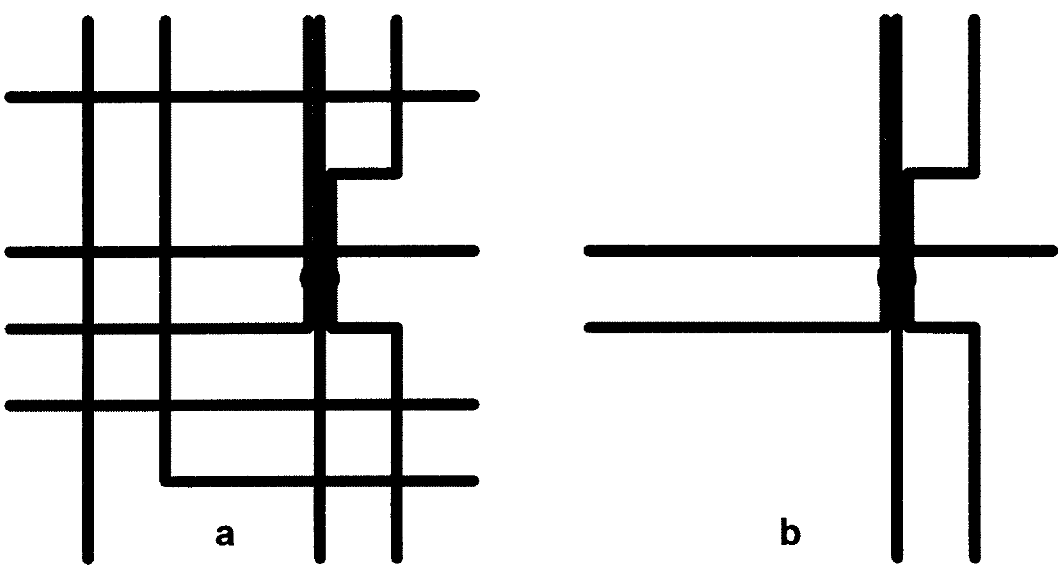


FIGURE 3.7. SIMPLIFYING A LOCAL BUS ACCESS NETWORK BY ELIMINATING TRANSFERS

Omitting bus transfers greatly reduces network complexity; the only trips not represented are those that would need to make multiple transfers, which is a relatively infrequent trip.

Step 3. Select final destination. Create a single node to be the final destination. In most software packages, this node should be capable of being an origin or destination for trips. This type of node is usually called a "centroid". Provide one link from each transfer facility to this final destination node. The time on such a link should be a suitably constructed disutility function containing the following trip elements.

A. Fare;
B. Line-haul time;
C. Parking charges at the facility; and
C. Transfer time at the facility.

Refer to Chapter 1 for more specific guidelines on constructing disutility functions.

Figure 3.8 illustrates how an access network should be drawn. There are two stations, North and South, and a single final destination. Each station is connected to the final destination with a link. The final destination is much further away from either station than is shown in this figure.

Step 4. Reverse links. Reverse the direction of all links in the network. If the travel times on each two-way link are the same for both directions, then it is only necessary to reverse one-way links.

Step 5. Build tree. Build a shortest path tree from the final destination to the rest of the network. Since the links have been reversed, the resulting tree will actually constitute the shortest paths from all origins to the final destination.

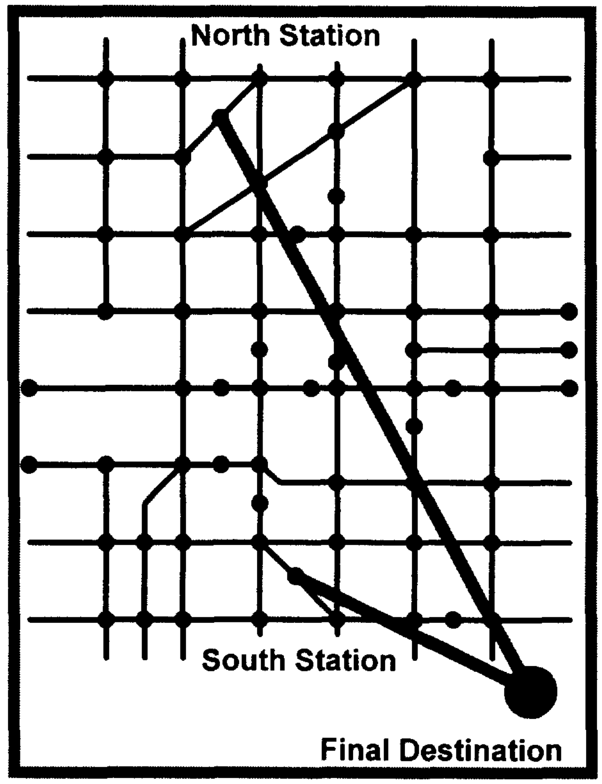


FIGURE 3.8. A KISS-N-RIDE ACCESS TO TWO STATIONS

Step 6. Outline subtrees. If a facility is not dominated, it will have a subtree of links and nodes emanating from it. See Figure 3.9 for the shortest path subtrees from the network of Figure 3.8. Outline the subtrees from each facility. This outlining process is illustrated in Figure 3.10. The outlines will show the precise market boundaries. Compare the precise market boundaries to the quick market boundaries (Step 1) to determine if the results are reasonable.

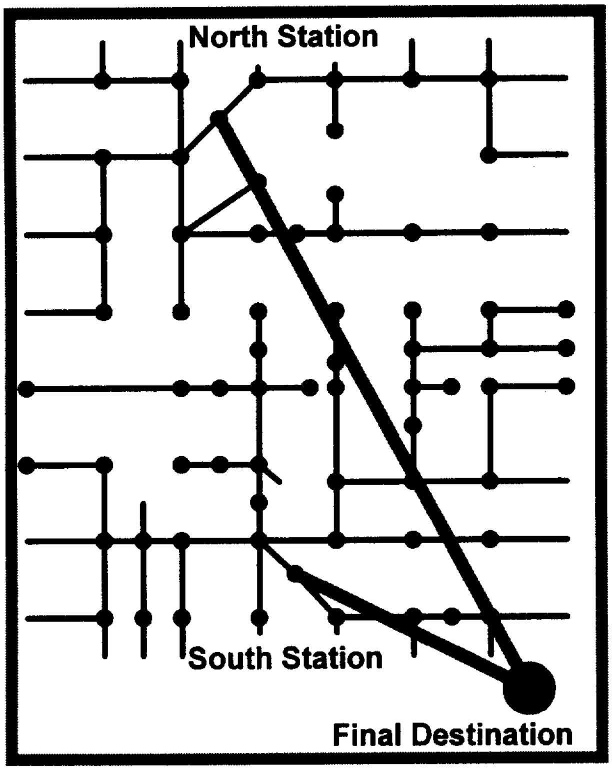


FIGURE 3.9. SUBTREES FOR EACH FACILITY

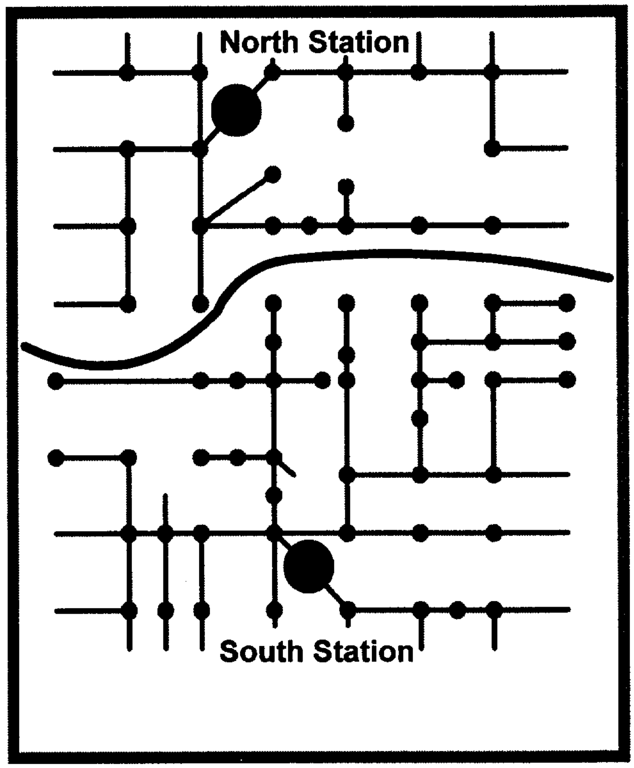


FIGURE 3.10. OUTLINING SUBTREES TO CREATE MARKET AREAS

Example: High Speed Rail Station Location

Step 1. Complete Quick Market Boundary Analysis. This example problem involves the same three stations as before, so refer to the previous sections for the solution to the quick market boundary analysis.

Step 2. Build network. Shown in Figure 3.11 is a network that consists of major arterials in Our City. Speeds on surface arterials were set to either 20 or 25 mph, speeds on freeways were set to 50 mph and freeway ramp speeds were set to 30 mph. Congestion effects were ignored. Link travel times were calculated for each access mode, as follows.

A. Park-n-Ride.

Link Time = (60)(Link Length)/Speed

where Link Length is in miles, Speed is in mph, and 60 is the number of minutes in an hour.

B. Kiss-n-Ride.

$$\text{Link Time} = (2)(60)(\text{Link Length})/\text{Speed}$$

where the 2 weights travel by kiss-n-ride at twice that for park-n-ride and the other terms are the same as before.

C. Taxi.

$$\text{Link Time} = (\text{Link Length})[60/\text{Speed} + (\text{Fare Rate})/(\text{Value of Time})]$$

where the Fare Rate is $1.50/mile and the Value of Time is $0.10/min.

Step 3. Select final destination. Connector links were drawn between each of the stations and a single node (called To Big City). A weighted travel time (or impedance) was given to each link according to the following formula.

$$\text{Connector Time} = \text{Line-Haul Time} + (\text{Parking}/2 + \text{Fare})/(\text{Value of Time})$$

The completed network is illustrated in Figure 3.9.

Steps 4-6. Reverse links, build tree and outline subtrees. After reversing the direction of links, a shortest path tree was built from the To Big City node to the remaining parts of the network. Since the network was reversed, this is the set of shortest paths from all possible origins to the final destination. The subtrees from each facility were identified and outlined. The park-n-ride tree is shown in Figure 3.12 and the taxi tree is shown in Figure 3.13.

Comparison to Quick Analysis

For the park-n-ride access mode, the Westside station is dominated by the Airport. Downtown has a small market area and it is quite volatile; a slight increase in costs at this station would cause it to lose its whole market area. For the taxi access mode the market areas are more equitable. Westside serves the whole far western portion of the Our City. Downtown serves the middle and northeast areas and the Airport serves the southern-most portions of Our City.

FIGURE 3.11. SOUTHERN AND MIDDLE PORTIONS OF OUR CITY HIGHWAY ACCESS NETWORK FOR PARK-N-RIDE, KISS-N-RIDE AND TAXI

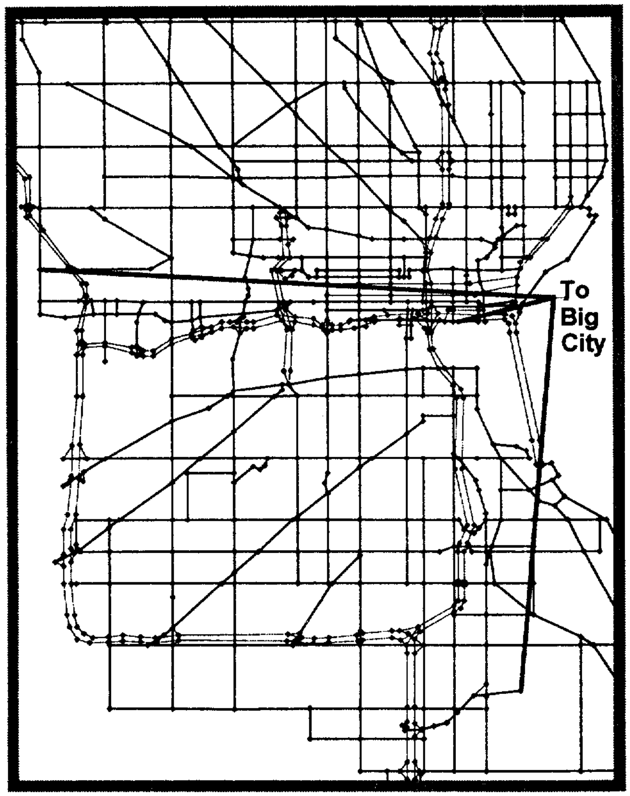


FIGURE 3.12. MARKET BOUNDARIES FOR PARK-N-RIDE

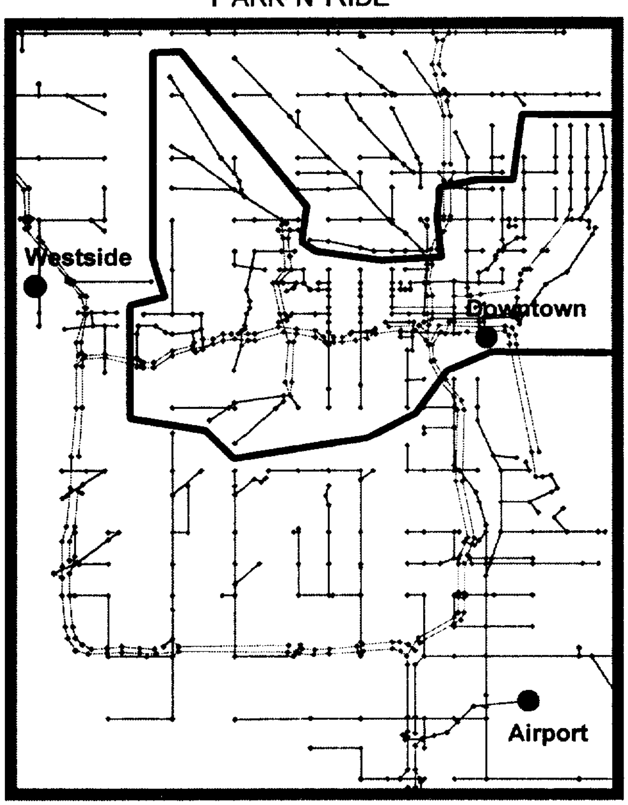
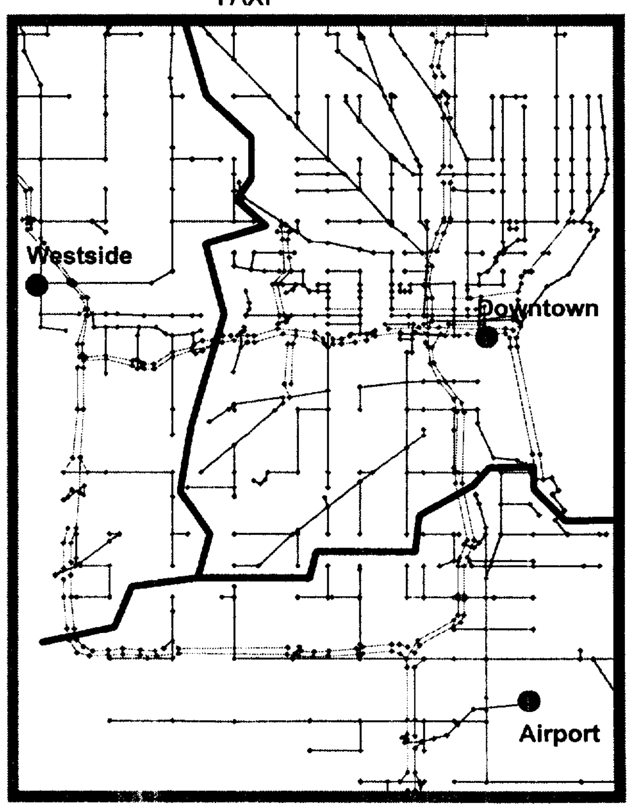


FIGURE 3.13. MARKET BOUNDARIES FOR TAXI



Chapter 4. Evaluation of Institutional Arrangements

Overview

Provisions for effective institutional arrangements are important from the earliest planning of an intermodal passenger transfer facility. The quality of institutional arrangements ultimately determines whether the facility will successfully meet its goals and objectives. Institutional arrangements should not be looked upon as something to do after an alternative has been selected. Rather, the development of institutional arrangements should go hand-in-hand with the design of physical elements of the project. This chapter focuses on the necessary steps in the development of an integrated transportation system and for pursuing appropriate financial backing for the facility.

Development of System Integration Plans

Purpose

To provide the basis for operating all publicly and privately owned services as though they were parts of a single transportation system, so that an intermodal transfer facility can operate most efficiently.

Integration Objectives

Maximize
- System coordination: information & fares
- Reliability of tranfers
- Temporal connectivity
- Spatial connectivity

Minimize
- Service duplication
- Difficulty of ticketing or fare payment
- Fare inconsistecies
- Institutional barriers to transferring
- Negative impact on existing transportation services

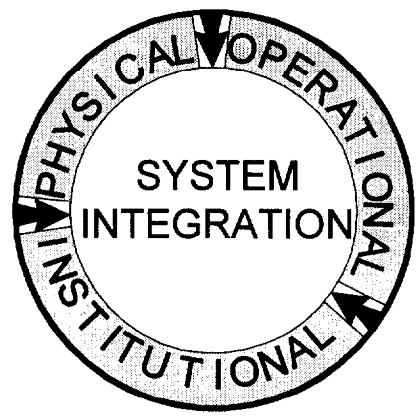
Requirements

- At least two mass transportation modes and/or operators.
- The willingness and capability to develop an integrated system on the part of local officials and operators.
- Sufficient time for meetings and communication.

Background

System integration's development can be traced to a number of European cities, where its potential was first realized. Limited forms of system integration are in existence in some US cities, such as New York and Los Angeles, but most urban public transportation systems have not developed the full potential of integration. Granted, conditions exist in Europe that make system integration more easily attainable than it would be in the United States. However, an advanced level of system integration is still achievable in many US cities.

The need for system integration as part of any intermodal transfer facility plan is derived from the benefits it produces. System integration's intention is to create a highly coordinated structure among a region's various public transportation agencies and operators. This coordination will produce shorter trip times, simplified trips, quicker transfers and a larger service area for passengers. Better service increases ridership and has associated community and environmental benefits. System integration occurs on three levels:



1. Institutional Integration;
2. Operational Integration; and
3. Physical Integration.

All three levels involve intragovernmental integration, intraoperator integration and integration between government agencies and operators. System integration must begin at the institutional level, and then continue through to operations and physical facilities.

Institutional integration involves the establishment of agreements, or a ruling body, for the purpose of system planning and financing. Institutional integration can take on several forms and occur on both the interregional and intraregional levels. *Operational integration* involves the elimination of duplicate services, the distribution of revenues, the development of a system-wide fare structure, the adaptation of modes to service requirements and the development of public information systems. *Physical integration* involves such things as the development of intermodal transfer facilities, pedestrian facilities and the standardization of vehicles, information, symbols and signs.

Steps

Step 1. Conduct a survey of the current service environment. Before the groundwork for system integration can begin, a survey of the existing transportation environment must be conducted. An inventory covers the type of service provided, who provides it and how it is provided. A Service Inventory Questionnaire is reproduced in Figure 4.1.

Inventory of Existing Transportation Service

We are currently conducting a study concerning the possiblity of better integrating the transportation system in the (City name) region. As a preliminary step, we want to assess the existing level of service, including any system integration. Because additional integration is not possible without the cooperation and input from the current transit operators and agencies, we are contacting your (agency/company) in order to both inform you of our study and to invite your participation in the process. If there are any additional questions or comments please feel free to include them or contact us at (phone #). Thank you for your time.

Service Name: ______________________

Address: ______________________
street
____
city/state/zip

Contact Person: ______________________

Title: ______________________

Phone: ______________________

Type of service provided: (Check all that apply)

☐ Fixed Route	☐ Agency (exclusive to agency clients)	☐ Limo	☐ Charter
☐ Taxi	☐ Specialized	☐ Commuter Rail	☐ Intercity Bus
☐ Intercity Rail	☐ Rideshare/Vanpool	☐ School	☐ Other: ________

How would you characterize the level of service in the area?
☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor
Is there room for improvement? If so where? ________(Leave space for answer)________

Is your (*company/agency*) currently integrated at some level with other agecies or companies? If so, explain the integration structure and the problems and benefits that have resulted from the integration? ________
(Leave space for answer)

Current integration structure	Between Operators: Within Each Mode	Between Operators: Between Each Mode
Are routes coordinated?	☐	☐
Are schedules coordinated?	☐	☐
Are fares coordinated?	☐	☐
Are transfers available?	☐	☐
Are transfer facilities provided?	☐	☐
Is information on routes, schedules, etc. available from one central source?	☐	☐

If transfers between operators are permitted, how are the revenues distributed? (Leave space for answer)

FIGURE 4.1. EXISTING SERVICE QUESTIONNAIRE

Would your (company/agency) be willing to work towards an integrated transportation system or increase the level of existing integration? ☐ Yes ☐ No Explain: ____(Leave space for answer)____________

If "yes" which of the following should be included (check all that apply)

- ☐ Coordination of routes
- ☐ Coordination of public information
- ☐ Revenue sharing
- ☐ Coordination of schedules
- ☐ Interoperator use of maintenance facilities
- ☐ Intermodal transfer facilities
- ☐ Intermodal transfers
- ☐ Interoperator transfers
- ☐ Integrated management and operation under a single agency
- ☐ Standard fleet
- ☐ Standard signs and symbols
- ☐ Other (please describe)____________(Leave space for answer)____________

What appear to be the critical problems or issues that would impede the development of an integrated transportation system?____(Leave space for answer)____________

Additional comments: ____(Leave space for answer)____________

Please return survey to: (insert address)

FIGURE 4.1 (CONT.). EXISTING SERVICE QUESTIONNAIRE

Step 2. Promote concept of system integration to operators and relevant agency officials. Most operators and agency officials have probably not given serious consideration to the development of an integrated transportation system. They will need to be briefed on the basics of system integration, its impact on the community and themselves and the roles they would play in the integrated system. They need to establish a firm understanding of the concept and its benefits, so that they will be willing to become actively involved in the process without feeling that integration will threaten the well-being of their operations or the control of their agencies.

Step 3. Gauge the willingness of operators and officials to participate in development of an integrated transit system. If little interest exists among the group to participate in system integration, then either a stronger attempt is needed to sell the idea or the idea should be abandoned. Effective system integration requires the active participation of most, if not all, public transit operators and government agencies.

Step 4. Establish frameworks for communication. The process of establishing an integrated transit system will take considerable time, with the effectiveness of the final plan dependent on successful cooperation among the various agencies and operators. This cooperation will only be successful if strong communication structures and relationships are established from the beginning. Interagency coordination requires a separate set of procedures and protocols than does interoperator coordination.

Step 5. Establish institutional integration. An integrated system will require coordination and cooperation between agencies and operators to oversee system planning and to establish integration policies.

Step 5a. Develop a regional planning and policy coordinating organization. Although involvement of a regional planning organization is not a requirement of an integrated system, a primary lesson learned from successful European transit systems is that close coordination of regional planning and transit planning on the institutional level is required if system integration is to be effective (INTERPLAN, 1973). A regional planning organization's purpose in system integration is to establish institutional integration among government agencies. A regional planning organization can operate in a variety of forms: regional planning commission; constituted committee; and ad hoc planning committee.

Regional Planning Commission. A regional planning commission has legislated to it absolute authority to carry out decisions. The power granted to the authority is the main advantage that it enjoys over other types of regional organizations. A problem with this type of commission is that it requires legislative action to give it the necessary authority. This action may draw stiff resistance from local governments unwilling to give up decision making powers.

Planning Integration Check preferred option	
Constituted independent committee	
Legislated area commission	
Ad hoc coordinating regional committee	
No coordinating regional authority	

Constituted Committee. A constituted committee has some legislative powers, but must defer implementation of its decisions to other organizations who are not legally bound to follow the recommendations. The lack of implementation power is the weakness of this type of organization. The committee could make completely sound decisions that do not become implemented. Initially, this lack of power could be beneficial because the committee would be better received by local authorities and operators who would not be relinquishing existing powers. In many communities, the metropolitan planning organization (MPO) can provide the framework for a constituted committee.

Ad Hoc Planning Committee. An ad hoc committee is only allowed to make recommendations to its members or other organizations. The absolute lack of power is a major weakness of the ad hoc committee. Nonetheless, if the committee is able to establish a sound reputation for decision making and expertise and if it is able to secure financial support, then this form of organization can work well. It is the simplest of the regional planning operations to form because it requires no transfer of powers. Securing financial support from participating members can become a potential obstacle to the success of an ad hoc committee.

Step 5b. Develop a regional transportation authority. Formation of a single regional transportation authority could serve the same purpose as a regional planning and policy organization, mainly to establish institutional integration among government agencies. A transportation authority differs from a regional planning organization by dealing with the operation of transportation services, along with transportation planning and policy making. A regional transportation authority can operate in cooperation with a regional planning authority, as part of a regional planning authority or in lieu of a regional planning authority. However, an integrated transit system cannot consistently function well without a regional transportation authority. This authority can take on one of three forms: single transportation authority; public transit authority; or single publicly owned operator.

Single Transportation Authority. The ideal form of transportation planning authority depends on the level of integration desired and existing conditions. The most comprehensive transportation authority would be one that oversees all transportation issues, including public transit and highway planning. This authority would deal with planning, policy and operation of the system. This form of authority would have the power to establish routes, level of service and fare structure, along with having control over highway planning and implementation decisions.

Public Transit Authority. A public transit authority would have the same planning, policy making and operation structure as the *single transportation authority*, except for dealing with highway issues.

✔	Transportation Planning Integration *Check preferred option*
Agency responsible for all regional transportation	
Single publicly owned operator	
Agency responsible for all regional public transit	

Single Publicly Owned Operator. The third form would involve a transit district or single publicly owned operator handling all public transit planning. This level is possible only if there is a single transit operator in the region.

Step 5c. Develop a coordinating structure for intraregional public transit. Developing a coordinating structure for intraregional public transportation is an essential step in system integration. The purpose is to develop a coordinating structure among *operators.* It can take on one of many forms. Although the structure need not involve all operators in the region, as some may initially choose to opt out of the group, the more operators that can be involved, the stronger the integrated system. There are five typical structures: single regional operator; transit federation; transit community; tariff association and coordination agreements.

Single Regional Operator. Having a single regional operator is the strongest way to institute operator coordination, because it brings all decision makers into one organization. This is accomplished by merging independent firms or agencies into one agency. The firms and agencies either lose their identity or act as subsidiaries of the operator. This form of coordination will not be possible if there is more than one major operator or if the system consists of both public and private operators, as is true in most medium to large cities.

Transit Federation. A transit federation overcomes the obstacles encountered by the single regional operator structure by forming a federation among both public and private operators. The members delegate powers related to system planning, fares and revenue distribution to the federation. This is an effective structure, particularly if all operators are involved and if decisions are the best for the system as a whole, rather than the best for the dominant operator in the region.

Transit Community. A transit community maintains agreements for common tariffs and coordination of routes and schedules, but the basic power to plan routes and schedules remains with individual operators. This form of coordination is appealing from an operator's standpoint because the operator maintains effective control of its respective operation. The drawback to this system is that it leaves open the chance that an inefficient system will remain or develop because it does not prevent route duplication or assure that all areas are served.

✔ Intraregional Transit Coordinating Structure *Check preferred option*	
Route and schedule coordination agreements	
Single regional operator for all public transit	
Tariff association	
Transit community	
Transit federation	

Tariff Association. A tariff association involves operator coordination on joint tariffs and joint distribution of revenues. The narrow scope of this association makes it unsuitable for system integration of public transportation on a regional level.

Route and Schedule Coordination Agreements. A route and schedule coordination agreement structure is the minimal form of operator coordination. It is beneficial in that it may eliminate duplicated routes and allow for easier transfers, but it does not address problems of fare structures and system planning that are essential to effective system integration.

Step 5d. Develop a coordinating structure for interregional transportation. Integrating the interregional transportation modes into the intraregional transportation network increases the system's efficiency. It can be incorporated into the intraregional coordination discussed above or handled through the formation of separate committees or agreements.

✔ Interregional Transportation Coordinating Structure — *Check preferred option*			
Out-of-region operator participation in intraregional organization		Responsibility allocated internally within intra-area operators	
Coordinating agreements between individual operators		Coordinating committee of operators	

Step 5e. Develop a coordinating structure for specialized modes. Specialized services are an important component of any transit system and should be included in the integration mix. Like the interregional modes discussed in previous steps, specialized services can be included in intraregional coordination or integrated through side agreements or committees.

✔ Specialized Modes Coordinating Structure — *Check preferred option*	
Specialized operators participating in intra-area coordination organization	
Coordinating agreements between individual operators	
Coordinating committee of operators	

Step 5f. Locate sources for funding capital investment. New information systems or new rolling stock required for the expected expanded service will require substantial funds that may not be presently available. The existing sources of local funding should be used along with the state or federal grants.

✔ Potential Funding Sources for Capital and Operational Costs — *Check preferred options*			
Stock Issue *(For capital costs only)*		Local sales taxes	
Bond Issue *(For capital costs only)*		Government grants	
Local property taxes		Parking fees	
License and fuel taxes		Revenue from fares	
Revenue from advertising, air rights, etc.		Revenue from other services	

Step 5g. Locate sources for financing operating costs. Overall operating costs for the transportation system may increase or decrease, depending on the results of

integration. Costs may decrease through the creation of a leaner, more efficient system, but additional costs may arise from an increase in service.

Step 6. Establish operational integration. An integrated system will require adjustments in existing schedules, routes, fare collection and public information systems to achieve effective coordination.

Step 6a. Plan for coordinated routes. The coordination of routes is one of the best ways to increase system efficiency. By eliminating duplicated routes, the stock that had been used in the redundant routes becomes available to serve areas that currently do not have service or are under serviced.

Route Coordination *Check preferred options*				✔
Park-n-ride commuter routes		Extend routes and plan new routes		
Eliminate duplicate routes				
Design bus routes as feeders to rail		Bus routes for certain times of the day		
Expand, create express services		Use para-transit modes as feeders		

Step 6b. Plan for change in transportation demand characteristics through public information. The public must be informed of schedule, route and fare changes. People must be given ample opportunity to reschedule routine trips. Businesses must be allowed to reschedule starting and quitting times.

Step 6c. Develop a basic system-wide fare structure. The creation of a system-wide fare structure results in a simplified, less confusing and attractive system. There are many fare structure options that can be selected. It is recommended that fares be collected for the total revenue of the system, where possible. If operators insist on maintaining separate fare collections, revenues could be pooled and redistributed according to a predetermined formula. Private operators may be excluded from participating in parts of the fare structure because of antitrust laws.

<table>
<tr><th colspan="5">Integrated Fare Structure
Check preferred option</th><th>✔</th></tr>
<tr><td colspan="2">Fare set by number of transfers</td><td></td><td colspan="2">Unlimited free transfers, single mode</td><td></td></tr>
<tr><td colspan="2">Limited free tranfers, intermodal</td><td></td><td colspan="2">Distance graduated fare system</td><td></td></tr>
<tr><td colspan="2">Unlimited free transfers, intermodal</td><td></td><td colspan="2">Limited free transfers, single mode</td><td></td></tr>
<tr><td>Flat fare</td><td></td><td>No free transfers</td><td></td><td>Zonal fare</td><td></td></tr>
</table>

Step 6d. Plan for coordinated schedules. Schedules should be coordinated to meet riders' demands for decreased headways and decreased transfer times. The coordination of schedules is of utmost importance for transfers between modes. The

time savings through efficient coordination will result in attracting more riders to the system.

Schedule Coordination *Check preferred options*			✓
Intercity demand schedule coordination with mainline rail, buses and airport		Intermodal connection coordination	
		Extend service times	
Bus route connection schedule coordination		Rider oriented schedules	
		Rider oriented headways	

Step 6e. Develop fare collection procedures. The type of fare collection procedure used will depend on the structures in place. There are a wide variety of options available. The existing fare collection procedures may be incorporated, modified or replaced depending on the desires of the passengers and operators.

Fare Collection Procedures *Check preferred option*					✓
Tickets sold off vehicles		Tickets sold on vehicles		Driver collects fare	
Proof of payment system		Pass system		Automated machines	
		Cash system			
Ticket system		Exact fare		Token system	

Step 6f. Develop procedures for public information systems. The coordination of public information systems will reduce operating costs, increase efficiency and simplify the system. Routes maps, timetables and public relations that currently are maintained by each operator can be combined into one system. This is an important step towards giving the system a unified appearance. By placing system-wide information at stations and stops, and on maps and timetables, the rider's use of the system is simplified. This coordination will decrease costs by eliminating duplicated services and enjoy the benefits of operating at an economy of scale.

System-wide Public Information Systems *Check preferred options*					✓
Public relations program		Route maps at stops		System-wide schedules	
Labeling of stops and vehicles		Multi-lingual information		System-wide info on train platforms	
System-wide info near fare collection areas		Schedule information at stops		Clearly labeled information areas in facilities	

Step 6g. Develop supplementary fare structure policies. Supplementary fare structure policies include incentives for time and type of trip and special rates for socioeconomic groups. These policies can be used to increase off-peak demand, shift some demand

away from peak hours and make trips more accessible to certain users who may not be able to afford the full fare.

System-wide Supplementary Fare Structure *Check preferred options*					✔
Special rates for socio-economic groups		Special rates by time of day		Special rates by time of week	
Intermodal combination passes		Daily system passes		Special rates by type of trip	
Free or discount return trip in off-peak hours		Seasonal passes		Special rates by area of city	

Step 7. Establish physical integration. An integrated system may require new or modified hardware to support enhanced services and to provide the desired system image.

Step 7a. Plan for acquiring equipment to aid operations. The fare structure will determine what type of collection equipment is needed. Collection equipment may need to be acquired if existing equipment is incompatible with the new fare structure. Communication equipment may be required for system-wide coordination.

✔ Equipment to Aid Operations *Check preferred options*	
Radio/TV communication systems	
Automatic fare collection machines	
Intelligent vehicle highway systems (IVHS)	

Step 7b. Plan for acquiring standard vehicles.
The standardization of the operating fleet will present the opportunity to pursue pooling agreements. It will also give the system a standard design that will provide a familiar appearance for the transit passenger, no matter which operation the passenger is patronizing. A standard fleet appearance will give the system the "look and feel" of being a single operation. Standardization can occur as old vehicles are replaced and through the addition of any new vehicles that are required for an expansion of service.

Step 7c. Develop operator pooling agreements. Consolidation or sharing of joint terminal and maintenance facilities will produce benefits and savings through increased efficiency. The pooling can also lead to cooperative arrangements for driver or vehicle substitution. The feasibility of such arrangements depends upon the degree of standardization and interchangeability of personnel and equipment.

✔ Integrated Pooling *Check preferred options*	
Joint use of personnel	
Standardized equipment	
Common spare parts pool	
Common maintenance facilities	
Joint use of capital equipment	

Step 7d. Plan for acquiring uniform signs and symbols. An integrated system should look integrated to the users. Consistent symbols and other visual elements must be obtained. Signs and symbols should be consistent with those used in the intermodal passenger transfer facility.

Step 8. Evaluate alternatives. The evaluation of alternatives for their quality of system integration is an exercise in careful speculation. True system integration will take considerable time to implement and may not have an established framework in place at the time of alternative evaluation. However, system integration is essential for a successful intermodal facility. The process towards achieving system integration, at least, should have been initiated. It may be the case that a single integration plan is being considered regardless of which alternative is selected. If this is the circumstance, then the evaluation of the integration plan itself will not figure into the selection of the best alternative. A sample evaluation form is illustrated in Figure 4.2.

System Integration Evaluation	***Alternative #*** ______
Scoring: ● Excellent ◓ Very good ◉ Good ◒ Fair ○ Poor	
Rate level of institutional integration considered for alternative.	○
Rate level of physical integration considered for alternative.	○
Rate level of operational integration considered for alternative.	○
Minimum passing score is *good* ◉	***Overall Score*** ○

FIGURE 4.2. SYSTEM INTEGRATION EVALUATION FORM

Project Financing

Purpose

To establish funding for planning, construction and operation of an intermodal passenger transfer facility.

Financing Objectives	
Maximize	Income from nontransport activities Joint development
Minimize	Cost

Requirements

Costs estimates for all phases and alternatives.

Background

Project financing is the one of the most delicate issues involved in the evaluation of an intermodal passenger transfer facility. Financing is the one issue that will face the greatest public scrutiny in the evaluation process, and it should be handled with care. Difficulties develop when tradeoffs arise requiring the sacrifice of certain elements for the benefit of other elements in the facility. The evaluation of financing relates back to the initial goals and objectives of the project. There are specific costs associated with achieving each goal and objective. Concurrently, there are cost constraints that must be met for the project to be politically acceptable. Evaluation requires a careful balancing of goals and objectives within cost constraints.

Steps

Step 1. Determine appropriate scale of facility. A realistic alternative is one that fits into the existing and future transportation system and fits within a community's budget. Each alternative must be weighed against a community's willingness and ability to pay. The ability to pay can be different for each alternative. It is very possible that one alternative will produce more revenue than another alternative due to its generation of additional development or increases in property values in the area surrounding the proposed site. An alternative that on its face alone exceeds the financing ability of a community, may be within budget once these secondary revenues are considered. Since the costs of construction and operation are proportional to the scale of the facility, alternatives must be appropriately sized – both financially and structurally.

Step 2. Determine planning, design and construction costs. Costs must be as accurate as possible and reflect the true construction costs of each alternative. Publicly financed projects have a long history of costing far in excess of initial projections. Public support for a project will dissipate if cost estimates are questionable. Cost estimates should not be designed solely to fit into available budgets.

Step 3. Determine operating costs. Operating costs must be calculated on a near-term and long-term basis. Start-up operating costs may exceed the normal operating costs of the facility. In the long-term there will be costs for repairs and improvements that can substantially increase operating costs in a given year. These costs must be anticipated but will not be the same for each alternative.

Step 4. Determine secondary revenues of each alternative. Each alternative creates a unique opportunity for secondary revenues. Secondary revenues can be substantial enough to make a higher cost alternative feasible to a community. Examples of secondary revenues include:

- Increased property tax revenues through increased assessments of surrounding properties;
- Increased sales tax revenues through increased activity in surrounding establishments; and
- Increased income tax revenues through primary and secondary job creation.

Step 5. Determine secondary costs of each alternative. Secondary costs include, but are not limited to:

Financing Facility Feasibility & Planning Study
Examples of Funding Sources

	FUNDING SOURCE	FACILITY SITE
FEDERAL	FHWA Congestion Mitigation & Air Quality Funds	Rensselear, New York
	FTA Section 8 Planning Grant	Atlanta, Georgia
	FRA/FTA Grant Section 26b	Detroit, Michigan
	FTA Section 8 Study Grant	Jackson, Mississippi
	FHWA Section 112 Funds	San Antonio, Texas
	FTA Section 9	Greensboro, North Carolina
STATE	Department of Transportation Grant	Jacksonville, Florida
	Intermodal Development Program	Ft. Lauderdale, Florida
	State STP Funds	Austin, Texas
	State Congestion Mitigation & Air Quality Funds	Albuquerque, New Mexico
LOCAL	Local Transit Authority Funding	Jacksonville, Florida
	Local Match from MPO	Austin, Texas
	City Contribution	San Antonio, Texas

FIGURE 4.3. SOURCES OF FUNDING FOR FEASIBILITY AND PLANNING STUDIES

- Relocation costs of utilities
- Relocation costs of businesses
- Relocation costs of residences
- Relocation costs of other facilities

Step 6. Determine budgetary impact of financing options. The financing options being considered must be able to be incorporated into existing budgets without requiring program cuts or tax increases that are not politically or financially feasible.

Step 7. Determine which financing options are available. Separate financing options are available for the planning, construction and operation stages of the project. Options vary by region with financing available at local, state and federal levels. Some funding options are listed in Figures 4.3, 4.4 and 4.5. In addition, many communities have paid for substantial portions of their transportation projects through Federal funds specifically earmarked in legislation. Local bonding options should be explored. For further information concerning funding sources and requirements contact the local MPO, the State Department of Transportation and the regional offices of the US Department of Transportation.

Step 8. Select suitable financing strategy. It is useful to compare alternate financing plans to show their expected impact on the local millage rate and on the financial position and credit rating of the community. Three possible financing options exist.

- Pay-as-you-go: Complete project financing from current revenue;
- Pay-as-you-use (financing): Project financed completely through debt and bond financing; and

- Combination: Combines up front payments from current revenue with long-term debt servicing.

The financing strategy selected is dependent upon the circumstances, both fiscal and political, of the community or agencies funding the project. The decision on which strategy is best for a community can be supplemented by the following factors. The factors are general indicators that a particular financing approach is the most appropriate.

Factors supporting pay-as-you-go approach:

- Level capital program requirements;
- Level revenue flow matching capital program requirements;
- Significant expected future capital needs;
- Unstable revenue sources;
- Little capacity to withstand reduction in Federal funding;
- No identified inflation savings from financing;
- Existing ability to fund from cash;
- Unsure as to the continued use of the asset;
- High existing debt burden.

Financing Facility Design and Construction

Examples of Funding Sources

	FUNDING SOURCE	FACILITY SITE
FEDERAL	Federal Congestion Mitigation & Air Quality Funds	Tampa, Florida
	National Trust for Historic Preservation Loan Fund	Greensburg, Pennsylvania
	ISTEA STP Funds Transferred to FTA Section 9	Toledo, Ohio
	Federal 130 Grade Crossing Program	Alexandria, Virginia
	Community Development Block Grant	Oakland, California
	HUD Special Purpose Grant	Albuquerque, New Mexico
	ISTEA Enhancement Grant	Lafayette, Louisiana
	FEMA Relief Fund	Oakland, California
	Amtrack Contibution	Tampa, Florida
	FTA Section 9	Seattle, Washington
	FTA Section 3	Richmond, Virginia
STATE	State Congestion Mitigation and Air Quality Funds	Albuquerque, New Mexico
	State Historic Resources Special Category Grant	Tampa, Florida
	Urban Aid to Highways Funds	Richmond, Virginia
	Rail Bonds	Oakland, California
LOCAL	Urban Renewal Funds	Portland, Oregon
	Developer Contribution	Charlottesville, Virginia
	Tax Revenue Bond	Emeryville, California
	Tax Levy	Meridian, Missouri

FIGURE 4.4. SOURCES OF FUNDING FOR FACILITY DESIGN AND CONSTRUCTION

Factors supporting pay-as-you-use approach:

- Major imbalance in revenues and project requirements;
- One time project funding needs;
- Strong cash flow position;
- Stable revenue sources;
- Ability to withstand reduction in Federal funding;
- Need for additional project funding in current year;
- Opportunity to reduce inflation impacts by advancing projects;
- Inability to fund current program of projects;
- Discipline in terms of investment savings;
- Expected ability to fund future capital program.

Source: Curry, 1992

Funding Operating Costs

Examples of Funding Sources

Beneficiary	Funding Source
RIDERS	Farebox Bulk Sales
PROPERTY OWNERS	Property Tax Special Assessments Impact Fees Joint Development Fees Mortgage Recording Tax Transfer Tax
BUSINESS	Employment Tax Business Use Tax Income Tax Hotel/Motel Tax Rent
VEHICLE OWNERS	Gas Tax Parking Tax Vehicle Registration Fees Traffic Fines
PUBLIC AGENCIES	City General Fund State Appropriation Federal Appropriation Transit Agency Funds
CITY RESIDENTS	Sales Tax Wage Tax
SYSTEM VENDORS	Advertising Revenues Concession Revenues Rent

Source: Alternative Analysis and Draft E.I.S.
Central Area Circulator, Chicago, Illinois

FIGURE 4.5. SOURCES OF FUNDING FOR OPERATING COSTS

Step 9. Secure long-term financial agreements with contributing communities and agencies. Conflicts can arise surrounding sustained financing of an intermodal facility if the agency in control of construction and operation of the facility is not the sole financier of the project. A secure long-term funding framework is needed to prevent agencies and local governments from disassociating from facility operating costs once capital costs are funded.

Step 10. Evaluate alternatives. The evaluation of financing packages put forward by each alternative suggest that the bottom line cost estimates will determine which alternative is the logical choice for a community. Unfortunately, this final figure cannot account for the components that are unquantifiable. Additionally, substantial consideration must be put into evaluating the political feasibility of the financing proposals. Without demonstrated support for proposed financing mechanisms from the public and from the politicians there is little chance of the alternative being constructed.

Financing Evaluation	**Alternative #**	
Scoring: Yes=1 No=0 Not clearly specified=0	______	
Has a financing package been established?	**1**	**0**
Is there demonstrated financial and political support for the financing option selected?	**1**	**0**
Minimum Passing Score is 2 ***Score***		
Community share of planning and design costs?	$	
Community share of construction cost?	$	
Community share of first year operating costs?	$	
Community share of long term operating costs (10 yrs)?	$	
Community share of annual secondary revenue?	$	
Community share of total secondary costs?	$	
Net community budget impact first year	$	
Net community budget impact first 10 years	$	

FIGURE 4.6. FINANCING EVALUATION FORM

Chapter 5. Evaluation of Community Development

Overview

The construction of an intermodal passenger transfer facility represents a major opportunity to reshape the development of a community. This chapter considers two community development concerns: joint development and historic preservation. Joint development can offset a large portion of the public costs of the facility, while maximizing the community development opportunities made available by the facility. Historic preservation can increase the economic and cultural value of the facility and help maintain the value of the surrounding neighborhood. Historic preservation is important to a new facility, as well as a renovated one. Furthermore, community support for preservation and local preservation ordinances can strongly influence the design and location of the facility.

Joint Development Planning

Purpose

To decrease costs of the intermodal passenger transfer facility and increase revenue and ridership of connecting modes.

Maximize	Income from nontransport activities Joint development Amenities Informal vending	Joint Development Objectives
Minimize	Cost	

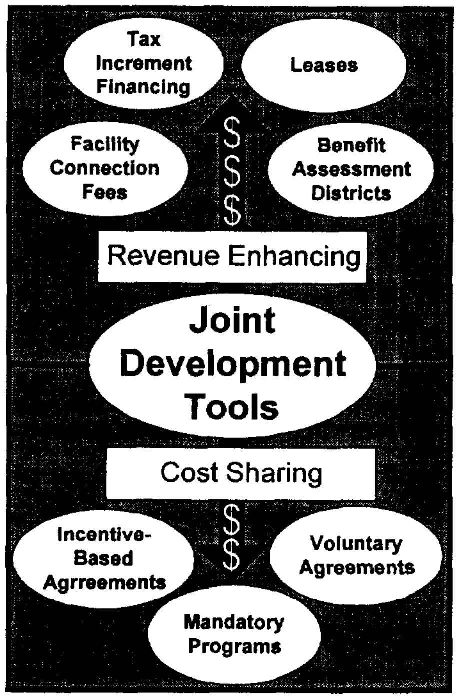
Requirements

- Interested private sector partners.
- Available legal framework for joint development.
- Active and healthy local real estate market.

Background

The funding for public transportation infrastructure within the last thirty years has been considered the responsibility of government. Yet, the private sector routinely receives benefits from public transportation, such as increased value of land in proximity to a transportation facility. Furthermore, public transportation has historically operated with a deficit. Joint development is one way to reduce operating deficits and reclaim a portion of the increased value from those in the private sector who receive benefits.

Joint development occurs when the public sector transfers some costs of an intermodal facility to those in the private sector. Beyond lowering public sector costs, joint development can draw additional passengers to the system and improve the environment around the intermodal facility. Additionally, joint development can increase the number of private interests who could benefit from locating near public transportation. The development of an intermodal transfer facility creates an attractive retail market and real estate development opportunity that through joint development can result in financial gain for both the public and private sectors.



Joint development can occur as a revenue enhancing venture for the public sector or as a cost sharing venture with the private sector. Examples of revenue enhancing options include the following:

Leases. Leases are the most common form of revenue enhancing joint development. The transportation agency or local government leases land parcels, air or subterranean rights or unimproved space to private developers or commercial tenants.

Facility connection fees. The fee is collected from a landowner or private tenant for the right to physically connect a project to a facility by a passageway.

Benefit assessment districts. These are specially designed districts around an intermodal transfer facility. A portion of subsequent increases in property tax revenue accruing to projects within the district goes directly to the transportation agency.

Tax increment financing. In this approach the property tax bases from benefiting property owners are frozen as of a certain date. Then, additional incremental gains in property tax receipts are designated for funding operating deficits or securing capital obligations for facility-area improvements.

Examples of joint development options available for sharing the costs of development of an intermodal facility include the following:

Voluntary agreements. These agreements are executed between transportation agencies, developers and private property owners. The agreements reduce the development costs of each party through coordinated planning, design and construction.

Incentive-based agreements. Public agencies grant real estate development bonuses in exchange for partial or full funding of an intermodal facility.

Mandatory programs. Mandatory programs are established that require developers building in a designated area to provide transportation facilities and services as traffic mitigating measures of their development projects.

Joint development is not limited to one of these forms. It can occur as a combination of two or more forms or with a completely different approach. Each project has its own unique joint development opportunities that require custom tailoring for optimal results.

Steps

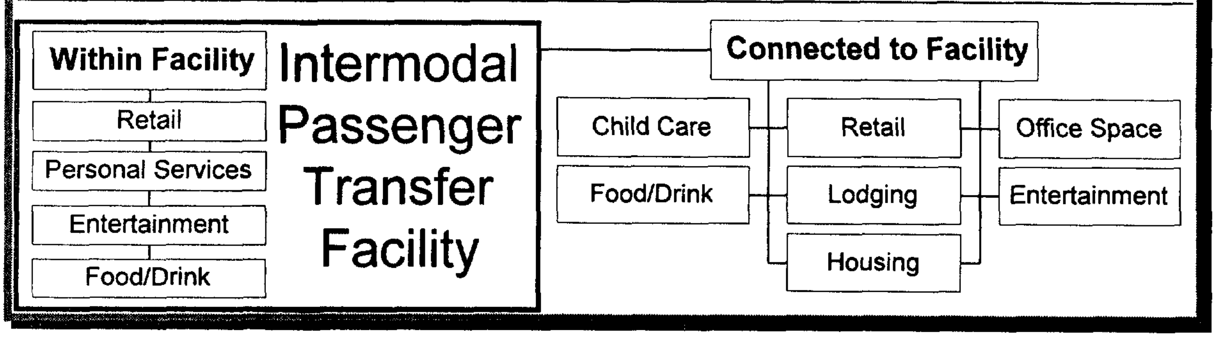
Step 1. Establish the need for joint development. An intermodal passenger transfer facility can be expensive to build and operate. However, the potentially high passenger traffic at the facility provides an attractive incentive for private sector participation. With careful planning and coordination, public expenditures on the facility can decrease, while the passenger volumes increase and the private sector profits. Joint development should be viewed as a potential win-win situation for public transportation agencies and the public. The public sector should approach joint development knowing that their benefits go beyond an increase in revenues. Successful joint development projects increase the number of transportation users and improve the environment around the facility.

Step 2. Select an agency or official to lead the process. Any joint development requires a strong relationship between public officials, private developers and property owners. This relationship will be strongest when there is a clear direction to the project, when the roles of the respective interests are clearly defined and when the process is clearly defined from the planning stage to the implementation stage. An agency or official should be assigned the responsibility of overseeing joint development projects. The selected agency or official should possess the skills required for accomplishing joint development, including the ability to act as an effective mediator between public and private parties and have a strong entrepreneurial inclination.

Step 3. Determine available tools to attract joint development. Joint development can take on many forms with each form requiring different markets, planning and financing. There are a variety of strategies and potential funding options. A good understanding of these tools will be required in the planning and implementation processes.

Step 4. Determine existing legal barriers. It is possible that some local legal barriers might prevent the use of certain joint development tools. Tax increment financing, as an example, may not be allowed in certain places. If legal obstacles exist, then other joint development tools should be selected or the barriers should be challenged or amended.

Possible Joint Development Opportunities



Step 5. Identify joint development opportunities. Many economic advantages of joint development may not be known or accepted by either the public or the private sector. A complete market analysis should be undertaken which establishes the benefits of joint development. The analysis should determine expected passenger levels at candidate facility sites and the feasibility of development around each candidate site. Joint development will not work unless all sides are winners. Both public and private sectors must gain from the venture. However, the price of a facility at a site that encourages joint development must be weighed against lower cost facilities at sites that are less effective in attracting joint development.

Step 6. Define joint development goals and policies. The public should help define joint development goals and policies. Their involvement will assist in determining the type and quantity of development desired in the community. Clear goals and policies will simplify the selection of development strategies and partners.

Step 7. Coordinate land use and transportation policies. If joint development is to occur, the land around the intermodal facility must be properly zoned. The transportation system capacity around the proposed facility should be able to accommodate the increase in traffic that will occur.

Step 8. Establish a well-defined link between planning and implementation procedures. Prospective public and private interests will shy away from a joint development project if they do not feel that the planning efforts will be followed through to implementation. The link between planning and implementation can be strengthened through strong leadership and commitment from the public sector and through the presence of secure financial backing.

Step 9. Identify potential private partners. The large volume of people using the intermodal passenger transfer facility provides an attractive market for retail activities, office complexes and/or hotels. Existing businesses in the area should be identified, along with other businesses that may be interested in joint development. Joint development provides several benefits to the private sector not available in a typical development. These benefits will help attract potential private partners. Possible benefits include the following (Public Technology, Inc., 1993).

- The opportunity to share expenses and risks with a public agency;
- The possibility of avoiding land acquisition and site preparation costs;
- The chance to capitalize on markets created by the linkage to the facility; and
- The opportunity for improved internal circulation and amenities that can give a project a competitive advantage.

Step 10. Begin formation of joint development agreements. Joint development through public-private partnerships is a complex and lengthy process requiring frequent problem solving and constant coordination and negotiation between the public sector and the private sector. Problems can arise due to the two sectors' differing *modus operandi.* First, the public sector requires longer time frames to put projects together than does the private sector. For example, any major public project will require public involvement and environmental review. Second, the two sectors have differing objectives for the final plan. The private sector is concerned with profit maximization, while the public sector factors in additional inputs, such as voter satisfaction. The two sets of objectives may be in conflict with each other. Problems can often be resolved, but they can also lead to impasses that result in no development or an ineffective joint development plan.

Step 11. Establish joint planning of development. If the private sector is to share in the costs of constructing an intermodal transfer facility then they will want to have a say about the design of the facility. The design of the facility should be a cooperative effort from the beginning.

Step 12. Evaluate alternatives. Each alternative must be evaluated as to its inclusion of joint development. A sample evaluation form is provided below along with a minimum passing score. If an alternative does not meet or exceed this score further planning is needed. Joint development can contribute significantly to the success of an intermodal facility. Any alternative not considering joint development in its design is limiting its potential for success.

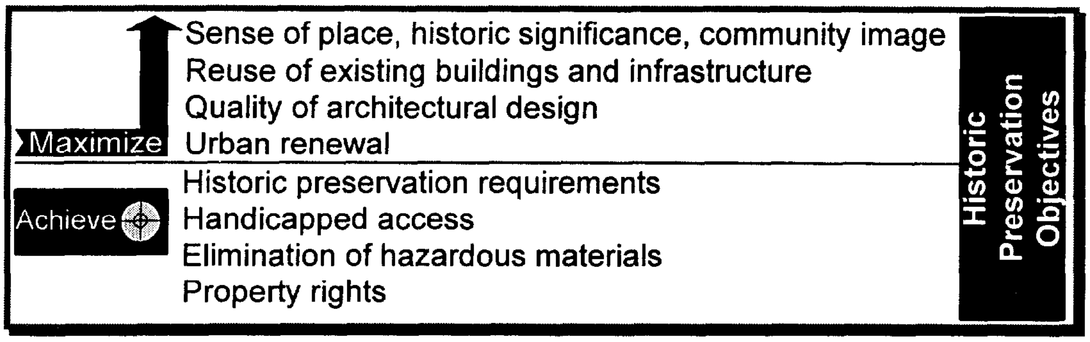
Joint Development Evaluation	***Alternative #***	
Scoring: Yes=1 No=0 Not clearly specified=0	______	
Has joint development been considered for alternative?	1	0
Have legal obstacles been considered and overcome?	1	0
Has a specific financing plan been developed?	1	0
Construction costs offset by joint development.	**$**	
Operational costs offset by joint development.	**$**	
Minimum passing score is 1 ***Overall Score***		

FIGURE 5.1. JOINT DEVELOPMENT EVALUATION FORM

Historic Preservation Planning

Purpose

To preserve the historical character of the neighborhood and community.



Requirement

Compliance with Federal, state and local historic preservation guidelines.

Background

Careful consideration of historic preservation requirements is imperative in the planning of an intermodal facility. When an existing station or building will be used for an intermodal facility, specific procedures must be followed in the restoration process. Even with a new intermodal facility, historic preservation concerns must be addressed. For example, a survey of surrounding properties must be conducted to assess the new facility's impact on existing historic properties.

An intermodal facility that is housed in an existing building has the potential for benefits beyond a new intermodal facility. Any historic preservation project can bring pride to the community, but the rehabilitation of a transportation facility is particularly exciting. The reuse of an existing facility presents a unique opportunity to reclaim a property that has played a vital role in a community's past and incorporate it into the daily lives of its potential users. The intermodal facility can also be located in a restored building other than a train station. There have been several examples of grand preservation efforts to intermodal facilities, including Boston's South Station and Baltimore's Penn Station. Washington's Union Station is an excellent example of combining restoration of a transportation facility with the adaptive reuse of a portion of the facility for shopping and entertainment. The preservation of a historic facility can bring financial benefits to a community through increased property values, neighborhood revitalization and tourism. However, historic preservation is not a panacea. Restoration can be expensive, sometimes costing more than the construction of a new intermodal facility. The potential historic site may be less than an ideal location for an intermodal terminal. Furthermore, historic preservation regulations can effect the whole intermodal system. The addition of any transportation component, such as a bus shelter or overhead power lines can cause problems for historic buildings at some distance from the project.

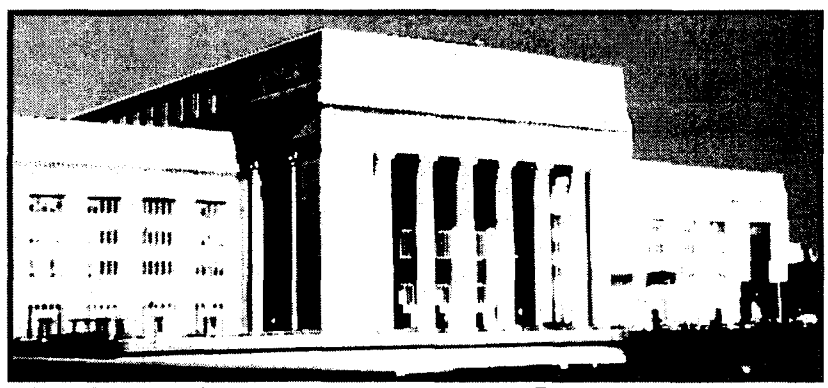
Regulations Governing Transportation Related Historic Preservation

The National Historic Preservation Act (1966) requires that each Federal agency designate a qualified official to coordinate the agency's preservation activities. As part of the intermodal project it is recommended that the designated officials be contacted for input. There are designated officials in the Department of Transportation, the Federal Railroad Administration, the Federal Highway Administration and the Federal Transit Administration. Other important historic preservation regulations include:

1. *Section 8(f)1 Federal Transit Act, as amended through June 1992.* Requires MPO's to consider preservation of existing facilities and ways to meet transportation needs by using existing transportation facilities more efficiently when they are developing transportation plans and programs.

2. *"Section 4" Title 49, United States Code, §303 (c).* Gives the Secretary of Transportation the right to approve a project that requires use of land of a historic site only if there is no prudent and feasible alternative to using the land and the project includes all possible planning to mitigate harm to the historic site resulting from use.

3. *Section 106 of the National Historic Preservation Act of 1966. Title 16, United States Code, §470f.* Requires the head of any Federal agency who has direct or indirect jurisdiction over a federally assisted project to consider the effect of the project on any 00district, site, building, structure or object that is included, or eligible for inclusion, in the National Register before approval for expenditure of Federal funds.



30TH STREET STATION, PHILADELPHIA, PENNSYLVANIA

Steps

A. Steps for new intermodal facility

Step 1. Identify historic properties that may be affected. In consultation with the State Historic Preservation Officer (SHPO), historic properties that may be affected must be identified. The process of identifying historic properties should follow the Secretary of

Interior's "Standards and Guidelines for Archeology and Historic Preservation"[1] and meet the National Historic Preservation Act requirements.[2] If no historic properties are found to be potentially affected by the project, then no further steps are required beyond notifying the SHPO and other interested parties of the results of the investigation.

Union Station, Washington, DC

Step 2. Assess effects of project on identified historic properties. A project can either have no effect, a nonadverse effect or an adverse effect upon historic properties. Determination of effect dictates further steps in the process.

No effect. If historic properties are found but the project will have no effect on the integrity of the properties and upon notifying the SHPO and interested parties and upon receiving no objections from the SHPO, then no further steps are required.

Effect, nonadverse. If the project is found to have a nonadverse effect on historic properties the SHPO must concur with the finding. The conclusion must be submitted to the Advisory Council of Historic Preservation for approval. If the Advisory Council approves the finding then no further actions are required.

Adverse effect. If it is found that the proposed project will have an adverse effect on historic properties, then an attempt must be made to mitigate the impact. Adverse effects include:

1. Physical destruction, damage or alteration of all or part of a historic property;
2. Isolation of the property from, or alteration of the character of, the property's setting when that character contributes to the property's qualification for the National Register for Historic Places;
3. Introduction of visual, audible or atmospheric elements that are out of character with the property or alter its setting;
4. Neglect of a property resulting in its deterioration or destruction; and

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1 The Standards and Guidelines for Archeology and Historic Preservation are found in 48 Federal Register 44716. The criteria for evaluation of the significance of a property are found in the *Code of Federal Regulations, Title 36, Part 60.*

2 The requirements are found in Section 110(a)(2) of the National Historic Preservation Act.

5. Transfer, lease or sale of the property.

Step 3. Reach agreement on a plan for dealing with adversely effected historic properties. If the project will have adverse effects on historic properties a serious attempt should be made to minimize or eliminate the adverse effects. Mitigation may involve minor adjustments to the project or a substantial modification to the project design or project location. Regardless, an agreement on how the effects will be handled should be reached with the SHPO and with the Advisory Council on Historic Preservation (if they participated in the consultation). Although it is not explicitly required that an agreement be reached, it is in the best interests of project officials to reach an agreement to avoid litigation or opposition from preservation organizations and the public.

Step 4. Evaluate alternatives. The intermodal facility alternatives must be evaluated as to their consideration of historic preservation planning. A sample alternatives evaluation form is provided at the end of this section.

B. Steps for upgrading an existing station to an intermodal facility

Step 1. Determine whether facility qualifies as a historic landmark. The local historic preservation commission or the State Historic Preservation Officer (SHPO) can determine the historical significance of the site. Train stations usually qualify as historic landmarks if they: remain in the site they were originally constructed; have not been structurally altered in a significant way; are at least fifty years old; and have served as the focus of a community's transportation system and commerce.

Step 2. Determine whether the location of the facility justifies consideration as a site for an intermodal facility. A community's transportation system may have undergone significant changes since the facility was originally constructed making the current site a poor location for an intermodal facility. Preserving a historic facility for the sake of historic preservation, but at the expense of an efficient transportation system, will only make for an expensive rehabilitation of a building that will be lightly used and not significantly improve the transportation system.

Step 3. Determine whether the facility has the capacity to meet transportation needs of the community. Most of the older facilities were built at a time when the use of mass transportation played a significantly larger role in the transportation system, so it would likely have the capacity to handle passenger traffic. However, an increase in the number of modes may require more site space than the facility currently has.

Step 4. Determine the condition of the facility. Just because a facility would qualify for historic landmark designation does not imply that the community should rehabilitate the site for use as the intermodal transfer facility. The facility or site may be in such disrepair as to make rehabilitation financially infeasible.

Step 5. Conduct environmental site assessment. Beyond obvious structural problems it is possible that the facility or site may have environmental problems. Assessment should be conducted on site to determine existence of visible hazards (such as containers), groundwater or soil contamination and the presence of asbestos. If environmental hazards are found, then a clean-up program must be established.


PENNSYLVANIA STATION, NEWARK, NEW JERSEY

Step 6. Estimate cost of rehabilitating facility. Individuals familiar with rehabilitation of historic buildings should be contracted to conduct an estimate of the costs of preserving the facility. It is important for accuracy that the person doing the estimating is familiar with historic preservation, because rehabilitation requires that the facility retain its original design and construction, including materials and detailing at their original specifications.

Step 7. Survey financing alternatives available for restoring historic properties. Historic properties can have financing and tax advantages. Some financing possibilities originate at the local level and may not be available in certain areas. Consultations with local or state historic preservation officials are recommended to get a complete list of financing options available for a specific site. The financing options available for a preservation project depend upon ownership. If the facility is privately owned, then tax incentive options are available. Joint development opens the possibility of combining Federal grants to the public sector with property tax relief to the private sector. Financing options include funds available for public or private preservation and financing incentives for private preservation.

Funds Available for Public or Private Preservation

A. *Revolving funds.* A preservation organization establishes funds available for acquisition of historic properties that are returned to the organization for further funding after the property is rehabilitated.

B. *Grants.* Grants are often available for funding preservation projects. The Department of Housing and Urban Development's Community Development Block Grants (CDBG) can be used for acquisition, renovation and improvements of historic stations. There may also be grants available from other Federal agencies, including the Federal Railroad Administration. There are several grant options available at the state level, particularly through the State Historic Preservation Officer. Grants are a key source of financing when the facility is to be owned by the public.

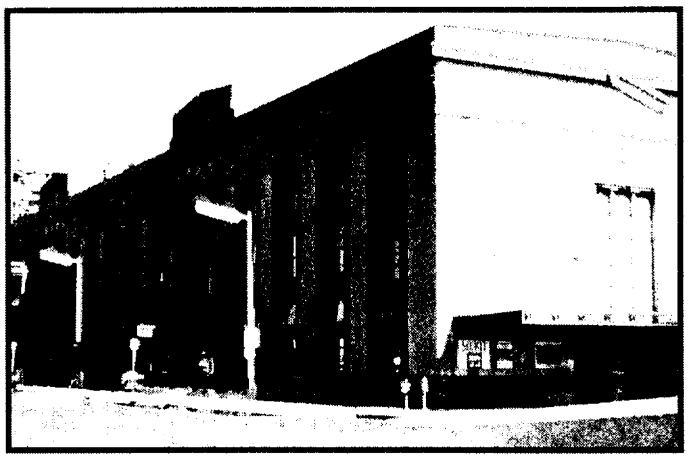
C. *Intermodal Surface Transportation Efficiency Act Funds (ISTEA).* Enacted in 1991, ISTEA provides funds to states for transportation projects, including funding under the following programs:

   1. *Transportation Enhancement Activities.* This program provides funds for transportation enhancement activities including rehabilitation and operation of historic transportation buildings and acquisition of historic sites.

   2. *Congestion Mitigation and Air Quality Improvement Program (CMAQ).* A transportation project is eligible for CMAQ funds if it is likely to contribute to attainment of a national ambient air quality standard.

Financing Incentives for Private Preservation

A. *Tax Increment Financing.* In this option the property taxes of benefiting property owners are frozen as of a certain date. Then, additional incremental gains in property tax receipts are designated for payment of preservation expenses.



PENNSYLVANIA STATION, NEWARK, NEW JERSEY

B. *Tax Credits.* The 1986 Tax Reform Act makes 20 percent of the qualifying restoration costs eligible as a tax credit. The renovation must be done in accordance with Department of Interior guidelines and be approved at both state and federal levels in order to qualify for the tax credit. Additionally, tax credits may be available through the state or locality.

C. *Property Tax Abatement.* Tax abatements can decrease or delay taxes on a given property for a fixed period. The programs either reduce a specific percentage of taxes due or apply a lower rate than usual.

D. *Property Tax Freeze.* A tax freeze is accomplished by holding assessments at pre-rehabilitation levels and by not taxing increases in value for qualifying properties. This method is also referred to as *special valuations* or *special assessments*.

Step 8. Meet local zoning requirements and design guidelines. Communities have specific requirements for treatment of historic properties, particularly if the property is within the boundaries of a designated historic district or zone. Typically, there are specific design guidelines that must be followed. The requirements vary from city to city. Refer to local ordinances for specific requirements.

Step 9. Identify historic properties that may be affected by the undertaking and assess effects project will have on identified historic properties. Even though the project is preserving a historic property it may have an adverse effect on other historic properties. The steps outlined for evaluating a new intermodal facility (Part A) must be followed.

Step 10. Evaluate alternatives. Each proposed alternative must be evaluated as to its inclusion of historic preservation planning. In the sample form, Figure 5.2, a minimum passing score has been established. If an alternative does not receive a score equal to or greater than the minimum, then the alternative has not effectively considered historic preservation and should be recommended for further planning and study.

Historic Preservation Evaluation	***Alternative #***	
Scoring: Yes=1 No=0 Not clearly specified=0	______	
Has a survey of historic sites been completed?	**1**	**0**
Will the facility be completed without damaging the integrity of any historic sites?	**1**	**0**
Has a serious attempt been made to minimize or eliminate adverse effects on historic properties?	**1**	**0**
Has it been demonstrated that the alternative will comply with all Federal, state and local prèservation regulations?	**1**	**0**
What is the estimated cost of upgrading existing facility? (enter "0" if alternative is a new facility)	$	
What is the cost to minimize adverse effects on historic sites?	$	
Minimum passing score is 3 — ***Overall Score***		
Preservation Costs	$	

FIGURE 5.2. HISTORIC PRESERVATION EVALUATION FORM

Chapter 6. Evaluation of Site Design and Access

Overview

The three major aspects of the physical design of an intermodal passenger transfer facility concern its site design, its access requirements and its internal design. Since it is not possible to plan a site without considering modal access, these two topics are discussed together in this chapter. The evaluation of interior design is presented in Chapter 7.

This chapter presents broad methods for the design and evaluation of external elements of the facility. Methods are detailed for developing a rank order of modes by their access priorities, for eliciting access requirements from modal operators and for determining whether modal access points are appropriately accessible from one another. Also given in this chapter are methods for identifying barriers to travel on the site, for developing concept diagrams of movement in and around the site, for analyzing the length and difficulty of pedestrian trips across the site and for identifying significant environmental impacts. Appendix B contains a list of general principles for the design of access to a facility.

Developing Access Priorities

Purpose

To develop an access priority ranking for all modes accessing the intermodal passenger transfer facility.

Steps

Step 1. List all modes that will access facility. Refer to Table 1.1 in Chapter 1 for a comprehensive list of modes. Eliminate modes from this list or combine modes, as necessary.

Step 2. Group modes of similar access priority. To simplify the matrix, modes that require similar access priorities should be grouped together. To be grouped together, modes must access the facility by the same type of guideway and have the same requirements for storage, queuing and loading/unloading (including fare collection).

Step 3. Develop Access Priority Matrix. The matrix should compare each mode (or modal grouping) to every other mode (or modal grouping). the matrix requires that the rankings be transitive: if A has priority over B and B has priority over C than A has priority over C. (*Situations that do no conform to this principle are discussed in Steps 6 and 7).* For ranking purposes, the matrix should be design so a total score can be given to each mode.

Step 4. Establish access priorities. Compare each mode to every other mode. In each comparison the mode having priority receives credit in the corresponding box. Each comparison is completed twice in the matrix, first by comparing A to B and then by comparing B to A. This duplicate comparison is needed to give a consistent total for each mode. When comparing modes in the matrix make sure the duplicate comparison matches its original comparison. After all comparisons are made, record the total number of access priority occurrences for each mode in the **total** column.

Step 5. Rank modes by priority. Develop a final ranking of modes based on the totals calculated in the Access Priority Matrix. The mode receiving the highest total receives the highest ranking, the mode receiving the second highest total is ranked second, etc.

Step 6. List access situations that do not conform to matrix. There may be certain situations that do not conform to the matrix. For example, bicycles may have priority over automobiles on the site and on an adjacent local road, but they may not have access priority on the regional highway that connects to the site. These situations are not easily representable in the matrix but still must be incorporated into the design. It is quite possible that such situations will not exist at a given site.

Step 7. Establish procedures to deal with nonconforming situations. If situations exist that do not conform to the matrix, an individual determination of site design guidelines must be established for each nonconforming situation.

Step 8. Plan for incorporation of access priorities into facility design. It is important that the priority ranking be carried over into the design of the facility. The site must be designed so that modes can realize their intended priorities.

Example: Ranking Access Priorities

Step 1. List all modes. The Big City Intermodal Passenger Transfer Facility has these 9 modes:

- Pedestrians
- Kiss-n-Ride
- Park-n-Ride
- Local Buses
- Other Buses
- Taxis
- Motorcycles
- Bicycles
- HOVs

Step 2. Group modes of similar access priority. Because there are so few modes, it is not necessary to form groups. Had the list been longer, it could have been shortened by combining motorcycles with park-n-ride.

Step 3. Develop Access Priority Matrix. The final matrix is illustrated in Figure 6.1.

Step 4. Establish access priorities. The results of the comparisons are derived from Hoel and Richards (1981, see Appendix B). The comparisons assume that there are not any nonconforming access situations at this site.

Step 5. Rank modes by priority. The final access priority ranking is illustrated in Figure 6.1. Pedestrians received the highest total (8) from the Access Priority Matrix, consequently pedestrians have the highest priority ranking (1). Park-n-Ride received the lowest total, thus it should have the lowest access priority at the site.

Steps 6-8. Nonconforming situations and implementation. These steps do not apply to this example.

Access Priorities

Access Priority Matrix

	Pedestrians	Kiss-n-Ride	Park-n-Ride	Local Buses	Other Buses	Taxis	High Occ. Vehicles	Motorcycles	Bicycles	Total
Pedestrians		P	P	P	P	P	P	P	P	8
Kiss-n-Ride	P		K	L	O	T	K	K	B	3
Park-n-Ride	P	K		L	O	T	H	M	B	0
Local Buses	P	L	L		L	L	L	L	B	6
Other Buses	P	O	O	L		O	O	O	B	5
Taxis	P	T	T	L	O		T	T	B	4
High Occ. Vehicles	P	K	H	L	O	T		H	B	2
Motorcycles	P	K	M	L	O	T	H		B	1
Bicycles	P	B	B	B	B	B	B	B		7

Instuctions:

1. Compare two modes, fill in **Bold** letter of mode that should have access priority.
2. Total across the number of occurrences where mode had access priority.
3. Rank modes by priority. *(Highest Total = Highest Access Priority)*

Access Priority

Mode	*Rank*
Pedestrians	1
Kiss-n-Ride	6
Park-n-Ride	9
Local Buses	3
Other Buses	4
Taxis	5
High Occ. Vhcls.	7
Motorcycles	8
Bicycles	2

FIGURE 6.1. SAMPLE ACCESS PRIORITY MATRIX AND RANKING

Access Requirements Questionnaire

Purpose

To establish criteria for determining the mode access requirements for the intermodal passenger transfer facility.

Requirements

- Panel of officials representing modes that will be accessing the facility.
- List of all access routes and modes.

Steps

Step 1. List all modes that will access facility, both existing and proposed. The existing modes can be derived from lists developed for the Access Priority Matrix. Modes that do not currently exist in the community but could conceivably exist in the future must also be included. These modes' requirements should now be considered in the facility design, so their later incorporation into the site is made easier.

Step 2. Determine general access requirements criteria for each mode. In order to develop a comprehensive questionnaire, all criteria that will determine access requirements must be included. Each mode will have its own set of criteria. A question covering each criterion is needed. To prevent overlooking criteria, representatives of each mode must be contacted and asked about the criteria that should be considered.

Step 3. Develop Access Requirements Questionnaire. Using the criteria developed in Step 2, create an Access Requirements Questionnaire. The questionnaire should be divided into sections, one section for each mode. Ask panel members to respond only to the sections applicable to the mode(s) they are representing. A sample questionnaire is illustrated in Figure 6.2. The following hints should help in obtaining quality responses.

- Each question should be accompanied by a list of possible answers. Avoid questions that require open responses. Provide enough choices to accommodate all reasonable responses.
- Maximize the ease of understanding the format. Provide only brief instructions and make the format self-explanatory. People have a tendency to skip over instructions when filling out questionnaires.
- Include a phone number so panel members can ask for help.

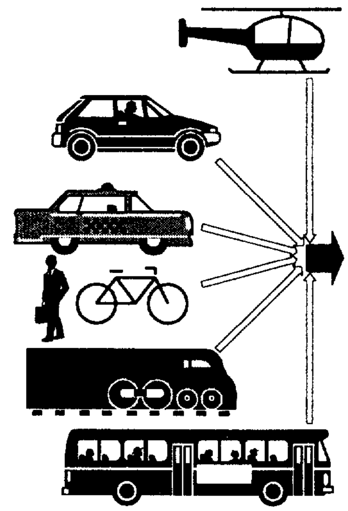
Step 4. Pretest questionnaire. If the panel is small or highly specialized, then pretesting may not be very helpful. For a large panel, pretesting can avoid problems with format and wording. Select a few knowledgeable individuals to complete the questionnaire before distributing it to the whole panel. Invite their comments and criticisms, then make any necessary revisions.

Step 5. Establish a panel. Contact all agencies and companies that will have modes accessing the facility. One member from each agency is needed for the panel. Explain the need for their input and the benefits they will receive from the inclusion of their responses. The same individuals selected for the panel for the Functional and Space Requirements Questionnaires (Chapter 7) can be used for the Access Requirements panel, if they are knowledgeable about the access requirements. Members of the Planning Advisory Group (PAG) should be used when possible. For modes that do not currently exist in the community but are being considered for the future, enlist an individual familiar with the modes' requirements.

Step 6. Distribute and collect questionnaire. Send out questionnaire with a self-addressed return envelope. After two weeks have passed, contact all panel members who have not returned their questionnaire. Reiterate the importance of their contribution. A gentle reminder to those who do not return questionnaires is usually sufficient.

Step 7. Compile responses. The results must be compiled into a format that will guarantee their inclusion in the final design. If a panel member did not provide clear answers or they did not fully answer the questionnaire, contact the member and correct the problem.

Facility Access Questionnaire



Name ______________________________
Agency ______________________________
Telephone # ______________________________
Fax # ______________________________

This questionnaire addresses the criteria for determining the mode access requirements for the intermodal passenger transfer facility. Respond only to the those questions which apply to the mode you are representing. If there are access requirements that are not addressed or sufficient space is not provided for answers, please continue them on the back side of the questionnaire. If you have any questions contact Joe Smith at 800-555-1212. Thank you for your time.
Return questionnaire to: *(insert return address)*

[illegible]	
Regional highways with access	Is direct ramp access to regional highway network needed? ☐ Yes ☐ No
Principal arterials with access	Is direct access to nearby principal arterials needed? ☐ Yes ☐ No
[illegible]	
Rail corridors with access	What rail corridors within the *BIGCITY* metro area could potentially be used? ☐ XYZ Main Line *(example)* ☐ XYZ Trunk Line *(example)* *List all corridoor possibilities*
[illegible]	
Regional highways with access	Is direct ramp access to regional highway network needed? ☐ Yes ☐ No
Principal arterials with access	Is direct access to nearby principal arterials needed? ☐ Yes ☐ No
Designated bus lanes	Are designated bus lanes needed? ☐ Yes ☐ No
[illegible]	
Access time	Average walking time from parking facility to terminal platform, including time to review signage, should not exceed: ☐ 2 minutes ☐ 4 minutes ☐ 6 minutes ☐ 8 minutes ☐ 10 minutes
Access route	Is direct access from surrounding pedestrian paths needed? ☐ Yes ☐ No

FIGURE 6.2. FACILITY ACCESS QUESTIONNAIRE

Bicycle Access	
Access route	Is direct access from surrounding bicycle paths needed? ☐ Yes ☐ No Should bicycle paths be separated from pedestrian paths? ☐ Yes ☐ No
Air Access	
Airspace with access *VTOL: Vertical Take Off and Landing* *STOL: Short Take Off and Landing*	Is direct access for VTOL transportation needed? ☐ Yes ☐ No Is direct access for STOL transportation needed? ☐ Yes ☐ No If no, should facility design consider possible VTOL or STOL access in the future? ☐ Yes ☐ No
Waterway Access	
Waterways with access	Is direct access for waterborne transit vehicles needed? ☐ Yes ☐ No
Emergency Access	
Special requirements	Are there special requirements that must be included in facility design to allow for emergency vehicle access? ☐ Yes ☐ No If yes, please describe ______________________

FIGURE 6.2 (CONT.). FACILITY ACCESS QUESTIONNAIRE

Modal Interaction

Purpose

To evaluate levels of interactions between modes and determine whether an alternative creates an acceptable level of interaction.

Requirement

A planning advisory group (PAG) or similar committee that understands the technical aspects of intermodal transfer facilities.

Steps

Step 1. Develop list of all modes. The list of existing modes can be derived from lists developed for the Access Priority Matrix. Modes that do not currently exist in the community but could exist in the future must be included.

Desired Modal Interaction

Instructions:

1. Rule out columns and rows that do not apply to this transfer facility.
2. Rate each cell for the desired degree of interactions from 0 (interaction unnecessary) to 10 (interaction is essential).
3. For each alternative, rate each cell for the estimated level of interaction from 0 (no interaction) to 10 (extremely close interaction).

Kiss-n-Ride																														
Park-n-Ride																														
Private HOV																														
Package Drop Off																														
Disabled (Automobile, Van)																														
Rental Automobile																														
Pedestrian: Abled																														
Pedestrian: Disabled																														
Light Rail Transit																														
Metrorail																														
Personal Rapid Transit																														
Pedestrian Assist Systems																														
Automated Guideway Transit																														
Vertical Takeoff and Landing																														
Short Takeoff and Landing																														
Local Bus																														
Express Bus																														
Intercity Bus																														
Shuttles																														
Tours, Limos																														
Taxis																														
Bicycles																														
Commuter Rail																														
Intercity Rail, Conventional																														
Intercity Rail, High Speed																														
Handicapped Service																														
Package Delivery																														
Freight Delivery																														
Historic Vehicles																														
Boats, Ferries																														
Modal Interaction Matrix	Kiss-n-Ride	Park-n-Ride	Private HOV	Package Drop Off	Disabled (Automobile, Van)	Rental Automobile	Pedestrian: Abled	Pedestrian: Disabled	Light Rail Transit	Metrorail	Personal Rapid Transit	Pedestrian Assist Systems	Automated Guideway Transit	Vertical Takeoff and Landing	Short Takeoff and Landing	Local Bus	Express Bus	Intercity Bus	Shuttles	Tours, Limos	Taxis	Bicycles	Commuter Rail	Intercity Rail, Conventional	Intercity Rail, High Speed	Handicapped Service	Package Delivery	Freight Delivery	Historic Vehicles	Boats, Ferries

FIGURE 6.3. SAMPLE DESIRED MODAL INTERACTION MATRIX

Step 2. Develop matrix for desired modal interaction. A matrix is needed to rate the desired levels of modal interactions. The Desired Modal Interaction Matrix's purpose is to establish the ideal level of interaction between each pair of modes. The matrix should list the modes across the bottom and the along the left side. The matrix should be set up so each mode can be compared to every other mode. Modes are not compared to themselves. An example of a modal interaction matrix is illustrated in Figure 6.3.

Step 3. Rate desired levels of modal interaction. Using the matrix developed in Step 2, identify the desired levels of modal interaction. The interactions should be rated on a scale of 0 (interaction unnecessary) to 10 (close interaction is essential). The average rating should be approximately 5. The rating process requires subjective judgment. Arriving at desired levels can be accomplished either by group consensus (see discussion about the Delphi Method in Step 4 of Procedure: Evaluating Generic Objectives in Chapter 2) or by consolidating matrixes completed individually by members of the Planning Advisory Group. Individually completed matrixes will take considerable time to administer. The staff may be able to expedite the process by preparing a draft matrix.

Step 4. Develop modal interaction matrix for each alternative. Each alternative will need its own modal interaction matrix. The matrix should have three cells for each modal interaction: one cell for the expected interaction based on the alternative's design; a second cell for the ideal level of modal interaction entered in the corresponding cell of the Desired Modal Interaction Matrix; and a third cell for displaying the difference between the expected and the desired levels of modal interaction. A sample modal interaction comparison is depicted in Figure 6.4. The matrix should provide space for summing the calculated differences.

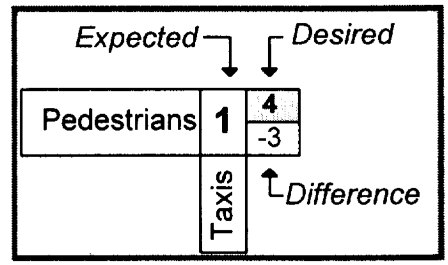


FIGURE 6.4. MODAL INTERACTION COMPARISON

Step 5. Rate modal interactions for each alternative. The same process that generated the desired levels of interaction should be used to generate the expected levels of modal interaction for each alternative. Interactions can be determined using the concept diagrams (see later section) and site plans. Once expected modal interactions are established, find the difference between expected and desired interactions for each cell. Total all **negative** differences. The matrix is intended to identify deficiencies in the design, so positive differences do not count.

Step 6. Evaluate calculated totals of each alternative. After totals have been calculated for each alternative, they must be interpreted. Wide variations in totals among the alternatives will make the interpretation easy, but it is likely that the variation will be small (see following example). The best alternatives have the smallest negative score. It is suggested that the score be normalized to remove bias due to the size of the matrix.

$$\text{Normalized Score} = 100 * \text{Total}/(\text{Number of Cells})$$

The number of cells in the matrix is always n(n-1)/2, where n is the number of rows or columns.

An alternative's normalized score will be dependent upon the established desired levels of interaction. On average a desired interaction should be approximately 5 to minimize that dependency. Interpretations (good, bad, etc.) should be given to ranges of normalized scores.

Example: Big City Modal Interaction Evaluation

Step 1. Develop list of all modes. The following is a list of all modes that may be part of an alternative at the Big City Intermodal Passenger Transfer Facility.

- Pedestrians
- Kiss-n-Ride
- Park-n-Ride
- Local Buses
- LRT
- Other Buses
- Taxis
- Motorcycles
- Bicycles
- HOVs

Step 2. Develop desired modal interaction matrix. The desired modal interaction matrix is illustrated in Figure 6.5.

Step 3. Develop modal interaction matrix for each alternative. The alternatives' modal interaction matrixes are also illustrated in Figure 6.5.

Step 4. Rate desired levels of modal interaction. The desired levels of modal interaction are illustrated in Figure 6.5. *Note: These ratings were generated for the purpose of this example only.*

Step 5. Rate modal interactions for each alternative. The expected levels of modal interaction for each alternative are illustrated in Figure 6.5. The bottom row in each matrix represents totals of the negative differences for each matrix column with the last cell (on the far right) representing the total of all negative differences in the entire matrix. This last total is used for rating and evaluating alternatives.

Step 6. Evaluate calculated totals of each alternative. In this example, the calculated totals for the three alternatives are:

Alternative #1: -40 *Alternative #2: -22* *Alternative #3: -37*

Since there are 10 modes the normalized scores are:

Alternative #1: -89 *Alternative #2: -49* *Alternative #3: -82*

Range of Normalized Scores	Rating
0 to -50	**Excellent**
-51 to -100	**Very Good**
-101 to -150	**Acceptable**
-151 to -200	**Deficient**
201 to -250	**Unsuitable**

Given an average desired rating of 5, a normalized score of worse than -250 is clearly very bad. In this example, five levels of acceptability have been defined.

Alternative #2's expected modal interactions are rated as *Excellent*, while Alternatives #1's and #3's expected modal interactions are rated as *Very Good.*

Modal Interaction

	Pedestrians	Kiss-n-Ride	Park-n-Ride	Local Buses	Other Buses	Taxis	High Occ. Vehicles	Motorcycles	Bicycles	Light Rail Transit
Pedestrians										
Kiss-n-Ride	1									
Park-n-Ride	1	1								
Local Buses	9	9	9							
Other Buses	9	9	4	9						
Taxis	1	1	2	3	5					
High Occ. Vehicles	7	1	9	2	1	1				
Motorcycles	0	7	1	9	3	0	0			
Bicycles	0	1	1	9	2	0	0	1		
Light Rail Transit	9	9	9	9	4	3	2	9	9	

Desired Modal Interaction Matrix

Instuctions:

1. Using the *Desired Modal Interaction Matrix*, rate each cell for the **DESIRED** degree of interactions, from 0 (interaction unnecessary) to 10 (interaction is essential).
2. Using a *Modal Interaction Matrix* for every alternative, rate each cell for the expected degree of interactions, based on the alternative's proposed design. Rate from 0 (no interaction) to 10 (maximum interaction).
3. Copy the interaction ratings from the *Desired Modal Interaction Matrix* into the corresponding shaded cells of each alternative's *Modal Interaction Matrix*.
4. Subtract the desired interaction rating from the alternative's expected interaction rating for each cell. Place totals in cell below shaded cells.
5. Sum NEGATIVE differences by column. **Ignore any positive differences.**
6. Sum row of NEGATIVE totals. This total represents the difference between an alternative's expected modal interaction and the desired modal interaction.

Alternative's Matrix Key:

Expected / *Desired*

	Taxis
Pedestrians	1 / 4 / -3

Difference

Modal Interaction Matrix Alternative #1

(each cell: Expected / Desired / Difference)

	Pedestrians	Kiss-n-Ride	Park-n-Ride	Local Buses	Other Buses	Taxis	High Occ. Vehicles	Motorcycles	Bicycles	Light Rail Transit
Pedestrians										
Kiss-n-Ride	1 / 1 / 0									
Park-n-Ride	2 / 1 / +1	4 / 1 / +3								
Local Buses	6 / 9 / -3	8 / 9 / -1	7 / 9 / -2							
Other Buses	7 / 9 / -2	7 / 9 / -2	4 / 4 / 0	5 / 9 / -4						
Taxis	1 / 1 / 0	0 / 1 / -1	4 / 2 / +2	4 / 3 / +1	3 / 5 / -2					
High Occ. Vehicles	7 / 7 / 0	1 / 1 / 0	7 / 9 / -2	3 / 2 / +1	2 / 1 / +1	2 / 1 / +1				
Motorcycles	0 / 0 / 0	6 / 7 / -1	1 / 1 / 0	4 / 9 / -5	4 / 3 / +1	0 / 0 / 0	1 / 0 / +1			
Bicycles	0 / 0 / 0	0 / 1 / -1	0 / 1 / -1	4 / 9 / -5	0 / 2 / -2	1 / 0 / +1	2 / 0 / +2	3 / 1 / +2		
Light Rail Transit	9 / 9 / 0	9 / 9 / 0	7 / 9 / -2	8 / 9 / -1	6 / 4 / +2	3 / 3 / 0	1 / 2 / -1	8 / 9 / -1	8 / 9 / -1	
Sum of negative differences	-5	-6	-7	-15	-4	0	-1	-1	-1	***Total*** -40

FIGURE 6.5. EXAMPLE OF MODAL INTERACTION COMPARISON

Alternative's Matrix Key:

Expected → Pedestrians / Taxis: 1 · Desired: 4 · Difference: -3

Modal Interaction Matrix Alternative #2

	Pedestrians	Kiss-n-Ride	Park-n-Ride	Local Buses	Other Buses	Taxis	High Occ. Vehicles	Motorcycles	Bicycles	Light Rail Transit
Pedestrians										
Kiss-n-Ride	2 1 +1									
Park-n-Ride	1 1 0	2 1 +1								
Local Buses	9 9 0	8 9 -1	9 9 0							
Other Buses	8 9 -1	8 9 -1	5 4 +1	9 9 0						
Taxis	1 1 0	1 1 0	1 2 -1	2 3 -1	7 5 +2					
High Occ. Vehicles	8 7 +1	1 1 0	8 9 -1	1 2 -1	1 1 0	1 1 0				
Motorcycles	0 0 0	3 7 -4	3 1 +2	9 9 0	4 3 +1	0 0 0	0 0 0			
Bicycles	1 0 +1	0 1 -1	0 1 -1	7 9 -2	3 2 +1	0 0 0	2 0 +2	2 1 +1		
Light Rail Transit	6 9 -3	9 9 0	9 9 0	8 9 -1	6 4 +2	3 3 0	1 2 -1	8 9 -1	8 9 -1	
Sum of negative differences	-4	-7	-3	-5	0	0	-1	-1	-1	***Total* -22**

Modal Interaction Matrix Alternative #3

	Pedestrians	Kiss-n-Ride	Park-n-Ride	Local Buses	Other Buses	Taxis	High Occ. Vehicles	Motorcycles	Bicycles	Light Rail Transit
Pedestrians										
Kiss-n-Ride	1 1 0									
Park-n-Ride	2 1 +1	2 1 +1								
Local Buses	6 9 -3	6 9 -3	8 9 -1							
Other Buses	6 9 -3	8 9 -1	6 4 +2	8 9 -1						
Taxis	1 1 0	3 1 +2	2 2 0	3 3 0	4 5 -1					
High Occ. Vehicles	5 7 -2	3 1 +2	8 9 -1	5 2 +3	0 1 -1	0 1 -1				
Motorcycles	0 0 0	6 7 -1	0 1 -1	7 9 -2	2 3 -1	0 0 0	1 0 +1			
Bicycles	0 0 0	1 1 0	2 1 +1	8 9 -1	2 2 0	1 0 +1	1 0 +1	2 1 +1		
Light Rail Transit	8 9 -1	6 9 -3	9 9 0	8 9 -1	7 4 +3	3 3 0	1 2 -1	5 9 -4	5 9 -4	
Sum of negative differences	-9	-8	-3	-5	-3	-1	-1	-4	-4	***Total* -38**

FIGURE 6.5 (CONT.). EXAMPLE OF MODAL INTERACTION COMPARISON

Barrier Checklist

Purpose

To identify barriers that obstruct direct paths from origins to destinations.

Requirements

For each alternative, a site plan and an interior space plan (drawn to scale) and a concept diagram. These plans are not necessary when alternative is an existing, unmodified building.

Steps

Step 1. Identify types of barriers that could impede direct path. Identify types of barriers that could be found in a facility. Be as comprehensive as possible. Develop a checklist that incorporates all barrier types. The checklist should have a column for the type of barrier, a column to identify whether the barrier exists along a path and a column for comments about each particular barrier. An example Barrier Checklist is illustrated in Figure 6.6.

Step 2. Select a sample of trips. Several trips will need to be evaluated. Identify the major trips through the facility by origin and destination. The selected trips should include transfer trips, access trips and egress trips. If possible, use the same set of trips evaluated in the Trip Segment Analysis (see later section).

Step 3. Evaluate selected trips. Using the Barrier Checklist, record any barriers that impede a direct trip from origin to destination. Make brief comments about each barrier that is encountered. Comments should describe the barrier as to whether it can be removed, the general nature of the barrier and the approximate disutility penalty attributable to the barrier. Each trip will require its own checklist. For a new facility trips can be analyzed by reference to site plans and interior space plans. For an existing facility trips can be evaluated at the site itself.

Barrier Checklist		
Trip between: ____________________ and ____________________		
Barrier	Present	Comments
Heavy Vegetation		
Man-made Physical Barriers		
Uneven or Unlevel Ground		
Fare Gates		
Unprotected Cross Traffic		
Protected Cross Traffic		
Pedestrian Cross Traffic		
Inadequate Lighting		
Lack of Secure Feelings		
Cleanliness		
Vagrants		
Narrow Passageways		
Assisted Level Changes		
Unassisted Level Changes		
Transfer or New Fare Payment		
Schedule Inconsistencies		
Insufficient Information		
Poor Sight Lines		
Confusing Paths		
Areas Exposed to Weather		
Areas with Severe Environmental Problems		
Solicitation and Promotion		
Handicapped Specific Barriers: Curbs		
Steep Ramps		
Stairs, Escalators		
Rough Pavement		
Turnstiles		
Shuttle Vehicles Improperly Equipped		

FIGURE 6.6. BARRIER CHECKLIST

Development of a Concept Diagram

Purpose

To establish a conceptual relationship between the most important elements and functions of a facility.

Steps

Step 1. Recognize all elements and functions that are important to the design of the facility. The establishment of a conceptual relationship between the modes, the surrounding area and points of access to the facility is important to the success of an intermodal passenger transfer facility. The relationships developed in the concept diagram will be carried forward to the final design of the facility and site. Elements and functions that must be shown include:

- *Points of Access*
- *Transfer Points*
- *Nearby Transportation Corridors*
- *Important Areas of the Facility*
- *Neighborhood Land Use*
- *Landmarks*
- *Environmental Setting*
- *Joint Development*

Step 2. Design legend for diagram. The purpose of the concept diagram is to depict a visual interpretation of the interaction between the important elements and functions. A symbol representing each important element must be developed. The symbols should be easily recognizable and distinguishable when included in the diagram. An example concept diagram legend is illustrated in Figure 6.7.

Step 3. Develop concept diagram. Using the symbols designed in Step 2, develop a concept diagram that depicts the important elements and functions. An example of a concept diagram is illustrated in Figure 6.8. The concept diagram should detail site boundaries, the footprint of each building, major paths, landmarks, points of major services, storage areas, major barriers to flow and related development.

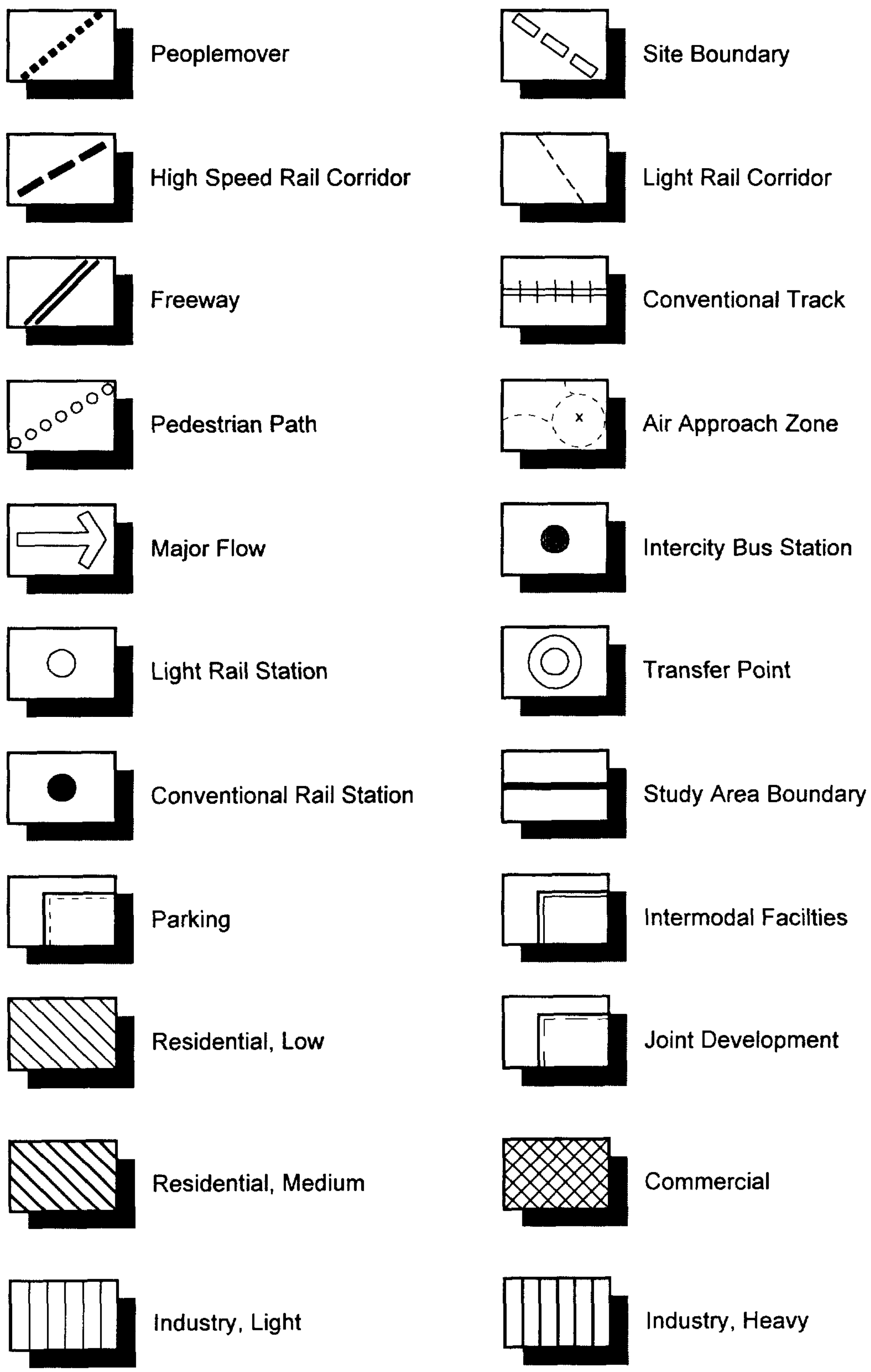


FIGURE 6.7. CONCEPT DIAGRAM LEGEND

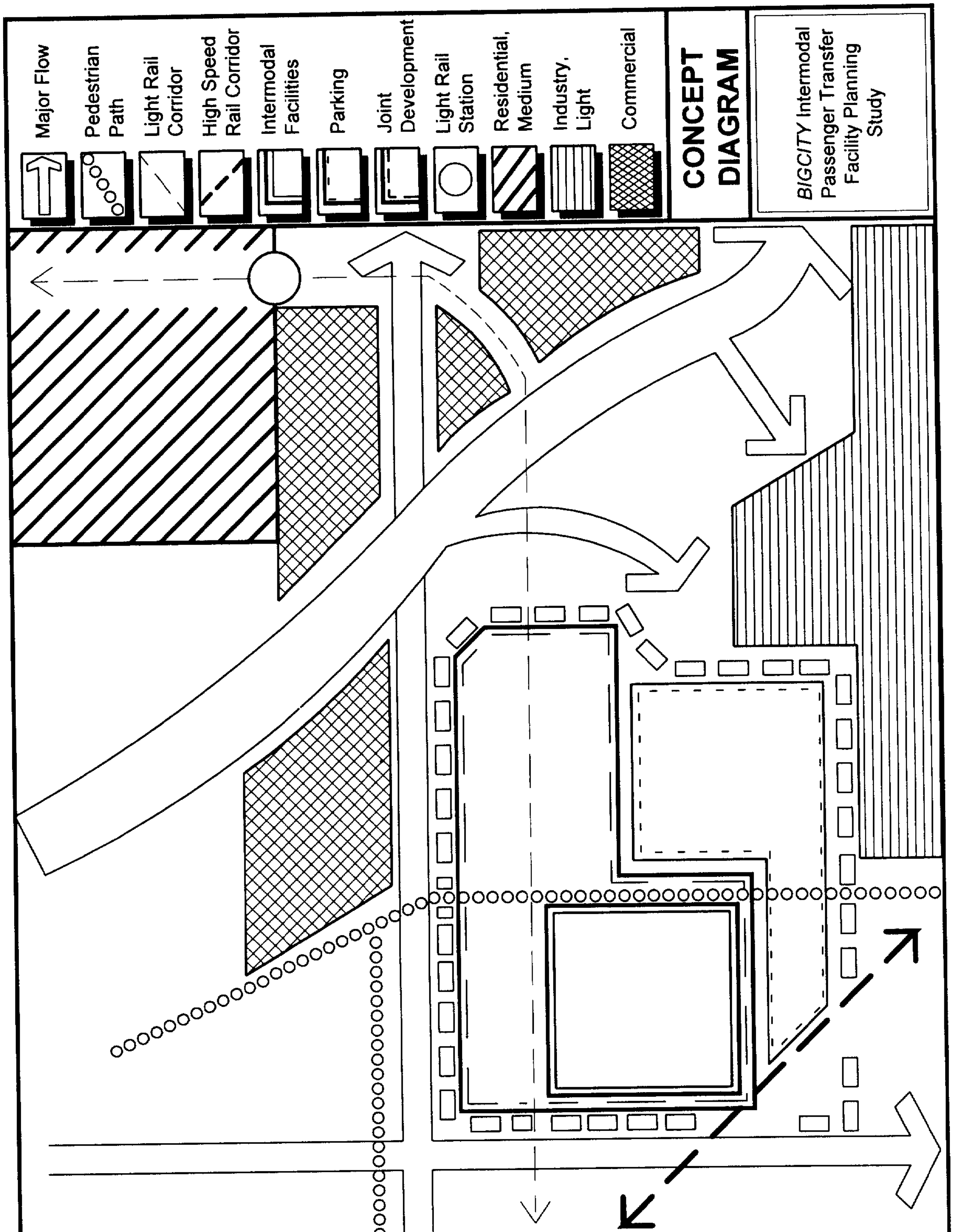


FIGURE 6.8. EXAMPLE OF A CONCEPT DIAGRAM

Trip Segment Analysis within Facility

Purpose

To determine a measure of ease of travel for frequent trips near and within the facility; to compare these trips across alternatives for a single site; and to prepare data required for determining the travel impact of each alternative.

Requirements

- For each alternative, a site plan and an interior space plan, drawn to scale and a concept diagram.
- Each alternative should serve a similar set of modes.

Background

Many of the objectives of an intermodal facility relate to reducing the difficulty of making transfers between selected modes and gaining access to selected modes. A good indication of how well this objective has been met for each alternative can be found by comparing the disutility of portions of trips within the facility. Everything else being equal, a better alternative at a specific site is one that reduces disutility for all or most trips.

It is well known that reductions in trip disutility for a mode lead to increases in travel for that mode. Such increases in travel can come from trips diverted from unrelated modes, from trips diverted from unrelated paths or from entirely new trips. With trip segment analysis, it is not possible to directly assess travel impacts of an alternative. Instead, the importance of the trip is estimated on a 0 to 10 scale. That importance, once determined, is held constant. Should the travel impact be large, trip segment analysis will tend to understate the benefits of an alternative. In such cases, it is necessary to perform consumer surplus analysis, described in Chapter 8.

Steps

Step 1. Complete network preparation. The study area for trip segment analysis is the site of the intermodal facility. Portions of trips that occur outside the facility are ignored. For each alternative a network should be drawn that shows major travel paths between points within the facility. See Chapter 1 for an overview of network construction and network elements (links and nodes). It is particularly helpful if the network is drawn with a suitable network editor, but a pencil-and-paper sketch can suffice. To keep the network simple, use the technique of *windowing* by showing only links and nodes that are contained within the site. Place nodes at all entrances and exits to the site, including gates and driveways, to serve as *external stations*. These external stations will become the origins and destinations for many of the trips. Estimate walking speeds and delays on each link in the network, estimate speeds on pedestrian assist systems and estimate delays at nodes.

Step 2. Establish disutility weights and penalties. It is especially important to weight each trip segment according to the perceived difficulty of travel across that segment. All segments must have a weight, a penalty or both a weight and a penalty. Normal travel within a vehicle has an assumed weight of 1.0 and no penalty. Segments that are perceived to be more difficult have a larger weight. Penalties are given to activities that consume little time but are still perceived to be difficult. Table 1.3 in Chapter 1 lists several weights and penalties that may be used when locally derived values are unavailable. Note that weights and penalties can vary by the type of activity, mode and conditions of travel. Table 1.3 also lists suggested values of time, which are necessary if a trip segment has an associated monetary cost.

Step 3. Select a sample of trips. Identify the major trips through the facility. Choose a subset of these major trips that can be made in all alternatives. Place these trips into three categories:

A. Transfer Trips: Trips that enter the facility from a line-haul mode and leave by another line haul mode;
B. Access Trips: Trips that enter the facility by walking or automobile and leave by a line-haul mode; and
C. Egress Trips: Trips that enter the facility by a line-haul mode and leave by walking or automobile.

Identify the trips by their origins and destinations. Be sure to consider a fair representation of trips that start, end and stay within the facility. Develop an alternative summary table of trips, which include separate columns for trip importance, the trip disutility and the trip score. Figure 6.9 is an example of such a table.

Trip	Importance	Disutility	Score
Parking Lot B to Intercity Bus Bays	6	41	246
Intercity Bus Bays to Parking Lot B	6	35	210
Intercity Bus Bays to LRT Platform	3	32	96
Averages	5		184

FIGURE 6.9. ALTERNATIVE SUMMARY TABLE OF MAJOR TRIPS WITHIN FACILITY

Step 4. Rate trip importance. Rate trips by importance on a 0 (least important) to 10 (most important) scale. For this rating consider the expected frequency of use, time sensitivity of the trip and whether the trip is an essential component of the whole transportation system. The average importance rating should be close to 5, so adjust all ratings accordingly. If there are too many low rated trips, eliminate some from the analysis.

Step 5. Develop trip segment tables. Develop trip segment tables for access, egress and transfer trips. Example tables are shown in Figures 6.10, 6.11 and 6.12. Each table should have columns for nodes along the path, the segment time, the segment penalty, the segment weight and the weighted time. Leave a blank line between pairs of nodes to record information about the link that connects to these nodes.

Step 6. Estimate segment and trip disutilities. Identify all trip segments for each trip. Estimate time in each trip segment (by the shortest path), then find total disutility. Follow this procedure.

A. Identify all segments of a trip by scanning the network.
B. Determine the time required for each trip segment by the best possible path.
C. Assign a weight and/or penalty for each trip segment.
D. Determine the disutility for each trip segment.

segment disutility = (time)(weight) + penalty

E. Identify any access costs (parking fees, tolls) and record their total. Divide parking fees by two.
F. Determine the value of time for the trip. Record its reciprocal (as a weight) in units of minutes/dollar.
G. Determine the disutility of the access costs.

access cost disutility = cost/(time value)

H. Find the total disutility for the trip by summing the segment disutilities.

Judge whether congestion affects the choice of paths; repeat if necessary.

Step 7. Compare alternatives. For each alternative, fill in the alternative summary table created as part of Step 3. Multiply the importance and disutility; then compute the score for each trip. Find the average importance and the average score.

Compare results across alternatives and against the null alternative. Find total weighted improvement in disutility over the null alternative. You may use Table 6.1 to interpret the changes from the null alternative.

Example

A trip segment analysis is required for the Big City Intermodal Passenger Transfer Facility. Only one alternative has been developed at this time, so it can only be compared with the null alternative. The concept diagram for this alternative has already been prepared (see Figure 6.8).

Access
Trip Leaving by: ____________________

Intermediate Point	Time	Penalty	Weight	Disutility
Origin				
Parking				
Curb				
Baggage Check				
Ticketing or Fare				
Security				
Waiting Area				
Gate or Platform				
Leave Terminal				
Access Costs				
Total				

FIGURE 6.10. EXAMPLE TRIP SEGMENT TABLE, ACCESS

Egress
Trip Arriving by: ____________________

Intermediate Point	Time	Penalty	Weight	Disutility
Enter Terminal				
Baggage Claim				
Curb				
Parking				
Destination				
Egress Cost				
Total				

FIGURE 6.11. EXAMPLE TRIP SEGMENT TABLE, EGRESS

Transfer

Trip between: ____________ and ____________

Intermediate Point	Time	Penalty	Weight	Disutility
Enter Terminal				
Baggage Claim				
Shuttle				
Baggage Check				
Ticketing or Fare				
Security				
Waiting Area				
Gate or Platform				
Leave Terminal				
Transfer Costs				
Total				

FIGURE 6.12. EXAMPLE TRIP SEGMENT TABLE, TRANSFER

TABLE 6.1. INTERPRETATION OF THE WEIGHTED SCORES

Difference in Average Weighted Score	Interpretation
0 to 10	Insignificant
11 to 20	Small Improvement
21 to 40	Moderate Improvement
41 or More	Large Improvement

Step 1. Complete network preparation. The immediate site of the facility, including parking and joint development, forms a window that is then isolated from the rest of the community. All major points of access to the site are denoted on the concept diagram as triangles (see Figure 6.13) and serve as external stations. This particular transfer facility has three points of automobile access (North, Northwest and South), two points of pedestrian access (East and West) and two passenger drop-off points (West and South) that handle the needs of local buses, kiss-n-ride and taxi. Within the site nodes

are placed where there are changes in modes, essential en route services, delays or turns. These nodes are shown as dots. Vehicular and pedestrian paths are indicated by links. The network has been drawn so it is possible to move between any point of access to the site and any point of access to a line-haul mode. Links are drawn as straight lines, not necessarily following the exact alignment of the portion of path it represents.

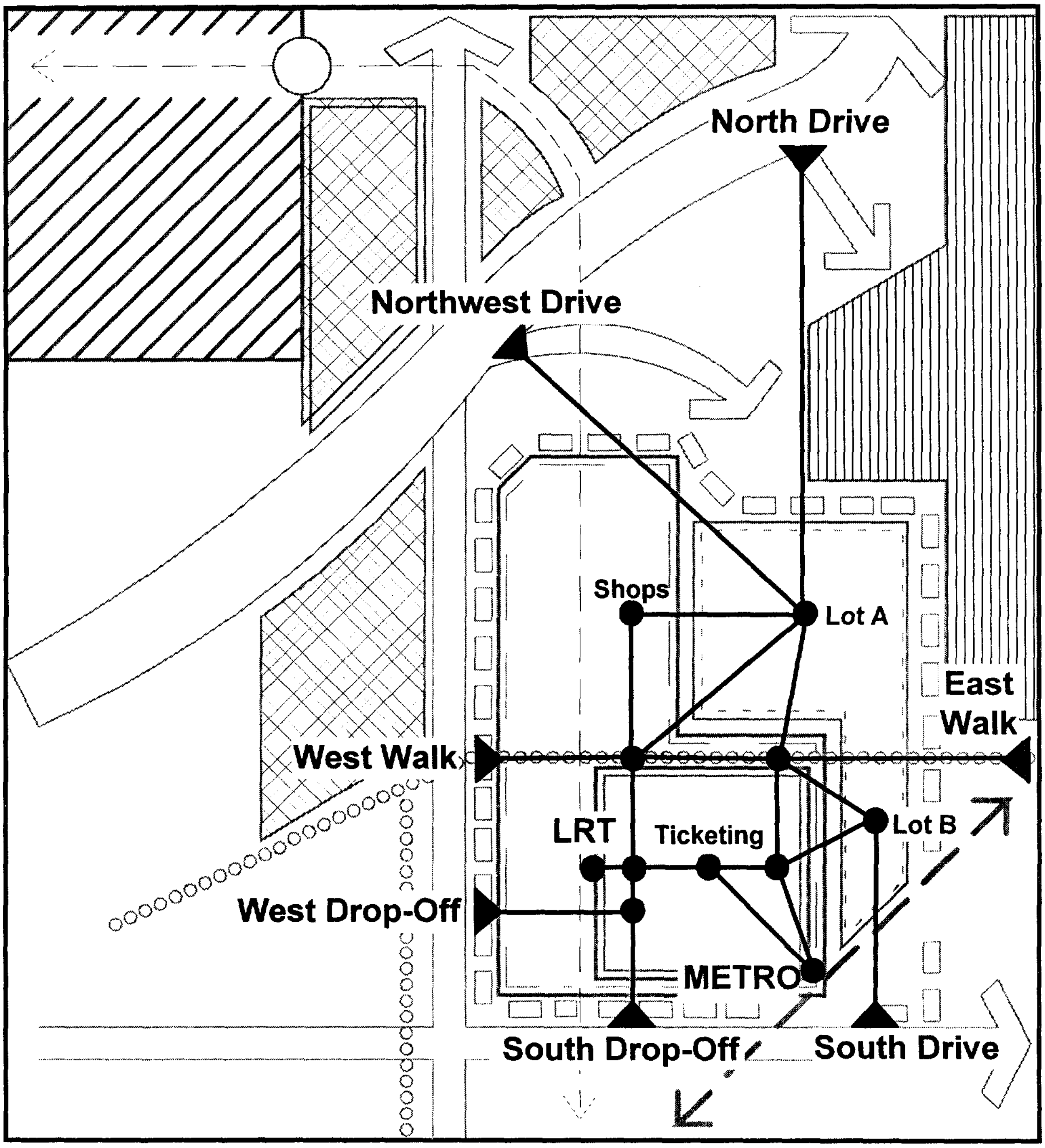


FIGURE 6.13. INTERNAL NETWORK FOR BIG CITY INTERMODAL PASSENGER TRANSFER FACILITY

Walking speeds are estimated to be 240 ft/min; vehicles average 480 ft/min within the site; each level change adds 2 minutes of time; and there are no pedestrian assist systems for horizontal movement. A single level change is required between the concourse and either METRO or LRT gates. Approximately 50% of the people parking in Lots A and B require level changes to reach the concourse. Parking costs $3 per day and the average wage rate for persons using the facility is $12.00/hr.

Step 2. Establish disutility weights and penalties. Since local data is unavailable, the weights and penalties shown in Chapter 1, Table 1.3 are used. The selected weights and penalties assume (1) good weather conditions, (2) little or no baggage, (3) untimed transfers, (4) travel to and from work and (5) unproductive waiting.

Steps 3 and 4. Select a sample of trips and rate importance. Seven out of 16 possible trips have been selected, as shown in Figure 6.14. Each trip has been rated for importance, with the ratings adjusted so they average 5.0.

Trip	Importance	Disutility	Score
Northwest Drive to METRO	5		
South Drive to LRT	3		
South Drop-Off to LRT	4		
East Walk to METRO	2		
LRT to METRO	10		
LRT to West Walk	4		
METRO to West Drop-Off	7		
Averages	5		

FIGURE 6.14. ALTERNATIVE SUMMARY TABLE AND SAMPLE OF TRIPS IN THE BIG CITY INTERMODAL PASSENGER TRANSFER FACILITY

Steps 5 and 6. Develop trip segment tables and estimate disutilities. The example trip segment tables were adapted for the Big City Intermodal Passenger Transfer Facility. Lines in the table are provide for all nodes and all segments (links) between the nodes. The mode of travel is indicated where it is applicable. Figure 6.15 shows a completed table for the trip between the South Drive external station and the LRT (light rail transit) vehicle. This trip had surprisingly high total disutility of 66 minutes, due principally to a vehicle-to-vehicle transfer penalty of 16 minutes and a $3 per day parking charge. The null alternative, with outdoor parking at $1 per day but no weather protection, had a disutility for this trip of 74.5 minutes (not shown).

Access Trip Leaving by: South Drive to LRT				
Intermediate Point	**Time**	**Penalty**	**Weight**	**Disutility**
Origin				
Automobile	**2.5**		**1.0**	**2.5**
Parking, Lot B	**0.5**		**2.0**	**1.0**
Walk, Stairs	**4.0**		**1.25**	**5.0**
East Concourse				
Walk	**0.4**		**1.25**	**0.5**
Ticketing	**1.0**		**2.0**	**2.0**
Walk	**0.4**		**1.25**	**0.5**
West Concourse				
Walk, Escalator	**3.2**		**1.25**	**4.0**
LRT Gate				
Wait, Transfer	**6.0**	**16**	**2.0**	**28.0**
Leave Terminal				
Access Costs	**$3.00/2**		**15 min/$**	**22.5**
Total				**66.0**

FIGURE 6.15. EXAMPLE TRIP SEGMENT TABLE FOR A TRIP FROM SOUTH DRIVE TO LRT

Step 7. Compare alternatives. The results of Step 6 are entered into the alternative summary table, as illustrated in Figure 6.16. An average score over the seven trips was calculated to be 167. The average score for the null alternative was 191 (not shown). Thus, from Table 6.1 it is seen that the considered alternative represents a "moderate improvement" over the null alternative.

Trip	Importance	Disutility	Score
Northwest Drive to METRO	5	66.5	333
South Drive to LRT	3	66.0	198
South Drop-Off to LRT	4	34.0	136
East Walk to METRO	2	22.3	45
LRT to METRO	10	35.5	355
LRT to West Walk	4	9	36
METRO to West Drop-Off	7	9	63
Averages	5		167

FIGURE 6.16. COMPLETED ALTERNATIVE SUMMARY TABLE

Paths by Process Diagrams

Purpose

To better understand the nature of flow through a transfer facility.

Steps

Step 1. Obtain a scaled map of the facility and immediate neighborhood. The map need not be very detailed, but it should show all points of access and egress, roads and paths and the major interior features of the facility. Show any element of the facility that would be on a direct path from any origin to any destination. Omit services that are not essential to any trip.

Step 2. Determine the process and develop paths. A process is identified by its:

Object:	Item to be transported (e.g., person, package, freight).
Purpose:	Reason for the trip.
Vehicle(s):	Method of internal travel (e.g., pedestrian, wheelchair, shuttle).
Origin:	The place within the facility (or neighborhood) where the trip starts.
Destination:	The place within the facility (or neighborhood) where the trip ends.

There can be many paths between the origin and destination. Path determination can usually be done by inspection. Eliminate unusual or inefficient paths. For simplicity, combine similar paths. Be sure to show distinct paths where they may differ by the need to overcome barriers or the existence of points of decision. Identify any points along each path where (1) a service might be rendered, (2) a delay might be incurred or (3) a barrier might need to be overcome.

Step 3. Show the paths as a Process Diagram. The process of traveling from an origin to a destination can be shown as a flow diagram. Standard symbols are given in Figure 6.17. All elements of the trip should be shown, including its origin, its destination, points of decision, barriers, required services, queues, general waiting and traveling. Label each symbol and connect them with arrows to indicate direction of movement.

Example: Self Parking to Intercity Travel

The process to be drawn is a trip between an automobile and an intercity mode, where the ticket is inspected at the gate and there is no security.

Step 1. Obtain a scaled map of the facility and immediate neighborhood. A detailed scaled map is unwieldy for this problem, so a schematic map is used instead. The station and most of its site are shown in Figure 6.18.

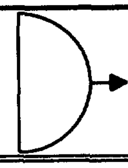
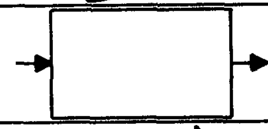
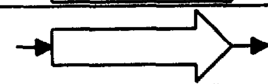
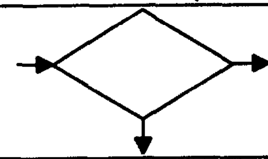
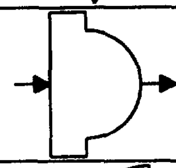
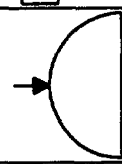
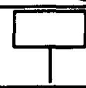
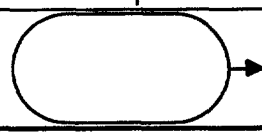
Source of Traffic (Origin)	
Server or Transport	
Queue	
Routing Decision	
Barrier	
Sink (Destination)	
Required Information	
Alternate Symbol for Source or Sink	

FIGURE 6.17. PROCESS DIAGRAM SYMBOLS

Step 2. Determine the process and develop paths. The process was identified as shown below.

Object:	Person
Purpose:	Leaving City
Vehicle:	Pedestrian (all portions of trip)
Origin:	Parking, Center of Short-term Lot
Destination:	Gates 2-4

Only two distinct paths were found. These are shown in Figure 6.19. They differ by whether the passenger has already purchased a ticket. With a ticket, luggage is checked at curbside. Otherwise, luggage is checked at the time the ticket is purchased.

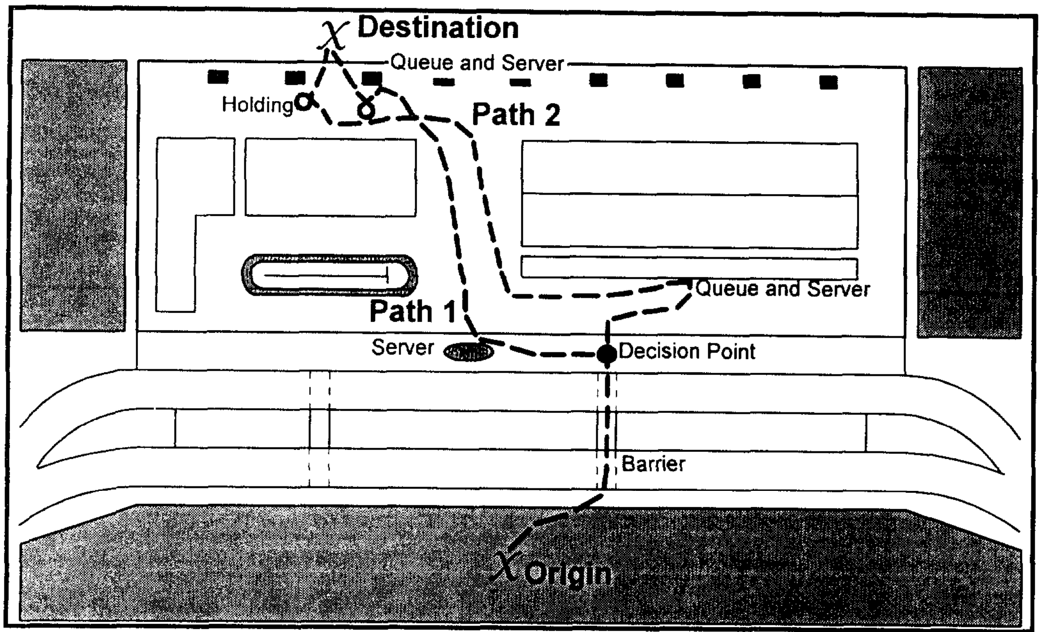


FIGURE 6.18. STATION, SITE AND PATHS FROM SOURCE TO SINK

Because of optional services, actual paths may be more complicated than shown. Passengers could use holding time to visit concessions, attend to personal needs or engage in work or recreational activities.

Step 3. Show the paths as a Process Diagram. Figure 6.19 shows the resulting process diagram. Each process has been labeled. *Note that walking is considered a process and that queues and servers are shown separately.*

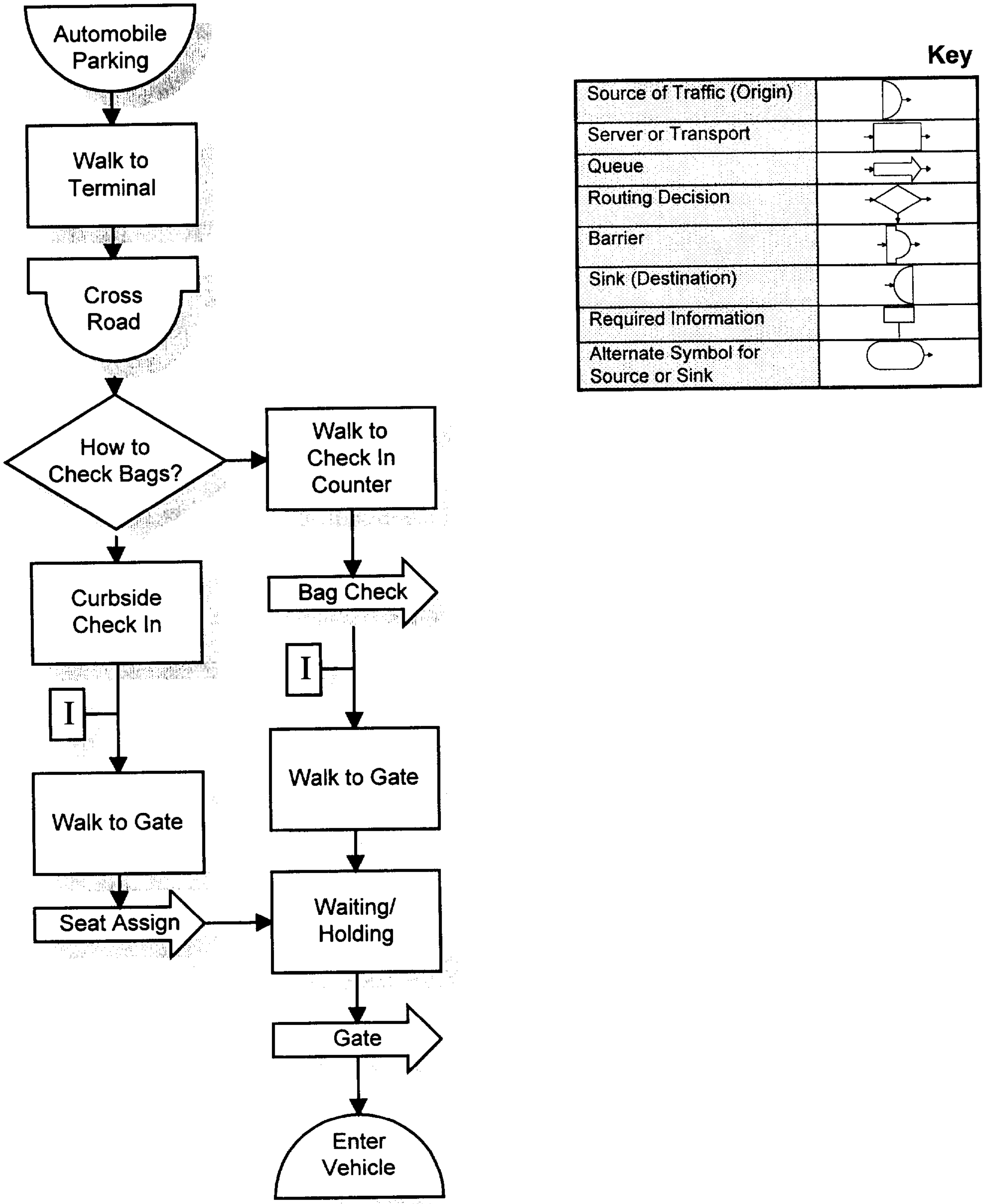


FIGURE 6.19. AN EXAMPLE PROCESS DIAGRAM

External Environment Checklist

Purpose

To ensure that all external environmental elements are considered in facility design.

Background

A checklist is a helpful tool for guaranteeing that all necessary environmental elements are respected in the design, or at least were considered in the planning process. Such a checklist is easy to develop and administer relative to its benefit to the planning and design processes. The checklist should be developed prior to designing any of the alternatives. Early use of the checklist in the design of alternatives will help those alternatives better meet their objectives.

Steps

Step 1. List all external design elements. List all external design elements that should be considered in the planning process. Refer to the complete list of goals and objectives when developing the list. The list must be very comprehensive. Consult knowledgeable officials for an analysis of the list and edit the items, as appropriate.

Step 2. Create External Environment Checklist. Develop a checklist of elements from the list created in Step 1. The checklist's format should include a box next to the design element for a check. The checklist should also leave space next to each element for a brief description of how the element is handled in the alternative's external environment or why it was not included in the design. The checklist should be arranged so those design elements that were not included in the planning process can be easily recognized. An example of a checklist is illustrated in Figure 6.20.

Step 3. Evaluate each alternative. Use a separate checklist for each alternative. Remember that all external environmental elements need not be included in an alternative's design. All elements must, at a minimum, be considered for inclusion in the design. If an element was considered and found unsuitable for an alternative, place a check by the element and describe the reason for the finding.

Step 4. Revisit any elements that were not previously considered. All environmental design elements that were not checked should be reinvestigated. A missed, but important design element can diminish the value of the whole alternative.

External Environment Checklist	A
Design Element	**Description**
❑ Topography	
❑ Historic Preservation	
❑ Reuse of Existing Buildings	
❑ Asbestos Removal	
❑ Other Hazardous Materials Handling	
❑ Integration with Existing Land Uses	
❑ Integration with Existing Open Space	
❑ Efficient Use of Utilities	
❑ Proximity to Commercial	
❑ Proximity to Residential	
❑ Proximity to Recreation	
❑ Proximity to Government	
❑ Proximity to Other (Describe)	
❑ Joint Development	
❑ Resolution of Property Rights	
❑ Resolution of Easements	
❑ Resolution of Air Rights	
❑ Zoning Consistency	
❑ Expansion Potential, Capacity	
❑ Expansion Potential, Joint Development	
❑ Expansion Potential, Modal Access	

FIGURE 6.20A. EXTERNAL ENVIRONMENT CHECKLIST

External Environment Checklist	B
Design Element	**Description**
❑ Visual Quality, Vistas	
❑ Architectural Design	
❑ Air Quality (Local and Regional)	
❑ Noise Pollution	
❑ Impact on Parks and Open Space	
❑ Impact on Historic Sites	
❑ Impact on Scientifically Significant Sites	
❑ Shoreline Preservation/Enhancement	
❑ Secondary Land Use Impacts	
❑ Construction Impacts	
❑ Impact on Flood Plains	
❑ Other Physical Impacts (Describe)	
❑ Cultural Impacts and Enhancements	
❑ Community Image	
❑ Community Pride	
❑ Community Disruption	
❑ Impact on Community Cohesiveness	
❑ Impact on Culturally Significant Sites	
❑ Housing Losses/Gains	
❑ Local Job Creation	
❑ Local Job Quality	

FIGURE 6.20B. EXTERNAL ENVIRONMENT CHECKLIST

External Environment Checklist	C
Design Element	**Description**
❑ Welfare System Impact	
❑ Crime	
❑ Other Social Impacts (Describe)	
❑ Archeological Impacts	
❑ Impact of Local Traffic Flow	
❑ Impact on Local Traffic Safety	
❑ Energy Impacts	
❑ Other Infrastructure Impacts (Describe)	
❑ Land Consumption of Terminal Buildings	
❑ Land Consumption of Roads/Guideways	
❑ Land Consumption of Parking	
❑ Land Consumption of Developments	
❑ Other Land Consumption (Describe)	
❑ Creation of Physical Barriers	
❑ Relocations	
❑ Freight Service on Shared Track	
❑ Property Values and Tax Base	
❑ Conformance with Codes/Laws	
❑ Impact on Emergency Services	
❑ Impact on Blighted Areas	
❑ Impact on Neighborhood Safety	

FIGURE 6.20C. EXTERNAL ENVIRONMENT CHECKLIST

External Environment Checklist	D
Design Element	**Description**
❑ Attractive Maintenance/Storage Areas	
❑ Pedestrian Use of Existing Paths	
❑ Pedestrian Open Spaces	
❑ Pedestrian Street Crossing Priority	
❑ Skywalks, Tunnels	
❑ Protection of Pedestrians from Vehicles	
❑ Pedestrian Wayfinding Information	
❑ Microclimate Impacts	
❑ Informal Vending near Entry Points	
❑	
❑	
❑	
❑	
❑	
❑	
❑	
❑	
❑	
❑	

FIGURE 6.20D. EXTERNAL ENVIRONMENT CHECKLIST

Note: List assumes an urban location with considerable existing development. In rural locations also consider ecological impacts, wetland preservation and farmland preservation.

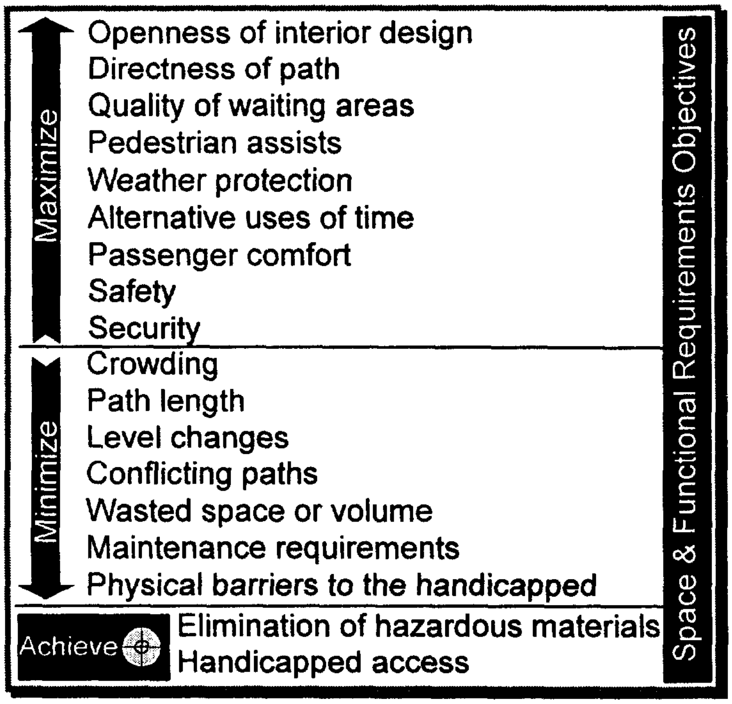
Chapter 7. Evaluation of Internal Design

Overview

Many internal elements are thought of as being details and are often left to the architectural design stage – well after an alternative has been selected. However, a good interior space plan is required for an evaluation, and it requires a good understanding of space requirements, functional requirements, pedestrian paths, waiting and holding. So that consistency is maintained, consideration of the arrangement of interior spaces should run parallel to consideration of external spaces and access. This chapter presents several tools for developing and evaluating interior space plans, including a space requirements questionnaire, orientation analysis, interior pedestrian-trip assignment, queuing theory and a preliminary review of signing needs.

Space and Functional Requirements

The space and functional requirements of an intermodal facility are best determined by the potential operators at the facility. Each of the potential operators should participate in the development of specifications necessary to accommodate their respective operations and to integrate all functions into a highly coordinated system.



Potential operators' participation is accomplished through their involvement in the Planning Advisory Group and by their completion of both a Functional Requirements Questionnaire and a Space Requirements Questionnaire. Although separate questionnaires are advisable, many of the operators can designate one individual to complete both forms, so long as that individual is familiar with the complexities of both functional requirements and space requirements.

Generally, the potential operators will be answering the questionnaires without considering operational interaction with other modes and/or functions. The questionnaires' purpose is to establish minimum requirements of each potential operator. After all operators submit their responses, the staff and Planning Advisory Group can work toward operational integration – eliminating duplication and resolving conflicts. See Chapter 4 for a discussion of system integration.

Functional Requirements Questionnaire

Purpose

To establish the functional requirements of potential operators at the intermodal passenger transfer facility.

Requirements

Panel of officials representing potential operators at the facility.

Steps

Step 1. Determine general functional requirements criteria. In order to develop a comprehensive questionnaire, all criteria for determining functional requirements must be included. Each function will have its own set of criteria, and a question covering each general criterion is needed. To prevent overlooking criteria, people involved with each function must be contacted before developing the questionnaire and asked about general criteria that should be included. Items that the questionnaire should cover include:

- Accessibility to other modes;
- Visibility of operations;
- Mode turnover;
- Operational relationship with other modes;
- Mode specifications;
- Ticket sales, check-in and fare collection needs;
- Track and platform design;
- Mode parking and storage arrangements; and
- Future expansion.

Step 2. Develop Functional Requirements Questionnaire. Using the criteria developed in Step 1, create a space requirements questionnaire. Ask panel members to respond only to the sections applicable to the functions they are representing. A sample questionnaire is illustrated in Figure 7.1. *Note: See Do's and Don'ts of Questionnaire Process in Chapter 2 for suggestions about developing and administering a questionnaire.*

Step 3. Pretest questionnaire. If there are a large number of potential operators, then a pretest is advisable. Select a few knowledgeable individuals to complete the questionnaire before distributing it to the panel. Have them pay particular attention to the format and wording. Invite their comments and criticisms, then make any necessary revisions.

Step 4. Establish a panel. Contact all potential operators at the facility. One representative from each operator is needed for the panel. Explain the need for their input and the benefits they will receive from the inclusion of their responses. Solicit the name of the individual at the operator who is best suited for answering the questionnaire. Ideally, one person should complete both the Functional Requirements Questionnaire and the Space Requirements Questionnaire. Otherwise, the responses from different people from the same operator must be made consistent. For modes that do not currently exist in the community but are being considered for the future, enlist an individual familiar with the modes' functional requirements to complete the questionnaire.

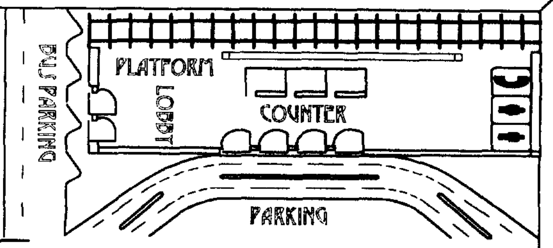
Step 5. Administer questionnaire. Send out each questionnaire with a self-addressed return envelope. After two weeks have passed, contact all panel members who have not returned their questionnaire. Reiterate the importance of their contribution. A gentle reminder to those who do not return questionnaires is usually sufficient.

Step 6. Compile responses. The results must be compiled into a format that will guarantee their inclusion in the alternative designs.

Step 7. Evaluate alternatives. See Step 7 of the Space Requirements Questionnaire later in this chapter.

Functional Requirements Questionnaire

Name: ______________________
Agency: ______________________
Telephone #: ______________________
Fax #: ______________________
Mode: ______________________



This questionnaire addresses the criteria for determining the functional requirements for the intermodal passenger transfer facility. Respond only to the those questions which apply to the mode you are representing. If sufficient space is not provided for answers, please continue them on the reverse side of the questionnaire. If you have any questions contact Joe Smith at 800-555-1212. Thank you for your time.
Return questionnaire to: *(Insert return address)*

All Modes [illegible]	
Modal operations	Operational relationship with other modes: ☐ Separate ☐ Integrated Locational relationship to other modes: ☐ Separate ☐ Separate, but adjacent ☐ Integrated Accessibility to other modes: ☐ Direct ☐ Indirect ☐ None Mode turnover: Vehicles per peak hour: ________ Vehicles per off-peak hour: ________ Visibility of operations: ☐ Direct/High ☐ Indirect/Low Hours of operation: ________ to ________ Peak hours: A.M.: ________ P.M.: ________
Mode specifications	Turning radius: ________ Height: ________ Width: ________
Baggage pick-up area	Should there be a baggage pick-up area? ☐ Yes ☐ No If yes, what is the preferred location? ☐ Curbside ☐ Central facility area ☐ Adjacent to platform ☐ Adjacent to ticket counter ☐ Other ________
Ticket sales/check-in counters	Should ticket counter be connected to office area? ☐ Yes ☐ No
Future growth	Will additional space be required to accommodate operations in the future? ☐ Definitely ☐ Probably ☐ Probably not ☐ Definitely not

FIGURE 7.1. FUNCTIONAL REQUIREMENTS QUESTIONNAIRE

Railroad	
Platform design	Roof: ________% of platform covered. Seating: ________ *total number* Boarding: ☐One side ☐Both sides Maximum engine length ________ft. Railcar length ________ft. Minimum vertical clearance from top of rail ________ft. Potable water? ☐Yes ☐No 480V Standby? ☐Yes ☐No Toilet dump? ☐Yes ☐No Enroute water stations? ☐Yes ☐No If yes, how often? Every ______ft. On all tracks? ☐Yes ☐No
Track geometry approaching terminal	☐Single track ☐Dual track If dual track, what is the minimum spacing requirement between tracks? ____ft. (on tangent) Minimum right of way? ____ft. Minimum vertical distance? ____ft. Minimum radius? ____ft. Maximum grade? ____percent
Bus	
Parking	Check preferred parking configuration ☐Sawtoothed ☐Parallel ☐Other ___________
All Modes	
Other requirements	List any other functional requirements not included above. *Some requirements may appear in the* ***Space Requirements Questionnaire*** ______________________________ ______________________________ ______________________________

FIGURE 7.1 (CONT.). FUNCTIONAL REQUIREMENTS QUESTIONNAIRE

Expected Functional Requirements

A survey of functional requirements was conducted for the Planning and Feasibility Study of Memphis Central Station. AMTRAK, Greyhound, an airport shuttle, a taxi operator, a tour bus operator and the Memphis Area Transit Authority all contributed to the survey. Table 7.1 summarizes their functional requirements. Similar requirements can generally be expected for most new facilities. This list can be expanded or shortened depending upon the mix of potential operators at the facility.

TABLE 7.1. EXPECTED FUNCTIONAL REQUIREMENTS BY MODES

Intercity Bus

1. Direct access from street for bus operations
2. Separate public entry/drop-off at street level
3. Connection to other transit operations
4. Covered bus loading dock area
5. Sufficient turning radii (55' minimum)
6. Separate terminal and package express areas
7. Separate public/service circulation
8. Secure environment for all operations
9. Waiting areas located adjacent to bus loading areas
10. Baggage areas located adjacent to ticketing and bus interface
11. Lobby area that is focal point of facility with all functions radiating out from the hub
12. Restaurant combined with other transit operations outside terminal

AMTRAK

1. Capability of handling 150-300 passengers per peak hour
2. Located adjacent to tracks
3. Public drop-off adjacent to lobby
4. Parking convenient to operations
5. Security of track area
6. Connection to other transit operators
7. Covered platform for length of train
8. Baggage area adjacent to ticketing and trackside
9. Future growth allowance

Tour Bus

1. Day and night operations
2. Secure area
3. Adjacent parking
4. Clients parking at operations center and depart tour
5. Buses from hotels to operation center prior to tour

Local Bus

1. High turnover local bus operation
2. Excellent bus accessibility
3. Proximity to other transportation modes
4. Direct access to light rail transit
5. High visibility
6. Bus loading area capable of using stepped parallel queue

Light Rail Transit

1. Proximity to other transportation modes
2. Direct access to transfer station

Airline*

1. Travel agent
2. Baggage checking and claiming

**no direct connection*

Taxi

1. Adjacent to other transit operators

Source: Memphis Area Transit Authority, 1991

Space Requirements Questionnaire

Purpose

To establish space requirements of potential operators and potential services at the intermodal passenger transfer facility.

Requirements

Panel of officials representing operators and services that will require space at the facility.

Steps

Step 1. Determine general space requirements criteria for each function. In order to develop a comprehensive questionnaire, all criteria that will determine space requirements must be included. Each potential operator or service will have its own set of criteria. A question covering each general criterion is needed. To prevent overlooking criteria, representatives of each function must be contacted before developing the questionnaire and asked what general criteria should be included. Areas the questionnaire should cover include:

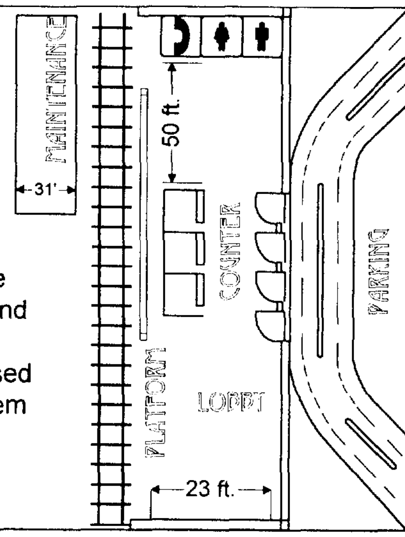
- Employee and customer parking;
- Counter space for ticket sales;
- Restrooms, public telephones and information;
- Administration;
- Mode vehicles;
- Maintenance;
- Security; and
- Storage.

Step 2. Develop Space Requirements Questionnaire. Using the criteria developed in Step 1, create a Space Requirements Questionnaire. The questionnaire should be divided into sections, one section for each mode. Ask panel members to respond only to the sections applicable to their operation. A sample questionnaire is illustrated in Figure 7.2. *Note: See Do's and Don'ts of Questionnaire Process in Chapter 2 for tips on creating and administering the questionnaire.*

Step 3-6. Follow Steps 3-6 described in preceding section on Functional Requirements Questionnaire.

Step 7. Evaluate alternatives. Using the Service Requirements Evaluation form illustrated in Figure 7.3, determine the total functional and space area requirements of each alternative.

Space Requirements Questionnaire



Name: ____________________
Agency: ____________________
Telephone #: ____________________
Fax #: ____________________
Mode: ____________________

This questionnaire addresses the criteria for determining the space requirements for the intermodal passenger transfer facility. Respond only to the those questions which apply to the agency you are representing. If there are space requirements that are not addressed or sufficient space is not provided for answers, please continue them on the back side of the questionnaire. If you have any questions contact Joe Smith at 800-555-1212. Thank you for your time.
Return questionnaire to: *(insert return address)*

Automobile Parking	
Employee	Number of employee spaces needed: ______ Parking requirements: *(check all that apply)* ☐ Remote location ☐ Adjacent location ☐ Separate entrance ☐ Security provisions ☐ Separate from other operator's employees ☐ Other ____________
Passenger: short-term	Number of spaces needed: ______
Passenger: long-term	Number of spaces needed: ______
Rental car for passengers	Number of spaces needed: ______ Does rental car parking need to be located close to the facility? ☐ Yes ☐ No
Bus Requirements	
Bus parking	Number of bus bays needed Intercity? ______ Local? ______ Should space be provided for long term layovers? ☐ Yes ☐ No Number of bays? ______

FIGURE 7.2. SPACE REQUIREMENTS QUESTIONNAIRE

[illegible]	
Passengers	Peak number of passengers expected in facility? _____
Passenger waiting area	Size of waiting area needed? ________sq. ft. Number of seats in waiting area? ________
Ticket sales/check-in counters	Number of counter positions needed? ________ Operational area needed per ticket counter? ____sq. ft.
Baggage handling facilities	Should handling facilities be shared by operators? ☐ Yes ☐ No Should there be curbside check-in service? ☐ Yes ☐ No Should there be check-in counter service? ☐ Yes ☐ No
Passenger drop-off area	Number of automobile staging spaces needed for peak period? ________
Retail facilities	Should retail business be located in the facility? ☐ Yes ☐ No If yes, what type and what size? *(check all that apply)* ☐ Restaurant ________sq. ft. ☐ Newspaper stand ________sq. ft. ☐ Gift shop ________sq. ft. ☐ Coffee shop ________sq. ft. ☐ Other ______________ ________sq. ft. ☐ Other ______________ ________sq. ft.
Car rental and airline agencies	Should car rental agencies operate at the facility? ☐ Yes ☐ No Should airlines have counters at the facility? ☐ Yes ☐ No
Handicapped services	Explain special handicapped service/access needs: ____
Other services	Public restrooms? ☐ Yes ☐ No Public information center? ☐ Yes ☐ No If yes, where should it be located? ☐ Adjacent to offices ☐ In center of facility ☐ Other ________________ Where should pay phones be located? ☐ In facility Number? ________ ☐ On platform Number? ________ Should lockers be available? ☐ Yes ☐ No If yes, how many? ________ Size of each locker ________sq. ft. Should mail boxes be located in the facility? ☐ Yes ☐ No

FIGURE 7.2 (CONT.). SPACE REQUIREMENTS QUESTIONNAIRE

Rail Platform Requirements	
Platforms	Number of platforms ________ Station tracks ________ Mail tracks ______ Storage tracks ________
Platform dimensions	Length ________ft. Width ________ft. Boarding height ________ft.
Railroad Requirements	
Storage tracks	Are storage tracks needed? ☐ Yes ☐ No If yes, describe requirements: Number__________ Length __________
Administrative and Operational Requirements	
Personnel	Total personnel ________ Peak number of employees in facility ________
Employee facilities	Private restrooms? ☐ Yes ☐ No Breakroom ________sq. ft. Driver ready room? ☐ Yes ☐ No If yes, what is minimum size? ________sq. ft. Locker rooms? ☐ Yes ☐ No If yes, what is minimum size? ________sq. ft.
Offices and meeting rooms	Type and minimum size: Support ________sq. ft. Locational requirement ___________________ Engineering ________sq. ft. Locational requirement ___________________ Transportation ________sq. ft. Locational requirement ___________________ Reception area ________sq. ft. Locational requirement ___________________ Conference area ________sq. ft. Locational requirement ___________________ Passenger services ________sq. ft. Locational requirement ___________________ Other administrative ________sq. ft. Locational requirement ___________________
Parcel Services	
Delivery services	Counter to counter delivery services? ☐ Yes ☐ No Customer service area? ☐ Yes ☐ No Number of counters ________ Operational area per counter ________sq. ft. Office area requirements ________sq. ft. Locational requirements ____________________
Mail service	U.S. mail service? ☐ Yes ☐ No Operational area ________sq. ft. Office area requirements ________sq. ft. Locational requirements ____________________

FIGURE 7.2 (CONT.). SPACE REQUIREMENTS QUESTIONNAIRE

[illegible]	
Security operations	Cash counting room? ☐ Yes ☐ No If yes, what is minimum size? ________sq. ft. Security desk? ☐ Yes ☐ No If yes, what is minimum size? ________sq. ft. Locational requirement ______________________
Dispatch operations	Do dispatch operations require a separate space? ☐ Yes ☐ No If yes, what is minimum size? ________sq. ft. Locational requirement ______________________
Maintenance operations	Equipment storage ________sq. ft. Mechanical offices? ☐ Yes ☐ No If yes, what is minimum size? ________sq. ft. Locational requirement ______________________ Inspection facilities? ☐ Yes ☐ No If yes, what is minimum size? ________sq. ft. Locational requirement ______________________
[illegible]	
Train operations	Is enclosed space needed? ☐ Yes ☐ No Purpose ______________________ If yes, what is minimum size? ________sq. ft. Locational requirement ______________________ Is open area space needed? ☐ Yes ☐ No Purpose ______________________ If yes, what is minimum size? ________sq. ft. Locational requirement ______________________
Bus operations	Is enclosed space needed? ☐ Yes ☐ No Purpose ______________________ If yes, what is minimum size? ________sq. ft. Locational requirement ______________________ Is open area space needed? ☐ Yes ☐ No Purpose ______________________ If yes, what is minimum size? ________sq. ft. Locational requirement ______________________
Other modes	Is enclosed space needed? ☐ Yes ☐ No Purpose ______________________ If yes, what is minimum size? ________sq. ft. Locational requirement ______________________ Is open area space needed? ☐ Yes ☐ No Purpose ______________________ If yes, what is minimum size? ________sq. ft. Locational requirement ______________________

FIGURE 7.2 (CONT.). SPACE REQUIREMENTS QUESTIONNAIRE

Service Requirements			***Alternative:***		
Instructions: For each alternative indicate needs and area size for all required services. **Needs:**. Indicate the number of sites or "M" for many sites. If not needed, leave blank. **Area Size:** Indicate size (sq. ft.) for all sites. Include access requirements.					
Service	**Needs**	**Area Size**	**Service**	**Needs**	**Area Size**
Access to Vehicles			Vehicle Maintenance/Repair/Clean		
Egress from Vehicles			Crew Areas		
Passenger Transfer			Vehicle Fuel		
Weather Protection			Vehicle Waste Disposal		
Security			Vehicle Service Equipment Storage		
Surveillance/Inspection			General Information		
Fire Protection			Orientation/Wayfinding Information		
Emergencies—Crowd Control			Arrival/Departure Information		
Emergency Egress			Baggage Information		
Ticketing			Public Address		
Fare Collection Vending Areas			Safety Information		
Fare Evasion Control/Barriers			Baggage Checking		
User-Nonuser Separation			Baggage Assistance		
Fare Enforcement (No Barriers)			Baggage Internal Handling		
Rental Car Counters			Baggage Sorting		
Freight Handling/Loading			Baggage Claiming		
Waiting Areas			Restaurants		
Passenger Work Areas			Personal Services		
Level Changes			News/Books/Gifts		
Modal Path Separation			Other Concessions		
Terminal Cleaning			Restrooms		
Terminal Maintenance			First Aid Areas		
Terminal Offices			Vending Machines		
Terminal Meeting Rooms			Public Phones		
Terminal Trash Disposal			Courtesy Phones		
Terminal Loading Docks			Games		
Modal Offices			Observation Areas		
Short-term Parking			Bars		
Long-term Parking			Televisions		
Rental Parking			Assembly Areas		
Disabled Parking			Special Event Areas		
Local/Express Bus Layover			Mailboxes		
Taxi Queues			Art/Music		
Shuttle Parking			Advertising		
Intercity Bus Parking			Mixed Use: Shopping		
Bicycle Storage			Mixed Use: Offices		
VTOL Storage			Mixed Use: Entertainment		
Rail Vehicle Storage			Mixed Use: Hotels		
Vehicle Food, Supplies			Mixed Use: Child Care		
Total of *area size* columns					
			TOTAL AREA REQUIRED		

FIGURE 7.3. SERVICE REQUIREMENTS EVALUATION FORM

Orientation Analysis

Purpose

To measure the legibility of pedestrian space within the facility.

Steps

Step 1. Determine desired service interaction. Prepare a Service Interaction Matrix to establish the desired degree of interaction in the facility. The matrix should be set up so each pedestrian space within the facility can be compared to every other space. Sum all cells of the matrix and multiply the total by two to determine desired service interaction. The Service Interaction Matrix assumes that the desired view from A to B will be the same as the desired view from B to A. A full-scale Service Interaction Matrix is illustrated in Figure 7.4.

Step 2. Create Sight Line Matrix. The Sight Line Matrix is used for rating each alternative. The sight line is rated from an "observer" looking at a "view." For each cell in the Sight Line Matrix, enter one of two numbers:

If the "view" cannot be seen from the "observer", enter a zero.
If the "view" can be seen from the "observer", enter the corresponding value from the Service Interaction Matrix.

A "view" can be considered to have been seen if the "observer" can ascertain the location of the "view" though signs or other clues, even where it is not directly visible. A full-scale Sight Line Matrix is illustrated in Figure 7.5.

Step 3. Calculate orientation index. Find the maximum possible score, S, by summing all the cells of the Service Interaction Matrix and multiplying by two. Find the score for this particular facility, s, by summing all the cells of the Sight Line Matrix. Compute the orientation index, I:

$$\boxed{I = 100*s/S}$$

Desired Degree of Interaction

Instructions:

1. For each cell in the Service Interaction Matrix, enter the desired degree of interaction in the facility. Rate the desired interaction from 0 (No interaction necessary) to 10 (desired interaction extremely important)

2. Sum all cells of the matrix. Multiply the total by 2 to establish the maximum possible score, "S"

Service Interaction Matrix	Access to Vehicles	Egress from Vehicles	Security/Surveillance	Emergency Egress	Ticketing	Fare Collection	Rental Car Counters	Freight Handling/Loading	Waiting Areas	Passenger Work Areas	Level Changes	Terminal Operations	Meeting Rooms	Loading/Trash Disposal	Modal Offices	Short-term Parking	Long-term Parking	Rental Parking	Disabled Parking	Vehicle Storage	Vehicle Services	Baggage, Checking	Baggage, Claiming	Restaurants	Personal Services	Concessions	Entertainment	Assembly Areas	Shopping	Other Mixed Use	Σ Rows
Access to Vehicles																															
Egress from Vehicles																															
Security/Surveillance																															
Emergency Egress																															
Ticketing																															
Fare Collection																															
Rental Car Counters																															
Freight Handling/Loading																															
Waiting Areas																															
Passenger Work Areas																															
Level Changes																															
Terminal Operations																															
Meeting Rooms																															
Loading/Trash Disposal																															
Modal Offices																															
Short-term Parking																															
Long-term Parking																															
Rental Parking																															
Disabled Parking																															
Vehicle Storage																															
Vehicle Services																															
Baggage, Checking																															
Baggage, Claiming																															
Restaurants																															
Personal Services																															
Concessions																															
Entertainment																															
Assembly Areas																															
Shopping																															
Other Mixed Use																															

Total (Σ column)

x 2

Maximum Possible Score "S"

FIGURE 7.4. A FULL-SCALE SERVICE INTERACTION MATRIX

Alternative #______

Instructions:

1 For each cell in the Sight Line Matrix, enter one of two numbers

If the "view" cannot be seen from the "observer", enter a zero
If the "view" can be seen from the "observer", enter the corresponding value from the Service Interaction Matrix

2 Sum all cells of the matrix to find the score, "s", for the altenative

Sight Line Matrix

OBSERVER / VIEW	Access to Vehicles	Egress from Vehicles	Security/Surveillance	Emergency Egress	Ticketing	Fare Collection	Rental Car Counters	Freight Handling/Loading	Waiting Areas	Passenger Work Areas	Level Changes	Terminal Operations	Meeting Rooms	Loading/Trash Disposal	Modal Offices	Short-term Parking	Long-term Parking	Rental Parking	Disabled Parking	Vehicle Storage	Vehicle Services	Baggage, Checking	Baggage, Claiming	Restaurants	Personal Services	Concessions	Entertainment	Assembly Areas	Shopping	Other Mixed Use	∑ Rows
Access to Vehicles																															
Egress from Vehicles																															
Security/Surveillance																															
Emergency Egress																															
Ticketing																															
Fare Collection																															
Rental Car Counters																															
Freight Handling/Loading																															
Waiting Areas																															
Passenger Work Areas																															
Level Changes																															
Terminal Operations																															
Meeting Rooms																															
Loading/Trash Disposal																															
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Long-term Parking																															
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Disabled Parking																															
Vehicle Storage																															
Vehicle Services																															
Baggage, Checking																															
Baggage, Claiming																															
Restaurants																															
Personal Services																															
Concessions																															
Entertainment																															
Assembly Areas																															
Shopping																															
Other Mixed Use																															
																															Total (Σ column)

FIGURE 7.5. A FULL-SCALE SIGHT LINE MATRIX

Example

Step 1. The Service Interaction Matrix for a small train station is shown in Figure 7.6.

Service Interaction Matrix	Restrooms	Ticket Counter	Gates	Restaurant	Totals
Restrooms					
Ticket Counter	3				3
Gates	6	9			15
Restaurant	8	1	4		13
					31
					Total
					x2
					62
					Maximum Possible Score "S"

FIGURE 7.6. AN EXAMPLE SERVICE INTERACTION MATRIX

Step 2. The Sight Line Matrix for this same facility is shown in Figure 7.7. Each cell in the Service Interaction Matrix appears twice in the Sight Line Matrix, both above and below the diagonal.

Alternative: *Small Station*					Totals
OBSERVER / VIEW — Sight Line Matrix	Restrooms	Ticket Counter	Gates	Restaurant	
Restrooms		3	6	8	17
Ticket Counter	3		9	0	12
Gates	6	0		4	10
Restaurant	8	0	4		12
					51
					Total

FIGURE 7.7. AN EXAMPLE SIGHT LINE MATRIX

Step 3. Twice the sum of the cells in the Service Interaction Matrix, S, is 62. The sum of the cells in the Sight Line Matrix, s, is 51. The orientation index is:

$$I = 100*s/S = 100*51/62 = 82\%$$

Discussion. Note that the Sight Line Matrix is not necessarily symmetrical. In this case it is possible to see the gates from the ticket counter, but it is not possible to see the ticket counter from the gates.

Capacity and Assignment

Purpose

Methods of traffic assignment from traditional travel forecasting can be used to determine whether sufficient capacity is available or can be made available for pedestrian paths through the facility.

Background

A traffic assignment consists of summing all trips that use specific links within a network in order to determine the volumes of traffic . A pedestrian assignment at an intermodal facility uses the same algorithms as traffic assignment and it gives the same type of results. Performing a pedestrian assignment is especially important when sizing a new facility or when additional service is provided at an existing facility. The assignment gives as results the number of passengers using each pedestrian path or path segment over a period of time. Thus, it is possible to compare the assigned pedestrian volumes to various level-of-service (LOS) criteria to determine whether pedestrian traffic is moving at a reasonable pace.

Pedestrian assignment can be readily accomplished with algorithms provided in microcomputer software packages that perform travel forecasting. Some of these packages permit a variety of assignment options. The most popular traffic assignment methods are: all-or-nothing assignment; capacity-restrained equilibrium assignment; and stochastic multipath assignment. All three methods require as input data a network and a trip table. A network is prepared with a network editor – a special computer program for drawing links and nodes and for giving them attributes. A trip table is a list of the number of trips between each origin and each destination within the system. A trip table can be prepared by observing and extrapolating upon existing passenger movements or by mathematical modeling.

Steps

Step 1. Obtain a space and site plan and delineate pedestrian paths. Clearly show all path segments and points where path segments intersect. Be sure to indicate level changes and barriers.

Step 2. Draw a pedestrian network. With a suitable network editor, draw a network of pedestrian paths through the facility. Show each decision point, each stopping point and each turning point as a node. Show the path segments between each node as a link. For each link, record the free-flow travel time from its beginning to its end and indicate its width in units consistent with the chosen measure of level of service. For calculating free-flow travel time assume that pedestrians walk at a rate of 260 ft/min or 1.32 m/s.

Step 3. Identify origins and destinations for pedestrian trips. Each origin and each destination within the facility must be identified. These origins and destinations are shown as nodes on the network.

Step 4. Determine a table of trips from each origin to all destinations. From survey information and information from modal operators, build a person-trip table showing the number of trips from any destination to any origin. It may be necessary to synthetically create such a trip table. If so, consult a good reference for creating trip tables by the Fratar Method or by a *gravity model.*

Step 5. Choose a traffic assignment algorithm. Different traffic assignment algorithms have different uses. There are three distinctly different approaches to traffic assignment.

All-or-Nothing: With all-or-nothing assignment each trip is assigned to the shortest travel-time path between its origin and its destination. No attempt is made to divert trips because of congestion along a link. This assignment technique requires the least amount of data and is useful for indicating the desired amount of travel along links.

Capacity-Restrained Equilibrium: In a capacity-restrained equilibrium assignment travel times along links are adjusted to reflect delays due to congestion. Relationships between delay and capacity must be given for all links in the network. If there is sufficient delay along some links, this assignment technique can split trips across several alternative paths.

Stochastic Multipath: A stochastic multipath assignment assumes that only some pedestrians make optimal choices of paths. The remaining pedestrians do not necessarily choose the path with the shortest travel time between their origin and destination. Second, third and even fourth best paths can be selected. A stochastic multipath assignment spreads trips across the many available paths, giving more trips to paths with the lowest travel time.

There are some differences in the way these algorithms are handled in the various travel forecasting packages, so it is necessary to consult the software documentation for operational details

When capacity-restrained equilibrium assignment is selected, it is necessary to provide a relation between travel time and capacity. The following relation is consistent with the LOS criteria of the *Highway Capacity Manual* and can be easily used with most travel forecasting software packages.

$$\text{link travel time} = 3.85*\text{length}*(1 + 0.73*(\text{volume}/25*\text{width})^3)$$

Where link travel time is given in minutes, link length is given in thousands of feet, the width of the path is given in feet, and the volume is given in pedestrians per minute.

Step 6. Assign traffic and evaluate level of service. Run the traffic assignment algorithm and obtain volumes on each link in the pedestrian network. Choose a criterion for level of service. Two criteria for straight pedestrian path segments are shown in Tables 7.2 and 7.3. Assess path conflicts by adding together the volumes of the conflicting paths. Rate each link on an A (best) to F (worst) scale.

TABLE 7.2. LEVEL OF SERVICE CRITERIA FOR GENERAL PEDESTRIAN FLOW

Level of Service	Space ft^2/ped	Average Speed ft/min	Flow Rate ped/min/ft
A	≥130	≥260	≤2
B	≥40	≥250	≤7
C	≥24	≥240	≤10
D	≥15	≥225	≤15
E	≥6	≥150	≤25
F	<6	variable	variable

Source: Highway Capacity Manual, 1985

TABLE 7.3. LEVEL OF SERVICE CRITERIA FOR PLATOON FLOW IN TERMINALS

Level of Service	Area Module m^2	Average Speed m/s	Flow Rate ped/min/m
A+	≥2.3	≥1.4	≤37
A	1.7-2.3	1.3-1.4	37-46
B	1.3-1.7	1.2-1.3	46-57
C	1.0-1.3	1.1-1.2	57-68
D	0.8-1.0	1.0-1.1	68-75
E	0.7-0.8	0.7-1.0	75-57
F	≤0.7	≤0.7	≤57

Note: The above LOS criteria are intended for pedestrians in terminals where many passengers are carrying baggage.
Source: Davis and Braaksma, 1987

Basic Queuing Relationships

Purpose

To determine the size of holding, waiting and surge areas when there are both a time-invariant service rate and a time-invariant arrival rate. These relationships are for a single server with a single queue (such as moving walkways, security checking, fare payment and concession checkout).

Steps

Step 1. Identify the type of server. In terminal areas there are typically two types of servers: random service times and constant service times. Some judgment must be used to select the type of server. Use these examples as guides:

Random
- *Security*
- *Car Rental Pick-Up*
- *Curbside Baggage Check-In*

Constant
- *Turnstiles*
- *Moving Sidewalks*
- *Parking Lot Entry*

A queuing system consists of two parts -- the queue itself and the server. There can be a person being served without having a queue, but the reverse is not possible. A typical queue is illustrated in Figure 7.8.

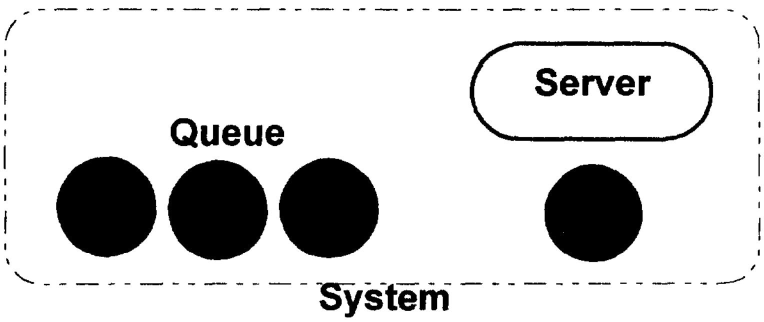


FIGURE 7.8. A TYPICAL QUEUE

Not all queuing systems can be analyzed by these basic relationships. Exceptions include systems with multiple servers (ticket counters) and systems where the service rate is discontinuous (elevators).

Step 2. Identify the service rate. The service rate is the average number of people that can be served in a fixed time interval. The service rate is usually expressed in units of persons per minute. Let the letter s represent the service rate.

Step 3. Identify the arrival rate. The arrival rate is the average number of people who arrive at the system within a fixed time interval. It is analogous to the flow rate. The arrival rate is usually expressed in units of persons per minute. Let the letter a represent the arrival rate.

Step 4. Calculate queue performance. Different formulas are provided for constant and random service types. The queue does not count the person being served. Calculate the utilization ratio, r, from the following formula:

$$r = \text{(arrival rate)/(service rate)} = \frac{a}{s}$$

The service rate must be greater than the arrival rate for a stable queue. If r is greater than 1, then recheck rates and assumptions.

Apply the appropriate formulas in Table 7.4.

TABLE 7.4. BASIC QUEUING FORMULAS

	Constant Service Type	**Random Service Type**
Average Number in Queue	$\frac{2r-r^2}{2(1-r)}$	$\frac{r^2}{(1-r)}$
Average Number in System	$\frac{2r-r^2}{2(1-r)}+r$	$\frac{r}{(1-r)}$
Average Time in Queue	$\frac{r}{2s(1-r)}$	$\frac{a}{s(s-a)}$
Average Time in System	$\frac{2-r}{2s(1-r)}$	$\frac{1}{s-a}$
Probability of Empty System	1 - r	1 - r

Note: Formulas assume Poisson arrivals. Random service assumes exponential service times.

TABLE 7.5. TYPICAL SERVICE RATES AT TERMINALS

Activity	Service Rates (Passengers/Minute)
Air Passenger Ticketing	0.3
Air Express Baggage Checking	1.6
Air Check-in w/ Seat Selection	2.2
Air Check-in w/o Seat Selection	2.7
Air Deplaning via Jetway	32
Air Deplaning via Aircraft Stairs	22
Air Deplaning via Mobile Stairs	29
Intercity Bus Ticketing	1.4
Intercity Bus Boarding	15
Railroad Ticketing	0.9
Parking Get Ticket	10
Parking Pay Fee	5
Parking Leave with Attendant	2
Automobile Pay Flat Toll	10
Pedestrian Automatic Turnstile	50
Pedestrian Escalator (2-ft)	60

Source: Morlok, 1978 and Bruggeman and Worrall, 1970

TABLE 7.6. LEVEL OF SERVICE CRITERIA IN QUEUING AREAS

Level of Service	Average Pedestrian Area (sq. ft.)	Average Interperson Spacing (ft.)
A	≥13	≥4
B	≥10	≥3.5
C	≥7	≥2
D	≥3	≤2
E	≥2	Close contact

Source: Highway Capacity Manual, 1985

Multiple-Server Queuing Relationships

Purpose

To determine the size of holding, waiting and surge areas when there are both a random service rate and a time-invariant arrival rate. These relationships are for multiple servers with a single queue (such as ticket vending in a small area and baggage check-in).

Steps

Step 1. Identify the number of servers. A typical multiple-server queue is illustrated in Figure 7.9. Let k represent the number of servers.

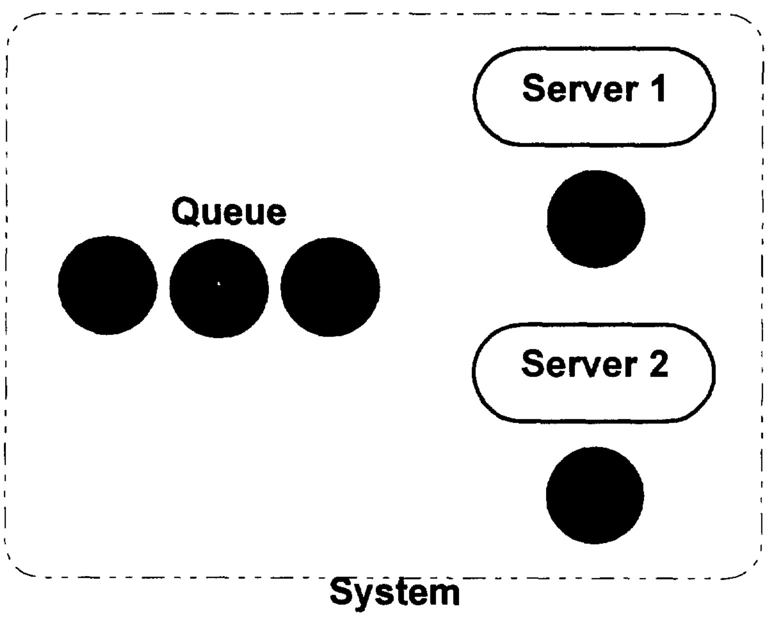


FIGURE 7.9. MULTIPLE-SERVER QUEUE

In order for a system to be considered multiple-server, the servers must act in parallel.

Step 2. Identify the service rate. The service rate is the average number of people that can be served in a fixed time interval by one server, only. The service rate is usually expressed in units of persons per minute. Let the letter s represent the service rate.

Step 3. Identify the arrival rate. The arrival rate is the average number of people who arrive at the system within a fixed time interval. It is analogous to the flow rate. The arrival rate is usually expressed in units of persons per minute. Let the letter a represent the arrival rate.

Step 4. Calculate queue performance. The queue does not count the person being served. Calculate the utilization ratio, r, from the following formula:

$$r = \text{(arrival rate)/(service rate)} = \frac{a}{s}$$

The value of r can be greater than 1. Then calculate the probability that the system is empty.

$$p = \frac{1}{\left[\sum_{n=0}^{k-1} \frac{1}{n!} r^n\right] + \frac{1}{k!} r^k \frac{ks}{ks - a}}$$

Then calculate the average time in the queue, W_q:

$$W_q = \frac{psr^k}{(k-1)!(ks-a)^2}$$

Finally apply the appropriate formulas in Table 7.7.

TABLE 7.7. MULTIPLE SERVER QUEUING RELATIONSHIPS

Average Number in Queue	aW_q
Average Number in System	$aW_q + r$
Average Time in Queue	W_q
Average Time in System	$W_q + \frac{1}{s}$
Probability of Empty System	p

Note: Formulas assume Poisson arrivals and exponential service times.

Signing, Wayfinding and Passenger Information

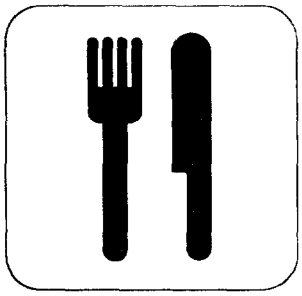
Purpose

To determine whether the proposed facility is adequately designed for wayfinding and to judge the adequacy of passenger information systems.

Maximize	System legibility Passenger information	Signing, Wayfinding, Passenger Information Objectives
Minimize	Disorientation & confusion	

Background

Signs and other passenger information devices are often designed along with architectural elements of the transfer facility, so the quality of the information systems can not be readily brought into the evaluation of alternatives. Signing becomes important to an evaluation only when constraints are placed on the design that result in less than ideal arrangements of modes and services. In these instances two questions can be posed.



1. *Can driver and passenger information systems overcome the deficiencies of the physical design, leading to a more cost effective alternative?*
2. *Can wayfinding considerations suggest a more effective arrangement of internal design elements?*

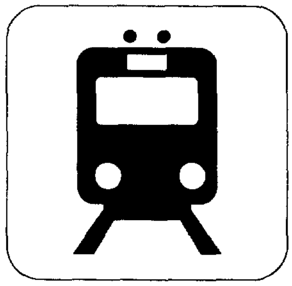
Thus, from the standpoint of evaluations of a physical design there are five guidelines relating to passenger information that can be followed.

Guideline #1. Signs and other passenger information devices are required only when normal human behavior, common sense and visual clues fail to provide adequate guidance to drivers and passengers. Passenger information devices are not ends in themselves; they derive their value from helping people reach destinations. Although some redundancy is useful, passenger information systems that duplicate a person's natural wayfinding abilities are of lower value and can add to clutter and confusion.

Guideline #2. There is an appropriate level of signing and other passenger information devices for any given facility. Passenger information requirements increase with the size and complexity of the facility and with the complexity of modal operations. Facilities with many indirect, long or incoherent paths, obstructed sight lines and distractions will have greater passenger information requirements.

Guideline #3. The need for signs and other passenger information devices should be minimized through careful space planning, site design, vehicle access design, modal planning and system integration. Since some signs are provided to overcome problems with the physical design, they can be eliminated when problems are fixed. Good modal planning (coordinated transfers, clearly delineated routes, readily understandable schedules and well-defined points for both access and transfers) and good system integration can further reduce the need for passenger information devices.

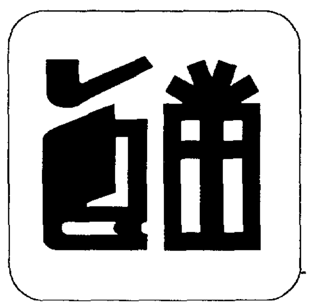
Guideline #4. It is undesirable to use signs and other passenger information devices to overcome poor physical design and poor operating policies. Instead, the design and policies should be remedied or better project alternatives should be explored.



Guideline #5. The needs for signing and other passenger information devices should be considered early in the planning and design process. Early consideration of issues relating to information systems can reveal flaws in the physical design. In short, the quality of the space and site design can be judged by the simplicity of the required passenger information systems.

The physical elements of the facility should suggest the appropriate paths for drivers and passengers. Andre (1991) has found that the environmental features of a facility can aid wayfinding by having a high degree of differentiation of features, a high degree of visual access and a simple spatial layout. In other words, the facility should provide good landmarks and other visual clues through contrasting details, allow destinations and intermediate points to be readily seen from a distance and reduce the complexity of path choice. In addition, Fruin (1985) has noted that having well-defined paths reduces the burdens of passenger information. Paths should be designed so that they:

- Have easily recognized decision points;
- Are direct between decision points;
- Have clear lines of sight between decision points;
- Have a good relationship to landmarks and other distinctive design elements;
- Have well defined edges;
- Are of appropriate width and length for their purpose; and
- Has a logic to the sequence of events between origin and destination.

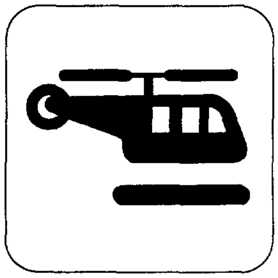


Unfortunately, paths cannot always meet the above criteria. Path design is limited by existing structures and existing modal access points and by the shape, size and nature of the site. Signs can serve as a low cost method of linking separated spaces of an intermodal facility or for mitigating problems caused by an awkwardly shaped site.

Steps

Step 1. Develop site and space plans. These plans are more detailed than the concept diagrams discussed in Chapter 6. They need not be complete architectural drawings, but they must show:

- Locations of services;
- Barriers;
- Points of access;
- Paths;
- Intersections of paths and path conflicts;
- Decision points; and
- Open spaces and sight lines.



Step 2. Develop maps and process diagrams for passenger movements through the facility. From the plans and drawings from Step 1, draw maps showing major passenger paths through the facility. It is suggested that the maps use the same schema as had been used for concept diagrams (see Chapter 6). Then draw process diagrams for the major passenger movements through the facility. Answer the following questions.

1. Is each decision point easily recognized?
2. Are the paths between decision points direct?
3. Are there clear lines of sight between decision points?
4. Is there good logic to the sequence of decisions from origin to destination?

Step 3. Perform Sight Line Analysis. Perform sight line analysis, as described earlier in this chapter, and compute an overall orientation index.

Step 4. Develop a passenger information plan. A passenger information plan contains a description of the major passenger information devices, their locations and their methods of operation. The passenger information plan should cover the five categories of media: visual, aural (voice and other sounds), distributed written materials (maps, timetables, etc.), interactive information devices and advice from personnel. The information plan should attempt to correct unavoidable deficiencies in the site and space plans.

Step 5. Evaluate the passenger information plan.
"A well designed information system in a large transfer facility will promote rapid passenger processing, minimize crowding and enhance safety and security" (Fruin, 1985). To meet these objectives, rate the passenger information plan according to the following criteria.

Redundancy

Repetition of the message to assure that it has been delivered.

Consistency

Standardization of signs; delivering the same intended meaning each time the message is presented; and having signs compatible with paths and other visual clues.

Legibility

Being able to readily see or hear the message.

Understandability

Terseness, familiarity and simplicity of message; consistency of internal format; no ambiguity.

Utility

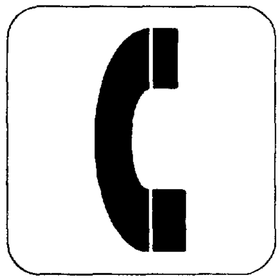
The quality of servicing a well-defined purpose.

Placement

Appropriate locations for wayfinding decision; well located within the field of view.

Context

No information overload; message is not lost in its environment; message is not lost among other messages; no distractions.



Standards

Satisfies, as necessary, the Manual on Traffic Control Devices; meets integrated system design requirements.

To complete the evaluation answer this question:

To what degree are information devices required to overcome deficiencies in the space and site plans?

Note: The pictograms in this section are taken from the Northeast Corridor Design Manual.

Internal Environment Checklist

Purpose

To ensure that all internal elements are considered in facility design.

Background

A checklist is a helpful tool for guaranteeing that all necessary internal elements are respected in the design, or at least were considered in the planning process. Such a checklist is easy to develop and administer relative to its benefit to the planning and design processes. The checklist should be developed prior to designing any of the alternatives. Early use of the checklist in the design of alternatives will help those alternatives better meet their objectives.

Steps

Step 1. List all internal design elements. List all internal design elements that should be considered in the planning process. Refer to the complete list of goals and objectives when developing the list. The list must be very comprehensive. Consult knowledgeable officials for an analysis of the list and edit the items, as appropriate.

Step 2. Create Internal Environment Checklist. Develop a checklist of elements from the list created in Step 1. The checklist's format should include a box next to the design element for a check. The checklist should also leave space next to each element for a brief description of how the element is handled in the alternative's internal environment or why it was not included in the design. The checklist should be arranged so those design elements that were not included in the planning process can be easily recognized. An example Internal Environment Checklist is illustrated in Figure 7.10.

Step 3. Evaluate each alternative. Use a separate checklist for each alternative. Remember that all internal environmental elements need not be included in an alternative's design. All elements must, at a minimum, be considered for inclusion in the design. If an element was considered and found unsuitable for an alternative, place a check by the element and describe the reason for the finding.

Step 4. Revisit any elements that were not previously considered. All internal design elements that were not checked should be reinvestigated. A missed, but important design element can diminish the value of the whole alternative.

Internal Environment Checklist	A
Design Element	**Description**
☐ Control of Litter	
☐ Control of Graffiti	
☐ Control of Dust	
☐ Control of Odor	
☐ Control of Noise	
☐ Control of Vibration	
☐ Control of Temperature	
☐ Control of Humidity	
☐ Control of Internal Air Movement	
☐ Control of Wind	
☐ Control of Water, Snow, Ice, Sun	
☐ Other Environmental Controls	
☐ Separating Users/Nonusers	
☐ Entrance Shutdown	
☐ Eliminating Blindspots, Isolated Areas	
☐ Emergency Phones	
☐ Presence of Surveillance Equipment	
☐ Presence of Security Personnel	
☐ Presence of Other Activities	
☐ Pedestrian/Vehicle Separation	
☐ General Pedestrian Safety	

FIGURE 7.10A. INTERNAL ENVIRONMENT CHECKLIST

Internal Environment Checklist	B
Design Element	**Description**
❑ Illumination	
❑ Obstruction-Free Areas	
❑ Good Walking Surfaces (All Weather)	
❑ Platform Edge Warning	
❑ Pedestrian Assists	
❑ Other Physical Elements (Describe)	
❑ Courtesy/Helpfulness of Personnel	
❑ Newcomer Orientation/Station ID	
❑ Visibility of Destinations within Facility	
❑ Information: General Signing	
❑ Information: Symbols/Pictograms	
❑ Information: Color Codes	
❑ Information: Maps	
❑ Information: Destination Signs	
❑ Information: Floor markings	
❑ Information: Multilingual Signs	
❑ Information: Uniqueness of Design	
❑ Information for Blind	
❑ Information for Hearing Impaired	
❑ Information for Physically Disabled	
❑ Other Handicapped Information	

FIGURE 7.10B. INTERNAL ENVIRONMENT CHECKLIST

Internal Environment Checklist	C
Design Element	**Description**
❑ System Information: Fares	
❑ System Information: Schedules	
❑ System Information: Transfers	
❑ System Information: Baggage	
❑ System Information: Other	
❑ Transfer Information Onboard Vehicles	
❑ Pedestrian Paths Legibility	
❑ Personal Space on Paths	
❑ Personal Space in Surge Areas	
❑ Pedestrian Interference with Activities	
❑ Seating: Arrangements	
❑ Seating: Scale of Space	
❑ Seating: Personal Space	
❑ Seating: Privacy	
❑ Seating: Circulation Space	
❑ Seating: Benches in Outdoor Areas	
❑ Seating: Comfort	
❑ Design: Architectural	
❑ Design: Landscape	
❑ Design: Furniture, Fixtures	
❑ Cultural and Historical Elements	

FIGURE 7.10C. INTERNAL ENVIRONMENT CHECKLIST

Internal Environment Checklist	D
Design Element	**Description**
❑ Passenger Productivity: Working	
❑ Passenger Productivity: Computing	
❑ Passenger Productivity: Communicating	
❑ Recreation: Reading/Conversing	
❑ Recreation: Listening/Viewing	
❑ Recreation: Playing	
❑ Other Recreation (Describe)	
❑ Personal Needs: Shopping	
❑ Personal Needs: Eating	
❑ Other: Personal Needs	
❑	
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FIGURE 7.10D. INTERNAL ENVIRONMENT CHECKLIST

Chapter 8. User Benefits

Benefits of Travel

Improvements in transportation system components, including intermodal transfer facilities, usually result in increases in benefits to users, taken as a group. Users accrue benefits by being able to reach destinations with less time and cost. Users benefit from improvements in comfort and convenience. They benefit from being able to reach more desirable destinations for existing travel needs and they benefit by being able to make entirely new trips.

User Benefits Objectives

Maximize
- User benefits
- Alternative uses of time
- Coordination of transfer scheduling
- Connections between routes
- Reliability of transfers
- Directness of paths for modes
- Weather protection

Minimize
- Costs
- Waiting
- Queuing delays
- Exertion
- Path length
- Negative impact on existing transportation services

Many of the most important objectives for an intermodal transfer facility can be met by maximizing user benefits. Any alternative that improves the efficiency of transfers, increases the likelihood of a transfer or increases travel on modes involving transfers will have a higher level of user benefits.

Under some limited circumstances it is possible to ascertain user benefits by measuring the decrease in total disutility and (perhaps) converting disutility to units of money. This method is analogous to finding a total time savings for a build alternative over a null alternative. Trip segment analysis (Chapter 6) is based on this concept. However, simply measuring changes in disutility ignores shifts in trips across modes and ignores the possibility of new or different trips.

A better method of assessing user benefits is the calculation of net consumer surplus between alternatives. Consumer surplus is a well-developed notion of transportation economic theory, usually involving a simple relationship between the amount of travel and the cost of travel. However, travel through an intermodal transfer facility can involve many different activities with many different characteristics. In this report consumer surplus has been extended to include a broad range of trip attributes. The major drawback to calculating net consumer surplus is the need for a good travel forecast.

Place Utilities

The gross benefit that an individual receives for reaching a desired destination is called the trip's place utility. Place utility will vary with the purpose of the trip, the feelings of the traveler toward the destination and the time available for the trip. Place utility is closely related to the maximum amount of time and resources a traveler is willing to spend on a trip.

Table 8.1 shows average maximum travel times in minutes for typical trips in an urban area (Horowitz, 1980). This data was obtained by asking adult travelers about the maximum time they would be willing to spend regularly traveling to each destination by automobile. It should be noted that nonwork trips on weekdays are during the evening hours when most people have only a limited amount of time for discretionary activities.

On average the maximum length for a nonwork trip is about 30 minutes. The average maximum length for a work trip is about 55 minutes. The maximum length for long distance travel or for work-related travel is unknown, but they would be expected to vary considerably from trip to trip. These maximum trip lengths could be directly converted into place utilities by accounting for out-of-pocket costs of travel.[1]

TABLE 8.1. TYPICAL PLACE UTILITIES

Purpose	Weekend	Weekday
Workplace	–	54.6
Shopping Center	35.0	29.3
Friend's House	28.7	27.4
Outdoor Recreation Area	34.6	24.2
Theater	28.0	22.2
Nonwork Average	31.6	25.8

To calculate place utilities, it is first necessary estimate the gross benefits from a new trip. Assuming a wage rate of $12 per hour, a value of time for nonwork travel of one-sixth of the wage rate and out-of-pocket costs of $0.019 per person-minute[2], the monetary benefit from attaining a nonwork destination is about $1.50. For a work trip with a value of time of one-third of the wage rate and out-of-pocket costs of $0.045[3] per person minute, the monetary benefit is about $6.00. Converting back to units of minutes, the place utility for a work trip is approximately 90 minutes and the place utility for a nonwork trip is somewhere near 45 minutes. Of course, the net benefit to a user would be considerably less after accounting for the time and cost spent while actually traveling.

Automobile ownership costs are not included in these estimates of place utilities. Should a traveler be able to sell an automobile or avoid the purchase of an automobile,

[1] All respondents had access to an automobile and were told the trip would be by automobile. Vehicle ownership was a given. Therefore, it is argued that vehicle ownership costs should not be included in estimates of place utility.

[2] Assumes an out-of-pocket cost of $0.10 per mile, a speed of 20 miles per hour and an automobile occupancy rate of 1.8. It is further assumed that there are no tolls or parking charges.

[3] Assumes an out-of-pocket cost of $0.10 per mile, a speed of 30 miles per hour and an automobile occupancy rate of 1.12. It is further assumed that there are no tolls or parking charges.

all ownership costs associated with an automobile can be counted as additional benefits. Furthermore, these estimates of place utility do not include the benefits associated with removing an automobile from the road – improved speeds for the remaining drivers and reductions in pollutant emissions.

Characteristics of Users

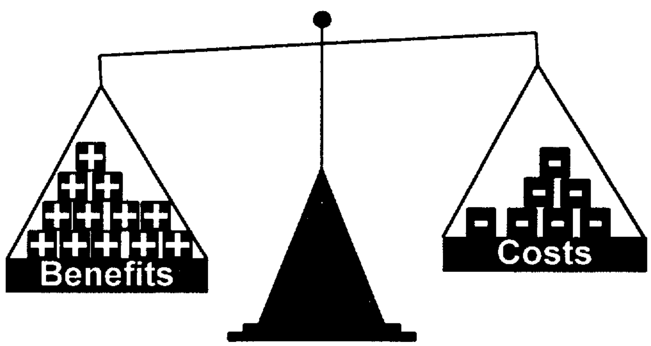
When ascertaining place utilities it is necessary to assume that people have a range of options in meeting their travel needs. For example, a person might choose to move either his job or his residence should his trip to work exceed his maximum trip length. Should trips become too long, a person without an automobile might purchase one or a passenger might choose to drive.

Not all people have a good set of travel options. Those who face travel constraints include persons with low income or without access to an automobile, the elderly, the young, nondrivers and the handicapped. Place utility is affected by travel constraints. People without travel options can only choose between making and not making a trip. When the trip is absolutely necessary, the place utility can be very large. Large place utilities translate into large net benefits when the trip is made.

Consumer Surplus Analysis

Purpose

To determine the user-benefits of the facility.



Requirements

A travel forecast that is sensitive to the design of the facility.

Background

User benefits can be ascertained by measuring the net change in consumer surplus – the difference between a person's willingness to pay for a good or service and its price. The calculation of net consumer surplus requires a travel forecast for the considered alternative and for the null alternative.

For a travel forecast to be sensitive to a new or upgraded transfer facility, it must use information about the difficulty of traveling. An indicator of travel difficulty is a trip's disutility. A typical disutility function for a complete trip would look like:

Disutility = automobile riding time +
(transit riding time)(transit riding weight) +
(**walking time**)(walking weight) +
(**waiting time**)(waiting weight) +
(**transfer time**)(transfer weight) +
initial wait penalty + **first transfer penalty** +
second transfer penalty +
fare/(value of time) +
(tolls + **parking costs** + vehicle operating costs)/(value of time) +
(vehicle ownership costs)/(value of time).

In this case disutility has units of minutes of automobile riding. The terms indicated in bold-face type are those usually associated with an improvement in intermodal transfers, although it is possible for an intermodal transfer facility to affect any component of this disutility function.

Weights have the effect of multiplying the disutility of a component of travel. For example, if waiting time is perceived as being twice as onerous as riding time, the waiting weight is 2.0. On the other hand, penalties simply add disutility for an unpleasant activity that takes little time by itself. See Chapter 1, Table 1.3, for approximate weights and penalties.

Travelers gain utility by reaching desired places, even though they lose utility by getting there. For a trip to be worthwhile,

place utility > trip disutility

where place utility is also expressed in units of time. Place utility varies by destination, purpose and traveler.

Figure 8.1 shows the disutility of a trip between its origin and a place (destination). Two trajectories, before and after, are shown. Trip B (before) requires a difficult transfer at location B, so it incurs a sizable transfer penalty. Trip A (after) has a less difficult transfer at an intermodal facility. The place utility is shown as a horizontal line. Trip B, had it been made, would have a trip disutility greater than the place utility. Trip A, on the other hand, can be made with less trip disutility than place utility. Thus, Trip A would be made and Trip B would not be made. The net utility for Trip A is shown.

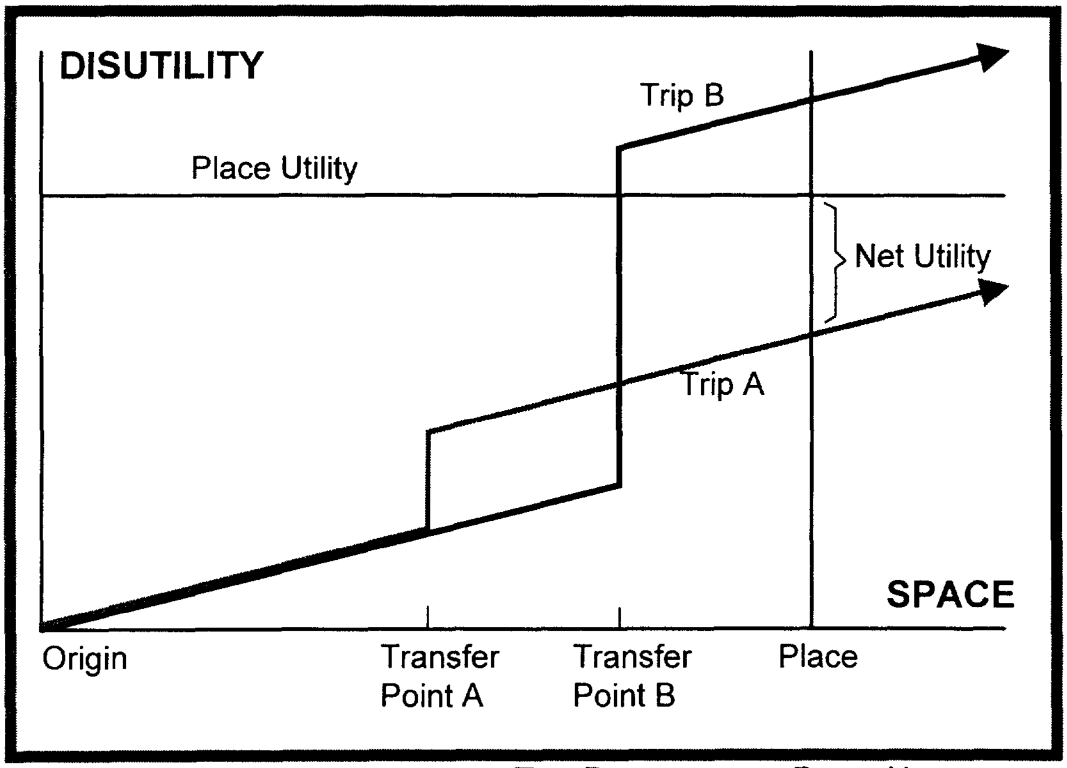


FIGURE 8.1. RELATIONSHIP BETWEEN TRIP DISUTILITY AND PLACE UTILITY

To determine the total amount of utility improvement a person gets from a new facility, it is necessary to compare that person's trip making before and after the change.

$$\text{Total Net Utility} = \sum (\text{place utility} - \text{trip disutility})_{\text{after}} - \sum (\text{place utility} - \text{trip disutility})_{\text{before}}$$

The number and types of trips and the destinations after the change may be different from before.

When a dollar amount is assigned to one unit of utility, then economists refer to the net gain as a consumer surplus. Typically, consumer surplus is proportional to net utility, so the two terms are often used interchangeably.

Finding the total amount of net utility (or consumer surplus) across the whole population requires an assumption about the importance of a unit of utility for each individual. This is a controversial problem that has no satisfactory solution. It is recommended for evaluation of intermodal facilities that all people be treated alike, but that various trip purposes may have differing weights and various places may generate differing amounts of utility.

Looking at each individual's daily trip patterns would be very difficult. Economists have developed a method of calculating consumer surplus that greatly reduces the amount of required information and is consistent with available methods of travel forecasting.

Disutility is calculated for a trip from a specific origin to a specific destination. Typically, groups of origins and destinations are organized into zones; however this practice can introduce errors if not done properly. For any given trip, the consumer surplus can be calculated in disutility units with only the following information:

Disutility Before the Change, D_0	Travel Before the Change, Q_0
Disutility After the Change, D_1	Travel After the Change, Q_1

For a rational set of travelers, there should be travel increases for any decrease in disutility. This relationship is illustrated in Figure 8.2. The demand curve shown in this figure is entirely artificial; it is the output of a travel forecast. It would not be possible to observe such a curve in reality.

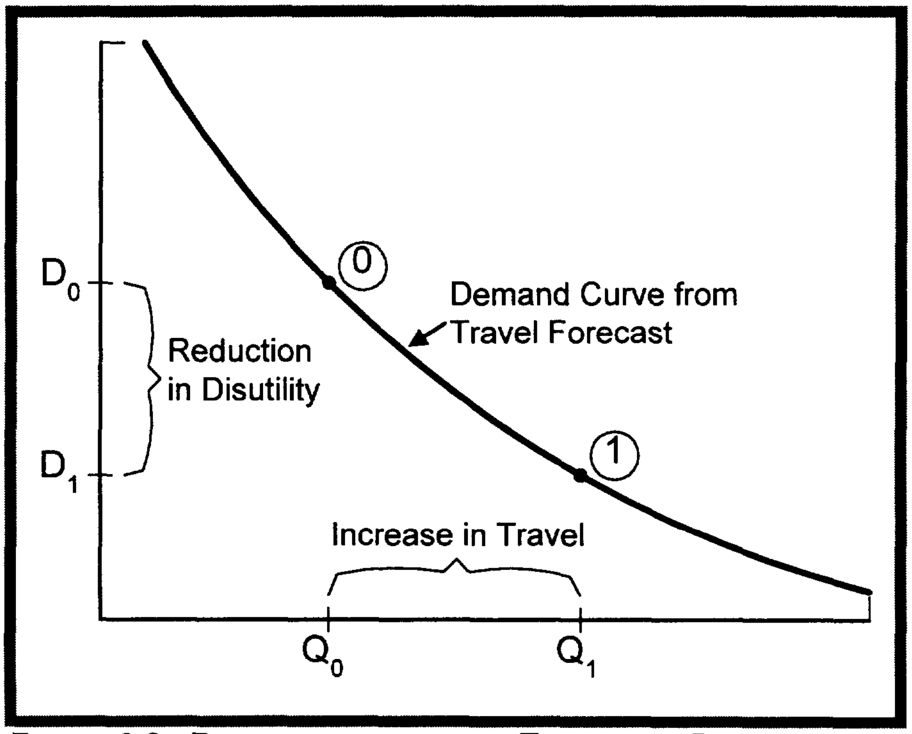


FIGURE 8.2. RELATIONSHIP BETWEEN TRAVEL AND DISUTILITY

Consumer surplus has two components, as illustrated in Figure 8.3. First, old users gain a windfall decrease in disutility, assuming that they do not change their trip making patterns. Their total consumer surplus is the rectangular area on the left. Second, new users' consumer surplus is found from the roughly triangular area on the right. We can be reasonably assured that all new users' place utility must be less than D_0 and greater than D_1. If their place utility were greater than D_0, they would already be traveling. If their place utility were less than D_1, they would not travel. Furthermore, the greater a traveler's place utility the greater the traveler's personal consumer surplus.

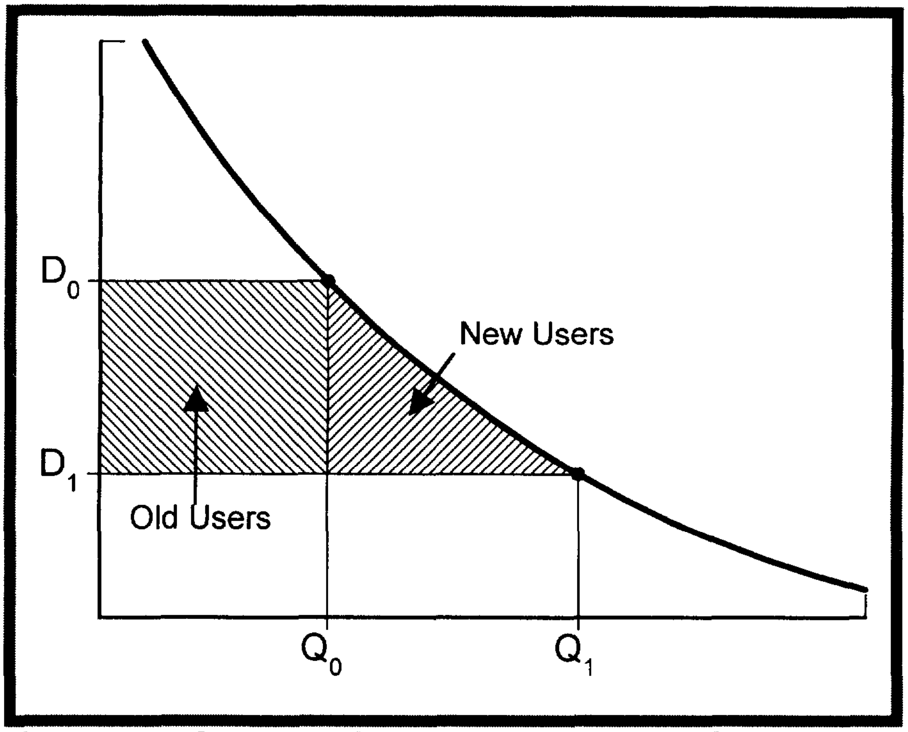


FIGURE 8.3. CONSUMER SURPLUS FROM A DEMAND CURVE

Consumer surplus is most often calculated from the area of the shaded trapezoid in Figure 8.3:

$$\text{Consumer Surplus} = (0.5)(D_0 - D_1)(Q_0 + Q_1)$$

A more precise calculation of consumer surplus in rarely warranted. Since disutility has units of minutes, the consumer surplus has units of person-minutes. It has a similar interpretation to a time savings, but it accounts for the differing perceptions of travel time. Like time savings, consumer surplus can be multiplied by a monetary value of time to convert it to units of money.

Expressing consumer surplus in monetary units has both advantages and disadvantages. When monetary units are used, it is possible to compare user benefits to costs. A facility is justified without any further analysis, when user benefits exceed costs and when there is an absence of severe environmental problems.

Converting disutility to monetary units requires an assumption about the value of time of each individual. Poor people have lower values of time than rich people. Consequently, alternatives that principally serve the rich tend to have greater user benefits than alternatives that serve the poor. Such a bias may be unacceptable for transit projects whose principal purpose is to provide transportation for the mobility disadvantaged.

Steps

Step 1. Develop reasonable alternatives. There should be a single null alternative and one or more build alternatives. Alternatives should differ markedly in their travel characteristics. The null alternative should be the future state of the system without making any major changes from today.

Step 2. Develop a travel model. Consumer surplus analysis requires a travel forecasting model that is sensitive to quality of stations and transfer opportunities. The model must be built so that it can be calibrated, that is to determine certain unknown coefficients. It is best if a survey of current travelers is available to guide this effort. Without such a survey, it is only possible to adopt most parameters from models that have been used elsewhere. Still the model can be customized to the situation at hand by (a) careful selection of alternative modes and (b) varying one or two parameters until the model matches existing travel patterns.

Step 3. Conduct Before and After Analysis. The demand should be estimated for the null alternative and for each build alternative. It is important to preserve the results for each mode, each purpose and each trip – a trip being defined as a single person's journey from an origin zone to a destination zone. As part of the application of the travel forecasting model, it would be necessary to calculate the disutility from each origin to each destination by each mode and by each purpose. That information should be retained, as well.

Step 4. Compute consumer surplus in disutility units. Define the disutility from origin i to destination j by mode m for purpose k and for alternative n to be: D_{nijkm}. Similarly, define the number of trips from origin i to destination j by mode m for purpose k and for alternative n to be: Q_{nijkm}. For the null alternative, let n = 0. Thus, the consumer surplus for alternative 1 and for purpose k, C_{1k}, can be found from:

$$\boxed{C_{1k} = 0.5 \sum_i \sum_j \sum_m (D_{0ijkm} - D_{1ijkm})(Q_{0ijkm} + Q_{1ijkm})}$$

Step 5. Determine value of time. Determine whether it is necessary to express consumer surplus in monetary units. If so, ascertain values of time. If local information is not available, the following values are recommended:

Travel from home to work:	33.3% of the prevailing wage rate
Nonwork travel:	16.7% of the prevailing wage rate
Work related travel:	200% of the prevailing wage rate

The value of time, V_k, should be expressed in dollars per minute.

Thus, the monetary consumer surplus across all trip purposes is:

$$\boxed{C_1 = \sum_k C_{1k} V_k}$$

Example

Step 1. Develop reasonable alternatives. An intermodal transfer facility is planned to connect Amtrak with an intercity bus service. As of now there is a 4 block walk between the Amtrak station and the bus station. The intermodal facility will eliminate the walk and provide an opportunity for schedule coordination. A typical set of trips involving a transfer goes from Foxville to Big City and back to Foxville. There are four ways to make the return trip:

A. Automobile all the way
B. Automobile from Big City to facility, then bus to Foxville
C. Amtrak from Big City to facility, then automobile to Foxville
D. Amtrak from Big City to facility, then bus to Foxville

Two hundred people are known to make this round trip in a day. Ridership surveys have shown that on a good weather day, the following trips are made.

Trip	Demand
Automobile-Automobile	160
Automobile-Bus	0
Amtrak-Automobile	35
Amtrak-Bus	5

In addition, the following is known about the trips.

Walking time between stations:	12 minutes
Walking time within the intermodal facility:	2 minutes
Waiting time for bus at bus station:	20 minutes
Waiting time for bus at intermodal facility:	3 (coordinated)
Access and riding time on Amtrak:	90 minutes
Egress and riding time on bus:	80 minutes
Automobile time from Big City to bus station:	100 minutes
Automobile time from Amtrak station to Foxville:	50 minutes
Automobile time from Big City to Foxville:	140 minutes
Walking from station to parking (Amtrak or Bus):	4 minutes
Automobile Operating Costs:	$0.08/minute
Parking at Big City:	$6

Parking at Amtrak or bus station:	\$2
Amtrak Fare:	\$12.00
Bus Fare:	\$5.00
Value of Time:	\$0.10 per minute
People making this trip carrying baggage:	50%

Step 2. Develop a travel model. A logit model was adopted for find the proportion of trips using any mode m, p_m:

$$p_m = \frac{\exp(-zD_m)}{\sum_m \exp(-zD_m)}$$

where z is a calibrated parameter and D_m is the disutility of mode m. The model will be calibrated to data for the return trip only. It is seen from current data that there is no demand for the automobile-bus trip. This mode combination can be eliminated from further analysis.

Step 3. Conduct Before and After Analysis. The disutility for each of the remaining three mode combinations are shown below. All weights and penalties are taken from those suggested for Trip Segment Analysis (see previous section), except for walking. Because 50% of the people carry baggage, and average weight of 2.125 was adopted. The introduction of the intermodal facility had three effects: (1) walk time decreased from 12 to 2 minutes; (2) waiting time decreased from 20 to 3 minutes; and (3) the transfer became coordinated, thereby dropping the transfer penalty from 16 to 4 minutes.

Mode	Disutility
Auto-Auto	(6/2)/0.10 + 140(1 + 0.08/0.10) = 282
Amtrak-Auto	90 + 12/0.10 + (2/2)/0.10 + 4*2.125 + 16 + 50*(1 + 0.08/0.10) = 334.5
Before: Amtrak-Bus	90 + 12/0.10 + 12*2.125 + 20*2 + 16 + (5/2)/0.10 + 80 = 396.5
After: Amtrak-Bus	90 + 12/0.10 + 2*2.125 + 3*2 + 4 + (5/2)/0.10 + 80 = 329.25

All these disutilities assume fair weather conditions.

The value of z can be found by fitting it to the existing ridership data. The table below compares the forecasted ridership with actual ridership with z equal to 0.03. A close fit to the Amtrak-bus ridership is desirable, because this mode will have the greatest effect on consumer surplus.

Trip	Actual	Before Forecast
Automobile-Automobile	160	162
Automobile-Bus	0	0
Amtrak-Automobile	35	33
Amtrak-Bus	5	5

Using the new disutility for the Amtrak-bus mode, the forecasted riderships are:

Trip	After Forecast
Automobile-Automobile	138
Automobile-Bus	0
Amtrak-Automobile	29
Amtrak-Bus	33

Step 4. Compute consumer surplus in disutility units. Because the disutility of the automobile-automobile and the Amtrak-automobile modes are unchanged, they can be ignored when computing consumer surplus. Therefore,

$$C_{\text{Amtrak-Bus}} = 0.5\,(396.5 - 329.25)*(5 + 33) = 1277.75 \text{ minutes}$$

This is the consumer surplus for the return trip only. The consumer surplus for both directions of travel would be twice this number or 2555.5 minutes.

Step 5. Determine value of time. It is hoped to be able to compare facility costs with benefits, so consumer surplus must be expressed in monetary units.

$$C_{\text{Amtrak-Bus}} = (2555.5 \text{ minutes})*(\$0.10 \text{ per minute}) = \$255.55$$

Discussion. This amount of consumer surplus applies to a single day's travel between one particular origin and one particular destination. To determine the total value of the facility, all possible trips must be considered.

Intangibles of Facility Design and Condition

There is some evidence that improvements in facility design and condition can lead to greater user benefits. It may be hypothesized that aesthetically pleasing and comfortable facilities reduce the disutility of time while waiting and while walking. Table 8.2 gives some idea about the magnitude of such a reduction.

Riders of the New York City (NYC) subway system were asked whether they would accept a fare decrease in lieu of station modernization (Charles River Associate, 1987). The fare was $1.00 at the time of the study. The program would increase the number of NYC modernized subway stations from 3.4% to 26.8%. Table 8.2 shows the fare reduction that is equivalent to the modernization program. The equivalent average fare reduction is about $0.10. Extrapolating, a complete modernization program would be equivalent to a fare reduction of about $0.40 – a surprisingly large figure. The $0.40 could be simply added as an additional user benefit, but it would make more sense to reduce trip disutility by a suitable amount. The most appropriate way of adjusting trip utility would be to modify the weights associated with walking, waiting and transferring.

TABLE 8.2. FARE EQUIVALENTS OF STATION UPGRADING

Type of Traveler	Fare Decrease
NYC peak riders	$0.14
NYC off-peak riders	$0.09
NYC nonriders	$0.08
External peak riders	$0.07
External off-peak riders	$0.09
External nonriders	$0.14

Source: Charles River Associates, 1987

In an earlier study of the NYC transit system, Cantilli (1971) asked riders how they would allocate $1.00 to upgrade stations. The rank order of station attributes is shown on Table 8.3. While it would be difficult to directly use this information for benefits assessment, it helps interpret the meaning of "station upgrading" to travelers. Travelers were most interested in improving the cleanliness and warmth of stations and least interested in air conditioning. It is surprising that comfort-related attributes are spread throughout the list and "police" ranked near the bottom. The rank order suggests that travelers have minimum expectations about certain station attributes and are willing to spend money on those particular attributes they see as being deficient. Improving a station beyond users' minimum expectations would yield little additional benefits.

TABLE 8.3 RANKING OF STATION ATTRIBUTES

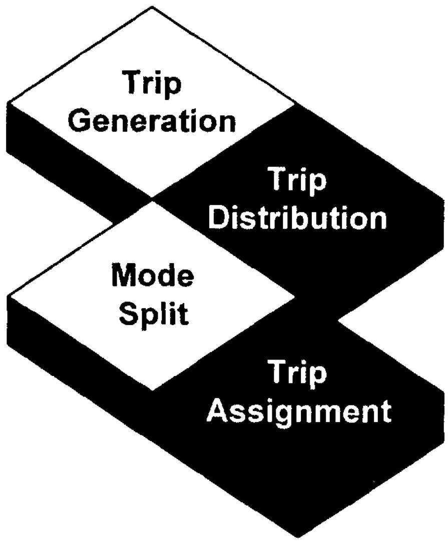
1. Cleaning
2. Heating
3. Redecoration
4. Escalator
5. Train Service
6. Lighting
7. Noise
8. Police
9. Air Conditioning

Source: Cantilli, 1971

Travel Forecasting Issues

A good evaluation of the benefits of an intermodal passenger transfer facility requires a good travel forecast. Most planning agencies are well versed in the art of "multimodal" travel forecasting, but there has been little experience to date with "intermodal" travel forecasting. A clear distinction between these two styles of travel forecasting is necessary to properly assess an intermodal passenger transfer facility. A complete discussion of travel forecasting is beyond the scope of this report, but it is possible to present general guidelines on the best way to approach an intermodal travel forecast.

Multimodal travel forecasting usually involves a four-step procedure consisting of trip generation, trip distribution, mode split and trip assignment. The trip generation step determines the number of trips that are produced from and attracted to each zone in an urban area. Trip distribution determines the number of these trips that go between each pair of zones. Mode split determines the number of trips that use each available transportation mode. Trip assignment finds the number of trips and vehicles that use each link in a network. An intermodal travel forecast must pay particular attention to the two last steps, mode split and trip assignment.



Mode Split Issues

Mode split is most often performed with some variation of the logit model. An elementary form of the logit model was used earlier in this chapter to accomplish the example travel forecast for the consumer surplus analysis (see Steps 2 and 3 of the example). The results of any logit model largely depend upon the relative values of disutility on competing modes. A mode with a large disutility will be uncompetitive and will receive a small share of trips. Conversely, a mode with a small disutility will be desirable and will receive a large share of trips. For a mode split model to be properly sensitive to the characteristics of an intermodal transfer facility, those characteristics must somehow be represented in the disutility function.

An intermodal travel forecast, as opposed to a multimodal travel forecast, must pay greater attention to time spent walking, waiting and transferring. The minimum recommended specification of a disutility function has been presented earlier in this chapter (see the Background discussion in the section on Consumer Surplus Analysis). This disutility function specification can be readily adapted to formulations of the logit model that are more complex than the one presented here.

Prior to a multimodal travel forecast, agencies often find all the weights and penalties within a disutility function by statistically calibrating the mode split model to match observed travel behavior of a small sample of people. Unfortunately, a statistical calibration may prove unsatisfactory for an intermodal forecast because: (a) a small sample may contain too few people making transfers between relevant modes; (b) there may be no trips presently using a comparable transfer facility; (c) all relevant modes may not yet exist in the community; and (d) certain trip segments tend to occur together, making it difficult to separate the individual effect of each segment. Unless these problems can be overcome, it is recommended that the weights and penalties from Chapter 1, Table 1.3 be used within the disutility function. These weights and penalties can be adjusted, as necessary, to match known travel patterns.

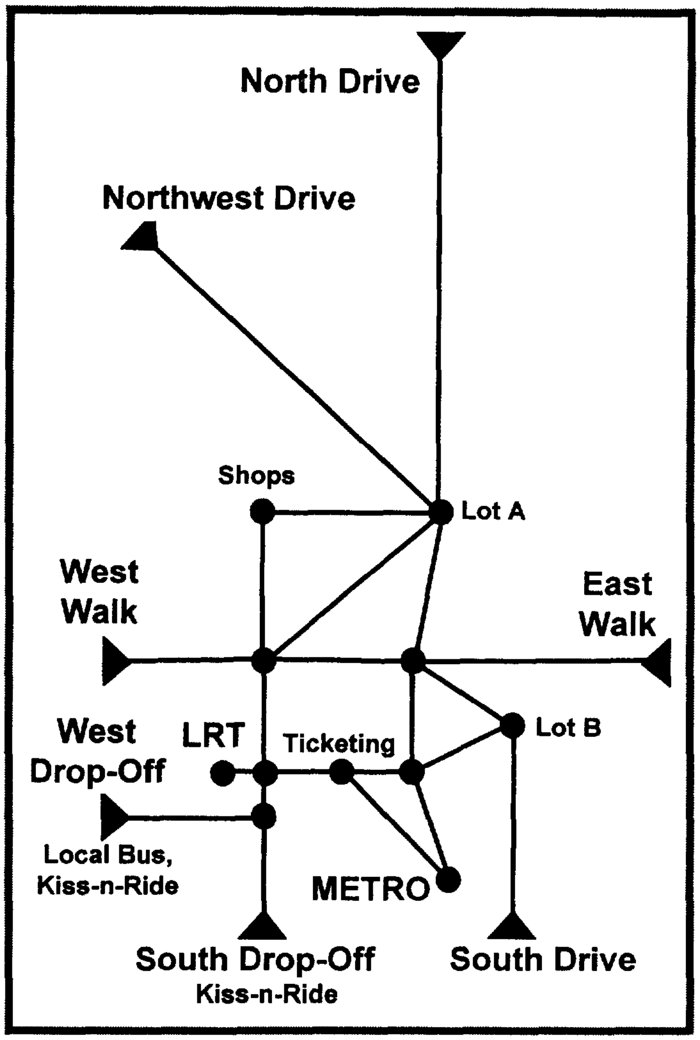
In a multimodal travel forecast, weights and penalties are held constant across forecasts for all alternatives. In addition, most agencies prefer not to vary weights and penalties across vehicular modes. However, in an intermodal forecast variations in weights and penalties may be necessary to evaluate certain elements of a facility. For example, it has been shown earlier in this chapter that the condition of the facility affects disutility. A clean, modern station would likely have lower weights for waiting and walking than a dirty, old station. Similarly, these weights would be less when the trip segment is protected from weather or when pedestrian assists are available. A better intermodal facility can reduce the disutility of a trip without actually reducing the trip's travel time or travel cost.

A multimodal travel forecast defines only a few modes. Most forecasts have automobile and transit as separate modes. Some forecasts include walking. Still other forecasts break transit into a few distinct submodes, such as commuter rail, metro rail, and bus. So far things are manageable. A problem develops as soon as intermodal transfers are allowed. Each combination of modes becomes a separate choice within the mode split model, and the number of combination modes can grow to be unreasonably large. An intermodal transfer facility serving only 5 distinct modes would permit 25 different choices. Unless the majority of these choices can be ignored, the mode split model becomes unreasonably complicated. To properly consider all combinations of modes, it may be necessary defer the modeling of some of these choices to the trip assignment step.

Trip Assignment Issues

In a multimodal forecast the algorithm for trip assignment depends upon the mode. Each mode requires a separate network. The assignment of automobiles to a highway network is usually done with an algorithm that sends vehicles along the shortest time path to their destination, allowing for slowing due to other vehicles on the road. The assignment of riders to transit routes is usually done with a different algorithm that places riders on the shortest time path, considering both in-vehicle and out-of-vehicle time. Neither of these algorithms are very sophisticated in the way they represent travel behavior. They cannot easily handle transfers across modes, and they are insensitive to many important features of an intermodal transfer facility.

An intermodal forecast needs an intermodal network. Such a network must encompass all modes allowing for intermodal transfers, and transfer opportunities must be accurately represented. Figure 6.5 (in the section on Trip Segment Analysis) is a portion of an intermodal network. Within this network fragment, transfers are allowed between six possible modes – metro rail, light rail, park-n-ride, kiss-n-ride, local bus and walk access. A traveler should be able to enter the network by any mode and leave the network by any mode, while incurring the correct disutility for all traversed trip segments.



An intermodal forecast needs to make intermodal choices. With one of the traditional trip assignment algorithms applied to an intermodal network, modes would compete strictly on their computed disutilities. However, planners know that the computed disutilities do not apply equally to every traveler. Some travelers have personal constraints, circumstances and likes and dislikes that predispose them toward certain modes.[4] An intermodal assignment algorithm must be able to handle this complex choice process. In essence, an intermodal assignment algorithm must apply a choice model (e.g., logit) each time a traveler has the option of changing modes.

Having the assignment algorithm make intermodal choices sounds complicated, but algorithms exist that do it. One such algorithm is a stochastic multipath assignment algorithm originally developed by Dial (1971) and extended by Horowitz (1987). An assignment algorithm that emulates transfer choices removes this burden from the mode split step.

[4] Planners who model travel behavior make a distinction between deterministic disutility and random disutility. Deterministic disutility can be measured by observing transportation system attributes. Random disutility varies with the individual and cannot be measured. A travel choice is made by users on the basis of the sum of deterministic and random disutilities. It is possible for a seemingly inferior mode to attract a trip, because a traveler has a strong preference for the mode. A logit model, which incorporates the concept of random disutility, correctly represents the ability of a traveler to choose an inferior mode.

Given the availability of such a choice-based assignment algorithm, a typical mode split step for a intermodal forecast is reduced to finding the fraction of travelers who:

A. Travel strictly by automobile;
B. Strictly walk; and
C. Travel by a combination of modes.

Trip assignment for automobile and walking are done in the usual way. Trip assignment for mode combinations would be done with a suitable stochastic multipath assignment algorithm and would yield the number of travelers who use each mode and the number of travelers who make intermodal transfers.

Critical Elements of an Evaluation

Determining the worth of any proposal for an intermodal passenger transfer facility is made difficult because the large number of design elements and the breadth of impact. The answers to the following questions will help determine whether an alternative has sufficient merit.

Has a Consumer Surplus Analysis been performed for the alternative that shows user benefits exceeding the public cost of the facility? A consumer surplus analysis is important if there are large shifts in demand. This chapter outlines the major steps in a consumer surplus analysis. The maximum countable benefit for a new trip should not exceed the trip's place utility in monetary units – an average of $6.00 for work trips and $1.50 for nonwork trips.

> *Alternatively, can the total reduction in users' trip disutility justify the public cost of the facility?* When little new demand is expected, a complete consumer surplus analysis may not be required. In such cases, the facility can only be justified on basis of improvements in travel for existing users.

Have local agencies established objectives for the facility and have they demonstrated that those objectives can be met? It is important that rigorous analysis be presented justifying any claims of met objectives by an alternative. Claims of congestion relief and reductions in air pollution emissions must be substantiated with good travel forecasting methods.

Have all concerns about security and safety been addressed? Meeting safety and security objectives are of the highest priority and deserve special attention.

Does the alternative contain a sufficiently strong system integration plan to assure that the facility will be effectively and cooperatively used by modal operators? Are private modal operators appropriately included in the plan? Chapter 4 discusses procedures for establishing a system integration plan.

Does the alternative fully exploit opportunities for joint development and private sector tenants? The ability of the community to include joint development into an intermodal facility and then to capture substantial revenues from such development can often make or break the project. Chapter 5 outlines steps in the development of joint development plans.

Does the alternative contain a financial plan that assures there will be adequate funds to build, maintain and operate the facility? Chapter 4 discusses the major elements in a financial plan for an intermodal passenger transfer facility. The financial plan must demonstrate that the facility, once built, can be operated and maintained without placing an undue burden on taxpayers.

Does the alternative achieve all minimum requirements? These requirements include: (a) all applicable laws and regulations; (b) freedom from significant, negative environmental impacts; and (c) technical requirements of modal operators.

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Evaluation of Intermodal Passenger Transfer Facilities

Expert Panel Questionnaire

Name: ______________________

Position: ______________________

Organization: ______________________

Phone: ______________________

Return to: Intermodal Facilities Questionnaire
Big City Transportation Commission
P.O. Box 1234
Big City, XX 55555
Phone: 111 222-3333
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Return envelope enclosed

Listed on the following pages are several possible objectives for an intermodal passenger transfer facility. Please review and rate the level of importance of each objective to the design of an intermodal passenger transfer facility. C ircle one number for each objective. **(0 is not important, 10 is extremely important. If you have no opinion on an objective circle N.)** Note: A "mode" is a means of transportation (for example, automobile, local bus, intercity bus). A sample objective has been provided below as an example. Thank you for joining our expert panel.

Sample objective for a hypothetical evaluation of a Park-and-Ride lot.

1. Maximize separation of automobile movements and bus movements.	N	0	1	2	3	4	5	6	7	8	9	10

Reason for answer: Separate circulation routes and areas for automobiles and buses are good ideas because of the large number of automobiles using the lot at the same time buses are entering and leaving.

System Objectives

The complete transportation system in the region.

	No Opinion	Not Important										Extremely Important	Comments
1. Maximize system coordination of information and fares.	N	0	1	2	3	4	5	6	7	8	9	10	Coordination includes unified fare structures and the elimination of duplicate information and services.
2. Maximize coordination of transfer scheduling.	N	0	1	2	3	4	5	6	7	8	9	10	
3. Maximize user benefits.	N	0	1	2	3	4	5	6	7	8	9	10	User benefits principally are perceived savings and real savings in travel costs and travel time
4. Maximize income from nontransport activities.	N	0	1	2	3	4	5	6	7	8	9	10	Nontransport income could include income from advertising, leases of retail space, consessions and joint development
5. Maximize market areas for each mode.	N	0	1	2	3	4	5	6	7	8	9	10	Market areas are the physical extent of the people, places and activities that are competitively served.
6. Maximize amount of connections between routes.	N	0	1	2	3	4	5	6	7	8	9	10	
7. Maximize system legibility.	N	0	1	2	3	4	5	6	7	8	9	10	Legibility relates to a passenger's ability to understand system connections and to plan trips involving two or more modes.
8. Minimize regional air pollution emissions.	N	0	1	2	3	4	5	6	7	8	9	10	
9. Minimize fare inconsistencies.	N	0	1	2	3	4	5	6	7	8	9	10	Fare inconsistencies include different rates among operators or inconsistent rates among like modes.
10. Minimize regional energy consumption.	N	0	1	2	3	4	5	6	7	8	9	10	
11. Minimize negative impact on existing transportation services.	N	0	1	2	3	4	5	6	7	8	9	10	A facility can have undesirable effects on operators that cannot participate or on operators whose routes are disrupted or face additional competition
12. Minimize service duplication.	N	0	1	2	3	4	5	6	7	8	9	10	Service duplication includes redundant or competing routes
13. Minimize cost.	N	0	1	2	3	4	5	6	7	8	9	10	Costs include operating and capital expenditures.

Internal Objectives

Within the site of the intermodal transfer facility.

	No Opinion	Not Important										Extremely Important	Comments
1. Maximize passenger comfort.	N	0	1	2	3	4	5	6	7	8	9	10	
2. Maximize directness of path.	N	0	1	2	3	4	5	6	7	8	9	10	The most direct paths for walking are nearly straight lines between places within the facility.
3. Maximize pedestrian assists.	N	0	1	2	3	4	5	6	7	8	9	10	Pedestrian assists include elevators, escalators and moving sidewalks.
4. Maximize security.	N	0	1	2	3	4	5	6	7	8	9	10	
5. Maximize aesthetics.	N	0	1	2	3	4	5	6	7	8	9	10	Aesthetics: visual quality of the internal environment.
6. Maximize passenger information.	N	0	1	2	3	4	5	6	7	8	9	10	
7. Maximize weather protection.	N	0	1	2	3	4	5	6	7	8	9	10	Weather protection can occur both indoors and outdoors.
8. Maximize alternative uses of time while waiting.	N	0	1	2	3	4	5	6	7	8	9	10	Alternative uses of time include recreation, eating, socializing, listening, working and attending to personal needs.
9. Maximize openness of interior design.	N	0	1	2	3	4	5	6	7	8	9	10	Openness: large, airy and unobstructed places.
10. Maximize ease of fare collection.	N	0	1	2	3	4	5	6	7	8	9	10	
11. Maximize reliability of facility services.	N	0	1	2	3	4	5	6	7	8	9	10	Reliability relates to the dependibility of the services and the physical plant.
12. Maximize amenities.	N	0	1	2	3	4	5	6	7	8	9	10	
13. Maximize quality of waiting areas.	N	0	1	2	3	4	5	6	7	8	9	10	
14. Maximize safety.	N	0	1	2	3	4	5	6	7	8	9	10	

Internal Objectives (cont.)

	No Opinion	Not Important										Extremely Important	Comments
15. Minimize physical barriers to handicapped.	N	0	1	2	3	4	5	6	7	8	9	10	
16. Minimize path length.	N	0	1	2	3	4	5	6	7	8	9	10	
17. Minimize conflicting paths.	N	0	1	2	3	4	5	6	7	8	9	10	
18. Minimize queuing delays.	N	0	1	2	3	4	5	6	7	8	9	10	Queuing delays are times spent waiting in line while traveling within the facility, while accessing modes and while obtaining services.
19. Minimize exertion.	N	0	1	2	3	4	5	6	7	8	9	10	Exertion is the physical effort required to reach a vehicle.
20. Minimize maintenance requirements.	N	0	1	2	3	4	5	6	7	8	9	10	
21. Minimize crowding.	N	0	1	2	3	4	5	6	7	8	9	10	
22. Minimize barriers.	N	0	1	2	3	4	5	6	7	8	9	10	Barriers include anything that disrupts a direct path between two points.
23. Minimize wasted space.	N	0	1	2	3	4	5	6	7	8	9	10	
24. Minimize level changes.	N	0	1	2	3	4	5	6	7	8	9	10	Changes in level require stairs, ramps, elevators or escalators
25. Minimize disorientation and confusion.	N	0	1	2	3	4	5	6	7	8	9	10	
26. Achieve elimination of hazardous materials.	N	0	1	2	3	4	5	6	7	8	9	10	Site and previous buildings might contain hazardous materials, such as asbestos, which must be removed.
27. Achieve handicapped access.	N	0	1	2	3	4	5	6	7	8	9	10	

External Objectives

Outside the site of the intermodal transfer facility.

	No Opinion	Not Important										Extremely Important	Comments
1. Maximize use of local employment.	N	0	1	2	3	4	5	6	7	8	9	10	
2. Maximize informal vending.	N	0	1	2	3	4	5	6	7	8	9	10	Informal vending includes sales from carts and vehicles that can be moved from place to place
3. Maximize community pride.	N	0	1	2	3	4	5	6	7	8	9	10	
4. Maximize quality of architectural design.	N	0	1	2	3	4	5	6	7	8	9	10	
5. Maximize reuse of existing buildings and infrastructure.	N	0	1	2	3	4	5	6	7	8	9	10	
6. Maximize flexibility for expansion.	N	0	1	2	3	4	5	6	7	8	9	10	
7. Maximize urban renewal.	N	0	1	2	3	4	5	6	7	8	9	10	
8. Maximize sense of place, historic significance, and community image.	N	0	1	2	3	4	5	6	7	8	9	10	
9. Maximize positive cultural and social elements.	N	0	1	2	3	4	5	6	7	8	9	10	Possible elements include art, displays, assembly areas and meeting spaces.
10. Maximize joint development.	N	0	1	2	3	4	5	6	7	8	9	10	Joint development involves the public and private sectors sharing the facility and its costs and revenues.
11. Minimize negative cultural impacts in surrounding neighborhood.	N	0	1	2	3	4	5	6	7	8	9	10	Cultural impacts include relocation of churches, community centers and cemeteries and the removal of historic properties.
12. Minimize construction impacts.	N	0	1	2	3	4	5	6	7	8	9	10	
13. Minimize negative social impacts in surrounding neighborhood.	N	0	1	2	3	4	5	6	7	8	9	10	Negative social impacts include increased presence of strangers in the neighborhood and loss of part of an ethnic neighborhood.
14. Minimize disruptive land acquisition.	N	0	1	2	3	4	5	6	7	8	9	10	Land acquisition can become disruptive when the property is already serving a useful purpose or when households are displaced.
15. Minimize physical impacts to surrounding neighborhood.	N	0	1	2	3	4	5	6	7	8	9	10	
16. Minimize conflict with surrounding land uses, existing and proposed.	N	0	1	2	3	4	5	6	7	8	9	10	

External Objectives (cont.)

External Objectives (cont.)	No Opinion	Not Important 0	1	2	3	4	5	6	7	8	9	Extremely Important 10	Comments
17. Achieve compliance with historic preservation requirements.	N	0	1	2	3	4	5	6	7	8	9	10	
18. Achieve same or lower air pollution emissions.	N	0	1	2	3	4	5	6	7	8	9	10	
19. Achieve property rights.	N	0	1	2	3	4	5	6	7	8	9	10	All buildings and land must be purchased and rights of usage and access must be obtained

Mode Interface Objectives

Aspects of the facility directly related to transfers.

Objective	No Opinion	0	1	2	3	4	5	6	7	8	9	10	Comments
1. Maximize ease of operations for modes.	N	0	1	2	3	4	5	6	7	8	9	10	Operations include vehicle maintenance, vehicle storage, ticketing, baggage handling, and accounting.
2. Maximize directness of paths for modes.	N	0	1	2	3	4	5	6	7	8	9	10	Direct paths go from origin to destination without jogs, loops, bends, or other deviations
3. Maximize safety and security of operations of modes.	N	0	1	2	3	4	5	6	7	8	9	10	
4. Maximize efficient access and egress.	N	0	1	2	3	4	5	6	7	8	9	10	
5. Maximize reliability of transfers.	N	0	1	2	3	4	5	6	7	8	9	10	

Objective	No Opinion	0	1	2	3	4	5	6	7	8	9	10	Comments
6. Minimize difficulty of ticketing or fare payment.	N	0	1	2	3	4	5	6	7	8	9	10	
7. Minimize path conflicts between modes.	N	0	1	2	3	4	5	6	7	8	9	10	Conflicts arise when paths cross and interfere with the flow of traffic
8. Minimize waiting.	N	0	1	2	3	4	5	6	7	8	9	10	
9. Minimize difficulty of baggage handling.	N	0	1	2	3	4	5	6	7	8	9	10	
10. Minimize institutional barriers to transferring.	N	0	1	2	3	4	5	6	7	8	9	10	Institutional barriers include transfer fares and poor coordination of schedules
11. Minimize physical barriers of transferring between modes.	N	0	1	2	3	4	5	6	7	8	9	10	

Thank you again for participating in our expert panel questionnaire.

Appendix B. Earlier Views

This appendix contains material, not otherwise cited, that was used in constructing the generic objectives and many of the check lists in this report.

Objectives

Demetsky and Hoel:

General User

- Minimize travel impedances
- Minimize delays
- Minimize conflicts (crossing movement paths)
- Minimize crowding
- Minimize disorientation
- Maximize safety
- Maximize reliability
- Collect fare efficiently
- Minimize level changes

Special User

- Eliminate level changes
- Reduce fare collection barriers
- Avoid crowding
- Eliminate physical barriers
- Provide locational guides

Operator

- Maximize equipment reliability
- Control entry efficiently
- Maximize safety
- Process flow efficiently
- Provide adequate space

User Environment

- Provide comfortable ambient environment
- Provide adequate lighting
- Provide clean surroundings
- Ensure and aesthetically pleasant environment
- Provide for personal comfort
- Provide services and concessions
- Provide adequate weather protection
- Provide adequate security

Operator Environment

- Provide adequate security
- Provide adequate safety

Other

- Minimize maintenance, cleaning, and replacement needs
- Obtain an efficient return on incremental investment
- Receive adequate income from non-transport activities
- Utilize energy efficiently
- Minimize total cost
- Exploit joint development
- Provide opportunity for expansion

Source: Demetsky and Hoel, 1981

Atlanta:

Meet program requirements for terminal (modes and services)
Enhance overall surface transportation network
Locate terminal for direct link to existing rapid transit rail system
Minimize impact of passenger traffic on existing freight service
Create a landmark to give a sense of place
Complement existing and proposed CBD activity centers
Enhance a pedestrian open-space network linking major activity centers
Private cooperation
Flexibility to accommodate future changes in markets and technology
Minimize adverse construction impacts and disruptions
Maximize efficiency of train movements in terminal area
Minimize bus travel time to interstate highway system
Minimize the need for acquisition of private property
Minimize traffic and transfer point impacts of buses
Maximize platform efficiency by providing sufficient storage and service track space
Minimize transfer time between commuter modes and rail transit
Stimulate complementary new development and reuse of existing vacant buildings
Minimize neighborhood environmental impacts
Source: Atlanta Regional Commission, 1992

Los Angeles:

Provide on-site service when possible
Provide bus service dedicated to commuter rail patrons
Establish easily recognizable commuter rail buses
Utilize and build upon existing bus service

Utilize buses already in-service
Avoid making radical changes to existing bus service
Establish inexpensive fares and easy transfers for bus service
Source: Union Station Bus/Rail Interface Plan

San Francisco, BART:

Maximize the value of the public investment in the BART system
Encourage use of the system by maintaining and improving the accessibility of the station to all modes of transportation
Conserve fuel and reduce pollution by encouraging use of public feeder transit service to the BART station
Improve patron comfort and safety in the station area.
Encourage development in the station area that will relate to and enhance the value of the BART station as a multimodal transportation terminal.
Source: BART Multi-Modal Terminal Plan, City of Walnut Creek, Califomia, MTC, 1974

Evaluation Criteria

Orange County:

Bus bay demand to capacity
Potential for on-street expansion
Demonstrated demand for express service
Commuter rail interface
Traffic congestion (ADT, LOS)
Daily passenger ons and offs
Number of interfacing lines
Number of modes served
Buses per peak hour
Recovery (layover) buses per hour
Scale of activity center
Commercial use of facility
Source: Schneider, 1981

Eugene, Oregon:

Distance from major downtown activity areas
Maximize coordination with intercity public transportation
Proximity to retail/commercial employees
Proximity to government employees
Proximity to retail floor space

Proximity to residential units
Future employment growth nearby
Future growth in retail floor space nearby
Future residential growth nearby
Use of contraflow lands and signal preemption to expedite bus movements
Linkage to major pedestrian corridors
Linkage to major bikeway facilities
Minimize bus miles in downtown areas
Average walking distance to employment locations
Opportunity for private sector participation through potential joint development
Provision of adequate bus bays to allow for layover points and for schedule coordination
Site flexibility for future expansion of local transit or intercity carriers
Pedestrian space devoted exclusively to transit patron use
Distance between buses for transferring passengers
Maximization of a sense of security and safety
Maximization of capability to be understood by the public
Maximization of visibility of transit center
Maximization of opportunity for imaginative, quality architectural design
Noise impacts on adjacent environments
Air quality impacts on adjacent environments
Utilization of downtown land with potential development opportunities for transit use
Proximity to adjacent uses
Traffic impacts resulting from bus operations
Parking impacts
Energy conservation
Retail disruption
Capital costs for construction
Capital costs for right-of-way
Annual operating and maintenance costs
Fiscal impact of removing site from tax rolls
Potential for funding availability from discretionary and demonstration monies
Source: Schneider, 1981

Demetsky and Hoel (long list):

Total walk time
Total time in system
Route travel times
Area per person
Total delay
Queue length
Flow conflicts
Connectivity

Orientation Aids
Safety features
Design hazards
Back-up facilities
Inspection procedures
Number of levels
Mechanical and ramp level change aids
Fare collection-entry barrier
Physical barrier to special users
Entry control
Station size
Odor concentration
Suspended aerosols and particulates
Inflow air rate
Air discharges
Air velocity
Pressure changes
Thermal comfort
Noise
Lighting
Personal comfort facilities
Cleanliness
Pleasantness
Advertising
Concessions
Weather exposure
Security
Maintenance and repair
Cleaning requirements
Funds available (budget) vs. funds required
Income (non-transport activity)
Incremental return (relative to low cost alternative)
Energy requirements
Joint development provisions
Expansion potential

Demetsky and Hoel (short list):

Travel time measures
Area provided for personal movements
Queues (delays)
Crossing flow for paths
Connectivity (directness of travel paths)
Effectiveness for directional aids

- Potential safety hazards
- Security risk potential
- Barriers to special users
- Air quality
- Thermal comfort
- Noise levels
- Illumination
- Personal comfort facilities
- Cleanliness
- Advertising
- Concessions
- Weather protection
- Maintenance requirements
- Cost effectiveness
- Joint development potential
- Design flexibility

High Speed Station Evaluation Criteria/Categories:

Provision of Facilities/Services for Connecting Modes Not Currently Available at Site

- Auto/carpool/vanpool/park-n-ride – surface lots
- Auto/carpool/vanpool/park-n-ride – structured parking
- Kiss-n-ride facilities
- Local bus transit connections
- Metropolitan express bus/limo connections
- Intercity bus connections
- Auto rental services
- Specialized shuttle bus services (hotels, large employers)
- Automated peoplemover system connections
- Light rail transit connections
- Commuter rail connections
- Pedestrian connections
- Bicycle accessibility and storage
- Motorcycle/motorscooter surface parking
- Motorcycle/motorscooter structured parking
- Helicopter/tiltrotor connections
- Ferry system connections
- Truck access(loading/unloading goods, parcels, supplies)

Revisions to Existing Connecting Services Required

- Impacts on competing modes
- Impacts on complementary modes

Impact on Current Railroad Operations at Existing Station

Interference with existing passenger operations
Interference with existing freight operations
Required rail facility capacity/safety improvements (near term)
Required rail facility capacity/safety improvements (long term)
Passenger safety/security concerns

Proximity to Major Facilities and Destinations
Freeway Interchanges
Major Arterials
International Airport
Second Level Airport
Hotels/Motels/Restaurants
Major Employment Centers
Major Shopping Center
Residential Areas

Potential Funding Sources
Federal funding potential
State funding potential
Private funding potential (capital)
Private funding potential (O & M)
Local (city/county) costs (capital)
Local (city/county) costs (O & M)

Potential Costs
Facility development costs
Relocation costs – utilities
Relocation costs – residences
Relocation costs – businesses
Relocation costs – other facilities
Near-term operation and maintenance costs
Long-term operation and maintenance costs

Development/Redevelopment and Tax Base Enhancement Potential
Private development potential
Public/private joint development potential
Public facility development potential
Long-term revenue generation potential
Long-term regional job growth potential
Long-term local job growth potential

Community Impacts
Perceived safety and security in/around station
Overall conformance/consistency with local comprehensive (land use) plans
Conformance with current zoning
Overall functional compatibility with existing land uses in area

Urban design integration potential
Visual intrusion/integration potential
Nonmonetary, socioeconomic benefits
Possible land acquisition problems (e.g. use of eminent domain power likely)

Environmental Impacts
Noise
Air quality
Water quality concerns

Traffic Mitigation
Local traffic capacity improvements required (e.g. new signals, larger intersection capacities, new freeway ramps)
Traffic safety improvements required (including more law enforcement activities)

Metropolitan Urban Form and Socioeconomic Impacts
Likely changes in the urban accessibility pattern
Urban growth potential impacts

Source: Schneider, 1994

Passenger Amenities

Benches
Information signs
Shelters
Enclosed or semi-enclosed structures
Concrete bus pads
Public telephones
Recovery (layover) area
Restrooms
Landscaping
Ticket and information booth
Bicycle racks
Lighting
Vending machines
Private carrier accommodations
Public parking
Commercial/Office Space

Source: Schneider, 1981; from Orange County, CA

Human Elements in Station Design

Convenience
- Minimize Delay
- Minimize Exertion
- Avoid Crowding
- Directional Information
- Service Reliability
- Consumer Services

Comfort
- Climate Control
- Rest Room Facilities
- Avoid Crowding
- Waiting Areas
- Cleanliness, Sanitation
- Esthetic Design

Safety
- Police Protection
- Emergency Response
- Avoid Crowding
- Emergency Egress
- Safe Walking
- Surfaces
- Lighting

Source: Fruin in Hoel and Richards, 1981

Station Functions

Transmits image of transportation services within
Reception center
Business office
Waiting area
Vehicle access and egress
Communications center
Operations center
Commercial center
Source: Wilfred Sergeant, in Hoel, Richards, 1981

External Attributes, Rank Ordered

Health Effects of Pollution
Property Values
Number of Jobs
Accessibility of Emergency Facilities
Pattern of Land Development
Safety on Adjacent Highway
Number of Business Firms
Level of Income
Number of Housing Units
Aesthetic Effects of Pollution
Personal or Group Stress
Amount of Open Space
Number of Welfare Recipients
Community Oriented Contacts
Neighborhood Stability
Aesthetic Value of Right-of-Way
National Defense
Community Cohesiveness
Barrier Effect
Blend Highway into Background
Personal or Business Contacts
Visual Quality of Highway
Number of Historic Sites
Temporary Economic Effects
Financial Capability of Government
Municipal Services
Community Security
Temporary Aesthetic Effects
Public Participation in Government
Satisfaction with Government
Source: Weiner and Deak, 1972; Highway Facilities; Most Important to Least Important

Traffic Congestion Near Home
Safety From Crime
Safety From Traffic Accidents
Parking Near Home
Helping or Blocking from Getting to Places
Vibration Inside/Around Home
Trees and Other Natural Features
View from Inside Home
Travel Time to Work
General Appearance of Neighborhood
Source: Ross and Stein, 1985; Rail Stations; Most Negative to Least Negative

Transfer Penalties

Bus-To-Bus Untimed
- 23 Minutes *(Horowitz/QRS II)*
- 22.8-45.6 Minutes *(20-40 Minutes of Riding Time, Horowitz, 1981a)*
- 28 Minutes *(Horowitz, 1981b)*
- 49.5 Minutes *(Includes wait, Algers, Hansen, Tegner, 1975)*
- 30 Minutes *(Han, 1987)*

Bus-To-Bus Timed
- 12 Minutes *(Horowitz/QRS II)*

Bus-To-Rail
- 23 Minutes *(Includes wait, Algers, Hansen, Tegner, 1975)*

Rail-To-Bus

Rail-To-Rail
- 14.8 Minutes *(Includes wait, Algers, Hansen, Tegner, 1975)*

Metro-Metro
- 4.4 Minutes *(Includes wait, Algers, Hansen, Tegner, 1975)*

All Modes
- 30.8 Minutes *(Includes wait, Algers, Hansen, Tegner, 1975)*

Note: Median transit headways were 10 minutes in the AHT study

System Integration

Transit System Integration Techniques

Institutional Integration
- Merger
- Federation
- Passenger Transport Executive

Operation Integration
- Adaptation of Mode to Service Requirements
- Public Information Systems
- Unification and Coordination of Fares
- Honor Payment System
- Fare Discounts
- Parking Control
- Bus-only Lanes and Streets
- Staggered Work Hours

Physical Integration
- Intermodal Terminals
- Pedestrian Facilities
- Park-n-Ride Facilities

Source: Interplan, 1973

Ideal Integrated Transit System Characteristics

Accessibility
- Adequate Distribution of Routes
- High Frequency of Service
- Sufficient Time Span for Service
- Availability of Seating
- Adequate Information on Routes, Schedules, Fares
- Adequate Identification of Boarding Zones
- An Image of the Transit Service that Attracts Users
- Ease of Paying the Required Fare

Efficiency
- High Vehicle Speed
- Absence of Delays from Traffic Congestion
- Minimum Loading and Unloading Delays
- Sufficient, but Not Too Frequent, Stops
- Coordinated Scheduling Between Lines
- Transfer Arrangements which Avoid Long Walks
- Direct Routing
- Elimination of Duplicate Service
- Minimum Personnel Requirements
- Equipment Which Is Easy to Maintain
- Adequate Repair and Maintenance Facilities
- Efficient Management Information Systems

Reliability
- Adherence to Schedules
- Low Frequency of Breakdowns
- Information on Potential Delays
- Special Service to Compensate for Delays
- Guaranteed Availability of Transfer Service

Comfort
- Adequate Ventilation and Air Quality
- Adequate Temperature and Control
- Low Noise Levels
- Well-Designed Lighting
- Smooth Ride
- Sufficient Seating
- Comfortable, Generous Seat Space, Including Leg Room
- Accommodation for Packages
- Adequate Handholds for Standing Passengers
- Easy Entrance and Exit
- Pleasing Vehicle Design
- Well-Maintained Vehicle Interior
- Ease of Fare Collection
- Weather Shelters at Stops

Attractive Stations
Absence of Noise and Ugly Elevated Rails
Minimum Noise and Exhaust Emissions
Neat and Attractive Maintenance Facilities and Yards

Safety

Absence of Vehicle Accidents
Adequately Placed and Marked Loading Zones
Safe Steps and Doors on Vehicles
Absence of Sharp Edges on Both Interior and Exterior of Vehicles
Absence of Theft from Drivers and Passengers
Absence of Physical Violence on Vehicles or at Loading Areas
Absence of Vandalism to Vehicles, Shelters or Stations

Cost

Reasonable Fare Structure
Free Transfer Privileges
Fare Reductions for Multiple-Ride Tickets and Passes
Fare Reductions for Children, Students, and Senior Citizens
Graduated Fares

Source: Interplan, 1973

Access Priorities

Pedestrians
Bicycles
Local Buses
Other Buses
Taxis
Kiss-n-Ride
High Occupancy Vehicles
Motorcycles
Park-n-Ride

Source: Hoel and Richards, 1981

Principles of Transit Station Design

Transit Generates Business; Business Generates Transit
Transit Should Be and Integrated Part of Activity Centers
Access to Activity Centers Should be Provided for a Variety of Modes
Activity Centers Should Be Places Where People Change Modes
Transit Facilities Should be of the Highest Quality to Compete with the Automobile
Transit Facilities Need to Be Actively Managed and Designed for Change
Transit Should Be Clean, Safe, Accessible, Secure, Informative and Comfortable

Source: Rabinowitz, Beimborn, Lindquist and Opper, 1989

Access for Intermodal Facilities

Direct Benefits of Access Improvements

1. Minimize travel times for access user.
2. Minimize travel costs for access user.
3. Possibility of increasing reliability of service for access user.
4. Reduced congestion on other access modes.

General Access Design Principles

1. Facilitate intermodal transfers and the growth of intermodalism by providing sufficient access capacity to serve existing and anticipated demand.
2. Define "sufficient access capacity" by:
    a. evaluating current capacity for each access mode;
    b. assessing current and projected future demand for each mode;
    c. identifying trade-offs among competing modes; and
    d. setting overall performance objectives and standards to be met by the provision of access.
3. After setting performance standards, develop design plans to meet the established criteria.
4. Avoid or minimize negative impacts on other modal systems.
5. Avoid or minimize environmental impacts, particularly in residential neighborhoods adjoining intermodal facilities.
6. Where feasible, utilize existing investments in facilities and right of way.
7. Allow for improvements that may be needed to accommodate unanticipated future access demands.
8. Incorporate new technologies and allow for the potential use of emerging technologies.
9. Carefully consider the relationship between modes.

Source: Vickerman Zachary Miller, 1994

Appendix C. Glossary of Terms and Abbreviations

A

Abled adj. Relating to a person with normal physical abilities, ant. disabled.

Access n. (1) The process of gaining entry to a mode. (2) The ability to gain entry.

Access Mode n. A means of travel for connecting with a line-haul mode.

Accessibility n. A measure of the ability of all persons to travel between various origins and destinations.*

ACHP n. Advisory Council on Historic Preservation.

Activity n. A human endeavor that occupies a block of time at a specific location.

ADA n. Americans with Disabilities Act.

AGT n. Automated Guideway Transit, syn. peoplemover, GRT.

Airline Distance n. Straight line distance between two points, not necessarily following roads or paths.

Alignment n. The specific location of a road or guideway.

Alternative Mode n. Another means of travel, usually in a choice process.

Amenity n. Any element of a station that does not directly relate to transportation, but helps make the experience more productive or enjoyable.

Arrival Rate n. The average number of pedestrians or vehicles arriving at a point of service over a fixed period of time.

Assignment n. (1) A technique for estimating the total number of people or vehicles using a link by summing the trip on that link going between each pair of origins and destinations. (2) The estimating loadings on all links.

Attribute n. A condition that helps define the state of a design element.

B

Barrier n. Any obstacle that impedes, discourages or prevents movement in a given direction.

Benefit Assessment District. n. A specially designed district around an intermodal transfer facility, where a portion of subsequent increases in property tax revenue accruing to projects within the district go directly to the transportation agency.

C

CAAA. n. Clean Air Act Amendments of 1990.

Capacity n. The maximum flow rate of people or vehicles for a given link.

Capacity Restraint n. A feature of some traffic assignment algorithms that assures that forecasted traffic volumes do not exceed the capacity of any link.

Captive Rider n. A person who must use transit for tripmaking, ant. choice rider.

Category Scale n. A rating method used in questionnaires, where the respondent must provide one of a finite number of responses within a range.

CBD n. Central business district, syn. downtown.

CDBG n. Community development block grant.

Centroid n. A type of node in a network that shows the point of origin or destination for trips, often located near the center of a traffic analysis zone.

Checklist n. An evaluation method consisting of a list of issues to be investigated, often with spaces to describe the results of the investigation or to rate the importance or magnitude of each issue.

Choice Rider n. A person who can freely choose, over the long term, the mode of transportation, ant. captive rider.

CMAQ n. Congestion Mitigation and Air Quality Improvement Program, part of the Intermodal Surface Transportation Efficiency Act, for funding transportation projects that are likely to contribute to the attainment of a national ambient air quality standard.

Concept Diagram n. A schematic drawing of a facility site and paths of access.

Conflicting Paths n. Paths that cross at the same level.

Connection Fee. See Facility Connection Fee.

Consistency n. For passenger information systems, standardization of signs; delivering the same intended meaning each time the message is presented; and having signs compatible with paths and other visual clues.

Consumer Surplus n. (1) For any purchase, the difference between the buyer's willingness-to-pay and the selling price. (2) The summation across all buyers' individual consumer surpluses.

D

Delay n. The amount of time for a trip, beyond the amount that would be experienced under uncongested, free-flow conditions.

Destination n. (1) The point at which a one-way trip ends. (2) The zone in which a one-way trip ends.

Disabled adj. Relating to a person with physical handicaps that limit mobility.

Distance Advantage n. The extra distance a person is willing to travel to a given station over a neighboring competing station, because of a lower price of access or a lower fare to the final destination.

Disutility n. A measure of dissatisfaction with the travel portions of a trip, usually a weighted function of time and cost, ant. utility.

E

EA n. Environmental assessment as required by the National Environmental Policy Act of 1969 for certain Federal actions.

Egress n. (1) The process of leaving a mode. (2) The ability to leave a mode.

Egress Mode n. A means of travel for connecting with a line-haul mode.

EIS n. Environmental impact statement as required by the National Environmental Policy Act of 1969 for certain Federal actions.

Elasticity n. The fractional change in an output divided by the fractional change in an input, syn. sensitivity. Elasticity is sometimes reported as a positive number, regardless of the computed sign, esp. in price-demand relationships.

External Environment n. Aspects of a transfer facility beyond its immediate site.

External Station n. A type of node used in network construction that represents an area beyond the extent of the network.

F

FAA n. Federal Aviation Administration of the US Department of Transportation.

Facility Connection Fee. n. A fee collected from a landowner or private tenant for the right to physically connect a project to a facility by way of a passageway.

FHWA n. Federal Highway Administration of the US Department of Transportation.

Formal Vending n. Retail sales at well established stores or counters.

FRA n. Federal Railroad Administration of the US Department of Transportation.

Fratar Method n. A mathematical technique for updating an old trip table so that it matches current totals for trip origins and trip destinations.

Frequency. n The number of transit vehicles moving in the same direction past a given point over a specified period of time, usually measured in vehicles per hour.

FTA n. Federal Transit Administration of the US Department of Transportation.

G

Gate n. A barrier to immediate entry to a vehicle, where tickets are checked.

Gravity Model n. A method of synthetically building trip tables.

GRT n. Group Rapid Transit, syn. peoplemover, AGT.

Guarantee Time n. For vehicle operators, the difference between a standard work week and the actual amount of work performed, which is still paid under contract provisions.

Guideway n. A well-defined path for vehicles that provides direction for movement.

H

Highway Capacity Manual n. A publication of the Transportation Research Board that provides methods for ascertaining levels of service for highway, transit, bicycle and pedestrian facilities.

Headway n. The time interval between successive vehicles on the same road or guideway, measured nose to nose.

HOV n. High occupancy vehicle.

I

Impedance n. (1) Disutility of a trip or link. (2) The conditions that may restrict travel volume over a link.*

Incentive-based agreements. n. Public agencies granted real estate development bonuses in exchange for partial or full funding of an intermodal transfer facility.

Informal Vending n. Retail sales of products from vehicles, carts or stands that can be moved from place to place or are of a temporary nature.

Institutional Integration n. A system of organizations, committees, laws, regulations, financial mechanisms, and policies that provide for coordination of operations across modal operators.

Integration n. Having the appearance and functionality of a single system among many independent operators.

Internal Environment n. Aspects of the transfer facility within the boundaries of the site.

J

Joint Development n. Public and private sectors sharing in the costs and benefits of a project.

L

Landmark n. A visually prominent land form or manmade object, either inside or outside a facility.

Layover n. A short break period following the completion of a transit route in a single direction, for rest and for making up lost time in the schedule.

Lease n. The most common form of revenue enhancing joint development, where a transportation agency or local government sells temporary rights to land parcels, air or subterranean space, or unimproved space to private developers or commercial tenants.

Legibility n. (1) For passenger information systems, being able to readily see or hear the message. (2) For the passenger environment, having sufficient clues for proper orientation and wayfinding.

Level Change n. Any significant change in elevation along a pedestrian path, usually requiring steps, ramps, elevators or escalators.

Level of Service n. A rating of the quality of traffic flow, often an A to F scale.

Light Rail Transit n. A form of rail transit that permits operation of vehicles both on streets and exclusive guideways, typically involving electric motive power obtained from overhead wires.

Line-Haul Mode n. A mode that carries passengers over long distances and at high speed without stopping.

Link n. A part of a network that represents a road or guideway segment between two nodes.

Logit n. (1) An "s" curve that is often used to estimate the probability of some event as a function of the event's characteristics. (2) A popular method for estimating mode split.

LOS n. Level of service.

LRT n. Light rail transit.

M

Mandatory Program. n. A program requiring developers building in a designated area to provide transportation facilities and services as traffic mitigating measures of their development projects.

Manual on Uniform Traffic Control Devices n. A publication of the US Government, maintained by the Federal Highway Administration, that gives standards for design and use of traffic signs, signals and pavement markings.

Market Boundary n. A curve on a map delineating the service areas of competing stations or transfer facilities.

Matrix n. A table of numbers, arranged in row and columns.
Microclimate n. Meteorological conditions in small outdoor places.
Millage Rate. n. Unit of measurement for property taxation in dollars of tax per 1000 dollars of assessed value.
Mobility Disadvantaged n. A person with physical, social, age or economic limits on his or her ability to travel by the most appropriate mode.
Modal adj. Relating to a mode.
Modal Operations n. Actions necessary to transport passengers or to support the transport of passengers, including maintenance, vehicle storage, fare collection and office work.
Mode n. A means of travel.
Mode Split n. (1) The proportion of total person-trips using available modes. (2) The process of estimating the proportion of person-trips using each available mode.

N

Network n. A graphical description of a transportation system consisting entirely of links and nodes.
Network Editor n. A computer program for drawing links and nodes and for giving them characteristics.
Node n. A network element that forms the end of one or more links, usually and intersection or a centroid.

O

OD Pair n. Origin-destination pair.
Operational Integration n. Cooperation between modal operators to coordinate service and fare payment and to eliminate service duplications.
Operator n. (1) A person or a company that operates a transportation mode. (2) A person who operates a transportation vehicle, syn. driver.
Orientation n. (1) The ability to determine a direction. (2) The ability to perceive the relationship between objects (building, signs, landmarks, etc.) so as to readily determine a path to a destination.
Origin n. (1) The point at which a one-way trip begins. (2) The zone in which a one-way trip begins.
Origin-Destination Pair n. A description of a trip, given by its point of origin and its point of destination, often used when describing total trip making between points in a transportation network.

P

Path n. A sequence of links and nodes from an origin to a destination.
Path Conflict n. Having two or more paths from the same or different modes cross at the same level.
Path Separation n. The quality of having vehicle paths (or pedestrian paths) from different modes in the same vicinity without crossing at the same level.
Pay-as-you-go n. Complete project funding from current revenue.
Pay-as-you-use n. Funding project costs with long-term financing.
Pedestrian Assist System n. One or more vehicles or devices to carry passengers over paths that would otherwise be walked, such as elevators, escalators, moving sidewalks and shuttle buses.
Penalty n. A term in a disutility function that represents the dissatisfaction with a specific action, independent of

the amount of time spent taking that action.

Physical Integration n. Shared and compatible facilities across a range of modal operators.

Pictogram n. A symbol, usually found on signs, that represents a service, a location or a requested action, syn. pictograph.

Pivot Point n. A quick method of estimating mode split.

Place Utility n. The amount of utility gained by reaching a desired destination.

Placement n. For passenger information systems, appropriate locations for wayfinding decisions and viewing.

Platooned Flow n. The grouping or bunching of moving pedestrians because of internal or external traffic impedances.

Policy Committee n. A group of people who provide the goals for an intermodal facility design and who are responsible for choosing the recommended alternative.

Priority n. (1) Permission for a vehicle to execute a maneuver ahead of any competing or conflicting vehicles. (2) A quality of a mode that gives it more ready access to a facility.

Process n. Any step in the provision of a service or in the transportation of people or goods that takes a significant amount of time.

Process Diagram n. A flow diagram showing all processes in a required task or trip.

Productive Waiting n. Waiting time effectively used for other productive purposes, such as working or attending to personal needs.

Property Tax Abatement. n. A decrease or delay in taxes on a given property for a fixed period, either waiving a specific percentage of taxes due or applying a lower rate than usual.

Property Tax Freeze. n. A holding of assessments at prerehabilitation levels, thereby not taxing increases in value for qualifying properties, sometimes referred to as special valuations or special assessments.

Protected adj. (1) Not being subjected to weather conditions. (2) Given priority of movement at an intersection, ant. unprotected.

PRT n. Personal rapid transit, a yet to be implement technology involving small, automated vehicles.

Q

Queue n. Waiting line.

Queuing Theory n. Methods for determining the average length of queues and the average waiting time in a queue.

R

Recovery n. A layover.

Redundancy n. For passenger information systems, repetition of the message to assure that it has been delivered.

Revolving Fund n. Money set aside by a preservation organization for acquisition of historic properties that are returned to the organization for further use after the property is rehabilitated.

S

Schema n. A consistent set of symbols and attributes for representing elements of a system or network.

Schematic adj. (1) Based on a schema. (2) Relating to a drawing that shows design elements as symbols.

Scoping n. An early part of the environmental impact assessment process when the important issues are identified and the nonissues are discarded.

Secondary Cost n. Any cost that results from accommodating the location of the facility. Secondary costs include the relocation of utilities, residences, businesses and other facilities.

Secondary Revenue n. Any revenue that results from the location and impact of the facility. Secondary revenues include taxes from increased property values, sales tax revenues and income tax revenues.

Server n. In queuing theory, the entity that performs the service and thereby allows the queue to discharge.

Service Rate n. The maximum number of pedestrians or vehicles that can depart a point of service over a fixed period of time.

SHPO n. State Historic Preservation Officer.

Shuttle n. A public conveyance that travels back and forth over a particular route, especially a short route or one that connects two transportation systems.*

Site Planning n. Designing the physical layout of a site, including access to it by various modes.

Skim Tree. n. A network tree showing only the shortest paths from a single origin to all destinations or for a single destination to all origins.

Spacing n. Distance between two vehicles operating in the same direction on the same road or guideway, measured nose to nose.

Spatial adj. Relating to space, usually a location on the earth's surface.

Special Assessment n. See Property Tax Freeze.

Special Valuation n. See Property Tax Freeze.

Spread Time n. For vehicle operators, extra compensation for working within an especially long shift, even when the total of hours worked is not excessive.

Station Car n. A very small vehicle available for short-term rental at a station.

STOL n. Short take-off and landing aircraft.

System n. (1) A group of interrelated components. (2) All facilities of a single mode or of many integrated modes. (3) A set of transportation facilities as described by a network.

System Integration n. See Integration.

System Planning n. The broadest aspects of facility planning, dealing principally with the relationships between components and overall system performance.

T

Tax Increment Financing. n. A way of obtaining project funds by freezing property tax bases from benefiting property owners as of a certain date, then earmarking incremental gains in property tax receipts for funding operating deficits or for securing capital obligations to station-area improvements.

Technical Advisory Committee n. For facility planning and design, a group of people with technical expertise who advise staff on modal requirements and impacts.

Temporal adj. Related to time.

Timed Transfer n. A passenger transfer between two vehicles, where the vehicle schedules have been coordinated to assure little or no waiting.

Tour n. (1) A sequence of visits to a number of destinations in a vehicle, starting at home and ending at home. (2) An recreational trip involving many stops, often as part of a group by a mass transportation mode.

Transfer Fare n. An extra payment, less than full fare, for accessing a second vehicle on a trip.

Transportation Enhancement Activities (TEA) n. An ISTEA program that provides funds for transportation enhancement activities including rehabilitation and operation of historic transportation buildings and acquisition of historic sites.

Tree n. A special type of network where there is only one possible path between any two points, usually containing only a subset of links from a more complex network.

Trip n. (1) Travel by a single person or vehicle from a single origin to a single destination. (2) For travel forecasting, travel by any number of people or vehicles from a single origin to a single destination.

Trip Distribution n. The process of estimating the number of trips between origins and destinations.

Trip Generation n. The process of estimating the number of trips that are produced or attracted to a zone, usually broken out by trip purpose.

Trip Purpose n. The primary reason for making a trip.*

Trip Segment n. A part of a trip path, often the part occurring within the site of an intermodal transfer facility.

Trip Table n. A table or a matrix in computer readable form that shows the number of trips between each origin and each destination.

U

Understandability n. For passenger information systems, terseness, familiarity and simplicity of message.

Unproductive Waiting n. Time spent waiting where no productive activities, such as working, take place.

Unprotected adj. (1) Subject to weather conditions. (2) Not given priority of movement at an intersection, ant. protected.

Utility n. (1) A measure of satisfaction gained by acquiring a product or service, ant. disutility. (2) For passenger information systems, the degree to which an information device serves its intended purpose.

V

Value of Time n. The rate at which a person is willing to trade time for money when choosing a path or mode of travel, often used in benefit-cost studies of transportation projects.

Vending n. Retail sales of a product.

Vista n. A particularly pleasing view from a given location.

Volume n. The number of pedestrians or vehicles passing a given point in the same direction within a specific period of time.

Voluntary Agreements. n. Agreements executed between transit agencies, developers and private property owners to reduce the development costs of each party through coordinated planning, design and construction.

VTOL n. Vertical take-off and landing aircraft, usually a helicopter.

W

Wayfinding n. The process of a person determining a path to a destination by references to information devices and other visual clues.

Weight n. A part of a disutility function that increases the disutility of time spent while engaging in abnormally unpleasant actions.

Windowing n. A style of network construction where the extent of the network is strictly contained within a small area and where external stations along the boundary are used to represent places outside this small area.

*Note: Definitions indicated by a * were adapted from Transportation Research Board Special Report #179, "Glossary of Urban Public Transportation Terms.*

Appendix D. Comments on Intermodal Passenger Facilities

Example Facilities

In order to better understand the needs of travelers passing through intermodal transfer facilities, a group interview was conducted with the Transit List of the Internet. The interview was conducted entirely by e-mail, with all members of the Transit List being able to see everyone's responses. This appendix contains excerpts from some of the comments. The first question asked users to name and describe good examples of intermodal terminals in North America. Many stations were mentioned; here are the better examples and more interesting discussion.

Los Angeles

Union Station

Union Station in Los Angeles had a MAJOR facelift in 1992, not just in appearance, but in sheer volumes of passenger traffic.

The main catalyst was the Metrolink commuter rail network, which opened in October of last year - several improvements to the station were made, most obvious of which was the repainting and rehabilitating of the old, rusty "butterfly" passenger canopies over the platforms—no longer rusty and decaying, they are now colored cream with and accent of aqua blue. The platforms also now have "Los Angeles" signs on them, demarking the station's name.

Due to increased rail traffic, a new electronic arrival/departure sign was installed last year between the ticketing offices and the easternmost side of the waiting area. This sign announces Amtrak, Metrolink and Amtrak Thruway buses' arrivals and departures.

Yet another great addition came early this year—The Metro Red Line subway. As the easternmost terminus for the subway, Union Station now has a more convenient and rapid connection to the rest of Downtown LA, making it the mode of choice for suburban Metrolink commuters heading from Union Station to their offices.

Union Station is the cornerstone for an even larger development - called the Alameda District. This new development will include office buildings, including the new Metropolitan Transportation Authority headquarters now being built, shops, restaurants, a bus plaza and even an indoor sports stadium.

Also, by 1997, the Metro Blue Line light rail to Pasadena will occupy tracks 1-2 on the station platforms, making yet another addition to LA's most important surface transportation hub.

UNION STATION GATEWAY - This is a bus facility currently being constructed which will serve buses going to/from the El Monte Busway. This facility is located just east of L.A. Union Station, and will provide multimodal connections not only between local and express buses and shuttles, but Amtrak, Metrolink, the Metro Red Line subway and (by 1997) the Metro Blue Line light rail to Pasadena.

--Elson Trinidad

Boston

South Station
North Station
Back Bay Station

The only thing "intermodal" about South Station is that there's now a subway entrance inside the station; before the reconstruction you had to go out onto the sidewalk to get to the subway entrances. Intercity busses do stop nearby, but construction of the "intermodal" bus station (over the RR tracks) has only recently begun. There's also talk (but so far only talk) that when the new tunnel under Boston Harbor is completed, there will be an airport baggage check- in at South Station with buses straight to the airport boarding areas. (The tunnel will exit on the airport grounds.)

The reconstruction of South Station itself has been an unqualified success. From a cavernous dump in the mid-1970s, the station has been transformed into a popular yuppie food court with numerous fast food stands and shops. At lunch time it attracts workers from the nearby office buildings, and the day the X-2000 was in town the place was downright crowded on Saturday, even though relatively few of the people there seemed to be interested in going through the train. I'd have to say that South Station still falls short of the almost incredible restoration of Union Station in Washington, but it's even more successful than the New Haven and Baltimore stations (although both of them are highly successful restorations).

Work is also proceeding on the reconstruction of North Station, although again an integrated subway station may be its only claim to intermodality. Back Bay station is similar - commuter trains, Amtrak intercity trains, and the MBTA subway.

--Robert K. Coe

Philadelphia

Upper Darby Station (69th Street)
Pennsylvania Station

But in terms of local or regional transit, the 69th Street Terminal in Upper Darby deserves to be included on the list. It is (I believe) the oldest such transfer facility in the US (begun 1906, placed in service 1907) and combined three (now four) distinct services: rapid transit (Market Street Elevated), suburban streetcar service (Red Arrow Lines) and interurban lines (Philadelphia and Western) in a single facility. As buses began to replace streetcars, they too used berths in or adjacent to the terminal, and a parking lot for cars (predecessor of today's "park-and-ride" facilities) was added in the 1950's. A major reconstruction in the late 1980's included restoring the terminal lobby to its original appearance, refurbishing the streetcar platforms, and adding new, more convenient berths for suburban and city buses on the terminal's south and north sides.

As "intermodal" facilities go, this surely can be considered a pioneer in the field.

--Sandy F. Smith Jr.

When Amtrak turned its hand to renovating Philadelphia's Pennsylvania ("30th Street") Station, IMO, they were more sensitive to its function. They had to be; the train "concourse" also happens to be the building's central lobby, thus making it impossible to slip a shopping mall in the middle. Instead, they converted the south half into a Reading Terminal-style food market that has proven popular with commuters and workers in the area. The train station, though, remains the building's heart and soul.

Unfortunately, the station falls a bit short in the "intermodal" category. The problem lies in the location of the building itself, about 200 feet or so northwest of the

Market-Frankford subway station at 30th Street. Originally, a tunnel connected the subway station mezzanine with the train station's southwest concourse, but the tunnel was closed about 15 or so years ago because of safety concerns. The tunnel cannot be reopened as is due to new rules on handicapped access, so patrons must cross 30th Street, a short-term parking lot, and the service drive around the building in order to enter the station—hardly what I'd call "pedestrian-friendly." OTOH, the station does have something unusual for a big-city train station, especially on the East Coast: excellent expressway access (the facility also sits astride Exit 39 on the Schuylkill Expressway).

--Sandy F. Smith Jr.

Hoboken

Hoboken Terminal

HOBOKEN TERMINAL is an intermodal facility from c.1907 that once included PATH's predecessor H&M, mainline railroad, trolley, elevated trolley, and ferry. It now has PATH, NJ Transit Rail, local bus, bus to New York, and ferry.

--Joe Brennan

New York

Penn Station
Grand Central Terminal
Flatbush Ave. Station
Jamaica Station
Several PATH Stations
St. George Ferry Terminal

Penn Station New York, Grand Central Terminal, and Flatbush Ave station in Brooklyn all have built-in connections to multiple subway lines. Jamaica station LIRR also now has a direct subway connection.

--Joe Brennan

Newark

Penn Station

NEWARK PENN STATION is an intermodal facility from c.1935 (renovated late 1980's) with PATH, Amtrak, NJ Transit Rail, City Subway, and local bus.

--Joe Brennan

Newark Penn Station is also served by intercity Greyhound buses.

--Jishnu Mukerji

Irvine

Irvine Station

It is very definitely pedestrian and bicycle UNfriendly. The street fronting the station is a major arterial, very difficult to cross. The station itself sits well back from the street and from the surrounding businesses, surrounded by a large surface parking lot on two sides, taxi and kiss and ride driveways on a third side, and El Toro (I think it is El Toro) Air Base on the fourth. I did not see bike racks anywhere, nor a marked bike path on the driveway from the street, although I am certain the bike racks are somewhere.

A person walking from the parking lot to the station wouldn't be faced with too much hassle, but a person walking from the station to one of the surrounding businesses, or someone trying to reach the station by bicycle is engaging in an activity that is made both slow and highly dangerous due to the auto-oriented design of the streets.

--James Edward Marca

Miami

Metrorail/Tri-Rail Connections
Government Center Station

In Miami, a Metrorail station provides an interchange with the Tri-Rail commuter rail line. Although you have to go through a fare barrier to transfer from one to the other, Tri-Rail tickets (which have a magnetic stripe on the back) can be used in the Metrorail turnstiles as if they were Metrorail tickets, providing free transfer from Tri-Rail to Metrorail.

Also in Miami, the Government Center station downtown serves both the Metrorail and the Metromover (automated "people-mover" system). Since the Metrorail fare is $1.25 while the Metromover fare is $0.25, transfers are barrier-free in one direction but not in the other.

--Jon Bell

Atlanta

Several MARTA Stations

In Atlanta, many rail transit stations provide fare-free transfers to and from buses using the scheme Mark Brader has described for Toronto.

--Jon Bell

Toronto

Kennedy Station
Several Subway Stations
Union Station

The Toronto subway system includes a number of stations with convenient transfer facilities to buses and/or streetcars.

The layouts vary according to the number of surface routes served and the form of the site, but the walk from the subway platform to the bus/streetcar platform is often less than the 500-foot length of the subway platform. At most stations the two modes are served from a single fare-paid area, so that even though the so-called "honor" or "proof of payment" system is not used, passengers can walk freely between vehicles and can use all doors when boarding a bus/streetcar.

The TTC generally provides escalators at subway stations only in the up direction and then only along one route from subway to street. There are exceptions at the busier stations, where down escalators and multiple up escalators are provided. Only one station has elevator access. In stations with individual bus platforms, they are always accessed by stairs.

--Mark Brader

Toronto Union Station: TTC subway, GO commuter trains, VIA intercity trains, and a TTC LRT line (plus a couple of surface bus routes). GO trains also meet the TTC subway at a couple of other points.

--Colin R. Leech

Montreal

Terminus Voyageur/Berri-UQAM Metro Station
Windsor Station/Bonaventure Metro Station
Central Station
Dorval Station

You probably know something about Montreal's transit situation: the Terminus Voyageur, the main downtown bus terminal, is at Berri-UQAM (formerly Berri-De Montigny) Metro station. Central Station (owned by Canadian National Railways, with VIA and Amtrak intercity trains and STCUM commuter trains) and Windsor Station (Canadian Pacific, STCUM commuter trains only) are linked by tunnel to Bonaventure Metro station. However, there's a new development: South Shore buses, run by the Societe de Transport du Rive-Sud de Montreal (STRSM, Montreal South Shore Transit Corp.) operate out of a new terminal in the lower level of a high-rise office building adjacent to the Bonaventure Metro station, so that commuters from the South Shore have very good connections with the Metro, and can make those connections without having to go outside.

--Nigel Allen

I would add Vendome station in Montreal: connection between the metro (line 2, orange) and a commuter train line (Montreal- Dorion-Rigaud on CP tracks), with the usual facilities for local transit buses. The metro and train platforms are parallel but at different levels; the ticketing hall for the metro station is linked by a very short tunnel to the stairs up to the commuter train platforms.

Dorval station is also interesting. There are two railway stations, end-to-end on adjacent rights-of-way (CP tracks for the commuter train, same line as Vendome; CN tracks for VIA Rail intercity trains), a major transit bus terminal, and an airport three minutes' drive away. A free shuttle runs between the VIA station and the airport, and a transit bus serves the airport from the bus terminal. VIA trains pick up passengers outbound (to Ottawa or Toronto) and drop them off inbound. The commuter train service is heavily concentrated at peak hours (2 hour headways off-peak), and is supplemented by an express bus to Lionel-Groulx metro station, which is located between Vendome and downtown, at an interchange between metro lines 1 and 2.

--Justin Bur

The South Shore Transit (STRSM) now has an indoor terminal at 1000 de la Gaucheterre, with a convenient connection to Bonaventure Metro. STRSM buses enter the terminal and stop either at platforms in the center (all times), or around the periphery (rush hour only). These platforms are accessed by stairways/escalators from above. Woe betide a passenger who heads for the wrong set of platforms, for it is forbidden (I think) to cross directly from one to the other without going up and down stairs. There's an STRSM ticket office at this terminus (only at the center platform, I think), which never seems to be open when you need it.

Dorval Train Station/bus station provides car parking, and connects Dorval Gardens Shopping Center, the Dorval city bus (MUCTC) terminal, and West Island train station. Commuters say they can get train or bus service to town, but they have to make up their minds: the tunnel linking the two is too long to make it possible to catch whichever comes first. Note also that there is service to nearby Dorval Airport every half-hour from here. And since the MUCTC territory is the whole island of Montreal, you can travel between anywhere on the island and this airport, for a single fare (using the free transfer privilege, of course), provided you can handle the baggage, and have lots of time.

--Peter Jones

There was a recent opening of a short-cut off the Central Station Passage (actually, this is the link to the new STRSM terminal, but also goes on to the Bonaventure Metro station).

Another snag with "Le Passage" is that it tends to be closed at certain off-peak hours, especially if later VIA trains arrive. Finding one's way to Bonaventure station becomes a royal pain, and even an outdoor adventure. There might be a link through the hotel way to Square-Victoria station, though, if going the other way.

STRSM's terminal connects with Bonaventure and the 1000 de la Gauchetiere building (home of Teleglobe, and a few snack shops on the main level).

--Mickey Way

Montreal: Commuter and intercity train stations are adjacent to metro (subway) stations. The intercity bus terminal sits right on top of the main interchange station where the original 3 metro lines meet.

--Colin R. Leech

Washington, DC

Union Station

Last summer while visiting DC, I took a jaunt out to Baltimore for two days via Union station and MARC. On the way back, I came into Union Station, stashed my day-pack in a locker there for a buck or so, and left the station on foot to meet a friend in a pub for happy hour. The pedestrian access/egress in my opinion is a bit harrowing as far as speeding cars and jaywalking goes, but not as bad as Orange County. There are also a LOT of panhandlers around the pedestrian entrances to the station, but that seems to be SOP for D.C. After I left the pub, I returned to Union Station and caught the metro out to Dupont Circle. The station is well designed in that respect, I think, with the Metro exits leading you right up through a glitzy new shopping area to the Amtrak/MARC station area. The rail passenger services, such as lockers and bathrooms and waiting areas, left something to be desired, but then again, they were on a par with what I saw in Paris.

--James Edward Marca

I was at DC Union Station about 2 years ago; the Amtrak and MARC lines connect conveniently. The station incorporates a large mall and connects with the subway system. The city bus system doesn't go into the station, but there are bus stops outside for a few routes. Taxis, of course, are eager to handle Metroliner/MARC passengers.

--Mickey Way

My last visit to Washington was a few months after the unveiling of the new Union Station shopping mall, and while I won't quibble with the justification for the conversion—better a beautifully restored shopping mall than a decrepit train station—my impression was that DC Union Station is now a shopping mall with train platforms in the rear. The facility now exists as much to entertain the tourists and locals as it does to serve rail passengers, which I suspect contributes to James Marca's less-than-completely-satisfied feeling about the place.

--Sandy F. Smith Jr.

General Design Issues

Intermodal Origins

How many Union Stations are there, anyway?

There were at one time very many. There was a "union station movement" starting sometime in the late 19th century and extending into the 20th. Any station serving two or more railroads may be called a Union Station. In the very early days, railroads always built individual stations and often required passengers to go some short distance across town. Local people like it this way, as they got to make money transporting people and goods locally. As the railroads became more networked after the Civil War, and needed larger stations anyway, often where railroads crossed a single Union Station would be put up, to convenience people changing trains and also, I think, to save money on construction. Many small towns had Union Stations. A slight disadvantage is that the Union Station might be away from the old town center, located where railroads crossed.

In some larger cities, large Union Stations were more expensive projects and were located off the old line of one or more of the railroads involved. The goal was still to facilitate changing trains and to reduce construction costs compared to each railroad building its own; such large city stations are often monumental in scale, like those in Washington, Chicago, Cleveland, Cincinnati, and St Louis, as examples that come quickly to my mind. These Union Stations often were separate companies jointly owned by the railroads involved, and owning not only the station but the trackage shared by the owner roads. In such cases the Union Station Company might even own switch engines and some maintenance rolling stock. Washington and Cleveland did, I know.

In some cases, even where there was a Union Station, one or more railroads might decide not to participate for some reason. The Pennsy was a holdout at Cleveland and Toledo. At Chicago, early proposals for a Union Station actually suggested bringing *all* the railroads in, believe it or not, but many had good terminals already in place, and I can't imagine how many tracks it would have needed to handle the volume... still, for travelers it would have been welcome, if rather like modern airports in how far one might have to walk between trains.

--Joe Brennan

Baggage Handling

Most train stations don't have lockers, for obvious security reasons (breaking them in, non-claimed items/unreturned keys, the possibility of bombs placed in lockers, etc). On a recent trip to the East Coast, hours after I got off the plane at Newark Airport and took PATH into NYC, I wanted to leave my bags in some kind of locker. The closest thing was Amtrak's $1.50 per-item Parcel Check-In area, where items can be left for up to 24 hours. Those bags were killing me, trying to walk through 33rd St, so $3.00 for a few hours was more than worth it and left me enough time to sample the Long Island RR before catching the X2000 to Philadelphia.

A similar parcel check-in area at Philadelphia's 30th St. station also proved convenient, for it provided a place to store my bags after checking out of my hotel and giving me time to tour the city for the rest of the day.

Another reason why there are no more lockers is space. Lockers take up space, and a Parcel Check-In area about 20'x40' can store several times more bags than lockers taking up that space.

--Elson Trinidad

In my experience, I think it is more common for train stations to have lockers rather than attended left luggage facilities. Some (London Victoria and Madrid Chamartin come to mind) have attended lockers—at Chamartin my bag had to be X-rayed before I could put it in a locker.

But my experience may be slanted by the set of countries I've been to—and by the somewhat random subset of stations where I've actually needed to leave luggage.

--Mark Brader

Handicapped Access

As a parent and city dweller, I'd like to add that ramps and elevators don't only help people in wheelchairs. They are also great for people with baby strollers, luggage and packages. We're all more or less handicapped at certain times. Easy access could be a great promotional tool to attract riders. If we had ramps and elevators in the subway, I'd sure be happier to take my little daughter around town.

--Joe Brennan

Barrier Free Design and Fare Payment

I can't see how [barrier free design] could be a cost savings device when you deal with any sort of large volume of passengers, both because of the increased prospects for dishonesty as well as the ability to then cover the added costs of barrier and "barrier maintenance" (staffing, etc) with the increased revenue.

--Mark Foggin

All rail transit in California except BART and San Francisco's Muni is barrier free. That's the San Diego Trolley, Los Angeles' Red and Blue lines, Santa Clara light rail, and Sacramento light rail. It must be working reasonably well, because all rail systems being planned include it. All the systems that currently use it report that the noncompliance rate is very low. It seems to be merely a matter of adjusting the fine for noncompliance and the rate of inspection to such a level that the total revenues are the same as that for a system with barriers.

--Ed Suranyi

Sure there are people who beat the honor system. But there are people who jump fare gates, or even suck tokens out of machines. With the honor system, not only are the fines higher, it's more humiliating personally to the offender since most of the time they are cited in full public view of the other riders, giving yet another deterrent to fare evasion.

The Metro Red Line subway in LA was originally supposed to be a gated system, since all of its stations were underground. But the light rail Blue Line that opened before it was designed as a barrier-free line, and so I guess for convenience and sake of relative standardization as far as fare payment, they switched to the honor system for the subway.

--Elson Trinidad

Do turnstiles really inhibit passenger movement?

Absolutely. I've waited many minutes waiting for crowds to pour through the El Cerrito del Norte BART station. I've waited so long that the next train came in!

It's slow because it was designed as just another stop in the middle of the line, but in practice (although Richmond is the end of the line) most people drive to El Cerrito del Norte and park there.

I've often wished for a proof of fare system while waiting in the large crowd.

--Aaron Priven

The most interesting (non-)barriers I've seen are in the Moscow Metro. There, the gates are *open* - these are gates like BART or DC Metro, low turnstile-ish things. If you deposit a token before you walk through, no problem. If you don't, a photoelectric cell sees you go through and the gates slam closed. You can get a mean thwack in the leg - not enough to do real damage but enough so you make that mistake only once.

--Mike Feldman

Operator Information

In Moscow the trains on most lines run on 90-sec or 120-sec headways. At the end of each platform, up on the wall over the tunnel entrance, is a big digital clock that tells not only the time of day but also the elapsed time since the last train. I suspect it's to help the drivers with timekeeping, but it's fun for passengers too.

--Mike Feldman

The Paris Metro uses clocks for timekeeping. Unlike the Moscow ones (which show headway), these show departure time offset by travel time, so if he is running to time, the driver of the 12:34 train will see the clocks all read 12:34:00 as he leaves each station.

--Clive D.W. Feather

System Integration

The prime examples of system integration are in Europe. This started, I believe, in Hamburg around 1960, and is characterized by unified fares (usually zoned, but covering *every* line, be it regional rail, local rapid transit, bus, whatever), usually passes which are likewise good on all lines in the zones paid, and honor system fare payment. This is now the norm in Germany and Austria; each metropolitan area has a "Verbund" (transit association) covering all operators, and is seamless so that the passenger doesn't know or care who is actually running the line. In The Netherlands, the whole country (admittedly it's not a *big* country) is on a unified basis; if you buy a strip ticket good for, say, 10 rides or 10 zones of travel, it is accepted on all local and regional transit systems.

Doesn't the Metropolitan Transit System in San Diego involve coordination between a number of operators at a uniform fare with free transfer? I think so. I do know from their transfers (transfers are my own odd specialty) that there are about 20 different agencies, many with rural dial-a-ride service only, but all use the same fare structure and the same transfer.

--Robert Saxon

In San Diego County (CA), several transit operators (North County Transit, San Diego Transit, San Diego Trolley and many small suburban and rural operators) all use the same pass ($45/mo.) and transfers. Cash fares vary between $1 and $1.50, although transfers are free and the day pass (once again, useable on all systems) is attractively priced at $4.

In Los Angeles county, a special "Inter-Agency" transfer is provided by municipal (non-MTA) routes for use on MTA and other municipal lines (The MTA provides the bulk of bus and rail service in LA County; however, many suburbs have their own local bus lines) MTA transfers are accepted on most municipal lines, and either type of transfer entitles the bearer to a discount on Metrolink (commuter rail) routes.

In the Bay Area, there is a BART Plus pass which can be used as a "flash pass" on most major Bay Area Transit systems, as well as being used as a regular BART ticket with a stored value. There is also an experiment with stored value cards useable on both BART and County Connection (Contra Costa County) buses.

--Charles Hobbs

In Canada, much of the integration comes from having a single operator providing all service within a metropolitan area.

Vancouver is an excellent example. The Vancouver Regional Transit System, part of BC Transit, serves all communities in the Lower Mainland area. They have different fare zones, but otherwise the system is seamless from community to community. They cover a very large geographic area.

In the Ottawa area, OC Transpo operates all service within the Regional Municipality of Ottawa-Carleton, covering the 7 urban municipalities within RMOC. There are free transfer privileges with the Societe de transport de l'Outaouais (STO), which is also a regional agency covering numerous municipalities on the Quebec side of the Ottawa River. All but one of the Ottawa River bridges are downtown, so the two systems essentially meet at a single point, which is downtown Ottawa.

Montreal has a similar situation. The island of Montreal (can't remember how many municipalities, but probably over 20) is all served by the STCUM. A person can buy a monthly pass that is also good for travel on the STRSM (South Shore Transit Commission, across the St. Lawrence River) and Laval (to the north across the Riviere des Prairies). Again the number of bridges limits the potential number of interchange points, although less so for Laval. STCUM also operates the regional commuter rail lines.

Toronto has its plusses and minuses. On the plus side, most of the smaller cities and towns outside Toronto have some sort of fare integration with GO Transit, the regional commuter rail operator. Their main focal points tend to be the GO stations (since there really aren't any other major transit trip generators), and schedules generally coordinate with the GO trains (for the same reason). GO also has some fare integration with TTC.

The Toronto Transit Commission (TTC) covers all of Metropolitain Toronto, which has 6 (?) constituent municipalities. Unfortunately this pattern of providing a fully-integrated regional service (established decades ago) has not been repeated in the surrounding municipalities as they have grown. Although there are 5 Regional Governments in the area around Metro Toronto, only Hamilton-Wentworth has a regional transit system, and Hamilton is more of an independent city than a satellite of Toronto. All of the others have separate systems for each city, with little integration of service or fares among them. There are a few isolated cases of integration, but as a whole, there is a long way to go.

--Colin R. Leech

The Inter-Agency Transfer in Los Angeles, discussed by Paul Robinson, is issued by all of the municipal transit systems in L A County (but not SCRTD or its successor, L A County Metropolitan Transportation Commission). There are now considerably more than 6, and the Inter-Agency Transfer has been revised a few times to keep up with this changing pattern. A separate I-A Transfer (different from the local transfers issued by the municipal systems for use on their own lines) is desirable since the local fares are typically lower than the county-wide LACMTC fare; you have to pay the uniform county-wide fare to get the I-A Transfer. Since regular LACMTC routes charge the county fare anyway, no separate transfer is needed to ride on local systems such as Montebello, Gardena, Torrance, Culver City, etc., etc.

An analogous arrangement is in effect at San Diego, where you can be issued a Local or a Metro transfer depending on the fare paid. A Metro transfer is good on a variety of local services, even to change from a fixed route to a dial-a-ride or vice versa.

--Robert Saxon

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TECHNOLOGY SHARING

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