public bus, and Buffalo, there are differential-fare policies that increase revenues and also improve equity.

Generally, increased peak-hour fares in combination with low off-peak fares will have a negative impact on either revenue or passenger levels. No program can produce a revenue increase without a corresponding decrease in passenger volume.

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Approach to the Planning and Design of Transit Shelters

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For a transit patron, the transit shelter is one of the most easily recognizable elements of the transit system, but, at present, this type of transit-interface facility is considered simply for its cosmetic value. This attitude creates a weak link between the transportation system and its users and can threaten the viability of the urban transit system. This paper presents the theses that transit shelters have a more significant role in the community and in the transit system than being just a windbreak or weather-protection device; that they are an interface point with the system and should protect, comfort, inform, and guide the user; that they should blend into the surroundings but still be visible; and that they should not be isolated or passive agents. The paper sets forth an innovative approach to the planning and design of shelters and describes what a shelter facility is versus what it ought to be. It also describes the types of activities that are involved in the development of the transit shelter and the types of functional, social, financial, physical, and user issues that should be considered. The benefits that can be derived through the use of this approach are discussed.

A transit stop is a primary interface between the patron and the transit system. A well-designed stop will encourage ridership and provide comfort, security, information, and a place to rest. When a patron arrives at a stop and there is no bus in sight, a commonplace occurrence, he or she waits and watches automobile traffic pass by. This increases the illusion or reality that transit is inferior to the automobile in terms of travel time. However, if the patron is comfortable and occupied while awaiting the arrival of the bus, the passage of time may lose some of its significance.

To help increase the viability of the transit system in this respect, shelters have been recommended. These shelters need not be isolated passive agents but can and should be fully integrated into both the immediate environment and the balance of the transit system. In addition, they should be active agents in encouraging the use of the system. The traditional hardware approach to shelter and bus stops is a beginning, but recognition that the shelter and stops are parts of a complex design issue is very important. Figure 1 illustrates conceptually the manner in which the hardware and the environment are parts of a system that actively seeks to integrate the community, the transit system, and the patron.

As the interface among these, the shelter and stop have several important roles that may differ from residential location to activity-center location to employment-center location. These differences may affect the emphasis that given roles might have, although no role should ever be ignored if the shelter is to successfully serve the community, the transit system, and the patron.

Well-designed transit-shelter facilities should include more than a windbreak and a roof and be similar to transit facilities such as airport terminals or union stations. Although capital investment and space limitations will restrict options, the environment of a bus stop and shelter ideally should reflect the following (Figure 2).

1. Shelters provide security. The environment of the bus stop should be designed in a manner that encourages people to use the facility and provides them with a sense of security. At night a well-lighted stop permits bus drivers to see waiting patrons and provides patrons with the ability to see their environment. Lighted open spaces, rather than dark and confining areas, increase the users' feeling of well-being. The availability of a telephone or police and fire call box or both can also increase personal security.
2. Shelters provide a rest area. A relatively large number of transit riders are to some extent restricted in their mobility. Rest facilities, including benches to sit on and racks on which to place packages, increase the attractiveness of the system. If a person is already tired from walking to a bus stop, he or she is probably a less than completely satisfied customer. Benches and parcel racks, and perhaps a drinking fountain, would certainly be welcomed.
3. Shelters provide for the needs of the handicapped. Consideration should be given to the needs of people using wheelchairs, walkers, crutches, and other aids. As transit systems and vehicles seek to serve the handicapped better, the emphasis should be not on accentuating differences and difficulties, but rather on ameliorating them. Curb cuts at appropriate points near and en route to shelters, smooth pavements, wide access, low-level signs, and grab rails should be included to make use of the facility possible for people restricted to wheelchairs.

Vision-impaired individuals cannot rely on standard signs and signs in braille should be provided. Sharp corners and edges should be avoided and differences in textures can be used to provide information such as the direction in which to proceed. If transit routes are color coded, the spelling of the name of the color is essential for people who have difficulty in distinguishing colors.

4. Shelters protect against the weather. A shelter is helpful in all seasons, for it can protect people from sun, wind, and precipitation. Analysis of the prevailing

Figure 1. Bus-shelter design process.

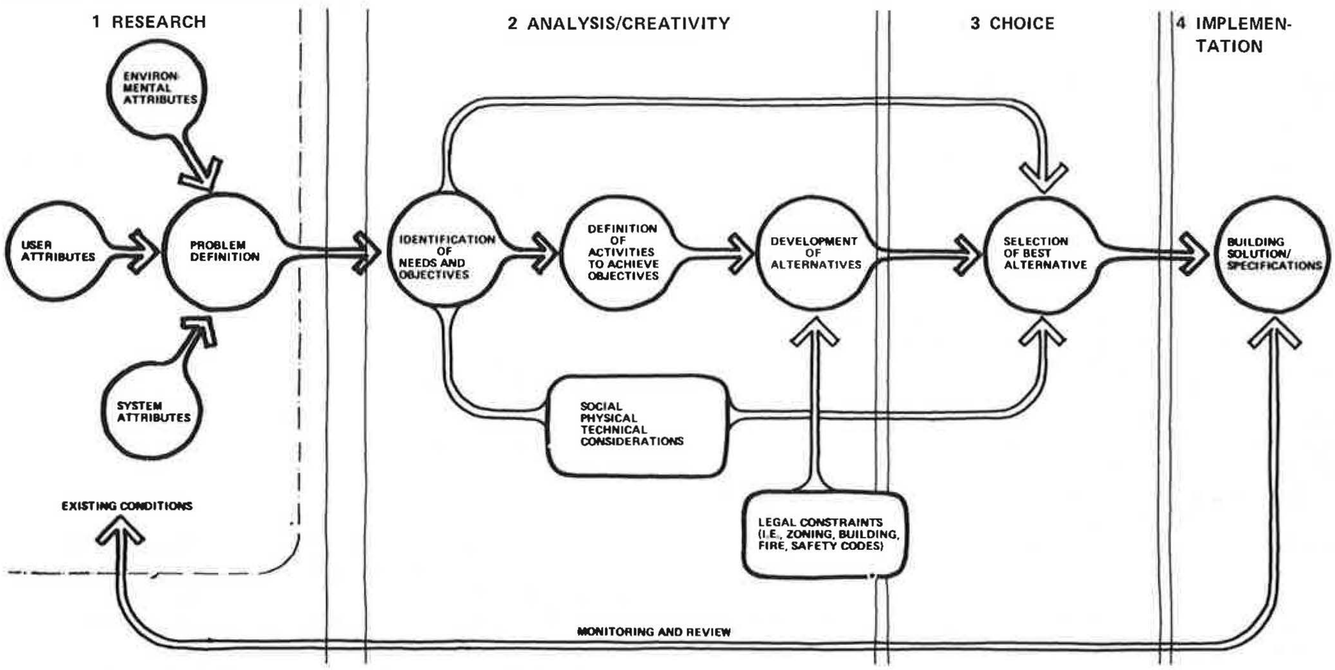
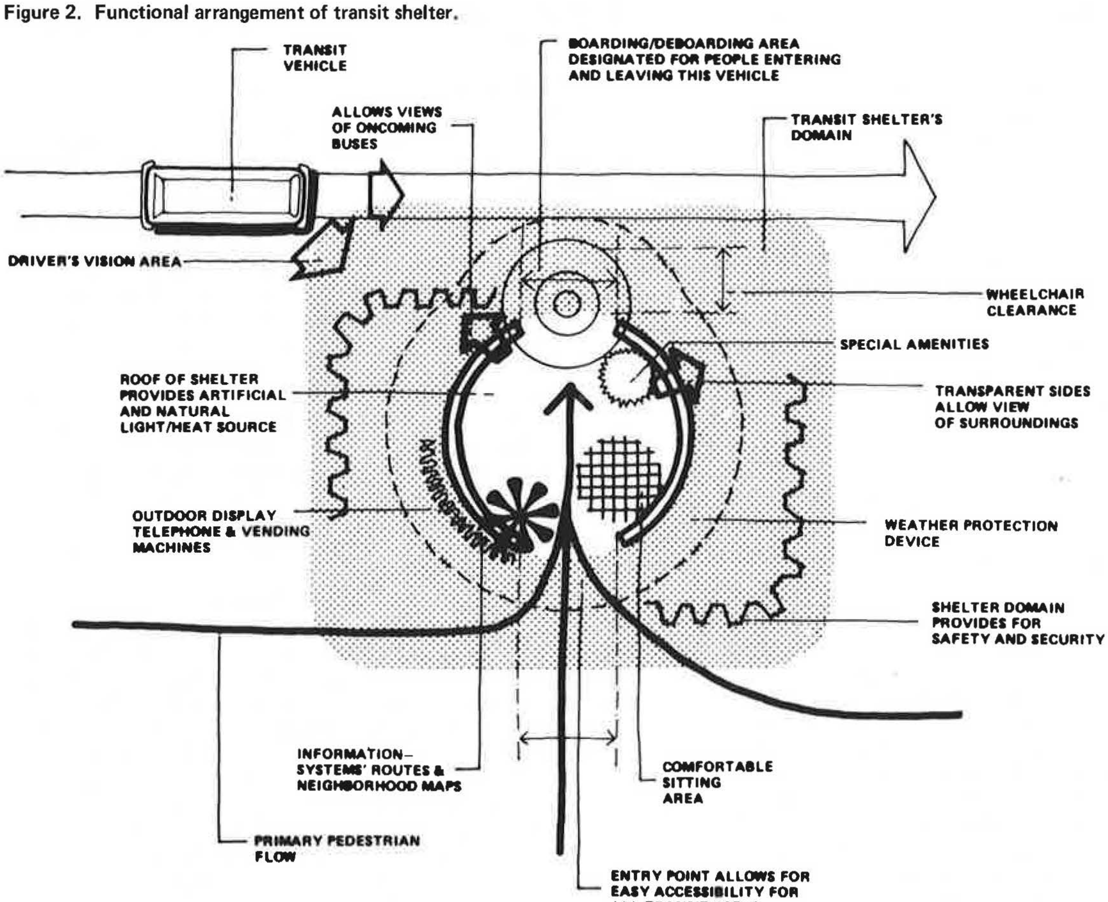


Figure 2. Functional arrangement of transit shelter.



wind direction at specific shelter locations will permit construction of shelters that shield the patron from the weather while he or she awaits the arrival of the bus and then boards it. The access to shelters should not result in the shelter acting as a sail and collecting wind, rain, snow, and rubbish.

5. Shelters increase transit service areas. Transit shelters have consistently been an important consideration for system patrons. In surveys designed to determine whether improved services would increase the use of a system, patrons have always responded in the affirmative. When employees in one smaller midwestern city were asked how far they would walk to a bus stop without a shelter as opposed to how far they would walk to one with a shelter, on the average sheltered stops attracted people from a half-block farther away.

LOCATION OF TRANSIT SHELTERS

To this time the primary emphasis in the development of analytical tools has been on (a) the definition of transportation networks, (b) the identification of levels of service, (c) the identification of vehicle requirements, and (d) the analysis of transit-system options. There are only limited quantitative tools available (2, 3, 4) for locating and designing transit shelters, which have generally been placed on the streets according to rules of thumb and subjective professional judgment, a practice that has resulted in the use of the following type of criteria (5, 6):

1. One shelter per block in central business district (CBD) or high-density residential areas;
2. One shelter every two or three blocks in medium-density residential areas; and
3. One shelter every six or more blocks in low-density residential areas.

Similar guidelines for the placement of shelters with respect to traffic flows have also been promulgated (7). These include midblock, near-block, and far side of intersection placements.

1. Midblock placements are primarily used at locations where bus routes require left turns at the next corner or where traffic volumes are low.
2. Near-block (near side of intersection) placements are primarily used at signalized intersections to facilitate passenger crosswalk movements. It is also used where on-street parking is not permitted, where there are heavy left-turn movements, and where through traffic is heavy.
3. Far side of intersection placements are primarily used at intersections with heavy right-turn movements or on streets with limited curb lengths due to on-street parking facilities.

SPATIAL REQUIREMENTS FOR TRANSIT SHELTERS

Two types of areas are currently used to determine the total spatial requirements for bus stops (8). These are the bus curb loading zone and the pedestrian-and-patron waiting area. The former is usually given in distance and may vary according to the location and the number of bus loadings required. The pedestrian-and-patron waiting area is that space wherein a shelter would be located and has been narrowly defined as that area occupied by the shelter structure. The most commonly recommended pedestrian shelter varies between 4.5 and 7.6 m^2 (50 and 84 ft^2) (9, 10). Given the weak and piecemeal character of the techniques that are presently used for the planning of bus-stop shelters and the need to improve bus and transit interface facilities, appropriate procedures and guidelines that will encourage new alternatives in the location and design of transit shelters should be developed.

Guidelines that will aid in the location and design of the appropriate shelter(s) that best meets community needs must consider a series of evaluation criteria. These include

1. Users of the facility,
2. Types of transit systems that the shelter will support,
3. Types of pedestrian and vehicular systems that it will reinforce,
4. Design objectives and constraints,
5. Space availability,
6. Incorporation of activities and amenities,
7. Materials,
8. Flexibility,
9. Maintenance,
10. Resistance to vandalism,
11. Accessibility for the mobility-limited,
12. Weather protection, and
13. Aesthetics.

FINANCIAL IMPLICATIONS

The 1976 prices for relatively simple shelter facilities range from approximately \$1000 to \$2400. These shelters are 1.8 and 6.75 m^2 (20 and 75 ft^2) respectively and contain few amenities. A minimal graphics installation costs between \$750 and \$1000. The average cost of installation of these structures is about \$200 and requires 7 to 10 person-h. Shelters with benches and panels for information dissemination or advertisements are double or triple these prices, depending on site conditions and location.

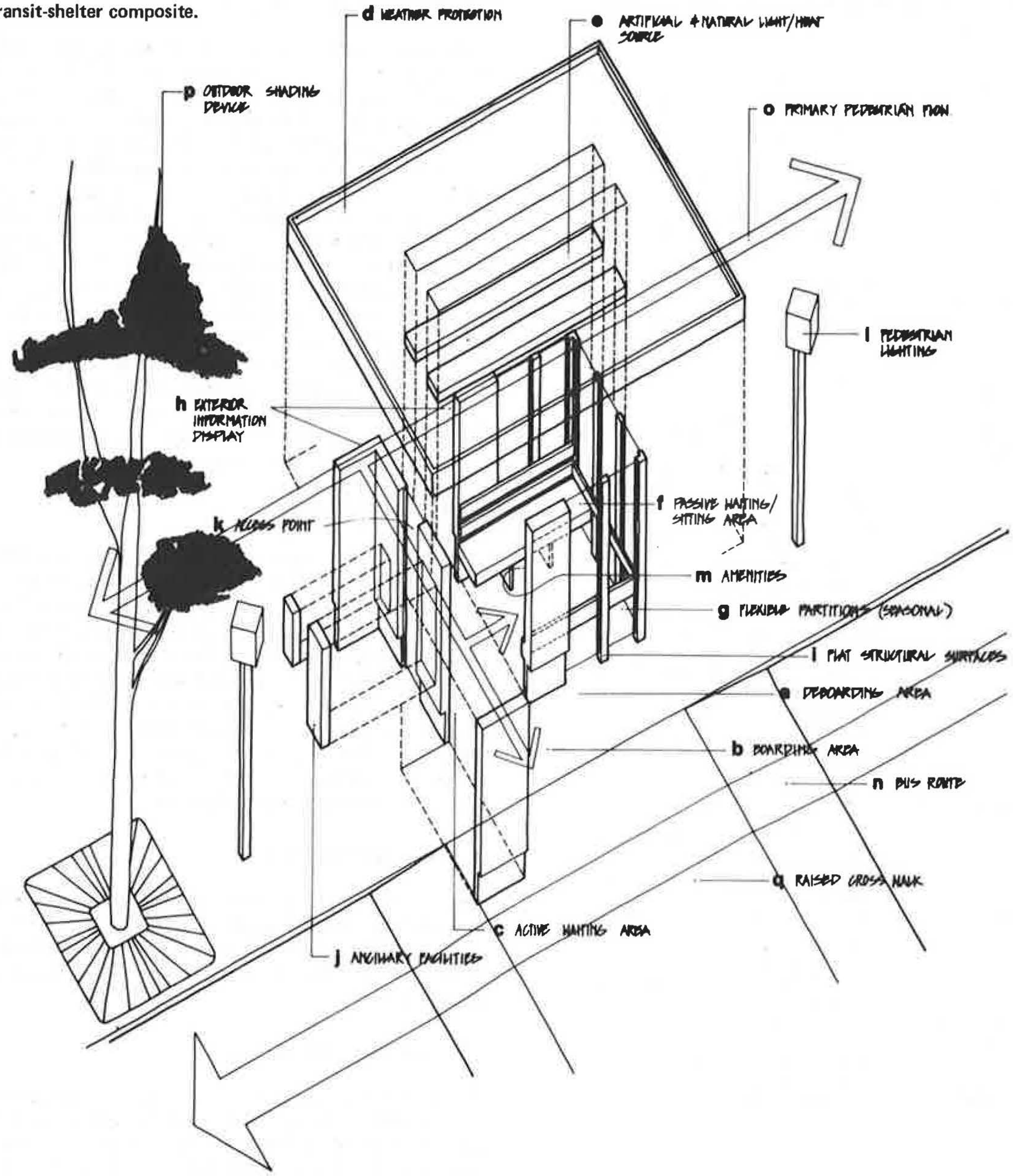
Perhaps the most ambitious shelter project undertaken is in Austin, Texas. There, as part of a bicentennial downtown redevelopment project, two shelters were erected at a cost of \$30 000 each and site preparation costs of \$90 000. Only the best materials were used, the needs of people and transit vehicles were taken into full consideration, and there are many amenities.

Who takes responsibility for shelter placement and programs? In Austin it was a combined public and private effort; in the Chicago region there is a combined federal, state, and local effort; and in New York City the effort is largely a private enterprise. This case is the most interesting. A commercial firm that erects 4.3-m^2 (48-ft^2) lighted shelters with large advertising panels has been established. The revenue from the advertisements is sufficient to pay for the installation of the shelters by the city as well as a fee of five percent of the revenue from the advertising to the city. There are 254 shelters in Manhattan and the Bronx and 600 new ones are planned for 1977. A similar enterprise will soon be under way in the Chicago area.

When public money is used for shelter projects, the usual source has been 80 percent from section 3 of the Urban Mass Transportation Administration and 20 percent from local matching. This approach has been used by the northeastern Illinois Regional Transportation Authority (RTA) to build several hundred shelters: Funds for shelters have come from local community money, directly from the RTA, and from the Illinois Department of Transportation (IDOT). IDOT has also used the shelter concept to provide facilities at railroad stations rather than construct new depots.

Another source of funds for the construction of shel-

Figure 3. Transit-shelter composite.



ters is from commercial property owners. As a joint development effort, both the retailers and commercial interests and the transit operators can be served.

Beyond the capital and construction costs are the maintenance outlays. These can be large in cities and communities with large programs. Vandal-resistant materials are often essential, and lights, heater elements, information inserts, cleaning, and resupplying vending machines will require attention. Annual maintenance costs per shelter vary greatly, reaching $1000 for weekly inspection and service, with labor costs being the largest part of the expense. More detailed maintenance experience will become available as more units are installed in more cities.

PROCESS FOR IMPLEMENTATION

The usual approach to the implementation of a bus-shelter program involves jumping from the recognition of the problem to a hardware solution. The recognition that a process-oriented effort is needed is an improvement on this because a planner is then involved with the complex design problem. This paper proposes a creative effort that consists of a number of phases and activities that overlap and are aimed at identifying, describing, and analyzing the problem prior to the attempt to synthesize the solution.

Figure 1 provides a summary of a creative yet pragmatic approach to the planning and design of transit shelters. Briefly, the following questions must be considered.

1. Environmental attributes: What are the physical surroundings at the specific site?
2. User attributes: Who is most likely to come to the transit system at the specific site? Is it the elderly or the mobility-limited? How many people will there be?
3. Problem definition: What, based on environmental, user, and system attributes, is hoped to be accomplished at the site?
4. Identification of needs and objectives: What types of shelters meet the specific sociogeographic requirements?

Table 1. Identification key for transit-shelter placement and design.

Key	Element	Identification
A	Deboarding area	Area into which people leaving buses walk, preferably when exiting through vehicle rear door; so located that these patrons do not interfere with those boarding the bus or waiting to board that or any other bus
B	Boarding area	Area between shelter and bus itself where people queue for access to vehicle; pavement treatment in areas with sidewalks, paved area in areas without sidewalks to designate path between shelter and vehicle
C	Active waiting area	Area reserved for standing while waiting for bus and incorporating features that facilitate passage of time; includes informational displays, art work, or any other acceptable exhibit
D	Weather protection	Overhead protection from sun and rain; shelter from wind
E	Artificial and natural light and heat source	Roof of shelter designed to permit natural daylight to enter and also provide shade; should hold light fixtures for nighttime illumination and heat lamps for cold weather
F	Passive waiting and sitting area	Area in which people rest while waiting for buses; light enough for reading; comfortable seating; open view to arriving vehicles
G	Flexible partition (seasonal)	Protection in winter; freer air flows in summer
H	Interior and exterior information display	Panel of shelter wall to contain route and system information (maps, telephone number, schedules) for boarding passengers and neighborhood information for arriving passengers; use of both sides of panel minimizes loss of transparency and increases number of people who can refer to the information at any given moment
I	Flat structural surface	Flat surfaces to facilitate maintenance and cleaning
J	Ancillary facilities	Vending machines, telephone, trash receptacles placed on outside of shelter so as to not interfere with transit function
K	Access point	Entry point to shelter; placed to be immediately recognizable to patrons approaching from either major pedestrian flow or buses; essential if transfers are possible or patrons desire to meet others at shelter
L	Pedestrian lighting	Outside light
M	Primary pedestrian flow	Major direction of approach to shelter
N	Curb cut	Ramps cut into curbs at corners
O	Wheelchair clearance	Minimum horizontal clearance of 90 cm

Note: 1 cm = 0.4 in.

5. Social, physical, and technical considerations: Are shelters accessible to all potential users? Do proposed shelters conflict with the immediate surroundings? How does the proposed hardware enhance personal comfort and safety?

6. Definition of activities to achieve objectives: Which activities (waiting, reading, or resting) are compatible with the shelter and the site?

7. Development of alternatives: What is the range of design concepts?

8. Selection of the best alternative: Which alternative best meets the social, physical, technical, legal, and financial concerns of the community?

9. Building solutions and specifications: How shall the shelter program be implemented? What are the architectural guidelines for shelter construction and monitoring?

DESIGN CONSIDERATIONS

The desired attributes of the transit shelters must be translated into design considerations.

Functional Considerations

A transit shelter should not create conflict within its own surroundings by becoming a barrier and obstructing circulation or access. It should support the series of activities that will take place there. It should be a key element in the planning and development of pedestrian and street networks and their immediate land uses. Tailored to the existing natural and man-made features and local climatic conditions, the facility should contribute to the overall appearance of its surroundings and become an integral part of the streetscape. The transit stop should be the portal or entryway to the transit system and should support the functioning of that system through its physical, social, and technological attributes. The shelter and the transit system can help reinforce the community's social, physical, and economic goals. Finally, any shelter must meet vehicle and system operational requirements as to capacity, geometrics, and facilities.

User Considerations

Any transit shelter should be easily accessible to all potential users, regardless of age or mobility restrictions. The internal arrangement of such a facility and its pedestrian-circulation pattern should be easy for the user to understand. The design should accommodate optimal passenger densities and help to increase the patron's safety through proper site location and lighting, elimination of visual and physical barriers and of blind ends, coordination of entry and exit points with external pedestrian and vehicular traffic flows, and appropriate external surveillance.

Social Considerations

The bus stop and the transit shelter should help increase the passenger's perception of system reliability, which will be accomplished if the facility is a dynamic environment in which the user is comfortably active while awaiting the bus.

Physical Considerations

The structural system of any shelter should be flexible in size and arrangement of partitions to facilitate maintenance and allow for potential change in patronage and spatial or climatic conditions. The walls should allow for maximum transparency to facilitate visibility through and from the shelter. This is important for the patron's sense of security, especially if he or she is alone or with one other person. Insulating devices are desirable to decrease noise discomfort, vibration, and the effects of inclement weather. A heat source to provide warmth and eliminate the formation of ice on the floor during the winter is essential in certain geographic areas. At night, there should be a level of artificial lighting adequate to permit reading of personal material and posted information. The inclusion of any ancillary activities (e.g., telephones, advertising, vending machines, and trash receptacles) should, to the extent possible, serve the transit user exclusively and not conflict with the waiting area by inviting nontransit users into the facility.

Signs should be visible, and the information system should be concise and sufficiently flexible to allow changes. Signs should be properly scaled and should direct passenger boarding and alighting activities. The needs of the visually handicapped must be considered.

Flat structural surfaces will allow easier assembly and maintenance, and the avoidance of totally enclosing surfaces will reduce the accumulation of trash and dust in corners. Construction materials should be durable and economical without sacrificing the needs of the user or attractiveness. Figure 3 illustrates a typical prototype shelter. The critical elements of this shelter are identified in Table 1. The mass-produced shelters currently available are not apt to meet the criteria and considerations discussed above, although modifications to them can lead to a successful program.

In addition to the space available for the shelter, the availability of pavement is also important. While there are sidewalks and pavements in the CBD and other high-activity locations, they are sometimes absent in residential neighborhoods. This should not preclude shelter placement in low-density residential areas without paved walkways. The placement of a shelter should encourage its use and not inhibit pedestrian flows. Therefore, the ideal location is at curbside when wide sidewalks are available, set back across narrow sidewalks, and close to curbside (with a pavement added) when there is no sidewalk. In all cases, there should be provisions for people with mobility limitations so that wheelchairs or walking aids are not hampered.

CONCLUSION

The viability of our transit systems is going to depend not so much on their own technology as on those elements of the system that represent them to the community. A key element that symbolizes transit systems in our cities and communities is the transit shelter, the place where the components of transit service interact. The patron meets the operators and equipment, pays fares, gains information about the system, and forms opinions about the level of service. The operator should intend that such a facility be more than simply wind and weather protection. The role of the transit shelter should be carefully identified through a close analysis of the community and its perceived needs, the patrons themselves, and the system as a whole.

The present approaches to the planning and design of transit shelters have been piecemeal at best and limited in scope. This paper suggests a more systematic, yet flexible, approach, and a methodology that will allow better definition and analysis of the problem and encourage more creative thinking toward the planning and design of transit shelters. By examining transit shelters in the context proposed here, they will have the potential to transcend their identity as simple waiting areas. Shelters could function as indoor-to-outdoor rooms for the transit user in which he or she would not only wait but might also socialize, read, rest, listen, or watch in a safe environment; i.e., transit shelters could become social places oriented to the needs of all the system's patrons, including the elderly, the mobility-limited, the young, the commuter, and the choice rider.

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Role of Simulation Models in the Transit-Station Design Process

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This paper summarizes the ways in which a transit-station simulation model could be developed to function as a more integral part of the design process. It examines in detail the interface of the user with the model. Specific problems dealing with network and spatial representation are discussed, and the model output is matched with the information needs of the designer at the appropriate stages in the design process. The paper concludes with a discussion of the cost-effectiveness of station-simulation models.

Over the past several years, the Urban Mass Transportation Administration (UMTA) has been developing an analytical tool to assist transportation planners and engineers in the design of public transportation facilities. Recently, a pilot version of a computer program to evaluate transit-station designs was tested and evaluated (1). The role of simulation models in the design process was examined in detail, and a number of ideas about the expanded range of analysis possible when computer models are used to supplement more conventional techniques of facility design were developed. This paper summarizes