DESIGN OF OUTLYING RAPID TRANSIT STATION AREAS

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Design of modern rapid transit stations in outlying areas is a complex process that has had only limited documentation. The paper attempts to help the designer in organizational and technical aspects of his or her work. Steps in the design procedure are outlined, and data needed for design are listed. The designer's work starts with an analysis of the requirements of the 3 interested parties: passengers, transit system operator, and community. Design principles and standards emphasize priority sequence for different access modes: pedestrians, feeder bus, kiss-and-ride, and park-and-ride. Maximum separation of modes is desirable: Bus stops should be close to the station entrance, preferably in a separate transit area; kiss-and-ride should be next in distance from the station; park-and-ride should be in the farthest areas. Design should be such that the maximum concentration of automobile traffic is on the periphery of the station, for close-in areas have pedestrian concentrations. Safe and convenient pedestrian movement must be provided for throughout the station area. Examples of design elements for each mode are presented. Finally, the paper contains several examples of total designs of different types of stations.

• RAPID transit lines serving low density suburban areas must rely on several access modes: walking, bicycle, bus, kiss-and-ride, and park-and-ride. Automobile access, the latter 2 modes, requires a larger land area and has a higher cost than do the other modes. And, if the design for automobile access is inadequate, it can result in major traffic problems, cause delays to passengers, discourage potential system users, and impose negative impact on the surroundings. Development of proper design for stations of extensive automobile access is therefore very important.

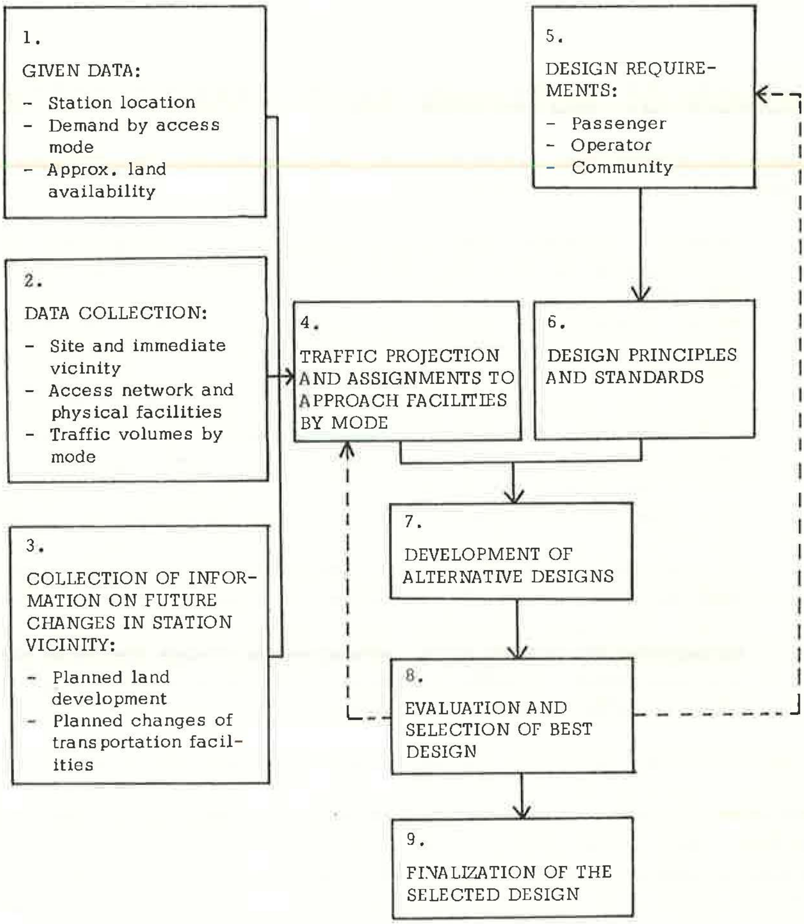
The organization of transit station design consists of the major steps shown in Figure 1. Transit line planners decide on right-of-way alignment and location of stations and determine projected volumes of passengers by access mode. Although planners have to take into account local conditions, highway network land use, and the like, they do not make detailed analyses of the immediate station surroundings. The designer must therefore supplement the basic data with data on existing and planned facilities relevant to station area design from other sources. Then, the designer develops composite projections of traffic on adjacent streets and highways for each mode. The designer must also have a systematic and detailed list of requirements as well as principles and standards for station area design.

After combining the data, principles, and standards, the designer makes several alternative station area designs and then evaluates them based on the degree to which they satisfy the design requirements and principles as well as how they can handle projected volumes. After the evaluation the selected design is finalized.

PURPOSE AND SCOPE

This study has 3 primary purposes: first, to define a methodology of design of outlying rapid transit station areas in a form that can be used in actual planning and design; second, to collect and systematically present basic principles and standards of design; and, third, to present designs of the individual components of stations.

Figure 1. Station design procedure.



DATA COLLECTION

Site and Immediate Vicinity

The designer should have at least some influence on the station area land acquisition and its future shape. Therefore, information on land costs for each lot that may be considered for acquisition must be collected. Data on topography and general condition of the area (such as other rights-of-way, land uses, and trends of expansion) must be obtained also. The designer must also know the total investment available for land and construction.

Access Network and Physical Facilities

All available data on adjacent or influencing transportation networks, land use in the area, and individual facilities should be collected, particularly on

1. Highway and street networks in the vicinity (their basic dimensions, capacities, and traffic regulation on individual streets);
2. Feeder transit services with routings, schedules, and types of vehicles;
3. Pedestrian facilities and volumes; and
4. Facilities for other access modes that may be used by bicycles, organized car pools, minibuses, and the like.

Traffic Volumes

For each access mode, average daily traffic and peak-hour traffic (30-, 15-, or 5-min peak volumes are best, if possible) must be estimated from present volumes, traffic growth in the area, and the projected traffic to be generated by the station. These composite volumes, assigned to individual facilities, must be analyzed for any hours that may be critical. Design hour volumes should then be determined. These are usually based on the highest 30-min volume in a week.

DESIGN REQUIREMENTS AND CONSIDERATIONS

Well-designed stations with coordinated services have been accepted favorably by passengers. Thus, passenger requirements should be given major attention in design. The 2 other concerned parties—operator and community—also have requirements that the designer must carefully provide for.

Passenger Requirements

Passengers approaching the station building have the following basic requirements for station design:

1. Minimum transfer time and distance—short walks between modes and good schedule coordination;
2. Convenience—good information service, adequate circulation patterns and capacity, easy boarding and alighting, and provisions for handicapped people;
3. Comfort—aesthetically pleasing design, weather protection, and small vertical climb; and
4. Safety and security—maximum protection from traffic accidents, safe surfaces, and good visibility and illumination to deter vandalism and prevent crime.

Operator Requirements

Operator's requirements that design must satisfy are

1. Minimum investment cost;
2. Minimum operating cost;
3. Adequate capacity;
4. Flexibility of operation; and
5. Passenger attraction.

Community Requirements

The community is interested in having an attractive and efficient transit system, so the station should be both attractive to passengers and efficient for the operator. This requirement coincides with the requirements listed for the operator and passengers. But the community also is interested in both the immediate and long-range effect of the station on its surroundings. The immediate effects include environmental impact, visual aspects, noise, and possible traffic congestion. Long-range effects include the type of developments in the vicinity that may be stimulated or discouraged by the design of the station. Design must therefore consider the relationship of the station to its immediate surroundings.

DESIGN PRINCIPLES AND STANDARDS

Every rapid transit station must be custom designed. Consequently, prototype designs cannot be produced. However, it is possible to define the basic principles and standards that are valid for overall design and for individual components.

General Principles

The most important principles that are valid for a general approach to design are as follows:

1. Give priority to individual station access modes in this sequence—pedestrians, bicycles, surface transit (feeder buses), taxis, kiss-and-ride modes, park-and-ride modes to pay areas, and park-and-ride modes to free areas.
2. Provide maximum possible separation of modes at all points. (Separation of pedestrians from motor vehicles is the most important one.)
3. Minimize distance between access modes and the station platform.
4. Provide easy orientation and smooth and safe circulation to and within the station area for all modes.
5. Provide adequate capacity for each access mode based on its design volume. Capacity should be uniform but, if there are space constraints, it should be provided to individual modes in the order of their priorities. If capacity for park-and-ride modes is insufficient, greater emphasis should be placed on other modes to divert passengers and reduce demand for parking.

Size of the station site depends mostly on the required capacity for kiss-and-ride and park-and-ride facilities. Parking area requirements depend on the necessary capacity and the design vehicle. A kiss-and-ride area, which requires easier circulation than a park-and-ride area, takes more space per stall, but its operation is less sensitive to capacity constraints.

The shape of the site is often influenced by the street network and land availability. Because the platform and station structure are typically 400 to 700 ft (120 to 210 m) long and 50 to 60 ft (15 to 18 m) wide, parking, circulation, and terminal facilities can be grouped around a long, narrow station island. If other factors are constant, site shape should be such that the weighted average walking distance of all passengers is minimal. This distance depends on the number and location of entrances to the station building, so it is desirable to have many strategically placed entrances.

Allocation of areas to different modes should be based on the priority sequence from principle 1.

Traffic Routing and Access Points

Traffic routing to and from the station must be analyzed for each mode. The basic objectives are

1. To provide direct access for each mode to its terminal area;
2. To minimize conflicts of station-destined traffic with other highway traffic;
3. To provide smooth, continuous flow and minimize traffic conflicts within the station area; and
4. To provide at least 2 choices for access so that drivers can recover from errors or avoid congestion.

The number of access points is determined separately for each mode based on design volume, fluctuations, and geometric and operational constraints of the network and the site. Ideally, buses should have 1 or 2 access points leading to the station terminal area; kiss-and-ride should have its own access points leading to the terminal area; sometimes buses and kiss-and-ride can share access points without major problems.

For park-and-ride, each peak volume must be analyzed separately. The morning peak is typically less pronounced than the afternoon peak; its importance may not be, though, for 2 reasons. First, people are in a greater hurry and more impatient in the morning than in the afternoon. Second, traffic backups that occur take place on adjacent streets in the morning, but are contained within the site in the afternoon. A minimum of 2 access points (4 lanes) is desirable for adequate traffic flow and reliability in emergencies. For larger lots when the capacity requirement governs, 1 pair of lanes per 300 spaces is adequate for stations with high peaks, but this ratio may be as high as 1 pair of lanes per 450 spaces if peaks are less pronounced.

Three major factors should be considered for location of access points. First, access points should not be located directly on major arterials. Access by way of minor streets allows some dispersal of traffic and better control at intersections with arterials. Second, access points should be evenly distributed to different sides of the station. Third, access points and major circulation routes should be located at the periphery of the parking area to minimize vehicle-pedestrian conflicts. Access points for kiss-and-ride and buses should, on the contrary, be closer to the station building.

Access points are usually designed as a T or a 4-legged intersection. Reversible lanes often can be employed because of directional peak flows. Special attention should be given to providing adequate space for both entering traffic in the morning peak period and exiting traffic during the afternoon peak period. Directional design for entrances and exite often reduces weaving on adjacent streets.

Pedestrians, Bicycles, and Provisions for the Handicapped

Walking should be favored over all other access modes. This is achieved by providing a continuous network of pedestrian walkways throughout the station area. The network must connect all adjacent streets, residential areas, stores, and other locations that generate pedestrian trips, as well as the park-and-ride and kiss-and-ride areas. The walkways must be separated from automobile and other mechanized traffic as much as possible. Pedestrian crossings should be carefully designed, well marked, and, if necessary, controlled by signs or signals.

Pedestrian paths should be as direct as possible from origin to destination. The coefficient of directness—the ratio between the actual length of the path and the aerial distance from origin to destination for each passenger—should never exceed 1.4, and, desirably, should be below 1.2. The walkways should have at least 2 lanes, with each lane being a minimum of 27 in. (68 cm) and preferably 30 in. (75 cm) wide. Pedestrian crossings of streets are usually 9 to 12 ft (2.7 to 3.6 m) wide, although very low or very high pedestrian volumes may justify narrower or wider crossings. Crossings that are more than 50 ft (15 m) long (across 4 or more lanes) should have a refuge area on the median for safety.

The main circulation road in the parking area, as shown in Figure 2, should be far from the station building to feed the lot from the outside as pedestrians gravitate toward the station building. This minimizes conflicts between pedestrians and automobiles. At some station entrances, particularly if the station serves a stadium or airport, the concentration of pedestrians can reach volumes that would justify a grade separation (overpass or underpass).

Use of bicycles for access should be encouraged. All stations should have bicycle racks with locks. If the use of bicycles is substantial, special paths, signalized crossings, and markings should be provided. Two-way bicycle paths should be at least 6 ft (1.80 m) wide.

Design must also provide for safe and convenient access for the handicapped. Lowered curbs, mild gradients, and adequate doors would allow access of wheelchairs into the stations, where special facilities such as those in the Bay Area Rapid Transit (BART) system should be provided.

Feeder Transit

Because feeder transit vehicles bring large numbers of people and require little space, their use should be strongly encouraged. Therefore, design should provide for their easy movement with efficient terminal operations and convenient passenger transfer.

Approach Routing—Feeder transit lines in the vicinity should have few turns and little interference with other flows.

Feeder-Line Stops—These should be as close to the station entrance as possible. A separate stop location for each route (except those with low frequencies) should be provided; they can often share common locations to reduce space requirements. Separating the arrival from the departure area at heavily used stations can provide increased capacity and more precise schedule maintenance. The number of stops depends on the number of feeder transit routes, the frequency of service on each route, boarding and alighting times, and the required reserved spaces for bus storage.

Figure 2. Separation of vehicular and pedestrian flows.

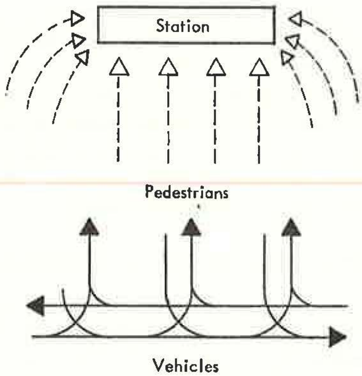
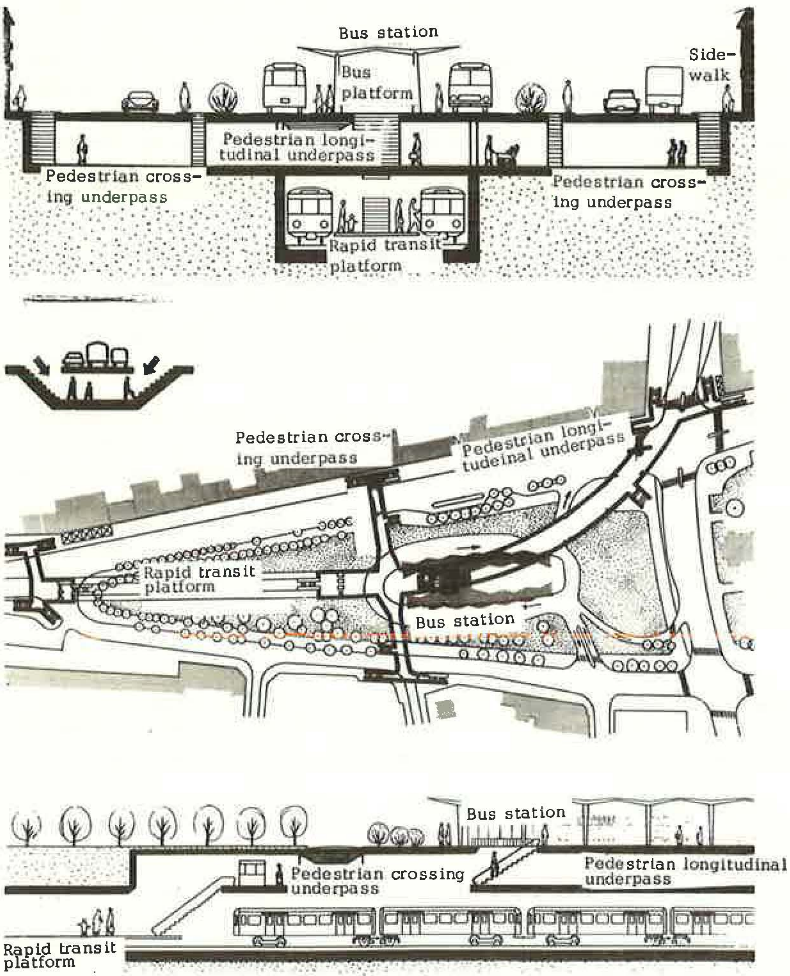


Figure 3. Oval bus island, Hamburg.



Routing in the Station Area—When the station is alongside an arterial and feeder routes pass the station rather than terminate at it, their stopping zone can be either on a wide median or on 1 side of the street, with the 2 directions crisscrossing. This allows pickup and discharge of all passengers from the same area that leads to the escalators toward station platforms. When feeder routes terminate at the station, a loop arrangement is necessary. The entering vehicles cross the path of the existing ones and circle around the island in a clockwise direction. At stations where more than 1 route arrives, this design permits arrivals from more than 1 direction to travel in the same direction as departures in a continuous 1-way flow. The loop roadway can be rectangular or oval, as shown in Figure 3 (3), with at least 2 lanes to allow passing. (An additional lane is often needed for storage of buses.) This design allows alighting on 1 side; buses could then be driven to boarding or to storage areas. The benefits of this are that there is a 1-way flow of passengers on the island and a better use of curb loading capacity. When there are many buses, more than 1 island may be necessary. Bus boarding and alighting areas are doubled, but pedestrians must cross the middle roadway, or special stairways (escalators) must be provided for them from each island. When straight or slightly curved curbs are used, the geometric problem of bus arrival exactly to the curb always exists and much space between standing buses cannot be used. A design, shown in Figure 4, that permits better use of space is the sawtooth pattern. This design also gives the passengers standing in the vicinity a good view of all stop locations.

Kiss-and-Ride and Taxis

Kiss-and-ride has 2 distinctly different functions. In the morning, passengers are dropped off. Because this procedure is very short, all that is needed is sufficiently long curb space close to the station entrance. The pickup function in the afternoon hours is different, though, because the driver usually arrives before the passenger. The average waiting is longer in short headway lines than in long headway lines because approximate times are agreed on for meeting. Kiss-and-ride pickup therefore requires not only a curb zone but also a special short-term parking area that should be easy to drive into and out of because of the high turnover of cars. Ideally, the kiss-and-ride area should be designed as angled parking with through stalls. Some elements of kiss-and-ride area design are shown in Figure 5 (11).

Based on these drop-off and pickup characteristics, the following principles should be observed:

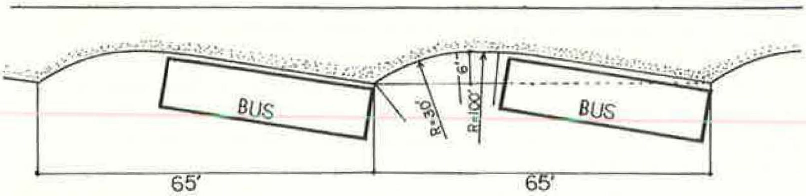
1. There should be 1 kiss-and-ride area easily accessible for automobiles from all directions and by walking from the station building.
2. A drop-off and pickup zone, preferably with loading on the right side, should be sheltered.
3. The kiss-and-ride area should be laid out for 1-way traffic and permit convenient return to the direction of arrival.
4. The kiss-and-ride waiting area should be located close to the pickup zone, have good visibility of the station exit, and permit recirculation.
6. Kiss-and-ride parking stalls should be a minimum of 9 by 18 ft (2.75 by 5.50 m).

Park-and-Ride

Capacity for a park-and-ride facility is difficult to plan with precision. Because of the cost involved in land acquisition and construction of a park-and-ride facility, overdesign should be avoided. Inadequate capacity, though, has often proved to be a bottleneck in the use of transit lines, thus limiting their effectiveness.

Aisles should be perpendicular to the station to facilitate pedestrian walking. If this is not possible, pedestrian walkways can be created across the aisles by well-marked 5-ft (1.5-m) wide paths. Right-angled parking should be used in all park-and-ride areas because it allows simpler circulation and more orderly parking and has lower area requirement per space.

Figure 4. Sawtooth bus loading area.



Note: 1 ft = 0.3048 m.

Figure 5. Kiss-and-ride and short-term parking.

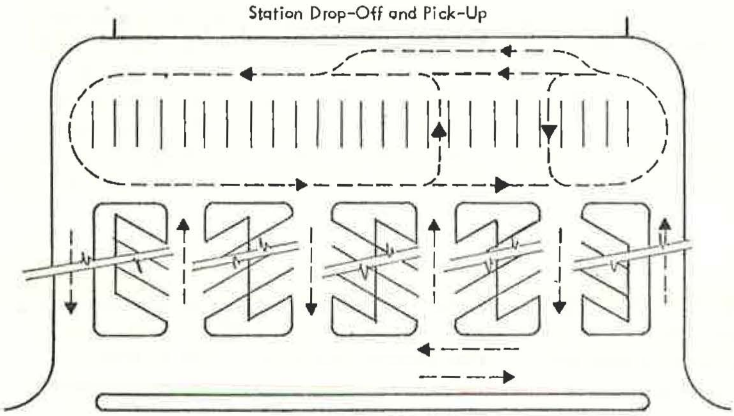


Table 1. Recommended parking dimensions.

Access Mode	Stall Width (ft)		Aisle Width (ft)	
	Generous	Acceptable	Generous	Acceptable
Kiss-and-ride		10		66
Park-and-ride				
Standard car	8.67	8.33	64	62
Compact car[a]	7.5	8	52	48

Note: 1 ft = 0.3048 m.

[a]Cars not more than 16.5 ft (5.14 m) long.

Dimensions of parking aisles and stalls can be smaller than those for shopping centers and other areas because cars arrive in sequence and have low turnover. Table 1 gives the dimensions considered advisable for park-and-ride areas at rapid transit stations.

The average area needed per parking space varies with the shape and size of the facility. To provide adequate circulation 320 to 350 ft^2 (29.8 to 32.5 m^2) per space for standard cars and 200 to 220 ft^2 (18.6 to 20.4 m^2) for compact cars would be required. If there were awkward site geometry or extensive landscaping, a 30 to 50 percent greater area might be required. When 7 stations of the Lindenwold Line in Philadelphia were redesigned to accommodate compact rather than standard cars, parking capacities increased 40 to 60 percent. And, when parking demand is high, as is typical for outer terminal stations, construction of parking garages should be considered.

EXAMPLES OF STATION DESIGNS

The first 2 examples of well-designed stations (Hamburg and Munich) provide for pedestrian and surface transit access only; the following 2 (Toronto and Oakland) have pedestrian, bus, kiss-and-ride, and park-and-ride access; the last example represents an ideal design developed in the course of this research.

Wandsbek Station, Hamburg

Wandsbek Station (Fig. 3), which was opened in 1962, is a major transfer point for rapid transit and 15 suburban bus lines. The transfer area is an island directly above the station platform. Pedestrian access from the surrounding streets is through entrances on opposite sides of the streets. All bus passengers are discharged on or picked up from the island. Escalators connect the island with the rapid transit station below it.

Ostbahnhof, Munich

During extension and modernization of the regional rail system in Munich, completed in 1972, 1 major station at the fringe of the central city was rebuilt to improve transfers from light-rail and bus feeders to the regional rail station. The design, shown in Figure 6 (6), has a major island for light rail stops, several islands for bus stops, and loop arrangements for both modes. A pedestrian underpass connects all islands with the station to provide safety and convenience for passengers.

Finch Station, Toronto

This facility, shown in Figure 7 (7), was opened in 1974. It provides for circular flow of kiss-and-ride vehicles with drive-through parking stalls for waiting vehicles so that the driver who does not find his or her passenger can either park or make another circle.

Fruitvale Station, Oakland

Interesting features of this BART station, shown in Figure 8 (11), include the proper allocation of areas: Buses are separated from other traffic and come directly to the south station entrances; kiss-and-ride areas are also adjacent to the station; outer portions of the site are for park-and-ride. Most of the traffic approaches the station on East 12th Street, from east and west. These traffic flows are directed into the site in 2 nonintersecting back-to-back loops. The 2 kiss-and-ride frontages on the north side use the curb along the station frontage, as well as both sides of the pedestrian island. This island permits direct connection for pedestrians from the station to East 12th Street. This traffic flow pattern provides for a minimum number of conflicting movements at the adjacent intersections.

An Ideal Station

An ideal station design is shown in Figure 9. It was assumed that the station coincided with a 700-ft (214-m) long city block and that the site consisted of an area

Figure 6. Ostbahnhof, Munich.

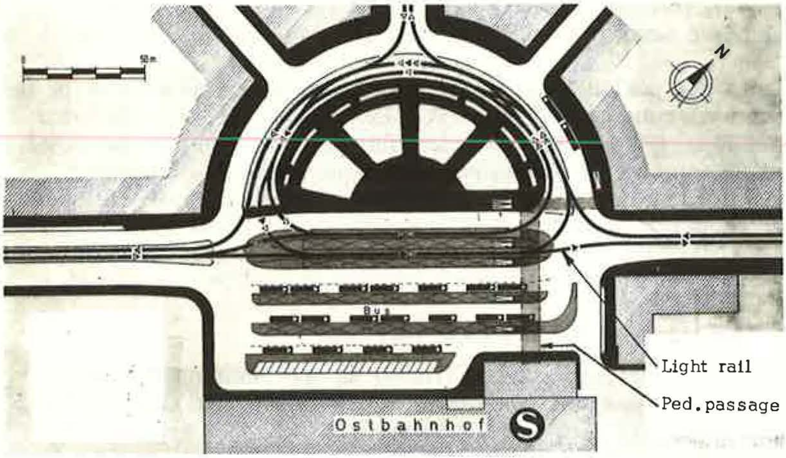


Figure 7. Kiss-and-ride facility at Finch Station, Toronto.

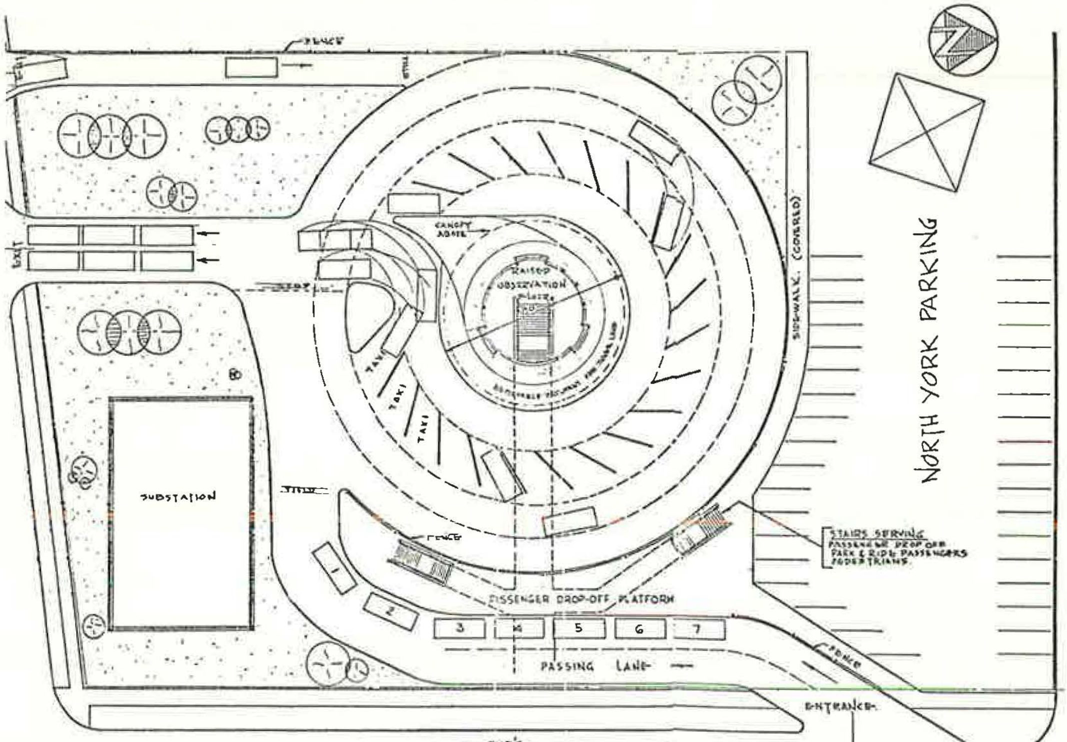


Figure 8. Fruitvale Station, Oakland.

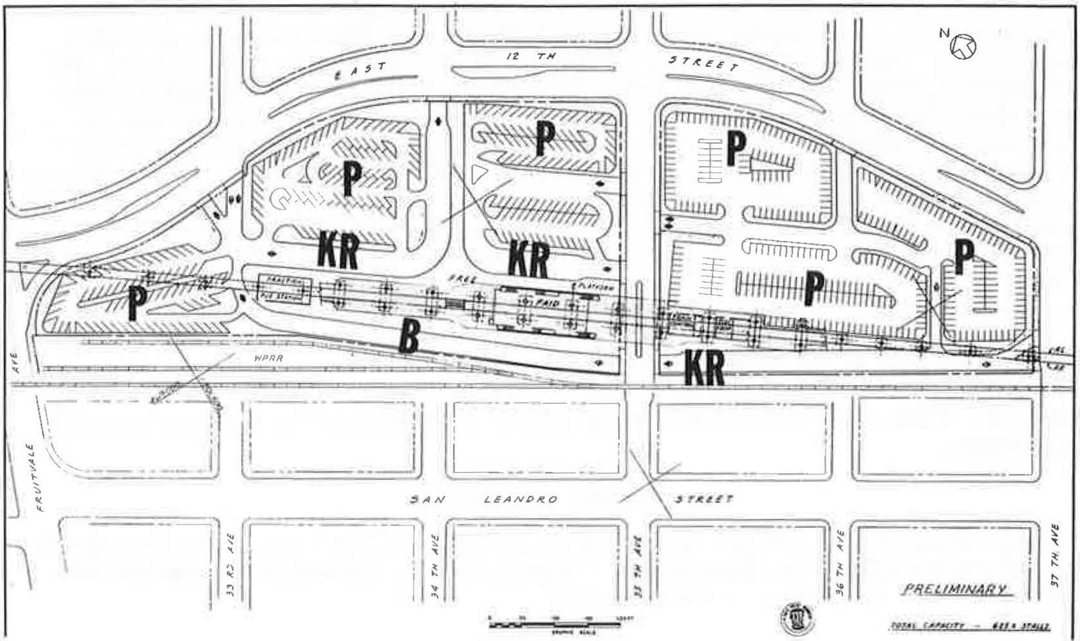
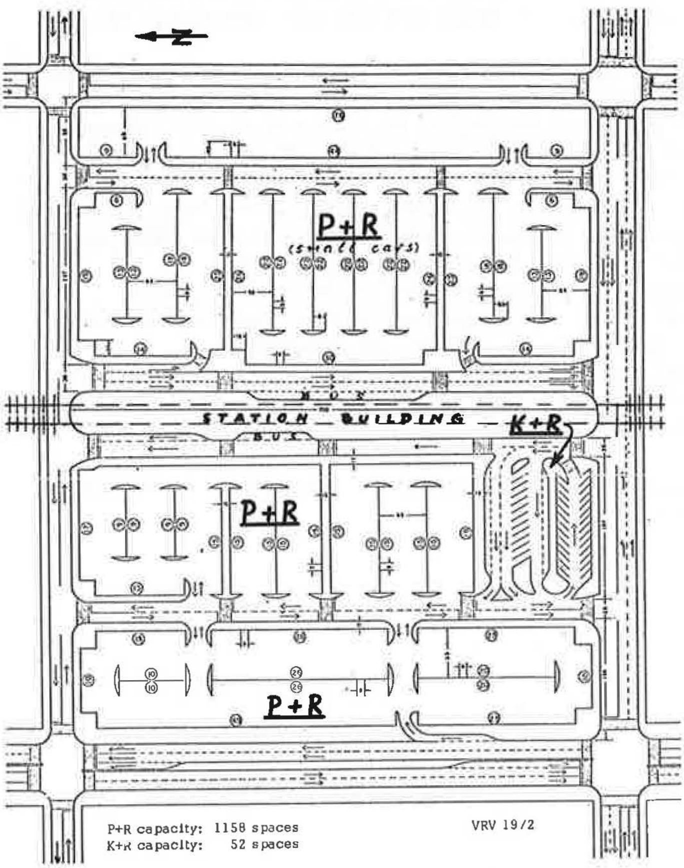


Figure 9. Ideal station.



between the station and a major arterial on its west side with a minor street on its east side. All access points, with the exception of 1 right-turn entrance, are from side streets. Buses have roadways directly along the station with stops close to the entrances; kiss-and-ride vehicles enter together with buses, but then branch off into their specially designed area. The eastern bus roadway is shared on both ends by park-and-ride vehicles. The park-and-ride facility consists of several areas with aisles perpendicular to the station axis for easier pedestrian movement. Several aisle dividers separate the parking area into sections at the inner sides of the parking areas. These dividers prevent cruising of automobiles in search of parking spaces in those areas where pedestrian concentration is high and serve as continuous pedestrian ways through the station area.

This ideal design has very generous parking dimensions, which would apply primarily to areas with low land cost. For locations with higher land cost or high demand for parking, dimensions given in Table 1 are recommended.

Although it is not likely that this design would ever apply in its entirety to a real situation, many of its sections and design details could be used for portions of nearly any station.

ACKNOWLEDGMENTS

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