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TRANSPORTATION RESEARCH FORUM

THIS PAPER is based on a study conducted for the Metropolitan Transportation Authority and the City of New York by Kaiser Engineers, Stanford Research Institute, Alan M. Voorhees and Associates, and The Okamoto Associates.

The background of the Mid-Manhattan peoplemover project is extensive and complex, and it will be sketched only briefly here. The special role of SRI was in the analysis and evaluation of alternative systems. The paper briefly describes the entire Mid-Manhattan project, but the major emphasis is placed on SRI's concerns.

STUDY AREA

The area selected for study is the section of Manhattan Island extending from 42nd Street on the south to 57th Street on the north and from the Hudson River on the west to the East River. (Figure 1) Landmarks in the study area include the United Nations complex, Grand Central Terminal, Rockefeller Center, and Times Square.

Primary attention was assigned to the development of services on or near 48th Street and to major waterfront developments within a few blocks of 48th Street —especially to the United Nations on the East Side and to a planned convention center and a planned passenger ship terminal on the Hudson.

LAND USE CHANGES

The assignment of priorities was related to a general plan by the City of New York to encourage very substantial growth in those areas. That expectation is displayed graphically in Figure 2. The residential space profile across the study area is shown for 1970. The growth anticipated by 1990 is superimposed. Note the huge growth on the West Side. The figure also shows the office space profile for 1970 and growth anticipated by 1990. It is easy to see that the expectations of large growth were extremely important inputs for the transit study.

TRANSIT SERVICE DEFICIENCIES

Mid-Manhattan has long suffered from two serious deficiencies in transit service. One deficiency is not peculiar to the area —the commonly observed lack of transit service for that great class of trips that are too long for walking and too short for bus or train. The other deficiency is the unbalance between the scant east-west service in the 48th Street corridor and the highly developed north-south services intersecting the corridor. To be specific, the 48th Street corridor is crossed at the present time by five north-south subways and one commuter rail line. It will be crossed by a total of eight rail lines when the planned Second Avenue subway and the Long Island Rail Road lines are completed. On the other hand, it is served by a single east-west bus line operating on 49th and 50th Streets.

The 1970 data make it clear that land developers and travelers have accommodated to the unbalanced transit services. High rise buildings are located in the central area for the most part. Travel to areas at ranges beyond walking distances from the main north-south transit routes, especially west of 8th Avenue, is quite low.

These deficiencies have been of concern to city and transit officials for several decades, but in most of that time means for their correction were not available. Buses and trains were simply not well suited to the job. In the late 1960s it began to appear that entirely new families of transit systems could be developed to solve many old problems, including service for multitudes of transient visitors within major activity centers. At about the same time it was recognized that plans for more intense utilization of land along the 48th Street corridor would depend on concurrent plans for improved transit.

In 1969, the peoplemover study for 48th Street was authorized. Work began in 1971 and was substantially completed a year later. The final report was published in January 1973 (see Reference 1).

In 1971, hopes were high that actual design and construction would follow the study without delay. However, in November 1972 those hopes were shattered by failure of a major bond election. Thereafter the peoplemover study was modified in many respects, some of which are described in this paper.

Phase 1 included groundwork tasks, such as identification of goals and constraints, specification of service requirements, location of data sources, identification of potentially usable routes, and assessment of available hardware systems. Nineteen system concepts were established, and in a short time ten were discarded as being unsuitable for a variety of specific reasons. This left nine alternatives to be studied in greater detail. The alternatives had these principal features:

One system used buses on one-way streets—mainly along 48th and 49th.

One system used rubber-tired rapid transit trains on one-way aerial structures also mainly on 48th and 49th streets.

Two used conventional steel-wheel trains entirely in subways.

Five used underground routes east of 8th Avenue and aerial structures on the West Side where it was assumed that transit structures could be incorporated

Peoplemovers For Mid-Manhattan

by

*Clark D. Henderson**

in the design of new buildings. Three of them used rubber-tired trains and differed from one another with respect to specific alignments. One used rubber-tired trains only on the West Side and conventional low-speed pedestrian conveyors otherwise. The fifth of this class used a continuous capacity vehicle system which is described below.

One might reasonably ask "Why didn't the consultants and the client consider a greater variety of technological alternatives?" The answer is simple—when the systems were selected in 1971, actual design was expected to begin a year later and operation was expected to start in 1976. Under that stringent five-year schedule, no other hardware alternatives were realistic. Indeed, there was concern that consideration of the continuous capacity vehicle system was over-optimistic.

The alternatives were described and studied in sufficient detail to allow the consultants to form judgments about the relative standings of each with respect to urban impacts, service characteristics, engineering considerations and capital costs. Numerical ratings were made for many detailed characteristics, and the ratings were combined according to a weighting scheme.

The results of that evaluation did not indicate that any one alternative dominated all others. Furthermore, failure of the bond election had made it clear that funds would not be available for early construction of a costly system, and it was no longer vitally important to narrow the field to one alternative and begin preliminary design. Consequently, the field was narrowed to only three alternatives. A variety of revisions was made and study was continued.

It should be noted that none of the three alternatives finally studied made use of aerial structures except on the West Side as mentioned above. This decision was made by the client and is easily understood in the light of past experience. In New York City many elevated rail lines were constructed during the late 19th and early 20th centuries. Those lines were extremely noisy and aesthetically offensive and most have been torn town, one by one, in a long and costly process. The policy of avoiding aerial structures is not likely to be reversed until advanced designs are proven to be inoffensive.

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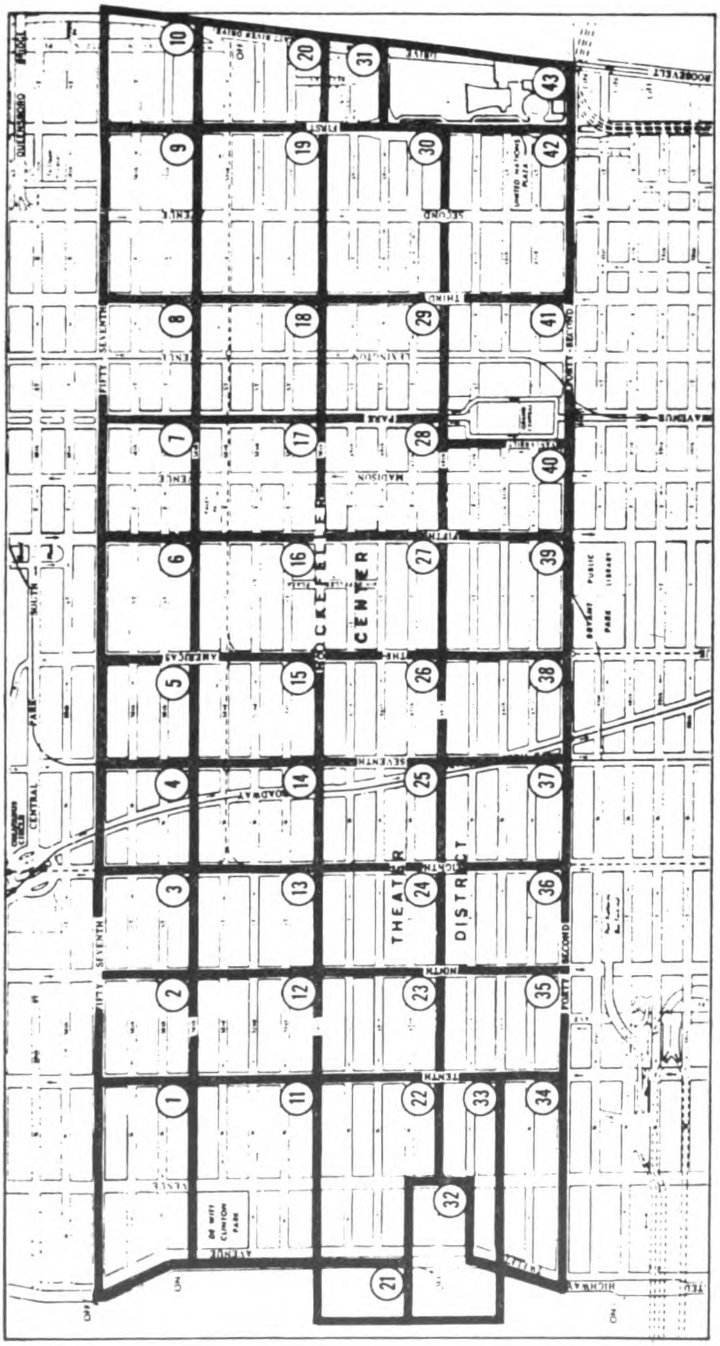
Finally, in Phase I the consultants outlined a need to develop a test and demonstration facility for the continuous capacity vehicle system. At a later stage of study, it was decided that a small fraction of the trackage in the Grand Central Terminal complex would provide a suitable demonstration site.

The three system alternatives and the test and demonstration facility are described at length in the final report (see References). Only a few characteristics of particular interest are outlined in this paper.

Alternative 3E uses rubber-tired trains operating under manual controls. (See Figure 3.) The route closely follows 49th Street between First and Twelfth avenues with extensions southward to the United Nations complex at the east side and to the Convention center on the Hudson. The passenger service route is 11,330 feet long. There are 11 stations, eight underground and three elevated. Parts of the route would have to be as much as 80 feet below grade to pass beneath north-south rail lines. For many trips, travel time between deep station platforms and ground level would be a significant fraction of the whole trip. Maximum speed of the rubber-tired vehicles is 40 mph. Average speed for long trips is 13.7 mph. Trains are made up of six cars for an overall length of 180 feet. Train capacity is 372 passengers, 156 seated and 216 standing. Headways are 60 seconds, and line capacity one-way is 22,320 passengers per hour.

Alternative 4E (Figure 4) uses two conveyor-based systems neither of which currently is in passenger service. The continuous capacity vehicle system would be used from the planned convention center to Third Avenue, a distance of 8,545 feet. The high-speed pedestrian assist system would be used between Third and First avenues, a distance of 1,560 feet. There are 16 stations, four elevated and 12 underground. Only one part of the route, at Park Avenue, is as much as 80 feet below grade.

The vehicles of the continuous capacity system would operate at a maximum speed of 15 mph and would average 6.7 mph on long runs. Vehicles would oper-



SCALE 0 1000 2000 FEET

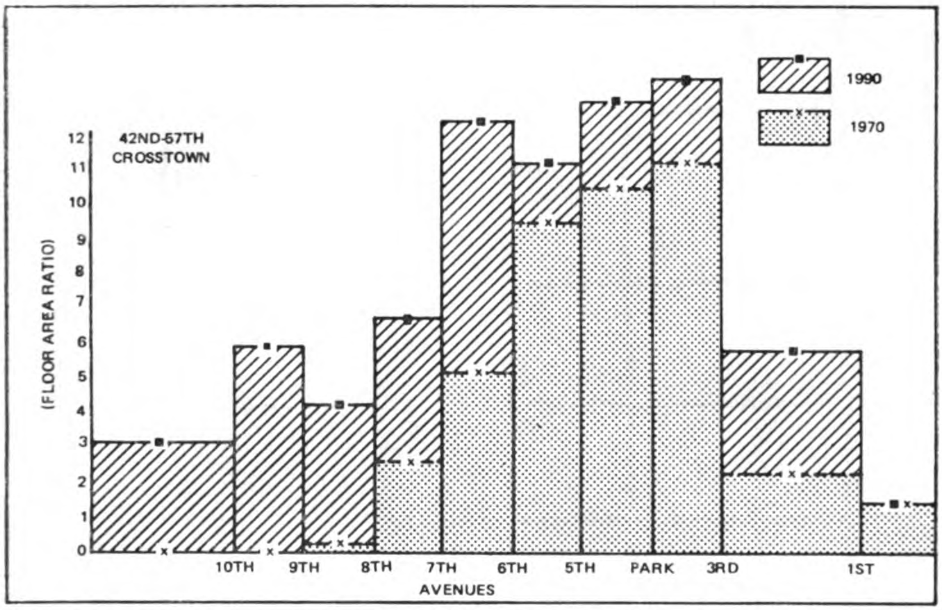
MIDTOWN MANHATTAN
NEW YORK

Zone Boundary

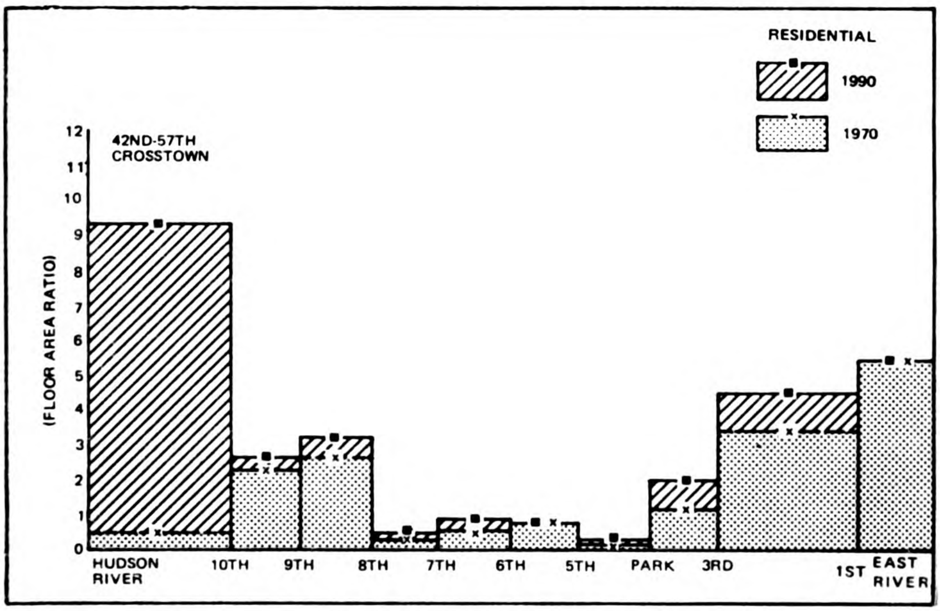
(00) Internal Zone Number

SOURCE: Alan M. Voorhees and Associates.

FIGURE 1 STUDY AREA AND INTERNAL ANALYSIS ZONES



(a) MIDTOWN OFFICE SPACE PROFILE



(b) MIDTOWN RESIDENTIAL SPACE PROFILE

SOURCE: Kaiser Engineers.

FIGURE 2 HISTORICAL AND EXPECTED LAND USES

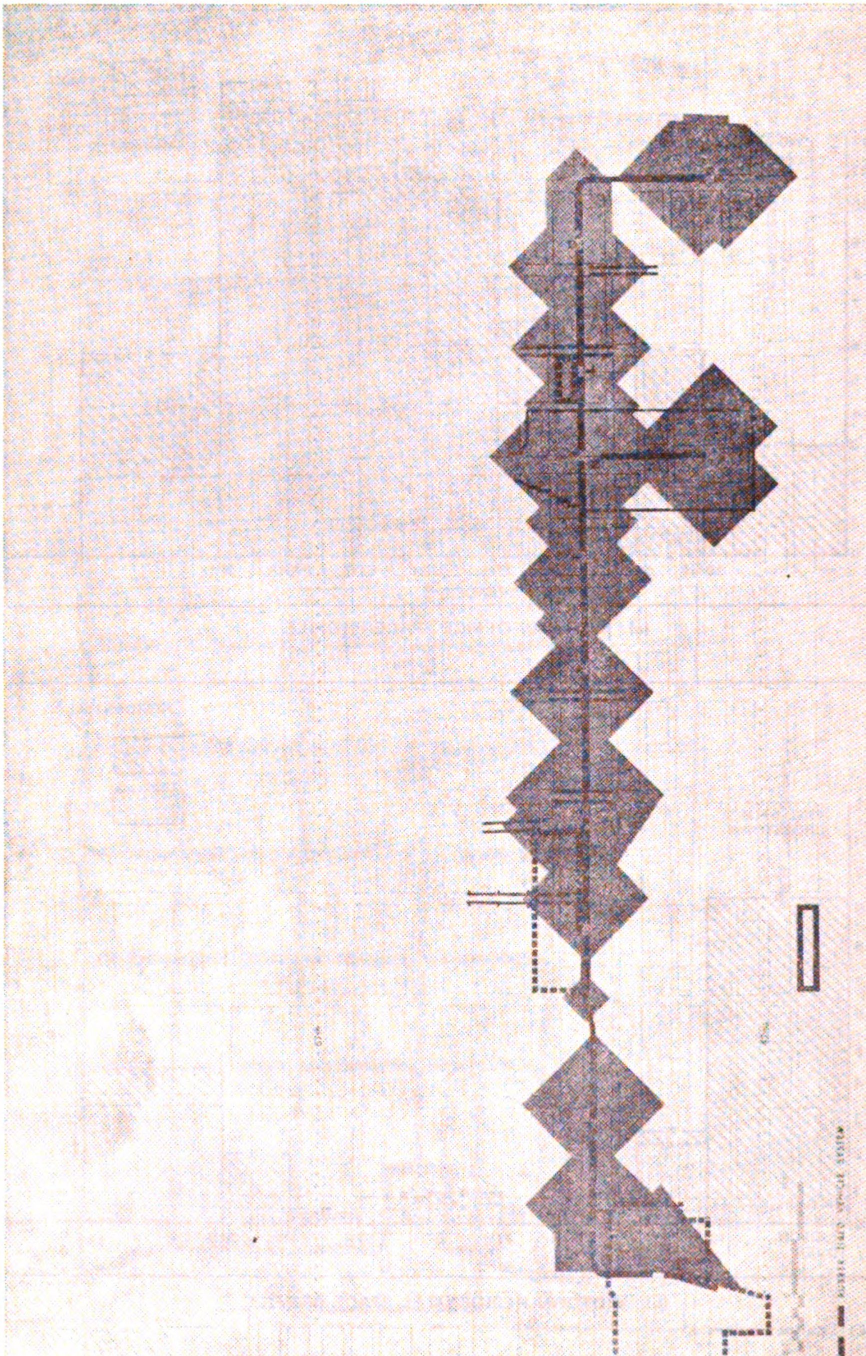


FIGURE 3 LAYOUT AND PLACES SERVED BY ALTERNATIVE 3E

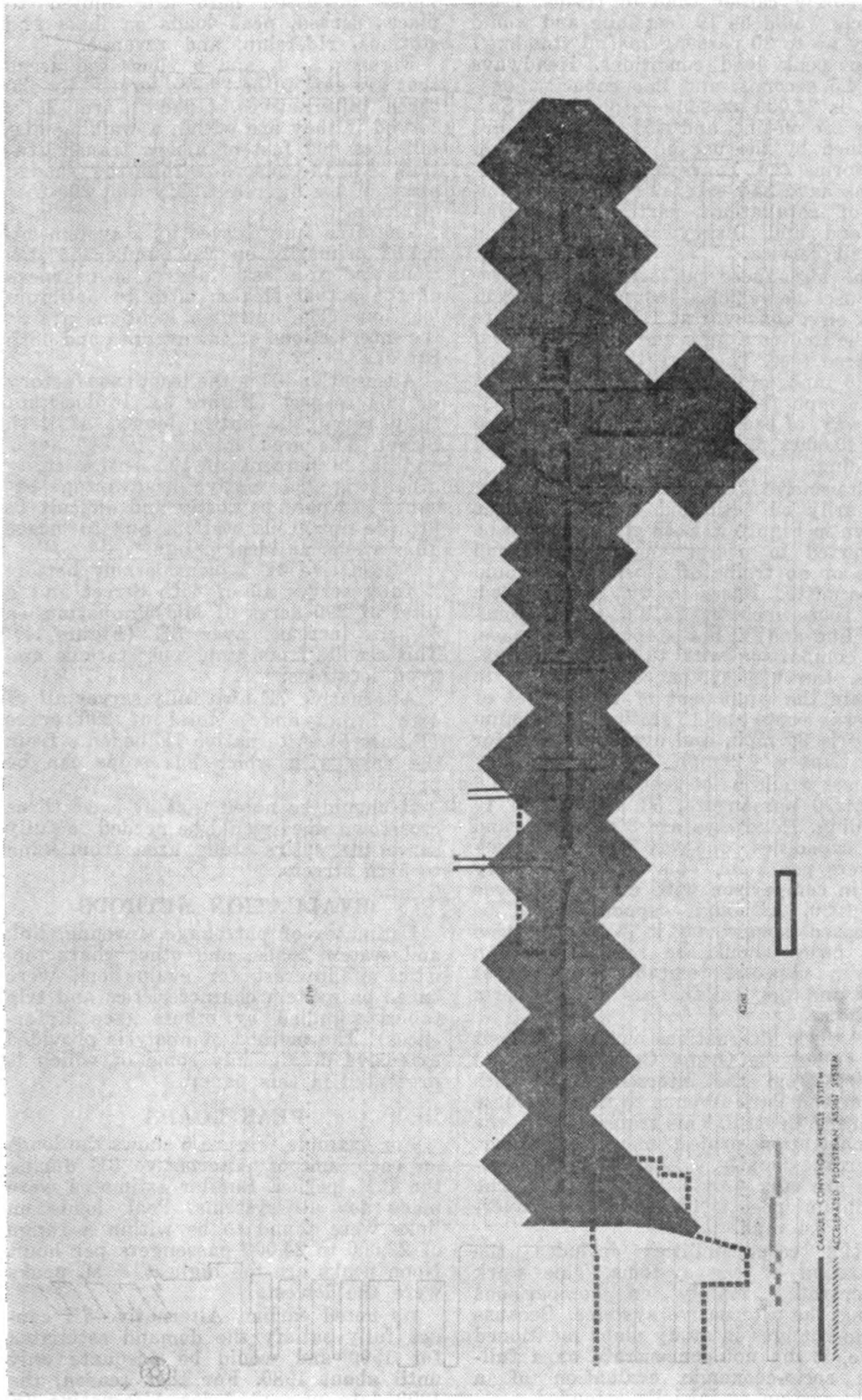


FIGURE 4 LAYOUT AND PLACES SERVED BY ALTERNATIVE 4E

ate singly rather than in trains. Each vehicle would be 10 feet long and would carry up to 30 passengers (all standing) under peak load conditions. Headways are 4.5 seconds, and line capacity, one-way, is 24,000 passengers per hour. Stations are on-line, and close headways are attained by the use of dynamic station platforms (i.e., conveyors). Similar platforms have had extensive use in a number of installations, particularly at Disneyland and Disneyworld, but not in transit service.

The high-speed pedestrian assist system uses no vehicles. Instead, passengers walk on a conveyor at 1.5 mph; they are accelerated to 8 mph and carried several hundred feet. They are then decelerated to 1.5 mph and step off. Average speed is 5.6 mph for long trips. The capacity, one-way, of each conveyor was estimated at 10,000 passengers per hour—all standing.

Alternative 7E uses buses, traveling primarily on 48th and 49th streets, as shown in Figure 5. Both streets would be converted to pedestrian-bus ways, and little or no traffic of other types would be permitted. Buses are driver-controlled. The route includes 24,420 feet of one-way line and 30 bus stops, all at grade. For comparison with the other alternatives, the bus system can be said to contain the equivalent of 12,200 feet of two-way route and 15 stations. Maximum speed is 30 mph, and average speed for long trips is 7.2 mph.

Buses would be 40 feet long and would carry 70 passengers, 53 seated and 17 standing. Headways are 30 seconds, and line capacities, one-way are 8,400 passengers per hour. This capacity is very low in comparison with estimated needs for 1990. Although capacity could be increased somewhat, it was concluded that buses should be regarded as an interim measure, suitable until about 1980 and not suitable as a long term solution.

All three alternatives include a transit link called the Grand Central Terminal Feeder from the intersection of 48th Street and Park Avenue to the concourse of Grand Central. This transit link is the demonstration project mentioned above. The route length is 1,097 feet, and stations are only provided at the ends. The maximum speed is 15 mph and the average is 9.4 mph.

SRI's responsibilities included the evaluation of the systems. This work concentrated mainly on comparisons among the alternative systems. Because of the changes in study plans mentioned above, it did not concentrate on a full-scale socio-economic evaluation of a single system as initially intended.

A number of factors were evaluated. Those discussed here are limited to places served, peak loads on links and stations, ridership, and revenue.

Figures 3, 4, and 5 show the areas that are said to be "fully served" by the three alternatives. Places are fully served if they are within a walking distance of 800 feet of a new transit station. All the places within the shaded areas of the figures satisfy that 800-foot criterion.

The area fully served by a system depends primarily on the number of stations and to a lesser degree on nearness of the actual station sites to optimum locations. The optimum locations are at the intersections of the avenues and 48th Street.

Alternative 3E is the least satisfactory in this respect (Figure 3). It does not fully serve the entire length of 48th Street. The area amounts to 240 acres and is 29 percent of the entire study area. It is at a relative disadvantage because it would be costly and difficult to provide numerous stations and to locate all stations at ideal points.

Alternative 4E is considerably better; it fully serves all of 48th Street and a total of 290 acres of Mid-Manhattan—a 50-acre increase over 3E (Figure 4). This results from numerous stations and good locations.

Alternative 7E also fully serves all of 48th Street and a total of 290 acres (Figure 5). Alternative 7E benefits from the ease with which bus stops can be provided.

It should be noted that at least three crosstown lines would be needed to fully serve the entire study area from 42nd to 57th streets.

EVALUATION METHODS

Estimates of patronage, revenue, link and station loads, and other characteristics of interest for evaluations were based on system characteristics and trip tables supplied by others (see References). The method of analysis provided extensive detail, only some of which is presented in this paper.

PEAK LOADS

For example, Figure 6 shows the loads on each link of Alternative 3E during the P.M. period. Similar estimates were made for all systems. Peak loads on links were found to be within a range of 22,000 to 24,000 passengers per hour. Noon peaks are the highest, A.M. peaks were the lowest.

As noted earlier, Alternative 7E cannot fully satisfy the demand estimated for 1990 and would be adequate only until about 1980. For that reason, the 1990 data presented for Alternative 7E are unrealistic.

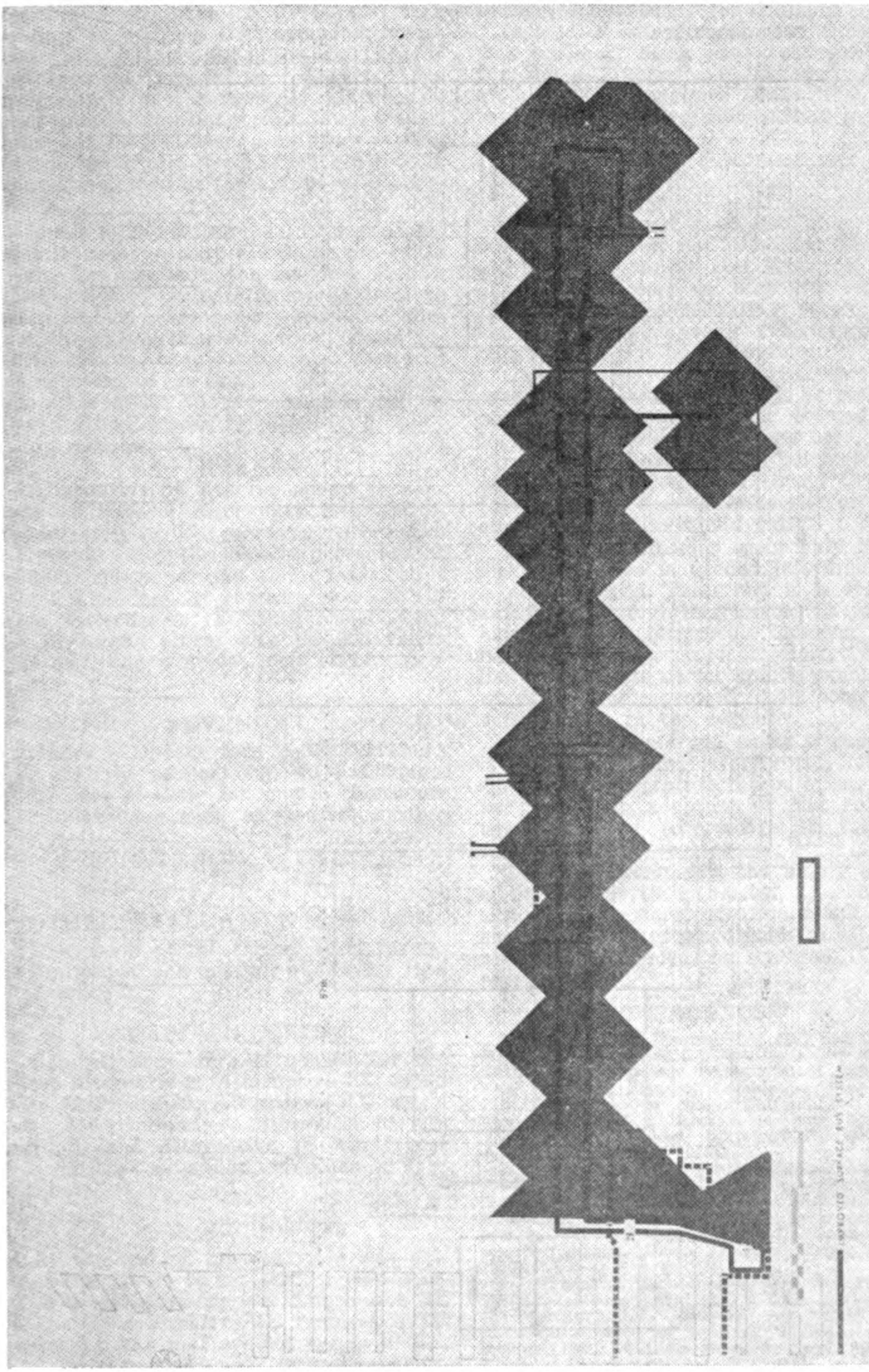


FIGURE 5 LAYOUT AND PLACES SERVED BY ALTERNATIVE 7E

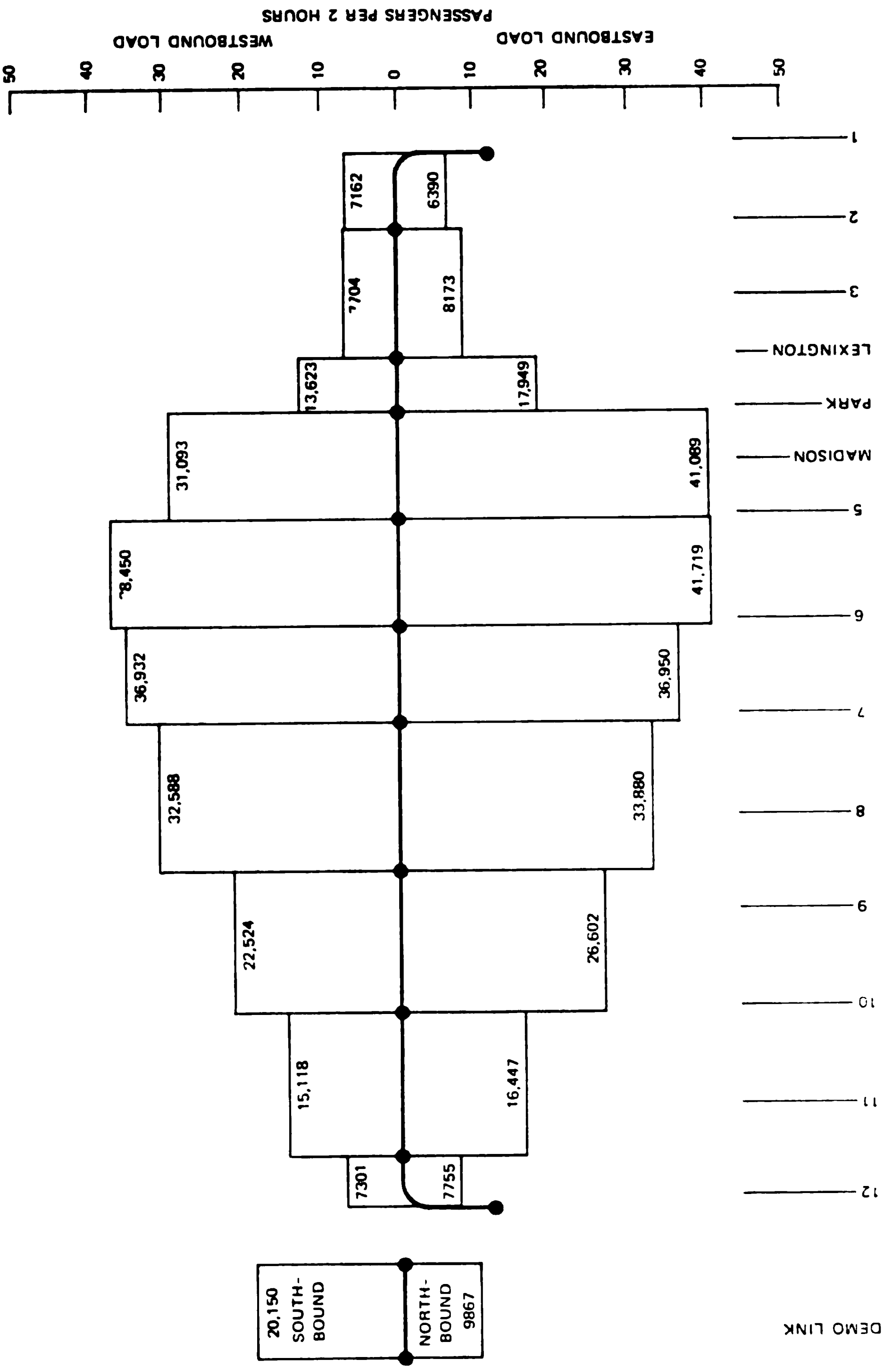


FIGURE 6 SAMPLE LINK LOADINGS FOR ALTERNATIVE 3E (TWO HOURS AT PM PEAK)

Even for Alternatives 3E and 4E, the estimates of loads in 1990 are high enough to suggest that capacity limitations may become serious in the 1990s if development occurs as forecast. This prospect is not necessarily alarming—presumably, additional crosstown transit lines can be constructed on other streets to the north and south of 48th Street if that line should be threatened with overloads.

Loads were also computed for stations, and in many cases peak loads are quite high. For example, the heaviest station load observed for Alternative 3E is more than 31,000 deboarding passengers during the two-hour noon period. These results indicate that considerable care will be required in the final design to provide adequate space in the stations and on the vertical access facilities.

PATRONAGE

Alternative 3E has the lowest patronage at 691,000 riders per day and a modal split of 12.2 percent. Alternative 4E would enjoy the highest patronage at 883,000 riders per day and a modal split of 15.5 percent. If capacity were available, Alternative 7E using buses would be in second place, with 847,000 riders per day, and a modal split of 14.9 percent.

REVENUE

Under a 10-cent fare policy, revenues are strictly proportional to patronage. Estimates of daily revenue in thousands of dollars for each alternative system are:

3E	4E	7E
$69	$88	$85

OTHER EVALUATION RESULTS

Discussion of other evaluation results is omitted in the interest of brevity (see Reference 2).

CAPITAL COSTS

Capital costs were estimated for the three alternatives. Alternative 3E would cost $229 million, Alternative 4E would cost $156 million (a difference of $73 million) and Alternative 7E would cost $43 million (a further difference of $113 million).

CONCLUSIONS

At the end of the study, it was evident that there is one serious disadvantage to each alternative. Alternative 3E is costly, Alternative 4E requires hardware systems that are not yet available, and Alternative 7E lacks capacity. Therefore, the results of the study did not provide a basis for decision.

Instead, a set of contingent outcomes was outlined. Each case assumed that the bus alternative will be adopted for an interim period until about 1980, and that the test and demonstration project will be carried out.

The contingent outcomes recognize these possible differences: Projected growth is uncertain. Therefore, additional service beyond that available from buses may or may not be needed. Financing of a high-capital cost system is also uncertain—it may or may not be arranged. The demonstration results for the continuous capacity vehicle system may or may not be acceptable.

Under these uncertainties, six outcomes are possible. Two will be realized only if additional capacity beyond bus service is not needed. In one case, 48th Street would have both an adequate bus service and a successful Grand Central feeder. In the second case, only an adequate bus service would exist.

Two more outcomes occur only if additional service is needed but financing is not arranged. These outcomes are the same as the first and second as far as hardware is concerned. However, the lack of transportation capacity would limit crosstown travel and, presumably, would prevent growth that otherwise would occur in the corridor.

A fifth outcome will occur if capacity is needed, financing is arranged, but the system demonstration is not acceptable. In that case, adoption of the rubber-tired trains of Alternative 3E is indicated.

The last outcome is the happy one—additional service is needed, financing is arranged, the demonstration results are acceptable, and conveyorized transit systems are provided for service in the early 1980s.

REFERENCES

1. "Peoplemover Systems for Mid and Lower Manhattan," prepared for New York City Transit Authority, Metropolitan Transportation Authority, New York City Planning Commission, New York City Transportation Administration, by Kaiser Engineers, Stanford Research Institute, Alan M. Voorhees & Associates, Inc., and The Okamoto Associates, (January 1973).

2. "Manhattan Passenger Distribution Project: Effectiveness of Midtown Manhattan System Alternatives," by Clark Henderson and John W. Billheimer, prepared for Kaiser Engineers Corporation, SRI Project MSD-1317, Stanford Research Institute, Menlo Park, California (June 1972).

3. "Manhattan Passenger Distribution Project, Technical Memorandum No. 7, Trip Distribution for Mid-Manhattan," prepared for Kaiser Engineers Corporation, by Alan M. Voorhees & Associates, Inc., Westgate Research Park, McLean, Virginia (April 1972).