Times Square Subway Complex Pedestrian Movement Analysis

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ABSTRACT

Reconstruction of the Times Square Station is an integral part of the 42nd Street Development Project. The new development, planned for the sites above and adjacent to the subway station, creates the opportunity for complete reconstruction of the station. An analysis of pedestrian flows within the station was conducted to assist in selecting the design concept. The movement analysis task takes on a special significance because of the size, the number of possible entrance and exit points, and the number of alternative paths available to get from place to place within the station. The complexity of the station area is such that it precludes the use of existing station area models, including the UMTA Transit Station Simulation (USS) program. Highway network and assignment techniques were adapted and the Urban Transportation Planning System (UTPS) was used to simulate pedestrian networks and to project pedestrian volumes on discrete station elements. UTPS has proved to be valuable for analyzing alternatives and for providing pedestrian flow data that are needed to refine the design concepts. Information generated by UTPS helped to evaluate the overall performance of the alternatives with respect to each other and the existing station. It also pinpointed the location of the problem areas within each alternative.

Times Square Station, one of the three largest subway stations in New York City, was built over the three decades between 1900 and 1930 by three different private transit companies. This complex is currently the major interchange of four subway lines: the 7th Avenue Interborough Rapid Transit (IRT), the Broadway Brooklyn-Manhattan Transit (BMT), the Flushing IRT, and the 42nd Street Shuttle. The station contains an upper and lower mezzanine, the lower one stacked between the Flushing and 7th Avenue IRT lines, and is also connected to the 8th Avenue line and the Port Authority Bus Terminal through the 41st Street pedestrian tunnel. The station platforms are connected by a maze of concourses, stairs, ramps, escalators, passageways, and entrances.

Reconstruction of the Times Square Station is an integral part of the 42nd Street Development Project. The new development, planned for the sites above and adjacent to the subway station, creates an unprecedented opportunity for the reconstruction of the station. The design of the modernization is being prepared under the direction of the New York City Public Development Corporation (PDC) in cooperation with the project steering committee.

THE ASSIGNMENT

Development of reliable estimates of pedestrian flow volumes is an important task in the design of facilities for pedestrian use. In most cases, estimates of the number of users during a selected design period, perhaps by direction of movement, are sufficient to permit elements of the facility to be properly sized and designed. However, the movement analysis task for developing a design concept for the Times Square Subway Complex takes on a special significance because of its size, the number of possible entrance and exit points, and the number of alternative paths available to get from place to place within the station.

Table 1 contains a list of all possible access and egress points for the existing station. Between most pairs of points, there is more than one logical or reasonable path. Furthermore, those who want to enter or leave the subway complex have a choice of 20 station access and egress locations. Therefore, estimates of the volume of passengers who will want to use the station in the design period in some future design year provide only part of the information required to design improved pedestrian flow station elements. Reliable estimates of pedestrian flow volumes through each element in the subway complex must be developed if the design is to be functional.

The complexity of the station area precludes the use of existing station area models, including the UMTA Transit Station Simulation (USS) program. Highway network and assignment techniques were adapted and the Urban Transportation Planning System (UTPS) programs (1), including MBUILD, UMATRIX, HR, and UROAD, were used to simulate pedestrian networks and to project pedestrian volumes on discrete station elements. The analysis procedure was validated by comparing the actual pedestrian counts with the counts produced by the simulation procedures. The validated procedures were then applied, and pedestrian volumes were projected for the four different alternatives, including the existing system in the design year. The selected alternative was further evaluated by testing several different design concepts for specific components of the station. This is the first known application of highway assignment techniques to evaluate capacity and levels of service for pedestrian facilities.

ANALYSIS METHODOLOGY

In assessing the information requirements for developing design concepts for the Times Square Subway

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TABLE 1 Access and Egress Locations for the Times Square Subway Complex

Location No.	Description
1	Southwest corner of the 43rd Street and Broadway intersection
2	South side of Broadway midblock between 42nd and 43rd Streets
3	Northeast corner of the 42nd Street and 7th Avenue intersection (exit only)
4	Northwest corner of the 42nd Street and 7th Avenue intersection (two stairways)
5	Southeast corner of the 42nd Street and Broadway intersection
6	Southwest corner of the 42nd Street and 7th Avenue intersection
7	West side of Broadway midblock between 41st and 42nd Streets
8	Northeast corner of the 41st Street and 7th Avenue intersection (two stairways)
9	Northwest corner of the 41st Street and 7th Avenue intersection
10	Southwest corner of the 41st Street and Broadway intersection
11	Southeast corner of the 41st Street and 7th Avenue intersection (exit only)
12	Southwest corner of the 41st Street and 7th Avenue intersection
13	Northeast corner of the 40th Street and Broadway intersection
14	Northwest corner of the 40th Street and Broadway intersection
15	Southeast corner of the 40th Street and Broadway intersection
16	Southwest corner of the 40th Street and Broadway intersection
17	Southeast corner of the 40th Street and 7th Avenue intersection
18	South side of 40th Street just west of 7th Avenue
19	South side of 40th Street midblock between 7th and 8th Avenues (exit only)
20	The 41st Street passageway at the station for the 8th Avenue IND line
21	Track 1 platform for the 42nd Street shuttle
22	Track 2 platform for the 42nd Street shuttle
23	Track 4 platform for the 42nd Street shuttle
24	Uptown platform for the Broadway BMT
25	Downtown platform for the Broadway BMT
26	Uptown platform for the 7th Avenue IRT
27	Downtown platform for the 7th Avenue IRT
28	Flushing IRT platform

Complex, and in evaluating the nature of the problem of developing estimates of the information, the analogy between the prediction of vehicular traffic volumes on individual elements of a highway and street network became obvious. In the highway and street network case, estimates are first derived for the volume of traffic between each origin-destination pair. Paths are then identified between the origins and destinations, and the volumes for each origin-destination pair are assigned to the elements that comprise the paths. The sum of the volumes assigned to an element for each origin-destination pair is the estimate of total volume on that element.

This entire process has been computerized and is available from the Urban Mass Transportation Administration in the form of a battery of computer programs referred to as UTPS. Although application of UTPS to a pedestrian flow network requires adjustments in the methods of describing the characteristics of the elements of the pedestrian network, such adjustments are easily made and readily understandable.

In the UROAD program of the UTPS, highway speed and capacity are determined by facility type (a maximum of six facility types), by area type (a maximum of five area types), and by the number of lanes (a maximum of nine lanes). To adapt the UROAD program, pedestrian facilities within the study area were divided into six different facility types: walkways, platforms, ramps, stairs, escalators, and entry and exit facilities. Each facility type was further categorized by using an area type code and a number of lanes code. For example, Facility Type 1, walkways, was divided into four different area types: walkways within the station, sidewalks, street crossing, and centroid connectors. Area Type 1, Facility Type 1, was further partitioned by the number of lanes representing the width of the walkways. After definitions were developed for the various facility types, area types, and number of lanes, the travel speed and capacity of each link type were determined by using the level-of-service definitions developed by Fruin (2).

Further, travel speeds were represented in the description of station elements as 10 times actual speeds, and distances as 100 times actual distances. As a result, estimates of travel times and speeds produced by the computer process must be divided by 10 to obtain the actual times and speeds. On station elements where two-way flows are permitted, that is, all elements except escalators and exit-only locations, the width of the facility had to be apportioned to the flow by direction. This is not required for highways on which lanes are dedicated to one direction only, but in a pedestrian facility the effective width for a given direction will vary with the directional split throughout the day. In interpreting the assignment results, judgment must be used in determining whether sufficient capacity exists for both directions of flow. Volume estimates for various station elements need no adjustment however.

Although the analogy between the prediction of pedestrian flow volumes on elements of a pedestrian network and the prediction of vehicular flow volumes on a highway network is striking, it is not complete. There are two major differences in the problem to be solved for pedestrian flow facilities that are not adequately addressed by the highway network analysis procedures. The model is unable to predict the impact of channelization of flow versus the mixing bowl effect that occurs in areas where many conflicting movements meet. The model is also incapable of accounting for the effects of orientation and the ease of pathfinding. The travel time estimates are, thus, not sensitive to these pedestrian facility characteristics. The shortcomings of the process, while failing to account for some of the likely differences between alternatives in terms of travel times and travel speeds, will not influence the estimates of pedestrian flow volumes. The predicted flow volumes are the most important product of this analysis because the number of people using the various elements of the facility will be used to size and design these elements.

In the following sections of this paper a brief description is given of the data that were collected and compiled for this study, the procedures for projecting travel demands for the design conditions, and the results of the analyses. The ways that the analysis procedures influenced the development of design concepts are then presented, followed by the conclusions reached as a result of the movement analysis.

DATA COLLECTION AND MODEL VALIDATION

Pedestrian flow volume data were collected over a 2-week period in November 1982. Counts were recorded in 5-min increments from 7:30 a.m. to 9:30 a.m. and from 4:30 p.m. to 6:00 p.m. (3). These counts were then used to identify morning and evening peak-hour flow volumes on each element within the station.

To complete the description of present pedestrian flows in the Times Square Subway Complex, it is necessary to determine the volumes of people that want to transfer between trains and the volumes that want to travel between the trains and the surrounding area. The trip table given in Table 2 was developed from sample data collected during a transit user survey conducted in 1978 (4), expanded to estimate the origin-destination characteristics of all Times Square Station users, and adjusted based on the pe-

TABLE 2 Times Square Subway Complex Modernization Project—Existing Trip Table (1982) Morning Peak Hour (8:00 to 9:00 a.m.)

Destination / Origin	Station Platforms						Zones Surrounding Times Square														Total
	7 IRT NB[a]	7 IRT SB	B BMT NB	B BMT SB	F IRT	SHUT	122	124	PABT 129	130	133	134	139	140	142	154	161	162	163	164	
1 7 IRT NB[a]			346		1,205	1,525	12	115	148	207	91	51	462	184	7	22	24	12	7	7	4,425
2 7 IRT SB			446	1,671	2,723	2,565	21	184	238	338	149	82	754	298	12	36	41	21	13	9	9,601
3 B BMT NB	405				52	959	12	137	381	789	377	21	2,990	592	81	239	89	57	216	159	7,556
4 B BMT SB	302	228			52	135	3	57	153	324	155	6	1,222	241	34	97	38	22	89	64	3,222
5 F IRT	621	1,596	0	17		0	72	184	880	953	602	46	1,491	578	67	292	21	46	283	102	7,851
6 SHUT	771	1,949	116	171	0		0	86	0	835	272	56	1,162	165	0	56	25	63	81	18	5,826
7 122	23	20	3	7	94																147
8 124	23	25	13	37	1,135	114															1,347
9 PABT 129	623	622	166	499	933	57															2,900
10 130			14	44	308	239															605
11 133					94																94
12 134			3	10																	13
13 139			3	10	88																101
14 140	34	37																			71
15 142																					0
16 154																					0
17 161																					0
18 162																					0
19 163					94																94
20 164					50																50
TOTAL	2,802	4,477	1,110	2,466	6,828	5,594	120	763	1,800	3,446	1,646	262	8,081	2,053	201	742	238	221	689	359	43,903

[a]See Table 3 for definitions of origins and destinations.

destrian volume data collected in 1982. Definitions of the zones are given in Table 3 and Figure 1.

The trip table presented in Table 2 is for the morning (8:00 a.m. to 9:00 a.m.) peak period. An analysis of the pedestrian-flow volumes collected in 1983 indicated that there was little difference in the volumes between the morning and evening peaks. This indicated that the morning peak-hour flows adequately represent typical peak-period flow conditions. Thus, the remaining analyses were conducted using the morning peak-hour trip table.

TABLE 3 Description of Zones Used in Trip Tables

Zone No.	Designation	Description
1	7 IRT NB	Northbound platform of the 7th Avenue IRT line
2	7 IRT SB	Southbound platform of the 7th Avenue IRT line
3	B BMT NB	Northbound platform of the Broadway BMT line
4	B BMT SB	Southbound platform of the Broadway BMT line
5	F IRT	Platform of the Flushing IRT line
6	SHUT	Platforms of the 42nd Street shuttle line
7	122	Zone 122[a]
8	124	Zone 124
9	PABT 129	Port Authority Bus Terminal and Zone 129
10	130	Zone 130
11	133	Zone 133
12	134	Zone 134
13	139	Zone 139
14	140	Zone 140
15	142	Zone 142
16	154	Zone 154
17	161	Zone 161
18	162	Zone 162
19	163	Zone 163
20	164	Zone 164

[a]Zones defined for use in conjunction with the Metropolitan Transit Authority's Midtown Underground Pedestrian Connections Study as illustrated on the map shown in Figure 1.

The existing morning peak-hour trip table was assigned to the existing Times Square Subway Complex pedestrian network using the UROAD program. The results of the assignment (i.e., the predicted volume of pedestrians on each element in the network) were compared to the morning peak-hour flow volumes compiled from the 1982 survey. Table 4 contains the results of this comparison.

It should be noted that validation results within 5 percent by facility type are considered to be excellent. Volume predictions on major station components can be expected to be within 15 percent of the counts. For minor elements, large variations sometimes occur, especially where volumes are low and where alternative paths exist. Care must be exercised in the interpretation of the computer results in these areas.

It is very difficult to check the accuracy of the system totals such as the total number of hours of travel and the average travel time per person. The travel times appear reasonable based on limited field observations, but no comprehensive data on travel times are available. Tests conducted for this project indicate that variations of one to two percent frequently occur in these numbers when very minor changes in system elements are made. This leads to the conclusion that the system totals used to compare the alternatives are accurate to 2 percent relative to other alternatives.

In addition to the testing of the computer modeling process, the results of the data collection and analysis were used to evaluate the existing station. Points of congestion were identified and verified by field observations. Correlations between computer predicted trouble spots and observed points of congestion and delay within the station were excellent. Recommendations for improvements were made. The results of this evaluation formed the basis for developing alternative design concepts.

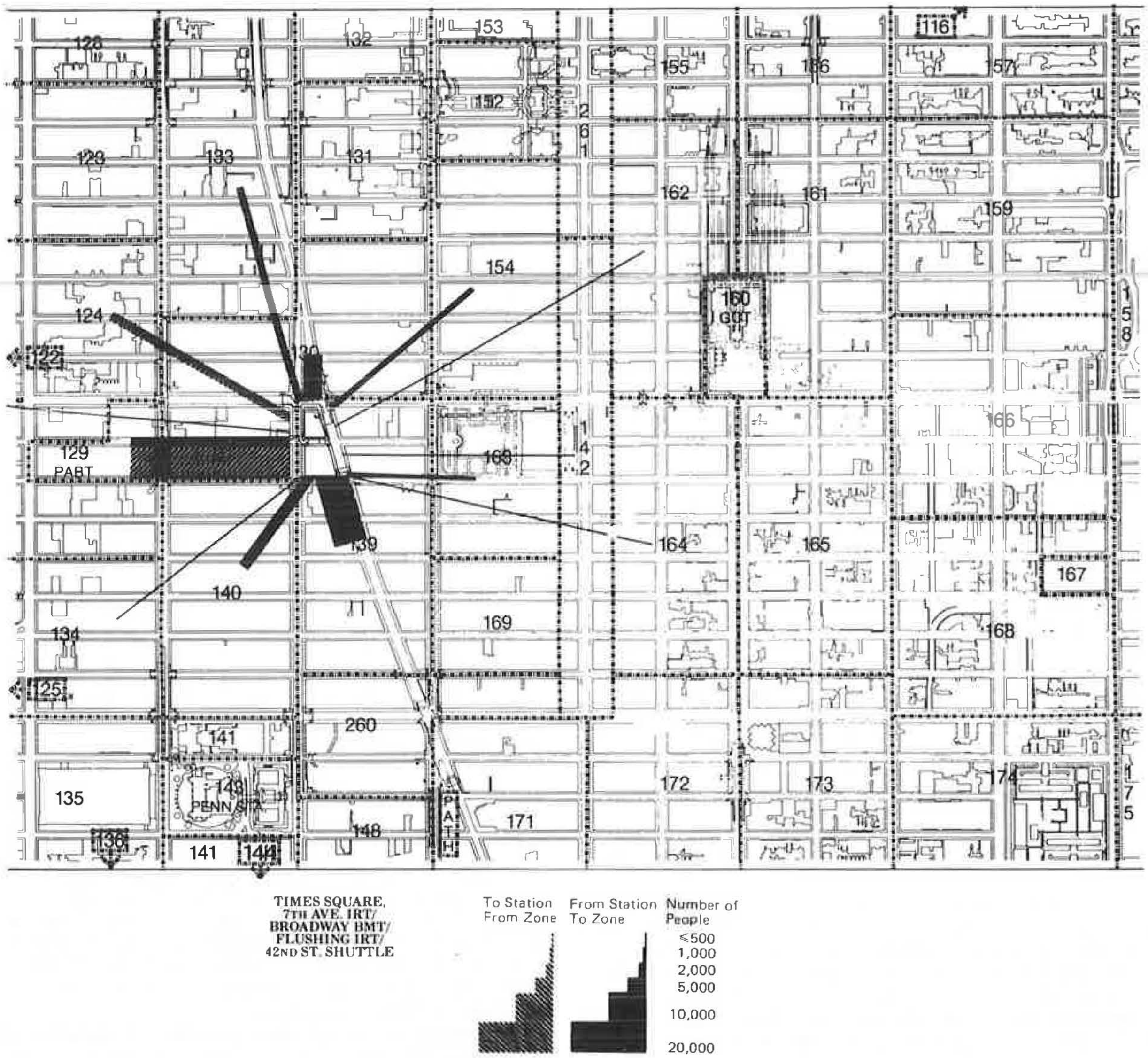

FIGURE 1 Map showing subway station origin and destination zones.

TABLE 4 Predicted Volume Versus Actual Count Summaries by Facility Type—Morning Peak Hour Existing Trips in the Existing Station

Facility Type	Predicted Volumes (P)	Actual Count (A)	P/A
Walkways	431,100	532,200	0.81
Ramps	37,700	37,000	1.02
Stairs	102,400	111,300	0.92
Escalators	4,300	4,200	1.02
Entrances and exits	21,200	20,800	1.02

Note: Total person hours of travel per morning peak hour = 4,219; total number of trips in the peak hour = 43,903 person trips; average travel time per person in the peak hour = 5.8 min.

FUTURE DEMANDS

The proposed improvements to the Times Square Station should be designed to accommodate not only the volumes of pedestrians that currently use the station but also those that are expected to use the station in the future. To predict future passenger use of the station, it was first necessary to identify the conditions for which the station should be designed. Then, the impact of these conditions on trip-making activity could be estimated.

In discussions with representatives of the New York City Department of City Planning, the New York City Transportation Authority, the Metropolitan Transit Authority, and the New York City Public Development Corporation, it was decided to assume the following conditions would exist in the design year:

1. All development currently planned for the Times Square area would be completed, including the 42nd Street Development Project, the Portman Hotel, and the Durst Site Development.
2. Changes in the current configuration of subway stations in the Times square area would result in the extension of the paid zone to include the 8th Avenue and 6th Avenue subway stations at 42nd Street.
3. General growth and increased density of activity in Manhattan would result in a 13 percent increase in subway users.

The trips were partitioned into three categories to account for the impacts of these assumptions:

1. People moving between the surrounding development and the subway station;

2. People transferring between the 8th Avenue line and other lines in the station and those transferring between the 6th Avenue line and other lines in the station; and

3. People transferring among the Shuttle, the Broadway BMT, the 7th Avenue IRT, and the Flushing IRT.

Future pedestrian trips between the subway complex and the surrounding developments were estimated using information developed and acquired as a result of the work on the Midtown Underground Pedestrian Connections study (3). Currently, 26,048 people use the Times Square Subway Complex to go to or to leave from developments surrounding the complex, including the Port Authority Bus Terminal in the morning peak hour. When planned developments are completed, this volume is expected to increase to 33,596, an increase of nearly 30 percent.

Projections of interline transfers between 8th Avenue and the remaining lines had to be based on estimates of what will happen when the 8th Avenue Paid Zone is connected to the Paid Zone for the rest of the complex, a modification that will take place in the near future. The New York City Transit Authority has estimated that 550 people would transfer from the Flushing line to the 8th Avenue line and 400 would transfer from the 7th Avenue line to the 8th Avenue line in the morning peak hour under existing conditions. These volumes were increased by 13 percent to 622 and 452, respectively, to represent future conditions. The number of people who would transfer between the current station complex and the 6th Avenue line was judged to be insignificant, and therefore, no adjustments were necessary in the trip table for this assumed change.

The remaining portion of the trip table (the interline transfers among the shuttle, the 7th Avenue IRT, the Broadway BMT, and the Flushing IRT) was increased by 13 percent to account for the general growth in the subway system utilization. The existing morning peak-period interline transfer volume of 17,855, therefore, increased to 20,194.

The total increase in trip-making activity between present conditions and the design conditions is expected to be 25 percent from about 44,000 currently to about 55,000. The resulting future trip table is contained in Table 5. Descriptions of the zones are contained in Table 3.

During the analysis of the pedestrian volume counts that were compiled in November 1982, it was noted that flows were not steady over the entire peak hour. Surges lasting as long as 15 min frequently occurred during which time the flows were 20 to 30 percent greater than for the remainder of the peak hour. It was also known that the daily volume of passengers is not constant. Transit use tends to increase on days when the weather is inclement and during peak shopping days in December, for example.

A third trip table was prepared for use in tests of alternative station design concepts to estimate the impacts of these surge or unusually high flow volumes on station performance. Each cell in the trip table was multiplied by 1.25 to represent a 25 percent increase in trip-making activity. Twenty-five percent was selected as an appropriate value based on observed variations in pedestrian flow volumes in the station area. Results of testing alternatives with this trip table will also indicate the ability of the alternative design concepts to accommodate unexpected increases in pedestrian flow volumes that might occur in future years.

TESTING ALTERNATIVES

The testing of alternatives involves the assignment of future trips to the networks that represent the

TABLE 5 Times Square Complex Modernization Project—Future Trip Table (Design Conditions) Morning Peak Hour (8:00 to 9:00 a.m.)

Destination / Origin	Station Platforms						Zones Surrounding Times Square														Total
	7 IRT NB[a]	7 IRT SB	8 BMT NB	8 BMT SB	F IRT EB	SHUT	122	124	PABT 129	130	133	134	139	140	142	154	161	162	163	164	
1 7 IRT NB[a]			391		1,363	1,725	12	115	227	623	108	51	522	184	7	22	24	12	7	7	5,400
2 7 IRT SB			504	1,890	3,080	2,901	21	184	818	1,016	178	82	851	298	12	36	41	21	13	9	11,955
3 8 BMT NB	458				59	1,085	12	137	507	1,459	405	21	3,086	592	81	239	89	57	216	159	8,662
4 8 BMT SB	342	258			59	153	3	57	205	598	167	6	1,261	241	34	97	38	22	89	64	3,694
5 F IRT	702	1,805	0	19		0	72	184	1,582	1,374	620	46	1,551	578	67	292	21	46	283	102	9,344
6 SHUT	872	2,204	131	193	0		0	86	28	982	278	56	1,183	165	0	56	25	63	81	18	6,421
7 122	23	20	3	7	94																147
8 124	23	25	13	37	1,135	114															1,347
9 PABT 129	636	635	171	512	962	59				2,302	98		330								5,705
10 130	72	72	38	116	463	251			360												1,372
11 133	27	26	9	27	152	5			134												380
12 134			3	10																	13
13 139	10	10	7	20	109	2			50												208
14 140	34	37																			71
15 142																					0
16 154																					0
17 161																					0
18 162																					0
19 163					94																94
20 164					50																50
TOTAL	3,199	5,092	1,270	2,831	7,620	6,295	120	763	3,911	8,354	1,854	262	8,784	2,058	201	742	238	221	689	359	54,863

[a]See Table 3 for definitions of origins and destinations.

alternatives being considered. In this study, the existing system and the design guidelines (5) alternative were tested first. Scheme Nos. 1 and 2 were then developed to mitigate the problems identified as a result of the first tests.

Much of the effort involved in the development of alternatives focused on the creation of a station complex that reflects the importance and significances of Times Square. Specific attention was paid to the elimination of narrow, dark passageways, opening the station up to light and air from street level, and the creation of underground connections among the new buildings of Times Square. However, care was exercised to ensure that congestion and delays were avoided by the number and the size of the facilities serving each major movement.

The analysis of the tests on the existing system and the design guidelines began by identifying those station elements or links that had volume-to-capacity ratios of 1.00 or more. A further check was made of the volume in the other direction. The two-way volume-to-capacity ratio was then computed. If the two-way volume was found to exceed the capacity of that station element, it was identified as a problem area. This process was necessary because of the method used to assign or proportion the widths of the various station elements to directions of flow. Design options were then developed to improve passenger flow conditions at the problem area. Solutions included widening stair cases, entranceways and ramps, adding escalators and stairways, and realignment of certain facilities to improve pedestrian flows.

The summary results of the tests are given in Table 6. The total travel time in hours is the summation of the travel time spent by each pedestrian moving through the station in the morning peak hour. It does not include time spent waiting for a train. The average travel time per person in minutes is the average time spent by pedestrians moving through the station, again excluding waiting time on the platforms. In both of these categories, lower numbers imply more efficient operation of the station.

The other three categories of system performance measures deal with the number of station elements or links that fall within different level-of-service [illegible] originally developed to describe vehicular traffic conditions on highways. Fruin (2) later applied similar concepts to the flow of pedestrians. As volumes increase, freedom to maneuver and to select a desired travel speed decrease until capacity is reached. When capacity is reached, travel speeds are low, and small disruptions can cause flow to cease altogether for short periods of time. Level of service A represents the least congested conditions. Level of service C is generally considered as the appropriate design criterion. Level of service D is considered acceptable, although not desirable. Level of service E represents conditions at or near capacity, that is, when the station element or network link is carrying as much volume as it can possibly handle. Level of service F represents the conditions that occur when speeds decrease, densities increase, and flow volumes decrease because congestion is so severe.

Specific definitions of levels of service A through F are provided for walkways, stairways, and queuing areas. These definitions basically follow and correspond to the general description of levels of service for highways presented earlier. Thus, the analogy between the prediction of highway and street network flow conditions and the prediction of pedestrian network flow conditions extends to this part of the analysis. From the description of the level-of-service concept, it is evident that the better the level of service, the better an individual station element or network link performs. Also, the fewer the number of links operating at or below a selected level of service, the better the overall performance of the alternative.

The summary results given in Table 6 indicate that Scheme No. 1 performs better than the other alternatives. The measures of total and average travel times show that Scheme Nos. 1 and 2 perform substantially better than either the existing system or the design guidelines. There is very little difference between Scheme Nos. 1 and 2 based on the total time spent by pedestrians traveling in the system or the average travel time per pedestrian. Scheme No. 1 does, however, perform slightly better than Scheme No. 2 in terms of the numbers of links that operate at or below the various selected levels of service. Scheme No. 1 performs better in this regard than any other alternative except that Scheme No. 1 has two more links than Scheme No. 2 for the number of links at level of service C or below for the future trip table.

CONCLUSIONS

[illegible] Scheme No. 1 was found to be better than any other alternative based on the travel time spent by pedestrians moving from place to place within the station complex and on the number of congested links. Changes introduced as a result of the analysis of flows in the existing station and those projected for the design guidelines improved the overall performance of Scheme Nos. 1 and 2, with Scheme No. 1 performing somewhat better than Scheme No. 2. The results of

TABLE 6 Summary of Computer Simulation Results

System Performance Measures	AM Peak Hour Trip Table	Existing Station	Design Guidelines	Scheme No. 1	Scheme No. 2
Total travel time in hours	Existing	4,219	NA	NA	NA
	Future	5,390	5,305	5,134	5,048
	Surge	7,178	6,909	6,462	6,506
Average travel time per person in minutes	Existing	5.77	NA	NA	NA
	Future	5.89	5.80	5.61	5.52
	Surge	6.28	6.04	5.65	5.69
Number of links at level of service "C" or below	Existing	96	NA	NA	NA
	Future	124	106	69	67
	Surge	180	148	99	105
Number of links at level of service "D" or below	Existing	44	NA	NA	NA
	Future	64	72	30	34
	Surge	96	92	50	62
Number of links at level of service "E" or below	Existing	24	NA	NA	NA
	Future	25	45	14	18
	Surge	55	56	30	34

Note: NA = not applicable.

tests conducted to determine the impact of unusually high flows that are expected to occur during bad weather or on days of peak activity also illustrate that Scheme No. 1 is better able to handle the additional traffic. These results support the selection of Scheme No. 1 as the preferred scheme. The results of the movement analysis of Scheme No. 1, particularly the flow volumes, were used to refine elements of the selected scheme. Further tests were conducted to demonstrate the effects of suggested design changes.

The use of the UTPS computer programs for predicting pedestrian flow volumes has proved to be valuable for analyzing alternatives and for providing pedestrian flow data that are needed to refine the preferred design concept, Scheme No. 1. Information generated by the UROAD program helped to evaluate the overall performance of the alternatives with respect to each other and the existing station. It also pinpointed the location of problems within each alternative.

ACKNOWLEDGMENTS

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