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LOS ANGELES DOWNTOWN PEOPLE MOVER (DPM) OPERATIONAL ANALYSIS

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FINAL REPORT

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16. Abstract

Two different studies have been performed by TSC in response to UMTA concerns about the ability of the planned Los Angeles DPM to handle the projected passenger demand for the year 2000. The first study addressed the question of whether the approximately 100,000 passengers per day in the year 2000 can be handled if the system headway is reduced to 60 seconds. The second study examined the more general issue of what train capacities are required at different headways to handle the demand with alternative passenger waiting time goals.

The first study showed that the demand level projected for the year 2000 can be handled not only with 60-second headways but also with 75-second headways using the nominal 164-passenger capacity train. The demand can even be satisfied with 90-second headways if 200-passenger (crush-loaded) capacity trains are employed.

The second study produced curves showing minimum train capacities required at headways ranging from 45 to 105 seconds to meet the requirement that 95 percent of the passengers at the worst-case station have waiting times of less than two or three minutes. The train capacities increased monotonically from eighty or so up to the 240 range.

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16. Abstract

Two different studies were performed by the Research and Special Programs Administration of the Transportation Systems Center in response to the concerns of the Urban Mass Transportation Administration about the ability of the planned Los Angeles Downtown People Mover (DPM) to handle the projected passenger demand for the year 2000. The first study addressed the question of whether the approximately 100,000 passengers per day in the year 2000 can be handled if the system headway is reduced to 60 seconds. The second study examined the more general issue of what train capacities are required at different headways to handle the demand with alternative passenger waiting time goals. This paper addresses these two areas separately, even though the second one arose from the first study. The approach used to analyze each issue is given, along with the underlying assumptions that were made. The results are then presented and conclusions drawn.

The first study showed that the demand level projected for the year 2000 can be handled not only with 60-second headways, but also with 75-second headways using the nominal 164-passenger capacity train. The demand can be satisfied with 90-second headways if 200-passenger (crush-loaded) capacity trains are employed. The second study produced curves showing minimum train capacities required at headways ranging from 45 to 105 seconds to meet the requirement that 95 percent of the passengers at the worst-case station have waiting times of less than two or three minutes. The train capacities increased monotonically from eighty or so up to the 240 range.

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PREFACE

This study was performed in support of the UMTA Office of AGT Applications as part of their effort on the Downtown People Mover (DPM) Program. The Transportation Systems Center has developed computer representations for the proposed deployments in each of the DPM cities to use in conjunction with the System Operations Studies models. In this context, the present study provided an independent assessment of the capability of the proposed Los Angeles system to handle the projected passenger demand for the year 2000. The authors wish to thank George Scheck of Systems Development Corporation for his invaluable assistance, and extend their thanks to S. Barsony, V. De Marco, and J. Marino of UMTA, and G. Hicks and F. Needels of the Los Angeles Community Redevelopment Agency for their assistance.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

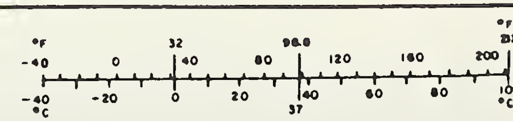

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1. INTRODUCTION

Two different studies have been performed by the Transportation Systems Center (TSC) in response to UMTA concerns about the ability of the planned Los Angeles Downtown People Mover (DPM) to handle the projected passenger demand for the year 2000. The first study addressed the question of whether the approximately 100,000 passengers per day in the year 2000 can be handled if the system headway is reduced to 60 seconds. The second study examined the issue of what train capacities are required at different headways to handle the demand with alternative passenger waiting time goals.

This paper addresses these two areas separately, even though the second one arose from the first study. The approach used to analyze each issue is given, along with the underlying assumptions that were made. The results are then presented and conclusions drawn.

2. BASELINE STUDY FOR YEAR 2000 DEMAND

The first study performed was concerned with ascertaining whether the projected passenger demand for the year 2000 could be accommodated with the basic system design. The prime question was whether operating at a 60-second headway would be adequate.

2.1 APPROACH

The DPM simulation model, developed under the System Operations Studies program, was used at TSC with the current Los Angeles data base to analyze the operations for the year 2000. The passenger demand matrices for 1990, as provided by Los Angeles, were simply multiplied by a factor of 1.38 (reflecting the increase from 72,400 to 100,000 passengers per day) to develop demand matrices for the year 2000 (see Figure 1 and Table 1). The time period studied was from 3:30 PM to 6:30 PM, which includes the 20-minute peak demand. The simulation was started 20 minutes before data collection began to initialize the system. Headways of 60,75, 90, 105, and 120 seconds were considered.

In the analyses, not only were system-level waiting time measures computed, but also values at the individual stations. It is important not to allow overall system performance to mask difficulties at any particular station.

In addition to computing both average and maximum passenger waiting times, it was also important to calculate the 95th percentile passenger waiting times to avoid any possible aberrations in the tails of the waiting time distributions. This value reflects the waiting time which is not exceeded by 95 percent of the passengers.

2.2 ASSUMPTIONS

The Los Angeles DPM network used is given in Figure 2.

The train capacity was 164 for normal operations, with a crush capacity of 200 used in some of the analyses. Both fixed

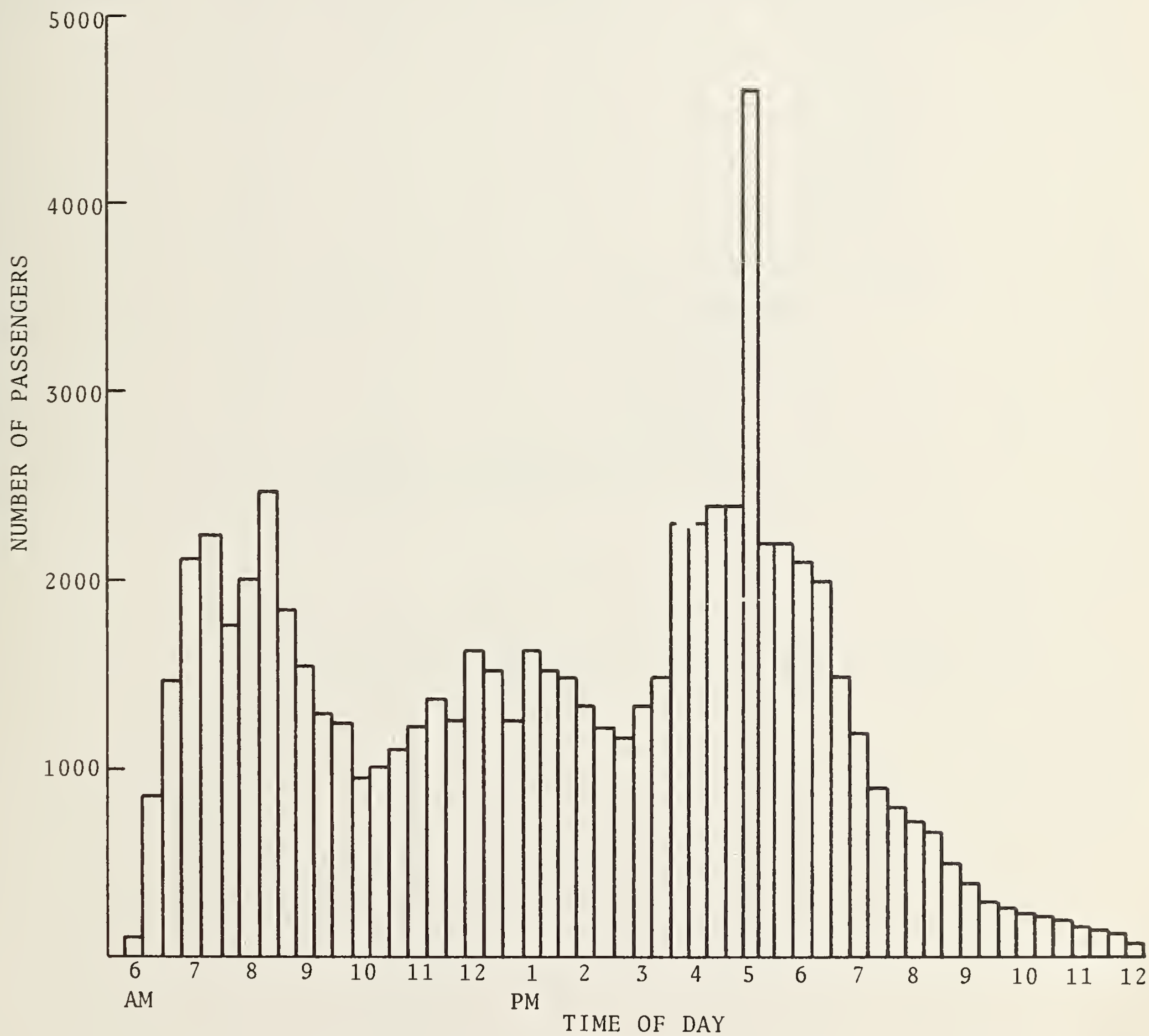

FIGURE 1. LOS ANGELES DPM DEMAND PROFILE - 1990

TABLE 1. DPM DEMAND PROFILE - P.M. PEAK PERIOD, 1990

Interval	Time	Demand	Scaling Factors: Demand ÷ 4600	Scaling Factors: Demand ÷ 9200	Interval
1	3:30 - 3:50	2,300	.500	.250	2
2	3:50 - 4:10	2,300	.500	.250	3
3	4:10 4:30	2,400	.522	.261	4
4	4:30 - 4:50	2,400	.522	.261	5
5	4:50 - 5:10	4,600	1.000	.500	6
6	5:10 - 5:30	2,200	.478	.239	7
7	5:30 - 5:50	2,200	.478	.239	8
8	5:50 - 6:10	2,100	.457	.228	9
9	6:10 - 6:30	2,000	.435	.217	10

Peak hour (4:30 - 5:30) = 9,200 trips

Peak 20 minutes (4:50 - 5:10) = 4,600 trips
(rate of 13,800 per hour (max))

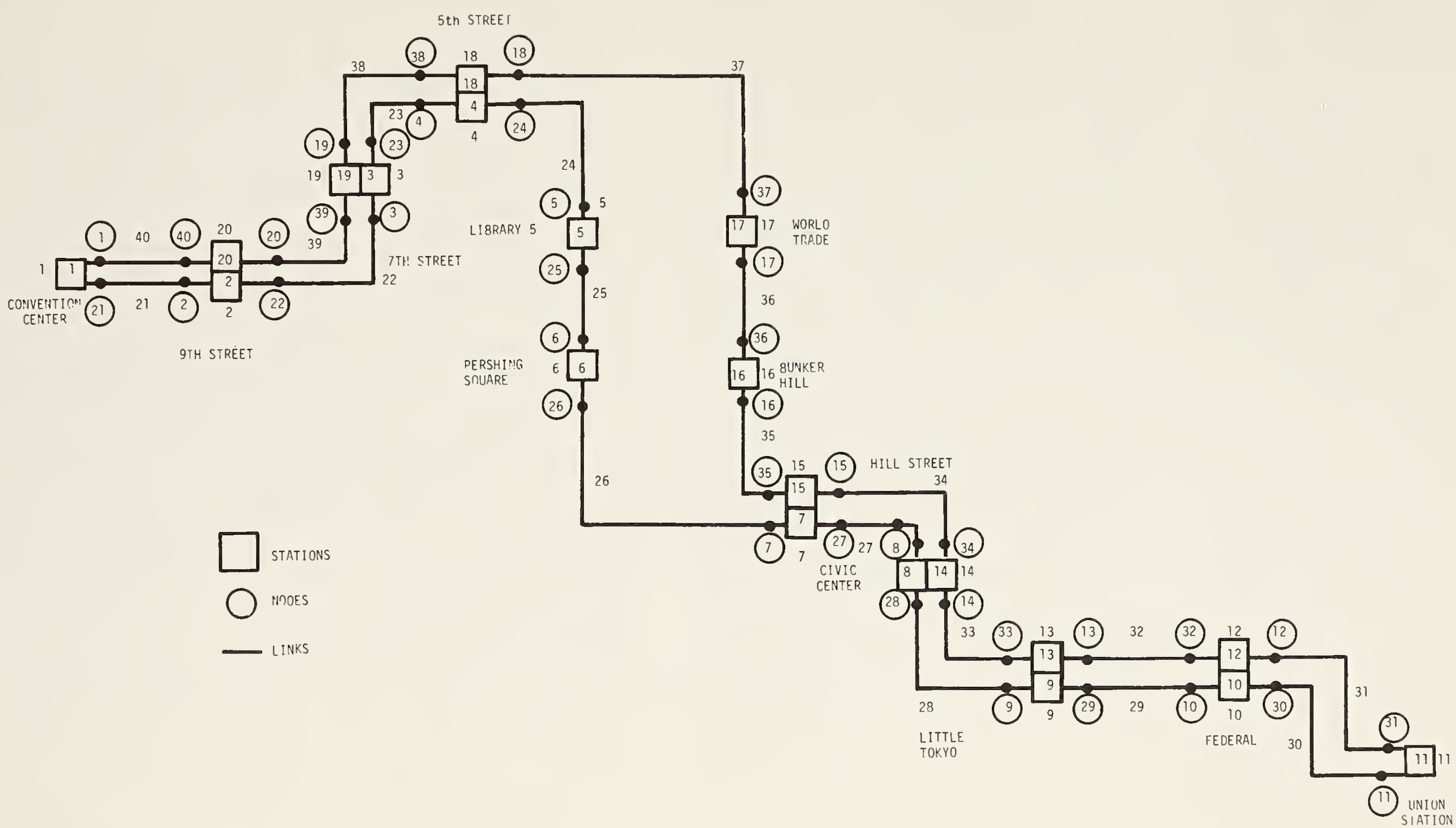

FIGURE 2. LOS ANGELES DPM NETWORK

dwell and variable dwell options were permitted at the stations. Fixed dwell times considered were 20 or 30 seconds. For the variable dwell studies, average dwell times of 20 to 30 seconds were used (to determine headway separations). Minimum door-open times were set at 5 seconds, with 2 seconds used in two cases. The maximum door-open times were set at 30 seconds (corresponding to the 2-second minimum), 35, and 50 seconds.

From performance data obtained from operating systems such as SeaTac and AIRTRANS, two rates were used to reflect the boarding and deboarding time per passenger per vehicle: 0.2 and 0.4 second. These rates take into consideration the number of doors per vehicle and the door widths. The assumption was also made that the necessary hardware was available to operate the end stations in a manner consistent with the specified headways.

2.3 RESULTS

Nominal headways of 60, 75, 90, 105, and 120 seconds were used in the analyses. The actual headways occasionally differed slightly due to the fact that an integral number of vehicles are used in the system.

The average dwell time used (for spacing purposes) was primarily 30 seconds; 15 seconds of "dead time" (as indicated in the Los Angeles specification) for vehicle positioning, door movements, etc., and 15 seconds of door-open time. If it were possible to reduce the average door-open time to 5 seconds, the number of trains required would be reduced, as indicated below:

Nominal Headway (Seconds)	Actual Headway (Seconds)	Average Dwell (Seconds)	No. Trains
60	60	20	23
	59	30	27
75	73	30	19
	75	30	21
90	92	20	15
	88	30	18

From an analysis of the results, the major congestion point in the system is Pershing Square (Station 6). The passenger volume at this station is the prime factor controlling the system design.

Fixed dwell times of 20 and 30 seconds, with a corresponding number of trains, give comparable waiting time results for both 60- and 75-second headways. If it is possible to use the shorter fixed dwell, the same level of service can be provided with fewer trains.

Fixed dwell and variable dwell roughly give similar results in these cases, with the fixed dwell providing slightly lower waiting times. The variable dwell, with some type of sensor, appears more realistic in an operational environment, and thus most of the studies used a variable dwell.

In variable dwell, the door-open time is equal to a constant term plus the number of passengers boarding and deboarding times the boarding rate. In this demand range, the performance measures are fairly insensitive to the boarding time per passenger, so it is not a key parameter, and thus does not have to be varied in this study.

In terms of the most stringent waiting time goal that could be imposed, namely that not only the 95th percentile waiting time but also the maximum waiting time be less than 2 minutes, the proposed 164-passenger trains can meet the year 2000 demand at headways of both 60 and 75 seconds. However, in order to meet the demand with a headway of 90 seconds, it is necessary to use a train with a 200-passenger capacity (which could be the assumed crush-loaded capacity of the nominal 164-passenger train).

Note from the data on the last two runs on sheet 3 (see the appendix) that the maximum door-open time has to be extended beyond 35 seconds in the 90-second headway case to avoid leaving passengers on the platform while there is still space available in the train. Upon further examination, this problem occurs only at the end station - Union Station (Station 11) due to the influx of passengers at the peak period. In fact, from looking at the results, a maximum door-open time of about 38 seconds would be sufficient (50 seconds was used as an upper limit).

Reviewing the results from using longer headways, only a crush-loaded 200-passenger capacity train was used. For a 106-second headway, the maximum waiting time was 5.7 minutes, the 95th percentile system waiting time over the three hours was 2.3 minutes, and the 95th percentile waiting time at Pershing Square was 3.7 minutes.

In the 122-second headway case, the maximum waiting time was 12.3 minutes, the 95th percentile system waiting time was 4.0 minutes, and the 95th percentile waiting time at Pershing Square was 8.5 minutes.

The sensitivity of system performance to increased demand levels was briefly examined (see data sheets 4 and 5 of the appendix). The nominal system configurations for 59- and 75-second headways were tested with demand levels of 125,000 and 150,000 passengers per day using 200-passenger (crush-loaded) capacity trains. For the 59-second headway both the 95th percentile and maximum waiting times were less than 1.5 minutes for each demand level. With the 75-second headway, these waiting times were less than 2 minutes for the 125,000/day passenger rate, but at the 150,000/day rate, the 95th percentile waiting time at Pershing Square exceeded 6 minutes.

2.4 CONCLUSIONS

The demand level projected for the year 2000 can not only be handled with 60-second headways but also with 75-second headways using the nominal 164-passenger capacity train. The demand can even be satisfied with 90-second headways if 200-passenger (crush-loaded) capacity trains are employed.

Further, a 50-percent increase in demand beyond the year 2000 could be accommodated at 60-second headways, while a 25-percent increase could be accommodated at 75-second headways.

3. TRAIN CAPACITY VS. HEADWAY STUDY

After completing the above study for the train capacity specified of 164 passengers, UMTA wanted to study the sensitivity of this vehicle capacity value.

3.1 APPROACH

An approach similar to that used in the first study was also used here. For a given headway, alternative vehicle capacities were selected and the 95th percentile passenger waiting time at the worst station - Pershing Square - was computed. Goals of 2 and 3 minutes were used for this value, as shown in Figures 3 through 5. (From 3 to 7 points were required to plot these curves.) For each goal, the minimum train capacity for each headway was determined and used to plot the curves shown in Figure 6. This process was repeated for a small increase (3 percent) in the projected passenger demand to assess the sensitivity of the train capacity to this value and allow for proper margin in the system design.

3.2 ASSUMPTIONS

The basic assumptions of the first study were also used here. To simplify matters, only variable dwell was used, and a door-open range of 5 to 50 seconds was set to be certain this variable did not cause any problems in the analysis. The boarding time per passenger was 0.2 second. To reduce computer costs only 2 hours of the peak period where simulated instead of 3 hours as in the previous study.

3.3 RESULTS

The summary statistics from the individual runs of the DPM Simulation Model are given in sheets 6-16 in the appendix. The first sheet for each of the five headways used - 45, 59, 75, 88, and 106 seconds - is with the baseline passenger demand, while the second sheet is for an increased demand. The waiting time

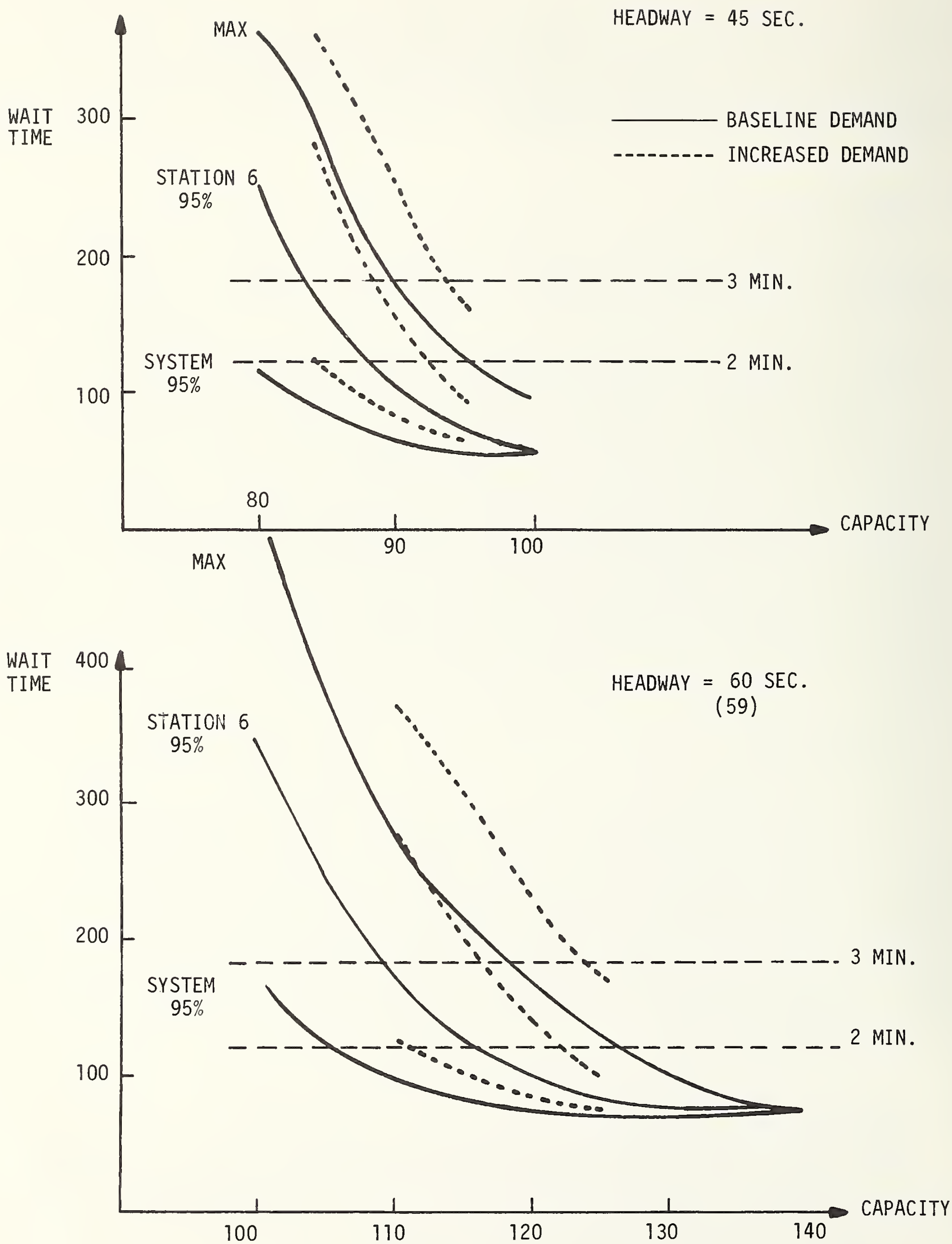

FIGURE 3. WAITING TIME VS. CAPACITY (45- AND 60-SECOND HEADWAYS)

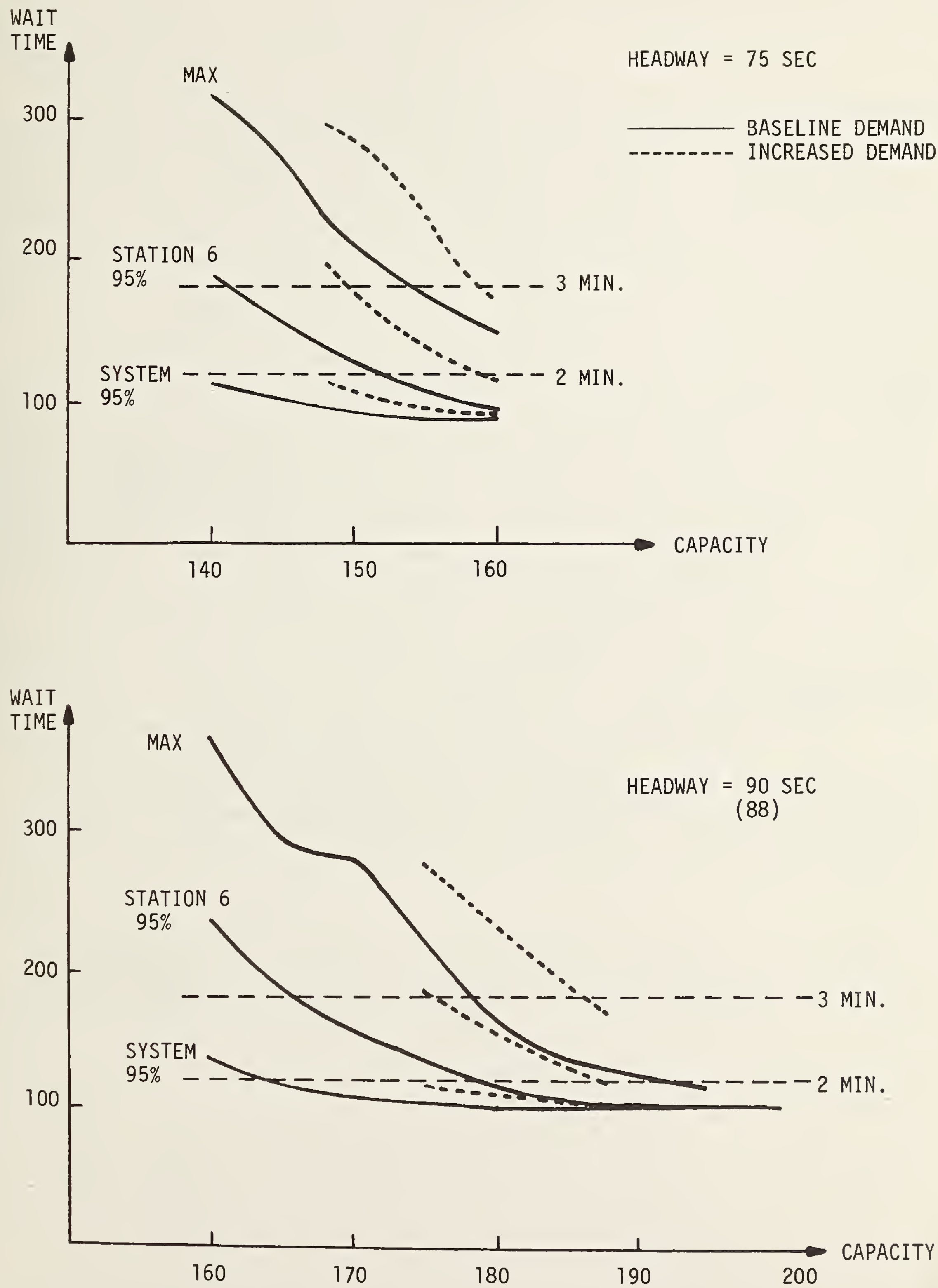

FIGURE 4. WAITING TIME VS. CAPACITY (75- AND 90-SECOND HEADWAYS)

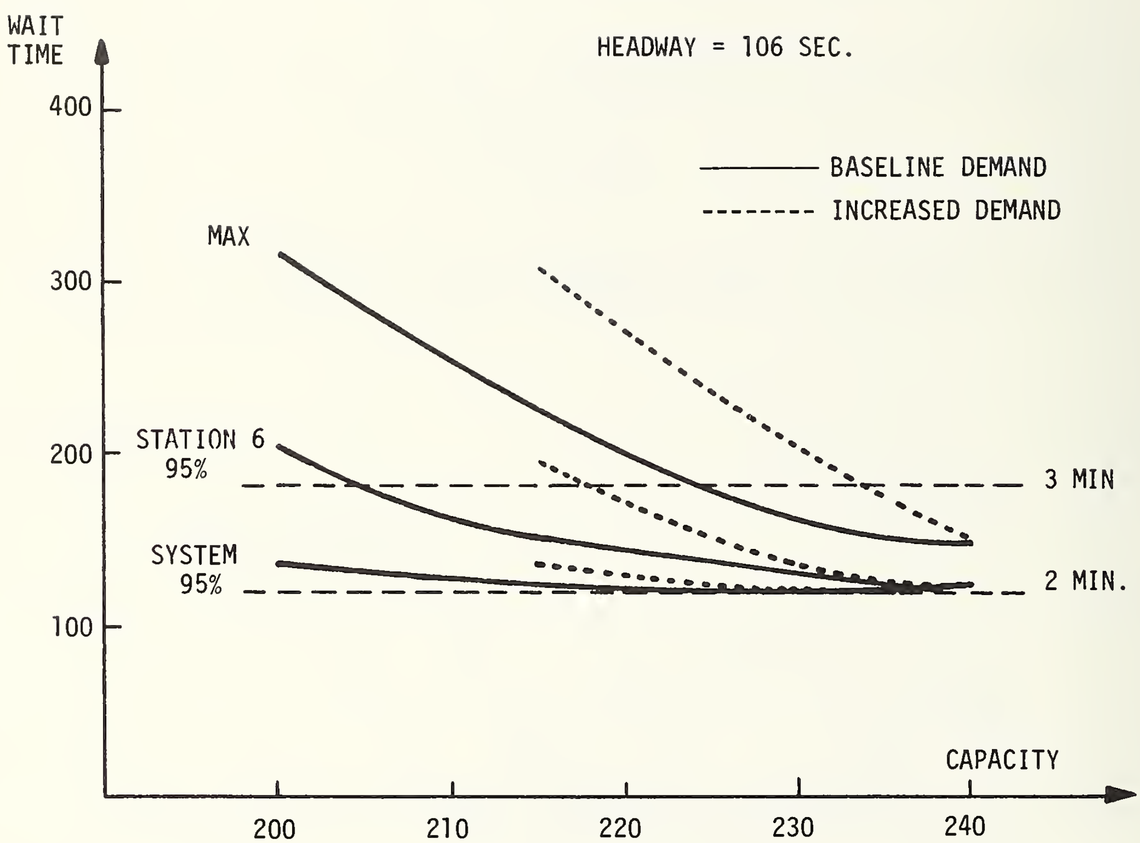

FIGURE 5. WAITING TIME VS. CAPACITY (106-SECOND HEADWAY)

vs. train capacity curves are given in Figures 3 through 5, while the train capacity vs. headway curves (as a function of the waiting time goal) are in Figure 6.

For a given headway, it can be seen that the system average waiting time decreases fairly slowly as the train capacity increases. For example, for 45-second headways (see Data Sheet Number 6) a change in train capacity from 80 to 100 only reduces the system average waiting time from 37.2 to 30.7 seconds. Thus the system average waiting time is not a very sensitive parameter.

The opposite extreme of behavior is exhibited by maximum waiting time (both systemwide and at the worst station) which decreases dramatically as the train capacity increases. For example, in the 45-second headway case, it decreases from 379 seconds to less than 100 seconds. This highly volatile behavior is indicative of the measurement of an extreme value.

The average waiting time at the worst station (Pershing Square) is more sensitive to an increase in train capacity than the overall system average waiting time. Again, in the 45-second headway example it decreases from 72.8 to 32.3 seconds.

The 95th percentile waiting time measure is fairly sensitive to changes in the train capacity, with the value at the worst station being more volatile than the systemwide value (see Figure 3, for example).

In Figures 3 through 5, the maximum waiting time values are drawn to indicate their variability. The systemwide 95th percentile waiting time values are shown to indicate their relative insensitivity. Note that the curves asymptotically approach some value that is roughly 10 to 20 percent greater than one headway (due most likely to random passenger arrivals). Thus, for the 106-second headway case, the curves do not quite cross the 2-minute goal line.

Data Sheet 16 of the appendix gives statistics that are collected for only the peak 30 minutes rather than the full 2 hours, in case one wishes to place much more stringent performance requirements on the system. For instance, comparing the 59-second

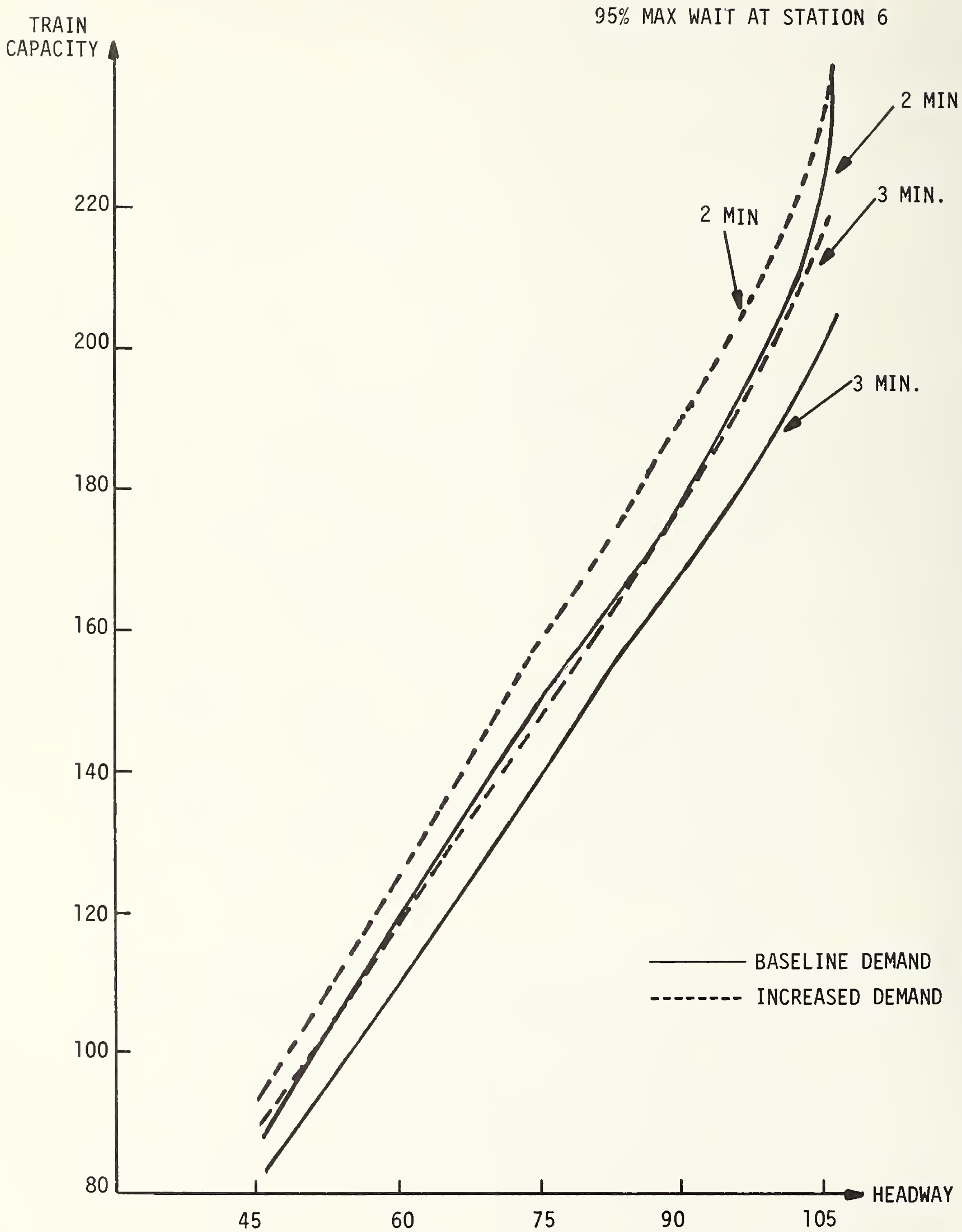

FIGURE 6. HEADWAY VS. CAPACITY

case on sheet 16 with the middle case on sheet 8, it can be seen that the system avearage and 95-percent values increase a little, whereas the worst station average and 95-percent values increase about 50 percent.

3.4 USING SIMULATION RESULTS TO DETERMINE VEHICLE CAPITAL COSTS

Once the relationship between wait time goals, capacity, and headway have been estimated using the simulation model, the information can be used for other planning needs. Vehicle capital cost comparisons can be made between alternative configurations as a function of vehicle capacity and headway. The combinations of number of trains, headway, and train capacity which meet the wait time goals (95% of passengers wait less than 2 minutes at the worst station) for the LA DPM year 2000 demand are derived from Figure 6 and are shown below:

Trains (#)	Headway (sec)	Train Capacity (Pass)
35	45	92
27	59	122
21	75	158
18	88	188
15	106	240

The number of vehicles in the fleet (excluding spares) can be determined by dividing the train capacity by the vehicle capacity, rounding up to the nearest integer and multiplying by the number of trains. The total vehicle capital cost can be estimated by an equation such as

$$\text{Total Cost} = 1.67 + (.2 + (\text{VCAP} \times .0025)) \times \text{FLEET SIZE}$$

(millions of 1978 dollars)

where VCAP = vehicle capacity

FLEET SIZE = number of vehicles

This equation estimates total vehicle capital cost as a fixed cost (manufacturing set-up) plus a variable cost which is a function of fleet size. The unit cost of each vehicle is a function of a fixed cost (necessary parts) plus a variable cost which is a function of vehicle capacity. The numbers in the equation were derived from data on existing automated vehicles. Since fleet size is inversely proportional to vehicle capacity, the total vehicle capital cost can be minimized by setting the vehicle capacity equal to the train capacity required at a given headway. In the LA DPM example, for headways greater than 45 seconds,the minimum cost solution is to buy vehicles if capacity equal to 1.34 x $(\text{headway})^{1.11}$ which is the analytic relationship derived from Figure 6. The vehicle capacity at a 45-second headway is 92.

If vehicles with capacity less than 92 are desired, the solution becomes lumpy. Figure 7 plots the total vehicle capital cost as a function of vehicle capacity for combinations which meet the wait time goal. Total costs vs vehicle capacity are plotted for five headways. Figure 7 shows that:

(a) The minimum total vehicle capital cost decreases as a function of vehicle capacity.
(b) For headways greater than 45 seconds the minimum cost is obtained for the vehicle capacities shown by the lower boundary curve (solid line) from capacity equal to 92 corresponding to 45-second headways to capacity equal to 240 for 106-second headways.
(c) The lines rising from the minimum cost point represent the increased cost of using too large a vehicle at that headway.
(d) From Figure 5 we know that headways greater than 106 seconds do not satisfy the 2-minute wait time goal.
(e) If maximim vehicle capacity is limited to less than 92, Figure 7 can be used to find the capacity-headway combination to minimize cost. (By drawing a line through the circled dots.)
(f) If the minimum headway is limited and the maximum vehicle capacity is limited then the line obtained above (e) can be extended to the right. For example, if 88 seconds is the

VEHICLE FLEET CAPITAL COST VS VEHICLE CAPACITY
FOR VARIOUS HEADWAYS (H) FOR VEHICLE FLEETS
WHICH MEET THE WAIT TIME GOAL FOR LA DPM YEAR 2000 DEMAND

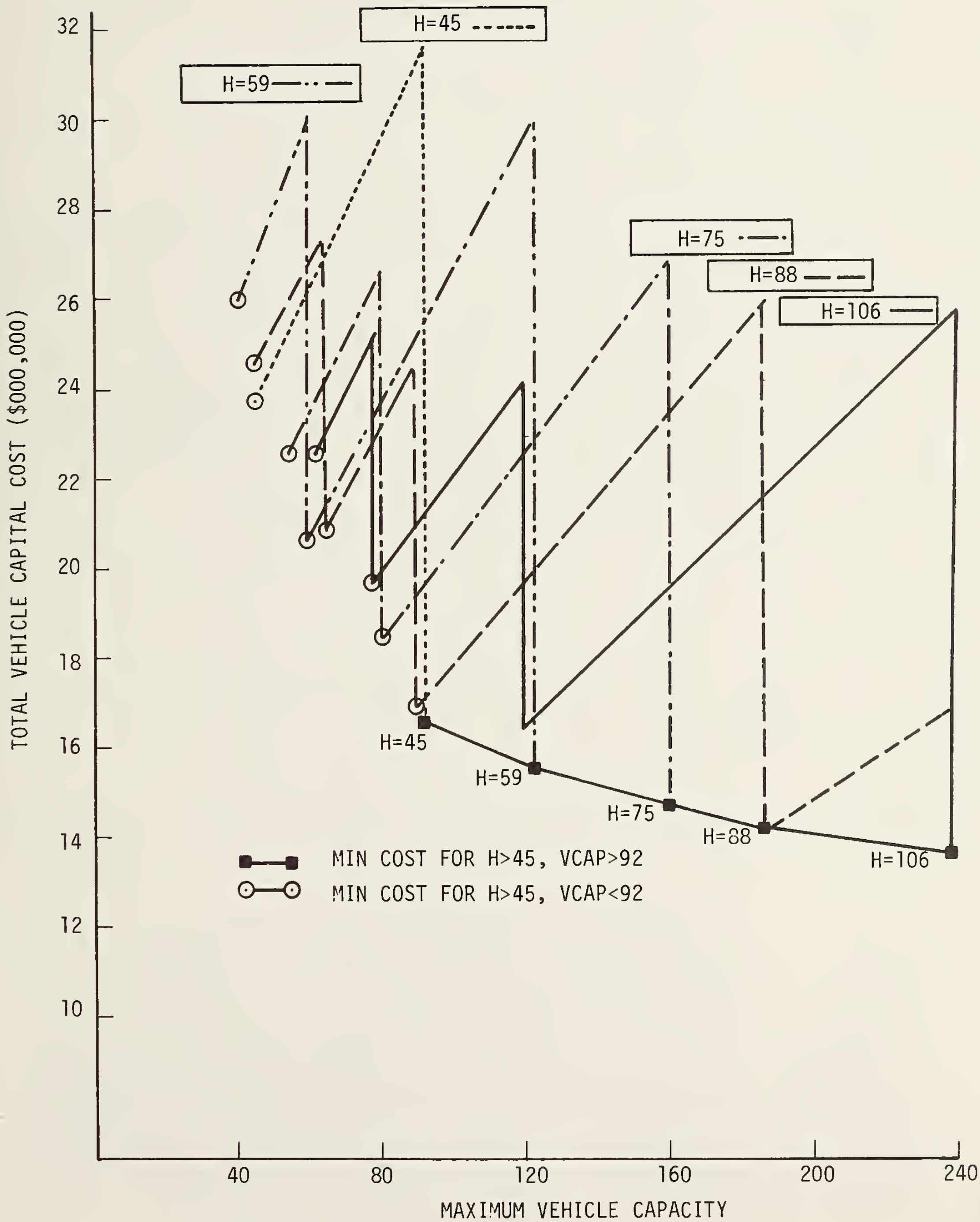

FIGURE 7. VEHICLE CAPITAL COSTS

minimum headway and if vehicle capacity is limited to between 120 and 188, then the headway should be 106 seconds. If the vehicle capacity is limted to between 80 and 120, the headway should be 88 seconds, which is the minimum cost line for that range of vehicle capacities.

3.5 CONCLUSIONS

The simulation model was used to develop a relationship between the LA D M wait time goals, and train capacity and headway. Relationships for two alternative demand levels and two goals were derived. This relationship can then be used to estimate many cost and design parameters. As an example, total vehicle capital costs were estimated on a function of vehicle capacity, given the simulation derived relationship and a capital cost relationship derived from existing data.

APPENDIX - SUMMARY DATA FROM COMPUTER SIMULATIONS

LA DPM 8/79	SHEET NO. 1 (fixed capacity - baseline demand)					
HEADWAY (SECS.)	60	59	60	59	60	
TRAIN CAPACITY	164	164	164	164	164	
DWELL (FIXED OR VARIABLE)	F	F	V	V	V	
AVERAGE DWELL (OR FIXED DWELL; SECS.)	20	30	20	30	30	
MIN. DOOR-OPEN TIME (SECS.)	-	-	2	5	5	
MAX. DOOR-OPEN TIME (SECS.)	-	-	30	35	35	
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	-	-	.2	.2	.4	
NUMBER OF TRAINS	23	27	23	27	27	
AVERAGE WAIT (SECS.)	30.4	29.4	31.5	39.3	37.8	
95 PERCENT WAIT (SECS.)	65.6	63.5	66.4	-	-	
MAX. WAIT (SECS.)	71.9	59.1	76.6	69.4	69.4	
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	30.2	29.2	30.5	39.1	37.3	
95 PERCENT WAIT (SECS.)	65.0	63.5	65.2	-	-	
MAX. WAIT (SECS.)	71.3	59.0	69.6	68.6	68.6	
LOAD FACTOR	.238	.225	.240	.235	.237	
ELAPSED TIME (HRS.)	3	3	3	3		
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	100,000	
ARRIVING PASSENGERS	36,991	36,992	36,997	36,986		
RUN NUMBER	2592	3559	2595	3565	3560	

LA DPM 8/79	SHEET NO. 2 (fixed capacity - baseline demand)					
HEADWAY (SECS.)	73	75	75	73	75	75
TRAIN CAPACITY	164	164	164	164	164	200
DWELL (FIXED OR VARIABLE)	F	F	V	V	V	V
AVERAGE DWELL (OR FIXED DWELL; SECS.)	20	30	30	20	30	30
MIN. DOOR-OPEN TIME (SECS.)	-	-	5	2	5	5
MAX. DOOR-OPEN TIME (SECS.)	-	-	35	30	35	50
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	-	-	.4	.2	.2	.4
NUMBER OF TRAINS	19	21	21	19	21	21
AVERAGE WAIT (SECS.)	37.1	38.2	43.9	37.8	45.9	43.8
95 PERCENT WAIT (SECS.)	79.4	82.6	87.9	80.0	-	-
MAX. WAIT (SECS.)	101.5	109.9	96.1	84.9	95.9	85.4
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	37.9	39.3	43.6	37.6	46.5	43.1
95 PERCENT WAIT (SECS.)	80.5	84.2	87.7	80.0	-	-
MAX. WAIT (SECS.)	101.5	109.9	96.1	84.9	95.9	84.4
LOAD FACTOR	.288	.289	.302	.293	.301	.248
ELAPSED TIME (HRS.)	3	3	3	3	3	3
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	100,000	100,000
ARRIVING PASSENGERS	36,990	36,977	36,987	36,994	36,983	36,987
RUN NUMBER	2590	3558	4515	2982	3564	5696

LA DPM 8/79	SHEET NO. 3 (fixed capacity - baseline demand)					
HEADWAY (SECS.)	92	88	88	88	88	88
TRAIN CAPACITY	164	164	164	164	200	200
DWELL (FIXED OR VARIABLE)	F	F	V	V	V	V
AVERAGE DWELL (OR FIXED DWELL; SECS.)	20	30	30	30	30	30
MIN. DOOR-OPEN TIME (SECS.)	-	-	5	5	5	5
MAX. DOOR-OPEN TIME (SECS.)	-	-	35	35	35	50
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	-	-	.2	.4	.4	.4
NUMBER OF TRAINS	15	18	18	18	18	18
AVERAGE WAIT (SECS.)	52.4	47.8	56.1	54.3	51.3	50.2
95 PERCENT WAIT (SECS.)	147.9	121.8	-	129.3	108.0	101.7
MAX. WAIT (SECS.)	474.4	339.1	338.6	360.1	289.6	102.4
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	88.6	70.6	77.0	77.1	48.9	48.9
95 PERCENT WAIT (SECS.)	303.6	221.3	-	229.9	100.4	100.4
MAX. WAIT (SECS.)	474.4	339.1	338.6	360.1	100.9	100.9
LOAD FACTOR	.365	.337	.353	.355	.291	.291
ELAPSED TIME (HRS.)	3	3	3	3	3	3
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	100,000	100,000
ARRIVING PASSENGERS	36,997	36,982	36,990	36,990	36,990	36,990
RUN NUMBER	2588	3557	3563	4517	4509	5691

LA DPM 8/79	SHEET NO. 4 (fixed capacity - baseline demand)					
HEADWAY (SECS.)	106	106	122	122	59	59
TRAIN CAPACITY	200	200	200	200	200	200
DWELL (FIXED OR VARIABLE)	V	V	V	V	V	V
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30	30	30	30
MIN. DOOR-OPEN TIME (SECS.)	5	5	5	5	5	5
MAX. DOOR-OPEN TIME (SECS.)	35	50	35	50	50	50
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.4	.4	.4	.4	.4	.4
NUMBER OF TRAINS	15	15	13	13	27	27
AVERAGE WAIT (SECS.)	68.1	61.4	96.7	78.6	36.8	35.7
95 PERCENT WAIT (SECS.)	202.5	139.7	370.9	241.7		70.9
MAX. WAIT (SECS.)	771.1	342.8	1215.7	739.2	69.4	87.7
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	79.0	80.2	134.6	144.3	35.3	34.2
95 PERCENT WAIT (SECS.)	216.2	223.4	455.2	507.4		69.6
MAX. WAIT (SECS.)	345.2	342.8	671.9	739.2	68.5	87.7
LOAD FACTOR	.350	.350	.403	.403	.257	.311
ELAPSED TIME (HRS.)	3	3	3	3	2	2
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	125,000	150,000
ARRIVING PASSENGERS	36,986	36,986	36,997	36,997	32,381	39,143
RUN NUMBER	4513	5695	4512	5692	6702	6706

LA DPM 8/79	SHEET NO. 5 (fixed capacity - parametric demand increase)					
HEADWAY (SECS.)	75	75				
TRAIN CAPACITY	200	200				
DWELL (FIXED OR VARIABLE)	V	V				
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30				
MIN. DOOR-OPEN TIME (SECS.)	5	5				
MAX. DOOR-OPEN TIME (SECS.)	50	50				
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.4	.4				
NUMBER OF TRAINS	21	21				
AVERAGE WAIT (SECS.)	42.9	51.3				
95 PERCENT WAIT (SECS.)	87.2	163.8				
MAX. WAIT (SECS.)	105.5	516.5				
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	44.0	107.1				
95 PERCENT WAIT (SECS.)	90.0	365				
MAX. WAIT (SECS.)	105.5	516.5				
LOAD FACTOR	.328	.396				
ELAPSED TIME (HRS.)	2	2				
DAILY PASSENGER FLOW	125,000	150,000				
ARRIVING PASSENGERS	32,385	39,150				
RUN NUMBER	537	538				

LA DPM 8/79	SHEET NO. 6 (vary capacity - baseline demand)					
HEADWAY (SECS.)	45	45	45	45		
TRAIN CAPACITY	80	85	90	100		
DWELL (FIXED OR VARIABLE)	V	V	V	V		
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30	30		
MIN. DOOR-OPEN TIME (SECS.)	5	5	5	5		
MAX. DOOR-OPEN TIME (SECS.)	50	50	50	50		
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2	.2		
NUMBER OF TRAINS	35	35	35	35		
AVERAGE WAIT (SECS.)	37.2	33.6	32.0	30.7		
95 PERCENT WAIT (SECS.)	114.8	81.4	66.3	58.0		
MAX. WAIT (SECS.)	378.6	266.2	169.3	97.9		
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	72.8	51.8	41.5	32.3		
95 PERCENT WAIT (SECS.)	251	155.8	102.9	60.7		
MAX. WAIT (SECS.)	378.6	266.2	169.3	78.5		
LOAD FACTOR	.388	.365	.345	.311		
ELAPSED TIME (HRS.)	2	2	2	2		
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000		
ARRIVING PASSENGERS	25,827	25,827	25,827	25,827		
RUN NUMBER	1741	4092	2790	1777		

LA DPM 8/79	SHEET NO. 7 (vary capacity - increased demand)					
HEADWAY (SECS.)	45	45	45	45		
TRAIN CAPACITY	84	88	90	95		
DWELL (FIXED OR VARIABLE)	V	V	V	V		
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30	30		
MIN. DOOR-OPEN TIME (SECS.)	5	5	5	5		
MAX. DOOR-OPEN TIME (SECS.)	50	50	50	50		
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2	.2		
NUMBER OF TRAINS	35	35	35	35		
AVERAGE WAIT (SECS.)	37.9	34.8	33.6	31.8		
95 PERCENT WAIT (SECS.)	122.2	91.5	80.8	64.3		
MAX. WAIT (SECS.)	366.7	293.2	253.9	162.3		
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	80.3	60.2	53.0	39.8		
95 PERCENT WAIT (SECS.)	280.1	188.7	155.1	93.9		
MAX. WAIT (SECS.)	366.7	293.2	253.9	162.3		
LOAD FACTOR	.383	.366	.357	.339		
ELAPSED TIME (HRS.)	2	2	2	2		
DAILY PASSENGER FLOW	103,000	103,000	103,000	103,000		
ARRIVING PASSENGERS	26,679	26,679	26,679	26,679		
RUN NUMBER	7341	7370	8522	8528		

LA DPM 8/79	SHEET NO. 8 (vary capacity - baseline demand)					
HEADWAY (SECS.)	59	59	59	59	59	59
TRAIN CAPACITY	100	105	110	115	120	140
DWELL (FIXED OR VARIABLE)	V	V	V	V	V	V
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30	30	30	30
MIN. DOOR-OPEN TIME (SECS.)	5	5	5	5	5	5
MAX. DOOR-OPEN TIME (SECS.)	50	50	50	50	50	50
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2	.2	.2	.2
NUMBER OF TRAINS	27	27	27	27	27	27
AVERAGE WAIT (SECS.)	49.1	44.3	41.3	39.9	39.0	37.9
95 PERCENT WAIT (SECS.)	162.1	121.8	95.8	83.6	77.4	72.5
MAX. WAIT (SECS.)	492.6	383.3	284.1	212.3	167.5	74.4
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	100.3	76.4	59.0	50.8	45.2	37.7
95 PERCENT WAIT (SECS.)	349	249.1	171.9	128.7	99.8	72.4
MAX. WAIT (SECS.)	492.6	383.3	284.1	212.3	167.5	74.4
LOAD FACTOR	.406	.387	.369	.353	.338	.290
ELAPSED TIME (HRS.)	2	2	2	2	2	2
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	100,000	100,000
ARRIVING PASSENGERS	25,826	25,826	25,826	25,826	25,826	25,826
RUN NUMBER	1779	5635	4094	4433	2810	2813

LA DPM 8/79	SHEET NO. 9 (vary capacity - increased demand)					
HEADWAY (SECS.)	59	59	59			
TRAIN CAPACITY	116	120	125			
DWELL (FIXED OR VARIABLE)	V	V	V			
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30			
MIN. DOOR-OPEN TIME (SECS.)	5	5	5			
MAX. DOOR-OPEN TIME (SECS.)	50	50	50			
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2			
NUMBER OF TRAINS	27	27	27			
AVERAGE WAIT (SECS.)	41.4	39.9	38.7			
95 PERCENT WAIT (SECS.)	99.0	86.3	74.8			
MAX. WAIT (SECS.)	292.9	227.8	168.6			
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	63.9	54.0	44.9			
95 PERCENT WAIT (SECS.)	185.6	138.8	98.4			
MAX. WAIT (SECS.)	292.9	227.8	168.6			
LOAD FACTOR	.363	.351	.337			
ELAPSED TIME (HRS.)	2	2	2			
DAILY PASSENGER FLOW	103,000	103,000	103,000			
ARRIVING PASSENGERS	26,673	26,673	26,673			
RUN NUMBER	7338	8531	8533			

LA DPM 8/79	SHEET NO. 10 (vary capacity - baseline demand)					
HEADWAY (SECS.)	75	75	75	75	75	
TRAIN CAPACITY	140	145	150	155	160	
DWELL (FIXED OR VARIABLE)	V	V	V	V	V	
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30	30	30	
MIN. DOOR-OPEN TIME (SECS.)	5	5	5	5	5	
MAX. DOOR-OPEN TIME (SECS.)	50	50	50	50	50	
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2	.2	.2	
NUMBER OF TRAINS	21	21	21	21	21	
AVERAGE WAIT (SECS.)	47.6	46.4	45.5	44.8	44.3	
95 PERCENT WAIT (SECS.)	110.5	101.5	95.3	90.9	89.1	
MAX. WAIT (SECS.)	316.8	271.2	206.4	174.0	150.0	
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	67.7	61.1	55.4	50.6	46.9	
95 PERCENT WAIT (SECS.)	187.8	157.0	130.0	106.9	95.2	
MAX. WAIT (SECS.)	316.8	271.2	206.4	174.0	135.6	
LOAD FACTOR	.370	.358	.346	.335	.324	
ELAPSED TIME (HRS.)	2	2	2	2	2	
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	100,000	
ARRIVING PASSENGERS	25,820	25,820	25,820	28,820	25,820	
RUN NUMBER	1781	4095	2815	4097	2816	

LA DPM 8/79	SHEET NO. 11 (vary capacity - increased demand)					
HEADWAY (SECS.)	75	75	75			
TRAIN CAPACITY	148	152	160			
DWELL (FIXED OR VARIABLE)	V	V	V			
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30			
MIN. DOOR-OPEN TIME (SECS.)	5	5	5			
MAX. DOOR-OPEN TIME (SECS.)	50	50	50			
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2			
NUMBER OF TRAINS	21	21	21			
AVERAGE WAIT (SECS.)	47.2	46.0	44.5			
95 PERCENT WAIT (SECS.)	111.1	101.6	91.6			
MAX. WAIT (SECS.)	298.6	255.1	172.6			
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	71.0	62.8	51.5			
95 PERCENT WAIT (SECS.)	196.7	160.1	113.2			
MAX. WAIT (SECS.)	298.6	265.1	172.6			
LOAD FACTOR	.363	.354	.336			
ELAPSED TIME (HRS.)	2	2	2			
DAILY PASSENGER FLOW	103,000	103,000	103,000			
ARRIVING PASSENGERS	26,671	26,671	26,671			
RUN NUMBER	8534	7340	8537			

LA DPM 8/79	SHEET NO. 12 (vary capacity - baseline demand)					
HEADWAY (SECS.)	88	88	88	88	88	88
TRAIN CAPACITY	160	165	170	175	180	200
DWELL (FIXED OR VARIABLE)	V	V	V	V	V	V
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30	30	30	30
MIN. DOOR-OPEN TIME (SECS.)	5	5	5	5	5	5
MAX. DOOR-OPEN TIME (SECS.)	50	50	50	50	50	50
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2	.2	.2	.2
NUMBER OF TRAINS	18	18	18	18	18	18
AVERAGE WAIT (SECS.)	55.4	53.5	52.4	51.6	50.9	50.2
95 PERCENT WAIT (SECS.)	133.6	119.0	112.5	107.9	104.1	102.2
MAX. WAIT (SECS.)	361.1	290.1	279.2	220.2	164.2	117.9
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	82.4	70.8	64.2	59.4	54.4	49.7
95 PERCENT WAIT (SECS.)	234.2	184.3	159.2	136.8	114.2	102.6
MAX. WAIT (SECS.)	361.1	290.1	279.2	220.2	159.8	117.1
LOAD FACTOR	.380	.369	.358	.348	.338	.304
ELAPSED TIME (HRS.)	2	2	2	2	2	2
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	100,000	100,000
ARRIVING PASSENGERS	25,828	25,828	25,828	25,828	25,828	25,828
RUN NUMBER	2818	5637	4434	5639	4100	4101

LA DPM 8/79	SHEET NO. 13 (vary capacity - increased demand)					
HEADWAY (SECS.)	88	88				
TRAIN CAPACITY	175	188				
DWELL (FIXED OR VARIABLE)	V	V				
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30				
MIN. DOOR-OPEN TIME (SECS.)	5	5				
MAX. DOOR-OPEN TIME (SECS.)	50	50				
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2				
NUMBER OF TRAINS	18	18				
AVERAGE WAIT (SECS.)	53.5	51.0				
95 PERCENT WAIT (SECS.)	118.2	104.2				
MAX. WAIT (SECS.)	274.2	169.4				
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	72.7	56.4				
95 PERCENT WAIT (SECS.)	184.3	119.1				
MAX. WAIT (SECS.)	274.2	169.4				
LOAD FACTOR	.360	.335				
ELAPSED TIME (HRS.)	2	2				
DAILY PASSENGER FLOW	103,000	103,000				
ARRIVING PASSENGERS	26,685	26,685				
RUN NUMBER	8539	8541				

LA DPM 8/79	SHEET NO. 14 (vary capacity - baseline demand)					
HEADWAY (SECS.)	106	106	106	106	106	106
TRAIN CAPACITY	180	200	210	220	230	240
DWELL (FIXED OR VARIABLE)	V	V	V	V	V	V
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30	30	30	30
MIN. DOOR-OPEN TIME (SECS.)	5	5	5	5	5	5
MAX. DOOR-OPEN TIME (SECS.)	50	50	50	50	50	50
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2	.2	.2	.2
NUMBER OF TRAINS	15	15	15	15	15	15
AVERAGE WAIT (SECS.)	70.8	62.0	60.6	59.8	59.2	58.9
95 PERCENT WAIT (SECS.)	200.7	136.5	127.6	123.8	121.5	121.0
MAX. WAIT (SECS.)	558.1	316.5	252.9	199.7	166.7	152.8
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	128.4	79.6	70.6	65.6	60.8	59.1
95 PERCENT WAIT (SECS.)	404.5	204.4	163.8	141.6	126.3	122.5
MAX. WAIT (SECS.)	558.1	316.5	252.9	199.7	159.9	152.8
LOAD FACTOR	.406	.366	.348	.333	.318	.305
ELAPSED TIME (HRS.)	2	2	2	2	2	2
DAILY PASSENGER FLOW	100,000	100,000	100,000	100,000	100,000	100,000
ARRIVING PASSENGERS	25,828	25,828	25,828	25,828	25,828	25,828
RUN NUMBER	2819	5642	4435	4104	4437	5644

LA DPM 8/79	SHEET NO. 15 (vary capacity - increased demand)					
HEADWAY (SECS.)	106	106				
TRAIN CAPACITY	215	240				
DWELL (FIXED OR VARIABLE)	V	V				
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30				
MIN. DOOR-OPEN TIME (SECS.)	5	5				
MAX. DOOR-OPEN TIME (SECS.)	50	50				
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2				
NUMBER OF TRAINS	15	15				
AVERAGE WAIT (SECS.)	60.8	58.3				
95 PERCENT WAIT (SECS.)	133.4	120.5				
MAX. WAIT (SECS.)	306.9	153.3				
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	78.4	59.3				
95 PERCENT WAIT (SECS.)	193.8	122.1				
MAX. WAIT (SECS.)	306.9	143.2				
LOAD FACTOR	.353	.316				
ELAPSED TIME (HRS.)	2	2				
DAILY PASSENGER FLOW	103,000	103,000				
ARRIVING PASSENGERS	26,669	26,669				
RUN NUMBER	8545	8547				

LA DPM 8/79	SHEET NO. 16 (increased demand; peak 1/2 hr)					
HEADWAY (SECS.)	59	75	88			
TRAIN CAPACITY	120	155	180			
DWELL (FIXED OR VARIABLE)	V	V	V			
AVERAGE DWELL (OR FIXED DWELL; SECS.)	30	30	30			
MIN. DOOR-OPEN TIME (SECS.)	5	5	5			
MAX. DOOR-OPEN TIME (SECS.)	50	50	50			
BOARD TIME PER PASSENGER PER VEHICLE (SECS.)	.2	.2	.2			
NUMBER OF TRAINS	27	21	18			
AVERAGE WAIT (SECS.)	42.5	46.8	54.1			
95 PERCENT WAIT (SECS.)	103.6	109.3	122.6			
MAX. WAIT (SECS.)	227.8	231.0	225.8			
STATION 6 (PERSHING SQ.):						
AVERAGE WAIT (SECS.)	81.4	81.1	89.3			
95 PERCENT WAIT (SECS.)	198.2	191.3	203.1			
MAX. WAIT (SECS.)	227.8	231.0	225.8			
LOAD FACTOR	.520	.514	.520			
ELAPSED TIME (HRS.)	.5	.5	.5			
DAILY PASSENGER FLOW	103,000	103,000	103,000			
ARRIVING PASSENGERS	9779	9793	9795			
RUN NUMBER	1126	1124	1123			

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