

N
8883

SCRTD METRO RAIL PROJECT

Preliminary Engineering

OPERATIONS ANALYSIS FOR THE

MINIMUM OPERABLE SEGMENT

WBS 15B

Prepared by

BOOZ-ALLEN AND HAMILTON, INC.

August, 1983

MTA LIBRARY

TABLE OF CONTENTS

		<u>Page</u>
Chapter 1:	INTRODUCTION	1
Chapter 2:	SYSTEM DESCRIPTION	
	2.1 Metro Rail System	2
	2.2 Minimum Operable Segment	3
Chapter 3:	SYSTEM OPERATING PLAN	
	3.1 Patronage Levels	8
	3.2 Trip Times	8
	3.3 Peak-Hour Service	8
	3.4 Off-Peak Service	13
	3.5 Operating Statistics	16
	3.6 Fleet Requirements	16
	3.7 Future Refinement of the Operating Plan	19

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1-1	Route Alignment for the Minimum Operable Segment	5
3-1	Boarding, Alighting and Link Volumes by Direction, Average Daily Volumes	9
3-2	Boarding, Alighting and Link Volumes by Direction, A.M. Peak Hour Volumes	10
3-3	Boarding, Alighting and Link Volumes by Direction, P.M. Peak Hour Volumes	11

LIST OF TABLES

<u>Table</u>		<u>Page</u>
3-1	Recommended Policy Headways	7
3-2	Peak Period Travel Times	12
3-3	Service Requirements for Peak Periods	14
3-4	Proposed Weekday Morning Schedule	15
3-5	Summary of Weekday Service	17
3-6	Summary of Saturday, Sunday, and Holiday Service	18
3-7	Summary of Operating Statistics	19

CHAPTER 1

INTRODUCTION

An operations analysis of the minimum operable segment (MOS) is presented in this report. The MOS is defined as the portion of the Metro Rail system between Union Station and the Beverly/Fairfax station. As was determined by SCRTD staff in concert with UMTA officials, this is the shortest and least costly segment of the system which could be operated and still provide an adequate public service.

The report defines service and operating characteristics for the minimum operable segment for the year 2000 to permit an assessment of the impacts of initially constructing only the shortened system. Included is a description of service needs, operating schedules, fleet requirements and operating statistics.

The operations analysis was based on several key inputs, chief among these being patronage estimates, simulated travel times and adopted service standards.

Metro Rail ridership was provided by the SCRTD Planning Department using recently improved forecasting models. Travel times were based on recent train performance simulations. Service standards were the same as those defined in the Preliminary Operating Plan and restated in the Milestone 8 Report. (1)

The information in the report is contained in two other chapters. Chapter 2 presents a description of the minimum operable segment and compares it with the full Metro Rail system. Chapter 3 presents the main body of the operations analysis for the minimum operable segment including summaries of service levels, operating statistics and fleet requirements.

CHAPTER 2

SYSTEM DESCRIPTION

2.1 Metro Rail System

The Metro Rail system is conceived as a conventional two track, steel wheel, steel rail system. The complete initial line will be approximately 18 miles long in a subway configuration. Eighteen stations are presently planned with distance between stations ranging from 0.5 miles in the downtown area to 2.7 miles through the Santa Monica mountains.

Stations will be cut and cover construction with either one or two mezzanines and fare collection areas and with one or multiple entry/exit points to street level. Additional exits will be provided for use in emergencies. Escalators, stairs and elevators will provide vertical circulation between surface, mezzanine and platform levels, with elevator access limited to one route per station. Plans call for equipping the station for both attended and unattended operation. Some stations will have adjacent parking facilities, pickup/drop-off areas and/or bus pull-in areas to accommodate patrons arriving by automobile or by bus.

The passenger vehicle for the Metro Rail system will be a 75-ft-long, standard gauge, steel wheel vehicle capable of operating at speeds up to 70 mph. The vehicles will run on 750v DC power and will be capable of regenerative braking. The basic unit will be a married pair (two cars, coupled together, which share some equipment). Each vehicle will hold about 70 seated passengers, and up to about 100 standees at normal loads and over 200 standees at crush loads.

The interior will include seating for able-bodied and handicapped patrons and include handholds and stanchions for standing patrons. Vehicles will be equipped with lighting, heating, ventilating, and air conditioning apparatus to maintain a comfortable environment for passengers.

Vehicles will operate in trains of as many as six cars. Trains will be automatically controlled with an operator performing some functions.

The main storage yard and the shop facility for the starter line will be located in the vicinity of the southeastern terminus. A limited number of storage tracks will be located near the North Hollywood terminal. Crossover tracks, storage tracks, and pocket tracks will be situated at suitable locations to enable trains to turn back at both ends of the corridor and at selected midline locations. These tracks will also provide temporary storage for malfunctioning trains, and permit reverse running during emergency situations.

2.2 Minimum Operable Segment

The minimum operable segment is the shortest portion of the entire Metro Rail line which is capable of operating as a stand alone system. The segment is 8.8 miles long and extends between Union Station and the Beverly/Fairfax station. It contains twelve stations with station spacing varying between .5 and 1.4 miles. To aid in regular and emergency train operation, crossovers are provided at Union Station, Wilshire/Alvarado, Wilshire/La Brea and Fairfax/Beverly. The storage and maintenance facility for the minimum operable segment remains at the downtown location with the option to reduce its initial size to match the demands of the shortened system.

The horizontal alignment of the minimum operable segment is shown in Figure 1-1 in the context of the full 18-mile system. The vertical alignment is available in the Milestone 10 report. The Beverly/Fairfax station was selected as the western terminus of the segment for three principal reasons:

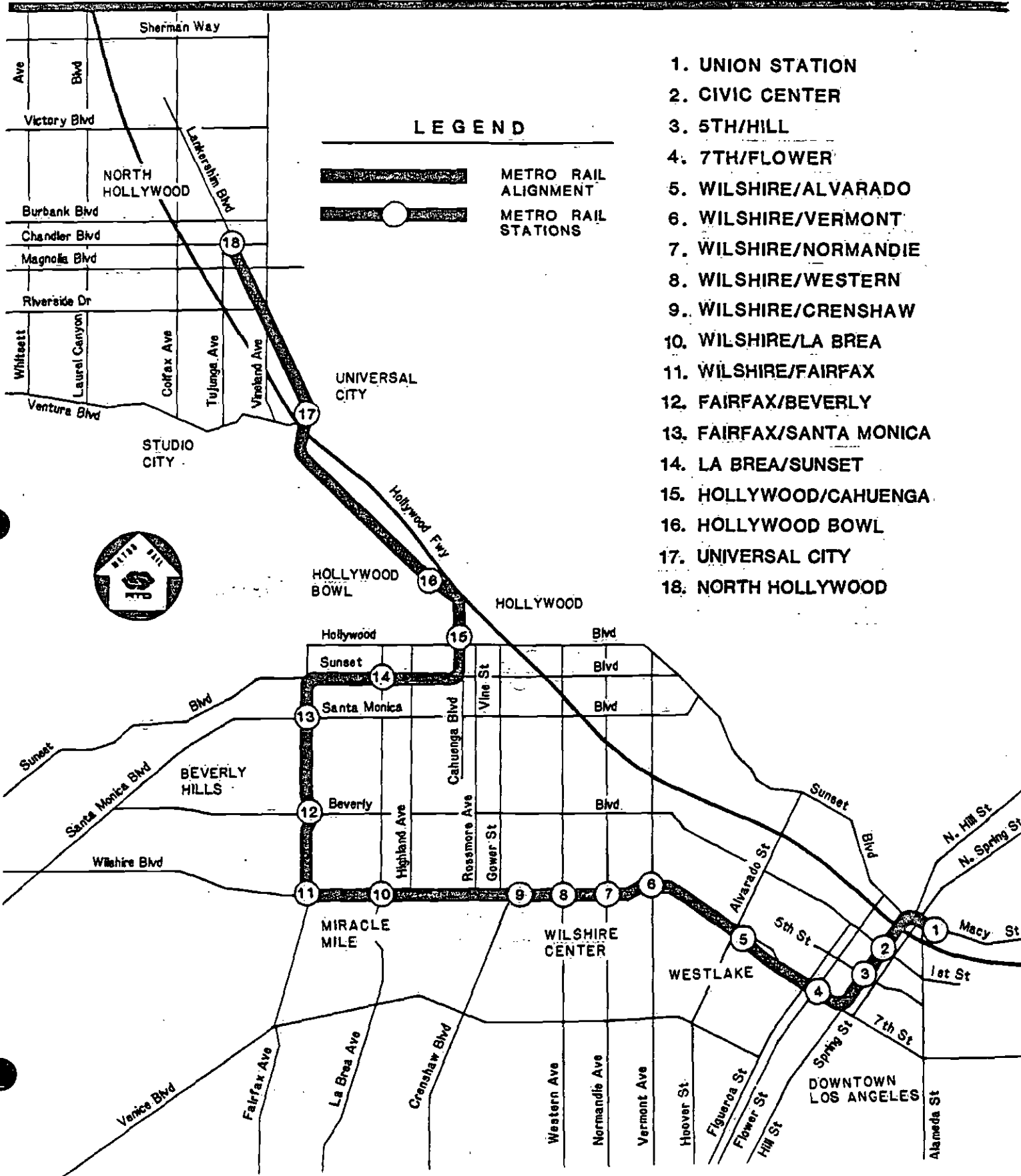
- ° Provision of direct access to the Fairfax Avenue bus line
- ° Availability of an adequate area to allow bus/rail transfer facilities
- ° Attraction of a large portion of total Metro Rail ridership.

By the year 2000, approximately 295,000 daily patrons are forecasted for the minimum operable segment compared with 365,000 for the full Metro Rail system.



Southern California Rapid Transit District Metro Rail Project

FIGURE 1-1



LEGEND



1. UNION STATION
2. CIVIC CENTER
3. 5TH/HILL
4. 7TH/FLOWER
5. WILSHIRE/ALVARADO
6. WILSHIRE/VERMONT
7. WILSHIRE/NORMANDIE
8. WILSHIRE/WESTERN
9. WILSHIRE/CRENSHAW
10. WILSHIRE/LA BREA
11. WILSHIRE/FAIRFAX
12. FAIRFAX/BEVERLY
13. FAIRFAX/SANTA MONICA
14. LA BREA/SUNSET
15. HOLLYWOOD/CAHUENGA
16. HOLLYWOOD BOWL
17. UNIVERSAL CITY
18. NORTH HOLLYWOOD



CHAPTER 3

SYSTEM OPERATING PLAN

This chapter provides patronage levels, trip times, service levels, fleet requirements, and operating statistics for the minimum operable segment. The operating plan was based on the preliminary service policy established in the Milestone 1 Report and recently reviewed during the Milestone 8 process. This policy is summarized below:

- ° Hours of Service
 - 20 hours per day, 7 days per week, between the hours of 5:30 AM and 1:30 AM.
- ° Policy Headways
 - As shown in Table 3-1
- ° Vehicle Loading Standards
 - Peak: 170 passengers per car through the maximum load point
 - Off-Peak: 91 passengers per car through the maximum load point.

As with the preliminary operating plan, this plan is based on the following operating philosophy:

- ° All trains operate the full length of the line, stopping at each station.
- ° Train service is provided at the policy headway unless passenger loading warrants additional service.
- ° Minimum schedule headways will be determined by the capacity needs of the peak 20-minute period.

Table 3-1
RECOMMENDED POLICY HEADWAYS

Period	Maximum Schedule Headway (Minutes)
Weekdays	
Early morning	5:30 a.m. - 6:00 a.m. 15 6:00 a.m. - 6:30 a.m. 7-1/2
Peak periods	6:30 a.m. - 9:00 a.m. 6 3:30 p.m. - 6:30 p.m. 6
Midday	9:00 a.m. - 3:30 p.m. 7-1/2
Evening	6:30 p.m. - 7:30 p.m. 7-1/2
Night	7:30 p.m. - 1:30 a.m. 15
Saturdays	
Morning	5:30 a.m. - 7:30 a.m. 15
Day	7:30 a.m. - 7:30 p.m. 10
Night	7:30 p.m. - 1:30 a.m. 15
Sundays and Holidays	
All Day	5:30 a.m. - 1:30 a.m. 15

3.1 Patronage Levels

Patronage estimates for the year 2000 for the minimum operable segment are displayed in Figures 3-1, 3-2, and 3-3. Displayed are station activity and link loads for daily, a.m. peak, and p.m. peak periods.

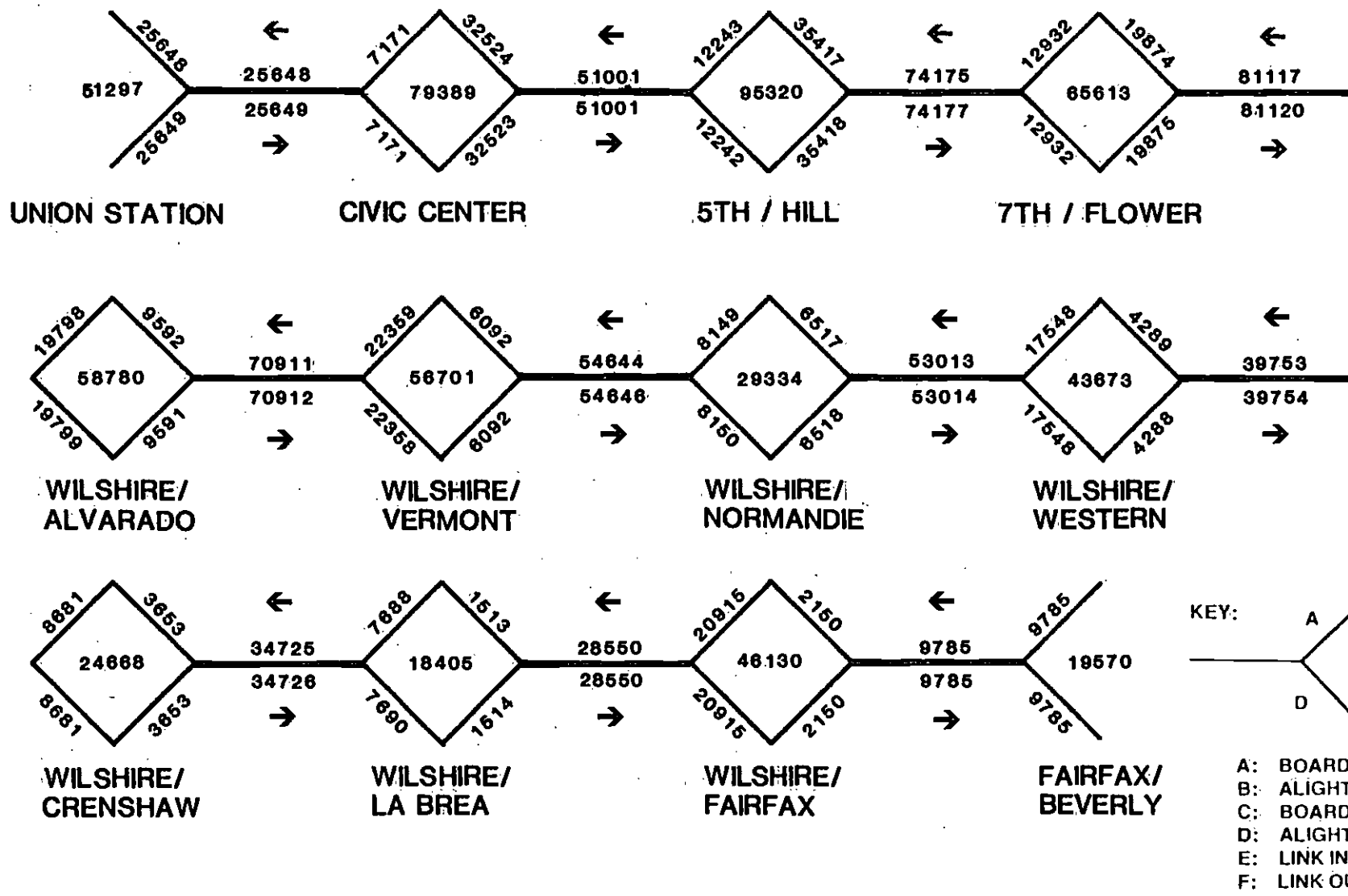
The maximum load point is between the 7th/Flower and Wilshire/Alvarado stations. 162,000 daily trips pass through this link with 10,609 inbound trips in the a.m. peak and 10,408 outbound trips in the p.m. peak. The most heavily used station is at 5th/Hill where approximately 48,000 persons (95,300 trips) are expected daily.(2)

3.2 Trip Times

Run times between stations were calculated using a train performance simulation and the alignment adopted in Milestone 10.(3) The simulation used an initial train acceleration of 3.0 mphps, a service braking rate of 2.7 mphps and, where civil constraints permit, a maximum speed of 70 mph. Run times between station pairs are presented in Table 3-2. The inbound and outbound times differ slightly because of the effect of grades along the alignment. Assuming an average 30 second dwell time at each mid-line station and a 3 minute scheduled turnback time at each terminal station, the round trip time is 44 minutes in peak periods. Station dwell times are smaller in the off-peak (an average of 20 seconds) and round trip time has been estimated at 40 minutes.

3.3 Peak-Hour Service

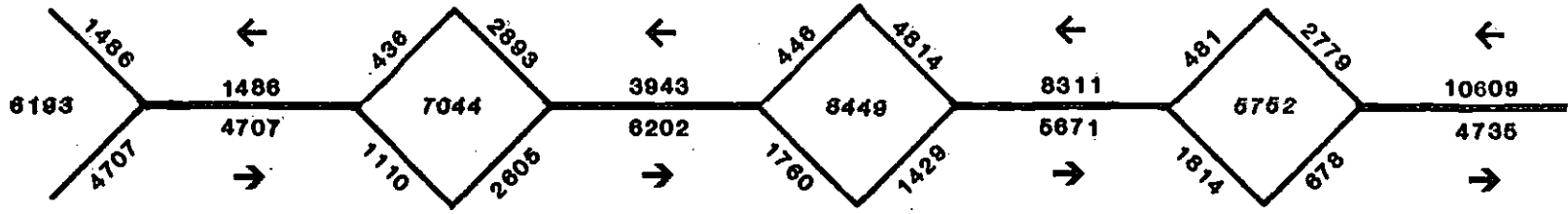
During peak periods, (6 a.m. - 9 a.m. - 6 p.m.) 6-car consists will be operated with a peak load standard of 170 passengers per car, resulting in total train capacity of 1,020 passengers. The greatest demand for Metro Rail service will occur in the morning peak hour (7 a.m. - 8 a.m.). To accommodate the estimated 10,600 inbound



MINIMUM OPERABLE SEGMENT
BOARDING, ALIGHTING & LINK VOLUMES BY DIRECTION
(2000) AVERAGE DAILY VOLUMES

FIGURE 3-1



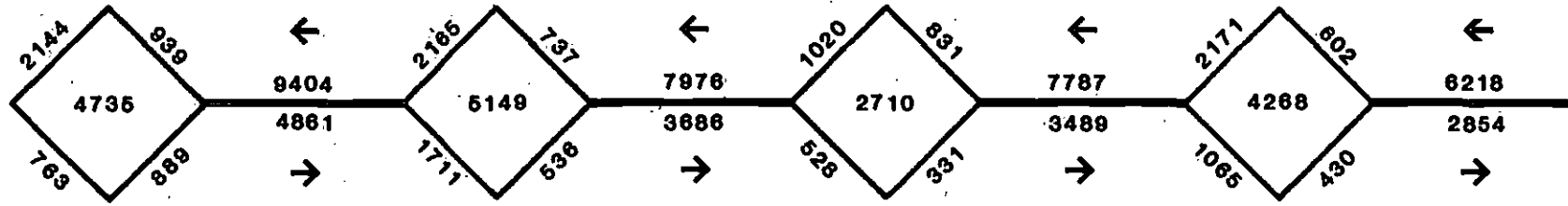


UNION STATION

CIVIC CENTER

5TH / HILL

7TH / FLOWER

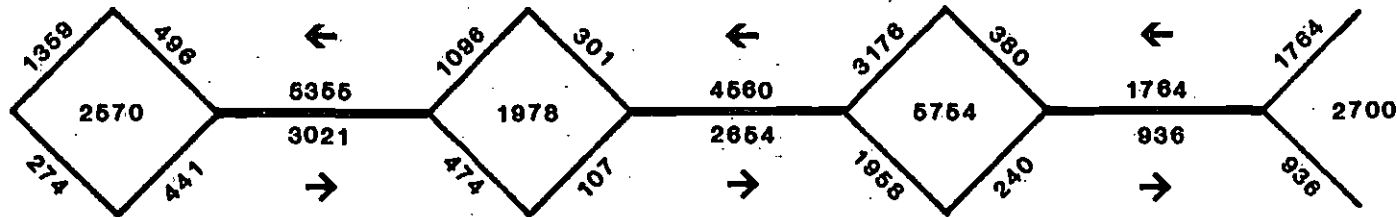


WILSHIRE/
ALVARADO

WILSHIRE/
VERMONT

WILSHIRE/
NORMANDIE

WILSHIRE/
WESTERN



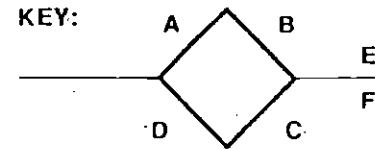
WILSHIRE/
CRENSHAW

WILSHIRE/
LA BREA

WILSHIRE/
FAIRFAX

FAIRFAX/
BEVERLY

KEY:

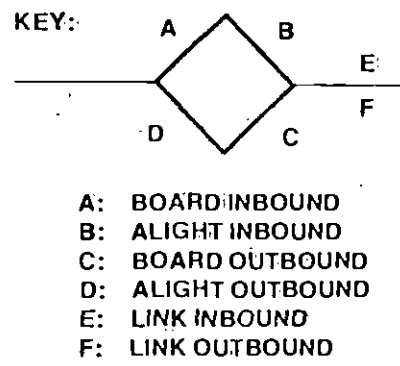
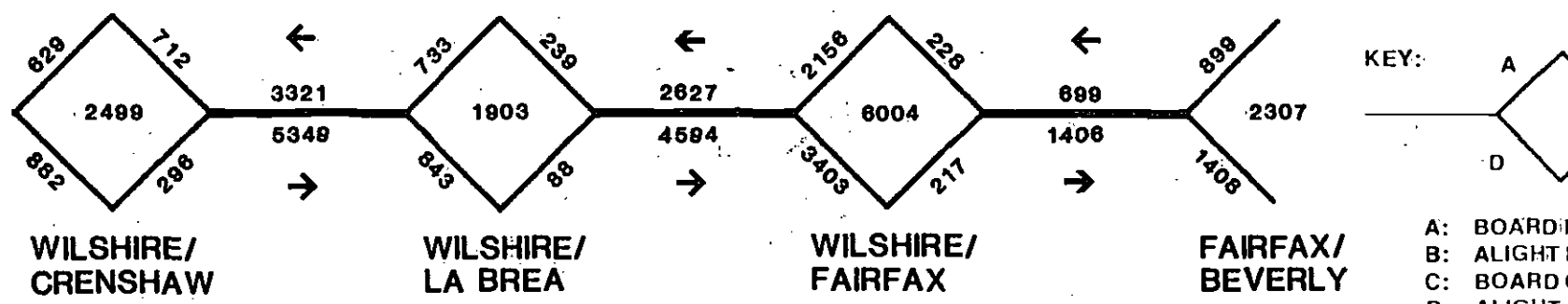
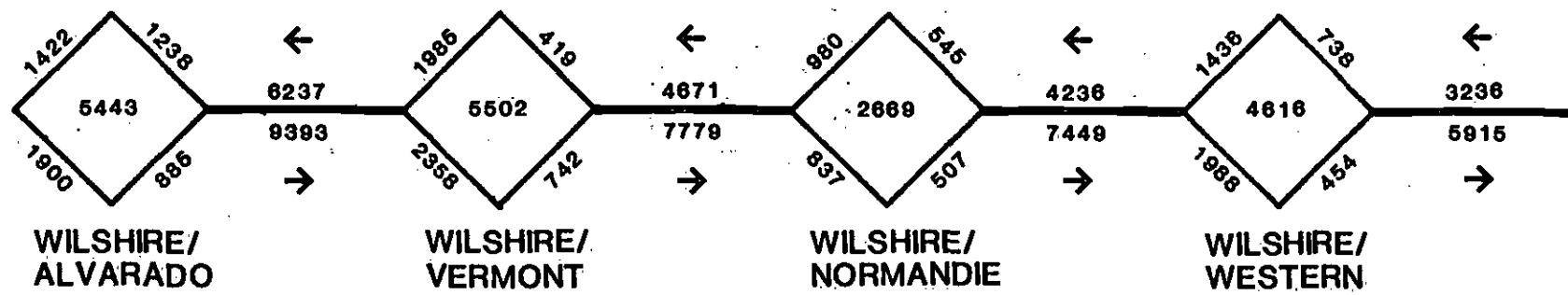
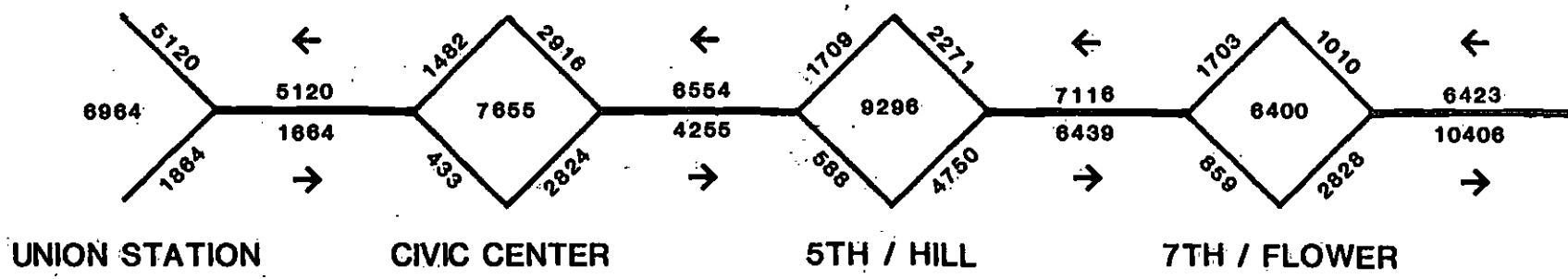


- A: BOARD INBOUND
- B: ALIGHT INBOUND
- C: BOARD OUTBOUND
- D: ALIGHT OUTBOUND
- E: LINK INBOUND
- F: LINK OUTBOUND

**MINIMUM OPERABLE SEGMENT
BOARDING, ALIGHTING & LINK VOLUMES BY DIRECTION
(2000) A.M. PEAK HOUR VOLUMES**

FIGURE 3-2





MINIMUM OPERABLE SEGMENT
BOARDING, ALIGHTING & LINK VOLUMES BY DIRECTION
(2000) P.M. PEAK HOUR VOLUMES

FIGURE 3-3



11

Table 3-2
STATION-TO-STATION RUN TIMES

<u>STATION</u>	<u>TRIP TIMES (SEC)</u>	
	<u>OUTBOUND</u>	<u>INBOUND</u>
Union Station	82	82
Civic Center	55	56
5th and Hill	62	62
7th and Flower	98	104
Wilshire/Alvarado	89	90
Wilshire/Vermont	66	66
Wilshire/Normandie	50	50
Wilshire/Western	65	65
Wilshire/Crenshaw	106	106
Wilshire/La Brea	69	69
Wilshire/Fairfax	94	94
Fairfax/Beverly		
	—	—
	836	844
 TOTAL		
Dwell Times (10 Stops)	300	300
One Way Trip Time	1,136	1,144
	18 min, 56 sec.	19 min, 4 sec

passengers in the peak hour, a minimum of 11 inbound trains will be needed in that period. Of these, 4 trains will be required in the peak 20-minute period to carry the projected 4,000 patrons travelling inbound in that period. Therefore, assuming a constant flow of passengers in the peak 20 minutes, a minimum headway of 5 minutes will be necessary. During the P.M. peak (4 p.m. - 5 p.m.) in the outbound direction, with 3,955 passengers traveling through the maximum load point in the peak 20 minutes, a headway of 5 minutes is required.

Service requirements for the peak periods are summarized in Table 3-3. Patronage, number of trains, and headways are given for the peak 20 minutes, the peak hour, and the remainder of the peak 2-hour period.

A proposed operating schedule for morning service is shown in Table 3-4. This is the period of greatest demand and fleet requirements are most severe in this period. The schedule assumes that all trains will be stored overnight at the downtown yard. Midday layover will also occur exclusively at the yard. As the table shows, light trains will be necessary to support the morning schedule.

3.4 Off-Peak Service

During the off-peak period, the policy headway will govern frequency of service. Train lengths will depend on demand. An average of 3,000 hourly midday passengers are expected to travel through the maximum load point in each direction between 9 a.m. and 2:30 p.m. Four-car trains operating at 7-1/2 minute headways will be sufficient to serve this volume. Two-car consists are not feasible in this period.

TABLE 3-3

SERVICE REQUIREMENTS FOR PEAK PERIODS

	<u>Peak 20 Min.</u>	<u>Remainder of Peak Hour</u>	<u>Remainder Peak 2 Hours</u>
<u>AM PEAK INBOUND</u>			
Maximum Local Ridership	4031	6578	7638
Number of Trains	4	7	8
Required Headway (Minutes)	5	6	7.5
Cars per Train	6	6	6
Train Capacity (passengers)	4080	7140	8160
<u>PM PEAK OUTBOUND</u>			
Maximum Load Ridership	3955	6453	7494
Number of Trains	4	7	8
Required Headway (Minutes)	5	6	7.5
Cars per Train	6	6	6
Train Capacity (passengers)	4080	7140	8160

TABLE 3-4
PROPOSED WEEKDAY MORNING SCHEDULE

<u>TRAIN NO.</u>	<u>DEPART UNION STATION</u>	<u>ARRIVE BEVERLY/ FAIRFAX</u>	<u>DEPART BEVERLY/ FAIRFAX</u>	<u>ARRIVE UNION STATION</u>
1	* 5:09	5:28	5:31	5:50
2	* 5:24	5:43	5:46	6:05
3	* 5:39	5:58	6:01	6:20
4	* 5:46	6:05½	6:08½	6:27½
1	5:54	6:13	6:16	6:35
5	* 6:01½	6:20½	6:23½	6:42½
2	6:09	6:28	6:31	6:50
6	* 6:16½	6:35½	6:38½	6:57½
3	6:24	6:43	6:46	7:05
4	6:31½	6:50½	6:53½	7:12½
1	6:39	6:58	7:01	7:20
7	* 6:45	7:04	7:07	7:26
5	6:51	7:10	7:13	7:32
2	6:57	7:16	7:19	7:38
6	7:02	7:21	7:24	7:43
8	* 7:07	7:26	7:29	7:48
3	7:12	7:31	7:34	7:53
4	7:17	7:36	7:39	7:58
1	7:23	7:42	7:45	8:04
7	7:29	7:48	7:51	8:10@
5	7:35	7:54	7:57	8:16
2	7:41	8:00	8:03	8:22
6	7:47	8:06	8:09	8:28
8	7:53	8:12	8:15	8:34
3	7:59	8:18	8:21	8:40
4	8:06½	8:25½	8:28½	8:47½
1	8:14	8:33	8:36	8:55@
5	8:21½	8:40½	8:43½	9:02½
2	8:29	8:48	8:51	9:10
6	8:36½	8:55½	8:58½	9:17½
8	8:44	9:03	9:06	9:25
3	8:51½	9:10½	9:13½	9:32½
4	8:59	9:18	9:21	9:40
5	9:06½	9:25½	9:28½	9:47½
2	9:14	9:33	9:36	9:55
6	9:21½	9:40½	9:43½	10:02½
8	9:29	9:48	9:51	10:10

*Departs yard
@Enters yard

In the evening (7:30 P.M. - 1:30 A.M.) 2-car trains can be operated, since demand will be very low, averaging 700 passengers per hour per direction at the maximum load point.

On weekends and holidays 4-car trains will be operated during the day and 2-car trains during the night.

3.5 Operating Statistics

Table 3-5 summarizes the service to be provided during the 20-hour operating period on weekdays. In each direction 143 trains will be operated. Table 3-6 summarizes Saturday, Sunday and Holiday service.

Operating statistics are summarized in Table 3-7. On an annual basis, the system will log 47,023 train trips, 34,478 train hours, 153,896 car hours, and 3,693,065 car miles.

These statistics do not include yard movements. All train trips will be operated as revenue service. No dead-heading will occur.

3.6 Fleet Requirements

A total fleet size of 60 cars will be required for year 2000 service.

This provides:

- ° 48 cars for revenue service
- ° 6 cars for terminal spares (gap trains) to replace in-service failures or to fill gaps resulting from significant service delays.
- ° 6 cars for maintenance spares, assuming a 90 percent availability.

TABLE 3-5
SUMMARY OF WEEKDAY SERVICE

PERIOD	HEADWAYS		TRAIN TRIPS		CAR TRIPS		CARS/TRAIN
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	
5:00 a.m. - 5:30 a.m.	--	15	--	2	--	12	6
5:30 a.m. - 6:00 a.m.	15	7.5	2	3	12	18	6
6:00 a.m. - 6:30 a.m.	7.5	7.5	4	4	24	24	6
6:30 a.m. - 7:00 a.m.	7.5	6	4	5	24	30	6
7:00 a.m. - 7:30 a.m.	6	5	6	6	36	36	6
7:30 a.m. - 8:00 a.m.	5	6	5	5	30	30	6
8:00 a.m. - 8:30 a.m.	6	7.5	5	4	30	24	6
8:30 a.m. - 9:00 a.m.	7.5	7.5	4	4	24	24	6
9:00 a.m. - 9:30 a.m.	7.5	7.5	4	4	22	16	6/4
9:30 a.m. - 2:00 p.m.	7.5	7.5	36	36	144	144	4
2:00 p.m. - 3:00 p.m.	7.5	7.5	8	8	34	40	4/6
3:00 p.m. - 4:00 p.m.	7.5	7.5	8	8	48	48	6
4:00 p.m. - 4:30 p.m.	7.5	6	4	5	24	30	6
4:30 p.m. - 5:00 p.m.	6	5	5	5	30	30	6
5:00 p.m. - 5:30 p.m.	5	6	6	6	36	36	6
5:30 p.m. - 6:00 p.m.	6	7.5	5	4	30	24	6
6:00 p.m. - 6:30 p.m.	7.5	7.5	4	4	24	24	6
6:30 p.m. - 7:30 p.m.	7.5	7.5	8	8	48	48	6
7:30 p.m. - 1:30 a.m.	15	15	<u>27</u>	<u>24</u>	<u>66</u>	<u>48</u>	2
			145	145	686	686	

TABLE 3-6
SUMMARY OF SATURDAY, SUNDAY AND HOLIDAY SERVICE

<u>PERIOD</u>	<u>HEADWAYS</u>		<u>TRAIN TRIPS</u>		<u>CAR TRIPS</u>		<u>CARS/ TRAIN</u>
	<u>Inbound</u>	<u>Outbound</u>	<u>Inbound</u>	<u>Outbound</u>	<u>Inbound</u>	<u>Outbound</u>	
	<u>SATURDAY</u>						
5:30 a.m. - 7:30 a.m.	15	15	8	8	32	32	4
7:30 a.m. - 7:30 p.m.	10	10	72	72	288	288	4
7:30 p.m. - 1:30 a.m.	15	15	<u>24</u>	<u>24</u>	<u>48</u>	<u>48</u>	2
			104	104	368	368	
	<u>SUNDAYS/HOLIDAYS</u>						
5:30 a.m. - 7:30 p.m.	15	15	56	56	224	224	4
7:30 p.m. - 1:30 a.m.	15	15	<u>24</u>	<u>24</u>	<u>48</u>	<u>48</u>	2
			80	80	272	272	

TABLE 3-7
SUMMARY OF OPERATING STATISTICS

<u>PERIOD</u>	<u>DAYS/YR</u>	<u>TRAINS</u>	<u>CAR TRIPS</u>	<u>TRAIN HRS</u>	<u>CAR HRS</u>	<u>CAR MILES</u>
Weekdays	255	145	686	106.3	503.1	12,073
Saturdays	52	104	368	76.3	269.9	6,477
Sundays/ Holidays	58	80	272	58.7	199.5	4,787
ANNUAL	365	47,023	209,842	34,478	153,896	3,693,065

3.7 Future Refinement of the Operations Analysis

The operations analysis for the minimum operable segment has been based on the latest system specifications and adopted operating policies, specifically:

- Station locations and route alignment
- Simulated travel times
- Estimated patronage
- Vehicle and other subsystem performance
- Passenger load standards, policy headways, and hours of operation

As these are modified, the operations analysis should be revised accordingly.

This analysis is the first important step in the development of an operating plan for the MOS. Additional analysis must be conducted and documented relative to the following subject areas before the operating plan is complete:

- Perturbed train operations including schedule recovery, abnormal operations, and emergency operations.
- Support for train operations including stations, fare collection, security, maintenance and management information systems.
- System start-up plan including departmental plans, training plan, rulebook, and start-up service.

The operating analysis has a strong influence on capital and operating and maintenance cost estimates. The vehicle fleet is a major component of system capital cost. As peak hour patronage estimates are revised, total fleet requirements are subject to change. Operating statistics such as train trips, vehicle miles, and vehicle hours have a major

This analysis is the first important step in the development of an operating plan for the MOS. Additional analysis must be conducted and documented relative to the following subject areas before the operating plan is complete:

- ° Perturbed train operations including schedule recovery, abnormal operations, and emergency operations.
- ° Support for train operations including stations, fare collection, security, maintenance and management information systems.
- ° System start-up plan including departmental plans, training plan, rulebook, and start-up service.

The operating analysis has a strong influence on capital and operating and maintenance cost estimates. The vehicle fleet is a major component of system capital cost. As peak hour patronage estimates are revised, total fleet requirements are subject to change. Operating statistics such as train trips, vehicle miles, and vehicle hours have a major influence on operating and maintenance cost. Labor costs for train operators, mechanics, and other personnel are incurred in proportion to the service levels provided. Similarly, costs for materials and other expenses including spare parts and electricity fluctuate with varying service levels.

Capital and operating and maintenance cost estimates should be updated on a frequent basis to reflect the latest planned operations as reflected in operating statistics.

REFERENCES

- (1) Booz, Allen & Hamilton, Inc. Preliminary Operating Plan, WBS 13 DAA, May 1982.
- (2) SCRTD Planning Department, Patronage Estimates for the Minimum Operable Segment, March 21, 1983.
- (3) Joel Sandberg, SCRTD, Station-to-Station Run Times Milestone 10 Alignment, March 24, 1983.