2920286

SCRTD METRO RAIL PROJECT

Preliminary Engineering

PRELIMINARY ENGINEERING OPERATING PLAN

SECTION I: PRELIMINARY OPERATING PLAN UPDATE

WBS 16DAA

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November 1983

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SUMMARY

This preliminary engineering operating plan defines service and operating characteristics for the SCRTD Metro Rail system in the year 2000. Its purpose is to describe operations as presently conceived, presenting a frame of reference for system design and for analysis of operating alternatives and operating costs.

As presently configured, the Metro Rail System will be a two-track, 18-mile line between downtown Los Angeles and North Hollywood with 18 stations. A train storage and maintenance facility will be constructed at the downtown terminus. Overnight storage of four trains will be possible at North Hollywood Station. Crossovers and pocket tracks along the line will provide the operational flexibility to minimize the impact on service of an equipment failure.

Rapid transit cars will be configured as dependent pairs and operate in trains of two to six cars. Two interior designs are under consideration: a "low-density" design and a "high-density" one. The low-density design, which seats 59 passengers and holds a peak period load of 162, has been used to develop the operating plan. During the peak period, terminal-to-terminal travel time will be 36½ minutes; round-trip times will be 79 minutes, including terminal layover. During off-peak hours, these times will be 34½ minutes and 75 minutes, respectively, due to shorter station dwell times.

Ridership in the year 2000 is projected to reach 364,000 trips daily. Of these, an estimated 44,000 will be made in the morning peak hour and 41,000 trips will be made in the evening peak hour.

Under current plans, the Metro Rail line will operate 20 hours per day, 7 days per week. Expansion of service to 24 hours will not be precluded by system design.

Service frequency and train length will vary by time of day, as shown in the table on the following page.

Peak-period service will be scheduled to carry 162 passengers in each car through the maximum load point. Off-peak service will conform to established policy headways. On weekdays, 156 train trips will operate in each direction; 104 trips will operate on Saturdays, and 80 will operate on Sundays.

During peak periods, 6-car trains will be run. Day-time service on weekdays and Saturdays will also use 6-car trains to ensure that few riders in the off-peak need to stand for more than one station stop. At other hours and on Sundays, 4-car trains will be sufficient.

A total of 130 cars (65 married pairs) will be required in the year 2000. This total includes a margin for maintenance needs and standby service. On an annual basis, the fleet will log 63,000 train hours, 351,000 car hours, and 9,942,000 car miles of service.

The system will be capable of operating service at 2-minute headways. This will provide sufficient capacity to permit an 86 percent increase in peak-period ridership levels, assuming 6-car trains and 162 passengers per car. If this capacity is achieved prior to an expansion of the 18-mile system, 240 cars will ultimately be required.

TABLE 1

SERVICE LEVELS BY TIME OF DAY

Period		Schedule Headway (minutes)	Consist (Cars)
Weekdays			
Early morning	5:30 a.m. - 6:00 a.m.	15	6
	6:00 a.m. - 6:30 a.m.	7½	6
Peak periods	6:30 a.m. - 9:00 a.m.	3½-6*	6
	3:30 p.m. - 6:30 p.m.	4-6*	6
Midday	9:00 a.m. - 3:30 p.m.	7½	6
Evening	6:30 p.m. - 7:30 p.m.	7½	6
Night	7:30 p.m. - 1:30 a.m.	15	4
Saturdays			
Morning	5:30 a.m. - 7:30 a.m.	15	4
Day	7:30 a.m. - 7:30 p.m.	10	6
Night	7:30 p.m. - 1:30 a.m.	15	4
Sundays and holidays			
All day	5:30 a.m. - 1:30 a.m.	15	4

* During the peak periods service levels will be adjusted to meet demand. During the peak 15-minutes, headways will be 3½ minutes in the morning and 4 minutes in the evening.

PRELIMINARY ENGINEERING OPERATING PLAN

SECTION I: PRELIMINARY OPERATING PLAN UPDATE

CHAPTER 1
INTRODUCTION

This report contains Section I of the preliminary engineering operating plan for the Southern California Rapid Transit District (SCRTD) Metro Rail system. Service and operating characteristics are described for the year 2000 to provide a point of reference for the proposed system's design and for further analysis of operating alternatives and operating costs. Service needs for the year 2000 are presented, including recommended service levels and standards, a proposed train operating schedule, revenue fleet requirements, and pertinent operating statistics. The ultimate capacity requirements of the initial line also are described. This report updates the preliminary operating plan report issued in May 1982.

There are three chapters in the report. Following this introductory chapter, Chapter 2 provides a description of the Metro Rail System and identifies key inputs that were used to develop the service requirements. Chapter 3 presents passenger service requirements including service standards, service levels, operating statistics and fleet requirements for the year 2000. Chapter 3 also defines the ultimate capacity requirements of the initial system.

Subsequent sections of the Preliminary Engineering Operating Plan will include plans for:

- Normal train operations including descriptions of train control and communications procedures, terminal operations, station stopping and system opening and closing.

- 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.

An outline of these planned sections is presented in the Appendix.

CHAPTER 2
SYSTEM DESCRIPTION

Several elements of the system design and analysis conducted in preliminary engineering served as key inputs for the operating plan. These include:

- System Configuration and Equipment: Including the alignment, stations, vehicle performance and capacity, yard and shops, and subsystems.

- Trip Times: Including run times, dwell times, and terminal turnback times.

- Patronage Forecasts: Including total daily trips, trips by time of day, and passenger loads by station and line segment.

The following sections describe these elements in detail.

2.1 SYSTEM CONFIGURATION AND EQUIPMENT

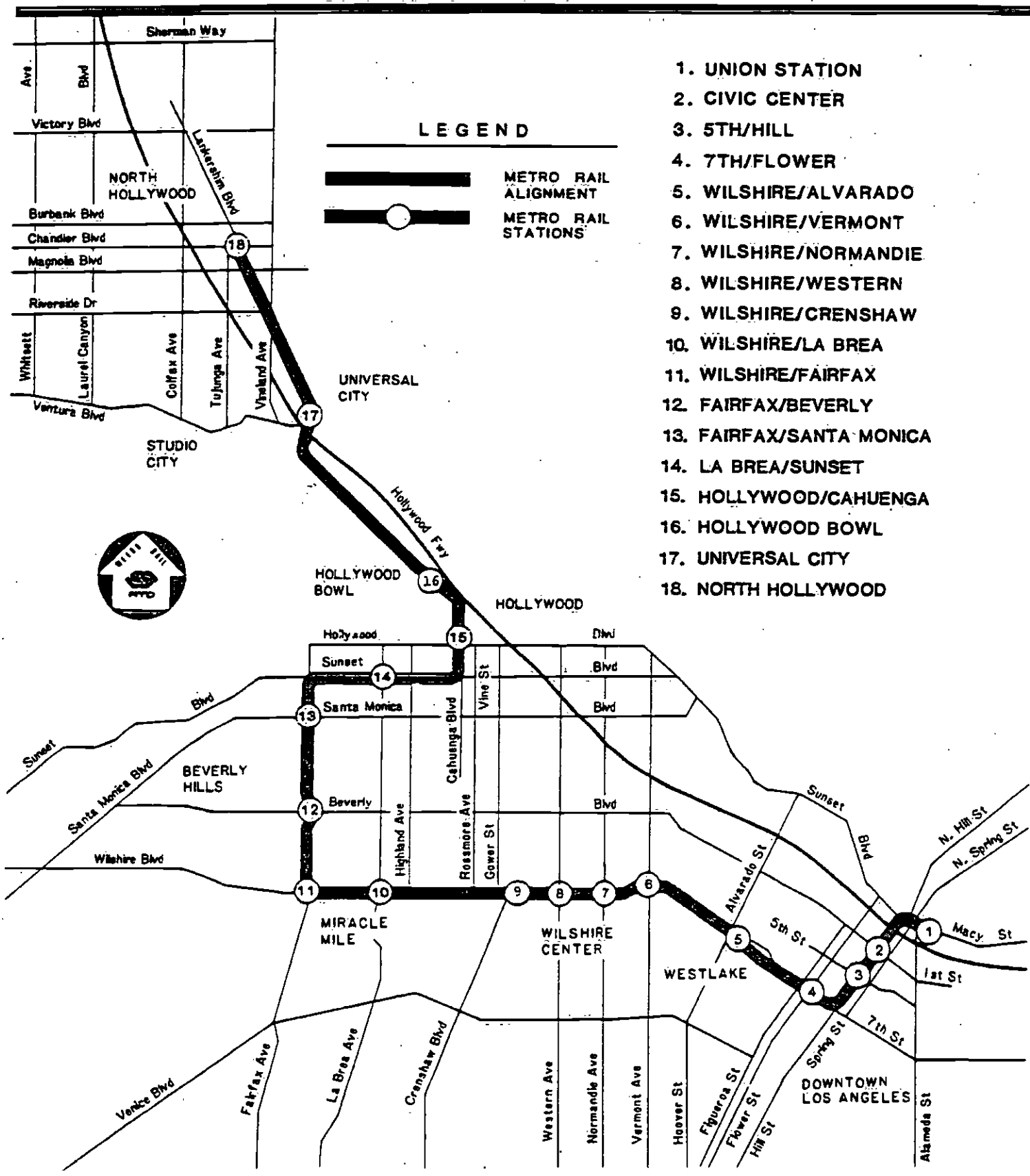
The Metro Rail System is currently planned to open in 1990. The adopted alignment is 18 miles long and will serve downtown Los Angeles, Wilshire, Fairfax, Hollywood, and the San Fernando Valley via its terminus in North Hollywood. It is anticipated that this will be the initial segment of a regional rail rapid transit system. Eighteen stations have been adopted by the SCRTD Board of Directors. Station spacings vary from 0.4 miles downtown to 2.5 miles through the Santa Monica mountains. Figure 2-1 shows the planned horizontal alignment and station locations.

The yard and shops facility near Union Station will be an all-purpose facility capable of vehicle storage, inspection, service, and major repairs and overhaul. Central

Southern California Rapid Transit District

Metro Rail Project

Figure 2-1



control encompassing communications, train control, dispatching, security and other functions, will also be located at a new facility adjacent to Union Station. At North Hollywood, two 500-foot tail tracks will be available for train storage. Crossovers and pocket tracks will be located along the line to provide the operational flexibility needed to minimize the impact on service of an equipment failure. A track schematic of the line is presented in Figure 2-2.

Metro Rail cars will be similar to those used on other new or recently developed rail systems, such as those in Atlanta, Washington, Miami, and Baltimore. The cars will be 75 feet long and will be configured in dependent pairs, with an operator's cab at each end of the pair. Two interior designs are currently under review (8). The high-density alternative includes four door openings on each side of the car, 47 seats, 1 wheel chair location, and 423 square feet of standing area. The low-density alternative includes three door openings, 59 seats, 1 wheelchair location and 338 square feet of standing area. Trains will consist of up to 6 cars.

2.2 TRAVEL TIMES

Round-trip time was calculated to permit an analysis of operations and fleet requirements for the service schedule developed in this operating plan. Based on an analysis of station-to-station run times, station dwell times, and terminal turnback times, a peak-period round trip time of 79 minutes for the 18-mile line has been used for scheduling purposes. Travel time characteristics are given in Table 2-1. The 36½ minute one-way travel time for the line results in an average speed of 30 mph in the peak period. Derivation of the travel time components is discussed in the following sections.

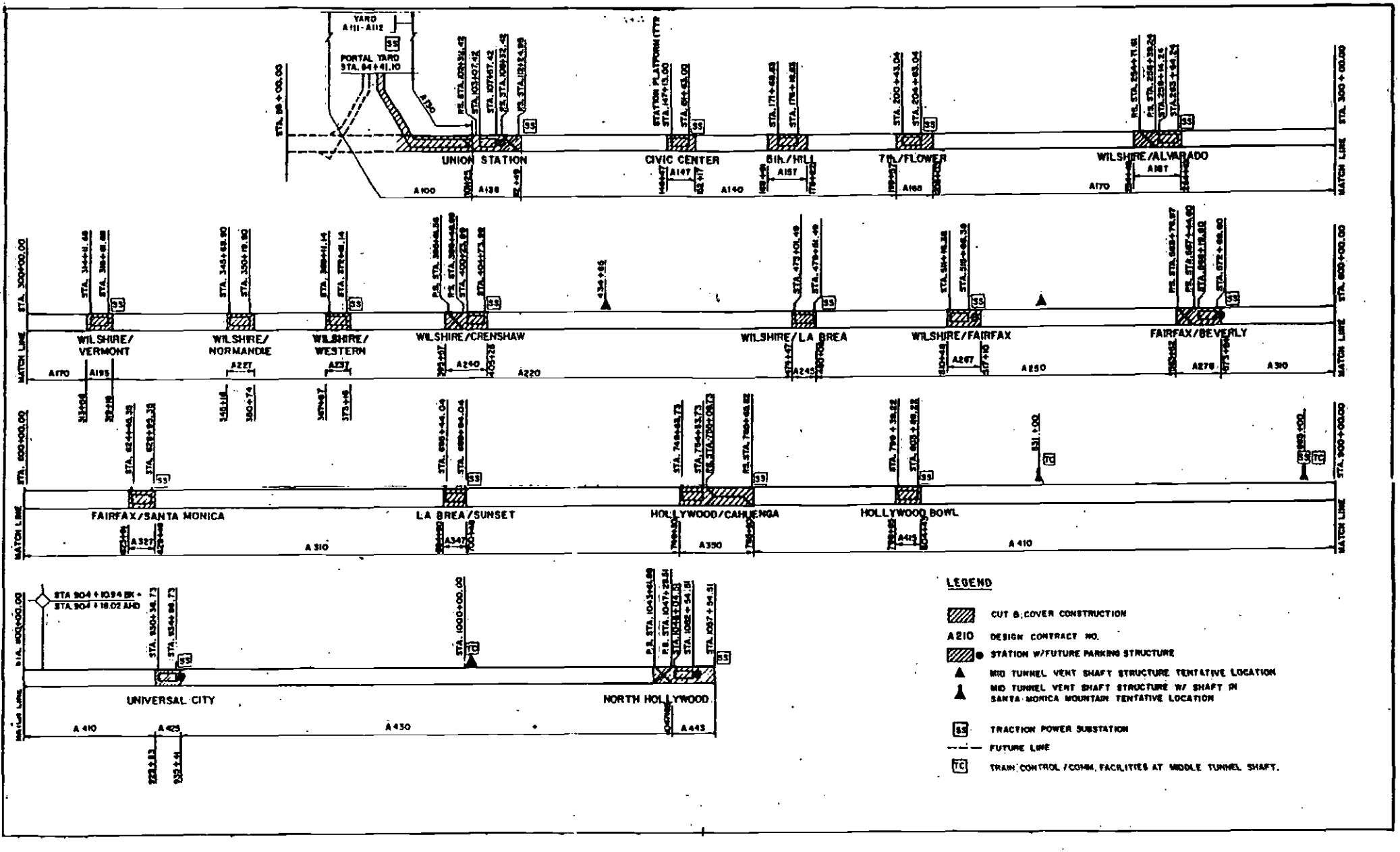


FIGURE 2-2

METRO RAIL TRACK SCHEMATIC

TABLE 2-1

METRO RAIL TRAVEL TIMES

	Run Time (seconds)	Dwell Time Peak (seconds)	Dwell Time Off-Peak (seconds)
Union Station	96		
Civic Center	59	25	20
5th/Hill	69	35	20
7th/Flower	112	35	20
Wilshire/Alvarado	98	35	20
Wilshire/Vermont	74	35	20
Wilshire/Normandie	53	25	20
Wilshire/Western	71	25	20
Wilshire/Crenshaw	111	25	20
Wilshire/La Brea	75	25	20
Wilshire/Fairfax	115	25	20
Fairfax/Beverly	108	25	20
Fairfax/Santa Monica	118	25	20
Sunset/La Brea	119	25	20
Hollywood/Cahuenga	109	25	20
Hollwood Bowl	179	25	20
Universal City	190	25	20
North Hollywood			

One-Way Travel Time:	PEAK:	36 minutes, 36 seconds
	OFF-PEAK:	34 minutes, 36 seconds
Round-Trip Travel Time:	PEAK:	79 minutes, 12 seconds
	OFF-PEAK:	75 minutes, 12 seconds

(Round-trip times include a 3-minute turnback time at each terminal)

Source: Run times are based on train performance simulations using Rail Transit Simulation (RTS) Model. Dwell times are Booz, Allen estimates.

2.2.1 Station-to-Station Run Times

Run times between stations were calculated using a train performance simulator - the Rail Transit Simulator (RTS) model developed by SRI for the Metro Rail Project. The rail system was defined by the route profile that is current as of October 1983. Vehicle performance assumed an initial acceleration rate of 2.7 mphps, a signal brake rate of 2.2 mphps and a station stopping rate of 1.8 mphps (1). These performance characteristics are currently under analysis. (A decision on the performance characteristics to be specified will take into account the impacts on travel time, energy consumption and vehicle motor reliability.)

Trains will be capable of achieving maximum speeds on the system of 70 mph. Under normal conditions, however, trains will operate at 90 percent of permitted civil speeds (9). The automatic train control system will utilize the higher speeds for schedule recovery purposes. Travel times presented in this operating plan were estimated at the 90-percent performance level.

2.2.2 Terminal Turnback Times

Terminal turnback time includes the time required to unload and load passengers and to change train direction. It is measured from the time the doors open to discharge inbound passengers to the time the doors close and the train departs outbound. The turnback time used in scheduling trains must be sufficient to provide a reasonable opportunity for recovery from delays. In light of this requirement, a minimum turnback time of 3 minutes has been used. This is based on analyses performed for the Baltimore Regional Rapid Transit System (2).

Short turnback times will be made possible by scheduling each train operator to "drop back" and depart the terminal on the next train to enter the terminal, rather than on the train in which the operator arrived. This procedure gives the operator time to leave the inbound train and move into position to board the next inbound train at its outbound front end.

2.2.3 Average Dwell Times

Peak-period dwell times are expected to average 35 seconds at major downtown stations and 25 seconds at the remaining stations. During the off-peak, average station dwell times are expected to be 20 seconds or less.

These estimates are supported by an analysis of the boarding and alighting activity expected to occur at each station and the experiences of other properties (3). A scheduling contingency has been included to provide for minor delays in passenger boarding and train operation. Under normal conditions, a minimum dwell time of 10 seconds will be required for door operation and starting the train. This includes time to assure that all doors are clear and a 2-second warning chime and delay between door activation and closure (4). Previous study indicates that passengers can board and alight at the rate of 2 seconds per passenger for each door lane (5). The low-density car design for Metro Rail, which was used for the dwell time analysis, will have three door openings per side with two door lanes per door opening.

2.3 RIDERSHIP FORECASTS

Patronage estimates have been generated by the SCRTD Planning Department for the year 2000 and have been adopted

for Metro Rail use per Design Directive DD-001 (September 1, 1983)(6). Patronage projections by time of day are presented in Table 2-2.

Weekday ridership is expected to reach 364,000 trips by year 2000. Of these, 55 percent will occur in the peak periods (6 a.m. - 9 a.m. and 3 p.m. - 6 p.m.) with 23 percent of the weekday ridership concentrated in the peak hours (7 a.m. - 8 a.m. and 4 p.m. - 5 p.m.).

A "peak-within-the-peak" has been defined for a 15-minute period in each peak hour. Ridership in this 15-minute period is expected to be 28.2 percent of peak hour ridership levels (6).

On a typical weekday, 24 percent of all trips will pass through the maximum load point, the link between 7th/Flower and Wilshire/Alvarado stations (except for outbound traffic in the morning peak which will occur between Civic Center and 5th/Hill). During the peak hours, the ratio of trips in the peak direction to trips in the opposite direction is expected to be roughly 2 to 1 at the maximum load point.

To accommodate ridership levels beyond the year 2000, the system is being designed to carry 1.5 times the year 2000 estimates (6).

TABLE 2-2

METRO RAIL PATRONAGE PROJECTIONS

BY TIME OF DAY

Time Period	Total Ridership	Maximum Load Point	
		Inbound	Outbound
Morning Peak Period			
6 a.m. - 9 a.m. peak period	94,083	26,550*	12,907*
7 a.m. - 8 a.m. peak hour	43,910	13,905	6,223
Midday			
9 a.m. - 3 p.m.	122,181	25,963*	25,963*
Evening Peak Period			
3 p.m. - 6 p.m. peak period	107,571	16,346*	29,856*
4 p.m. - 5 p.m. peak hour	41,314	6,746	12,653
Late Evening			
6 p.m. - 2 a.m.	40,302	8,665*	8,665*
Total Daily	364,137	88,395	88,407

Source: Design Directive DD-001 and additional time-of-day information provided by the SCRTD Planning Department. Asterisked (*) figures are estimates interpolated from the source data.

CHAPTER 3
METRO RAIL PASSENGER SERVICE

This chapter describes service standards for the Metro Rail line and the resulting service levels, operating statistics, and fleet requirements for the year 2000. The service standards are policies that set parameters for minimum service levels. Development of these standards was based on a review of the service levels of other systems and on estimates of year 2000 ridership levels on the Metro Rail system. A train schedule was developed to illustrate how demand levels and service standards would be met and to establish a basis for derivation of fleet requirements and operating statistics. The train schedule incorporated travel times based on characteristics of the route and the vehicle.

3.1 SERVICE STANDARDS

Service standards establish minimum comfort and convenience levels for passenger service. The maximum vehicle loads, hours of service, and minimum frequency of service defined in this operating plan determine the maximum level of crowding and waiting time that a passenger can expect.

3.1.1 Vehicle Load Standards

Three vehicle load standards -- off-peak, peak, and crush -- are defined in Table 3-1. They have been developed for the low-density car design. The first and second standards are for scheduling purposes; the third is for analysis of failure management strategies. The use of two load standards for scheduling purposes provides a means of responding to the different effects of peak and off-peak service levels. Peak service requirements have a greater impact on capital and

operating requirements than off-peak levels. Off-peak ridership, however, typically exhibits a greater sensitivity to service levels and ride quality. For a given service frequency and ridership level, the off-peak load standard will influence consist size.

Off-Peak Load. The off-peak load standard of 90 passengers per car corresponds to a load factor of 1.5. This standard will ensure that few passengers will have to stand for more than one station stop in off-peak periods. Analysis of station boarding and alighting patterns indicates that, with this standard, standing on off-peak trains would occur only between the Wilshire/Western and 5th/Hill stations and that, with regular turnover of passengers at stations along Wilshire Boulevard, no passengers would need to stand for more than 3 minutes.

Peak Load. A peak-load standard of 162 passengers per car will provide adequate room for circulation among standees and thus aid in minimizing station dwell times. This standard is comprised of the seating capacity for 59 passengers, one wheelchair location, and space for 102 standees, based on a standing density of 3.3 square feet per passenger. A standing density of 3.0 square feet per passenger is considered the minimum required for adequate circulation (7). In light of the boarding and alighting activity expected at stations near the maximum load point (typically 10 to 33 percent of passengers on the train will be alighting at each stop), this circulation is necessary to prevent undesirably long dwell times. A 10 percent contingency, resulting in 3.3 square feet per standee, was added to allow for imbalances in vehicle loading that occur during the peak period; such imbalances could result from deviations in the established headway or average passenger flow or from an uneven distribution of passengers on the train.

TABLE 3-1

VEHICLE LOAD STANDARDS

(LOW-DENSITY VEHICLE)

Load	No. of Passengers	Load Factor	Area per Standee (sq ft)
Off-peak	90	1.5	11.2
Peak	162	2.7	3.3
Crush	195	3.3	2.5

Crush Load. The crush load standard for the low-density car of 195 passengers per car has been defined by Metro Rail Transit Consultants for emergency egress planning purposes (8). It has been based on a 59-passenger seating capacity, one wheelchair location and 2.5 square feet per standee. This standing density is an average for a 6-car train, in which densities throughout the train may range between 2.0 and 3.0 square feet. (The crush load for structural design of the passenger vehicle has been defined as 229 persons (8).)

3.1.2 Hours of Service

Metro Rail is being designed to permit flexibility in establishing the hours of service. In light of the minimal demand anticipated for rail service between 1:30 and 5:30 a.m. and the availability of local bus service in the corridor during that period, a 20-hour service has been defined. Hours of service at the maximum load point will be approximately 5:30 a.m. to 1:30 a.m. daily, including Saturdays, Sundays, and holidays. Departure of the first train from the yard and arrival of the last train at the yard will occur slightly beyond these hours.

The period between 1:30 a.m. and 5:30 a.m. will be used for efficient, uninterrupted right-of-way maintenance. Nothing in the design of the Metro Rail system, however, will preclude 24-hour operation if such service becomes appropriate.

3.1.3 Policy Headway

Policy headway defines the maximum waiting time for patrons at different times of the day. Headways shorter than policy are provided as required to satisfy vehicle

loading standards or to relay equipment to points where it is needed. Deadheading will be restricted to disabled trains.

The policy headways adopted for Metro Rail are given in Table 3-2. Their definition took into consideration anticipated demand levels along the Metro Rail corridor and service levels on other systems.

Service frequencies on other systems range from 2 to 10 minutes between peak-period trains and from 5 to 10 minutes between midday trains. Service hours and off-peak frequency may be adjusted following the initiation of service as actual ridership characteristics become apparent.

3.2 SERVICE REQUIREMENTS

This plan is based on the following operating philosophy:

- All trains will operate the full length of the line, stopping at each station.
- Train service will be provided at the policy headway unless vehicle loading or vehicle relaying (positioning) requires additional service.
- Minimum schedule headways will be determined by the capacity needs of the peak 15-minute period. Peaking within that period has been assumed to be minimal.

3.2.1 Peak-Hour Service

During peak periods, the maximum consist of 6-car trains will be operated. With a peak load of 162 passengers per car, these trains can carry 972 passengers. To accommodate projected ridership levels, it will be necessary to carry

TABLE 3-2

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.	7½
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.	7½
Evening	6:30 p.m. - 7:30 p.m.	7½
Night	7:30 p.m. - 1:30 p.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

13,905 inbound passengers traveling through the maximum load point in the morning peak hour. As Table 3-3 shows, 14 inbound train trips must be scheduled in that 1-hour period. Similarly, a minimum of 4 train trips must be scheduled to accommodate the 3,921 inbound passengers at the maximum load point in the peak 15-minute period. Assuming a relatively constant passenger flow during the 15-minute peak, this latter requirement means that, at the height of the peak, a headway of 3½ minutes will be necessary.

Ridership in the evening peak period will be somewhat lower, with 12,653 riders traveling through the maximum load point in the peak hour. During the evening peak 15 minutes, 4-minute headways will be necessary to carry the maximum load ridership of 3,568.

With a nominal round-trip time in the peak period of 79 minutes, 18 6-car train sets will be needed to provide peak period service.

A proposed operating schedule for weekday morning service is shown in Table 3-4. Overnight train storage at North Hollywood is limited to four trains: two trains on the tail tracks and two in the immediate station area. As a result, most morning trains will be dispatched from Union Station. Trains operating in the outbound direction will be under capacity since headways are determined by ridership through the maximum load point in the inbound direction.

As is demonstrated in the table, 18 train sets are required to provide peak hour service.

TABLE 3-3

PEAK-HOUR SERVICE REQUIREMENTS

	Maximum Load Ridership	Mimimum No. of Trains	Req'd Headway (min.)
Morning Peak (Inbound Direction)			
Hour	13,905	14	--
Peak 15 Minutes	3,921	4	3.5
Remainder of Peak Hour	9,984	10	4.5
Remainder of Peak 2 Hours	10,012	10	6
Evening Peak (Outbound Direction)			
Hour	12,653	13	--
Peak 15 Minutes	3,568	4	4.0
Remainder of Peak Hour	9,085	9	5.0
Remainder of Peak 2 Hours	9,110	9	6

TABLE 3-4

WEEKDAY MORNING TRAIN SCHEDULE - YEAR 2000

Train No.	Depart Union Station	Arrive North Hollywood	Depart North Hollywood	Arrive Union Station		Train Headway
1			*5:13	5:47½		15
4			*5:28	6:02½		15
6			*5:35½	6:10		7½
7			*5:43	6:17½		7½
10	*5:13	5:47½	5:50½	6:25		7½
12	*5:20½	5:55	5:58	6:32½		7½
14	*5:28	6:02½	6:05½	6:41		7½
15	*5:35½	6:10	6:13	6:48½		7½
17	*5:41½	6:16	6:19	6:55½		6
18	5:47½	6:22	6:25	7:01½		6
1	*5:53½	6:28	6:31	7:07½		6
2	*5:59½	6:34	6:37	7:13½		6
3	*6:04	6:38½	6:41½	7:18	@	6
4	6:08½	6:43	6:46	7:22½		6
5	*6:12	6:47½	6:50½	7:27		4½
6	6:16½	6:52	6:55	7:31½		4½
7	6:21	6:56½	6:59½	7:36	@	4½
8	*6:23½	7:00	7:03	7:39½		3½
9	*6:27	7:03½	7:06½	7:43		3½
10	6:30½	7:07	7:10	7:46½		3½
11	*6:34	7:10½	7:13½	7:50		3½
12	6:38½	7:15	7:18	7:54½	@	4½
13	*6:43	7:19½	7:22½	7:59		4½
14	6:47½	7:24	7:27	8:03½	@	4½
15	6:52	7:28½	7:31½	8:08		4½
16	*6:56½	7:33	7:36	8:12½		4½
17	7:02½	7:39	7:42	8:18½	@	6
18	7:08½	7:45	7:48	8:24½		6
1	7:14½	7:51	7:54	8:30½		6
2	7:20½	7:57	8:00	8:36½		6
4	7:26½	8:03	8:06	8:41½		6
5	7:32½	8:09	8:12	8:47½	@	6
6	7:38½	8:15	8:18	8:53½		6
8	7:44½	8:21	8:24	8:59½		6
10	7:50½	8:27	8:30	9:04½	@	6
11	7:56½	8:33	8:36	9:10½		6
13	8:02½	8:39	8:43½	9:18		7½
14	8:08½	8:45	8:51	9:25½		7½
15	8:14½	8:51	8:58½	9:33		7½
16	8:20½	8:57				
18	8:27½	9:03	9:06	9:40½		7½

TABLE 3-4 (Continued)

Train No.	Depart Union Station	Arrive North Hollywood	Depart North Hollywood	Arrive Union Station	Train Headway
1	8:35	9:10½	9:13½	9:48	7½
2	8:42½	9:18	9:21	9:55½	7½
4	8:50	9:25½	9:28½	10:03	7½
6	8:58½	9:33	9:36	10:10½	7½
8	9:06	9:40½	9:43½	10:18	7½
11	9:13½	9:48	9:51	10:25½	7½
13	9:21	9:55½	9:58½	10:33	7½

* train departs from yard
@ train enters yard
_____ boundary of peak hour
-------- boundary of peak 15-minutes

3.2.2 Off-Peak Service

During the off-peak period, train lengths must satisfy the load factor standard of 1.5 times seated capacity, or 90 passengers per car. For the estimated hourly midday passengers traveling through the maximum load point in each direction, 6-car trains will be necessary for the specified headways of 7½ minutes. On Sundays and holidays and in the early mornings and evenings on weekdays and Saturdays, when low ridership levels are anticipated, 4-car trains will be operated at the specified 15-minute headways.

With an average dwell time of 20 seconds at the intermediate stations during the off-peak, nominal round-trip times will be 75 minutes. Ten trains will be required for midday service during the week and five trains will be needed for late evening service.

3.3 OPERATING STATISTICS

Table 3-5 summarizes the service to be provided during the 20-hour operating period on weekdays. Differences between the headways in Table 3-5 and the policy headways specified in Table 3-2 are due to peak-period demand levels that exceed minimum service capacity.

Operating statistics are summarized in Table 3-6. Train and car hours are based on average, not nominal, round-trip times. On a typical weekday, 156 train trips will be operated in each direction, logging 198.8 train hours, 1,143 car hours, and 32,256 car miles. On an annual basis, the system will log 63,000 train hours, 351,000 car hours, and 9,942,000 car miles.

TABLE 3-5

SUMMARY OF WEEKDAY SERVICE*

Period	Train Trips		Car Trips	
	Inbound	Outbound	Inbound	Outbound
5:00 a.m. - 6:00 a.m.	2	7	12	42
6:00 a.m. - 6:30 a.m.	4	7	24	42
6:30 a.m. - 7:00 a.m.	5	7	30	42
7:00 a.m. - 7:30 a.m.	7	5	42	30
7:30 a.m. - 8:00 a.m.	7	5	42	30
8:00 a.m. - 8:30 a.m.	5	5	30	30
8:30 a.m. - 9:00 a.m.	5	4	30	24
9:00 a.m. - 9:30 a.m.	4	4	24	24
9:30 a.m. - 10:00 a.m.	4	4	24	24
10:00 a.m. - 3:00 p.m.	40	40	240	240
3:00 p.m. - 3:30 p.m.	4	4	24	24
3:30 p.m. - 4:00 p.m.	4	5	24	30
4:00 p.m. - 4:30 p.m.	5	5	30	30
4:30 p.m. - 5:00 p.m.	5	7	30	42
5:00 p.m. - 5:30 p.m.	5	6	30	36
5:30 p.m. - 6:00 p.m.	7	5	42	30
6:00 p.m. - 6:30 p.m.	6	4	36	24
6:30 p.m. - 7:00 p.m.	5	4	30	24
7:00 p.m. - 7:30 p.m.	4	4	24	24
7:30 p.m. - 1:30 a.m.	28	24	128	104
	156	156	896	896

* Measured at Wilshire/Vermont, nearest the maximum load point.

TABLE 3-6

SUMMARY OF OPERATING STATISTICS

Period	Days Per Year	No. of Train Trips	No. of Car Trips	Train Hours	Car Hours	Car Miles
Weekdays	255	156	896	198.8	1,143.0	32,256
Saturdays	52	104	560	130.0	700.0	20,160
Sunday/ Holidays	58	80	320	100.0	400.0	11,520
Annual	365	49,828	276,160	63,254	351,065	9,941,760
Annualization Factor		319	308	318	312	308

3.4 FLEET REQUIREMENTS

A total fleet size of 130 cars will be required for 2000 service:

- 108 cars for revenue service (peak-hour service of 18 6-car trains)
- 6 cars for terminal spares (one gap train) to replace in-service failures or to fill gaps resulting from significant service delays
- 16 cars for maintenance spares, assuming 88-percent availability

3.4.1 Terminal Spares

One standby (or gap) train will be located at Union Station terminal. The gap train will enter service in the event that another train must be removed from service due to hardware failure or if additional equipment is required because of passenger volume irregularities. This will permit rapid response to equipment failure and limit the resulting impacts on service.

It is anticipated that at least one 6-car gap train will be needed two to four times each week during peak periods. This estimate is based on the mean-time-between-service-failures (MTBSF) experience of existing properties and the probability of vehicle failure during the 2-hour peak period (2).

During the off-peak periods, a second standby train will be stored at North Hollywood terminal. This will be placed in service in the event a train must be removed from service at North Hollywood due to equipment trouble. Although

it would be preferred that the standby train be stored there during the peak periods as well, the current track configuration of the North Hollywood terminal makes this impractical. Storing the train on one of the short 500-foot tail tracks would require that trains platforming on the adjoining track either enter the terminal under manual control with a stop-and-proceed procedure, or enter with a low commanded speed. This is undesirable for reasons of patron comfort and safety.

3.4.2 Maintenance Spares

Unavailability due to corrective maintenance is determined by vehicle reliability (mean-time-between-failures, or MTBF) and shop maintenance capacity. It is also influenced by fleet composition; lower availability can be expected with a fleet of married pairs than with one of single cars, since two cars are made unavailable by most failures. In addition, for planning purposes, the availability factor should consider the potential prolonged loss of equipment from active service due to unforeseen car damage.

During the early years of operation, lower levels of availability should be anticipated. An 88 percent availability level may not be achieved during the first 3 to 5 years. Once the Metro Rail system has matured, the targeted 88 percent availability factor should provide adequate contingency for vehicle loss and maintenance requirements provided that: (a) stringent vehicle specification and procurement procedures are implemented to ensure that reasonable reliability and maintainability goals can be achieved; and (b) maintenance facilities have sufficient capacity and are properly staffed for quick repairs and servicing.

3.5 ANALYSIS OF MIDLINE TURNBACKS

As described in Section 3.2 - Service Requirements, the Operating Plan is based on an operating philosophy in which every train operates from terminal to terminal stopping at every station on the line. This section examines an alternative operating strategy. In this scenario, half of the trains in the peak periods operate between Union Station and North Hollywood. Every other train, however, operates only between Union Station and a selected midline station such as Beverly/Fairfax. Stations north of the midline turnback station are, therefore, served by every other train in the peak period. During the off-peak period, the operating philosophy reverts back to terminal-to-terminal running for all trains.

Beverly/Fairfax station is a logical place for a midline turnback because 53 percent of all peak period boardings and alighting occur at stations between this and Union Station; this section of the 18-mile line represents, however, only 49 percent of its length. Operationally, a pocketback is required on the north end of the Beverly/Fairfax station for the midline turnback concept at this station to be feasible.

During the peak 2 hours in each peak period, every other train would turnback at the Beverly/Fairfax station, with the remainder continuing on to North Hollywood. No stations would be bypassed by trains, however. During the 15-minutes, trains would be dispatched from Beverly/Fairfax and from North Hollywood at 7-minute intervals, resulting in an average 3½-minute headway downtown. For the remainder of the peak 2 hours, trains would be dispatched at 9-minute intervals from each terminal, resulting in a 4½-minute headway downtown.

A sample train schedule of the morning peak period is presented in Table 3-7, showing turnback service at Beverly/Fairfax. As the schedule shows, 16 6-car train sets would be necessary for this service. Headways during the turnback operation have been skewed to ensure that passenger loadings among trains are even. Without this skewing, trains from North Hollywood would become overcrowded, because these trains will be serving more stations. Skewing will result in more passengers south of Beverly/Fairfax boarding the turnback trains.

Implementation of the turnback operation will reduce the fleet size needed for year 2000 service by 14 cars, 12 for revenue service and 2 for maintenance spares. Vehicle hours and miles will also be reduced, as shown in Table 3-8, resulting in lower annual operating and maintenance costs.

The chief disbenefit of the turnback operation is that service levels to peak-period patrons north of Beverly/Fairfax station will be roughly half of the baseline all-stop service. Under the baseline schedule (in Table 3-2), all patrons will receive 3½-6 minute service. With turnback service, 47 percent of the riders - those north of Beverly/Fairfax - will receive 7-10 minute service.

Alternating headways between 2½ minutes and 4½ minutes, while necessary to balance passenger loading, will limit the applicability of a turnback operation. As ridership grows beyond the projected year 2000 levels the 2½ minute headway will need to be reduced to 2 minutes. Eventually, when this, too, becomes inadequate, Metro Rail will need to revert to an even, unskewed headway to increase capacity.

In turn, the turnback service option will permit a reduction in initial procurement and annual operating and

TABLE 3-7

WEEKDAY MORNING TRAIN SCHEDULE

YEAR 2000, TURNBACK SERVICE

Train No.	Depart Union Station	Arrive Beverly/ Fairfax	Arrive North Hollywood	Train No.	Depart North Hollywood	Depart Beverly/ Fairfax	Arrive Union Station	Train Headway
				* 1	5:13		5:47½	15
				*102	5:28		6:02½	15
				* 3	5:35½		6:10	7½
				* 4	5:43		6:17½	7½
6	*5:13½		5:47½	6	5:50½		6:25	7½
105	*5:21		5:55	105	5:58		6:33½	7½
106	*5:28½		6:02½	106	6:05½		6:42	7½
				101		6:28	6:48	4½;9
9	*5:37		6:11½	9	6:14½		6:51	4½;9
				102		6:37	6:57	4½;9
10	*5:46		6:20½	10	6:23½		7:00	4½;9
				103		6:46	7:06	4½;9
1	5:55		6:29½	1	6:32½		7:09	4½;9
101	*5:59½	6:18		104		6:55	7:15	4½;9
2	*6:04		6:38½	2	6:41½		7:18	4½;9
102	6:09½	6:28		105		7:04	7:24	4½;9
3	6:13		6:47½	3	6:50½		7:27	4½;9
103	*6:17	6:37		106		7:11½	7:31½	3½;7
4	6:20		6:54½	4	6:57½		7:34	3½;7
				101		7:18½	7:38½	3½;7
5	*6:23½		7:00	5	7:04½		7:41	3½;7
104	*6:27	6:47		102		7:27	7:47	4½;9
6	6:30½		7:07	6	7:13½		7:50	4½;9
105	6:37	6:57		103		7:36	7:56@	4½;9
7	*6:40½		7:17	7	7:22½		7:59	4½;9
106	6:45	7:05		104		7:45	8:05@	4½;9
8	*6:48½		7:25	8	7:31½		8:08	4½;9
101	6:52½	7:12½		105		7:54	8:14	4½;9
9	6:56½		7:33	9	7:40½		8:17	4½;9
102	7:01½	7:21½		106		8:03	8:23@	4½;9
10	7:05½		7:42	10	7:49½		8:26	4½;9
103	7:10½	7:30½		101		8:12	8:32@	4½;9
1	7:14½		7:51	1	7:58½		8:35	4½;9
104	7:19½	7:39½		102		8:21	8:41@	4½;9
2	7:23½		8:00	2	8:07½		8:44	4½;9
105	7:28½	7:48½						
3	7:31½		8:09	3	8:15		8:51½	7½
106	7:36½	7:56½						
4	7:41½		8:19	4	8:23½		8:58	7½
101	7:45½	8:05½						
5	7:50½		8:28	5	8:31		9:05½	7½

TABLE 3-7 (Continued)

Train No.	Depart Union Station	Arrive Beverly/ Fairfax	Arrive North Hollywood	Train No.	Depart North Hollywood	Depart Beverly/ Fairfax	Arrive Union Station	Train Headway
102	7:54½	8:14½						
6	8:01		8:35½	6	8:38½		9:13	7½
7	8:07		8:41½	7	8:46		9:20½	7½
8	8:13		8:47½	8	8:53½		9:28	7½
105	8:19		8:53½	9	9:01		9:35½	7½
9	8:25		8:59½@					
10	8:31		9:05½	10	9:08½		9:43	7½
1	8:38½		9:13	1	9:16		9:50½	7½

* train departs from yard
@ train enters to yard
_____ boundary of peak hour
----- boundary of peak 15 minutes

TABLE 3-8

COMPARISON OF OPERATING STATISTICS

FOR TURNBACK SERVICE TO THE BASELINE

Period	Train Trips		Car Trips		Train Hours		Car Hours		Car Miles	
	Total	Δ %	Total	Δ %	Total	Δ %	Total	Δ %	Total	Δ %
Weekdays	162	3.9%	932	4.0%	193.2	-2.8%	1,109.0	-3.0%	31.544	-2.2%
Annual	51,358	3.1%	285,340	3.3%	61,817	-2.3%	342,395	-2.5%	9,760,200	-1.8%

maintenance costs, at some expense to peak period patrons, but will be feasible only until ridership grows to a level at which skewed headways are no longer possible.

3.6 ULTIMATE SYSTEM CAPACITY

The Metro Rail system must be designed to accommodate growth beyond the horizon year 2000, without requiring major reconstruction. This chapter examines the ultimate capacity that will be achievable by the current system design.

Three major factors determine throughput capacity:

- Maximum Train Length: Maximum train length has been established at 6 cars.

- Minimum Headways: The train control system has been specified to provide a design headway of 90 seconds (8). Under ideal conditions, trains will be able to operate at maximum performance at 90 second headways. In practice, schedule headways should be set higher than the design headway to compensate for random delays in train operation. For a 90-second design headway, it is prudent to schedule trains no less than 120 seconds apart.

- Vehicle Loading: Various levels of maximum vehicle loading can be assumed. Each has an associated passenger comfort level. A level of 162 passengers per car has been used in establishing system capacity. As was discussed in Section 3.1, this provides adequate room for circulation among standees and thus aids in minimizing station dwell times.

Having established these parameters, maximum capacity is 29,160 passengers per hour per direction. The corresponding peak 15-minute capacity of 7,290 is 86 percent greater than the year 2000 patronage estimate. When peak period ridership reaches this level, 240 cars will be necessary: 198 for revenue service, 12 for terminal spares and 30 for maintenance spares.

The passenger capacity provided at 2-minute headways exceeds the 50-percent increase over year 2000 ridership levels for which Metro Rail stations and facilities are being planned. A 50-percent increase in peak 15-minute ridership levels results in a maximum load of 5,882 riders which will require six 6-car trains operating at 2½-minute headways. Thus, while the system will be capable of operating 2-minute service, only 2½ minute service will be required before the design capacity of other elements of the system has been reached.

When ridership levels have reached levels 50-percent above the year 2000 projections, a total of 198 cars will be required: 162 for revenue service, 12 for terminal spares and 24 for maintenance spares.

3.7 REFINEMENT OF THE OPERATING PLAN

The operations described in this report is based on the latest understanding of Metro Rail design and system analysis. As further refinements are made to the design and specification of system elements, this plan should be revised accordingly.

Specific elements that have a major bearing on the operating plan include:

- Patronage estimates
- Subsystems specifications for vehicles and train control
- Fixed facilities including stations and trackwork
- Miscellaneous systems analysis including simulated travel times and minimum headways.

The operating plan should therefore be reviewed on a periodic basis and revised as necessary to reflect current patronage estimates, design decisions and operating philosophy.

REFERENCES

(1) Meeting with Les Durrant, RTD Transit System Development Department, regarding anticipated vehicle performance characteristics, November, 1983.

(2) Booz, Allen & Hamilton, Inc., Special Study of the Appropriate Fleet Size, Parts I and II, BRRTS, Section A, April, 1979.

(3) U.S. Department of Transportation, Urban Mass Transportation Administration, and Southern California Rapid Transit District, Summary of Peer Review Board Comments on Operational Features, August 13 and 14, 1981.

(4) Metro Rail Project, Passenger Vehicle Intermediate Specification, August, 1983.

(5) U.S. Department of Transportation, Urban Mass Transportation Administration, Alternatives Analysis Procedure and Technical Guidelines, Appendix A: Estimation of Transit Supply Parameters, December, 1980.

(6) Metro Rail Project Design Directive DD-001, "Metro Rail Project Design Patronage", September 1, 1983.

(7) John J. Fruin, Pedestrian Planning and Design, Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York, 1971.

(8) Memorandum from Metro Rail Transit Consultants, "Action Item #1 - Passenger Vehicle Specification Design Review", October 28, 1983.

(9) Metro Rail Project, Automatic Train Control Intermediate Specification August, 1983.

APPENDIX

Outline of Sections II and III
of the
Preliminary Engineering Operating Plan

SECTION II: PLANS FOR TRAIN OPERATIONS

4.0 NORMAL TRAIN OPERATIONS

4.1 Train Control

° A description of the train control system functions that will be provided for Metro Rail operations

- ATP
- ATO
- ATS

° A description of the personnel and their responsibilities in train operations

- train operators; note will be made of assumptions concerning their labor agreement
- central controllers and supervisor
- terminal and line supervisors
- yard operators, controllers, and supervisor

4.2 Communications

° A description of the communications that will be required and provided among operations and support personnel to control train operations. Personnel include:

- train operators
- central controllers and supervisor
- yard operators, controllers, and supervisor
- terminal and line supervisors
- station agents
- passenger communications operator

- maintenance of way supervisor
- vehicle maintenance supervisor
- fire and life safety supervisor
- transit security officer

4.3 Terminal Operations

° A description of the activities which occur at terminals

- transfer of trains between the yard and mainline through the transfer zones
- scenarios for turnback at terminals

  .. Union Station
  .. North Hollywood
  .. midline

- train makeup and breakup procedures, at:

  .. Union Station
  .. North Hollywood, if necessary
  .. pocket tracks

- use of standby equipment to maintain service reliability

  .. standby equipment positioning
  .. peak-fringe equipment transfers

4.4 Station Stop

° A description of the station stop procedures, including:

- ATO mode
- MTO mode
- runthrough, by Central and Train Operator command
- overshoot recovery
- door operation
- train departure

4.5 Daily Operations Procedures

° A description of the daily operations procedures for opening, running, and securing the system, including:

- system opening
  - .. equipment marshalling
  - .. subsystem initialization, including traction power, train control, MIS
  - .. sweeper train operation
  - .. station opening
- system running
- system shutdown
  - .. station closing
  - .. sweeper train operation
  - .. subsystem shutdown
  - .. maintenance coordination
  - .. record keeping

5.0 Perturbed Train Operations

5.1 Schedule Recovery

° A description of the techniques and procedures for restoring train operations to schedule after minor disturbances

- dwell control
- speed and acceleration modification
- terminal turnback time

5.2 Abnormal Operations

° A discussion of incidents and equipment failures or degradations, and their consequential service disruptions

- passenger-related disturbances
- train control failures
- vehicle propulsion failures
- vehicle braking failures
- traction power failures
- communication failures
- other equipment failures
- low speed derailment

° A discussion of strategies for resolving and minimizing the service impact of the service disruptions noted above

- reverse running
- midline turnbacks
- equipment bypass or cut-out
- consist breakup
- midline off-loading and train removal

.. removal to midline storage
.. removal at full speed
.. removal at reduced speed or increased train separation
.. removal by pushout

5.3 Emergency Operations

- A discussion of emergency incidents which provide a major peril to the users and operators of the system

  - fire and life safety emergencies, including earthquake
  - major structural failure
  - collision
  - high speed derailment

- A discussion of the strategies for controlling the impact and minimizing the hazards resulting from the emergency incidents noted above

  - train operations for fire and life safety incidents
  - system evacuation and equipment shutdown, including traction power
  - restricted system operation

SECTION III: SUPPORT FOR TRAIN OPERATIONS

6.0 STATIONS

6.1 Station Agent Duties

- A description of the responsibilities and support equipment for station agent, when present

6.2 Access

- A description of the means of control for access and egress during normal and emergency operations, including escalator operation and special provisions for bus/rail interchange

7.0 FARE COLLECTION

7.1 Fare Collection Equipment

- A description of the fare collection equipment and its use in passenger operations

7.2 Fare Collection Supervision and Maintenance

- A description of the supervision and maintenance staff and responsibilities required for operations support, including, central supervision, money or ticket restocking, soft jam clearance, and gate direction control

    - at stations, by station agents and mobile maintenance staff
    - at central, including information available at central on system patronage

7.3 Revenue Processing

- A description of the staff and activities required to transport and process system revenue

8.0 SECURITY

- A description of the security measures provided

  - station patrols
  - train patrols
  - yard and shop patrols
  - Central Control security
  - video surveillance for unattended station operation

9.0 MAINTENANCE SUPPORT FOR OPERATIONS

- A description of the maintenance activities which directly support train operations. The complete set of maintenance activities are described in the System Maintenance Plan.

9.1 Yard Operations

- A description of the procedures and activities conducted at the yard in support of train operations

  - train makeup and breakup
  - train delivery to and from transfer zones
  - vehicle delivery to and from shops
  - support for vehicle cleaning

9.2 Shops Operations

- A description of the shop activities supporting train operations, including:

  - quick vehicle repair
  - electronics repair facility support for high-impact subsystems, such as fare collection and automatic train control

9.3 Central Maintenance Supervisors

- A description of the support role provided by the central vehicle and maintenance of way supervisors during operations, including scheduling of single track or restricted operations to permit maintenance

9.4 Roving Maintenance

- A description of the roving maintenance staff assigned for quick response to equipment failures

10.0 MANAGEMENT INFORMATION SYSTEM

- A description of the information needed from the Management Information System (MIS) to support operations. Design of the MIS will be covered in a separate document. Information needed for operations includes:

  - percent of trips completed on-time, per direction and interval
  - headway at key system locations
  - off-load events per day or rush-hour

- vehicle availability
- vehicle hours and miles accumulated

° A description of the format, display medium, and report frequency for the MIS operations support data. The techniques required for generating new reports will be described

° A description of the sources and nature of the data,

  - train control system, and other central equipment monitor and control systems
  - fare collection system
  - maintenance reporting system
  - operations personnel

The means provided to transport or enter the source data to the MIS will be described.