Operating Assumptions

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I. INTRODUCTION

This Technical Memorandum is not a service plan for rail passenger services in the Puget Sound Region. Rather, it is intended to outline an operating strategy based on a set of policy assumptions for the purposes of determining annual operating costs, sizing the fleet, and identifying other facility requirements. The earlier conclusions and recommendations with respect to technology, civil structures and station designs are incorporated in this strategy. The conclusions and recommendations of the strategy document will be the basis of the modelling of operating and maintenance costs.

Beginning with the choice of the appropriate class of rail technologies, earlier studies have narrowed the specific technology recommended for use in the Seattle area. Light Rail Transit (LRT) has been judged to meet the following initial screening criteria:

- speed;
- capacity; and
- proven capability.

Furthermore, LRT vehicles can be accommodated in the Downtown Seattle Transit Tunnel (DSTT) and on the I-90 Floating Bridge without major structural changes. Figure 1 highlights the general characteristics of light rail vehicles.

In the following sections, a series of operating assumptions will be documented and used as the basis for describing a rail system alternative, including peak and off-peak service levels, and joint rail/bus use of the Downtown Seattle Transit Tunnel

GENERAL CHARACTERISTICS
OF
METRO RAIL VEHICLE

Vehicle Length	-	90 feet
Vehicle Width	-	8 ft. 8-3/4 inches
Passenger Capacity	- -	76 seated, 90-107 standees crush load 211-237 passengers
Maximum Speed	-	60 - 70 MPH
Power Supply	-	750v dc. - overhead
Train Consist	-	4 cars (max.)
Door Configuration	- -	4 sets of doors each side high and low platform access
Suspension	-	Steel wheel on steel rail
Gradient Capability	-	6% service grade. With ice conditions in Seattle, vehicles should be fitted with sanders.
Accessibility	-	lift equipment for low platform wheelchair access.

GENERAL CHARACTERISTICS
OF METRO RAIL VEHICLE
August 1990
Figure #1

II. RAIL OPERATING ASSUMPTIONS

The operation of a rail system as a component of the Metro transit network will be affected by the agency's existing service policies, projected passenger demands and the integration of bus and rail services. The following policy assumptions are key factors in the development of the rail operations and maintenance plans and budgets. These assumptions have been divided into two groups: operations and capital facilities. They are not a complete or comprehensive list of all policy matters in these areas, but are the basis of the operating strategy.

A. Operations Assumptions:

1. Generally parallel/competing bus services are assumed to be terminated or redirected to serve High Capacity Transit (HCT) stations. Travel time analysis will ultimately determine the structure of feeder services to stations.

2. A single-fare system with transfer privileges between modes is assumed.

3. Security personnel should be deployed on a random basis throughout the system (including stations and on vehicles).

4. In rush hours, a ratio of 1 to 2 standees for each seated passenger should be acceptable within high demand areas. In off-peak services, a seat for each passenger should be the goal.

5. The system should be accessible and barrier free.

6. Passengers on board a vehicle should be able to communicate with the vehicle operator and with transit central control.

7. All passenger areas in stations should be covered with CCTV.

8. All graphics for bus and HCT services should be similar.

9. Rail service hours should be:

   - Daily 0530 - midnight
   - Saturday 0530 - midnight
   - Sunday 0630 - midnight

10. Train frequency should be based on headways that reflect passenger demand and joint operations constraints in the DSTT.

11. Average operating speed for rail service is assumed to be 35 miles per hour.

12. Station dwell times for peak and off-peak services may vary, and dwell times at stations with low platforms should be longer.

13. Self service fare collection/ticketing is assumed.

14. Signalization pre emption for at-grade crossings is assumed.

15. Customer relations staff should be assigned to stations at busy times.

B. Capital Facilities Assumptions

1. Stations can be unique facilities that use common elements for ease of maintenance.

2. Station platforms will allow a maximum length of 380 feet.

3. Platforms may be covered for their entire length.

4. Platform heights may be mixed, (high and low).

5. Retail sales facilities, telephones, bank ATM machines, etc. may be provided for in stations.

III. SYSTEM DESCRIPTION

The rail transit system will eventually consist of four lines with approximately 100 miles of service. Linkages between lines and line segments is critical for passenger convenience and operating efficiency. The development of the system will take place over time, with growth taking place in two ways:

- Increased levels of service on existing segments, driven by ridership demand and;
- Additional line extensions and routes.

The first, will be the result of population and employment growth particularly around key station sites, as well as the system's ability to attract a larger market share. The second, will be generated by positive actions by Metro to extend the system and may be determined by financial and political protocol.

The issues of minimum operating segments and phasing of construction are not addressed in this memorandum. Rather, an initial operating system equivalent to the maximum extent of the Puget Sound Council of Governments (PSCOG) approved regional transportation plan (COG Box) is portrayed with furthest interim terminus. The second system described is the fully developed regional network. Figure 2 generally describes the system alignment components. Stations and alignment length have been derived form the Multi Corridor Project Report and subsequent extension studies. This figure is intended to be used for illustrative purposes only at this time, and will be refined in the detailed systems and operating planning phases of the HCT project.

A. Operating Strategies

Figures 3 and 4 indicate the proposed rail system operations strategy for the initial system and for the buildout case. The system has been divided into four lines:

- Line 1 — Northgate to Tacoma
- Line 2 — Everett to Bothell
- Line 3 — Alderwood to South Kirkland
- Line 4 — Redmond to South Renton

1. Hours of Revenue Service

Within the revenue day, passenger volumes will vary on the rail system in the same way that peaking occurs in the bus system and on the surface streets and highways. Based on experiences in other metropolitan systems, the revenue service day may be divided into six periods. Service frequencies between these periods of the day may be different, reflecting passenger demand levels.

COG Box

Line	Corridor Segment	No. of Stations	Length
--	Downtown Tunnel	5	1.3 miles
North	9th/Pine - Alderwood	11	16 miles
South	Int'l District - Star Lake	11	20.5 miles
East	Int'l District - Juanita	8	18 miles

Extensions

Line	Corridor Segment	No. of Stations	Length
North	Alderwood - Everett	6	12 miles
South	Star Lake - Tacoma	8	12 miles
East	Juanita - Bothell	3	4.5 miles
East	S. Kirkland - E. Sammamish	5	6.5 miles
East	S. Bellevue - Renton	7	8 miles

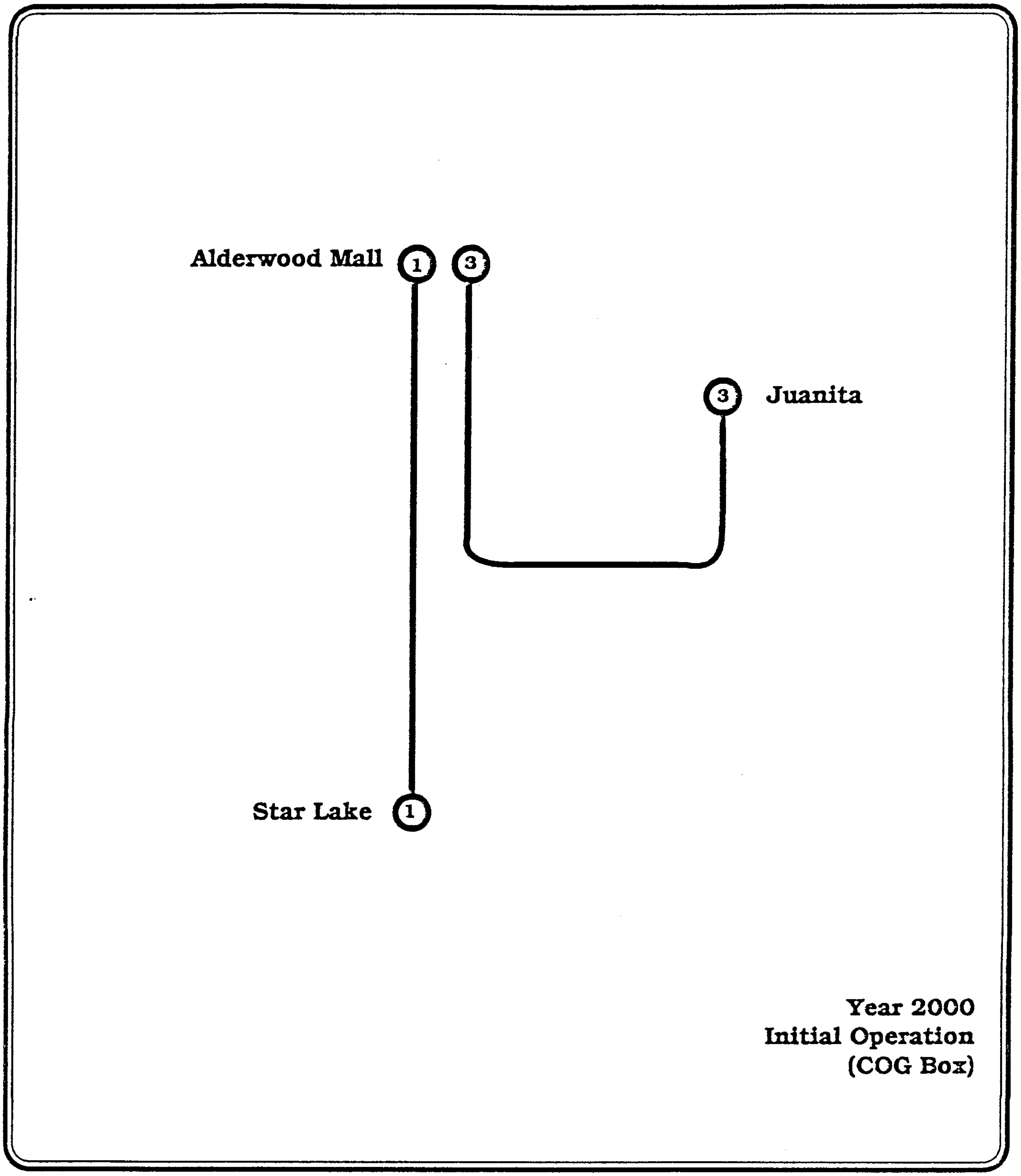
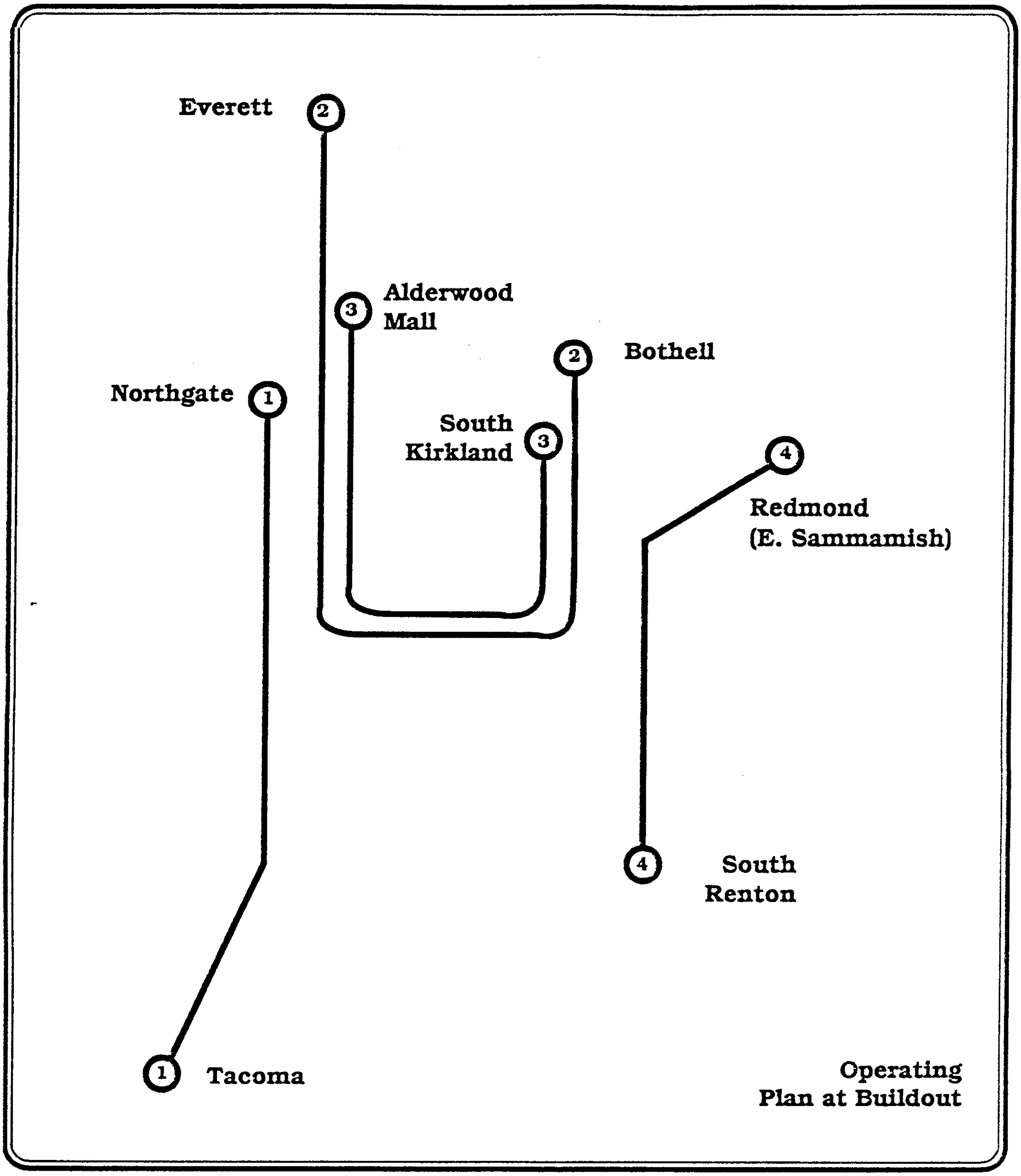

Alderwood Mall
1
3
Juanita
3
Star Lake
1
Year 2000
Initial Operation
(COG Box)

Figure #3



OPERATING
STRATEGY
August 1990
Figure #4

Figure 5 outlines the hours of service for the peak and off-peak periods. Morning, Mid-day, Evening, and Late Evening are considered to be off-peak.

2. Peak Hour Operations

Full peak hour service is programmed to last for two hours in the morning and two and one-half hours in the afternoon. These time periods correspond to the existing travel patterns of Metro commuters. During these periods, full train consists (4 cars) would be deployed in order to meet expected demand.

The Initial Operating Segment (Year 2000) and Buildout Strategies are reflected in Figure 6. Line 2 (Everett - Bothell) and Line 4 (Redmond - S. Renton) are added after service has been implemented. In the Buildout stage, the projected passenger volumes do not require the full daily operations of Line 3 (Alderwood to South Kirkland) after the initiation of Line 2.

Figure 7 indicates the rail system passenger capacity, based on the operating characteristics and peak hour service strategies. These capacities may be compared with the preliminary patronage projection prepared by Metro in earlier studies (1988). Such comparisons of projected peak hour link volumes and LRT capacity might include the following:

North Corridor	2020 Projected	Capacity
Alderwood - Lynnwood	5,200	9,960
Roosevelt - U. District	11,500	19,920
South Corridor		
Boeing Field - Interurban	9,300	9,960
East Corridor		
Mercer Island - Rainier	9,700	9,960
Bellevue - South kirkland	5,300	9,960

As more detailed and current projections of link volume requirements are produced, the peak-hour operations strategy will be fine tuned to correspond to the revisions.

OPERATING STRATEGY
HOURS OF SERVICE

Operations Mode	Daily	Saturday	Sunday/ Holiday
Morning	0530-0700	0530-0800	0630-0900
AM Peak	0700-0900		
Mid-Day	0900-1530	0800-1800	0900-1700
PM Peak	1530-1800		
Evening	1800-2100	1800-2100	1700-2100
Late Evening	2100-000	2100-0000	2100-0000

PEAK HOUR OPERATIONS: SERVICE FREQUENCY

Corridor	Year 2000 Frequency	Buildout Frequency
North:		
Line 1	12 min.	4 min.
Line 2	–	8 min.
Line 3	12 min.	8 min.
South:		
Line 1	12 min.	4 min.
East:		
Line 2	–	8 min.
Line 3	12 min.	8 min.
Line 4	–	7.5 min.

PEAK HOUR OPERATIONS:
SYSTEM CAPACITY

Corridor	Initial Operations Effective Headway	 Capacity Service Load	Buildout Effective Headway	 Capacity Service Load
North	6 min.	6640	2 min.	19920
South	12 min.	3320	4 min.	9960
East	12 min.	3320	4 min.	9960
Eastside	–	–	7.5 min	5312

3. Off-Peak Operations

Off-Peak services may be operated in four periods of the day, with service levels tailored to meet the passenger requirements. The operations strategy for off-peak services may also include smaller train consist to reduce operating costs and provide additional vehicle maintenance time.

Figure 8 outlines the Off-Peak Operations Strategy including frequency and train size options for the initial operations. The operating assumption, defining that in the off-peak. All passengers should have a seat, will have the effect of requiring more frequent service particularly at times when smaller train consists are in operation.

The following table in Figure 9 shows the off-peak capacity provisions that are provided in the operations strategy for Initial Operations. These headways and capacity provisions are in line with preliminary patronage projections for mid-day ridership. The following comparison indicates the levels of capacity and projected volumes for specific linkages for the year 2000.

North Corridor	2000 Projected	Mid-day Capacity
Seattle CBD - U. District	2,500	3,000
South Corridor		
Seattle CBD - SeaTac	1,200	1,500
East Corridor		
Seattle CBD - Mercer Island	1,100	1,500

The Build-out system can be tailored to meet off-peak passenger demand in a similar way, (i.e. altering headway and reducing vehicle consist). A detailed off-peak strategy will be developed when ridership figures are available. At this point, a preliminary off-peak program has been developed to facilitate fleet planning and budget estimations. Figure 10 provides the information on this component of the strategy.

OFF–PEAK OPERATIONS:
FREQUENCY & TRAIN SIZE
(Initial Operations)

OPERATIONS	NORTH CORRIDOR		SOUTH/EAST CORRIDOR	
	FREQUENCY (MIN)	TRAIN SIZE (CARS)	FREQUENCY (MIN)	TRAIN SIZE (CARS)
Morning	6–10	2	12–20	2
Mid–Day	6–10	4	12–20	4
Evening*	6–10	2	12–20	2
Late Evening	10–15	2	20–30	2

OFF-PEAK OPERATIONS
INITIAL OPERATIONS

System Capacity - Seated Loads
(per-hour - per-direction)

Corridor		Morning	Mid-day	Evening	Late Evening
North	Hdwy (min.) Capacity	7.5 1216	6 3000	10 912	15 608
East	Hdwy (min.) Capacity	15 608	12 1500	20 456	30 304
South	Hdwy (min.) Capacity	15 608	12 1500	20 456	30 304

OFF-PEAK OPERATIONS
BUILDOUT
SYSTEM CAPACITY
(Per-hour, Per Direction)

	MORNING HDWY – CAPACITY	MID-DAY HDWY – CAPACITY	EVENING HDWY – CAPACITY	LATE EVENING HDWY – CAPACITY
NORTH				
Everett – Northgate	8 MIN – 1204	8 MIN. – 2580	10 MIN. – 2064	10 MIN. – 1032
Northgate – CBD	4 MIN. – 2580	4 MIN. – 5160	5 MIN. – 4128	5 MIN. – 2064
SOUTH				
CBD – Tacoma	8 MIN. – 1204	8 MIN. – 2580	10 MIN. – 2064	10 MIN. – 1032
EAST				
CBD – Bothell	8 MIN. – 1204	8 MIN. – 2580	10 MIN. – 2064	10 MIN.– 1032
Redmond – Renton	8 MIN. – 1204	8 MIN. – 2580	10 MIN. – 1032	10 MIN. – 1032

IV. DOWNTOWN SEATTLE TRANSIT TUNNEL OPERATIONS

The transit tunnel through Downtown Seattle has been designed and constructed for joint rail/bus operations. An analysis conducted by ICF Kaiser Engineers ("Analysis of Joint Bus/LRT Operation in Downtown Seattle Transit Tunnel", 1989-90) has confirmed the feasibility of joint operations and identified the actions necessary to accommodate both sets of vehicles.

A. Tunnel Description

The Downtown Seattle Transit Tunnel is an integral part of the rail transit infrastructure. In September 1990, part of the tunnel begins operations, providing an exclusive right-of-way for transit vehicles through Downtown Seattle. Following the alignment of Third Avenue, the tunnel is 7,358 feet in length (1.3 miles).

There are five stations along the length of the tunnel, beginning with the Convention Center in the north, with Westlake, University, Pioneer Square, and International Station in the south. Convention Center and Westlake stations are only 1283 feet apart. Station platforms are low-level and are 380 feet in length.

A block signal system with signal lights at the entry portals and at entry/exit locations from stations, together with mid/block status signals has been installed for bus operations. Site lines are 100 - 300 feet throughout the tunnel and, therefore, an upgraded vehicle detection/signal system will be required for train operations.

B. Operating Assumptions

The following conditions, from the DSTP Design Standards, the ICF Kaiser reports and the Rail Operating Assumptions, have been integrated into the analysis of joint operations:

- initial rail operations will require six-minute headway to meet projected passenger demand on the North Line;
- all rail lines will serve Downtown Seattle and be routed though the tunnel;
- dual-mode buses will be dispatched in platoons of up to four buses, dispatched from staging areas;
- maximum bus speed will be 20 mph; and
- an upgraded signal system will be introduced prior to joint rail/bus operations.

C. Rail Operations

1. Hours of Service

Daily operation of the rail system will require that the tunnel stations be open for the entire service day. This will necessitate a revised station staffing program for public information and security. The hours of service daily (including Saturday) are assumed to be 0530 - midnight, with Sunday hours of 0630 - midnight.

2. Service Frequency

The parametric analysis of joint operations conducted by ICF Kaiser (1989) concluded that rail consists of four cars (90-foot vehicles) could be operated in conjunction with bus platoons on the following basis:

Rail Frequency	Bus Platoons (One-Way) # Between Trains	Buses/Hour
6 minutes	4	160
5 minutes	3	144
4 minutes	2	120
2 minutes	1	120
90 seconds	0	0

Further review of bus service plans and dispatch logistics indicated that maximum bus volumes of 110 buses per-hour, per direction were reasonable. Therefore, a revised frequency chart may be utilized. The following frequencies will be employed in the analysis:

Bus Frequency	Buses/Hr
7.5 minutes	110
6 minutes	80
4 minutes	70
2 minutes	0

The bus platoons would have a maximum speed of 20 mph in the tunnel. Rail operations were tested at maximum speeds of 20 and 25 mph. (Average operating speed 10.1 and 10.8 mph respectively). The speed limitations will provide safer braking distance, permitting closer spacing; lower consumption of power, reducing cost; and the travel time differences would not be significant.

The initial rail operating requirements, to meet expected passenger demands, indicate that six-minute frequencies will be necessary on the north corridor. Preliminary 2020 passenger demand projections indicate the two-minute headways will be necessary in later operations. The following table indicates the rail/bus operating frequencies and passenger capacities for these two time periods.

	Initial		2020	
	Frequency	**Capacity**	**Frequency**	**Capacity**
Rail	**6 minutes**	**6640**	**2 minutes**	**19920**
Bus	**3 minutes (average)**	**5440**	**-**	**-**
Joint Operations		**11080**		**19920**

3. **Operations Management**

The operating plan for all bus operations requires a management/supervisory function at each staging area (i.e., Convention Center and International stations). Bus platoons will be dispatched and their progress monitored by operations personnel.

With joint rail/bus operations, the dispatch function will be tied directly to the upgraded signal system. Buses should continue to be able to pass within station areas, but trains will not. A disabled bus will need to be moved from a platform location to reduce train delays.

Buses and trains in operation in the tunnel should use similar radio frequencies to facilitate joint operations management and avoid conflicts.

The signal system should provide information with respect to schedule implications of boarding delays, use of lift equipment, unusual operations circumstances.

V. STATION DWELL TIMES

A major factor in the determination of average system speed, is the length of time each train stops at stations to allow boarding/alighting. Dwell times are measured by the cycle time of doors opening to doors closing in a station. The length of time at each station stop is a function of the following:

- volume of passengers;
- platform configuration (i.e., high or low);
- time of day (commuters vs. occasional users);
- use of special access facilities (e.g. lifts for wheelchairs); and
- unusual occurrences (door malfunctions, etc.).

A survey of representative transit systems indicates that a twenty-second dwell time is most often employed for scheduling purposes. The following table provides this comparative data. Therefore, for the purposes of estimating cycle times, a twenty-second dwell time may be assumed for these purposes. Additional time in DSTT stations will be programmed due to heavier passenger volumes, and low platform stations.

Dwell Time Survey

Light Rail	Doors Open	Platform
San Jose	10 sec.	H
San Diego	20 sec.	L
Pittsburgh	20 sec.	H/L
Lindenwold	20 sec.	H/L
AGT		
Miami [1]	10 sec.	H
Vancouver	15 - 30 sec.2	H
Lille	15 sec.	H
Morgantown	20 sec.	H
Houston - Airport [2]	25 sec. 2.	H
Orlando (Disney) [3]	50 sec. 3	H
Heavy Rail		
Atlantic	20 sec.	H
BART	15 - 20 sec.	H
Toronto	15 sec.	H

Notes:

1. Computer programming permits variations of door cycle times, depending on loading conditions.

2. Dwell times set to provide time for passengers with baggage to load and unload.

3. Disneyworld monorail does not have transit seating configuration and thus dwell times are longer to provide opportunity for all passengers to find seats.

VI. VEHICLE MAINTENANCE AND ON-LINE STORAGE

A central maintenance and operations control facility has been planned for the Light Rail System. A second facility serving the eastside will be required as the system is expanded.

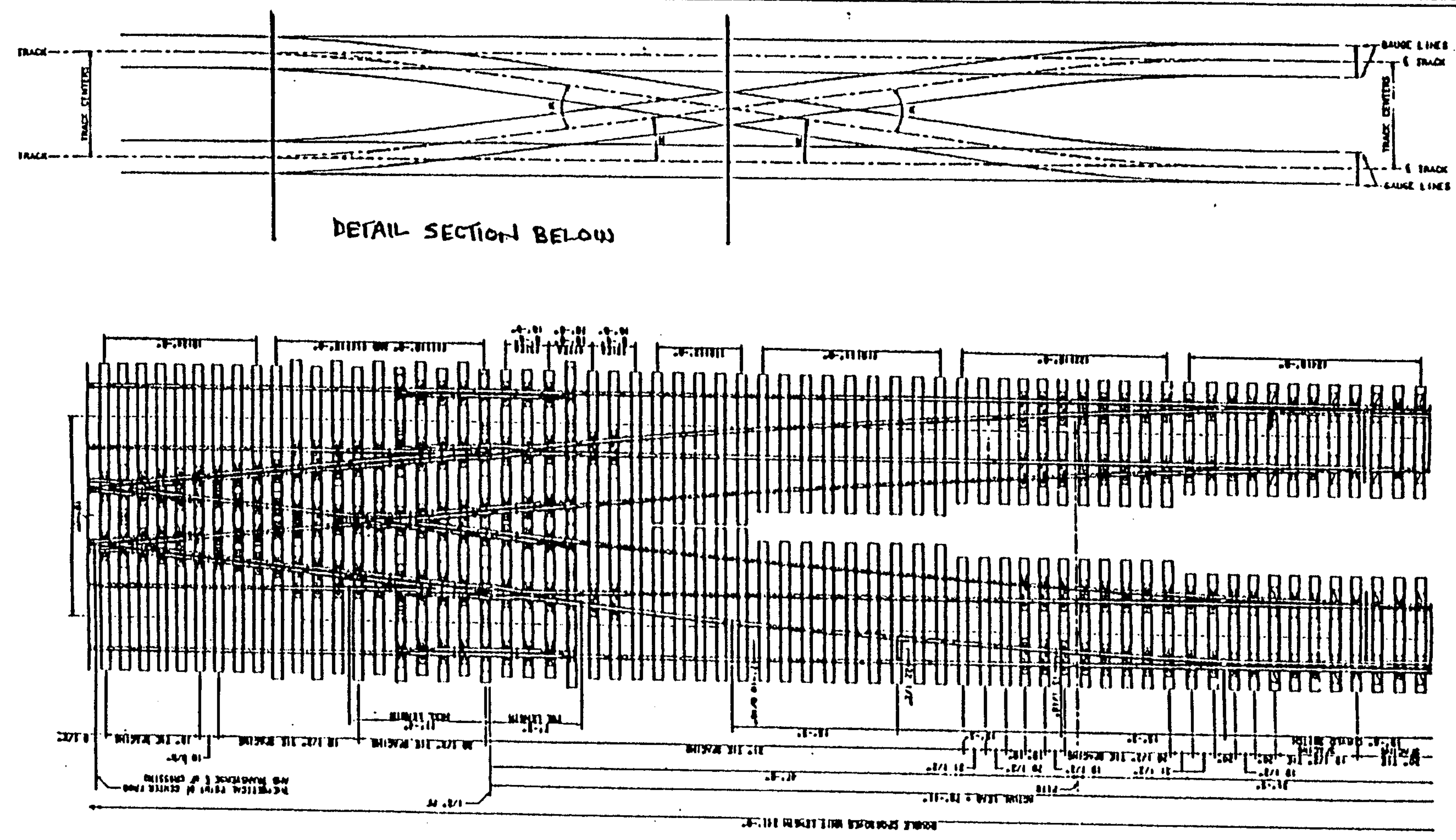
In order to provide flexibility and to reduce delays in cases of incidents on one track, the trackwork design and civil works will provide for double crossover switches. Access would be from both directions, and would be controlled by the central operations center. Trains (or sections of trains) could be short-turned at these locations or rerouted around incidents that occur between switches. The locations of these junctions will be dictated by the final operating plan, geometrics of the system, and emergency operating strategies. Figure 11 illustrates a double crossover plan.

The ultimate size of the Metro system and the length of the various lines dictate a dispersed stabling plan for on-line storage. This will reduce dead head mileage and unproductive labor time, facilitate the removal of crippled trains from the revenue lines, and increase response capability to restore revenue service when a train is taken out-of-service. In addition to a central maintenance facility (and ultimately a second servicing facility on the east line), storage lines would be provided as pocket tracks in the following general locations:

North Line:
- between Northgate and Mountlake Terrace Stations
- at Tacoma Station

South Line:
- between SeaTac and Angle Lake Stations
- at Tacoma Station

East Line:
- at Overlake or South Kirkland Stations
- at Bothell/Woodinville Station
- at Renton Station



DOUBLE CROSSOVER
PLAN

August 1990

VII. COMMUNICATIONS AND CONTROL

A central control facility will be an essential element of the system. It will be the focal point for operations and security on a system-wide basis. Train operations, passenger safety systems, (closed circuit television and audio communications) and systems monitoring would be handled from the central facility.

From this center, all coordination of at-grade signaling, track maintenance and liaison with fire/police services would be managed. Personnel assignments may be decentralized to other Metro operations facilities to reduce non-productive labor time. Operator reliefs would likely take place on-line for the most part.

Elements of the control and communications systems would include:

- closed circuit television coverage of passenger facilities;
- emergency telephone;
- alarm notification system (fixed facilities);
- public address systems;
- train control signal systems;
- radio communications for operations, maintenance, and security; and
- passenger information telephone.