VI. CORRIDOR REQUIREMENTS

In Section V of this memorandum, the Intermediate - High Speed class of transit technology was determined to be the most appropriate class from which to select a rail transit system to be built and operated in the Metro high capacity transit corridors. With the appropriate class of technology identified, the following subclasses of the Intermediate - High Speed class were presented in Section V:

- Light Rail Transit (LRT)
- Monorail
- Automated Guideway Transit (AGT)/Peoplemover

Figure 13 presents a summary of the characteristics of these three technologies. As explained in Section II and illustrated in Figure 2, the decision as to which of the above subclasses to select for implementation is made by analyzing the likely or anticipated corridor requirements in each corridor and then assessing the compatibility of these requirements with the specific physical characteristics of each technology subclass. If a given subclass has physical characteristics that cannot be accommodated in the corridor being analyzed, then that subclass of technology should not be considered for implementation in that corridor. Part of the analysis is to assess whether or not it is possible and practical to alter the design in order to eliminate the constraint that would limit construction or operation of that technology subclass. If the constraint cannot be removed with reasonable and affordable design modifications, the subclass should not be used for rail transit in the corridor.

Preliminary planning for implementation of high capacity transit was undertaken in the Multi-Corridor Project (MCP) by the Puget Sound Council of Governments (PSCOG) and Metro. Assuming that the system would be either light rail or fixed guideway technology, preliminary alignments and station locations were defined in order to evaluate and recommend high capacity transit corridors for implementation. Although the alignments developed in the MCP study are considered preliminary, they provide an accurate definition of the requirements and constraints that will need to be met by the transit technology eventually selected.

Presented in the following sections is a discussion of the Metro corridor requirements that may exist in one or more corridors followed by a description of the physical characteristics that would be compatible with those requirements and, hence, appropriate for Metro high capacity rail transit. The following corridor requirements are considered in this evaluation:

- Downtown Seattle Tunnel (Operational - September 1990)
- University District/Downtown Bellevue Tunnels (Future)

LIGHT RAIL

Transit Vehicle	Capacity: 26,560 @ 90 sec headway	o
Suspension	Steel Wheel/Rail	o
Control	Manual	o
Propulsion	Rotary Electric	o
Power Supply	Overhead	o
Running Surface	Mixed	o
	Separate R-O-W	

AGT/PEOPLEMOVER

Transit Vehicle	Capacity: 21,600 @ 90 sec headway	o
Suspension	Steel Wheel/Rail	o
	Magnetic/Air Cushion	
Control	Manual	o
	Automatic	
	Manual & Automatic	o
Propulsion	Rotary Electric	o
	Linear Electric	
Power Supply	Third Rail	
	Guideway	
Running Surface	Separate Guideway	

MONORAIL

Transit Vehicle	Capacity: 26,400 @ 90 sec headway	o
Suspension	Rubber Tire	o
Control	Manual	o
	Automatic	
Propulsion	Rotary Electric	o
Power Supply	Guideway	
Running Surface	Separate Guideway	

o Appropriate for Metro

- I-90 Floating Bridge (Existing & Future)
- Ship Canal Crossing (Existing & Future)
- At-Grade Crossings
- Aerial Structures

The first four requirements are specific to a particular location or corridor. The last two requirements could exist or be a requirement in any of the corridors being evaluated.

A. Downtown Seattle Tunnel

The downtown Seattle tunnel is currently under construction and is projected to commence operation in fall 1990. The tunnel has been designed to accommodate two-way bus operation in platoons of up to four buses. Staging areas are provided at either end where buses are grouped into platoons prior to passing through the tunnel. They also convert from diesel to electric operation at the staging area prior to entering the tunnel. As work was proceeding on construction of the tunnel, the decision was made to include tracks in the tunnel roadway in order to accommodate light rail transit vehicles. A detailed study is being undertaken to determine what additional work will be required to convert the tunnel for rail transit operation. Information currently available indicates that Light Rail operation will require fewer modifications to the tunnel and stations than would be required for other transit technology options.

The following analysis, which will determine which transit system physical characteristics are appropriate for Metro system operation, has been carried out with the assumption that whichever transit technology is selected, it must be capable of joint operation with the dual mode buses that will begin operation in the Fall of 1990.

1. Appropriate Physical Characteristics for Metro

Suspension: Rubber Tires or Steel Wheel/Rail

The tunnel cannot accommodate third rail, magnetic, air cushion, or monorail suspension because these technologies require a separate guideway. A separate guideway would prohibit joint tunnel operation with the dual-mode buses and each station would require considerable modification to interface with the individual rail vehicles.

Control: Manual Operation

Automated operation in the tunnel will not be possible because all automated systems require some type of guideway or rail to guide the path and control the speed of the vehicles. This requirement for a guideway or rail for automated operation would not be compatible with operation of the dual-mode buses. This constraint does not preclude automatic operation in any of the corridors connected to the downtown tunnel. There are existing transit systems in operation which operate under manual control for a portion of the line and then convert to automatic operation for the remainder of the trip.

Propulsion: Rotary Electric

The type of power used in the tunnel must be free of exhaust. Overhead wires have been installed in the tunnel to provide power to the dual mode buses which will be driven through the tunnel with electric motors. Engineering studies have demonstrated that an additional overhead wire can be added to supply power to rotary electric motors on rail transit vehicles. Linear induction requires either a reaction rail or some type of guideway to supply power to the vehicles. This arrangement would not be compatible with joint bus operation.

Power Supply: Overhead

The tunnel is already equipped with overhead wires to provide power to the dual-mode buses through the use of catenaries. Recent studies by ICF Kaiser, have shown that a second overhead power supply system can be installed to supply power to the rail transit vehicles. Since buses and rail vehicles have different power requirements, they will have two separate power supply systems. Power supply by third rail or guideway would physically interfere with dual-mode bus operation because the buses would not be able to drive on or over the third rail or guideway.

Running Surface: Mixed operation with low platforms

The tunnel cannot utilize technologies which require separate right-of-way or a separate guideway because joint operation of the tunnel requires that both the dual-mode buses and rail transit vehicles be able to use the same lane. A platoon of buses, for example, must be able to travel along the same lane that was used by the rail transit train going through the tunnel ahead of it. Passengers boarding at the stations must be able to board either vehicle systems from the same station platforms. A major issue that will need to be addressed is whether or not to install high level platforms for rail transit operation. These platforms would be expensive to install and may be difficult to operate in joint operation with buses using low level platforms. Studies completed to date indicate that retrofitting stations in the downtown tunnel with high-level platforms for rail transit is not cost effective or desirable. Rail transit vehicles should be capable of operating in mixed traffic (shared lanes) with the dual-mode buses with the ability to allow passengers to board from low-level platforms. This requirement for low-level platforms applies only to the downtown tunnel itself. There are numerous transit systems currently in operation where the vehicle is capable of accommodating both low and high-level platforms.

B. University District/Downtown Bellevue Tunnels

The transit corridors and alignments studied in the MCP study included options for constructing tunnels to accommodate high-capacity transit in both the University District and Downtown Bellevue. Since these tunnels have not yet been designed or built, they can be designed to accommodate any technology that is capable of being constructed and operated in a tunnel configuration. Tunnel stations for light rail operation can range from low cost, minimal function to high cost, multi-function. Tunnel stations for AGT/Peoplemover technologies will require higher expense due to the high-level platforms required for automatic train control. Although monorail tunnel stations can be built, this type of development would violate the inherent advantage of the technology and result in lowered performance and higher costs. It may be preferred or desirable to accommodate joint operation of rail transit and dual-mode buses in the new tunnels. If this is the case, all of the limitations and requirements discussed in the previous section for the downtown Seattle tunnel would be directly applicable to these new tunnels.

1. Appropriate Physical Characteristics for Metro

<u>Suspension: Rubber Tire, Steel Wheel/Rail, Magnetic, Air Cushion, and Monorail</u>

It is technically possible to accommodate the physical characteristics associated with suspension of all of subclasses of Intermediate - High Speed transit in the design of the new tunnels. If joint operation between bus and rail is desired or required, however, only transit systems suspended by rubber tires or steel wheel/rail would be appropriate.

Control: Manual and Automatic

The new tunnels could be designed to accommodate either manual or automatic operation. If joint operation of rail transit and buses is desired or required, however, only rail transit systems capable of manual operation in the tunnel would be appropriate. Vehicles could be operated automatically on other portions of the line.

Propulsion: Rotary Electric and Linear Electric

The new tunnels could be designed to accommodate either rotary electric or linear electric propulsion. Linear electric, which requires a separate guideway, would not be appropriate if joint operation with rail transit and bus is desired or required.

Power Supply: Overhead, Third Rail, and Guideway

The new tunnels could be designed to accommodate all types of power supplies. Only overheard wire power supply would be appropriate if joint operation with bus is desired or required.

Running Surface: Mixed Operation and Separate Guideway

The new tunnels could be designed to accommodate either mixed operation or separate guideway. Only mixed operation with low-level platforms would be appropriate, however, if joint operation with rail transit and buses is desired or required.

C. Interstate 90 Floating Bridge

Similar to the downtown Seattle tunnel, the recently opened I-90 floating bridge has also been designed to accommodate rail high-capacity transit vehicles. There would be three traffic lanes in each direction along with two additional lanes for two-way rail transit operation. The floating bridge structure will also have certain requirements and/or limitations for operation of high capacity transit technologies. While it is feasible to install and operate light rail and AGT/peoplemovers, monorail operation will not be possible. The bridge has not been designed to accommodate the unique static and dynamic loading that would be generated by a monorail system.

1. Appropriate Physical Characteristics for Metro

Suspension: Rubber Tire, Steel Wheel/Rail, Magnetic, and Air-Cushioned

The I-90 Floating Bridge was designed to accommodate rail transit and the use of an exclusive right-of-way. Monorail cannot be used because of the static and dynamic loading requirements.

Control: Manual and Automatic

All physical characteristics of the recommended transit technologies would be appropriate for operation on the I-90 Floating Bridge.

Propulsion: Rotary Electric and Linear Electric

All physical characteristics of the recommended transit technologies would be appropriate for operation on the I-90 Floating Bridge. More detailed studies will be required to determine the requirements for installing a linear induction motor system on the bridge.

Power Supply: Overhead and Guideway

All physical characteristics of the recommended transit technologies would be appropriate for operation on the I-90 Floating Bridge.

Running Surface: Mixed Operation and Separate Guideway

All physical characteristics of the recommended transit technologies would be appropriate for operation on the I-90 Floating Bridge.

D. Ship Canal Crossing

Implementation and operation of high capacity transit in the north corridor will require crossing the Ship Canal. There are several options for this crossing including the following:

- tunnel under
- low-level draw bridge
- high-level bridge
- use existing I-5 lanes and structure

The most appropriate solution will be identified as part of the North Corridor Study, but each alternative has a different set of requirements for the transit system that will eventually use the facility.

1. Appropriate Physical Characteristics for Metro

Suspension: Rubber Tire, Steel Wheel/Rail, Magnetic, Air-cushion, and Monorail

All physical characteristics of the recommended transit technologies would be appropriate for operation in crossing of the Ship Canal via a tunnel under or a high level bridge. Transit technologies that require a guideway will be difficult to implement with a low-level draw bridge or using existing I-5 traffic lanes and structures.

Control: Manual and Automatic

All physical characteristics of the recommended transit technologies would be appropriate for operation in crossing of the Ship Canal via tunnel and a high level bridge. Automatic train control will be difficult to install on a low-level draw bridge or in a traffic lane of I-5.

Propulsion: Rotary Electric or Linear Electric

All physical characteristics of the recommended transit technologies would be appropriate for operation in crossing of the Ship Canal via tunnel and a high level bridge. Linear electric propulsion will be difficult to install on a low-level draw bridge.

Power Supply: Overhead, Third Rail and Guideway

All physical characteristics of the recommended transit technologies would be appropriate for operation in crossing of the Ship Canal via tunnel and a high level bridge. Power supply by third rail and guideway will be difficult to install on a low-level draw bridge or in a traffic lane of I-5.

Running Surface: Mixed Operation and Separate Guideway

All physical characteristics of the recommended transit technologies would be appropriate for operation in crossing of the Ship Canal via tunnel and a high level bridge. A separate guideway will be difficult to install on a low-level draw bridge or in a traffic lane of I-5. Providing access for rail transit vehicles to a guideway occupying a lane of I-5 would require costly flyover ramps in order to prevent interference with conventional traffic lanes. Constructing and operating a draw bridge that would physically connect and disconnect adjacent guideway elements on a regular basis would be difficult to design and even more difficult to operate with a high level of reliability.

E. At-Grade Crossings

There may be locations in any of the transit corridors where it would be possible or desirable for the transit system to cross streets and roadways at the same elevation as crossing traffic. This is referred to as an at-grade crossing. The technology selected for implementation may need to be capable of negotiating these at-grade crossings. If the technology is not capable of doing this, it will be necessary to construct an underpass or overpass at each location in order to separate the transit system from crossing traffic.

1. Appropriate Physical Characteristics for Metro

Suspension: Rubber Tire and Steel Wheel/Rail

At-Grade crossings cannot accommodate technologies which require the use of a separate guideway. Exclusive use of right-of-way will not allow joint operation with other transportation modes.

Control: Manual

At-Grade crossings require the use of manual operation because of joint operation with other modes of transportation.

Propulsion: Rotary Electric

At-Grade crossings require the use of rotary electric propulsion because of joint operation with other modes of transportation.

Power Supply: Overhead

At-Grade crossings require the use of overhead power supply because of joint operation with other modes of transportation.

Running Surface: Mixed Operation

At-Grade crossings require that the transit technology selected be flexible enough to allow mixed operation, a combination of operation on exclusive right-of-way (or exclusive guideway) and joint operations with other transportation modes.

F. Aerial Structures

Aerial structures will be a part of system operations in every identified corridor. Whether it is a simple bridge crossing a drainage facility or a lengthy structure that allows the crossing of several miles of roadways, all of the identified transit technologies can accommodate the use of an aerial structure. Monorail was originally designed to operate exclusively on an aerial structure. The major considerations for aerial structures are cost and aesthetics.

1. Appropriate Physical Characteristics for Metro

Suspension: Rubber Tire, Steel Wheel/Rail, Magnetic, Air-cushion, and Monorail

All physical characteristics of the recommended transit technologies would be appropriate for operation on aerial structures.

Control: Manual and Automatic

All physical characteristics of the recommended transit technologies would be appropriate for operation on aerial structures.

Propulsion: Rotary Electric or Linear Electric

All physical characteristics of the recommended transit technologies would be appropriate for operation on aerial structures.

Power Supply: Overhead, Third Rail and Guideway

All physical characteristics of the recommended transit technologies would be appropriate for operation on aerial structures.

Running Surface: Mixed Operation and Separate Guideway

All physical characteristics of the recommended transit technologies would be appropriate for operation on aerial structures.

G. Summary

Two tables have been provided that more closely compare the available physical characteristics of the transit technologies with the appropriate technologies for Metro operation. Figure 14 provides a summary of the physical characteristics of the subject transit technologies and compares these to the appropriate characteristics required for Metro operation in each corridor. Figure 15 compares the appropriate physical characteristics for Metro operation with the available physical characteristics for each technology.

Examination of Figure 14 clearly indicates that Metro requirements dictate:

- a rubber tire/steel rail suspension
- manual control of the system
- rotary electric propulsion
- overhead power supply
- can be used in mixed traffic
- must be compatible with low platform stations.

Figure 15 takes these requirements and identifies what technologies, of the remaining three, fit all requirements. While AGT and Monorail meet some of the requirements, they do not provide the adequate characteristics necessary to operate in the Seattle downtown tunnel, and other tunnels in the three corridors. Light Rail Transit, however, meets all requirements.

CORRIDOR REQUIREMENTS

PHYSICAL CHARACTERISTICS		DOWNTOWN TUNNEL	UNIVERSITY DISTRICT/ BELLEVUE TUNNELS	I-90 FLOATING BRIDGE	SHIP CANAL CROSSING	AT-GRADE CROSSING	AERIAL STRUCTURES	APPROPRIATE FOR METRO *
SUSPENSION	- RUBBER TIRE OR RAIL	●	●	●	●	●	●	METRO
	- MAGNETIC OR AIR CUSHION						●	
CONTROL	- MANUAL	●	●	●	●	●	●	METRO
	- AUTOMATIC			●			●	
PROPULSION	- ROTARY ELECTRIC	●	●	●	●	●	●	METRO
	- LINEAR ELECTRIC			●			●	
POWER SUPPLY	- OVERHEAD	●	●	●	●	●	●	METRO
	- THIRD RAIL			●			●	
	- GUIDEWAY			●			●	
RUNNING SURFACE	- SEPARATE GUIDEWAY			●	●		●	
	- MIXED	●	●	●	●	●	●	METRO

* MINIMAL MODIFICATION OF EXISTING FACILITIES REQUIRED

Metro Rail Planning Study

Transit Technology Assessment

GANNETT - DELEUW

TRANSIT TECHNOLOGY EVALUATION

August 1990

	LIGHT RAIL	AGT	MONORAIL
TRANSIT VEHICLE			
CAPACITY: 8 – 10,000	*	*	*
SUSPENSION			
STEEL WHEEL/RAIL	*	*	
RUBBER TIRE		*	*
CONTROL			
MANUAL	*	*	*
MANUAL & AUTOMATIC	*	*	*
PROPULSION			
ROTARY ELECTRIC	*	*	*
POWER SUPPLY			
OVERHEAD	*		
THIRD RAIL/GUIDEWAY		*	
RUNNING SURFACE			
MIXED	*		
MIXED & SEPARATE GUIDEWAY	*		

APPROPRIATE TECHNOLOGY
CHARACTERISTICS FOR METRO

August 1990

Figure #15

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The overall purpose of this technology assessment is to identify and recommend appropriate rapid transit technologies that should be used as a basis for exploring the feasibility of implementing rail transit in any of the high capacity transit corridors being considered by Metro. The primary conclusion and recommendation from this assessment is that light rail transit (LRT) is the most appropriate rail transit technology because it best meets the overall performance requirements and specific corridor requirements for Metro's rail high capacity transit system. Presented in this section is a summary of the analysis undertaken along with conclusions and recommendations resulting therefrom.

A. Summary of Analysis Process

Selection of the appropriate rail transit technology for Metro high capacity transit corridors was accomplished by completing the following basic steps:

Step 1 - All available transit technologies were inventoried and then sorted into six basic transit classes. The transit classes were based on type of service provided, maximum operating speed and passenger capacity of a minimum operating unit. Transit technologies were sorted into the following transit classes:

- Small - Low Speed (PRT)
- Small - Low Speed
- Small - High Speed
- Intermediate - Low Speed
- Intermediate - High Speed
- Large - High Speed

Step 2 - Analysis was undertaken to determine the performance requirements that need to be met by the class of transit technology best suited for the high capacity transit corridors. The following performance requirements were specified:

- Speed - Minimum avg. speed - 35 mph
  Max. cruise speed - 60-70 mph

- Capacity 8,000 - 12000 passengers per hour per direction

Training - 1-4 cars per train

Step 3 - The above performance requirements were compared with performance capabilities of the various transit classes. It was determined that the Intermediate - High Speed class of transit technology best fit the Metro performance requirements. This transit class includes the following subclasses:

- Light Rail Transit (LRT)
- Automated Guideway Transit(AGT)/Peoplemover
- Monorail

Step 4 - Specific physical corridor requirements for rail transit were identified for the following locations or potential conditions:

- Downtown Seattle Tunnel
- University District/Downtown Bellevue Tunnels
- Interstate 90 Floating Bridge
- Ship Canal Crossing
- At-Grade Crossings
- Aerial Structures

Step 5 - The physical characteristics of LRT, AGT/Peoplemover and Monorail technologies were compared with the Metro corridor requirements to determine which technologies were compatible with requirements and should therefore be considered for implementation in the high capacity transit corridors. Results of this comparison generated the conclusion that LRT is the most appropriate technology for Metro rail transit implementation.

B. Conclusions and Recommendations

Summarized below are the conclusions and recommendations regarding each of the high capacity rail technologies investigated in this study.

Light Rail - This technology is likely to be the easiest technology to implement. Facilities such as the Downtown Seattle Transit Tunnel and the I-90 floating bridge have already been constructed to accommodate this technology. Higher average speeds can be achieved by reducing the number of at-grade crossings and/or extent of operation in mixed traffic. Stations can vary from simple and inexpensive to very substantial structures. This technology has proven itself in service in over a dozen systems throughout North America.

Automated Guideway (AGT)/Peoplemover - This technology has major constraints that would make it difficult to implement in the Downtown Seattle Transit Tunnel, the University District/Bellevue tunnels, and the Ship Canal. Existing technology still requires the use of a third rail as a power source for AGT. In addition, high level platforms are also required. These are not compatible with joint operations in any corridor tunnels. Given these constraints, this technology is not recommended for further consideration in the high capacity transit corridors.

Monorail - This technology has major constraints that would make it difficult to implement in the Downtown Seattle Transit Tunnel, across the I-90 floating bridge, and in certain options to cross the Ship Canal. Monorails are typically more cost effective if it is required that a large percentage of the guideway be elevated. Currently available monorail technology does not have adequate speed capability and train composition is difficult to adjust for different levels of ridership demand. This technology is not recommended for further consideration in the high capacity transit corridors.

Based on the information presented in the text of this document, it is recommended that the LRT be considered for implementation in the high capacity transit corridors. Figure 16 presents a summary of vehicle characteristics to used when designing both guideway and station facilities.

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.