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Factors Influencing Light Rail Transit Feasibility

MART KASK, Executive Director, Puget Sound Council of Governments, Seattle

As part of its regional transportation plan update for the post-1990 period, the Puget Sound Council of Governments (PSCOG) commissioned a study to assess the feasibility of a light rail transit system. The study found there would be sufficient demand to warrant some form of light rail for the Central Puget Sound Region of Washington by the year 2000. The feasibility study weighed the advantages and abilities of LRT and an all-bus transit system to meet future demand and found the cost of LRT, in the highest demand corridors, would be comparable to that of an all-bus system of the same capacity. LRT operating costs might be lower, and it would use less energy. LRT is a particularly attractive solution to Seattle central business district transit problems and has a potential for cost savings that could offset higher construction costs on other segments. The study identified two high-capacity regional corridors connecting with the CBD as the most feasible and cost-effective for LRT. PSCOG is working with the City of Seattle, Metro Transit, and the Downtown Seattle Development Association (private sector) to develop the scope and process and to obtain funding for further study.

The Puget Sound Council of Governments has recently completed an update of its regional transportation plan to the year 2000. A key recommendation is to consider light rail transit as an alternative transit mode in selected regional corridors in the post-1990 period. This recommendation was based on the results of a study conducted in fiscal year 1981 to determine the feasibility and justification of including fixed-guideway transit as a component of the long-range regional transportation plan.

The decision to consider fixed-guideway transit was made within the context of the following factors:

- Expanding areawide economy,
- Increased public acceptance and use of transit,
- Lack of support for major new highway projects,
- Need for energy conservation, and
- Regional development policies.

Forecasts of employment growth have been adjusted upward substantially in recent years. The ratio of transit ridership per capita in the Seattle urban area is one of the highest in the nation for urban areas of comparable size. The unique topography of the region has limited the mileage and capacity of the freeway system and compressed travel demand into a few well-defined corridors.

THE REGION

The Puget Sound Council of Governments is the Metropolitan Planning Organization (MPO) for the Central Puget Sound Region of Washington, consisting of the 4 counties of King, Kitsap, Pierce, and Snohomish. The population of the region is 2.2 million; 80 percent live in the urbanized areas of the 3 largest counties. The major population center is King County with a population of 1.3 million, including its central city, Seattle.

Like most urban regions, its transportation system was developed under diverse circumstances over many decades by numerous jurisdictional entities. In addition, the region has unique attributes and problems that offered opportunities and imposed constraints on past development of the region's transportation system and will influence determination of its future transit needs.

The region is both the victim and the beneficiary of its geographic location and topography. While the Puget Sound waterway, large inland lakes, and glacially formed topography that characterize the region provide unusual scenic beauty and numerous economic attributes, they also create an unusual setting for an urban transportation system. Generally, urban development has been a series of linear corridors, mostly north-south. Topography is a moderate to severe obstacle to most east-west corridors and, overall, has added significantly to the cost of providing the transportation facilities necessary to serve the area.

The north-south corridor runs for about 60 miles between the cities of Tacoma and Everett, with the Seattle CBD located midway. It is served by Interstate Route 5. New growth in King County has tended to locate in a 5- to 8-mile band due east of Seattle across Lake Washington. Transit service in the cross-lake corridor will be concentrated on Interstate Route 90, yet to be completed. These geographic features and the resulting pattern of urban development are particularly relevant to assessing the feasibility of light rail transit.

The Central Puget Sound Region has a dynamic economy because of its role as the preeminent business and financial center for the Pacific Northwest and Alaska. Population has increased commensurate with employment opportunities stemming from this economic growth. From 1950 to 1980, the region's population grew at an average annual rate of 2.1 percent compounded while the overall U.S. population increased at an annual average rate of 1.36 percent. The growth has consisted of about 55 percent net in-migration, a ratio expected to continue. There are many indications that the long-term growth of the region will continue at a rate greater than that of the nation as a whole by a margin at least as great as in the past. Growth forecasts figure prominently in the assessment of light rail feasibility.

The transportation plan update followed extensive efforts to define the area's urban development objectives. A regional framework for future growth was followed by the adoption of subregional development plans in each of the 4 counties. Individual local governments pursued policies, planning, and urban development strategies to better rationalize growth, especially in relation to transportation. The designation of activity centers encourages employment growth in nucleated areas where it can better be served by transit. These policies and strategies affect the subarea growth forecasts and the feasibility of fixed-guideway transit to serve the major activity centers.

CHANGING POLICIES AND PLANS

Regional comprehensive land use and transportation planning was initiated in 1961 by the Puget Sound Regional Transportation Study (PSRTS); work concluded in 1966 with development of alternative land use and transportation plans for 1990. The study produced a Recommended System of Freeways and Expressways that was adopted by the sponsors of the project—the Puget Sound Governmental Conference and the Washington State Highway Commission—in November 1966.

The proposed system was extensive and was based on projected growth and the facilities needed to meet that growth, as determined by the values of that time. Many of the facilities have since been deleted. Figures 1 and 2 show the substantial reduction made in the number of freeway miles proposed.

At the same time, however, growth was occurring at about the projected rate. The growth was partly accommodated through greater emphasis on transit; transit system management strategies were significant for achieving more efficient use of the existing system. Management was also helped by different travel patterns than were anticipated. But a large portion of the projected and realized growth has not been accommodated, and it has resulted in increased highway congestion. The region has had to accept a lower level of service because it cannot build all of the capacity needed to eliminate the congestion.

YEAR 2000 PLAN

The year 2000 plan calls for a very limited expansion of the freeway/expressway system. The area will rely heavily on increased auto occupancy and transit ridership.

Because of the peak-period transit volumes projected in the major regional corridors, especially those directly connecting with and serving the Seattle CBD, a high-capacity line-haul transit system will be required. Preliminary assessment indicates that light rail transit should be fully considered as an alternative transit mode in addition to an all-bus system.

How to accommodate transit demand in the Seattle CBD is perhaps the most serious problem. Current bus passenger volume has reached a level that is objectionable to many who work and do business in the CBD. Expected increases are unacceptable under current operating conditions. Two alternate solutions have been proposed: transit terminals with electric trolley service interconnection along a transit mall, and a grade-separated (subway) facility. The subway alternative would involve a major investment and require a detailed analysis. Before such an analysis can be done, a decision must be made regarding the justification and need for a fixed-guideway transit component because of its implications for the regional transportation system.

LIGHT RAIL FEASIBILITY STUDY

Elected officials who form the Puget Sound Council of Governments decided to devote a substantial portion of the region's UMTA planning grant to a study of the feasibility of light rail transit in the Central Puget Sound Region

Figure 1. Adopted regional plan of freeways and expressways, 1966.

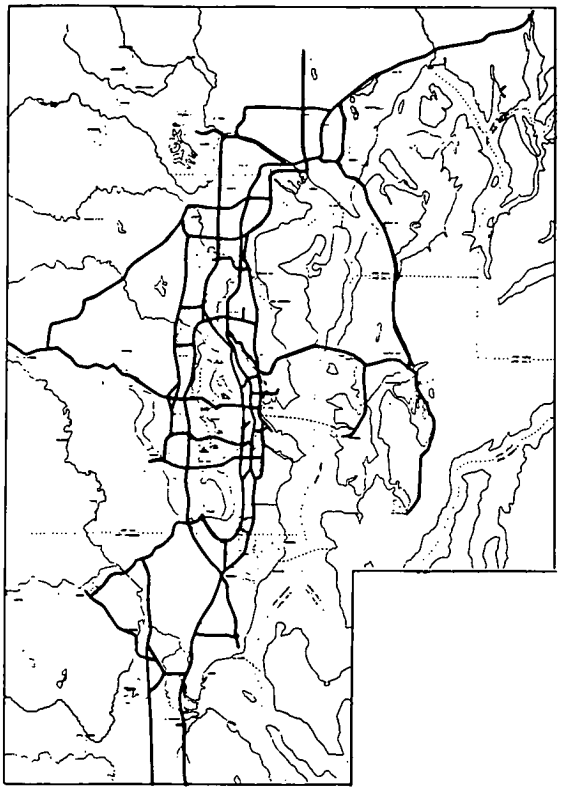
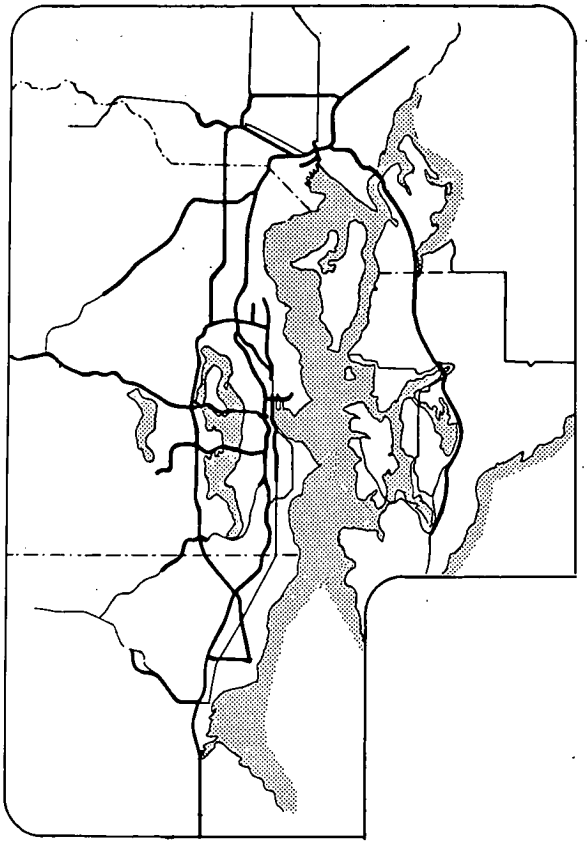


Figure 2. Year 2000 plan: freeway-expressway system, 1981.



after 1990. The objective of the study, as stated in the request for proposals, was to determine, at the systems level, whether growth trends, transportation factors, and the area's urban development objectives, projected beyond 1990, would justify a role for fixed-guideway transit in the regional transportation system.

The study was expected to provide the information necessary for a decision on whether to proceed with a detailed system level and corridor analysis of alternatives outlined in UMTA's procedure for major urban mass transportation investments.

Sponsors raised the following questions for the study to answer at a level of definition appropriate to an initial policy decision:

- Assuming incremental development of fixed-guideway segments in the transit system, what is the ridership potential compared to an all-bus system? What are the ridership thresholds in corridors and within activity centers that justify the detailed consideration of fixed-guideway technology as an alternative?
- Considering the current and forecast land use in the region, what are the potential impacts of fixed-guideway transit segments on urban and suburban development? Conversely, to what extent is justification of fixed-guideway technology dependent on changes in land use (increased densities)?
- What types of technology have a practical application in the region, and to what extent do alternative technologies have a bearing on the initial policy decision regarding fixed-guideway feasibility?
- To what extent does feasibility depend on the availability of rights-of-way and their locations for use by fixed-guideway facilities?
- Assuming incremental development of fixed-guideway transit facilities, how can an approximate estimate of capital costs be developed to provide a "benchmark" for comparison with other alternatives?
- How important are energy costs and the relative differences among energy sources in the question of fixed-guideway transit feasibility?

In October 1980, the consulting firm of Daniel, Mann, Johnson and Mendenhall (DMJM) was selected to conduct the light rail feasibility study. The draft report was presented in March 1981. Policy direction was provided by the PSCOG Standing Committee on Transportation, which includes local elected officials, State Department of Transportation officials, and transit operators. A technical advisory committee for the study was formed with representatives of the transit agencies and the State DOT.

Data Base

The feasibility study relied completely on existing data produced by the Council of Governments in the course of the transportation plan update. PSCOG had operational a battery of transportation models using the UTPS package. These models, including a mode-split model, had been validated with fairly recent data (1975 and 1977) and had been proved technically sound for estimating transit patronage. The consultant was provided with the network simulation and UTPS output information on two alternatives: a bus system substantially as it now exists, and a system with high-capacity and performance characteristics in major corridors. Existing (1977) and forecast data (1990 and 2000) for population, employment, and household groups by traffic analysis zone were already available. As part of the feasibility study, the consultant assessed the potential effect of a fixed-guideway transit component on future population and employment location. The consultant reviewed the projected transit patronage levels and found them to be "reasonable" for use in assessing a fixed-guideway system.

Apparent Decision Thresholds

To establish a threshold transit volume level for assessing the feasibility of fixed-guideway transit, the consultant examined various studies of theoretical capacities, the actual volumes of existing systems with high-volume bus and rail corridors, and the projected volumes of new systems just being implemented. Based on the data, an apparent decision threshold in the 4000 to 7000 passengers per hour range was thought reasonable. In the Puget Sound Region, maximum peak-hour volumes as projected for the year 2000 are more than 14 000 in the I-5 corridor (north-south) and over 7500 in the I-90 corridor (east-west)—well above that apparent threshold.

Criteria and Methodology

The consultant identified criteria by which to compare the all-bus and fixed-guideway alternatives. The criteria covered 4 major transit areas: performance and operating factors, cost factors, urban factors, and environmental factors. Within each area, from 2 to 5 sub-items were identified (Table 1) together with the basic analysis methodology used in the preliminary assessment.

Corridor Analysis

The first task was to identify the candidate corridors and to define, in concept form, alternative all-bus and combination rail and feeder bus systems to serve each corridor. The consultant used the projected year 2000 transit patronage and assignments and selected the following corridors:

- I-5 North (to Everett),
- I-5 South (to Tacoma), and
- I-90 East (to Bellevue and Kirkland).

Each is a radial corridor connecting with the Seattle CBD. The corridors were selected on the basis of projected transit volume and auto congestion levels.

With the definition of the study corridors and their respective demand volumes, concept level transit systems were developed for all-bus and light rail service.

Findings

Capacity

Either system has the capacity, under the assumed operating concepts, to satisfy the projected peak-hour demand volumes in the year 2000, as well as the ability to expand capacity, within limitations, if necessary. For the bus system, the stations and terminals are the limiting factor since the volume of buses per hour that can be handled in these facilities is a function of the size of the station/terminal. In the case of the rail system, the capacity is a function of the train length and headway.

CBD Issues

Capacity limitation is a particularly critical issue in the Seattle CBD. Among the options proposed as potential solutions, the one preferred is based on a twin terminal concept; regional buses would be intercepted at the north and south ends of the CBD, and CBD circulation then provided by electric trolleys operating in a mall or tunnel. This option was accepted for the LRT study and examined in the context of the impacts of a regional rail element. The evaluation found that the most dramatic impact of the regional light rail system is a major reduction in terminal sizes required. If a tunnel solution is adopted, additional savings would be realized because a smaller tunnel and stations would be required. Thus, a regional rail system

Table 1. Preliminary criteria list.

Factor		Analysis: Quantitative	Analysis: Subjective
1.	Performance		
	Capacity	X	
	Trip time (or vehicle speed)	X	
	Energy efficiency	X	
	Compatibility with demand distribution		X
	Expansion and growth potential		X
2.	Cost		
	Capital cost	X	
	perating and maintenance cost	X	
3.	Urban		
	Transit-induced development opportunities	X	X
	Accessibility		X
	Community disruption		X
	Interface with other modes		X
	Consistency with adopted subregional areawide plans		X
4.	Environmental		
	Aesthetics		X
	Noise		X
	Air pollution		X

will not only work with the various CBD concepts but also reduce the net cost significantly.

Travel Time

Corridor travel times were found to be comparable under either option.

Energy Efficiency

The consultant compared the energy efficiency of the two options only with regard to the unit consumption of each mode. Total annual operating miles were not developed, so neither the total operating energy requirement nor the construction energy requirement could be developed. The comparisons were made on the basis of energy per vehicle-mile, per passenger-mile at various load factors, and per passenger-mile based on average system productivity in actual system operations. The LRT vehicle was found to be the most energy efficient in each comparison.

Comparing the difference in cost (current prices) between diesel fuel and electricity to operating efficiencies, the energy cost per passenger-mile for the bus system is, on the average, about double the cost for LRT. The region's relatively low electricity cost is an important factor in keeping down the energy cost of rail modes.

Capital and Operating Costs

The level of detail in the feasibility assessment severely limited the development of cost data. However, the consultants were able to estimate a capital cost of $417 million to $582 million for the bus system, depending on the CBD solution used, and a capital cost of $825 million to $990 million for the entire rail system. The cost estimates assumed use of existing right-of-way for both systems, except for minor transition points. The rights-of-way include Interstate highway lanes and parts of the old interurban system that connected Seattle, Everett, and Tacoma. Thus, no major new structures would be needed.

Comparison at the total system level indicates that the total 80+ miles of rail probably cannot be justified. However, when assessed on a segment basis, the comparisons better indicate the relative value of the modal options. For example, bus system costs at the outer ends of the corridors are minimal; almost all its cost except for maintenance facilities and bus fleet is in the central, high-volume corridors. The capital cost of the rail system, however, is virtually the same throughout the corridor regardless of volume, except for vehicles and maintenance facilities. Nearly 40 percent of the rail segment is in lower volume segments; reducing the system by even 20 miles will bring the two systems' total capital costs closer together.

Operating cost estimates were based only on peak-hour service and were $14 450 for the rail system and $16 320 for the bus option.

Transit-Induced Development

The last criterion for which quantitative analysis was conducted related to the potential for transit-induced development under each option. This analysis, conducted by a subcontractor, reached the following conclusions:

- Major improvements would be needed to produce significant transit-induced development in the freeway corridors; development would be similar under either option.
- High-capacity transit located in nonfreeway corridors would be more likely to generate significant transit-induced development; rail impacts would be the most significant.
- The most likely development would be intensified residential development in the outer reaches of the corridors through in-filling or single-family and new multi-family residences near station stops.
- The most likely core area impacts would be to reinforce office/commercial development.
- The overall impacts would generally support current growth management policy.

Conclusions

The consultant study produced the following findings:

- A regional light rail element has the potential for

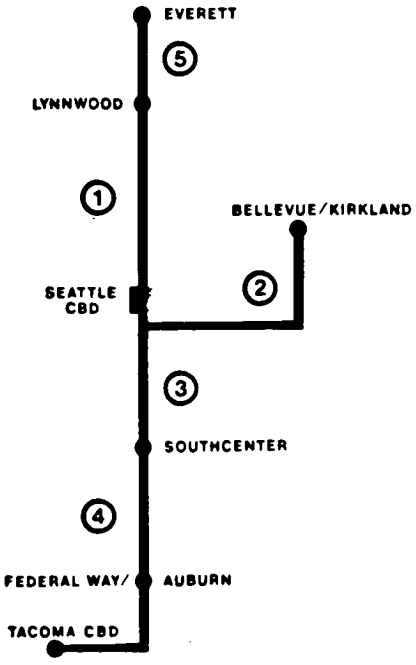


Figure 3. Ranking of corridors, light rail transit feasibility.

major cost savings and reduced transfer volume in terminals when compared to various bus-related options for solving the Seattle CBD issues.

- Light rail costs may be comparable to those of an all-bus system, considering the level of investment expected in the high-volume segments of the corridors with the all-bus option. Life cycle costs may also be comparable and potentially more favorable because of differences in operating costs and vehicle life. A more detailed analysis is necessary to determine these relationships accurately.
- LRT system operating costs may be lower at the demand levels projected by recent PSCOG studies.
- An LRT system has a significant potential for reduced energy consumption, particularly petroleum fuels.

These findings indicate that a feasible LRT project exists and warrants inclusion in a detailed alternatives evaluation. However, the findings also indicate that the project must be on a lesser scale than the full 80+-mile system described in this assessment. In that context, the probability of a feasible and cost-effective project within a corridor or combination of corridors may be ranked as follows (Figure 3):

1. The north corridor, including the Seattle CBD, between the CBD and the general Lynnwood area;
2. The east corridor from the Seattle CBD to some point north or northeast of Bellevue;
3. The south corridor to some point south of South Center (preferably in a nonfreeway corridor);
4. The south corridor to Tacoma; and
5. The north corridor to Everett.

FUTURE STEPS

The first step after completion of the feasibility study was to put light rail transit in the regional transportation plan update as a long-term recommendation.

The next step will be detailing the system and evaluating light rail compared to buses in individual corridors. This will involve looking at alignment, station location, system operation, and connections with a feeder bus system. The consultant has done a fairly detailed scope of work for this phase, and the PSCOG plans to request an UMTA Section 8 alternatives analysis grant when the FY 1982 appropriations bill becomes effective.

In the meantime, PSCOG is working with the City of Seattle and Metro on the environmental impact statement for the midrange transit alternatives for the Seattle CBD to ensure that light rail transit could be accommodated if it later became the chosen mode. The CBD project also has tasks, not yet begun, that deal with such long-term solutions as dual-mode vehicles operating in a tunnel, LRT in a tunnel, and LRT on the surface with terminals and a mall. The objective is to preserve the option for a future regional light rail transit serving the Seattle CBD.

Suburban and Interurban Applications of Light Rail Transit

RICHARD F. TOLMACH, California Department of Transportation

While most analysis of light rail transit has been focused on urban premetro and semimetro development, many of the more successful European light rail developments have been on routes that operate primarily on off-street surface trackage through low-density suburban and rural areas. This paper examines design and operations of light rail systems that serve areas of low population density. Six European and three North American examples are described, with attention to geographic, sociological, and financial aspects of their operating environments. Scheduling strategies, fare structures, and methods of traffic generation used by these systems are given special emphasis. The prospects for future North American interurban light rail developments are examined, with a view to San Diego's new system being a model for selected conversion of North American intercity railroad facilities to provide electric interurban services.

The words "light rail transit" often do not convey the technology or development philosophy symbolized by them. They are misunderstood by the public and even by some transportation professionals. Many Californians fixate on the word "light," and imagine light rail transit to be a form of automated people mover technology; this causes someone to explain that light rail is "modern streetcars." This simplified definition has been tolerated by transportation professionals, but it causes more misunderstandings. To describe the light rail systems being built in North America today in terms of streetcars is obviously inadequate. One can invoke such European terms as "pre-metro" or "Stadtbahn," but this does not help explain the attributes of light rail.

The model for light rail's development is not streetcars down Main Street but the interurbans' innovative use of a variety of rights-of-way. Light rail's future is not in