Sounder Commuter Rail
Tacoma to Lakewood Extension:
An Uphill Battle

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AREMA ABSTRACT

Sounder Commuter Rail Extension: An Uphill Battle

Jim Edwards
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Under Phase 1 of the Sound Move program, approved by the voters in 1996, Sound Transit committed to creating an 85-mile commuter rail system in Washington State from Everett to Lakewood. This includes 8.2 miles of track from Tacoma Dome Station to Lakewood -- 1.2 miles of new track within the City of Tacoma and reconstruction of 7 miles of existing rail corridor. Within Tacoma, the proposed alignment offers significant challenges in terms of topography and sensitive adjacent land uses. This segment of the corridor includes steep grades in the range of 3.5% and crossing a number of major arterials. Sound Transit is balancing various techniques of design feasibility studies, computer simulation modeling, and actual field testing in an existing corridor with similar grades to identify the optimal alignment that would allow Sound Transit to provide safe and efficient commuter rail operations. This paper outlines the process Sound Transit is undertaking to address some significant operational issues so that it may successfully advance the project.

Key Words: Steep grades, field testing
INTRODUCTION

Under Phase 1 of the Sound Move program, approved by the voters in 1996, Sound Transit committed to creating an 85-mile commuter rail system in Washington State from Everett to Lakewood. This includes 8.2 miles of track from Tacoma Dome Station to Lakewood, illustrated in Figure 1. Construction of 1.2 miles of new track within the City of Tacoma is required as well as rebuilding 7 miles of existing rail corridor, purchased from BNSF. Within Tacoma, the proposed alignment offers significant challenges in terms of topography and sensitive adjacent land uses. This paper outlines the process Sound Transit is undertaking to address some significant operational issues so that it may successfully advance the project.

With the terrain challenged by a grade in the range of 3.5% in a dense urban environment, Sound Transit is faced with a tough situation for constructing a new rail alignment that will meet safe operational expectations. The alignment will need to: meet safe operation requirements; be acceptable to the Tacoma community; be sited at an environmentally acceptable location; and fall within the budget approved by the voters. Sound Transit has a very challenging task at hand.

Although passenger rail service to Lakewood was to commence in 2008, addressing the challenges of the physical terrain and vehicle operations it is expected that service could be delayed until 2010.

HISTORY

This corridor has been studied by various agencies and entities several times over the last 10 years as a solution to address improved performance for high capacity rail services and provide additional freight capacity.

In 1994, RTA (precursor to the Sound Transit organization) initiated advanced planning for rail feasibility. This effort led to the Tacoma to Lakewood project being included in the Sound Move program. The evaluation identified an alignment with a 3.0% grade.
In 1998, the Port of Tacoma led a multi-agency study of this corridor to determine the best alignment to extend commuter rail from Seattle to Lakewood as well as adding freight capacity. Grades ranging from 3.5% to upwards of 4% were considered in the alignment options.

WSDOT Rail Division, serving Amtrak Intercity Rail, is currently undertaking an environmental impact analysis to identify infrastructure improvements required for high speed service along this corridor.

Sound Transit initiated the Environmental Impact Statement (EIS) on this corridor in 1998. The analysis considered a number of alignments for the new track section between D and M Streets in Tacoma, presented in Figure 2 on the next page. Consideration of the sensitivity of the adjacent land uses and potential property acquisitions led to the selection of the EIS Preferred Alternative in 2002. In 2002, Sound Transit received the Record of Decision from FTA for commencing design on the Preferred Alternative.

As Sound Transit was in negotiations with Burlington Northern Santa Fe Railroad for the purchase of the Lakeview Subdivision Line from 2002 and continuing until December 2003, design on the corridor did not begin until 2004.

D TO M STREET SEGMENT

This section in Tacoma presents many challenges to introducing a new railroad alignment. As the alignment heads south from the existing Tacoma Dome Station, there are many heavily traveled roadways, complex intersections, and numerous businesses that are interspersed along the route. Adjacent land uses include retail properties, a gas station, car wash, auto repair/tire shop, and numerous properties that are located within an historic district. Along South Tacoma Way there is the Tacoma Rescue Mission which provides community social services.

The Challenging Terrain

The corridor begins at Tacoma Dome Station, runs under I-705 overpass, crosses A Street, Pacific Avenue and runs parallel to South Tacoma Way. It runs beneath the Tacoma Avenue Bridge and joins the existing Lakeview Subdivision Branch Line. The route is complicated by steep slopes that flank both sides of South Tacoma Way with the grade climbing a significant elevation as it heads toward Lakewood. The terrain in this vicinity rises approximately 150 feet in 5000 feet.
EIS Preferred Alternative

The Preferred Alternative in the EIS, crosses Pacific Avenue at-grade and runs parallel to South Tacoma Way on the
easterly side. It crosses South Tacoma Way at-grade on a sharp skewed angle in order to fit beneath the Tacoma Avenue
Bridge columns. The profile climbs grades between 3.4% and 3.8% in various portions of the one-mile segment, as
illustrated in Figure 3.

The at-grade alignment would require crossing A Street, Pacific Avenue, Delin Street, and South Tacoma Way. Delin
Street which joins the intersection of Pacific Avenue and South Tacoma Way would need to be closed to allow a rail crossing
at this location. In order to soften the steep grade, grades at A Street would need to be raised so high that connections to the
cross streets would be prohibited. Therefore, it has been recommended that A Street be closed as well.

Two new, at-grade crossings, both at significant skewed angles, with one crossing a major intersection, would be
introduced with construction of the Preferred Alternative. The alignment crosses Pacific Avenue along a 40-degree skewed
angle, as depicted in Figure 5. A second at-grade crossing would be located just north of the Tacoma Avenue bridge as the
tracks cross to the west side of South Tacoma Way. The angle of this crossing would be approximately 15 degrees, more
severe than the crossing at Pacific Avenue, as presented in Figure 6.

Steep Grade/Vehicle Procurement

Beginning at Tacoma Dome Station and heading south to the Lakeview Subdivision Line, the topography rises
approximately 3 percent. In 1998 when Sound Transit began procurement of it locomotives, it set forth requirements for
operating along a grade of 3.5% in its specifications. Electro-Motive Diesel (EMD) attested that its F59PHI locomotive
could successfully traverse this grade and was selected as the vendor.

Because speeds in excess of 79 mph were not anticipated for the corridor, Sound Transit opted to have the gear ratio adjusted
to 66:20 to ensure better performance on the steep Tacoma grade. The locomotives are equipped with both a sanding system
and the Super Series electronic adhesion control system which would also enhance performance on the grade. Sand enhances
adhesion when the rails are slippery, while the Super Series system is designed to allow the wheels to creep slightly when
under a heavy pull.
PRELIMINARY DESIGN

Preliminary design on the at-grade alignment began in late 2004. An alignment that would have the least impact on the adjacent roadways would require grades ranging from 2.9% to 3.4% to 3.8% in a 7-degree curve along the corridor between D and M Streets. As part of its standard practice, Sound Transit sent the 30% designs out for independent operational and technical reviews. These reviews raised concerns about the ability of the locomotives to operate reliably on the steep grade and cautioned Sound Transit about introducing two new at-grade crossings in an environment where most jurisdictions are trending towards eliminating at-grade rail crossings.

OPERATIONS SIMULATIONS MODELING

To follow-through on the suggestions of the independent reviews, in July 2005 Sound Transit initiated a series of operations simulations analyses to model the train performance along this segment of the corridor. Grades of up to 3.8% were modeled to determine how Sound Transit’s equipment would perform along steep grades.

Several model runs along various grades were conducted to identify the most reliable operating parameters along this corridor. Modeling was performed for both dry and wet conditions, with one stop on the grade and without stopping, with full and crush loadings, and with various consist configurations.

The simulations were conducted using an interactive train operations simulation computer program. This program allows the operator to assume the role of the locomotive engineer and to operate the train on the computer according to the desired conditions and in accordance with the railroad’s operating rules. The computer program mathematically simulates the operation of the train as directed by the engineer/computer operator. This type of computer program serves as the basis for the locomotive simulators that are used by the railroads to conduct locomotive engineer training.
Input Variables

There are five main factors affecting the ability of the train to climb the South Tacoma Grade:

1) gradient
2) adhesion
3) number of passengers
4) number of cars on the train
5) horizontal curves.

A change in the gradient of the track has the greatest effect on the ability of a train to traverse the grade. As the initial simulations with grades up to 3.8% provided questionable operational results, Sound Transit modified the profile several times to identify the operational trade-offs associated with the various grades.

Although the adhesion available between the wheels of the locomotive and the rails is an important determination for how hard a locomotive can pull, the Super Series system of these advanced locomotives can maximize available adhesion by allowing an acceptable level of controlled wheel creep. In this study, typical adhesion values for wet and dry conditions were used for the EMD F59PHI locomotive.

Loadings considered both full and crush loads with a passenger weight of 155 pounds per person. Full loads equate to 100% of the seats filled, or 140 passengers. Crush loads are estimated to consist of 300 passengers.

Train consists, mimicking actual operating conditions, were comprised of 1-locomotive and 7 cars.

Results

The results of the modeling indicated that, under full load conditions, the trains were very close to their maximum performance limits when trying to restart a train in the uphill direction after stopping on the grade under slippery rail conditions. Sound Transit decided to field-verify the simulations results using an actual Sounder commuter train on a similar grade situation.
FIELD TESTING

Sound Transit conducted field testing in December of 2005 and again in May of 2006 to verify the results of the modeling that was done previously. This testing was done on a section of Tacoma Rail track in Tacoma, Washington which services a short line freight operation. A track survey was conducted prior to testing to confirm the suitability of the track and to confirm the gradient, horizontal curvature, vertical curvature, super-elevation in the curves, cross-level variation and gauge. This particular test site provided a good opportunity for testing on various grades, in spite of the presence of several horizontal curves.

Test Train Consist and Loading

The test train in December was comprised of Sounder coach and cab cars to closely simulate a real train. The test in May used equivalent trailing weight to simulate the weight of an actual train. The advantage of the simulated weight using locomotives instead of the Sounder passenger equipment resulted in a shorter train to mitigate the effects of the horizontal curves and eliminated the damage caused by the particularly tight combination of vertical and horizontal curves entering the territory. Both tests used a trailing load that would exceed the expected loads Sound Transit would experience for several decades to come in the Tacoma to Lakewood Corridor.

Operating Conditions

The manner in which the locomotive is operated will have a considerable impact on the results of the testing. The F59PHI locomotives have an extremely sophisticated control system which allows the locomotive to maximize the pulling power without human intervention through its Super Series operation. The field testing in December of 2005 relied on a more conventional human intervention and caution in attempting to manipulate the extreme grade. The test in May of 2006 relied exclusively on the Super Series operation to control the pull with virtually no human intervention. Both field tests were conducted on dry and wet rails for portions of the test. The field test conducted in May surpassed the results of both the December test and of the computer model simulations.

FOLLOW-UP OPERATIONS SIMULATIONS

Since considerable progress has been made on the most desired track profile and grade since the initial computer simulations were conducted, Sound Transit is now interested in possibly conducting further computer simulations with the new track profile and operating parameters to more closely simulate actual conditions.
HAZARD ANALYSIS

Beginning in August 2005, Sound Transit initiated a series of hazard analyses to determine the risk indices and the potential for fatal commuter/passenger train-to-motor vehicle collisions for the two major at-grade crossings between D and M Streets: Pacific Avenue and South Tacoma Way. Analysis was considered using various operating speeds (35 MPH, 18 MPH, and 14 MPH) and varying numbers of daily train trips.

The analysis addressed the risk of predicted fatal commuter/passenger train-to-vehicle collisions and injury collisions of a train, from among a total of 26 daily train trips through the crossings (consisting of 18 Sounder trains and 8 Amtrak passenger trains) and an automotive vehicle at the two at-grade crossings. It also addressed the risk of predicted fatal commuter train to vehicle collisions, and injury collisions of a train, from among a total 18 daily Sounder trains and an automotive vehicle at the two grade crossings. The 35 MPH train speed was selected as the maximum timetable speed on this route. The 14 MPH speed was selected because it yielded a case where the accident potential of the crossing could be acceptable.

Traffic volumes, average daily traffic counts (ADT), intersection configurations, crossing configurations, train speed, grades, engine characteristics, braking rates, and train consist configurations were evaluated to determine the train-vehicle accident potential for proposed Sounder crossings at: 1) Pacific Avenue/ South Tacoma Way/ 26th Street and 2) South Tacoma Way.

The predictions use USDOT formulas using grade crossing design and operational characteristics, in accordance with the FRA, Office of Safety Analysis, Rail-Highway Crossing Resource Allocation Procedure, User’s Guide, Third Edition, August 1987. The analysis also addresses the risk index associated with operating the trains at these two crossings without locomotive horns while using a FRA-defined compensating supplementary safety measure such as a non-mountable median curb in the design of these crossings. The analysis adjusts the risk for each of the two crossings based on the FRA-defined measures of effectiveness for supplemental safety measures to compensate for the risk of operating the trains at the two crossings without a locomotive horn.
For each of the two grade crossings, a risk index is calculated using the FRA methodology established in Final Rule, Part II, DOT FRA, 49 CFR parts 222 and 229 titled: Use of Locomotive Horns at Highway-Rail Grade Crossings; Final Rule dated April 27, 2005. The calculated risk index for each of the two grade crossings is compared to the FRA-established current Nationwide Significant Risk Index Threshold (NSRIT) which is based on data from 35,803 grade crossings, to determine if these two grade crossings qualify for train operation without the use of the locomotive train horn (Quiet Zone). The national annualized cost per crossing from all fatal and injury accidents in a grade crossing is $17,030.

Results

The results indicate that the South Tacoma Way at-grade crossing is within the acceptable risk limits under all of the conditions that were evaluated. Operations at the proposed at-grade crossing at Pacific Avenue, South Tacoma Way and 26th Street would be considered unacceptable with the additional 8 Amtrak trains. Sound Transit is currently working with partner agencies to address these limitations and explore other alternatives.

NEW ALIGNMENTS CONSIDERED

Based on concerns regarding train performance on the steep grade and the introduction of two new at-grade crossings that would limit future growth in passenger and freight operations along this corridor, Sound Transit decided to explore modifications to the D to M Street alignment.

Grade Separation At Pacific Avenue

A working group session was held in December 2005 with members of Sound Transit staff, City of Tacoma staff and consultant staff to determine what the limitations were for reducing the gradient along the South Tacoma Way alignment. Several modifications to the alignment were considered which would require raising Pacific Avenue several feet, lowering South Tacoma Way several feet, relocating many subsurface utilities, adding numerous small retaining walls at the intersection of Pacific Avenue and South Tacoma Way, and several longer, higher retaining walls along South Tacoma Way. During this effort, the group began to take another look at a grade-separated option that would eliminate the need for the two at-grade crossings at Pacific Avenue and South Tacoma Way and allow increased passenger rail traffic in the corridor for future use.
The corridor for a grade-separated alignment would cross A Street, Pacific Avenue and South C Street. As the alignment would remain on the westerly side of South Tacoma Way, the tracks would not have to cross that roadway. Closures of A Street and South C Street would be required. As BNSF ceased operations along the existing corridor in the vicinity of D to M Street several years ago, a simpler connection to the Lakeview Subdivision Line could be achieved than considered in earlier studies.

A structure would carry the rail corridor over Pacific Avenue, just north of the South Tacoma Way intersection. In order to achieve minimum clearance of 16.5 feet above the Pacific Avenue roadway and limit the grade of the track, Pacific Avenue would need to be lowered up to 12 feet. This would also require South Tacoma Way and other adjacent roadways to be modified to meet Pacific Avenue’s proposed grade. Lowering the roadways would also significantly impact the subsurface utilities.

While the 2001 EIS did consider an alignment to the west of the Pacific Avenue/South Tacoma Way intersection, this alignment was at-grade, not elevated. An Environmental Assessment may be required by FTA to review impacts associated with this change.

Because a significant number of businesses would be affected by this alignment and properties would need to be acquired, Sound Transit began to explore other options.

**New Alignment – West of South Tacoma Way**

Sound Transit is currently investigating the feasibility of an alignment that was suggested by the City of Tacoma in March 2006. This alignment crosses Pacific Avenue on structure and stays along the westerly side of South Tacoma Way. South Tacoma Way’s intersection with Pacific Avenue is shifted southward and aligns with 27th Street. This realignment eliminates an at-grade rail crossing of South Tacoma Way while providing a more direct through-route for traffic bound for I-705.

This rail alignment appears to offer significant improvements over the other alternatives that have been considered to date. It eliminates two major at-grade crossings; does not require significant property acquisition; and can be built with
grades lower than 3.4%. Designers are currently working to optimize the access for businesses which no longer abut South Tacoma Way.

**ACTION PLAN**

Sound Transit continues to explore its options to operate along this difficult topography and construct a corridor that will safely and reliably serve its passengers. Over the next several months, Sound Transit will be weighing the associated operational and infrastructure impacts and costs in order to achieve a suitable plan for moving forward.

**Vehicle Performance Issues**

In 2000, Sound Transit accepted EMD’s locomotive with the condition that EMD would conduct a field test along a 3.5% grade to confirm that the locomotive with a 10-car consist would start after a stop along the grade. EMD submitted the results of a simulations analysis and attested that they were confident that the vehicle would perform successfully on the required grade. The test that was conducted in May of 2006 confirmed the successful performance of the F59PHI locomotive in pulling a grade of 3.5%.

**Alignment Revisions**

A grade-separated alignment would allow additional future passenger rail service within the corridor. As this improvement would require additional funding, Sound Transit continues to explore discussions with potential beneficiaries.

**Scheduling Issues**

Passenger rail service to Lakewood is likely to be delayed until 2010. Until completion of the corridor, passenger demand could be met by express bus service operating from the Lakewood Transit Center. The center could be open for service in 2008.

**SUMMARY**

As with many projects, the course of action set forth at the onset may change many times along the path of development. The Tacoma to Lakewood Extension Project epitomizes this concept. Changes in political philosophy and support, property ownership, knowledge of expected equipment performance, risk factors, and other dynamics have led Sound Transit to the
current stage of development. With the plethora of new information that has been developed over the last six months, Sound Transit took a step back from its aggressive project delivery program for this corridor and looked hard at the major issues that would shape this corridor for many years to come.

Sound Transit continues to hold discussions with potential stakeholders in both the passenger and freight rail transport arenas to understand how the region’s needs could best be met. In concert with these partners, Sound Transit will explore what modifications to the project are required to meet the longer term needs and how funding may be achieved to accomplish these improvements. Once these issues have been adequately addressed, Sound Transit can develop the most appropriate plan for moving forward.
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