East Link Extension Project

June 6, 2017

Independent Review Team (IRT) Summary

Sound Transit's East Link Extension from downtown Seattle to Redmond includes 14 miles of light rail and 10 new stations. The extension also includes building and operating light rail transit across a floating bridge. To do this, engineers and designers considered a number of technical and operational issues that were identified by an Independent Review Team (IRT).

Background

In 2008, the Washington State Legislature commissioned an Independent Review Team to evaluate light rail operations on the I-90 Homer M. Hadley (HMH) Floating Bridge, which carries west bound and express lane traffic..

Independent Review Team

The team, assembled by the Washington State Department of Transportation (WSDOT), under the supervision of the Joint Transportation Committee of the Washington State Legislature, included nationally-recognized structural engineers, marine engineers, and corrosion experts. For more information about the team, please visit http://www.wsdot.wa.gov/partners/IRT/team.htm.

Evaluation

The IRT reviewed and evaluated a variety of issues to be considered by Sound Transit and WSDOT. Including:

- **Corrosion Control:** Assess the effects of stray current impacts to the bridge.
- **Track attachment:** Assess methods for attaching light rail track to pontoons, elevated roadways and transition spans.
- **Structural evaluation**: Evaluate structural impacts of light rail on the floating bridge.
- **Maintenance:** Assess impacts of light rail on WSDOT floating bridge maintenance procedures.
- **Bridge joints and other elements**: Evaluate the effects of light rail passenger loads on the transition span, bridge expansion joints, bridge decks and other elements.
- **Track Bridge:** Assess Sound Transit's rail expansion joint system design.

The IRT has concluded that all issues with placing Light Rail on the floating bridge can be addressed or mitigated. Their report identified 23 issues which should be considered, evaluated, and tested during the Final Design process. All 23 issues were addressed in the design by Sound Transit Engineers with WSDOT oversight. All issues were resolved with both WSDOT and FHWA concurrence.

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Summary of Issues

The IRT identified 23 issues that WSDOT and Sound Transit addressed in designing light rail for the floating bridge.

Track Bridge / Expansion Joint Design and Performance Criteria (Issue A)

The East Link light rail tracks will cross two expansion joints located at each end of the floating bridge. Engineers and designers had to consider a number of factors – including six ranges of motion as trains travel onto the floating portion of the I-90 Bridge. A track bridge prototype was designed, built and tested at the Transportation Technology Center in Pueblo, Colorado where over 500 channels of data were collected. The track bridge passed all critical test criteria with the ability to provide safe and comfortable light rail service at speeds up to 55 mph.

Operational Restrictions for Combination of Train Loading and One-year Storm Loading from North (Issue B)

Due to its location, the floating bridge is susceptible to northerly wind and wave events that may impact light rail operations. Wind speed monitoring and operational restrictions will be incorporated into the Operations and Maintenance Agreement between WSDOT and Sound Transit. Two trains can operate on the bridge at the same time. Just as vehicular activity may be limited or suspended today, to today, operations may be limited during storm events which are predicted to happen approximately once a year.

Seismic Vulnerability and Seismic Retrofit of Approach Spans and Transition Span (Issue C)

Sound Transit will seismically retrofit the approach spans to the floating bridge well as other structures to prepare for light rail operations.

West Approach Tunnel Design Criteria Consistency (Issue D)

The Mt. Baker Tunnel, at the west approach to the floating bridge, was analyzed for structural and seismic impacts of additional light rail transit appurtenance. The analysis did not result in the need for seismic retrofitting.

Need for Lightning Arrestors on Floating Bridge and Approaches (Issue E)

Sound Transit has analyzed and designed a lightning protection system to protect the bridge structural elements from a lightning strike. The system will be installed on the HMH floating bridge and approach structures.

Sound Transit's Adoption of North Link / Airport Link Stray Current Mitigation Design Criteria for Homer M. Hadley Floating Bridge Installation (Issue F)

Due to its location, stray current design is critical when applied to the floating bridge. To ensure the service life expectancy of the floating bridge, Sound Transit has developed stringent design criteria that are unsurpassed in the light rail industry. The criteria were established in collaboration with the WSDOT, and requires multiple independent and redundant levels of protection along with monitoring systems of each that will notify maintainers when inspection is necessary.

Impact of Stray Current Dispersion in Lake Washington on Environment and Fish (Issue G)

With light rail vehicles traveling across the floating bridge, small amounts of stray current could disperse into Lake Washington and affect aquatic life. Sound Transit conducted an analysis and

determined that the amount of stray current would be negligible compared to existing conditions. Adverse effects on aquatic life are unlikely and is not considered an issue.

Stray Current and Cathodic Protection System Interference and Compatibility (Issue H)
WSDOT's floating bridges all have cathodic protection systems which protect the anchor cables from corrosion. The IRT suggested upgrading the existing cathodic protection systems on the HMH floating bridge to address the addition of the light rail design conditions. Sound Transit has analyzed, designed and performed proof of concept testing of new cathodic protection equipment to help ensure corrosion does not affect the life expectancy of the floating bridge. All analysis and testing has been reviewed and observed by WSDOT. Inspection and testing during construction will ensure that the system performs as designed.

Analysis to Confirm Torsion Capacity of the Existing Bridge (Issue I)
In 2006, Sound Transit and WSDOT worked together to map actual stresses on the floating bridge during a full-scale loading test to simulate the trains traveling on the floating bridge. Tractor trailers loaded with weights mimicking fully loaded light rail vehicles were used to conduct this testing. This data was then used by the engineers to calibrate structural models and validate the torsional response of the bridge.

Analysis of "North Wind" Storm Effects on the Homer M. Hadley Floating Bridge (Issue J)
The bridge structural design considered load cases from extreme weather events. The most critical storms are those generated by winds from the north.

Criteria Established for Independent Review Team to Evaluate Numerous Issues (Issue K)
Due to the potential for major installation or cost impacts, the IRT recommended that Sound Transit provide design criteria for specific design issues related to the current bridge. The IRT developed the evaluation criteria to measure each issue.

Operation and Maintenance Coordination Agreement between Sound Transit and WSDOT (Issue L)
Sound Transit and WSDOT have agreed to four elements that form the basis for an Operations and Maintenance Agreement for the floating bridge and approaches that will ensure that the remaining years of bridge's life are fulfilled:

- Existing Agreements and commitments between WSDOT and Sound Transit
- Identified Operations and Maintenance coordination teams
- Agreed upon process for preparation of exhibits to the Agreement
- Agreed upon outline and topics for an Operations and Maintenance Agreement

Rider Comfort Performance for Light Rail Transit Track Bridge at Expansion Joints (Issue M)
Based on modeling, track bridge prototype testing at the Transportation Technology Center, and performance during initial operations testing, Sound Transit will adjust light rail vehicle running speeds for the various track bridge positions as needed to achieve rail federal rail transit passenger comfort standards. During initial testing prior to revenue service, Sound Transit will instrument trains and adjust light rail vehicle running speeds if needed to achieve rail passenger comfort standards. Expected normal operation speed is 55 mph.

Attachment of Overhead Catenary System Supports to Edge of Homer M. Hadley Floating Bridge Deck Cantilevers (Issue N)
The overhead catenary system (OCS) provides electricity to light rail vehicles through overhead wires supported by poles. A typical OCS system cantilevers from the side of the rail line and has large forces that are transmitted to the foundations. The OCS support system for the floating bridge was modified to a frame that substantially reduced loads on the bridge structure. The OCS for the floating bridge is designed within the structural strength limits of the bridge under the most stringent weather and code specified conditions. Structural analysis of both the OCS and the existing bridge structure has been performed and accepted.

Methods to be Utilized for Locating Rebar and Post Tensioning in Bridge Deck(Issue O)
The light rail tracks will be supported by plinths (concrete blocks) attached to the deck of the floating bridge. In order to do so, ground-penetrating radar and X-ray techniques are used for locating reinforcement and post-tensioning strands in the existing bridge deck. A track attachment system has been developed that relies on adhesion of plinth blocks to the bridge deck using grout and reduces the number of deck penetrations needed to install the track.

Determining Strength and Electrical Resistance of Existing Concrete (Issue P)
Concrete core samples were taken to determine the floating bridge's ability to resist stray current discharges. The concrete's electrical resistance and structural strength was found to be within predicted acceptable ranges.

Modification of Current Bridge Inspection Procedures if Light Rail Transit Approved (Issue Q)
The IRT identified the need to modify existing bridge inspection procedures to allow for more frequent and thorough inspections. Sound Transit is collaborating closely with WSDOT to develop updates to the WSDOT Operations, Inspection, and Maintenance (O&M) procedures to reflect the new operating conditions on the bridge.

Storm water Drainage System Modifications under new Light Rail Transit Track Bridge at Expansion Joints (Issue R)
The initial track bridge system included the removal of the existing center roadway expansion joints and would require storm water runoff to be collected and removed from the floating bridge. The track bridge's final design has resulted in the expansion joints remaining in place and therefore, no additional storm water drainage modification is necessary.

Median Barrier Relocation Design, Attachment, Maintenance and Drainage (Issue S)
As part of the I-90 Two-Way Transit & HOV Operations (R8A) Project, the median barrier separating the westbound outer roadway from the center roadway was proposed to be relocated to provide an extra two feet of refuge for disabled vehicles. The IRT expressed concern that this relocation would affect the structural integrity of the bridge and storm water drainage.

After additional analysis, WSDOT and Sound Transit concurred that the median barrier should remain in place. This has no impact on traffic operations.

WSDOT and Sound Transit's Goal for Life Expectancy of Bridge (Issue T)
Sound Transit agreed to add post tensioning to the bridge to maintain and likely extend its current useful service life.

Method for Identifying Stray Current Failure and Response / Repair Plan (Issue U)
The IRT identified the need for a plan to identify system failures and a procedure for repairing or replacing failed components. Sound Transit and WSDOT have agreed to a design for multiple levels of monitoring that will ensure the systems in place for mitigating stray current are operating properly. Regular visual inspection requirements and a variety of electrical system performance measurements have been agreed to and a response/repair plan matrix created. Once final components are selected the detailed operating and maintenance procedures will be created. This will ensure the mitigation measures to protect the floating bridge from stray current are kept in proper working order.

Effect of Light Rail Transit on Construction Operations Associated with Anchor Cable Replacement (Issue V)
Sound Transit and WSDOT evaluated floating bridge anchor cable replacement procedures based on IRT recommendations and consultations with marine construction contractors. Sound Transit and WSDOT have developed anchor cable replacement procedures based on these recommendations. Light rail will have minimal impact on the replacement of anchor cables, when required and the replacement procedure will have minimal impact on the light rail operations.

Additional Needs and Changes Needed Required for Light Rail Transit Installation to meet *Blue Ribbon Panel* Recommendation (Issue W)
In 1990, the Governor Gardner convened a *Blue Ribbon Panel* to conduct an independent investigation into the I-90 Lacey V. Murrow bridge's sinking. In 1991, the Panel released 14 recommendations to prevent similar events from happening in the future. WSDOT and Sound Transit have structured East Link's design and construction to implement these recommendations.