

Internal Audit Report:

**Link Light Rail Service Event
from November 26, 2021**

Report #: 2021-19

Sound Transit Audit Division

April 29, 2022

Sound Transit's Title VI notice of rights

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Abbreviations

ADA	Americans with Disabilities Act
CCTV	Closed circuit television
CEO	Chief Executive Officer
DCEO	Deputy Chief Executive Officer
EOR	Engineer of record
EMI	Electromagnetic interference
FTA	Federal Transit Administration
HVAC	Heating, ventilation and air conditioning
IGA	Intergovernmental agreement
KCM	King County Metro
LCC	Link Control Center
LRV	Light rail vehicle
NFPA	National Fire Protection Association
SCADA	Supervisory Control and Data Acquisition
SOP	Standard operating procedures
SMP	Standard maintenance procedures
ST	Sound Transit
WSDOT	Washington State Department of Transportation

Executive Summary

What happened

On the evening of November 26, 2021, an unprecedented service disruption event took place on Sound Transit's Link light rail system. Just after 8:20pm, a fully-loaded Series 2 light rail vehicle heading north from the University of Washington station lost power and stopped in the tunnel after leaving the Apple Cup college football game.

While the operator attempted to troubleshoot and restart the vehicle for several minutes, passengers received no communication about what was occurring and began to self-evacuate the vehicle into both the north- and southbound tunnels. This created a dangerous situation.

With passengers in harm's way, staff followed safety protocols by suspending all 1-Line service. This expanded the severity of the incident from what would have been a passenger transfer, with limited systemwide impact, to an impact similar to an emergency evacuation. While no passengers or staff were injured, service was suspended for several hours systemwide and thousands of passengers were unable to complete their trips.

Why is the Audit Division involved?

Due to the unprecedented severity of this event, Sound Transit CEO Peter Rogoff requested that the Audit Division conduct a broad investigation, identify gaps and lessons learned, and identify continuous improvement opportunities that will prevent future recurrences.

Background

Sound Transit is the owning transit authority for Link light rail and is the risk owner for any incidents or accidents involving Link. Since July 2009, Sound Transit has contracted with King County Metro to operate, maintain, and provide safety and emergency response and investigative actions. However, Sound Transit maintains overall responsibility.

The Audit Division is Sound Transit's independent assurance function that improves how the agency is operated and managed, ensuring public funds are managed transparently, and ultimately keeping employees, contractors and our riding public safe.

As part of the capital project expansion of the Link light rail system, Sound Transit awarded Siemens a contract to provide new Series 2 trains for the Link light rail fleet. Sound Transit received the first vehicle in June 2019, with the first coming into revenue service in May 2021.

In October 2021, Sound Transit also extended 1-Line service 4.3 miles from University of Washington Station to Northgate Station.

Audit Process

The audit involved reviewing multiple policies, procedures and records relating to Link light rail service. Over the course of eight weeks, we interviewed involved Sound Transit and King County Metro employees as well as agency executives.

The Audit Division presented our initial findings and draft report at Sound Transit's Rider Experience and Operations committee on February 9, 2022. Since then, we have reviewed and refined our findings and conclusions, resulting in this final report.

Simultaneously, Sound Transit and King County Metro management have been implementing corrective actions and will be reporting quarterly progress on those actions. Details of those actions are contained further in this report.

Our Findings

We grouped our audit findings into two categories: what caused train damage and stopped the vehicle, and the effectiveness of subsequent communications. We found the causes of train damage to be: rods embedded in the trackway that protruded above track height, the inadequate suspension of Series 2 cars under fully-loaded conditions, and location of power cables in such circumstances hanging lower than in Series 1 cars.

We found that communications failures occurred due to a combination of unclear roles and responsibilities, failure to follow on-call procedures, emergency procedures, and equipment functionality.

Management's Response

Both Sound Transit and King County Metro have been actively involved in the problem analysis as well as identifying and implementing corrective actions, and will report quarterly on their progress. Management comments are included in the report as well as an action plan.

Conclusions

Our audit results identified that the incident was preventable. Our findings identified the need for physical changes to the track and vehicles to address the cause of the vehicle stopping as well as procedural changes in the pre-revenue acceptance testing, maintenance reporting, operations communication and public communication areas.

There are multiple opportunities to strengthen operations procedures, such as emphasizing and clarifying Sound Transit's overarching accountability for 1-Line service. The fact of complex and diffused responsibilities should not diminish or change Sound Transit's accountability for risks. Sound Transit and KCM must strengthen their relationship and eliminate any confusion or ambiguity as to roles and responsibilities

To date, Sound Transit and King County Metro have already implemented some of those changes. Status and reporting of the actions taken based on the audit findings will be monitored and followed up by the Audit Division, as well as tracked and reported to the Washington State Rail Safety Oversight Program Office (SSO), and Federal Transit Administration (FTA) as part of our standard safety reporting requirements.

Timeline of events

At 8:20 (all times p.m.). on Nov. 26, 2021, an unprecedented service disruption event occurred on Sound Transit's 1-Line service when a four-car Series 2 train stalled, came to an abrupt stop, and lost power and HVAC systems. This occurred shortly after the train departed northbound from University of Washington Station headed north to U District Station after the Apple Cup college football game. The train stalled in the northbound tunnel, approximately 1,000 feet north of University of Washington Station.

Once the train stopped, and without knowing the full extent of the damage, the train operator attempted to troubleshoot and restart the train. Four minutes after the train stopped, having received no communication from the operator, some passengers pulled emergency door handles and began to self-evacuate, walking in both directions in the tunnel, with some passengers accessing cross-passages to walk in the opposing tunnel.

At 8:30, Sound Transit sent its first internal "Command Post" message stating that the train had stalled; however, this message did not note that the situation was an emergency. It wasn't until several minutes later that another Command Post message was sent stating that "passengers are in the cross passages".

At around 8:32, 12 minutes after the train stalled, the operator had walked to the opposite end of the train to continue attempting to restart the train. From this car they

made the first public address announcement to passengers. However, at this point the announcement was too late as many passengers had already exited the train.

At this time the operator also observed more passengers exiting the train and reported to the King County Metro (KCM) Link Control Center seeking help, and the LCC dispatched a rescue train. Due to the safety risk of passengers in the tunnel and cross passages, the LCC initially held all trains in place until all passengers were clear of the tunnel, at which point they would order single-tracking service to resume around the disabled train. This order to hold all trains expanded the service impact of the event to the entire Link light rail system, effectively shutting it down.

At 8:36, the LCC alerted the rescue train to proceed down the southbound bore from U District Station to the cross passage with caution and at a very slow speed to assist in getting passengers off the disabled train. At the same time, the LCC alerted the disabled train that rail supervisors were on their way to assist in evacuating more passengers.

At 8:46, 25 minutes after the initial failure, the first passengers from the disabled train boarded the rescue train with the assistance of KCM Rail Supervisors. The rescue train was delayed due to train operating orders that required trains to lower their pantographs (from overhead catenary systems power) if an emergency occurred to ensure passengers were safe from rail voltage. Additionally, passengers delayed trains further by pulling emergency door releases on the rescue trains as well.

At this time, KCM rail supervisors also noted that some passengers did not want to take the rescue train and chose to walk back to University of Washington Station.

At 8:57, the operator informed the LCC that they had a single ADA passenger remaining in one of the disabled train cars, and the operator remained with that person until another rescue train arrived.

By 9:15, 55 minutes after the initial failure, all passengers remaining from the disabled train (including the ADA passenger) who had not walked to University of Washington Station were transferred to the rescue train and were heading north to U District Station.

From 9:19 to 10:39, trains continued shuttling passengers from the platforms using single tracking. During this time, various staff members attempted multiple internal and external communications about the incident, as noted in the timeline below.

Between 9:35 and 9:37, Sound Transit Operations and KCM LCC staff made three attempts to call the Sound Transit Communications duty officer, who handles media

relations, but the duty officer did not answer because they had not properly forwarded the duty officer number to their personal cell phone.

At 9:53, the Sound Transit CEO was first notified of the situation by Sound Transit's Deputy Executive Director of Transportation and Maintenance and the Director of Public Safety.

At 9:57, a Communications staff member heard about the ongoing incident from an external media outlet.

At 10:00, Passenger Experience staff found out about the incident and sent the first "Rider Alert" message at 10:02 (1 hour and 48 minutes after the incident began).

By 10:58, KCM removed the disabled train and towed it back to the Operations and Maintenance Facility in SODO, ended single-tracking and resumed normal 1-Line service, two hours and 38 minutes after the initial failure.

At 11:57, ST Communications sent out a public blog post about the event.

Required safety reporting protocols

This service disruption and evacuation did not result in any injuries. However, as the owner of Link light rail, Sound Transit owns the risk for any incidents or accidents, despite the fact that Sound Transit chooses to contract operations, safety response and investigative actions to King County Metro. The Washington State Rail Safety Oversight Program Standard specifies that rail properties must follow notification protocols to the Washington State Department of Transportation and the Federal Transit Administration when safety events meet particular thresholds.

Additionally, contractual agreements require KCM to conduct a safety investigation as to the cause of why the train stopped and must submit and share that investigation report with Sound Transit for WSDOT approval.

In cases involving self-evacuations when not a fire-life-safety event, such as this incident, Link procedures did not state who initiates the notification process, nor do they delineate when an incident such as this goes from a routine "passenger transfer" to an emergency. This led to confusion and delays in response, reporting, notifying passengers impacted on the affected train, on other trains and in stations.

In this instance, KCM interpreted this event as a passenger transfer, in which staff merely need to transfer passengers from a disabled train to another train. However, this interpretation and the absence of crystal-clear guidance impacted the execution of emergency and communication protocols, prompting Sound Transit three days later to

seek clarification from our regulatory oversight agency and then properly reclassifying the event as an emergency evacuation.

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1. Findings summary

The Internal Audit team completed its review and identified areas where either processes/procedures exist and were not followed, or where necessary processes/procedures did not exist but should have. This report does not include areas where procedures exist and were properly followed.

We grouped findings into two categories:

- Causes of train damage and stoppage
- Effectiveness of communications

A summary of pertinent findings for each group is listed here. All audit findings will have an associated action plan to correct the deficiency and will be tracked to closure by the Sound Transit's Safety Department.

a. Causes of train damage and stoppage:

The train was disabled for three reasons:

1. The leading car of the Series 2 train struck a rod that holds the electromagnetic interference, or EMI, cable to the floating slab section of track between the University of Washington and U District stations.
 2. Pre-revenue testing processes on Series 2 vehicles did not fully consider differences between Series 1 and Series 2 vehicles under all operating conditions.
 3. Previous known rod strikes had been reported but not properly escalated for resolution.
- a.1. During the design phase of light rail expansion projects, Sound Transit design criteria specify required spacing between light rail vehicles and the top of rail. Engineering procedures require that any deviations from design criteria must be approved prior to design completion. Since the rod holding the EMI rod was designed and installed above the top of rail, the engineer of record should have sought approval of a deviation from design criteria, which did not occur.
- a.2. Additionally, construction procedures require field inspections to verify that contractors constructed all track infrastructure as designed. Shop drawings noted that EMI rod design would 1) protrude above the top of rail in design and after installation, and 2) that the EMI "Top of Rod was to be field cut"; however, it was

unclear on the shop drawing where to cut the rod and how much clearance to ensure.

- a.3. Testing of the dynamic envelope was limited to areas above and to the sides of the vehicle and neglected to verify that the spacing between the track gauge was free of obstacles above the top of rail as specified by design criteria.
- a.4. Siemens vehicle testing did not fully consider configuration differences between Series 1 and Series 2 light rail vehicles. These differences include suspension compression under heavy passenger load, ensuring constant floor height above top of rail, and ensuring proper clearance of conduit, couplers and cables.
- a.5. Sound Transit requires ground clearance testing to check ground clearances before introducing new vehicles into the transit system. The Siemens ground clearance testing for the Series 2 vehicles was completed. However, testing was incomplete because it was not done to simulate "crush load" weight nor tested at a historically high-ridership location.
- a.6. As part of its safety certification and field inspection oversight processes, Sound Transit verifies all items prior to approving projects to open for revenue service. While vehicle dynamic clearance testing is a certifiable item, the EMI rod identified between track clearances was not specifically listed in any check list which is why it was not verified prior to opening the Northgate Link Extension.
- a.7. While Sound Transit prescribed a 60-day transition period from completion of the Northgate Link capital project to the initiation of revenue service to resolve any final capital project deliverables, the current procedures governing this transition period do not prescribe when that period should formally begin, do not formally designate responsible and accountable authorities for the transition, and do not ensure that all pre-revenue and revenue planning activities will be thoroughly completed prior to revenue service.
- a.8. Beginning a month prior to the Nov. 26 event, maintenance work orders recorded several other incidents where 1-Line trains were striking an object under the vehicle, later determined to be the EMI rod that damaged the train on the night of Nov. 26.

While these incidents were properly entered into the work order system, they were not escalated to Sound Transit Operations or King County Metro Safety for evaluation.

- a.9. Link Standard Maintenance Procedures do not provide clear guidance on what mechanics do when they observe damage to light rail vehicles.

b. Effectiveness of communications

Sound Transit, as the owner of Link, has operating agreements that articulate the division of responsibilities between the agency and our contract operator, King County Metro. Relevant to this incident, the two agencies divide responsibility for ownership when it comes to emergency preparedness.

Sound Transit is responsible to design, test and ensure various emergency systems (such as public address) are working prior to revenue service, and is responsible for posting all applicable emergency signage.

Additionally, for special events such as the Apple Cup, Sound Transit provides crowd control and additional security, which supports the movement of passengers and informs agency staff and passengers if an emergency arises.

KCM's responsibilities include: providing a trained light rail operator, on-scene incident response, safety response and regulatory reporting for incidents, implementing "bus bridges" when rail service is interrupted, engaging with Sound Transit for support to move passengers and for deploying emergency procedures when warranted by emergency situations such as an evacuation.

- b.1. This event reveals that multiple failures occurred because Sound Transit does not have adequate processes in place to ensure passengers are promptly informed when emergencies occur. Furthermore, Sound Transit does not exercise sufficient oversight of its contracted operator.
- b.2. As the service owner, Sound Transit owns the risk for any incidents or accidents involving 1-Line service. Sound Transit contracts the operations, and safety response and investigation actions to KCM. Instances such as the Nov. 26 event require KCM to promptly notify WSDOT within reporting thresholds. However, in this event, KCM interpreted WSDOT's guidance for this event as a passenger transfer and not an emergency evacuation. This delayed emergency response, communication protocols, and caused the two agencies to miss required safety reporting deadlines.
- b.3. Intergovernmental Agreements (IGAs) established between Sound Transit (ST) and King County Metro (KCM) define each agency's roles and responsibilities during emergency & incident management. However, current contractual

language is not clear enough to delineate each agency's roles and responsibilities. Sound Transit believes it cannot exercise any direct authority to respond to emergencies and that incident roles and responsibilities were solely at the authority of KCM. At the time of the event, incident roles & responsibilities were neither clarified nor communicated between ST and KCM.

- b.4. Link Standard Operating Procedures (SOPs) are developed and agreed upon by both Sound Transit and KCM every 10 years. However, prior to the next scheduled update, several Link SOPs critical to incident and emergency protocols should be reviewed and updated to include the following:
- Bus Bridge Procedures (2009)
 - LRV Passenger Transfer & Evacuation Procedure (2017)
 - LCC Notification of a Disabled Train (2009)
 - Emergency Train Back-up Procedures (2016)
 - LRV Public Address Announcements (2015)
 - LCC Public Address Announcements (2009).
- b.5. While the operator followed prescribed training and SOPs by communicating with the LCC and troubleshooting the Series 2 train with a secondary handheld radio, there was no attempt to make an announcement to the passengers from the lead cab.
- b.6. During special events, ST staff draw from various departments to serve in an oversight role performing crowd control, helping ensure trains meet tight schedules, and monitoring KCM's provided service quality and overall performance. In this instance, ST special event staff did not have training or SOPs on what to do during emergency situations.
- b.7. King County Metro, as the emergency response authority on behalf of Sound Transit, did not establish an Incident Command within prescribed guidelines to support coordination and collaboration with required response partners.
- b.8. King County Metro LRV Operator training did not include additional components to prepare operators for the changing service environment to include areas such as safety critical training (disabled train in the tunnel). Frequency of training should also be re-evaluated.
- b.9. ST Operations Duty Managers are assigned on a rotational basis as part of ST's oversight of Link light rail day-to-day operations. From this event, we found there

are no official procedures or training clarifying roles and responsibilities, who to contact in the event of an emergency, clear guidance on what information to report, when to escalate and when to follow up.

- b.10. Per the Link IGA, ST delegates LCC duties to KCM, who is required to maintain SCADA systems; however, the SCADA network between UW Station and U District Station was not working properly on November 25, 2021 (the day prior) and was not prioritized as a critical repair. This affected the LCC's capability to remotely access the Public Address (PA) system, and have visual confirmation of passengers walking in the tunnels.
- b.11. On Thursday, November 25th an after-hours Network Outage was reported affecting transactions. As part of processes, the outage caused some LCC systems to be offline (cameras near cross-passages, and train tracking) between U District and University of Washington (UW) Station during the Apple Cup. During interviews, we were told that the SCADA network repair was not prioritized due to the fact that "on-call staffing" was not available during the holiday and special event period. This was further confirmed when we found no SCADA work orders entered on weekends or holidays.
- b.12. Sound Transit conducts fire protection confidence testing as required by the Seattle Fire Department for PA systems readiness. However, prior to the Apple Cup event, the PA system was not tested to ensure operability. We also found that confidence tests do not test door alarms at the cross passages.
- b.13. Link SOP 6.14 (Link Control Center PA Announcements) states that "passengers should be advised to exit the station in an emergency situation." The LCC controller stated they attempted to make this announcement. However, staff realized later that remote use of the of the public address system was not available due to the SCADA system outage.
- b.14. The cameras mounted near the cross passages are viewable through CCTV by the LCC when in normal operation. However, because of the SCADA network outage, these cameras were offline. Additionally, cross passages in the Northgate section of the tunnel system are not equipped with cameras. Cameras are adjacent to the cross passage doors.
- b.15. Other Sound Transit modes (i.e., Sounder trains) have "in case of emergency" evacuation signs posted to ensure passengers are aware of emergency exits and

how to exit the vehicle. However, no “in case of emergency signs” are posted in either type of Link light rail vehicles.

- b.16. On other Sound Transit modes (i.e., Sounder trains) audio messages tell passengers what to do in case of an emergency. There are no such messages on either Series 1 and Series 2 Link vehicles.
- b.17. Series 2 vehicles are equipped with blue lighting to illuminate the doors, and emergency door manual release controls; in this event, with the loss of power, this was the only lighting that was working. Passengers had no secondary emergency illumination to see emergency door release controls.
- b.18. In established procedures, if there are emergencies that cause significant delays to trains, KCM arranges and implements bus bridges to retain service between affected stations. KCM then communicates these details to Sound Transit staff to communicate to passengers. In this event, the bus bridges were arranged, but notifications and orders were only being sent to and from King County Metro and excluded Sound Transit.
- b.19. One tabletop emergency exercise for the Northgate Link Extension (NGLE) occurred in March and an exercise was conducted in August 2021. These exercises are required to be completed prior to the opening of new transit services, as required by federal and state, and ST certification guidance, and they are the responsibility of Sound Transit Emergency Management staff. After-action reports for both exercises noted that relevant parties from ST Communications and Passenger Experience (PX) did not attend, and that first responders attended the March tabletop exercise but not the August exercise due to COVID-19.
- b.20. The tabletop exercise to prepare for NGLE service did not consider the differences between the Series 1 and Series 2 trains.
- b.21. The ST Agency Incident Notification SOP for Safety instructs that the ST Executive Director of Operations notifies the CEO of a major incident. While we found that this procedure was revised in 2020, it was not used, nor followed.
- b.22. No procedures have been developed to ensure the positive confirmation of handover/takeover of duties and updating of phone forwarding for various ST duty officers (Communications, PX, Security, and Operations Duty Managers).
- b.23. The Communications Duty Officer would have been notified of the incident by “rider alerts” to their duty cell phone; in this event, communications were not

received due to the duty cell phone malfunctioning, and there was no backup system.

- b.24. Sound Transit does notify passengers of issues with “Rider Alerts” through website updates, Twitter posts, subscriber text messages and email alerts for those who sign up. No capability currently exists to send an immediate alert to passengers on a train, though this is under development with the upcoming Passenger Information Management System (PIMS).
- b.25. Passenger Experience (PX) staff maintain a duty officer rotation to facilitate information to our passengers and the public using “Rider Alerts” through website updates and Twitter, and through subscriber text and email alerts for those who sign up. In this event, because of the lack of official procedures to transfer duty officer responsibilities, the PX Duty Officer phone number was not transferred properly.
- b.26. “See something wrong” signage is posted for passengers on the Series 1 vehicles to contact ST Security in the event of an emergency; however, no such signage is posted on Series 2 vehicles.
- b.27. KCM staffs the LCC Customer Service Desk between 5 a.m. and 8 p.m., Monday through Friday, excluding holidays. Our interviews found that when the service desk is not staffed, the duties are handed over to the ST Operations Duty Manager but this is not formalized in a documented process or procedures.
- b.28. ST Safety certification processes, along with Link SOPs articulate that first responders will be trained to have access to and utilize station emergency communications systems and assist in tunnel evacuations. However, during this event, first responders did not remember and/or realize the capabilities they had from their training to access and operate these systems.
- b.29. Sound Transit Public Safety staff lack formalized procedures for crowd management, mitigations, and large events.
- b.30. Contracted security staff lack formalized training for special events, escalator monitoring, crowd management, and slips and falls. Additionally, they do not have formalized SOPs for special events.
- b.31. Signage along the Link service area does show the station the train is going to and that trains are running every 8–15 minutes. At the time of the event, they did not provide any visual indication of delays for trains nor approximate time trains

would arrive at stations, and many passengers were confused about the status of service.

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2. Approach to this audit

To comprehensively evaluate this incident, the ST Audit team looked across agency processes and functions to understand the steps involved to design and construct alignments and stations, test vehicles and ultimately enter them into revenue service.

Ultimately, we looked to see the big picture on what could have caused such an event to occur on a new alignment, with new and tested light rail vehicles.

ST Internal Auditors approached their work based on the following steps:

Step 1: Confirm scope and approach

When the ST CEO assigned the investigation, the entire audit team met to discuss the audit schedule, assign subject areas, define what Sound Transit and King County Metro staff were to be interviewed, and discuss initial logistics.

Step 2: Review documents

To better understand Sound Transit and King County Metro operating processes and procedures for 1-Line service, the audit team began by reviewing the latest (2019) Intergovernmental Agreement (IGA) that describes the contractual relationship between Sound Transit and King County Metro. The audit team next examined various documents, plans, and testing results related to how Sound Transit certifies and transitions capital projects into Operations (Revenue Service).

The team then reviewed the Link Light Rail Standard Operating Procedures (SOPs) and Standard Maintenance Procedures (SMPs), Sound Transit's communications protocols for incident notifications, special event processes, King County Metro LRV operator training and routine fire safety confidence testing.

We did this to see what day-to-day operations and testing looks like, review processes, create interview plans, and see if there are any gaps between documented processes and how things unfolded on November 26, 2021.

Step 3: Interview key Sound Transit and King County Metro staff

Following the initial document review, the audit team interviewed numerous individuals including:

- King County Metro Vehicle, Track, and Power Maintenance staff who were involved with reviewing the damaged Series 2 vehicle.

- Various Sound Transit and King County Metro staff who were involved in the safety certification process.
- Staff responsible for ensuring the on-site safety of our passengers.
- Various agency leadership responsible for oversight and service performance.

Step 4: Conduct follow-up interviews and document requests

Based on initial interviews with staff, the audit team gathered the information they learned, met to review if any items that they were inquiring about were missed, and set up follow-up interviews and supplemental document requests to verify items, activities, and tasks.

Step 5: Develop a Preliminary Summary & Final Audit Report

The audit team used the results from Steps 1 through 4 to provide a draft summary report of findings to the Sound Transit Chief Executive Officer (CEO) and selected Sound Transit Executive Directors. Once briefed, the audit team developed this Final Report for the Sound Transit CEO that identifies findings and deficiencies to share with Sound Transit's Executive Leadership Council and the agency's Board of Directors.

Audit Division Standards

The Audit Division conducted this work under the framework outlined in its charter. It governed itself adhering to the mandatory elements of The Institute of Internal Auditors' (IIA) International Professional Practices Framework (IPPF or "Red Book"), including the Core Principles for the Professional Practice of Internal Auditing, the Code of Ethics, the International Standards for the Professional Practice of Internal Auditing (the Standards), and the Definition of Internal Auditing.

The division conducts audits in accordance with Generally Accepted Government Auditing Standards (GAGAS or "Yellow Book") promulgated by the United States Government Accountability Office (GAO).

Additionally, the Audit Division is also committed to following safety oversight standards set forth by the Federal Transit Administration (FTA), Federal Railroad Administration (FRA); as well as all other relevant requirements or standards for auditing.

3. Background on Link service & capital projects

Service launched in July 2009 as “Central Link,” with an initial segment consisting of 13.9 miles between Westlake Station and Tukwila International Blvd. Station.

The initial segment alignment consisted of approximately 4.4 miles of elevated guideway and aerial structures, 2.4 miles of tunnels in downtown Seattle and Beacon Hill, and 7 miles of at-grade right-of-way in Seattle’s SODO and Rainier Valley neighborhoods. It included 12 stations: Westlake, University Street, Pioneer Square, International District/Chinatown, Stadium, SODO, Beacon Hill, Mount Baker, Columbia City, Othello, Rainier Beach and Tukwila Internal Boulevard. It also included the Operations and Maintenance Facility in Seattle’s SODO neighborhood. Service extended to SeaTac/Airport Station in December 2009.

In 2016, Sound Transit expanded service to three new stations, the elevated Angle Lake Station, and two tunnel stations at Capitol Hill and the University of Washington, near Husky Stadium.

Intergovernmental Agreements between Sound Transit & King County Metro

Re-approved in June 2019, the current IGA is the overarching operating agreement between Sound Transit and King County Metro and specifies the relationship between the transit agencies for Link oversight, operations, maintenance, safety and incident/emergency response.

Under the agreement, Sound Transit owns Link. King County Metro operates and maintains Link services, and Sound Transit retains responsibilities such as making policy decisions, maintaining financial control and management oversight over the IGA, providing and replacing facilities, as well as procuring equipment and vehicles.

Capital project: Northgate Link (U District, Roosevelt and Northgate Stations)

The Northgate Link Extension opened in **October 2021** and extends 4.3 miles from the University of Washington Station to Northgate Station (see figure 1). From UW, trains continue north in an approximately 3.3-mile twin-bore tunnel to U District Station under Brooklyn Avenue NE, south of NE 45th Street.

Continuing north through the tunnel, the route reaches Roosevelt Station, just west of 12th Avenue NE, between NE 65th Street and NE 67th Street.

From Roosevelt Station, trains move to the surface at Maple Leaf Portal located immediately north of the Lake City Way interchange with I-5.

From the portal, trains continue north at grade level along I-5, then cross over First Avenue NE, south of NE 100th Street on an elevated structure, and connect to the elevated Northgate Station.

Upon opening the Northgate Link Extension, Sound Transit also renamed the service as the 1 Line, in anticipation of opening East Link extension as the 2 Line in 2023.

Capital project: LRV Fleet Expansion - procurement and revenue service of Series 2 light rail vehicles

As part of the approved 2008 ST2 ballot measure¹, in 2016 the Sound Transit Board awarded Siemens a contract to provide 122 new Series 2 light rail vehicles to Sound Transit, and later approved an additional 30-car option order.

Sound Transit received the first vehicle in **June 2019**, and in order to serve the Northgate Link opening, Sound Transit required 40 new Series 2 vehicles to be in revenue service.

The first Series 2 vehicle underwent extensive commissioning, going through a 1,000-mile burn-in test period; subsequent LRVs underwent local testing and a 300-mile burn-in test period. The first Series 2 train entered service in May 2021.

To date, Sound Transit had 36 Series 2 vehicles operating in revenue service. There were an additional 21 Series 2 vehicles in various stages of onsite commissioning. The

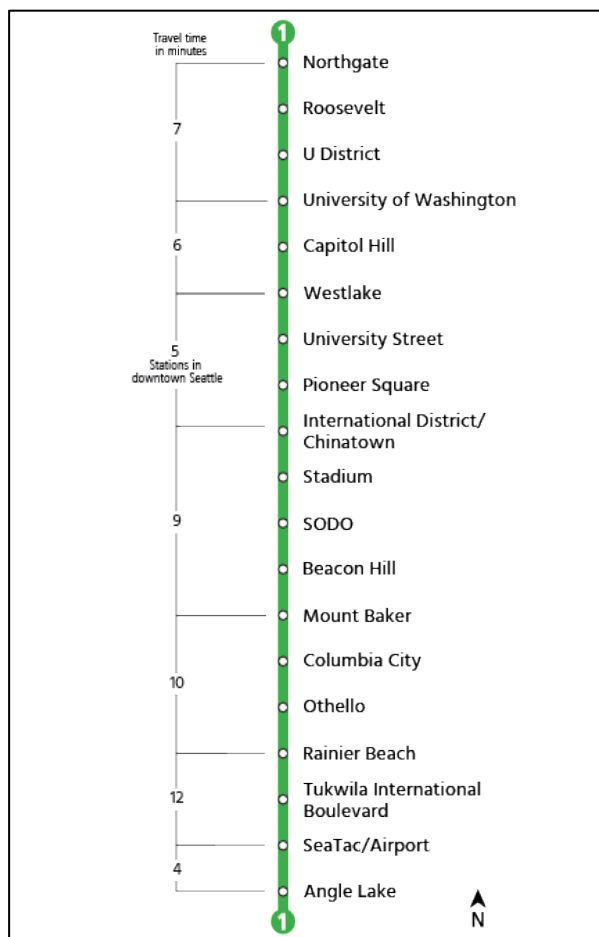


Figure 1. Sound Transit Link light rail station map, as of November 2021

¹ Available at <https://www.soundtransit.org/get-to-know-us/documents-reports/sound-transit-2#:~:text=On%20Nov.,a%2055%2Dmile%20regional%20system.>

remaining 95 vehicles were in various build stages at Siemens factory in Sacramento, California.

3.1 Vehicle fleet types

Sound Transit's 1-Line fleet consists of two different types of vehicles: Kinkisharyo (Series 1) and Siemens (Series 2). Sound Transit currently has 62 Series 1 vehicles and 36 Series 2 vehicles in service. All vehicles have an articulated center and operating cab on each end (A & B). These are similarly designed in order to be coupled and operate in multiple-car consists; however, there is no access between cars when coupled. Cab safety features include a fire extinguisher, a cab-mounted radio and two emergency intercom alarm buttons.



Figure 2. Sound Transit's Link light rail fleet includes Kinkisharyo Series 1 vehicles (left) and Siemens Series 2 vehicles (right).

3.2 Special event service

Since 2020, Sound Transit has assigned four-car train sets during normal and special event services. All trains originate at the Central Operations and Maintenance Facility off Airport Way, close to SODO Station in Seattle.

As part of special events support provided for UW home football games, Sound Transit adds service as needed to accommodate expected crowding levels. Trains run their regular schedules with additional trainsets as needed.

Nineteen four-car trainsets (13 regular service trains and six special event trains) were in service the night of Nov. 26, along with 19 operators assigned by King County Metro.

For these events, Sound Transit Operations, Public Safety and Emergency Management staff are normally located inside the Husky Stadium Command Post, as well as on the UW Station platform. Additional resources from the King County Sheriff's Office and contracted security staff also assist in crowd control.

4. Factual information

At 8:19 p.m. on Nov. 26, 2021, a four-car Series 2 train (Train 6, including cars 264, 259, 225 and 246) departed northbound from UW Station toward U District Station (see figures 3 and 4). All trains in service that night had one operator, provided by King County Metro.



Figure 3. Photograph from Train 6 (Car 246) arriving at UW Station.



Figure 4. Photograph from inside Train 6 (Car 246) leaving UW Station for U District Station.

At 8:20, about 1,000 feet into the northbound tunnel, the train appeared to have struck an object in the trackway, stalled and came to an abrupt stop. It appeared to have lost all power, including HVAC and presumably all communication capabilities with passengers (see figures 5 and 6). There were no injuries.

Once the train stopped, and without knowing the full extent of the damage, the operator attempted to troubleshoot and restart the train, which is an industry common practice and followed Link procedures on restarting a vehicle if there is a loss of power.

Throughout attempts to restart the train, the operator was in constant communication with the LCC, using a secondary hand-held radio, provided to operators only to be used in the event of communication loss to the LCC.

While the operator was making every effort to restart the train, passengers throughout the train were unaware of what was happening.

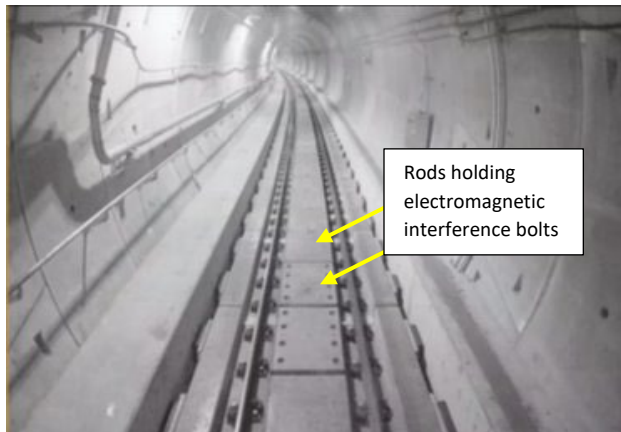


Figure 5. Photograph from Train 6 (Car 246) just before impact with rods holding EMI bolts on the floating trackway.

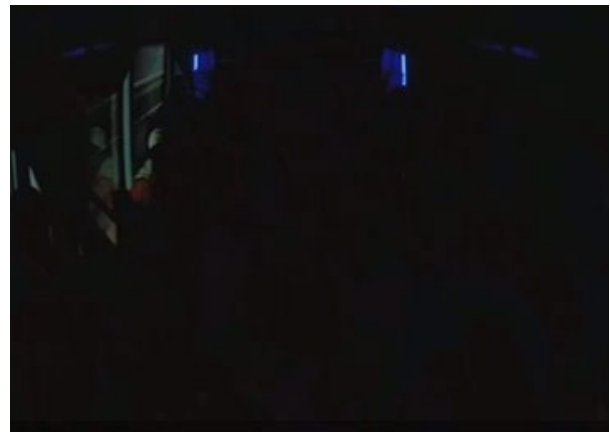


Figure 6. Photograph of Train 6 (Car 246) interior just after stopping in the northbound tunnel.

After several minutes without any communication from the operator, as early as four minutes after the train stopped and went dark, passengers started self-evacuating from the train using emergency door release handles.

The below camera views are not monitored, but are captured and time-stamped by trains' closed circuit television recorders. They were downloaded from the vehicle once it was towed back to the OMF on the evening of Nov. 26 (see figures 7 and 8).



Figure 7. Photograph of passenger self-evacuating Train 6 at 8:24.



Figure 8. Photograph of passengers self-evacuating Train 6 at 8:35.

Based on transmission transcripts, no formal communication from the operator to the passengers occurred for 12 minutes because the operator stated the screen went dark, implying that the power was out and the PA was not operable. This display (figure 9) shows the location of items relevant to communicating with passengers.

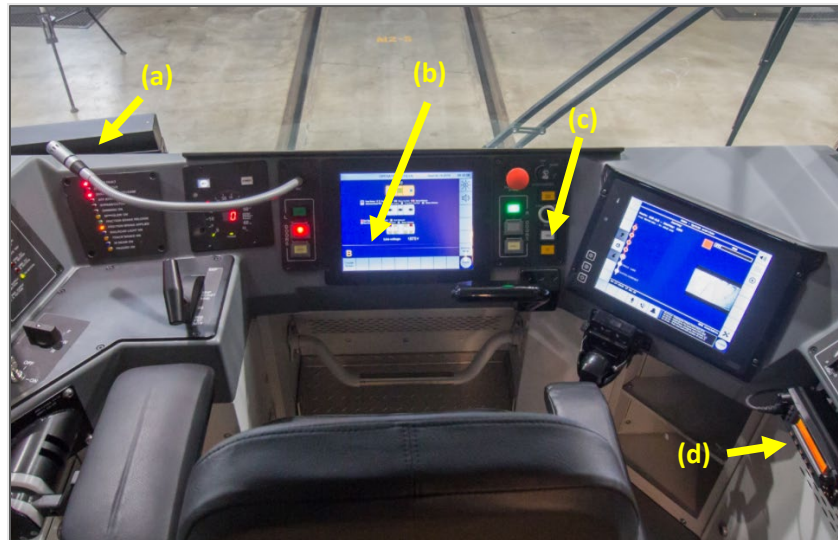


Figure 9. Photograph of inside the operating cab of Series 2 LRV with arrows pointing at (a) Microphone, (b) Live PA button location on TOD screen, (c) PTT button for intercom, and (d) LRV onboard radio. Source: LRV Operator Training Manual

Camera footage inside the cab confirmed that the operator did not attempt to use the internal PA system until approximately 8:32.

The operator stated during their interview that they “assumed that when the power went out, the Public Address system was down as well” since the display screen was off, which explains why the operator did not make any effort to update passengers.

However, according to light rail operator training² and Link SOPs, if a service delay or disruption over 3 minutes occurs, the operator must provide an announcement to the passengers and repeat every 5 minutes.

Finding b.5. While the Link LRV operator followed prescribed training and SOPs by communicating with the LCC and troubleshooting the Series 2 LRV with a secondary handheld radio, there was no attempt an announcement to the passengers from the lead cab.


Additionally, CCTV footage from the vehicle after the event showed that the operator left the impacted northbound car and moved to the opposite-end car to troubleshoot

² *Link Light Rail Operator Initial Training Manual*. King County Rail Training Section, Dated June 1, 2020

and attempted again to restart the train, but their attempts from that end also were unsuccessful.

According to Sound Transit Operations, and confirmed with documentation (see figure 10) operators were made aware of train orders for that day, which explain rules of the week, special events occurring (such as the Apple Cup) and any specific orders on the alignment (e.g., slowed speeds). Furthermore, these state any special instructions and advisories that operators should take notice of.

Listed in the special instructions, it notes that trains must have their pantographs down near the UW and U District Stations (see note #5).



Special Instructions	
1. Northbound - Approaching cross passage #19 (approximately MP 5.9N) - ATP has been dialed down to 45 MPH. Operators shall place the master controller in safe brake until reaching 45 MPH. Operators shall then place master controller in COAST until receiving ATP speed of 40 MPH.	
2. IDS: New signals IDS 4S /4N & IDS 2S/2N are in place. Switch points are locked in normal position. Stop and call LCC if you do not have a proceed signal.	
3. Platform Speed: On sight speed not to exceed 20 MPH.	
4. Per rule 7.44, operators encountering water anywhere on alignment over the top of the rail shall stop, notify LCC and follow instructions. Upon authorization, proceed at no more than 5 MPH through the standing water.	
5. Cross Passage #1(MP3.1N) to 300' south of UDS NB & SB: All trains must be panned down prior to personnel entering the trackway. Walkways 14 inches or more above the track are exempt.	
6. Roosevelt Station to End of Line at Northgate, S/B track only. <u>Siemens trains only</u> , when reverse running, cannot exceed 30 MPH.	
7. <u>University of Washington Station to University District Station, S/B track only. Siemens trains only, when reverse running, cannot exceed 30 MPH.</u>	

Figure 10. Excerpt from Nov. 19 the Link train order.

This special instruction listed in the train order, along with operators needing to be verbally cleared to proceed from U District Station down the southbound tunnel, are why the rescue trains were slow in reaching the damaged train on November 26.

4.1 Emergency declaration

The first passenger self-evacuation occurred four minutes after the train halted. According to radio transcripts between the operator and the LCC, the operator indicated at 8:25 that “people have opened emergency doors on the train.” During this time, in an attempt to assist the operator in trying to restart the train, the LCC advised the operator to check circuit breakers.

During this time, the LCC also asked for the closest mile marker and indicated that they were sending help, and they also mentioned to another train at 8:30 that they should “expect to lose their cab speed approaching Capitol Hill Station.”

At 8:32, about 11 minutes after the incident, more passengers self-evacuated the train, and the operator advised the LCC that more emergency door handles were being activated. At this time the operator made their first PA announcement in the train advising passengers to remain onboard while a rescue train was being dispatched to their location.

Up to this point, the LCC had yet to formally declare this incident an emergency.

Finding b.2. Because KCM interpreted WSDOT's guidance for this event as a passenger transfer and not an emergency evacuation, delays occurred in the execution of emergency responses, communication protocols and required safety reporting requirement deadlines.

Following the operator's announcement at 8:33, the LCC formally notified all trains over the radios that "trains would be held and single tracking immediately after notification of passengers exiting the LRV." However, Link SOP 7.1 (LRV Passenger Transfer and Evacuation Procedures) does not identify if there's a formal radio communication notification that informs that an emergency situation is occurring.

4.2 Incident command system

As defined by the Federal Emergency Management Agency, an ICS is a standardized management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures and communications operating within a common organizational structure.

An ICS establishes command and control, protocols and deployment of resources, along with clear roles and expectations for large events and emergencies. For sporting events such as the Apple Cup, FEMA (as well as guidelines from the American Public Transportation Association) recommends transit agencies establish a formal ICS to be used for incidents and emergency situations, along with coordinated incident action plans.

While Sound Transit staff were stationed inside UW's Command Post while it was activated, King County Metro, as the contracted emergency response authority, did not stand up an Incident Command for this large-scale event.

Finding b.7. King County Metro, as the emergency response authority on behalf of Sound Transit, did not establish an Incident Command within prescribed guidelines to support coordination and collaboration with required response partners.

In addition, during special events, Sound Transit and King County Metro draw staff from various departments to serve in roles based on their job qualifications. Sound Transit staff serve in an oversight role performing crowd control, helping ensure trains meet tight schedules, and monitoring service quality and overall performance of King County

Metro. King County staff are selected to operate the light rail and to provide immediate emergency response.

However, later we found out through interviews that in special event situations, Sound Transit said they have no authority to provide direction to King County Metro, and no clear roles and responsibilities as emergency situations unfold. Additionally, we discovered a gap in emergency training by both Sound Transit and King County Metro staff who are required to act in emergency situations.

Finding b.3. At the time of the event, incident roles and responsibilities were not clarified, or communicated between Sound Transit and King County Metro.

Finding b.6. Sound Transit special event staff do not have training or SOPs on what to do during emergency situations.

4.3 Train damage

Train 6 was towed back to the Operations and Maintenance Facility that evening. Car 264 sustained \$12,453.95 of damage to the trainline conduit.

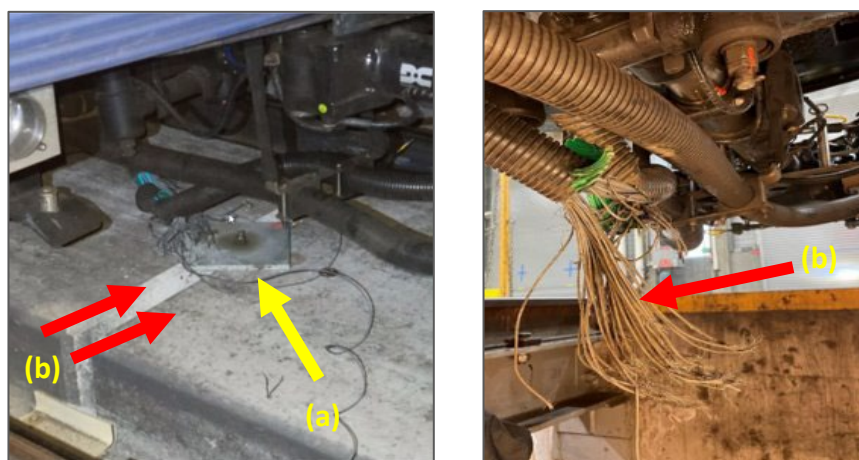


Figure 11. Photographs of damage from underneath Train 6 (Car 246) with arrows pointing at (a) the EMI rod and bolt that were struck by the conduit, and (b) the damage done to the power supply conduit cables.

Shortly after the incident, Sound Transit Link Operations instructed King County Metro to quarantine Car 264, pending the full investigation.

Quarantining the train allows time for proper inspections and vehicle data to be downloaded, which supports further internal investigations by King County Metro Safety, Sound Transit Link Operations, Safety and Audit.

On January 6, 2022, Car 264's repairs were completed, and it returned to service.

4.4 Personnel information

a. LRV operator

Train 6's operator has held their position with KCM since June 2020. A review of their training record shows they had been fully qualified to operate the vehicle, and had been recertified on February 17, 2021. At that time, they also had completed and passed a required operator check ride.

According to KCM Safety's review of the operator's duties prior to the event, the operator's last day off prior to the event was November 24, 2021, and while the operator stated in that interview that they had worked more than 40 hours per week twice out of the previous three weeks leading up to the event, they had last taken fatigue awareness training on June 30, 2020, and they were not required to retrain.

Prior to the November 2021 event, the operator had been involved in one collision event while operating an LRV in December 2020. That collision event is unrelated to the November 2021 event and involved a motor vehicle that made an illegal left turn directly in front of the train. KCM determined that the December 2020 accident was non-preventable and was approved to be sent to WSDOT by Sound Transit.

b. Operator training

Going through the operator's training history, we discovered that while new track qualification for Northgate Link was completed on August 23, 2021, the corresponding training was missing from the Link Operators Training Manual.

Furthermore, operators are only required to complete one-time training on passenger transfers and evacuations, fatigue awareness and public address announcements. We also found a gap in training where Link operators do not receive any training or instruction on special events.

Finding b.8. King County Metro LRV Operator training did not include additional components to prepare operators for the changing service environment to include areas such as safety critical training (disabled train in the tunnel). Frequency of training should also be re-evaluated.

5. Analysis

As part of our analysis of the November 26, 2021 event, areas are summarized with the associated findings listed below in that section.

5.1 Track design and testing

a. Floating slab design

Sound Transit has developed and implemented a Design Criteria Manual that provides guidance and specific engineering specifications that are used by Sound Transit engineering staff and consultants to help design new light rail systems, as well as improve the existing Link light rail system.

Sound Transit and their consultants designed and oversaw the construction of the section of tunnel under the University of Washington. Part of that design included 7,500 feet (3,800 in each tunnel bore) of floating concrete slab (see Figure 12) that reduces vibration and electromagnetic interference that normally comes from running light rail trains.

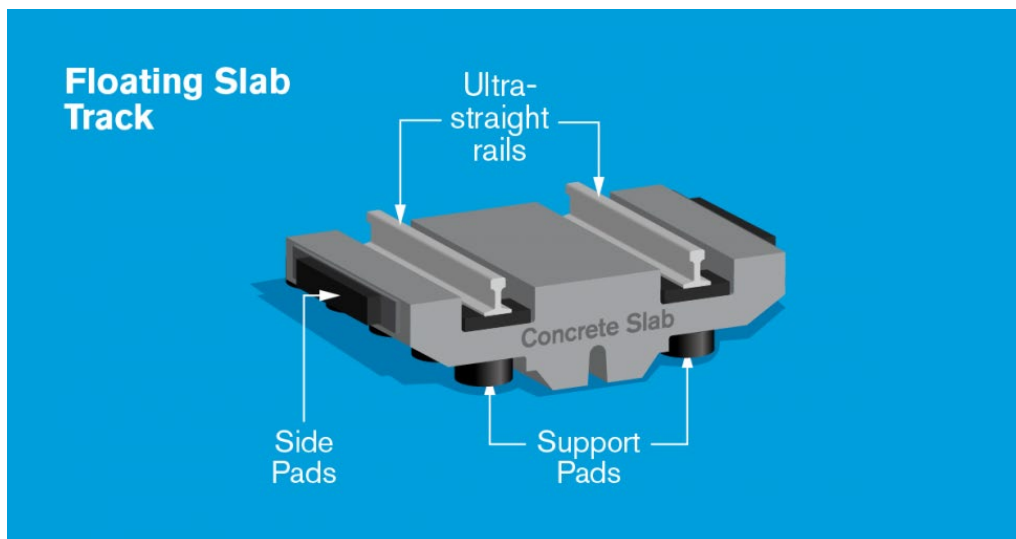


Figure 12. Illustration of the “floating slab” like the one installed between the University of Washington and U District stations.

The requirement comes from concerns raised by the University of Washington going back to 2007, when the university noted that light rail trains running under the campus would impact buildings with vibration-sensitive research. This resulted in a Master

Implementation Agreement (MIA) between the University of Washington and Sound Transit.³

However, Sound Transit had used the floating slab design prior to opening the Northgate Link Extension. A prototype section was previously used in 2016 for the U-Link project between Westlake and Capitol Hill Stations. This design was very similar what was installed from UW Station and U District Station; including the EMI feeder cable, EMI rod and bolt.

The U-Link's 440-foot-long prototype section was used to test and evaluate the design performance, and apply the lessons learned to improve the Northgate Link design.

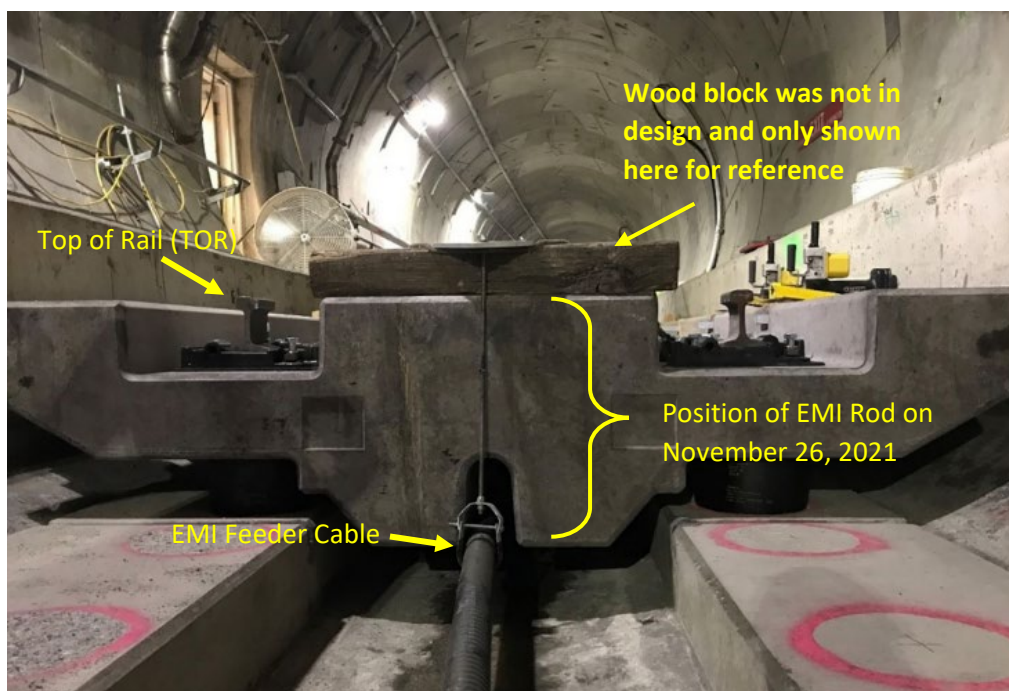


Figure 13. Photograph of the Northgate Link floating slab (Source: Rajaram and Nelson paper, modified by Audit Division)

The prototype sections in the U-Link sections of track were tested during pre-revenue testing and up to six months after the U-Link opening to refine and complete the design before finalizing the Northgate Link design specifications.

³ Sound Transit. (2007, June 14). *Sound Transit Staff Report motion no. M2007-62 contract*. Sound Transit. Retrieved January 30, 2022

Furthermore, the test results from the U-Link section of track indicated that this prototype met the goals for mitigating vibration⁴; as required by the MIA.

b. EMI feeder power cable and Electromagnetic Interference (EMI) rod

As part of the design of the Northgate Link Extension, along with the floating slab design also included an EMI feeder power cable (see Figure 13) that cancels magnetic fields produced by the traction power currents from the overhead power to the LRVs; also allowing for easier maintenance than embedding the conduit in the concrete.

The design, however, had two indicated concerns that were not found until after the November 26, 2021 event, shown below in this shop drawing: (a) that the rod and bolt holding the EMI feeder cable protruded above the top of rail (TOR), and (b) that the top of the rod was to be field cut. How much to be cut was not specified on this shop drawing.

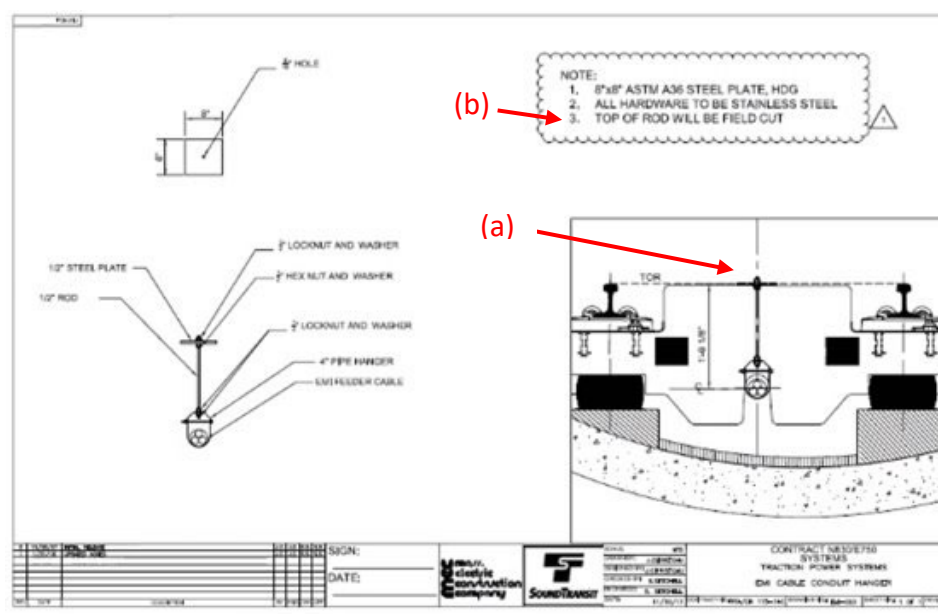


Figure 14. Shop Drawing of the EMI Feeder cable, along with the floating slab; showing (a) the EMI bolt and rod protruding TOR, and (b) that the rod needed to be field cut modified in red by Audit Division)

Through the course of our audit, we found that the issue between UW and U District stations was observed but not addressed three times prior to opening the Northgate Link extension:

- During the design phase (drawing shown above)

⁴ Rajaram, S., & Nelson, J. T. (2019). High-performance floating slab track: Design and construction improvements based on lessons learned from prototype slabs. Transportation Research Record: Journal of the Transportation Research Board, 2673(1), 300-309.

- During construction of that section of track; and
- During pre-revenue testing (expanded upon later in this section)

Through our interviews, we learned that the construction contractor, Mass Electric, had noted "cut off excess rod" as part of their 2017 construction work plan. However, Sound Transit's Construction Management Consultant, Mott McDonald, did not ensure the construction contractor completed the work and cut the rods, leaving the aforementioned rods exposed above the top of rail.

STEP NO. 7:	Install cable hangers as each slab is placed	DURATION	OQC
As each section of the floating slab is installed, install the cable hanger onto the cable with a string attached to the free end. After, secure the string to the inside of slab floor. Once the 2nd section of the slab is placed, use the string to lift the free end of the hanger up between the 2 sections. Secure the hanger end between the 2 sections with the 8x8 plate. Use a 1/2" washer and locknut on the top side of the plate to secure the cable. Do this as each section is placed. Raise the cable to 1'-7 3/8" from Top of EMI Cable to Center cable between rails. <u>Cut off excess rod to 2 threads exposed and cold galv.</u>			3
			4

Figure 15. 2017 EMI Cable Installation Workplan Step No. 7 note to cut excess EMI rod, modified in red by Audit Division

Finding a.2. It was noted on shop drawings of the Northgate Link Extensions' (NGLE) electromagnetic interference (EMI) conduit hanger that the rods which hold the EMI hangers on the floating slab had 1) protruded above the TOR in design and after installation, and 2) that the EMI "Top of Rod was to be field cut"; however, it was unclear on the shop drawing where to make the cut.

c. Approval process for design deviation

Sound Transit's Design Criteria Manual states that Engineers of Record are responsible for identifying all necessary departures from the criteria contained in this document and bringing them to the attention of Sound Transit. All changes to and/or deviations from the criteria must be reviewed and approved by Sound Transit Material Review Board (MRB) in accordance with Sound Transit Engineering Design Procedures prior to their use.

We inquired whether the EMI feeder cable design had followed the outlined deviation process prior to construction of the Northgate Link Extension and found that it had not been through Sound Transit's deviation approval process.

Finding a.1. Since the rod holding the EMI was designed and installed above the top of rail, the engineer of record (EOR) should have sought approval of a deviation from design criteria, which did not occur.

d. Systems integrated testing

Systems integration testing verifies that systems perform satisfactorily and as designed when connected to interfacing systems including those provided under other contracts and existing systems.

e. Pre-revenue operations simulation testing

Pre-revenue operations simulation tests are only conducted on new service extensions as the transit system expands. These tests include running simulated revenue train service during normal and abnormal conditions, including testing and emergency exercises and verifying proper training of operations staff.

Tests like these involve parties from the Rail Activation team with support from King County Metro, construction management, first responders, and our systems integration team.

For the Northgate Link Extension, the pre-revenue operations and the start-up plan requires that, following the completion of systems integration testing, Sound Transit dedicate 60 days of the project schedule to conduct pre-revenue operations training and simulation exercises. This includes table top and full-scale emergency evacuation drills.

e.1. 60-days pre-revenue transition period

In the case of the Northgate Link Extension, while the pre-revenue operations and start-up plan noted a generic 60-day transition timeframe to fulfill required drills and activities, it did not include time for maintenance activities in its schedule.

Moreover, with simulated service trains running with frequent headways, King County Power Maintenance and Track Department staff stated that the timeframe was too narrow and didn't allow time for proper walkthroughs, inspections and verification of the new power alignment of Northgate Link.

Finding a.7. While Sound Transit prescribed a 60-day transition period from completion of the Northgate Link capital project to the initiation of revenue service to resolve any final capital project deliverables, the current procedures governing this transition period do not prescribe when that period should formally begin, do not formally designate responsible and accountable authorities for the transition, and do not ensure that all pre-revenue and revenue planning activities will be thoroughly completed prior to revenue service.

e.2. Pre-revenue emergency preparation exercises

One tabletop emergency exercise for the Northgate Link Extension project occurred in March 2021, and one exercise occurred in August 2021, respectively. Emergency exercises are required prior to opening new transit service, as required by federal and state, and Sound Transit certification guidance, and are the responsibility of Sound Transit Emergency Management staff in concert with Sound Transit project staff.

These exercises require extensive coordination and collaboration on the part of agency and contract operator stakeholders, along with first responders to ensure all parties know how to respond and function in a crisis on the new track and are familiar with the differences between Sound Transit's vehicle fleet.

Through the course of the audit, we discovered that exercise participation and preparation require enhancement and increased importance. March 2021's exercise noted that those with "on call" duty obligations, as well as staff from Communications and Passenger Experience, were not in attendance. Additionally, first responders did not attend the August 2021 exercise because first responders were low on staff due to COVID infections.

Finding b.28. ST Safety certification processes, along with Link SOPs articulate that first responders will be trained to have access to and utilize station emergency communications systems and assist in tunnel evacuations. However, during this event, first responders did not remember and/or realize the capabilities they had from their training to access and operate these systems

Furthermore, exercises should consider developing a training curriculum that should consider both types of LRVs in Sound Transit's fleet.

Finding b.19. After-action reports for both table-top emergency exercises noted relevant parties from ST Communications, and Passenger Experience (PX) were not in attendance, and that first responders attended the one in March, but not in August.

Finding b.20. The tabletop exercise to prepare for NGLE service did not consider the differences between the Series 1 and Series 2 trains.

e.3. Siemens qualification tests

Siemens qualification tests are completed to ensure the vehicles perform as set by Sound Transit criteria and are intended to work out any issues prior to fully commissioning the vehicle.

These tests are led by Siemens staff and were conducted along the main line and at the Operations and Maintenance Facility upon arrival of the first Series 2 vehicles.

Listed in bold are tests that were noted with deficiencies.

Name of test conducted	Date(s) tests conducted	Date approved by Sound Transit
Battery qualification test	7/13/2020	10/31/2020
Communication system qualification test	7/9/2020	2/19/2021
Automatic passenger counter qualification test	10/1/2020	10/13/2020
TOD Self-Test Qualification	10/29/2020	3/19/2021
Layover heating set point verification test	1/23/2021, 2/13/2021	3/5/2021
Coupled vehicle clearance test*	3/26/2020, 8/1/2020	12/7/2020
Trainline test	10/27/2020, 6/11/2021	7/12/2021
Vehicle performance qualification test	11/19/2019 through 3/28/2020	1/14/2021
Wheel spin slide qualification test	12/18/2019	2/7/2020
Thermal capacity validation test	5/16/2020	7/6/2020
4-car consist load qualification test	4/18/2020	10/22/2020
Operational qualification test	12/19/2020 through 2/20/2021	3/17/2021
Ride quality test	12/9/2019 through 12/21/2020	2/2/2021
Noise and vibration test	12/9/2019 through 12/21/2020	2/2/2021
Ground borne vibration test	5/27/2020 through 6/18/2020	9/24/2020
Electromagnetic Compatibility Test	7/20/2020 through 11/17/2020	8/16/2021
Magnetic Perturbation Qualification Test Report for 1st Car Seattle	3/11/2020	3/11/2020
ATP system operational test	11/24/2019 through 10/30/2020	3/17/2021
TWC system operational test	2/19/2020 through 3/3/2020	8/18/2020
Vehicle envelope test*	1/22/2020 through 1/24/2020	9/24/2020
Parking Brake Test	3/24/2020 through 4/1/2020	8/7/2020

Table 1. Table of Siemens Qualification tests that were completed in Seattle upon arrival of the first Siemens S70 (Series 2) Light rail vehicle, highlighting the two (2) tests reviewed by the Audit Division.

e.3.1 Coupled vehicle clearance test

Coupled vehicle clearance tests, for use in this report as “ground clearance tests,” are completed by Siemens under Sound Transit oversight to verify the vehicle meets dimensional and clearance requirements. The first two cars fully built and delivered to Seattle (Cars 204 and 214) were checked for proper truck, coupler, cable and hose clearances with simulated passenger weight.

Ground clearance tests were also completed to check track clearance, horizontal curve clearance, and vertical sag clearances. Furthermore, these clearance tests were to be verified between the car body and truck components, but were only done in specified locations set by Sound Transit.

The testing locations, as chosen by Sound Transit were at the following locations:

Test Conducted	Location
Horizontal Curve Clearance	Track curve south from traveling alongside from S. Forest St. to Airport Way S.
Vertical Sag Clearance	From Pioneer Sq. Station travel to intersection of S. Washington St. and 4 th Avenue
Vertical Crest Clearance	Track curve south from traveling alongside from S. Forest St. to Airport Way S.

Table 2. Table of Siemens test locations from the Coupled Vehicle Clearance tests.

The locations noted for testing did not take into consideration places where the floating slab and EMI rods were located, nor was the test considered to be done at the new section of track heading towards Northgate Link. Moreover, project staff never considered using historical ridership data to locate an alignment section to simulate the weight test to align with actual service.

For the test, load capacity was simulated using pallets of water placed on board the LRV in specific locations, as well as in seats. During the noted ground clearance tests, the crush loads⁵ of the two Siemens vehicles were confirmed to be “one at AW0 and the other loaded to AW3 and with disabled secondary suspension”.

Crush Load	Load specifications
Single Person	Approx. 115 pounds (70.3 kilograms) per passenger
AW0 (Tare Load)	Empty Vehicle in running condition (Not to exceed 97,500 pounds)
AW1 (Seated Load)	Vehicle with all fixed seats occupied, plus 1 operator
AW2 (Design Load)	Vehicle with all fixed seats occupied, plus 1 operator, plus standees at 4 passengers per square meter
AW3 (Crush Load)	Vehicle with all fixed seats occupied, plus 1 operator, plus standees at 6 passengers per square meter
AW4 (Max Structure Design Load)	Vehicle with all fixed seats occupied, plus 1 operator, plus standees at 8 passengers per square meter

Table 3. Table of Vehicle “Crush Load” specifications used for Vehicle Clearance Test

⁵ Crush Load is the maximum level of passenger load. These are calculated for the number of passengers per area, standing up.

At the time, Sound Transit project and Siemens staff were unaware that the crush load weights limit they were testing were well under the capacity weight of the trains found on the night of November 26, 2021.

Finding a.5. Vehicle clearance testing was incomplete because it was not done at a proper crush load weight, nor tested at a historically high ridership location.

Continuing to use the incorrect weight load, train tests then checked to ensure it had a minimum 2-inch coupler clearance above top of rail when empty, as required. Again, at the time of fleet qualification testing, the minimum spacing test passed the coupled vehicle clearance test, but as we learned later, the 2-inch specification was not the correct measurement for a Series 2 train but rather, it matched the dimension appropriate for suspension design Sound Transit's other light rail vehicle, the Series 1.

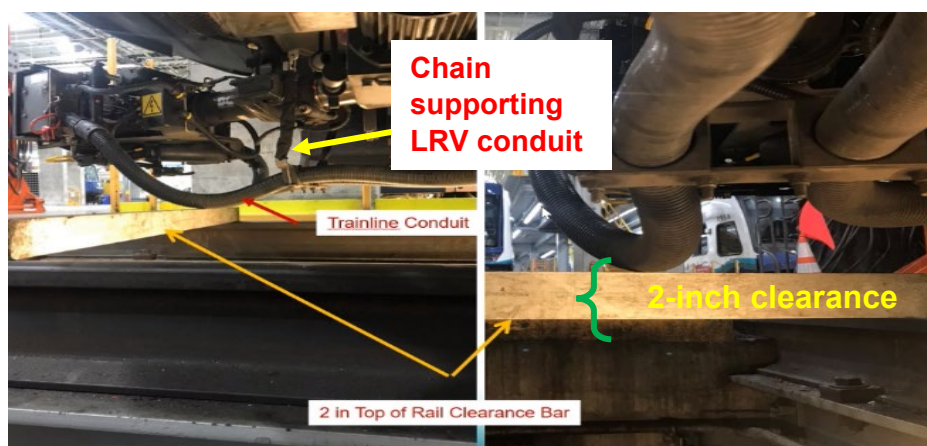


Figure 17. Photograph of Series 2 trainline conduit hanging near 2-inch clearance bar, as specified for a Series 1 vehicle and not a Series 2, modified in red by Audit Division.

Lastly, while the Series 1 vehicles maintain a consistent floor height above the top of rail, no matter the compression of weight, due to its pneumatic airbag motion suspension, the Series 2 vehicles use coil springs, which compress and lower the vehicle under severe weight. This requires hydraulics to activate at platforms.

Finding a.4. Siemens vehicle testing did not fully consider configuration differences between Series 1 and Series 2 light rail vehicles. These differences include suspension compression under heavy passenger load, ensuring constant floor height above top of rail, and ensuring proper clearance of conduit, couplers and cables.

e.3.2. Vehicle envelope clearance test

Train car movements are part of the vehicle envelope clearance test. These tests check to ensure that the sides and top of the vehicle do not have any obstructions and meet specifications while the vehicle traverses the tunnel. This test also ensures vehicles have a vertical clearance with the overhead structures and maintain track spacing.

However, this test does not include ensuring that the dynamic envelope between the track does not have obstacles which could reach above top of rail.

Finding a.3. Testing of the dynamic envelope was limited to areas above and to the sides of the vehicle and neglected to verify that the spacing between the track gauge was free of obstacles above the top of rail as specified by design criteria.

5.2 Safety certification

Sound Transit's Safety Department is responsible for developing, overseeing, and executing the agency's safety certification program.

Safety certification ensures that safety concerns and hazards are adequately addressed prior to the initiation of passenger operations for major capital projects that extend, replace, rehabilitate or modify an existing system, or to procure and replace vehicles and equipment. This formal process includes the following:

- Identification of specific safety requirements.
- Verification of compliance with agency Safety Plan(s), appropriate codes, guidelines, standards, and safety-related design criteria and technical provisions.
- Identification and resolution of non-compliance open items.

This process verifies that safety standards have been met or exceeded in the design, construction, and start-up of all capital projects. Sound Transit has Safety & Security Certification Specialists who certify rail transit activities. These activities are subject to the approval of the WSDOT State Safety Oversight (SSO) Program Office.

As part of the final review, the Sound Transit CEO reviews the Safety and Security Certification Verification Report, and signs the Safety Certification Verification Certificate. This certificate is then submitted to WSDOT SSO and must be approved prior to passenger revenue service.

Sound Transit received WSDOT's *conditional acceptance** for four Series 2 LRVs on May 6, 2021⁶; and full approval for revenue service for Northgate on October 1, 2021.

***Note:** While this initial letter shows WSDOT conditionally accepted four vehicles of the current Siemens fleet, Sound Transit agreed to provide WSDOT full access to any safety certifiable material, and to ensure Sound Transit was conforming to all identified safety and security requirements prior to putting additional Series 2 vehicles into revenue service.

a. Certifiable items list

Sound Transit is responsible for the preparation and maintenance of a safety certifiable items list (CIL) which identifies system and fire/life safety items and security requirements from technical provisions, plans and procedures that are subject to the safety certification process.

As part of safety certification, and field inspection oversight processes by both Sound Transit and King County Metro staff, safety certifiable items are identified and verified prior to approving projects for revenue service. However, for items such as verifying specification deviations in drawings, ensuring items being noted to be done by construction contractors and accounted for by a Construction Management Consultants should be vetted from a quality perspective, alongside a safety perspective.

Finding a.6. As part of its safety certification and field inspection oversight processes, Sound Transit verifies all items prior to approving projects to open for revenue service. While vehicle dynamic clearance testing is a certifiable item, the EMI rod identified between track clearances was not specifically listed in any check list which is why it was not verified prior to opening the Northgate Link Extension.

5.3 Operations

a. Intergovernmental agreements (IGAs)

Re-approved in June 2019, the current Intergovernmental Agreement (IGA) is the overarching governing document between Sound Transit and King County Metro and specifies the relationship between the transit agencies for oversight, operations, maintenance, safety and incident/emergency response.

Under the agreement, Sound Transit owns Link. KCM will operate and maintain the 1 Line service, and Sound Transit will retain responsibilities such as making policy

⁶ Memorandum between WSDOT and Sound Transit, Safety Certification concurrence, dated 5/25/2021

decisions, maintain financial control and management oversight of the IGA, provide and replace facilities, as well as procure equipment and vehicles.

b. Standard operating & maintenance procedures

In support of operating agreements, Sound Transit and King County Metro have formalized standard operating & maintenance procedures (SOPs & SMPs) that document rules and processes to ensure service is delivered consistently and efficiently. Additionally, procedures ensure processes are clearly communicated to provide employees with all operational information necessary to perform work properly.

Link standard procedures are reviewed at a minimum of every 10 years and must be reviewed by a Link Rules and Procedure Committee (LRPC). This committee, made up of King County Metro, Sound Transit, and WSDOT staff, meets monthly and is formed to review and recommend approval for Link rules and procedures.

Of the 228 SOPs and SMPs related to Link light rail service, our audit found ten relating directly to the incident that require immediate attention. We observed three that are critical to incident and emergency protocols and are outdated per Link procedure review cycles.

Seven additional procedures should be reviewed and updated based on outcomes from the November 26, 2021 incident, listed below:

Link Procedure review			
No.	Procedure title	Date	Status
SOP 2.4	Light Rail Vehicle Public Address Announcements	9/30/15	Review / Update
SOP 6.3	Link Control Center Emergency Response Procedure	5/15/20	Review/Update
SOP 6.5	Link Control Center Communication Procedures	7/31/15	Review / Update
SOP 6.9	Normal & Emergency Power Removal Restoration	9/10/18	Review / Update
SOP 6.12	LCC Upon Notification of a Disabled Train	4/20/09	Outdated
SOP 6.14	Link Control Center Public Address Announcements	12/4/09	Outdated
SOP 6.18	Bus Bridge Procedure	4/2/09	Outdated
SOP 6.23	Emergency Train Back-up Procedure	3/24/16	Review / Update
SOP 7.1	Light Rail Vehicle (LRV) Passenger Transfer & Evacuation Procedures	2/13/17	Review / Update
SMP 29.2	Emergency Phone System Maintenance	6/5/15	Review / Update

Table 3. Table of Link Procedures reviewed related to the November 26, 2021 incident.

Finding b.4. Because of this event, several Link SOPs critical to incident and emergency protocols should be reviewed and updated.

c. Prior damage to light rail vehicle undercarriage

In the transit industry, it is common for preventive maintenance checks to reveal minor damage to light rail vehicles. Transit tunnel systems are an environment where trash or other debris tend to accumulate. However, damage that is noticed and not properly reported could also be a leading indicator that vehicles are making contact with an object in the trackway and should be inspected.

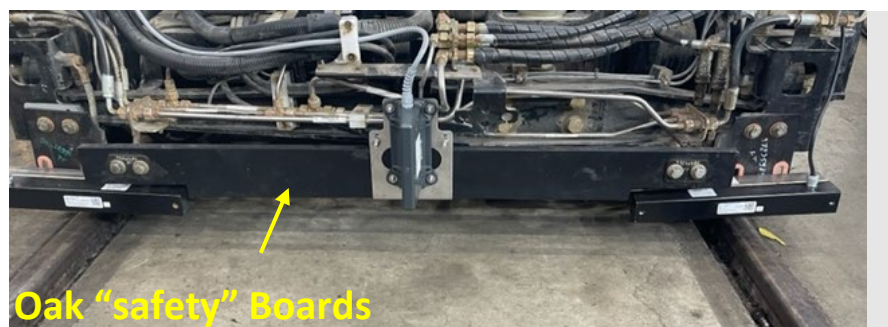


Figure 18. Photograph of a removed truck from Series 2 vehicle, and arrow pointing to an undamaged Oak "safety" Board

Prior to November 26, 2021, King County Metro vehicle maintenance staff were discovering Link vehicles being damaged on their oak boards, also known as Safety Boards, which help prevent people or objects from rolling under the train. As shown below, there is a large crack and gouge taken out of the board, denoting the train had struck an object at a considerable speed



Figure 19. Photograph of a damaged Series 2 vehicle, and arrow pointing to Oak "Safety" Board

King County Metro staff entered the information into their work orders system, also known as EAM System. This is where previous damage from incidents similar to the one like November 26, 2021 were being recorded. However, reporting these incidents in the work orders system did not provide a method to inform management and escalate the issue for further attention.

We reviewed approximately 2,800 work orders had been entered from around September 15, 2021 until the incident. Of that number, we filtered our search for specific keywords such as "Damage", "Oak Board Damage", as well as "EMI rod and bolts", and "Cut Bolts".

Ultimately, we found 16 work orders which related our keyword search, as shown below in Figure 19.

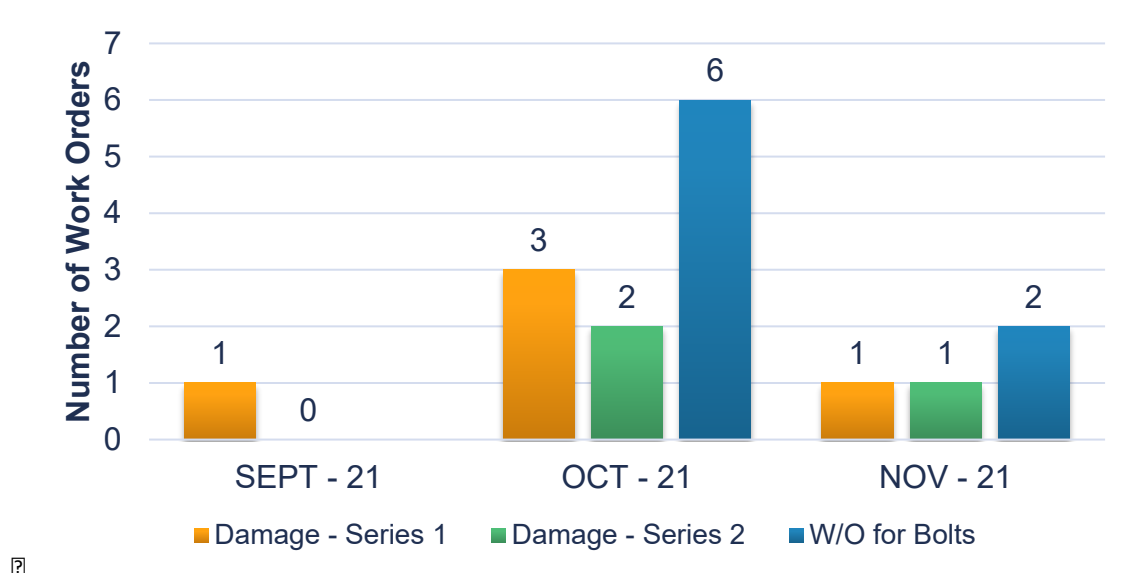


Figure 19. Vertical bar graph trends of reported work order damage for Series 1 and Series 2 trains, and work orders for "bolts".

As shown in the data here, Series 1 vehicles were the first being damaged. The graph above illustrates that the earliest work order for damage dates back to September. That work order, dated September 16, 2021, stated damage was done to the "Safety Bar" on a Series 1 train. The work order shows it was prioritized as a general repair and then closed four days later.

Our data analysis, did not find another work order stating "damage" again until October 2, 2021 when a series of work orders were reported within a week on both types of trains.

Additionally, we found that King County maintenance staff were aware of the damage, but stated they were not sure how to report it besides entering the damage into the EAMS work orders system. When we looked into Link maintenance procedures, we found no guidance in the procedure for entering and escalating items for management review.

Finding a.9. Link Standard Maintenance Procedures (SMPs) do not provide clear guidance on what mechanics do when they observe vehicle damage.

At this point, we found internal correspondence had occurred between King County maintenance staff regarding the why this damage was happening.

Though those messages occurred after the fact, Sound Transit knew King County was looking into what was occurring because there were work orders for “bolts” beginning on October 15, 2021. King County Metro found over 200 EMI rods protruding along both sections of the Link alignment a few days later and mentioned in work orders that the bolts needed to be cut down.

Around that same time, around a month prior to the incident, Sound Transit Engineering was informed about the damage and the rod strikes, but failed to make King County Safety, Sound Transit Operations, or Sound Transit Safety aware of the previous damage or the high EMI rod issues.

Finding a.8. Beginning a month prior to the November 26th event, several other incidents were recorded in work orders noting that trains struck an object under the vehicle, later determined to be the EMI rod that damaged the train on the night of the 26th. Additionally, multiple maintenance work orders had been recorded to note EMI rod issues in the Link system.

While these incidents were entered into the work order system, none of them were properly reported to Sound Transit Operations or Safety for evaluation.

We found no other correspondence or work orders relating to any of our search parameters until the incident.

d. Passenger emergency signage and announcements

d.1. Emergency signage

Emergency signage is important to give passengers a visual indicator on where to or how to get help. The “Seeing Something Wrong” poster on the Series 1 vehicles shows passengers how to contact Sound Transit Security in the event of an emergency.

However, the Series 2 vehicle involved in the incident the night of November 26, 2021, and additional vehicles sampled through the course of our audit, had no such signage. In the event of an emergency, passengers on Series 2 cars have no guidance on who to call in the case of an emergency or incident.

Finding b.26. "See something wrong" signage is posted for passengers on the Series 1 vehicles to contact ST Security in the event of an emergency, however, no such signage is posted anywhere on the Series 2 vehicles.

d.2. Evacuation procedures and messaging

Signage showing emergency evacuation procedures would help allow passengers to know exactly how to exit the light rail vehicle and advise them what they need to do in order to stay safe during an emergency. As best practice, this signage and audible messaging is already posted and frequently heard on Sound Transit's Sounder cars.

However, at present neither vehicle type in Sound Transit's light rail fleet has emergency evacuation signage posted. Furthermore, "what to do" emergency audible messages are not played over the light rail vehicle's interior speaker system.

Finding b.15. Other Sound Transit modes (i.e., Sounder trains) have "in case of emergency" evacuation signs posted to ensure passengers are aware of emergency exits and how to exit the vehicle. However, no "in case of emergency signs" are posted in either series of light rail vehicles.

Finding b.16. On other Sound Transit modes (i.e., Sounder trains) audible messages are circulated telling passengers "What to do in case of an emergency." For both series of light rail vehicles, there is no audible communication systems telling passengers what to do in an emergency.

d.3. Emergency illumination

Absent secondary backup lighting inside the light rail vehicle, emergency illumination strips can provide an indication of vehicle egress pathways. Absent redundancy in the catastrophic loss of power to the Series 2 vehicle, besides the "blue lighting" around the doors, which functioned as designed on the night of November 26, 2021, there were no secondary illumination strips in the vehicle to allow passengers to maintain awareness of their location or assist in finding emergency door releases. These may provide guidance in the event of a loss of power or during a fire.

Finding b.17. Series 2 vehicles are equipped with "blue lighting" to illuminate the doors and emergency door manual release controls. In this event, with the

loss of power, only “blue lighting” was working. Passengers had no secondary emergency illumination to visually find emergency door release controls.

5.4 Safety oversight

Safety oversight for the 1 Line is multi-layered to ensure processes and programs keep passengers, King County Metro staff, and Sound Transit staff safe. However, in this incident, the audit team found that clear oversight became confused with the complexity of diffused responsibility.

Sound Transit is the safety risk owner for the 1 Line, and largely gives King County Metro room to operate the light rail on our behalf. The first layer of safety oversight is accomplished by Sound Transit Operations staff who ensure process and procedure is followed by King County Metro’s Rail Division. The day-to-day assurances that occur to keep light rail operating depend solely on the working, collaborative, trusted relationships between the operating divisions of KCM.

The second safety level is overlayed by King County Metro’s Safety & Security Division and Sound Transit’s Safety Department. Safety reporting processes originate from King County Metro through various sections, in accordance with operating agreements. These processes may include emergency and incident investigation, reporting service issues to regulatory authorities, and paths to escalating an incident to an emergency.

In the wake of the incident, we found King County Metro staff did not fully review WSDOT’s reporting criteria and the activation of emergency notification protocols. Thus impacting the execution of emergency and communication protocols.

According to WSDOT’s reporting protocol, if an event such as the November 26, 2021 incident occurs, KCM is required notify only the SSO within two-hours if the rail vehicle evacuates for a non-life-safety reasons into the right-of-way or street; this is not identified or noted in Link procedures.

This prompted Sound Transit to both seek clarification as to the disposition of this event, and make the necessary regulatory notifications three days after the incident.

Finding b.1. This event reveals that multiple failures occurred because Sound Transit does not have adequate processes in place to ensure passengers are promptly informed when emergencies occur. Furthermore, Sound Transit does not exercise sufficient oversight of its contracted operator.

5.5 Communications

Several entities from both agencies serve as the communications “hub” where passenger, internal, and media incident coordination originate. Each entity serves as a connection between modal incidents, first responders, service disruptions, and informing the general public; with the centralized command point being the Link Control Center (LCC).

In the aftermath of the incident, the overall response was not coordinated. This inhibited the efficient and safe recovery of passengers on the train. Lack of information caused passengers to feel uncertain and unsafe, which prompted self-evacuation from the train.

Additionally, there were significant gaps found in how the public and agency staff were informed of incidents through various duty officers, as explained further below, who either had processes but didn't follow up for more critical information, had cell phone malfunctions and no backup systems, or those who didn't have processes or procedures at all.

The net effect was that Metro and Sound Transit had no way to know in real time which passengers were in which sections of tunnel, and no way to inform passengers who had accumulated at stations waiting for trains of what was happening, and how it would impact their travel.

a. Link Control Center (LCC)

The King County Metro Link Control Center is the centralized point for operating, controlling, monitoring, and dispatching 1-Line trains. It is operated by King County Metro staff. As part of the LCC's role as the pivot point of information, the LCC has the ability to dispatch vehicle maintenance, coordinate with King County Metro Safety, and alert other responsible authorities for actions on the Link alignment. Information is disseminated using an “Alert Sense” notification.

Additionally, in normal operations, the LCC has the capability to utilize and access the remote public address system and access station signage to keep passengers on platforms informed.

When interviewed, the LCC staff mentioned that they attempted to use the remote public address system for the affected area, but that it was inoperable. Furthermore, station signage was not utilized to give passengers visual awareness of what was going on and how the incident would affect them.

Finding b.13. Link SOP 6.14 (Link Control Center PA Announcements) states that “passengers should be advised to exit the station in an emergency situation.” The LCC controller stated they attempted to make this announcement. However, staff realized later that remote use of the of the public address system was not available due to the SCADA system outage.

Finding b.31. At the time of the event, they did not provide any visual indication of delays for trains nor approximate the time trains would arrive at stations. Many passengers were confused about the status of service.

Additionally, when a service interruption or stoppage is anticipated to be more than 60 minutes on any section of mainline track, a bus bridge will be initiated from the LCC to King County Metro Bus Operations.

During our interviews, we were informed that current standard practice dictates that Sound Transit staff rely on email messages from the LCC. However, Sound Transit staff said they were not notified on the bus bridge arrangement, delaying passenger transfers and clearing station platforms.

Finding b.18. In established procedures, if there are emergencies that cause significant delays to trains, bus bridges are deployed to transport affected passengers. Those bus bridges are arranged by King County Metro, and the information is communicated to Sound Transit staff to inform passengers. In this event, the bus bridges were arranged, but notifications and orders were only sent to and from King County Metro and excluded Sound Transit.

b. Supervisory Control & Data Acquisition (SCADA)

Supervisory Control and Data Acquisition, known in the transit industry as SCADA, is a grouping of systems that collects data and allows train dispatchers to control various light rail functions. SCADA also helps the staff at the Link Control Center monitor the status of train controls, switches, signals, tunnel conditions, and equipment that keep trains operating safely.

In addition to SCADA, other functions can be accessed remotely from the Link Control Center such as station public address systems and tunnel camera systems.

All of these functions are overseen, managed and maintained by various groups, including King County Metro’s SCADA team, along with Sound Transit’s Information Technology (IT), Operations Technology (OT), and Transit Systems teams. Depending on

the issue, these teams are notified and act to fix issues or assist in bringing the system back online.

However, having multiple groups responsible for issues slows response times, causing communication channels to become murky by repair priority determinations from the King County Metro's Link Control Center and limited access to information by Sound Transit's IT and OT teams.

b.1. SCADA Network outage

The day before the Apple Cup, Sound Transit experienced a network outage that made some critical functions of the SCADA and other systems inoperable between the UW Station and U District Station. This includes CCTV, remote access to station PA systems, and LCC monitoring of the train control system within the tunnel section. Moreover, we found out that a similar network outage on another portion of the Link alignment during the week prior to the Apple Cup.

So, when King County Metro's SCADA team received the issue on the 25th, and noting its similarity to the earlier outage, they chose to address the issue internally without informing Sound Transit. King County staff felt they didn't need to escalate the issue outside King County Metro since outages and repairs of this nature are somewhat routine and are generally handled in-house, and usually not addressed over the weekend or holidays, as we discovered with the lack of work orders.

Other factors at play in terms of not informing Sound Transit included the timing of the outage during the holiday weekend, the college football game, and limited staffing.

Before the incident occurred, King County Metro's SCADA team was actively troubleshooting the outage issue. By the time the incident occurred, functionality had not been restored, with CCTV and remote public address capabilities still offline and not available for Link controllers.

Later, Sound Transit IT and OT staff confirmed that they were not warned of the SCADA functionality issues the day before the Apple Cup, and were not deployed to assist in the repair solutions.

Finding b.10. Per the Link IGA, ST delegates LCC duties to KCM, who is required to maintain SCADA systems; however, the SCADA network between UW Station and U District Station was not working properly on November 25, 2021 (the day prior) and was not prioritized as a critical repair. This affected the LCC's capability

to remotely access the Public Address (PA) system for those stations, and have visual confirmation of passengers walking in the tunnels.

Finding b.11. On Thursday, November 25th an after-hours Network Outage was reported affecting transactions. As part of processes, the outage caused some LCC systems to be offline (cameras near cross-passages, and train tracking) between U District and University of Washington (UW) Station during the Apple Cup. During interviews, we were told that the SCADA network repair was not prioritized due to the fact that “on-call staffing” was not available during the holiday & special event period. This was further confirmed when we found no SCADA work orders entered on weekends or holidays.

Finding b.14. The cameras mounted near the cross passages are viewable through CCTV by the LCC when in normal operation. However, because of the SCADA network outage, these cameras were offline. Additionally, cross passages in the Northgate section of the tunnel system are not equipped with cameras. Cameras are adjacent to the cross-passage doors.

b.2. Fire protection confidence testing

Sound Transit must conduct fire alarm systems confidence testing in all Link tunnels annually. These tests are conducted by Sound Transit and King County Metro’s certified fire systems technicians according to Seattle Fire Department, and NFPA guidelines. Testing is coordinated between the Link Control Center, fire protection engineers from Sound Transit and King County Metro, as well as other observers who ensure systems operate as designed.

Due to the size of the alignment, tests are done once quarterly, with areas of the alignment split into specific sections. During these tests, fire control panels at the tested stations are placed in an activated testing status, known as “Vent Mode,” causing fire alarms to activate, test for back of house door alarms, test public address system capability both at stations, and remotely from the LCC, and ensure SCADA indicated systems are not impaired.

The last test at the UW Station and U District Stations occurred the nights of November 1st and 2nd, 2021 respectively and did not show any indication of impairment. Furthermore, these tests and showed the systems were operational, including the public address systems both at the station and from the LCC.

After reviewing testing protocols, we found a gap in testing where confidence tests are not done prior to large-scale events, such as the Apple Cup. Additionally, confidence tests do not check door alarms at tunnel cross passages.

Finding b.12. For the Apple Cup event, the PA system was not tested prior to the game to ensure operability. We also found that confidence tests do not test door alarms at the cross passages.

c. On-Call Duty Officers

The overall processes for on-call duty officers varies greatly depending on the nature of the event and on the officer's specific role.

Various duty officers contact only one or several people depending on the event and the people they contact may or may not contact others. Some details may or may not be shared with all those contacted and some stakeholders (e.g. Executive Leadership) may not be contacted until after an event has been resolved.

Under normal circumstances, if service delays impact Link service, all duty officers contact the LCC for additional information regarding the service delay; however, the LCC stated that they do not have the authority to declare the event an emergency.

However, in reviewing Link procedures 6.3 and 7.1, these procedures actually give the the LCC the authority to declare an emergency

In procedure 6.3, Section 4.0: "During any emergency event, the Controller is expected to take actions that will save the greatest number of lives, even if those actions require the Controller to deviate from the established procedure. The selection and use of AHRP Checklists during emergencies is mandatory.

If an emergency occurs, that does not exactly meet one of the emergencies listed below; the Chief Controller shall select the checklist or checklists that are the closest match to the evolving situation or emergency.

Additionally, in procedure 7.1, section 4.2: The LCC shall call the appropriate agency in the event of fire/emergency response. We found that both procedures lack clear instruction of when the LCC is to make the emergency determination or what should be done if a situation occurs to escalates events from a passenger transfer to an emergency.

Sound Transit would only be notified via the Alert Sense messaging system or through the Operations Duty Officer. That Operations duty officer would then the make subsequent informational phone calls back to the LCC in order to gather more

information and prepare the “Command Post” internal notification throughout Sound Transit.

Additionally, that Operations duty officer is also the pivot point, when necessary, for having information prepared for the ST Executive Director of Operations to notify the CEO. Crucial to the single source of information, the Operations duty officer should consult the agency’s reporting process in order to ensure the right staff are informed. However, in this incident, information came to the CEO through other sources than the Executive Director of Operations.

Finding b.21. The ST Agency Incident Notification SOP for Safety instructs that the ST Executive Director of Operations notify the CEO about a major incident. While we found that this procedure was revised in 2020, it was not used nor followed.

The Duty Officers ad-hoc format of event management leaves gaps in how critical communication is relayed from the incident to our affected riders; including whether all information is received, done in a timely manner, and acted upon in an appropriate manner by the right staff.

Finding b.9. From this event, we found there are no official procedures or training clarifying roles and responsibilities, who to contact in the event of an emergency, clear guidance on what information to report, when to escalate and when to follow up.

Finding b.22. No procedures have been developed to ensure the positive confirmation of handing over or taking over duties nor updating phone forwarding for various ST duty officers (Communications, PX, Security, and Operations Duty Managers).

Additionally, in the case of Sound Transit’s various on-call duty officers, none of them are co-located to effectively and efficiently disseminate information where it’s needed as incidents arise.

d. Security Operations Center (SOC)

The Security Operations Center (SOC) is operated and staffed 24 hours a day, 7 days a week by Sound Transit Security staff. SOC’s only responsibility is providing security awareness and is the focal point of who customers contact if there are issues on trains. The SOC has radio and phone communication with the LCC when services are impacted.

Additionally, passengers can text, email, or call the SOC in order to report any service issues.

On the night of November 26, 2021, the SOC was stationed on the UW Station platform in order to ensure safe passenger circulation within stations, liaise with the King County Sheriffs Office (KCSO), and help mitigate any crowd control issues. Additionally, Sound Transit Security augments crowd mitigation efforts by having transit police and contracted security staff assist along the alignment. When the incident occurred, there were an estimated 800 people waiting on the UW Station platform.



Figure 20. Photograph of UW Station Platform crowded with passengers boarding Train #6 on November 26, 2021.

Staff who dealt with crowd control found it difficult to hear and understand communication from the various communications channels (i.e., LCC or SOC).

We also found that it has been a standard practice at the UW Station that a temporary secondary public address system is utilized in order to communicate to passengers at the service level entrance. However, communications to and from the secondary PA was ineffective and inconsistent in advising passengers, adding to the confusion.

Additionally, it was found that transit police and contracted security staff were either lacking proper training on what actions needed to be taken, or lacking formal procedures in the event large-scale special events to assist staff and passengers, as needed.

Finding b.29. Sound Transit Public Safety staff lack formalized procedures for crowd management, mitigations, and large events.

Finding b.30. Contracted security staff lack formalized training for special events, escalator monitoring, crowd management, and slips and falls. Additionally, they do not have formalized SOPs for special events.

e. Operations Duty Manager

During normal operations, the LCC Customer Service Desk is staffed by King County Metro, which only operates the customer service desk between 5 a.m. and 8 p.m., Monday through Friday, also does not provide service on holidays. When those hours and holidays need staffing, they are filled by the Operations Duty Manager.

The Operations Duty Manager takes over duties once King County Metro's shift concludes, but are not formalized in any procedures, leading to the risk of missed alerts.

Sound Transit Link Operations assigns a Duty Manager outside normal working hours to gather information to and from the LCC. The Operations Duty Manager is a weekly rotational position held by various Link staff responsible to provide information in the case of a Link emergency or incident that will affect passengers on and off the train.

Finding b.27. Our interviews found that when the service desk is not staffed, the duties are handed over to the ST Operations Duty Manager, but this is not formalized in a documented process or procedures.

f. Passenger Experience Duty Officer

Sound Transit's Passenger Experience Duty Officer's role is to facilitate information that goes from the LCC to the Communications Department. This is completed through posting rider alerts via email, web and Twitter to keep passengers and the public informed of real-time information such as delays, bus bridges, and route changes.

If an alert is sent by the LCC, PX reviews it and pushes information to social media, passes the alert to Communications, who then inform external news sources and advise ST leadership of the event. Passenger Experience Duty Officers rotate shifts on a weekly basis from Wednesday to Wednesday.

At the beginning of their shift on Wednesday November 24, 2021, the oncoming duty officer failed to transfer their phone number; therefore, alerts were not received during that weekend. Up until November 26, the duty officer's phone was still having technical issues which prevented them from receiving Command Post emails that would have alerted them to the incident.

Finding b.24. Sound Transit does notify passengers of issues with "Rider Alerts" through website updates, Twitter posts, subscriber text messages and email alerts for those who sign up. No capability exists to send an immediate alert to passengers on a train.

Finding b.25. Because of the lack of official procedures to transfer duty officer responsibilities, the PX Duty Officer phone number was not transferred properly.

g. Communications Department Duty Officer

Sound Transit's Communications Duty Officer's role is to facilitate communications with external media sources, such as news stations and reporters, publish news releases, and blog posts regarding incidents and events. Communications additionally directs and facilitates communication to Sound Transit's executive leadership and Board of Directors.

Communications Duty Officers are responsible for transferring a Sound Transit phone number to their personal phone so they can receive notifications about situations that warrant media engagement. On the night of the incident the Communications on-call duty officer's phone did not receive notifications because the Information Technology (IT) forgot to enter a "9" when transferring the phone number.

Finding b.23. The Communications Duty Officer would have been notified of the incident by "rider alerts" to their duty cell phone; in this event, alerts were not received due to the duty cell phone malfunctioning, and there was no backup system.

6. Conclusion

Overall, as part of the continuous improvement process, our audit identifies several key improvement areas. There are multiple opportunities to strengthen operations procedures such as emphasizing and clarifying Sound Transit's overarching accountability for Link service. Diffused responsibility should not diminish nor change the agency's accountability for risks. As an agency, both Sound Transit and King County Metro must strengthen their operating relationship and eliminate ambiguities or confusion as to roles and responsibilities.

We also note that improvements need to be made to ensure that agency emergency communication processes between Sound Transit and King County Metro are robust if a similar unprecedented event occurs; or at worst, a severe emergency or accident occurs in the future.

As we noted throughout this audit, there were numerous instances where communications protocols were ineffective; from the Link Control Center to affected staff; and from operators to passengers; and amongst agency staff. All communications protocols need to be strengthened and enhanced.

7. Reference

Rajaram, S., & Nelson, J. T. (2019). "High-performance floating slab track: Design and construction improvements based on lessons learned from prototype slabs." Transportation Research Record: Journal of the Transportation Research Board, 2673(1), 300-309.

8. Appendix 1 – List of Interviewed staff (By Title)

Sound Transit:

- Chief Executive Officer

Operations Department

Link Operations

- Executive Operations Director
- Link Transportation Manager
- Maintenance Superintendent, Signals and Power (Duty Manager on 11/26/21)
- Enterprise Asset Management System Administrator

Operations Assets & Technology

- Director, Operations Engineering & Technology
- Transit Systems Operations Manager
- Transit Systems Electronics Technician
- Operations Fire-Life-Safety Systems Engineer

Passenger Experience Department

- Chief Customer Experience Officer
- Deputy Director, Passenger Services

Communications Department

- Deputy Executive Director, Communications

Portfolio Services Department (PSO)

- Systems Engineering & Integration
- Vehicle Engineering
- Track Engineering Manager
- Systems Testing & Commissioning
- Principal Construction Manager – Systems
- Corridor Design Systems Manager

Information Technology Department

- Chief Information Officer

Design, Engineering, and Construction Management Department (DECM)

- Northgate Link Project Director
- Consultant, LTK

Safety Department

- Chief Safety Officer
 - Transportation Safety & Security Division (TSS)
 - Emergency Management
 - Public Safety Division

King County Metro:

- Director, Rail Division
- Link Operations Manager
- Light Rail Maintenance Division
 - Vehicle Maintenance
 - Power Maintenance
 - Track Maintenance
 - Traction Power
- Safety & Security Division
 - Transportation Safety Superintendent
 - Transportation Safety Administrator
- Link Control Center (LCC)
- Light Rail Operator Training Division