

Subject: Cartridge Bearing Assembly Review

File Number: ACS2024-TSD-ES-0002

Report to Transit Commission and Light Rail Sub-Committee on 31 May 2024

**Submitted on May 22, 2024 by Renée Amilcar, General Manager, Transit Services
Department**

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Ward: Citywide

Objet: Examen de l'ensemble de roulements cartouches

Numéro de dossier : ACS2024-TSD-ES-0002

**Rapport présenté au Commission du transport en commun et Sous-comité du
train léger**

Rapport soumis le 31 mai 2024

**Soumis le 2024-05-22 par Renée Amilcar, Directrice générale, Services de
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REPORT RECOMMENDATION(S)

**That the Transit Commission and Light Rail Sub-Committee receive this report for
information.**

RECOMMANDATION(S) DU RAPPORT

**Que la Commission du transport en commun et Sous-comité du train léger
reçoive ce rapport pour information.**

BACKGROUND

The purpose of this report is to provide the Transit Commission with an update on the status of mitigation measures related to the cartridge bearing assembly of the O-Train light rail vehicles and the progress to identify the root cause and development of a sustainable solution.

On October 20, 2023, the Transit Commission received the LRT Disruption – Root Cause Review report ([ACS2023-TSD-ENG-0020](#)), which reviewed the findings of the axle-bearing related investigations, outlined where further findings were expected to complete the root cause analysis, and set out short, medium and long-term actions to resolve the issue and increase rail service reliability.

This report will provide details of the following:

- Reports received since October 20, 2023, related to the Cartridge Bearing Assembly
- Status of Short-term containment plan
- Status of Medium-term mitigation plans
- Status of Long-term mitigation plans
- Summary and next steps

DISCUSSION

1.0 Previously submitted report to Transit Commission

The LRT Disruption – Root Cause Review report ([ACS2023-TSD-ENG-0020](#)), discusses three events related to the cartridge bearing assembly that have led to full or partial shutdowns. As a result, various containment measures have been implemented on the Confederation Line to ensure the continuation of safe LRT service. Simultaneously, the City, RTG, and their external safety and engineering consultants continue to make progress on the development of additional mitigation measures that will provide a stable and resilient LRT service. Ultimately, the City and RTG are working towards a sustainable solution that will eliminate the need for containment measures and the resumption of full service that achieves Project Agreement performance requirements.

2.0 Investigations and Reports Undertaken

2.1 Third Instrumented Axle Test Campaign Report March 2024

This report from Alstom discusses the test campaign from July 2023 that was designed to:

- Confirm efficiency of a top of rail friction modifier system to reduce coefficient of friction and reduce lateral forces.
- Explore effects of flange lubrication.
- Compare trailer and motor bogie behavior.
- Evaluate low-cost inductive sensors for hub/wheel displacement.
- Assess the impact of restraining rail contact.

In summary, the report concluded:

- Top of rail friction modifiers are effective for reducing lateral loading.
- Railside wear on high rail in curves demonstrates regular contact with wheel flange indicating that a higher strength material would be better suited for these curves.
- Analysis following the testing of axle beam/wheel displacement sensors demonstrates a method to detect axle play.

2.2 Cartridge Bearing Assembly Failures Root Cause Analysis Report, February 2024

This report discusses the investigation by Alstom into the root cause of the cartridge bearing assembly failures experienced on the Confederation Line. The report includes analysis, evidence, and justification for the conclusions. The three principal areas of focus were:

- The root cause of excessive lateral loads.
- Any root cause related to the materials or assembly processes that could lead to a loss of pre-load in the assembly or unlocking of the crimp nut.
- Any root cause that results in bearing damage leading to loss of pre-load in the assembly or unlocking of the crimp nut.

The report's main conclusions include:

- In Alstom's opinion, the contributory factors leading to high lateral loads include wheel/rail interface issues such as wheel profile, rail profile, track and rail geometry, and coefficient of friction.

- A possible contributing factor to the unlocking of the crimp nut was identified as the method adopted to crimp the nut.

Alstom describes the failure sequence as:

- i. Fretting under the small bearing
- ii. Wear of parts in the assembly leading to axial play
- iii. Loss of pre-load on the assembly/nut
- iv. Micro-rotation of the nut
- v. Damage to the nut crimps
- vi. Loss of the nut crimps (nut unlocks)

RTG is currently working with its own Independent Engineering Firm, James Boyle Associates (JBA), to review the Alstom Report and will produce a consolidated document that captures the findings of all reports completed to date.

2.3 National Research Council (NRC) Canada Report to RTG on Ottawa LRT Confederation Line, April 2024

This report discusses the review by NRC of the proposed sustainable solution identified by Alstom. In support of this exercise, NRC provided substantiation from the following activities:

- Visit to Alstom's Truck Centre for Excellence in Le Creusot, France to discuss root cause analysis failure issues.
- Coefficient of friction measurements from Confederation Line track.
- Rail-based measurements of wheel/rail forces.

Report Observations

The report does not specify conclusions but makes the following observations:

- The simulation model demonstrated in Le Creusot requires additional refinement to fully compensate for the resilient wheel, slewing ring, track stiffness and track defects.
- NRC advised that the friction coefficient under dry conditions on similar railways across North America is in the range of 0.5 – 0.8.
- The proper design of the lateral position of restraining rails and their placement is important.
- The original wheel/rail profile offers more benefits than subsequent proposals.

- High strength rail should be swapped in for the existing 115RE in tight curves. Rail replacement would normally occur when the rail is out of tolerance for the standards set out for the system.
- Track buckling issues should be a maintenance priority.

2.4 James Boyle and Associates Independent Engineering Report

Following the suspension of service in July 2023, JBA was engaged by RTG to complete a Status and Remedial Actions Report. This report will summarize the various analyses by Alstom, NRC, and TTCI into a single consolidated document. The Report will also provide analysis and conclusions and set out RTG's next steps in relation to the axle bearing assembly issue. In addition to a review of all relevant reports, tests and investigations related to the CBA issue, JBA has undertaken its own testing of axles and interviewed technical teams for Alstom and their sub-contractors.

The JBA draft report was provided to the City on May 22nd and is being reviewed by the City and its own technical experts.

2.5 City of Ottawa – Mott MacDonald

The City is currently reviewing the Alstom Root Cause Analysis Report to determine its next steps for a permanent resolution. In anticipation of the RTG Status and Remedial Actions Report, the City has engaged the engineering firm, Mott MacDonald, to provide a third-party opinion of all the received reports and investigations in relation to the axle bearing assembly issues.

3.0 Containment Plans – Short Term

3.1 Return to Service

Transit Engineering Services continues to work with Transit Services' Chief Safety Officer and Transportation Research Associates (TRA) to review any changes proposed by RTG that change the operating conditions of the railway. This is in line with Ottawa Light Rail Public Inquiry recommendations.

3.2 Alstom Safety Notes

Alstom continues to issue monthly updates to their Safety Note. The latest version, Rev N, indicates that TSRs may be removed, however, this has not been requested by RTG.

The City awaits additional objective test results indicating that it is safe to remove the Axle Bearing TSRs prior to considering their removal.

3.3 Axle inspection and Replacement Program

All LRVs are being retrofitted with cartridge bearing assemblies that are nut-pinned. When all LRVs have been retrofitted with nut-pinned cartridge bearing assemblies, there will be consideration for modifying the inspection regime. The criteria for hub replacement is expected to be extended to 400,000 kilometres, five years, or a failed prybar or backlash check.

At the time of submitting this report, half of the motor bogies have received the pinned hub replacement.

3.4 TSRs in curves

Temporary speed restrictions remain for curves under a 250-metre radius.

3.5 Restraining Rail Adjustment

RTG continues to maintain the restraining rail in a “no-contact” position in adherence to the Alstom Safety note requirements. To increase the stability of the restraining rail supporting brackets, steel “bracket stoppers” have been inserted into the slotted base plates.

3.6 Ongoing Oversight

Transit Engineering Services and TRA continue to provide oversight through audits, monitoring of maintenance, inspections, review of procedural changes and submitted documentation.

4.0 Mitigation Plan – medium term

4.1 Top of Rail Lubrication

RTG has installed wayside equipment for the deployment of Top-of-Rail (TOR) friction modifiers. The precise deployment of friction modifier will reduce the friction between the

wheels and railhead and will diminish noise and vibration and the lateral force applied to the LRV cartridge bearing assemblies.

Twelve out of 21 TOR lubrication devices have been commissioned so far. The remaining above ground devices will be complete by the end of May. Installation of tunnel mounted TOR lubricators will occur in the summer of 2024. Following completion of the deployment program, Alstom will conduct another instrumented bogie testing (#4) campaign to validate any improvements to the wheel/rail interface.

4.2 Bearing Condition Detectors

The NRC has successfully designed, fabricated, and commissioned a wheel, bearing and brake testing rig to accept the axle configuration from the Alstom Citadis Spirit LRV. Testing of a “new” cartridge bearing assembly has occurred and is now being compared with test results from a worn CBA to determine a clear vibration signature associated with a degraded unit. If the testing can demonstrate that vibration monitoring with accelerometer devices such as “Smart Bugs” can successfully identify a degraded bearing assembly, deployment across the fleet can be considered. If implemented, this bearing assembly condition monitoring system will address comments provided by TSB based on their investigation of the first derailment event.

4.3 Nut Pinning Measure

As part of the Alstom containment measures, a proposal for nut pinning was prepared by Alstom and presented by RTM to the Transit Commission on October 12, 2023. Specifically, this measure was implemented to address the loss of preload of the bearing assembly restraining nut leading to unscrewing of the loose nut and failure of the integrity of the CBA. Following a quality assurance program conducted with new and used hubs with nut pinning, the City approved the conversion of the Ottawa fleet to axles with pinned hub nuts in early 2024.

5.0 Plan – Long term

5.1 Re-design of Cartridge Bearing Assembly – Sustainable Solution

RTG has committed to provide a permanent solution to the axle bearing issue and this includes a re-design of the cartridge bearing assembly. The cartridge bearing assembly redesign will focus on strengthening the structure of the assembly to better withstand the lateral forces experienced on the Confederation Line and deliver a product that meets

reliability, availability, maintainability, and safety requirements. Alstom has indicated that a Sustainable Solution can be achieved without a redesign and is not currently working on this initiative. The City has formally communicated the imperative for the re-design work to re-commence.

5.2 RTG Consolidated Document

In Q4 2024, the City is expecting to receive the consolidated document from RTG.

6.0 Conclusion and Next Steps

RTG has responded to several of the recommendations resulting from the extensive investigations undertaken in the aftermath of the first derailment event. Automated gauge face lubrication, top of rail friction modifiers, restraining rail resetting, railhead re-profiling, nut-pinning and ballast strengthening are all improvements that will enhance reliability of the system. Further work will occur during a partial shutdown in October 2024 including a grinding program to re-establish the rail head profile and track ballast strengthening.

These mitigations, however, do not resolve the outstanding lack of consensus on root cause of the CBA failures. It is imperative that RTG works with its track and vehicle teams to reach agreement on the corrective action plan that will ensure the sustainability of the railway.

FINANCIAL IMPLICATIONS

There is no financial implication to receiving this report for information.

LEGAL IMPLICATIONS

There are no legal impediments to receiving this report for information.

CONSULTATION

As part of the ongoing review and analysis of the issues identified in this report, Transit Services has continued to work closely with RTG, RTM, and Alstom. Additionally, experts have been consulted to provide reports and recommendations. Those experts include the National Research Council (NRC), Transportation Safety Board (TSB), MxV Rail, Transportation Resource Associates (TRA), and JBA.

ACCESSIBILITY IMPACTS

One of OC Transpo's mission statements, as outlined in the Five-Year Roadmap is: We promise to deliver safe, clean, dependable, and accessible public transit. All components of the transit system, including O-Train Line 1 adhere to the *Accessibility for Ontarians with Disabilities Act (AODA)*.

Staff will continue to engage persons with disabilities and accessibility stakeholders to ensure that their perspectives are considered and incorporated, and to promote inclusion. The vehicles identified in this report are fully accessible light rail vehicles.

ASSET MANAGEMENT IMPLICATIONS

OC Transpo's assets are identified as one of the five pillars in the 5-Year Roadmap. In the coming years, OC Transpo will be adding all Stage 2 O-Train extensions and their associated properties, vehicles, infrastructure, and technologies required to operate these new systems. OC Transpo's new and existing assets will be maintained and managed through systematized departmental administrative processes. As noted in the Roadmap, one initiative, the Core Business Review, will identify all key assets to ensure that Transit Services is making the best use of each of them.

RISK MANAGEMENT IMPLICATIONS

Risk management implications are outlined in the report.

TERM OF COUNCIL PRIORITIES

This report supports the following Term of Council Priorities:

- A city that is more connected with reliable, safe, and accessible mobility options
- A city that is green and resilient

DISPOSITION

Transit Services will continue to provide progress updates for Transit Commission and Council.

As part of Transit Services' commitment to providing Transit Commission a final solution for the axle bearing issue, staff will provide a follow-up report in Q4 2024 which will outline the next steps to a resolution.