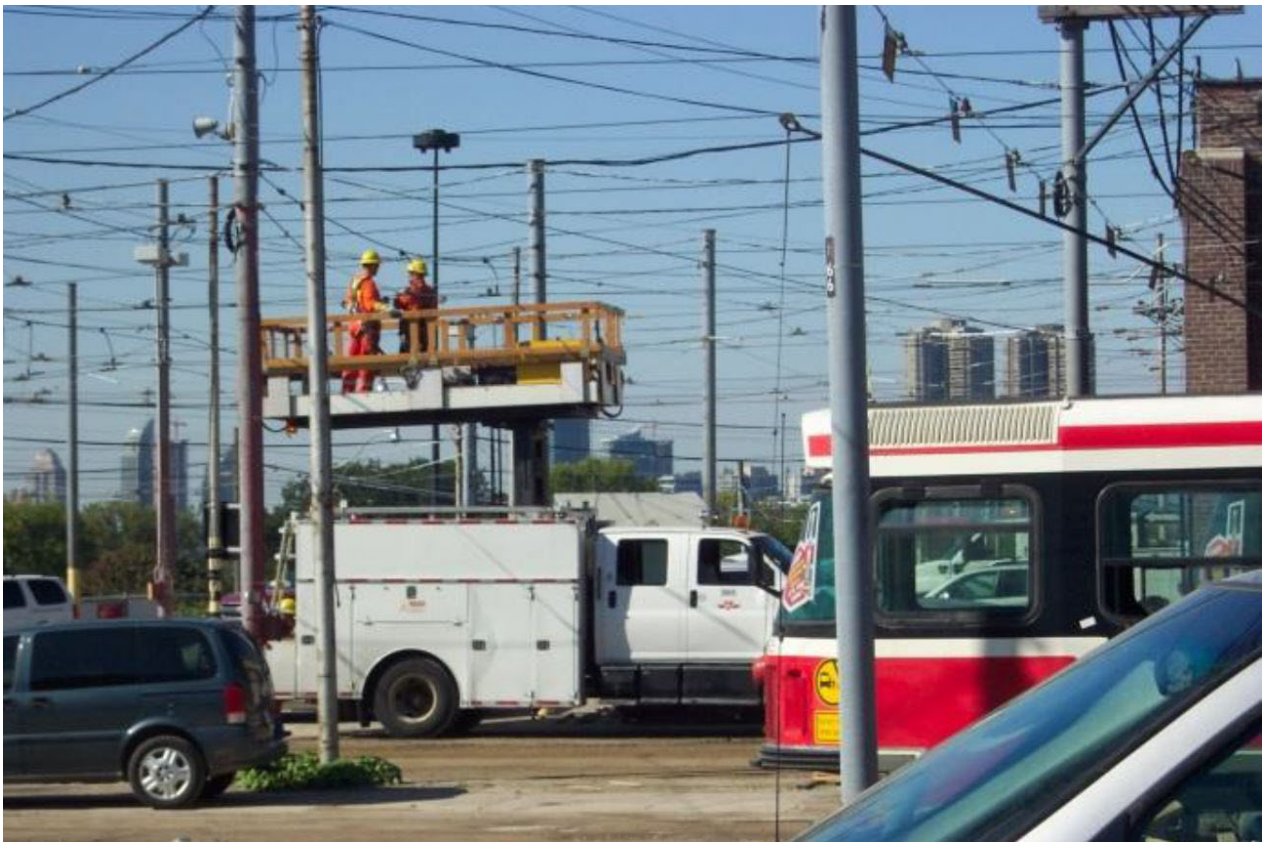

Audit of the Toronto Transit Commission's Streetcar Overhead Assets: Strengthening the Maintenance and Repair Program to Minimize Asset Failures and Service Delays

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Tara Anderson, CPA, CA, CIA, BAcc
Auditor General

AUDITOR GENERAL TORONTO

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Executive Summary

Operational audit of TTC's streetcar overhead maintenance and repair program

The Auditor General's 2022 Work Plan included an operational audit of the Toronto Transit Commission's streetcar operations and services.

TTC's mission to provide reliable, efficient and safe service

The mission of the Toronto Transit Commission (TTC) is to provide a reliable, efficient, and integrated bus, streetcar, and subway network that draws its standards of customer care from its traditions of safety, service, and courtesy.

The TTC's organizational structure is divided into several departments that all play a role in providing streetcar services. The three key departments are: 1. Streetcar Infrastructure (with four sections including Overhead Operations, Overhead Engineering, Streetcar Way (tracks), and Streetcar Way Engineering), 2. Streetcar Transportation (streetcar operators), and 3. Streetcar Maintenance (vehicles).

Responsibility of Streetcar Infrastructure – Overhead Operations section (Overhead Operations)

This audit focuses on Overhead Operations, a section of the Streetcar Infrastructure department, that is responsible for the capital construction and installation (State of Good Repair program), as well as ongoing maintenance and repairs of the Overhead Contact System (OCS) and electrical components of the electrical track switches.

The OCS is an electrically powered suspension system that provides 600 volts of direct current (VDC) electricity to power the streetcar vehicles. The OCS is critical to streetcar operations as asset failures can result in service disruptions and delays and pose public safety risks.

Preventative and corrective maintenance program can help reduce the risk of asset failures

Overhead Operations has a preventative and corrective maintenance program. This program includes conducting regular inspections of the OCS to identify and perform corrective maintenance and repairs before there is a failure or breakdown of the OCS. Both preventative inspections and corrective maintenance and repairs can help reduce the risk of asset failures, leading to increased public safety and service reliability.

Emergency maintenance and repair is performed for an unexpected malfunction, failure, or damage to the assets

Emergency maintenance and repair is reactive in nature and performed when there is an unexpected malfunction, failure, or damage in the various asset components in the OCS or electrical switch system due to external factors. These failures typically cause a disruption and delay in the scheduled streetcar service and pose potential public safety risks.

Audit objectives and scope

In reviewing streetcar overhead maintenance and repair activities to assess whether they support the TTC's goal of providing safe and reliable streetcar operations, this audit aimed to answer the following questions:

- Are the TTC's streetcar overhead infrastructure assets maintained and repaired in accordance with TTC's policies and procedures and relevant industry standards?
- Are there opportunities for the TTC to further leverage the use of data and technology in managing its work orders, informing decision-making, and managing Overhead Operations services?
- Are there opportunities for the TTC to strengthen its policies, procedures, standards, and Key Performance Indicators related to streetcar overhead?

Our audit mainly focused on Overhead Operations' maintenance and repair activities during the period of January 1, 2022 to December 31, 2022. Where relevant to our audit, we examined certain records and data outside of this period. Our findings and conclusions are based on the information and data provided by the TTC at the time the audit was completed.

What We Found: Significant Audit Results in Brief

We found that there are opportunities for improvement in the following areas:

A. Minimize the Risk of Asset Failures through Effective Preventative Inspections and Corrective Maintenance, and Investigations into Emergency Maintenance Incidents

According to Overhead Operations' performance report, 507 emergency maintenance and repair work incidents occurred in 2022.[1] Some emergency maintenance and repairs cannot be prevented when caused by external factors (e.g., third-party damage, damage due to adverse weather). However, we found that untimely and incomplete preventative inspections and corrective maintenance work may have contributed to some of these emergency incidents. In these cases, the failed asset was either not inspected or waiting for corrective maintenance and repair at the time of the incident, which resulted in streetcar service delays and disruptions.

[1] We were unable to verify the accuracy and completeness of Overhead Operations' performance reporting and confirm the number of emergency maintenance and repair incidents as we noted differences between the performance reporting results and the supporting paper records. See detailed scope limitation on page 65.

Root cause investigations are not completed in accordance with TTC's internal policy

According to Overhead Operations' policies and procedures, employees must fill out a root cause analysis for all service delays greater than five minutes. However, we found that Overhead staff were either unaware or had a different interpretation of this policy. As a result, root cause analyses were not always completed by Overhead Operations staff for all service delays greater than five minutes.

Completing a root cause analysis ensures that management is assessing the cause of service delays, while also considering the asset's life expectancy, latest inspection date, and annual inspection target. It also allows Overhead staff and management to assess, consider, and conclude on whether the asset failure and service delay could have been prevented through a change to their preventative and corrective maintenance program.

No cross-departmental effort to reduce the number of failed switch emergency calls

In addition, in 2022, 268 emergency calls related to failed electrical switches were made. Emergency crews spent a significant amount of time attending these calls to perform inspections of the failed switches, but in most of these cases no repairs were required. In 2022, the total hours spent on these cases was 1,392 hours. However, no cross-departmental efforts have been made to reduce the number of these electrical switch emergency calls.

It is important for emergency maintenance and repair calls to be accurately tracked and monitored at a sufficient level of detail, to identify instances and trends that may require further investigation. The data collection and analysis should be done collaboratively with other TTC departments where appropriate, to perform the necessary investigation and analysis to conclude on the root cause and brainstorm potential solutions and action plan responses.

B. Perform and Document Preventative Inspections in a Consistent Manner

Maintenance Schedule was incomplete

We found that the Maintenance Schedule used by Overhead Operations to plan, schedule, and track preventative inspections was incomplete, increasing the risk of missed preventative inspections for some assets. We also noted that the inspections completed were manually tracked in the schedule, leading to incomplete inspection details.

Lack of maintenance and inspection manuals, policies, procedures, and standards

Further, we noted considerable variability in how preventative inspections were performed and documented. This was due to a lack of formalized maintenance and inspection manuals, policies, procedures, and standards that clearly define and outline the expectations for Overhead Operations' staff and crews; incomplete and outdated inspection job plans; and a lack of monitoring to enforce consistency among crews.

Considerable variability in how inspections are performed and documented make it difficult to monitor asset conditions

The variability in how inspections are performed and documented makes it difficult for staff and management to track what work was performed and the results and observations from that work, to effectively monitor the conditions of the assets.

For example, we found instances where partially completed inspections were logged as fully completed. Inspections not being performed or documented consistently also makes it difficult to use the results to perform meaningful data and trend analysis and asset condition monitoring. More importantly, this may cause service delays if assets are not repaired or replaced in time.

Inspection planning and scheduling need improvements to optimize use of resources and effectiveness of the preventative inspection program

Lastly, we noted that annual preventative inspection targets were not complied with in 2022—specifically, the actual number of inspections performed were either less or more than the annual target. We also noted that preventative inspections were not completed in accordance with Overhead Operations' specified time intervals, which does not optimize the use of resources and effectiveness of the preventative inspection program. For optimal performance of the OCS, a formalized process overseeing completed work orders is needed to ensure operations comply with both the annual inspection targets and specified time intervals.

C. Strengthen Corrective Maintenance and Repairs

Lack of criteria to determine when corrective maintenance is required

Management requires the consistent assessment of assets and documentation of results to generate, prioritize, and schedule corrective maintenance and repair work. However, we found that Overhead Operations has not established clear criteria for what asset conditions (e.g., worn, heavily worn, very bad) require corrective maintenance work, based on risks and implications. This lack of guidance could result in inconsistencies in applying different criteria for determining if a corrective maintenance work order (CM work order) should be generated.

In addition, due to the manual and paper-driven work order process, we were unable to determine if all preventative inspections were reviewed to assess whether any CM work orders were required. Both these reasons may have contributed to missed CM work orders.

58% of sampled preventative inspections with issues identified did not have corrective maintenance work performed

As a result, 58 per cent of the preventative inspection work orders we reviewed in our audit sample had no corresponding CM work order generated, despite issues identified by crews during the preventative inspection.

No clear timing expectations for reviewing inspections and prioritizing and completing corrective maintenance

Overhead Operations has not established clear timing expectations for reviewing completed preventative inspections and preparing any necessary CM work orders. Overhead Operations also does not have clear criteria and timing expectations for the prioritization and completion of CM work orders based on risks and implications.

While some CM work orders are more complex and require more time and resources to complete (e.g., those that require setting up route closures and diversions), Overhead Operations staff informed us that there is no formal policy, however, the general expectation is to complete corrective maintenance and repair work within two to four weeks after issues are identified through preventative inspections.

Average time to complete corrective maintenance after the inspection was 5 weeks

Based on our review of 2022 work orders, we found that it took an average of five weeks to complete corrective maintenance work and repairs after issues were identified through preventative inspections. This is longer than Overhead Operations' general expectation of approximately two to four weeks.

To ensure effectiveness of the maintenance program, corrective maintenance and repairs should be prioritized and completed in a timely manner. This will reduce the risk of asset failures and service delays.

D. Leverage Technology to Improve Streetcar Overhead Operations

Maximo system is used in a limited capacity to print work orders

Maximo is an enterprise asset management software solution that the TTC uses in several of its departments. Overhead Operations uses Maximo in a very limited capacity, that is, primarily to print work orders. Management advised there are future intentions to use Maximo as both an asset management system and workflow management system, similar to how it is used in other departments such as Streetcar Maintenance (vehicles). However, an implementation strategy has not yet been developed.

Staff have not received training on how to use Maximo

In the Overhead Operations section, frontline crews do not currently use Maximo. In contrast, all frontline crews in the Streetcar Way (tracks) section and Streetcar Maintenance (vehicles) department use Maximo to complete and update work orders. Further, staff have not received formal training on how to use the software.

Without optimizing the use of Maximo, the manual and paper-driven process is inefficient and results in lost information

As a result, staff primarily use a manual process that is paper-driven and has several weaknesses that could be improved by leveraging the technology and functionalities offered by the Maximo system. The process weaknesses result in inefficiencies such as redundant manual data entry, risk of data loss if paper files are misplaced or lost, and limited data-driven analysis. For example, we found that there were approximately 840 hours spent on performing manual data entry into the Maximo system in 2022.

Fully implementing Maximo as an asset and workflow management system can improve Overhead Operations' efficiency and effectiveness

If effectively planned and implemented, using Maximo as an asset management and workflow management system could provide more efficient and effective solutions to the following Overhead Operations processes:

- automating the planning and scheduling of recurring inspection work orders;
- tracking work order results and observations—using Maximo Anywhere technology, these can be inputted directly into Maximo by crews, eliminating the need for paper copies of work orders;
- real-time monitoring of work order statuses;
- ensuring all activity tasks included in a job plan are performed consistently and completely;
- conducting complex data mining, trend analysis, etc. to perform investigations and support other continuous improvement initiatives, such as optimizing the efficiency and effectiveness of the preventative inspection program; and
- reporting on Key Performance Indicators—this reporting will be more accurate and complete if the data is sourced from Maximo, with supporting details being easily accessible for further analysis, if needed.

E. Enhance Data Collection and Performance Reporting to Improve Streetcar Overhead Operations

Key Performance Indicators (KPIs) and the reporting process can be further improved

While Overhead Operations has continuously made changes to increase management oversight and monitoring of its performance, we have identified the areas below where further improvements can be made.

More outcome-focused KPIs that measure the timeliness and quality of maintenance and repair services

Through our review of maintenance and repair activities in 2022 and KPI benchmarking with other TTC streetcar departments, we noted that Overhead Operations can benefit from KPIs that measure the timeliness and quality of maintenance and repair services.

KPIs should be consistently measured

From our review of the KPI packages and available supporting documentation, we noted that several KPIs (e.g., the ratio between preventative inspection and corrective maintenance, overtime hours) are not consistently measured across the different departments/sections. This can lead to KPIs that are not accurately measured or misaligned with what management intended to be measured.

KPI targets should be appropriate and clearly defined

We also noted that some KPIs (e.g. number of preventative inspections, the ratio between preventative inspection and corrective maintenance) do not have clearly defined and established targets, or different targets were used for different reports. Without appropriate and clearly defined targets for each KPI, Overhead Operations may not be able to effectively communicate short-term goals, hold its staff accountable, or measure performance on a consistent basis.

Accurate and complete KPI reporting is critical for its effectiveness

In our review of a sample of KPI reports, we found discrepancies and data that do not reconcile between reports. Overhead Operations was unable to provide all the supporting data and documents for their KPIs. Without these, the reliability and usefulness of the KPI reporting is limited. Given that KPI reporting is meant to help drive change and continuous improvement decisions, the KPI data used to make these decisions must be accurate and complete.

Conclusion

The TTC's Overhead Operations' maintenance and repair program plays a vital role in preventing and minimizing Overhead Contact System asset failures and streetcar service disruptions, which impacts the safety and customer service of streetcar operations.

For our first objective, to assess the TTC's streetcar overhead maintenance and repairs activities, we found that more data collection and investigations into the causes of asset failures is needed to prevent similar asset failures and resulting service delays in the future. We also found that Overhead Operations does not always meet its preventative inspection annual targets, and corrective maintenance is not always performed in a timely manner.

For our second objective, to assess the TTC's use of data and technology in managing operations and informing decisions, we found that Overhead Operations is underutilizing its enterprise asset management system, Maximo, which has resulted in primarily using a manual and paper-driven process. Optimizing Maximo's capabilities and using it as an information database will allow Overhead Operations to perform data analytics that will support its continuous improvement initiatives to increase service reliability and safety, while optimizing the use of time and resources.

For our third objective, to assess the TTC's policies, procedures, and performance reporting related to streetcar overhead, we found a lack of formalized maintenance and inspection manuals and standards that clearly define and outline the expectations for Overhead Operations crews. This has led to variability in how preventative inspections are performed and documented, and contributed to untimely corrective maintenance and repairs. While we acknowledge that Overhead Operations has made improvements to its KPI reporting process, further improvements can be made by tracking more outcome-focused Key Performance Indicators and improving the accuracy and completeness of the supporting information and data.

20 recommendations to improve efficiency and effectiveness of the Overhead Operations' maintenance and repair program

In our view, implementing the 20 recommendations contained in this report will help the TTC improve the efficiency and effectiveness of Overhead Operations' maintenance and repair program, by strengthening their asset and workflow management processes, leveraging technology, and enhancing their policies and procedures.

In particular, the recommendations identify opportunities for:

- better planning, scheduling, and tracking of the preventative inspections and corrective maintenance and repairs to optimize the use of available resources;
- strengthening policies and procedures that provide clear guidance and expectations to Overhead Operations staff and crews to improve consistency;
- improving performance monitoring and reporting, as well as the effectiveness of the maintenance and repair program as a whole; and
- leveraging technologies and enhancing the way data is captured and used to improve decision-making abilities and continuous improvement initiatives.

Thank you to management and staff

We would like to express our sincere appreciation for the co-operation and assistance we received during our audit from the management and staff of the Toronto Transit Commission.

Background

TTC's mission is to provide reliable, efficient and safe service

The mission of the Toronto Transit Commission (TTC) is to provide a reliable, efficient, and integrated bus, streetcar, and subway network that draws its standards of customer care from its traditions of safety, service, and courtesy.

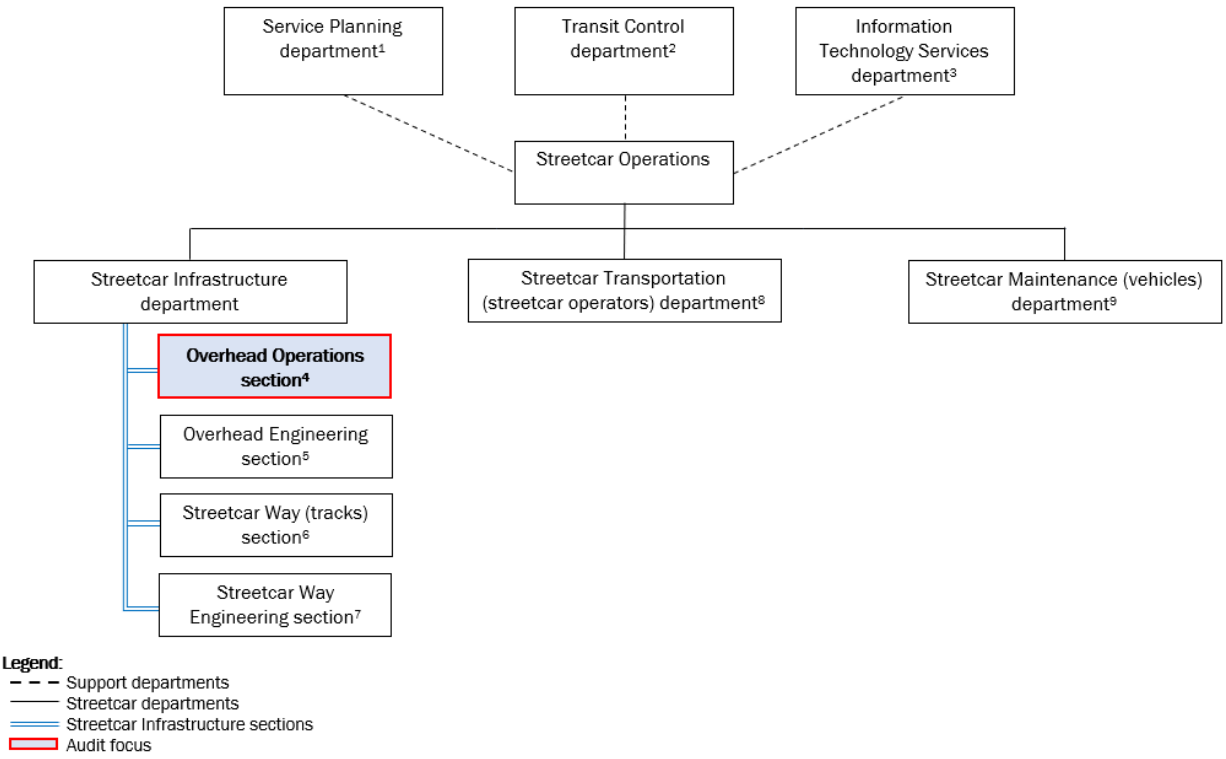
204 TTC streetcars operated on 9 routes, and served over 38 million streetcar boardings in 2023

According to the TTC, it has a fleet of 204 streetcars and had average weekday streetcar boardings of 196,000 from January 1 to July 31, 2023 (350,000 in 2019, pre-COVID-19 pandemic). During the same period, TTC had over 38 million streetcar boardings. With nine routes located primarily in Downtown Toronto, the TTC operates most routes from 6 a.m. to 1 a.m. from Monday to Saturday, and from 8 a.m. to 1 a.m. on Sundays.

Roles and responsibilities of the TTC departments

The TTC's organizational structure is divided into several departments that all play a role in providing streetcar services. See **Figure 1** for a general overview of each department.

Figure 1: An Overview of the TTC's Streetcar Departments and Other Support Departments



Notes:

1. Department responsible for the planning and scheduling of TTC services, including the streetcar routes.
2. Department responsible for the day-to-day evaluation, assessment, and coordination of rapid transit operations across the various transportation modes (bus, streetcar, subway). Transit Control tracks vehicle movements, dispatches assistance, assigns maintenance orders, and confers with vehicle operators.
3. Department responsible for delivering business technology solutions to enable the departmental objectives of the Streetcar Infrastructure department, which includes but is not limited to planning, design, delivery, and on-going support of business technology.
4. Streetcar Infrastructure section responsible for completing the capital projects and ongoing maintenance and repairs of the Overhead Contact System and electrical components of the electrical track switches.
5. Streetcar Infrastructure section responsible for planning the capital project construction and installation (State of Good Repair [SOGR] program) of the Overhead Contact System and electrical components of the electrical track switches.
6. Streetcar Infrastructure section responsible for completing the capital projects and ongoing the ongoing maintenance and repairs of the rail tracks and non-electrical components of all track switches.
7. Streetcar Infrastructure section responsible for planning the SOGR program of the rail tracks and non-electrical components of all track switches.
8. Department responsible for the delivery (quality and reliability) of scheduled streetcar transit services to customers, as well as the planning, directing, and overseeing of streetcar vehicle operators.
9. Department responsible for the capital SOGR program, as well as ongoing maintenance and repairs of existing streetcar vehicles.

This audit mainly focused on the Overhead Operations section's ongoing maintenance and repairs of the Overhead Contact System (OCS) and electrical components of the track switches. See **Exhibit 1** for areas and components of the OCS. The OCS is critical to streetcar operations as asset failures can result in service disruptions and delays and pose public safety risks.

TTC's operating and capital expenses for Streetcar Infrastructure – Overhead Operations Section (Overhead Operations) was $15.6M

The TTC's budget is jointly funded by federal, provincial, and municipal funding sources, as well as TTC's own revenue. In 2022, the total operating and capital expenses for Streetcar Infrastructure – Overhead Operations section (Overhead Operations) was $15.6 million.

TTC's streetcar network consists of an OCS, rail tracks, and switches

The TTC's streetcar network includes 101 intersections and loops across approximately 180 kilometres of the OCS (i.e., electrical wires), rail tracks, and more than 300 electrical and manual track switches, which allow streetcars to change from one track to another.

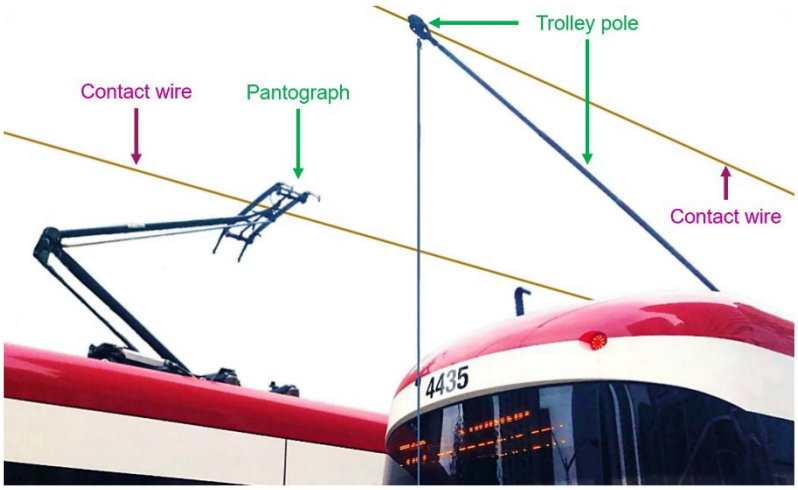
The following components are attached to the streetcar vehicle and allow the streetcar to draw electrical current from the OCS to power the streetcar:

- Trolley pole – A long shaft mounted on the roof of the streetcar, with an electrical current collection device at the top end that presses upwards against the underside of the contact wire.

- Pantograph – An electrical current collection device fitted on top of the streetcar, hinged to allow it to vary in height as it rubs along the contact wire.

The streetcar vehicle part used impacts the design and maintenance of the OCS. **Figure 2** below shows a pantograph system on the left and a trolley pole system on the right.

Figure 2: Pantograph System Versus Trolley Pole System



Note: Contact wire – The overhead electrical wire with which the pantograph or trolley pole makes contact to supply power to the streetcar vehicle. The contact wire carries 600 volts of direct current (VDC) electricity.

Overhead infrastructure changes to accommodate the new streetcar fleet

Over the last decade or so, Overhead Operations has been converting its network from a trolley pole-only system to a hybrid system to a pantograph-only system to accommodate the rollout of its newest streetcar fleet.

From 2012 to 2020, the TTC replaced its legacy streetcars with a new fleet of accessible, low-floor streetcars. The legacy streetcars operated strictly on trolley poles. The new streetcars operate most optimally on the pantograph but can also operate on the trolley pole. Given some legacy streetcars were still in operation, a hybrid system was needed to allow both the legacy and new streetcars to operate on either the trolley pole or pantograph on the same network.

Up until spring 2023, some areas of the streetcar network could only be navigated using the trolley pole. As a result, the streetcar operators needed to be aware of when to use the trolley pole or pantograph. In 2022, instances arose where streetcar operators navigated on the system using a pantograph in a trolley pole-only area, causing damage to the OCS.

Therefore, since the decommissioning of the legacy fleet in 2019 and starting in 2020, the TTC took the opportunity to start moving to a pantograph-only system.

As of spring 2023, the network is a mixture of the hybrid and pantograph-only systems, allowing all streetcars to operate exclusively using the modernized pantograph system. Therefore, the trolley poles on the streetcars are no longer used. The previously installed hybrid systems will continue to be upgraded to the pantograph-only system as part of the ongoing Streetcar Infrastructure State of Good Repair program.

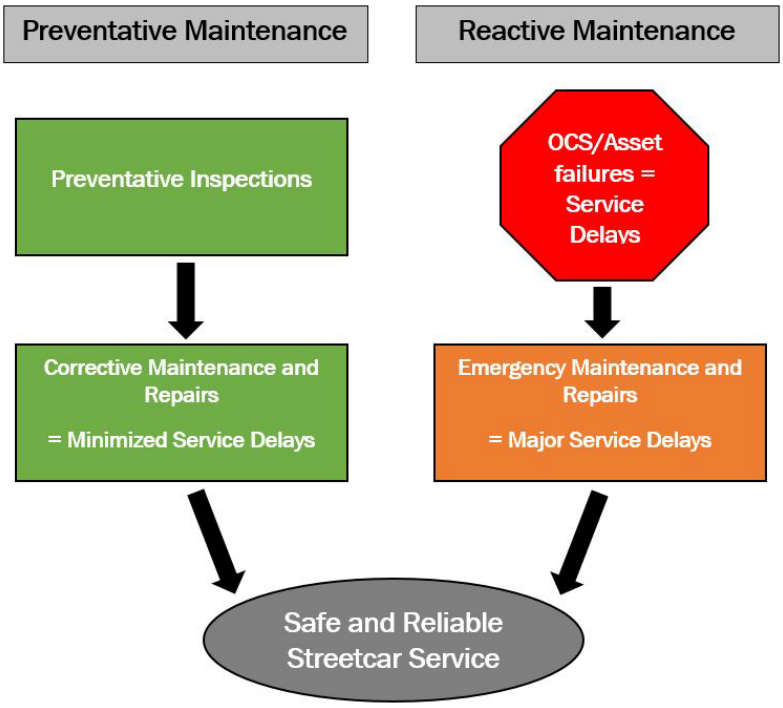
With all the legacy streetcars now decommissioned, the current hybrid system is not necessary for the current fleet. The pantograph system is a modern technology commonly used today in the light-rail industry. This system has many benefits such as allowing for better vehicle performance and reducing the number of delays caused by trolley pole disconnections from the overhead contact wire.

The challenge of having the hybrid system is that it still contains components that were necessary for the old trolley pole system but are not required for the pantograph. Given that streetcars are now operating exclusively on the pantograph, removing the hybrid system and switching completely to a pantograph-only system will help simplify the OCS and optimize the current fleet's performance. According to the TTC, the upgrade to a completely pantograph-only system as part of the State of Good Repair program will be completed by 2043.

Exhibit 2 at the end of the report shows the current state of the OCS and status of the upgrades to a pantograph-only system. The green routes are the pantograph-only system, and the blue routes are the hybrid system.

Overhead Operations is responsible for the maintenance and repair of the OCS and electrical components of the track switches. **Figure 3** below shows that Overhead Operations is broken down into *preventative* maintenance and *reactive* maintenance, both of which are required to ensure safe and reliable streetcar services.

Figure 3: An Overview of the TTC's Streetcar Overhead Operations



Note:
Preventative Maintenance – Overhead Operations performs regular preventative inspections of the OCS to identify and perform corrective maintenance and repairs before there is a failure or breakdown of the OCS or electrical switch system.

Reactive Maintenance – Emergency maintenance and repairs occur after there is an unexpected malfunction, failure, or damage in the various asset components of the OCS or electrical switch system. Sometimes these asset failures could have been prevented through preventative inspections and corrective maintenance and repairs, and at other times they are outside the control of the TTC (e.g., third-party truck travelling without storing its loader arms causing damages to the OCS).

Buses are dispatched to replace streetcars during service disruptions

When a component of the OCS or electrical switch system malfunctions or fails, streetcar service is disrupted. To accommodate the disrupted service and allow time for emergency repairs to occur, the TTC's Transit Control must coordinate and dispatch buses to replace the streetcars on the routes. Often, the replacement buses are pulled from nearby bus routes, which then impacts the service on those bus routes. Therefore, it is imperative for Overhead Operations to attend to the emergency calls and make the necessary repairs as soon as possible to resume regular service of all impacted streetcar and bus routes.

Potential public safety risk when OCS assets fail

In addition to causing service disruptions and delays, OCS asset failures can also pose public safety risks. For example, exposure to the live 600 VDC overhead electrical wires can put the public, passengers, and operators at significant risk of safety issues and may result in serious injuries and fatalities.

An example is the 505 Dundas streetcar that caught fire in the overhead wires at the intersection of Dundas Street West and Lansdowne Avenue on December 30, 2022. There were multiple root causes of this incident, with one of the contributing factors being a failure in the cotter pin, which is a metal fastener used to assemble the OCS. Fortunately, Overhead Operations' crews arrived on scene quickly and no one was injured. This example shows the importance of dispatching crews as soon as possible to make the emergency repairs needed to prevent safety risks.

Note: TTC streetcar fire on December 30, 2022. Left: a wire is downed in front of a streetcar; right: the top of a streetcar catches on fire.
Source: TTC Safety Bulletin #23-STCTR-001, dated January 13, 2023

Length of service delay depends on severity of asset malfunction or failure

The length of the service delay depends on the severity of the asset malfunction or failure and the time required to repair it. In some cases, temporary repairs can be made to resume service, although Overhead Operations will send crews back subsequently to make more permanent repairs. In other cases, the failure cannot be fixed temporarily, resulting in longer service disruptions.

Asset failures can be caused by external factors outside of Overhead Operations' control and can also be outside of the TTC's control

Various factors can cause emergency maintenance and repairs, some of which are outside Overhead Operations' control and would not be possible for the section to prevent, such as:

- Streetcar operators improperly using the streetcars – For example, as previously discussed, instances occurred where streetcar operators navigated on the system using a pantograph in a trolley pole-only area, which caused damage to the OCS. Although this situation is outside of the Overhead Operations' control, it still falls under the TTC's control.

- Third-party damage – For example, in 2022, a garbage truck travelling without storing its loader arms caused damage to the OCS. This is an example of a situation that is outside the TTC's (and Overhead Operations') control.

Timely and effective preventative inspections, and corrective maintenance and repairs help to prevent asset failure

While the above causes are out of Overhead Operations' control, assets also fail or malfunction due to a lack of continuous monitoring of asset condition and proper maintenance. An effective maintenance program, comprised of the following two components, can provide early detection of problems and allow corrective maintenance and repairs to occur before asset failure:

- scheduled and recurring preventative inspections that assess and monitor the condition of the OCS; and
- scheduled corrective maintenance and repairs, which are identified through the preventative inspections.

Maintenance Schedule manually tracks preventative inspections and targets

Overhead Operations has developed a Maintenance Schedule in a manually maintained Excel file, to help plan and schedule preventative inspections. The schedule also keeps track of preventative inspection completion dates as well as preventative inspection targets (e.g., 1/year, 2/year, 4/year, 12/year) for each of the assets in the OCS and electrical switch systems.

Overhead Operations has a staff complement of 122, including 100unionized employees

The 2022 total budgeted full-time employee headcount for the Overhead Operations section is 122, which consists of 22 non-unionized employees and 100 unionized employees. In 2022, the average employee vacancy was two non-unionized employees and 14 unionized employees, for a total headcount of 106 full-time employees.

The Overhead Operations section consists of the following roles:

- Crews – Perform the installations, inspections, maintenance, and repairs, and are the only unionized Overhead Operations employees.
- Forepersons – Plan, schedule, assign, and review completed work orders and crew reports.
- Supervisory Staff (Supervisors, Manager, and Department Head) – Provide oversight and directional guidance to forepersons and crews.
- Engineering Technologists – Are responsible for performance reporting, drafting standard operating procedures and bulletins, fleet maintenance requirements, as well as coordination and general operational support.
- Senior Clerks – Assist with administrative tasks in the office, such as Maximo data entry and scheduling.

Audit Results

This section of the report contains findings from our audit work, followed by specific recommendations.

Audit objective #1 - Maintenance and repairs of streetcar overhead assets in accordance with TTC's policies and procedures

Our first audit objective examined whether the TTC's streetcar overhead infrastructure assets are maintained and repaired in accordance with the TTC's policies and procedures and relevant industry standards. Sections A to C below summarize our audit findings for this first objective.

Opportunities for improvement in Overhead Operations' preventative inspection and maintenance and repairs processes

We noted opportunities for improvement in Overhead Operations' preventative inspection and maintenance and repairs processes. In particular, we found there is inadequate data collection and investigation into the causes of a number of asset failures, which is critical to preventing similar failures in the future. We noted that preventative inspections do not always meet their annual inspection targets. We also found the corrective maintenance and repairs program lacks the clear guidance and criteria needed to prioritize the completion of corrective maintenance and repairs in a timely manner.

A. Minimize Asset Failures through Effective Preventative Inspections and Corrective Maintenance, and Investigations into Emergency Maintenance Incidents

A. 1. Minimize the Risk of Asset Failures through Effective Preventative Inspections and Corrective Maintenance

An effective preventative maintenance program helps to prevent asset failures

An effective preventative maintenance program helps prevent asset failures and service delays by ensuring routinely scheduled inspections and corrective maintenance and repairs are performed. This in turn keeps assets in good working condition and provides early detection of issues that could potentially cause larger problems or failures.

According to Overhead Operations' performance report, 507 emergency maintenance and repair work incidents occurred in 2022.[2] Our review of emergency work orders found that untimely and inadequate preventative inspections and corrective maintenance may have contributed to several of these incidents. As previously discussed in the Background section of this report, some emergency maintenance and repairs cannot be prevented by the Overhead Operations' actions, as they are caused by external factors outside of the section's control.

In this section, we outline examples we found of these incidents and resulting service delays which demonstrate the need and importance to further improve the effectiveness of Overhead Operations' preventive and corrective maintenance program. Our detailed findings and related recommendations on preventative inspections and corrective maintenance follow later in **Sections B** and **C**.

Emergency repairs due to untimely preventative inspections

The following is an example of a service delay that may have been prevented through timely preventative inspections. We evaluate this service delay cause in further detail and provide our recommendation in **Section B. 3.**

- On January 14, 2022, a service delay occurred at King Street West and Shaw Street. The delay was due to worn contact wire (see **Figure 2** for a description and diagram of this asset) and a worn frog (see **Exhibit 1** for a description and diagram of this asset), which is a hardware component in the OCS that allows the streetcar to travel seamlessly through connecting or diverging overhead contact wire. According to the Maintenance Schedule, the preventative inspection of this intersection (including the specific assets that failed) should be completed once a year, but no preventative inspection was performed in 2021. This missed inspection contributed to the service delay, as it could have identified the worn assets had it been conducted.

Emergency repairs due to using incomplete and inaccurate job plans (i.e., activity tasks) during preventative inspections

When performing preventative inspections, crews use a job plan, which is a set of activity tasks determined by Overhead Operations, to identify which assets and also which specific attributes of these assets (i.e. wire size, worn condition) they need to inspect and report on. Therefore, it is important for the activity tasks to be complete and accurate.

[2] We were unable to verify the accuracy and completeness of Overhead Operations' performance reporting and confirm the number of emergency maintenance and repair incidents as we noted differences between the performance reporting results and the supporting paper records. See detailed scope limitation on page 65.

The following are examples of service delays that may have been avoided if the preventative inspection was performed using an accurate and complete job plan. We evaluated this service delay cause in further detail in **Sections B. 2.** and **B. 3.**

- On March 28, 2022, a service delay occurred at High Park Loop, caused by one of the OCS poles leaning in. Further investigation into the root cause determined that activity tasks included on the preventative inspection job plans did not specifically include an inspection of the OCS poles, which were therefore not being inspected. According to Overhead Operations staff, poles are only inspected during an emergency work order if overhead asset failures indicate there may be an issue with the pole.

- On August 24, 2022, a service delay occurred at Queen Street East and Broadview Avenue. The delay was due to a worn frog, a hardware component in the OCS described in a previous example (see **Exhibit 1** for a description and diagram of this asset). As the most recent preventative inspection of this asset took place only eight days earlier on August 15, 2022, that inspection likely should have identified this as a problem that needed to be fixed. Upon inspecting the job plan used during the August 15, 2022 preventative inspection, we noted that the plan's activity tasks did not specifically include an inspection of the asset's 'Condition.' However, this activity task appears in other preventative inspections' job plans for the same asset.

- On December 30, 2022, a service delay occurred at Dundas Street West and Lansdowne Avenue due to a fire to the roof of the streetcar. A failure in the cotter pin, a metal fastener used to assemble the OCS, caused this asset failure. Further investigation into the root cause determined that as the activity tasks in the preventative inspection job plans did not specifically include inspecting the cotter pins, they were therefore not inspected. Overhead Operations indicated they will be adding an activity task to the preventative inspection job plans to specifically inspect the cotter pins.

Emergency repairs due to untimely corrective maintenance and repairs

The preventative inspections identify any required corrective maintenance and repairs, which are then scheduled and completed by crews. The aim is to complete the maintenance and repairs before the asset potentially fails and causes a service delay.

The following are examples of service delays that may have been prevented if corrective maintenance and repairs were performed in a timely manner. We evaluate the service delay cause(s) in further detail and provide our recommendation in **Sections C. 1.** and **C. 2.**

- On August 18, 2022, a service delay occurred at Queen Street East and Church Street. The emergency crew found a defect in one of the combined frog and glider combination units (see **Exhibit 1** for a description of this asset). Approximately 10 weeks prior to this incident, on June 10, 2022, a preventative inspection was performed on this intersection, where crew identified and reported problems with the same OCS asset that contributed to the asset failure. After the preventative inspection, a corrective maintenance work order (CM work order) was created on June 14, 2022; however, the work order was still outstanding at the time of the service delay incident (over two months since the preventative inspection). If the corrective maintenance and repairs identified in the June 10, 2022 preventative inspection were prioritized and completed in a timely manner, this service delay likely could have been prevented.

- On May 20, 2022, a service delay occurred at Queen Street East and Leslie Street due to a damaged glider (see **Exhibit 1** for a description of this asset). Per review of the most recent preventative inspection, completed on August 20, 2021, the crew reported several issues that required corrective maintenance and repairs, including installing a piece of protective hardware that would protect the glider from being damaged. Although four CM work orders were created to fix the other issues identified during the preventative inspection, there was no CM work order created to add the protective hardware to the glider. In response to the service delay on May 20, 2022, the emergency crew had to make temporary repairs to resume service at that intersection. Management's permanent corrective action was to install the same protective hardware the inspection crew already suggested during their previous preventative inspection on August 20, 2021. This service delay could have been prevented if a CM work order to install the protective hardware was created and completed in a timely manner after the August 20, 2021 inspection.

- On January 29, 2022, a service delay occurred near King Street West and Shaw Street due to a failure in the diode asset (see **Exhibit 1** at end of report for a description of this asset). On February 1, 2022, the emergency crew repaired all the problems that caused the service delay. These were the same problems previously identified in the preventative inspection on October 16, 2021. Following this inspection, on October 27, 2021, CM work orders were created to perform the same maintenance and repairs the emergency crews completed after the asset failed on January 29, 2022. However, these CM work orders were not completed on a timely basis and were outstanding for over three months when the delay incident occurred. If the corrective maintenance and repairs identified in the October 16, 2021 preventative inspection were prioritized and completed in a timely manner, this service delay likely could have been prevented.

A. 2. Strengthen the Investigation and Root Cause Analysis Process for Service Delays and Overhead Asset Failures

Overhead Operations' policy is to fill out a root cause analysis for service delays greater than 5 minutes

According to Overhead Operations' policies and procedures, employees must fill out a root cause analysis for all service delays that are greater than five minutes.

Root cause analysis policy should be more clearly defined

Through our review of emergency maintenance incidents in 2022 and our inquiry with Overhead Operations, we noted variability in the causes of OCS-related service delays (e.g., third-party damage, OCS asset failure, streetcar operator error). To optimize the use of resources, the policy should be reviewed and reassessed to provide more criteria and clarity on the nature and extent of investigation required.

Root cause analyses allow staff to make an assessment on opportunities for continuous improvement to prevent similar service delays in the future

Completing a root cause analysis ensures that management is making an assessment on the cause of a service delay, while also considering the asset's life expectancy, latest inspection date, and annual inspection target. It also allows Overhead Operations staff and management to determine whether the service delay and asset failure could have been prevented through a change to their preventative and corrective maintenance program (e.g., ensuring timely inspections and repairs, increasing the annual inspection targets, changing or adding job plans/activity tasks, developing and implementing new operating procedures). Various forms are used to complete a root cause analysis depending on the type of service delay.

Delays greater than five minutes

No root cause analysis and investigation were completed for service delays that exceeded 5 minutes

Through our review of paper files, we found that root cause analyses were not completed by Overhead Operations staff for service delays greater than five minutes long, except when it was an Automatic Drop Down incident (see next section for details). Based on our inquiry with Overhead Operations staff, we found that staff were unaware of the policy requiring a root cause analysis to be completed for delays greater than five minutes or had a different interpretation of this policy.

Instead of conducting the root cause analyses, crews that responded to emergency calls documented a summary of their observations and actions performed on their daily work reports. For incidents related to electrical switches, details were sometimes also documented using specific switch inspection forms. The crews' documentation of these various events did not include an investigation and conclusion on the root cause of these service delays.

Understanding the root cause of a service delay is required to prevent the same type of issue from recurring

It is important for staff to comply with the TTC's policy that a root cause analysis and investigation must be completed for all service delays that exceed five minutes, as Overhead Operations can only prevent the same issue from recurring if they understand what caused the issue in the first place. If the root cause analysis and investigation are not performed, it is not possible to make informed decisions to support continuous improvement and optimization of the maintenance and repair program.

Delays due to Automatic Drop Down incidents

Automatic Drop Down incidents result in service delays that exceed 5 minutes and can be caused by OCS asset failures/malfunctions or external factors

Automatic Drop Down incidents are one specific type of service delay that generally exceeds five minutes. The pantographs have a safety feature known as Automatic Drop Down, which allows the pantograph to automatically drop down, or lower itself, away from the OCS if the pantograph itself becomes damaged or comes into contact with any irregularities in the OCS (e.g., due to OCS asset failures/malfunctions or externally caused damages). This safety feature is designed to minimize and reduce the risk of damage to the pantograph and the OCS assets.

A cross-departmental working group meets weekly to determine the root cause of each Automatic Drop Down incident

In 2022, a cross-departmental working group (Streetcar Infrastructure, Streetcar Maintenance (vehicles), Streetcar Transportation (streetcar operators), Transit Control) was created to meet weekly to discuss the Automatic Drop Down incidents that took place that week. The goal was to determine the cause of each Automatic Drop Down incident and assign accountability to the appropriate department.

The root cause was determined for 86% of Automatic Drop Down incidents, and undetermined for 14%

Based on our review of the root cause analysis forms completed and the tracking file used in the cross-departmental working group, 104 Automatic Drop Down incidents occurred in 2022. Eighty-nine (or 86 per cent) of these incidents had a determined root cause, while the root cause for 15 (or 14 per cent) of these incidents was undetermined.

Recommendation:

1. The Board request the Chief Executive Officer, Toronto Transit Commission, to support continuous improvement and increase streetcar service reliability by:

a. Reassessing and strengthening existing policies and procedures in Streetcar Overhead Operations to provide more criteria and clarity on the nature and extent of the root cause analysis and investigation required for service delays;

b. Determining the root causes for those delays that require investigation according to the policy, in order to prevent the same issues from recurring; and

c. Developing and implementing a process in Streetcar Overhead Operations to ensure compliance with the policies and procedures regarding root cause analyses and investigations of service delays.

A. 3. Collaborate with Other Departments to Investigate and Improve Efficiencies Related to Switch Emergency Calls

Fail-to-operate (FTO) switch emergency calls occur when an electrical switch does not respond to operator's commands

The streetcar network consists of both manual and electrical track switches, which control the streetcar's direction (i.e., proceeds straight or turns). Based on our review and inquiries with Overhead Operations staff, it is a common occurrence that the electrical switch, initiated when the streetcar operator pushes a button on the streetcar's dashboard, fails to operate (FTO) and does not respond to the streetcar operator's commands.

When that happens, the operator first calls the Transit Control department to report the "potential" problem with the electrical switch, and then gets out of the streetcar to manually change the switch on the tracks to proceed in the intended direction. Transit Control then notifies Overhead Operations, who sends a crew to perform a switch inspection and document the results using a switch inspection form.

268 FTO switch emergency calls in 2022, with multiple calls on 60 of the 184 days

In 2022, 496 switch-related emergency calls, of which 268 (54 per cent) were FTO switch emergency calls, were made. These calls occurred on 184 days in 2022, with 60 days having multiple FTO switch emergency calls.

Better Tracking of FTO Switch Emergency Calls

FTO switch emergency calls and the resulting switch inspection results are not tracked

These FTO switch emergency call incidents are not tracked in the Transit Control's service delay records, since no service delay occurs if the streetcar operator uses the manual switch when the electrical switch has failed. Overhead Operations also does not separately track these FTO switch emergency calls in their Key Performance Indicator (KPI) reporting, but instead groups them together with all other switch-related emergency calls for switch failures.

Investigate FTO Switch Emergency Calls with Other Departments

FTO switch inspections often result in "No Trouble Found" with the electrical components of the switch

Based on our review of the switch inspection results in the individual crew members' summary reports for the 268 FTO switch emergency calls in 2022, we found that 197 (74 per cent) of these calls resulted in "No Trouble Found" with the electrical components of the switch. In these scenarios, if there is "No Trouble Found," management has indicated the crew does not need to replace any of the switch components or perform any repairs. In 2022, the total crew time spent on these No Trouble Found calls was 464 hours per crew member (three crew members = 1,392 hours) at an estimated cost of $46,089 (1,392 hours at $33.11/hr).

According to Overhead Operations staff, the failed switch is likely a result of:

- operators attempting to operate the switch when the streetcar is not in the correct location (i.e., too far or too close) to operate the switch electrically; or
- streetcars following too closely to one another, which can impact the switch signals.

Inspection results are not communicated to other related TTC departments

There is no policy or procedure to communicate the results of these emergency inspections to any other departments. Therefore, the 197 "No Trouble Found" inspection results in 2022 were not communicated to other streetcar departments to follow up and investigate the reasons for the failed switches.

No cross-departmental effort to reduce the number of FTO switch emergency calls

According to staff from the Overhead Operations section, as well as the Streetcar Transportation (streetcar operators) and Streetcar Maintenance (vehicles) departments, no cross-departmental efforts to reduce the number of FTO switch emergency calls have been made.

As a result, the underlying problem(s) causing the significant number of these emergency calls will likely continue to occur and occupy Overhead Operations resources.

Recommendation:

2. The Board request the Chief Executive Officer, Toronto Transit Commission, to improve communication and information sharing across relevant streetcar and other departments, in order to support continuous improvements and reduce the number of fail-to-operate switch emergency calls. Information collection and sharing across these departments should include:

a. Collecting and tracking appropriate and relevant data regarding fail-to-operate switch emergency calls, including but not limited to switch IDs, number of calls, and their results; and

b. Using the data collected to perform root cause analyses and investigations with the goal of reducing the number of fail-to-operate switch emergency calls.

A. 4. Develop an Accurate and Complete Centralized Asset Database to Facilitate Asset Tracking, Including the Streetcar Network's Switches

An accurate, complete, and centralized database of all Overhead Operations' infrastructure assets (e.g., switches, diodes) is critical to facilitate tracking the assets, identifying what preventative and corrective work is needed, and optimizing the use of resources.

Inefficient use of resources as crews were dispatched to inspect switches that were out of service

However, we noted that for 39 (eight per cent) of the total 496 switch-related emergency calls, the crews found they were for out-of-service switches when they attended the calls to perform an inspection of the switch, which was not a productive use of their time.

In 2022, the total crew time spent on inspecting these out-of-service switches was 79 hours per crew member (three crew members = 237 hours) at an estimated cost of $7,847 (237 hours at $33.11/hr).

No centralized asset database for streetcar overhead assets

Streetcar operators, Transit Control, and Overhead Operations should be aware when switches are not operating due to being out of service. However, this is not currently possible as there is no centralized inventory database that shows the switches' operating status.

For example, the various streetcar-related departments/sections use multiple tracking files with regards to switches. There is some duplication as some of the responsibilities overlap. Figure 4 below summarizes the five decentralized switch asset inventory sources.

Figure 4: A Summary of Five Decentralized Switch Asset Inventory Sources

Responsible Department/Section	Description of Switch Asset Inventory Sources
Overhead Operations	Maintenance Schedule used to plan, schedule, and track inspections (maintained in Excel)
Overhead Operations	Assets set up within the section's work order IT system, Maximo
Overhead Engineering	An inventory listing of electrical and manual switches, out-of-service switches, and manual switches roughed in for future electrification (maintained in Excel)
Transit Control	An inventory listing of switches on the network and whether they are manual or electrical (maintained in the department's IT system)
Streetcar Way (tracks)	A digitally created map of electrical and manual switches

Discrepancies and inconsistencies between the various asset lists and databases across departments/sections

Through our comparison of the various decentralized lists/databases maintained by the various departments/sections, we found the following inconsistencies:

- 52 instances where the switch is not listed in all databases (i.e., is excluded from at least one source)
- 30 instances where discrepancies regarding whether the switch was manual or electrical were found among the separately maintained lists/map
- six electrical switches included in the 2022 Maintenance Schedule which have not been added to Maximo; and
- six instances where a source lists a switch that does not exist.

Recommendation:

3. **The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and use a centralized database of Overhead Operations' assets across departments (Streetcar Infrastructure, Transit Control, Streetcar Transportation) to ensure Streetcar Overhead Operations is using an accurate and complete asset database, including a centralized switch inventory, to inform their operational decision-making and optimize their resource allocation.**

B. Perform and Document Preventative Inspections in a Consistent Manner

B. 1. Keep Complete and Accurate Information of Assets and Dates

Keep Maintenance Schedule Current with a Complete and Accurate Listing of Assets

Maintenance Schedule is used to plan and track assets' preventative inspections

According to Overhead Operations' performance report, 695 preventative inspections occurred in 2022.[3] In order to know which overhead assets require preventative inspection and when, it is critical to have complete and accurate information of these assets and target dates for preventative inspection. Overhead Operations staff maintains an annual Maintenance Schedule, using an Excel spreadsheet, to manually plan and track preventative inspection work orders against inspection targets. If the information in the Maintenance Schedule is not complete and accurate, there is an increased risk of asset failures due to assets not being scheduled for regular preventative inspections.

We noted that the list of assets included in the 2022 Maintenance Schedule was missing some assets and included other assets that did not actually require maintenance or were not commissioned for use. This is due to a lack of policies and procedures, including those related to oversight and monitoring, that would help ensure the assets included in the Maintenance Schedule are accurate and complete.

2022 Maintenance Schedule did not include some assets that required inspections

In particular, our review found that the 2022 Maintenance Schedule excluded the following assets which required preventative inspections:

- 13 operational electrical switches (five of these did not have any preventative inspections in 2022);
- seven diodes and section insulators (three of these did not have any preventative inspections in 2022); and
- two intersections, one of which was only added to the schedule in Q4 2022 when Overhead Operations realized it was missing (one of these did not have any preventative inspections in 2022).

[3] We were unable to verify the accuracy and completeness of Overhead Operations' performance reporting and confirm the number of preventative inspections because we noted differences between the performance reporting results and the supporting paper records. See detailed scope limitation on page 65.

An incomplete Maintenance Schedule increases the risk that preventative inspections for these assets will not be planned and performed, which in turn would decrease the reliability of the streetcar OCS and electrical switches.

2022 Maintenance Schedule included assets that did not require maintenance or were not commissioned for use

In addition, we found that the 2022 Maintenance Schedule included other assets that did not require inspections. Specifically, we identified six track switches that were either manual switches or not commissioned for use. In either case, these switches do not require Overhead Operations' preventative inspections. Including assets that do not require inspections increases the risk of using time and resources inefficiently by scheduling and allocating crews to inspect assets that do not need inspecting.

Recommendation:

4. The Board request the Chief Executive Officer, Toronto Transit Commission, to implement policies and procedures in Streetcar Overhead Operations, including oversight and monitoring policies and procedures, to ensure the assets in the Maintenance Schedule are always accurate and complete, and that any required asset changes, additions, and/or removals are made to the Maintenance Schedule on a timely basis.

Ensure Maintenance Schedule Contains Reliable Preventative Inspection Completion Dates

Maintenance Schedule contains annual inspection targets for each asset

The Maintenance Schedule is used by forepersons to plan, schedule, and track preventative inspections against targets. Each asset has a specified annual target (e.g., 1/year, 2/year, 4/year, 12/year) for how frequently a preventative inspection should occur. The Maintenance Schedule also tracks the dates on which the preventative inspections were completed by crews.

Preventative inspections should be scheduled and completed at specified time intervals to optimize the effectiveness of the inspections and the use of time and resources. This is consistent with industry best practices and the American Public Transportation Association's (APTA) rail transit systems standard for *Traction Electrification Distribution System Inspection Maintenance Testing (APTA RT-FS-S-006-03)*, which states that assets' maintenance and repair program should have specified inspection and maintenance frequencies (e.g. "Biannually (once every six months)").

Maintenance Schedule contains preventative inspection completion dates

We reviewed the preventative inspection completion dates recorded in the Maintenance Schedule to assess whether the forepersons have accurate and complete information to schedule preventative inspections effectively and ensure they are completed. However, Overhead Operations lacks policies and procedures to ensure all completed preventative inspections are recorded in the Maintenance Schedule.

Completion dates were missing

We selected 53 completed preventative inspection work order forms (manual) that were filed in the Overhead Operations office and traced them to the Excel-based Maintenance Schedule. We found that 25 (47 per cent) completed inspections were not recorded in the schedule. Unrecorded completed work orders could result in duplicate and redundant preventative inspections, which is an inefficient use of time and resources. For example, we found instances of repeated inspections, as well as inspections that were completed within a short period, because the schedule had no record of the completed inspection.

Furthermore, we traced a total of 95 inspection completion dates from the Maintenance Schedule to the completed work order forms (manual) and found that only 62 (or 65 per cent) of those completion dates were recorded in the forms. The remaining 33 (or 35 per cent) completion date samples included 15 (16 per cent) samples that were missing a documented completion date on the related work order form, and 18 (19 per cent) samples where a supporting work order could not be found.

Inspection completion dates are needed to efficiently plan the next inspection

It is important for forepersons to know when the last inspection was completed in order to plan and schedule the next one. Without this information, forepersons cannot efficiently plan and schedule inspections to meet the specified annual target for that asset.

Individual directional diode assets were not tracked properly on the Maintenance Schedule

We also found that individual directional diode assets (see **Exhibit 1** for a description of this asset) were not tracked properly on the Maintenance Schedule. A preventative inspection is performed for each individual directional diode asset (e.g., north and south, east and west), but the Maintenance Schedule is not currently set up to track the completion dates for the inspections of both directional diode assets. For example:

- Diode OVH-D12 – This asset represents both the eastbound and westbound diodes. The Maintenance Schedule showed that a preventative inspection was performed on April 20, 2022, and it appeared that the target of four inspections per year was met. However, per review of completed work orders, only the westbound diode was inspected on April 20, 2022. The eastbound diode was not inspected and therefore did not meet its 2022 inspection target.

Since the Maintenance Schedule is not set up to track for both directions, forepersons need to track the inspection completion dates separately, otherwise the required inspections may be missed.

Recommendation:

5. **The Board request the Chief Executive Officer, Toronto Transit Commission, to implement policies and procedures in Streetcar Overhead Operations to ensure all completed work orders are recorded on the Maintenance Schedule, in order to plan, manage, and schedule preventative inspections in an efficient manner that optimizes the use of time and resources.**

B. 2. Provide Clear Directions to Staff on Preventative Inspections – Develop Maintenance and Inspection Manual, Update Inspection Targets, and Establish Time Expectations

Develop Maintenance and Inspection Policies, Procedures, and Manual to Provide Clear Directions to Staff

No formalized OCS maintenance and inspection manual

We noted Overhead Operations does not have a formalized Overhead Contact System (OCS) maintenance and inspection manual that clearly defines and outlines expectations for Overhead Operations' staff and crews. We found that the absence of this manual contributed to the variability we noted in how preventative inspections' activity tasks were performed and documented by crews. This is discussed further in Section B. 3.

The TTC hired external consultants in 2021 to develop a draft manual, intended to assist Overhead Operations staff and crews with the maintenance and inspections of the OCS. However, the latest draft, dated July 15, 2022, is currently still undergoing reviews and approvals by Overhead Operations, Overhead Engineering, and management, and has not yet been finalized.

Current sources of operational guidance are incomplete, outdated, or not formally documented

In the absence of a formalized maintenance and inspection manual, Overhead Operations staff and crews currently rely on a combination of Standard Operating Procedures, work order job plans, technical and operational bulletins, the 2022 Overhead Rule Book and Electrical Safe Practices, the Light Rail Overhead Contact Systems Lineperson Apprenticeship training materials, and on-the-job training and verbal instructions for operational guidance and understanding of roles, responsibilities, and performance expectations. We noted areas for improvement as these current sources of operational guidance are incomplete, outdated, and/or not formally documented.

Standard Operating Procedures are incomplete and outdated

The Standard Operating Procedures (SOPs) do not provide clear expectations as to how preventative inspections should be performed. For example:

- We noted that many of the SOPs are dated prior to the TTC's conversion from the trolley pole to hybrid to pantograph system. The SOPs should be regularly reviewed and updated for accuracy, completeness, and relevance under the current OCS.

- SOPs do not exist for all major inspection areas such as intersections, tangent lines, underpasses, yards, and tunnels (see **Exhibit 1** for a description of these OCS areas). We also noted that SOPs typically focus on the installation of Overhead Operations' assets but not the subsequent inspection and maintenance of these assets.

- Some SOPs, while still relevant to the pantograph system, are outdated. For example, the SOP titled "*Diode Controlled Section Breaks Inspection and Maintenance*" is dated April 6, 2009. The pictures of the diode assets included in the SOP do not align with the diode assets currently being used in the OCS. The activity tasks in the SOP's sample work order also do not align with current work orders completed by crews.

- Some SOPs are incomplete and still in draft form. For example, the SOP titled "*Electric Track Switch (SEL/SESS) Inspection Procedure*" is the first and only version of the SOP and the appendix of this document is incomplete (blank).

Job plans are outdated

We also noted there are no formal procedures or processes to regularly review the preventative inspection work order job plans to ensure the activity tasks listed in the job plan are up-to-date. In addition, we found instances where crews left activity tasks on job plans blank because they were outdated and no longer relevant. This is discussed further in **Section B.3**.

Apprenticeship training materials focus more on installation rather than the maintenance of assets

We reviewed the Light Rail Overhead Contact Systems Lineperson Apprenticeship training materials and found that, similar to SOPs, they focus on the installation of assets but not the subsequent maintenance and inspection of these assets. Further, some of the procedural materials are very brief and the Scenario Q&A material is dated 2010, prior to the TTC's conversion from the trolley pole to hybrid to pantograph system.

On-the-job training is verbal and not documented

As the OCS has undergone significant changes over the last few years, on-the-job training has become more prevalent as policies, procedures, and SOPs have not yet been updated or developed. Through inquiries and discussions with Overhead staff, we believe many Overhead staff have extensive operational knowledge and industry expertise. However, much of this knowledge is not documented but only shared verbally. It would be beneficial for Overhead Operations to ensure this knowledge and expertise is formally documented for future reference and guidance. Staff should also receive training on the formally documented maintenance and inspection policies, procedures, and manuals to ensure they are aware of and understand their roles, responsibilities, and performance expectations.

Recommendation:

6. The Board request the Chief Executive Officer, Toronto Transit Commission, to review, update, and approve all maintenance and inspection policies, procedures, and manuals in Streetcar Overhead Operations to ensure they are accurate, complete, and relevant, and provide training to staff on them.

Ensure Changes Made to Inspection Targets Are Supported by A Formalized Data-Driven Analysis and Assessment

No formalized process for reassessing and updating the annual inspection targets

Preventative inspection targets should be regularly reviewed and updated to reflect the current operational requirements and to optimize the effectiveness of the inspections. However, Overhead Operations staff indicated there is no formalized process for reassessing and updating the annual preventative inspection targets on a regular basis.

In our comparison of the annual Maintenance Schedules between 2020 and 2023, we noted several changes were made in 2021 to increase and decrease the annual inspection targets. Overhead Operations staff indicated these changes were determined through verbal discussions with the Supervisors, Manager, and department Head, and made considering the following factors:

- the notice of wear and tear on the different routes;
- the amount of traffic each route received (e.g., information received from the Service Planning department regarding long-term route diversions); and
- the number of preventative and corrective maintenance work orders from the previous year and staffing levels.

Changes to preventative inspection targets should be supported by data analysis

However, Overhead Operations staff were unable to provide any data-driven analysis and assessment to support the changes made in 2021. Changes made to annual preventative inspection targets (e.g., inspection frequencies) should be supported by a formalized data-driven analysis and assessment.

Sometimes inspection targets changed informally without updating the Maintenance Schedule

We also noted that the targets in the Maintenance Schedule have remained the same since 2021. Per discussion with Overhead Operations staff, targets are sometimes changed informally via verbal internal discussions, but are not updated formally in the Maintenance Schedule.

Recommendation:

7. The Board request the Chief Executive Officer, Toronto Transit Commission, to:

a. Review and update the annual preventative inspection targets in Streetcar Overhead Operations on both an annual and as-needed basis; and

b. Establish policies and procedures to provide clear guidance in Streetcar Overhead Operations on which source data and information is needed for the reassessment.

Establish Standard Time Expectations for All Common Preventative Inspections and Use GPS Technology to Improve Operational Efficiency

Not all common preventative inspections have established standard time expectations

Overhead Operations has not established standard time expectations (e.g., the amount of time typically required to perform a specified task or set of tasks under normal operating conditions) for all common preventative inspections. Per review of the 2022 Maintenance Schedule, shift expectations are documented for only three of the nine preventative inspection categories (see Exhibit 1 for a description of these OCS areas):

- intersections (ranges from one to three 10-hour shifts)
- underpasses (ranges from one to two 10-hour shifts)
- loops (ranges from one to two 10-hour shifts).

Without standard time expectations, it would be difficult for management to measure the efficiency of preventative inspections performed, or to improve efficiency of staff performance. We acknowledge that some tasks may take longer than the prescribed time frame and some flexibility is needed, but it would be prudent for management to monitor and follow up if a linesperson's or crew's work consistently and significantly exceeds expected time frames.

Use GPS technology to improve operational efficiency

Enabling GPS on Overhead Operations' vehicle fleet can be an effective tool to monitor performance and improve operational efficiency. Currently, the vehicles Overhead Operations uses for preventative, corrective, and emergency maintenance (except Overhead Operations' three anti-icing trucks) do not have GPS installed. Therefore, management is unable to use GPS technology to monitor and assess crew performance and efficiency. In comparison, all streetcars are GPS-enabled and monitored by Transit Control. The Streetcar Way (tracks) section's vehicle fleet is also partially GPS-enabled.

Recommendations:

8. **The Board request the Chief Executive Officer, Toronto Transit Commission, to establish and implement standard time expectations for common preventative inspections in Streetcar Overhead Operations and incorporate them into the employee performance evaluation.**

9. **The Board request the Chief Executive Officer, Toronto Transit Commission, to install and enable GPS on Streetcar Overhead Operations' non-revenue vehicles to effectively monitor and assess performance.**

B. 3. Ensure Preventative Inspections Are Performed and Documented Consistently, and Comply with Inspection Targets and Frequencies

Consistently Perform and Document Preventative Inspections

Performance and documentation are two important aspects of a preventative inspection

Performance and documentation are two important aspects of a preventative inspection.

- Performance – Crews perform all activity tasks listed in the job plan of an inspection work order to assess the condition of an asset and identify the need for any corrective maintenance repairs. This reduces the risk of asset failures and service delays.

- Documentation – Crews should document the results and observations of each activity task for forepersons and management to review, in order to inform decision-making (e.g., scheduling corrective maintenance to replace or repair parts). It is critical that this information is accurate and complete for appropriate decisions to be made, to ensure the reliability of the assets.

Variability in how crews perform the same task and how inspections are documented

Our review of work orders found that job plan activity tasks were not consistently performed in the same manner by crews. We also noted considerable variability in how crews documented and recorded the results and observations of preventative inspections. This variability is largely due to the lack of a formalized OCS maintenance and inspection manual that clearly defines and outlines expectations for Overhead Operations' staff and crews, as previously discussed in Section B.2.

If inspections are not performed or documented consistently, then forepersons and management may not know what activity tasks were performed or the results and observations from the work performed. This inconsistency also makes it difficult to use the results to perform meaningful data and trend analysis, and to monitor the condition of assets.

More importantly, this may cause service delays if assets are not repaired or replaced in time, or lead to a misuse and inefficient use of time and resources if corrective maintenance and repairs are scheduled for assets that did not need repair or replacement.

Performance of Preventative Inspections' Activity Tasks

Variability in how wire measurements were taken

One variability we noted in how crews perform activity tasks is where wire measurements were taken from. Some crews measured the entire overhead wire, while others only measured the wire exposed underneath the wire fitting (e.g., a hardware component of the OCS). For example:

- We reviewed a work order performed by two different crews separately on March 2 and March 18, 2022 (16 days apart). The wire measurements on March 18 doubled the measurements taken on March 2 because the crew on March 2 took their measurements from under the wire fitting, while the crew on March 18 measured the whole wire.

- We noted one work order measured the wire size at 6 mm, which would appear to mean that the wire was very worn and needed to be replaced urgently. However, staff did not create a corrective maintenance work order because the crew only measured from under the wire fitting instead of the whole wire.

- We reviewed a work order that measured the whole wire (11.8 mm) while another work order for the same asset measured only from under the wire fitting (4.5 mm).

Crews did not document where the wire measurements were taken from

Overhead Operations staff informed us that they have previously verbally communicated with certain crew members on how to take wire measurements. Nevertheless, we still noted inconsistencies in how crews take wire measurements and that crews did not record where measurements were taken from on the completed work order form. It was unclear from the form whether certain wire measurements should trigger a replacement.

Documentation of Preventative Inspections' Activity Tasks

Variability in the extent of observations and measurements recorded for preventative inspections

Documentation of preventative inspection results and observations is done manually by staff on paper. We noted considerable variability in the extent of observations, measurements, and comments recorded. For example:

- We compared two preventative inspections performed at the same College Street and Lansdowne Avenue intersection. One inspection documented more observations, measurements, and comments regarding asset condition than the other. In addition, the name of the hanger (see **Exhibit 1** for a description of this asset) type was documented as the 'Contact Wire Clamp Type' in one inspection and as 'Fitting Type' in the other.

Format of measurements being taken was inconsistent

- The format of measurements being taken was inconsistent. We compared two preventative inspections for the same asset. One inspection recorded two measurements (5.7 mm + 5.5 mm) for an activity task, while the other inspection recorded just one measurement (4 mm) for the same task.

- Some inspections have wire size measurements recorded using a wire gauge sizing scale (i.e., "4/0" or "3/0"), while other inspections have those measurements recorded in millimetres. Per inquiry with Overhead staff, crews used to measure wire sizes using the wire gauge sizing scale as far back as five years ago when they were using an old measuring tool. The current expectation is that crews use the newer measuring tools and record measurements in millimetres as this method is more accurate. However, some crew members still use the old measuring tool and record measurements using the wire gauge sizing scale.

Use of exception reporting was not standardized

- We found two completed inspection job plans with blank activity task pages. However, the cover page for one plan indicated there were no problems found, while the cover page for the other indicated a problem was identified and documented. Regardless of whether or not problems are identified during the inspection, crews are expected to record observations on the activity task pages.

- We found some work orders with activity tasks checked off to indicate the tasks were completed, while these same activity tasks were left blank in other work orders. Similarly, some inspections had more documented measures than other inspections that left those same activity tasks blank. It was unclear whether or not those activities were performed when they were left blank.

Many potential causes for blank activity tasks on job plan

Based on our inquiries with Overhead staff, blank activity tasks on the job plan could indicate the following:

- Incomplete tasks – Crews were unable to perform the activity tasks for various externally caused factors such as traffic, areas where the crew could not stop, blocked curbs, inclement weather, the crew being sent to attend another call (e.g., emergency repairs), or insufficient time in the crew's shift.

- No issue found – The activity task was performed but the result was not documented as no issue was found. For example, according to Overhead staff, for "Span Condition" activity tasks, which examine the condition of the span wire (see **Exhibit 1** for a description of this asset), crews will record if the span has issues but leave the task blank if it does not.

- Irrelevant tasks – The activity task was considered, but not performed as it was not applicable. For example, for "Splice type" activity tasks, crews are expected to inspect and document the type of splice present (see **Exhibit 1** for a description of this asset). However, according to Overhead staff, splices are not always present because this piece of hardware is only added to the OCS when two pieces of contact wire need to be joined (e.g., in corrective maintenance when a section of the contact wire needs to be replaced). In cases where no splice is present, crews leave this activity task blank.

- Outdated tasks – The activity tasks and assets included in the work orders are outdated (inaccurate and incomplete) and therefore not applicable.

Need for consistent documentation of work orders for effective monitoring

If not clearly documented by the crews, blank activity tasks could represent many things, including a partially completed inspection. The lack of documentation makes it difficult for forepersons and management to track what work was performed and monitor the conditions of the assets. Clear expectations should be provided as to what and how the information should be recorded in the work order forms, to ensure crews consistently document inspections' maintenance activities.

Recommendation:

10. The Board request the Chief Executive Officer, Toronto Transit Commission, to:

a. Ensure policies, procedures and manuals in Streetcar Overhead Operations provide clear directions as to how preventative inspections' activity tasks, results, and observations should be performed (including the measurement method) and documented; and

b. Develop and implement an oversight process in Streetcar Overhead Operations (e.g., quality assurance audit program, spot checks, increased supervision) to ensure the accuracy, completeness, and reliability of the documented work orders and consistency of the work performed.

Comply with Preventative Inspection Targets

No formalized process to ensure preventative inspections are completed in accordance with their annual inspection targets

Overhead Operations does not have a process in place to ensure preventative inspections are scheduled and completed in accordance with the internally established inspection targets specified in the Maintenance Schedule. As a result, we found that 28 (64 per cent) of the total assets we sampled were inspected less than or more than their annual inspection target, with 16 (36 per cent) meeting their target.

48% of assets sampled were below the preventative inspection targets

We sampled 44 assets from the Maintenance Schedule and found that for 21 (48 per cent) of these assets, the actual number of inspections was below the preventative inspection target. For example:

- A section insulator had a target of four preventative inspections per year, but only three inspections were completed in 2022.
- An intersection had an annual target of two preventative inspections, but only one inspection was done in 2022.
- A diode had a target of four preventative inspections per year, but only one inspection was recorded as completed in 2022.

Preventative inspection targets not being met increases the risk of asset failures and the need for emergency maintenance repairs, resulting in service delays, such as the examples previously discussed in Section A. 1.

16% of assets sampled exceeded the preventative inspection targets

In addition, seven of the 44 assets (16 per cent) sampled from the Maintenance Schedule had more inspections performed than their preventative inspection targets. For example:

- We found that a tangent line (see **Exhibit 1** for a description of this asset) inspection had a target of one preventative inspection per year, but three inspections were performed in 2022 (March 21, July 20, and July 25). Overhead staff were unable to provide us with an explanation or documentation to support why this asset was inspected two more times than required.

Preventative inspections exceeding the annual inspection target indicate either ineffective work order management processes or outdated inspection targets. This increases the risk that time and resources are used inefficiently by scheduling and allocating crews to inspect assets that have either already been recently inspected (i.e., duplicated and redundant work) and/or do not need to be inspected yet.

Perform Preventative Inspections at Specified Time Intervals

No formalized process to ensure inspections are scheduled and completed at specified time intervals

Annual inspection targets (e.g., 1/year, 2/year, 4/year, 12/year) have been established for each asset, and inspections should be performed at specific time intervals (e.g., every 12 months, every 6 months, every 3 months, every month) to optimize the use of resources and the effectiveness of the inspections. As previously mentioned, this is consistent with industry best practices and the American Public Transportation Association's (APTA) rail transit systems standards.

However, we found that Overhead Operations uses a manual process to track and schedule preventative inspections. There is also no formalized process to ensure that preventative inspections are scheduled and completed at specified time intervals, and in compliance with the annual preventative inspection targets in the Maintenance Schedule.

Preventative inspections were not performed at specified time intervals

Based on our review, we noted that inspections were not performed at specified time intervals. For example:

- Inspections of a diode asset were performed on March 3 and March 29, 2022. According to the Maintenance Schedule, inspections should occur every three months, but the inspections were performed only 26 days apart.

- Inspections of a diode asset were performed on July 24, August 27, and December 13, 2022. According to the Maintenance Schedule, inspections should occur every three months, but the first two inspections were performed one month apart from each other, while the third inspection was performed three-and-a-half months after the second inspection.

Preventative inspections should be performed in accordance with Overhead Operations' specified time intervals

If assets are inspected too early (i.e., shorter time interval between inspections than specified), then time and resources may be used inefficiently.

If assets are inspected too far apart (i.e., longer time interval between inspections than specified), then service delays may occur as deteriorating asset conditions could go undetected and therefore not be scheduled for corrective maintenance and repairs before a potential asset failure and service delay.

Therefore, preventative inspections should be performed in accordance with Overhead Operations' specified time intervals to optimize the use of resources and effectiveness of the preventative inspection program.

Recommendation:

11. The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement formalized processes in Streetcar Overhead Operations to:

a. Ensure preventative inspections comply with annual inspection targets; and

b. Ensure preventative inspections are scheduled and completed in accordance with Overhead Operations' specified time intervals.

Follow Up On, Track, and Reschedule Incomplete Inspections

Lack of policies and procedures on how crews should communicate and document partially completed preventative inspections

Sometimes, crews are unable to complete all the activity tasks listed in the preventative inspection job plan for a variety of reasons. However, we found there was a lack of policies and procedures that provide clear instructions on how crews should communicate and document partially completed preventative inspections. Similarly, there were no established processes and procedures to keep track of partially completed inspections and ensure they are appropriately followed up on to complete the unfinished work.

Variability in how incomplete work was documented

As a result, we found the extent of documentation on completed work order forms varied. In some instances, as previously discussed above, crews left activity tasks blank on the completed work order forms. Other times, crews specifically documented that they were unable to complete the preventative inspection work for a specific reason. In comparing the same inspections performed more than once during the year, we also found instances where more activity tasks were completed in one work order than in the other with no explanation provided on why the amount of work carried out was different. Discussion with forepersons indicated that some work orders may have only been partially completed.

Incomplete preventative inspections were not rescheduled, tracked, or followed up on, but were instead logged as completed and closed

Where we identified the work order could not be completed due to an external factor, we found instances where the crews did not go back to complete the inspection work because no subsequent work order was created for the unfinished work. In all these cases, the work orders were still incorrectly marked as completed in the Maintenance Schedule and/or closed in Maximo.

Crews should communicate and document when preventative inspections are only partially completed. These inspections should then be tracked and rescheduled for their full completion. However, we found that partially completed inspections were not tracked by Overhead Operations, and therefore these work orders were not being followed up on or rescheduled to finish the work. If preventative inspections are not fully completed, then the risk of emergency calls and resulting service delays is increased.

Recommendation:

12. The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement policies and procedures in Streetcar Overhead Operations to:

a. Provide clear expectations and training as to how crews should communicate and document preventative inspections that are only partially completed; and

b. Track and ensure partially completed inspections are appropriately rescheduled to be fully completed.

C. Strengthen Corrective Maintenance and Repairs

C. 1. Identify, Prioritize, and Complete Corrective Maintenance and Repair Work in a Timely Manner

Establish Criteria to Determine if Corrective Maintenance and Repair Work is Needed

Need to establish clear criteria and standards for when CM is required

Consistent assessment and documentation are critical for management to identify, prioritize, and schedule corrective maintenance and repair work. However, we found that Overhead Operations has not established clear criteria as to what asset conditions warrant the generation of a corrective maintenance work order (CM work order), based on risks and implications.

Overhead Operations staff use an internally developed guide that outlines the standard for gauging, reporting, and replacing worn overhead wire. However, the guide does not outline clear criteria for when corrective maintenance and repairs are needed for the other types of assets. This results in staff needing to use their judgment, which can lead to inconsistencies in the criteria applied to determine if a CM work order needs to be generated.

No measurable metrics or standards for assessing certain assets

Specifically, for OCS hardware assets (i.e., frog, section insulator, glider, adjustable crossover, and hanger), crews perform a visual inspection of the asset, then use their knowledge, experience, and judgment to determine whether the asset is worn enough to require a repair or replacement. We noted that crews documented on their inspection sheet the condition of the asset, with comments including but not limited to “worn,” “heavily worn,” “very bad,” or “needs replacing,” but there are no measurable metrics or standards to ensure the assessment of these assets’ conditions are made correctly and consistently by crew members.

Judgment is also then applied by the foreperson when reviewing the crews’ inspection results to determine if a CM work order is required. Clear asset condition criteria and standard documentation would help both crews and forepersons to ensure consistency in determining when CM work orders are needed.

58% of sampled preventative inspections had no CM work order generated to address issues identified by crews

We selected a sample of 38 preventative inspections that had crew members documenting an issue was found. We noted that 22 (58 per cent) of these inspections had no CM work order generated to address the issues identified.

- For one of the 22 preventative inspections, Overhead Operations staff informed us that while no CM work order was generated, the repair was made after the issue was identified. However, staff was unable to provide us with any documents to support the CM work was done.

- For the other 21 of the 22 preventative inspections, no repairs were performed to fix the issues identified by the crew. For example, during one inspection, the crew identified a wire size that, according to Overhead Operations' internal guide, would require a replacement, but no CM work order was generated and the wire was not replaced. In another example, the crew identified that the OCS hardware asset was "worn," but no CM work order was generated and the hardware asset was not replaced.

Not performing corrective maintenance and repairs for problems identified in the preventative inspections increases the risk of asset failures and service delays. Therefore, Overhead Operations should provide crews and staff with clear criteria and guidance that outline when corrective maintenance and repairs are needed to ensure problems identified during preventative inspections are addressed in a timely manner.

Supervisory Review of Preventative Inspections Is Manual and Prone to Errors

No formal policy, procedure, and sign-off for supervisory review of preventative inspections

In the current process, a supervisory staff (e.g., foreperson) must review the completed preventative inspections to determine if CM work orders are required based on the crews' inspection results and observations. However, in our review of the completed preventative inspections, we were unable to determine whether all the inspections were reviewed for potential CMs as this review does not require a formal sign-off.

We also noted that the current manual and paper-driven work order process is prone to misfiled work orders and human error. Therefore, CM work orders may have been missed if the completed inspection was misfiled and not reviewed by supervisory staff, or if the completed inspection was reviewed but the problem identified by the crew was missed in the supervisory review.

Prioritize and Complete Corrective Maintenance and Repairs in a Timely Manner

Need to establish response times for CM work orders

Overhead Operations has not established formalized time expectations for reviewing and generating CM work orders after a preventative inspection is completed, nor for prioritizing and completing CM work orders once they have been generated, based on risks and implications.

No policy or procedures on timing expectations for reviewing completed preventative inspections

We noted there is no policy regarding how quickly preventative inspection observations and results should be reviewed by forepersons after completion. As a result, there are no standards or expectations regarding how soon CM work orders should be generated after issues are identified through inspections. This has contributed to the delays in generating CM work orders.

In our review of all 469 CM work orders from 2022 provided by Overhead Operations staff,[4] we noted that 380 had a documented completion date. We then selected 95 of the 380 CM work orders to assess how long it took for the work order to be generated after the preventative inspection was completed and reviewed. These 95 CM work orders were generated out of 47 preventative inspections (one inspection can result in multiple CM work orders if multiple assets require corrective maintenance).

14% of preventative inspections sampled took 2 to less than 4 weeks and 14% took 4 to 9 weeks to generate CM work orders after the completion of preventative inspection

We found that for about 33 (72 per cent) of the 47 preventative inspections sampled, the CM work order was generated less than two weeks of the preventative inspection being completed. Seven (14 per cent) took between two to less than four weeks, and the remaining seven (14 per cent) between four to nine weeks, for the CM work orders to be generated after issues were identified during the preventative inspections.

Figure 5 below provides a breakdown of the time taken between preventative inspection completion and CM work order generation for the 47 samples tested.

Figure 5: A Breakdown of the Time between Preventative Inspection Completion and CM Work Order Generation

Time between Inspection Completion Date and CM Generation	Preventative Inspections That Generated CMs	
	Number	%
<1 week	26	56
1 to <2 weeks	7	16
2 to <3 weeks	5	10
3 to <4 weeks	2	4
4 to <5 weeks	2	4
5 to <6 weeks	1	2
6 to <7 weeks	1	2
7 to <8 weeks	2	4
8 to <9 weeks	1	2
Total	**47**	**100**

[4] We were unable to verify the completeness of the number of corrective maintenance work orders due to limitations of the paper-based system used by Overhead Operations. See detailed scope limitation on page 65.

14% of CM work orders took 2 to less than 4 weeks and 32% took 4 weeks to 4 months or more to complete the work from the time the CM work order was generated

Furthermore, we reviewed all 380 CM work orders to assess how long it took to complete the work from the time the work order was generated. We found that out of the 380 CM work orders, 206 (54 per cent) were completed less than two weeks from the date the work order was generated; 52 (14 per cent) were completed between two to less than four weeks; and the remaining 122 (32 per cent) took between four weeks to four months or longer to complete.

Figure 6 below provides a breakdown of the time between CM work order generation and completion.

Figure 6: A Breakdown of the Time between CM Work Order Generation and CM Work Order Completion

Time between CM Generation and CM Completion	CM Work Orders	
	Number	%
<2 week	206	54
2 to <4 weeks	52	14
4 to <6 weeks	59	15
6 to <8 weeks	26	7
8 to <10 weeks	8	2
10 to <12 weeks	5	1
12 to <14 weeks	6	2
14 to <16 weeks	10	3
16 to <40 weeks	8	2
Total	**380**	**100**

While some CM work orders are more complex and require more time and resources to complete (e.g., those that require setting up streetcar route closures and diversions), management informed us that a CM work order is generally expected to be completed within two to four weeks after a preventative inspection identifies the issue(s).

Based on our review of 2022 CM work orders:

- The average time it took to generate a CM work order was about two weeks after the preventative inspection was completed.
- The average time it took to complete a CM work order was about three weeks after the work order was generated.

Average time to complete CM after preventative inspection was 5 weeks

Therefore, during 2022, the average time it took to complete corrective maintenance and repairs after issues were identified through preventative inspections was about five weeks, which is longer than Overhead Operations' general expectation of approximately two to four weeks.

To ensure effectiveness of the maintenance and repair program, CM work orders should be prioritized and completed in a timely manner. This would reduce the risk of asset failures and resulting service delays, such as the examples previously discussed in Section A. 1.

Recommendation:

13. **The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement policies and procedures for Streetcar Overhead Operations' preventative and corrective maintenance program, which includes but is not limited to providing:**

    a. **A set of criteria for each asset type to determine if corrective maintenance and repair work orders need to be generated, based on risks and implications;**

    b. **Clear timing expectations for reviewing completed preventative inspections and generating any necessary corrective maintenance work orders; and**

    c. **Clear criteria and timing expectations for the prioritization and completion of corrective maintenance work orders, based on risks and implications.**

C. 2. Ensure Reliability of Measuring Tools Used by Crews

Reliability of inspection measurements dependent on tools and equipment being in good working order

The Overhead Operations' Standard Operating Procedures currently do not outline the steps crews should take to check that tools and equipment are in good working order (i.e., yields accurate measurements) prior to commencing work. There is also no process that audits or ensures crew members are checking that their tools are in good working order. This lack of formalized procedures has likely caused issues related to the reliability and accuracy of measurements recorded by crews. As demonstrated by the example below, this in turn can lead to inefficient use of crews' time and resources.

About 7% of CM work orders did not actually require any maintenance or repair work

From our review of all 469 CM work orders in 2022 provided by Overhead Operations staff, we noted that CM crews did not perform any maintenance or repair work in 33 (7 per cent) of these cases due to inconsistent observations between the preventative inspection crew and the CM crew (i.e., the preventative inspection crew observed that the asset needed maintenance or repair, but the CM crew observed no maintenance or repair was required).

Some of these inconsistent observations between the crews were related to discrepancies in wire measurements. For example, in a preventative inspection performed on September 21, 2022, the crew measured the contact wire size to be 9 mm, which would typically require a replacement. Therefore, the foreperson generated a CM work order for the wire replacement. Subsequently, on October 18, 2022, the CM crew measured the wire to be 11 mm, which does not require a replacement. Hence, the contact wire was not replaced by the CM crew for this work order. It could not be determined which of the two wire measurements was accurate.

Discrepancies in wire measurements could be due to faulty measuring tools

Discrepancies in wire measurements could be due to faulty measuring tools (e.g., calipers) used by the crews. The crew is responsible for checking that the tools are in good working order prior to commencing work. If a tool is determined to be faulty or broken, the crew leader must report it to the foreperson so the tool can be replaced or repaired.

No process to audit or verify the accuracy of data recorded on work orders

We inquired with Overhead Operations staff, who explained that the foreperson generates CM work orders according to what the preventative inspection crews report on their preventative inspection work orders. As previously discussed in Section B. 3., there is no process to audit or verify the accuracy of data being recorded on work orders.

It is a misuse of time and resources when crews are sent to perform corrective maintenance and repairs but no work is performed due to discrepancies in observations and measurements. Instead, crews could be spending their time performing other work, such as preventative inspections, or other corrective or emergency maintenance work. However, we were unable to quantify how much time was spent on these work orders as the crews did not document this information.

Recommendation:

14. The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement in Streetcar Overhead Operations:

a. Standard Operating Procedures that outline the steps to be taken to ensure the measuring tools used by crews during inspections (e.g., calipers) are in good working order; and

b. An oversight process to monitor and ensure compliance with the Standard Operating Procedures.

D. Leverage Technology to Improve Streetcar Overhead Operations

Audit objective #2 - Leveraging the use of data and technology

Our second audit objective examined whether there are opportunities for the TTC to further leverage the use of data and technology in managing its work orders, informing decision-making, and managing Overhead Operations services. Section D below summarizes our audit findings for this second objective.

Overhead Operations is underutilizing Maximo, its enterprise asset management system, which has resulted in primarily manual and paper-driven operations

We noted that Overhead Operations is underutilizing its enterprise asset management system, Maximo, which has resulted in primarily manual and paper-driven operations. Maximo is currently only being used to print work orders. Using it to its full potential as an asset management and workflow management system would help Overhead Operations transition to a digital data environment and reduce inefficient manual processes. Optimizing Maximo's capabilities and using it as an information database would also allow Overhead Operations to perform data analytics that will support their continuous improvement initiatives to increase service reliability and safety, while optimizing the use of time and resources.

D. 1. Leverage Maximo's Full Capacity as An Asset and Workflow Management System

Maximo is an enterprise asset management software solution

Maximo is an enterprise asset management software solution used by the TTC in many of its departments. Maximo software can help with the planning, and performance and maintenance monitoring, of an organization's assets throughout their entire lifecycle. Maximo was first introduced to Overhead Operations in the early 2000's, and the section began using it to print work orders in 2007. Both the Information Technology Services department (ITS) and Overhead Operations section confirmed they have not expanded the use of Maximo for Overhead Operations beyond printing work orders. In addition, no comprehensive Maximo implementation plan (with timelines and action items) has been developed for Overhead Operations since Maximo's rollout about two decades ago.

TTC has future intentions to expand the use of Maximo, but no implementation strategy or roadmap developed at time of audit

Based on discussions with management and Overhead Operations staff, we learned there are intentions to adopt and expand the use of Maximo as an asset and workflow management system for Overhead Operations in the future. This would mean using Maximo not just to print work orders, but also to potentially manage all assets, use geolocation technology to track and overlay the assets' location on a map, document work order results and observations, and support performance reporting and monitoring.

An Enterprise Asset Management Systems Implementation RFP is currently under review

In fact, ITS indicated that an Enterprise Asset Management Systems Implementation Request for Proposal (RFP) is currently under review by various departments/sections, including Overhead Operations, and that operational requirements are being developed for 2024/2025.

Maximo Anywhere being piloted by emergency crews

In addition, at the time of our audit, Overhead Operations was piloting the use of Maximo Anywhere on four mobile work laptops for emergency crews only. Maximo Anywhere is a mobile application platform that allows employees to enter live updates into the Maximo system remotely. However, ITS still needs to develop a comprehensive implementation plan and a Maximo training plan for Overhead Operations. As of July 4, 2023, Overhead Operations' management and ITS were unable to provide a timeline for this initiative.

In contrast, per discussion with TTC staff, the Streetcar Way (tracks) section has been using Maximo Anywhere since November 2019, and the Streetcar Maintenance (vehicles) department has been using computer workstations in the carhouses since July 2019, to complete and update work orders to Maximo in real-time. Refer to Section D. 4., which discusses how Streetcar Way (tracks) and Streetcar Maintenance (vehicles) leverage Maximo in their day-to-day operations.

Recommendation:

15. The Board request the Chief Executive Officer, Toronto Transit Commission, to develop a comprehensive Maximo implementation plan to ensure Maximo is implemented as both an enterprise asset management system and workflow process management system for Streetcar Overhead Operations. This implementation plan should include, but not be limited to:

a. Detailed implementation target dates and timelines; and

b. Implementation of Maximo Anywhere to all crews, not just emergency crews.

D. 2. Provide Appropriate Maximo Training to Staff

Overhead Operations frontline crews do not use Maximo

Unlike crews in other streetcar departments/sections, frontline crews in the Overhead Operations section do not use Maximo. Currently, only a limited number of forepersons and senior clerks use Maximo.

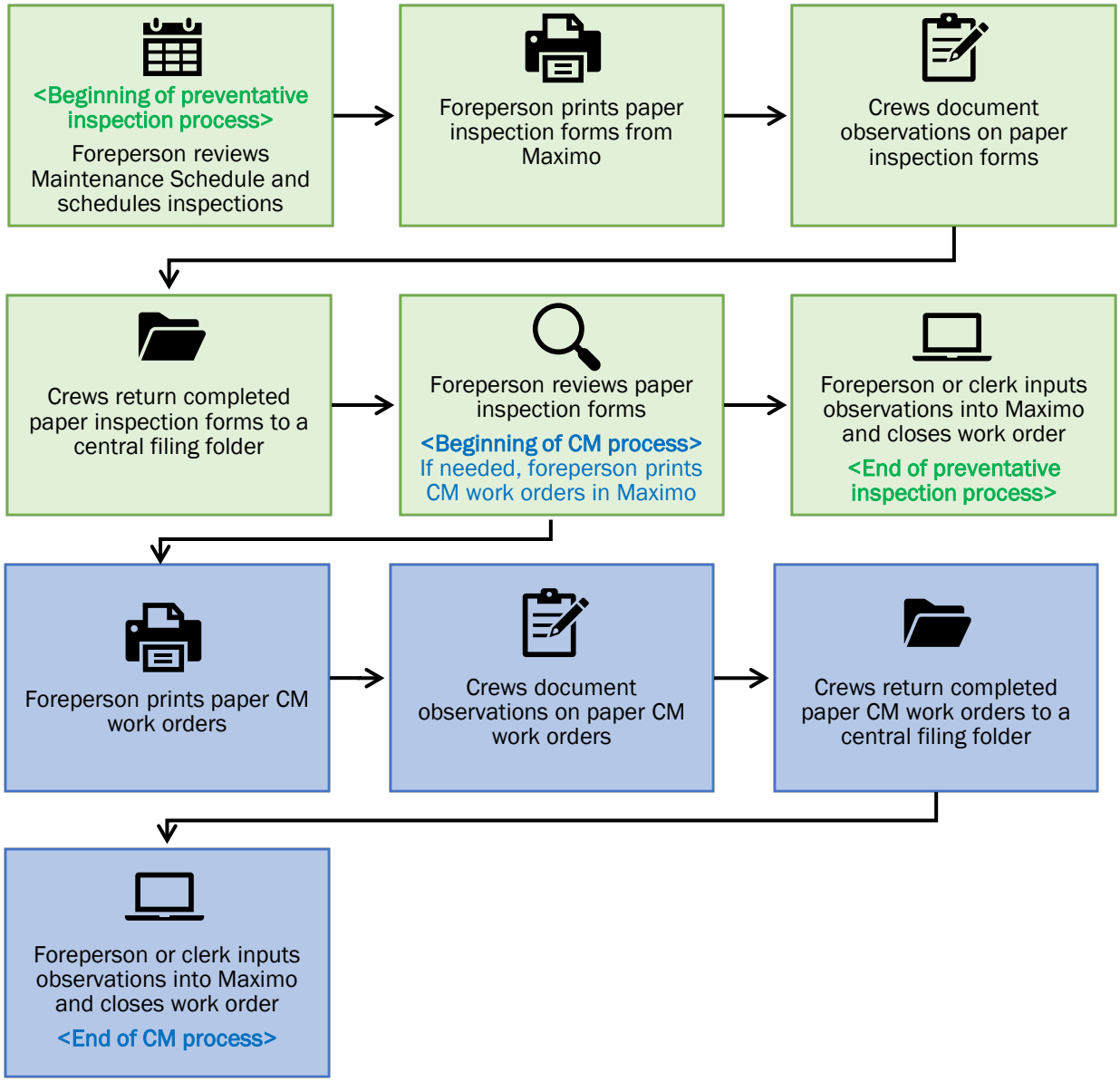
No formal Maximo training provided to Overhead Operations staff

Overhead Operations staff that do use Maximo have not received formal training on how to use it. This has limited Overhead Operations' adoption of Maximo's functionality and capabilities.

Manual and paper-driven work order process

As a result of this limited access and training, the process for work orders from Maximo involves first completing the paper printouts and then later, when time permits, inputting the information into Maximo. The current manual and paper-driven process for preventative inspections and CM work orders is outlined below in **Figure 7**.

Figure 7: Overhead Operations' Preventative Inspection and Corrective Maintenance (CM) Work Order Process



Although the work orders are ultimately generated from Maximo, the process is mostly manual and paper-driven. As evidenced by our review of work orders completed in 2022, this has led to the following inefficiencies and weaknesses that could be improved by leveraging the technology and functionalities offered by the Maximo system:

Inefficiencies due to manual data entry

- Under the current process, crews need to document their results and observations on paper printouts when they perform their work orders. Then, the Senior Clerk must manually input the information into Maximo. In 2022, the Senior Clerk spent approximately 840 hours per year performing data entry and manually closing work orders in Maximo. This is an inefficient use of the Senior Clerk's time, which could be better used on continuous improvement activities such as performing data analytics.

Risk of data loss

- We noted examples of closed work orders in Maximo that had no observations included, while the paper file had documented notes. If paper files are lost or misplaced before the Senior Clerk inputs the data into Maximo, observations and results from the work order will be permanently lost. During our audit, we noted many instances where Overhead Operations staff were unable to locate and provide us with copies of paper files.

These inefficiencies and risk of data loss would be prevented had Maximo Anywhere been implemented fully, as it has been in TTC's other streetcar departments, since crews could then input data directly into Maximo as work orders are being performed.

Recommendation:

16. **The Board request the Chief Executive Officer, Toronto Transit Commission, to provide appropriate Maximo training to responsible frontline crews/technicians/staff and management in order to fully leverage existing Maximo technology for Streetcar Overhead Operations.**

D. 3. Review and Update Asset Inventory Listing and Job Plans in Maximo

Inspection work orders are printed based on assets and job plans that are set up within Maximo

There are two key components to ensure Overhead Operations' preventative inspection program is efficient and effective:

- Overhead Operations' staff plan and schedule the preventative inspections in accordance with TTC's internal preventative inspection targets; and

- Crews complete the preventative inspection job plans (which include a set of activity tasks) consistently and completely.

Assets and job plans in Maximo are incomplete and inaccurate

We noted that Overhead Operations does not have complete and up-to-date asset information and job plans in Maximo. The sections below discuss how this impacts the planning, scheduling, and performance of preventative inspections.

Planning and Scheduling of Preventative Inspections

We found that information on the following assets and job plans were missing from Maximo:

- eleven electrical switches and one diode;
- some intersection assets and their respective inspection job plans; and
- some assets from the streetcar yards and their respective inspection job plans.

Overhead Operations manually schedules preventative inspections, whereas other streetcar departments/sections use Maximo to automate scheduling

When information on assets and job plans is not complete or accurate, Overhead Operations staff are unable to fully leverage and use Maximo functionalities to plan and schedule recurring preventative inspections. Instead, staff rely on an Excel-based Maintenance Schedule that requires manually setting and tracking work order targets on an annual basis. As previously mentioned in Section B. 3., we noted the inspections are not performed at specified time intervals and instances where annual preventative inspection targets are not met.

In contrast, the Streetcar Way (tracks) section and the Streetcar Maintenance (vehicles) department use the time-driven, system-generated work order feature in Maximo for recurring preventative inspections. This means that work orders are automatically generated after the set period (e.g., 1 week, 1 month, 6 months, 1 year) after the last completed work order lapses. This helps to ensure the scheduling of inspections is not missed and inspections are performed at specified time intervals.

Performance of Preventative Inspections

Overhead Operations crews require complete and up-to-date asset information and job plans with detailed activity tasks to understand what the assets are, where the assets are located, and what activity tasks to perform when they inspect the assets.

Not all assets have Maximo job plans

As discussed above, Overhead Operations does not have all the job plans with detailed activity tasks set up in Maximo. For these inspections, Overhead Operations crews must rely on Overhead Engineering's network prints/drawings and document their observations and results manually on blank inspection sheets.

We reviewed a sample of these inspections and noted they were either unclear or not sufficiently detailed enough to ensure the work was performed accurately, completely, and consistently. For example, we compared the completed manual inspection sheets for work performed at Leslie Barns, one of TTC's yards, from February 2022 to November/December 2022, and noted several inconsistencies between the two inspections, including the number of assets inspected.

Some Maximo job plans are incomplete and outdated

For those work orders with job plans set up in Maximo, we found instances of the following:

- Assets were missing from the job plan – As a result, either these assets were not inspected and/or observations were not documented by crews (see **Sections B. 2.** and **B. 3.** for details);

- Activity tasks in the job plan were incomplete or outdated – As a result, crews did not perform certain activity tasks and did not report the need for corrective maintenance and repairs, which increased the risk of asset failures and service delays (see **Sections B. 2.** And **B. 3.** for details); and

- Assets listed in the job plan do not exist – If these errors go unnoticed, confusion can arise and crews may mistakenly record measurements and observations for the wrong assets. We noted work orders where crews crossed out their observations after realizing the job plan listed an asset ID that did not exist.

Whether crews are using manual inspection sheets or work orders printed from Maximo, a lack of up-to-date assets and job plans containing accurate and complete activity tasks increases the risk of assets not being inspected. Given Maximo is a helpful tool for Overhead Operations to make improvements and address many of our recommendations, it will be important to not only use the system, but to ensure that the asset inventory, job plans, and activity tasks in Maximo are complete and accurate.

Recommendation:

17. The Board request the Chief Executive Officer, Toronto Transit Commission, to review and update Streetcar Overhead Operations' asset inventory and job plans/activity tasks in Maximo to ensure they are complete, accurate, and up-to-date, in order to support the planning and completion of repair and maintenance work.

D. 4. Use Maximo to Track Status of Work Orders and Asset Inventory Information

No electronic real-time work order status monitoring process

Overhead Operations does not have complete and accurate data about the status of the work orders in Maximo. Management must rely on paper files and a paper filing system (e.g., work orders, daily work reports) to manage work orders and determine which are completed or outstanding, or need further action or follow-up. For example, preventative inspections and corrective maintenance work orders that have been printed from Maximo but are not completed, are kept in physical folders in the Overhead Operations office that are labelled "Preventative Inspections to be completed" and "CMs to be completed," respectively.

Work orders are not closed in Maximo in a timely manner

According to Overhead Operations' work order process, forepersons or clerks should be closing work orders in Maximo when paper files are completed and returned by the crews. **Figure 8** below summarizes the open work order statuses in Maximo as of June 6, 2023, which illustrates that work orders are not being closed in a timely manner in Maximo. While we were unable to determine the number of Maximo work orders that were not completed, we did identify work orders that were completed but not closed in Maximo.

Figure 8: Open Work Order Statuses* in Maximo, as of June 6, 2023

	Work orders generated in:		
	2022	**2021**	**2020**
# of work orders with open status	777	978	1,043
# of total work orders	2,016	2,283	3,681
% of open work orders over total work orders	39%	43%	28%

* These only represent the work order system statuses shown in Maximo. An open status does not necessarily mean the work order has not been completed.

Through our review of work orders completed, we noted it often takes several months for these work orders to be updated and closed in Maximo. See **Figure 7** in **Section D. 2.** for a diagram of the work order process. Without up-to-date information on the status of work orders, it is difficult for Overhead Operations to manage work orders and ensure that required repairs and maintenance work allocated to the crews are completed as required and that no duplication or redundant work is being performed.

Maximo work order statuses are inaccurate

We found that the lack of up-to-date information on work order statuses led to the same work order being completed multiple times. This is an inefficient use of time and resources, as well as an indication of poor documentation practices. For example, in one of the instances noted in Section B. 3., the same work order was completed twice with the redundant second inspection completed just 16 days after the first inspection. This error occurred because the first inspection was neither recorded in the Excel-based Maintenance Schedule, nor was it updated and closed in Maximo after completion.

Other streetcar department/section use Maximo to manage work orders more efficiently and effectively

In contrast, per discussion with TTC staff, forepersons and supervisors from the Streetcar Way (tracks) section and the Streetcar Maintenance (vehicles) department use the information and reports in Maximo to manage work orders. For example:

- The Streetcar Maintenance (vehicles) department generates a report on all the 'open' work orders, which the scheduler can use to plan and allocate work to technicians;
- The Streetcar Way (tracks) section generates a report on work order statuses to identify which preventative inspections are approaching their next scheduled date and which ones may be overdue, to help manage and prioritize work; and
- The Streetcar Way (tracks) section also uses Maximo to send auto-generated email notifications to forepersons when work orders are not closed within 72 hours. This helps forepersons to follow up and investigate open work orders in a timely manner.

Recommendation:

18. The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement a process in Streetcar Overhead Operations using Maximo to track the real-time status of work orders to support ongoing work order management and supervision.

Use Maximo to Collect and Track Asset Inventory Information for Data and Trend Analysis

Asset and related maintenance work details are incomplete in Maximo

In addition to updating the status of completed work orders, the observations, comments, and results of work orders (e.g., measurements, problems found, actions taken) should also be input into Maximo from the paper copies of the work orders. However, we noted these details were not always entered into Maximo and therefore were not always tracked.

Emergency maintenance details are not logged and tracked in Maximo

If work order observations and measurements are not input into Maximo, Overhead Operations staff will likely lose track of them after the paper copy is filed away or if it is misplaced. Additionally, per discussion with TTC staff, unlike the Streetcar Way (tracks) section and the Streetcar Maintenance (vehicles) department, Overhead Operations does not use Maximo to log and track details of its emergency maintenance work (e.g., asset, location, date/time, issue, action). Therefore, forepersons and supervisors rely on paper files, such as the crews' daily work reports, when reviewing and assessing emergency maintenance work performed.

Maximo system data is incomplete and cannot be used for data analytics

Because information is primarily retained only in the paper copies of work orders and other hard copy crew reports, Overhead Operations does not have complete and accurate information about the assets within Maximo for trend analysis and data mining to identify systemic issues. This makes it difficult to identify opportunities to support continuous improvement in the preventative maintenance program.

Inefficient and limited data-driven analysis

For example, predicting how often wire or fittings need to be replaced is based on historical data. As wear and tear depends on streetcar traffic, the replacement frequency will vary across the network. Historical data needs to be collected and analyzed to determine when assets will most likely fail, which could then dictate an optimal preventative inspection and asset replacement frequency.

Currently, to perform this analysis, staff would have to review thousands of paper copies of preventative inspections, corrective maintenance and emergency maintenance work orders, and records related to the asset. This would require considerable time to both find the paper copies and perform the analysis manually.

Opportunity to use Linear Asset Manager in Maximo in future

Given the linear nature of the assets (e.g., the contact wire between two intersections, the span wire between two poles) within the OCS, Maximo Linear Asset Manager can be used to define and maintain linear assets effectively. Crews would be able to locate specific assets or the area requiring maintenance more effectively, as the precise location needing attention is recorded as a measurement along the linear asset. For example, a section of the contact wire between two intersections that requires replacement would be precisely measured and defined in Maximo so it is easily located by crews. Management advised that Maximo Linear Asset Manager is part of Overhead Operations' long-term intention to use Maximo as an asset management system.

Collecting and storing the appropriate data and information about the assets within Maximo will provide Overhead Operations with an opportunity to better define its assets and perform data analyses to optimize the effectiveness and periodicity of its maintenance activities.

Streetcar Way (tracks) and Streetcar Maintenance (vehicles) use Maximo as a database for data analytics, KPI reporting, and asset condition monitoring

In contrast, per discussion with TTC staff, the Streetcar Way (tracks) section and Streetcar Maintenance (vehicles) department use Maximo as an information database, which leverages the benefits of this technology. For example, staff of Streetcar Way (tracks) and Streetcar Maintenance (vehicles) advised that:

- They use Maximo to document issues noted during inspections, repairs, and maintenance work performed. Therefore, they can generate exception reports or customized parameter reports in Maximo to identify potential issues that may require them to perform more in-depth investigations to determine root causes. These reports can also support their efforts to continuously improve their maintenance and repair programs and procedures.

- They use Maximo data to improve the accuracy of their KPI reporting (see **Section E. 4.** for details on this issue for Overhead Operations).

- They use Maximo's Condition Monitoring application to ensure that asset conditions are within the acceptable ranges.

Recommendation:

19. **The Board request the Chief Executive Officer, Toronto Transit Commission, to leverage Maximo to collect and track observations from Streetcar Overhead Operations' assets inspections, and information about maintenance and repairs activities, that can be used for data mining and trend analysis to support Key Performance Indicator reporting and inform decision-making.**

E. Enhance Data Collection and Performance Reporting to Improve Streetcar Overhead Operations

Audit objective #3 - Streetcar overhead policies and procedures, and performance reporting and monitoring

Our third and last audit objective examined whether there are opportunities for the TTC to strengthen its policies, procedures, standards, and Key Performance Indicators (KPI) related to streetcar overhead.

Opportunities for TTC to strengthen its streetcar overhead policies and procedures as well as to further improve its performance reporting processes

As previously discussed in **Sections B** and **C**, there is a lack of formalized maintenance and inspection manuals, policies, procedures, and standards that clearly define and outline expectations for Overhead Operations staff and crews. There is also a lack of oversight processes that monitor and enforce consistency among crews. This has led to considerable variability in how preventative inspections are performed and documented, and to corrective maintenance and repairs not always being completed in a timely manner.

In **Section E**, we note opportunities to further improve Overhead Operations' performance reporting process by adding more outcome-focused KPI metrics that assess the timeliness and quality of the maintenance and repair services.

E. 1. Establish Outcome-Focused Key Performance Indicators

Overhead Operations' Key Performance Indicators (KPI) reporting process

Overhead Operations' regular Key Performance Indicator (KPI) reporting includes measures such as the number of preventative inspections, maintenance and repairs performed in the period, Supervisory Spot Checks (to comply with legislative safety requirements), overtime, OCS failures, electrical switch failures, delay incidents and minutes, and data specific to Automatic Drop Down delays (refer back to **Section A. 2.** for details on Automatic Drop Down delays).

Overhead Operations has been proactively making improvements to its KPI reporting process

In comparing the monthly KPI packages in 2022 and 2023, we noted that Overhead Operations has been proactively making improvements to its KPI reporting process during this period. In particular, we noted more commentary and details being tracked and documented, as well as more robust variance analysis and explanations provided with the KPI results. For example, Overhead Operations have added:

- an explanation for the differential between the period's preventative inspection target and the actual number of preventative inspections performed;
- details regarding corrective maintenance work orders that are still outstanding at the end of each period; and
- a prior period comparison on the number of Automatic Drop Down incidents, as well as a breakdown of departmental accountability for these incidents.

We acknowledge that Overhead Operations has continuously made changes to improve its KPI reporting process. In addition, we have identified the following areas for further improvement:

More outcome-focused KPIs for timeliness and quality of maintenance and repair services

Through cross-departmental benchmarking of KPIs, we noted that the Streetcar Maintenance (vehicles) department reported on the following monthly KPIs that the Overhead Operations section did not, but could benefit from adding to their KPI reporting:

A KPI that measures the timeliness of maintenance and repair services

- Timeliness of repairs and maintenance – This KPI will be useful for Overhead Operations as we identified 174 (46 per cent) of 380 CM work orders in 2022 that were completed two weeks or more after the work order was generated. Please refer back to **Section C. 1.** for more details on this testing.

A KPI that tracks the number of overdue preventative inspections

- Overdue preventative inspections – This KPI will also be useful for Overhead Operations as we identified that the annual preventative inspection target was not met for 21 (48 per cent) of the 44 sampled assets tested. Please refer back to **Section B. 3.** for more details on this testing.

KPIs that measure the quality and reliability of maintenance and repair services

- Repeat emergency repairs, frequent corrective maintenance and unresolved problems – These KPIs will be helpful as we noted instances of recurring work orders for the same issue on the same assets at the same locations in 2022. These KPIs measure the quality and reliability of maintenance and repair services performed.

E. 2. Ensure Key Performance Indicators Are Appropriate and Accurately Measured

From our review of the Overhead Operations' KPI reports and available supporting documentation, we noted the following KPIs that need improvement:

Operating and capital overtime were understated by 27% and 17%, respectively

One of Overhead Operations' KPIs currently tracks the number of overtime hours worked per period. However, unlike the Streetcar Maintenance (vehicles) department, Overhead Operations only tracks the overtime of unionized employees and not that of non-unionized staff (i.e. supervisory staff) in its KPI reporting. As a result, Overhead Operations' reported overtime was understated by 1,228 (27 per cent) operating hours and 912 (17 per cent) capital hours in 2022.

KPI that measures the preventative inspections-to-CM ratio (PM-to-CM ratio) should be reassessed

We also noted the following issues with the accuracy and calculation of Overhead Operation's KPI on PM-to-CM ratio:

- We noted that the number of CMs included in the PM-to-CM ratio calculation did not include the corrective maintenance work that was performed on the spot during the preventative inspection because no CM work order was created for these activities. As a result, the amount of CM work performed may be understated in the current KPI reporting.

- The degree of time and effort required to complete work orders can vary significantly. However, this was not taken into consideration as Overhead Operations' current PM-to-CM ratio is measured only by the number of work orders completed and not the time spent.

- We also noted inconsistency in how the PM-to-CM ratio is calculated. Overhead Operations includes only CM work orders while the Streetcar Way (tracks) section includes both CM and emergency maintenance work orders when calculating the CM component of the ratio.

E. 3. Ensure Performance Targets Are Clearly Defined

Establish clearly defined performance targets

From our review of the KPI reports and available supporting documentation, we noted that several KPIs did not have clearly defined and established targets. For example, the PM-to-CM ratio does not have an established target, and other KPIs such as Automatic Drop Down incidents have informal targets that are not documented in the KPI reporting package.

We also noted that Overhead Operations used different targets for different reports. For example, we found the KPI reports showed an annual target of 956 preventative inspections, whereas the Maintenance Schedule (which is used to plan, schedule, and track preventative inspections) showed an annual target of 822, a difference of 134 work orders in total.

Without clearly defined targets for each KPI, Overhead Operations may not be able to effectively communicate short-term goals, keep Overhead staff accountable, and measure performance on a consistent basis.

E. 4. Retain and Verify the Accuracy of Supporting Data Used for KPI Reporting

Overhead Operations should retain the data necessary to support reported KPIs

Overhead Operations was unable to provide all the data and documents to support the numbers being reported in their KPIs. Without available and complete/accurate supporting data, the reliability and usefulness of the KPI reporting may be limited and cannot fully inform continuous improvement initiatives.

Accurate and complete KPI reporting is critical for its effectiveness

It is important for Overhead Operations to retain and verify the accuracy of data used for KPI reporting, as we found discrepancies in the data in our review of a sample of KPI reports. For example, for period three of 2022, the KPI report's number of preventative inspections, CMs, and emergency maintenance work orders did not reconcile with the actual count of work order paper files. Based on our understanding of the current process and practice, the differences could be due to any or a combination of, but are not limited to, the following:

- Work order paper files were misplaced after being counted for the KPI reporting.
- Work order paper files were not returned in time for the Overhead Operations staff to include in the KPI reporting.
- Understanding of which types of maintenance and repair work should be counted for preventative inspection, corrective maintenance, and emergency maintenance work orders was inconsistent.
- Work orders were miscounted.

We also noted the total overtime hours presented in the monthly KPI reports did not reconcile with the hours in the payroll system report, which was used to calculate the actual overtime expenditures for the period. Management informed us that the discrepancies may be due to the following reasons:

- KPI information includes all overtime worked, which may include overtime taken as lieu time, whereas the payroll system report only includes paid overtime.
- Job information on the daily work reports that is entered for KPI reporting could subsequently be changed (e.g., due to errors found) before it is entered into the payroll system. These changes are not always communicated back to Overhead Operations to update the KPI reporting.

Accurate and complete KPI reporting is critical for being able to measure performance and use the reporting for informed decision-making to help drive change and continuous improvements.

Recommendation:

20. The Board request the Chief Executive Officer, Toronto Transit Commission, to improve the Key Performance Indicator reporting for Streetcar Overhead Operations by:

a. Establishing clearly defined, appropriate, outcome-focused Key Performance Indicators and targets;

b. Developing short- and long-term strategies to meet these targets;

c. Regularly reassessing to determine whether Key Performance Indicators and targets need to be revised; and

d. Retaining supporting data and verifying the accuracy of data used for Key Performance Indicator reporting, ongoing oversight, and management decision-making.

Conclusion

TTC's Overhead Operations' maintenance and repair program's goal is to support safe and reliable streetcar service

This report highlights the results of our audit of the Toronto Transit Commission's Streetcar Overhead Operations' maintenance and repair program, whose goal is supporting safe and reliable streetcar services. Overhead Operations' maintenance and repair program plays a vital role in preventing and minimizing asset failures and resulting service delays, which impacts the safety and customer service of streetcar operations.

Annual inspection targets and corrective maintenance timeline targets not met

Inadequate investigation of asset failures

For our first audit objective, to assess the TTC's streetcar overhead maintenance and repairs activities, we found the preventative inspections are not always meeting their annual inspection targets. We also found that the corrective maintenance and repairs program lacks the clear guidance and criteria needed to prioritize the completion of corrective maintenance and repairs in a timely manner. Most importantly, we noted inadequate data collection and investigations into the root causes of a number of asset failures, which is critical to preventing similar asset failures in the future.

Maximo implementation and digital transformation required to improve efficiency and effectiveness of operations

For our second audit objective, to assess the TTC's use of data and technology in managing operations and informing decisions, we found that Overhead Operations is underutilizing Maximo, which has resulted in using a primarily manual and paper-driven process. Using Maximo to its full potential as an asset management and workflow management system will help Overhead Operations transition to a digital data environment and reduce inefficient manual processes. Using Maximo as an information database will also allow Overhead Operations to perform data analytics that will support the section's continuous improvement initiatives to increase service reliability and safety, while optimizing the use of time and resources.

Needs to strengthen policies, procedures, and monitoring of maintenance and repair program

For our third and last audit objective, to assess the TTC's policies, procedures, and performance reporting related to streetcar overhead, we found that a lack of a formalized maintenance and inspection policies, procedures, and manuals, coupled with a lack of oversight processes, led to considerable variability in how preventative inspections are performed and documented. This also resulted in untimely corrective maintenance and repairs. We noted opportunities to further improve Overhead Operations' performance reporting process by adding more outcome-focused KPI metrics that assess the timeliness and quality of the maintenance and repair services, and improving the accuracy and completeness of the supporting information and data.

20 recommendations to improve efficiency and effectiveness of TTC's Overhead Operations' maintenance and repair program

In our view, implementing the 20 recommendations contained in this report will help the TTC improve the efficiency and effectiveness of its Overhead Operations' maintenance and repair program, by strengthening their asset and workflow management processes, leveraging technology, and enhancing their policies and procedures.

In particular, the recommendations identify opportunities for:

- better planning, scheduling, and tracking of the preventative inspections and corrective maintenance and repairs to optimize the use of available resources;
- strengthening policies and procedures that provide clear guidance and expectations to Overhead Operations staff and crews to improve consistency;
- improving performance monitoring and reporting, as well as the effectiveness of the maintenance and repair program as a whole; and
- leveraging technologies and enhancing the way data is captured and used to improve decision-making abilities and continuous improvement initiatives.

Audit Objectives, Scope, and Methodology

Audit included in the 2022 Work Plan

The Auditor General's 2022 Work Plan included an audit to assess the effectiveness and efficiency of TTC streetcar operations and services.

Audit objectives

The objective of this audit is to assess whether the TTC's streetcar overhead maintenance and repair activities support safe and reliable streetcar operations. This audit aims to answer the following questions:

- Are the TTC's streetcar overhead infrastructure assets maintained and repaired in accordance with the TTC's policies and procedures and relevant industry standards?
- Are there opportunities for the TTC to further leverage the use of data and technology in managing its work orders, informing decision-making, and managing Overhead Operations services?
- Are there opportunities for the TTC to strengthen its policies, procedures, standards, and Key Performance Indicators related to streetcar overhead?

Audit scope

The audit scope focused on the TTC's Overhead Operations, although some limited work was done in the TTC's other streetcar sections and departments to gain an understanding of the benefits of fully using the Maximo system. As there have been significant changes to the Overhead Contact System (OCS) over the last few years (e.g., transitioning from the trolley pole to hybrid to pantograph only system), the audit period focused on the more current ongoing preventative inspections, maintenance, and repairs performed by Overhead Operations, from January 1, 2022 to December 31, 2022. Where relevant to our audit, we examined certain records and data outside this period. Our findings and conclusions are based on the information and data provided by the TTC at the time the audit was completed.

Limitations

From our review, we were unable to rely on the accuracy and completeness of the data within the Maximo system. As a result, our scope of the maintenance and repairs program was limited to the records retained from Overhead Operations' paper-based system. In some instances, the paper records of work orders could not be found and data from prior periods was unavailable. Consequently, we were unable to confirm the completion of the maintenance work performed due to a lack of supporting documents.

In addition, we were also unable to verify or rely on the accuracy and completeness of Overhead Operations' performance reporting results of the number of preventative inspections, CMs, and emergency maintenance work orders, as we noted differences in our reconciliation between the KPI results and the supporting paper records. Based on our understanding of the current process and practice, and as previously discussed in **Section E. 4.**, the differences between the KPI report's results and the paper records could be due to misplaced paper records, paper records not being included in the KPI reporting, a misunderstanding of which types of maintenance and repair work should be included in the KPI reporting, and/or work orders being miscounted in the KPI reporting.

Areas not covered within the scope of this audit

The following areas were not covered within the scope of this audit:

- capital planning, construction, and installation of OCS assets and electrical switches; and
- pre-servicing and cleaning of streetcar vehicles, which includes work on the trolley poles that attach to OCS assets (a responsibility of the Streetcar Maintenance department).

In addition, the scheduling of Overhead Operations crews was not within the scope of this audit. An audit of TTC's Workforce Planning and Management, which will include streetcar operations, is included in our Office's 2023 Work Plan.

Support services provided by other departments were also not specifically within the scope of this audit. However, we used these other departments for best practice research and benchmarking with Overhead Operations, where applicable.

Methodology

Our audit methodology included:

- reviewing Acts, legislations, regulations, and any other relevant industry best practices and standards;
- reviewing TTC policies and procedures, and any other relevant internal guidelines;

- reviewing TTC budget information, strategic plans, and internal and external reviews;
- reviewing delay logs, paperwork order files, Key Performance Indicator (KPI) reports, and Maintenance Schedule and daily crew reports;
- reviewing assets and work order records and details within Maximo;
- conducting site visits of TTC streetcar facilities and yards;
- interviewing staff from various TTC departments/sections such as:
    - Streetcar Infrastructure – Overhead Operations
    - Streetcar Infrastructure – Overhead Engineering
    - Streetcar Infrastructure – Streetcar Way (tracks)
    - Streetcar Maintenance (vehicles)
    - Streetcar Transportation (streetcar operators)
    - Transit Control
    - Service Planning
- performing ride-alongs with overhead crew;
- conducting other procedures that were deemed relevant.

Compliance with generally accepted government auditing standards

We conducted this performance audit in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Exhibit 1: Areas and Components of the Overhead Contact System

Areas of the Overhead Contact System (OCS) Network

Intersection – An area of the OCS network (e.g., road intersection) where two or more overhead contact wires intersect.

Tangent line – An area of the OCS network with no intersecting overhead contact wires.

Underpass – An area of the OCS network where the overhead assets are installed in an above-ground, street-level tunnel that passes under a raised roadway or railway.

Tunnel – An area of the OCS network where the overhead assets are installed in an underground tunnel between an underground streetcar stop and the above-ground, street-level network.

Loop – An area of the OCS network where the streetcar travels in a circular route to turn around to proceed in the opposite direction.

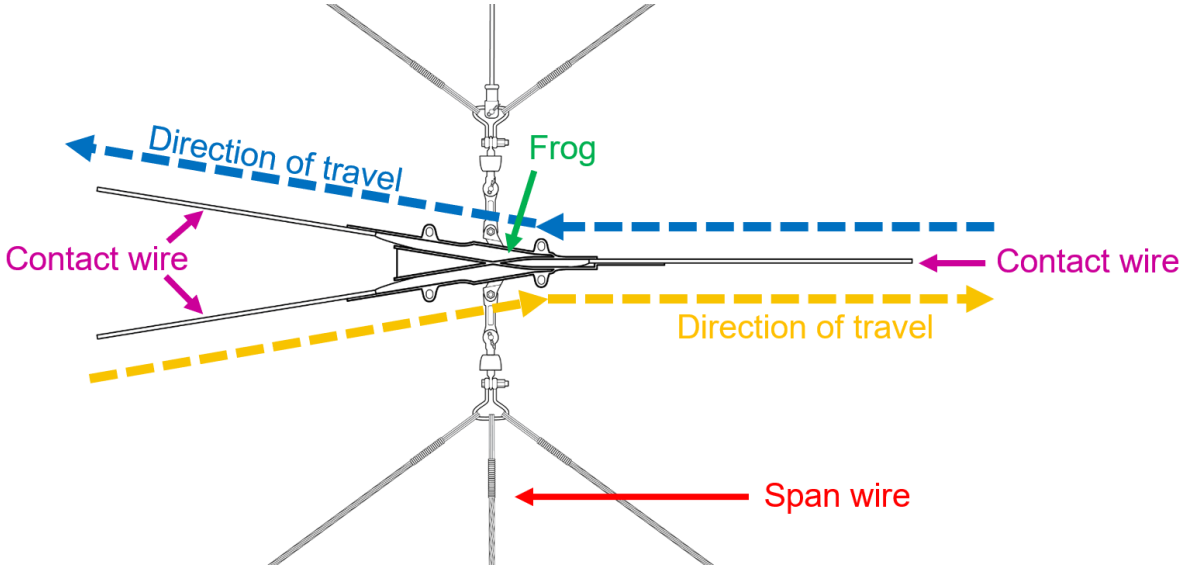
Yard – An area of the OCS network where the streetcar vehicles are stored and serviced when not in service.

Overhead Contact System Assets Maintained by Overhead Operations

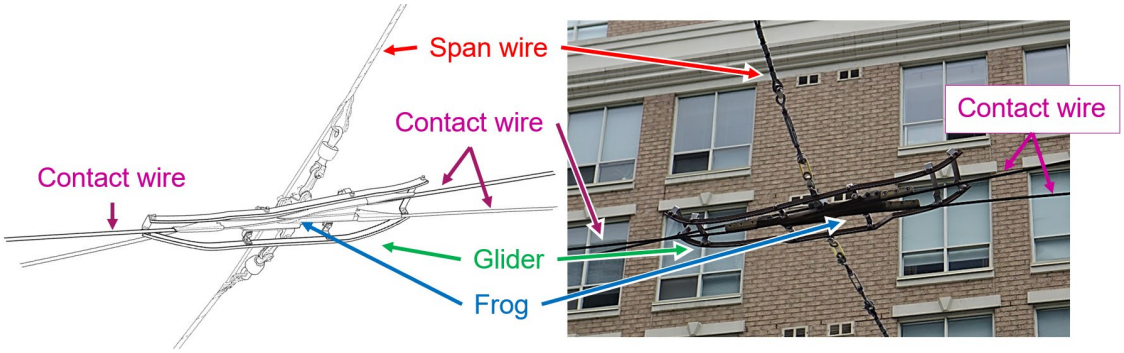
Contact wire – The overhead electrical wire with which the pantograph or trolley pole makes contact to supply power to the streetcar vehicle. The contact wire carries 600 VDC electricity.

Frog – A frog allows the trolley pole to travel along connecting (yellow arrows) or diverging (blue arrows) overhead contact wire (usually through a switch). The blue and yellow arrows indicate the different directions streetcars can travel through the frog.

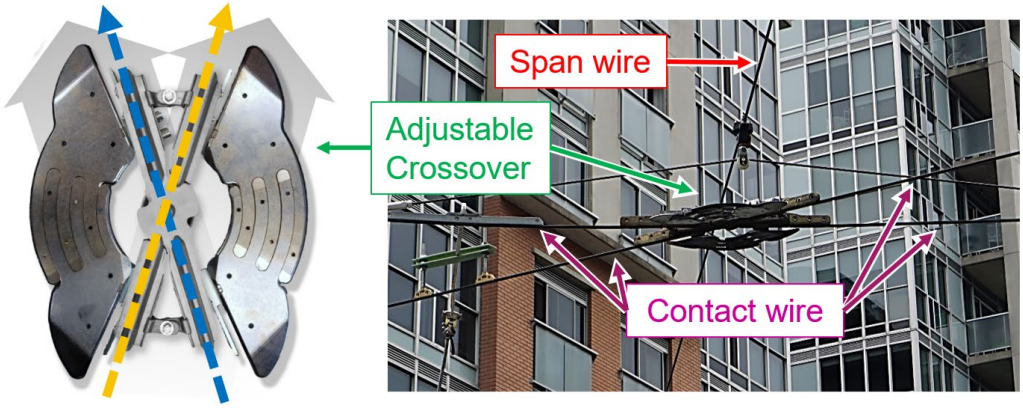
Span wire – Span wires hold up and support the OCS's hardware components and contact wire. They are insulated at both ends and attached to buildings or poles.



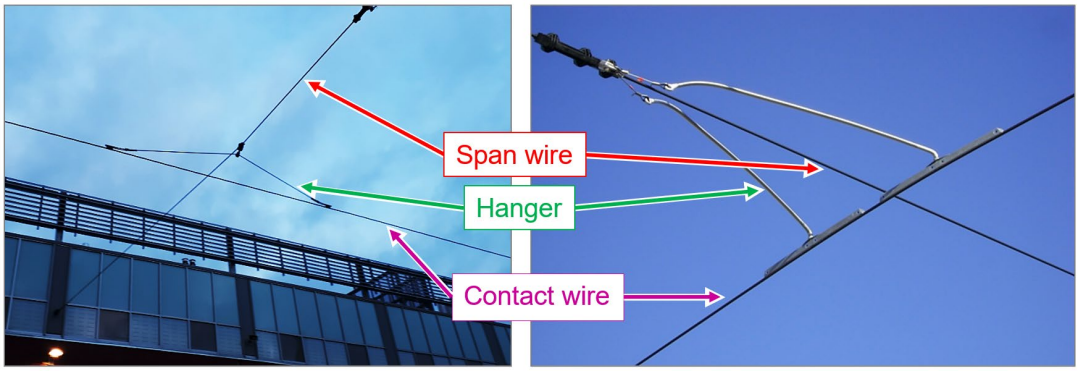
Glider (also, frog and glider combination unit) – As the pantograph cannot travel through a frog, gliders are added under the frogs. Gliders force the pantograph under the frog but let the trolley pole travel through it.



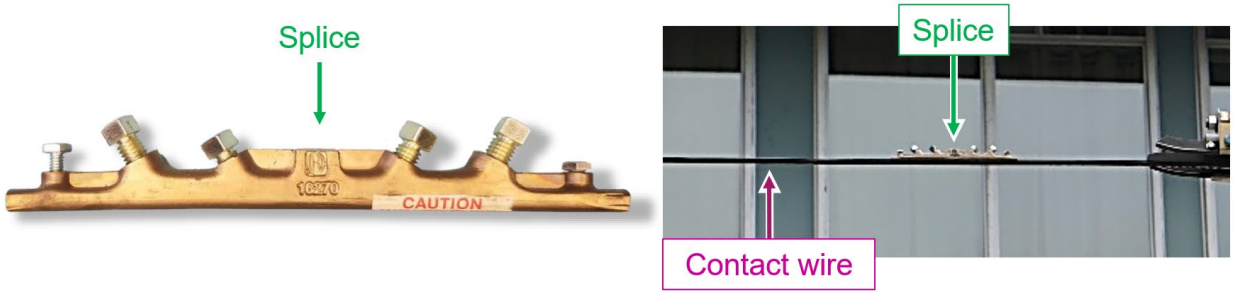
Adjustable crossover – An adjustable angle fitting that facilitates contact wires to intersect at angles between 30 and 90 degrees. This hardware piece allows streetcars to travel unhindered without electrical disconnection past a point where contact wires intersect (e.g., in intersections). The blue and yellow arrows illustrate the direction the streetcars would travel through the adjustable crossover.



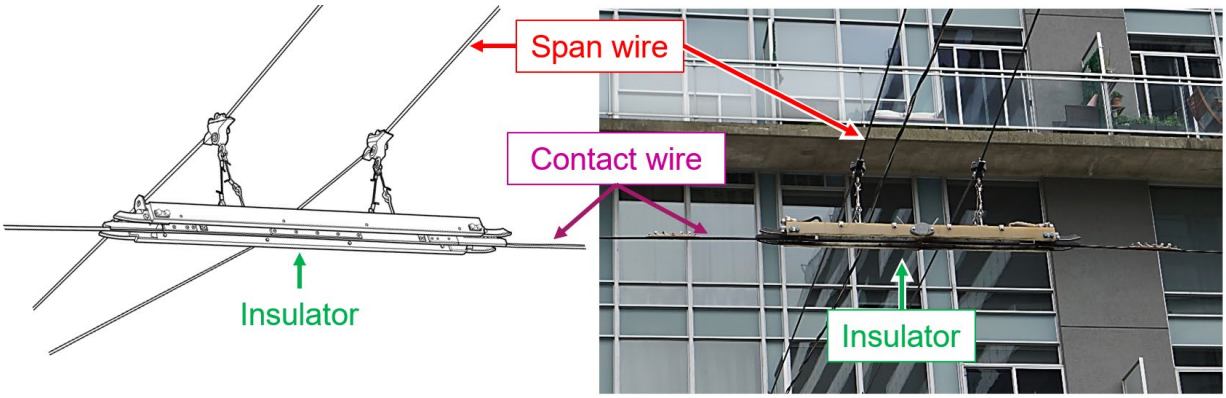
Hanger – Hangers clamp and hold the contact wire up and away from the span wires. The OCS uses two different types of hangers. Left: a stitch (suspension) hanger, used mainly for straight roadways; right: a pullover (high-tension conductor) hanger, used in intersections to follow track curves.



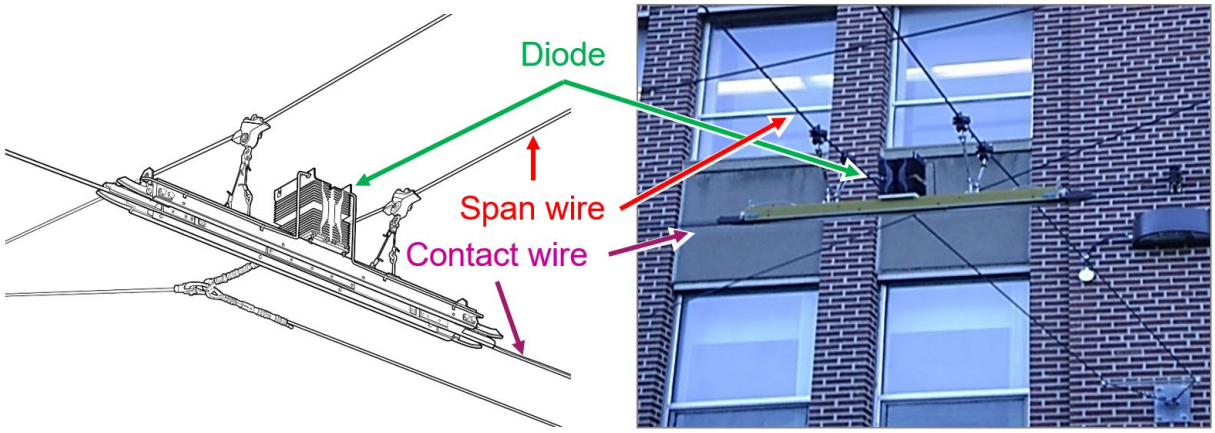
Splice – A hardware component that joins two pieces of tensioned overhead contact wire together and allows streetcars to travel through.



Section insulator – A device for dividing a contact wire into two electrical sections so if one area needs to be de-energized for maintenance, it will not affect the rest of the line.



Diode – A diode is a device that acts as a one-way switch for electrical current. It allows the electrical current to flow easily in one direction, but severely restricts current from flowing in the opposite direction.



Other Assets Maintained by Overhead Operations

Electrical switch control box – The electrical switch control box is located on a pole near the electrical switch point. It contains the electrical hardware that receives, processes, and acts on wireless signals initiated by the streetcar operators that are approaching the electrical track switch.

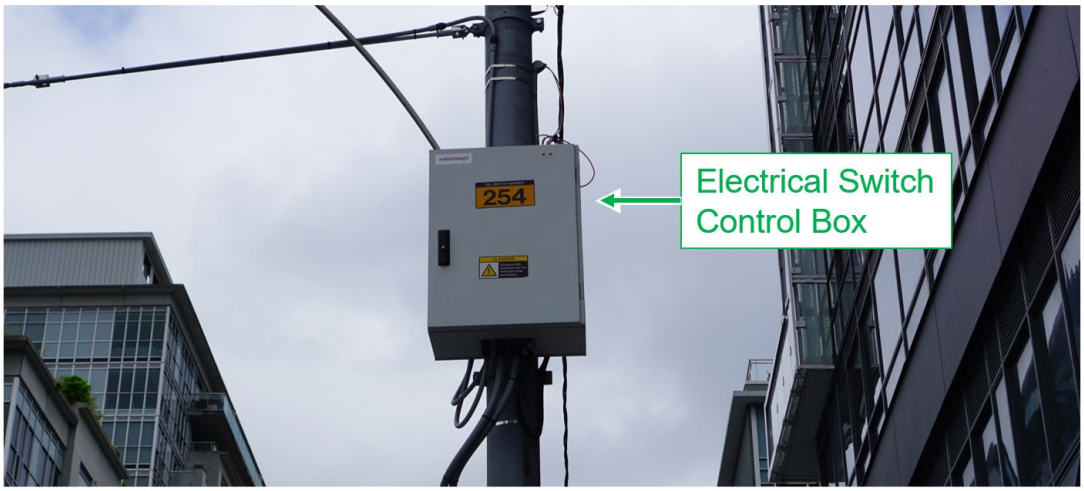
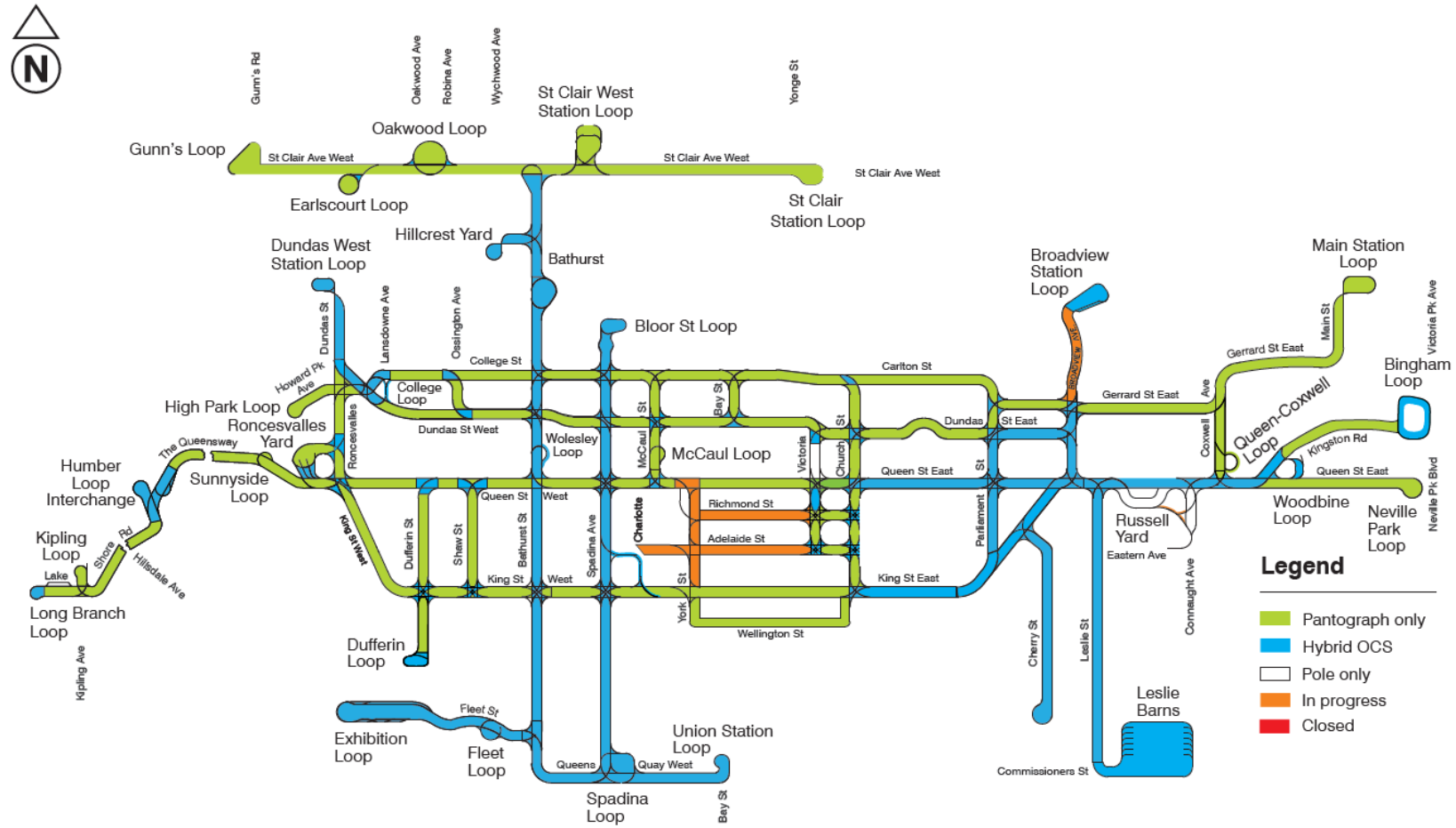


Exhibit 2: TTC's Streetcar Overhead Contact System, as of October 28, 2023



Source: TTC Streetcar Overhead Operations

Appendix 1: Management's Response to the Auditor General's Report Entitled: "Audit of the Toronto Transit Commission's Streetcar Overhead Assets: Strengthening the Maintenance and Repair Program to Minimize Asset Failures and Service Delays"

Recommendation 1: The Board request the Chief Executive Officer, Toronto Transit Commission, to support continuous improvement and increase streetcar service reliability by:

a. **Reassessing and strengthening existing policies and procedures in Streetcar Overhead Operations to provide more criteria and clarity on the nature and extent of the root cause analysis and investigation required for service delays;**

b. **Determining the root causes for those delays that require investigation according to the policy, in order to prevent the same issues from recurring; and**

c. **Developing and implementing a process in Streetcar Overhead Operations to ensure compliance with the policies and procedures regarding root cause analyses and investigations of service delays.**

Management Response: ☒ **Agree** ☐ **Disagree**
Comments/Action Plan/Time Frame: We agree with the above recommendations and as part of our on-going comprehensive review of the current policies and procedures, we will focus on investigating root cause for service delays. Specific criteria and clarity for root cause analysis and investigations for service delays will be established by quarter 1 of 2024. Although we currently conduct investigations and determine the root cause to prevent the same issues from reoccurring on safety-critical incidents and incidents resulting in significant delays, such as Automatic Drop Down incidents, we commit to further investigations of root causes based on the criteria outlined above after reassessing and strengthening existing policies and procedures. Ensuring compliance with policies and procedures will be achieved through a combination of strategies such as defined documentation, training & awareness, consistent audits and inspections, well-established reporting mechanisms, employee feedback, continuous improvement and management oversight to reinforce the importance of adherence to policies and procedures by quarter 4 of 2024.

Recommendation 2: The Board request the Chief Executive Officer, Toronto Transit Commission, to improve communication and information sharing across relevant streetcar and other departments, in order to support continuous improvements and reduce the number of fail-to-operate switch emergency calls. Information collection and sharing across these departments should include:

a. **Collecting and tracking appropriate and relevant data regarding fail-to-operate switch emergency calls, including but not limited to switch IDs, number of calls, and their results; and**

b. **Using the data collected to perform root cause analyses and investigations with the goal of reducing the number of fail-to-operate switch emergency calls.**

Management Response: ☒ **Agree** ☐ **Disagree**
Comments/Action Plan/Time Frame: We commit to improving the collection and tracking of appropriate and relevant data regarding fail-to-operate switch emergency calls, including but not limited to switch IDs, the number of calls, and their results by quarter 2 of 2024, with the support of an Engineering Technologist. Currently, some of the data

is captured in the delay logs which can be data mined to determine current frequency and trends at various switch locations across the network. In the short term, an analysis for sharing the current data with all relevant stakeholder departments will be conducted. Reducing the number of fail-to-operate switch emergency calls and correlated delays has been an on-going goal for Streetcar Overhead. Furthermore, data collected and analyzed will be used to determine if incidents are discrete in nature or systemic for the purposes of implementing appropriate mitigation measures to address specific types of failures. In the long term, we will engage our IT department to assess the most suitable method to collect and track data related to fail-to-operate switch emergency calls in an enterprise database that can be shared across the TTC. Subsequently, we will proceed with their recommendation, taking into account budget and implementation considerations.

Recommendation 3: The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and use a centralized database of Overhead Operations' assets across departments (Streetcar Infrastructure, Transit Control, Streetcar Transportation) to ensure Streetcar Overhead Operations is using an accurate and complete asset database, including a centralized switch inventory, to inform their operational decision-making and optimize their resource allocation.

Management Response: ☒ **Agree** ☐ **Disagree**

Comments/Action Plan/Time Frame:

We agree with the recommendation and will collaborate with the relevant departments to create a centralized switch inventory to be incorporated into an enterprise asset database to be used as a single source of truth when referring to any and all switch assets in the streetcar network. The target to establishing a centralized switch inventory system will be end of quarter 3 2024. As part of the on-going enterprise asset management program, TTC is updating its asset hierarchy, establishing asset data model and data strategy, which will be used in the data collection and data cleansing process prior to migrating Streetcar Overhead asset data into a centralized database of assets. This will be completed by quarter 4 of 2025.

Recommendation 4: The Board request the Chief Executive Officer, Toronto Transit Commission, to implement policies and procedures in Streetcar Overhead Operations, including oversight and monitoring policies and procedures, to ensure the assets in the Maintenance Schedule are always accurate and complete, and that any required asset changes, additions, and/or removals are made to the Maintenance Schedule on a timely basis.

Management Response: ☒ **Agree** ☐ **Disagree**

Comments/Action Plan/Time Frame:

In order to satisfy Ontario Regulation 588-17 recently invoked, Streetcar Overhead recruited for asset management resources, with responsibilities that include but are not limited to providing oversight in ensuring accuracy and completion of assets in the Maintenance Schedule. We concur with the recommendation and will continue to establish and implement policies and procedures within Streetcar Overhead, particularly focusing on oversight and monitoring, to ensure the Maintenance Schedule accurately and comprehensively represents our assets. The on-going review of the policies and procedures will include ensuring the swift and efficient incorporation of any required changes, additions, or removals into the enterprise asset database and the corresponding updates to the Maintenance Schedule. Please see Recommendation 5 for an applicable execution plan.

Recommendation 5: The Board request the Chief Executive Officer, Toronto Transit Commission, to implement policies and procedures in Streetcar Overhead Operations to ensure all completed work orders are recorded on the Maintenance Schedule, in order to plan, manage, and schedule preventative inspections in an efficient manner that optimizes the use of time and resources.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We concur with the recommendation and will continue to establish and implement policies and procedures of work orders in the Maintenance Schedule to improve the planning, management, and scheduling of preventative inspections. As an extension of the action plan in Recommendation 4, we will utilize the recruited asset management resources to improve the oversight of preventative maintenance management. In the short term this will allow for better record keeping and scheduling. In the medium term, there will be a request for proposal (RFP) reviewed and issued for on-boarding support of a vendor that will review the current applications used for work management and provide recommendations towards consolidating through one source. The RFP is set for issuance in quarter 1 of 2024 with a year-end target of having the successful vendor awarded by end of 2024. Long term completion of this implementation is dependent on vendor resources and timelines.

Recommendation 6: The Board request the Chief Executive Officer, Toronto Transit Commission, to review, update, and approve all maintenance and inspection policies, procedures, and manuals in Streetcar Overhead Operations to ensure they are accurate, complete, and relevant, and provide training to staff on them.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We concur with the recommendation. In prior years, Streetcar Overhead had brought on the consulting services of Gannet Fleming, to produce a manual that will assist maintenance personnel with the maintenance and inspection of Toronto Transit Commission's (TTC) Overhead Contact System (OCS). This manual was provided to the department in 2022, and is currently under review by the workforce for acceptance. Given the volume of content and shortage for dedicated reviewers, the targeted completion date will be quarter 2 of 2025. At an enterprise level, organization has brought on consulting services to assist in establishing an asset management plan, which includes aligning all maintenance and inspection policies, procedures, and manuals in Streetcar Overhead to industry standards. This framework along with resource requirements will be identified by the consultants, taking into consideration that the consultants will be supporting all departments within organization. In the interim, Streetcar Overhead will work with Overhead Engineering to conduct a review of the existing maintenance, inspection manuals, policies, and procedures to ensure that they are aligned with industry best practices and are accurate, complete and relevant. Subsequently, Streetcar Overhead will update the relevant training accordingly.

Recommendation 7: The Board request the Chief Executive Officer, Toronto Transit Commission, to:

a. **Review and update the annual preventative inspection targets in Streetcar Overhead Operations on both an annual and as-needed basis; and**

b. **Establish policies and procedures to provide clear guidance in Streetcar Overhead Operations on which source data and information is needed for the reassessment.**

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We agree with the recommendation and have commenced the regular review and revision of the annual preventative inspection goals in Streetcar Overhead right away. In the short term, a review and update of targets will be conducted by the Engineering Technologist and sections with a target completion of quarter 1 2024. In the medium to long term, and as an extension of Recommendation 6, we will improve on and create policies and procedures that offer precise direction per the advisement of the enterprise asset management consultants.

Recommendation 8: The Board request the Chief Executive Officer, Toronto Transit Commission, to establish and implement standard time expectations for common preventative inspections in Streetcar Overhead Operations and incorporate them into the employee performance evaluation.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We concur with the recommendation and commit to its implementation. Streetcar Overhead will assess existing activities within the section that can serve as benchmarks to establish and enforce standardized time expectations for routine preventative inspections. Once measurable benchmarks are established and expectations are clearly defined, the employee performance appraisal template will be revised. Target completion for the revised employee performance evaluation is dependent on both the request for proposal and findings of the consultants that are identified in Recommendation 4 and 5. We will also be incorporating the action plan from Recommendation 7 to satisfy this recommendation.

Recommendation 9: The Board request the Chief Executive Officer, Toronto Transit Commission, to install and enable GPS on Streetcar Overhead Operations' non-revenue vehicles to effectively monitor and assess performance.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We agree with the recommendation and have been working with Vehicles Group to finalize an agreement for purchasing GPS equipment for departments to evaluate the optimal approach for installing and activating GPS systems on non-revenue vehicles to efficiently monitor and evaluate employee performance. The target in the short term is to have the agreement issued by quarter 1 of 2024. In the medium term, installation of GPS tabs will take place in 2024, with expected completed installation to be by quarter 2 of 2025.

Recommendation 10: The Board request the Chief Executive Officer, Toronto Transit Commission, to:

a. Ensure policies, procedures and manuals in Streetcar Overhead Operations provide clear directions as to how preventative inspections' activity tasks, results, and observations should be performed (including the measurement method) and documented; and

b. Develop and implement an oversight process in Streetcar Overhead Operations (e.g., quality assurance audit program, spot checks, increased supervision) to ensure the accuracy, completeness, and reliability of the documented work orders and consistency of the work performed.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We agree with the recommendation and are dedicated to its prompt execution. We will conduct an immediate audit of the existing documentation to both documented policies, procedures, manuals as well as the crew's documented work orders, by taking a risk based approach to prioritizing those in most need of improvement. Furthermore, we will explore the most efficient means of implementing these improvements. As identified in Recommendation 4, in order to meet the Ontario Regulation 588-17 by July 2025 Streetcar Overhead will utilize consulting support for overall process oversight and improvement, while in the short term will be utilizing an asset management planner to provide increased supervision and quality control to on-going audit programs and spot checks.

Recommendation 11: The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement formalized processes in Streetcar Overhead Operations to:

a. Ensure preventative inspections comply with annual inspection targets; and

b. Ensure preventative inspections are scheduled and completed in accordance with Overhead Operations' specified time intervals.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We agree with the recommendation. Streetcar Overhead Operations will continue to create and put into operation formalized procedures to ensure preventive inspections comply with annual inspection targets. These procedures will serve the dual purpose of ensuring that preventative inspections align with the annual inspection targets and that they are scheduled and executed within specified time intervals. In the short term, our IT department has been engaged to assess the most suitable method and strategy to leverage the existing Maximo software features for generating work orders to help deliver this recommendation. In the medium and long term, as an extension to Recommendation 5, this strategy includes the request for proposal as well as the enterprise asset management roll out of Maximo. Subsequently, we will proceed with their recommendation, taking into account budget and implementation considerations.

Recommendation 12: The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement policies and procedures in Streetcar Overhead Operations to:

a. Provide clear expectations and training as to how crews should communicate and document preventative inspections that are only partially completed; and

b. Track and ensure partially completed inspections are appropriately rescheduled to be fully completed.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We accept the recommendation and will continue to carry out the following actions by quarter 4 of 2024 • Update the inspection form to provide greater clarity on the specific inspection areas that were not fully completed and still require attention. • Provide additional training to our workforce to ensure they furnish comprehensive information on the inspection sheet.

- Provide comprehensive training to new employees as they enter Streetcar Overhead
- Conduct audits of inspection sheets through predetermined review process.
- Use TTC's enterprise database to track partially completed work orders until they are fully completed. We will involve the Information Technological Services department to assess the most suitable method for fulfilling this request. Subsequently, we will proceed with their recommendation, taking into consideration budgetary and implementation factors.

Recommendation 13: The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement policies and procedures for Streetcar Overhead Operations' preventative and corrective maintenance program, which includes but is not limited to providing:

a. A set of criteria for each asset type to determine if corrective maintenance and repair work orders need to be generated, based on risks and implications;

b. Clear timing expectations for reviewing completed preventative inspections and generating any necessary corrective maintenance work orders; and

c. Clear criteria and timing expectations for the prioritization and completion of corrective maintenance work orders, based on risks and implications.

Management Response: ☒ Agree ☐ Disagree

Comments/Action Plan/Time Frame:

Streetcar Overhead actively participate in Institute of Electrical and Electronics Engineers standards committee meetings with industry peers. This is to ensure internal KPIs are being measured effectively against other agencies. We are also participating in meetings with Network Rail Consulting, American Public Transportation Association and International Association of Public Transport. It is important that we are engaging and constantly measuring ourselves against industry standards and practices.

As required by the Ontario Regulation 588-17, by the end of 2025 we will assess what other agencies similar to TTC are doing to ensure that we capture the best-known practices. Additionally, we accept the recommendations, and Streetcar Overhead Operations will develop and implement a maintenance program based on, but not limited to, the following elements:

- Establishing specific criteria for each asset type to determine the necessity of generating corrective maintenance and repair work orders.
- Defining clear timeframes for reviewing completed preventative inspections and initiating any required corrective maintenance work orders.
- Providing distinct criteria and timing expectations for prioritizing and executing corrective maintenance work orders.

Recommendation 14: The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement in Streetcar Overhead Operations:

a. Standard Operating Procedures that outline the steps to be taken to ensure the measuring tools used by crews during inspections (e.g., calipers) are in good working order; and

b. An oversight process to monitor and ensure compliance with the Standard Operating Procedures.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We agree with the recommendations. Streetcar Overhead Operations will formulate Standard Operating Procedures (SOPs) delineating the necessary steps to guarantee the proper use of measuring tools by inspection crews. Additionally, we will establish a periodic review process to maintain the quality of data and both crew documentation and documented work orders. By the end of quarter 2 of 2024, Streetcar Overhead Operations will conduct a review of all existing SOPs, noting any that are not available or outdated. Streetcar Overhead will continue to cooperate with the Capital Delivery Office to ensure timely and accurate issuance of SOPs and investigate if there is a need for additional resources. In the interim, an audit process will be established for oversight and compliance to current SOPs.

Recommendation 15: The Board request the Chief Executive Officer, Toronto Transit Commission, to develop a comprehensive Maximo implementation plan to ensure Maximo is implemented as both an enterprise asset management system and workflow process management system for Streetcar Overhead Operations. This implementation plan should include, but not be limited to:

a. Detailed implementation target dates and timelines; and

b. Implementation of Maximo Anywhere to all crews, not just emergency crews.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We agree with the recommendation and commit to the implementation. Streetcar Overhead Operations has identified a need for a more comprehensive use of Maximo in conducting functional requirement workshops with the Information Technological Services department. As outlined in Recommendation 5, the scope of service of the request for proposal aims to ensure Maximo and Maximo Anywhere is implemented as both an enterprise asset management system and workflow process management system. A timeline along with target dates will be established once a vendor has been selected. a. As part of the on-going enterprise asset management program, TTC is conducting an as-is assessment of current asset management practices and will establish a comprehensive roadmap for the program. By quarter 1 of 2024, the TTC will re-baseline its Maximo implementation project to align with the Asset Management roadmap and establish updated implementation target dates for Streetcar Overhead Operations. b. Within the enterprise asset management program's scope includes the roll-out of mobile devices with the ability to interface with the work order system, which will be rolled-out by quarter 4 of 2025.

Recommendation 16: The Board request the Chief Executive Officer, Toronto Transit Commission, to provide appropriate Maximo training to responsible frontline crews/technicians/staff and management in order to fully leverage existing Maximo technology for Streetcar Overhead Operations.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We fully support the recommendations, and as identified in Recommendation 4, formal training will be provided once the rollout of Maximo and Maximo Anywhere has been complete. As part of the on-going enterprise asset management program, end-to-end life cycle management processes for Streetcar Overhead will be re-engineered and implemented within Maximo by quarter 4 of 2025. This includes establishing Standard Operating Procedures (SOPs), development of a formal training program that will be

available and delivered as required to responsible frontline crews, technicians, and staff. It is important to note that following the evaluation of the consultants, there will be changes to come on process and maintenance activities, which will impact the tools and facilitation of the training. However, in the short term Streetcar Overhead Operations will continue to follow a “train the trainer” approach.

Recommendation 17: The Board request the Chief Executive Officer, Toronto Transit Commission, to review and update Streetcar Overhead Operations’ asset inventory and job plans/activity tasks in Maximo to ensure they are complete, accurate, and up-to-date, in order to support the planning and completion of repair and maintenance work.

Management Response: ☒ **Agree** ☐ **Disagree**

Comments/Action Plan/Time Frame:

We accept the recommendations to assess and revise the asset inventory and job plans/activity tasks within Maximo for Streetcar Overhead Operations. We will initiate an immediate examination of the existing documentation and establish a timeline to improve those sections that are in the most suboptimal condition. Furthermore, the effort will aim to ensure their completeness, accuracy, and currency, facilitating the planning and execution of repair and maintenance tasks. The RFP mentioned in Recommendation 3 includes reviewing and improving current Maximo usage of Streetcar Overhead. Once a vendor has been awarded, expected in quarter 1 of 2024, a clearer implementation plan to technological improvements can be shared. In the interim, Streetcar Overhead Operations will audit available job plans for completion and accuracy as well as identifying any missing job plans of repair and maintenance work that can be generated.

Recommendation 18: The Board request the Chief Executive Officer, Toronto Transit Commission, to develop and implement a process in Streetcar Overhead Operations using Maximo to track the real-time status of work orders to support ongoing work order management and supervision.

Management Response: ☒ **Agree** ☐ **Disagree**

Comments/Action Plan/Time Frame:

We acknowledge the recommendation and are committed to its adoption. Streetcar Overhead will maintain its partnership with our IT department to assess the most suitable method for implementing Maximo Anywhere. Following this assessment, we will proceed in accordance with the specified implementation target dates and recommended timeline, taking into consideration budget and implementation considerations. The RFP mentioned in Recommendation 3 includes reviewing and improving current Maximo usage of Streetcar Overhead. Once a vendor has been awarded, expected in quarter 1 of 2024, a clearer implementation plan to technological improvements can be shared.

Recommendation 19: The Board request the Chief Executive Officer, Toronto Transit Commission, to leverage Maximo to collect and track observations from Streetcar Overhead Operations' assets inspections, and information about maintenance and repairs activities, that can be used for data mining and trend analysis to support Key Performance Indicator reporting and inform decision-making.

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: We acknowledge and endorse the recommendation. Currently, Streetcar Overhead relies on certain Maximo features to monitor maintenance activities, but the majority of work orders are paper-based, which hinders efficient data mining due to the labor-intensive process of reviewing hard copy files. Streetcar Overhead is committed to collaborating with our IT department to proactively implement Maximo Anywhere, as suggested. This implementation will occur in advance of the TTC-wide Maximo enterprise rollout scheduled for the next few years. Maximo Application Suite 8.0 will be launched by quarter 4 2024, with functionalities including dashboard customizations, data mining and trend analysis of different types of activities. The updated application will allow for improved KPIs as a result better decision making.

Recommendation 20: The Board request the Chief Executive Officer, Toronto Transit Commission, to improve the Key Performance Indicator reporting for Streetcar Overhead Operations by:

a. **Establishing clearly defined, appropriate, outcome-focused Key Performance Indicators and targets;**

b. **Developing short- and long-term strategies to meet these targets;**

c. **Regularly reassessing to determine whether Key Performance Indicators and targets need to be revised; and**

d. **Retaining supporting data and verifying the accuracy of data used for Key Performance Indicator reporting, ongoing oversight, and management decision-making.**

Management Response: ☒ Agree ☐ Disagree
Comments/Action Plan/Time Frame: Streetcar Overhead actively participate in Institute of Electrical and Electronics Engineers standards committee meetings with industry peers. This is to ensure internal KPIS are being measured effectively against other agencies. We are also participating in meetings with Network Rail Consulting, American Public Transportation Association and International Association of Public Transport. It is important that we are engaging and constantly measuring ourselves against industry standards and practices. We agree with the recommendations. Streetcar Overhead will continue to work towards enhancing KPI reporting through the following actions to be completed by quarter 4 of 2024: • Establishing well-defined and relevant outcome-focused KPIs and targets. • Creating both short-term and long-term strategies to achieve these targets. • Conducting regular reassessments to gauge the need for any revisions to KPIs and targets. • Preserving supporting data and verifying its accuracy for KPI reporting, continuous oversight, and informing management decisions.

AUDITOR GENERAL TORONTO