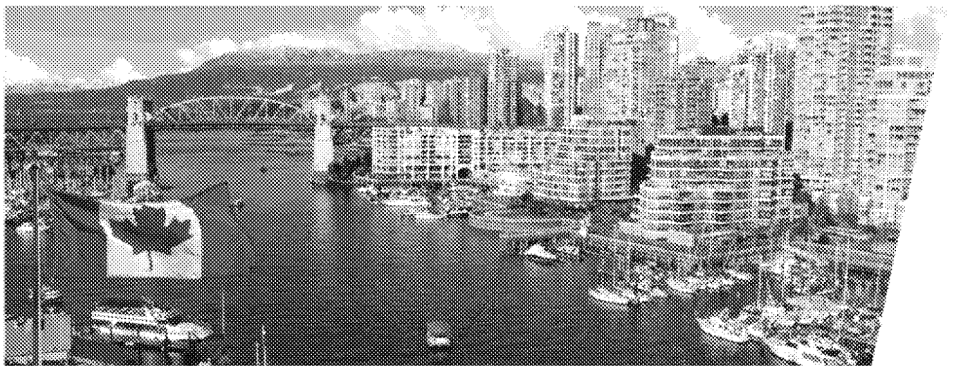
NetworkRail

Consulting

Rideau Transit Maintenance

Maintenane Assessment - Ottawa LRT

5 December 2021



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Executive Summary

Our Background

Network Rail Consulting is the international division of Network Rail Infrastructure Limited, the owner, operator and maintainer of the rail network in Great Britain. Network Rail has been independently rated in the top 10% of asset intensive industries for Asset Management maturity and top in rail.

Our team for this assessment was drawn from the UK based staff to bring together experience of maintenance and asset management of infrastructure, rail vehicles, facilities and structures. We used our Heart of Asset Management maturity assessment that has been developed from our internal experience and refined following assignments in the US and Australia. Our team has undertaken maintenance reviews for clients in Australia and Saudi Arabia.

Our Approach

We delivered this assessment by undertaking a review of key documents, including the Project Agreement, Asset Management Plans, Maintenance and Rehabilitation Plans, APPM reports to understand the structure and context of the maintenance activity. We then spend one week at the Belfast Maintenance and Storage Facility conducting interviews and discussions with members of the RTM and Alstom teams.

Our Findings

We have split our findings into sections reflecting that different asset classes have different maintenance arrangements. In addition, we have made some observations outside of the direct scope of the assessment that we believe you may find useful.

Having undertaken maintenance assessments on the arrangements for newly commissioned railways before, we have identified that teams on these types of projects are balancing three priorities:

- Project close-out (mainly management of defects and collation of documentation such as technical drawings and manuals);
- O&M start-up (e.g. creation of procedures and processes, finalisation of maintenance contracts and one-off activities such as bulk population of assets and maintenance plans into the Asset Information System); and
- Steady-state operation (e.g. management oversight and monitoring of maintenance contracts, dealing with arising issues).

These priorities interact with one another so that oversight is difficult in the absence of defined processes and the definition of processes is hampered by the need to resolve outstanding issues from the construction phase, whilst the outstanding issues themselves impede the ability to deliver a reliable service.

Two years from the start of revenue service, we observe that many of the fundamentals of good maintenance are in place. Maintenance subcontracts are signed, asset registers have been created, maintenance specifications and standards are in place and reliability is improving. There are still construction defects outstanding.

We did not expect to find a fully mature organisation but there are some areas that are less mature than we would like to have seen.

Asset Management Planning

The plans, reports and the organisation are focussed on delivering day-to-day maintenance. There is very little in the way of planning for heavy maintenance or renewals. The network is relatively new, but we have worked with organizations where this view has persisted for decades, meaning that nobody had planned for sustaining asset life. The asset will not remain new for long and we observed that there are sections of rail that have already sustained more than half of their allowable wear.

The biggest concern in this area is not that there are no plans for asset renewals, but as yet, there is no firm view of what indicators and measures will be used to determine current condition and predict remaining asset life that can be used to plan renewals.

There are other areas such as configuration management, resourcing and failure and incident response that would benefit from further development. The asset management process is built around an inspect and repair philosophy. Areas such as rail management and hot weather management would benefit from a more proactive approach to mitigate predictable issues rather than finding them on inspection and then reacting to them.

Supervision and Oversight

The structure of the preventative maintenance process is quite thin. All the inspections are completed by front line staff and there are no documented requirements for anyone else to review asset condition.

There does not appear to be particularly strong oversight of the work done by front line staff. The shift supervisors are predominantly office based and their role in the verification of completed work appears to be limited to confirming that the paperwork is complete.

Assurance

The Quality department have a schedule of internal audits that have been well delivered and documented. However, these are limited to desktop review, confirming that procedures are up to date and that there is suitable evidence of compliance. They do not review the quality of finished work.

At Network Rail, we operate a “3 lines of defence” assurance model:

- Self-assurance; am I doing what I am supposed to do?
- Internal assurance: are you doing what you are supposed to do?
- Independent assurance: is what you are supposed to do delivering the right outcomes?

Independent assurance is not necessarily external and could be delivered for example by the engineering team on the maintenance function.

Without a robust assurance framework in place, it is difficult to be confident in the delivery of outputs.

Reporting

We did not see a structured reporting and review process. In a single week, we would not expect to see a full cycle of reviews, but we came away with the impression that a lot of reviews are done at a low level with little aggregation or trending. Discussions seem to be dominated by individual issues, sometimes down to work order level, rather than prioritizing and tackling the biggest risks and trends.

The operational management reports such as the Alstom backlog and reliability reports can feed good decision making but there are no equivalents of these at top management level, partly due to limitations on the information contained in IMIRS. The asset management reports such as the condition reports and APPM Achievement are aggregated but not analysed. They rarely contain causes, assessment of the risks or remedial action.

We conclude that it is difficult to for management to get a high-level picture of what is going on and to be able to drill down into detail to identify and prioritize appropriate actions.

Relationships

Whilst it was not strictly within our scope, we would like to make reference to the issue of relationships. Clearly, there have been serious difficulties in delivering a high quality and reliable service to passengers on the Ottawa LRT. From issues remaining from construction, be they outstanding defects, missing information or poor reliability, difficulties recruiting and retaining sufficient staff to serious incidents, the initial period of service has not been what anybody hoped. Against such a background, it is difficult to build confidence, trust and collaboration.

The City of Ottawa is understandably having difficulty gaining confidence in the delivery of maintenance but by imposing penalties outside the contractual performance regime is creating problems for those trying to make improvements. RTM have a poor impression of Alstom but does not seem to have sight of some of the good things we have seen. Alstom are content to wait on responses from RTM to issues rather than seeking to work together to mitigate and resolve them.

In this environment, the biggest losers are those whom everyone should be striving to serve – the customers of the LRT service. We were not tasked with assessing the commercial arrangements between the parties or any claims or disputes, but viewed from the outside, the current situation looks unsustainable.

Whether it is in areas of interface, such as EROs providing detail when they report faults or vehicle maintainers reducing wear and tear on depot equipment, the area of information sharing such as supplying detail of planned rather than just completed work into IMIRS or the area of dealing with projects close-out issues, resolution will always require a joint approach and action on both sides of the contract boundary so the practice of passing issues between the parties is unlikely to succeed.

To make the next 28 years more successful than the first two, a fundamental rest of the relationships between the parties is required.

Next Steps

The decision by RTM to split the activity into assessment and monitoring phases was a good one. Having taken the time to consider and document our findings, we have been able to provide recommendations on where the monitoring phase needs to focus. We have tried to structure these recommendations so that they follow on from our observations at the assessment phase and could be delivered either by ourselves or by another organisation.

Acknowledgements

We would like to acknowledge the help and support of everybody involved in the review. We were provided with access to almost all the documents we requested, quickly and efficiently. Many of the team rearranged their schedules with little notice to make time to meet with us in the short window available and followed up with the examples and evidence that we requested from them.

1. Scope

NRC was requested to provide a technical assessment of the effectiveness of RTM and its sub-contractor's maintenance framework and organization on the following asset groups as described in Appendix A of schedule 15-3 of the Project Agreement:

- Revenue Vehicles (Attachment 2)
- Infrastructure, comprising Systems and Track (Attachments 3 and 4)
- Facilities and structures (Attachments 6 and 9)

We were asked to assess:

- Asset Management Plans
- Quality Plans
- Appropriateness of the frequency and scheduling of
  - Preventive Maintenance
  - Corrective Maintenance
  - Retrofits
  - Backlog
- Effectiveness of maintenance management and reporting systems.
- Workorder management
- Appropriateness of employee:
  - Training
  - Experience
  - Qualifications
- Appropriateness of maintenance organization;
  - Staffing levels
  - Shift coverage
  - Supervision/oversight
- Support departments (Engineering, sourcing, etc.)
- Adequacy of tools and equipment
- Adequacy of QA/QC processes

As this was a relatively short review, we do not intend to formally examine the efficiency and effectiveness of individual work activities; however, anything we observe that we believe could benefit from improvement, whether or not it is part of our structured protocol, will be documented and shared with RTG.

2. Our Approach

Our approach to undertaking a review of maintenance is to use a structured review protocol and competent people.

For this assignment, we propose to use our "Heart of Asset Management" question set. Based on best practice, this is not a full review of corporate asset management capability, rather it focusses specifically on maintenance and looks at the day-to-day activities undertaken within the maintenance function.

The question set covers:

- Inspections, including standards, frequency, planning and compliance management;
- Defect management, including classification and competence;
- Fault and incident response, including resourcing, prioritisation and reliability management;
- Work prioritization and access planning, including process, planning horizon, works integration and learning;
- Gaining access to the infrastructure, including managing impact on operations, access control and safety/security technology;
- Repair processes, including standardisation, resources, competence, risk and assurance;
- Management of spares including assessment of required quantities and process for maintaining adequate inventory;
- Engineering data and assurance, including data management, condition reporting, data driven maintenance and renewal interventions and asset operation information. We will look at whether data is collected, stored and processed systemically or by use of ad hoc spreadsheets;
- Renewal definition and scoping (may not be immediately relevant but there will be renewals required during the term of the contract and the approach to how these will be defined should be of interest);
- Asset information, including records, updates, monitoring and review, reporting and learning; and
- Strategy and organisation, including goals and objectives, organisation structure and performance appraisals.

Each question is assessed on a scale of maturity from 1 to 5, and the results expressed as:

- At risk (responding to accidents);
- Reactive (managing on red);
- Managing (preventative maintenance);

- Engaging (reliability based maintenance); and
- Robust (predicted and tailored intervention).

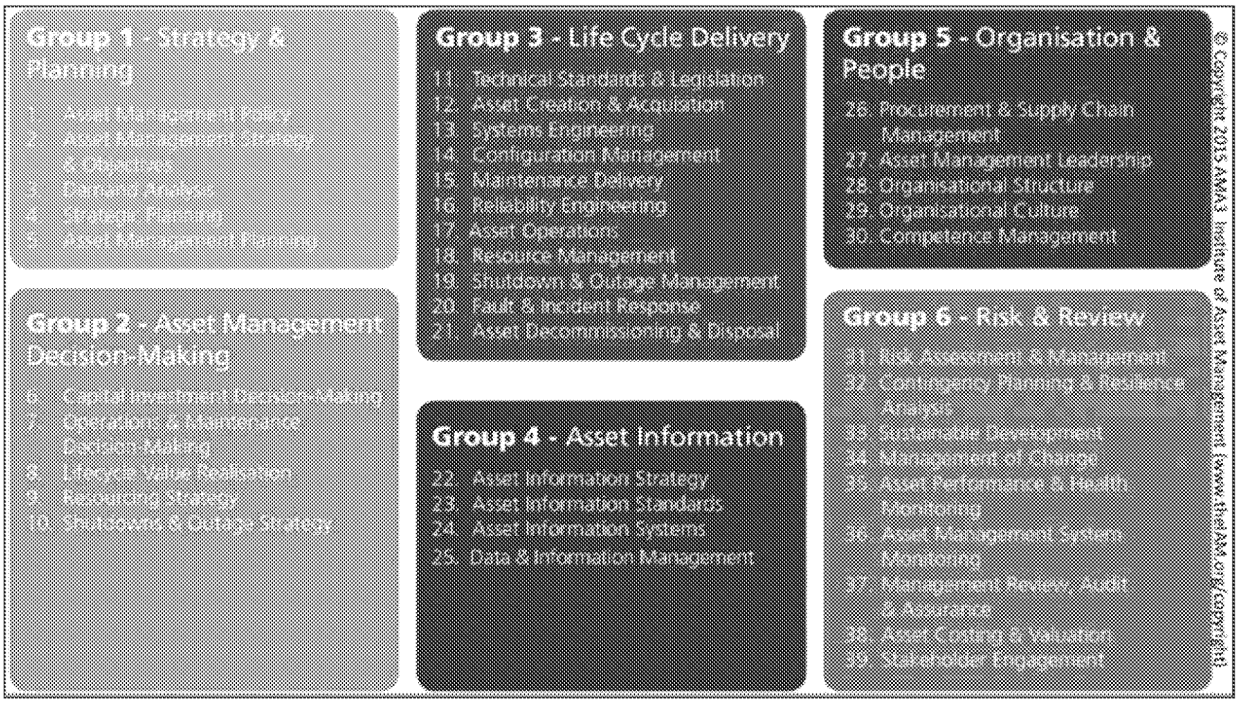
3. Common Findings

When reviewing the asset management plans for each asset group, we identified some findings that are common across all of the asset groups and so we have recorded them here.

3.1 Asset Management Plans

The asset management plans for all of the disciplines in our assessment follow the same layout. In reviewing the documents, we have assessed their coverage against the subject areas contained with the Institute of Asset Management Anatomy of Asset Management

Figure 3.1 Institute of Asset Management Anatomy



3.1.1 Alignment with objectives

All of the asset management plans state that their objective is to deliver the performance measures defined in Schedule 15-3 of the Project Agreement.

3.1.2 Alignment with other disciplines

The asset management plans contain no detail about how the interventions for the different disciplines will be aligned and integrated.

3.1.3 Resourcing Strategy

The asset management plans do not describe the strategy for assessing the requirement for resources, including labor, plant and materials. The area of resourcing is a particular risk for the Ottawa LRT. In terms of labor resources, Ottawa has no history of railway maintenance and little of

its GDP comes from manufacturing making skilled technicians and fitters a scarce resource. Competition in the high-tech sector, which represents around 19% of the city's GDP (greater than that of Federal government) is fierce meaning that retention of skilled staff is a challenge.

Similarly, many of the components of the LRT system were sourced from overseas making repair and replenishment more complex.

3.1.4 Shutdowns and Outages

The asset management plans make no mention of how engineering access to the railway infrastructure will be managed nor how the system can meet its performance targets whilst planned maintenance and overhauls reduce the number of available vehicles.

Access to the network is severely restricted with daily/weekly access being composed of very short windows and the annual allowance for disruptive access equating to being able to get a 12 hour window on each section roughly every two years.

The current method of work favours undertaking all activities during system shutdowns. Some of the systems, particularly the Traction Power Supply system, have a level of redundancy that would allow systems to be taken offline for maintenance without degrading the service to customers. Whilst taking outages on redundant systems does create an availability risk, with proper risk assessment and mitigation, this can be minimised and does bring the advantage that maintenance can be undertaken without time pressure. As part of the planning process, arrangements can be rehearsed during engineering hours to confirm that the systems behave as expected in the degraded mode.

3.1.5 Configuration Management

The asset management plans do not describe how configuration management is achieved. Configuration management includes the Bill of Materials that describes the required parts and modification states, As Built drawings that show how systems, subsystems and components are interconnected and software and configuration files.

All these items are vital when designing system changes or restoring service after a failure or incident. Difficulties in accessing configuration information can extend the time taken to rectify a failure or could result in an older version of configuration being used, maybe reverting a change made to improve safety or reliability.

The configuration management section could also consider the extent to which spares and rotating (repairable) parts are tracked at serial number level.

3.1.6 Reliability Engineering

There is no information within the asset management plans to describe how reliability will be measured or managed and no targets and timescales for a desired level of reliability to be reached.

We observed some good practice being undertaken to monitor reliability and were told about meetings where this information is reviewed and actions planned but there is no overall reliability management plan.

3.1.7 Fault and Incident Response

The asset management plans describe the preventative maintenance in some detail but do not describe how faults and incidents are to be managed. There is no description of the response and repair time requirements and no description of the strategy to meet the requirements of the Project Agreement in this regard.

3.1.8 Asset Information

During our assessment we did not see any requirements for the management of asset information. The asset register has grown organically, and some maintenance is attributed to location areas rather than individual assets, even where the assets exist in the register. The allocation of corrective work orders to individual assets is also inconsistent.

There are no standards for the quality of the data, processes for the verification of data or formal means to correct errors or to identify the root cause of errors.

3.1.9 Competence Management

Competence is a key element of good asset management. All the strategy, planning and delivery of works has little value if the individuals who perform the work are not demonstrably competent.

We saw examples of the competence management systems in place for various assets but the asset management plans do not contain any overarching strategy for competence management for the specific assets and no reference to competence management system documents.

3.1.10 Risk Assessment and Management

The asset management plans do not address how asset specific risks are identified, assessed and mitigated. There will be some assets, owing to design, environment, accessibility etc. that present a risk to network performance. Similarly, where assets are awaiting repair or are operating with know reliability or potential safety issues a level of risk exists. The asset management plans should describe how these risks are escalated so that they can be properly managed.

3.1.11 Contingency Planning and Resilience Analysis

No assets are 100% reliable, especially over the long term. There may be parts of the network where that can be subject to a single point of failure. These should be identified through resilience analysis and appropriate contingency plans drawn up such that there is a structured means to respond with appropriate arrangements already in place.

3.1.12 Management of Change

There can be a wide range of permanent and temporary changes that need to be considered in relation to asset management, such as the need to comply with new legislation or regulations or the introduction processes or changes to the asset itself, such as upgrading of technology.

Any changes to assets or asset management will almost certainly involve people and the success of the change is impacted by how well the change is documented and communicated. The asset management plan should describe a process, proportional to the scale of the change, to ensure that affected individuals have the awareness and updated information that they require.

3.1.13 Asset Performance and Health Monitoring

None of the asset management plans contain much detail about the Asset Preservation Performance Measures and how they indicate asset condition and likely remaining life. We have identified in each of the asset sections that the long term monitoring of asset condition with a view to planning heavy maintenance and renewals is immature.

3.1.14 Conclusion

The above comments refer to the documentation of the subject areas within the Asset Management Plans. As will be described in the individual asset class sections, some of these asset management requirements are in place but it would be good practice to document then within the plans.

4. Revenue Vehicles

4.1 Asset Management Plan

4.1.1 Asset Management Plan Overview

The RTM Document: RTM-MC-PLN-459 Asset Management Plan is a brief document detailing the responsibilities and documentation required to understand the guidelines on the management of all the 'O-Train Line 1 assets'. The documents states that Appendix C cover Alstom's scope, including LRV maintenance and infrastructure asset such as signals, communications systems, guideway maintenance, TPSS equipment, OCS, non-revenue vehicles and tunnel systems. Appendix C titled 'ENG-SV-OTT-PRO-001 Version D' is a 35-page document intended to cover scope of all of the subcontractor Alstom's scope of work. The construction and alignment to the supplier's scope within this document in itself isn't an issue but it does feel like it has missed valuable fleet management information, We recommend that RTM and Alstom consider creating a standalone Fleet Asset Management Plan (FAMP) or adding the following sections to the existing Asset Management Plan due to the complexity of rail vehicle maintenance.

4.1.2 Vehicles

The Asset Management Plan (AMP) refers to the fleet as comprising of 38 vehicles. On the 'MU Readiness' board in the supervisor's office vehicle numbers up to 41 were displayed. We recommend that RTM and Alstom consider updating the asset list to include unique identification of all vehicle to ensure there is no complication between phase 1 and phase 2 assets or in the event an asset is removed from service permanently.

4.1.3 Organisational Structure

The job titles within the team are noted and listed (Page 4 Responsibilities for the Execution of this Procedure) as 'responsible', 'accountable' or 'players'. We recommend that RTM and Alstom consider aligning these to key roles to give clear line of sight on responsibility and potentially add names of the individuals and their nominated delegates to ensure competence can be covered during periods of absence this would also assist with training needs analysis for succession planning.

4.1.4 Risk Management

The Asset Management Plan details the risk management process and the creation of a risk register which is reviewed annually. Alstom have put in place PMT-SV-OTT-MAN-001 Project Safety Management Plan 'Plan to describe the management of all railway risks'. They declined to provide this document to us. We recommend that consideration should be given during the monitoring phase to determine if the process includes vehicle maintenance risks and if the vehicle maintenance risks should be documented separately and reviewed more frequently due to the risk of serious injury or death within any maintenance organisation.

4.1.5 Engineering Change

The Asset Management Plan makes no reference to how engineering change will be managed. We recommend that RTM and Alstom consider detailing or referring to their engineering change process.

4.1.6 Contractual Arrangements

The Asset Management Plan makes no reference to the contracting of subcontractors or 3rd party maintenance or engineering organisations. We recommend that RTM and Alstom consider adding this detailing who is responsible for this activity and how the appropriateness of subcontractors or 3rd party maintenance suppliers would be assessed including any minimum standard requirements they must meet, what assurance activity is required and what regular reviews or meetings are undertaken.

4.1.7 Transfer of Information

The Asset Management Plan makes no reference to the transfer of information from engineering or maintenance management to the frontline staff. *NOTE: This was discussed during the assessment and information was distributed via staff iPads and toolbox talks.* We recommend that RTM and Alstom consider detailing the process for the transfer for of information within the Asset Management Plan and include staff sign off to ensure they have both received and understood the information provided.

4.1.8 Maintenance Document Control, Review and Revision

The Asset Management Plan makes no reference to how changes to the vehicle maintenance instruction updates will be reviewed, stored, controlled or how frequently planned reviews would take place. *NOTE: During the assessment it was clear that vehicle maintenance documentation was being reviewed, improved and updated frequently with the vehicle maintenance instruction currently at revision L.* We recommend that Alstom review documents REF-PRO-001 and OTT-GNR-QUA10-PRO-001 to confirm that they contain sufficient detail relating to how the vehicle maintenance documentation is reviewed, stored, controlled and the frequency of planned reviews.

4.1.9 Removal and Release Vehicles from Revenue Service

The Asset Management Plan makes no reference to how a vehicle should be removed from revenue service, adequate removal from service process is critical to ensure vehicles with defects are not returned to revenue service unintentionally. The Asset Management Plan also makes no reference to how a vehicle should be released to revenue service after being removed, this process is critical to ensure any vehicle which has followed the removal from service process is able to return to service without being stopped. We recommend that Alstom consider adding a release of vehicles to revenue service process.

4.1.10 Deferral of Maintenance or Repair

The Asset Management Plan does supply tolerances for acceptable delays to planned maintenance with a figure of 5% for minor servicing and 10% for major servicing but makes no reference to how any delays outside of this tolerance would be managed or who would be responsible for signing a deferral off. We recommend that Alstom consider adding a deferral management process with the use of a risk matrix and responsible person for sign off would be advisable if this isn't already in place. Any deferral for an individual task should also have a work order created in the chosen maintenance management system (GSI).

4.1.11 Post Incident or Accident

The Asset Management Plan makes no reference to how a vehicle should be inspected or recovered post incident or accident. This process is critical to ensure the vehicle is recovered in a safe manor which does not add risk to people, infrastructure or further vehicle damage. We recommend that RTM and Alstom consider adding a post incident or accident process based on specific levels or types of vehicle damage or failure should be referenced here to ensure safe and effective vehicle recovery.

4.1.12 Maintenance Recording

The Asset Management Plan makes no reference to how maintenance activity is recorded, We recommend that Alstom consider adding maintenance recording details specifically focusing on where maintenance is recorded and what components require additional documentation e.g. serialised assets, safety critical components, rotating assets, dimensional data or tools like torque wrenches which may require recording on each workorder.

4.1.13 Handling and Storage of Safety Related Equipment

The Asset Management Plan makes no reference to how asset spares or materials are managed and does not detail how min/max levels are decided or reference any suitable procedures for storage, handling, and transportation of components / parts, specifically wheelsets, axle-bearings, and safety-critical parts. We recommend that RTM and Alstom consider adding a process or a reference to the process for handling and storage of safety related equipment.

4.1.14 Reporting of Corrective Maintenance and Repairs

The Asset Management Plan makes no reference to how faults and defects are reported. We recommend that Alstom consider adding a process or a reference to the process for how defects are reported by any user, including maintenance technicians and train drivers as a minimum.

4.2 Quality Plans

The Asset Management Plan cites document QUA-SV-OTT-MAN-001 as the Project Quality Plan. The document is relatively short and most of the information is contained in referenced documents. Alstom declined our request for copies of these documents, citing them as sensitive. We therefore cannot comment on the adequacy of the QA/QC plans.

4.3 Maintenance

Vehicle maintenance is undertaken by RTM's subcontractor Alstom.

4.3.1 Preventative Maintenance

Preventative maintenance is subcontracted to the maintenance provider Alstom and undertaken at the Belfast Road facility in the City of Ottawa. Most of the preventative maintenance activity is completed at night when the vehicles have returned from revenue service. We attended the Belfast Road maintenance facility for 5 days from Monday 29th of November to Friday 3rd of December. Due to prior arrangements, key member(s) of the Alstom team were unavailable at the time of

assessment which made it difficult to properly assess the preventative maintenance, some comments supplied by the team were not verified due to the short timescale and we recommend an additional monitoring phase to fully assess the quality of preventative maintenance. The monitoring phase should look to provide an insight into the overall quality of maintenance delivery to include but not limited to the planning of a task, documentation issuing and briefing, technical ability of the team, availability of technical support, suitability of tools and equipment, effectiveness of supervision, timescales for task completion and quality of workmanship.

The vehicle OEM Alstom provided each asset with a cyclical maintenance plan based on kilometres travelled. Preventative maintenance is broken down into 3 levels, P1 for Daily Checks, P2 and P3 for servicing. The services are completed at the following intervals:

- 5,000 KM
- 10,000 KM
- 25,000 KM
- 50,000 KM
- 100,000 KM
- 150, 000 KM
- 200,000 KM
- 300,000 KM/ 330,000 KM/ 375,000 KM
- 400,000 KM
- 500,000 KM

The preventative maintenance schedule and tasks are relatively predictable and similar to that seen elsewhere with comparable vehicle types. Some maintenance interventions may be irrelevant to the use of the vehicle or decrease the life expectancy of components E.g. daily checks of door open/close buttons when the doors are opened automatically at stations. We recommend that, in future when enough data is held to review the efficacy of the individual tasks based on the environment and usage of the vehicles.

The vehicle maintenance instructions are described as Work Method Statements (WMS) and appeared to be a cross between a maintenance instruction and task risk control. The particular WMS task viewed was at revision L which provides a high level of confidence that documentation is being continually reviewed and improved and provided a good level of detail including images to assist the technician. Overall, the documentation was of a good standard.

Preventive maintenance tasks are assigned to the maintenance technicians by the shift supervisor, there were two supervisors on site and at the time of assessment one had vehicle maintenance background but the other was from a different discipline. After completion of the task the supervisor is responsible for signing off the task and allowing release to revenue service. At the time of assessment this process failed, and a vehicle was released to service without having the checks (or without having proper sign off) mandated after the derailment and shut down period. The investigation into the cause of this failure was ongoing at the time of assessment. We recommend that process is created to enhance the daily check to confirm that all outstanding maintenance and modifications have appropriate concessions before the vehicle is released to revenue service.

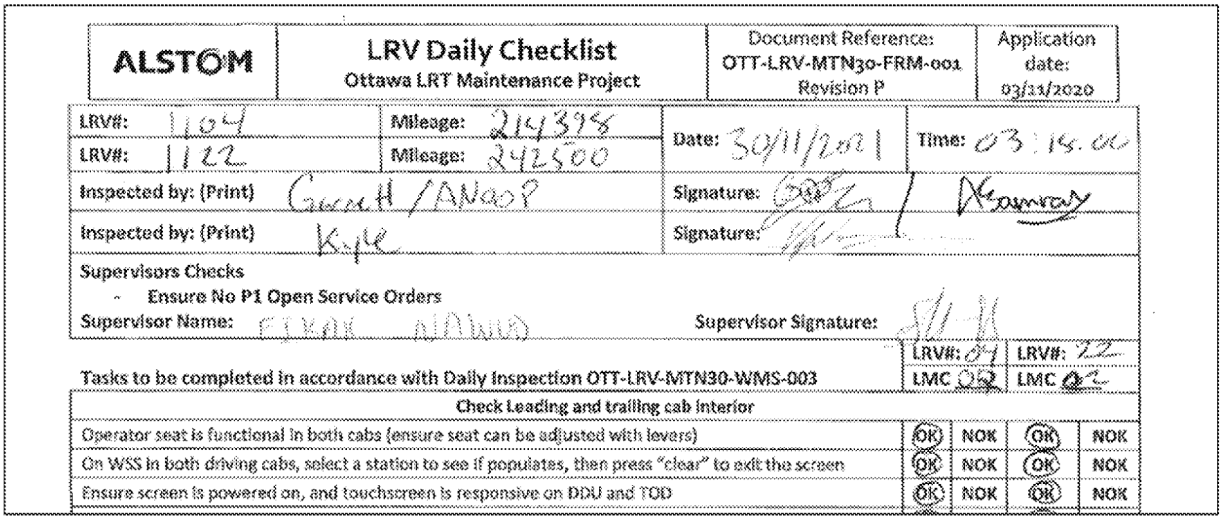
Documentation is transferred to maintenance technicians via an iPad, any updates to controlled documentation are uploaded and previous versions removed, changes are then briefed by the engineering team during a toolbox talk. While the use of digital technology to control documentation

is good practice there was no evidence to demonstrate that technicians were required to acknowledge the issue of a briefing or that they understood it.

Individual maintenance tasks on the 'LRV Daily Checklist' are circled as 'OK' or 'NOK' by the maintenance technician when complete, which is then followed by a 'defect record sheet' to record any arising work. Daily checklists were provided from 30/11/2021 and should activity on 4 vehicles, LRV 04, 22, 09 and 14. These checklists should be reconsidered as they fail to provide clear traceability to the maintenance task 'owner'. These contain 3 potential issues:

1) It isn't clear which technician undertook the work on which vehicle.
2) On the checklist for LRV 04 and 22 there are 3 technicians listed so no way of identifying who undertook the individual tasks
3) The document is utilised for 2 vehicles and should be intended to be used as both a reminder to undertake the task and sign off. If only one document exists for 2 vehicles it would be impossible to complete progressive sign off if the technicians are working simultaneously on different vehicles, leaving potential for missing tasks.

Figure 4.1 Example of Daily Checklist with multiple vehicles/technicians



ALSTOM	LRV Daily Checklist Ottawa LRT Maintenance Project	Document Reference: OTT-LRV-MTN30-FRM-001 Revision P	Application date: 03/11/2020

LRV#: 1104	Mileage: 214398	Date: 30/11/2021	Time: 03:15.00
LRV#: 1122	Mileage: 242500		
Inspected by: (Print) Gareth / Nash		Signature:	
Inspected by: (Print) Kyle		Signature:	

Supervisors Checks
- Ensure No P1 Open Service Orders

Supervisor Name: [illegible] Supervisor Signature:

Tasks to be completed in accordance with Daily Inspection OTT-LRV-MTN30-WMS-003	LRV#: 04 LMC 02		LRV#: 22 LMC 02	
Check Leading and trailing cab interior				
Operator seat is functional in both cabs (ensure seat can be adjusted with levers)	OK	NOK	OK	NOK
On WSS in both driving cabs, select a station to see if populates, then press "clear" to exit the screen	OK	NOK	OK	NOK
Ensure screen is powered on, and touchscreen is responsive on DDU and TOD	OK	NOK	OK	NOK

We recommend that the LRV Daily Checklist is updated to make it clear who did which checks on each vehicle.

During the assessment stage it wasn't possible to provide any analysis of the of the time given for preventative maintenance events. Consideration should be taken to determine if this would be required and included in any future monitoring stage.

During the assessment it was accepted that previously, renewable parts had arrived late for major preventative maintenance outages, due to the timescales it wasn't possible determine the root cause of the delays or the quality of the preventative maintenance planning. Consideration should be taken to determine if this would be required and included in any future monitoring stage.

The daily checklist supplied was on issue 'P' which demonstrates the documentation is continually reviewed to ensure appropriateness.

Some areas of good practice were identified during the tour of the workshop:

Figure 4.2 Witness marking and torque pattern clearly visible

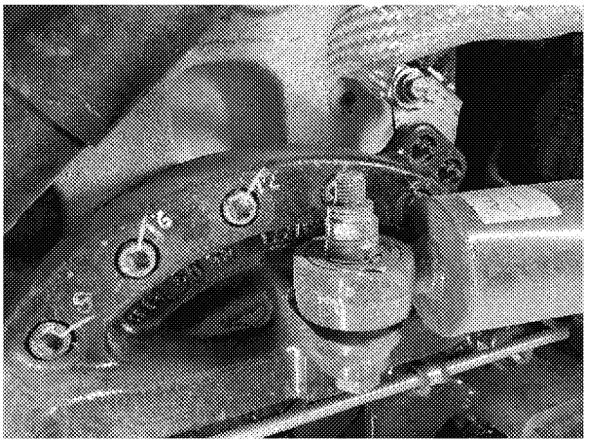


Figure 4.3 Shadow boards for task specific materials

Figure 4.4 Visual management boards in use (missing some vehicles)

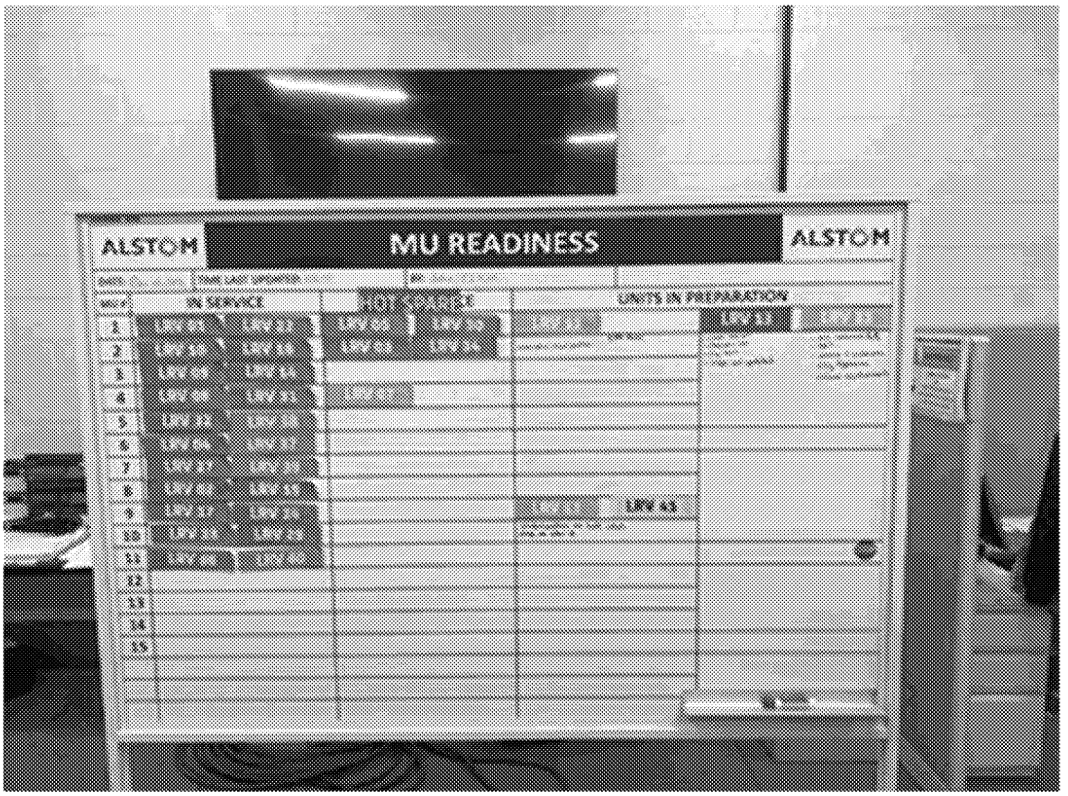
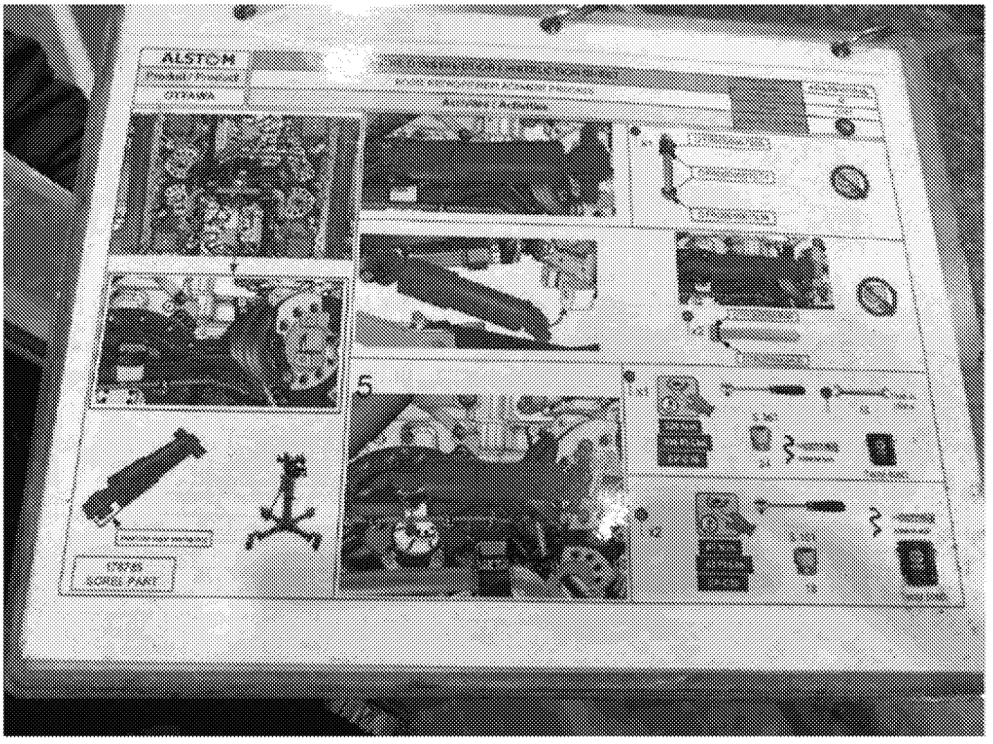


Figure 4.5 Quarantine area and clearly identifiable parts tags

Figure 4.6 Installation instruction manuals



4.3.2 Corrective Maintenance

Corrective maintenance is reported from any of the 5 sources listed below:

- Daily inspections (level 1);
- Preventative Maintenance (levels 2 & 3);
- Customer reports;
- Incidents; and
- Performance monitoring.

Daily inspections

The daily checklists supplied had no arising work so during the assessment it wasn't possible to tell if the reporting of corrective maintenance was taking place in the given timeframe, however the 'Work Order Backlog Report' suggests corrective maintenance is completed on time.

Preventative maintenance

There were no preventative maintenance events taking place during the time in the workshop, so it wasn't possible to tell if the reporting of corrective maintenance was taking place as required at the time of assessment. Preventative maintenance tasks being overdue were the majority of the tasks listed on the 'Work Order Backlog Report', so evidence suggests that this may be a problem area. While it wasn't witnessed at the time of assessment, we suspect this is due to lack of spares availability.

The warranty team had a vehicle on jacks with the bogies removed, there was a visible crack in the windscreen, windscreen defects require permission from the City prior to returning to service if not rectified. When the team were asked if crack had been reported I was told 'no' *NOTE: it may have been reported and the individual asked didn't know.* Additional process or collaborative working could reduce vehicle downtime.

Figure 4.7 Vehicle with the bogies removed

Customer reports

When interviewed several staff members stated that there were issues with the reporting of defects at this level, the Alstom team felt that the quality of the reporting was not always sufficient to diagnose faults and be confident of the rectification prior to returning to revenue service. Concise fault reporting is key to 1st time fault diagnosis. We recommend that Alstom consider the use of 'key information' cards to prompt the drivers to note or report specific details relating to environment, track geography or vehicle status.

Incidents

At the time of the assessment discussing post incident defect management was kept minimal to avoid conflict. It was clear that Alstom were undertaking significant levels of work to avoid repeat failure and that route cause analysis and mitigation techniques were being deployed.

Performance monitoring

A daily failure review is completed to ensure any defects are contained and mitigations put in place. Where a repeat failure occurs the engineering, team lead the investigation using FRACAS to report, classify, analyse and create preventive actions, if the failure poses a risk to the safety of people or infrastructure the engineers will follow the 8D process. 8D is a process widely accepted as good practice following a safety related failure.

During the assessment several Excel and PowerBI performance related charts and graphs were displayed.

Figure 4.8 Example of LRV reliability growth chart

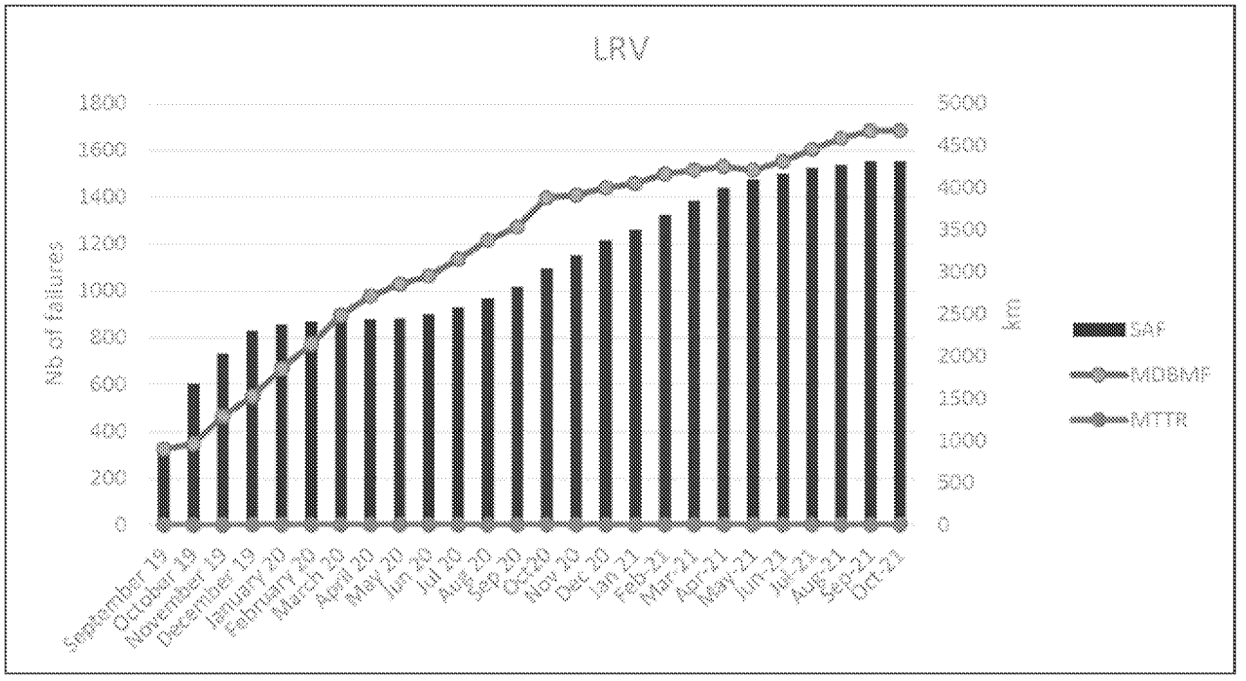
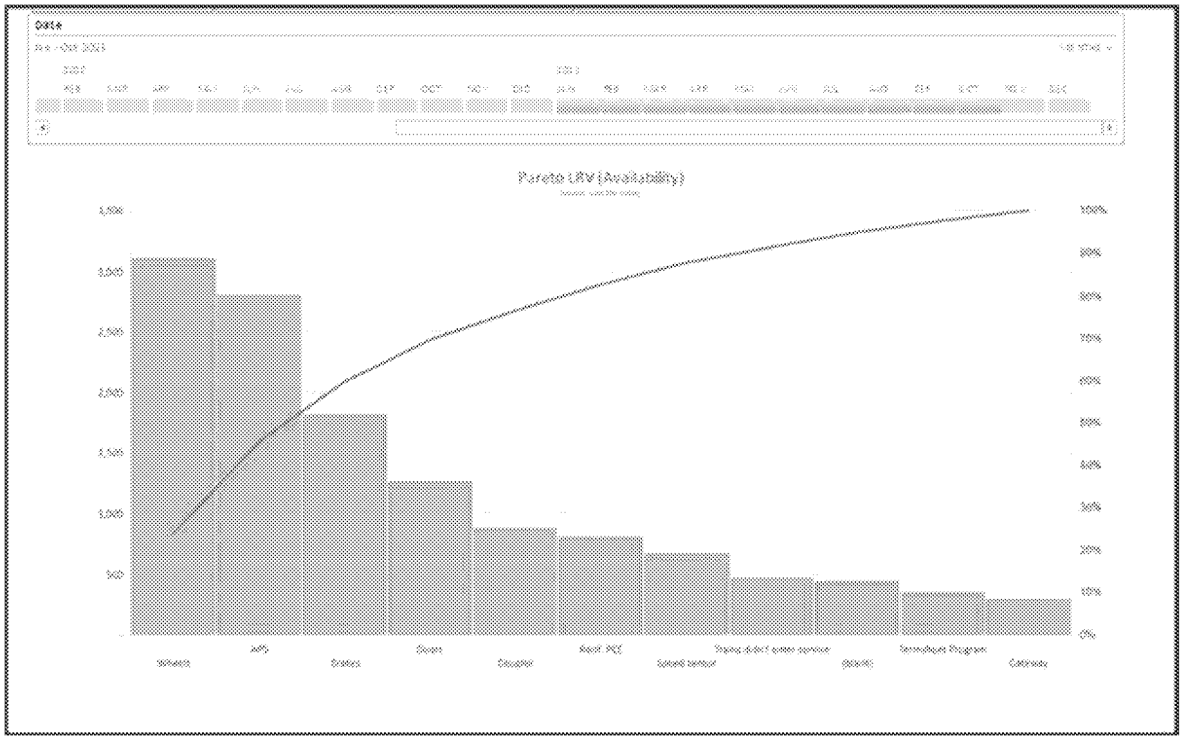
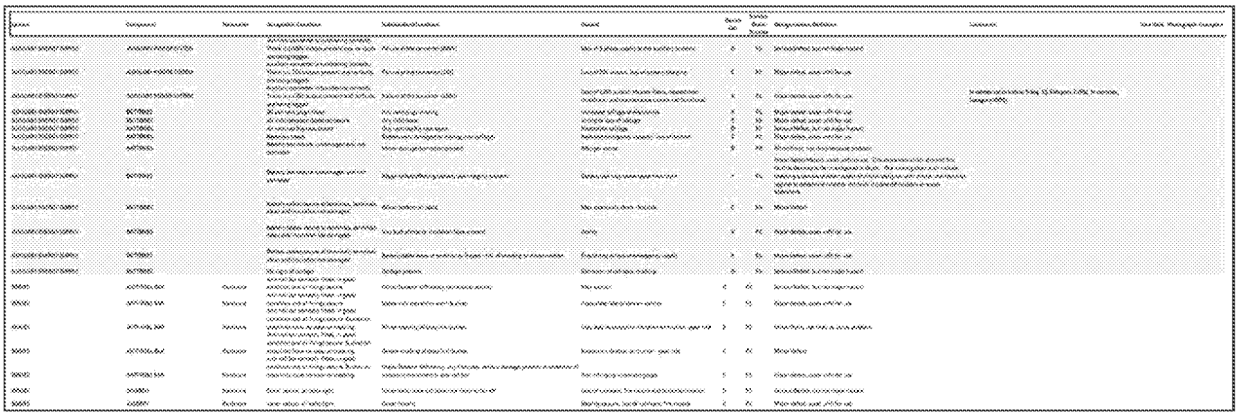


Figure 4.9 Example of reliability apportionment chart



The data collection and analysis was effective and easy to create links between past performance and vehicle defects. When the defects are raised, the on-shift supervisor sets the priority level using pre-existing guidelines. A defect matrix is being created as defects arise which will be used to build future preventative maintenance events.

Figure 4.10 Example of the defect prioritization matrix (in development)



Defect severity is categorised from P1 – P5, 1 being the highest level of risk and 5 being the lowest. Supervisors are able to make decisions about maintenance concessions for risks in the P3-P5 category but where they fall in category P1 or P2 they must be evaluated by an engineer. A P1 severity defect requires engineering risk assessment at each maintenance event and a P2 requires an engineering risk assessment on the first event and a supervisor assessment on consequent events where there is no further degradation.

Work orders for any maintenance concessions are added to GSI and a concession register is maintained.

The process is relatively robust however a monitoring stage could be applied to ensure the effectiveness of its application.

4.3.3 Retrofits

The maintenance technicians are divided into 2 teams, one team undertaking preventative maintenance and the other referred to as the 'warranty team' or 'rolling stock' team completing warranty and retrofit tasks.

Through assessment and interview it was apparent that vehicle availability has been impacted significantly by the need for retrofit works to be undertaken. The data suggested that the largest causes of vehicle failure were doors, wheels, APS Modules, brakes and bogies most of which have either been subject to retrofit or are currently undergoing retrofit.

During the assessment the general opinion was that the retrofit tasks were improving asset reliability and where actions were complete i.e. vehicle doors, the door runner had been improved, a driver override button fitted and an improved locking system fitted had significantly reduced the likelihood of failure.

During several discussions, the vehicles were described as 'concept' or 'hybrid' build type. The Citidas itself isn't a new design, it is referred to by the team as a concept due to some changes made from the normal design for the usage and environmental demands of the Ottawa railway network. We were advised that the vehicle testing stage was reduced from 7 months to just 1 month and while this doesn't justify issues running into year 2 of service it does explain why some early reliability problems were not resolved prior to revenue service.

Assuming a high quality of maintenance is provided, defects are managed appropriately, and major warranty issues closed it would be feasible to predict an increase in vehicle performance.

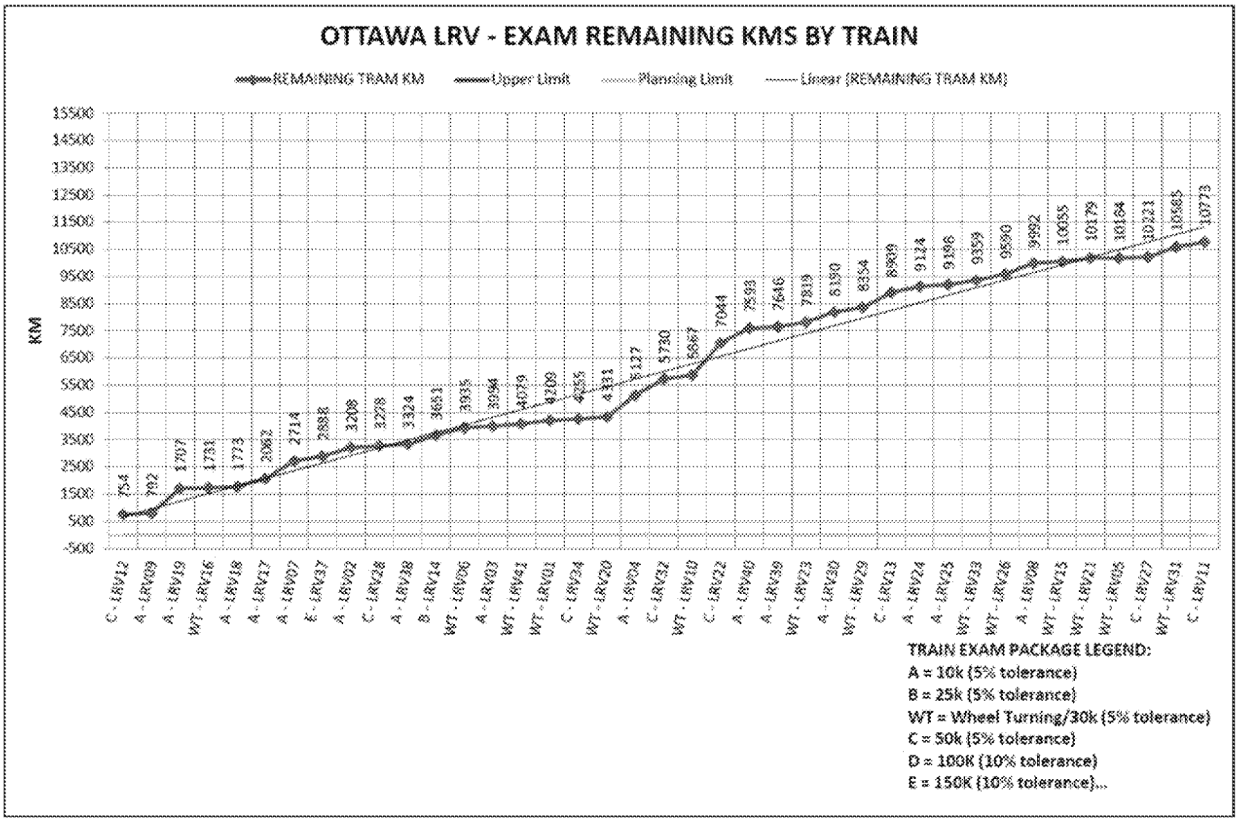
4.3.4 Backlog

A further monitoring stage would be required to fully investigate any issues with the backlog of maintenance tasks. The annual RTM audit process didn't highlight anything to suggest a serious backlog of planned maintenance events or defects and the November Work Order Backlog Report showed zero planned maintenance tasks overdue.

Vehicle maintenance is evidently the largest source of overdue reactive maintenance tasks with 369 tasks featuring on the report. Of the 369 tasks, assuming 'status' open or assigned with no 'completion' comments means the task remains overdue, 173 tasks remain overdue. The 'Work Order Backlog Report' makes no reference to the severity or impact of the overdue task and does not supply a reason for the deferral of the repair activity. We recommend that the work order backlog report be enhanced to aid prioritization. The report lacked in fault detail and some training could be given to staff to ensure an adequate and consistent level of reporting.

Alstom also use a "waterfall chart" to monitor the next maintenance intervention for each vehicle. The chart allows them to see any overdue maintenance and to plan to smooth out any peaks in maintenance by moving services early or late, within the allowable tolerance.

Figure 4.1 Example waterfall chart showing next maintenance intervention for each vehicle



The ongoing warranty issues affecting workshop availability and 'out of stock' or 'never stocked' items would be the most likely threats to undertaking maintenance tasks on time in a maintenance organisation at the current level of maturity.

4.4 Effectiveness of maintenance management and reporting systems.

At the time of assessment, it was mentioned that Alstom were considering changing to a time based maintenance schedule. Time based maintenance scheduling can be appropriate within a maintenance organisation where there is a limited pool of assets or when major maintenance events occur at the same point in time because of consistent usage (km) across the fleet. The analysis process wasn't discussed due to lack of availability of the maintenance management however it is worth considering whether this is the most effective methodology, given the increased asset availability post retrofit campaigns. Time-based maintenance could have cost increase implications.

Reliability data and reporting was well established within the Alstom team but it wasn't clear how well the data is shared between Alstom and RTM. We recommend that RTM and Alstom create joint metrics to assess the vehicle reliability to truly understand asset performance and reduce their reliance on just the availability metric. The availability metric currently used is a contractual KPI so holds value, but it can mask or detract attention from reliability problems.

4.5 Workorder management

Alstom use their Global Single Instance (GSI) system worldwide to manage activities including maintenance workorders this is linked to SES which is a mobile device platform used by the technicians to view workorders. Maintenance plans are assigned to assets and auto-generate work orders. Work orders contain a checklist of tasks due to be completed at each service and a link to the corresponding Work Method Statement to enable the technicians to have access to the task detail and specific risks relating to the task. Updates are completed digitally and changes are briefed to technicians by the engineering team via toolbox talks. There is a mapped interface between GSI and IMIRS (RTMs asset management system).

GSI is a SAP based system which is used worldwide for asset management/ enterprise resource planning and is a relatively robust tool.

4.6 Appropriateness of employee:

4.6.1 Training

We were advised that a competence framework has been created for the maintenance technicians. This was not made available due to availability of key people, but it is understood that the competencies listed in the framework focus on the technician being trained on the use of workshop equipment rather than specific areas of vehicle maintenance i.e. braking systems or wheels and bogies. We recommend that Alstom consider creating a new competence matrix that includes specific vehicle systems competence.

When asked about OEM or specialist training programmes for technicians it was confirmed that these are not in place. We recommend that Alstom consider creating a “route to competence” including specialist and OEM training. Where training was given it did not always include initial assessment, mentoring or re-assessment. We recommend that all training events contain an assessment to confirm that delegates have adequately understood the content as part of demonstrating competence.

4.6.2 Experience

It was explained during the assessment that most of the maintenance technicians had originally been involved in the vehicle construction phase prior to it being relocated and some were engineers recruited as technicians with the supervisors being promoted from the pool of technicians.

Recruitment of skilled and experienced rail vehicle maintenance technicians is difficult in Ottawa as there is no history of railway maintenance. There is local competition for technically capable staff, which is creating a problem with staff turnover. We recommend that consideration is given to a grading and progression structure for technicians to reward them for increasing knowledge and experience.

4.6.3 Qualifications

The geographic location makes it difficult to recruit qualified vehicle technicians. Maintenance technicians’ qualifications varied from ex-construction technicians from the build phase to

engineering graduates. Whilst we did not investigate the qualifications of individuals in detail, we observed that there is an opportunity to bring in staff without formal qualifications and support them to become qualified. We recommend that consideration in given to apprenticeship type new entrant programs as a way of attracting and retaining technical staff.

4.7 Appropriateness of maintenance organization;

4.7.1 Staffing levels

We were advised that the sizing of the organization is still based on the information submitted in the tender.

A time and motion type study would be required to assess the actual nightshift staffing levels appropriateness, based on the limited access times to the entire fleet during engineering hours given (but assuming trains are removed from revenue service sequentially) and the quantity of staff available undertaking daily checks with the addition only minor corrective repairs it would be feasible assuming the 'hot spare' vehicles are maintained and ready to be exchanged if required it is feasible that under normal operation the staffing levels are appropriate.

4.7.2 Shift coverage

At the time of assessment "7 technicians were on dayshift and 20 on nightshift" further analysis would be required to assess the appropriateness of this accurately any major maintenance outages and the continued retrofit would also have to be factored in due to the impact on hot spares. On dayshift (excluding warranty repairs) only 2 vehicles were in the workshop both receiving winterisation maintenance events or part of the maintenance event which had been deferred. Using some very basic analysis of available resource and estimated task lengths it is feasible that under normal operation the shift coverage is proportionate.

4.7.3 Supervision/oversight

The role of supervisor is an office-based role and generally recruited from the maintenance technician pool, which is logical; however, as this is the only form reward or succession for technicians it would lead to the best technicians being promoted and losing talent from the workshop floor. Two supervisors are present during shifts. One supervisor is from a vehicle maintenance background and the other from another discipline, although this may just have been on the day of assessment.

The supervisor from the vehicle maintenance background is responsible issuing and signing off work orders. Supervisors assign tasks to technicians based on their skills, this could open to interpretation and influenced by the availability of staff, as vehicle specific competence does not exist. Supervisors stated they do walk around the workshop and check the quality of the maintenance being completed but we were unable to verify this.

4.8 Support departments (Engineering, sourcing, etc.)

4.8.1 Engineering

The engineering team cover a number of activities including updates to maintenance documentation, reliability management, training and risk assessment. The documentation reviewed was well considered, had been updated and was of good quality. Their reliability management process was effective and made the linking of data and potential issues easy, they also applied credible processes to manage reliability defects.

We were not able to assess the quality of training delivered by the engineers. It is good practice that those delivering training should have a qualification to train. There is a risk that a knowledgeable engineer will make assumptions about the level of pre-existing understanding by the technicians and may go too fast to embed a thorough understanding of the material with the delegates.

We recommend that consideration is given to focussing the engineers on creating comprehensive training material to be delivered by a qualified trainer, rather than delivering the material itself.

4.8.2 Warehousing

The warehousing team were not interviewed due to the short timescales, we noted that at present they had a vacant management position which they intended to fill. Stock min/max levels are created on a reactive basis. We recommend that a review is undertaken of the requirement for spares and suitable levels of stock are procured.

4.8.3 Facilities

The facilities team provided a good service, all depot equipment was in working order and maintained. There were concerns from the facilities team that equipment such as the wheel lathe was damaged by the maintenance team due to unintentional improper use. We recommend that the facilities staff work alongside the vehicle maintenance team to understand how the equipment is being used and provide advice on how it can be operated reliably.

4.9 Adequacy of tools and equipment

Only a visual review of the adequacy of tools and equipment was completed due to time limitations. The workshops were well prepared with good access to pits, jacks and working at height equipment, toolboxes were placed regularly down the length of the maintenance roads and several signs of good practice were visible; LOTO procedures applied, shadow boarding and quarantining of out of date lifting equipment. The workshops and all the equipment within were all relatively new, maintained and of good quality.

The workshops were in a good condition and kept clean and free from tripping hazards. The design of the workshop isn't optimal and didn't help with the 'flow' of maintenance activity, having no through roads could cause operational difficulties and add time or complications to maintenance planning. We recommend that Alstom consider studying workshop usage and develop a robust plan to ensure workshop space and movements are efficient as possible.

4.10 Adequacy of QA/QC processes

RTM undertake an annual Alstom vehicle maintenance audit, the audit contains 21 sections, 19 of which are planned maintenance record or certification checks, section 20 is a training record check and 21 a visual inspection of physical work being undertaken.

The last audit of vehicle maintenance raised several NCRs for vehicles receiving maintenance outside the required mileage tolerance. In each case, the corrective action stated, “Inspections for the trains shall be conducted as per prescribed mileage and within the allowable tolerance.” But did not identify the root cause or suggest additional controls be put in place to address this issue.

We have made further observations on the assurance framework in section 8.1.

5. Infrastructure

5.1 Asset Management Plan

We reviewed the Asset Management Plan ENG-SV-OTT-PRO-001 version D dated 31/12/2020. The PA requires to the asset management plan to be updated annually by 31st December, so this is the latest version.

The Asset Management Plan for Infrastructure is structured in the same format as those for other assets. We have included some comments that apply to all plans in section 3.1.

During this assessment, we have not reviewed every reference document in detail, but we have referred to some of them in drawing our conclusions about the completeness of the Asset Management Plan.

Section 1.1 Asset Inventory

The plan states: "*Due to the unavailability of the Constructor's Asset Register, Alstom has, and continues, to collect asset information from available drawings and conduct field audits to capture and ensure accurate records of infrastructure assets under Alstom maintenance scope.*" Despite this caveat, from our assessment of the asset database in GSI, a range of sources has been used to compile a comprehensive asset register that is now being used to manage maintenance.

Section 3.1 Scope

This section includes a definitions of maintenance "levels". Level 1, which includes inspection, is described as requiring only basic technical knowledge and training. Later in the document, daily inspections are confirmed as being level 1 and it is questionable whether the guideway inspection is appropriate to be undertaken by an individual with only basic knowledge, particularly as the Trackwork Maintenance Manual (RES-22-0-0000-MAN-0003) states that "*This inspection shall be performed by personnel who have been trained to identify early signs of defects, safety of operation and have passed oral and written examinations on the principles of this Maintenance Manual.*"

Appendix B4 Guideway Maintenance

Daily Guideway Inspection

The guideway daily inspection is referred to the Work Method Statement OTT-GWY-MTN-10-WMS-014. This method statement states that the daily inspection is undertaken in 4 scheduled guideway sweeps in the morning prior to start-up of daily service. The Trackwork Maintenance Manual states: "*The inspection of track is usually performed by a revenue vehicle (guideway "sweep") or by Hi-rail vehicle prior to the start-up of daily service. The crew on special trackwork and switch machines shall perform their work by walking and visually checking all special trackwork.*" Therefore the daily WMS is not fully compliant with the requirements of the designers requirements with regard to special trackwork inspection.

It is evident from both interviews and review of the asset management plan that there is a layered inspection regime, but it is solely undertaken by the Guideway Technician. Whilst we recognise that there is a means for managing Guideway Technician competence, it removes the assurance provided by having a tiered hierarchy asset management inspection.

Provisions are set out within Network Rail's maintenance standards for three levels of track inspection:

- Level 1 Basic visual track inspection;
- Level 2 Section Manager; and
- Level 3 Track Maintenance Engineer.

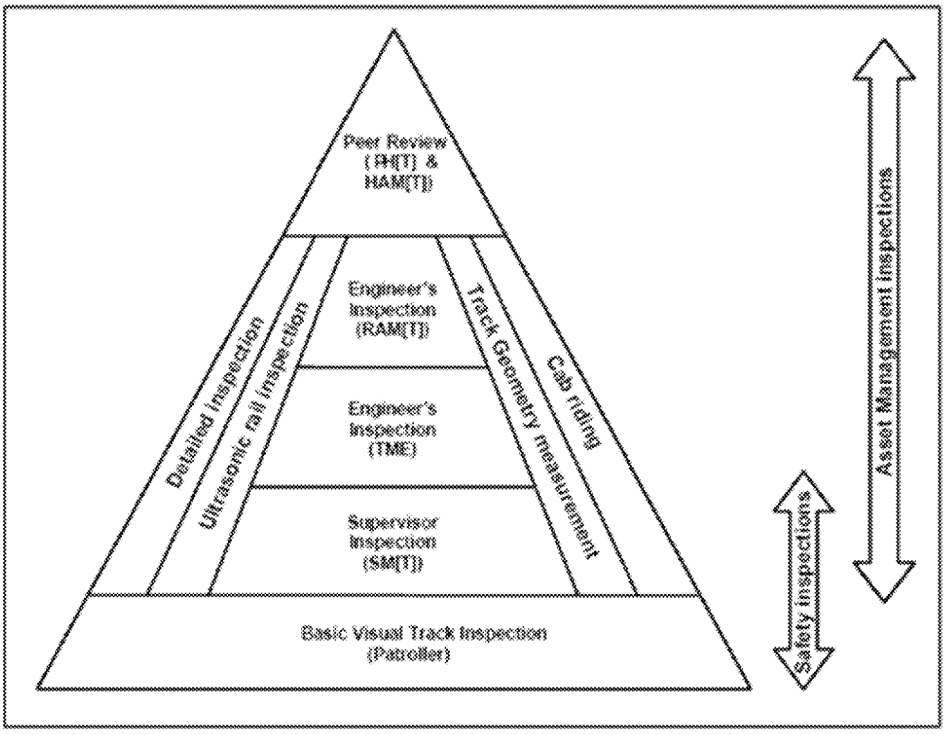
Note: Level 1 Inspections have predominantly now been replaced with a Plain-Line Pattern Recognition (PLPR) Inspection vehicle, automating the identification and classification of defects.

The inspection frequencies for Level 1 and 2 vary and are based on the asset type and associated track category (taken from the track category matrix). The Level 3 inspections are completed at two-yearly frequency for all track categories.

This is summarised in the inspection hierarchy within Figure 5.1 which also shows the peripheral inspections that are conducted to support. The levels complement each other and provide a level of assurance ranging from short-term risk, medium-term planning, and longer-term strategy.

The Level 3 Track Maintenance Engineer inspections confirm the integrity of the track asset reviewing quality / volume of works undertaken, reviewing renewal proposals and assurance checking the other inspections. This for example, includes Engineers undertaking re-inspection and re-assessment of defects, to ensure that safety risks are managed.

Figure 5.1 Hierarchy of Track Inspection (NR/L2/TRK/001)



The Basic Visual Inspection (BVI) identifies immediate safety defects and records the progress of other defects. The purpose of the supervisory inspection is to verify that the results of the BVI match the asset condition, including confirming the correct prioritization of defects, to validate the standard of previously completed work and to assist with planning of future rectification work.

The track is inspected by the responsible maintenance engineer every two-years to confirm that it remains in an acceptable condition and to assist with the specification and planning of renewals. A sample of track is inspected by the Route Asset Manager to verify the specification of renewals and to ascertain that the maintenance is being undertaken to prolong asset life.

The delivery of all inspections at guideway technician level provides no assurance as to the condition of the asset, the quality of inspection, the appropriate prioritization of defects and the quality of corrective work. There is no overall condition assessment or early identification of the requirement for renewals.

We recommend that a process is put in place for competent guideway supervisors to undertake routine inspections to verify the technician's inspection and rectification work and that the Engineering team have a process to validate that the maintenance they specify is meeting the customer requirements.

Hot Weather Management

We have been advised that the system has experienced several track misalignments (kinks) and are concerned that the process for managing track stability appears very reactive.

Currently there is a Work Method Statement for extreme weather inspection (OTT-GWY-MTN30-WMS-004). This is triggered by a temperature fluctuation of >20°C or a rail temperature of >30°C. The inspection is a general inspection across the network for signs of track movement.

Misalignments are not created solely by hot weather. They are triggered by the presence of at least one other factor (a deficiency, a disturbance or incomplete preparatory maintenance work). The most common are:

- a low stress-free temperature;
- ballast deficiency (e.g. insufficient ballast in the cribs or on the shoulder);
- ballast disturbance (e.g. tamping, lifting and packing, sluing track);
- rail creep;
- poor lateral and/or vertical alignment (e.g. voiding sleepers, misalignments);
- sleeper and bearer changing; or
- disturbance of the track system caused as result of intervention to non-track infrastructure.

It is therefore possible to assess and mitigate the likelihood of misalignments before the onset of hot weather.

The ballast and tie assessment included within the monthly inspection (OTT-GWY-MTN10-WMS-016 part 1C) should be used to identify sites with ballast deficiency and could be modified to identify recent ballast disturbance. Checks 2B and 3B will identify poor lateral and vertical alignment.

Alstom state that they have undertaken some mitigation work such as strengthening the ballast shoulder on the Hurdman to Tremblay corridor.

We recommend that the work orders resulting from deficiencies identified during these inspections and records of sites with unknown or low neutral stress are analysed prior to spring and work is prioritized to rectify the deficiencies to reduce the likelihood of track kinks.

Furthermore, we recommend that a process be put in place to identify those sites with outstanding deficiencies and those sites that have been subject to disturbance and have not yet been consolidated such that mitigations can be put in place rather than waiting for the temperature to rise and going out to inspect for kinks.

Alstom state that they have not received any records of the stress neutral temperature. We recommend that this is immediately rectified by requesting the records from OLRTC.

Rail Management

Chapter 4 of the Track Maintenance Manual (Technical Standards & Maintenance Work) describes the need for ultrasonic testing of rail to be completed annually or more often in the event of a significant increase in failures or detected defects. The asset management plan makes no reference to non-destructive testing of rail. We were advised that ultrasonic testing is currently planned three times per year (4-monthly).

The current ultrasonic testing provider (Hertzog) has found very few rail defects. Alstom report that find this unusual, as do we. They are engaging a different contractor (Sperry), to undertake the next test of the network.

Chapter 3 of the Track Maintenance Manual (Guideway Scheduled Inspection & Maintenance) states the routine requirement for ultrasonic testing of rails and welds and requires that: major flaws must be recorded, and remedial action promptly taken. The manual provides no further guidance on timescales for correction of defects.

We consider that the arrangements for management of the risk of broken rails is inadequate. We recommend that the approach for rail flaw detection and correction be included in the next update to the asset management plan.

Chapter 11 of the Track Maintenance Manual describes the need for condition monitoring and subsequent rail grinding. The asset management plan states that rail assessment is undertaken during the monthly inspection (OTT-GWY-MTN10-WMS-016). Task 2A refers to visual identification of rail flaws but the full range of examples from the Track Maintenance Manual are not covered. We recommend that the WMS be updated to assist the Guideway Technician in recognizing all of the types of rail flaw identified by the designer.

The Work Method Statement states: "*The qualified Guideway Technicians will walk or inspect the track on hi-rail*" Given the nature and purpose of this WMS, we recommend that the option to undertake the inspection by hi-rail be removed and that this inspection becomes mandated as a walking inspection.

We were advised that there is currently no proactive rail grinding program. The asset management plan does not explain how the results of the inspection are used to determine the frequency of grinding and therefore does not cover the requirement 11.2.2 of the Track Maintenance Manual. We recommend the asset preservation measures section of the asset management plan be updated to describe how the frequency of rail grinding is determined to maintain rail profile and condition.

Track surfacing

The Track Maintenance manual makes no reference to tamping of plain line after the initial installation of the track, other than spot tamping to rectify loose ties. The chapter 13, section 3.13 recommends annual tamping of special trackwork, but this is not included in the asset management plan.

A program of tamping was undertaken in June 2021, but we were advised that this was hampered because the tamper was out of gauge for some parts of the network.

We recommend that the asset management plan be updated to include the asset preservation measures used to determine the tamping program. The section should also include the approach to procuring a suitable tamping machine to avoid the need to dismantle elements of the stations to achieve the required gauge clearance.

Appendix B5 TPSS Maintenance

There are activities within the Maintenance and Rehabilitation Plan (RTM-MC-PLN-042) such as the requirement to maintain leakage of DC current in the Hydro Ottawa system neutral below agreed thresholds. Whilst we did not examine all the Work Method Statements, the annual inspection (OTT-TPS-MTN10-WMS-002) is the only intrusive inspection and yet it does not include any measurement of stray DC current.

We recommend that the content of Asset Management Plan and the TPS Work Method Statements are reviewed against the maintenance handbook and the Maintenance and Rehabilitation Plan to confirm that all the required activities are included.

Appendix B6 OCS Maintenance

The OCS preventative maintenance consists of inspections a 2, 6 and 12 month intervals. We noted that the Work Method Statement quoted for the 6-monthly maintenance (OTT-OCS10-MTN10-WMS-001) states a frequency of 3 monthly in section 2. Checking with the Table Nr. 1 in the maintenance handbook (MVA-54-0-S017-MAN-1000), the inspection frequency can be relaxed from 3-months to 6-months at the end of the first year of operation.

The maintenance handbook includes a 5-yearly inspection and component replacement. There is no such activity in the Asset Management Plan; however, we did not check the detail of the WMSs to see if the activities have been included in those for more frequent services.

We recommend that the frequency and detail of inspections checked against the maintenance handbook and the relevant documents updated to reflect the correct requirement.

OCS is inspected from the ground at a two-monthly interval. This inspection is always undertaken during Engineering Hours, meaning that the OCS is never inspected in daylight, making it difficult to achieve a thorough inspection. We recommend that consideration is given to arranging alternate inspections to be carried out during the day, with suitable protection from traffic to improve the early detection of defects and deteriorating condition.

5.2 Quality Plans

The Asset Management Plan cites document QUA-SV-OTT-MAN-001 as the Project Quality Plan. On reviewing this, we find the latest version, dated 22nd January 2021, to be titled Ottawa CITADIS Maintenance Project Quality Plan. The Scope of Application states: "*This document applies to all the maintenance activities for the CITADIS Spirit LRVs according to the second amended and restated Maintenance Subcontract.*"

We were therefore unable to find a Quality Plan that includes the infrastructure in its scope.

The document contains reference to many more detailed processes and procedures, which Alstom have confirmed they are not prepared to share. The titles of these reference documents suggest that many are generic processes that would be applicable to both the vehicles and the infrastructure.

We recommend that the Quality Plan is reviewed and amended to reflect the full scope of the Alstom contract, adding in the requirements both in the plan and in the library of reference documents arising from expanding the scope to include infrastructure.

5.3 Maintenance

Using our Heart of Asset Management maturity assessment template, we reviewed the maintenance information, documentation, processes and asset information.

5.3.1 Preventative Maintenance

The Asset Management Plan contains a schedule of Preventative Maintenance by Asset. The schedule contains the frequency of each inspection and a reference to the Work Method Statement detailing the maintenance tasks. There is also a table of the tolerances within which each maintenance activity can be performed. An example is shown in Figure 5.2 below.

We were advised that the Asset Management Plan has been compiled from the Project Agreement and the Maintenance Manuals handed over by OLRTC, but the document does contain the caveat "*Upon availability of the specific OMM manuals, this schedule will be updated to include manufacturer recommendations and further information regarding maintenance planning for years 2 to 5 for all the systems."* We have seen maintenance manuals for most of the systems so from our observations during the assessment phase, we do not believe there are any fundamental omissions.

Figure 5.2 Example of the Preventative Maintenance Schedule for TPSS

B-5. Maintenance for TPSS (Traction Power Sub Station)

Frequency	Asset	Maintenance Activity	Reference Code
Monthly	Building assembly	TPSS Visual Inspection	OTT-TPS10-MTN10-WMS-001
	HVAC (*Visual inspection*)		
	Fire detection system		
Bi-Annual	Building	TPSS Cleaning	OTT-TPS10-MTN10-WMS-003
	Eye wash Station	Eye wash station refilling	OTT-TPS-MTN10-WMS-007
Seasonal	HVAC Inspection	HVAC Seasonal Inspection	OTT-TPS-MTN10-WMS-006
Annual	DC (*Direct Current*) Breaker	TPSS Annual Inspection	OTT-TPS10-MTN10-WMS-002
	AC (*Alternating Current*) Breaker		
	Rectifier Transformer		
	Battery Charger + Battery bank		
	Disconnect Switch		
	Fire detection system		
	Distribution panels		
	Cable inspection		

Tolerances for TPSS Preventive Maintenance

MAINTENANCE INTERVAL	TOLERANCE (±)
Monthly	7 days
Semi-Annual	7 days
Annual	14 days

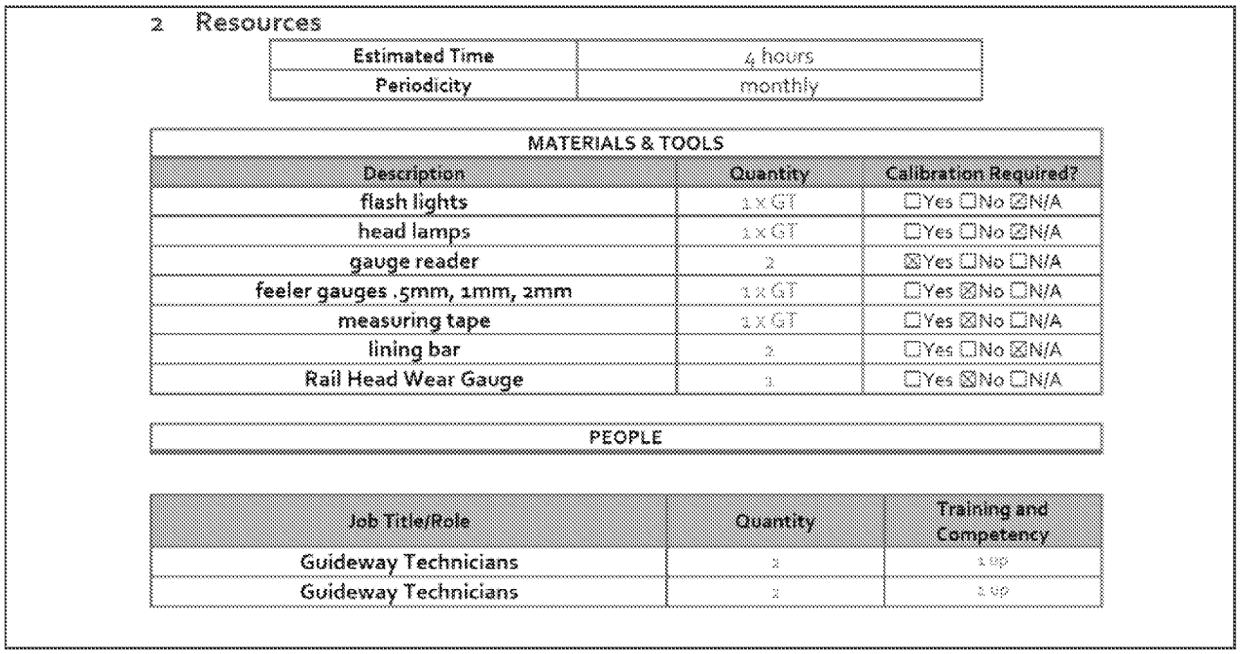
Work Method Statements

Each scheduled inspection has an associated Work Method Statement. From our observations during the assessment phase, these appear reasonably consistent with the Maintenance Manuals, but we have not undertaken a detailed requirement-by-requirement review to confirm full coverage.

Work Method Statements are separated into sections covering the purpose and scope, resources, safety and the detailed work procedure. As such they provide a comprehensive reference both for the technician undertaking the work and for the work planner.

The Resources section includes the required tools and highlights where calibrated equipment is required. In the People part of the section, the WMS shows the number and competencies of the staff required.

Figure 5.3 Example Work Method Statement (Resources Section) for Monthly Track Inspection



2 Resources

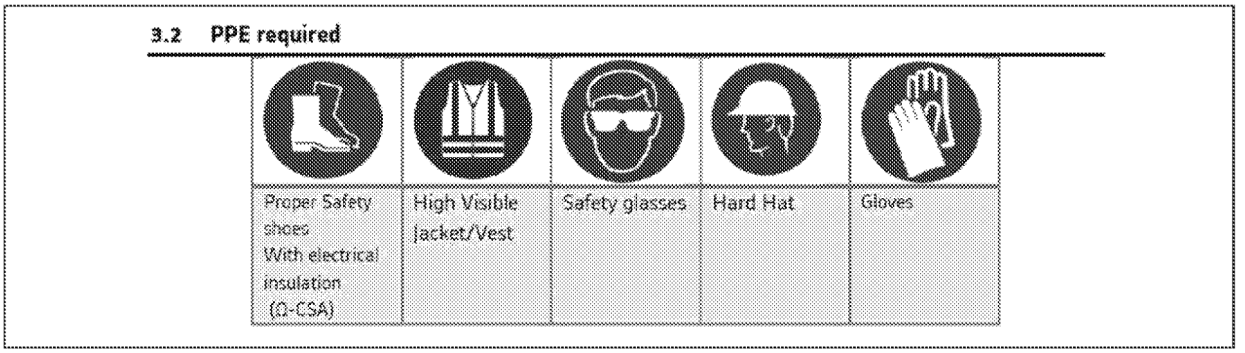
Estimated Time	4 hours
Periodicity	monthly

MATERIALS & TOOLS		
Description	Quantity	Calibration Required?
flash lights	1 x GT	☐Yes ☐No ☑N/A
head lamps	1 x GT	☐Yes ☐No ☑N/A
gauge reader	2	☒Yes ☐No ☐N/A
feeler gauges .5mm, 1mm, 2mm	1 x GT	☐Yes ☒No ☐N/A
measuring tape	1 x GT	☐Yes ☒No ☐N/A
lining bar	2	☐Yes ☐No ☒N/A
Rail Head Wear Gauge	1	☐Yes ☒No ☐N/A

PEOPLE		
Job Title/Role	Quantity	Training and Competency
Guideway Technicians	2	1 op
Guideway Technicians	2	1 op

The Safety section provides pictographic information on the required PPE and lists the risks and mitigations associated with the activity. Most of the risks listed are generic risks associated with working on the guideway. It is questionable whether the impact of these risks is lost by replicating them in every Work Method Statement.

Figure 5.4 Example Work Method Statement (Safety Section) for Monthly SER Inspection



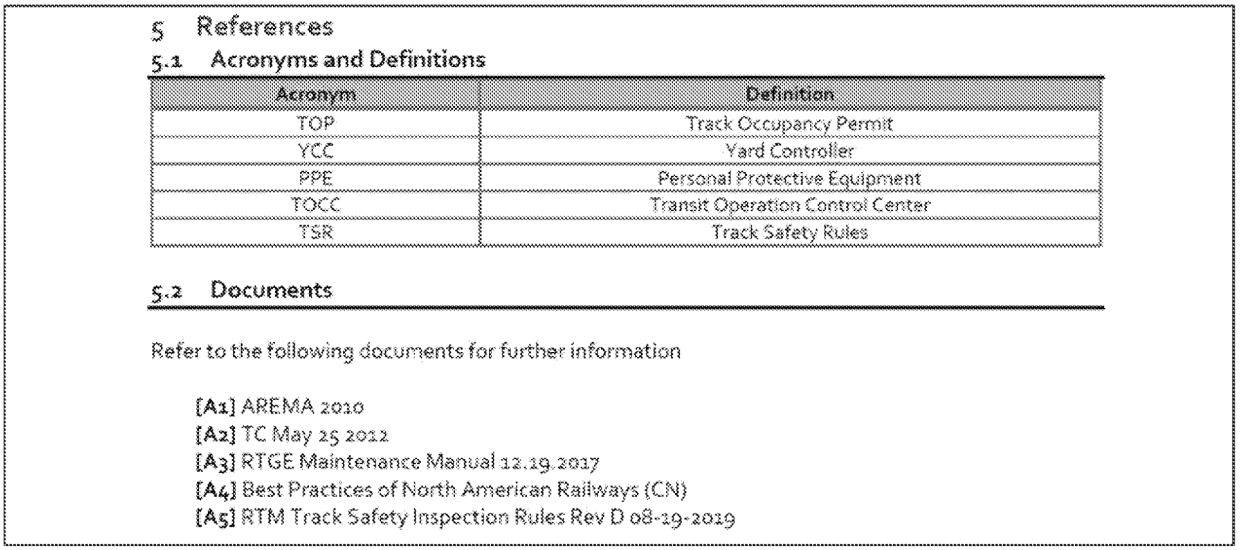
3.2 PPE required

Proper Safety shoes With electrical insulation (Ω-CSA)	High Visible Jacket/Vest	Safety glasses	Hard Hat	Gloves

Section 3 of each WMS also contains environmental considerations and details of who to contact in an emergency.

Section 5 of the WMS records the documents on which the task list is based so that the requirements are traceable and WMSs that require updating as a consequence of an update to a feeder document can be quickly identified.

Figure 5.5 Example Work Method Statement (References Section) for Monthly Track Inspection



5 References

5.1 Acronyms and Definitions

Acronym	Definition
TOP	Track Occupancy Permit
YCC	Yard Controller
PPE	Personal Protective Equipment
TOCC	Transit Operation Control Center
TSR	Track Safety Rules

5.2 Documents

Refer to the following documents for further information

[A1] AREMA 2010
[A2] TC May 25 2012
[A3] RTGE Maintenance Manual 12.19.2017
[A4] Best Practices of North American Railways (CN)
[A5] RTM Track Safety Inspection Rules Rev D 08-19-2019

In this case, reference [A3] refers to the 12.19.2017 version of the RTGE Maintenance Manual whereas the latest version of RES-22-0-0000-MAN-0003 is dated 02.05.2019 (albeit at Rev. 0). Whilst it is unlikely that there will be future versions of this particular manual, we recommend that Alstom consider establishing a process to ensure that changes to reference documents are reviewed to determine their impact on Work Method Statements that are based on them.

Section 7 of the Work Method Statement comprises a Control Sheet, showing the issue status of the document. The Control Sheet includes details of the modifications made at each revision, making it easy for readers to identify the changes that impact them.

Overall, we consider that the Work Method Statement format is consistent with best practice and the process for producing the documents is satisfactory but could be improved in line with our recommendations.

The tasks listed in the Work Method Statements are based on the information provided by the Constructor, including guidance from the OEM. In our experience, OEMs do not tailor their maintenance requirements to the operating context and often have little practical experience of the performance of their equipment in the field.

Alstom have recognized this and whilst the maintenance manuals make a good starting point and only now is sufficient experience available to commence a maintenance optimization program, we recommend that they put in place such a program to review the efficiency and effectiveness of the Work Method Statements using a formal assessment technique such as RCMII to refine the maintenance activities and align them to the performance and preservation requirements of the Project Agreement.

Similarly, the Work Method Statements have not been "industrialized" to remove waste and increase efficiency and there is an opportunity to use techniques such as LEAN to achieve this.

We recommend that a sample of the inspections are observed during the monitoring phase to confirm that they are being undertaken fully. The team undertaking monitoring should take copies of all the open reactive work orders to confirm that the physical state of the asset aligns with the records.

5.3.2 Corrective Maintenance

Corrective maintenance is managed by means of service requests and work orders. Corrective work orders are assigned to assets, but the quality of the assignment is variable, depending on the level of understanding of the individual creating the work order. Whilst this does not affect the rectification of the defect, it has an impact later in the asset lifecycle when using the data to make decisions based on asset reliability and performance.

There is a prioritization system for incoming work (P1 to P4) but no standardized method for assigning priorities such that rectification can be monitored against pre-determined time scales.

We heard various descriptions of the prioritization hierarchy as: P1 – safety related defects, P2 – service affecting failures, P3 and P4 other priorities.

Where defects are identified during maintenance, the risk they pose is assessed by the Engineering group who then instruct a rectification timescale and any mitigation measures. This approach has several disadvantages, for example:

- The risk is determined by an individual on a given day. Depending on their perception of risk, the outcome may be overly restrictive or insufficiently robust;
- There is a daily workload placed on engineers who would provide better value by working on medium and long term policies and processes;

- There is no advice to technicians on the immediate action required. Where an operational restriction such as a speed restriction is required to protect the defect, this requirement may not be identified until several hours later when an engineer has completed their review.

We recommend that the immediate mitigations and remedial timescales for common defects are defined and made available to technicians.

There is an informal "reinspect or repair" methodology being used whereby the repair timescale for a defect can be extended if it has been reinspected and not deteriorated. However, we did not see a robust system for managing this. We recommend that Alstom consider making the extension of defect rectification timescales by reinspection into a formal process, with an appropriate means to control compliance and sufficient oversight to avoid the risk of persistent extension without proper assessment.

Work Method Statements

We were advised that Work Method Statements are being prepared for some common corrective maintenance tasks. This will be beneficial as it will standardize the repair processes, including documenting the competence required and the requirement to take any safety critical measurements prior to restoration to service.

It will also be beneficial in supporting future analysis for maintenance optimization or reliability improvement by capturing how frequently particular interventions are made.

Good progress is being made on Communications and some created for Power. The signalling system is well documented by Thales and this information is being formatted into Work Method Statements.

Fault and incident response

The Article 1.5(f)(v) of the Project Agreement requires that "Project Co shall establish a plan detailing Project Co's Maintenance strategy in the event of the failure of any system, equipment or component of the System. The plan shall include response and repair strategies." We did not see such a strategy.

The Article 7(b) of the Project Agreement contains specific requirements for immediate response in the event of a failure or incident. None of the reports we saw contained analysis of performance against these requirements.

We recommend that a response and repair strategy is created as required by the Project Agreement and that suitable reporting is put in place to monitor performance against it.

The network is supported by 24/7 coverage of technicians who can respond to failures and incidents; however, we are advised that the assessment of some defects can only be done during engineering hours.

Thales have produced contingency plans to show how to operate trains with particular portions of line obstructed but there are no equivalent plans for other events such as switch disturbances or wayside equipment outages.

The CBTC system includes the concept of Work Zones. Work Zones can be used to protect staff working on the track by preventing trains from entering a section or restricting the speed of trains. With the right enabling processes, this function could be used to protect staff during the day, allowing them to undertake initial diagnosis of failures or disturbances of equipment.

Whilst this could have an operational impact for the duration of the inspection, it enables the maintenance team to prepare to undertake the remedial task in the next available engineering hours. If the diagnosis is made to wait until the end of service, it may not be possible to complete the remedial work the same night, potentially leaving a safety or performance issue in place for a further service day.

Alstom are in the process of producing troubleshooting guides for some equipment. The guides are being produced by technicians with experience of real world failures.

Restoration to service

We did not see any evidence of the requirements for restoration to service following a failure or incident. There are cases where the defect or associated restoration work may disturb or alter asset set up, for example switch opening and detection, rail stress or height and stagger following re-erection of OCS. In these cases, safety critical tests, checks or measurements are required before assets are restored to service or defect mitigations such as speed restrictions or operational restrictions are removed. We were advised that Engineering are usually involved with restoration to service but that this is not to a documented procedure.

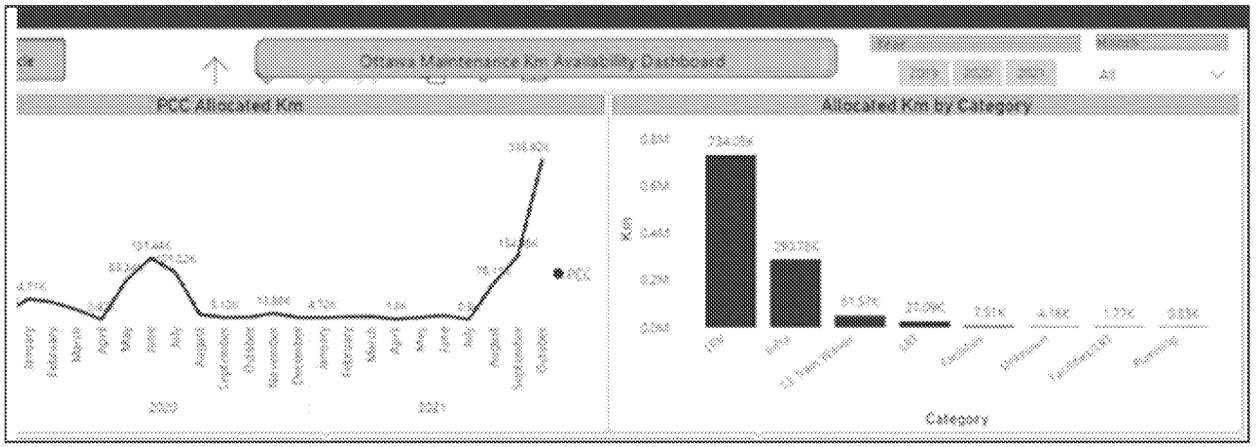
We recommend that where tests or checks are required following corrective maintenance, these are detailed in the Work Method Statement for the activity, along with a definition of the competence required to authorise the restoration of the affected assets to service.

Reliability management

Alstom produce a Monthly Performance Report that includes reliability statistics but there is very little analysis (see section 5.4.1).

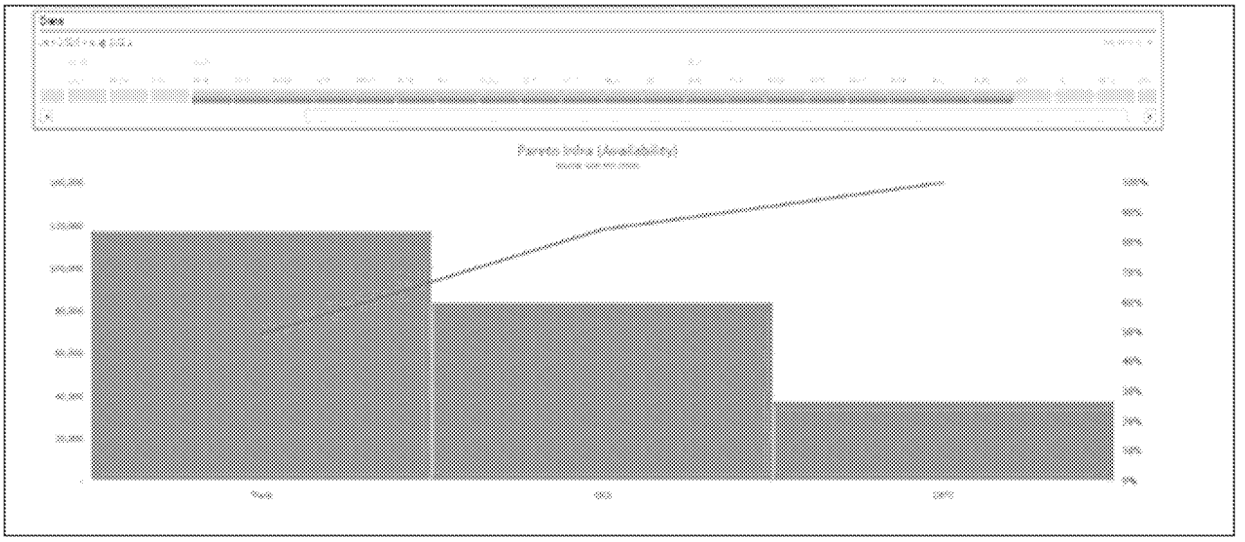
They do, however have their own PowerBI dashboards that provide a greater level of granularity.

Figure 5.6 Analysis of failures by km impact



The highest impact is caused by LRVs but this total includes corrective work orders for cleaning issues and so it is not clear which technical systems cause the highest impact.

Figure 5.7 Example drill down of infrastructure failure categories



The vehicle maintenance team have a regular Failure Review Board. A similar process is starting for infrastructure imminently; however, its effectiveness may be limited by the availability of support from the OEM. There are further observations on OEM support in section 5.8.2.

Recording of defects corrected on maintenance

We were able to observe how corrective maintenance work orders are analysed to identify reliability issues. However, we were not able to ascertain that all corrective work is recorded. This issue potentially arises when remedial work such as reapplying lubrication, tightening of bolts or reinsertion of track clips is undertaken during preventative inspections.

Completing work such as this supports the inspection result being recorded as “OK” but if no record is made of the work undertaken, reliability issues that result in frequent corrective activity being undertaken during inspections may go undetected.

An example of this might be where a safety critical bolted connection is regularly checked and frequently requires tightening. If this is not recorded, the Engineering team will not be aware of the loss of torque between inspections. Similarly, if the action of switch heating is drying out slide chair lubrication, it may be appropriate to increase the frequency of lubrication during the heating season to mitigate failure.

We recommend that consideration is given to recording corrective activities undertaken during routine preventative maintenance.

Spares

There is no comprehensive inventory of required spares. We were advised that there is a warehouse facility in the BMSF that has the capability to manage spares and consumables using the SAP system, but that they only hold a subset of the required inventory lines.

When issues are found with not having adequate spares, an assessment is made of the requirement based on population, turnover and lead time and the required quantity is added to the inventory and managed by the warehouse. Similarly, some stock lines have been added following a partial review by the engineering team.

We recommend that a review is undertaken of the requirement for spares and suitable levels of stock are procured.

Configuration Information

The availability and completeness of configuration information is a concern. Where information has been provided, Alstom have filed this on a SharePoint site and made it available to the engineers and technicians, however there is no process to make sure that the information in SharePoint reflects the latest configuration. We recommend that a process be put in place to control the introduction of configuration changes to the network such that the correct information is available from the point of the commissioning of the change.

The configuration information in the SharePoint site is limited to manuals and as-built drawings. There are no copies of firmware or configuration files such as those that might be required to program replacement hardware or repair a corrupted configuration. We recommend that an inventory of programmable and configurable systems is created and a controlled storage for configuration data is established.

Delivery of corrective maintenance

Alstom do not hold a full range of capabilities in house. Activities such as rail stressing and welding are undertaken by subcontractors. We did not investigate the arrangements for the management of competence and work quality for tier-2 contractors. We recommend that these arrangements are investigated during the monitoring phase.

5.3.3 Retrofits

Both in our review of the asset preservation measures report and our discussions with members of the Engineering and Maintenance teams, we have not seen any evidence of planning for future asset renewals. Whilst the network is still relatively new, we would expect to see some level of prediction of future renewal activity.

For example, looking at the Track Tracer report (OTT-ENG-REP-055) dated 31/03/2021, we see in section 3.2.2 that rails on many of the curves have horizontal head wear at or above 50% of the allowable limit, meaning they are likely to require replacement in the next two years, but we did not see a plan for this.

We were advised that OCS contact wire wear is measured annually but this is not reported in any of the asset condition reports.

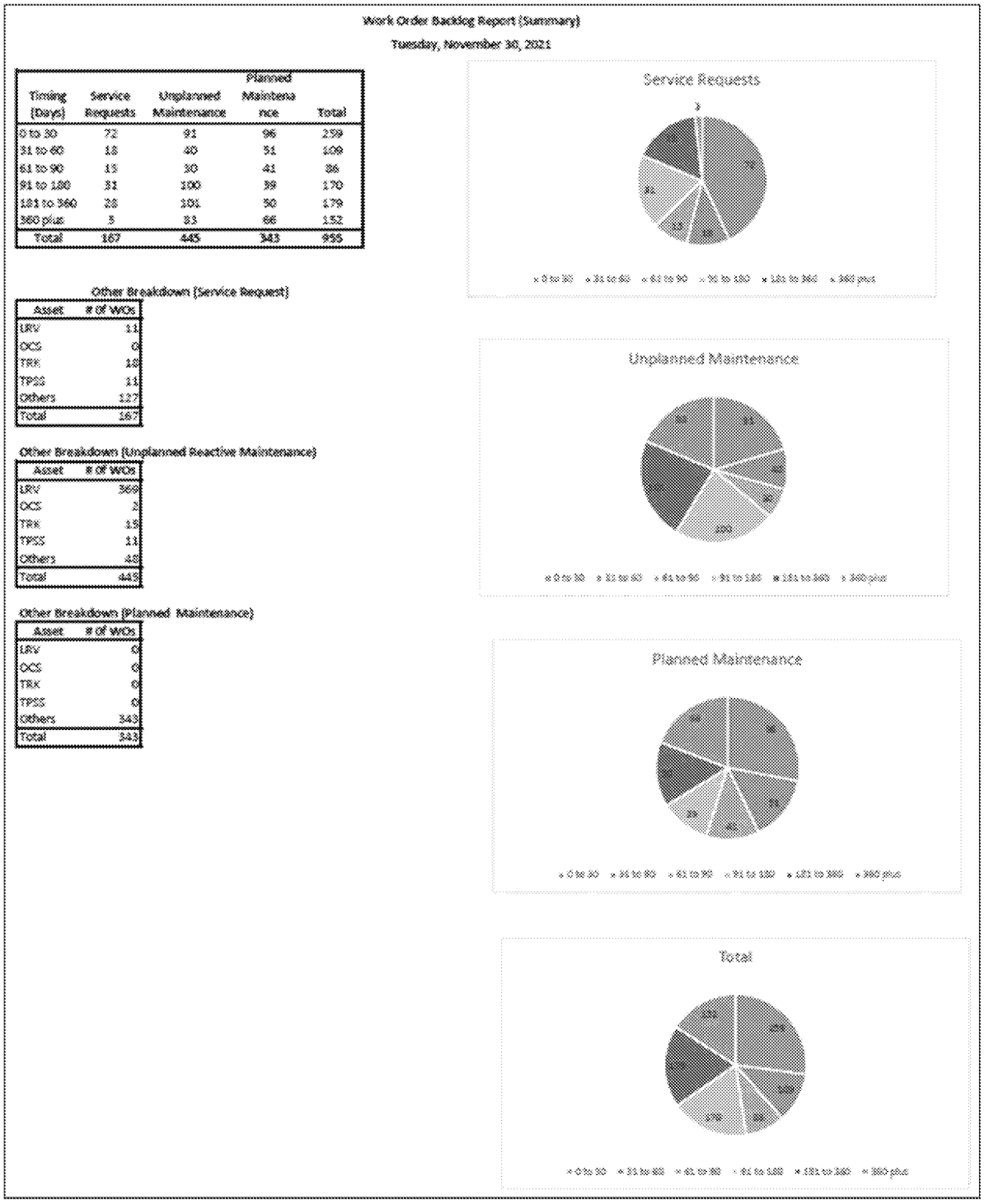
There do not appear to be robust arrangements in place to manage obsolescence. Some types of equipment, particularly items with embedded microprocessors and Commercial-off-the-Shelf equipment such as CCTV, access control, comms equipment and PC hardware have a very short life cycle compared to the duration of this contract. Hardware obsolescence may lead to shortages of spares, necessitating a last time buy. End-of-life for embedded operating systems or other software may lead to a need to upgrade equipment to retain support for patches for security issues or for versions that can run on available hardware. Many of these issues will be known by the OEMs years in advance, allowing time for the appropriate mitigations to be planned.

We recommend that a program of work is started to identify the Asset Preservation Performance Measures that will be used to plan renewal and replacement. These should then be used to develop estimated degradation rates and hence the asset renewal cycle. Renewal work can then be levelled to prevent a bow wave effect.

5.3.4 Backlog

To manage the backlog of maintenance activity, Alstom run a daily “Work Order Backlog Report”. The report contains an aged summary of the maintenance work that is overdue as shown in Figure 5.8 below.

Figure 5.8 Work Order Backlog Report



Work Order Backlog Report (Summary)

Tuesday, November 30, 2021

Timing (Days)	Service Requests	Unplanned Maintenance	Planned Maintenance	Total
0 to 30	72	91	96	259
31 to 60	18	40	51	109
61 to 90	15	30	41	86
91 to 180	31	100	39	170
181 to 360	28	101	50	179
360 plus	3	83	66	152
Total	167	445	343	955

Other Breakdown (Service Request)

Asset	# Of WOs
LRV	11
OCS	0
TRK	18
TPSS	11
Others	127
Total	167

Other Breakdown (Unplanned Reactive Maintenance)

Asset	# Of WOs
LRV	369
OCS	2
TRK	15
TPSS	11
Others	48
Total	445

Other Breakdown (Planned Maintenance)

Asset	# Of WOs
LRV	0
OCS	0
TRK	0
TPSS	0
Others	343
Total	343

The report that is shared with the maintenance managers includes details of every work order so they can drill down to individual missed activities. The current structure of the summary does not provide an immediate view of the priority of the late work orders. We recommend that the report is

updated to use the scheduling tolerance to differentiate those work orders where the activity is missed (beyond the allowable tolerance) and those that are late (beyond the scheduled date but within tolerance) so that priority can be given to planning and delivering the missed activities.

Similarly, we recommend that the required completion timescales are added to corrective maintenance work orders so that they can be prioritized and tracked.

During the assessment phase, we were not able to observe how this information is used to manage the completion and closure of work orders and therefore we recommend that this should be checked during the monitoring phase.

5.4 Effectiveness of maintenance management and reporting systems.

We reviewed both the formal reports, submitted in accordance with the Project Agreement and the internal reports used in routine management of maintenance activity.

We noted that Appendix B article 5.0(c) of the Project agreement requires: “electronic files shall be compatible with the most recent version of Microsoft Office and be editable”. The files we were supplied relating to Alstom reports were in Portable Document Format (PDF), meaning that, where we were supplied tables of data, we had to convert them back to the specified format to analyse them.

5.4.1 Daily Operating Report

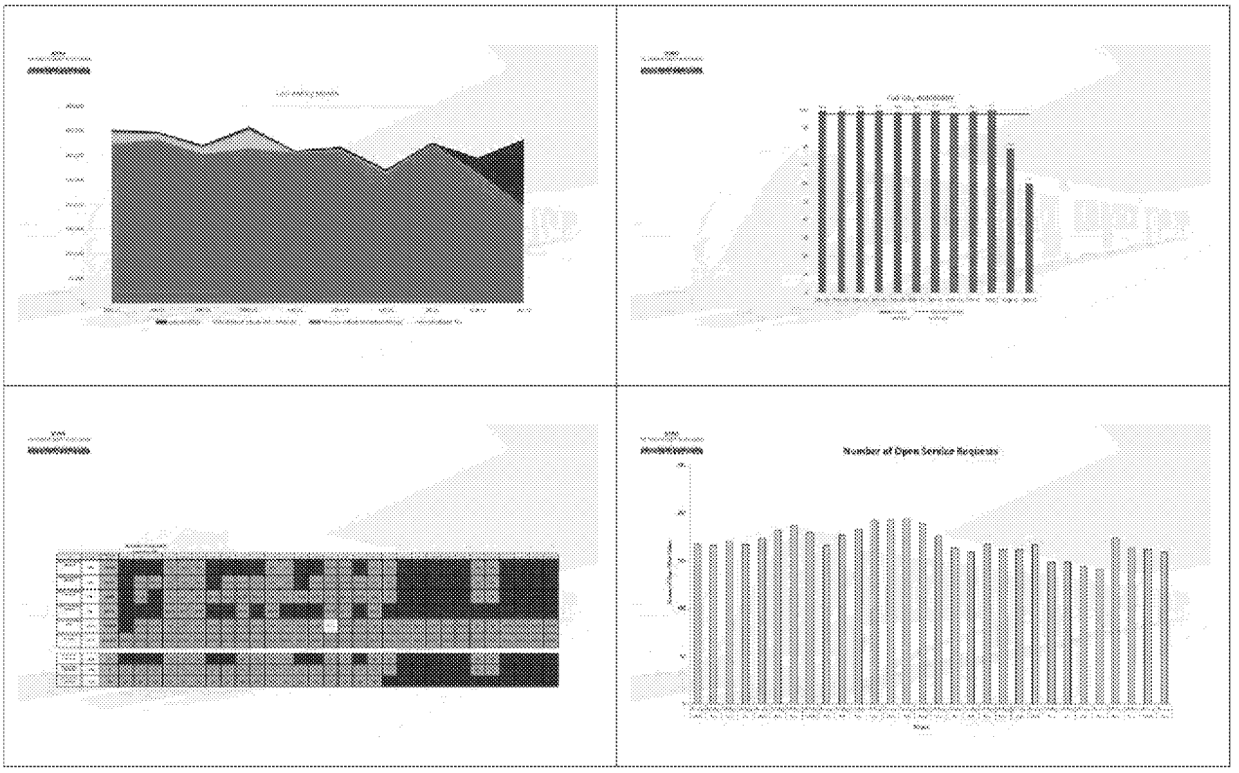
The Daily Operating Report provides a flash report of performance on the previous day. It contains the main parameters such as vehicle km availability and station availability and details the main lost km events.

90% of the report is taken up with listing open work orders. Whilst it is useful to show those that were open or closed during the day, it is unlikely that those whose status has not changed are reviewed daily.

5.4.2 Monthly Performance Report

The monthly report produced by the RTM team covers performance against the contract parameters such as lost km and availability

Figure 5.9 Examples of charts from the Monthly Performance Report



The report provides a good visualisation of performance but requires drilling down to identify the causes of issues within the month.

5.4.3 Monthly Reliability & Maintainability Report

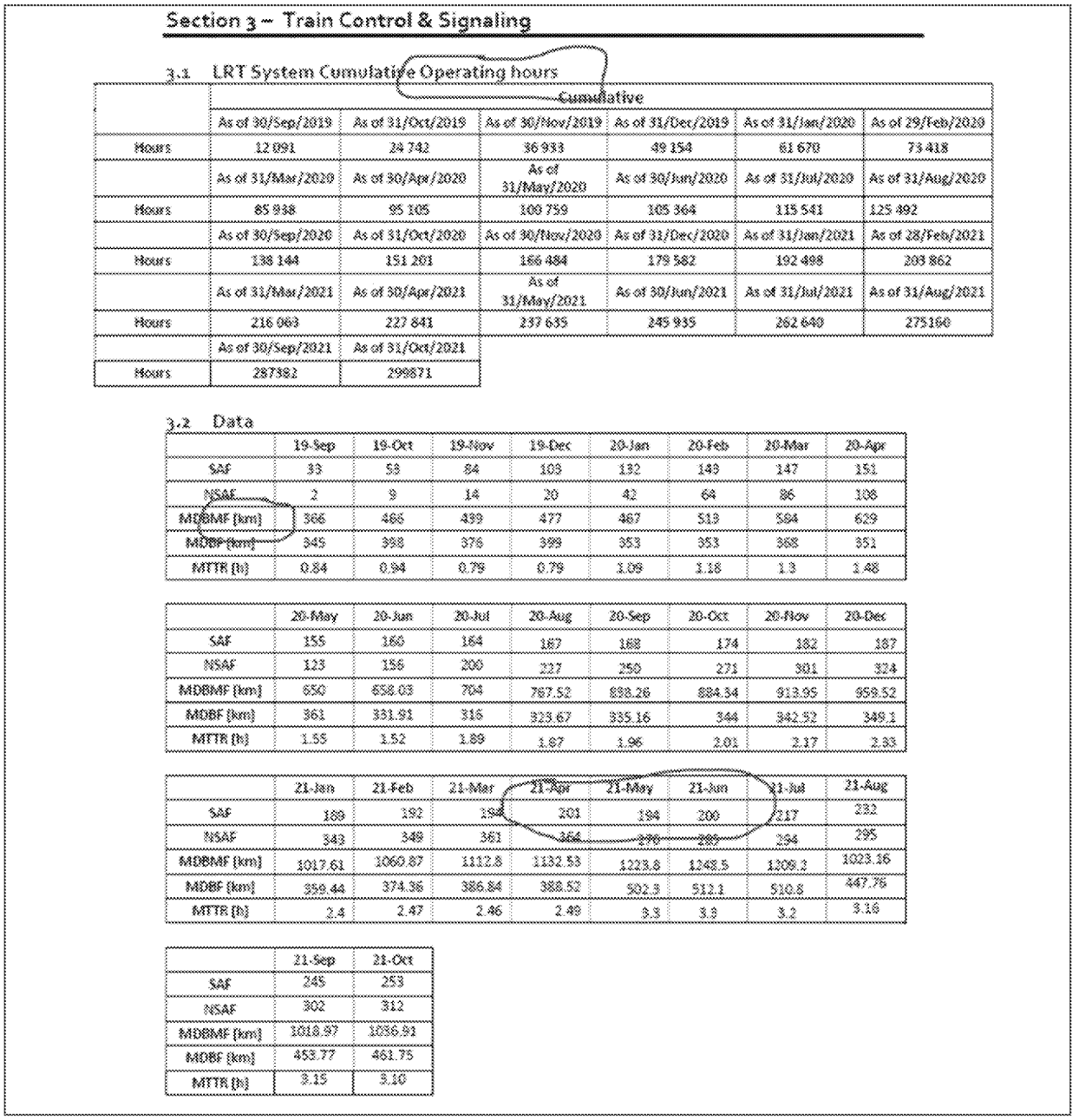
We reviewed the Monthly Reliability & Maintainability Report (OTT-GNR-ENG10-REP-004) dated 01/11/2021.

It was difficult to make sense of the report for the following reasons:

- Each of the infrastructure systems has a Cumulative Operating Hours table. The number of operating hours each month exceeds the number of elapsed hours in the month, so we assume the operating hours has a factor representing multiple assets. However, the table contains identical operating hours for each asset class and so it is not clear how this table is calculated;
- We did consider that rather than hours, it may be cumulative km, however the figures are too low and they continue to accumulate, in line with the run rate, during September and October 2021;
- The number of failures appears to be cumulative, however there are cases where the figures reduce in subsequent months (e.g. for Train Control and Signalling, the figures for May-21 and June-21 are lower than those for April-21); and

- The data tables have rows for “MDBMF [km]”. These figures correlate roughly with a figure that could be calculated using the cumulative hours table, but they are not identical, so it is unclear what these figures represent.

Figure 5.10 Example of reliability statistics for Train Control and Signalling



Section 3 – Train Control & Signaling

3.1 LRT System Cumulative Operating hours

	Cumulative					
	As of 30/Sep/2019	As of 31/Oct/2019	As of 30/Nov/2019	As of 31/Dec/2019	As of 31/Jan/2020	As of 29/Feb/2020
Hours	12 091	24 742	36 933	49 154	61 670	73 418
	As of 31/Mar/2020	As of 30/Apr/2020	As of 31/May/2020	As of 30/Jun/2020	As of 31/Jul/2020	As of 31/Aug/2020
Hours	85 938	95 105	100 759	105 364	115 541	125 492
	As of 30/Sep/2020	As of 31/Oct/2020	As of 30/Nov/2020	As of 31/Dec/2020	As of 31/Jan/2021	As of 28/Feb/2021
Hours	138 144	151 201	166 484	179 582	192 498	203 862
	As of 31/Mar/2021	As of 30/Apr/2021	As of 31/May/2021	As of 30/Jun/2021	As of 31/Jul/2021	As of 31/Aug/2021
Hours	216 063	227 841	237 635	245 935	262 640	275160
	As of 30/Sep/2021	As of 31/Oct/2021				
Hours	287382	299871				

3.2 Data

	19-Sep	19-Oct	19-Nov	19-Dec	20-Jan	20-Feb	20-Mar	20-Apr
SAF	33	53	84	103	132	149	147	151
NSAF	2	9	14	20	42	64	86	108
MDBMF [km]	366	466	499	477	467	513	584	629
MDBF [km]	345	398	376	399	353	353	368	351
MTTR [h]	0.84	0.94	0.79	0.79	1.09	1.18	1.3	1.48

	20-May	20-Jun	20-Jul	20-Aug	20-Sep	20-Oct	20-Nov	20-Dec
SAF	155	165	184	187	168	174	182	187
NSAF	123	156	200	227	250	271	301	324
MDBMF [km]	650	658.03	704	787.52	838.26	884.54	913.95	959.52
MDBF [km]	361	331.91	316	323.67	335.16	344	342.52	349.1
MTTR [h]	1.55	1.52	1.89	1.67	1.96	2.01	2.17	2.33

	21-Jan	21-Feb	21-Mar	21-Apr	21-May	21-Jun	21-Jul	21-Aug
SAF	189	192	198	201	194	200	217	232
NSAF	343	348	361	366	279	289	294	295
MDBMF [km]	1017.61	1060.87	1112.8	1132.53	1223.8	1248.5	1209.2	1023.16
MDBF [km]	359.44	374.36	386.84	388.52	502.3	512.1	510.8	447.76
MTTR [h]	2.4	2.47	2.46	2.49	3.3	3.3	3.2	3.16

	21-Sep	21-Oct
SAF	245	253
NSAF	302	312
MDBMF [km]	1018.97	1056.91
MDBF [km]	453.77	461.75
MTTR [h]	3.15	3.10

Even setting aside the potential errors in the figures, the report provides very little in the way of useful information. There is no explanation of the changes, even at system level. There is no breakdown to guide the reader to which subsystem is having most impact on reliability. There are

no targets to show whether the observed reliability is acceptable or not and most importantly, there is no description of the actions being taken to improve reliability.

5.4.4 Yearly Annual Condition Data Report

We reviewed the Yearly Annual Condition Data Report (OTT-GNR-ENG10-REP-001) dated 14/10/2021.

The first line of section 3.0.1 shows 100% completion of daily inspection work orders. In our experience, it would be unusual to complete 100% of maintenance, especially a daily task. The RTM QMS audit on track maintenance (RTM-QMS-FRM-681) confirmed this view. Drilling down into the full list of completed work orders in Appendix A of the report, we identified that whilst the report shows 366 completed work orders, there are only 363 daily visual inspection work order records in the appendix.

More importantly, removing records where more than one daily inspection work order was closed with the same date, there are only 290 records. It appears that once an inspection has been completed, all preceding missed work orders are closed as completed.

There is no tolerance shown in section B-4 of the Asset Management Plan for daily inspections; however, there are 58 cases (16% of the total) where the gap between inspections is 3 or 4 days.

Section 3.0.3 includes 4 work orders for ultrasonic testing but omits to show that the intervals between these tests was 30, 206 and 9 days.

The 16 reported turnout and crossover inspections masks the fact that this is four guideway sections and the BMSF and the guideway section inspections were only completed 3 times during the year. The fourth quarterly inspection is scheduled to be covered during the annual inspection; however, this is not the way the Work Method Statements are constructed. There is more detail on this issue in section 5.5.

Section 3.2.2 shows the inspection schedule for Rail Condition but there is no summary of the findings, description of rail condition or areas of concern. Rail flaw detection is shown as being carried out a one month and three month intervals but there are no work orders in Appendix B of the report for rail defects.

Reviewing section 4.0.2, the signalling daily and weekly inspections match the work order table.

There is no information provided on the target number of work orders; the reader would need to know the number of assets subject to each inspection to calculate this for themselves. Neither is there a commentary on the level of achievement, issues preventing achievement or areas of concern on the network.

Appendix B of the report contains a list of corrective work orders. For some asset types, only a Scheduled date is shown meaning it is not possible to determine the closure timescale for the work order. Even where a “Changed On” date is included, the reader is not informed as to the expected timescale for closure meaning it is not possible to determine whether the work was completed within the required timescale.

There is no analysis of the corrective work orders highlighting areas of poor reliability or increased risk. There is no analysis of the response and closure times.

From this snapshot, we conclude that the report is not particularly useful and does not satisfy the requirement as an asset condition report.

5.4.5 APPM Achievement Report

We reviewed the APPM Achievement Report (OTT-GNRENG10-REP-002) dated 28/11/2021.

Section 5.0 of Appendix B of the Project Agreement sets out the requirements for the APPM Achievement Report:

1. An annual summary of the Maintenance Services (including routine, preventive, and corrective maintenance, rehabilitation and asset preservation activities) performed in the preceding year;
2. Methodologies for calculating the Asset Preservation Performance Measures;
3. Analysis and presentation of the results from the annual data collection program for the Asset Preservation Performance Measures for all System assets as defined in the Asset Management Plan;
4. Reporting of the results of surveys; and
5. Reports of the compliance and non-compliances with the APPM, and corrective actions

Achievement of Maintenance Services

Parts of requirement 1 are covered by the Yearly Annual Condition Data Report (see section 5.4.4 of this report) although there is little in the summary other than the numbers of work orders in each category.

Asset Preservation Performance Measures

The report contains details of some Asset Preservation Performance Measures; however, these are not directly analogous to the measures in the Project Agreement.

For example, the Project Agreement lists a series of measures in Appendix B, tables 6.5.3 A, B C and D. The table in section 2.1.1 of the report lists measures that appear to be related to those in Project Agreement table 6.5.3 D but there is nothing on track structure (6.5.3 A) or rail condition (6.5.3 B).

The measures in the Signalling (also numbered 2.1.1) and Communication (2.2.1) sections are maintenance measures, in that if the measured value was out of tolerance, it would be rectified by an immediate repair or component replacement. There is no identification of obsolescence that may impact the longevity of hardware or supplier support life that may impact the serviceability of software.

For Power and OCS (2.3.1), the measure for contact wire covers height and stagger but does not cover wire wear.

We recommend that the Asset Preservation Performance Measures are reviewed to (a) bring them in line with the requirements of the Project Agreement and (b) reflect asset condition and remaining life as well as performance.

Analysis of collected data

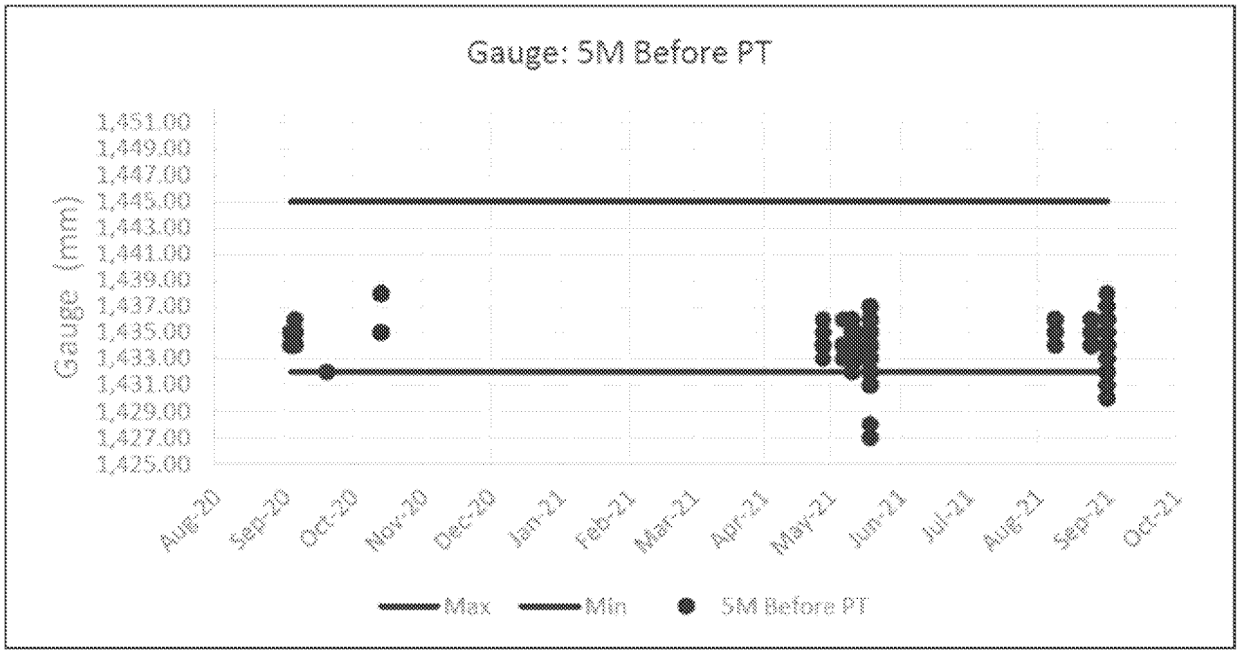
The analysis section of the report consists primarily of graphs of the collected data. The commentary of the graphs is not particularly strong.

For example, the analysis of No. 6 Switch Offset identifies variability in the measurements and states that it "may have lateral movement, due to the fasteners embedded on wood". It does not go on to say whether the ties have ben inspected to identify whether the fasteners are loose and whether they can be tightened or the ties need to be plugged or replaced. There is a proposed corrective action to "*Check for rail head gauge wear*" but it is not clear from the charts that the offset is increasing and therefore whether wear is a credible cause of the variability in the measurements.

Similarly, the analysis of No. 8 Switch Offset attributes the measurements that are outside tolerance as "likely error to due to measurement error, due to the low occurrences over repeated measurements". However, given that the lack of robustness of the measurement technique can lead to erroneous measurements outside of tolerance, the author gives no confidence that those measurements within tolerance are not also erroneous. The proposed corrective action is to "*Reinforce measurement technique via toolbox talk*" whereas a more appropriate action would be to conduct a Gauge R&R study on the measurement technique. Furthermore, there is noting in the report to suggest that any action was taken on the out-of-tolerance measure, such as verification of the readings or remedial action to restore the measurement to tolerance.

In the gauge 5m before point section, the graph shows several tight gauge measurements. It is not clear which readings are from which turnout and hence whether the variation occurs across time, site or technician.

Figure 5.11 Chart of gauge measurements showing values below the minimum



The analysis states "*The measured data are generally within bounds. No data point has reached the threshold requiring corrective actions. The data with significant deviation from nominal (i.e.. May 2020) can be attributed to measurement errors as subsequent measurements carried out are consistently within limits*." Again, there is no evidence of action taken in response to the readings below the minimum value and no improvement action to eliminate the issue of measurement error.

The Signalling and Communications and TPSS sections consist of long lists of completed inspections. Where non-conformances have been identified during maintenance, they are listed but there is no reference to the remedial action.

The Contact Wire section (3.5.2) describes the heights and staggers as having been measured and all within tolerance but again there is no detail about wire wear that would inform the reader about sites of high wear or the likely replacement timescale for some or all wire runs.

The section on the Tunnel Ventilation System (3.6.1) is more comprehensive and describes some areas of concern. The purpose of measuring the frequency as an asset preservation metric is not clear. Frequency is a function of the balance between generation and demand on the electricity transmission network rather than anything asset specific. Even where frequency is used for speed control, it is a function of the speed demand rather than the condition of the fan or motor.

The report states the allowable variation is +/- 1.2Hz whereas the Hydro One limit is +/-0.5Hz. This may well relate to information from the OEM who has designed the system to operate within a wider frequency range than the electricity supplier is committed to provide to avoid issues at the fringes of the tolerance The variability of frequency is impossible to see on a chart plotted to +8.8Hz, -11.2Hz.

The section on FDAS (3.6.2) describes an issue identified at St Laurent station on 21/02/2021 but as of the date of the report nine months later, it is not clear whether this has been resolved.

The commentary on sump pumps, heat trace and tunnel lighting is more useful.

We recommend that the process for the analysis of the collected data and the commentary is reviewed so that it is more closely aligned with the maintenance actions taken and provides useful information to the reader.

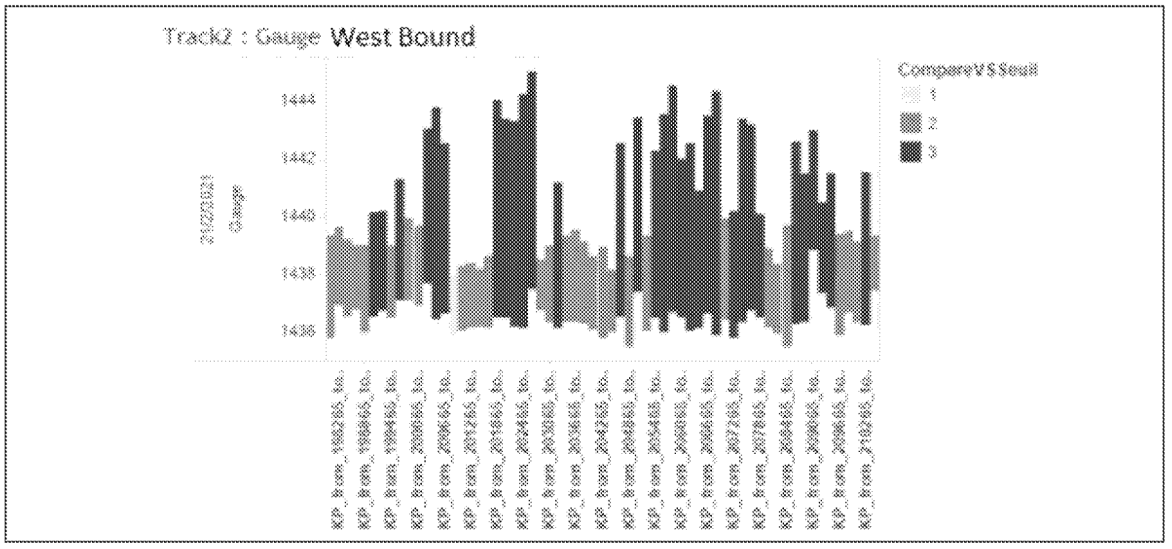
Reporting the results of surveys

The results of surveys are reported as a long list of closed work orders. We recommend that these are summarised for the purpose of annual reporting.

The report contains an Appendix detailing the measurements made by the Track Tracer.

Taking track gauge as an example, whilst there was no track that breached the gauge value condemning limit, we noted a substantial portion of track infrastructure that did reaches the red limits for gauge. There was no explanation as to the cause of this. More worryingly, several sections were reported to be “close to the condemning limit” without any action being specified. We recommend that the Asset Preservation Measures are reviewed to prompt remedial action to maintain the assets such that they do not reach the condemning limits.

Figure 5.12 Example of track gauge measurements from Track Tracer



There are no surveys reported outside the scope of routine maintenance.

Compliance and non-compliances with the APPM, and corrective actions

As reported in section 5.4.4, although the total quantity of completed work orders is provided, there is no information on the quantity of scheduled work orders to allow an assessment of compliance. The report contains no analysis of compliance, for example the number of instances of work missed or undertaken outside of the scheduling tolerance. We recommend that the report contains an

analysis and commentary on compliance with the APPM, detailing corrective action to address identified non-compliances.

5.5 Workorder management

Alstom manage workorders through their own system Global Single Instance (GSI).

5.5.1 Asset Inventory

In section 1.1 of the Asset Management Plan, Alstom claim that they were not provided with a comprehensive asset register. They have, however, examined configuration information and as built drawings to create their own asset register. This process appears to have been robust and therefore we believe that the asset register in GSI is satisfactory. We recommend that this is tested further during the monitoring phase by means of sampling and comparing the asset register against either as-built records or a physical inspection of some areas of the network.

The asset records have been organized in a location – function – category hierarchy, which mirrors that in IMIRS for consistency of referencing. The structure of the linear assets mirrors that used by RTM.

5.5.2 Maintenance Scheduling

Each maintainable area has a Work Plan associated with it. The work plans are currently configured by the smallest unit of time applicable to the work area. For example, areas requiring monthly inspection have 12 work orders. Since the Work Method Statements for the 3-monthly maintenance do not contain the monthly tasks, these tasks are not specified to be performed when the 3-monthly maintenance is undertaken. Similarly, the monthly and 3-monthly tasks are omitted when the annual maintenance is scheduled. Alstom has recognized this and is in the process of redefining the work plans as shown in Table 5.1 below.

Table 5.1 Example of work order planning

Month											
1	2	3	4	5	6	7	8	9	10	11	12
Current Method											
M	M	Q	M	M	Q	M	M	Q	M	M	A
Proposed Method											
M	M	M	M	M	M	M	M	M	M	M	M
		Q			Q			Q			Q
											A

The work plans automatically generate work orders for the scheduled preventative maintenance. Alstom use 12-month planning horizon to be able to see and analyse the plan a year ahead.

In common with many Enterprise Asset Management Systems (EAMS), GSI offers a choice of scheduling mechanisms including replan on scheduled date and replan on completion date. Alstom have opted for the first of these, allowing them to keep a consistent maintenance plan at the expense

of delivering maintenance after less than the prescribed interval if the previous occurrence was late. We agree that this is the most appropriate methodology for this contract.

GSI is linked to SES, which is the system for the assignment of work orders to individuals using mobile technology. Each work order includes a "maintenance certificate" which contains a checklist of all the tasks in the Work Method Statement. In addition, the certificate requires the technician to record their name and the serial numbers of any calibrated tools used during the activity for traceability.

The work order contains a link to the Work Method Statement so that the technician always has access to the latest version. We were advised that technicians are advised by means of a toolbox talk when the WMS has changed. We recommend that the effectiveness and adherence to this process be examined during the monitoring phase to confirm that technicians routinely access the documents and that they are aware of changes to them.

As reported in section 5.4.4, it appears that missed work orders are being closed once a subsequent inspection has been completed. We recommend that only work orders where the activity has been genuinely carried out are closed as completed. Where work is not completed, work orders should be given the status of "missed" or similar.

5.5.3 Work order closure

For preventative work orders, a maintenance certificate replicating the task list is completed by the technician undertaking the work. Completion of the certificate is verified by the supervisor. There is no evidence that supervisors inspect the work to validate that it has been done correctly and completely.

Where a task produces a result of "Not OK", the technician is prompted for a comment. We understand that these comments are often incomplete, which as well as missing useful information, can lead to a penalty.

5.5.4 Maintenance records

Where the maintenance activity requires the use of calibrated tools, details of these are recorded on the maintenance certificate. We observed that it is possible for this information to be extracted as structured data, thereby enabling all maintenance activity completed using a specific tool to be traced.

We also observed that where readings or measurements are taken, these can also be extracted. This facility is used during the creation of the asset condition and APPM reports.

5.5.5 Interface to IMRIS

There is a two-way interface between GSI and IMRS; however, there are some limitations, for example:

- Some work order descriptions and comments are truncated when being passed from GSI to IMRS; and

- Only completed work orders are visible in IMRS meaning that RTM do not have sufficient information to manage maintenance compliance.

We recommend that the specification of the interface between GSI and IMRS is reviewed to confirm it meets the needs of managing the maintenance of the network.

5.6 Appropriateness of employee

Section 8.0 of the Maintenance and Rehabilitation Plan (RTM-MC-PLN-042) requires that in performing M&R services on the Confederation Line, RTM and its subcontractors are will ensure that maintenance staff have appropriate backgrounds and are trained and competent to perform work in their functional areas. In recruiting maintenance staff, RTM and its subcontractors target tradespersons with trades qualifications that are appropriate for the work to be performed and systems to be maintained.

RTM's Training and Competency Plan (RTM-ADM-PLN-123) contains a competence matrix for RTM generic safety competencies and the specific technical competencies within the scope of the RTM delivered maintenance activities.

Section 5.7 of the Training and Competency Plan requires subcontractors to comply with the training requirements listed in 7.2 of the plan, but it does not specifically require subcontractors to identify the individual competencies that their staff need and hold.

Alstom have their own competency management system which consists of a role specific competence matrix with an associated certificate for each individual stating what they are and aren't competent to undertake. There is also an annual competency conversation held between managers, supervisors and technicians where personal development plans for competencies which are required but missing are agreed.

Figure 5.13 Examples of Competency Assessment Form

ALSTOM	Observational Competency Assessment Form	Document Reference: OTT-GNR-HRM10-FRM-010 Rev B	Application date: 21-Apr-2020

Employee Name	[redacted]	Assessor Name	[redacted]
Competency		Date	

Maintain and troubleshoot the assets on the guideway of the line (track, fence, turnout, ballast and concrete structure...) in line with the Health & Safety, Quality and Operation procedures.

Note* do you swear to answer these questions with all honesty and to the best of your ability if yes please state. Yes.

Topic	LEVEL 1 Action, behaviour, knowledge	√	LEVEL 2 Action, behaviour, knowledge	√	LEVEL 3 Action, behaviour, knowledge	√	Comments
	Be proud to be a GT, act as a professional	X	Has received the TIGS Training and has more than 1 year experience with Alstom	X	Has received the Train-The-Trainer training	-	
	Comply with the GT Training : look at the trackwork, spot suspicious problems, raise hand	X	Name 3 area properly all the components of a turnout & associated jewellery	X	Train on WMS and GT Trainings	-	
	Learn & apply WMS, ask questions if needed	X	Identify & report errors in WMS, make suggestion for improvement	-	Coach others, share skills / information to others	-	ASK GOOD QUESTION ABOUT THE WMS*

ALSTOM	Observational Competency Assessment Form	Document Reference: OTT-GNR-HRM10-FRM-010 Rev A	Application date: 28Apr-2020

Topic	LEVEL 1 Action, behaviour, knowledge	√	LEVEL 2 Action, behaviour, knowledge	√	LEVEL 3 Action, behaviour, knowledge	√	Comments
Tools & Equipment	Use basic tools: Multi-meter, Network cable tester	✓					
	Using general programs and apps such as SharePoint, Outlook, Team ...	✓	Run the technical applications	✓	Know how to check the ports	✓	
	Take care of and store tools and equipment properly	✓	Able to decide how, when, where to apply tools	✓			
	Familiar with customs interface software	✓					
Preventive Maintenance	Record measures accurately in SBS	✓	Know how to create Corrective Orders in SBS	✓	Decide if a Corrective Order needs to be created	✓	
	Detect defected camera	✓	Inspect the cameras and their ports	✓			
	Notify FIDS equipment	✓	Know how to assess and replace sensors				Knows the basic of FIDS Needs hands on experience
	Find location of IAC equipment	✓	Recognize the types of IAC ports	✓			
	Able to recognize Network switches	✓	Inspect the ports on a switch	✓	Troubleshoot the switches		Need hands-on experience with switches
	Detect the different boxes for GIDS and the sensors	✓	Inspect the parts inside the boxes	✓	Troubleshoot the parts	✓	
	Recognize the location and model of PA/PIS equipment	✓	Check the operation of each part of system	✓			
	General understanding from SCADA	✓	Familiar with SCADA interface	✓			
	Recognize different part of HSBR	✓	Check health of the equipment	✓	Detect troubled areas of defective part	✓	
	Detecting Fibreoptic and its connection	✓	Know how to check healthy fibre optic	✓			

We noted that two versions of the individual competence assessment documents exist, but Alstom management stated that individuals would be transitioning to the newest version as and when their next annual competence assessment took place.

The competence assessment does not contain any specific "last line of defence" competencies such as releasing vehicles for service, removing temporary speed restrictions or restoring signalling equipment to service.

5.6.2 Training

Some training has been procured by training suppliers and external bodies but much of the training received by Alstom technicians is delivered in house, generally by the Engineering department. Training includes general technician training and specific programs covering packages of Work Method Statements.

Section 9 of the Training and Competence Plan includes a methodology for reviewing both students and trainers but this is not mandated on the subcontractors. We were not advised of any requirements on those making the competence assessment judgements. A formal training and assessment competence should also be considered for those making the competence decisions on their people to ensure that they are qualified to make these judgements and decisions.

5.6.3 Experience

We also noted that there is a lack of experience in some areas of the maintenance organisation. Alstom delivered activities which are specific to rail, recruitment of experienced staff has been more challenging. Staff retention was also stated to be difficult with competition from high-tech industries in the Ottawa area.

5.6.4 Qualifications

We were advised that a proportion of the team have been recruited from overseas. These staff are often well qualified, in some cases to PhD. Level. Whilst these staff have can gain a good understanding of the working of systems, they may not have the aptitude to undertake physical work.

5.7 Appropriateness of maintenance organization;

5.7.1 Staffing levels

Alstom have built their organization based on the assumptions that were included in the original tender. We were shown examples of a workload and staffing assessment model; however, this is an internal Alstom document that they were not prepared to share.

The assessment is carried out by the operations department, based on the crew size and duration for maintenance activities provided by the engineering department in the Work Method Statements, the frequency of the activities and the number of assets to which they apply. The assessment currently only includes planned maintenance and not an estimate for corrective work.

Crucially, in its current state, the model only assesses the necessary "time on tools" and does not contain productivity factors such as travel, breaks or site set up time. Without an assessment of these parameters, the model cannot be credibly used to calculate the required size of the workforce.

5.7.2 Shift coverage

During the assessment phase, we were unable to gain a comprehensive understanding of the level of shift coverage that is being achieved. Anecdotally we were advised that there are issues with sufficient staff being available to cover shifts but we were not able to find any aggregated performance reporting on this issue.

5.7.3 Supervision/oversight

The role of the supervisor appears to be more administrative than technical. In our discussions we were told the supervisors run start and end of shift briefings and sign off work orders. Whilst there is generally a vehicle supervisor on each shift, infrastructure supervision is drawn from a pool of supervisors with skills in one of the discipline areas. Whilst this does not necessarily impact negatively on the way the shifts currently work, it does leave the question of how the supervision of the individual disciplines works.

We did not observe the process firsthand as part of the assessment phase and we did not interview any staff at this level, but it appears that the supervisory sign off of work orders simply verifies that all of the task activities have been ticked off as complete. As the supervisors are primarily office based, they do not undertake checks of the work.

From what we could see, there is no responsibility for the quality of the work or the competence of the staff at supervisory level. We would expect that junior management responsibility for delivery of the work starts at this level. In our experience, we consider that the role of the supervisor would include:

- First line management of staff, including shift cover, leave, sickness, training, discipline etc.;
- Deployment of staff to deliver work orders;
- Management of work orders for the discipline, including backlog;
- Asset inspection to validate the quality of work and overall asset condition;
- Direct observation of staff undertaking work to verify competence;
- Undertaking formal competence assessments;
- Briefing of staff on new and changed processes and procedures; and
- Undertaking level 1 self-assurance to satisfy themselves that they are meeting all the requirements of the Asset Management Plan, Maintenance and Rehabilitation Plan and other processes and procedures.

In other words, we would expect to see one individual with day-to-day responsibility for the delivery and quality of maintenance for a given discipline and the staff who undertake it.

We recommend that RTM and Alstom review where this responsibility lies and how it is discharged.

5.8 Support departments (Engineering, sourcing, etc.)

5.8.1 Engineering

Alstom have established an engineering team to support the project. The team is led by a Maintenance Engineering Manager and has systems engineers for each discipline; tunnel ventilation, traction power, overhead catenary, track and signalling and comms.

The team is responsible for defining maintenance standards, including preventative maintenance, corrective maintenance and one off campaigns and checks. They are also responsible for materials. The engineering team deliver some training to front line staff and undertake safety investigations. Engineering produced the initial technician competence record forms although these are to be replaced by a system developed by the operations part of the maintenance organisation.

As described in section 5.3.1, the Work Method Statements for preventative maintenance are comprehensive and have been regularly updated. We did not see any Work Method Statements for corrective tasks but these are being developed to the same format.

As described in our observations on the Asset Management Plans, the asset management approach is very much based on inspection and rectification. There are no whole lifecycle plans for assets that include both routine maintenance and longer term overhaul and replacement. There are no asset specific approaches such as a rail management plan covering routine inspection, defect rectification, proactive wear and profile management. Similarly, there are no plans for risks such as hot weather. We have made recommendations on these elsewhere in the report, but we would expect the engineering department to take the lead on these types of issues.

We understand that the engineering department is quite involved in day-to-day activities such as prioritizing and classifying defects, producing risk assessments and validating completed work. Whilst there may be insufficient confidence in the maintenance technicians and supervisors to allow them to carry these out, we recommend that the engineering department invest some time in codifying their decisions to provide guidance and standards to the maintenance technicians to allow routine decisions to be delegated to them.

During the assessment, we did not review the competence requirements for the engineering team. We recommend that this is reviewed during the monitoring phase, including areas such as the level of professional qualifications required by the job descriptions to the individual competence and experience requirements for each role in the team.

From what we could ascertain, the maintenance instructions have been updated as a result of lessons learnt and feedback either on reliability issues or from the maintenance staff. This is an important source of updates but we did not confirm that other sources of update are proactively reviewed. In a mature organisation, standards updates could be triggered from a number of sources such as level 2 and 3 assurance as described in section 8.1, technology change, legislative or regulatory change or waivers and concessions.

In particular, there is no formal process for the engineering team to spend time of the infrastructure verifying that the outcomes of the standards they have written are as the expect and to validate that they meet the requirements of the contract.

At Network Rail, we have a process of Engineering Verification (NR/L2/RSE/070) whereby members of the Technical Authority (the Engineering function within the Safety, Technical and Engineering Directorate) undertake planned site visits verify how well our control processes work by physically inspecting infrastructure assets, at all stages of their life, to check that they:

- comply with standards;
- are free from defects or problems which may affect the safety of the line, even if the assets comply with standards;
- are in a condition consistent with asset records; and
- are in the condition that would be expected from the inspections carried out and the work recorded as being needed in work databases.

It is additional to other assurance processes such as audit or regular process checks, complementing them by:

- being focussed on the physical state of the asset, such as the reliability and integrity of the asset, as well as whether it complies with standards;
- looking at the wider safety picture; and
- assessing whether standards are appropriate.

The process was put in place following a fatal accident at Grayrigg in 2007 because the report produced by the Rail Accident Investigation Branch identified that "*the audits that were performed did not detect the inconsistencies in the documented maintenance regime and its practice*." In other words, whilst the assurance process managed compliance with standards, there was no process to confirm that they and their application were delivering the desired outcomes.

We recommend that Alstom consider an engineering verification process whereby the engineering team validate the output of their standards against the outcomes required by the project.

5.8.2 OEM support

The arrangements for OEM support for systems are incomplete. Support is available from major suppliers such as Thales but other systems such as access control have no such arrangements in place.

We did not investigate details of the support contracts. We recommend that RTM confirm the arrangements are sufficiently comprehensive and cover areas such as:

- Technical support – support to rectify failures or reliability issues, with appropriate in-hours/out-of-hours response time;
- Obsolescence management – proactive identification of parts and product lines with reducing availability;
- Repairs – schedule of rates for repair of faulty parts to avoid the risk of one-off prices for repairs;

- Training and/or training material – provision of technical training or production and updating of training material to allow internal training to be delivered; and
- Software updates – provision of software updates to mitigate reliability or security issues.

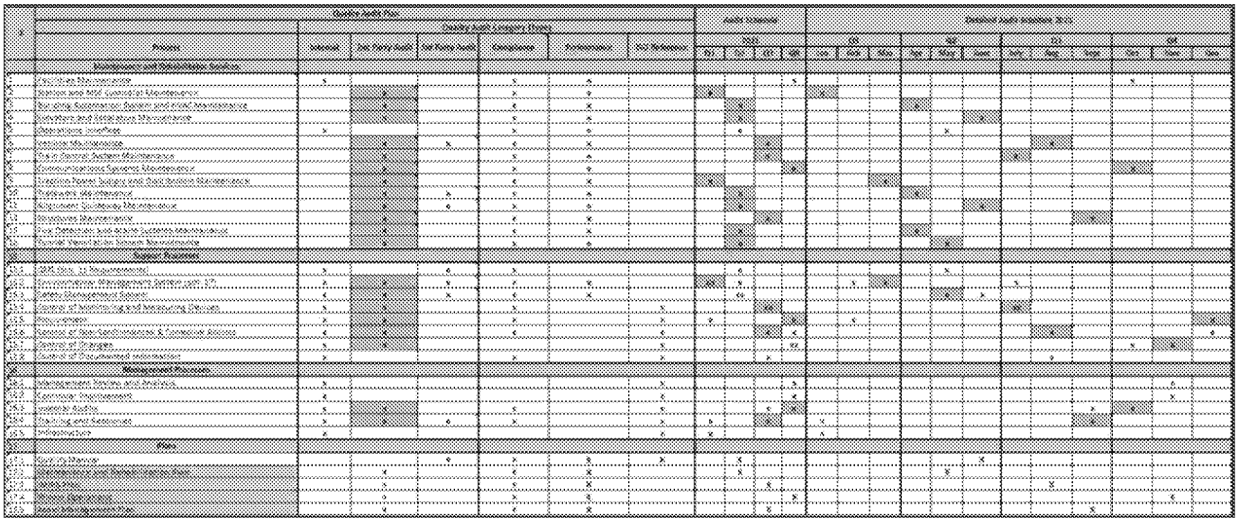
5.9 Adequacy of tools and equipment

During the assessment phase we did not spend any time on site with the staff. From our desktop review of documents and discussions with the team, we can see that the tools and equipment required for each maintenance task are documented. Where measurements are made using calibrated tools, we confirmed from a sample of work orders that the tools had been available. The method of managing records of tools and equipment used for critical measurements allows for traceability. We did not undertake a check of calibrated equipment but, notwithstanding questions of the scope of the document and that fact we were unable to see the detailed appendices (see section 5.2), the Maintenance Project Quality Plan (QUA-SV-OTTMAN-001) does seek to control this issue.

5.10 Adequacy of QA/QC processes

RTM manage and undertake audits of the infrastructure maintenance. Audits are planned and executed in accordance with section 9.2 of the Quality Manual (RTG-04-0-0000-QMS-0001).

Figure 5.14 2021 Quality Audit Plan



We reviewed some examples of audit reports and found them to be well organised and well recorded. However, we have made two observations about this part of the overall assurance process.

Firstly, the audits are process based in that they focus on documentation and records. It is important to audit these areas, as without proper documentation it would be hard to control the maintenance process and without good records, impossible to demonstrate that it had been completed. The current audit process lacks any assurance that the documented processes are embedded and being followed in practice.

Secondly, the non-conformances are focussed on correcting the issue as found and could be expanded to look at correcting the root cause. For example, in audit report RTM-QMS-FRM-681 (Track Maintenance - Sub-Contractor: Alstom) there are multiple case where maintenance was found to have not been completed in line with the maintenance schedule. In each case, the corrective action is “inspections shall be conducted as scheduled in the Maintenance Plan” or similar. There is an opportunity to identify whether there is a robust way to identify missed maintenance, who is aware of it and what is done about it so that this risk can be properly controlled.

We recommend that, in line with section 10.2.2 of the Quality Plan, auditors require auditees to determine the root cause of non-conformance and put in place actions to correct it.

Alstom state that they use a 3P (People, Parts, Process) assurance system but did not present any evidence of this being routine. A typical 3P was described as checking that the correct WMS was used with the right tools, calibrated equipment and recording any improvements that could be made.

We have made further observations on the assurance framework in section 8.1.

6. Facilities

6.1 Asset Management Plan

The purpose and context of maintenance is set out in the RTM 2021 Station Facilities Systems Asset Management Plan (AMP). The current published version is Revision 1.

The Asset Management Plan for Facilities is structured in the same format as those for other assets. We have included some comments that apply to all plans in section 3.1.

During this assessment, we have not reviewed every reference document in detail, but we have referred to some of them in drawing our conclusions about the completeness of the Asset Management Plan.

The scope of the AMP is noted as applicable to all conveying systems, plumbing systems, HVAC systems, fire protections systems, electrical systems, integrated artwork, Light Rail Vehicle Wash facility and MSF facility. This sits in line with the requirements laid out in table 5.2 of Appendix B of the LRT Project Agreement.

Our review of the AMP found it adequately listed the requirement for an accurate asset management database as per the Project Agreement, with assets listed individually to allow faults to be assigned to a particular asset. The AMP lists the systems that require preventative and corrective maintenance, as well as outlining which systems require specialist contractors. Due to the time-constraints for this assessment we were unable to verify the accuracy of the data, we recommend that this task is included in any future monitoring.

Section 11 – Risk Management & Mitigation Measures outlines the requirement for all technicians and sub-contractors to be competent to carry out the task but does not contain detail on risk mitigation measures which would be important to include, particularly for high-risk assets. As mentioned in Section 6.4 Effectiveness of Maintenance Management and Reporting Systems of this report, we recommend that details of where Risk Assessments or Risk Mitigation Plans can be located is recorded within this section of the AMP.

The AMP notes a desire to understand the expected condition performance of the asset and a 5-year asset preservation plan however the AMP is vague on the details of how this is to be achieved. Recommendations relating to renewals and asset performance are discussed further in Section 6.3.3 of this report.

Given the extreme temperature variations throughout the year in Ottawa, specialist maintenance requirements are needed to keep the stations safe for public use all year round. The need for a winter management plan is known and listed within the Project Agreement as a requirement to keep the buildings facilities accessible and free from snow. In line with this requirement RTM does have a winter management plan with a team of contractors brought in over the winter period to clear the snow.

Due to the consistent low temperatures the snow requires transporting away when removed. For some stations transporting this snow to street level can be a logistical problem that is resolved locally

within the shovelling teams. These are listed in the Winter Management Plan but not referenced in the AMP

Certain assets such as the elevators and escalators can be required to be taken out of service to allow maintenance activities to be carried out. This has affects accessibility for passengers that needs to be strategically managed to maintain the accessibility of the station. It was observed that some stations have multiple exits whilst some stations have one escalator for going up and one for going down. There is the potential to redirect passengers as necessary if one escalator is out of service for a period. Where the maintenance of assets may affect the accessibility of the station, this should be recorded in the asset management plan with the necessary mitigation process detailed on how passengers are to be re-directed. We recommend that the AMP be updated to list assets that could affect accessibility with detail recorded on how the passengers are to be re-directed during this period of maintenance.

6.2 Quality Plans

RTM has produced a Quality Manual (document ref: RTG-04-0-0000—QMS-001) that oversees the quality management system for the network. The document itself provides a high-level overview of governance requirements with little detail into Buildings Facilities specific quality management. References are made to other documents in relation to asset specific quality plans.

Quality Management for Buildings Facilities is mentioned in the Section 4.1 of the AMP but links to the Maintenance and Rehabilitation Plan. Our review of the Maintenance and Rehabilitation Plan found no asset specific reference for quality management of maintenance undertaken.

We recommend that a Buildings Facilities specific Quality Plan is produced outlining the assurance required and procedure for signing off work items for each system.

6.3 Maintenance

The Maintenance and Rehabilitation Plan (document reference: RTM-MC-PLN-042) outlines the contractor responsible for maintenance and rehabilitation for each Asset. For Buildings, all maintenance and rehabilitation works are the responsibility of RTM. For Non-specialist facilities maintenance, RTM has a team of in-house technicians that are trained to complete these preventative and corrective maintenance tasks. All specialist maintenance activities (structural inspection, elevator, escalator, fire safety systems, building automation systems and HVAC) are outsourced to specialist sub-contractors.

A list of maintenance activities that require specialist contractors is listed in Section 5.8 of the Maintenance and Rehabilitation Plan, however this list is noted as not definitive. Further detail for the systems that require specialist contractors is listed in Section 6 of the Asset Management Plan with a description of the system and timescales between inspections also recorded. We recommend that all specialist maintenance activities be recorded within the Maintenance and Rehabilitation Plan to align with the activities noted in Section 6 of the Asset Management Plan.

As this was a relatively short review, the assessment was not able to formally examine the efficiency and effectiveness of individual work activities and consisted of interviews with the relevant members of staff, observation of process, reporting and compliance.

6.3.1 Preventative Maintenance

Depending on the complexity of the task, Preventative Maintenance is carried out by either specialist contractors or by RTM's internal Facilities Maintenance Team. Preventative Maintenance tasks are recorded in the Asset Management database IMIRS for all tasks including items for specialist sub-contractors, with an explanation of the task and compliance period for the task to be completed recorded in the system.

Sub-contractors are provided with an annual yearly preventative maintenance list, with any recommendations for changes reliant the competence and advice from the sub-contractor. Changes are agreed locally, with no specific issues were raised during our assessment.

Specialist tasks are completed by sub-contractors that are competent to carry out the task. Section 1.2.2 of the AMP outlines the systems that require preventative and corrective maintenance with the requirement based on regulatory need.

Completion of these tasks is monitored through a mixture of daily operating reports submitted by the Facilities Maintenance Supervisor and through the daily update meetings held with the City.

6.3.2 Corrective Maintenance

Corrective Maintenance is issued when a Service Request is created within the Maintenance database after a fault has been called into the faulting hotline. The hotline is operated 24 hours a day in line with the requirement of the Project Agreement so faults can be attended in the necessary timescales. Once the fault is recorded in the system the Facilities Maintenance Supervisors receives notification on their phone of the fault and will be required to respond within the allocated timescale. The Facilities Manager is also notified of the fault and can track the status of the fault through the IMIRS System.

At the end of every shift the Facilities Maintenance Supervisor submits a daily operating report to the Facilities Manager detailing the work undertaken by their team during the shift, including whether the Work Order has been completed or is still awaiting completion. This information in this report is then used to update the City in the daily operating meeting. This process is documented in section 2.1 of the Asset Management Plan.

6.3.3 Retrofits

As per the Project Agreement, at the end of the contract RTM are required to hand back the facilities in the same condition as when they first took on the maintenance responsibility. As such the renewal of life-expired or failing assets is going to take on vital importance over the contract life cycle, with an increased level of focus over the coming years.

As the network has only been in service for two years, the plan for renewals within the Buildings portfolio is only in its early development stages. During our assessment, we were shown the early

development of a renewals plan spanning over the 30-year contract length. Assets were listed within the plan with estimated dates of renewal based on life expectancy and historical experiences.

We found little evidence of a documented approach to the renewal of assets. The process for estimating the renewal dates was taken trough local knowledge with no definition into the type of intervention required for the renewal (i.e. full renewal of the asset or localised replacement of asset parts). Forecast costs were estimated at a very high level, with no breakdown into the cost build up and as a result will contain a high level of risk to achieving the cost. To achieve more accurate cost forecasts, renewals will need to be remitted early with commercial and engineering support to understand the most efficient delivery strategy.

Utilising asset data to forecast the intervention point is a vital part of asset management as this allows for forward planning based on real-life condition. Early interventions or localised repairs can be planned to spread the costs and reduce the likelihood of a bow-wave of renewals being required over a short period. As the network was only recently constructed, there is a high risk of assets becoming due for renewal around the same time, creating this bow wave. A planned renewal strategy is created could mitigate this.

Whilst a 30-year renewals strategy has been created, the ability to plan renewals beyond a 5-year period is extremely difficult. Assets can fail unexpectedly and costs for some projects can exceed forecast amounts, putting pressure on yearly budgets and lead to the deferral of some schemes. We recommend that RTM begin to plan their delivery strategy for the renewal of assets, with intervention points defined and the process for renewing assets referenced in the AMP and documented in the Maintenance and Rehabilitation Plan. The type of intervention should also be considered, whether that be a full renewal of targeted repairs, dependant on the asset condition reports and most efficient delivery methods.

6.3.4 Backlog

Yearly audits by the HSQE team identify if any works in the past year required as part of the Project Agreement are outstanding. Our review of the most recent audit reports for the year 2021 found that there were no outstanding work items that had not met the requirements of the Project Agreement.

We were provided with records for the raised preventative and corrective work items raised in the past 24 months, an example of these records is shown below:

Figure 6.1 Extract of Preventative work items

Appendix A: Infrastructure Preventive Service Order

TPSS Preventive Maintenance Work Orders

Order Type	Order	Functional Loc.	Description	Sched. start	Actual start	System status
Preventive	60836479	OTTIF-TP01	IF SPRING SUB CON TPSS HVAC INSP	2021-03-23	2021-03-25	Completed
Preventive	60591711	OTTIF-TP01	IF FALL SUB CON TPSS HVAC INSP	2020-12-01	2020-12-01	Completed
Preventive	61058832	OTTIF-TP01-FCLTY	IF 1M FDAS TP01-10 INSPECTION	2021-08-23	2021-08-20	Completed
Preventive	60848247	OTTIF-TP01-FCLTY	IF 1M FDAS TP01-10 INSPECTION	2021-04-23	2021-04-24	Completed
Preventive	60757832	OTTIF-TP01-FCLTY	IF 1M FDAS TP01-10 INSPECTION	2021-02-23	2021-02-18	Completed
Preventive	60461223	OTTIF-TP01-FCLTY	IF 6M SUB CON TPSS HVAC INSP	2020-05-14	2020-05-14	Completed
Preventive	60983412	OTTIF-TP01-FCLTY	IF 1Y FDAS TP01 CONCESSION	2021-06-30	2021-07-02	Completed
Preventive	60983402	OTTIF-TP01-FCLTY	IF 1Y FDAS TP01 CONTAINMENT CONCESSION	2021-07-01	2021-07-01	Completed
Preventive	60593792	OTTIF-TP01-FCLTY	IF 6M EYEWASH STATION REFILL	2020-11-19	2020-11-23	Completed
Preventive	60693272	OTTIF-TP01-FCLTY	IF 3M FDAS TP01 INSPECTION	2021-01-20	2021-01-16	Completed
Preventive	60976803	OTTIF-TP01-FCLTY	IF 3M FDAS TP01 INSPECTION	2021-07-20	2021-06-26	Completed
Preventive	60717441	OTTIF-TP01-FCLTY	IF 1M FDAS TP01-10 INSPECTION	2021-01-24	2021-01-21	Completed
Preventive	60803359	OTTIF-TP01-FCLTY	IF 1M FDAS TP01-10 INSPECTION	2021-03-23	2021-03-19	Completed
Preventive	60676749	OTTIF-TP01-FCLTY	IF 1M FDAS TP01-10 INSPECTION	2020-12-25	2020-12-16	Completed
Preventive	60736886	OTTIF-TP01-FCLTY	IF 1Y FDAS TPSS1 INSPECTION	2021-09-04	2021-09-02	Completed
Preventive	60821918	OTTIF-TP01-FCLTY	IF 3M FDAS TP01 INSPECTION	2021-04-20	2021-04-19	Completed
Preventive	60587789	OTTIF-TP01-FCLTY	IF 1M FDAS TP01-10 INSPECTION	2020-10-22	2020-10-22	Completed

All work items registered in the system were listed as Completed. With preventative maintenance it is unclear how it is recorded if a cyclical maintenance task is missed and then completed on its next scheduled date. It would appear from the records that all work items are signed off a completed. The problem with this is that it does not highlight the number of missed tasks. If these missed tasks were recorded then over time this could highlight trends causing issues, for example access issues. Equally if the original task is missed, there is a potential risk to the asset that remains unknown until the task is completed, be that the original task or its next scheduled date. It is vitally important that any risks are understood, with mitigations put in place if necessary.

6.4 Effectiveness of maintenance management and reporting systems.

From interviewing individuals, we observed that RTM have an effective local facility reporting structure that allows for faults to be tracked and updates provided to the Facilities Manager that can be used to inform the City in the daily update meetings. New faults are investigated for root cause with contingency plans put in place to mitigate against future risk. These contingency plans rely on previous experience and are not recorded in the Maintenance and Rehabilitation Plan. We recommend that Risk Mitigation plans for high-risk assets are recorded or linked to in the Maintenance and Rehabilitation Plan with reference in the Asset Management Plan

We were given a run-through of the maintenance management system IMIRS with a step-by-step explanation of how the process works. Each asset has its own profile with information on the asset and a list of historical faults. Due to time constraints, we were unable to verify the accuracy of the

information in the system and the quality of the information input. We recommend that a technical audit be carried out to confirm the asset data and the detail of the information input into the system.

Maintenance that required specialist contractors was identified with the requirements tracked as Work Items in IMIRS.

As part of the assessment, we were given a run through of the current report structure for the Buildings facilities maintenance. Currently RTM report to the City on a percentage available format account for all Buildings facilities over a monthly period. This scoring works on the format that if part of a station is closed off, this would reduce the availability achieved percentage for the month. There is a monthly target of 98% that is required, evidence was shown of the reporting format with RTM achieving their target each month this year.

Figure 6.2 Extract from Daily Operating Report Dated 11/29/21

Station Availability - Peak Periods

Metric	Group 1	Group 2	Group 3	Day Aggregate*
Passenger-Facing Availability Ratio	0.00%	0.00%	0.00%	0.00%
Contractual Availability Ratio	0.00%	0.00%	0.00%	0.00%
Scheduled Station Hours	0.00	0.00	0.00	0.00
Station Availability Failure Hours	0.00	0.00	0.00	0.00
NPCC Station Availability Failure Hours	0.00	0.00	0.00	0.00

**The daily Aggregate ratios are weighted by Station Group in the same way as the monthly calculation in PA Schedule 20*

Other reporting requirements for the Buildings team is listed in the extract from Section 2.1 of the Asset Management Plan below:

Figure 6.3 Reporting Requirements listed in the AMP

Stream	Report	Responsibility	Frequency	Due Date
Maintenance	Daily Operating Report	RTM	Daily	At least (2) hours prior to the morning meeting
	Monthly Activity Report	RTM	Quarterly	7 days after each completed quarter
	MSC Monthly Reliability & Maintainability Report	RTM	Quarterly	
	Asset Management update	RTM	Annually	December 31
	Annual APPM Achievement Report	RTM	Annually	November 30
	Structure Condition Data	RTM	Annually	September 30
	Facilities Condition Data	RTM (Electrical, Mechanical & Fire Protection systems only)	Annually	
	Other Assets Classes Condition Data	Other Structure Assets – RTM Drainage & Sedimentation Control Structure – Subcontractor Mechanical Systems – RTM Electrical Components – RTM Fire/Life/Safety – RTM	Annually	
	MSC System Asset Inventory	RTM	Annually	
	As Built Drawings (Structural Components)	RTM	Annually	

These reporting requirements are in line with Schedule 15-3 of the Project Agreement. Documentation relevant to each reporting requirement was observed apart from the Annual APPM Achievement Report as this was not provided as part of this assessment.

The IMIRS system has the capability of providing a monthly breakdown of number of asset failures and service requests produced per asset. This information could be utilised to identify problematic assets and to monitor high risk assets. Visibility in trends of asset failure could also be identified, allowing for early interventions and to plan future maintenance schedules if observed achieving the goal stated in the Asset Management Plan (Section 14 - Expected Condition Performance of the Asset).

6.5 Workorder management

During our assessment, we were shown how work orders are currently managed. Work orders are managed through RTM's IMIRS maintenance management system. Both Preventative and Corrective maintenance tasks are created in the system and assigned to the necessary asset, with a basic remit and target completion dates in line with the Project Agreement. The IMIRS system has a dashboard that allows for outstanding maintenance activities to be highlighted. Assets with the highest number of reported faults are also visible in the dashboard. This information can used to

highlight when assets are close to reaching a larger intervention point or assets that may require are more detailed preventative maintenance schedule.

Updates on the status of maintenance activities are also reported by the Facilities Maintenance Supervisor to the Facilities Maintenance Manager at the end of each shift with a handover period between shifts to make sure that activities are not missed or left outstanding. This reporting gives the Facilities Manager visibility of the status of maintenance activities allowing for them to focus on troublesome items and plan activities accordingly.

The data from the IMIRS system is used by RTM to report in the daily operating meeting. Outstanding work orders that have missed their target completion deadline and high-risk activities are discussed at this meeting, to make sure that there is an action plan to complete the works.

6.6 Appropriateness of employee:

6.6.1 Training

The RTM Training and Competence Plan (RTM-ADM-PLN-123) outlines the training requirements for all RTM staff, including training requirements dependant on the role. Section 7.13 outlines the training requirement of Maintenance staff. This gives an example of the types of training that could be required by a member of the maintenance team but does not list role or task specific requirements. A Training Matrix is also held by RTM recording the training each employee has undertaken.

Section 7.13 of the Training and Competence Plan also specifies the need for a performance assessment to be carried out at 6- and 18-month intervals as an assurance check to make sure that staff are still competent to carry out the task. We were unable observe an assessment to confirm to how performance assessments are being carried out, we recommend that these reviews are sampled during the monitoring phase.

Training records for RTM employees were held within the HSQE team. The competency for specialist activities required either faith in the sub-contractors own competency management or the capability of checking the relevant professional body for the certified member. We recommend that requirements for competence management are included in the facilities subcontracts to provide assurance that appropriately trained and qualified staff are being deployed to work on the network.

6.6.2 Experience

Due to the limited timescale for the assessment, we were unable to interview every member of staff listed in the organisation chart to make an assessment on levels of experience. Where we were unable to spend time with particular individuals, an overview was given by the Facilities Manager.

Members of staff in senior roles were found to have a high level of knowledge on the maintenance requirements with their experience of the network giving them an understanding of the high risk and problematic assets. The Facilities Manager had a detailed understanding of maintenance activities, which activities require specialist contractors and was kept up to date on the condition of the facilities and status of the Work Items through daily reports. It was mentioned that Facilities Maintenance Supervisors were promoted into their roles based on competence and experience in the technician role, thus giving them the skills required to supervise maintenance activities. No issues with

maintenance activities were highlighted during our assessment to suggest that there was an issue with the levels of experience within the facilities maintenance staff members, however monitoring would be required in future to confirm this.

It is worth highlighting that the Facilities Maintenance Supervisor role is a key role within the asset management process. This role acts as the link between the on-site task completion and reporting to the City. The role is ultimately responsible for making sure that tasks are completed to the required standard and for signing off to say that the asset is maintained to a steady-state level. For maintenance activities that require specialist sub-contractors, assurance that the work is completed to the necessary standard lies with the sub-contractor. As the competency to confirm this does not lie within RTM there is a risk to the standard of these works.

For the entry level roles, non-qualified staff were employed and then trained up through a mixture of training and learning on the job under supervision. Currently no standardised training or apprentice scheme exists for entry level roles within RTM. This approach would allow for a consistent level of training and experience for new employees and would allow for the competence of new employees to be monitored through assessment and training plans produced if necessary.

6.6.3 Qualifications

Section 3 of the AMP (Scope and Obligations) lists a levels-based system for activities based on the complexity/qualification required to carry out the task. This levels-based system shows that RTM understands the need to manage the qualification when planning works.

We did not validate the qualifications of all staff members involved in the buildings facilities maintenance team. RTM has a Training and Competency Plan (RTM-ADM-PLN-123) that lists out the expected competencies and qualification for each role. From our interviews it is apparent that at entry level, staff members are not expected to hold technical qualifications, with a mixture of on-the-job supervision and training provided to bring them up to the required standard. The Facilities Manager had detailed understanding of the maintenance activities and the qualifications required to carry out the task.

Records of qualifications are held within the HSQE team. Gaps in training and competence are identified by the HSQE team with the requirement for the individual to complete the necessary training.

6.7 Appropriateness of maintenance organization;

6.7.1 Staffing levels

Section 13.3 of the Maintenance and Rehabilitation Plan lists the number of staff within RTM's Facilities Maintenance department. This consists of:

- 1 x Facilities Maintenance Manager
- 4 x Facilities Maintenance Supervisor
- 6 x Facilities Maintenance Technician

- 1 x Fire and Life Systems Specialist
- 1 x Millwright
- 1 x Facilities Coordinator

All posts were filled at the time of the assessment apart from the Fire and Life Systems Specialist. The Facilities Maintenance Manager explained that this position was not going to be filled, with the requirements of the role undertaken by the Facilities Maintenance Technicians. The process for undertaking the Fire Systems and Life Systems Specialist role is not captured in the Asset Management Plan.

During the winter period, RTM employs a team of Snow and Ice removal contractors. This is listed as a team of 10 seasonal employees. During interviews it was explained that these workers are employed from recruitment agency and there has been difficulty in retaining contractors for the necessary period, with contractors not turning up for work an issue. Competition from external industries has also become a problem, whilst in previous years RTM have managed to reach their required team quota, as of the end of November 2021 there is still an on-going recruitment process for the upcoming winter period.

6.7.2 Shift coverage

As per the requirements of the Project Agreement, RTM is required to provide 24/7 coverage or response to maintenance issues. The organisational structure of the Buildings team has been developed to meet these needs.

The Facilities Manager is on shift Monday-Friday during daytime hours and is contactable out of hours and at weekends. This is a local arrangement and is not documented as a requirement in the Maintenance and Rehabilitation plan.

A Facilities Maintenance Supervisor and two Facilities Maintenance Technicians are always on shift to meet the 24/7 coverage requirements. We observed evidence from reports that RTM regularly meets its expected response timescales and therefore appears to be sufficiently resourced to meet their requirements. Where Maintenance is carried out by the RTM technicians it is the responsibility of the Facility Maintenance Supervisor to assure that maintenance activities are completed to the necessary standard.

6.7.3 Supervision/oversight

Supervision of maintenance activities currently relies on the Facilities Maintenance Supervisor. Tasks are signed off as completed by the Facilities Maintenance Supervisor and as the last checker, they are relied upon to as a single layer of assurance. The role is required to provide a daily report to the Facilities Manager providing information on the activities completed, highlighting any issues, and providing photographs alongside the text. Due to time constraints, we were unable to verify the level of supervision provided for each task. It is recommended that this forms part of the scope for future monitoring.

A yearly audit is also carried out by the HSQE team to review if maintenance targets are being met in line with the Project Agreement, however this does not focus on the quality of the work.

Having the Buildings team managed internally is an advantage to RTM as it allows them greater control over the quality and prioritisation of works. Whilst no concerns were noted, if there were concerns over the quality of work this can be investigated transparently internally allowing for a faster and accurate resolution. Reactive maintenance can be arranged quickly with the management roles kept up to date through local updates and reporting. This can then be fed back to the City through the daily operating meetings.

Whilst currently there is little internal assurance, during interviews with the Performance Manager it was explained that there is a desire to develop an internal assurance function within RTM. This role is anticipated to be the responsibility of the Performance Manager, however currently there is a greater focus on reactive maintenance with little time to develop this function.

As discussed in Section 6.3.3 – Retrofits of this report, future oversight planning should also focus on the development of a renewals management programme. As time goes on the focus on renewals is only going to increase and will eventually carry similar levels of importance and responsibility as the maintenance programme. In developing a renewals management structure early, RTM will be able to spread renewal costs and foresee the potential for early interventions helping to reduce costs.

6.8 Support departments (Engineering, sourcing, etc.)

During our assessment, we found that no Engineering support department currently exists within RTM. Technical knowledge of the tasks is reliant on the individual carrying out the task and can be reliant on sub-contractor knowledge for the specialist tasks with little capability of following up to assure the quality of the work. The disadvantage of a lack of engineering support is the potential lack of understanding of the most efficient practice when remitting works as well as a reliance on the assurance of work completed being outside the control of RTM. Currently the closest to this role within RTM is the Facilities Manager. From our interviews the Facilities Manager was found to be experienced and knowledge regarding maintenance requirements, challenging the completion of Work Items when reviewing the daily reports if a concern arises and showed a willingness to understand specialist activities to better manage the asset. For a network of this size, it is considered advantageous for this role to cover the technical support as well as facilities management.

When it comes to planning access for works, it was observed that the Buildings team works closely with the Maintenance Planner to arrange access and to discuss at planning meetings with the City. Sub-contractors are required to notify the Maintenance Planner two weeks in advance of their request for access. High risk items are discussed within a daily maintenance plan which includes the key information on the work including the person in charge, work limits and any applicable permits. Detail on the maintenance plan is contained within the Maintenance and Rehabilitation Plan. Having a single point of contact allows for clarity in access planning and reduces the risk of conflicting works being undertaken at a single site.

6.9 Adequacy of tools and equipment

For preventative maintenance work undertaken by RTM employees, only basic tools are required to complete the tasks. Specialist works requiring training/competency to use would be undertaken

by sub-contractors, with the responsibility for making sure the employee is competent lay with the sub-contractor. During our assessment, no concerns were raised as to the adequacy of tools used.

6.10 Adequacy of QA/QC processes

RTM currently has no internal technical support function to provide technical assistance for the buildings team. Maintenance activities completed by the specialist contractors rely on the competence of the contractor and their internal assurance process to complete the work to the required standard. There is no requirement for condition reporting or maintenance activities to be accepted by RTM before being signed off as completed, resulting in a lack of control on the quality of the work undertaken.

For a network of this size this is quite common and can be managed through local process, however as the network expands in the future it would be recommended to formalise this procedure. During our assessment, it was highlighted that if issues with the quality of work does arise, this is resolved locally between the contractor and RTM. No specific issues were highlighted during our assessment.

The buildings team is subjected to yearly audits that were provided to NRC during the assessment. The annual audit focussed on the maintenance achieved against the requirements. The audits do not review the technical delivery and do not consider the level of technical assurance of completed projects. This creates a risk that RTM are unable to control or verify the quality of work through a recommended 3 layers of assurance.

Whilst no issues have been highlighted so far, we recommend that audits include a review of the technical delivery. This will help to maintain quality levels. The audit reports that we reviewed as part of this assessment are:

- Station and MSF Custodial Maintenance (document ref: RTM-QMS-FRM-542)
- Fire Detection Alarm System Maintenance Part 1 (document ref: RTM-QMS-FRM-542)
- Fire Detection Alarm System Maintenance Part 3 (document ref: RTM-QMS-FRM-542)
- Building Automation System and HVAC Maintenance (document ref: RTM-QMS-FRM-542)

It was noted that each audit report contained the same document reference number.

All audits contain recommendations relating to missing evidence or inspection reports (see below for an extract). It is not clear if this is because these Work Items were not completed or if this evidence was provided later. It is unclear how recommendations made in the audit reports are tracked and if there is a requirement to implement recommendations.

Figure 6.4 Extract from the Station and MSF Custodial Maintenance audit

- Bee-Clean notes does not perform Bi-annual custodial maintenance tasks in Passenger stations such as window cleaning tasks. These are completed by another contractor. Carpet cleaning, and floor refinishing tasks are not required.
- Bee-clean has included the process of monitoring the Passenger Stations for defects and graffiti in the Daily station schedule/ scope of work. Completed work orders (00071450, 00065125 and 00059552) of recorded observations of vandalism and graffiti were observed on IMIRS. **(C)**
- Bee-Clean has implemented a walk-through monitoring document to inspect the MSF and Passenger Stations. (C)
- Bee-Clean has a training program for employees which includes training such as: washroom cleaning, waste collection, color coded cleaning, WHMIS/GHS, PPE, handwashing, floor care as well as RTM's Safety orientation.
- Monthly health and safety meetings are also held with the workers. **(C)**
    - Topics reviewed in 2020 include: bloodborne pathogens, sharps and body fluids, spill containment, Environmental Policy review, etc.

Opportunities for Improvement

- The schedule provided for the MSF needs to be further broken down to list the plan for performing custodial Maintenance tasks in the different rooms in the MSF
- Clarity is needed on all the areas in the MSF that fall under Bee-Clean's scope. The schedule provided lists the general areas but no specifics.
    - Bee-Clean notes that MSF 2 has not been included in their contract and they perform general cleaning at MSF2 weekly.
- Rating structure and reason for rating awarded was not clear on walkthrough monitoring document (#29269 and #30130). The form provided for the audit was also not completed fully. Information missing includes:
    - Ratings were not awarded for some sections/locations on the form.
    - Signature fields for the inspector and Customer was not completed.
- Frequency for the monitoring walk through in passenger stations was not clear on the document list provided.
    - Information for walkthrough in some stations such as Tremblay and Bayview stations were not found on list provided.

NOTE: A Copy of the Audit Plan and Checklist is attached to this report as Appendix A.

We that the most recent audit (dated 02/02/21) of the Station and MSF Custodial Maintenance (RTM-QMS-FRM-542) identified a lack of evidence of areas expected to be cleaned, naming the Facility maintenance Supervisors room in MSF1 and the Drivers waiting areas in MSF2. We observed the cleanliness of stations at various times of the day during the assessment period. We observed that whilst consistent footfall is going to contribute to reducing cleanliness, we saw examples of full waste bins at various times of day. We recommend that station cleaning be in included in future monitoring.

The audit report also recommends that clarity is required in on all areas in the MSF that Bee-Clean is expected to maintain. Information on Tremblay and Bayview stations were also missing/not provided. We recommend that clarity on the scope of the works including areas of responsibility for each station is included in the Maintenance and Rehabilitation Plan and referenced in the AMP. We further recommend that evidence of completed cleaning be included in the daily reporting requirements if not done already, with future monitoring to be undertaken to review the quality of the cleaning over a larger sample including stations.

7. Structures

7.1 Asset Management Plan

The purpose and context of maintenance is set out in the ART Engineering 2021 Fixed Infrastructure Asset Management Plan (AMP). The current published version is Version B.

The Asset Management Plan for Fixed Infrastructure is structured in the same format as those for other assets. We have included some comments that apply to all plans in section 3.1.

During this assessment, we have not reviewed every reference document in detail, but we have referred to some of them in drawing our conclusions about the completeness of the Asset Management Plan.

The scope of the AMP is noted as applicable to all fixed infrastructure within the system asset inventory in IMIRS that require structural condition inspections which is in accordance with Appendix B, Section 15-3 of the Project Agreement.

The AMP was found to adequately contain information on the types of assets applicable, condition survey requirements, maintenance and reporting requirements for Structure's assets. Section 1.2.2 of the AMP lists the Primary and Secondary structural types that categorise each asset, with this information listed in the asset management database as per the Project Agreement. Assets are listed individually within IMIRS to allow faults to be assigned to a particular asset.

The primary structural material is a useful method of categorising structures but is not mentioned in the AMP nor IMIRS. Having an overview of the number of assets per material provides a high-level insight into the types and scale of maintenance regimes (e.g. a large number of reinforced concrete structures means spalling/fractures are likely to be the most common defects across the portfolio).

One aspect of the AMP that is not mentioned is the identification and inspection of Hidden Critical Elements (HCE's). Inspection of HCE's becomes a vital aspect of managing the structural integrity as the assets age. The rail bridges carrying the Confederation Line network consists mainly of reinforced concrete decks. The reinforcement is designed to take the tensile forces and is permanently hidden by the concrete cover. Whilst these decks do not tend to suffer from capacity reducing issues, if there are quality issues with the reinforcement painting protection or water ingress this could lead to corrosion within these elements going undetected. We recommend that all Hidden Critical Elements are identified and listed in the AMP with an appropriate inspection regime also listed.

Our assessment also noted that no information is included within the AMP on the management of bridge strikes on the network. If a bridge is struck by a vehicle it is vital that the incident is reported as soon as possible so that the damage can be inspected to confirm that the structural integrity has not been affected.

In the event of an incident, there is no information at the bridge site of who to contact. On the GB network, bridges display a plate listing the street name, asset number and the number to call to

report an incident so that the bridge can be identified quickly, and any emergency measure be applied locally to the network in that area.

7.2 Quality Plans

No Quality Plan relating specifically to Structures was reviewed as part of this assessment. Section 4.1 of the AMP refers to compliance with RTM's Quality Management Plan. It is unclear what steps ART Engineering have undertaken to comply with the plan, we recommend that this is considered as part of any future monitoring.

The AMP discusses the process ART Engineering will undertake for quality management. There is a 3-layer internal assurance process with reports checked and approved by a Professional Engineer before being signed off. This process is consistent with the expected level of assurance for works of this nature. There is no mention of the need for somebody from RTM to review and accept reports. Currently the Stage Two Project Manager is fulfilling this task with any issues resolved ad-hox with ART Engineering. No issues with this process were noted during our assessment.

7.3 Maintenance

All maintenance of structures assets is sub-contracted to ART Engineering. The AMP outlines the intervention criteria for each asset type including the timeframe for the repair to be carried out.

The Assets that ART Engineering are responsible to maintain are listed as:

- Tunnel Structures
- Facilities
- Structures

As this was a relatively short review, the assessment was not able to formally examine the efficiency and effectiveness of individual work activities and consisted of interviews with the relevant members of staff, observation of process, reporting and compliance.

7.3.1 Preventative Maintenance

As most structures were recently constructed and tend to deteriorate slowly over several years there is not a big requirement for a preventive maintenance programme for structures on the network. The bulk of the preventative maintenance consists of the detailed visual inspections of each asset, with the project agreement specifying that all structures must have an inspection over a two-year period, with the report submitted to the city on 30th September of the second year. It was confirmed that all required reports were submitted for the year 2021, with no issues with compliance.

Completion of the detailed visual inspections is currently managed within RTM by the Stage Two Project Manager due to long term leave but would normally sit under Infrastructure Manager. The Stage Two Project Manager is required to input the defects into IMIRS and monitor that site work is undertaken in line with the programme submitted to RTM by ART Engineering.

As part of our assessment, we reviewed the information contained in a detailed visual inspection report for one structure and one station building. It was observed that the format for the reporting and information contained were consistent with the requirement details in the Ontario Structures Inspection Manual. As per the requirements of the Ontario Structures Inspection Manual, site visits are undertaken to carry out a touching distance inspection of the condition of each element of the structure, with photographs taken to support text within the report. Reports detail the condition of the asset per element and give a condition marking index score per element, with trigger points determining the need for intervention to carry out repairs. Recommendations are given for any repairs required with a scoring system of high, medium and low. This scoring system is outlined in the project agreement and repairs must then be carried out in timescales defined. Due to time constraints we were unable to verify the quality of the site visits to confirm all necessary information is captured, we recommend that this be included in the scope for any future monitoring.

Section 6.1.1 of the AMP mentions the creation of a Preventative Maintenance Plan. The Maintenance and Rehabilitation Plan (RTM-MC-PLN-042) includes a section on Structures maintenance (Section 13.4.4), which replicates the requirements from the Project Agreement.

7.3.2 Corrective Maintenance

Any defects noted within the condition reports are then input as a work item within IMIRS and assigned to the relevant asset. It is then the responsibility of ART Engineering to undertake the repair within the necessary timescale. ART Engineering are contracted to manage the resolution of the work item, which may require design. During our assessment it was mentioned that as the structures are new, repairs so far have consisted of small-scale patch repairs. It is unclear how more complex maintenance that require design are going to be managed to deliver for the most efficient cost. No issues were noted with outstanding defects and all work items were currently being resolved within the required timescales.

As part of our assessment, we discussed that when work items were completed, the RTM Project Manager would attend site to confirm that the repair is completed to a satisfactory standard. This layer of assurance is a local process created by the Project Manager and is not recorded in any of RTM's documented requirements. Reviewing completed works helps to assure a consistent level of quality and we recommend that this process is included within the AMP for managing corrective maintenance.

We also discussed that a list of defects is recorded within a spreadsheet as well as being uploaded within IMIRS. This is not recorded in any of RTM's documented requirements and is another process developed locally by the Project Manager. This spreadsheet records the asset and type of defect. This data can be used to identify trends in the defects such as the geographical local of similar defects or if a certain type of defect is more common than others. This can then be used to assist in determining the preventative maintenance plan by targeting repairs based on the most common types of defect. We recommend that the requirement to document defects in a tracking database is recorded within the AMP or within RTM's Maintenance and Rehabilitation plan.

7.3.3 Retrofits

As the structures and tunnels portfolio comprises recently constructed assets there is currently no renewals programme in place. Due to the life-expectancy of tunnels and structures assets it would not be expected for renewals to be applicable for the life cycle of RTM's contract with the city (barring exceptional circumstances).

Asset data taken from tracking defects and the condition index should be reviewed annually to determine rate of deterioration across the portfolio. If trends show a consistent decrease in the condition of the assets throughout the portfolio then the creation of a renewals programme would be recommended.

Localised strengthening and repair are covered through the corrective maintenance programme.

7.3.4 Backlog

From our assessment, all detailed visual inspection reports were completed and submitted to the city within the deadline as per the project agreement. ART Engineering has devised a programme for the completion of the next round of detailed visual inspections with the programme reviewed periodically by the Project Manager. This periodic review is not listed within the AMP and currently there is no reporting requirement within RTM to review the progress of the inspection programme. As the asset list is currently small this is not a concern, however once Stage Two works is complete it would be recommended that RTM include progress as part of their structure's management, to mitigate against any slippage in programme.

7.4 Effectiveness of maintenance management and reporting systems.

Maintenance is sub-contracted out to ART Engineering with the Stage Two Project Manager overseeing the work undertaken. Maintenance activities are input into the IMIRS system and highlighted at the Daily Operating Meeting with the city if required. RTM can request ad-hoc updates on the progression of work items if there are concerns over progress or high-risk items that require closure involvement but generally work items do not detail the action plan.

The relatively low number of assets allows the Project Manager to oversee more control over individual Work Items, attending site to approve the quality of repairs and tracking defects locally using their own spreadsheets. Photos are also uploaded into IMIRS as part of the Work Item completion process.

Updates on programme progress are held ad-hoc between RTM and ART Engineering with any project related issues highlighted if they happen. No specific issues were noted during our investigation. As the site work is non-intrusive inspections can be flexible to work around other maintenance activities within the area.

These processes are an effective method for managing the maintenance requirements given the current number of assets. As the network grows, we recommend that a more systematic approach is taken to the management and reporting of the structure's portfolio, with the AMP detailing requirements for defect tracking.

7.5 Workorder management

Work Orders are created in IMIRS by the Project Manager based on recommendations made within the detailed visual inspection report. Both Preventative and Corrective maintenance tasks are created in the system and assigned to the necessary asset, with a basic remit and target completion dates in line with the project agreement. There is also the capability to review historical defects for each asset. These items can then be reviewed and discussed at within the daily operational report presented to the city.

As inspections are spread out over a two-year period the need to produce work items is only needed on an ad-hoc basis and is input by the Project Manager only. As there is only a relatively small number of structures, we see no issue with the management of work orders.

7.6 Appropriateness of employee:

7.6.1 Training

As the Structures portfolio is entirely undertaken by sub-contractors, within RTM there is little internal training required for this role other than the network related safety competence.

As per Appendix B of the project agreement, RTM is required to employ qualified inspectors to carry out the inspections with a professional engineer responsible for signing off the report. These roles are all undertaken by ART Engineering. The AMP notes that all inspectors will have at least five years of inspection experience and attend a refresher course with the Ministry of Transportation every two years. This is compliant with the requirements listed within the project agreement.

From review of RTM's Training Matrix (RTM-SMS-REG-684) it does not appear that the qualified inspector competency is listed within the matrix. We recommend that this be included in the matrix along with the competencies of the individuals within ART Engineering that work on the structures portfolio.

7.6.2 Experience

As per the project agreement and AMP, qualified inspectors are required to have a minimum of five years' experience in carrying out inspections. Due to the short timescale of the assessment phase, we did not verify the level of experience of the qualified inspectors, however this was not described as being an issue during our interviews.

RTM's Stage Two Project Manager is a qualified civil engineer and from interviews showed to have the necessary level of experience and understanding to be able to manage the portfolio and review the condition reports.

Where corrective maintenance is required, these maintenance activities were also carried out by ART Engineering. We were unable to confirm the levels of experience of these individuals however no issues were noted during interviews.

7.6.3 Qualifications

The Stage Two Project Manager is a qualified civil engineer which is vital when overseeing the Structures portfolio. No issues were noted during our assessment.

The AMP notes that reports are signed off by Design Engineers who are required to be professional engineers. The professional competency of these engineers was cross referenced with the Professional Engineers Ontario website to assure that they are suitable to carry out the role. No issues were noted on this during our assessment.

7.7 Appropriateness of maintenance organization;

7.7.1 Staffing levels

Within RTM, the Structures portfolio is managed by the Stage Two Project Manager. It is this individual's responsibility to review condition reports, oversee the completion of the inspection programme, make sure work items are input into IMIRS and make sure they are completed to the necessary timescale.

ART Engineering are responsible for making sure they have an appropriate level of qualified inspectors, professional engineers and maintenance staff to carry out inspections and maintenance activities and that the management of these activities is overseen by a suitably qualified individual.

Our assessment found there to be adequate levels of staffing to oversee this programme.

7.7.2 Shift coverage

Due to the relatively low number of assets on the network, maintenance activities on structural elements in generally do not require the same levels of shift coverage as other parts of the infrastructure. Timescales to resolve Work Items tend to be in months rather hours and as such do not need 24/7 coverage. There is an on-call function that assures that any urgent faults can be dealt with.

Inspections require access to the network or road closures which an only be undertaken during engineering hours. There are no issues with the availability of staff to cover these hours when needed. NRC saw no issues with the level of coverage for shifts during our assessment.

7.7.3 Supervision/oversight

Supervision of the quality and completion of tasks is reliant on ART Engineering. RTM currently have no internal supervision requirements.

The process for signing off inspection reports requires the report to be approved by a professional engineer as per the Project Agreement. This gives a layer of assurance. From interviews it was observed that the RTM project manager had the required qualification and competence to be able to review the reports as well and it was noted that any issues in quality were resolved locally at project level, with no issues highlighted.

Having this extra layer of assurance is a beneficial and important aspect of managing the asset. Local knowledge of the assets is vital when planning maintenance activities and budgets and the

tracking of defects allows RTM to observe degradation and identify potential for early interventions to help minimise the future interventions that may be required.

It is noted that as the network grows there will be a greater number of structures to assure. We recommend that RTM formalise the need for internal report reviews/sign off through competent individuals so that this process is not lost.

7.8 Support departments (Engineering, sourcing, etc.)

During our assessment, it was found that no Engineering support department currently exists within RTM. Technical knowledge of the tasks is reliant on the individual carrying out the task and can be reliant on sub-contractor knowledge for the specialist tasks with no documented assurance following up to assure the quality of the work. The disadvantage of a lack of engineering support is the potential lack of understanding of the most efficient practice when remitting works as well as a reliance on the assurance of work completed not sitting within the control of RTM.

Currently there is the capability to fulfil this function through the Stage Two Project Manager.

Whilst now this is managed internally through reliance on ART Engineering, it is worth noting that as the network grows and the assets age there will be greater requirement to carry out maintenance and it will become more important these are remitted to consider the most cost effective and efficient solution. Having these tasks undertaken in house would give RTM more control over the standard of the work with greater to consideration to whole life requirements of the asset and less reliant on sub-contractors.

7.9 Adequacy of tools and equipment

Only basic tools are required as part of the inspection process. These include a hammer to remove spalled areas/corrosion, a tape measure to measure the size of defects, a camera and access equipment to reach all areas of the structures. Maintenance activities are planned with the availability of any specialist tools/equipment discussed as part of the planning process.

No concerns were noted with the adequacy of tools and equipment used on the network.

7.10 Adequacy of QA/QC processes

RTM currently has no internal technical support function to provide technical assistance for the Structures portfolio. The Asset Management Plan does not require RTM assurance of the inspection reports and maintenance activities completed by ART Engineering; however, due to the relatively low number of maintenance activities currently, work items are reviewed by the Stage Two Project Manager to assure that they are completed to a satisfactory standard. During our assessment, it was highlighted that if issues with the quality of work does arise, this is resolved locally between the contractor and RTM. No specific issues were highlighted during our assessment.

The structures team is subject to an annual audit that was provided to NRC during the assessment. For the 2021 audit, no issues were highlighted in the delivery of the programme or works undertaken. The annual audit focussed on the maintenance achieved against the required amount. The audits

do not review the technical delivery and do not consider the level of technical assurance of completed projects. This creates a risk that RTM are unable to control or verify the quality of work. Whilst no issues have been highlighted so far, we recommend that audits include a review of the technical delivery to provide assurance of the quality levels.

8. Other observations

8.1 Assurance Framework

During the assessment phase, we were shown the internal audit process and program and shown examples of completed audit. We did not see evidence of other assurance processes.

Network Rail operates a "3 lines of defence" model of assurance as follows:

- Level One – Operational Management Oversight. Confirms processes are well controlled to manage inherent risks. Assurance activity conducted within a business unit that primarily provides assurance to the business unit leadership. Primarily self-assurance.

  Are we doing what we said we would do?

- Level Two – Corporate and functional oversight. Assurance activity conducted independently of the business unit that primarily provides assurance of control performance (implementation and effectiveness) to the control owner. Primarily internal audit of compliance.

  Are you doing what you said you would do?

- Level Three – Assurance activity conducted independently of the business unit that primarily provides assurance of policy and control design and implementation. External audit of the risk control processes.

  Is what you said you would do still the right thing?

Level One

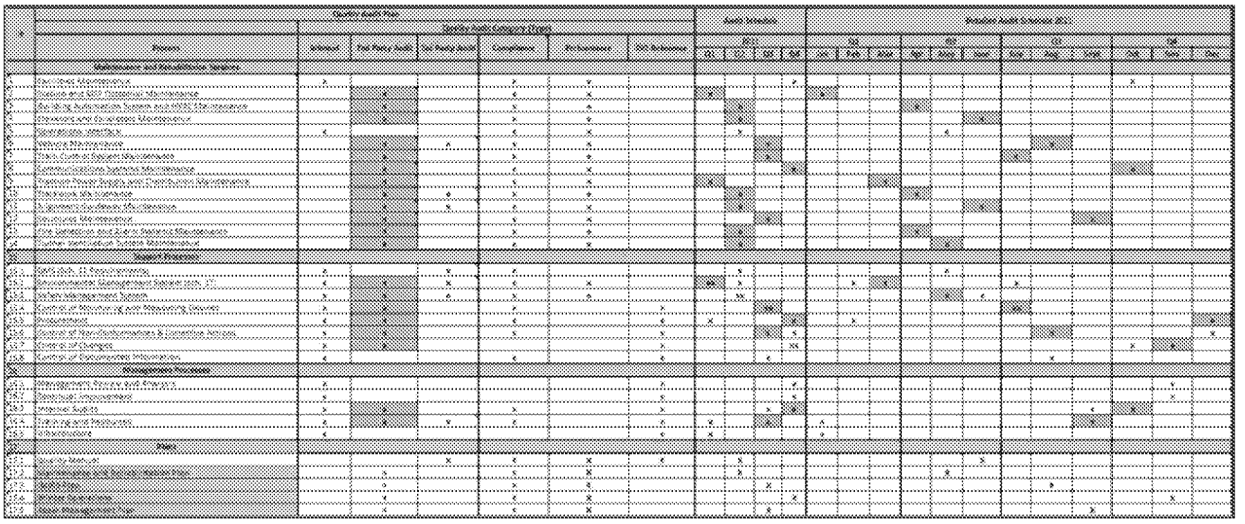
During the assessment phase, we did not see any evidence of Level One activities such as line manager monitoring of staff (reviewing their output to confirm compliance), planned assurance inspections (planned or unannounced checks of work activities and sites) or management self-assurance (manager's self-assessment of compliance with company processes). Such assurance activities provide the first line of assurance that processes and risk controls are being adhered to.

We recommend that RTM and Alstom consider formalising a requirement for self-assurance by each operating unit and implement a process to collate the results as a means of identifying systemic issues.

Level Two

Level two assurance is delivered by means of the RTM Quality department. RTM manage and undertake audits of the infrastructure maintenance. Audits are planned and executed in accordance with section 9.2 of the Quality Manual (RTG-04-0-0000-QMS-0001).

Figure 8.1 2021 Quality Audit Plan



We reviewed some examples of audit reports and found them to be well organised and well recorded. However, we have made two observations about this part of the overall assurance process.

Firstly, the audits are process based in that they focus on documentation and records. It is important to audit these areas, as without proper documentation it would be hard to control the maintenance process and without good records, impossible to demonstrate that it had been completed. The current audit process lacks any assurance that the documented processes are embedded and being followed in practice.

Secondly, the non-conformances are focussed on correcting the issue as found and could be expanded to look at correcting the root cause. For example, in audit report RTM-QMS-FRM-681 (Track Maintenance - Sub-Contractor: Alstom) there are multiple case where maintenance was found to have not been completed in line with the maintenance schedule. In each case, the corrective action is “inspections shall be conducted as scheduled in the Maintenance Plan” or similar. There is an opportunity to identify whether there is a robust way to identify missed maintenance, who is aware of it and what is done about it so that this risk can be properly controlled.

We recommend that, in line with section 10.2.2 of the Quality Plan, auditors require auditees to determine the root cause of non-conformance and put in place actions to correct it.

Level Three

We did not see a method to provide assurance that the processes and controls remain appropriate to the performance and risks of delivering maintenance. The purpose of Level Three assurance is to identify areas where the existing processes are not delivering the required outputs and that as such, the confirmation of compliance provided by levels one and two is not sufficient to provide assurance that the overall management system adequately controls the risks.

We recommend that RTG consider whether they have adequate assurance of delivery and management of risk for the OLRT maintenance.

8.2 Daily meeting

The Confederation Line daily operating meeting is a regular weekday meeting chaired by OC Transpo to review the previous day's operations and maintenance performance. While the meeting focuses on the Daily Operating Report, any ongoing maintenance issues, or anomalies, as well as a maintenance look ahead is included on the regular agenda of the meeting. RTM involvement in the meeting will include the Maintenance Director, and/or their designates and representatives from Alstom. During the meeting observed, the good practice of assessing future risks to service was observed, in this case the risk of snow.

Vehicle Kilometres Availability

Period	Actual KM	Schedule KM	Lost KM	NPCC lost KM
Saturday Daytime	6,218,038	7,717,000	1,498,962	
Saturday Evening	1,583,228	1,582,000	48,772	
Saturday Night	1,196,392	1,196,000	-0.392	
Day Aggregate	8,947,658	10,495,000	1,547,342	0.000

Station Availability - Peak Periods

Metrik	Group 1	Group 2	Group 3	Day Aggregate*
Passenger Facing Availability Ratio	0.00%	0.00%	0.00%	0.00%
Contractual Availability Ratio	0.00%	0.00%	0.00%	0.00%
Scheduled Station Hours	0.00	0.00	0.00	0.00
Station Availability Failure Hours	0.00	0.00	0.00	0.00
NPCC Station Availability Failure Hours	0.00	0.00	0.00	0.00

*The daily Aggregate values are weighted by Station Group in the same way as the monthly calculation in the Schedule 20

The content of the Daily Operating Report consists of approximately 7 pages of useful dashboard KPMs which indicate how the previous day's operations performed. There is then circa 55 pages of open corrective workorders, most of which appear to be faults which have not been closed out properly due to a lack of information available to close the workorders. Work orders are included in the report even when their status has not changed, making it difficult to use the information effectively.

We attended the Daily Operating Meeting on Wednesday 2nd December. The bulk of the meeting focussed on incidents from the previous day. In several cases, detailed information wasn't available because it was yet to be received from the technicians or further information was needed. It wasn't clear how the information was to be used or what decisions it was informing.

We recommend that the daily meeting is focussed more on the day ahead than the previous day. The meeting could review items such as:

- Out of use infrastructure, due to failures or defects, so that OC Transpo are aware, and focus can be given to resolving issues that affect future performance.
- Infrastructure at risk, due to unresolved issues from previous days or loss of redundancy following a failure where a further failure would affect service. The meeting could then review whether appropriate containment or mitigation is in place.
- Shortages in vehicle availability and vehicles in service with concessions. Actions in place to restore availability to the required level.
- Maintenance plan for the day, including:
  - "Golden maintenance" – items that if not completed will result in restrictions so that the attendees can support successful delivery;

- High-risk maintenance – work which creates a risk whilst it is being performed or could overrun the allotted time;
- High-stakes maintenance – inspections that could reveal defects that require operating restrictions or immediate action.

- Weather risks:
  - Availability of snow clearing teams, operability of switch heaters;
  - Flood risk, including availability of sump pumps;
  - Hot weather; operations status of HVAC systems controlling temperature of sensitive equipment, sites with low stress-neutral temperature

8.3 Work/access planning

Engineering Access

Train operations on the main line both before and after regular hours of operation sweep the guideway and position trains for the start of service, and to allow for trains to clear the line at the end of service means that the window both before and after regular hours of operation has restricted access to the guideway to perform maintenance work.

Below is the maximum time allotted for engineering work:

- Sunday 23:45 hrs until Monday 04:00 hrs
- Tuesday 01:43 hrs until Tuesday 04:00 hrs
- Wednesday 01:43 hrs until Wednesday 04:00 hrs
- Thursday 01:43 hrs until Thursday 04:00 hrs
- Friday 01:43 hrs until Friday 04:00 hrs
- Saturday 02:44 hrs until Saturday 04:49 hrs
- Sunday 02:44 hrs until Sunday 06:53 hrs

It should also be noted that time is also required for the issue of permits, setting up protection such as isolating the OCS, on-tracking and off-tracking any on-track plant or machinery and vehicles, and for removing any protection and clearing the track prior to the start of the revenue service.

This limited engineering access may not be sufficient to deliver the quality of work required in line with the instructions provided in several Work Method Statements (WMS). From the review of the WMS documentation carried out during the review, it was noted that many required significantly more time to complete these regular maintenance activities than is afforded by the available track access. Direct observation of these activities is required to confirm this, or otherwise.

Single Tracking

The Confederation Line has been designed with capacity to allow single track train operations between crossover locations at 15-minute headways. With this capacity, single tracking during late

night operating periods could facilitate limited pre-Engineering hours mobilisation and limited maintenance and inspection operations on the guideway after 23:00 each day.

Although single tracking will provide additional maintenance time prior to Engineering hours, the work to be performed will be limited to low-risk operations because of the proximity of passing trains on the adjacent track. Single tracking maintenance operations are generally limited to light maintenance operations using light equipment and hand tools and mobilisation of equipment and materials prior to the start of more intrusive works. Single tracking operations should be planned with notification provided to OC Transpo through the Weekly Planning Meeting and then subsequently on the Daily Maintenance Plan.

Through discussions with those involved in the planning process and works deliverers, there was a consensus that this method of gaining some additional engineering access is not currently being utilised as there is a concern that this may cause some unplanned disruption or lead to increased safety risk. While these concerns may be justified, consideration should be given to how this method could be safely implemented via change management processes.

Major Maintenance Shutdowns

The Confederation Line Project Agreement allows for a shutdown of portions of the system for up to 80 hours per year, (unused time can be carried over to the subsequent year up to a maximum of 160 hours) provided that such shutdowns are scheduled during weekends, certain holidays, and on weekdays between 23:30 and the start of revenue service the following day. Notification of major maintenance shutdowns must be provided to OC Transpo in writing at least 45 calendar days in advance and approvals must be granted for such shutdowns.

Major maintenance shutdowns will only be used for major maintenance and/or rehabilitation work on the guideway. This would generally consist of work on the track, OCS, or structures. Shutdowns will also be used for CBTC software updates, including testing and commissioning. RTM will review and plan the activities requiring a shutdown to be scheduled in a way to reduce as much as possible their duration, frequency, and extent. 80 hours per year for major maintenance shutdowns may prove to be a challenge if the need for significant campaigns such as tamping and grinding continue, however if the guideway has now reached an acceptable asset condition sustainable through normal maintenance volumes then this is likely to be sufficient until such times as assets start to become life expired and larger scale asset refurbishments and renewals are required.

Maintenance Planning

RTM's internal organisation has a maintenance planning position to prioritise, organise, and coordinate all maintenance work with OC Transpo.

The Maintenance Planner is the focal point for all maintenance plans from both RTM and Alstom and ensures that all maintenance requests are reviewed and approved as appropriate. The Maintenance Planner ensures that the work is executed as per the planning rules and that the maintenance schedules are followed. The Maintenance Planner leads a weekly meeting with the City to review the work for the next week which is attended by leads from teams responsible for the delivery of work.

The planning process is as follows:

Work requests are to be submitted to the Maintenance Planner 10 calendar days in advance of the start of the planned work.

The plan will be reviewed for conflicts and amended accordingly. The 10 day notice period is designed to allow sufficient time to amend plans.

The Maintenance Planner also reviews 2 weeks and 4 weeks look ahead based on the planned maintenance schedules for early identification of any conflict. This look-ahead shall include all known upcoming non-routine maintenance activities.

This is reviewed weekly during the weekly planning meetings. The weekly planning meeting is chaired by OC Transpo to discuss medium- and long-term maintenance activities. We recommend that RTM involvement in this meeting should include the Maintenance Director, Infrastructure Maintenance Manager, Maintenance Planner and subcontractors whose attendance is considered essential by OC Transpo.

RTM presented the proposed maintenance plan to OC Transpo at this meeting as input and after a joint review the approved list of maintenance activity for the following week should be distributed to all stakeholders on Friday prior to the beginning of the work week running from Monday to Sunday. Any major changes in form of additions to and schedule adjustments on the daily plan which has the potential to disrupt revenue service, impact passenger access or comfort at the stations should be brought to the notice of OC Transpo for approval.

We noted during this meeting that although every single work order item is contained within the plan being reviewed, only the higher risk activities were discussed. This ensured that the time during the meeting was used effectively but it may be worth considering removing all the low-risk items from the document and adding in some additional commentary for the higher risk work items to give confidence that all risks and control measures had been considered and put in place in advance of the meeting. This may remove the need for some of the additional questions during the weekly meeting.

During discussions with the Maintenance Planner, it was also noted that a considerable quantity of works isn't submitted in line with the 10 day advanced notice deadline. The result is the Maintenance Planner having to contact works deliverers frequently to request them to submit their maintenance plans. This is a common practice and often works aren't submitted and as such plans being amended up until a few days from their planned start date.

It was also noted during direct observation of the weekly coordination meeting that one significant work item was missing from the plan. This was highlighted by the representative from the City and resulted in a follow up action required to review any risks and conflicts that this work item may present.

Submission of the daily maintenance plan to OC Transpo should occur prior to 18:00 on weekdays and will cover work to be performed on the operating day. The daily maintenance plan includes details of all planned work which will require the involvement of OC Transpo, or which has the potential to impact train operations.

We recommend that consideration is given to how learning from the previous weeks fall downs and successes can form part of the weekly meeting agenda with a view to taking this learning and cascading to everyone involved in both the planning and execution staged of the work aiming at continuous improvement of the planning process.

8.4 Custodial maintenance

We used the opportunity of our time in Ottawa to form a “customer perspective” on the network. Customers, stakeholders and the media will have little solid information on which to judge the quality and completeness of the maintenance of the system, meaning their view will be disproportionately influenced by the look of the stations and trains. Therefore, good custodial maintenance can enhance the reputation of the network.

Figure 8.2 Example of escalator panel at Rideau station

This panel appears to have been cleaned with a dirty cloth or mop, suggesting a lack of care by the cleaner and a lack of checking or supervision of the work.

Figure 8.3 Escalator at Rideau Station

Figure 8.4 Example of general condition of the floor at Lyon station

We appreciate that wet and salty streets mean that a lot of dirty material is brought into the stations but there is a marked contrast between the look of the LRT stations and that of other high footfall areas such as the Rideau Center. Similarly, the cleanliness of the OLRT does not compare favourably to networks in similar environments, such as the TTC Subway in Toronto.

To check if it is difficult to maintain the cleanliness through day, we rode the network on the first train on a Sunday morning. The cleanliness of the train was excellent, but the stations looked dirty with floors looking much as they do all day and the garbage bins unemptied.

8.5 Human Resources

During discussions with the RTM HR Manager there were some good practices identified in terms of how HR integrate into the delivery of asset management plan. It was positive to see that the RTM organisation was fully resourced. Evidence was also provided of line-of-sight personal objectives from the CEO to the front-line technicians for objectives related to maintenance and delivery of the asset management plan. Alstom do not have HR based in Ottawa so we were unable to establish if the same could be said for the Alstom organisation.

9. Recommendations

Table 9.1 Recommendations

Section	Recommendation
4.1.1	We recommend that RTM and Alstom consider creating a standalone Fleet Asset Management Plan (FAMP) or adding further sections to the existing Asset Management Plan due to the complexity of rail vehicle maintenance.
4.1.2	We recommend that RTM and Alstom consider updating the asset list to include unique identification of all vehicle to ensure there is no complication between phase 1 and phase 2 assets or in the event an asset is removed from service permanently
4.1.3	We recommend that RTM and Alstom consider aligning these to key roles to give clear line of sight on responsibility and potentially add names of the individuals and their nominated delegates to ensure competence can be covered during periods of absence this would also assist with training needs analysis for succession planning.
4.1.5	We recommend that RTM and Alstom consider detailing or referring to their engineering change process.
4.1.6	We recommend that RTM and Alstom consider adding this detailing who is responsible for this activity and how the appropriateness of subcontractors or 3rd party maintenance suppliers would be assessed including any minimum standard requirements they must meet, what assurance activity is required and what regular reviews or meetings are undertaken.
4.1.7	We recommend that RTM and Alstom consider detailing the process for the transfer for of information within the Asset Management Plan and include staff sign off to ensure they have both received and understood the information provided.
4.1.8	We recommend that Alstom review documents REF PRO 001 and OTT GNR QUA10 PRO 001 to confirm that they contain sufficient detail relating to how the vehicle maintenance documentation is reviewed, stored, controlled and the frequency of planned reviews.
4.1.10	We recommend that Alstom consider adding a deferral management process with the use of a risk matrix and responsible person for sign off would be advisable if this isn't already in place.
4.1.11	We recommend that RTM and Alstom consider adding a post incident or accident process based on specific levels or types of vehicle damage or failure should be referenced here to ensure safe and effective vehicle recovery.
4.1.12	We recommend that Alstom consider adding maintenance recording details specifically focusing on where maintenance is recorded and what components require additional documentation e.g. serialised assets, safety critical components, rotating assets, dimensional data or tools like torque wrenches which may require recording on each workorder.
4.1.13	We recommend that RTM and Alstom consider adding a process or a reference to the process for handling and storage of safety related equipment.
4.1.14	We recommend that Alstom consider adding a process or a reference to the process for how defects are reported by any user, including maintenance technicians and train drivers as a minimum.
4.3.1	We recommend that, in future when enough data is held to review the efficacy of the individual tasks based on the environment and usage of the vehicles.
4.3.1	We recommend that process is created to enhance the daily check to confirm that all outstanding maintenance and modifications have appropriate concessions before the vehicle is released to revenue service.
4.3.1	We recommend that the LRV Daily Checklist is updated to make it clear who did which checks on each vehicle.

Section	Recommendation
4.3.2	We recommend that Alstom consider the use of 'key information' cards to prompt the drivers to note or report specific details relating to environment, track geography or vehicle status.
4.3.4	We recommend that the work order backlog report be enhanced to aid prioritization.
4.4	We recommend that RTM and Alstom create joint metrics to assess the vehicle reliability to truly understand asset performance and reduce their reliance on just the availability metric
4.6.1	We recommend that Alstom consider creating a new competence matrix that includes specific vehicle systems competence
4.6.1	We recommend that Alstom consider creating a "route to competence" including specialist and OEM training.
4.6.1	We recommend that all training events contain an assessment to confirm that delegates have adequately understood the content as part of demonstrating competence.
4.6.2	We recommend that consideration is given to a grading and progression structure for technicians to reward them for increasing knowledge and experience.
4.6.3	We recommend that consideration in given to apprenticeship type new entrant programs as a way of attracting and retaining technical staff.
4.8.1	We recommend that consideration is given to focussing the engineers on creating comprehensive training material to be delivered by a qualified trainer, rather than delivering the material itself.
4.8.2	We recommend that a review is undertaken of the requirement for spares and suitable levels of stock are procured.
4.8.3	We recommend that the facilities staff work alongside the vehicle maintenance team to understand how the equipment is being used and provide advice on how it can be operated reliably.
4.9	We recommend that Alstom consider studying workshop usage and develop a robust plan to ensure workshop space and movements are efficient as possible.
5.1	We recommend that a process is put in place for competent guideway supervisors to undertake routine inspections to verify the technician's inspection and rectification work and that the Engineering team have a process to validate that the maintenance they specify is meeting the customer requirements.
5.1	We recommend that the work orders resulting from deficiencies identified during these inspections and records of sites with unknown or low neutral stress are analysed prior to spring and work is prioritized to rectify the deficiencies to reduce the likelihood of track kinks.
5.1	We recommend that a process be put in place to identify those sites with outstanding deficiencies and those sites that have been subject to disturbance and have not yet been consolidated such that mitigations can be put in place rather than waiting for the temperature to rise and going out to inspect for kinks.
5.1	We recommend that the issue of missing stressing records is immediately addressed by requesting the records from OLRTC.
5.1	We recommend that the approach for rail flaw detection and correction be included in the next update to the asset management plan.
5.1	We recommend that the WMS be updated to assist the Guideway Technician in recognizing all of the types of rail flaw identified by the designer.
5.1	Given the nature and purpose of this WMS, we recommend that the option in the monthly inspection to undertake the inspection by hi-rail be removed and that this inspection becomes mandated as a walking inspection.

Section	Recommendation
5.1	We recommend the asset preservation measures section of the asset management plan be updated to describe how the frequency of rail grinding is determined to maintain rail profile and condition.
5.1	We recommend that the asset management plan be updated to include the asset preservation measures used to determine the tamping program.
5.1	We recommend that the content of Asset Management Plan and the TPS Work Method Statements are reviewed against the maintenance handbook and the Maintenance and Rehabilitation Plan to confirm that all the required activities are included.
5.1	We recommend that the frequency and detail of inspections checked against the maintenance handbook and the relevant documents updated to reflect the correct requirement.
5.1	We recommend that consideration is given to arranging alternate inspections to be carried out during the day, with suitable protection from traffic to improve the early detection of defects and deteriorating condition.
5.2	We recommend that the Quality Plan is reviewed and amended to reflect the full scope of the Alstom contract, adding in the requirements both in the plan and in the library of reference documents arising from expanding the scope to include infrastructure.
5.3.1	We recommend that Alstom consider establishing a process to ensure that changes to reference documents are reviewed to determine their impact on Work Method Statements that are based on them.
5.3.1	We recommend that they put in place such a program to review the efficiency and effectiveness of the Work Method Statements using a formal assessment technique such as RCMII to refine the maintenance activities and align them to the performance and preservation requirements of the Project Agreement.
5.3.2	We recommend that the immediate mitigations and remedial timescales for common defects are defined and made available to technicians.
5.3.2	We recommend that Alstom consider making the extension of defect rectification timescales by reinspection into a formal process, with an appropriate means to control compliance and sufficient oversight to avoid the risk of persistent extension without proper assessment.
5.3.2	We recommend that a response and repair strategy is created as required by the Project Agreement and that suitable reporting is put in place to monitor performance against it.
5.3.2	We recommend that where tests or checks are required following corrective maintenance, these are detailed in the Work Method Statement for the activity, along with a definition of the competence required to authorise the restoration of the affected assets to service.
5.3.2	We recommend that consideration is given to recording corrective activities undertaken during routine preventative maintenance.
5.3.2	We recommend that a review is undertaken of the requirement for spares and suitable levels of stock are procured.
5.3.2	We recommend that a process be put in place to control the introduction of configuration changes to the network such that the correct information is available from the point of the commissioning of the change.
5.3.2	We recommend that an inventory of programmable and configurable systems is created and a controlled storage for configuration data is established.
5.3.3	We recommend that a program of work is started to identify the Asset Preservation Performance Measures that will be used to plan renewal and replacement. These should then be used to develop estimated degradation rates and hence the asset renewal cycle. Renewal work can then be levelled to prevent a bow wave effect.

Section	Recommendation
5.3.4	We recommend that the backlog report is updated to use the scheduling tolerance to differentiate those work orders where the activity is missed (beyond the allowable tolerance) and those that are late (beyond the scheduled date but within tolerance) so that priority can be given to planning and delivering the missed activities.
5.3.4	We recommend that the required completion timescales are added to corrective maintenance work orders so that they can be prioritized and tracked.
5.4.5	We recommend that the Asset Preservation Performance Measures are reviewed to (a) bring them in line with the requirements of the Project Agreement and (b) reflect asset condition and remaining life as well as performance.
5.4.5	We recommend that the process for the analysis of the collected data and the commentary is reviewed so that it is more closely aligned with the maintenance actions taken and provides useful information to the reader.
5.4.5	The results of surveys are reported as a long list of closed work orders. We recommend that these are summarised for the purpose of annual reporting.
5.4.5	We recommend that the Asset Preservation Measures are reviewed to prompt remedial action to maintain the assets such that they do not reach the condemning limits.
5.4.5	We recommend that the report contains an analysis and commentary on compliance with the APPM, detailing corrective action to address identified non-compliances.
5.5.2	We recommend that the effectiveness and adherence to this process be examined during the monitoring phase to confirm that technicians routinely access the documents and that they are aware of changes to them.
5.5.2	We recommend that only work orders where the activity has been genuinely carried out are closed as completed. Where work is not completed, work orders should be given the status of "missed" or similar.
5.5.5	We recommend that the specification of the interface between GSI and IMRS is reviewed to confirm it meets the needs of managing the maintenance of the network.
5.7.3	We recommend that RTM and Alstom review where day-to-day responsibility for the delivery and quality of maintenance for a given discipline and the staff who undertake it lies and how it is discharged.
5.8.1	We recommend that the engineering department invest some time in codifying their decisions to provide guidance and standards to the maintenance technicians to allow routine decisions to be delegated to them.
5.8.1	We recommend that Alstom consider an engineering verification process whereby the engineering team validate the output of their standards against the outcomes required by the project.
5.8.2	We recommend that RTM confirm the OEM support contracts are sufficiently comprehensive
5.10	We recommend that, in line with section 10.2.2 of the Quality Plan, auditors require auditees to determine the root cause of non-conformance and put in place actions to correct it.
6.1	We recommend that details of where Risk Assessments or Risk Mitigation Plans can be located is recorded within this section of the AMP.
6.1	We recommend that the AMP be updated to list assets that could affect accessibility with detail recorded on how the passengers are to be re-directed during this period of maintenance.
6.2	We recommend that a Buildings Facilities specific Quality Plan is produced outlining the assurance required and procedure for signing off work items for each system.

Section	Recommendation
6.3	We recommend that all specialist maintenance activities be recorded within the Maintenance and Rehabilitation Plan to align with the activities noted in Section 6 of the Asset Management Plan.
6.3.3	We recommend that RTM begin to plan their delivery strategy for the renewal of assets, with intervention points defined and the process for renewing assets referenced in the AMP and documented in the Maintenance and Rehabilitation Plan.
6.4	We recommend that Risk Mitigation plans for high-risk assets are recorded or linked to in the Maintenance and Rehabilitation Plan with reference in the Asset Management Plan
6.6.1	We recommend that requirements for competence management are included in the facilities subcontracts to provide assurance that appropriately trained and qualified staff are being deployed to work on the network
6.10	We recommend that audits of the directly delivered activities include a review of the technical delivery.
6.10	We recommend that evidence of completed cleaning be included in the daily reporting requirements if not done already, with future monitoring to be undertaken to review the quality of the cleaning over a larger sample including stations.
7.1	We recommend that all Hidden Critical Elements are identified and listed in the AMP with an appropriate inspection regime also listed.
7.3.2	We recommend that the local process of the verification of structure repair quality is formalized within the AMP for managing corrective maintenance.
7.3.2	We recommend that the local process to document defects in a tracking database is recorded within the AMP or within RTM's Maintenance and Rehabilitation plan.
7.4	As the network grows, we recommend that a more systematic approach is taken to the management and reporting of the structure's portfolio, with the AMP detailing requirements for defect tracking.
7.6.1	We recommend that the qualifications required to undertake structures inspections be included in the matrix along with the competencies of the individuals within ART Engineering that work on the structures portfolio.
7.7.3	We recommend that RTM formalise the need for internal report reviews/sign off through competent individuals so that this local process is not lost.
7.10	We recommend that audits include a review of the technical delivery of structures inspections to provide assurance of the quality levels.
8.1	We recommend that RTM and Alstom consider formalising a requirement for self-assurance by each operating unit and implement a process to collate the results as a means of identifying systemic issues.
8.1	We recommend that, in line with section 10.2.2 of the Quality Plan, auditors require auditees to determine the root cause of non-conformance and put in place actions to correct it.
8.1	We recommend that RTG consider whether they have adequate assurance of delivery and management of risk for the OLRT maintenance.
8.2	We recommend that the daily meeting is focussed more on the day ahead than the previous day.
8.3	We recommend that consideration is given to how learning from the previous weeks fall downs and successes can form part of the weekly meeting agenda with a view to taking this learning and cascading to everyone involved in both the planning and execution staged of the work aiming at continuous improvement of the planning process.

Table 9.2 Recommendations for Monitoring Phase

Section	Recommendation
4.1.4	We recommend that consideration should be given during the monitoring phase to determine if the process includes vehicle maintenance risks and if the vehicle maintenance risks should be documented separately and reviewed more frequently due to the risk of serious injury or death within any maintenance organisation.
4.3.1	We recommend an additional monitoring phase to fully assess the quality of preventative maintenance. The monitoring phase should look to provide an insight into the overall quality of maintenance delivery to include but not limited to the planning of a task, documentation issuing and briefing, technical ability of the team, availability of technical support, suitability of tools and equipment, effectiveness of supervision, timescales for task completion and quality of workmanship.
5.3.1	We recommend that a sample of the inspections are observed during the monitoring phase to confirm that they are being undertaken fully. The team undertaking monitoring should take copies of all the open reactive work orders to confirm that the physical state of the asset aligns with the records.
5.3.4	During the assessment phase, we were not able to observe how this information is used to manage the completion and closure of work orders and therefore we recommend that this should be checked during the monitoring phase.
5.5.1	We recommend that the asset register in GSI is tested further during the monitoring phase by means of sampling and comparing the asset register against either as-built records or a physical inspection of some areas of the network.
5.8.1	We recommend that this is reviewed during the monitoring phase, including areas such as the level of professional qualifications required by the job descriptions to the individual competence and experience requirements for each role in the team.
6.1	We recommend that the facilities asset list is verified during monitoring.
6.4	We recommend that monitoring is carried out to validate the quality of the data being input into the IMIRS system.
6.6.1	We recommend that the competence reviews carried out on the facilities technicians are sampled during the monitoring phase.
6.10	We recommend that station cleaning be in included in future monitoring.
7.2	It is unclear what steps ART Engineering have undertaken to comply with the Quality plan, we recommend that this is considered as part of any future monitoring.
7.3.1	We were unable to verify the quality of the structures site visits to confirm all necessary information is captured, we recommend that this be included in the scope for any future monitoring.

Consulting

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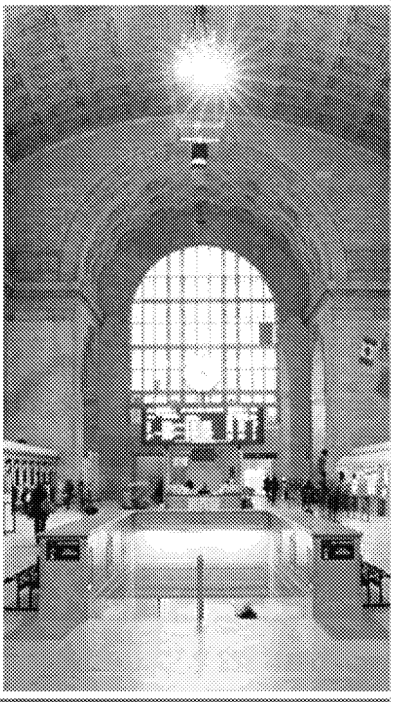

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