Los Angeles County
Metropolitan Transportation Authority

One Gateway Plaza
Los Angeles, CA 90012-2952

213.922.2000 Tel
metro.net

Metro

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**TO:** **BOARD OF DIRECTORS**

**THROUGH:** **PHILLIP A. WASHINGTON**
**CHIEF EXECUTIVE OFFICER**

**FROM:** **GREGORY G. KILDARE**
**CHIEF RISK, SAFETY & ASSET MANAGEMENT OFFICER**

**JAMES T. GALLAGHER**
**CHIEF OPERATIONS OFFICER**

**SUBJECT:** **CONDITION ASSESSMENT OF OLDER RAIL VEHICLE FLEETS**

## ISSUE

This Board Box summarizes the results of a condition assessment of our older light and heavy rail vehicle fleets (LRVs: P865, P2020, P2000, P2550, HRVs: A650 option buy). The A650 HRV base buy fleet was not included as they are scheduled for retirement in the next few years. CH2M Hill was contracted by the Enterprise Transit Asset Management (ETAM) department to develop a rating process, conduct inspections, analyze performance data and make findings and recommendations. The FTA's Transit Asset Management regulation requires transit agencies to conduct condition assessments at a level of detail sufficient to monitor and predict performance and to inform investment prioritization. This information will also be used to report to the FTA on changes to condition over time and progress toward meeting useful life performance targets. The process developed for this assessment will be used for periodic updates.

## DISCUSSION

Visual inspections were conducted during fall 2016 and followed with an analysis of performance data with the goal of assigning State of Good Repair (SGR) ratings for the fleets and for the major subsystems using the FTA's Transit Economic Requirements Model (TERM) SGR rating scale of 1 to 5, with 1 being poor and 5 being excellent. The assessment included the development of inspection guidance/criteria for visual condition and analyses to evaluate performance data.

The assessment process involved physical inspections of a subset of the fleet which represented a statistical sample of the overall fleet; discussions with rail vehicle maintenance and engineering staff to capture their judgment on conditions and performance of these assets. Additionally, to better represent an overall rating, three railcar performance measures (PMs) were used: reliability, availability, and corrective maintenance hours from fleet maintenance records and failure incidents in Metro's materials and maintenance management system (M3). The visual inspections are useful for assessing physical indications of deterioration while performance measures are good for indicating non visual conditions of electronic components and control systems.

## A. Conditions

Attachment A shows the SGR performance and condition inspection ratings separately by vehicle fleet type along with a total combined score that is weighted by relative impact of the performance and condition measures on predicting overall condition. For the A650 HRV and P2550 LRV approximately 80% of the cars have an adequate rating of three or better. For the P865, P2020 and P2000 fleets, most cars are in marginal to poor condition. These cars can still be operated safely but require more maintenance and have lower reliability. The P865s are in the process of being replaced by the new P3010s, the A650 Option cars started their mid-life rehabilitations in June 2017 and the P2000s are scheduled to start their mid-life rehabilitations during summer 2017. As no decision has yet been made to replace the P2020 cars, they are undergoing component overhauls to maintain them in safe and reliable condition for another 5-7 years to attain their 30 year design life.

Attachment B provides average failure rates per 10,000 miles for the major subsystems. This data has been extracted from Metro's M3 system which includes mean miles between failures. The data shows lower reliability of the older fleets (P2000, P865, P2020) due to delayed or no mid-life overhaul, more intensive at-grade operations and multiple redundant systems from different vendors for driverless operation (P2000). The A650 Option cars have better reliability (lowest failure rates) as they operate in a protected tunnel environment.

## B. Findings

Based on the inspections, performance data and interviews with maintenance staff, the systems and components with potential for impacts to car availability and reliability as well as consequential failure impacts were reviewed. The reliability analysis shows highest failure rates (resulting in delay) for propulsion, brakes, door, auto train systems and truck components. Inspections revealed the following areas for further investigation which were brought to the attention of the Rail Fleet Services (RFS) department: wheel wear, primary suspension deterioration, and antenna damage. The potential failure impact areas were reviewed, addressed and appropriate actions were taken by the Operations RFS department as shown in Attachment C.

Contributing factors to the deteriorated conditions include:

- Absence of, or delayed original equipment manufacturer (OEM) prescribed mid-life overhaul of the P865/P2020, P2000 and A650 Option fleets;
- Lack of dedicated personnel to run overhaul (capital maintenance) campaigns;
- Complexity of maintaining four different LRV fleets and two different HRV fleets with different car builders, different training needs with unique spare parts and vendors;
- Interruptions in parts availability impacting efficiency of component overhaul activity;
- Insufficient test equipment and test tracks.

**C. Obsolescence**

Obsolescence of technology and parts is an issue that impacts all vehicle types but will be addressed in the near term for the older P865, P2020, P2000, A650 Option buy cars with retirements or overhauls. Obsolescence is a particular concern for the P2550 fleet as the original supplier – AnsaldoBreda ceased support and its business was acquired by another firm (Hitachi Rail). Metro will need to determine for the mid-life overhaul if the new firm can provide sufficient technical support and parts or if a redesign of critical propulsion and auxiliary electrical systems will be needed.

**D. Data Acquisition**

Often subsystem failures are intermittent and difficult to troubleshoot. There is a need for improved processes, systems and training to facilitate investigation of rail car maintenance history before performing work and when completed to accurately match the root cause of failure to the applicable component or system. This will aid in identifying those subsystems and components that drive rail car availability, reliability and maintenance cost issues. A review of maintenance staff data entry practices (potentially including some retraining) to assure better data quality and accuracy, would help ensure that the performance measures are more accurate and meaningful. There is a need for an integrated and easy to use State of Good Repair system to automate asset registry, conditions, performance data, track overhaul/mid-life/predictive maintenance campaigns and link asset conditions and performance to development of capital renewal projects.

**E. Predictive Maintenance**

The assessment of the P2550 fleet reviewed a condition based approach to predict when maintenance should be performed. This approach has the potential of reduced costs, increased reliability and availability over time-based preventive maintenance as tasks are performed only when warranted. Predictive Maintenance (PdM) involves monitoring failure frequencies of components in fleets and initiating repairs or replacements as failure rates increase or just before historical trends indicate failures will start increasing. To implement PdM, additional upfront resources will be needed to monitor trends, stock parts, add appropriately skilled staff and shop space.

The majority of the P2550 fleet is in good condition for most subsystems. However, from interviews with RFS staff and review of the past year work order data, maintenance issues were identified with the propulsion and auxiliary power subsystems having in-service failures and issues obtaining repair parts. If the new OEM – Hitachi

Rail (or other acceptable vendor) can improve component availability then there is potential to reduce the 600,000 mile overhaul to address just the identified components in need of rehabilitation or replacement. If Hitachi (or other vendor) cannot provide component solutions then alternative subsystem designs may result in significant overhaul work. Consideration will be needed to either staff RFS appropriately or to subcontract the work.

**F. Recommendations**

The following are recommended actions to maintain and improve the condition of the rail fleet.

1. Overhaul Programs: Resume and continue component overhauls and mid-life campaigns per OEM recommendations on the P2000 LRVs and A650 Option HRVs and limited component overhauls of the P2020s until they are retired and replaced with the new P3010 LRVs. Evaluate implementing a Predictive Maintenance (PdM) pilot program on a test fleet such as the P2550 and/or specific systems such as truck sub-assemblies (wheels, journal bearings, truck housing, traction motors) pending availability of resources.

2. Staff Management: Conduct further analyses to assess the appropriate mix of technical staff to perform routine preventive, corrective maintenance, back shop and advanced maintenance activities per recommended industry standards. At each maintenance division there is a need for dedicated project managers to plan and run overhaul and mid-life capital maintenance campaigns, material planners to manage supply chains to ensure that kits and parts are available when needed and M3 data analysts to collect, report and analyze trend data. Before preventative maintenance analytic work can be performed, however, a parts data collection protocol needs to be enforced to ensure data accuracy and validity and improve data quality relative to its current state. There is also a need to develop the next generation of maintenance staff and engineers as retirements are accelerating and consider creating advanced levels of maintenance specialists for progression for needed specialized skills in electronic troubleshooting/rebuilding/improvising component redesigns. A workforce planning model should be developed that can estimate the number of FTEs by job/skill type and volume of work needed.

3. Training: Maintain sufficient training of technicians on all fleets to improve skills especially on new equipment, technology and for recording failure and root cause data in M3 to maintain reliability and improve trend analysis.

4. Obsolescence: Initiate a strategic obsolescence team to increase coordination between RFS, Vehicle Acquisition Engineering, Procurement, and Budget to anticipate changes in technology, parts suppliers, capacity for reverse engineering and plan accordingly.

5. Information Tools: Establish a consolidated standardized database to track and manage all overhauls in process at all rail maintenance divisions. Develop an

integrated and easy to use State of Good Repair system to automate asset registry, conditions, performance data, track overhaul/mid-life/predictive maintenance campaigns and link asset conditions and performance to development of capital renewal projects.

6. Facilities: Evaluate and establish a formal back shop program approach to accomplish component overhaul needs. Test tracks are needed to test repairs and more sophisticated bench test equipment that can simulate real operating conditions so that testing does not have to be done on the mainline. Wheel truing machines need to be checked for recalibration to specifications and rebuilt or replaced if necessary.

7. Fleet Planning: Review actual fleet availability and reliability data when updating the Rail Fleet Management Plan (RFMP) to ensure sufficient numbers of rail vehicles are available to maintain current and future expanded service.

## NEXT STEPS

The recapitalization of the rail vehicle fleets is now underway. For the light rail fleet, the P3010 will replace the P865 vehicles, and the P2000 vehicles are in the process of a mid-life overhaul. The P2020 vehicles are undergoing overhauls and a decision will be needed on their eventual replacement. The heavy rail initial 30 car base buy A650 fleet is scheduled for replacement. The 74 car option buy A650 fleet is also being overhauled and will eventually be replaced if a future option for the new generation HR 4000 vehicles is exercised. Therefore, in the medium term, the recapitalization of the vehicle fleets is underway, which should yield improvements in fleet reliability over time.

The ETAM department will continue working with RFS on periodic updates using the initial procedures and rating standards developed for this condition assessment. The results of this first condition assessment will be included in Metro's TAM inventory database. The ETAM department will use the results of this assessment in reporting conditions of rail vehicle assets to the FTA and SCAG and continue working with Information Technology Services and asset stakeholders to implement a State of Good Repair system to automate the asset management process.

## ATTACHMENTS

Attachment A – Total Combined Rail Car Scores
Attachment B – Rail Fleet Subsystem Reliability
Attachment C – Resolution of Potential Impacts

## Attachment A – Total Combined Rail Car Scores

### Total Combined Rail Car Scores (Performance and Condition): Fleet Averages

| | | Performance Scores | | | | Condition | Total | Total Combined Score Distribution (% of Fleet) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Make | Model | Availability | Reliability | CM Hours | PM Total | Rating | Score | Excellent | Good | Adequate | Marginal | Poor |
| Breda | A650 | 4.0 | 3.9 | 4.0 | 4.0 | 3.2 | 3.8 | 20.3% | 31.1% | 32.4% | 13.5% | 2.7% |
| AnsaldoBreda | P2550 | 4.1 | 3.9 | 3.0 | 3.7 | 4.0 | 3.7 | 12.0% | 40.0% | 30.0% | 16.0% | 2.0% |
| Nippon Sharyo | P2020 | 3.5 | 3.2 | 2.9 | 3.1 | 2.9 | 3.1 | | 13.3% | 46.7% | 33.3% | 6.7% |
| Nippon Sharyo | P865 | 3.1 | 3.0 | 2.4 | 2.8 | 2.8 | 2.8 | | 3.7% | 25.9% | 68.5% | 1.9% |
| Siemens | P2000 Base | 2.0 | 2.8 | 1.9 | 2.5 | 3.4 | 2.7 | | | 31.0% | 65.5% | 3.4% |
| Siemens | P2000 GE/ATP | 2.3 | 2.0 | 1.3 | 1.8 | 3.4 | 2.2 | | | | 73.9% | 26.1% |

# Attachment B – Rail Fleet Subsystem Reliability

## Rail Fleet Subsystem Reliability: Average Failure Rates per 10,000 Miles

| | | | Average Failure Rates per 10,000 Miles | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Make | Model | Total Rail Car | Auto Train Ops | Auto Train Protect | Aux Power | Battery | Brake System | Car Body | Comms | Coupler | Doors | HVAC | Lighting | Alter-nator | Panto-graph | Power Collect. | Propul-sion | Truck Suspen. | Truck Assem | Vehicle Systems |
| AnsaldoBreda | P2550 | 0.27 | 0.00 | 0.03 | 0.03 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.09 | 0.00 | 0.00 | 0.02 |
| Breda | A650 | 0.10 | 0.01 | 0.03 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| Nippon Sharyo | P2020 | 0.33 | 0.00 | 0.04 | 0.01 | 0.00 | 0.07 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.14 | 0.01 | 0.00 | 0.00 |
| Nippon Sharyo | P865 | 0.41 | 0.00 | 0.03 | 0.00 | 0.00 | 0.06 | 0.01 | 0.00 | 0.01 | 0.03 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.23 | 0.01 | 0.00 | 0.00 |
| Siemens | P2000 Base | 0.47 | 0.02 | 0.08 | 0.01 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.02 |
| Siemens | P2000 GE/ATP | 0.78 | 0.02 | 0.08 | 0.01 | 0.01 | 0.14 | 0.02 | 0.00 | 0.02 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.01 | 0.01 | 0.02 |

## Attachment C – Resolution of Potential Impacts

| Vehicle Type/Condition | RFS Resolution |
|---|---|
| A650 Option HRV | |
| • Rough surface on wheel flange and profile | Not a significant issue on Metro's fleets. |
| • Automatic Train Control/Operation (ATC/ATO) antenna, potential moisture intrusion | Antennas are checked during "A" level inspections and replaced if damaged. |
| P865/P2020 LRV | |
| • Possible wheel tire slippage (shunts out of position) | Determined no slippage. Wheel shunts are part of routine inspection performed per schedule by RFS |
| • Signs of contact between journal bearing housing and truck frame (deteriorated primary suspension) | Part of bearing overhaul program, issue resolved |
| • Possible bent traction rod on car 124 | RFS replaced |
| • Damaged center truck bolster on car 123 | RFS repaired and adjusted |
| • Floor repairs with plywood | The ply-metal replacement flooring approved by Metro Engineering does meet all smoke and flame requirements |
| P2000 | |
| • Signs of contact between journal bearing housing and truck frame (deteriorated primary suspension) | Part of bearing overhaul program, issue resolved |
| • Wheel Tire/Brake Discs worn to limits on car 302 | Checked on routine inspection and replaced |