ASSET MANAGEMENT IN METRO SYSTEMS

UIC-PARIS

APRIL, 2019
MetrôRio

First metro granted in Brazil

Largest private metro operator in Brazil

Second largest metro system in Brazil in network extension and ridership, behind only São Paulo

94% of client approval
3 Lines

41 Stations

900 Thousand passengers / day*
<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passengers per year</td>
<td>250 million</td>
</tr>
<tr>
<td>System length</td>
<td>53 KM</td>
</tr>
<tr>
<td>Substations</td>
<td>97</td>
</tr>
<tr>
<td>Installed power</td>
<td>360 MVA</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>368</td>
</tr>
<tr>
<td>Escalators</td>
<td>214</td>
</tr>
<tr>
<td>Moving sidewalk</td>
<td>21</td>
</tr>
<tr>
<td>Elevators</td>
<td>82</td>
</tr>
<tr>
<td>Vertical lift platforms</td>
<td>39</td>
</tr>
<tr>
<td>Inclined lift platforms</td>
<td>12</td>
</tr>
<tr>
<td>Trains</td>
<td>64</td>
</tr>
<tr>
<td>Alstom-Mafersa</td>
<td>30</td>
</tr>
<tr>
<td>CRC</td>
<td>34</td>
</tr>
<tr>
<td>Annual energy consumption</td>
<td>270,000 MWh</td>
</tr>
<tr>
<td>City population</td>
<td>113,000</td>
</tr>
</tbody>
</table>
2,714 Employees
(Dec/18)

10% Administrative
30% Engineering & Maintenance
60% Operations
The Metro was chosen by **87%** of the visitors for **World Youth Day** as the most reliable public service

Ministry of Tourism Survey

During **2014 Soccer World Cup**, the public rated MetrôRio as the **2nd best** thing in Rio de Janeiro

TV Globo

During the **Olympic Games**, the Metro was the best evaluated public transport, with an approval rating of **89%**.

Prestap/UERJ Survey
World Metros

Openings 1860-2016

169 SYSTEMS IN OPERATION

81 30+ YEAR-OLD LINE(S)
Fig. 10 Distribution of line opening per decade and regions.
Fig. 11 Evolution of the total length of metro lines according to world region
Total: 116.930
Average Expenditure and Reinvestment as a Proportion of Opex:

All Metros (Using Available Data, 1994-2015)

Older Metros: 60%+ Has Been Observed Over Long Periods Where There Has Been a Lack of Investment.
### Metros’ Main Sources of Funding for Asset Renewal Spending

<table>
<thead>
<tr>
<th>Source</th>
<th>As</th>
<th>As</th>
<th>As</th>
<th>Eu</th>
<th>Am</th>
<th>Eu</th>
<th>Am</th>
<th>Am</th>
<th>Am</th>
<th>As</th>
<th>As</th>
</tr>
</thead>
<tbody>
<tr>
<td>City / State Government</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>National government</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fares / Commercial +</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External borrowing</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* State City Govt fund only new extensions
+ “Commercial” includes property income

Source: Nova Group of Metros
What to do?

O&M best practice framework

Source: World Economy Forum  JF Consultoria em engenharia LTDA
# Checklist of o&m best practices/critical success factors

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase utility</td>
<td>Enhance peak capacity and effective throughput</td>
<td>Apply demand management</td>
<td>Optimize availability/reduce downtime</td>
<td>Implement lean and automated processes</td>
<td>Optimize procurement costs and outsourcing</td>
<td>Rightsize management and support functions</td>
<td>Invest in preventive and predictive maintenance</td>
<td>Control excessive asset consumption and stress</td>
<td>Enhance disaster resilience</td>
</tr>
<tr>
<td>Decrease total cost</td>
<td>Enhance the end-to-end user experience</td>
<td>Use smart technologies to refine user performance</td>
<td>Arrange comprehensive sustainability/HSE plans</td>
<td>Embed sustainability/HSE into routine operations</td>
<td>Cooperate with relevant stakeholders</td>
<td>Prioritize project options with whole life cycle CBA</td>
<td>Select contracting mode for best value for money</td>
<td>Prepare for efficient project delivery</td>
<td></td>
</tr>
<tr>
<td>Increase lifetime value</td>
<td></td>
<td></td>
<td>Dedicate user taxes via maintenance funds</td>
<td>Apply inclusive user charges</td>
<td>Capture ancillary business opportunities</td>
<td></td>
<td>Introduce asset management planning</td>
<td>Apply data, benchmarks and tools</td>
<td>Conduct training and develop talent</td>
</tr>
<tr>
<td>Enable O&amp;M best practice</td>
<td></td>
<td></td>
<td>Corporateize and professionalize public agencies</td>
<td>Foster cooperation between agencies</td>
<td>Consider private-sector participation &amp; competition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: World Economy Forum, JF Consultoria em engenharia LTDA

Note: HSE = Health Safety Environment; CBA = Cost-Benefit Analysis
“Every year, traffic accidents kill more than 1.2 million people around the world and injure up to 50 million.”
Options

- Maximize asset utilization;
- Enhance quality for users;
- Reduce O&M costs;
- Mitigate externalities;
- Extend asset life;
- Reinvest with a life cycle view.

Source: World Economy Forum  JF Consultoria em engenharia LTDA
• Adoption of asset management policy for a whole LCC;

• Attract private capital/ concessions;

• Improve the maintenance effectiveness;

• Improve risks analysis.
Private

- Fare regulation;
- Financial warranty.

Public

O&M projects have low political visibility, and long-term maintenance requirements do not make a good fit with the short political cycle.
Asset Renewal Projects
Overview: Initial Problem

Status

- Concession until 2038
- No plans for renewal assets
- Many assets with more than 30 years in operation

- No studies about Asset Management
- Obsolescence is obstacle for Operational Excellence
- Obsolescence is cause of several MetrôRio’s risks
Assets Mapping

- Workshops with managers and maintenance people
- Strategic Assets Mapping
- Necessary Investments for renewal projects
- Prioritization and categorization of renewal projects

Mapped Assets Situation

- Obsolete and on the end of their lifespan
- Suppliers will no longer make spares available and MetrôRio’s own spare parts holdings are now depleted
- Have no historical data and becoming unreliable with increasing risks of service disruption, and increasingly time consuming and costly to maintain
- Able to remain in service only due to the skill of engineers and Requiring urgent renewal

Technical Visit: Imperial College London

- Confirmed the situation of the mapped assets
- Validated the approach as good practice
- However, warned that it should consider other ‘upsides benefits’ besides risk
**Impacts**

- Probability of Failure
- Operation
- Costs (maintenance / operation)
- Security
- Image
- Regulation / compliance
- End of life cycle
- Investment
- Environment

**Initial Results**

- 51 infrastructure renewal projects
- Energy, Signalization, Accessibility, Civil e IT area
- Aprox. R$ 460,000,000 investment

**Order of Criticality (Risk)**


<table>
<thead>
<tr>
<th>Project</th>
<th>Value (R$)</th>
<th>Balance Score Card</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8,000,000</td>
<td>2.212.000</td>
</tr>
<tr>
<td>2</td>
<td>600,000</td>
<td>2.004.001</td>
</tr>
<tr>
<td>3</td>
<td>70,000,000</td>
<td>1.213.000</td>
</tr>
<tr>
<td>4</td>
<td>6,400,000</td>
<td>1.203.010</td>
</tr>
<tr>
<td>5</td>
<td>25,000,000</td>
<td>1.015.000</td>
</tr>
<tr>
<td>6</td>
<td>12,600,000</td>
<td>1.006.000</td>
</tr>
<tr>
<td>7</td>
<td>4,500,000</td>
<td>440.210</td>
</tr>
<tr>
<td>8</td>
<td>1,200,000</td>
<td>221.110</td>
</tr>
<tr>
<td>9</td>
<td>2,000,000</td>
<td>220.210</td>
</tr>
<tr>
<td>10</td>
<td>30,000,000</td>
<td>132.100</td>
</tr>
</tbody>
</table>
2nd Phase: Detailed analysis of each project

Data/ Information collection
- Workshops/ Interviews
- SAP/ MAC systems
- Management Reports
- Spread sheets
- Personal notes
- Professional experiences
- Estimative

Data (Past/ Future)
- OPEX/ CAPEX (Current asset/ new)
- Indirect Losses/ Gains (Current asset/ new)

Costs
- Maintenance
- Operation
- Consumable
- Energy consumption

Performance
- Reliability
- Availability
- Losses and Gains Revenue
- Delays

Risks
- Incidents
- Image
- Environment
- Penalties

Users
- Comfort
- Practice
- Accessibility
- Rapid
LCC - Life-Cycle Costing Methodology

"Value Premium" concept

- Economic performance of current asset
- Benefits of new asset

Best moment for replacement

<table>
<thead>
<tr>
<th>Project</th>
<th>Value (R$)</th>
<th>Balance Score Card</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8,000,000</td>
<td>2.212.000</td>
<td>2017</td>
</tr>
<tr>
<td>2</td>
<td>600,000</td>
<td>2.004.001</td>
<td>2014</td>
</tr>
<tr>
<td>3</td>
<td>70,000,000</td>
<td>1.213.000</td>
<td>2024</td>
</tr>
<tr>
<td>4</td>
<td>6,400,000</td>
<td>1.203.010</td>
<td>2014</td>
</tr>
<tr>
<td>5</td>
<td>25,000,000</td>
<td>1.015.000</td>
<td>2022</td>
</tr>
<tr>
<td>6</td>
<td>12,600,000</td>
<td>1.006.000</td>
<td>2026</td>
</tr>
</tbody>
</table>

Complete data

Definition of Best moment for replacement for each asset

Optimum point

2014 2015 2016 2017...
Best moment for substitution (Risk x Cost)

Probability of such assets cause events that may affect the operation...
Probability x Operational Impact of Assets
Considering the Investments Value
Assets with Potential for Positive NPV
<table>
<thead>
<tr>
<th>ASSETS</th>
<th>PROBABILITY</th>
<th>IMPACT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>29) 138 kV Armored SSP (BTF/FCN) - Pressure switches control/ protect</td>
<td>There is no spare part in the inventory. At each year one unit is lost.</td>
<td>Failures may cause a reduction to the traffic or the suspension of a station.</td>
<td>R$ 2.2 Mi</td>
</tr>
<tr>
<td>shielded substations in case of loss of gas SF6 pressure, indicating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and/or turning off the sectors to isolate the low pressure spaces.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20) Protection Relays - Protect the traction zones (750Vcc) in order</td>
<td>There are only 5 spare units for this model.</td>
<td>Failures may damage the rolling stock material and/or the substation due to poor isolation.</td>
<td>R$ 1.0 Mi</td>
</tr>
<tr>
<td>to minimize any failure due to overload or short circuit in the rolling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stock, traction cables and 3rd rail.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41) Traction Circuit Breakers – It is composed by 200 breakers dividing</td>
<td>There are only 5 spare units for this model.</td>
<td>Losing a traction breaker may reduce in at least 5% the departures at that zone.</td>
<td>R$ 3.9 Mi</td>
</tr>
<tr>
<td>in sectors the traction power supply to the tracks in order to protect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the system.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34) Pull-Through Cable (FCN) – Two 138kV lines with respectively 11</td>
<td>Only 2 pairs for each line are operating today.</td>
<td>In case the 2 pairs of each line fail, the mains substation of FCN and ESA would be lost.</td>
<td>R$ 1.0 Mi</td>
</tr>
<tr>
<td>pairs of cables carrying out the transference between LIGHT FCN and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MetrôRio FCN (Transfer trip).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35) Battery Chargers - Supply in 125Vcc the Auxiliary and Main Substations</td>
<td>The spare parts necessary for a proper maintenance are not produced anymore.</td>
<td>Failures may cause partial or total loss of the substation, and loss of power along the</td>
<td>R$ 4.0 Mi</td>
</tr>
<tr>
<td>to provide power to the station’s command, control, protection and</td>
<td></td>
<td>line following a partial or complete suspension.</td>
<td></td>
</tr>
<tr>
<td>emergency lighting systems.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22) Cooling Towers - Designed for the heat exchange of the cooling</td>
<td>Obsolete equipment with no spare parts for proper maintenance.</td>
<td></td>
<td>R$ 0.8 Mi</td>
</tr>
<tr>
<td>system at the stations, using water as cooling fluid.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51) IHM PMO – Panels and monitors comprising the teletransmission</td>
<td>Obsolete and incompatible with the new configuration of the yards. Its</td>
<td>A inefficient traffic control may cause wrong manual route formations, causing incidents</td>
<td>R$ 6.0 Mi</td>
</tr>
<tr>
<td>system to optimize the operation, centralizing the traffic commands and</td>
<td>adequation/modernization is impossible.</td>
<td>with the rolling stock material.</td>
<td></td>
</tr>
<tr>
<td>supervision and the traction of all yards.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>R$ 16.7</td>
</tr>
<tr>
<td>ASSETS</td>
<td>VALUE</td>
<td>GAINS</td>
<td>PAYBACK</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>--------</td>
<td>--------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>1) Fire Extinguishing System - Fire fighting piping along the station that distributes the water supply from the cistern (fire reserve) to the hydrants.</td>
<td>R$ 8.0Mi</td>
<td>Maintenance Costs</td>
<td>3 years</td>
</tr>
<tr>
<td>2) LCF Lubricators - Designed to lubricate the contact point between the wheel and the rail to reduce wearing and noise coming from the contact.</td>
<td>R$ 0.6Mi</td>
<td>Maintenance Costs, Wheel Wearing, Rails Wearing, Power Consumption</td>
<td>3 years</td>
</tr>
<tr>
<td>8) Switch Machines - Move the track change machine, in order to change the route of the trains indicated by the Control Center.</td>
<td>R$ 1.2Mi</td>
<td>Maintenance Costs</td>
<td>24 years</td>
</tr>
<tr>
<td>22) Cooling Towers - Designed for the heat exchange of the cooling system at the stations, using water as cooling fluid.</td>
<td>R$ 0.8 Mi</td>
<td>Maintenance Costs</td>
<td>20 years</td>
</tr>
<tr>
<td>25) Fan Coils - Act as cooler for the operational and technical rooms at stations, Maintenance Center and Administrative Center.</td>
<td>R$ 2.5 Mi</td>
<td>Maintenance Costs</td>
<td>11 years</td>
</tr>
<tr>
<td>TOTAL</td>
<td>R$ 13.1 Mi</td>
<td></td>
<td>TOTAL</td>
</tr>
</tbody>
</table>
To develop and implement a new way of working with assets, based on the ISO 55000 best practices, in order to reach sustainable business results.
Pro-Assets Project: Timeline

Asset Management Group

- Launching: 08.16.18
- Maturity Diagnostic: 09.19.18
- Interviews: 08.24.18
- Criticality Matrix: 12.17.18
- A. M. Guidelines: 12.17.18
- Strategic Plan: 12.21.18
- Training: 08.26.19
- Pilot Project: 05.29.20
- Final Report: 07.15.20

Legend
- Finished Activity
- Ongoing activity
- Activity not initiated
**CORPORATE LEVEL STAKEHOLDERS EXPECTATIONS**

"What we have"

1. Follow Regulatory Compliance and Ethics Code.
2. Maintain regular service for client transportation.
3. Monetize the Concession Agreement.
4. Ensure stakeholders' safety.
5. Fulfill the obligations stated in the Concession Agreement.
6. Operate and maintain the scope of assets.
7. Mitigate business risks.
8. Understand and fulfill the needs of our clients.
9. Assess what we do and learn from our mistakes.

**RESTRICTIONS**

"What will make our alignment process more difficult"

- Regulatory agency (Agetransp)
- Government / Transportation Office
- Investment compensation from the Government
- Investment capacity from MetrôRio / Invepar
- SLA (Procurement)
- Attracting and retaining talent
- Limiting beliefs
- Absence of technical staff in Government

**SHORT, MEDIUM AND LONG-TERM GOALS**

"What we want to achieve"

**Short-term:** 1 to 3 years (until 2021)
- Optimization of capital employed (Inventory and Capex Sustaining)
- Staff: ensure qualification, competence maintaining and acknowledgement
- ... 

**Medium-term:** 4 to 6 years (until 2024)
- Increase company value
- Optimize resources to enable affordable fares
- ... 

**Long-term:** ≥ 7 years (≥ 2025)
- Attract new passengers through network expansion
- Review technical adocuments

**Support Areas**

- Human Resources
- Information system
- Outsourced staff
- Long-term suppliers

Align corporate expectations with the operational activity of an organization, through an asset management system.
PHASES

- Staff awareness training
- Documents and manuals review
- Staff technical training

Maintenance Documents Standards
CoMET and Nova Metros Undertake Limited Planning for Life Cycle of Infrastructure Assets

- Most infrastructure assets may not be appropriate for whole life cycle analysis.
- Less than half of metros undertake life cycle planning for infrastructure assets due to:
  - age – but **new metros should already be planning for future needs**
  - funding constraints – but **planning can help to inform/justify funding**

- Only some metros show awareness of **ISO 55000 / PAS 55 principles**

- Infrastructure Asset Strategies, developed for a level below general asset class. Plan time horizons, longer term due to asset nature.

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Source: Hong Kong MTR Metrô  JF Consultoria em engenharia LTDA
PREMISES:

✓ Metro systems, historically, operate assets with long life-cycles. Digitalization strongly impacts this concept.

✓ Maintenance is the third higher cost in rail operations and reliability guarantees the fundamental value in the service industry: predictability.

✓ To fully optimize assets use, it is imperative that their life-cycles are evaluated integrally, from conception to decommissioning.

PROPOSAL:

Work towards the development of an Asset Management Policy.
Conclusions

GAINS:

✓ Wiser choosing of new assets;
✓ Determination of the right time for asset replacement. This previous knowledge prevents unnecessary investments;
✓ Prevention of additional maintenance costs due to asset use beyond its life-cycle span;
✓ Prevention of losses due to diminished reliability and resulting negative impacts on the Company’s reputation;
✓ Enables a future ISO 55000 certification.
THANK YOU

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SENIOR ADVISOR

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