ASSET MANAGEMENT IN METRO SYSTEMS

UIC-PARIS

APRIL, 2019

METRÔ RIO

UMA EMPRESA invepar MOBILIDADE URBANA

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

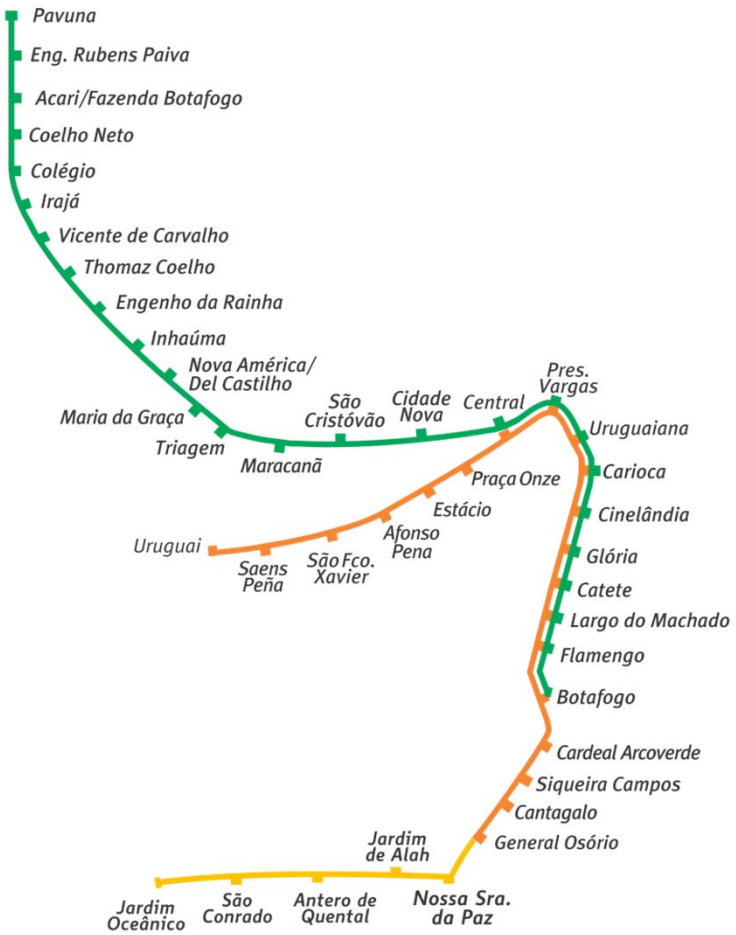
94% of client approval

MetrôRio

3 Lines

41 Stations

900 Thousand passengers / day*



Average Dec/2018

MetrôRio

250 million passengers per year

53 KM
System

97 substations
360 MVA installed power

64 trains
30 Alstom-Mafersa
34 CRC

368 transport equipment
214 escalators
21 moving sidewalk
82 elevators
39 vertical lift platforms
12 inclined lift platforms

Annual energy consumption of **270,000 MWh**, such as a city of **113,000 inhabitants**

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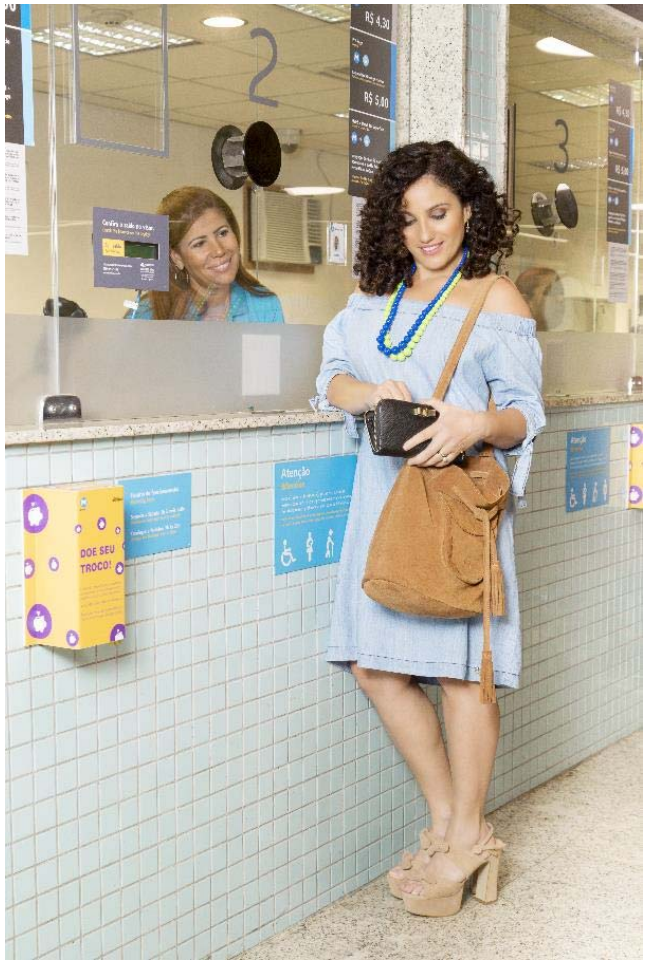
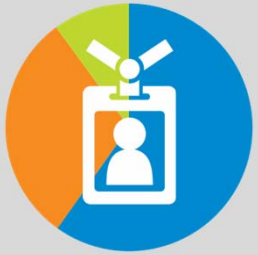
Staff



2.714
Employees
(Dec/18)

10%
Administrative

30%
Engineering & Maintenance



60%
Operations

Mega Events

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

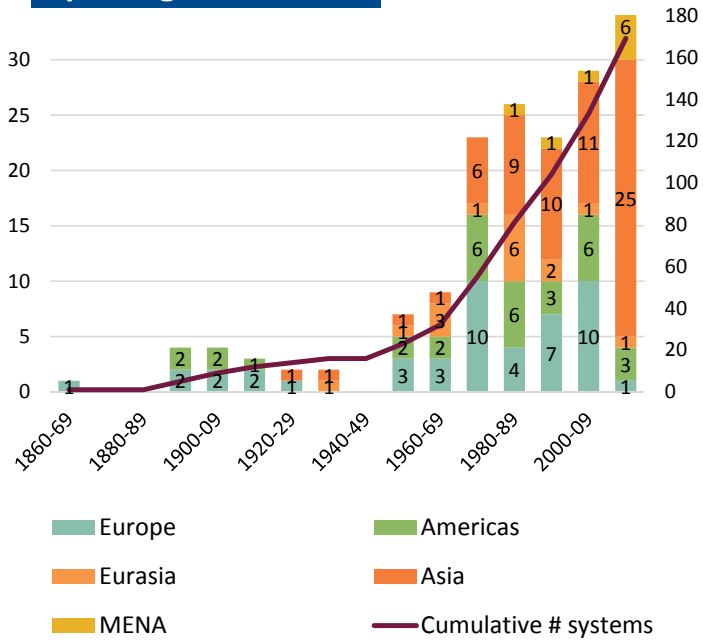
TV Globo

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

Prestap/UERJ Survey

World Metros

Openings 1860-2016

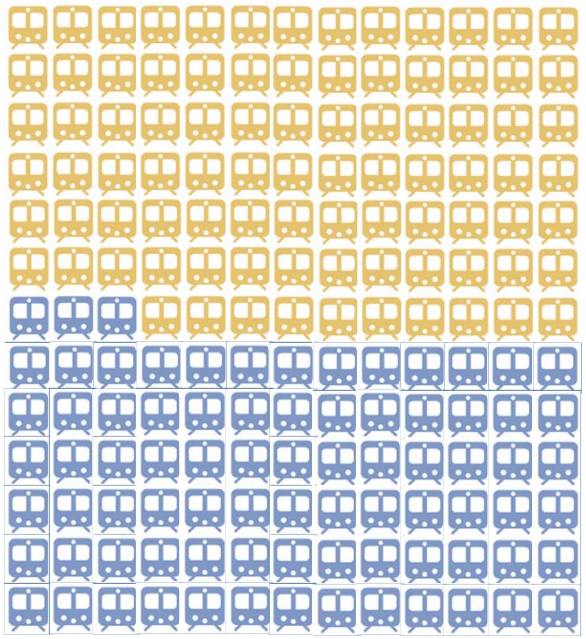


169

SYSTEMS IN OPERATION

81

30+ YEAR-OLD LINE(S)



Metro line openings by decades

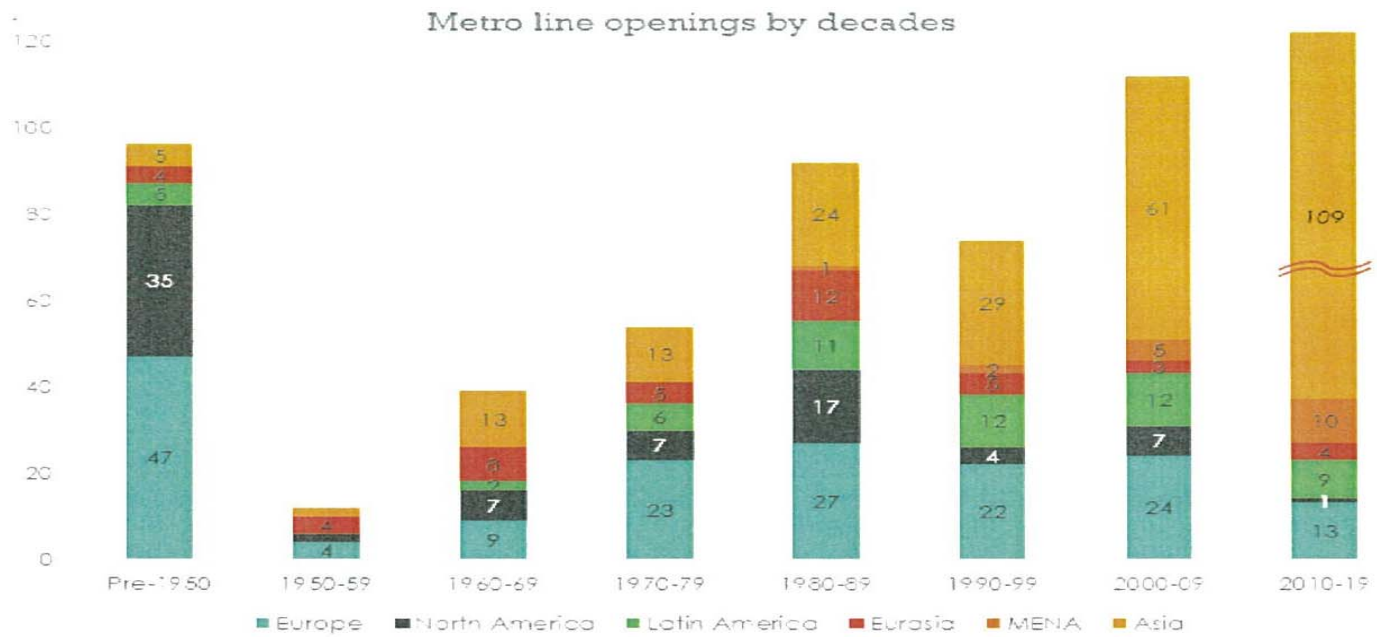


Fig. 10 Distribution of line opening per decade and regions.

Line length evolution (km)

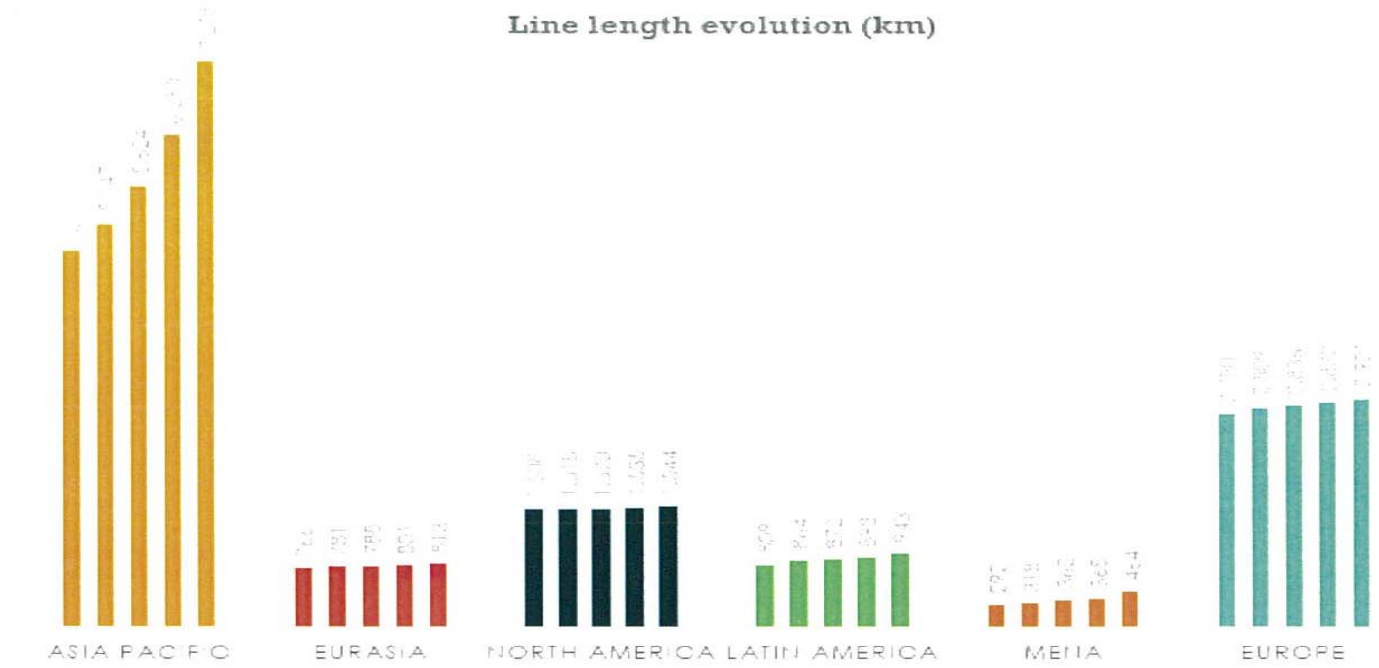


Fig. 11 Evolution of the total length of metro lines according to world region

Mobile asset: # cars

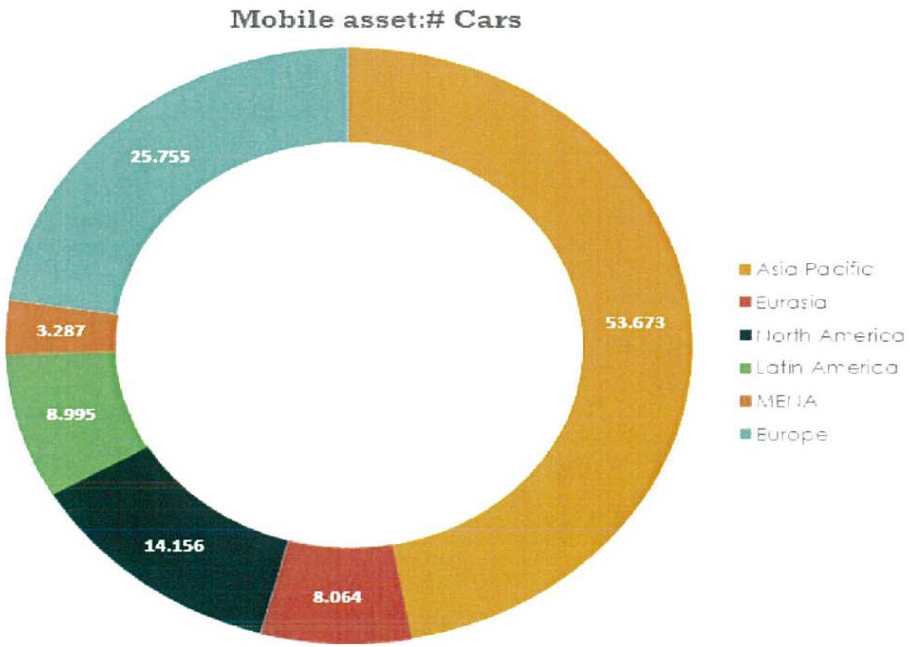
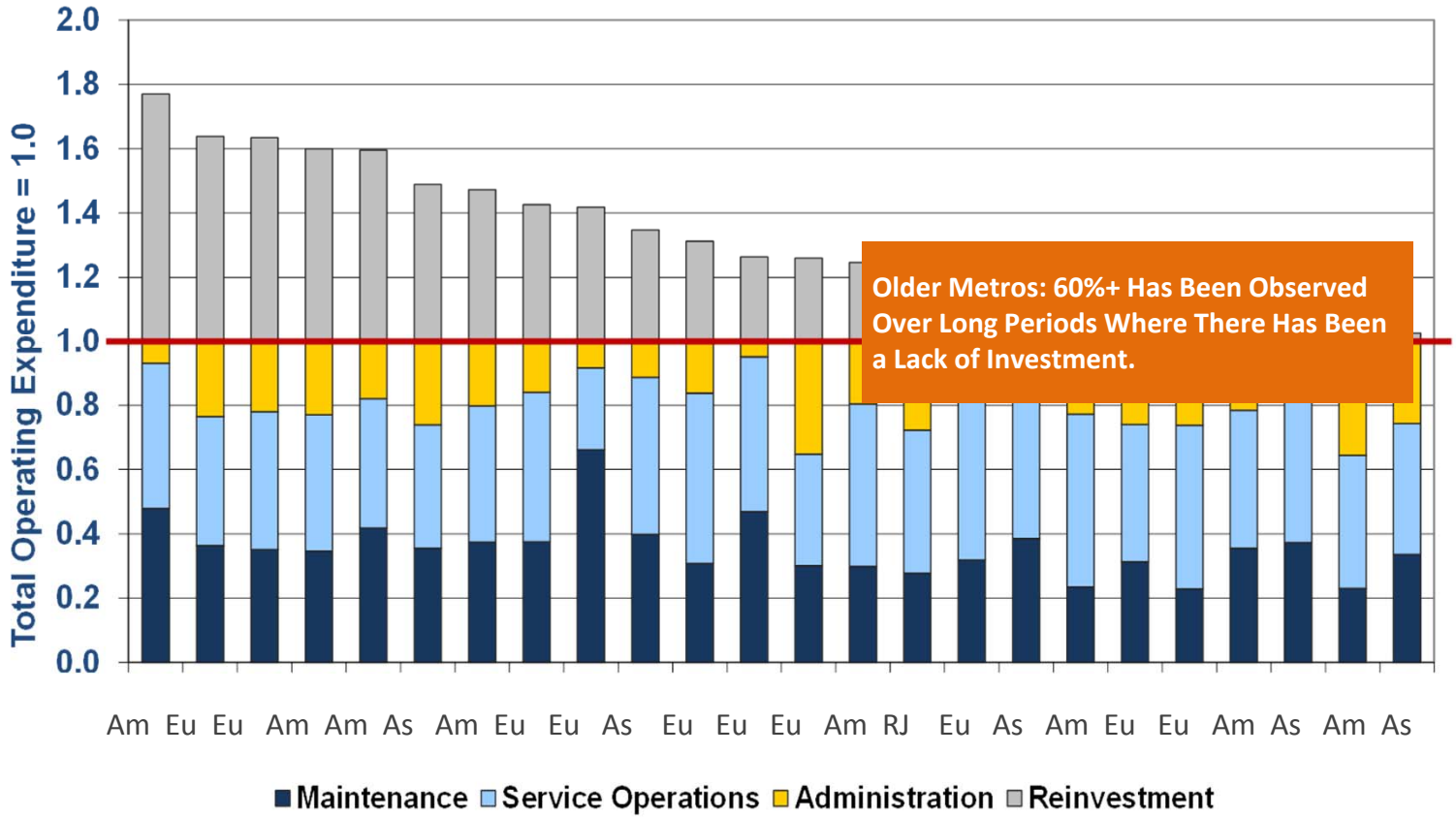


Fig. 13 Regional distribution of the number of metro carriages.

Total: 116.930

Average Expenditure and Reinvestment as a Proportion of Opex:

All Metros (Using Available Data, 1994-2015)



Metros' Main Sources of Funding for Asset Renewal Spending

Concession / Contract

Primary source

	As	As	As	Eu	Am	Eu	Am	Am	Am	As	As
City / State Government		✓	✶	✓	✓	✓	✓		✓	✓	✓
National government	✓			✓	✓		✓		✓		
Fares / Commercial +		✓	✓	✓				✓		✓	✓
External borrowing			✓	✓			✓	✓			

✶ State City Govt fund only new extensions

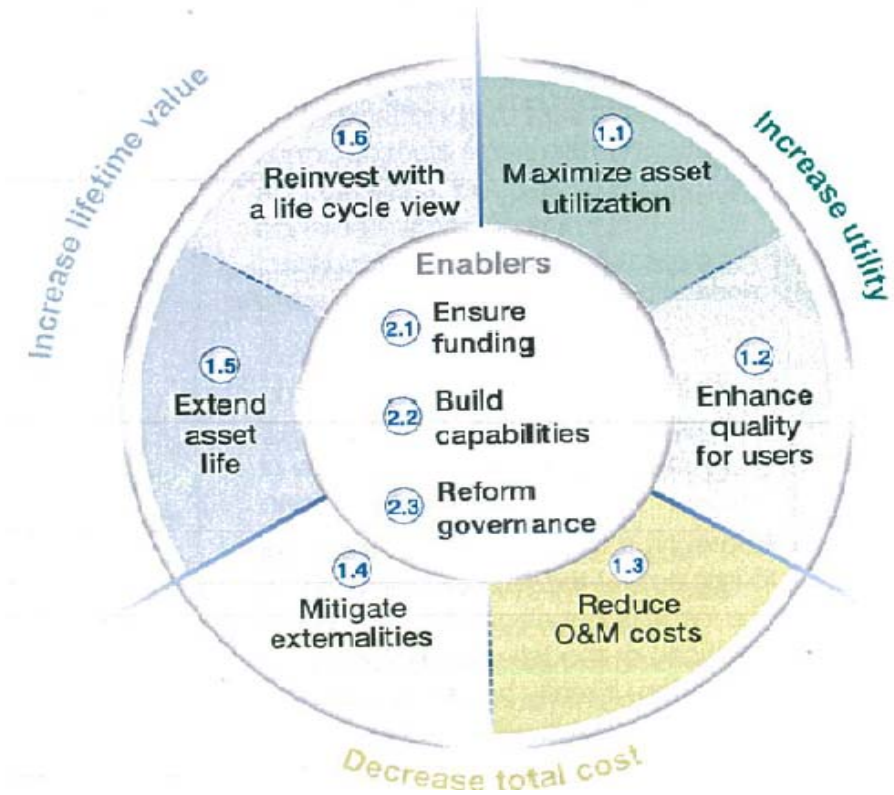
+ "Commercial" includes property income

	Am	Eu	Eu	As	Eu	Am	Eu	Eu	RJ	As	Am
City / State Government		✓	✓			✓	✓	✓	✓	✓	✓
National government	✓	✓	✓	✓	✓	✓	✓				
Fares / Commercial +		✓	✓						✓		
External borrowing			✓		✓	✓					✓

Source: Nova Group of Metros

What to do?

O&M best practice framework



Source: World Economy Forum JF Consultoria em engenharia LTDA

What to do?

Checklist of o&m best practices/critical success factors

Increase utility	1.1. Maximize asset utilization	Enhance peak capacity and effective throughput	Apply demand management	Optimize availability/ reduce downtime
	1.2. Enhance quality for users	Adopt a customer-centric operating model	Enhance the end-to-end user experience	Use smart technologies to refine user performance
Decrease total cost	1.3. Reduce O&M costs	Implement lean and automated processes	Optimize procurement costs and outsourcing	Rightsize management and support functions
	1.4. Mitigate externalities	Arrange comprehensive sustainability/HSE plans	Embed sustainability/HSE into routine operations	Cooperate with relevant stakeholders
Increase lifetime value	1.5. Extend asset life	Invest in preventive and predictive maintenance	Control excessive asset consumption and stress	Enhance disaster resilience
	1.6. Reinvest with a life cycle view	Prioritize project options with whole life cycle CBA	Select contracting mode for best value for money	Prepare for efficient project delivery
Enable O&M best practice	2.1. Ensure funding	Dedicate user taxes via maintenance funds	Apply inclusive user charges	Capture ancillary business opportunities
	2.2. Build capabilities	Introduce asset management planning	Apply data, benchmarks and tools	Conduct training and develop talent
	2.3. Reform governance	Corporatize and professionalize public agencies	Foster cooperation between agencies	Consider private-sector participation & competition

Note: HSE = Health Safety Environment; CBA = Cost-Benefit Analysis

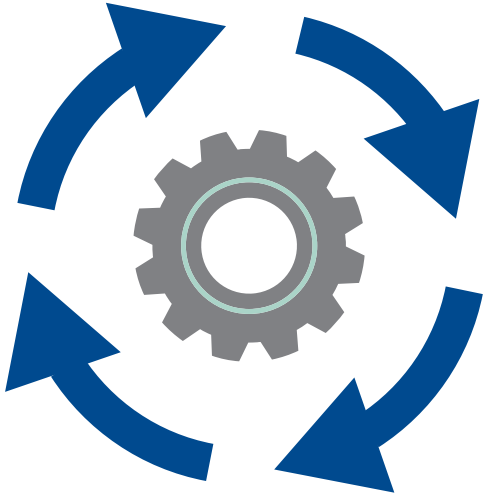
Source: World Economy Forum JF Consultoria em engenharia LTDA

What to do?

“Every year, traffic accidents kill more than 1.2 million people around the world and injure up to 50 million.”

Source: World Economy Forum JF Consultoria em engenharia LTDA

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

What is the most probable?

- Adoption of asset management policy for a whole LCC;
- Attract private capital/ concessions;
- Improve the maintenance effectiveness;
- Improve risks analysis.

Restrictions

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.

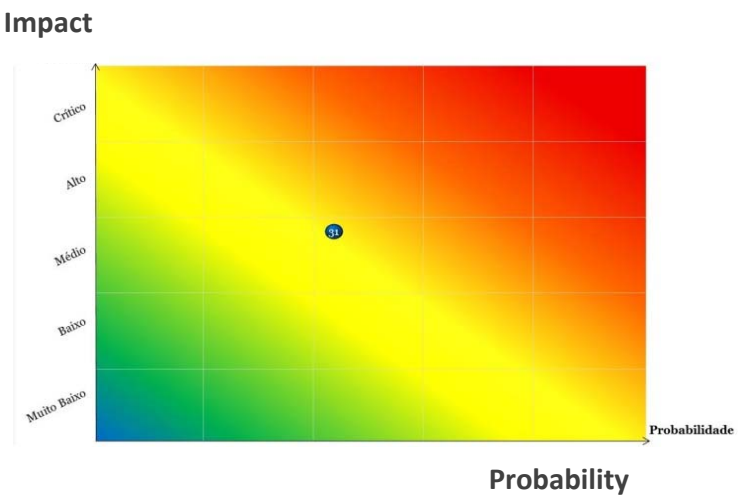
Asset Renewal Projects

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



Initial Approach

Consulting:

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

Core Business Analysis

Impacts

- ✓ Probability of Failure
- ✓ operation
- ✓ Costs (maintenance / operation)
- ✓ security
- ✓ image
- ✓ Regulation / compliance
- ✓ End of life cycle
- ✓ investment
- ✓ Environment

Consulting

Order of Criticality (Risk)

Prob. Failure x (Operation + Security + Costs + Image + Regulation + Investments + Environment) + Life Cycle.

Initial Results

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

Project	Value (R$)	Balance Score Card
1	8,000,000	2.212.000
2	600,000	2.004.001
3	70,000,000	1.213.000
4	6,400,000	1.203.010
5	25,000,000	1.015.000
6	12,600,000	1.006.000
7	4,500,000	440.210
8	1,200,000	221.110
9	2,000,000	220.210
10	30,000,000	132.100

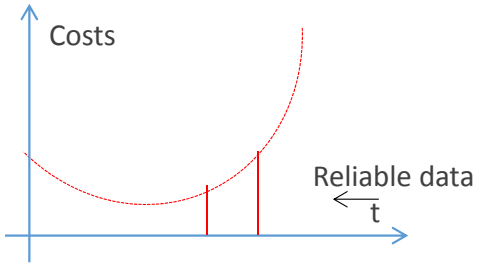
2nd Phase: Detailed analysis of each project

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

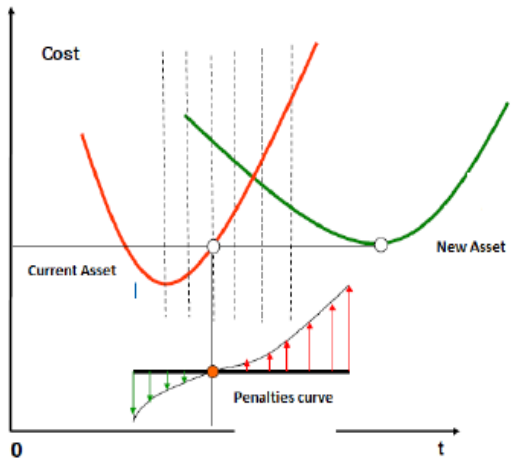
Users

- ✓ Comfort
- ✓ Practice
- ✓ Accessibility
- ✓ Rapid

Best moment for replacement

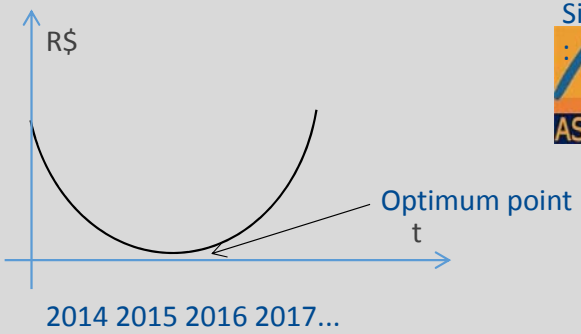
Complete data

LCC - Life-Cycle Costing Methodology



"Value Premium" concept

- ✓ Economic performance of current asset
- ✓ Benefits of new asset

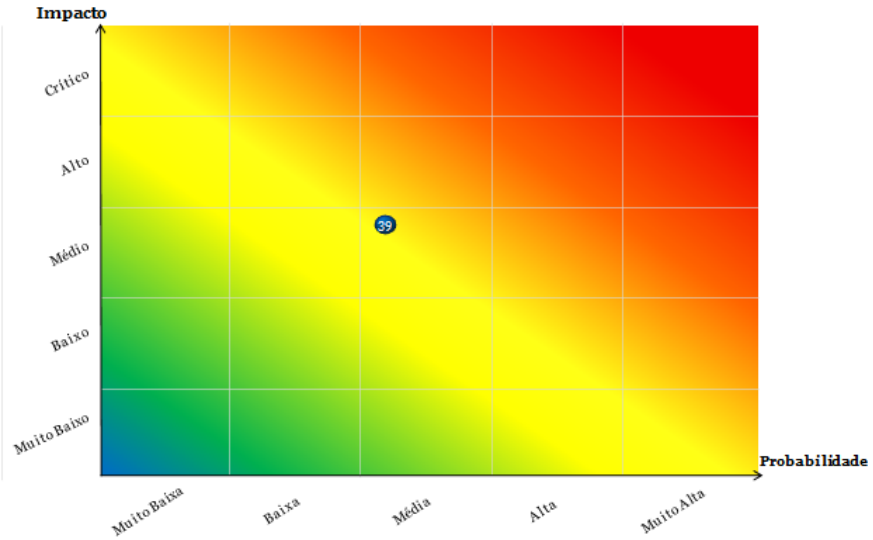


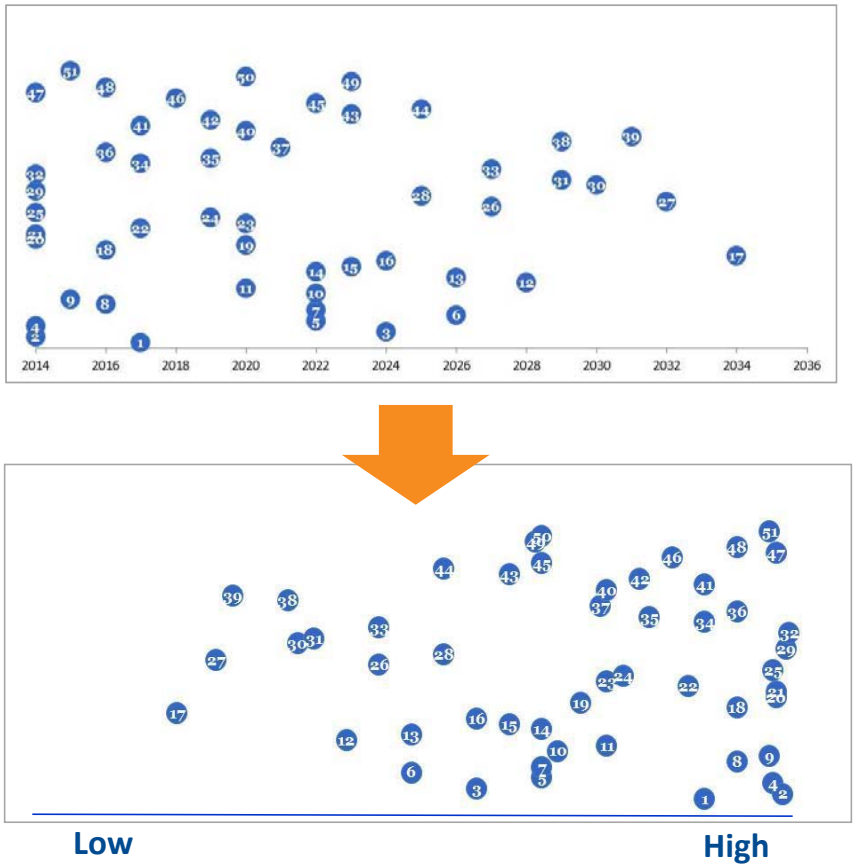
Simulation : ASSETSMAN

Definition of Best moment for replacement for each asset

Project	Value (R$)	Balance Score Card	Year
1	8,000,000	2.212.000	2017
2	600,000	2.004.001	2014
3	70,000,000	1.213.000	2024
4	6,400,000	1.203.010	2014
5	25,000,000	1.015.000	2022
6	12,600,000	1.006.000	2026

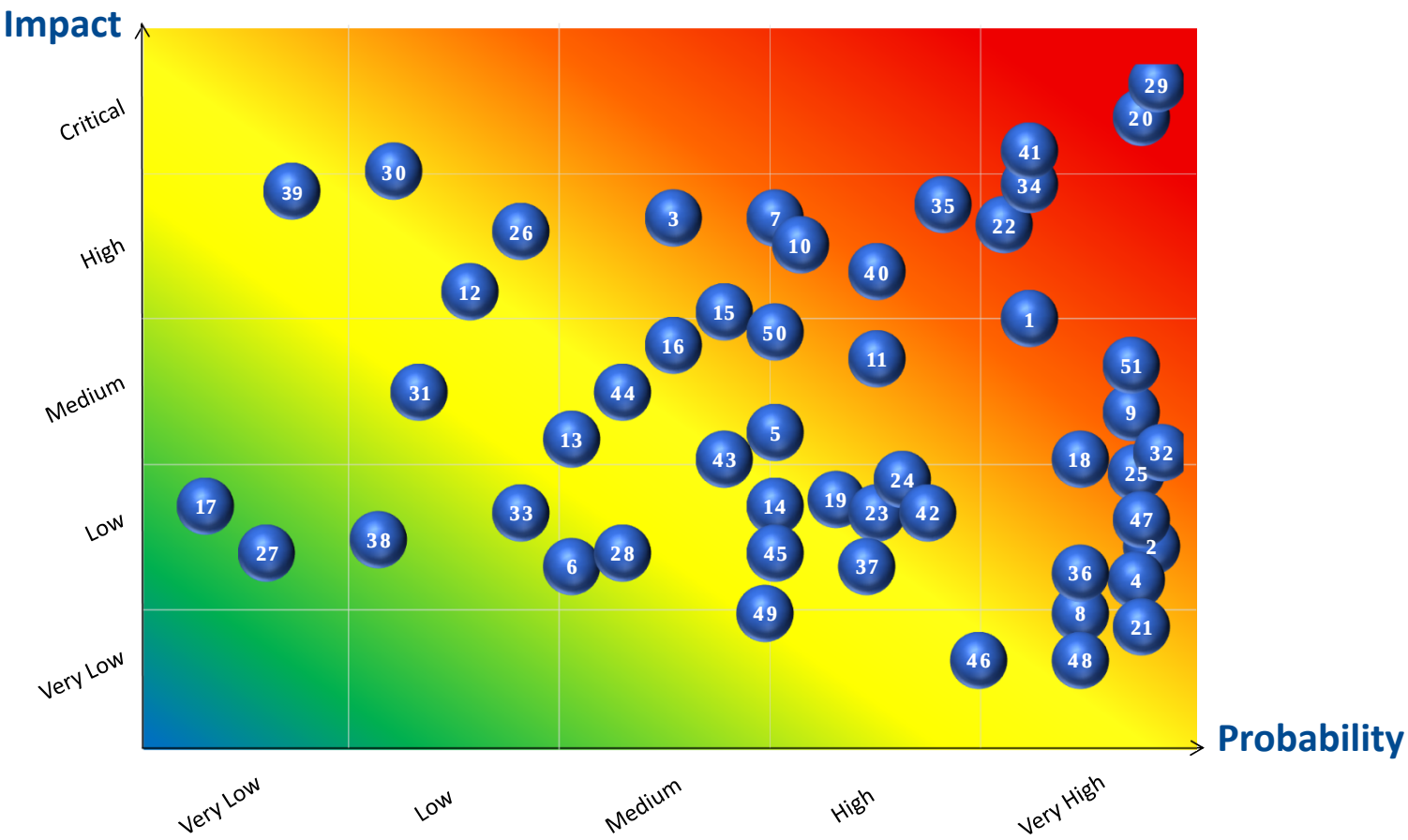
Best moment for substitution (Risk x Cost)



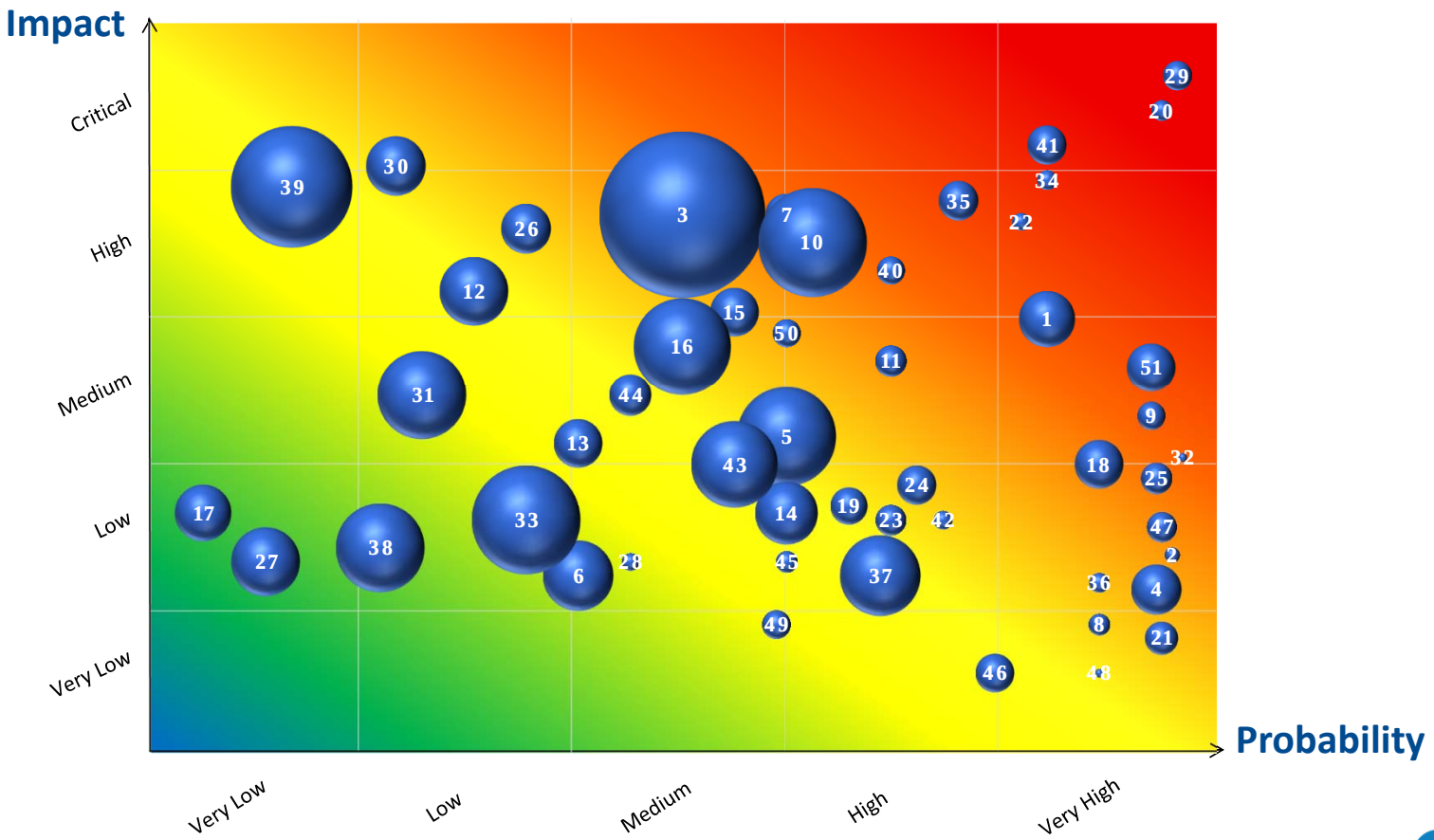


Probability of such assets cause events that may affect the operation…

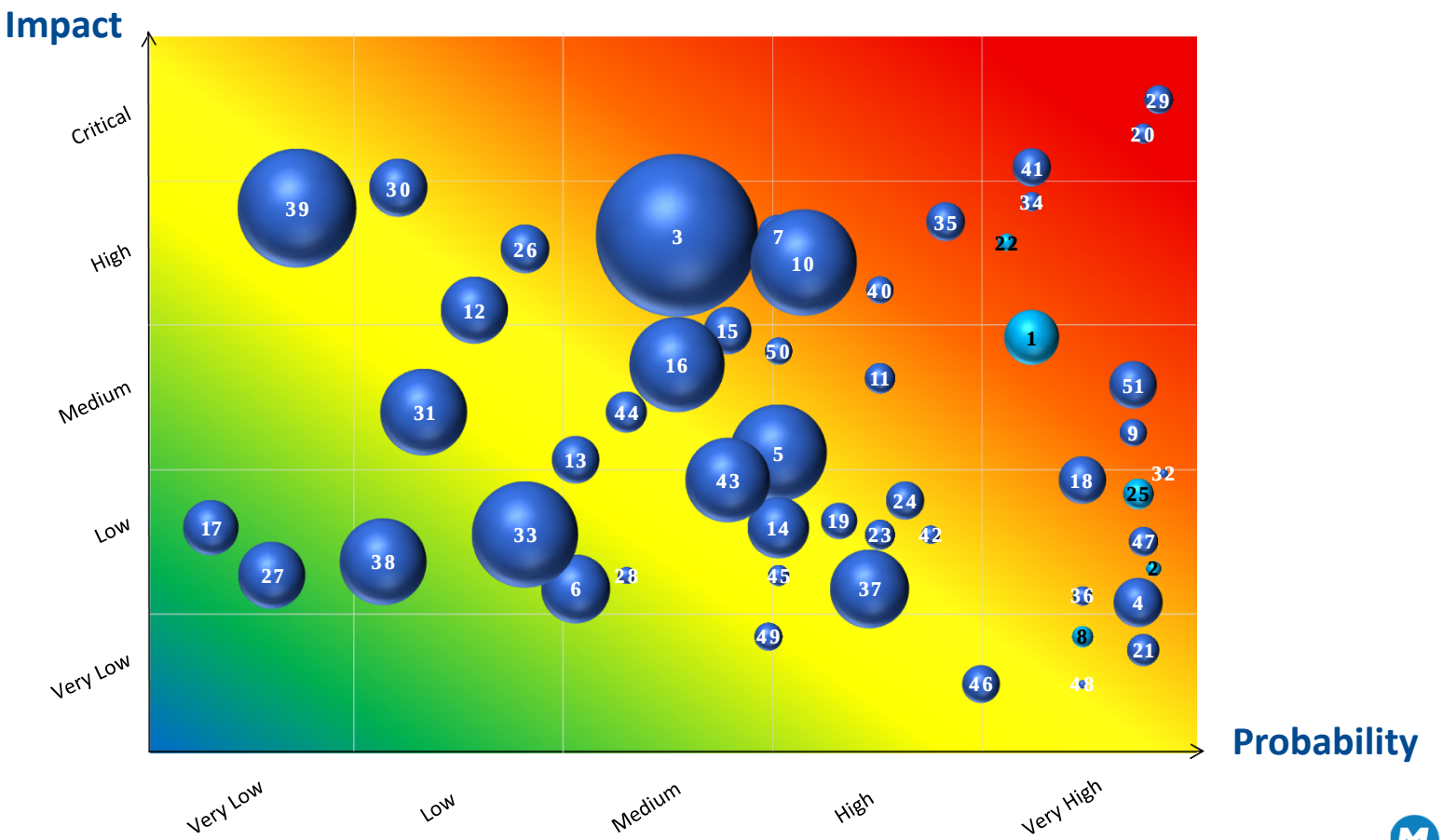
Probability x Operational Impact of Assets



Considering the Investments Value



Assets with Potential for Positive NPV



Assets with high/ critical probability and impact

ASSETS	PROBABILITY	IMPACT	VALUE
29) 138 kV Armored SSP (BTF/FCN) - Pressure switches control/ protect shielded substations in case of loss of gas SF6 pressure, indicating and/or turning off the sectors to isolate the low pressure spaces.	There is no spare part in the inventory. At each year one unit is lost.	Failures may cause a reduction to the traffic or the suspension of a station.	R$ 2.2 Mi
20) Protection Relays - Protect the traction zones (750Vcc) in order to minimize any failure due to overload or short circuit in the rolling stock, traction cables and 3rd rail.	There are only 5 spare units for this model.	Failures may damage the rolling stock material and/or the substation due to poor isolation.	R$ 1.0 Mi
41) Traction Circuit Breakers – It is composed by 200 breakers dividing in sectors the traction power supply to the tracks in order to protect the system.	There are only 5 spare units for this model.	Losing a traction breaker may reduce in at least 5% the departures at that zone.	R$ 3.9 Mi
34) Pull-Through Cable (FCN) – Two 138kV lines with respectively 11 pairs of cables carrying out the transference between LIGHT FCN and MetrôRio FCN (Transfer trip).	Only 2 pairs for each line are operating today.	In case the 2 pairs of each line fail, the mains substation of FCN and ESA would be lost.	R$ 1.0 Mi
35) Battery Chargers - Supply in 125Vcc the Auxiliary and Main Substations to provide power to the station's command, control, protection and emergency lighting systems.	The spare parts necessary for a proper maintenance are not produced anymore.	Failures may cause partial or total loss of the substation, and loss of power along the line following a partial or complete suspension.	R$ 4.0 Mi
22) Cooling Towers - Designed for the heat exchange of the cooling system at the stations, using water as cooling fluid.	Obsolete equipment with no spare parts for proper maintenance.		R$ 0.8 Mi
51) IHM PMO – Panels and monitors comprising the teletransmission system to optimize the operation, centralizing the traffic commands and supervision and the traction of all yards.	Obsolete and incompatible with the new configuration of the yards. Its adequation/ modernization is impossible.	A inefficient traffic control may cause wrong manual route formations, causing incidents with the rolling stock material.	R$ 6.0 Mi
		TOTAL	R$ 16.7

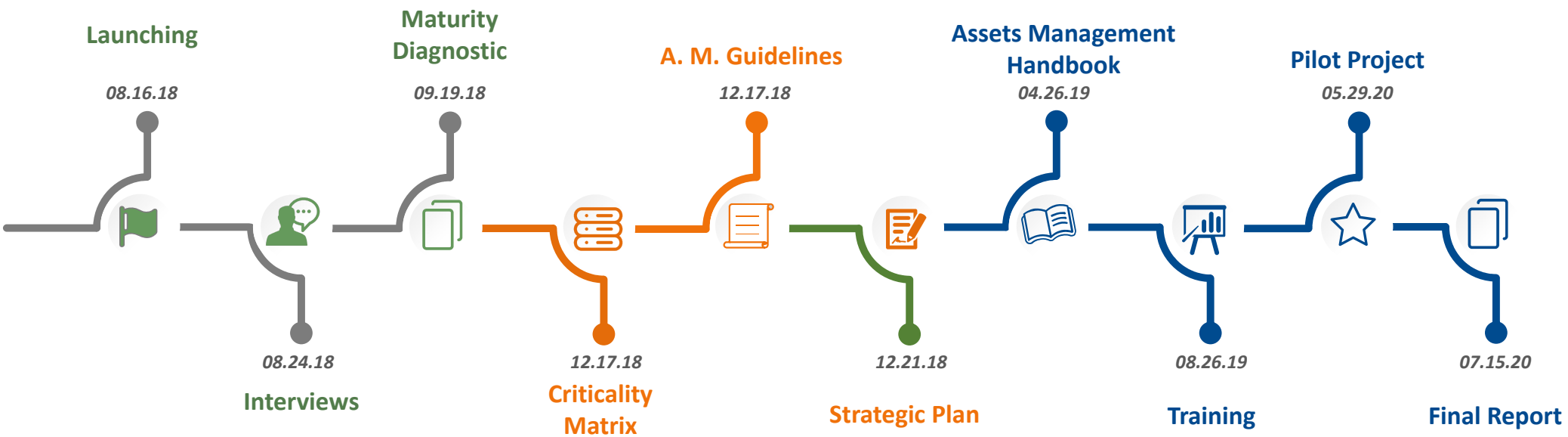
Assets with potential for NPV

ASSETS	VALUE	GAINS	PAYBACK	TIR	NPV
1) Fire Extinguishing System - Fire fighting piping along the station that distributes the water supply from the cistern (fire reserve) to the hydrants.	R$ 8.0Mi	Maintenance Costs	3 years	7.5%	Aprox 0
2) LCF Lubricators - Designed to lubricate the contact point between the wheel and the rail to reduce wearing and noise coming from the contact.	R$ 0.6Mi	Maintenance Costs Wheel Wearing Rails Wearing Power Consumption	3 years	86%	R$ 6.4 Mi
8) Switch Machines - Move the track change machine, in order to change the route of the trains indicated by the Control Center.	R$ 1.2Mi	Maintenance Costs	24 years	7.5%	Aprox 0
22) Cooling Towers - Designed for the heat exchange of the cooling system at the stations, using water as cooling fluid.	R$ 0.8 Mi	Maintenance Costs	20 years	8.5%	R$ 0.23 Mi
25) Fan Coils - Act as cooler for the operational and technical rooms at stations, Maintenance Center and Administrative Center.	R$ 2.5 Mi	Maintenance Costs	11 years	14%	R$1.5 Mi
TOTAL	R$ 13.1 Mi	TOTAL			R$8.1 Mi

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



Legend

- *Finished Activity*
- *Ongoing activity*
- *Activity not initiated*

Pro-Assets Project: Guidelines

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

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

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

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

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

"What will help us to achieve our alignment process"

SUPPORT AREAS

Maintenance Documents Standards

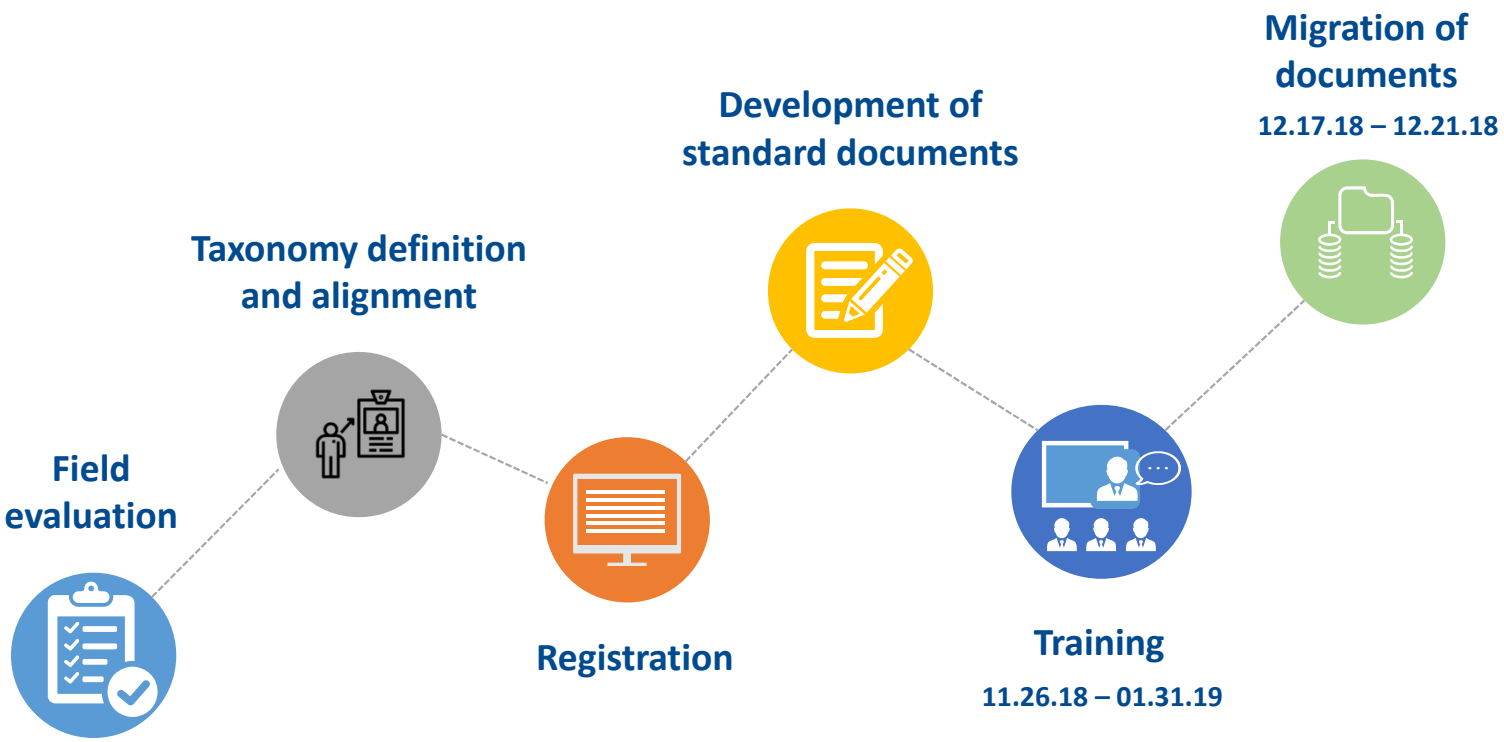
PHASES

Documents and manuals review

Staff awareness training

Staff technical training

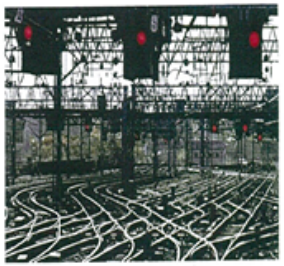
SAP PM

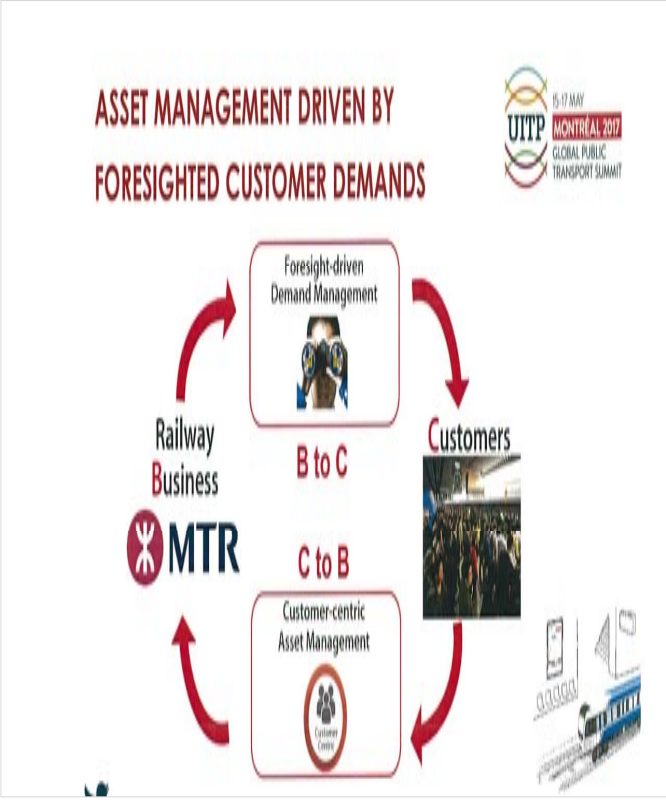

Field evaluation
Taxonomy definition and alignment
Registration
Development of standard documents
Training
11.26.18 – 01.31.19
Migration of documents
12.17.18 – 12.21.18

Benchmarking

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 undertakes **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





Source: Hong Kong MTR Metrô

JF Consultoria em engenharia LTDA

Conclusions

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.

PROPPOSAL:

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

JOUBERT FLORES

SENIOR ADVISOR

e-mail: joubert@metrorio.com.br
mobile: (55) (21) 99121-0318