Implementing Technologies in Brazilian Heavy-Haul Railways

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MRS Logistics S.A

Topics to be covered

Brazilian Freight Railroads

MRS Logistics overview and challenges

Wheel-Rail Project

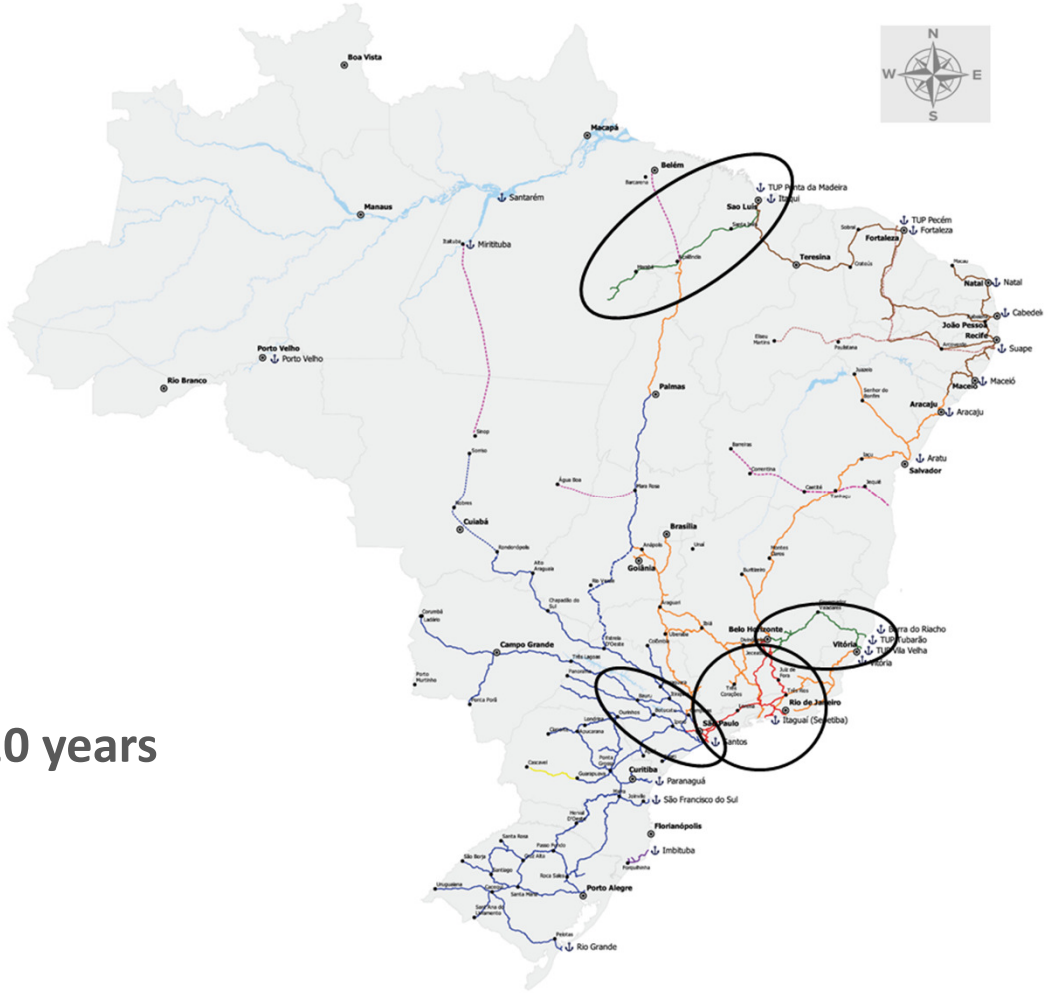
Dynamic Forces project

Big Data project

Conclusions

Brazilian Freight Railroads

- 11 Freight Operators (private concessions)
- 4 Class I Railroads – 32 to 36 tonne axle
- Network length 30.485 km
- 44.000 workers railway operators
- 3.500 locomotives
- 120.000 freight wagons
- 60% reduction in train accidents in the last 10 years
- Production increasing in 30% last 5 years
- Projected expansion in 5 years: 9.000 km



MRS Logistics S.A

We are a logistics operator responsible for a **rail network** in the region that concentrates about half of the Brazilian Gross Domestic Product (GDP).

1,643 km OF EXTENSION IN THE STATES OF MINAS GERAIS, RIO DE JANEIRO AND SAO PAULO

5 PORT OPERATION SANTOS, ITAGUAÍ, SUDESTE, GUAÍBA AND RIO DE JANEIRO

~16% OF THE NATIONAL FLEET

MORE THAN **18,800** WAGONS

MORE THAN **800** LOCOMOTIVES

Heavy Haul	8 products
General cargo	85 products

+ 80 Terminals

Chemical

Iron Ore

Pig Iron

Soy bean

Container

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30% of national railway production

100% of operational lines

6.000 direct employees

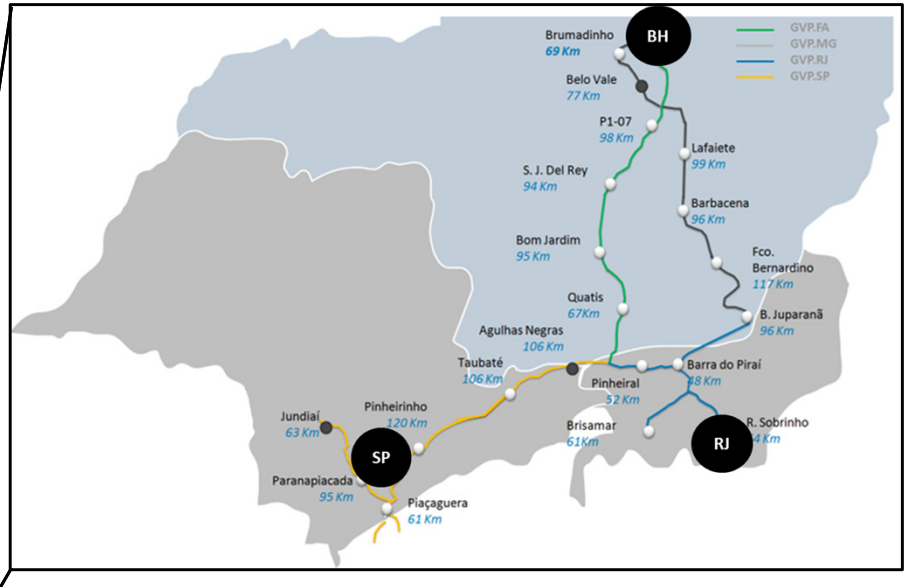
631
Railway bridges

1.000
Crossings

141
Tunnels

4.200
Culverts

5.814
Cuts and Fills



Within the most populated region in Brazil: 60 million people

MRS Logistics S.A

Ferrovia do Aço division

170 MGT
354 km length
50 km of bridges
45 km of tunnels
Max. Garde 1,2%
Radius min 600m
Built: 1989

Serra do Mar subdivision

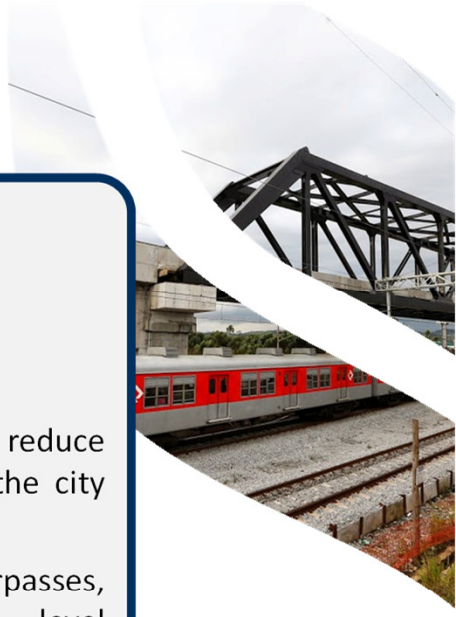
190 MGT
96 km length
4 km of bridges
10 km of tunnels
Max. grade 2,2 %
Radius min 150m
Built: 1880

Cremalheira subdvision

10 MGT
95 km length
Rack track: 8 km length
with 2 km of bridges
Max. grade 11,8 %
Radius min 200m
Built: 1960

Investment Projects: MRS 2056

The investment plan in the renewal of the MRS concession is built on three main pillars:



Capacity Expansion Performance Improvement

- Renew the track and support facilities.
- Construction and expansion of sidings (yards).
- Acquisition of new machines, locomotives and wagons.

MRS OPERATIONS

Supporting the Brazilian logistics program

- Reduce the logistics cost.
- Increase the railway participation from 15% to 40%.

Urban mobility

- Improve safety and reduce interference between the city and the railroad.
- Road Bridges, underpasses, footbridges, fences, level crossings, flow driver, etc.

PUBLIC STRATEGIES

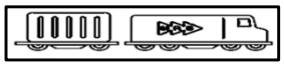
In the next 5 years...

- Increase the axle loads: 32,5 to 36 tonnes.
- Duplicate the train size to 272 wagons.
- Increase speed in 25%.
- Advance in hybrid and electric systems.

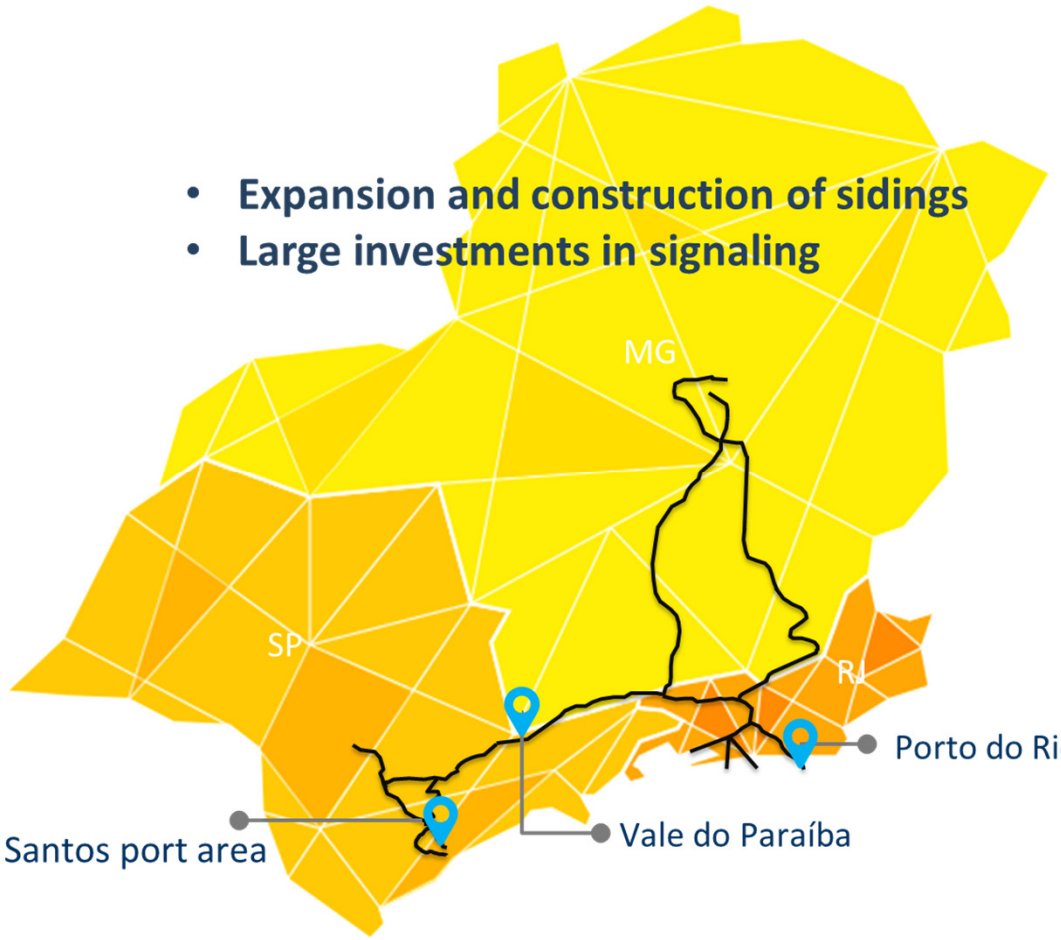
Track renewal

Track renewal of 600 km.
Clean the ballast and restore the drainage.
Replace more than 1 million ties.

Rolling stock

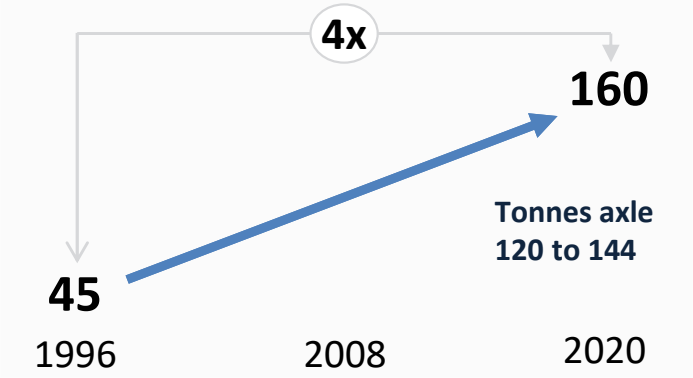


Acquisition of new generation of locomotives, wagons and machines.

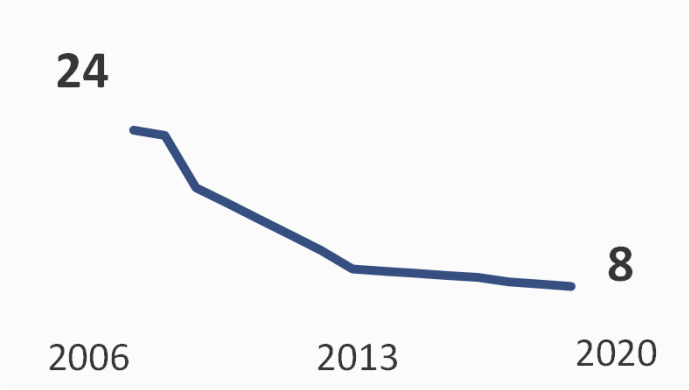


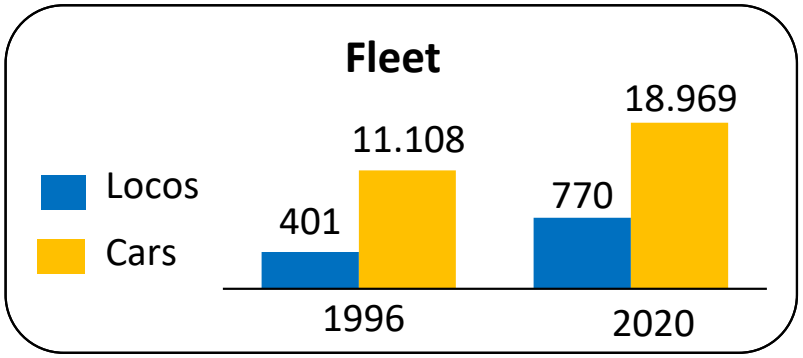
MRS in the last years

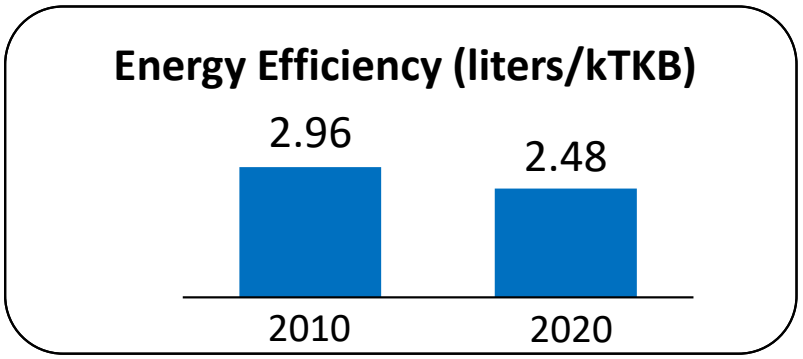
Total volume carried (millions of tonnes)



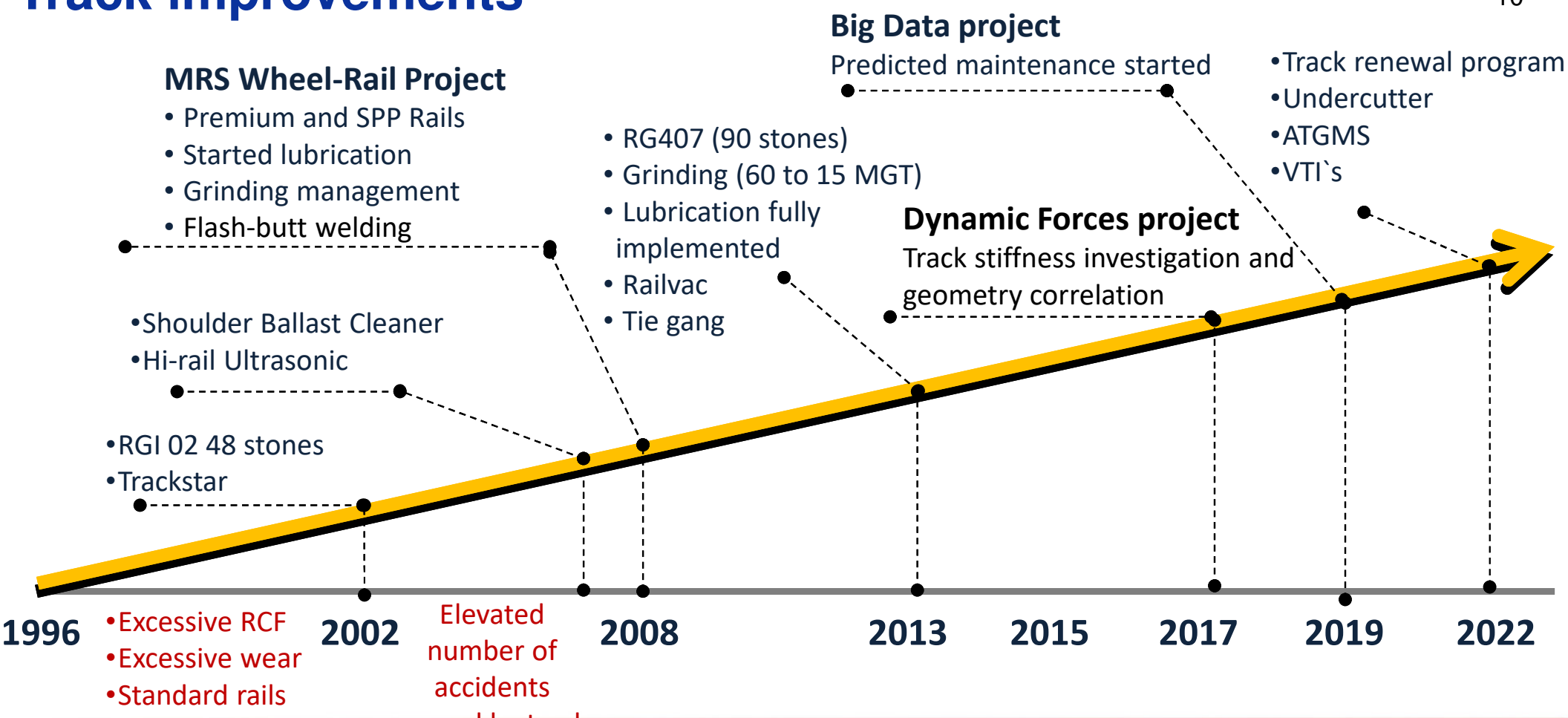
Number of Accidents per millions of trains







Track improvements



Rolling stock improvements

Dynamic Forces project

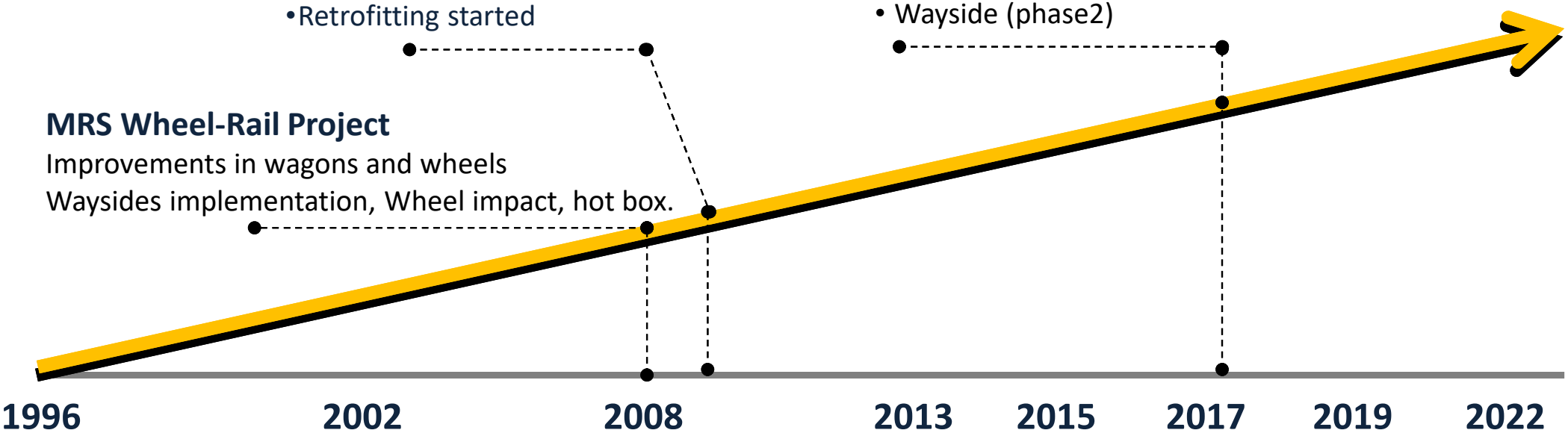
- Implantation of microalloyed wheel in locomotive
- Wheelset management
- Developments of new materials
- Implementation of Preventive wheel turning
- Spring elasticity improvements
- Wayside (phase2)

- New wheel profile (high conicity)
- Microalloyed wheels
- Radial trucks
- Retrofitting started

MRS Wheel-Rail Project

Improvements in wagons and wheels

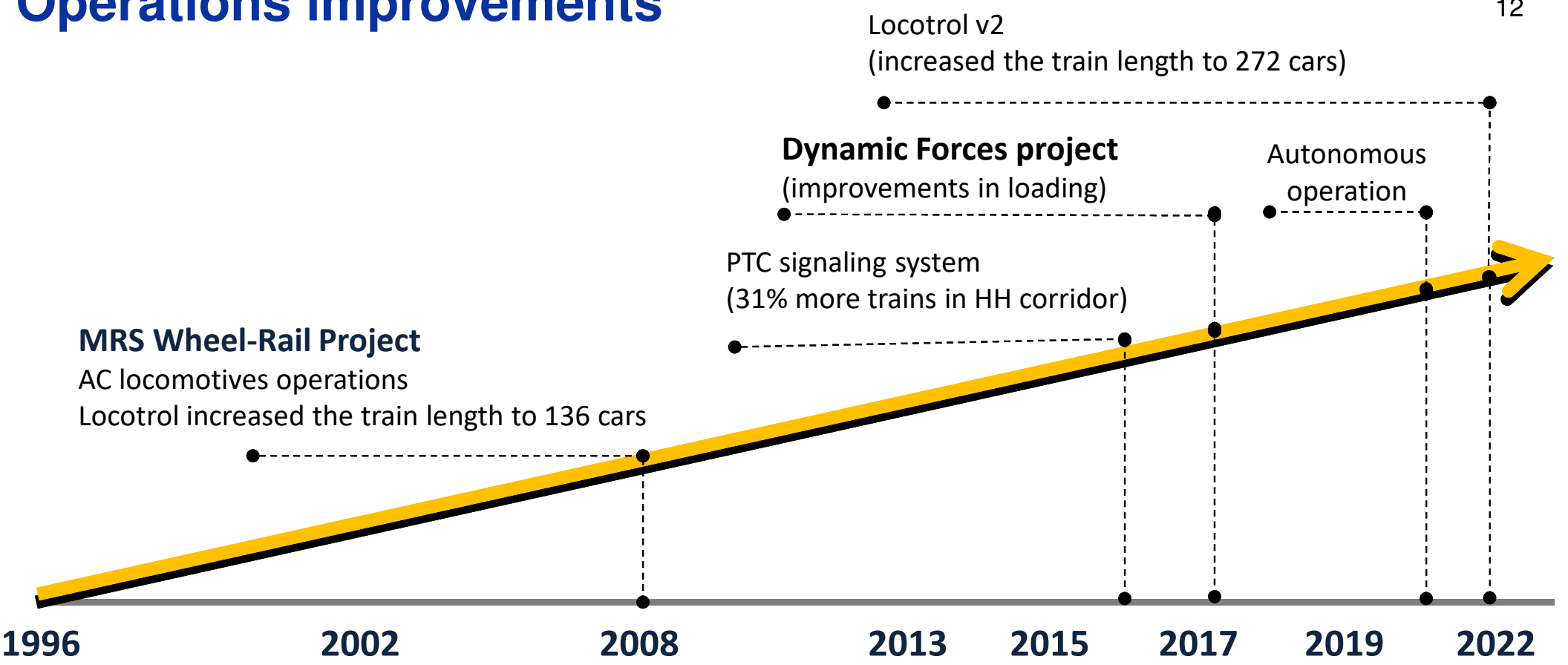
Waysides implementation, Wheel impact, hot box.



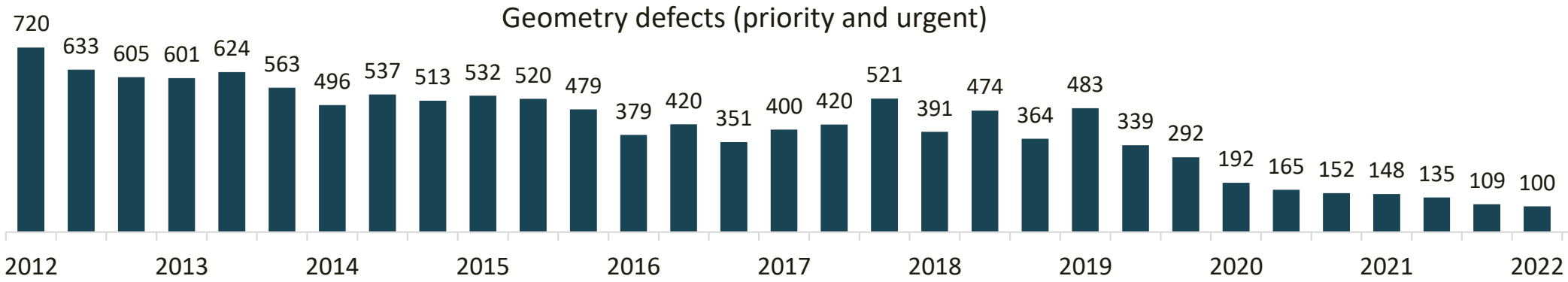
No advances in rolling stock implemented

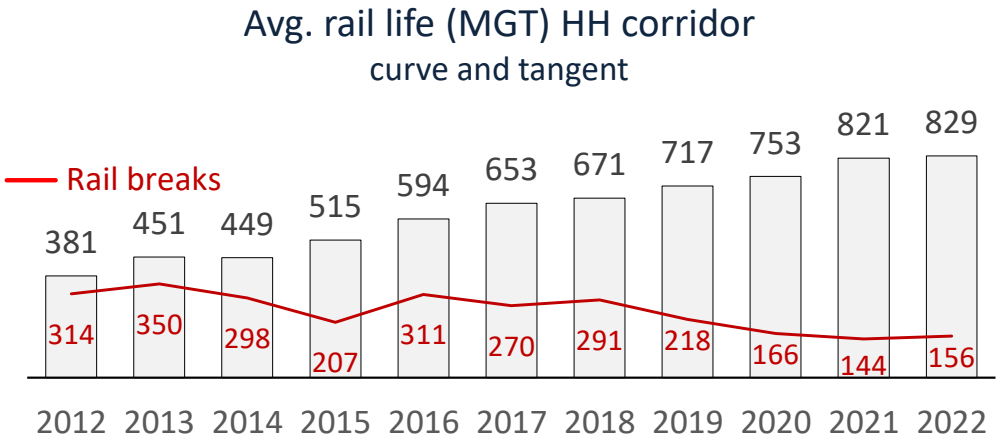
Shelling in GDT wheels

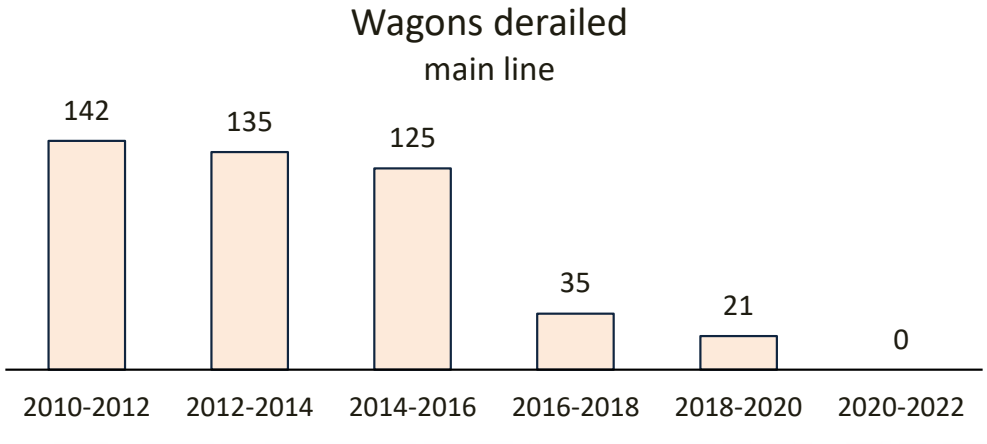
Operations improvements



Track condition







Track maintenance machines

TIE GANG

90 STONE GRINDING MACHINE

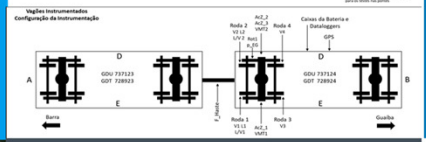
HIGHT PRODUCTION TAMPERS

SHOULDER BALLAST CLEANEAR

RAILVAC

Track inspection machines

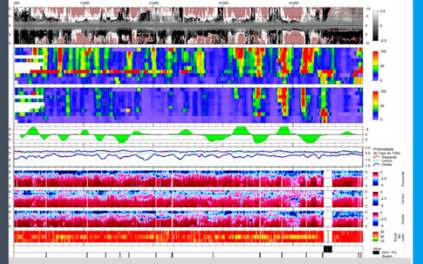
Ultrasonic Rail image

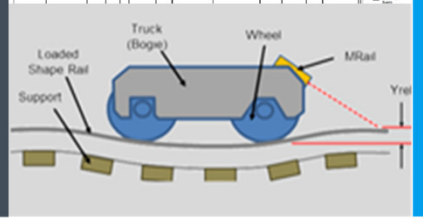


Substructure (GPR, MRail)

Geometry

Dynamics (instrumented wagon)





Unattended systems (VTI and ATGMS)

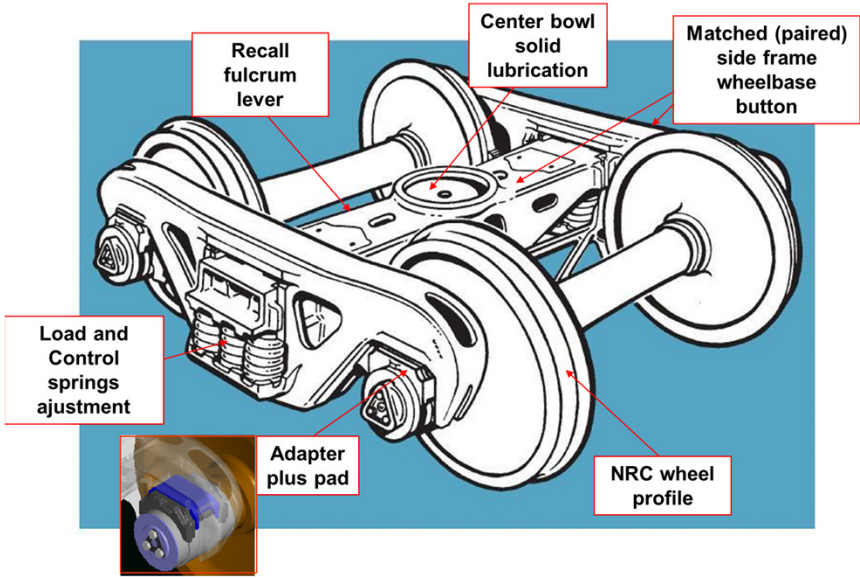
! Investment in research and data analysis to integrate the inspection technologies

Track Maintenance Strategy HH Corridor

PARAMETER	2020	2023
Ultrasonics inspection cycle	10 to 15 MGT	5 to 10 MGT
Track geometry inspection cycle	30 to 50 MGT	5 MGT (autonomous)
Rail grinding cycle	15 to 20 MGT	15 MGT
Avg. rail life	1.000 MGT in tangents 500 MGT in sharp curves	1.200 MGT in tangents 600 MGT in sharp curves
Resleepering	Annually 8% (wood)	Concrete ties with under tie pads (UTP) Track renewal program
Switch undercutting	Cycle not implemented (corrective with vacuum machine)	Every 5-8 years, incl. crossings
Ballast cleaning	Only shoulder cleaning - 3 years	Undercutter - 12 to 18 years Shoulder cleaning - 5 years
Production surfacing/tamping	1 – 3 years	1 – 3 years
Ditching	8 years	5 years
Substructure inspection cycle (MRail/GPR)	Initial studies	3 years

2008 Wheel-Rail Project

- Use of standard rails
- No structured rail grinding process (cycles, patterns, etc.)
- Inefficient attrition management
- No advances in rolling stock implemented
- Shelling in GDT wheels



2000

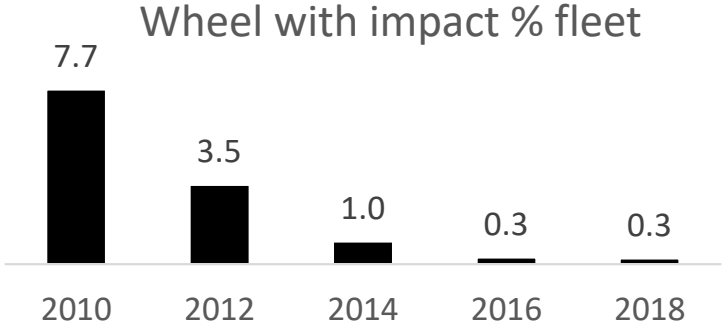
2002

2005

2008

- New wheel profile (high conicity)
- Microalloyed wheels
- Radial trucks
- Retrofitting started

2008 Wheel-Rail Project



2008

- RG407 (90 stones)
- Grinding (60 to 15 MGT)
- Lubrication fully implemented (160 units) TOR and GF

2012

- Premium and SPP Rails
- Lubrication started
- Flash-butt welding

2018

- Improvements in wagons and wheels
- Rail life increased 65%

2017 Dynamic Forces project

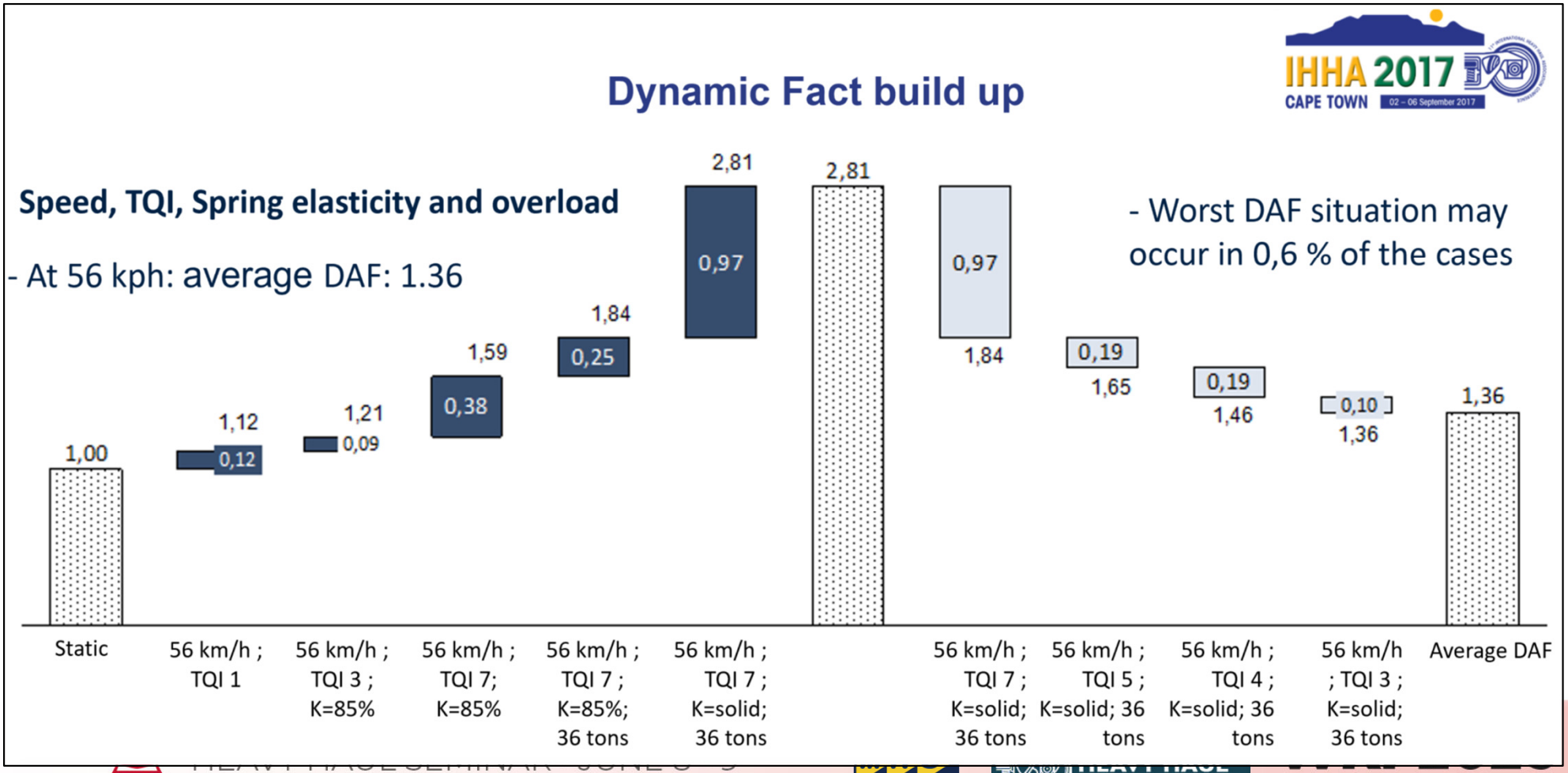
Purpose: Increase the tons/axle

Extensive project of simulation and instrumentation: involved Operations, Track and Rolling Stock teams to evaluate the maintenance parameters and create an action plan to reduce the dynamic loads in the MRS railway system.

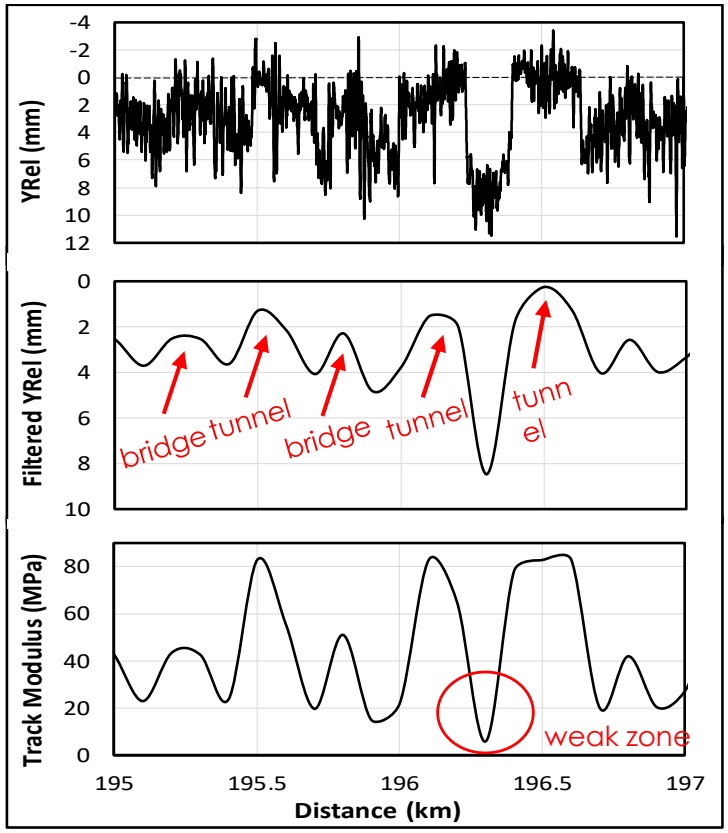
Dedicated train with deviations: Locomotive + 16 Gondola Wagons + Locomotive

Group 1	Group 2	Group 3	Group 4
- W/O apparent defects	- W/O apparent defects	- Wheel defects	- Damaged springs
- 35.91 tf/axle	- 30.04 to 36.64 tf/axle	- WIM system impacts 161 kN to 337 kN	- Springs less than 30% of elastic reserve
- σ = 0.38 tf/axle	- σ = 2 tf/axle	- (AAR Rule 41)	- W/O variation of tons/axle
- δ = 1%	- δ = 6 %	- W/O variation of tons/axle	

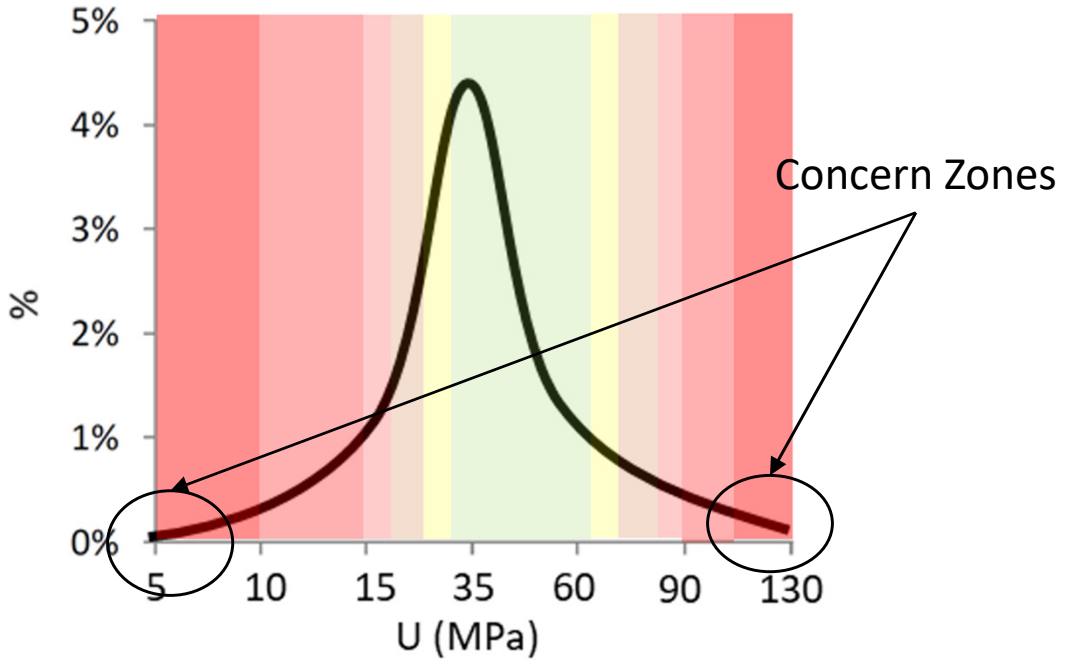
Dynamic Forces project



Track Stiffness Investigation



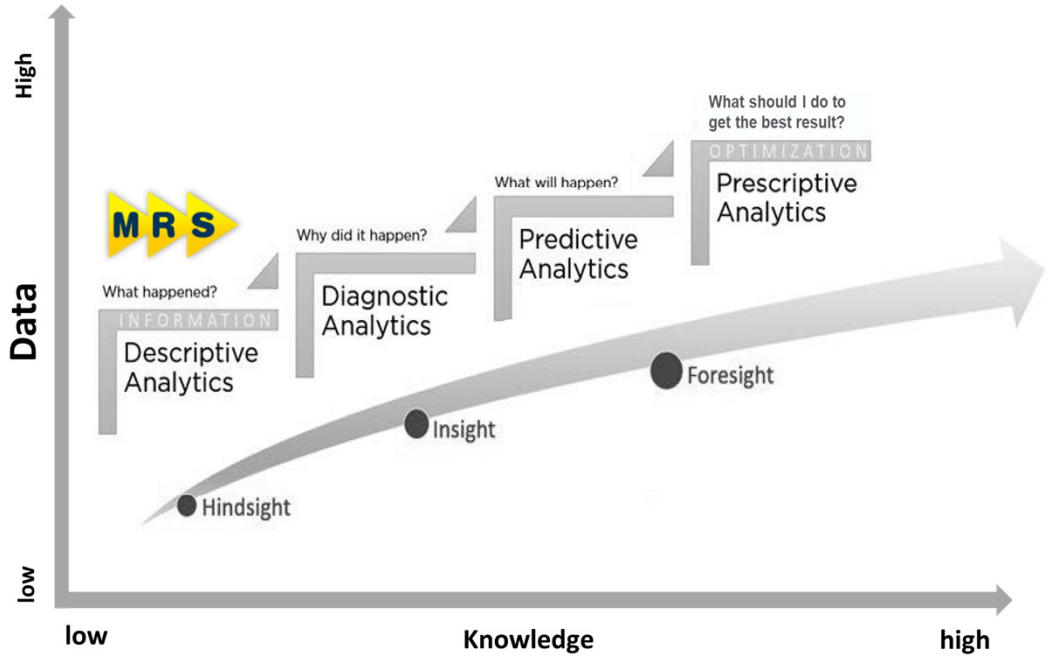
Track modulus for 2 km of track



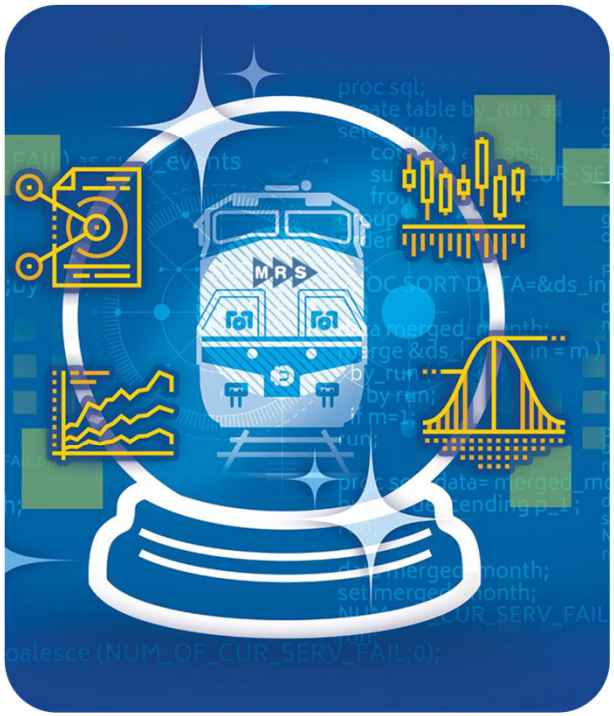
- The MRS average modulus is approximately **33 MPa**
- 6% experimented great influence of the wet season.
- The locations with low track modulus represent almost 34 km and are spread over MRS track.

2019 Big Data project

- Gigabytes of data were generated in each inspection cycle.
- In 2015 only 20 percent was used directly in maintenance activities.

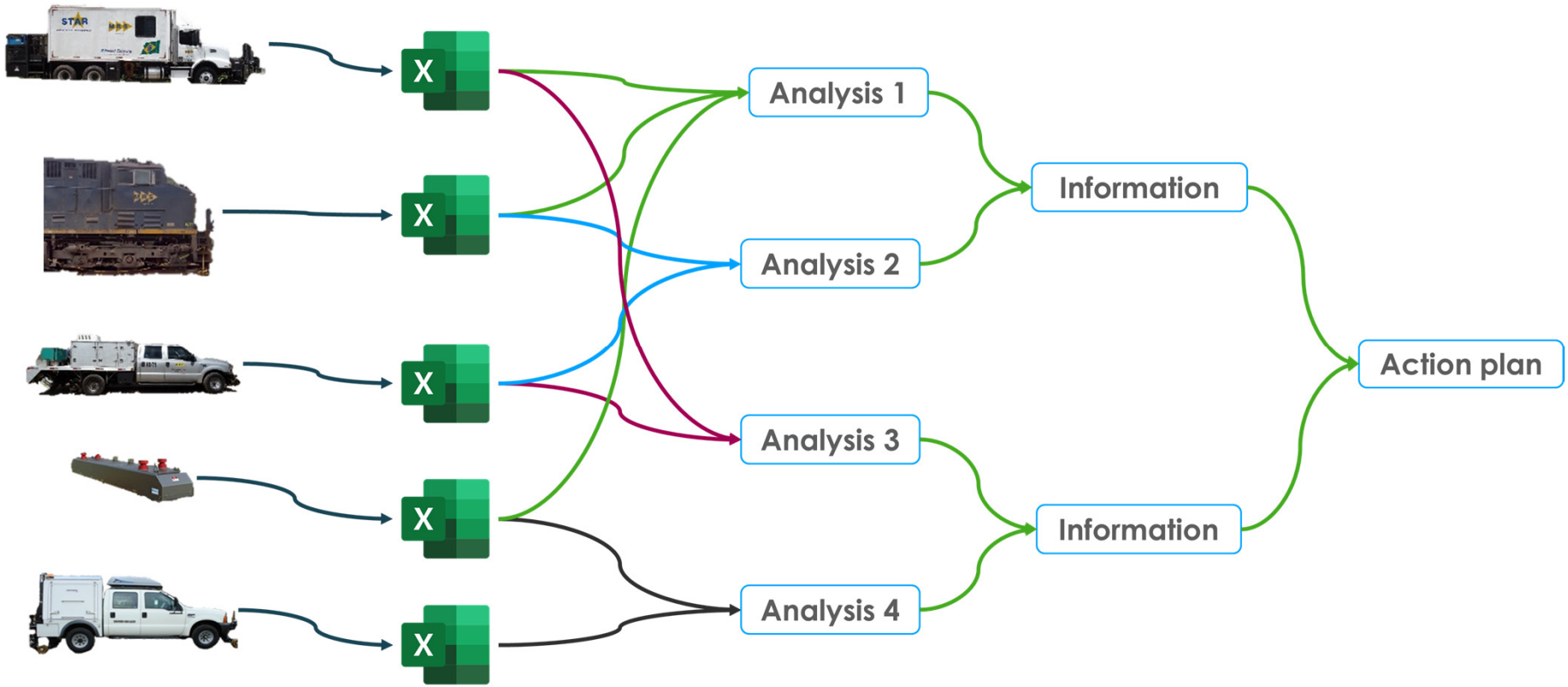


The future is beautiful!
But the future is now!



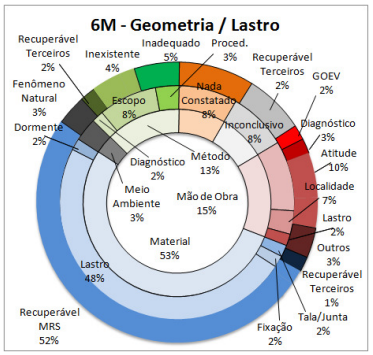
Do we use data properly? NOT AT ALL!
We could make much more information out the existing data!

Data processing in MRS (before)



Transforming data into action

Number of indications

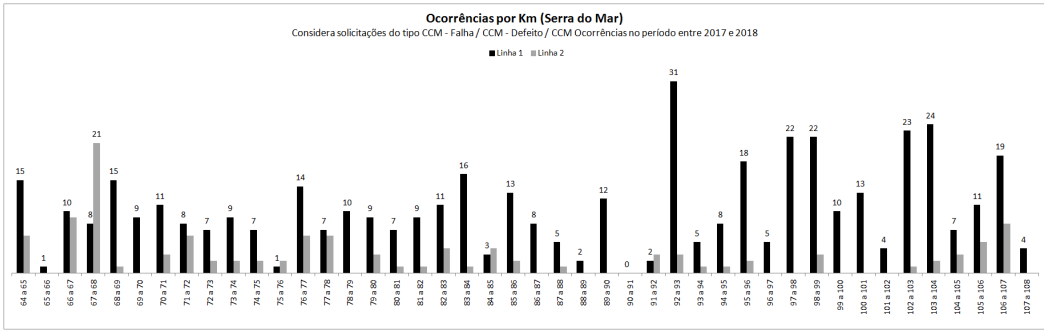


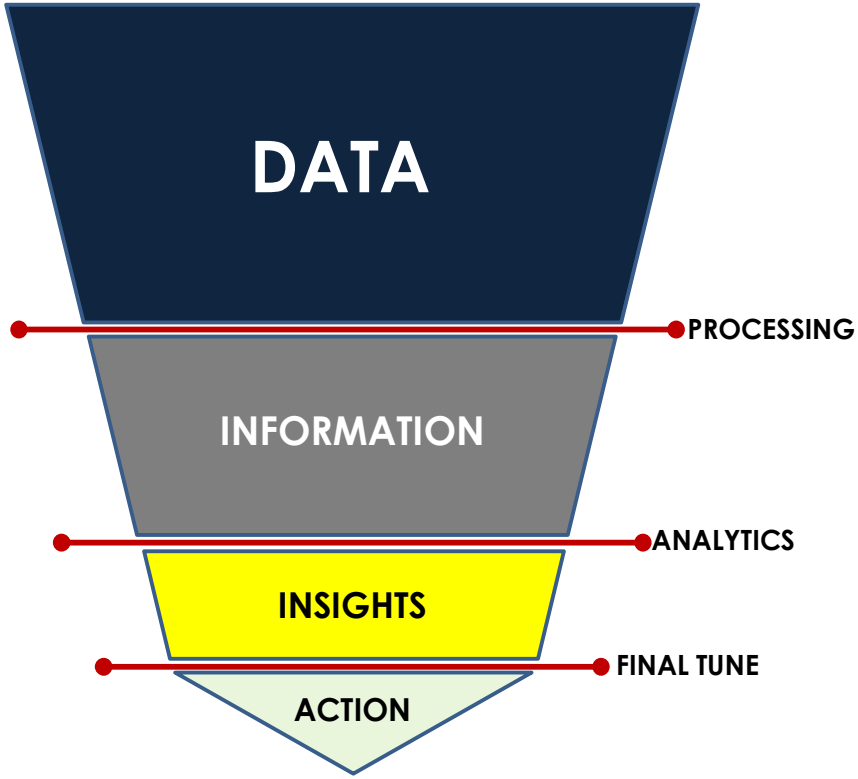
1,020

Independent concern locations

188

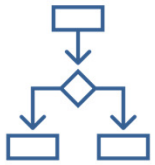
Combinated concern locations





Big Data project

Culture



Process

Equipment

01

Understanding the substructure issues and ballast fouling

02

Investigating the track stiffness and its effects to the geometry and train dynamics

03

Evaluating and controlling the dynamic forces

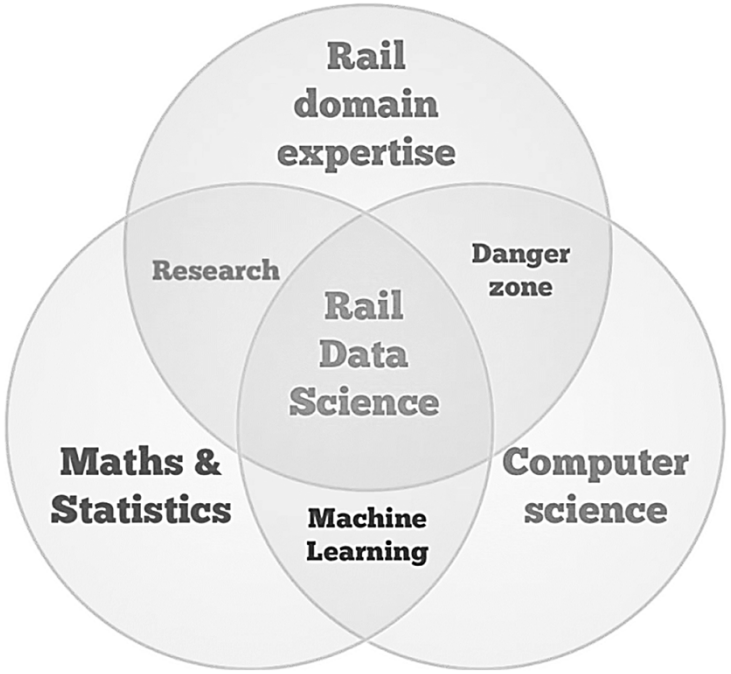
04

Application Big Data techniques to predictive maintenance

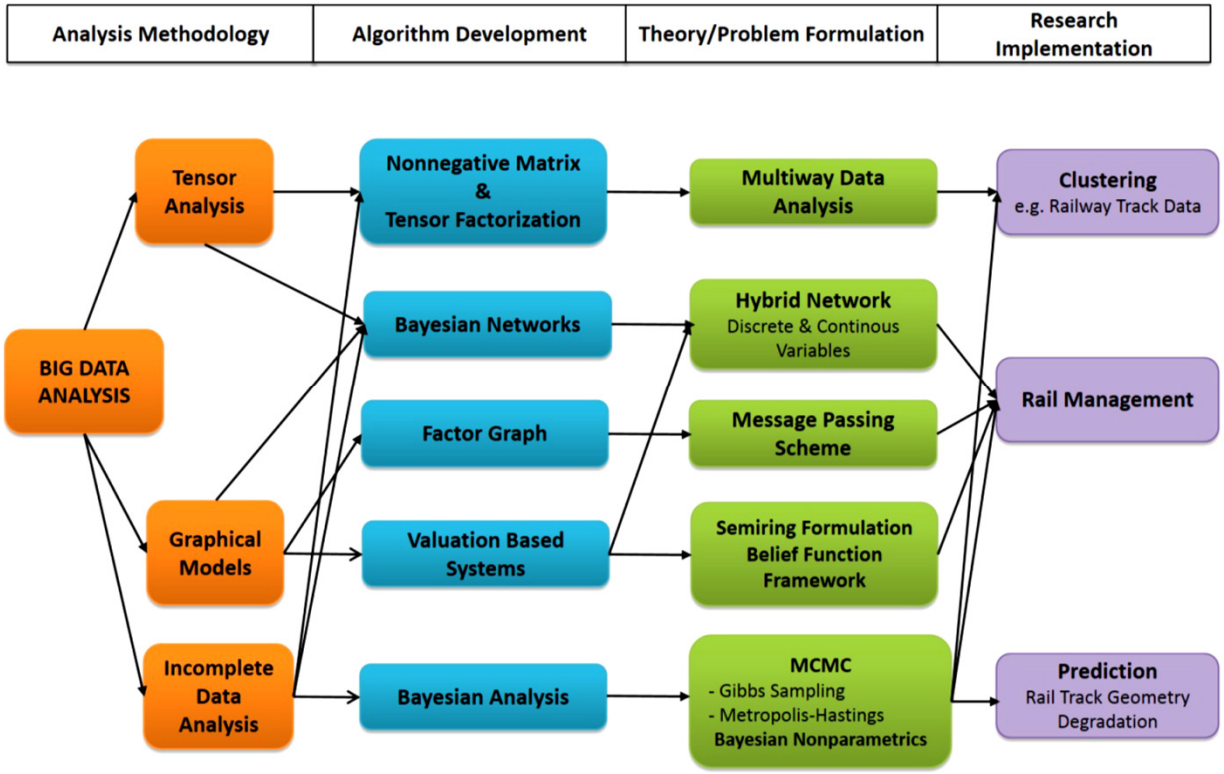
05

Adoption of new technologies

Data Techniques in the maintenance plan

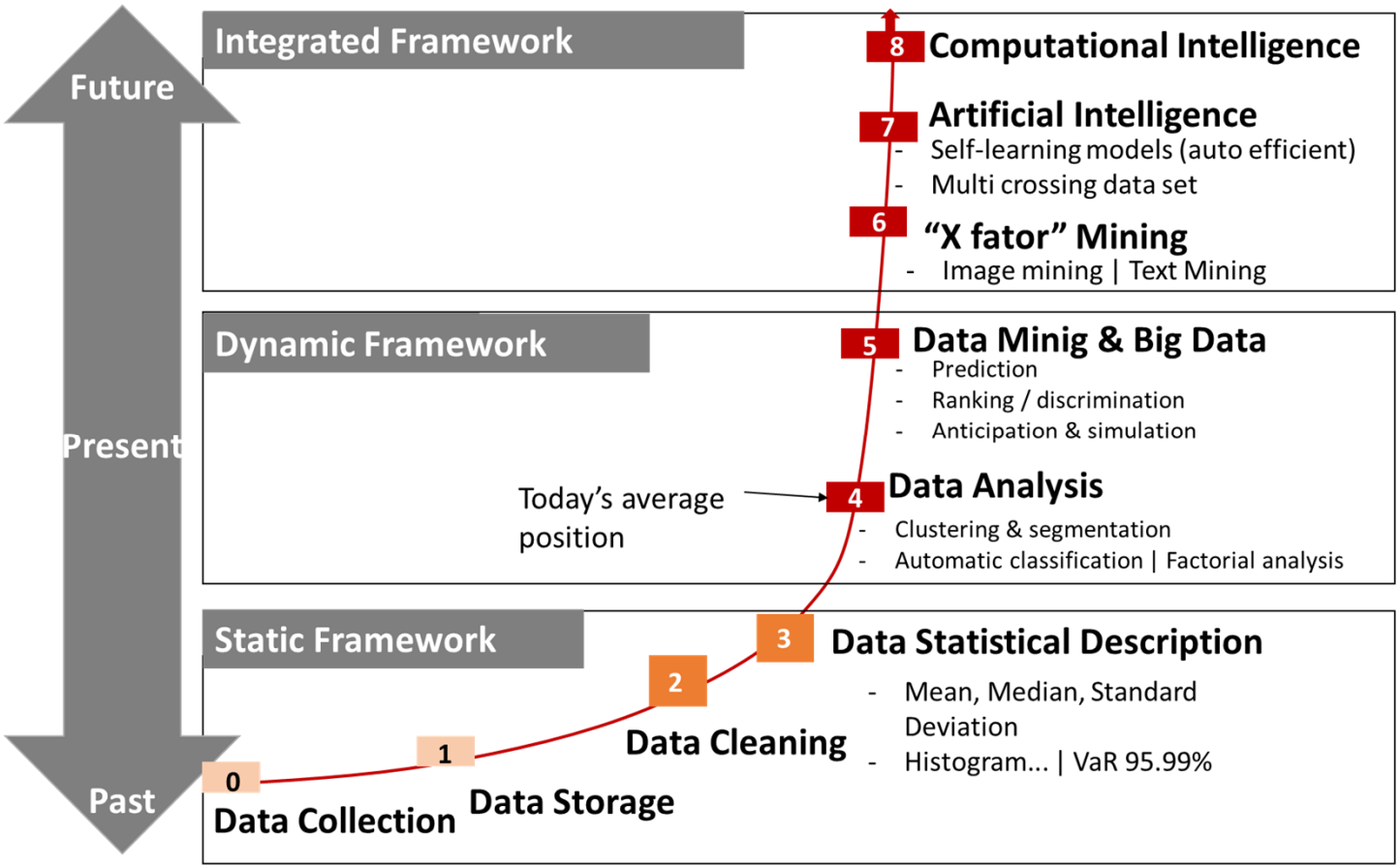


Look beyond our own domain expertise to improve the analysis



Example of Big Data (Nii Attoh-Okine 2019)

Big Data and forms of data processing



Example of Big Data
(Nii Attoh-Okine 2019)

Data processing in MRS (now)





DATA LAKE

Azure

ASSET MANAGEMENT PLATFORM

VISIOSTACK

- ANALYSIS TOOL
- SEGMENTATION
- DATA ALIGNMENT PROCESS
- FILTER DATA: AUTOMATED FILTERING METHODS (MACHINE LEARNING)
- SELECT REPORTABLE EVENTS AND DEFINE APPROPRIATED THRESHOLDS
- IDENTIFY PEAKS
- GENERATE LIST OF EVENTS
- REPORT AND ACTION PLAN

ACTION PLAN

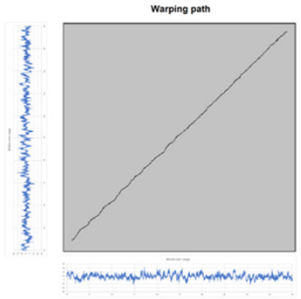
SAP

The same analysis that took 2 days, now takes 10 minutes

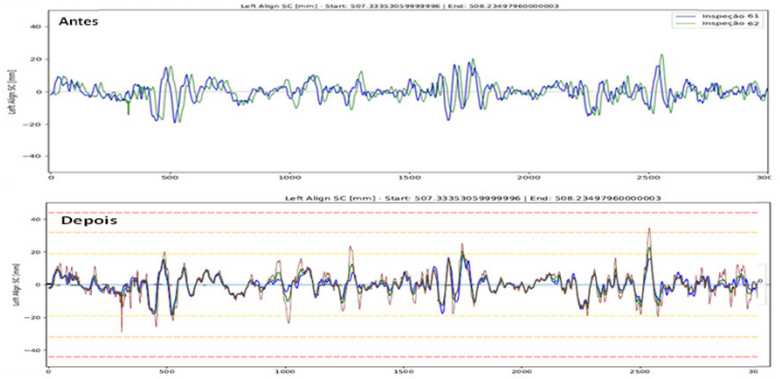
Data lake, not swamp!

Application of Data Analytics

Project of correlating different inspection technologies to identify the most suitable maintenance plan to reduce track failures.



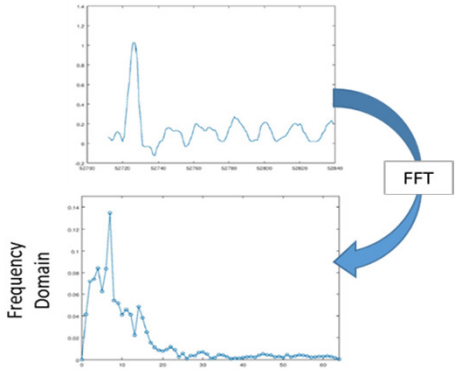
- Data processing improvements
- Agility to align inspections
- Improve analysis capacity and use most of the available data

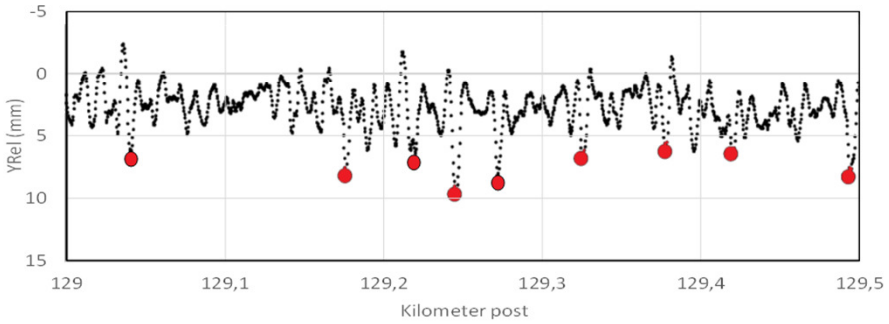


Example of data alignment

Evaluation of individual data signature

Example of mud spot affecting profile

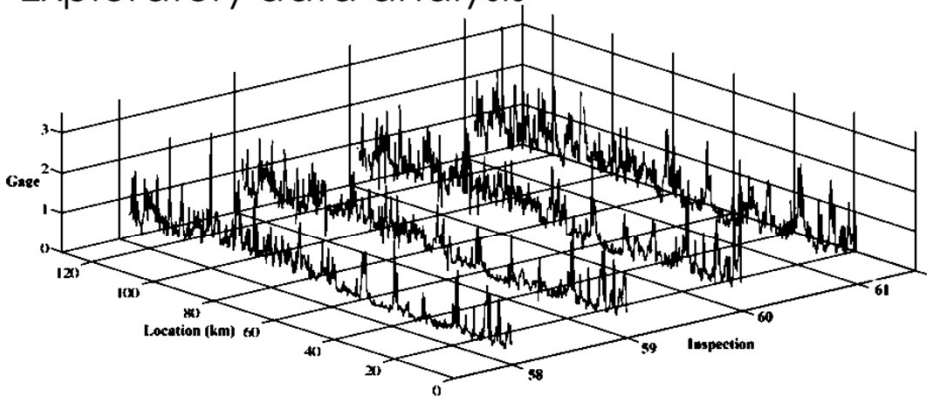


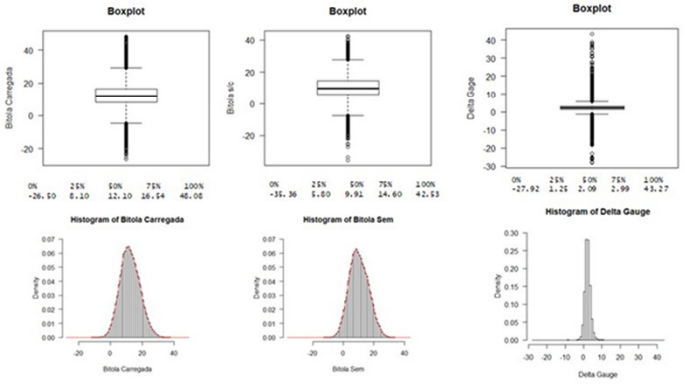


Mud spot signature identification over 500m

Degradation analysis

Exploratory data analysis

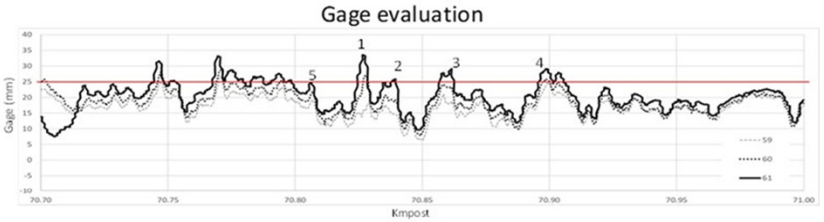


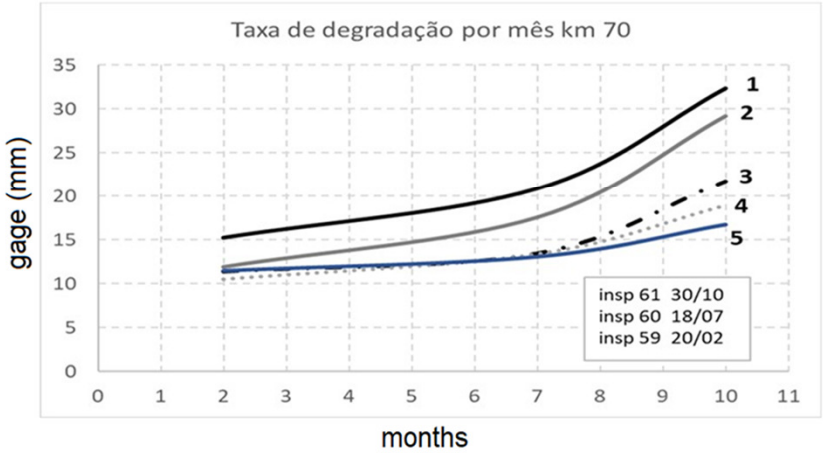


km		Feet	
Min.	:503.7	Min.	: 0
1st Qu.	:530.3	1st Qu.	: 798
Median	:557.4	Median	:1600
Mean	:557.3	Mean	:1603
3rd Qu.	:584.3	3rd Qu.	:2403
Max.	:611.1	Max.	:3524

Bitola Sem		Bitola Carregada	
Min.	:-35.36	Min.	:-26.50
1st Qu.	: 5.80	1st Qu.	: 8.10
Median	: 9.91	Median	: 12.10
Mean	: 10.25	Mean	: 12.41
3rd Qu.	: 14.60	3rd Qu.	: 16.54
Max.	: 42.53	Max.	: 48.08

Degradation evaluation

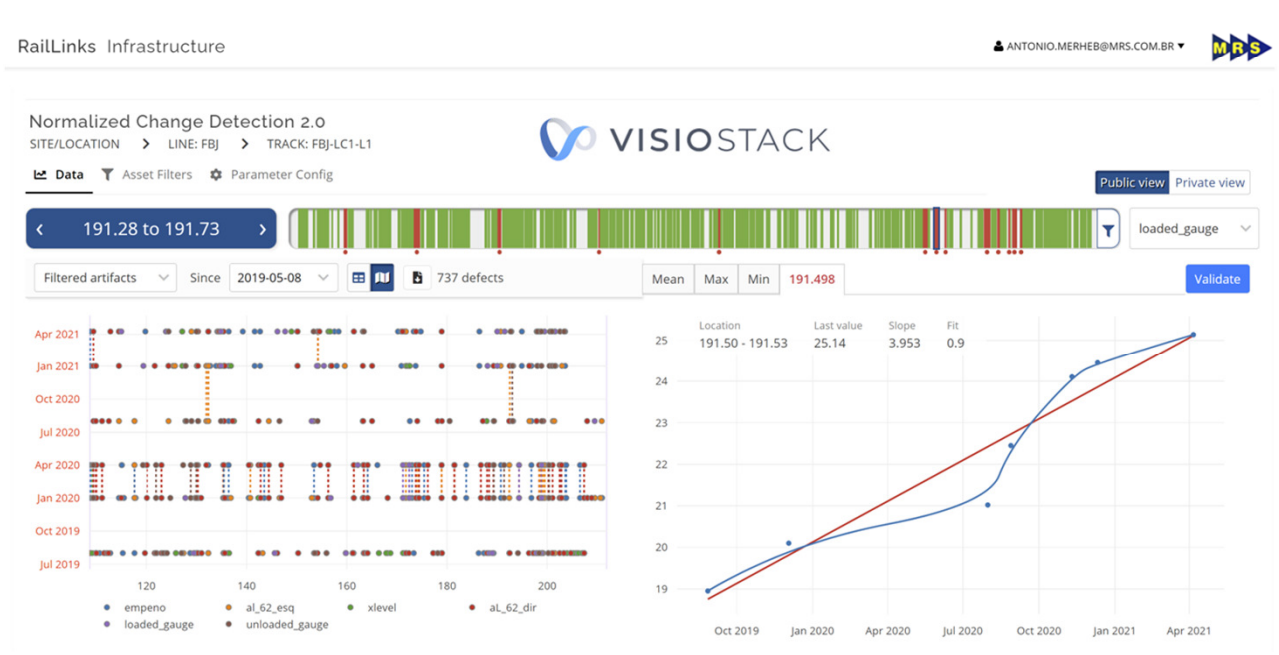


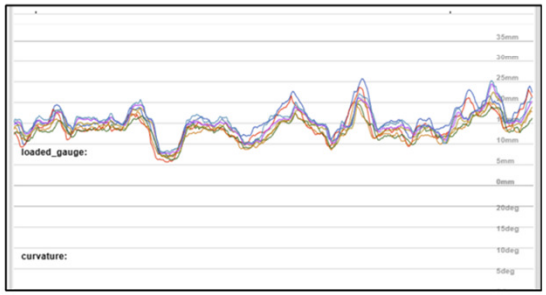


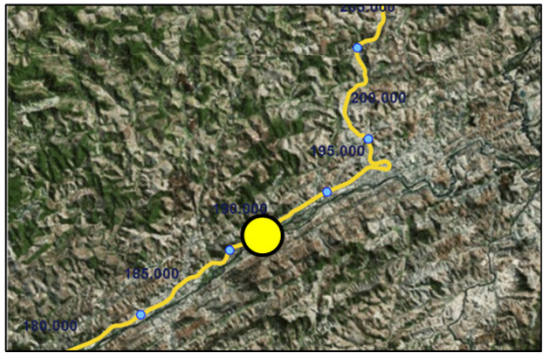
Predictive Maintenance

Interactive reporting framework to run scenarios on future network use and fine-tune renewal and replacement strategies.

Can optimize where critical maintenance assets should be used by prioritizing work.

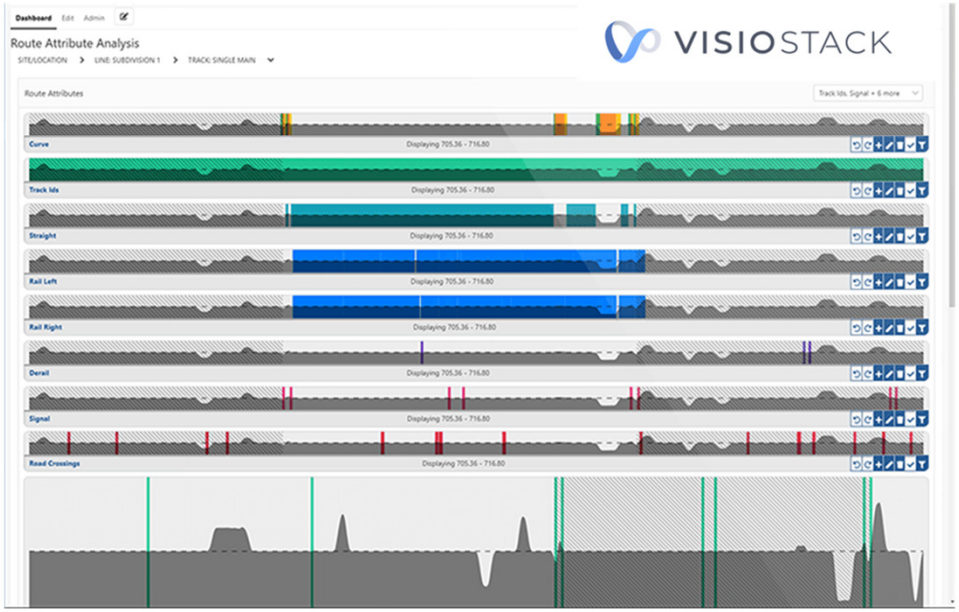






Predictive Maintenance

The system provides a modern approach to configuring, editing, maintaining and visualizing railway assets. Also provides tools to supplement and fill in asset attributes.



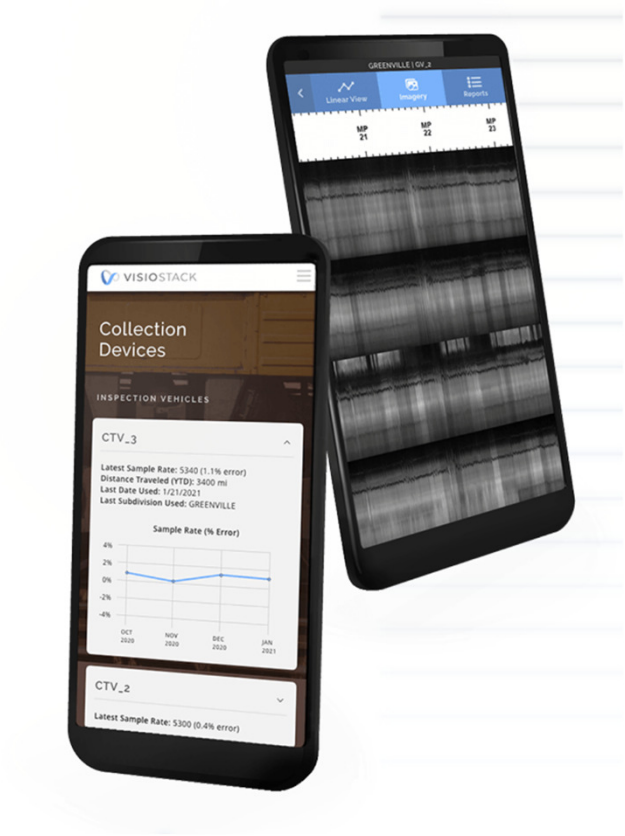
This will help us invest the correct amount of money, at the correct location, at the correct time.

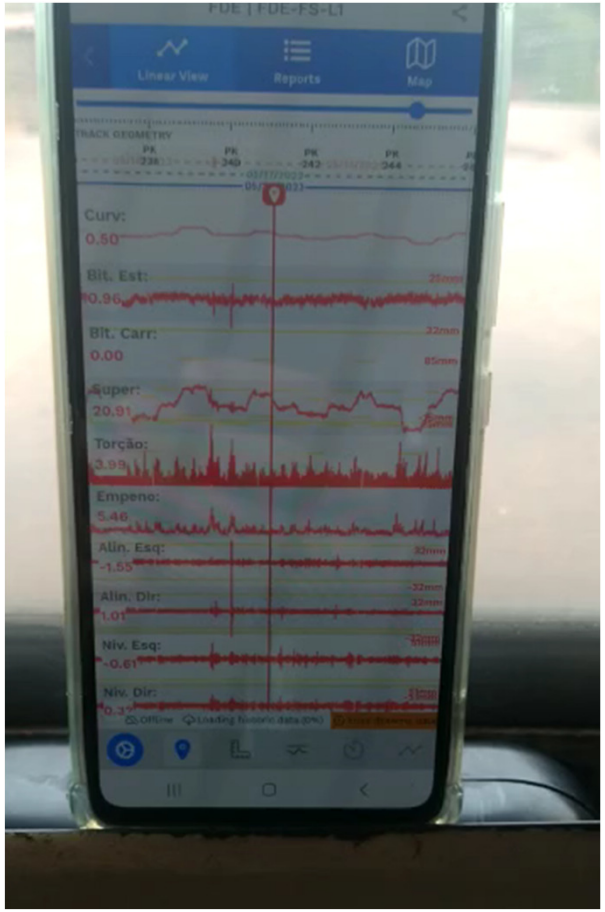
Track maintenance budget savings for 2022 of up to 6%

MRS started the utilization in June 2020

… converting the "Mountain" of data collected into effective maintenance planning information with agility.

Predictive Maintenance





DIGITAL RAILWAY

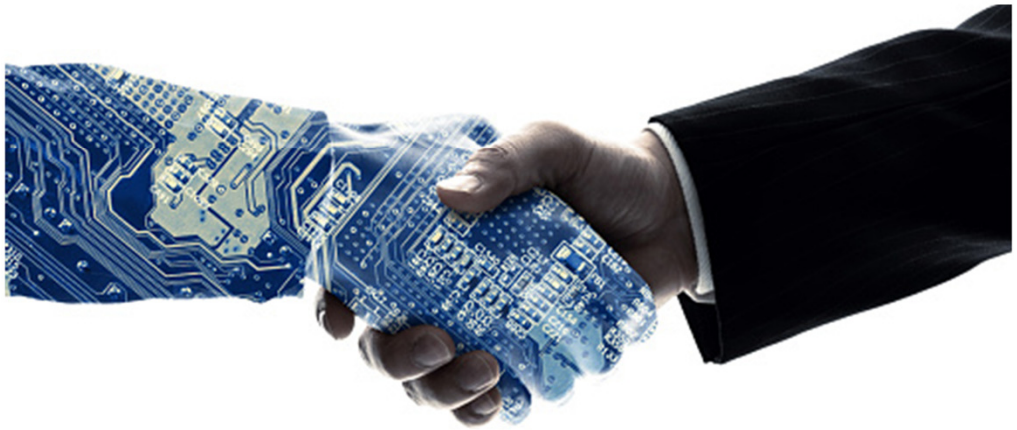
Improved asset sustainability (lower whole life costs)

Better performance for passengers and freight customers

Faster journey times

Increased capacity to keep pace with demand

Improves safety



Conclusion

… think not only on initial costs, but in long term evaluation.

… improve the track and rolling stock quality to control the dynamic forces.

… find the root cause of the problem and address the correct action.

… take full advantage of the data available to transform this potential in information.

… converting the "Mountain" of data collected into effective maintenance planning information with agility.

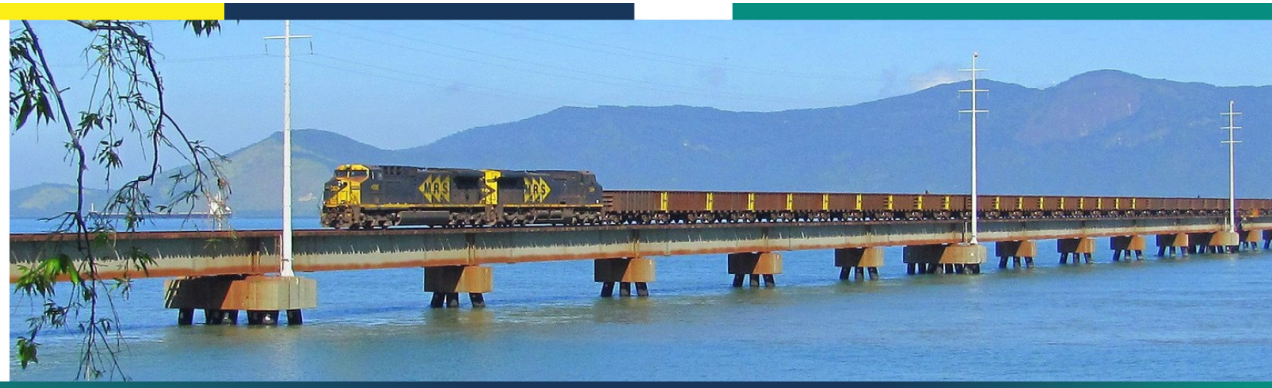
These will lead any rail HH system to achieve a sustainable asset management, minimize track maintenance costs and promote high reliability systems.

IHHA RIO 2023

12th INTERNATIONAL HEAVY HAUL CONFERENCE

27 – 31 August 2023
Rio de Janeiro, Brazil

Windsor Convention & Expo Centre



Application of Heavy Haul Innovations for a Sustainable World

Registration is Now Open!

For More Info Please Visit www.ihhario2023.com

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IHHA Conference program

Day 1 27 August (Sunday)	Day 2 28 August (Monday)	Day 3 29 August (Tuesday)	Day 4 30 August (Wednesday)	Day 5 31 August (Thursday)	Day 6 01 September (Friday)
REGISTRATION: Workshop & Conference	WORKSHOP Heavy Haul Best Practices & Technologies	REGISTRATION Conference	Plenary Session	Plenary Session	TECHNICAL TOUR
			Tea break	Tea break	
WORKSHOP Heavy Haul Best Practices & Technologies			Parallel Sessions	Parallel Sessions	
			Lunch	Lunch	
		Opening Plenary	Parallel Sessions	Parallel Sessions	
		Tea Break	Tea Break	Tea Break	
	REGISTRATION Conference	Plenary Session	Parallel Sessions	Closing Plenary	
		Welcome Cocktail (18h00 – 20h00)	Brazilian Dinner (19h30 – 22h30)	Farewell Cocktail (18h00 – 20h00)	
	Welcome Event (19h00 – 22h00) Sugar Loaf Mountain	Board Dinner (20:00 – 22:00)			

See you in Rio de Janeiro!


Thank you!