

Friction Management on *Emova* metro network

Practical Experiences in the Use of Friction Modifiers.



RAIL TRANSIT SEMINAR • JUNE 21

Emova 

WRI 2022

Buenos Aires Metro network

2

Agenda

- Presentation, Introduction and Context
- Case Study: E line
- Case Study: H line
- Q&A



Buenos Aires Metro

- A**
Plaza de Mayo
San Pedrito
- B**
L. N. Alem
J. M. de Rosas
- C**
Retiro
Constitución
- D**
Catedral
C. de Tucumán
- E**
Bolivar
Retiro
- H**
Fac. de Derecho
Hospitales

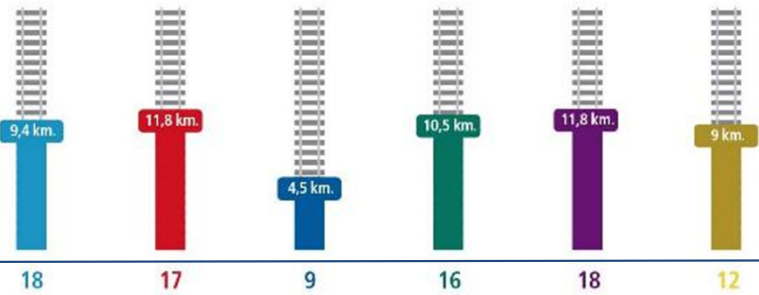
6 Lines



120 Trains
for service



1.245.000
Daily passengers
pre pandemic



100%
Underground
56,7 km Length
12 Workshops

90 Stations



RAIL TRANSIT SEMINAR • JUNE 21



WRI 2022

WRI - Cases of study



Line

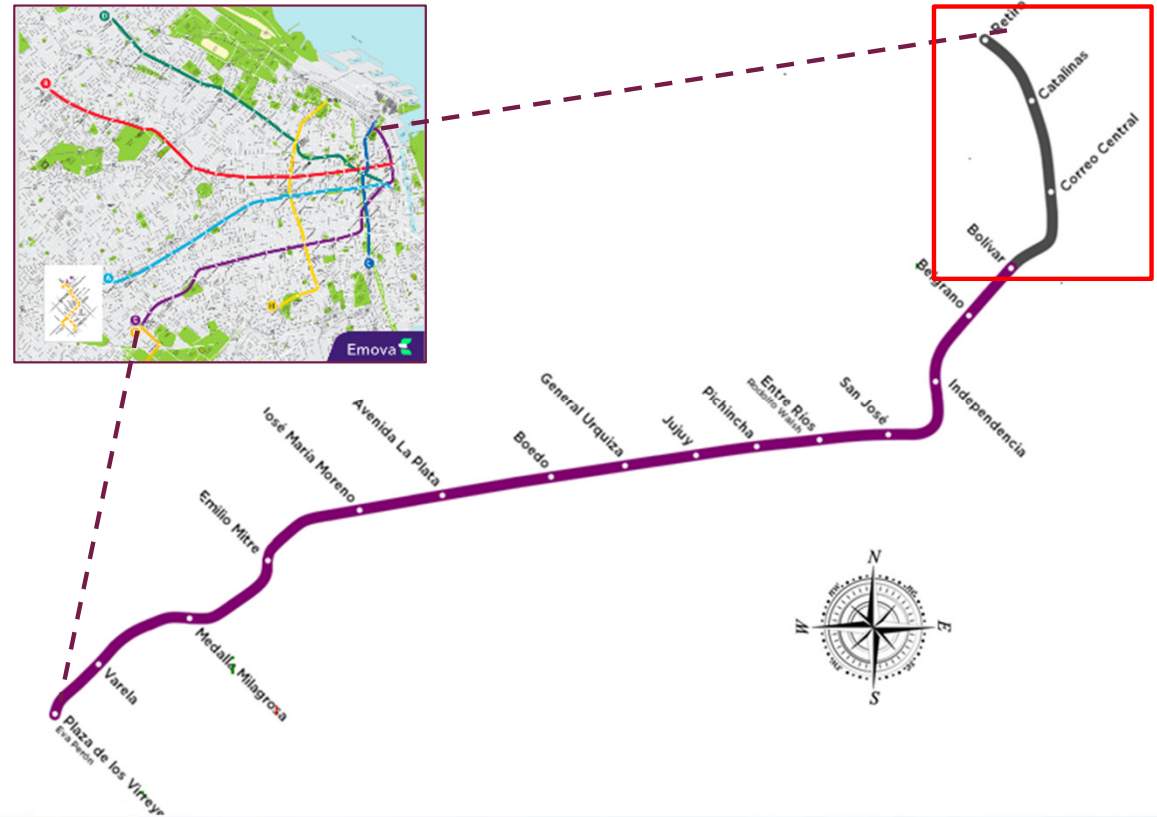


Line



E Line Case - General

1. **11,8Km** Total Length
2. **85K** Daily Passengers (2019)
3. **Total Track Renewal** (2017-2019)
4. **2 Km** Extension (2019)
5. Signalling system: **ATP**
6. **20 trains** for operation



E Line Case - Rolling Stock

FIAT-Materfer (80's)

- H type Bogie + Bolster Bearing
- 2,25m wheelbase distance
- Helicoidal spring 1° Suspension
- Air Spring 2° Suspension
- 1 Longitudinal TM per Bogie
- ORE S1002 Wheel Profile
- Mass per Car M **32.000kg** / R **23.100kg**



5 car Train configuration: Ma-Mb-Ma-T-Mb



E Line Case - Track Features

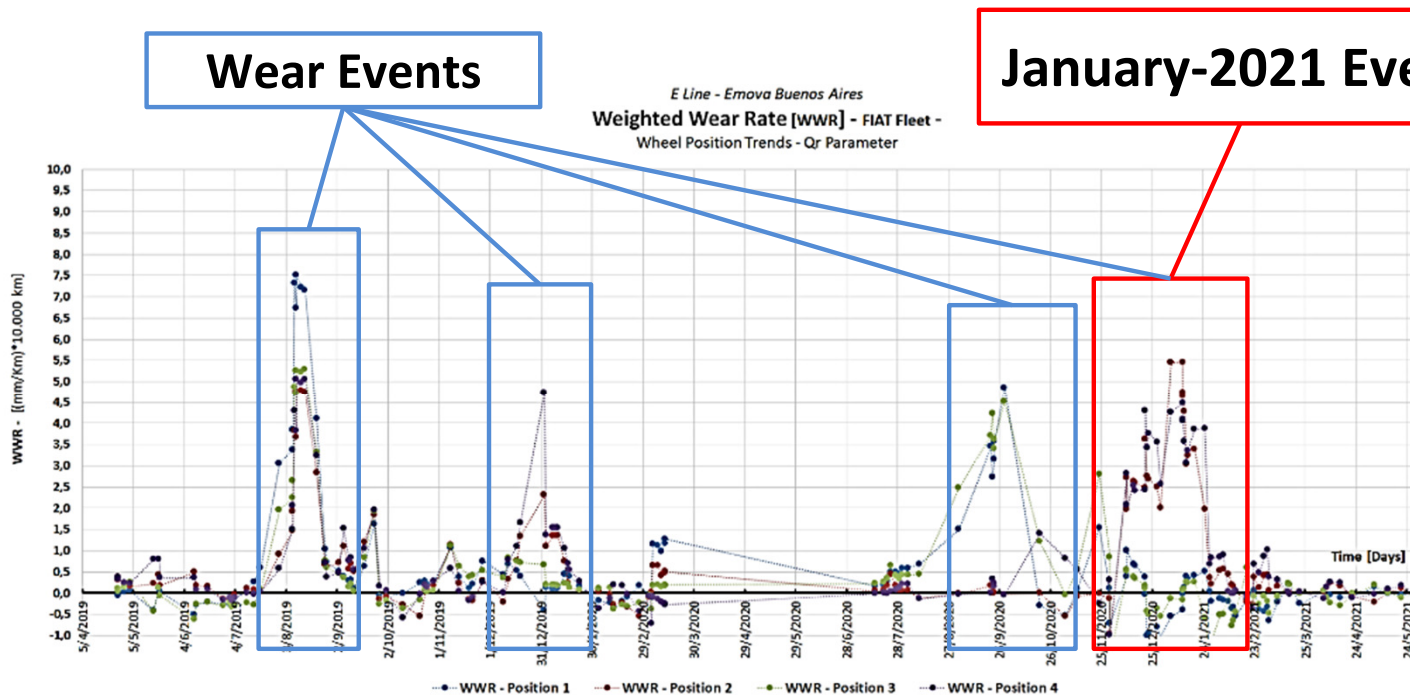


- **UIC54-E1** Rails
- **1:20** Rail Inclination
- **Bi-block concrete** sleeper
- **FastClip** fixation
- Mainly **Ballast** track
- WaySide **Gage Face Lubrication**
- WaySide **TOR FM** application
- Minimum Radius Curve: **190m**



E Line Case - Analysis

- Many **Wheel/Rail Wear Events** during track Renewal and Extension.

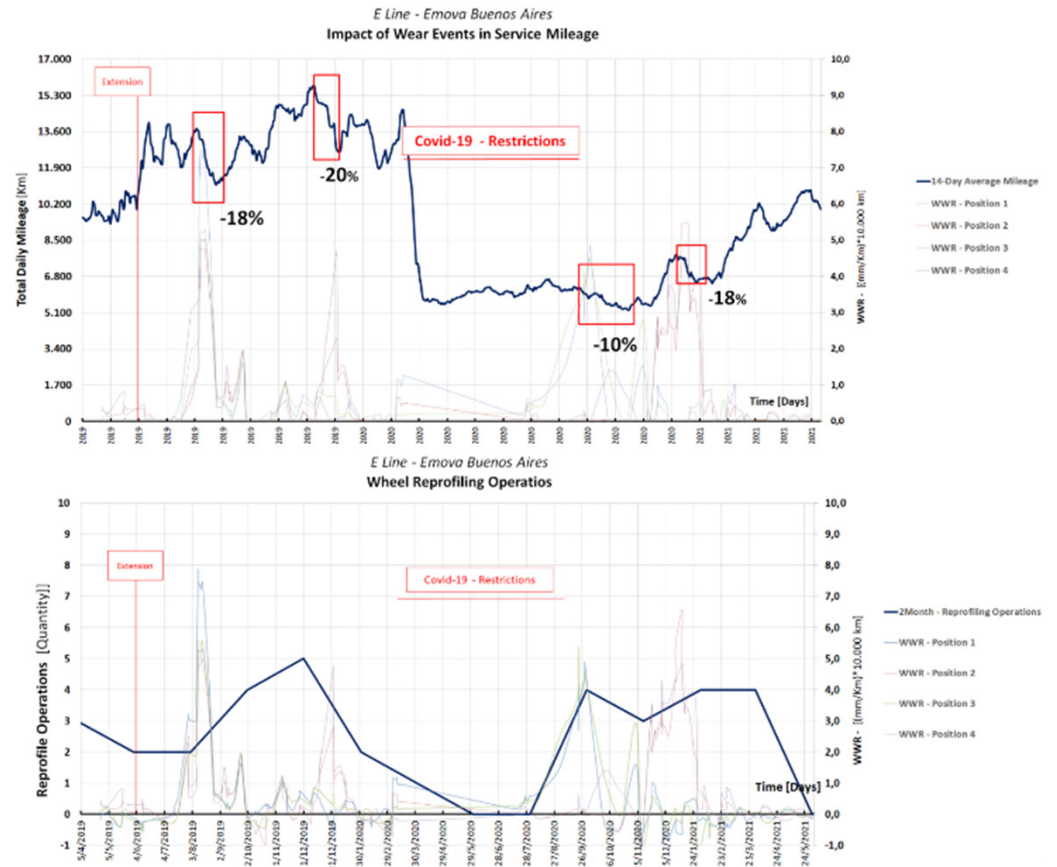


- Happens **unexpectedly**.
- Over a **sizeable population** of trains.
- Defined **Time gap**.



E Line Case - Analysis

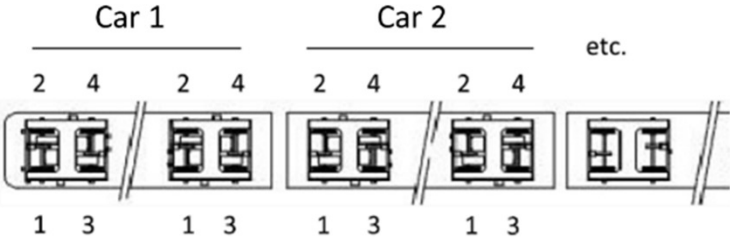
- Service Reduction
- Premature System Degradation
- Saturation of reprofiling operations
- Increase bogie and wheel Replacements
- Increase wheel purchase



E Line Case - Analysis

- Identification of **Wheel Position** and **Wear Pattern**

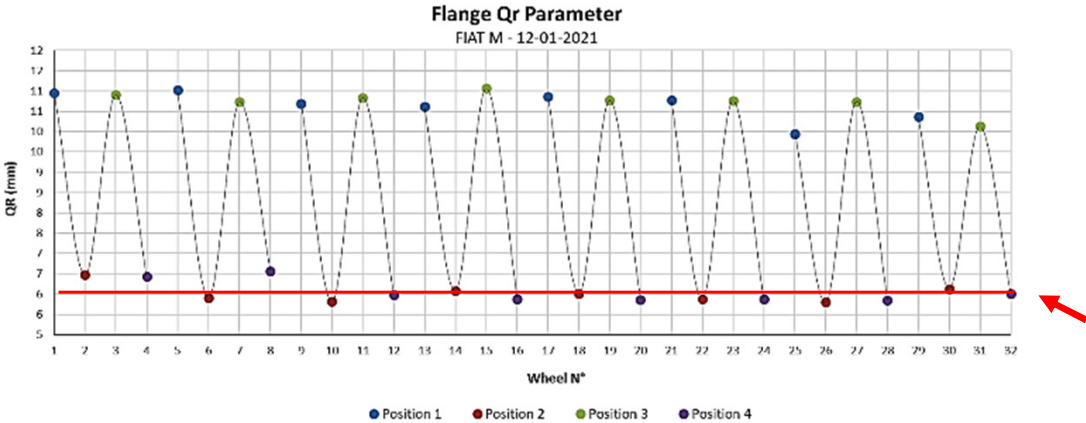
Model with 4 Wheel Position



Use of Wheel Qr parameter as reference.

Average of all values in the same relative position.

- Position 1
- Position 2
- Position 3
- Position 4

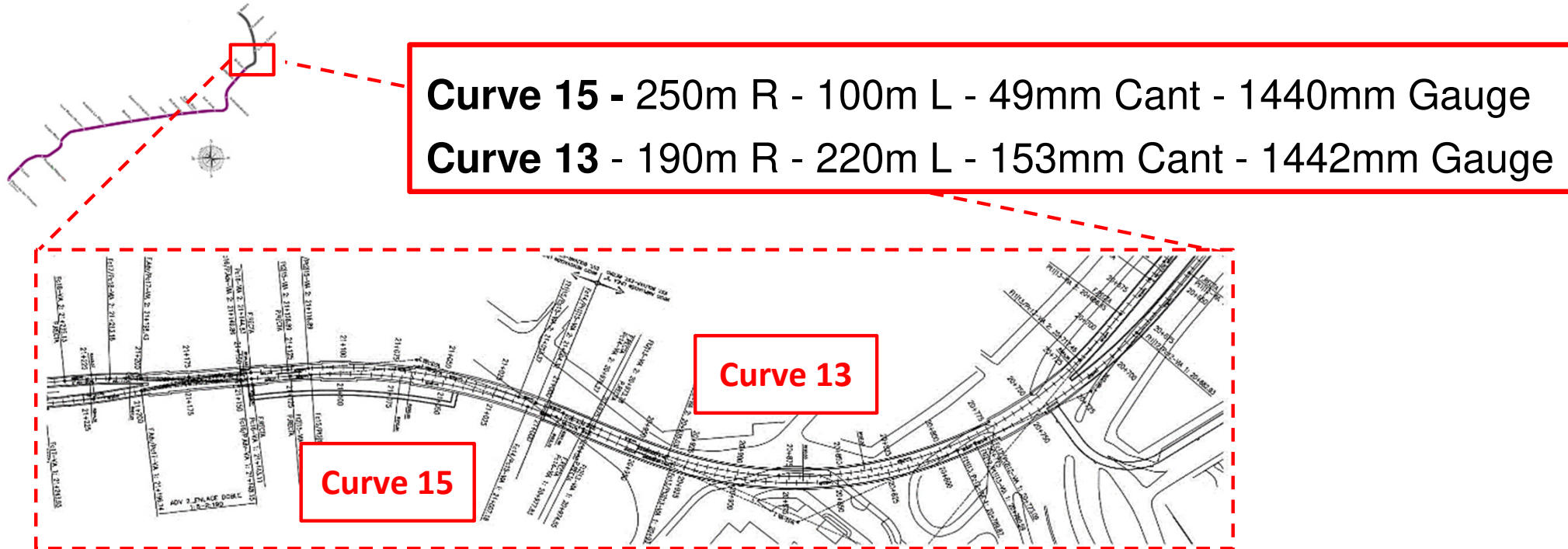


Lower Limit for Qr Parameter – 6,5mm



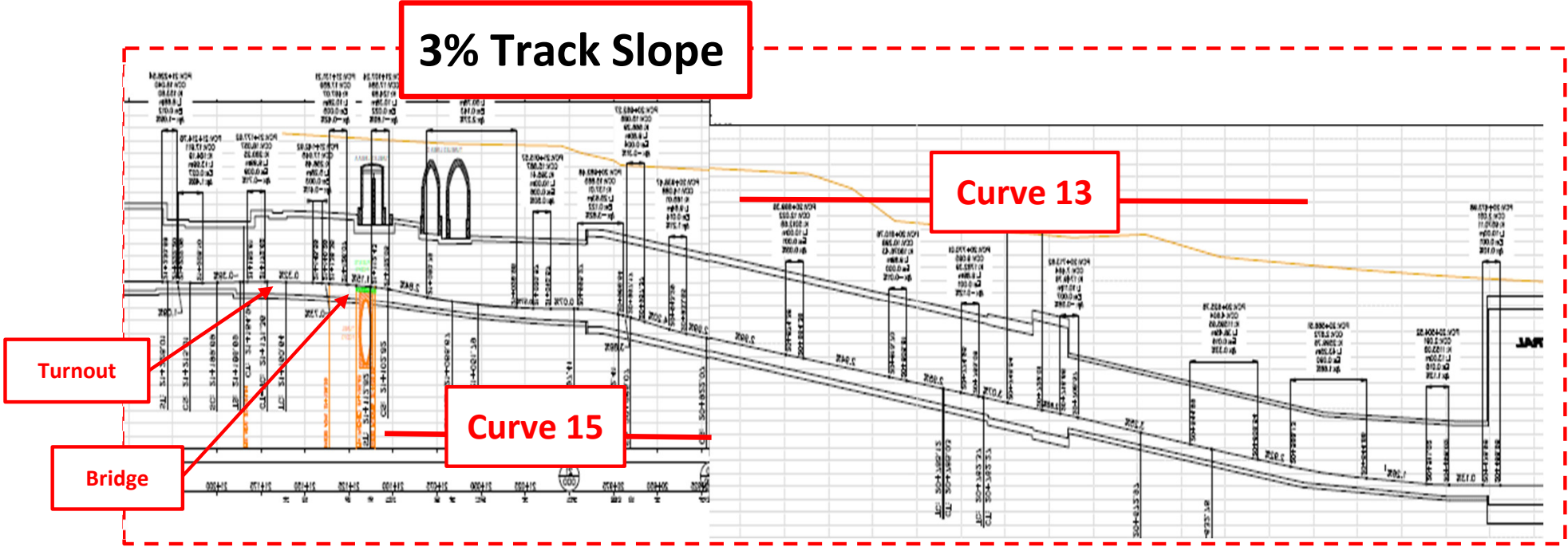
E Line Case - Analysis

- Track Measurements and Layout Analysis



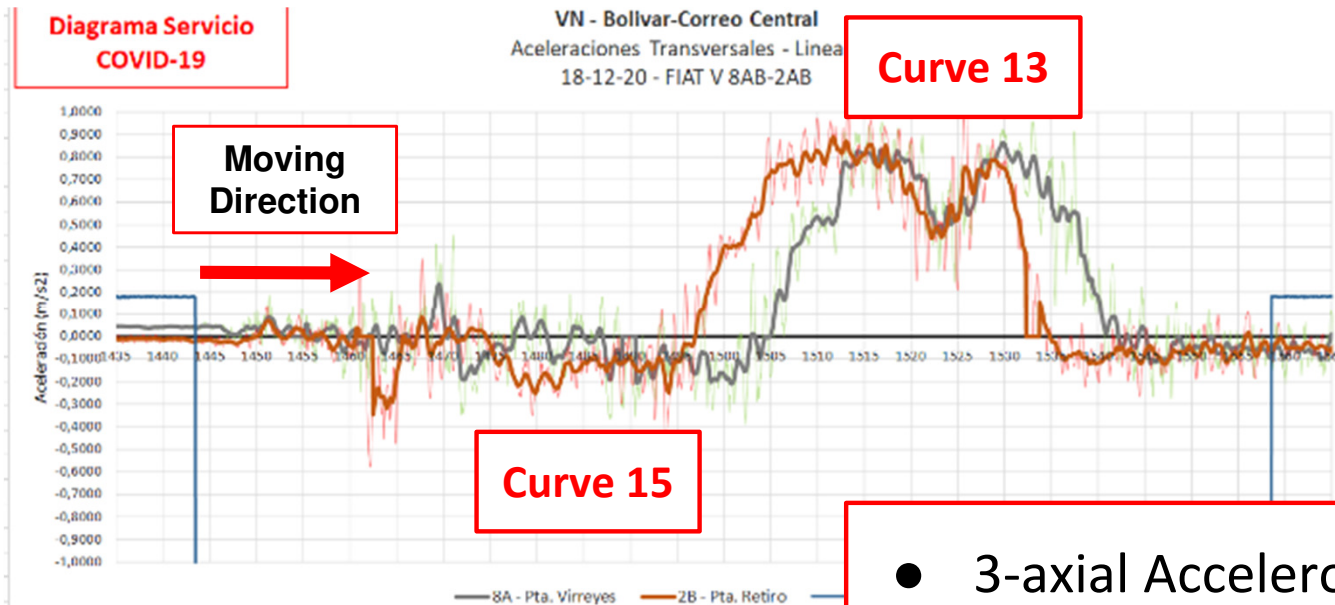
E Line Case - Analysis

- Track Measurements and Layout Analysis



E Line Case - Analysis

- Transversal Acceleration Mapping



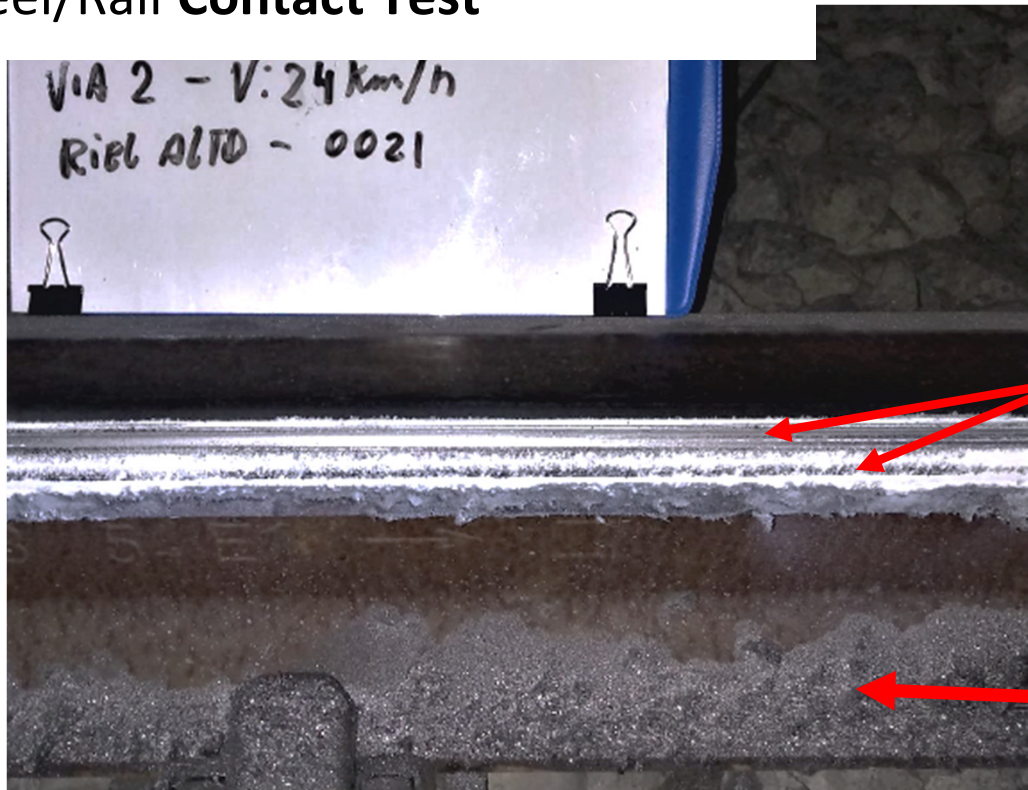
- Low Speed
- Track Cant Excess

- 3-axial Accelerometers, one each cab.
- Commercial Speed Mapping.



E Line Case - Analysis

- Wheel/Rail Contact Test



Curve 15

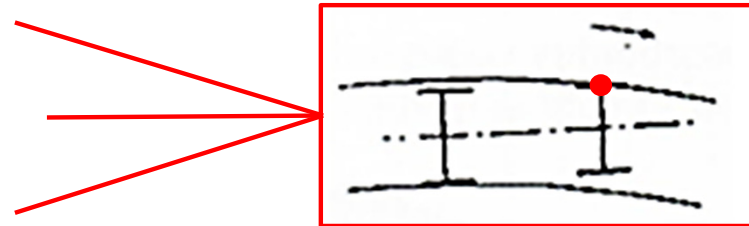
Gauge Corner Contact and
Flange Contact

Wear Debris



E Line Case - Analysis

- Low Speed, cant excess
- High Angle of Attack
- Forced condition Bogie in Curve



TOR Friction Management

- Reduce Lateral Force
- Reduce Angle of Attack
- Improve Bogie capabilities in low speed curve negotiation.



E Line Case - Analysis

- WaySide TOR-FM Installation

TOR-FM
Equipment
Location

Moving
Direction



E Line Case - Analysis

- Wheel/Rail Contact Test

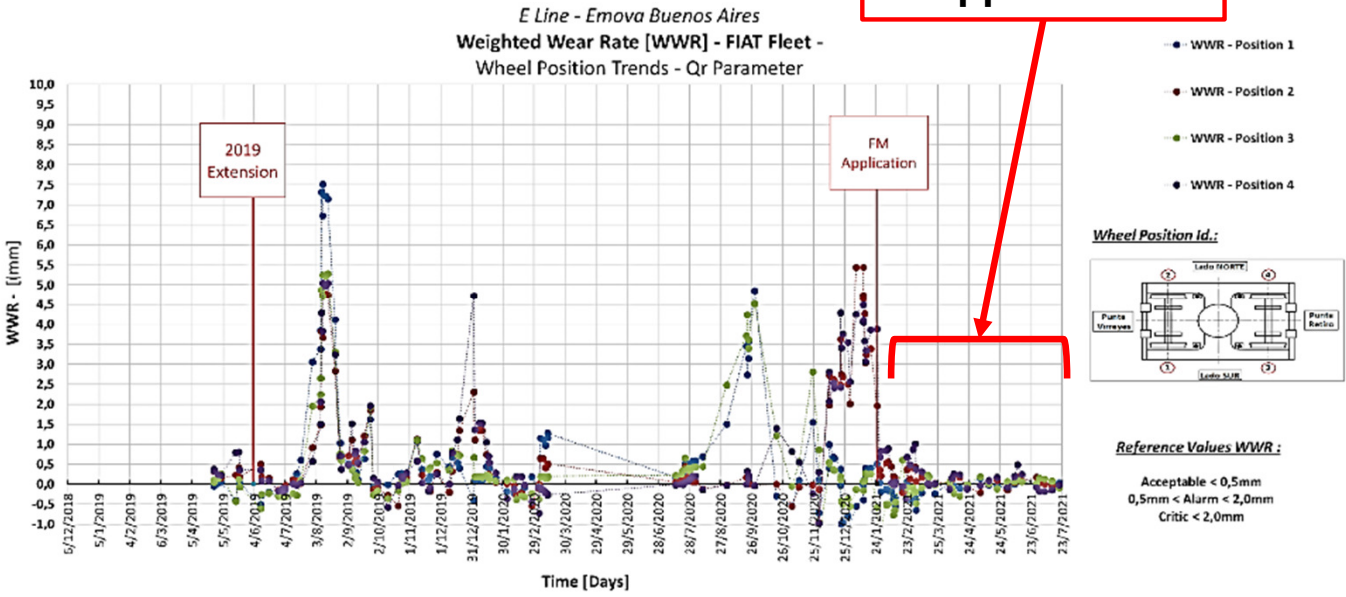


Before and After FM application



E Line Case - Analysis

- Wheel Wear Monitoring.



Wear Evolution Post FM application

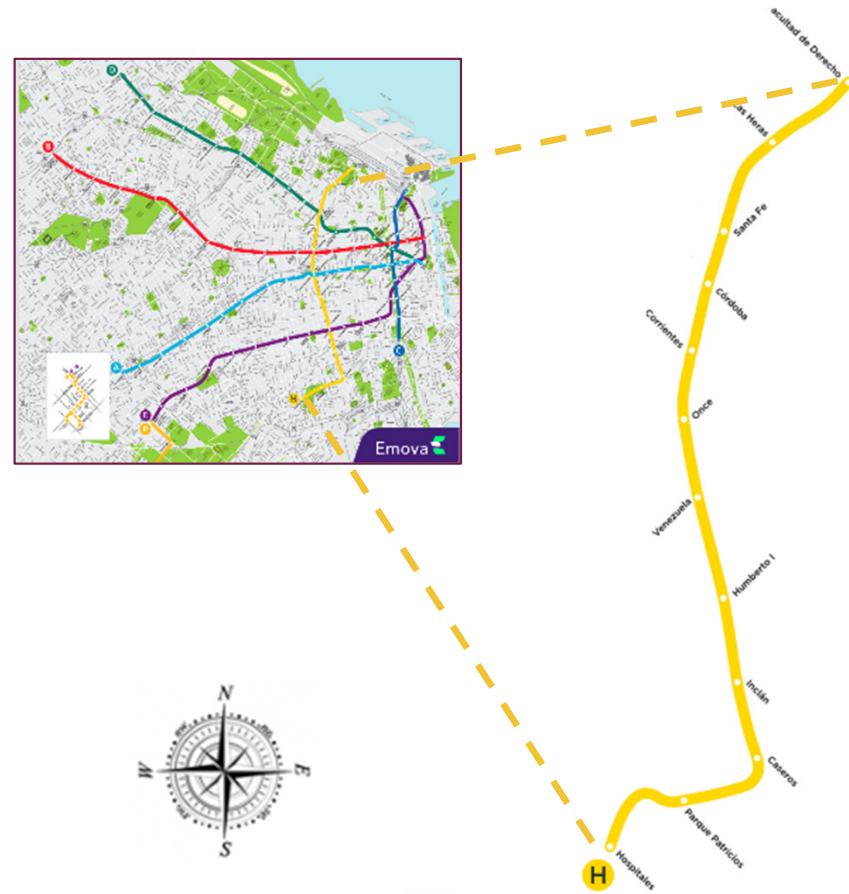
Successfully Strategy

- Controlled Event
- Wheel Wear Trends to zero.



H Line Case - General

1. **9 Km** Total Length
2. **125.000** Daily Passengers (2019)
3. Signalling system **CBTC GoA2.**
4. **15 Trains** for operation



H Line Case - Rolling Stock

Alstom Metropolis 300 series. (2015's)

- H-type **BolsterlessBogie**
- **2m wheelbase** distance
- **Rubber spring 1° Suspension**
- **Air Spring 2° Suspension**
- **2 TM** per Bogie
- **ORE S-1002** Wheel Profile
- Car Mass Rc **30.963 kg / M 32.412 kg**



Train configuration: **Tca-Ma-Mb-Mc-Md-Tcb**



RAIL TRANSIT SEMINAR • JUNE 21

Emova 

WRI 2022

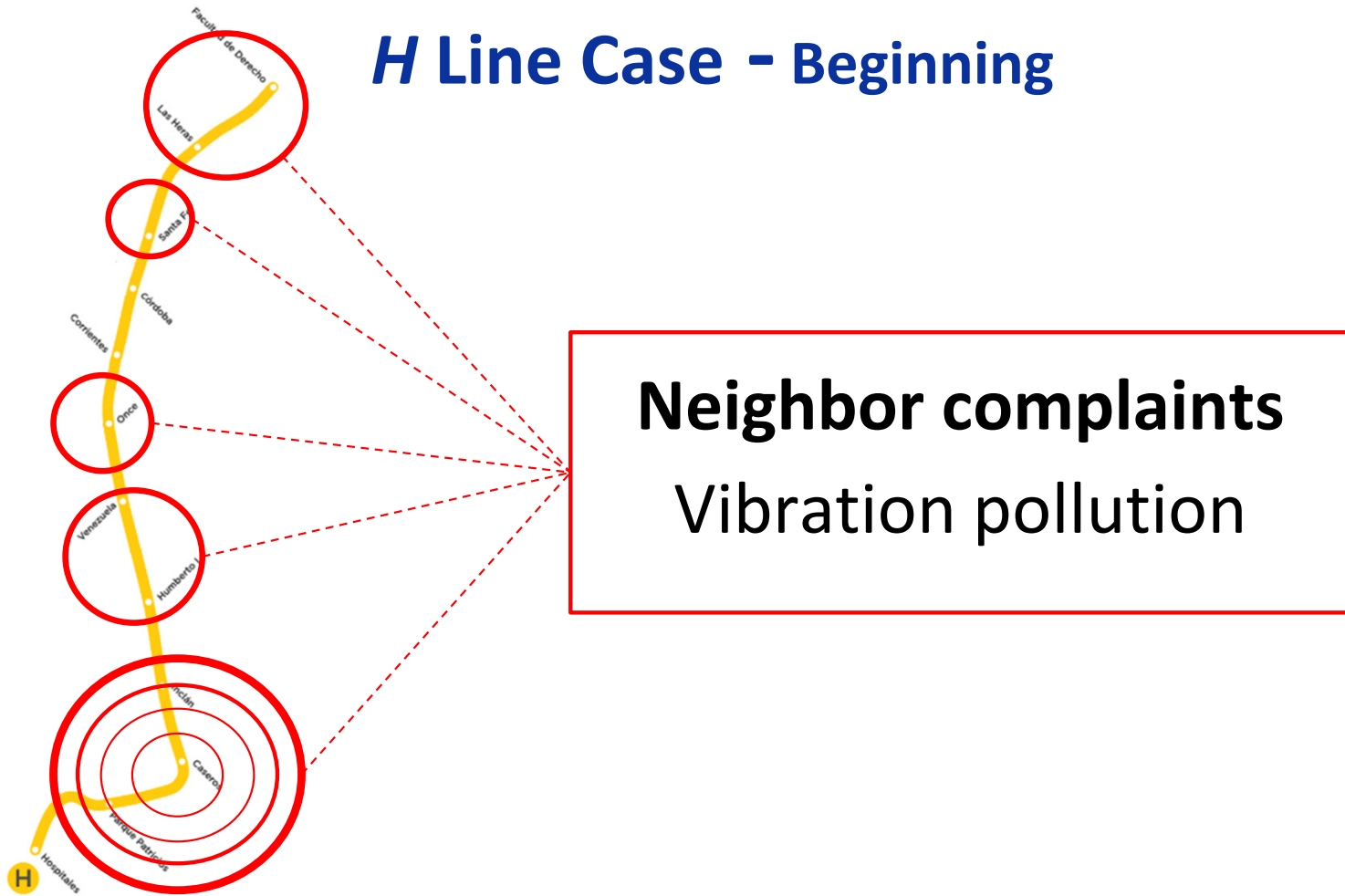
H Line Case - Track Features



- **UIC 54-E1 R260 / R350 Rails**
- **1:20 Rail inclination**
- **Bi-block concrete sleeper**
- **FastClip FC fixation**
- **Ballast subgrade**
- **WaySide Gage Face Lubrication**
- **WaySide TOR FM application**
- **Minimum Radius Curve: 119 m**
- **International gauge 1435 mm.**



H Line Case - Beginning



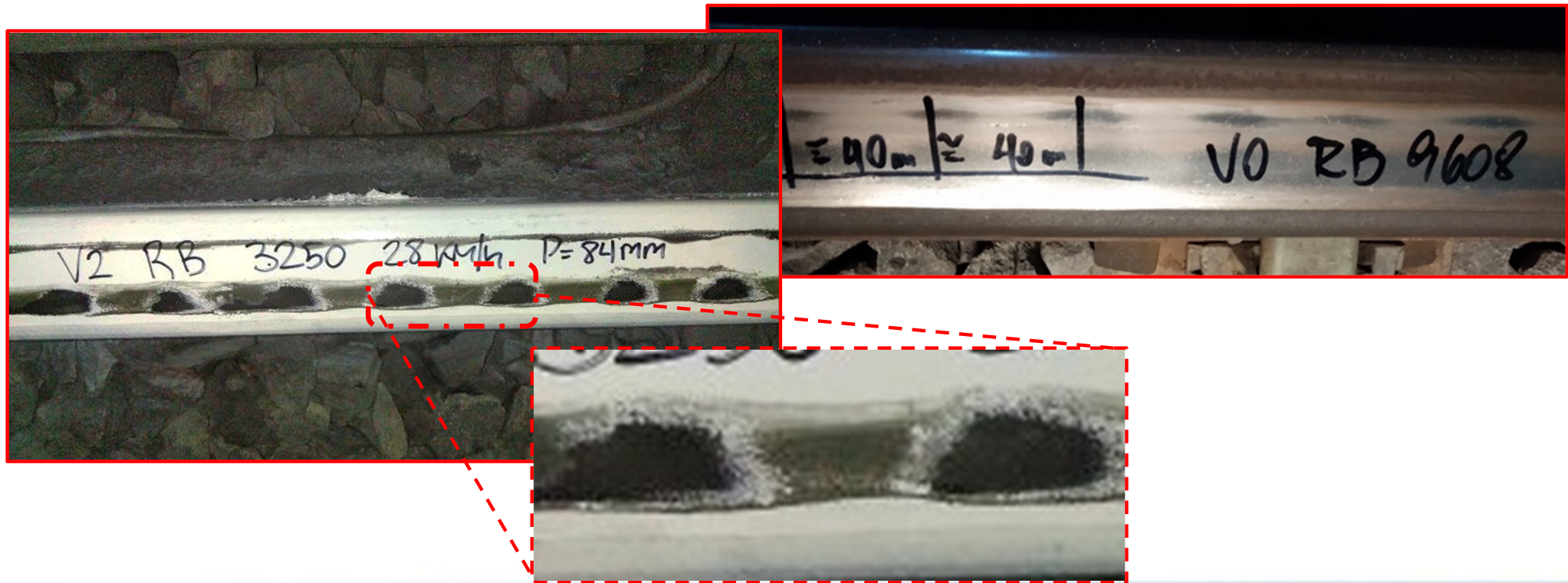
H Line Case - Field measurements

- **Visual inspection** of the track.
- **Wheelset parameters** measurements.
- **Vibration measurement and analysis.**
 - On infrastructure.
 - On rolling stock.
- **Transverse acceleration** mapping.



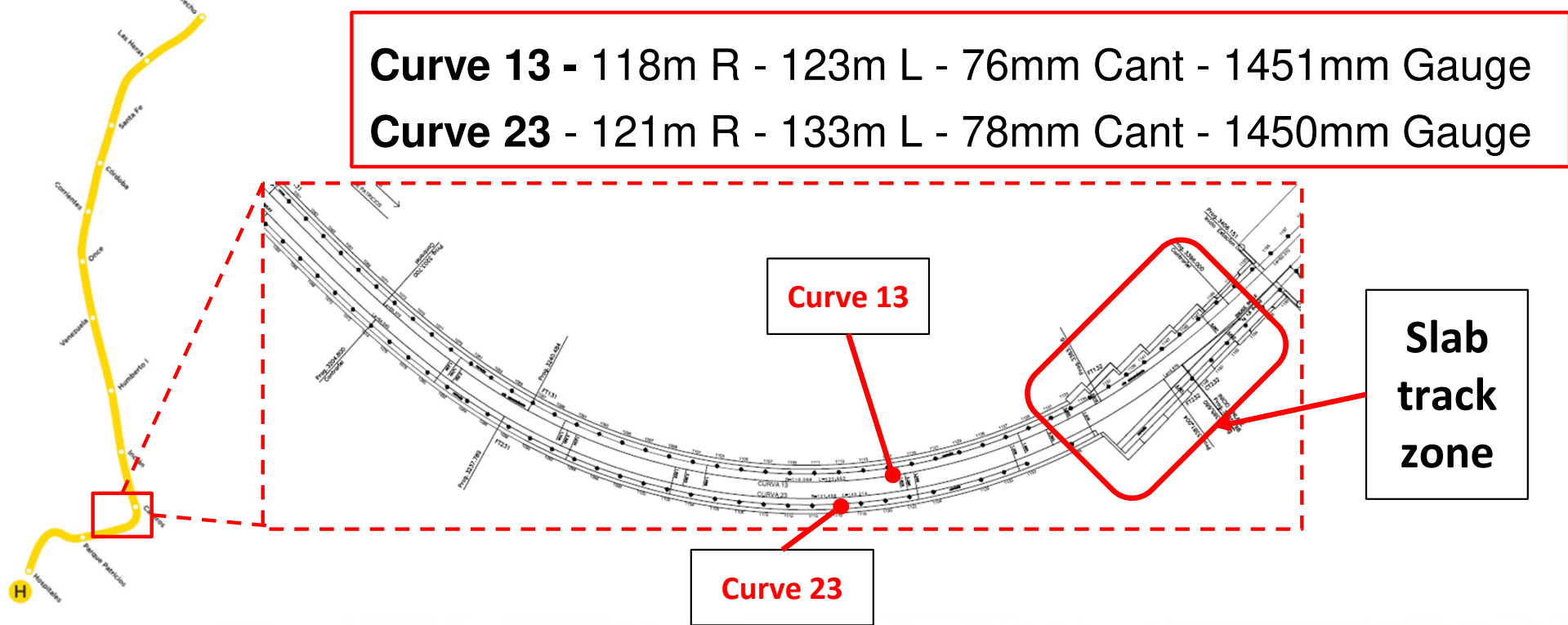
H Line Case - Field measurement

Track visual inspection - Low rail corrugation on curve



H Line Case - Analysis

Track Layout Analysis

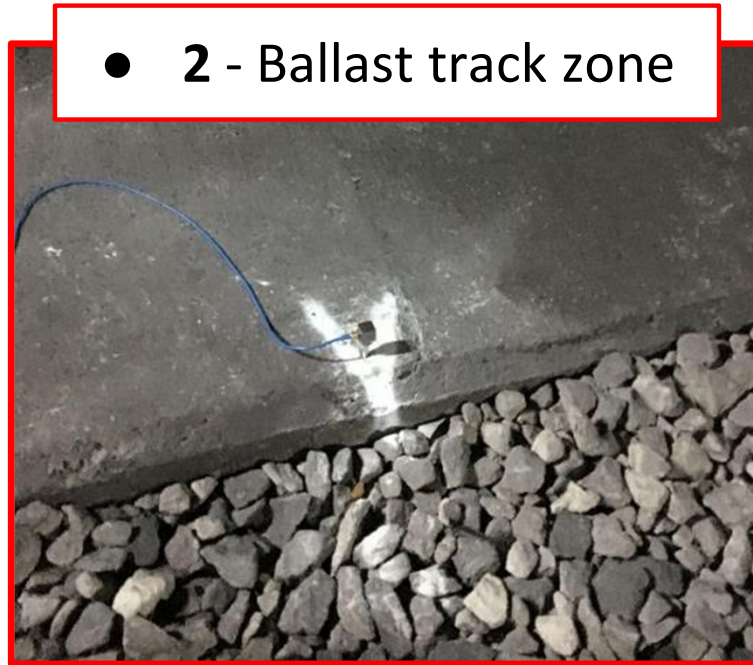


H Line Case - Vibration Analysis

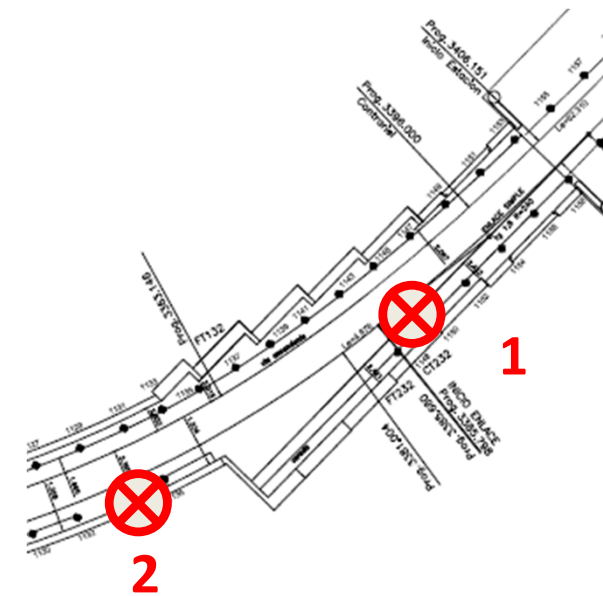
Infrastructure vibration measurements



● 1 - Slab track zone

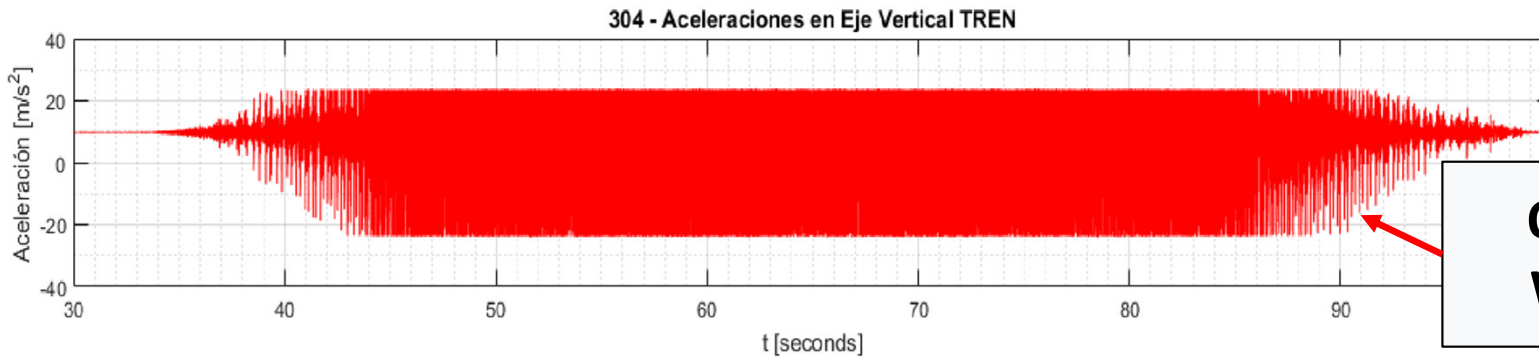


● 2 - Ballast track zone

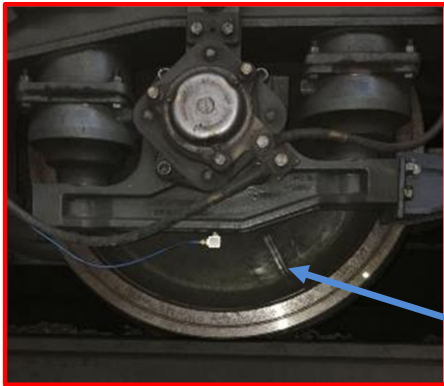


H Line Case - Vibration Analysis

Rolling stock vibration graphics

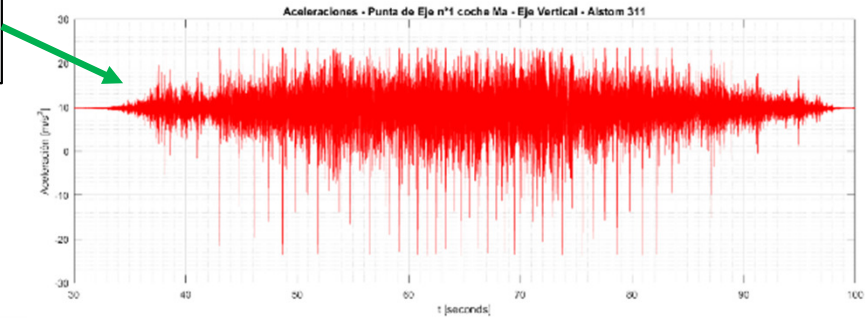


**Out of roundness
Wheel vibrations**



Normal vibrations

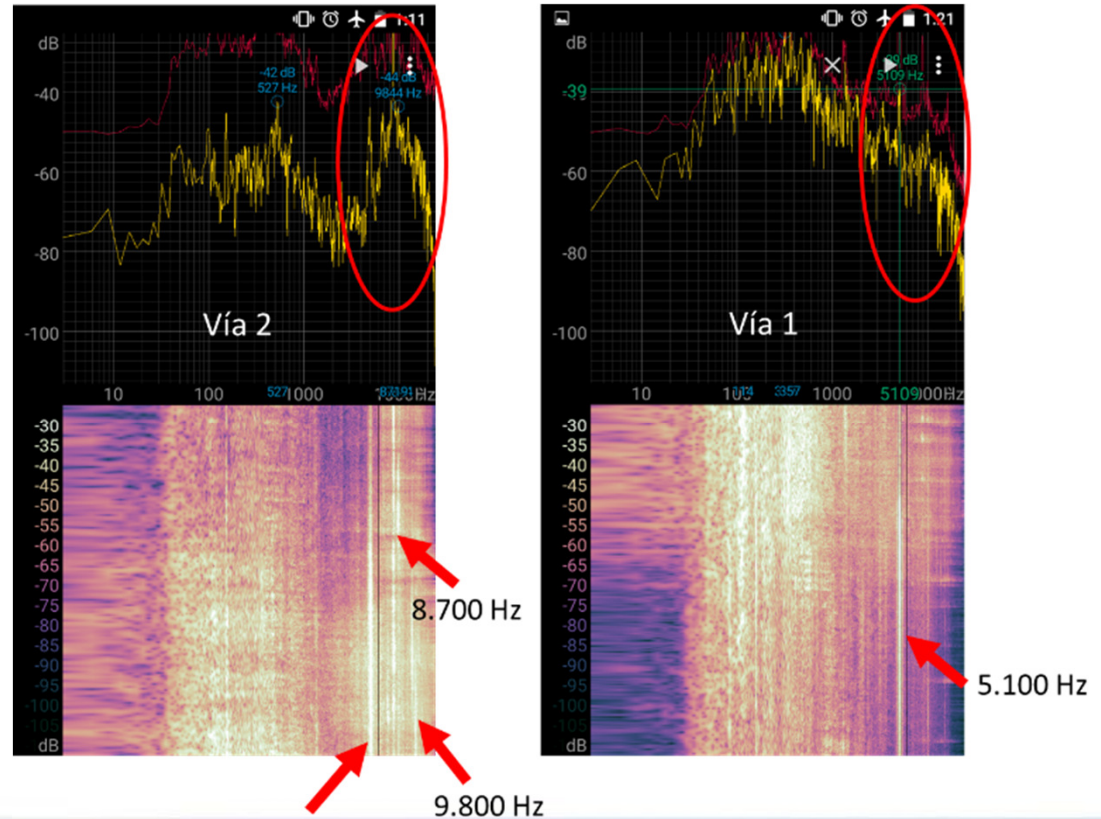
3-Axial Accelerometer



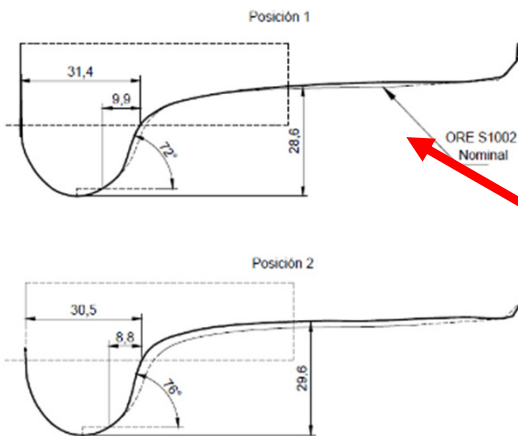
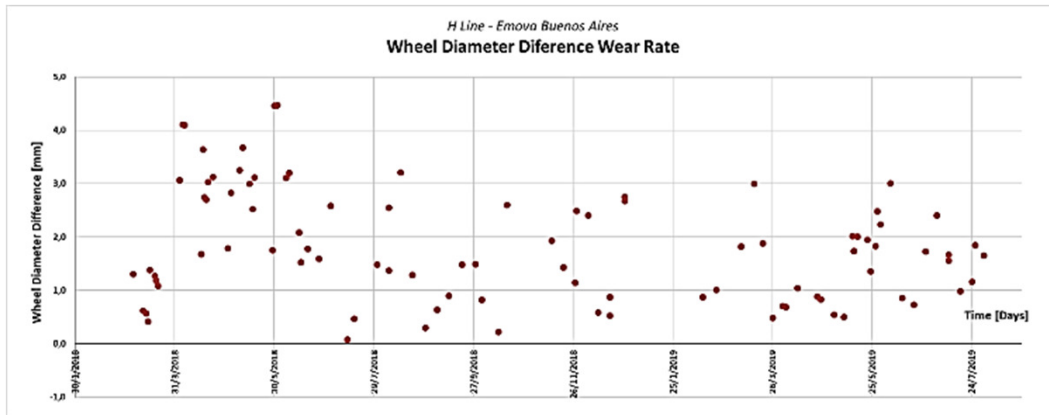
H Line Case - Noise emission

Initial noise measurement
on Patagones curve.

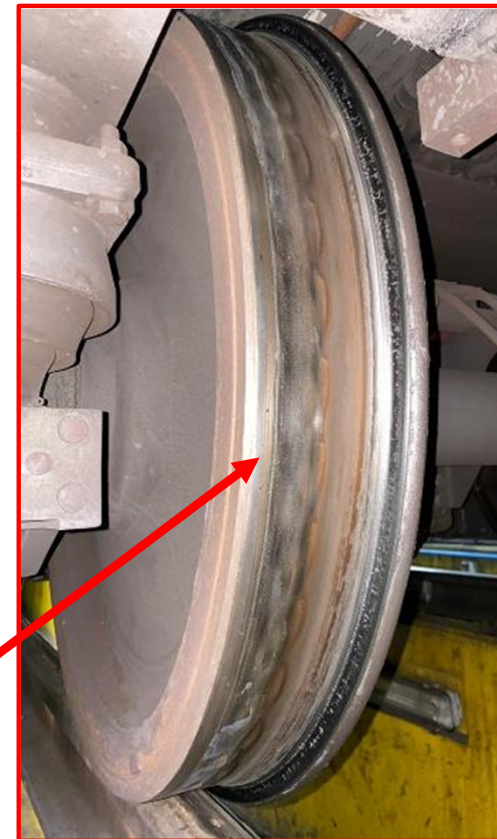
- Frequency spectrum.
- Time Duration.



H Line Case - Wheel parameters

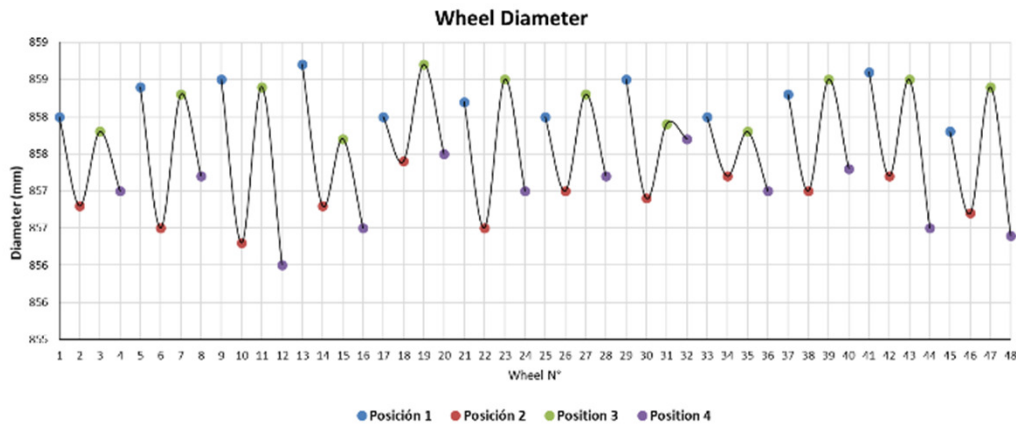
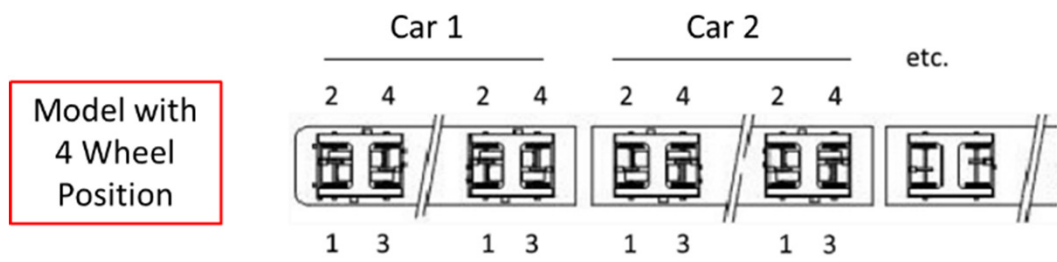


Wheels out of roundness and corrugation



H Line Case - Field measurement

Identification Wheel Position Damage

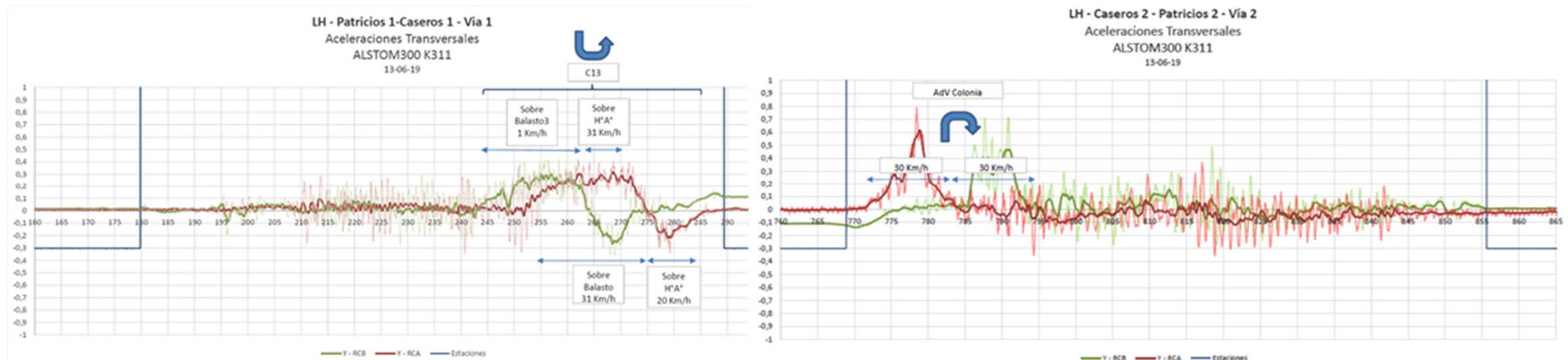


Wheel diameter average of all values in the same relative position.



H Line Case - Transverse acceleration mapping

Transversal Acceleration Mapping



- 2 (two) Tri-axial Accelerometers in both cab's
- Commercial Speed Mapping.



H Line Case - Hypothesis elaboration

Hypothesis elaboration.

1. Bibliography research.

2. Initial hypothesis of the phenomenon:

Rail/wheel corrugation ⇒ Wheel Out of roundness ⇒ Ground vibration

3. Possible solution:

Friction management, grinding rails, reprofile wheels.

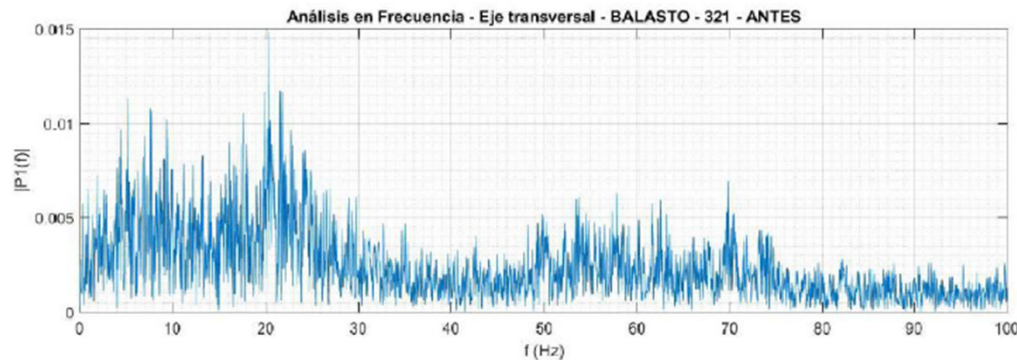
4. Confirmatory test: improvement achievement

Vibration and sound reduction, wheel wear reduction.

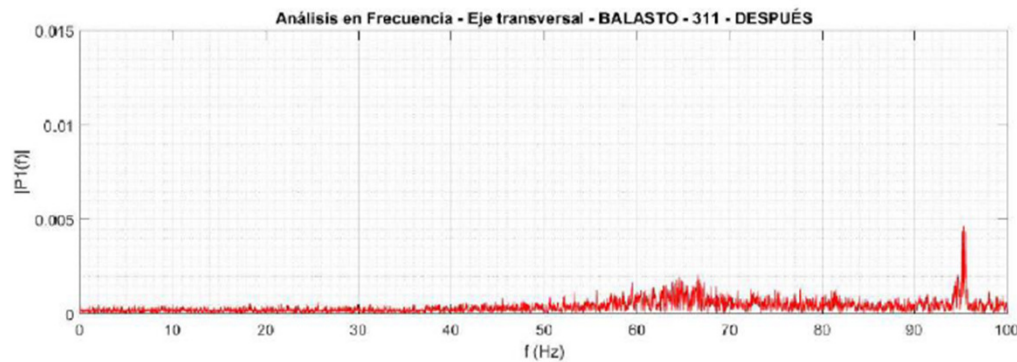


H Line Case - Confirmatory test

Post grinding rail vibration measurement.



Before grinding rail with good Wheels train. Ballast track



FFT post processing data

After grinding rail with good Wheels train. Ballast track



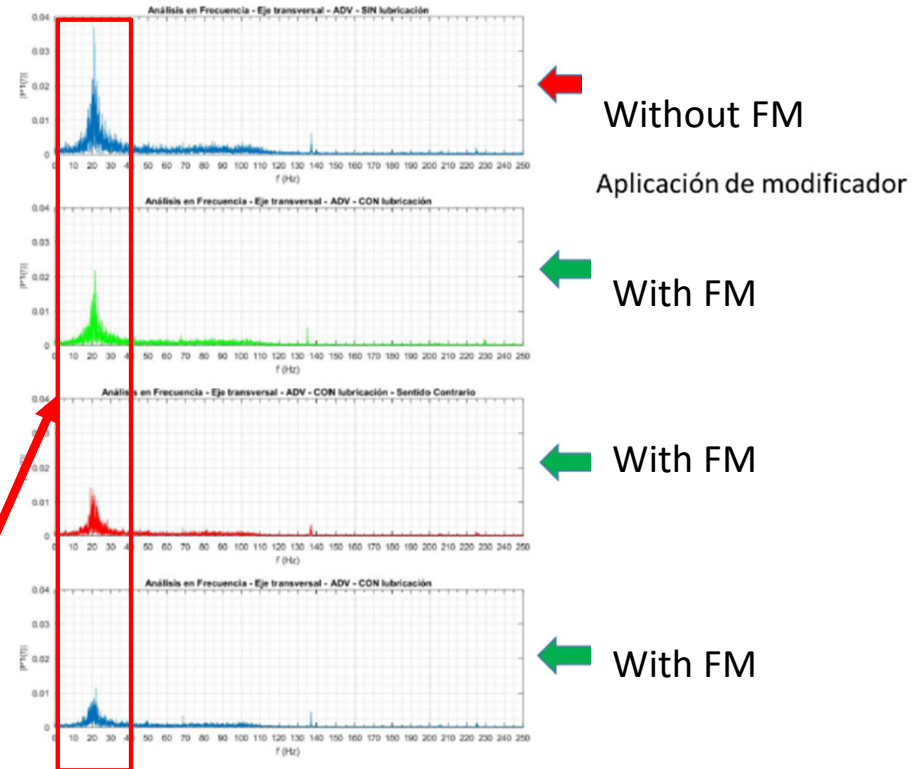
H Line Case - Confirmatory test

Friction Modifier - Track vibration measurement

Tri-axial accelerometer record

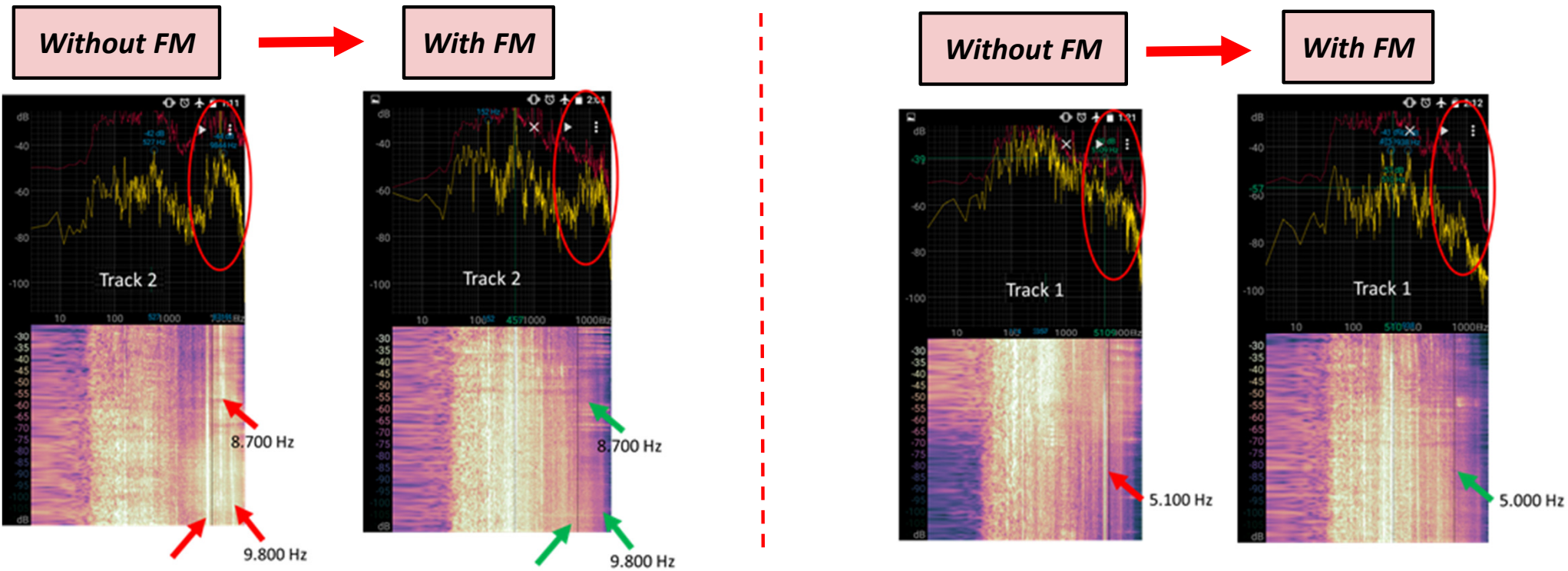
FFT post processing data.

Clear **vibration reduction** evidence.



H Line Case - Confirmatory test

Friction modifier - **Sound emission** - Noise reduction



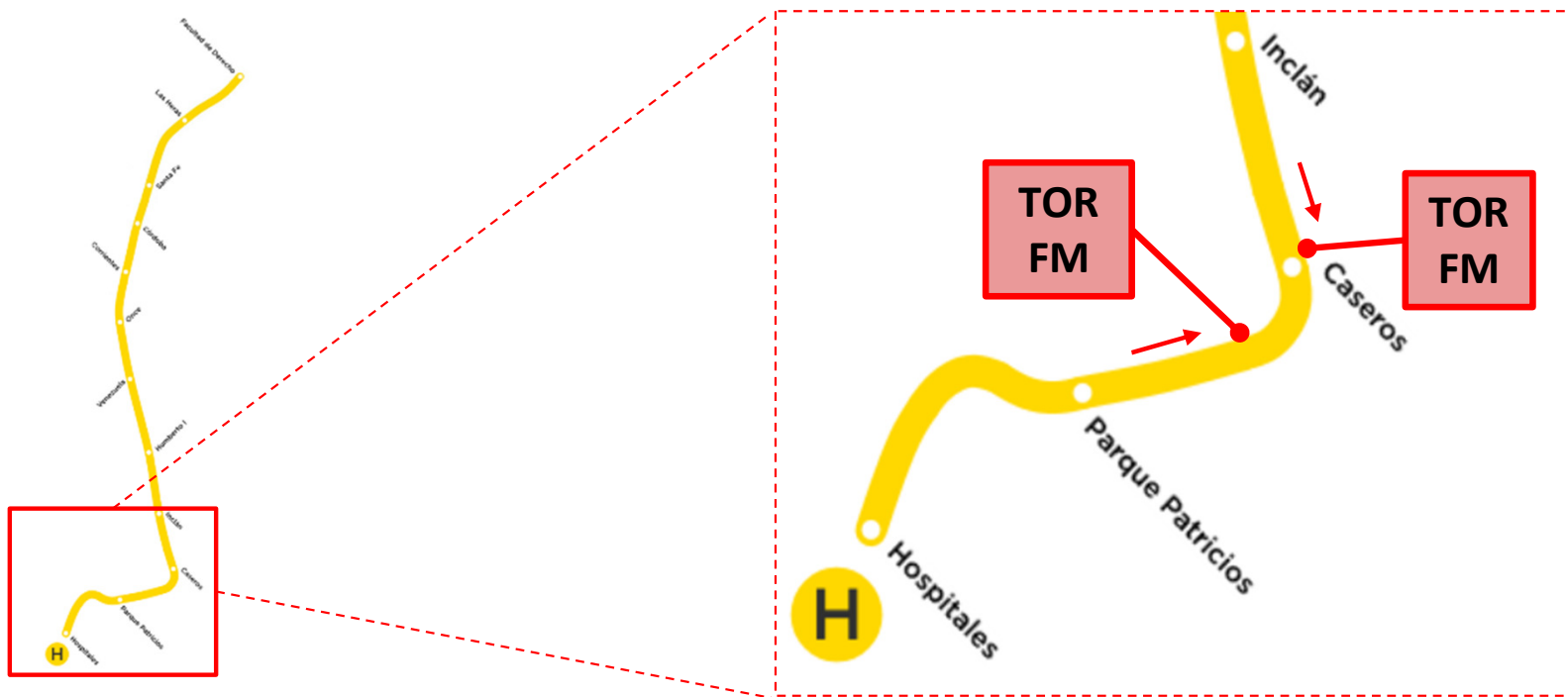
H Line Case - Action plan

- **Maintenance strategy.**
 1. **Friction Modifier** automatic equipment.
 2. **Wheel parameters** measurement.
 3. **Rail corrugation** measurement.
 4. **Rail grinding.**



H Line Case - Action plan

FM Units Positioning



Conclusions

- Use of **Friction Modifiers** as an alternative to mitigate wheel/rail wear.
 - related to lateral **wear processes, in E Line.**
 - related to vertical **wear processes, in H Line.**
- Work Plan within a **methodological process**
 - tests & controls
 - traceability and information management.



Acknowledgments

We would like to thank all the people who participated in these works.

- Eng. Mauro Rotondi
- Eng. Guillermo Baez
- Ariel Verón
- Maximiliano Pernice
- Juan Carlos Olivera (retired)

Among others.



Contact Information

- **Guido Ambrosio**
- **Gabriel Ehler**
- **Juan Fiori**

gambrosio@emova.com.ar
gehler@emova.com.ar
jfiori@emova.com.ar



Emova.com.ar



RAIL TRANSIT SEMINAR • JUNE 21

Emova 

WRI 2022

Questions ?



RAIL TRANSIT SEMINAR • JUNE 21

Emova 

WRI 2022

Thank you !



RAIL TRANSIT SEMINAR • JUNE 21

Emova 

WRI 2022