Session2.1 Room Karam2
Rolling stock / Design

Moderator : Mr. YANG Weijun
Senior Researcher (Locomotive and Rolling Stock),
CARS, China

Session 2.1 Rolling stock / Design Speaker Lists;

1	2	3	4	5
				
Dr.Federico Ulivi	Mr.Romain Bosramiez	Mr.Philippe Lucchese	Dr. Eduardo De la Guerra	Dr.Matteo Frea
Italy	France	France	Spain	Italy

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11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

ETR 1000: a story of success and forward-looking vision

Federico Ulivi
Trenitalia – Technical Direction, Italy
Session1- 2.1 Rolling Stock Design

ETR1000 – Our vision of High Speed and our excellence

The most important and innovative high-speed train within the Trenitalia fleet, the ETR 1000 (Frecciarossa 1000), is

- a symbol of excellence in Italy and the world
- a success story of how technical innovation and a forward-looking vision have allowed Trenitalia to acquire unparalleled experience in the field and foster its international projects.

The story

This foresight was already visible from the commissioning and planning phase:

the project – conceived more than 10 years ago – was intended to be a technically advanced train aimed at propelling Italian high-speed rail into the future, with performances well above industry standards ….

…. and aspired to be a project with an EU-wide perspective, **a platform** that would enable Trenitalia to extend its operations abroad.

The trains were therefore built in compliance with the essential requirements of the European Directives on Railway Interoperability and it was decided early on that the constructor would be the promoter of the homologation process.

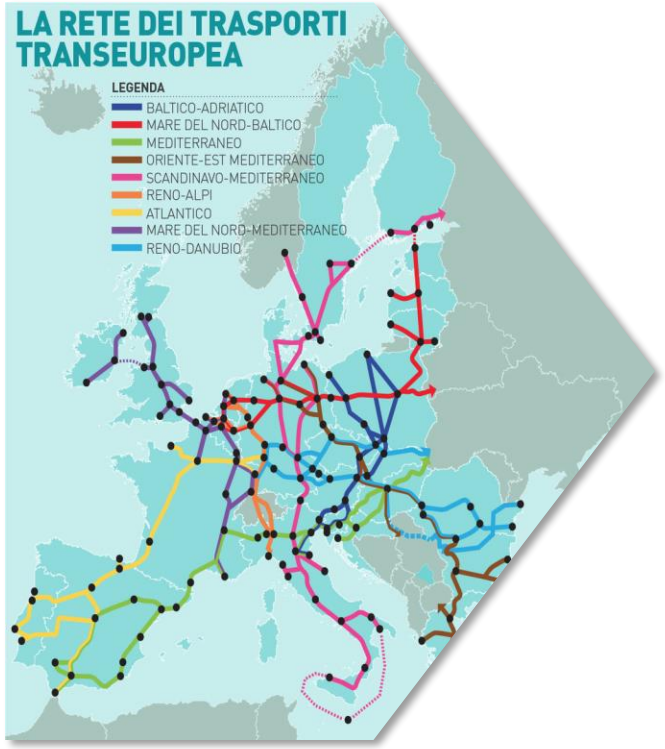
Velim 2013

Madrid 2021

Interoperability : our future

Design aimed to achieve technical acceptance for operation and circulate on foreign networks – namely France, Spain, Germany, Belgium, the Netherlands, Austria and Switzerland – having as basis of the certification process at European level the applicable Technical Specifications on Interoperability (TSIs).

The design : interoperability needs technology



EU-wide approach taken in the designing of ETR 1000

Bogies	Signalling	High Voltage

The design

High Voltage

- 16 motors - maximum power of 9,8 MW
- designed to operate in the Italian network conventional and High Speed (3 kV dc and 25 kV ac)
- additional equipment - in the abovementioned foreign networks (1.5 kV – 15 kV ac)

Predisposition for additional panto 1.5 kV

Predisposition for multivoltage trafo (25-15 kV)

Predisposition for additional panto 15 kV ac

Predisposition for additional panto 15 kV ac

Predisposition for additional panto 1.5 kV

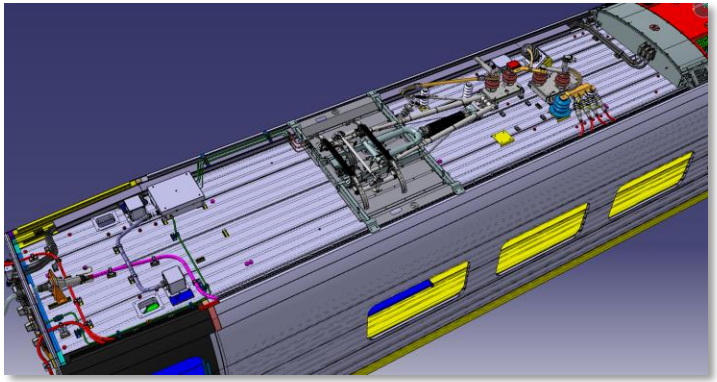
Predisposition for multivoltage trafo (25-15 kV)

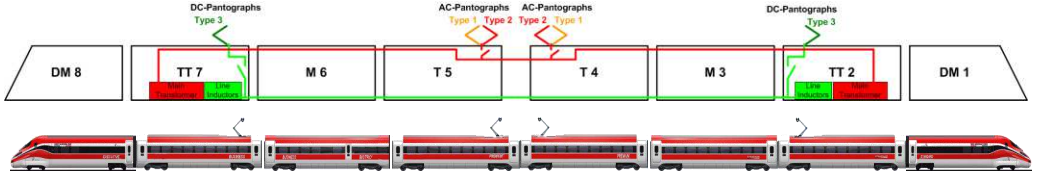
The design : interoperability needs technology

Pantographs

predisposition for the networks of Italy, France, Spain, Germany, Belgium, the Netherlands, Switzerland and Austria (3kV and 1.5kV, 25kV 50Hz and 15kV 16.7Hz),

ETR 1000 allows various pantograph configurations for both AC and DC networks (see figure below).

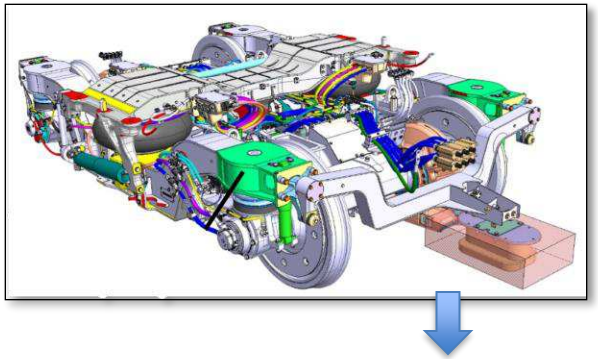




The design : interoperability meets technology

Boogies

Each car of the train has two bogies made of a welded steel frame and castings and forged elements, which comply with the European Interoperability Directives and are designed to meet the national requirements for five European corridors, including Italy



Additional signalling equipment fitted with dedicated brackets

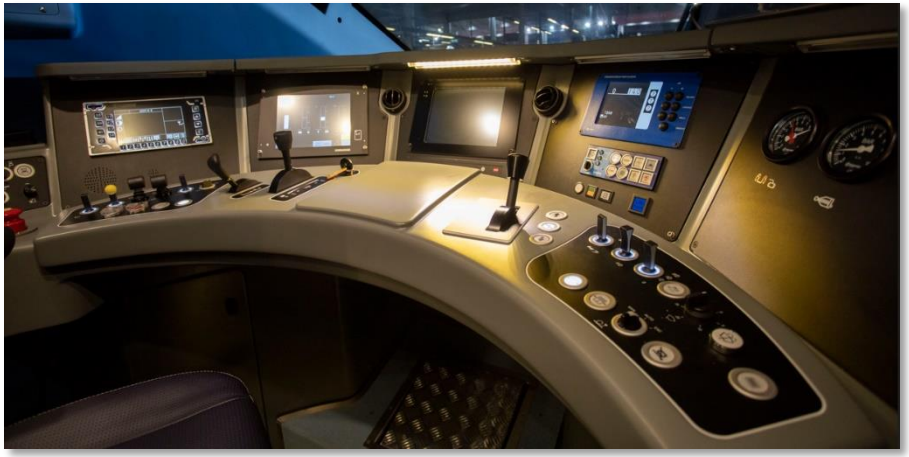
- designed to operate @ 360 km/h in commercial service
- common main components & spare parts for all the corridors
- addition sensors for bearing monitoring and CBM application
- predisposition for application of national signalling equipment

The design : interoperability meets technology

Signaling

The design of the driver's cab and the "electronic island" of the ETR 1000 were developed taking into account all the different signaling systems installed in various countries involved in the project,

- common modules to all Countries (diagnostic monitors, controls related to the functionality of the train)
- modular parts of various networks for national signaling systems and timetable sheets on the driver's desk or in dedicated electronic cabinets. Therefore, the driver's cab environment has been developed to accommodate drivers belonging to other European nationalities.



7 years of service : reilability grows

Trenitalia has gained significant experience in identifying

- how the product can be improved
  - new on-board services (Internet access, on-board wifi with access to entertainment, catering, …)

- how it can be made even more reliable
  - new TCMS functions
  - new CBM rules

- how it can be maintained at its best – in cooperation with the constructor – through the optimization of processes, making the company more then ready to build on that knowledge and use it to ensure successful operations in other Countries.

Our experience in EU international projects

Italy

Start: Jun 2015

Fleet:

- **50 trainsets (2015-17)**
- **8 trainsets (2021-22)**
- **6 trainsets (2025-26)**

France

Start: Dec. 2021

Fleet:

- **5 trainsets (2021)**
- **3 trainsets (2023)**

Spain

Start: Nov. 2022

Fleet:

- **16 trainsets (2022)**
- **4 trainsets (2023)**

THANK YOU

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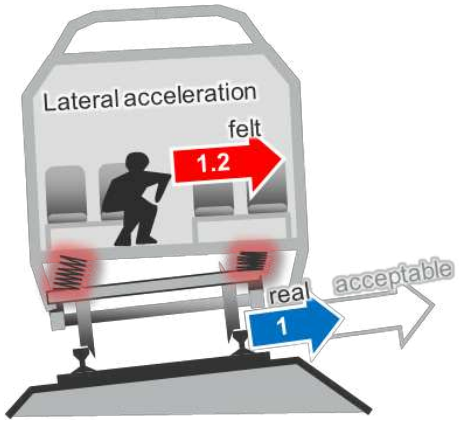
Next developments for tilting high-speed trains

Romain Bosramiez
Market & Portfolio Director for High-Speed platform, Alstom
Session1- 2.1 Rolling stock / Design

What are tilting trains?

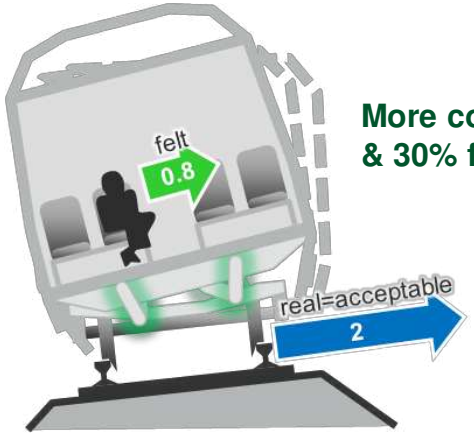
Non-tilting trains have to reduce speed in certain curves due to comfort

Non-tilting train



- Due to train roll, passengers feel even more lateral acceleration (centrifugal force) than at track level.
- The track accepts more acceleration in normal conditions, but comfort limits the speed.

Tilting train



More comfort & 30% faster

- Trains lean in curve so passengers feel less lateral acceleration than in conventional trains.
- The comfort does not limit, and the train runs as fast as normally authorized by the track.

Why tilting high-speed trains?

For passengers, high-speed is mainly about:

- Cutting travel times
- Travel experience
- Ticket price

How to cut travel time at a reasonable ticket price?

In some cases (ridership, topography, economy & social factors…)
→ Build a high speed line

And how to extend the services from high speed lines to conventional lines?

How to cut travel time without a new high speed line?

In certain cases, tilting trains can **cut travel times**, with **high comfort** and at a **reasonable price**.

Avelia Liberty for Amtrak, USA

Avelia Pendolino for SBB, Switzerland

Alstom active and anticipative tilting system

Tilting pantograph (counter tilting)

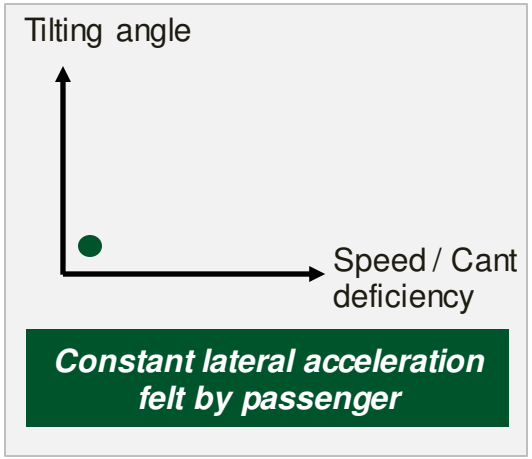
Tilting bogie (acting on the transom)

Actuator

Command transmission

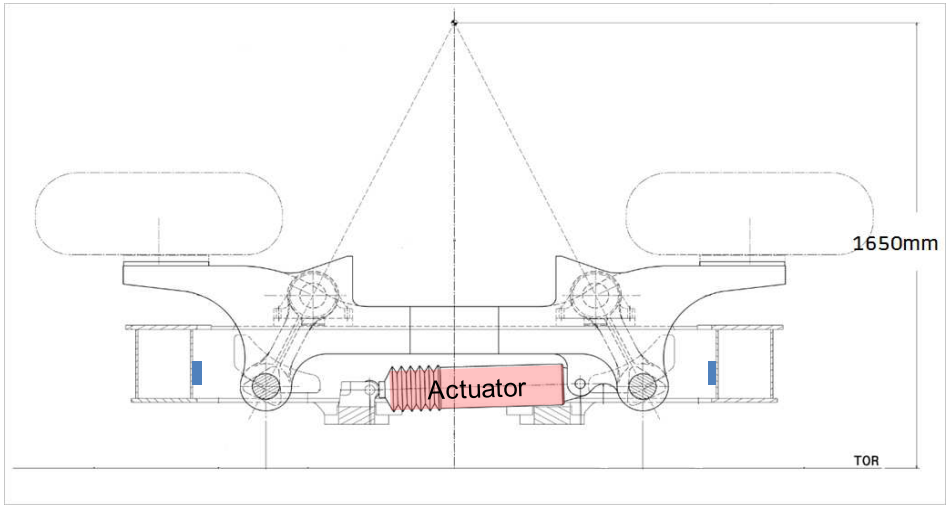
Actuator

Command transmision



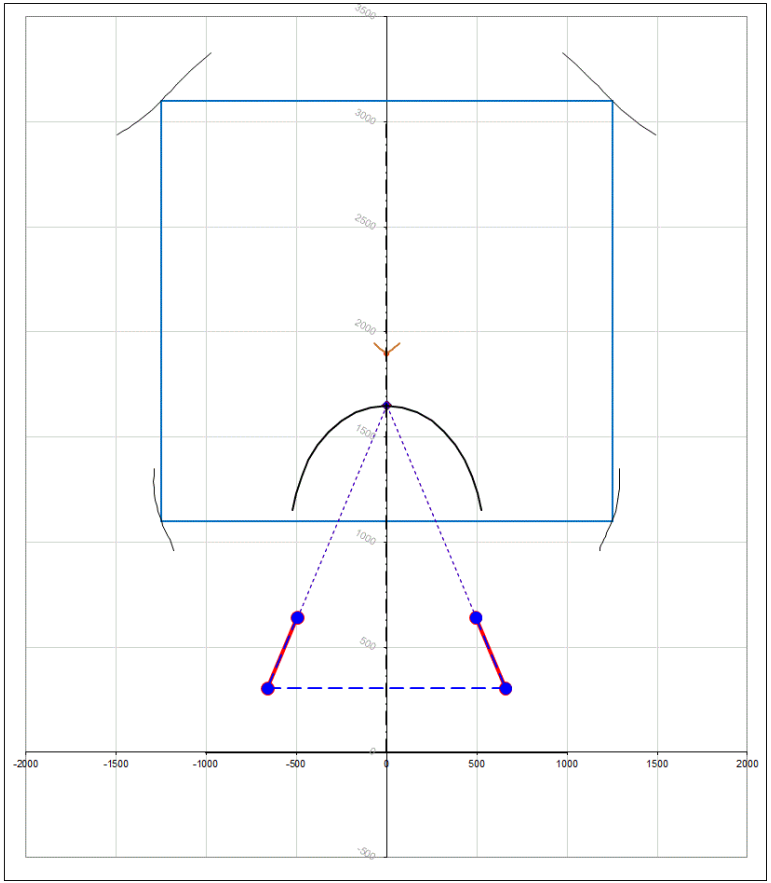
Alstom Tiltronix

How does the Alstom active tilting mechanism work?



Avelia Liberty example

- Pendulum mechanism below Secondary Suspension
- Max tilting angle → 6.3 deg.
- Mechanism design angle → 6.6 deg.



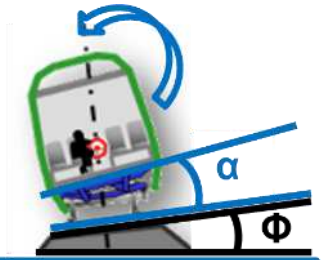
What is anticipative tilting as provided by Tiltronix?

SENSORS
Lateral acceleration + Angular velocity on forward and vertical axes

TRAIN SPEED

DATABASE
Track geometry, made by 3 type of segments: straight-line, transition and curve

TILTRONIX SYSTEM
Train position evaluation + Predictive algorithm



PREDICTED TILTING ANGLE (α)

SMOOTH CONTROL FOR MORE COMFORT

Anticipative tilting – Tiltronix upgrades

ANTICIPATING CURVES

- **Reducing delay for tilting to activate on the first car** (vs. traditional sensors)

SMOOTHING TILT

- **Avoiding** sudden rotations, jerks and limiting the angular velocity.

AVOIDING FALSE DETECTION

- Tiltronix positioning system **completely eliminates the false detections**

ADAPTING TILT TO SPEED

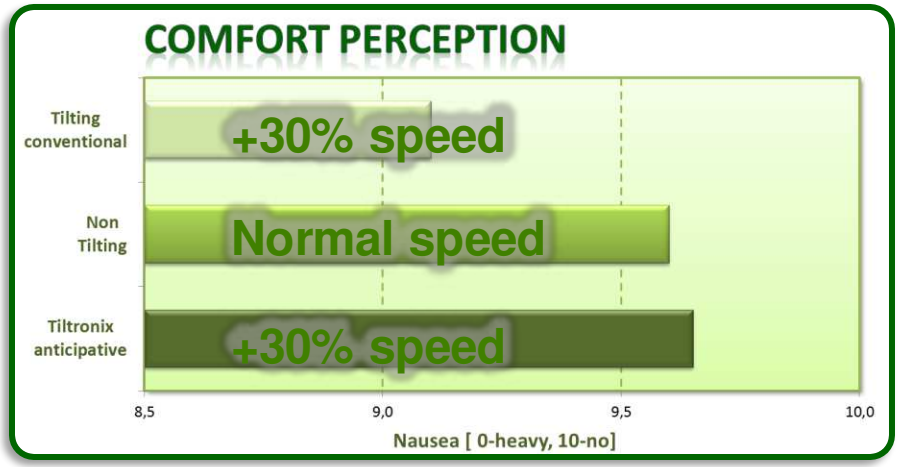
- **Maintaining the appropriate level of perceived lateral acceleration** (extremes can lead to motion sickness)

OPTIMIZED SENSOR USE

- New Tiltronix system **reduces sensors dependency** but also associated **energy consumption**

Impact of Tiltronix on motion sickness

- Line St.-Gallen ↔ Winterthur, Switzerland; 215 test persons (40 per day) recruited by SBB.
- 50% of passengers known susceptible to Kinetosis (motion sickness).
- Supported by Dept. of Neurology Zurich University Hospital and Dept. of Neurology, Mount Sinai School of Medicine, NY, USA



Even if running faster, Tiltronix can result in less kinetosis occurrence than on non-tilting trains

Tiltronix parameters might need some fine tuning during dynamic testing to adapt to real conditions

Source: SBB, Reisekrankheit (Kinetose / Motion sickness), Befragungen im Rahmen des Projekts „Bogenschnelles Fahren", Nov 2009

Story of Alstom tilting feature trough 5 generations

90s: CPA 4000 (P) - Alaris (E) – SM3 I (FI)

2002: Virgin WCML (UK)

4th Gen.
Electro-hydraulic actuators
Pendulum mechanism above Secondary suspension

2012: ETR610 II SBB (CH)

5th Gen.
Tiltronix - Pendulum mechanism below Secondary Suspension

Amtrak USA

90s: ETR4xx (I)

2nd Gen.

3rd Gen.
Electrical actuators
Roller mechanism below Secondary Suspension

2009: ETR6x0 Nuovo Pendolino (I-CH-D)

2010
SM6 Allegro (FI-RUS)

1st Gen.

1971: Prototype

1976: 1st Pendolino

80s: ETR 450 (I)

2004: CDT680 CD (CZ) - ETR310 SZ (SLO)

- Customized for different railway networks
- Compliant with various regulations
- Adapted to different track and loading gauges
- Adapted to extreme climatic conditions
- Articulated and non-articulated bogies

Case study: Avelia Liberty for Amtrak

Run faster, arrive sooner

- Improving requested journey times

=> New York - Washington, DC from 2h22 to 2h15

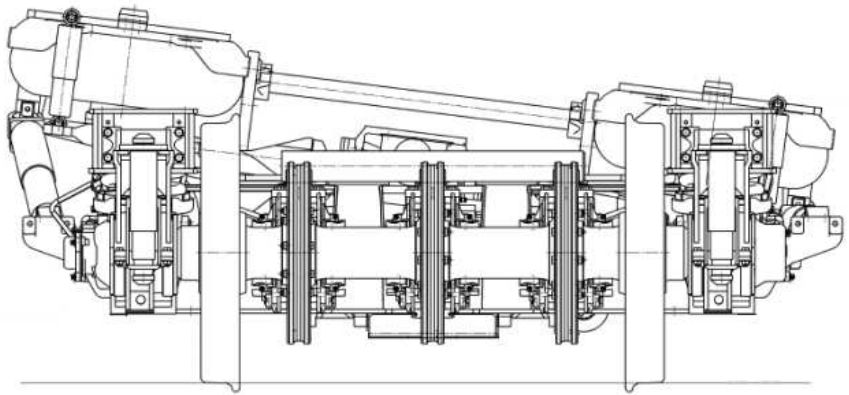
- Operate at the maximum speed of the line

=> Well proven up to 7º active tilting

- High acceleration

- Max. cant deficiency: **7”**
- Commercial speed: **257 km/h**
- Testing speed : **265 km/h**

6.3º are necessary to comply both with:
- journey time and
- onboard comfort



Conclusion

Alstom high-speed tilting trains can be a cost effective:

- **COMPLEMENT to high-speed lines**
- **ALTERNATIVE to high-speed lines**
- **ANTICIPATION for future high-speed lines**

THANK YOU

Romain Bosramiez
Market & Portfolio Director
High-Speed platform
romain.bosramiez@alstomgroup.com
www.alstom.com

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TGV M, THE HIGH SPEED OF TOMORROW

Philippe LUCCHESE
TGV M Project Manager, SNCF, France
Session1- 2.1 Rolling stock / Design

TGV FOR THE FUTURE

TGV has become a permanent part of French daily lives... and **high speed is no longer enough**, it has become a normal thing

The uses evolve in the years 2000 / 2010, with **the explosion of digital applications**

Competition among transport modes in France in the 2010s : the mobility market is growing but the number of passengers transported by SNCF is stable

TGV inspires mobility :
"we need to get back ahead of the game !"

INNOVATION PARTNERSHIP

Objective to design an **innovative and economically viable** TGV :

- Reduction of the purchase price
- Reduced operating costs
- Increased product attractiveness

Changing **the mindset and working method** :
SNCF and ALSTOM are thinking about the architecture of the train as a whole and are proposing innovations to achieve the objectives

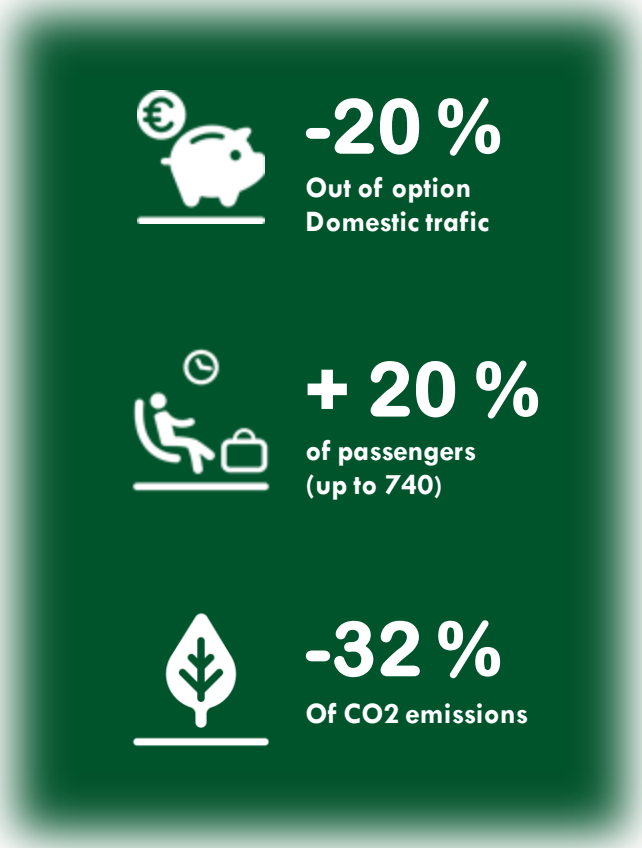
1100 ideas studied - **400 innovations retained**
Involvement of all partners at the earliest stage of design

A HISTORIC BID

115 TGV M trainsets bought, the largest TGV bid ever, for an investment of €3.5 billion

Today, the **industrialisation and approval phase** is underway and the first trains will be put into circulation in 2024 for the Olympic Games

A train that is more environmentally friendly than any other high-speed train, with **20% less energy consumption**



THE FIRST TRAIN

THE DRIVER'S CABIN

TGV M OFFERS MORE FOR LESS

Modularity to meet diverse needs and the ability to adapt to changes

For the first time, **a fully accessible train for everyone**, including wheelchair users

A hyper-connected train, with data to improve performance in all areas

AN AMBITIOUS COMMISSIONING PROGRAMME

The renewed customer experience, to atract more customers on trains

Optimised maintenance, thanks in particular to the deployment of **predictive maintenance**

A major investment programme **to adapt and modernise the maintenance workshops**

Stations adapted to support the increase in flows and take into account the particularities of TGV M

THANK YOU

Philippe LUCCHESE
TGV M Project Manager, SNCF, France
+33 6 21 50 21 81
philippe.lucchese@sncf.fr

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Development of a new traction system for independent rotating wheel bogie

De la Guerra, Eduardo
R&D Project Manager, Talgo, Spain
Session number and Name

Talgo in a nutshell

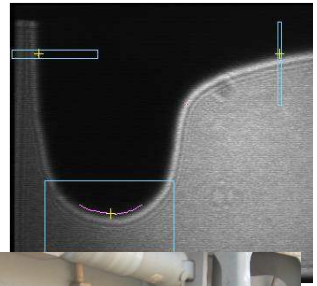
A global rail systems integrator

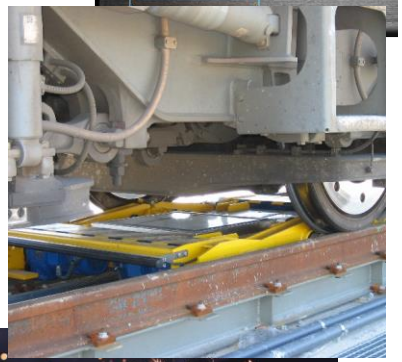
Rolling Stock

Maintenance

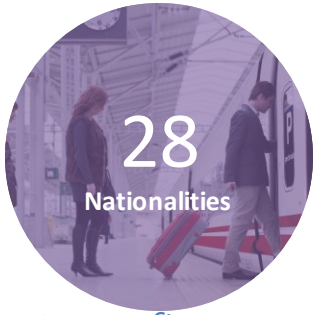
Maintenance equipment

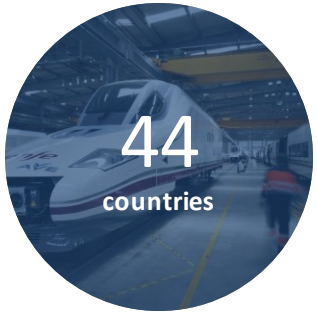
Overhauling





Talgo in a nutshell





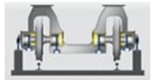
Some figures

- Germany
- Kazakhstan
- KSA
- Spain
- USA
- Uzbekistan
- Denmark (soon)
- Egypt

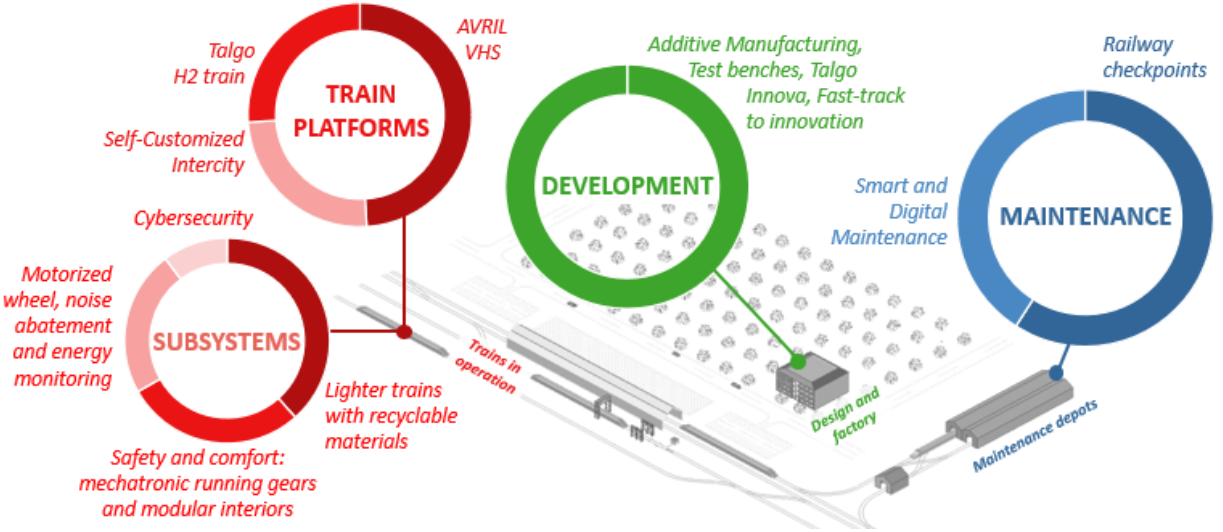
Development of a new traction system for independent rotating wheel bogie

Talgo

A differentiated technologies

Talgo Differentiation		Infrastructure	Operations	Maintenance	Unique of Talgo
1 Aluminium-based lightweight construction		✓	✓	✓	–
2 Natural tilting system		✓	✓	✓	✓
3 Articulated and mono axle		✓	✓	✓	✓
4 Wide body, short coach concept / improved accessibility		–	✓	–	✓
5 Automatic variable gauge system		✓	✓	–	–
6 Independent guided wheels		✓	✓	✓	✓
7 Hybrid Technology		✓	✓	–	–
		Lower investment requirement	Higher energy efficiency, reduced journey time and increased capacity	Reduced track and train maintenance	Unique technology adapted to client needs

Innovations



Smart maintenance	More efficient and cleaner traction systems	Reduced noise rolling stock	Lightness	New materials and manufacturing processes	Enhancing Passenger experience
Cybersecurity					
Circular economy					

PINTA3

This project has received funding from the European Union's Horizon 2020research and innovation programme under grant agreement No: 101014935

Distributed traction

Current traction perfomance

HS with interoperatibility **330 km/h**

Acceleration at 330 km/h: **0,05 m/s2**

Tractive initial effort: **200 kN (15% adhesión)**

Output power at wheel: **8800 kW**

Next:

HS with interoperatibility **360 km/h**

Acceleration at a 360 km/h: **0,05 m/s2**

Tractive initial effort: : **200 kN (15% adhesión)**

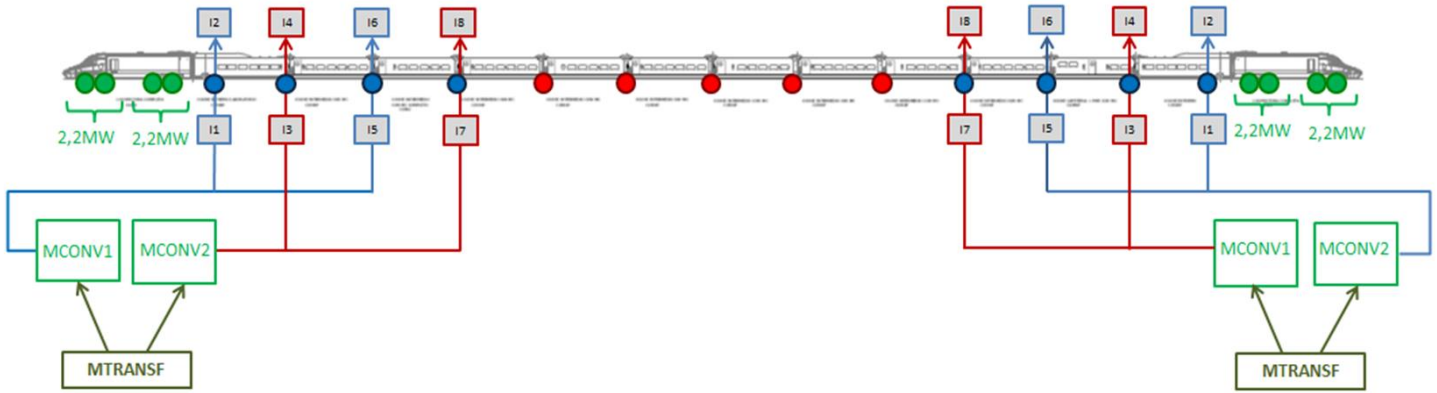
Output power at wheel: **10,9 MW**

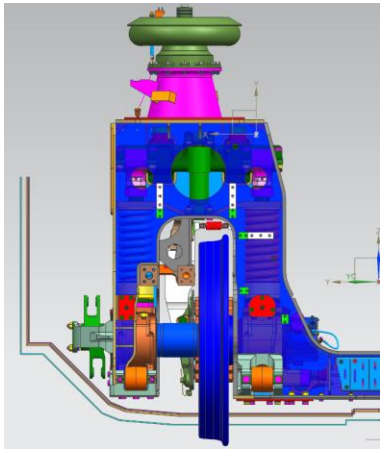
Concentrated traction

Distributed traction…

…with Talgo concepts

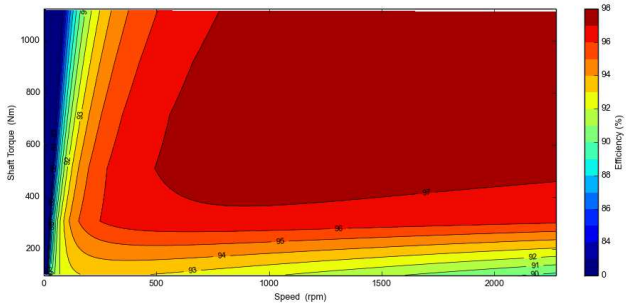
Motorised IRW





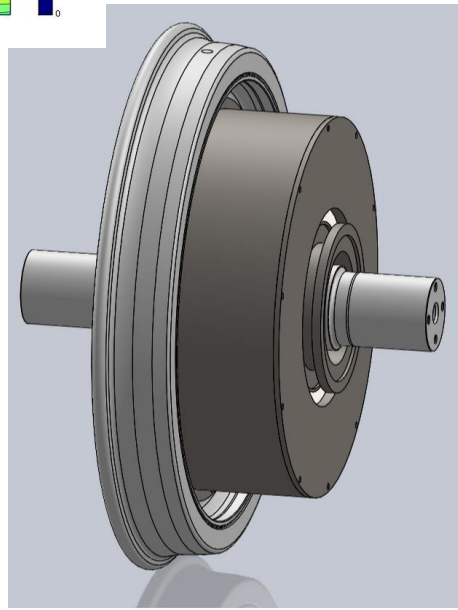
OPTION	Minimum power required at wheel per motor
8 Motorized axles (16 motors)	170 kW
6 Motorized axles (12 motors)	225 kW
3 Motorized axles (6 motors)	450 kW

Motorised IWR



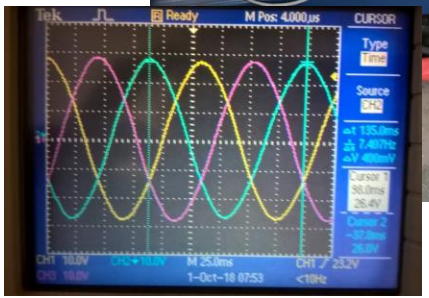
- PMSM
- Diameter: 660mm
- Length (from wheel web): 211 mm
- Direct Drive
- Maximum permitted rotational speed: 3000RPM
- Continuous Ratings
  - 2274RPM @ 1.1kNm (260kW) continuous
  - 2274RPM @ 1.3kNm (320kW) continuous (max allowed continuous winding temp)
- Transient Ratings

  Assumes motor initially at steady state at rated speed and torque at 45°C ambient
  - 1.5kNm: 4mins @ rated speed
  - 2kNm: 40s @ rated speed; 80s at <100RPM



Motorised IWR

- Enabling motorized independent wheel running gears for high-speed trains
- Test bench design and manufactured
- Prototype tested in different condition including at maximum speed in bench with good results
- More than 97% efficiency
- The high efficiency and not using geabox implies an energy reduction of ca. 3%, a maintenance cost reduction of 5% (less mechanical part, greater maintenance interval) and an increase of reliability



Conclusions

It is possible to provide the level of required performance using direct drive motors on independent rotating wheel. The permanent magnet synchronous machines (PMSMs) offer the most compact and appropriate solution to achieving the required performance maintaining the same height of platform and floor.

A continuous motor power of 350 kW with greater than 98% efficiency is possible within the space envelope available.

THANK YOU

Ph.D. Eduardo de la Guerra
Mail: edelaguerra@talgo.com
Web www.talgo.com

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DISTANCEMASTER™

Advance solutions for wheel rail adhesion enhancement

Matteo Frea

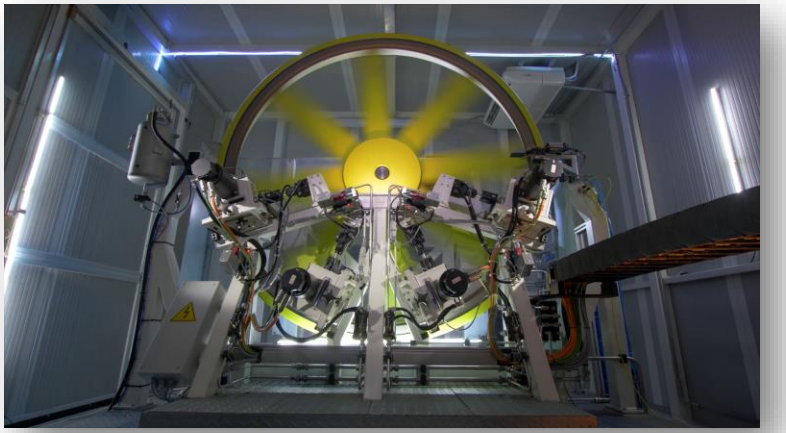
Head of R&D at Wabtec, Italy

Session1-2.1 Rolling stock / Design

In the frame of S2R, the rail industry stake holders have identified the wheel-rail adhesion as one of the most relevant bottle neck in rail transport efficiency.

- WABTEC has heavily invested in **fundamental research** and in dedicated field tests to explore the adhesion phenomena in terms of wheel-rail contact and in terms of adhesion recovery propagation.
- A **test rig ,** unique in the world, has been developed to recreate the adhesion conditions met on field.

the Wabtec multi-axle roller rig



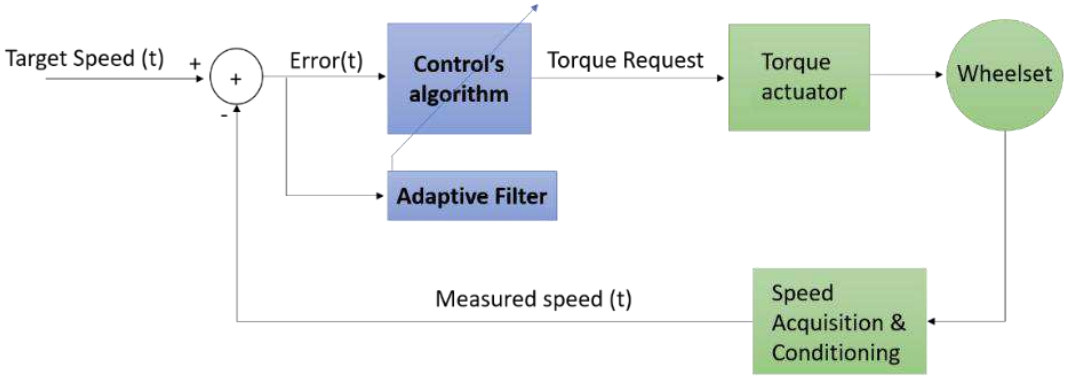
Maximizing brake performance stability, reducing dispersion, reducing maintenance costs

3 enablers:

- **DM-Adaptive WSP**: Optimizing slide control, when it happens
- **DM-Control+**: Maximize at train level the use of available adhesion
- **DM-Smart Sanding**: Generate locally adhesion when needed

The adaptive WSP addresses different market needs

- Increase the level of performance in degraded adhesion (stopping distance)
- Reduce WSP commissioning time
- Maintenance cost linked to wheel flats



- A new WSP algorithm based on "Adaptive Filter" technology
- During sliding, the Adaptive Filter performs a continuous tuning of the internal control coefficients, per each individual axle, based on the actual adhesion value, in every possible environmental conditions.
- DM-Adaptive WSP doesn't require manual tuning

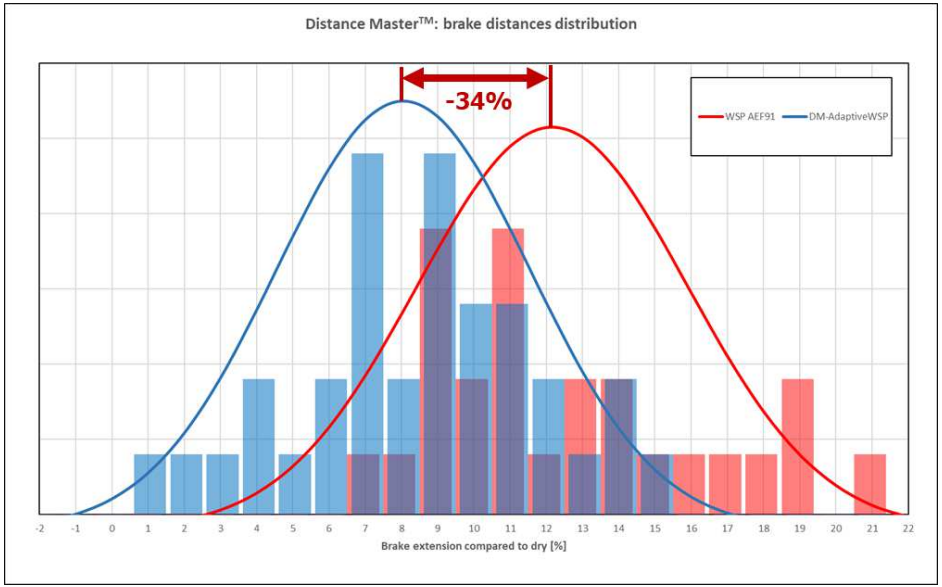
Adaptive WSP performance improvement in low adhesion (0,08 to 0,05)

Average braking distance elongation vs dry:

34% braking distance improvement

Test performed on Euskotren EMU – Bilbao, Spain

200+ brake applications

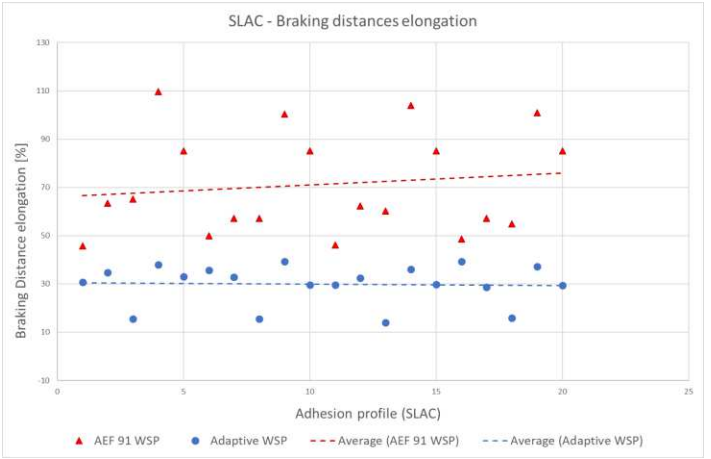


Adaptive WSP performance improvement in extremely low adhesion (0,01 and below)

- **Better protection against wheel flats, reduced maintenance costs - 80% on Regiolis fleet (200 trains monitored) vs state of the art previous generation WSP**
- **Reduced braking distance extension (from +70% to +30%)**
- **Reduced dispersion: More predictable braking distance**

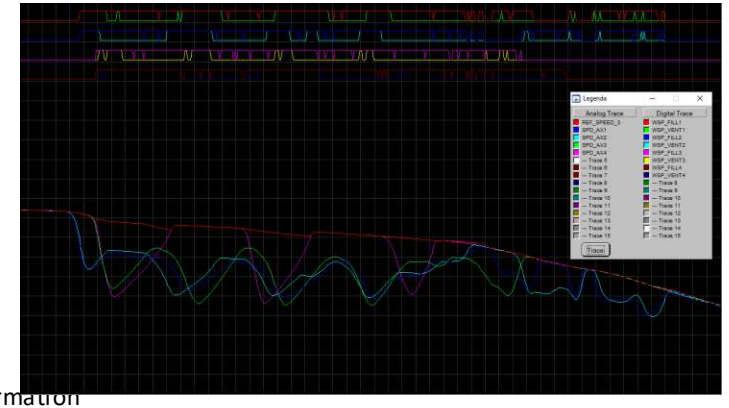
Test performed on WSPER test bench in sustained very low adhesion

- **AEF 91**: Average braking distance extension +70%, high dispersion
- **A-WSP**: Average braking distance extension +30%, much lower dispersion



Test performed during certification on oiled track, Regiolis (SNCF) - France

- Reference speed remains stable
- Not a single wheel flat during the test campaign



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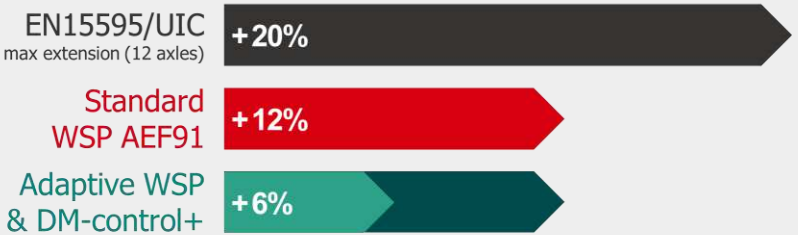
Adaptive WSP & Deceleration compensation performance improvement in low adhesion (0,08 to 0,05)

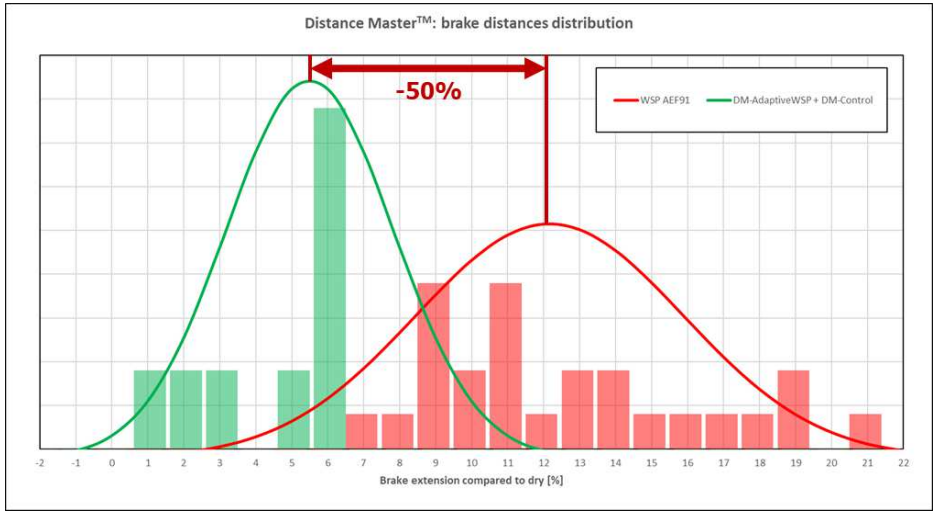
Adaptive wheel slide protection & Deceleration compensation

Average braking distance elongation vs dry:



50% braking distance improvement

Test performed on Euskotren EMU – Bilbao, Spain
200+ brake applications



- Due to the cleaning effect of each wheel on the track, braking effort redistribution along the train enables significant improvement
- In same conditions, braking distance improvement becomes -50% (+34% with A-WSP only), dispersion is also greatly reduced

Deceleration compensation also supports other degraded conditions

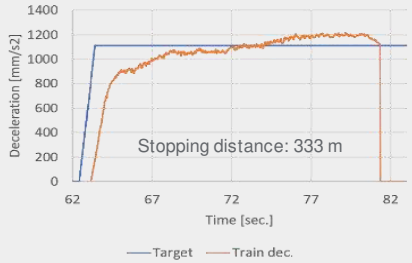
Deceleration Compensation **Disabled**

Deceleration Compensation **Enabled**

Performance improvement

DISTANCEMASTER™

Downhill -14‰



10% improvement on braking distance

1 bogie isolated / in failure

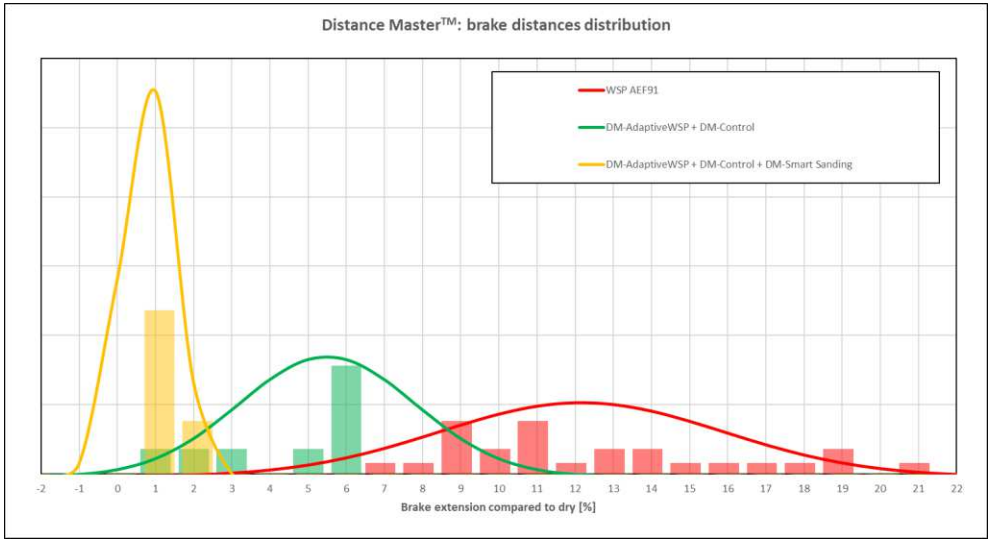
9% improvement on braking distance

SmartSanding:
Generate locally adhesion when needed.

Performance improvement in low adhesion (0,08 to 0,05)

Braking distance extension almost disappears (+1%)

Test performed on Euskotren EMU – Bilbao, Spain



- Result can vary upon number & position of sanding unit in the train
- A design tool has been created to optimise sanding system upon performance & available adhesion

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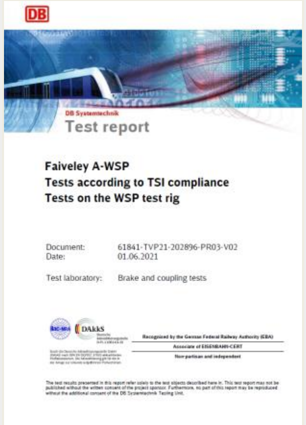
DM-A-WSP: TSI declaration of conformity

- Dynamic test in DBST lab (WSPER)
- Dynamic test on train Eurailtest / Regiolis
- Positive assessment by RINA
- EC Interopability Certificate (Sept 2022)

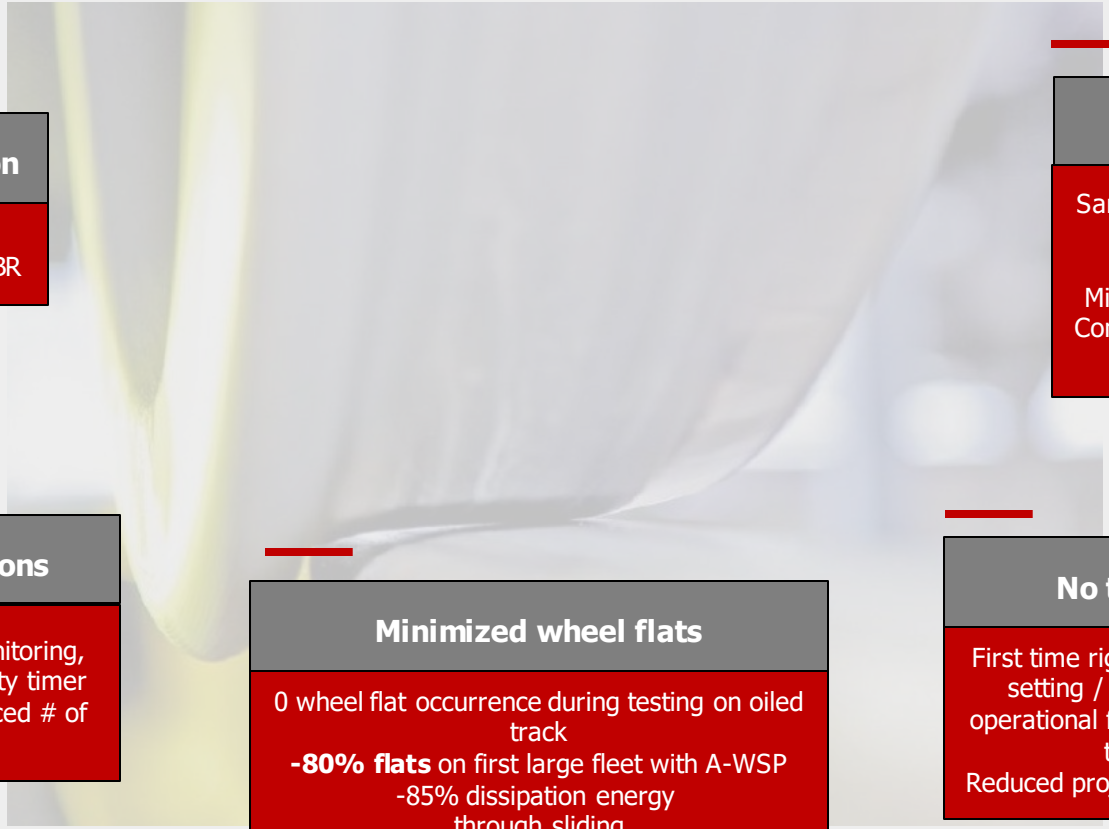
Ready for your projects !

- Ready for metros, TSI projects and UK applications
- Performance and functional compliance to:
  - GM/GN2695 at WSPER
  - EN15595:2011 and EN15595:2018


AGENCE D'ESSAI FERROVIAIRE
SNCF VOYAGEURS
RAPPORT D'ESSAI
LIG023695 - REGIOLIS WSP ADAPTATIF EN15595-2011
Référence Eurailtest : 7141_6770
Référence AEF : DOC059858-00 / LIG023695
eurailtest


DB
DB Systemtechnik
Test report
Faiveley A-WSP
Tests according to TSI compliance
Tests on the WSP test rig
Document: 61841-TVP21-202896-PR03-V02
Date: 01.06.2021
Test laboratory: Brake and coupling tests


EC Design Examination Certificate
Certificate Number: 0474/2/CH1/22/RST/EN/P0031381_AWSP



Up to -50% elongation

In EN15595 conditions:
Elongation=6% -> ↑ GEBR

Smart Sanding

Sanding controlled by WSP:
Elongation <2%

Minimal sand consumption
Compliant with TSI Loc&Pas and EN 15595

SIL 4 functions

Dynamic WSP monitoring, Less frequent safety timer intervention, reduced # of flats

Minimized wheel flats

0 wheel flat occurrence during testing on oiled track
-80% flats on first large fleet with A-WSP
-85% dissipation energy through sliding

No tuning

First time right: No need to setting / tuning, fully operational from first wheel turn
Reduced project risk & costs

THANK YOU