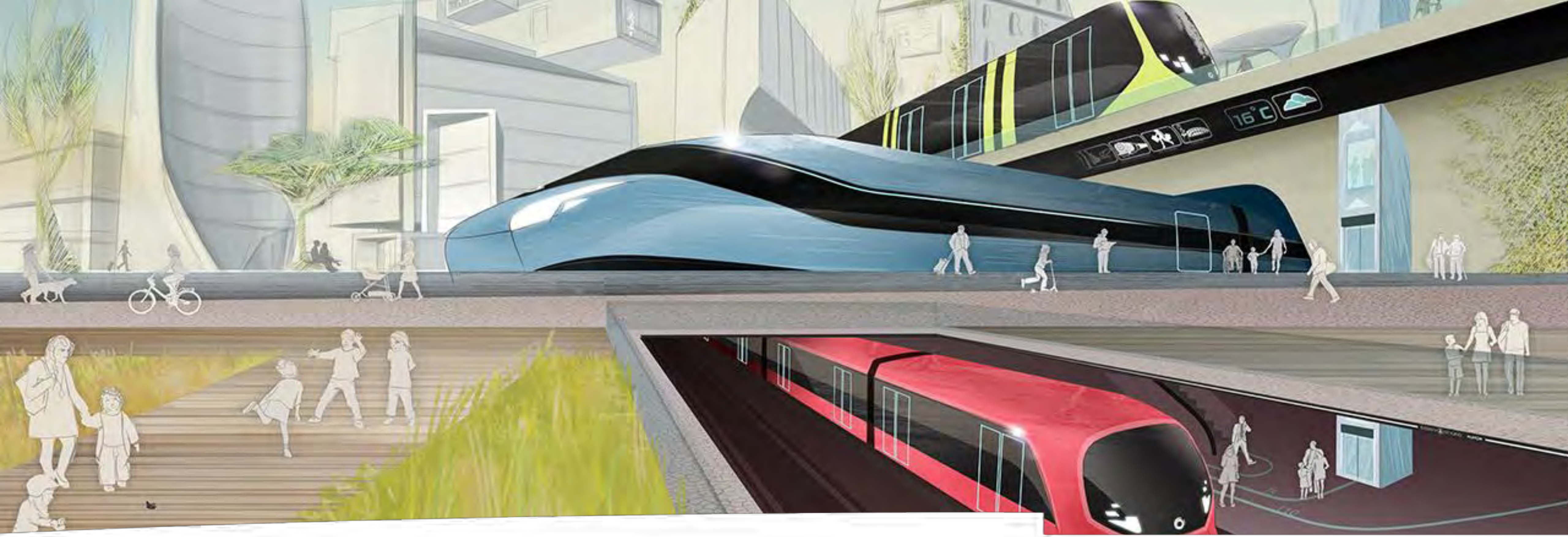

MORE THAN PROVIDING TRACKS & TRAINS: PROVIDING TRANSPORTATION SOLUTIONS

UNLV Railroad Infrastructure Diagnosis and Prognosis Symposium

Nicolas FLIX, October 2018

ALSTOM
Designing fluidity

More than providing Tracks & Trains : Providing Transportation solutions

1 **Introduction**

2 **The right Rolling Stock for the particular needs of every Railroad Operator**
Case of Tilting Trains technology

3 **Maintenance performance as project driver from premises**

More than providing Tracks & Trains : Providing Transportation solutions

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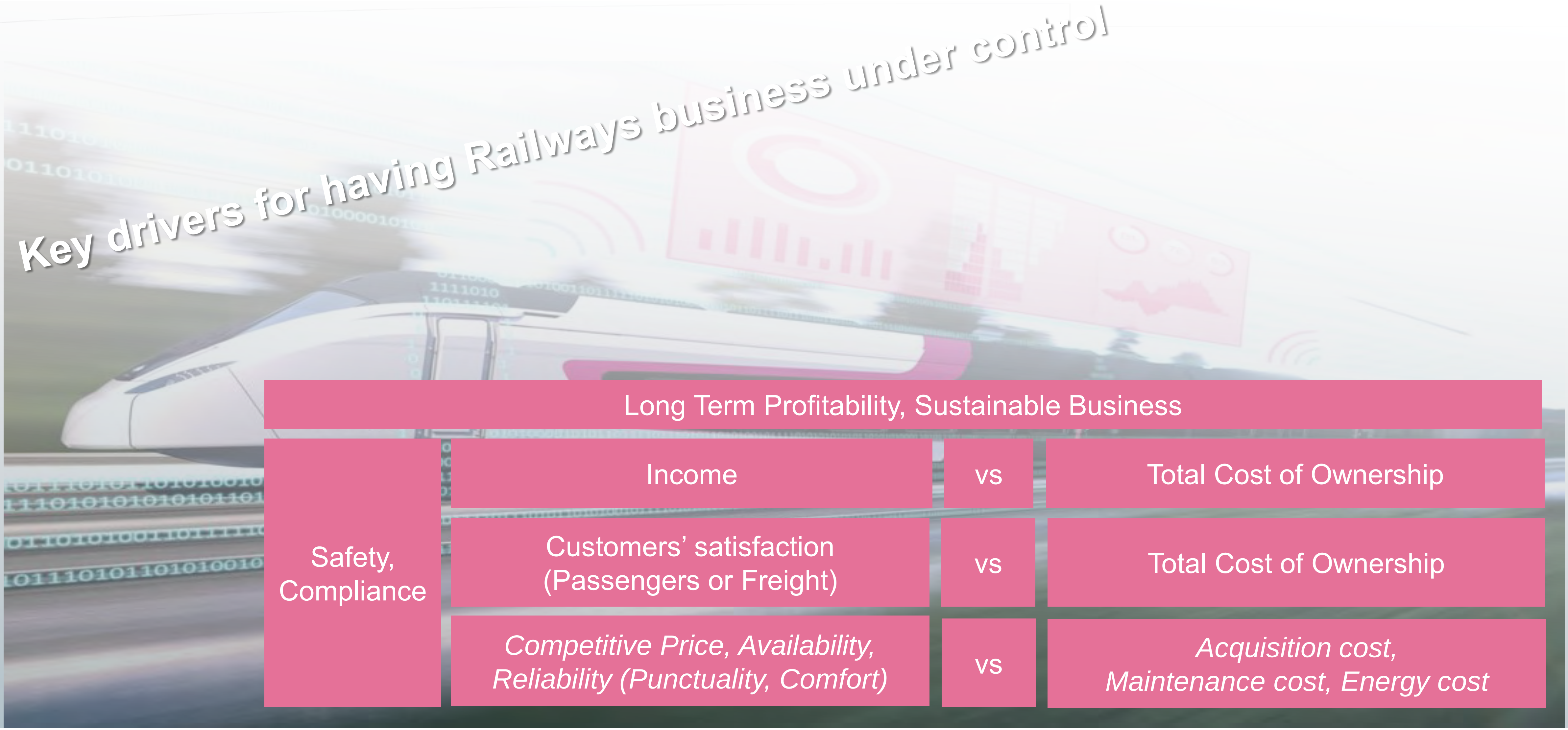

Long Term Profitability, Sustainable Business				
Safety, Compliance	Income	vs	Total Cost of Ownership
	Customers' satisfaction (Passengers or Freight)	vs	Total Cost of Ownership
	Competitive Price, Availability, Reliability (Punctuality, Comfort)	vs	*Acquisition cost, Maintenance cost, Energy cost*

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More than providing Tracks & Trains : Providing Transportation solutions
Introduction

Key drivers for having Railways business under control

Long Term Profitability, Sustainable Business			
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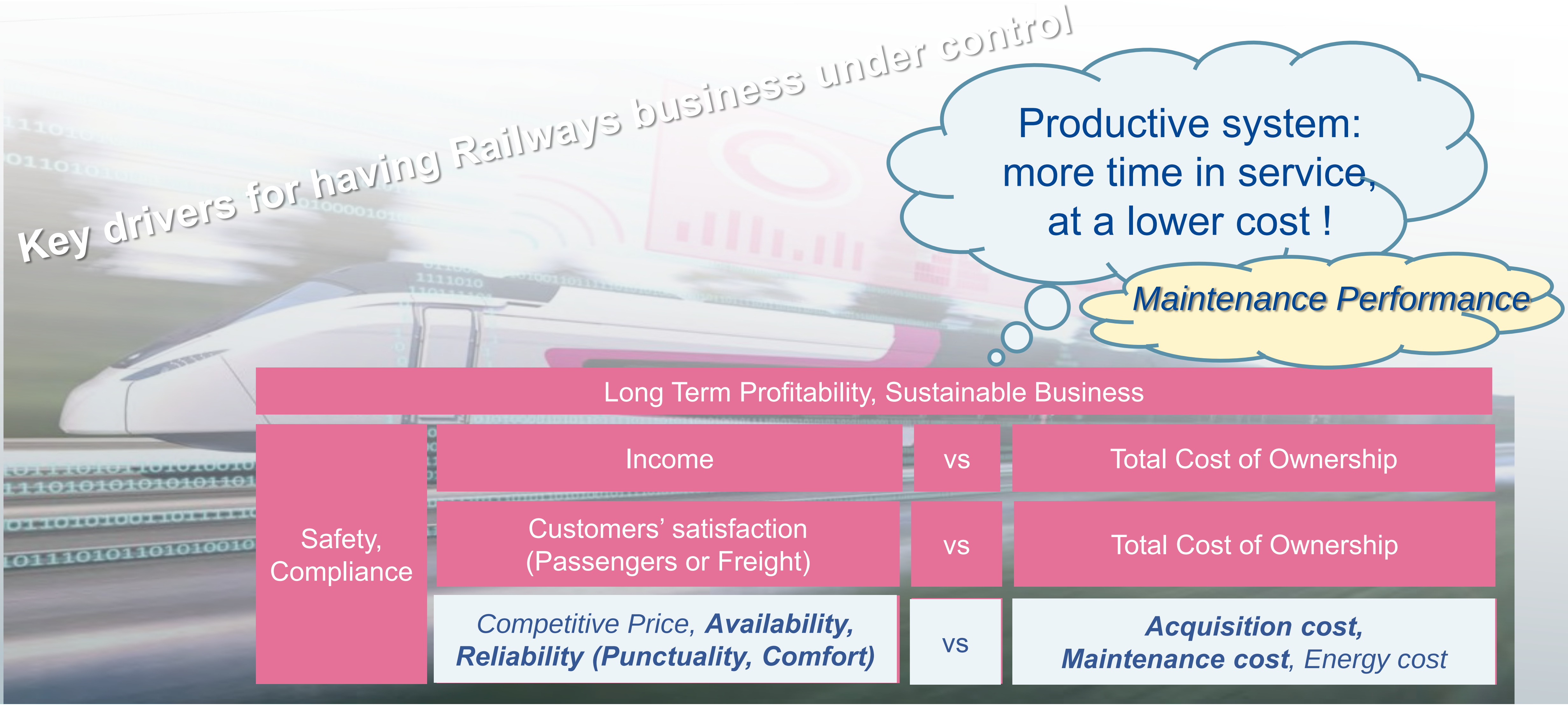
Introduction



Long Term Profitability, Sustainable Business			
Safety, Compliance	Income	vs	Total Cost of Ownership
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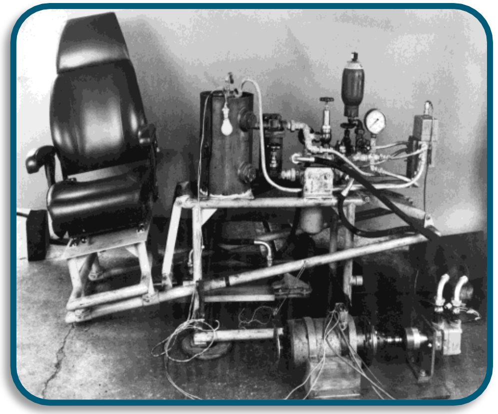
More than providing Tracks & Trains : Providing Transportation solutions

Case of Tilting Trains technology

Alstom tilting early history

…generation Pendolino train



1969

Prototype seat on

ALn 668.1999 loco.

Confirming «Tilting» **effect on comfort.**

Tests on Bra-Ceva **tortuous line**.

1970 - 1974

Y0160 **1st train** order from Italian Railways to FIAT Ferroviaria.

11-Oct-71 **first test**.

11-Jan-72 **2.2 m/s2**.

Same year **248 km/h**

1975 June 26th

2 power car first trip.

1976 April 8th

Revenue service Rome-Ancona.

ETR401 30 min save

250 km/h, 1.8MW, 4car

10º tilting angle

1988 May 29th

ETR450 started operating Rome-Milan

57min saving

Average 153 km/h

250 km/h, 5MW, 9car

8º tilting angle

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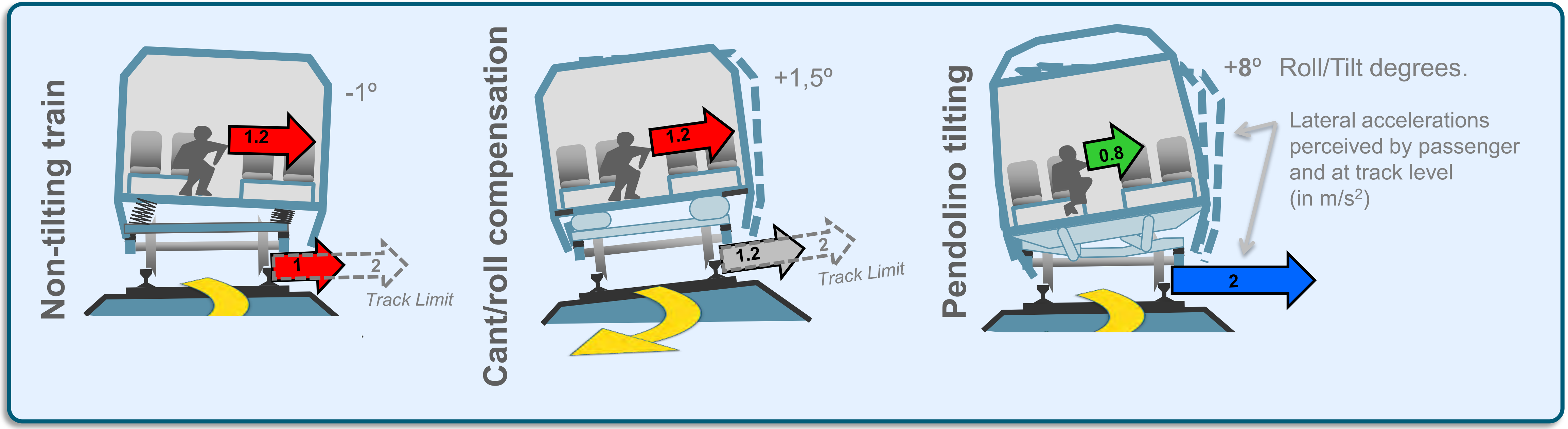
Case of Tilting Trains technology



Alstom tilting trains operate within the normal track limits (force, acceleration, etc.)
No need for special track design

Tilting Pendolino characteristics:

- ✓ Up to **2 m/s²** non compensated acceleration (n.c.a.) at track level
- ✓ Up to **30%** speed gain in curve

Lateral acceleration compared to non-tilting train:

- ✓ Perceived 33% less by passenger → **more comfort**
- ✓ 100% more at track level → **higher speed in curve**

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Case of Tilting Trains technology

Alstom High Speed Tilting references

1970s
1st Pendolino
(Italy)

1980/1990s
ETR 460/470
(Italy)

1996
Acela Express
(US) (bogies)

1998
Virgin WCML
(UK)

1998
ICE-T
(Germany)
(bogies & control)

1998
IC 2000 Alaris
(Spain)

1999
Alfa Pendular CPA 4000
(Portugal)

1999-2000
DTP2 Test Train
(France)

2004
Pendolino CZ
(Czech Rep)

2007
New Pendolino
(Italy, Switz,. Germ)

2010
Allegro
(Finland, CIS)

2011
ETR610
(Italy, Switz., Germ.)

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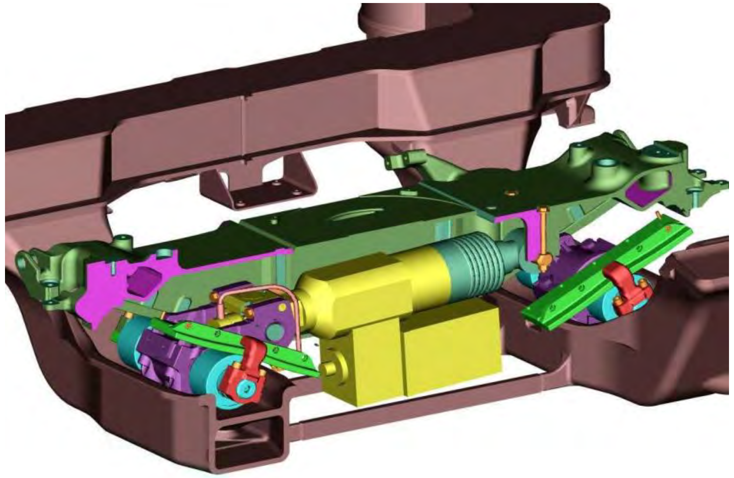
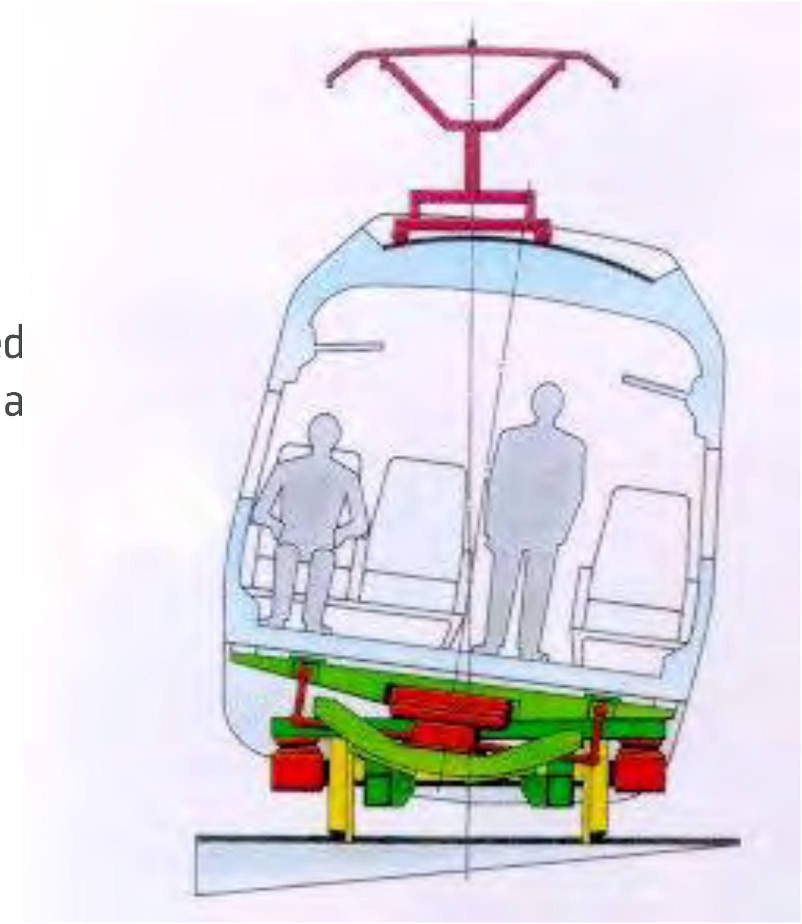
Case of Tilting Trains technology

Pendolino Titling system is composed of :

- **Bogies fitted with a Tilting Bolster,** supporting the carbody
- **Hydraulic units & actuators,** controlling the tilting bolster
- **Tilting Pantograph** (if installed on a tilting car)
- **Anticipative algorithms (TILTRONIX™)** processed by dedicated electronics, improving passengers comfort compared to a reactive system.





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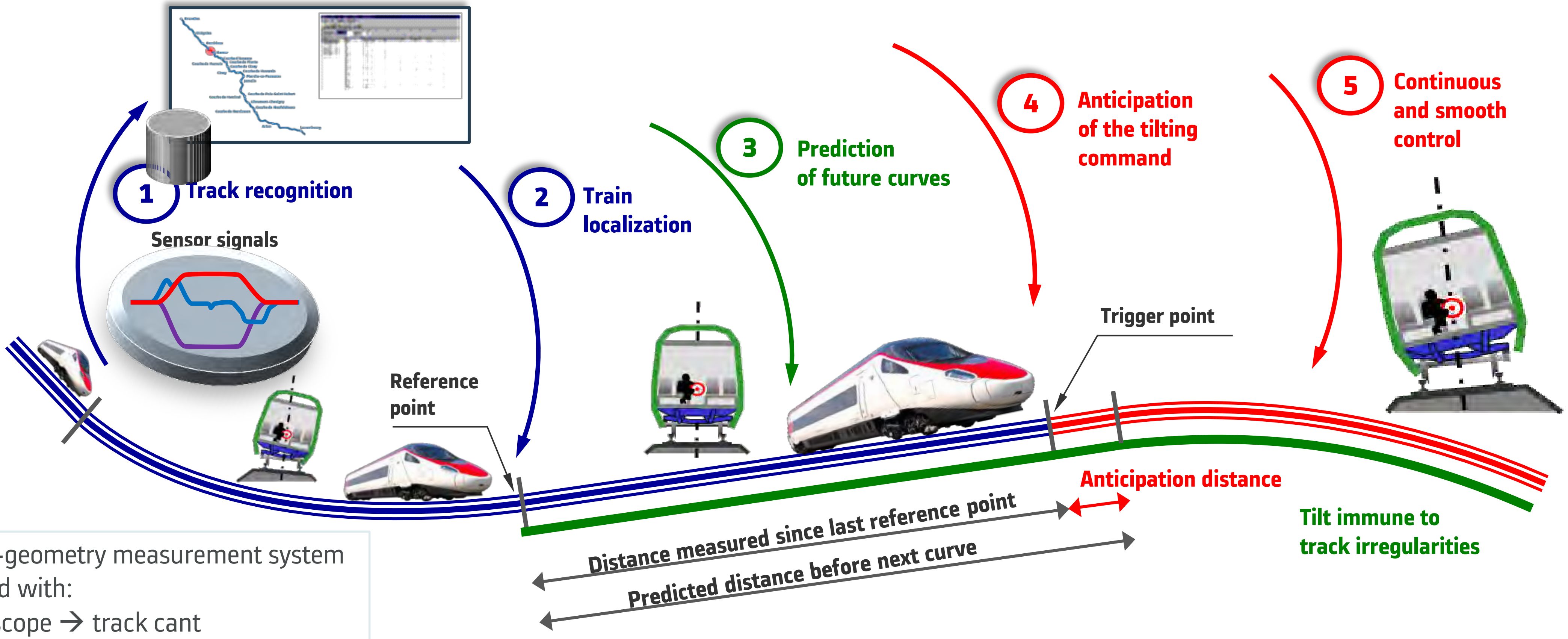
Case of Tilting Trains technology

Tiltronix™: Curve prediction without infrastructure devices



The track macro-geometry measurement system (SUT) is equipped with:

- -1 X axis gyroscope → track cant
- -1 Z axis gyroscope → curve radius
- -1 Y axis accelerometer → cant deficiency

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Case of Tilting Trains technology : new ACELA

DTP:

Prototype of Tilting Train

with articulated architecture

ACELA Tilting Train :

Proven trucks on the NEC

Pendolino Titling System :

Wide Return of Experience

& most advanced technology

NEW ACELA TILTING TRAINSET

- → **Articulated trainset**
- → **Up to 186 mph**
- → **Tilting Passengers cars,**
  Maximum tilting angle ≈ 6.3 degrees

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More than providing Tracks & Trains : Providing Transportation solutions

Case of Tilting Trains technology : new ACELA

Complex carbody kinematics of Pendolino for

SAFETY

- Gauge compliance
- Stability : self-centering independently of the load and non-compensated acceleration.

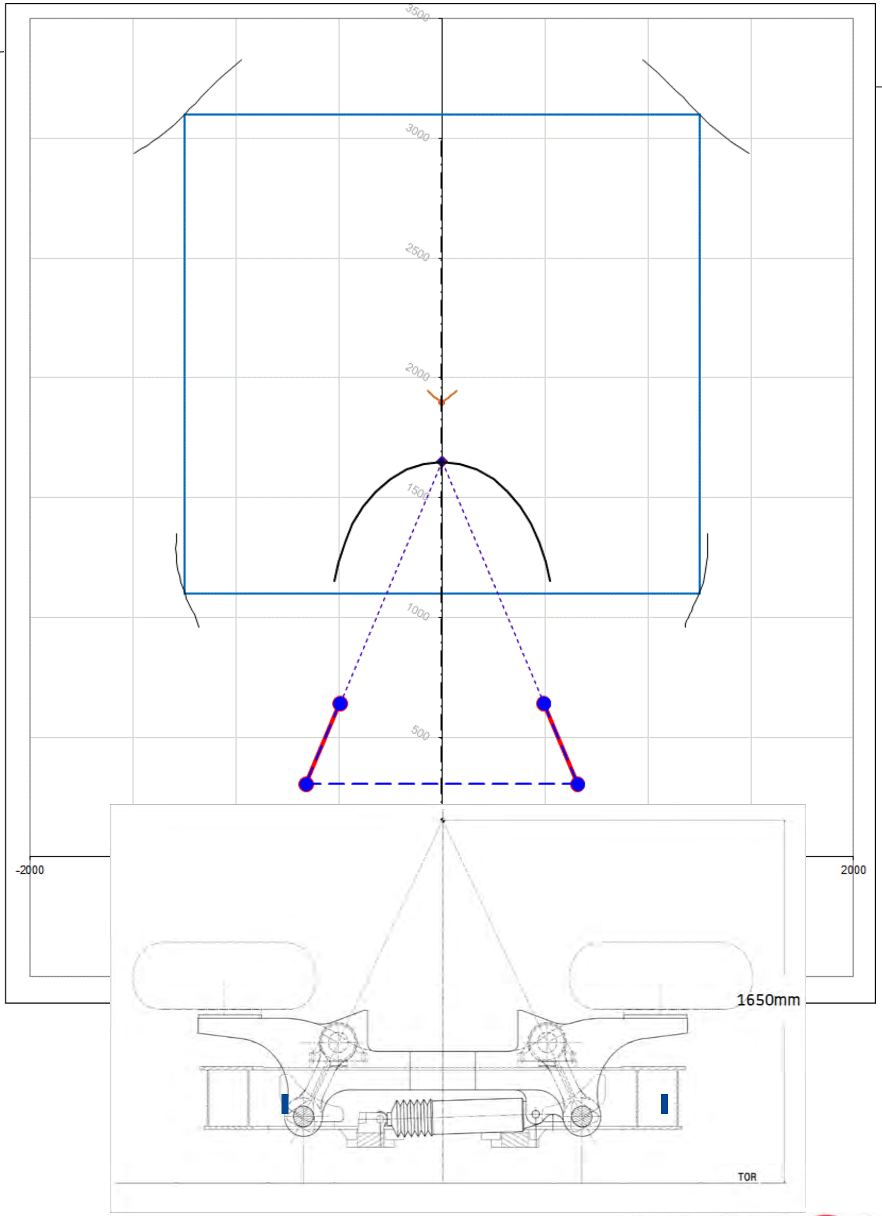
COMFORT

- Stability
- Belly-centered rotation (height of the Center of Instant Rotation close to the body center of the passengers)

TRACK FRIENDLINESS

Minimum wear related to limited wheel-rail contact force :

- Limited movement of carbody Center-of-Gravity
- Reduction of non-suspended masses
- Low primary suspended masses
- Designed for high cant deficiency
- Reduced bogie rotation stiffness



More than providing Tracks & Trains : Providing Transportation solutions

Case of Tilting Trains technology

The challenge

During decades Alstom evolved the tilting technology

- ☺ **To guarantee outstanding safety**: self-centering architecture…
- ☺ **To improve reliability**: high redundancy, onboard autonomy…
- ☺ **To ensure track friendliness**: lowest unsprung mass, passive axle orientation…
- ☺ **To ride at maximum speed**: we offer maximum n.c.a. possible
- ☺ **To offer best comfort**: belly-centered rotation, active control…

So, how can we still improve it ?

☹ **There are still few passengers affected by motion sickness if we run slower:** There's always a population sensible to motion sickness. The occurrence is low in railways, with just a 10-15% increase when running 30% faster on tilting trains.

☺ **The new challenge**: reduce motion sickness perceived by passengers

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More than providing Tracks & Trains : Providing Transportation solutions

Case of Tilting Trains technology

How to minimize motion sickness?

A combination of the best solutions based on 25 years of experience

	Pendolino & Tiltronix™	
Minimize vibration	Enhanced BOGIES comfort	
Minimize low frequency movements	Enhanced BOGIES comfort	Optimized structure
Minimize translational movements	Tilting mechanism Belly height centered	
Improve curve/tilt synchronization	Active tilting	+Anticipative

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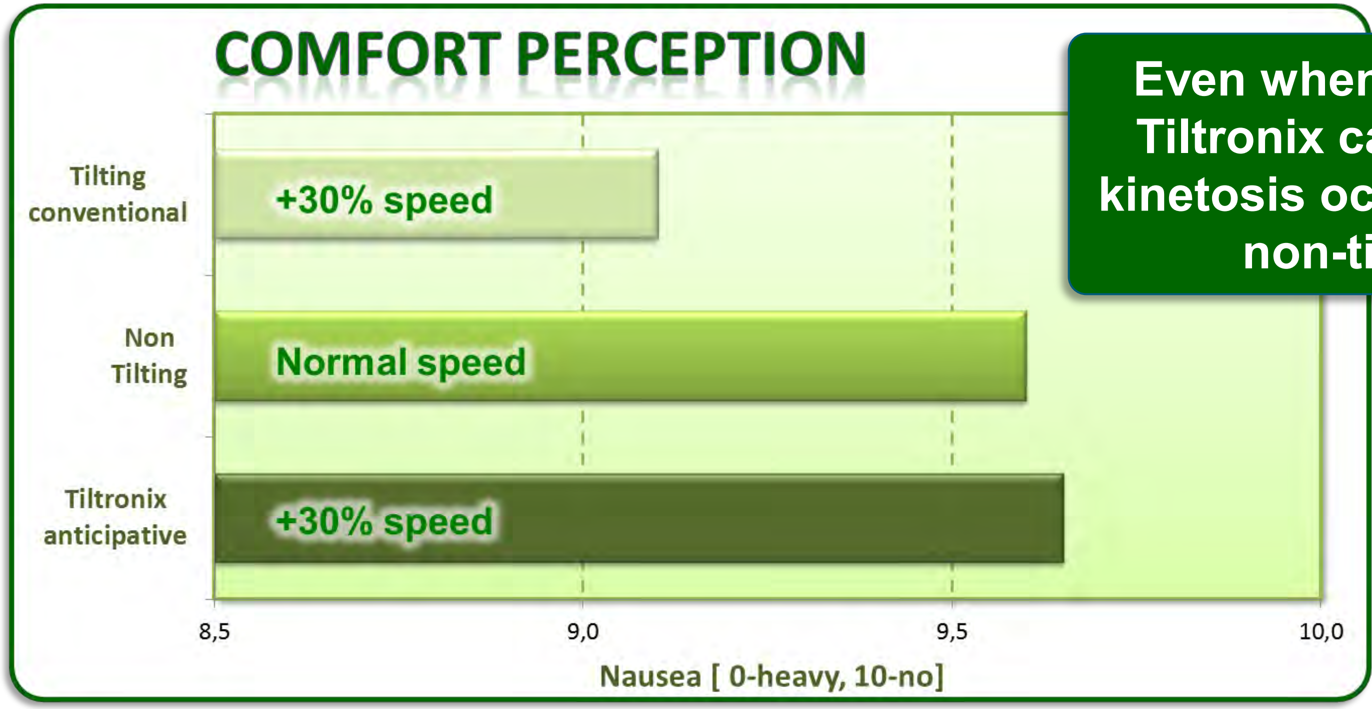
More than providing Tracks & Trains : Providing Transportation solutions

Case of Tilting Trains technology

Tiltronix™ is the answer again to motion sickness :



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

MOUNT SINAI SCHOOL OF MEDICINE

BROOKLYN COLLEGE

UNIVERSITAS TURICENSIS MDCCCXXXIII

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SBB CFF FFS

Tiltronix **medical validation** was performed in October 2009 with **250 people** recruited by SBB, **50%** of them being known to be **susceptible to Kinetosis** (motion sickness)

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

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3. **Maintenance performance as project driver from premises**
   - Design-for-Serviceability : how experts keep Maintenance performances under control
   - Modern means for continuous improvement of the maintenance all asset life-long

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More than providing Tracks & Trains : Providing Transportation solutions

Factoring Train Design into a comprehensive Maintenance System

Maintenance Engineering in New Build and Maintenance projects

Tender → Design → Mobilization → Warranty → Maintenance

- Commitment on targets of **Operational Performances**
- **Maintenance Concept & Strategy**, applicable regulations
- **Fleet sizing**
- **Workshops sizing**

  } Availability, Workload & Track occupancy simulations
- **Maintenance Cost Model**
- Definition of any **Service Support** required for reaching the ambitions (tailored offer including deployment of new processes & tools)
- Alstom Units & External Suppliers under control, especially **Material & Off-Train activities**

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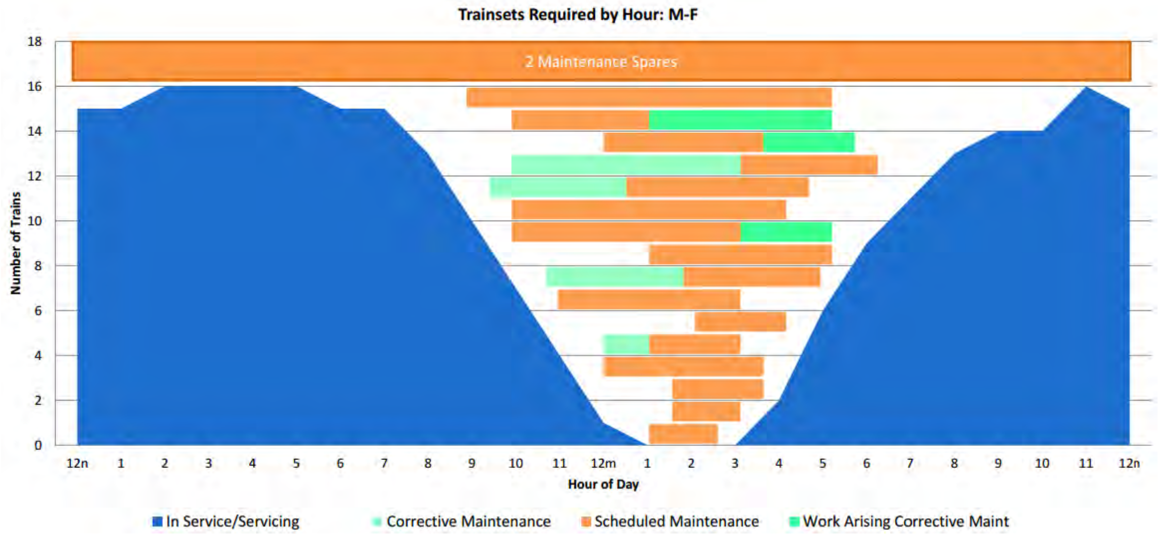
More than providing Tracks & Trains : Providing Transportation solutions

Key drivers for having Railways business under control

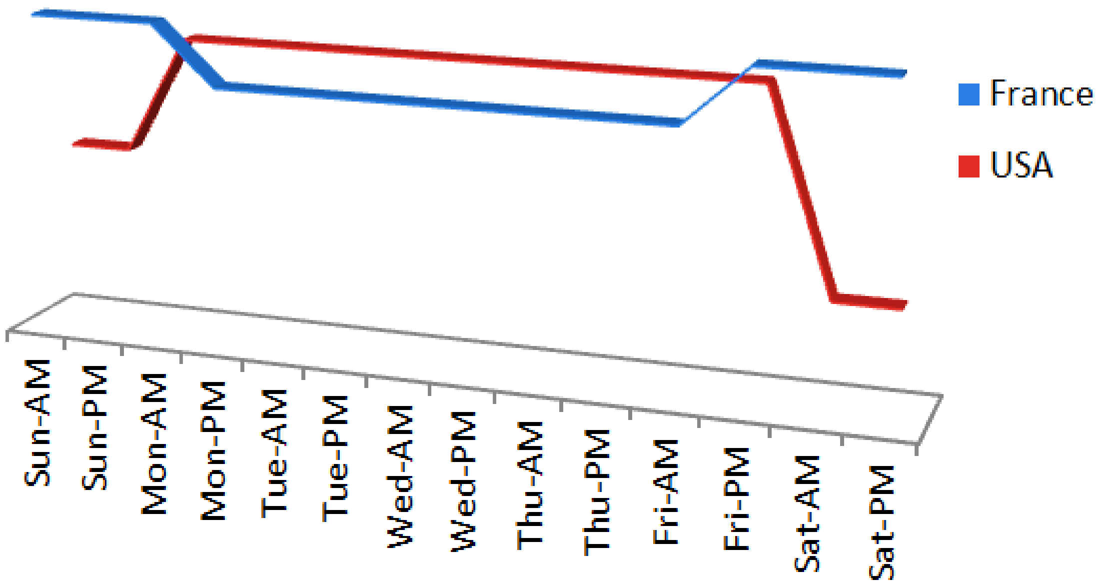
Availability as a dynamic target :

- ➔ Downtime costs « zero » when vehicles are not needed for revenue service !
- ➔ Good maintenance strategy often leads to fleet size optimization (impact on acquisition cost)



DAY VIEW (Passengers Main Line)

Downtime allocation for the different types of maintenance



WEEK VIEW (Passengers Main Line)

Typical needs for revenue service
(% trainsets available)

More than providing Tracks & Trains : Providing Transportation solutions
Key drivers for having Railways business under control

Maintenance LCC (Life Cycle Cost) :

Technical cost :

- Labour + Material
- Systematic Preventive → CBM → Corrective // Cleaning
- Make vs Buy (on-train, off-train)

Total cost :

- Operational procedures: handover, pre-service check…
- Productivity, workload variation
- Logistics (shunting, parts handling…)
- Support functions
- Training…

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Tender → **Design** → Mobilization

DESIGN–FOR–SERVICEABILITY (DFS)

- Maintenance performances : Cost, Downtime
- Means of reaching targets : Reliability, Accessibility, Testability, Cleanability, Depot facilities…
- Challenge & Rationalize all kind of maintenance including Safety-related tasks
- Obsolescence under control

DELIVERABLES OF INTEGRATED LOGISTIC SUPPORT (ILS)

- Logistic breakdown : LRUs & SRUs as input for DFS + ILS database as repository
- Maintenance Plan, Maintenances Tasks Analysis (MTAs), Maintenance & Operations Manuals, (lists of) Spares, Special Tools (including Test Equipment),Training material…

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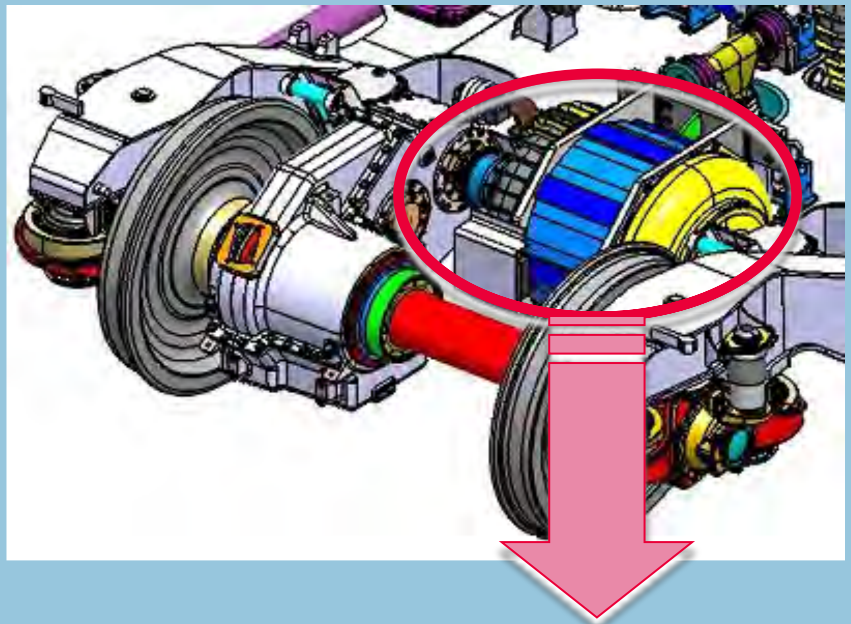
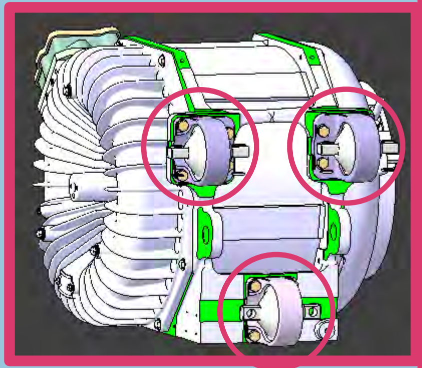
WHEN DESIGN–FOR–SERVICEABILITY SAVES A RAIL TRANSPORTATION BUSINESS



On AGV it is possible to remove the Traction Motor without removing the bogie or the wheelset.



This saved the business of the first private operator of passengers main lines transit in Italy, NTV, when at start of service the life-time of the original silent blocks was about 1.5 month… vs 3 years expected.

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MAINTAINABILITY DEMONSTRATIONS

- If they could not be completed on 3D model or in manufacturing facility

DELIVERY of « Final Documentation », Spares & Tools

TRAINING SESSIONS to Drivers and Maintainers

DEPLOYMENT OF MAINTENANCE :

COMPREHENSIVE SET OF PROCESSES & TOOLS… and PEOPLE !

- Management of Operational Performance : Reliability, Availability, Cost
- Maintenance Planning, Fleet Management
- Industrialization of Maintenance, Optimization of Execution

ONE TEAM

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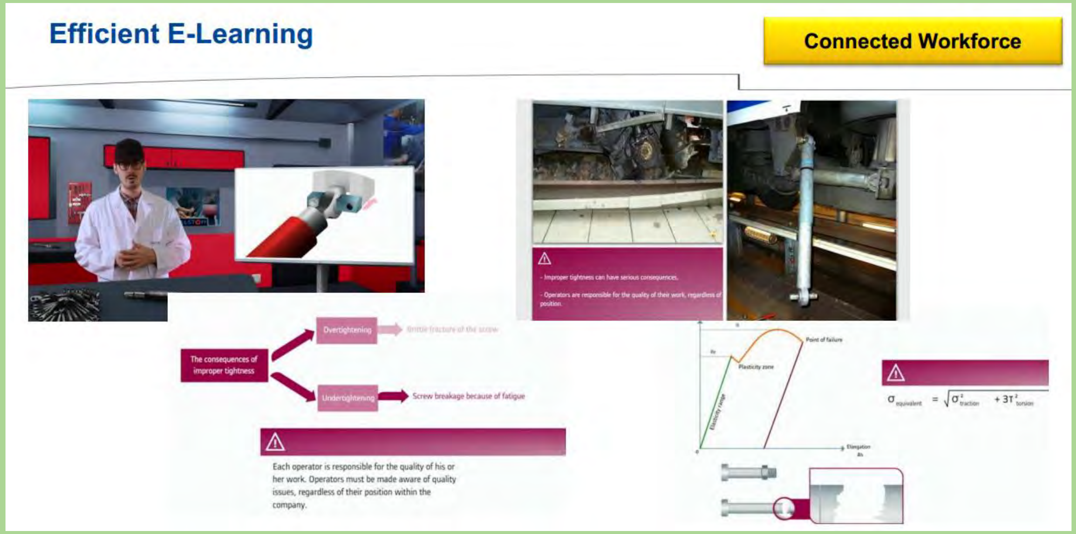
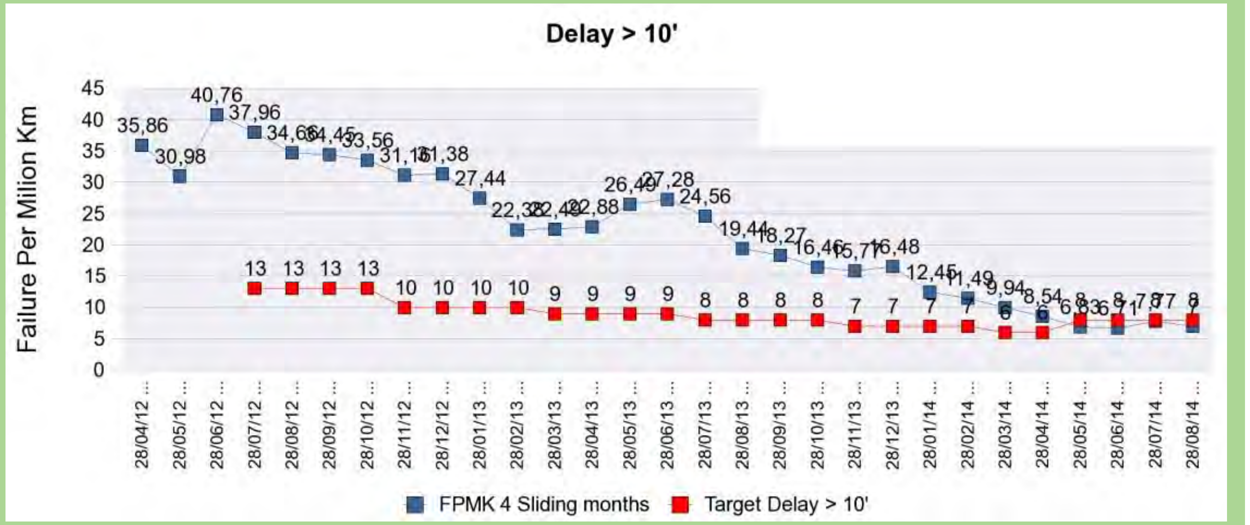
TRAINING : E-LEARNING



RELIABILITY MONITORING



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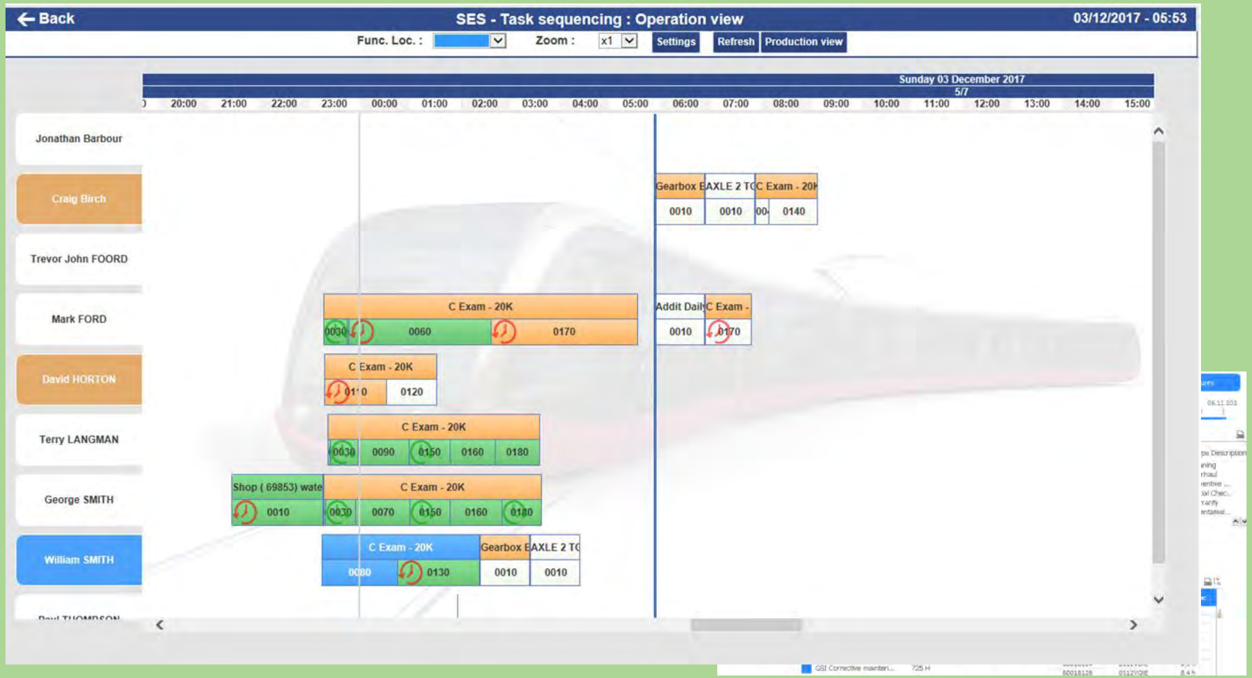
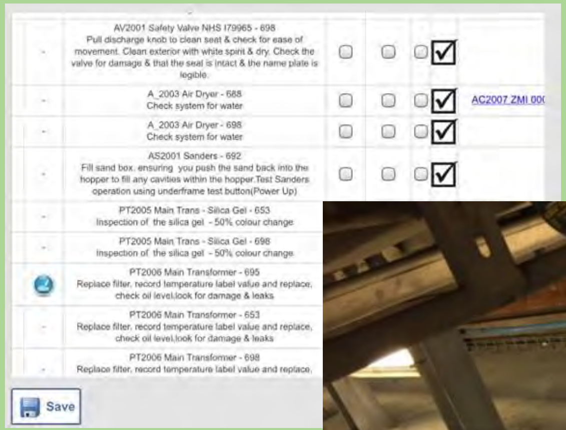
SERVICES EXECUTION SYSTEM (SES)





Reims (FR) ops with SES

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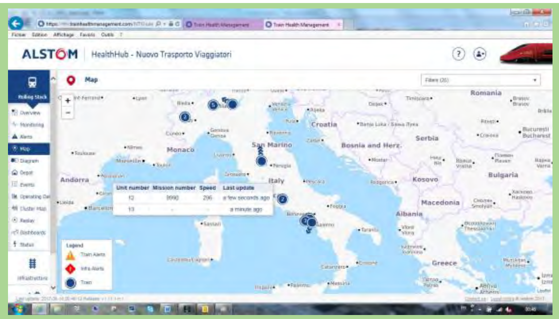
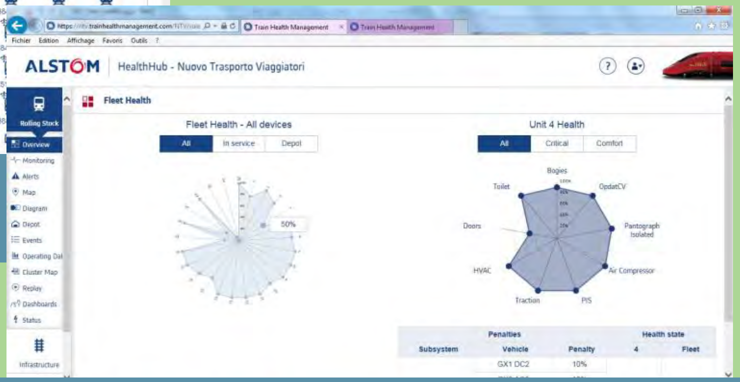
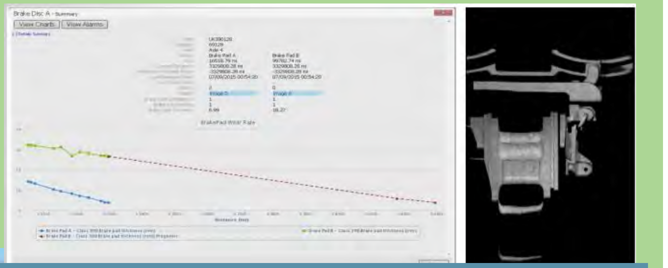
HEALTH HUB™

Ergonomic and scalable interface, adapted for any fleet size

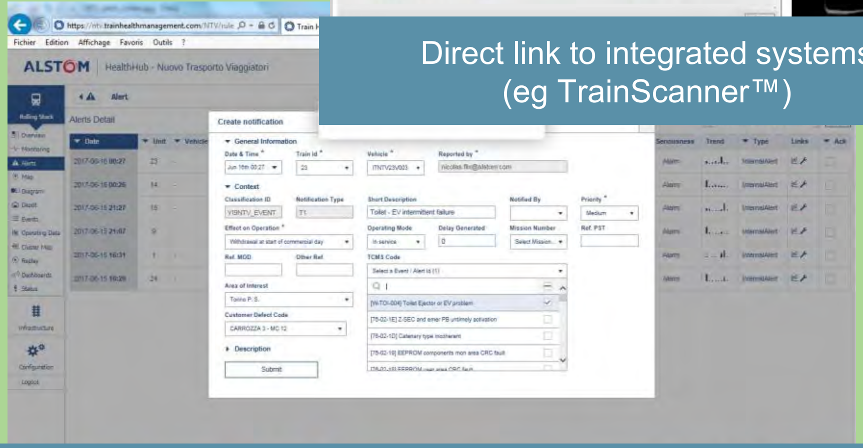




Unique train health radar for immediate assessment



Direct link to integrated systems (eg TrainScanner™)



Direct link to open a Work Order in the MMS (pre-captured) !

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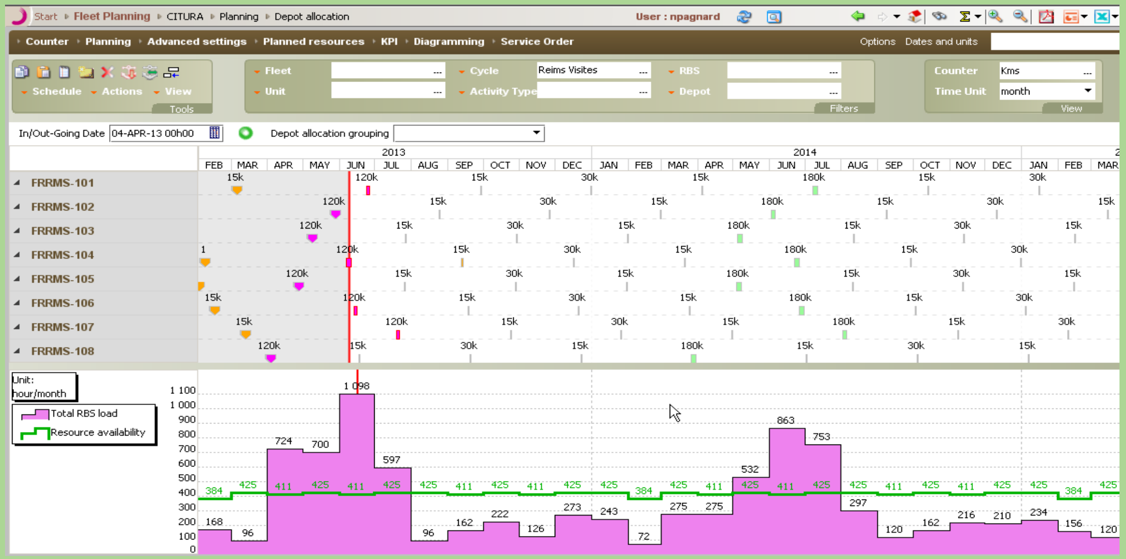
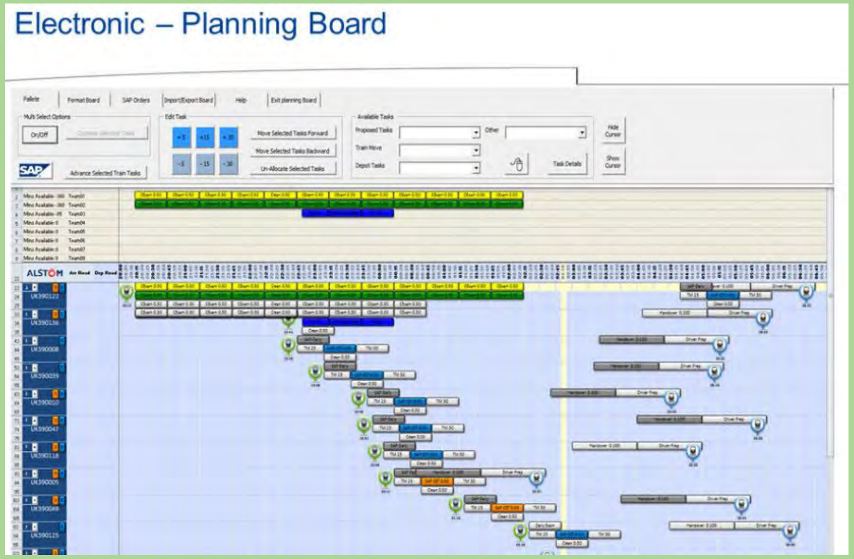
DYNAMIC MAINTENANCE PLANNING, DIGITAL PLANNING BOARD





TASKS SEQUENCER, DEMANDS OPTIMIZER

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