GNSS for rail automation & driverless cars: a *Give and Take* paradigm

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Speakers:

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Miami, September 28, 2018

RFI RETE FERROVIARIA ITALIANA
GRUPPO FERROVIE DELLO STATO ITALIANE

ION INSTITUTE OF NAVIGATION

European Global Navigation Satellite Systems Agency

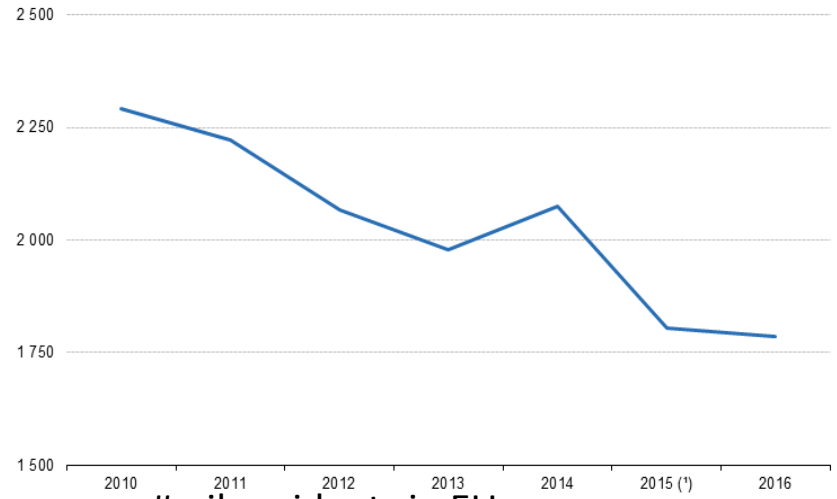
HORIZON 2020

SUMMARY

The European Railway Traffic Management System (ERTMS)

ERTMS has been designed to

- **replace** the different railway signalling systems in Europe with a **single system**:
  - Interoperable
  - Standard
  - Certifiable with harmonised procedures
- further **improve the safety**

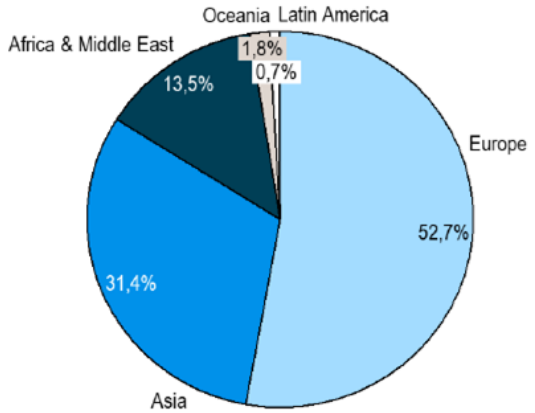


#rail accidents in EU (source Eurostat)

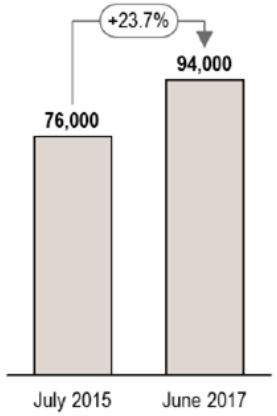
(*) Provisional data

ERTMS - A Key EU Rail Export

ERTMS trackside contracts by region

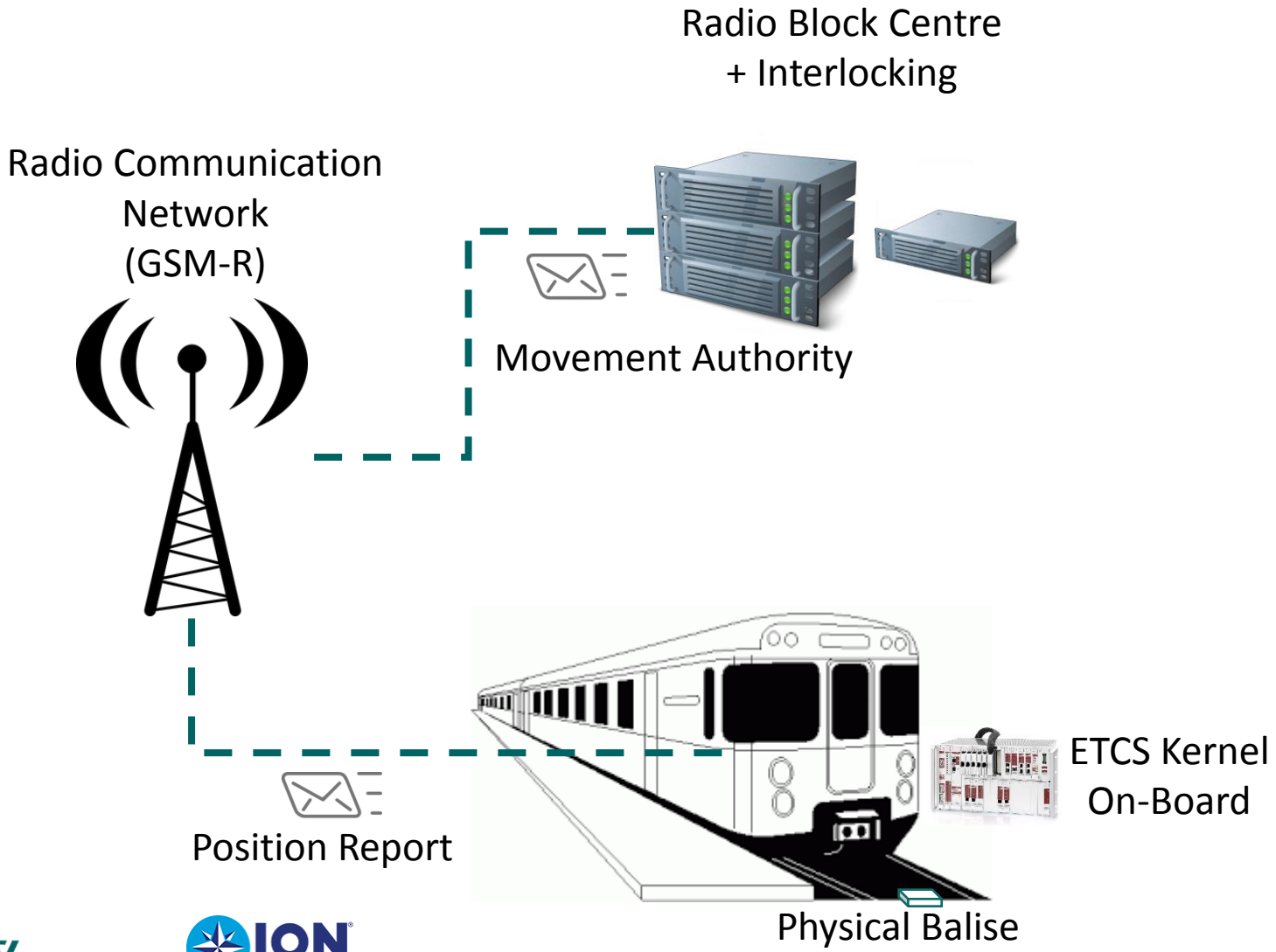


ERTMS trackside contracts in track km



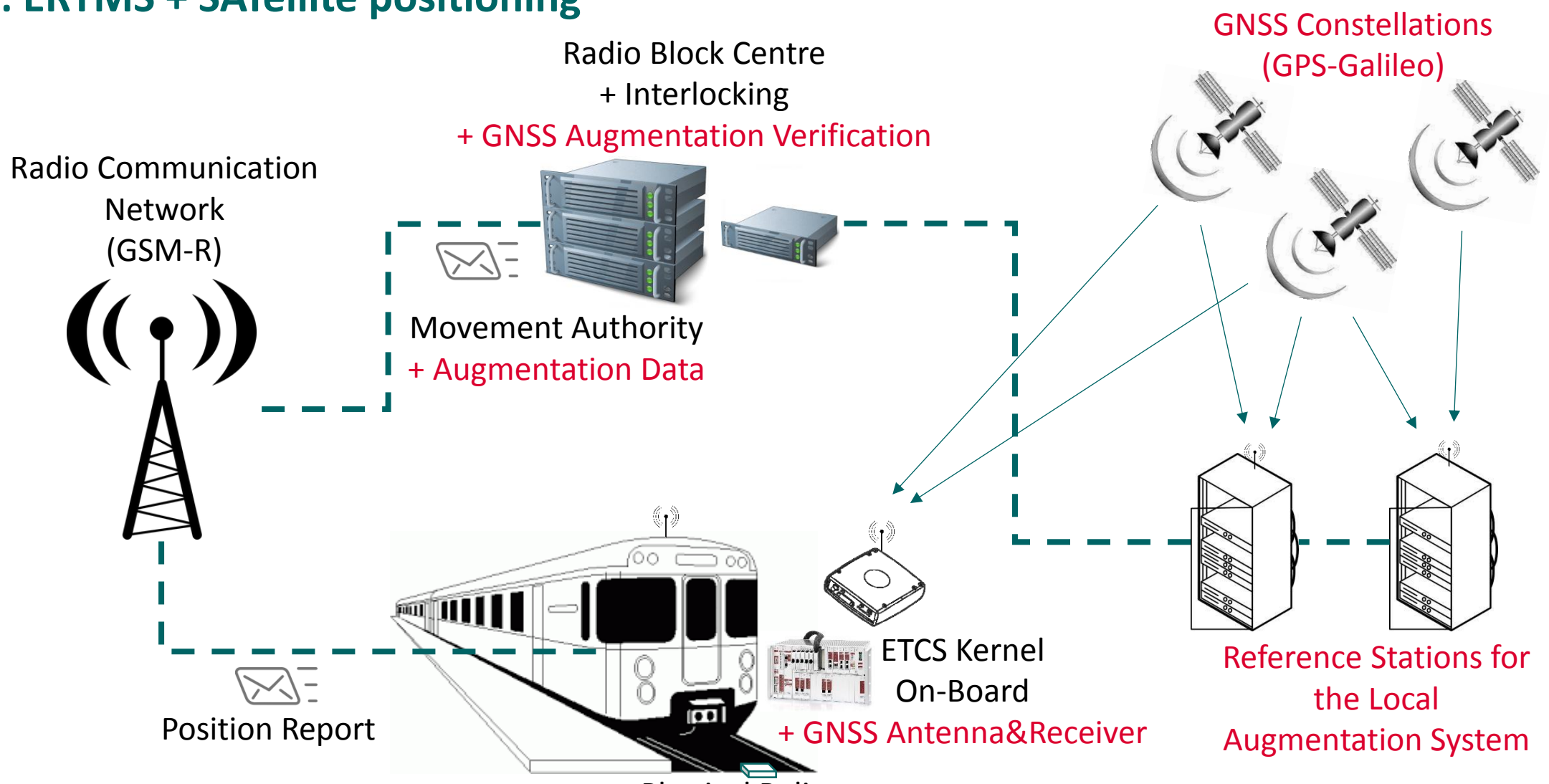
ERTMS reference architecture

in operation by 2005 in Italy @ 300 km/h, 2 train operators and 5 minutes headway



GNSS positioning in the ERTMS

ERSAT: ERTMS + SATellite positioning



Why introducing GNSS on the ERTMS

GNSS is one of the *Game-Changer* innovations for the ERTMS

virtual balises

Physical balises will disappear

Cost reduction

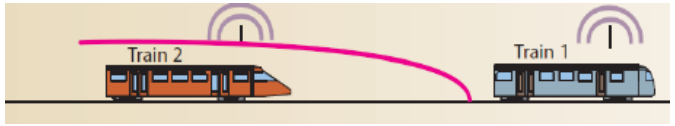
Interope-rability

Additional revenues

Applicability

the system is detected in the same way worldwide, certifiable for safety with an harmonised approach

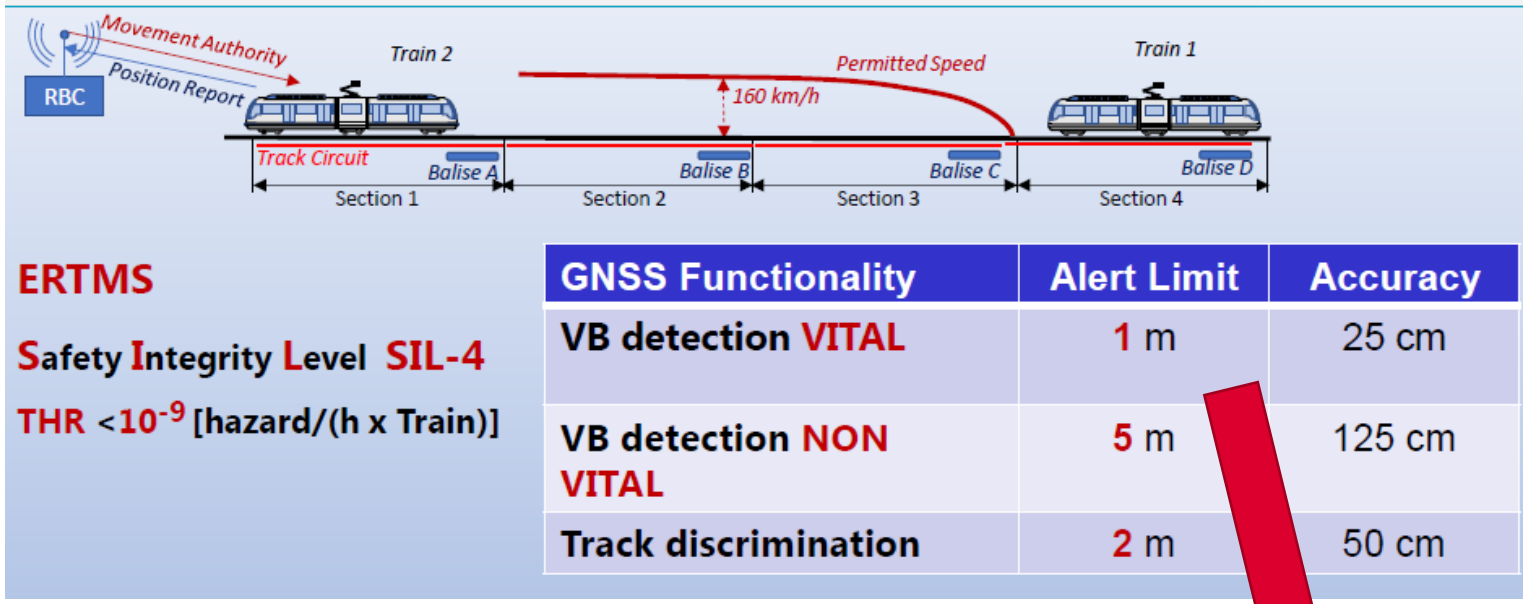
higher accuracy to increase line capacity



broadening of use, including regional and local lines

Challenges for the GNSS positioning

Along-track accuracy and track discrimination



Time and space dependency of the Signal

Local threats to the Signal in Space

Multipath

Non-Line-of-Sight

Interferences

Degraded performances

Using independent diagnostics the target GNSS integrity can be 10E-6/h

Train Positioning and Control Enhancement: ERSAT Program

2012	2013	2014	2015	2016	2017	2018	2019	2020

3inSAT
GNSS & Satcom Signalling Demonstrator

ERSAT EAV + GGC
ERTMS Application + Test Site

DB4RAIL
Anti-spoofing and Anti-jamming technology

SAT4Train
TLC Application

SBS phase 2
Technology Demonstrator

PILOT LINE
Regional line *Pinerolo - Sangone*

2013-2016 ***Feasibility Study***

2015-2019 ***Trail Site & Standardization***

Technology readiness

2017-2019

2017-2019

Commissioning

2018-2020

2017-2020

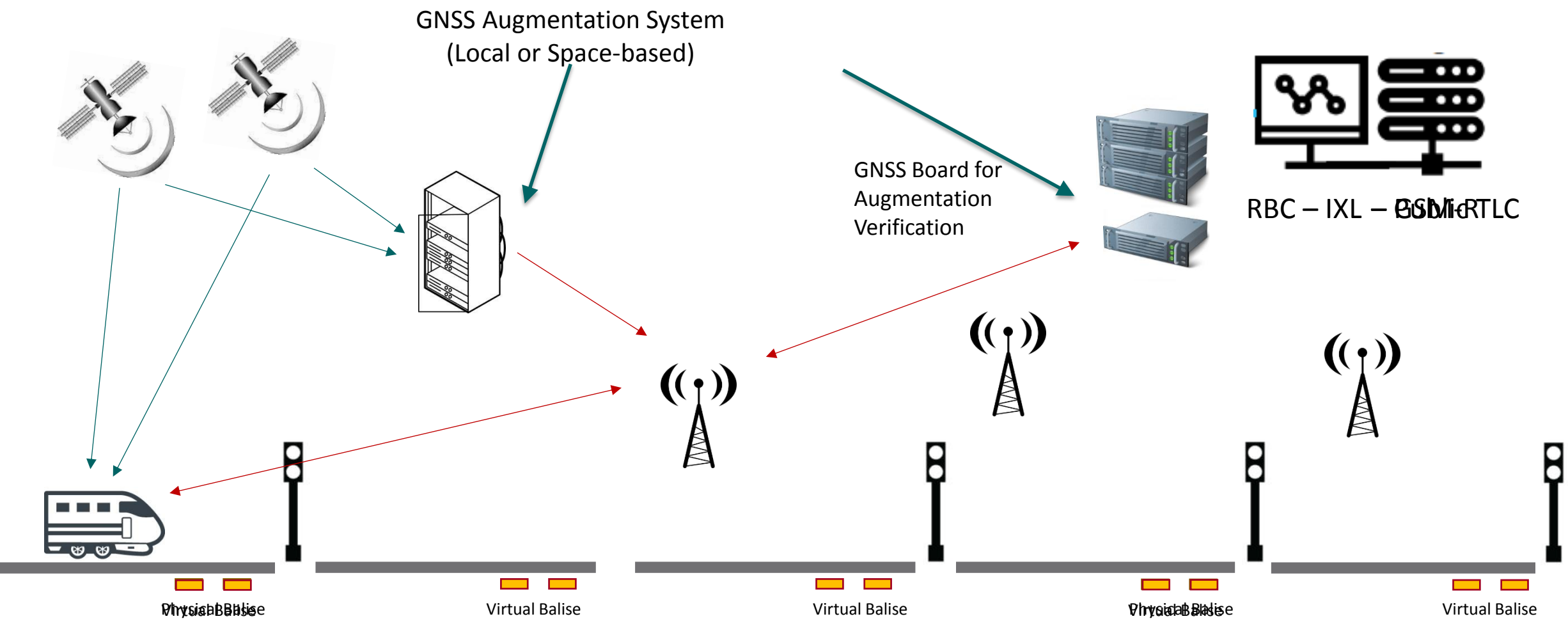
Working Group for the certification of GNSS into the ERTMS

Pilot line “Pinerolo – Sangone” (Piemonte, Italy)

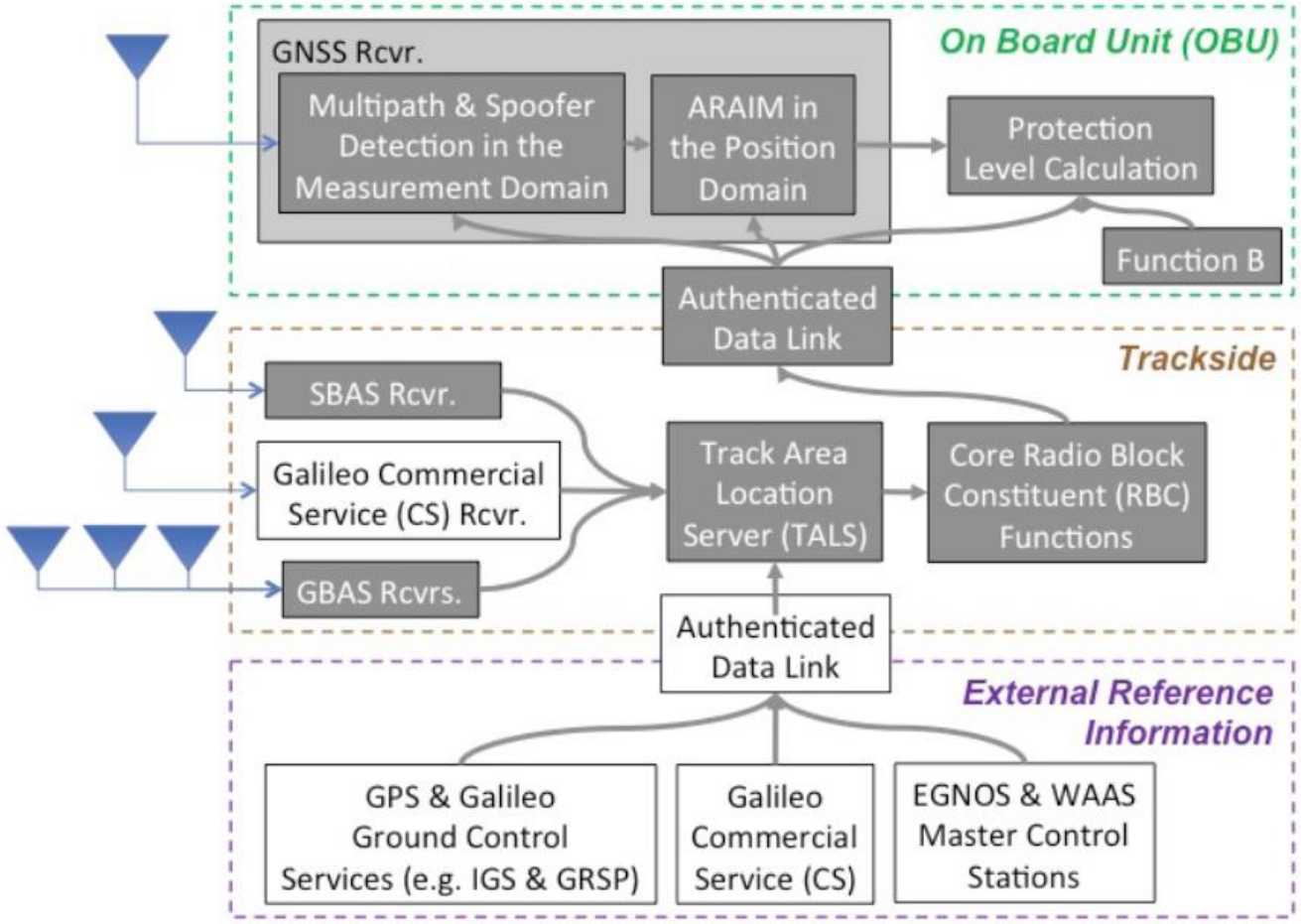
Formal process already activated

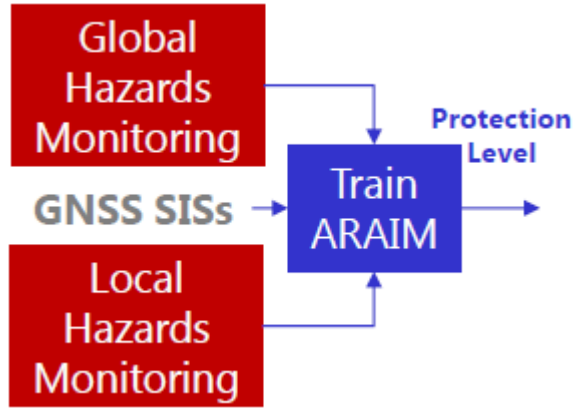
First step for the Railway certification

Safe introduction of GNSS with step-by-step approach



GNSS architecture for train control system





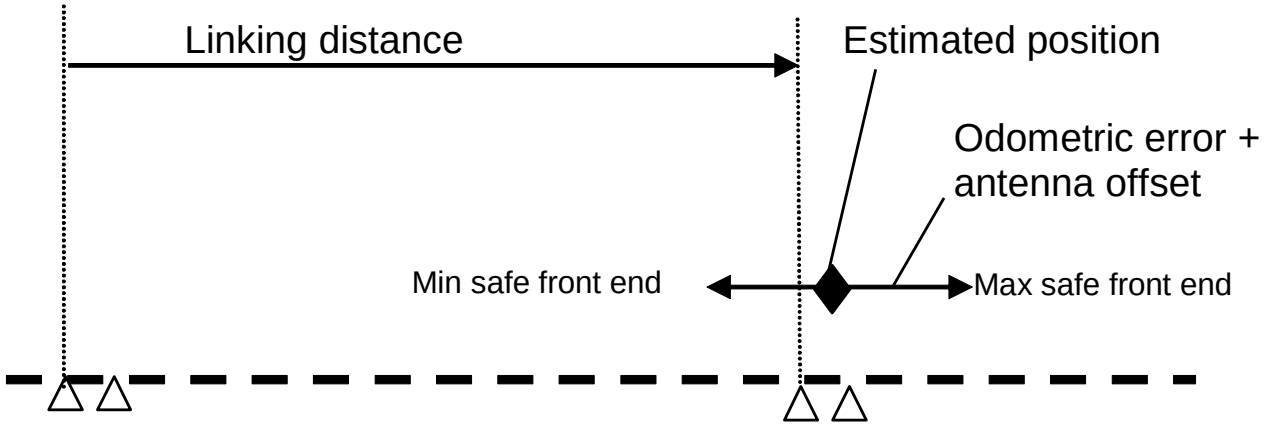
*«One of the main challenge is a technique to **reduce multipath that troubles the rail** application and so we must **monitor the air and automotive applications** of PPP, hoping they would provide **economy of scale** for the user equipment»*

Prof. Per Enge,
GSA White Paper – October 22, 2017

Reference RHINOS project

ERTMS Linking concept for safety

- Balises are linked: ID, expected position and orientation are known in advance
- Linking Safety Reaction: linking allows the train to check if balises are correctly detected or missed in the expectation window
- The safety reaction – emergency/service break - is configurable in terms of number of missed balises

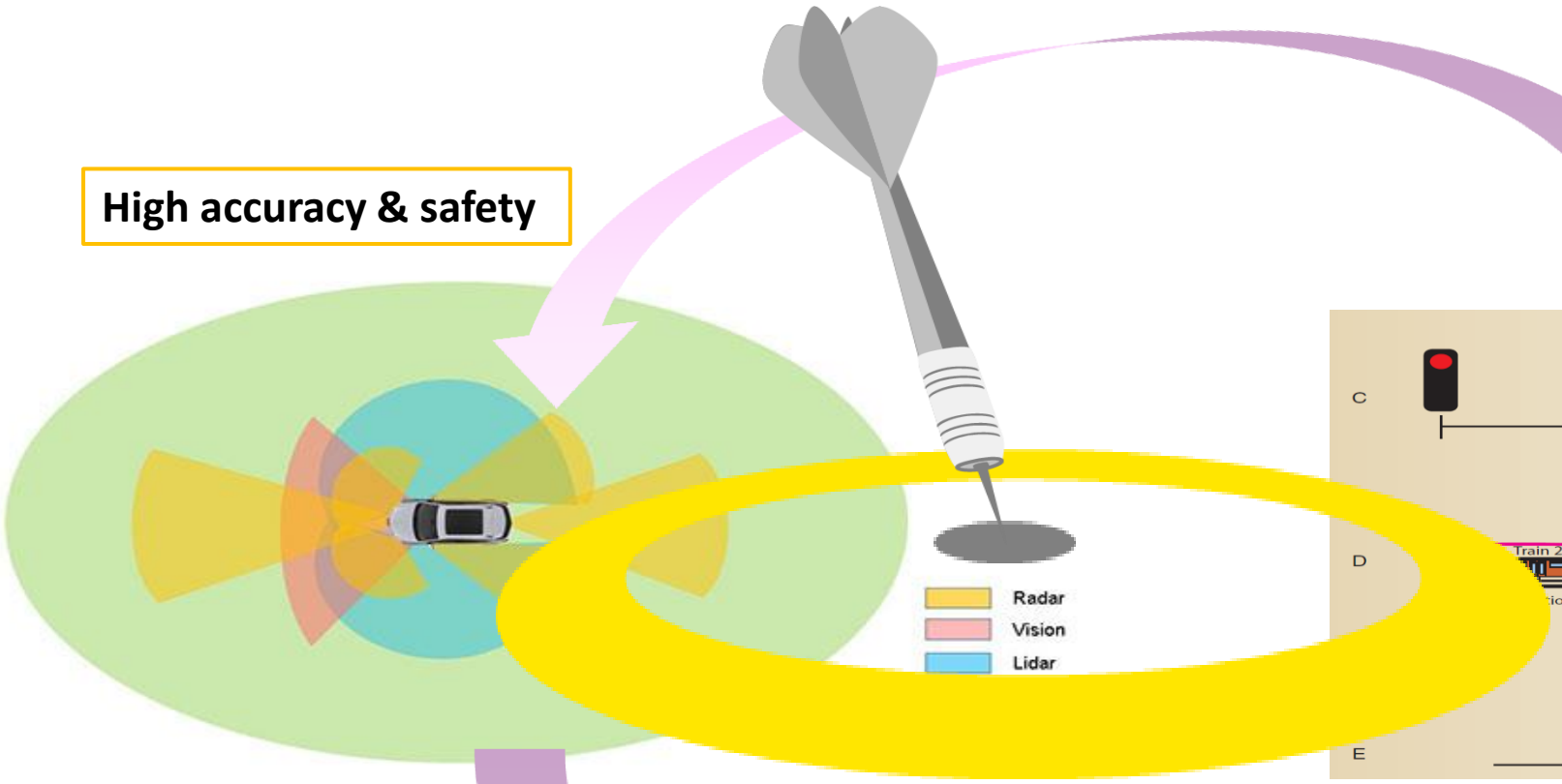


Car-Train sinergy for a safer and more efficient autonomous vehicles

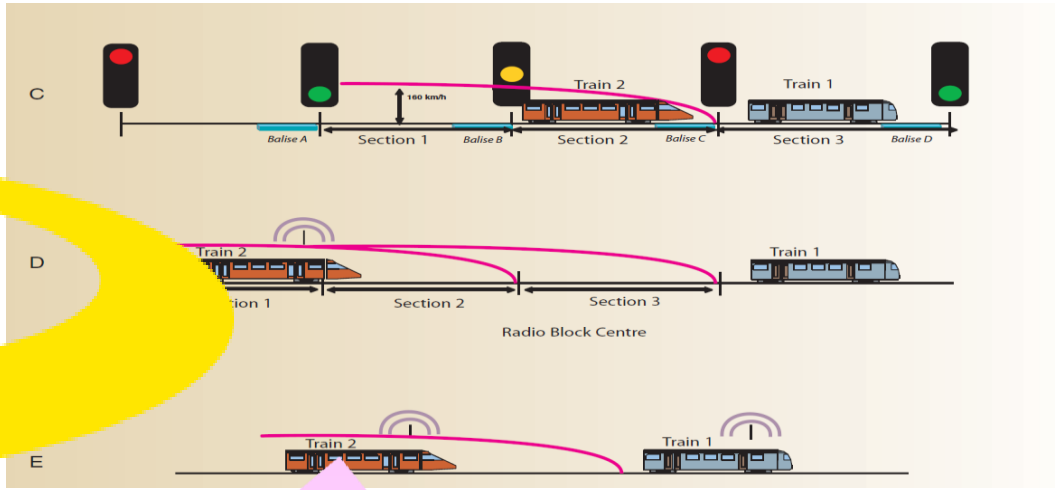
ERSAT GGC

GSA

High accuracy & safety



Automatic Train Control GNSS being validated



Video-GNSS positioning

Exploit safety primacy of train automation with autonomous cars market potential

More efficient Train Control

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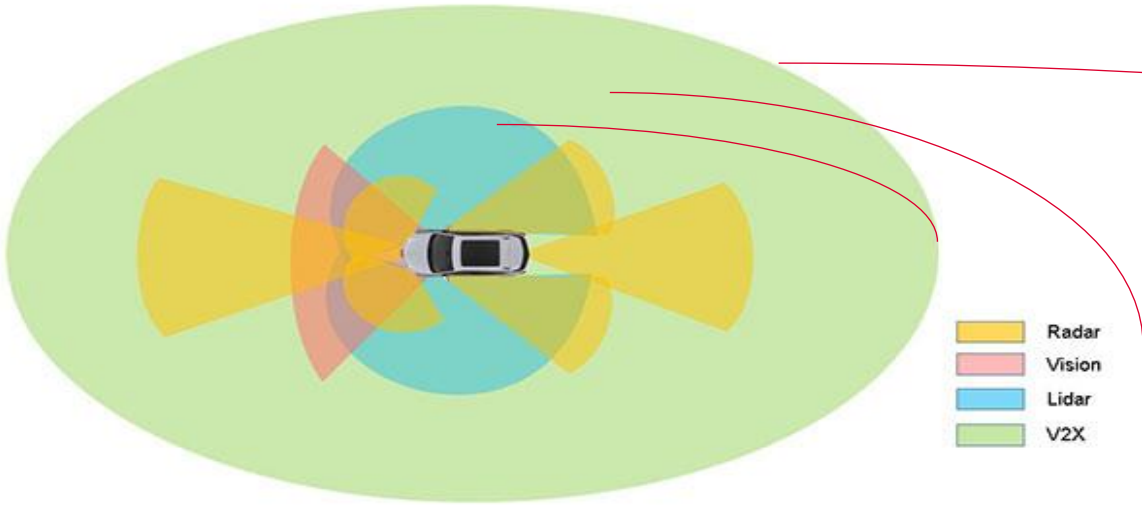
Stopping Distance

Driverless cars imply enhanced electronic horizons and ground based traffic control



Braking distance

Target Distance vs limit of Electronic Horizon

Electronic Horizon

Virtual track definition

Driverless cars imply enhanced electronic horizons and ground based traffic control

Safety issues related to:

- On board sensors field of view
- Breaking distance requirements

↓

Impact on safety/speed/availability

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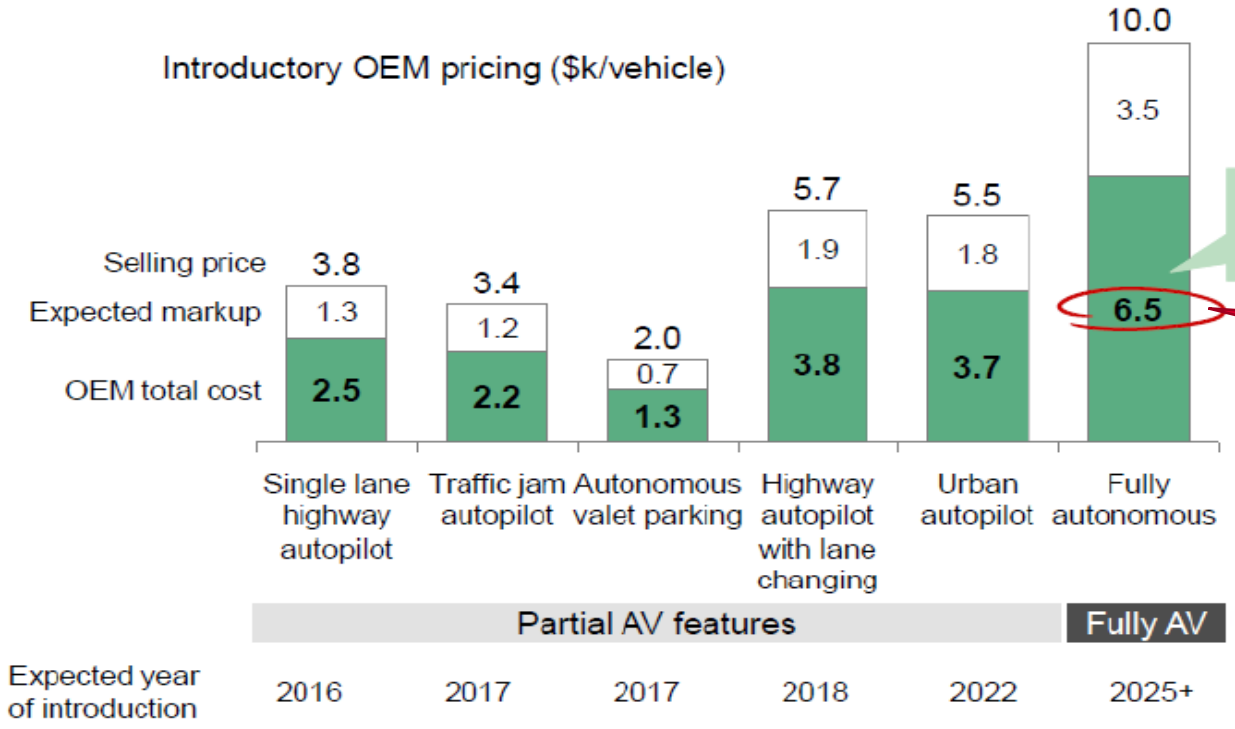
Definition of a virtual track with a centralized intelligence which

- Detects the line clearance / obstacles
- Foresees the movement of all the cars

Automotive prospects



Enrico Pisino, Connected and Automated Driving, Workshop ACI – Roma, 13 June 2017

Million units production rate

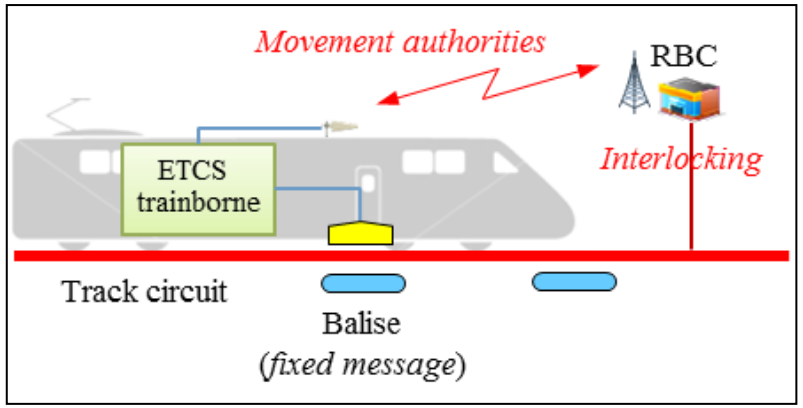
- R&D: 0.5k $/car
- Hardware: 4.0k $/car
- Overhead: 2.0k $/car

Estimated cost of autonomous driving device

ERTMS implementation plan in Europe

	Core network corridors	Core network	Comprehensive network
Length (km)	51 000	66 700	123 000
Cost extrapolation trackside (billion euro)	73	96	177
On-board retrofitment (billion euro)		11	
Total (billion euro)	**84**	**107**	**188**

ECA, EN 2018 - Special Report



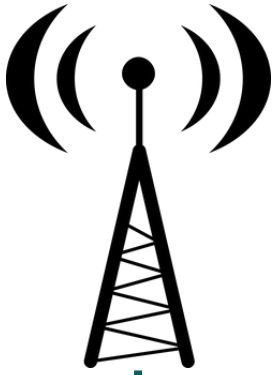
Highest level of safety: 10^{-9} hazards/(hour x train)

Applying the ERTMS principles to the Connected Cars

GNSS Constellations
(GPS-Galileo)

ERTMS Radio Block Center

Public Communication
Network
(3G-4G-5G-LTE-Satcom)



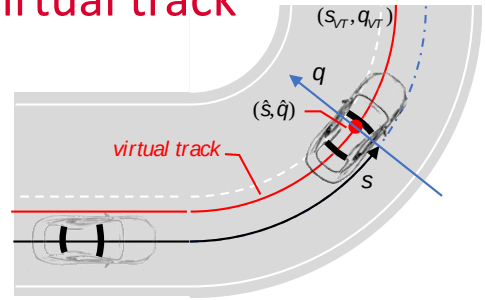
Movement Authority

Multi Modal
Public Augmentation
Network

ETCS Kernel
On-Board
+ GNSS Antenna&Receiver
+ Driverless

Position Report

Virtual track



The way forward

2024

Connected car using GNSS and public augmentation networks

Goal

Step3

2022

Safe obstacles detection

2021

Use of public operated augmentation networks

Step2

Step1

2020

Validation & Certification of a first GNSS-based ERTMS

Conclusions

- ERTMS achieved the highest safety levels and is a world-wide system
- GNSS introduction will lower TCO costs improving the benefits of ERTMS
- Autonomous vehicles should get know-how from ERTMS+GNSS, especially regarding safety and certification
- Car multi-sensor high-resolution platforms can further improve the ERTMS economical sustainability

A special tribute is due to the memory of professor Per Enge who has inspired this research and contributed to set a roadmap to extend to train control the benefits of GNSS

Thank you

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