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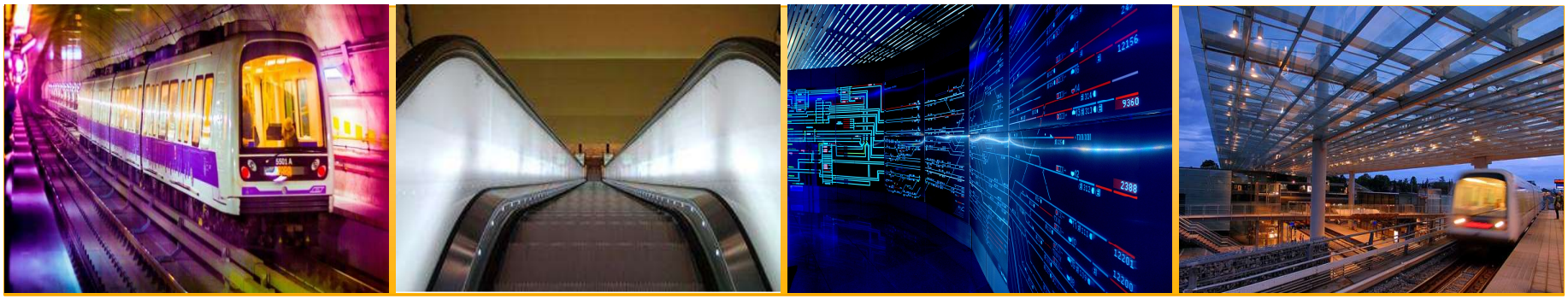

Main Rail Performance Requirements related to the GNSS Positioning

S. Sabina - Rev: 04

RTCM Paper 092-2018-SC134-011

Acknowledgements

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Disclaimer

The opinions expressed in this presentation may only belong to the speaker.

The mistakes are certainly mine alone.

RTCM Paper 092-2018-SC134-011

Outline

- ERTMS Location Principles and Train Position
- Measurement Error in the Detection of the Physical Balise
- Two Signalling Use Cases with High Precision and High Integrity
- Innovative Solution Based on the Concept of Virtual Balise detected by position computed by the Position Navigation and Timing (PNT) functional block
- Some Performance Requirements on GNSS-Based PNT functional block
- Other Related Critical Requirements

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ERTMS Location Principles and Train Position

The **Train Position** is defined as the **estimated position** of the train front end **in relation to the last Location Reference**; the location reference is associated with the location of an equipment, named Balise, mounted on the sleeper.

The **estimated train front end position** is determined by the **measured distance**, computed by the on-board odometry, **between** the Last Location Reference and the front end of the train.

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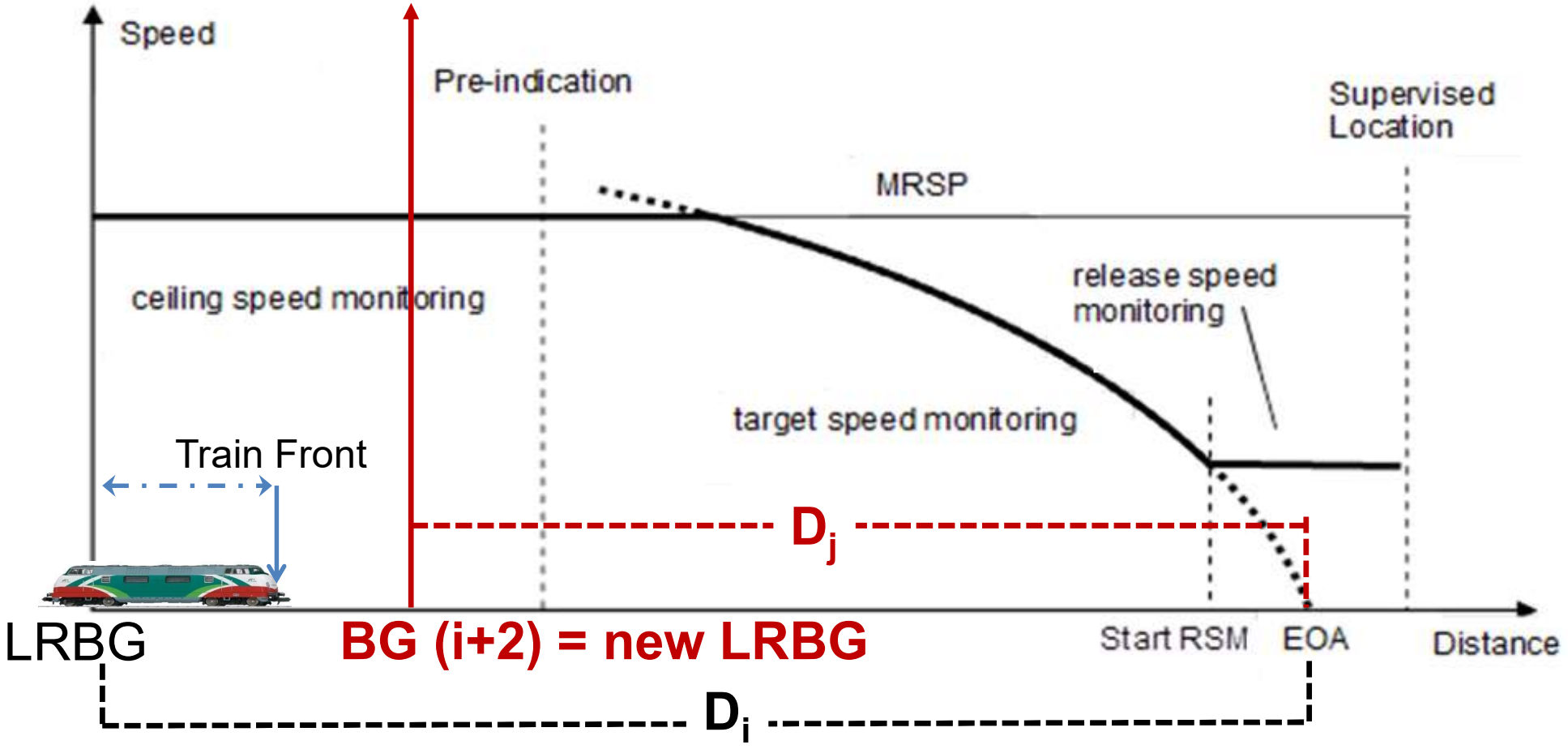
ERTMS Location Principles and Train Position (cont.)



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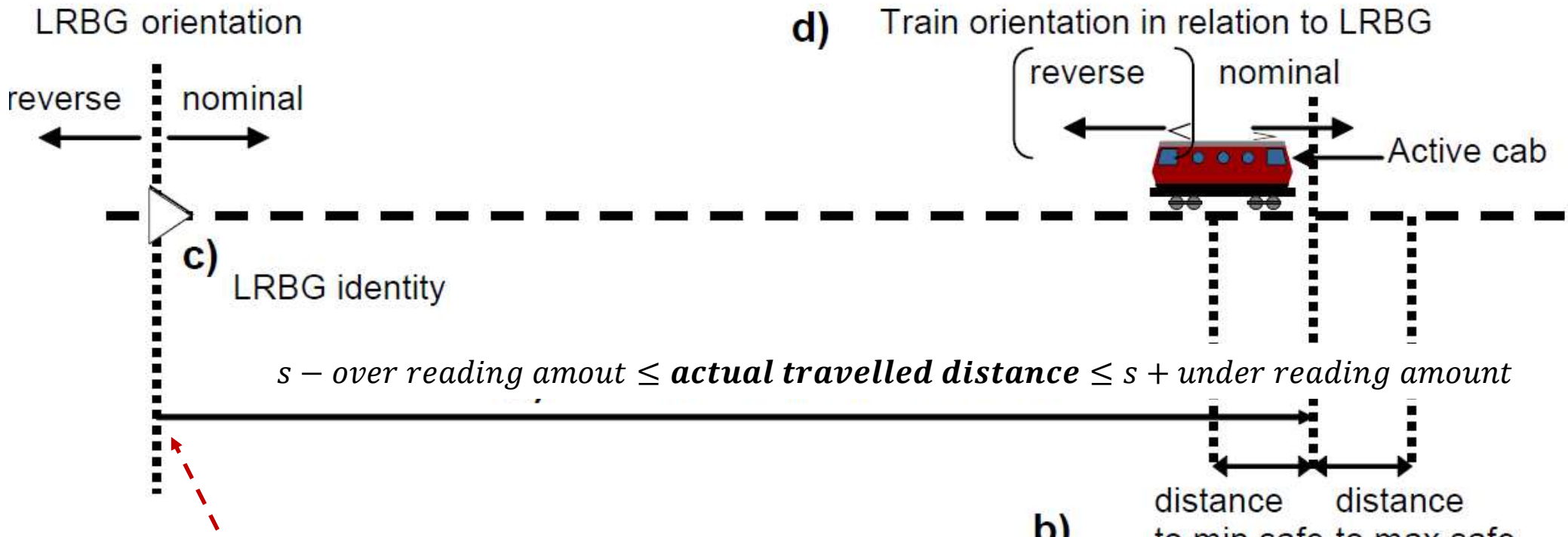
ERTMS Location Principles and Train Position (cont.)



The error (±1m) in the Location Reference is included in the uncertainties of the measured distance

$over/under\ reading\ amount$ ≤4 m + location reference error + **s*5%**.

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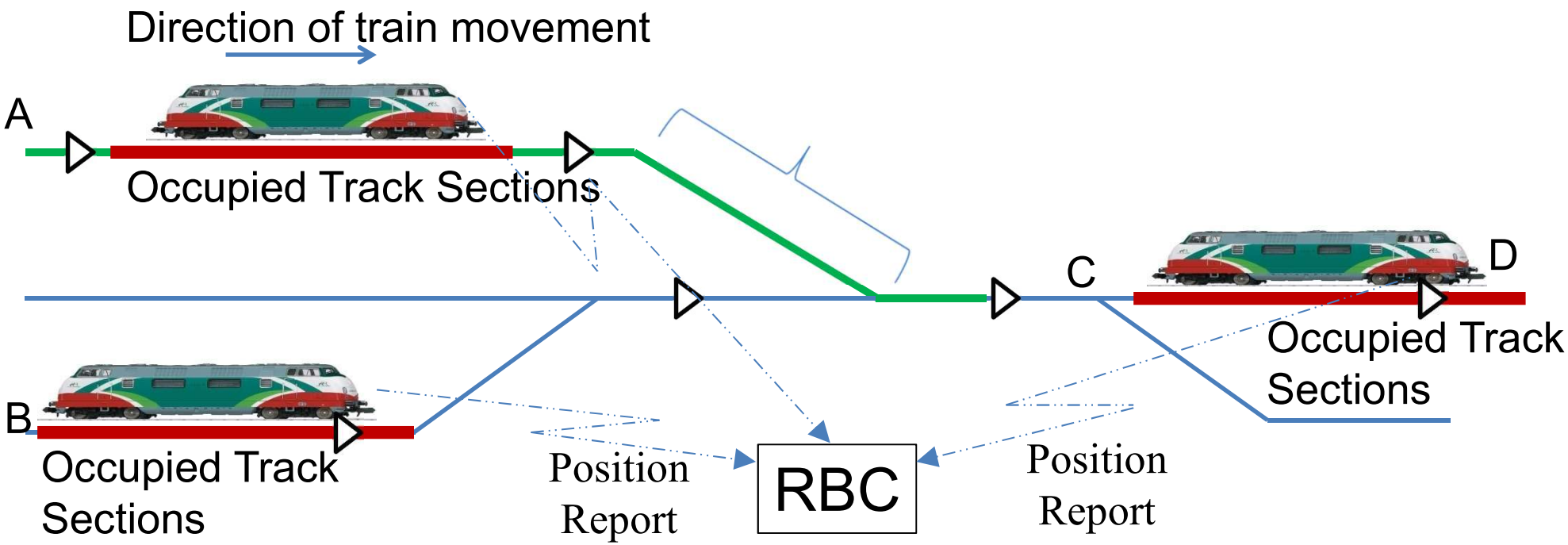
ERTMS Location Principles and Train Position (cont.)



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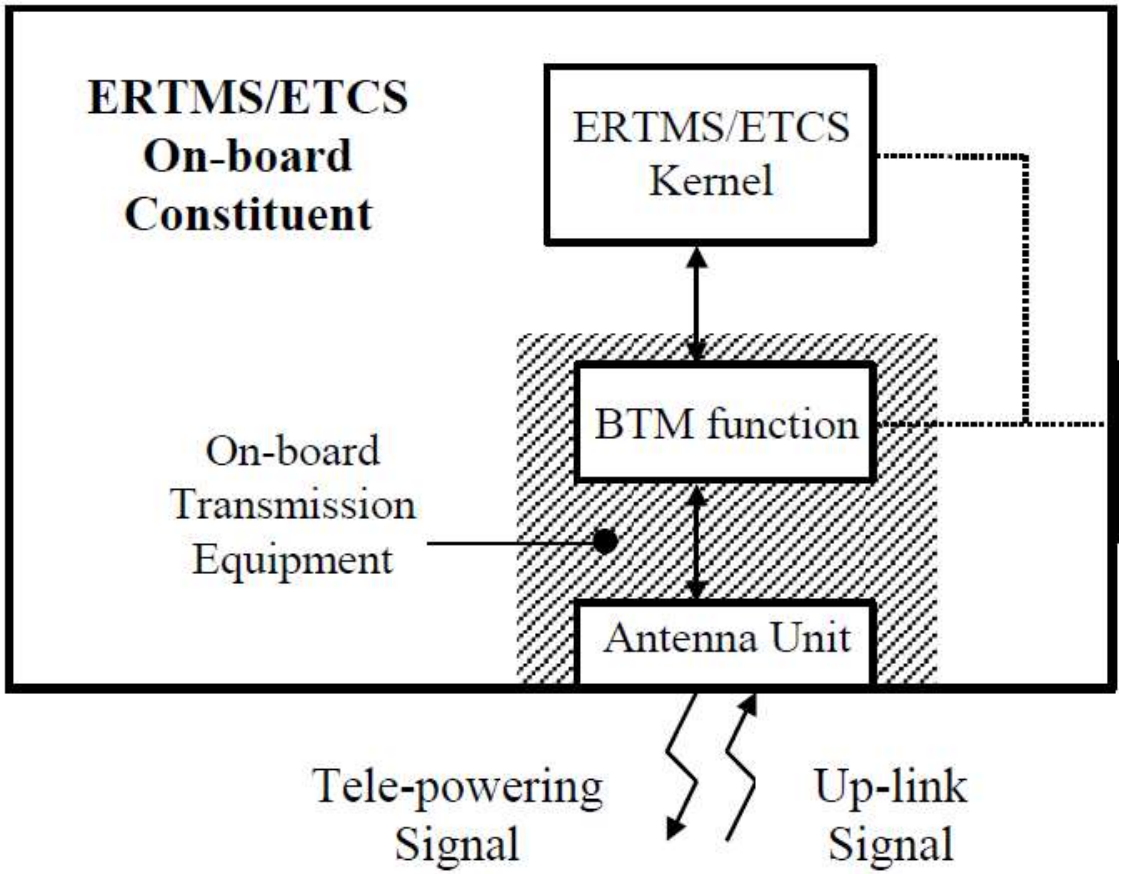
The Measurement Error in the Detection of the Physical Balise



The location error shall be within ±1 m for each Balise, when a Balise has been passed [Subset 036, v310].

Note: 1 m is the maximum absolute error.

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The Measurement Error in the Detection of the Physical Balise (cont.)

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Debris defined for the Eurobalise [Subset 036, v310]

Material	Description	Layer on top of Balise, [mm]	
		Class B	Class A
Water	Clear	100	200
	0.1 % NaCl (weight)	10	100
Snow	Fresh, 0 °C	300 (Note [36])	300 (Note [36])
	Wet, 20 % water	300 (Note [36])	300 (Note [36])
Ice	Non porous	100	100
Ballast	Stone	100	100
Sand	Dry	20	20
	Wet	20	20
Mud	Without salt water	50	50
	With salt water, 0.5 % NaCl (weight)	10	50
Iron Ore	Hematite (Fe_2O_3)	20	20
	Magnetite (Fe_3O_4)	2	20
Iron dust [37]	Braking dust	10	10
Coal dust	8 % sulphur	10	10
Oil and Grease		50	50

±1m guaranteed also under the debris conditions as specified in sections B5.2.2 and B5.2.3 of SUBSET-085.

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The Measurement Error in the Detection of the Physical Balise (cont.)

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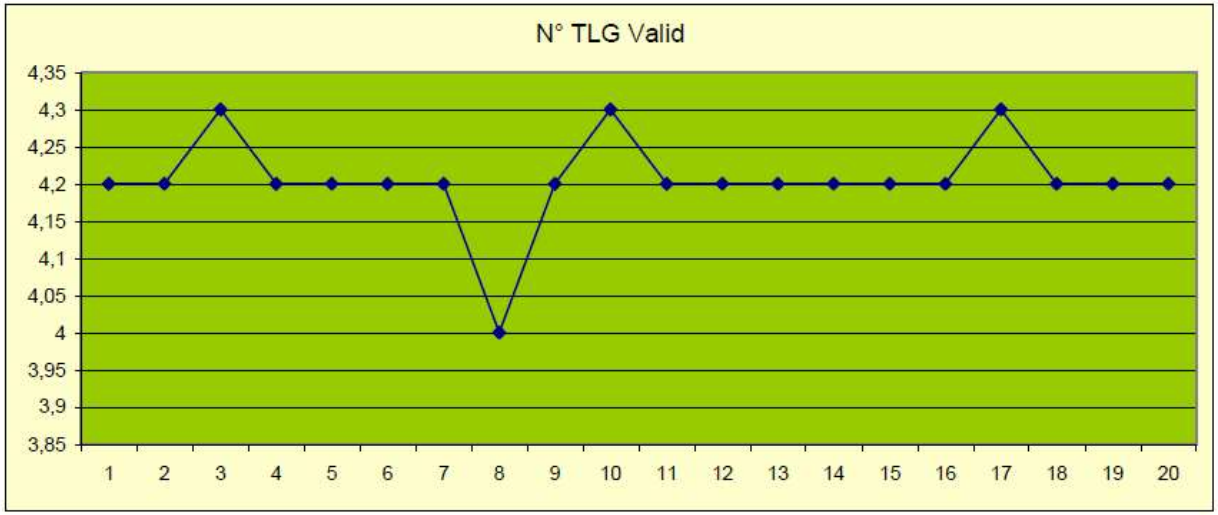
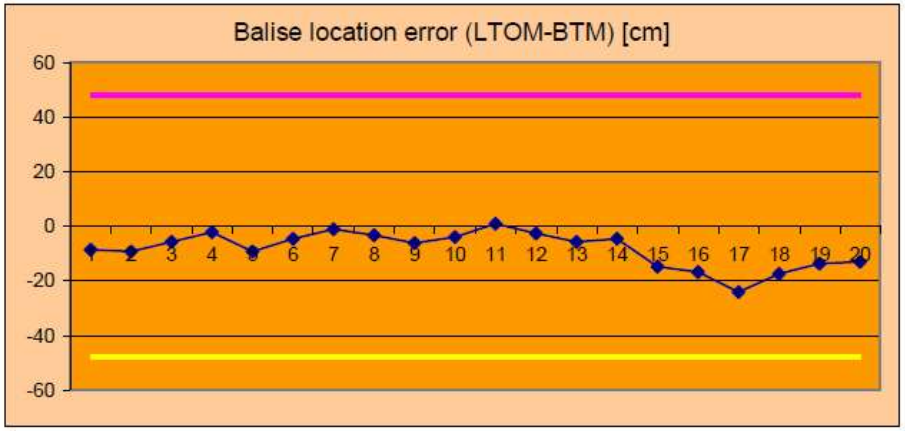
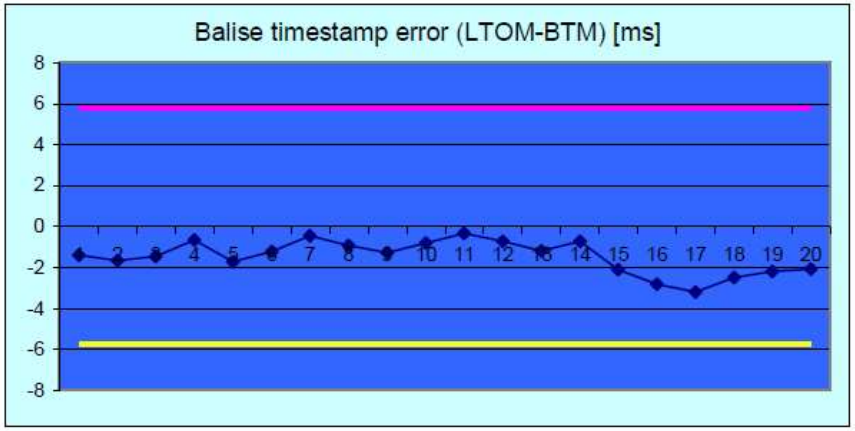
Date:	28/02/2012 14.29
Debris:	Free Air
Speed:	300
Reference Loop:	Reduced TRV
Balise	Weak
Telegram	18
Height	Zmax
Lateral deviation	60 mm
Operator	Livio Denegri
File name	[redacted]_02_2







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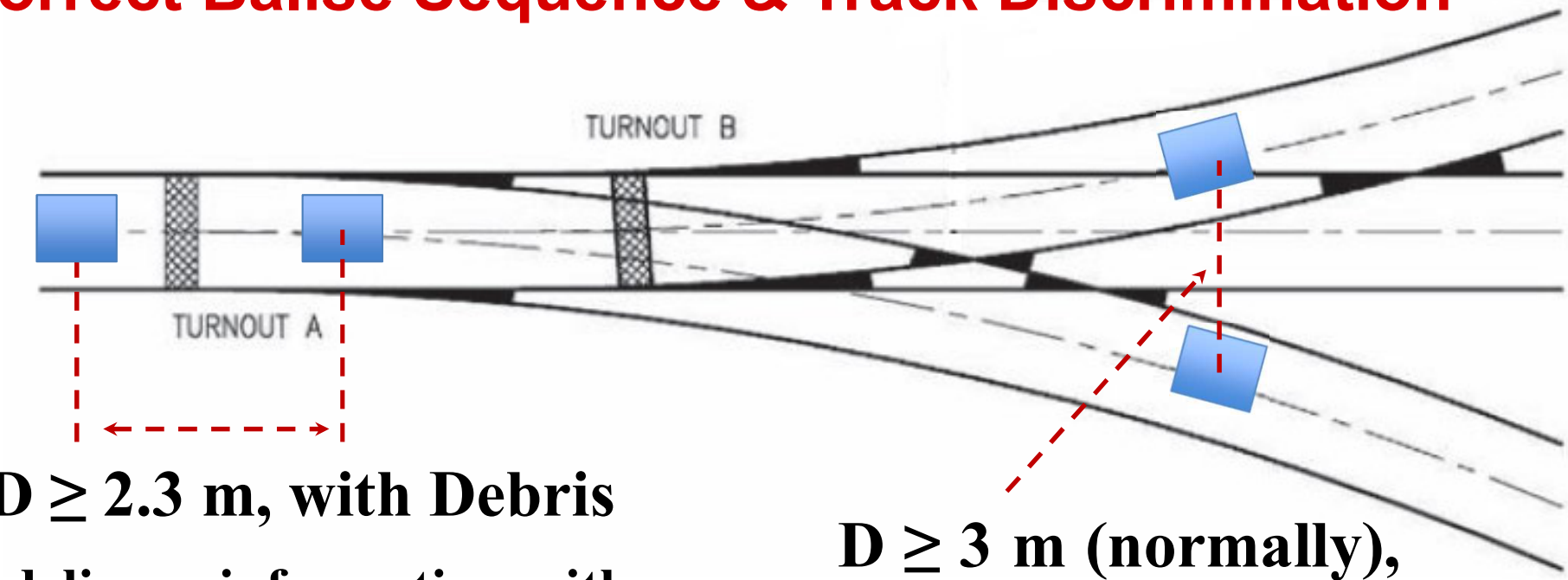
Correct Balise Sequence & Track Discrimination



D ≥ 2.3 m, with Debris

(to delivery information with the correct sequence)

D ≥ 3 m (normally), with Debris

Target THR = 1E-9 / h (Subset 091)

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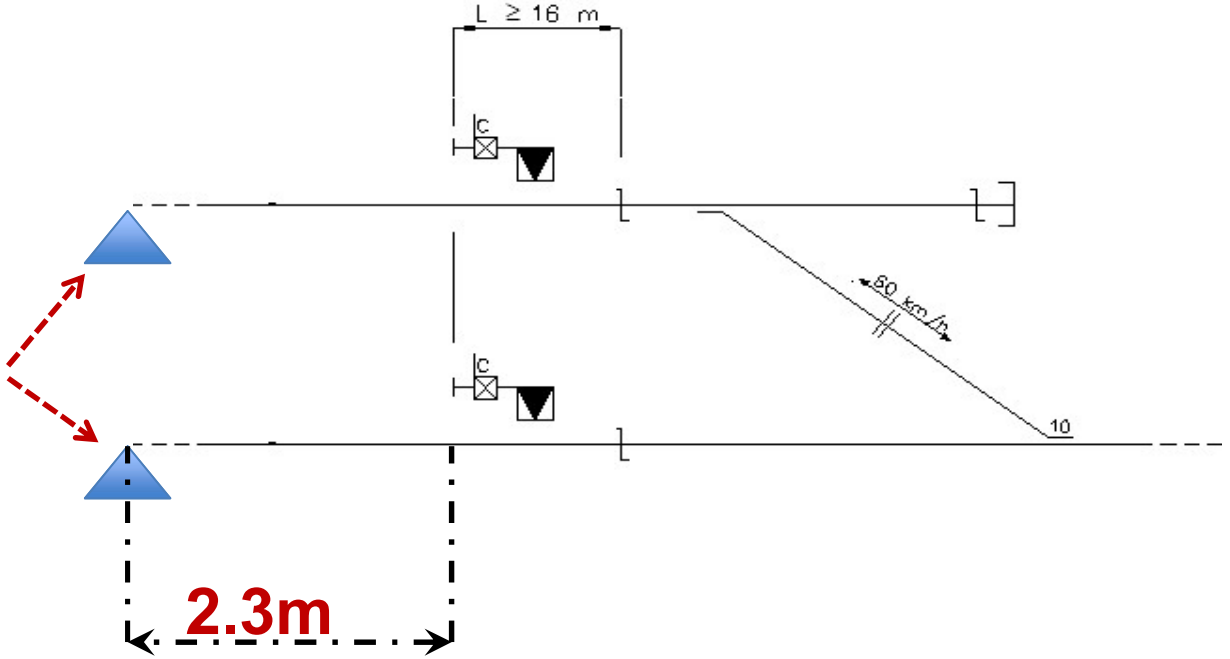
Protection of some Track Locations

Command "Stop if in Staff Responsible Mode"



for train movement in Staff Responsible Mode

Minimum distance between the balise group and the EOA/LOA shall be 1.3m plus the distance the train may run during the time Tn (equal to 100 ms for train speeds lower than 80 km/h) [Subset 040, v340]. **Note that 1.3m includes the maximum error in the Location Reference detection**.

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Innovative Solution Based on the Concept of Virtual Balise detected by position computed by the PNT functional block

Replacement of a **Physical Balise** with a **Virtual Balise,** whose detection is based on the **augmented GNSS Position and** the **Safe Odometry Information** (i.e. GNSS alone does not currently meet the THR required)

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Innovative Solution Based on the Concept of Virtual Balise detected by position computed by the PNT functional block

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Physical Balise

Virtual Balise Location

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Innovative Solution Based on the Concept of Virtual Balise detected by position computed by the PNT functional block

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BTM provides:

- User Bits
- Nominal Balise Location
- Max/Min Balise Detection Error = +/- 1m

GNSS Position matches the VB Position on the track

VBR provides:

- User Bits
- Nominal Balise Location
- Max/Min Balise Detection Error = f(**Prot. Level**, …)

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Some Performance Requirements on GNSS-Based PNT

Requirements		
Track Discrimination	**Minimum Distance 3 m**	**THR= 1E-9 / h** in presence of **Local Feared Events**
Virtual Balise Longitudinal Location Error under some ERTMS Operation Modes	**Less than 3m provided that an alarm is raised when the estimated error is greater than 3 m. Less demanding in other ERTMS Operational Modes**	**THR= 1E-9 / h** in presence of Local Feared Events

Other Related Critical Requirements: Security

CENELEC EN 50159 - Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems

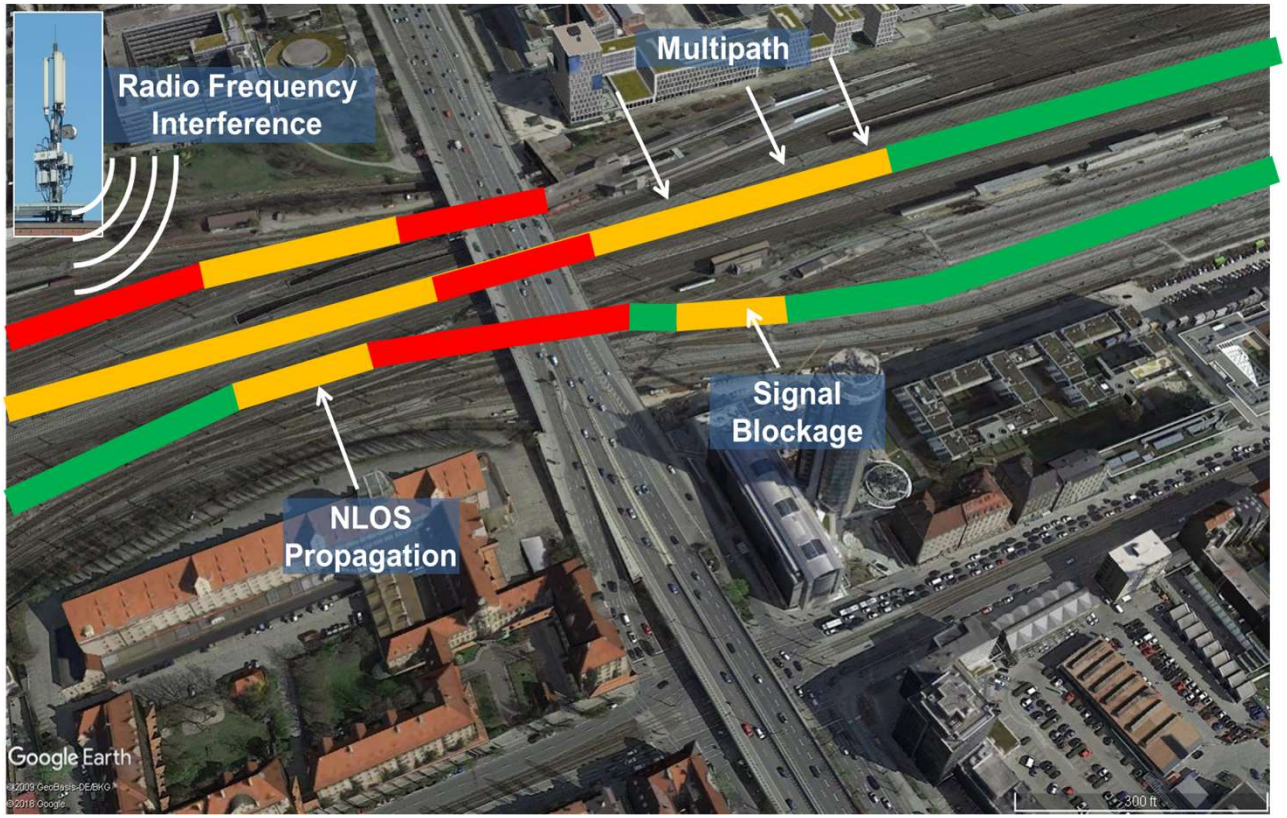
If a **safety-related electronic system** involves the transfer of information between different locations, **the transmission system** then forms an integral part of the safety-related system and it shall be shown that the end to end communication is safe in accordance with EN 50129.

The transmission system considered in this standard, which serves the transfer of information between different locations, has in general no particular preconditions to satisfy. **It is from the safety point of view not trusted, or not fully trusted**.

Other Related Critical Requirements: Security (cont.)

The SECURITY must be addressed at system level, based on the Signalling Properties

Other Related Critical Requirements. Track Area Survey



The classification of track area as **suitable** or **not suitable** for locating virtual balises must guarantee the ERTMS interoperability requirements.

A **standard track area classification process and procedures must be defined and used.**

THANK YOU FOR YOUR ATTENTION