European Train Control System (ETCS)

MODERN RAIL TRANSPORTATION SAFETY

MARK WEDLEY

Contents

- Brief History of Signalling
- European Rail Traffic Management System (ERTMS)
- European Train Control System (ETCS)
- ETCS Data Interpretation

A Brief History of the Railway

200 years in the making

Evolution of Signalling

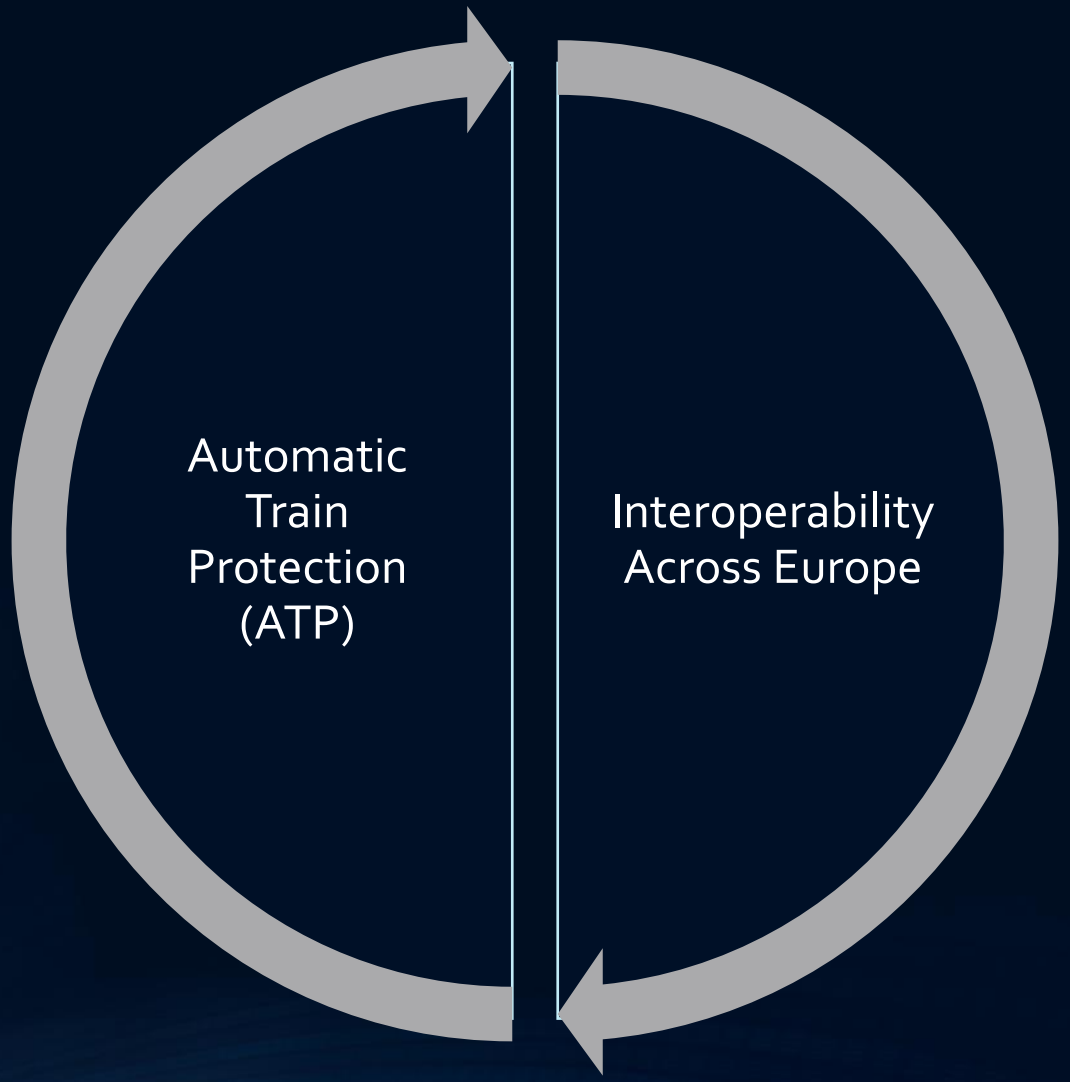
Why do we need ERTMS?

UK Class B Protection Systems

Automatic Warning System (AWS)

Train Protection Warning System (TPWS)

Class A Protection



European Rail Traffic Management System

(ERTMS)

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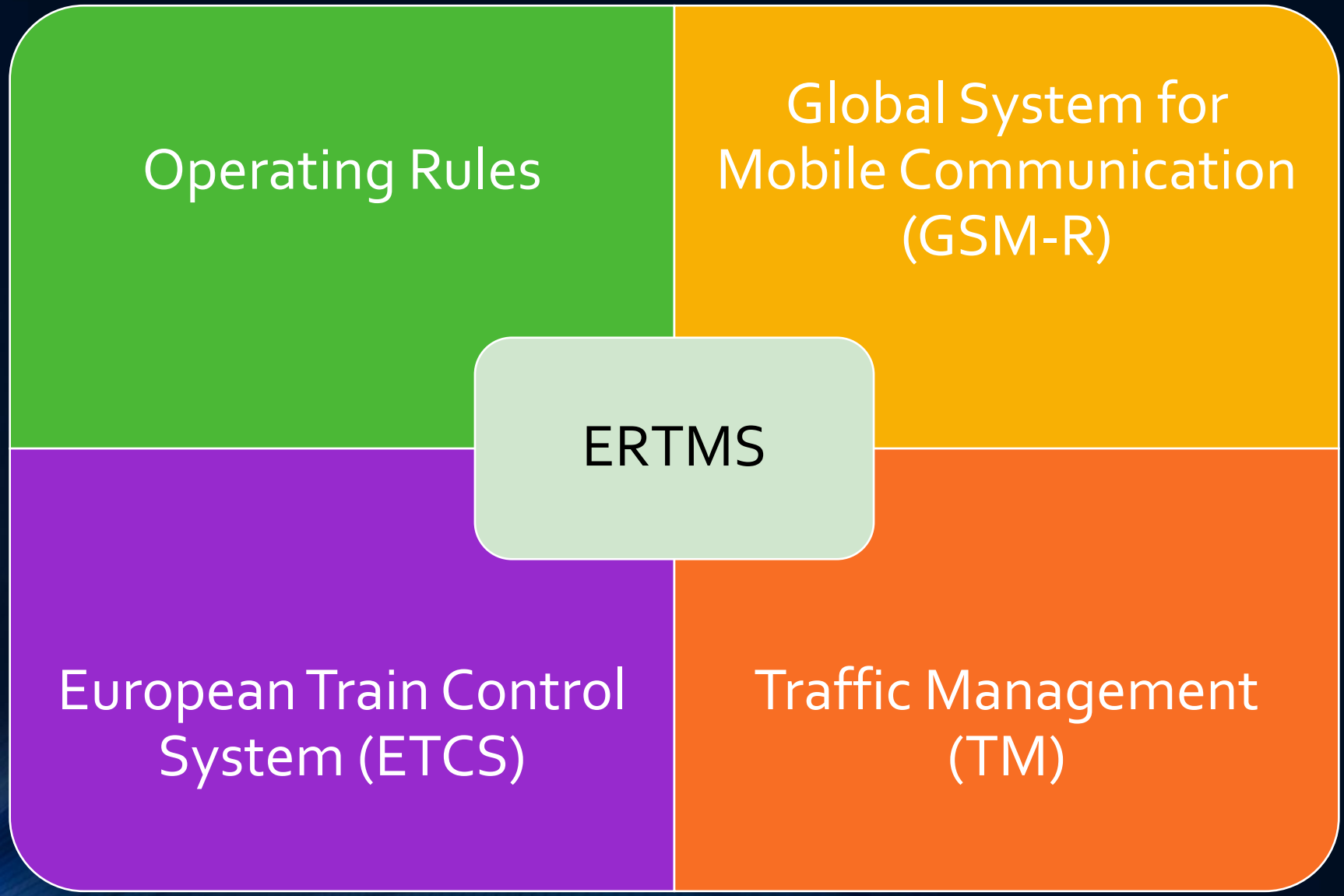
What is ERTMS?



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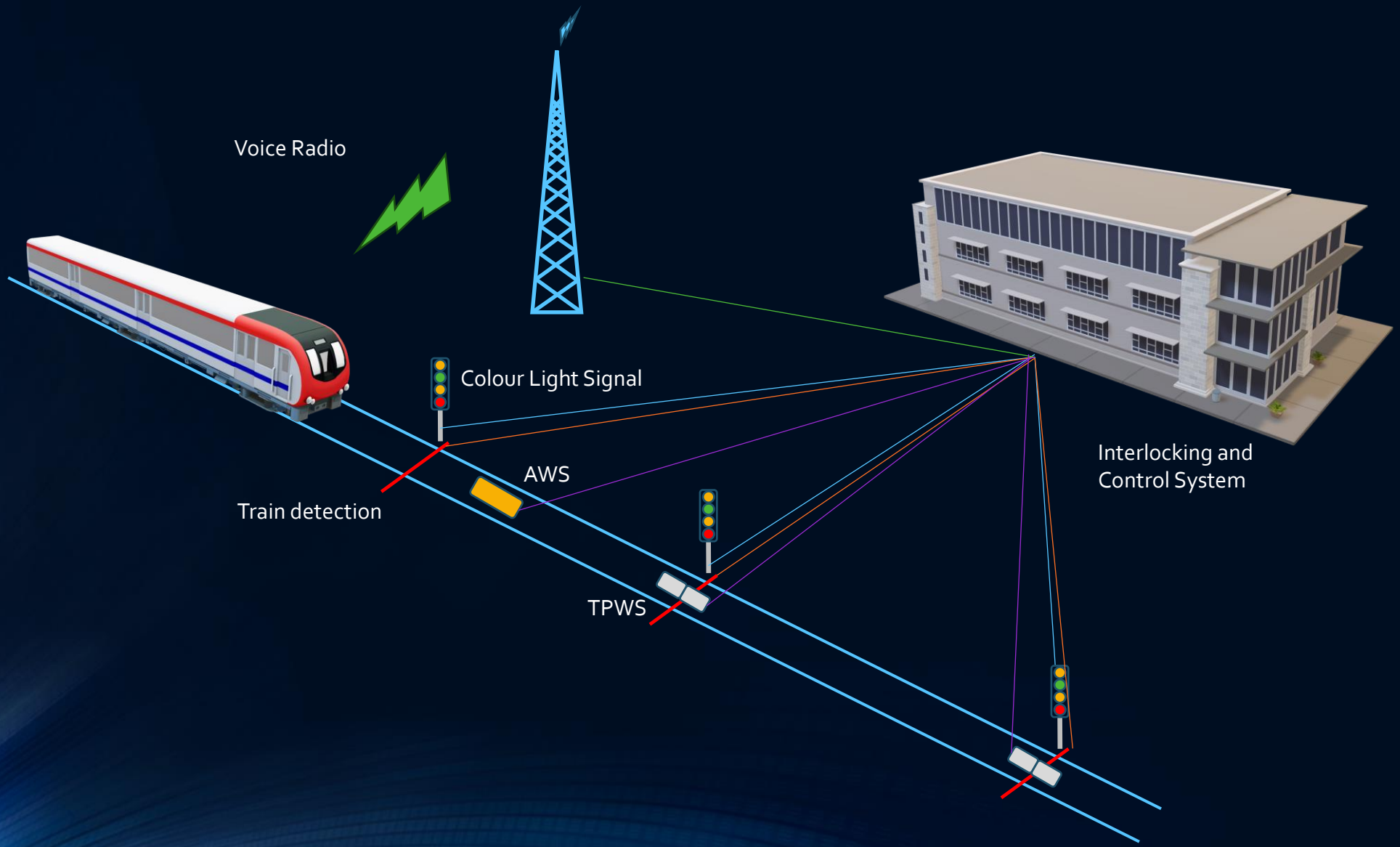
Benefits of ERTMS

European Train Control System

(ETCS)

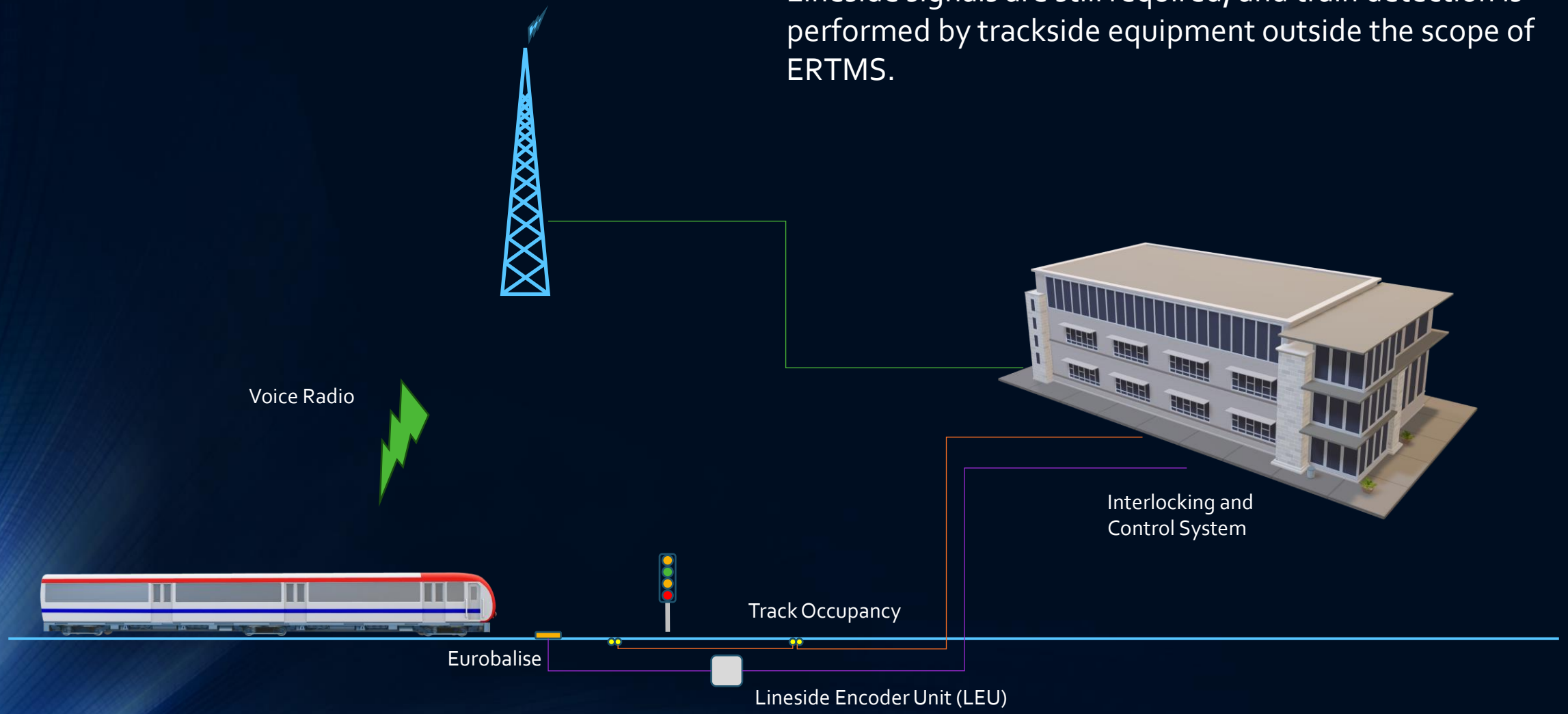
Conventional Signalling



ETCS Signalling

ETCS Level 1

Level 1 provides supervision of train speed Via Eurobalise and displays this on the driver's Digital Machine Interface (DMI) Lineside signals are still required, and train detection is performed by trackside equipment outside the scope of ERTMS.



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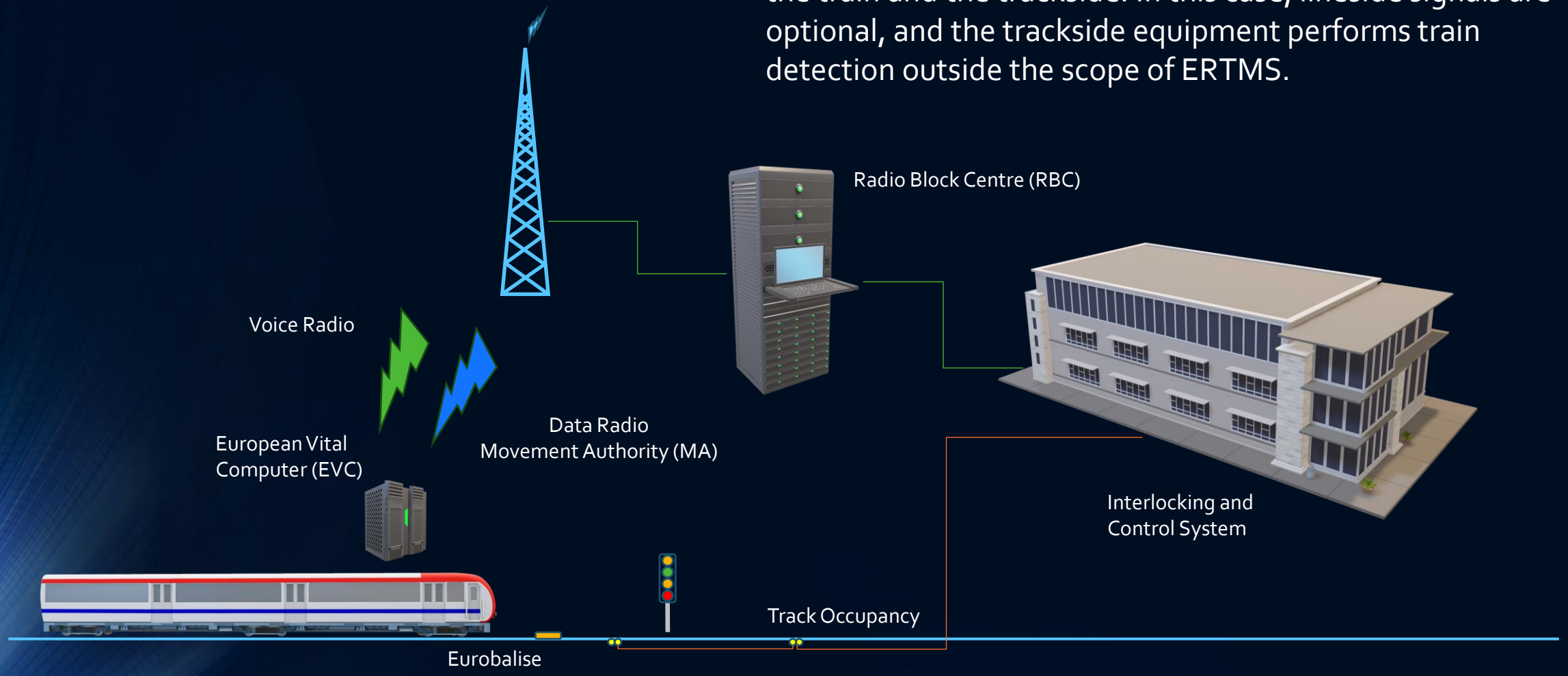
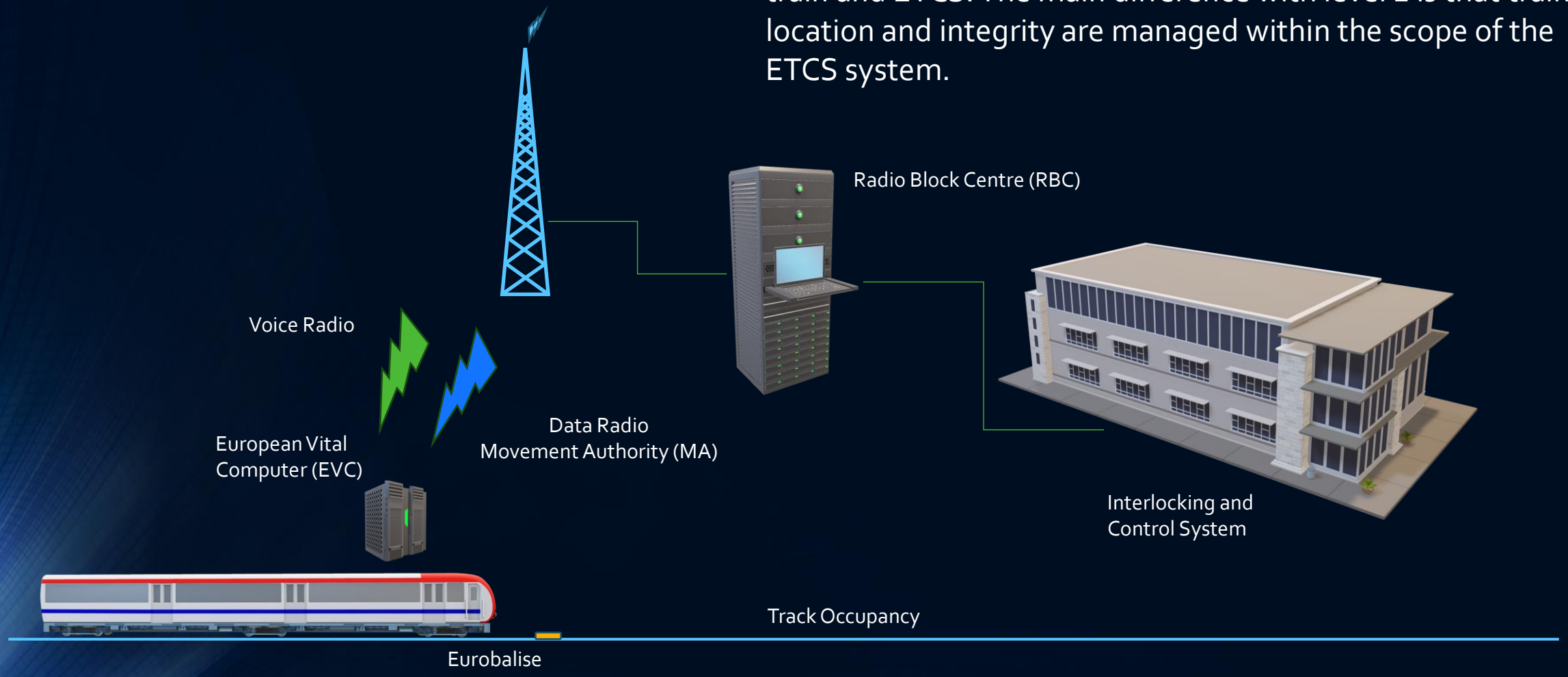
ETCS Level 2

Level 2 involves continuous supervision of train movement with continuous communication, provided by GSM-R, between the train and the trackside. In this case, lineside signals are optional, and the trackside equipment performs train detection outside the scope of ERTMS.



ETCS Level 3

Level 3 is also a signalling system that provides continuous train supervision with continuous communication between the train and ETCS. The main difference with level 2 is that train location and integrity are managed within the scope of the ETCS system.



Examples of Radio Block Centres (RBCs)

3 out of 3 (3003) system

2 out of 2 (2002)
Duplicated systems
with two RBCs

Safety Integrity Level (SIL) 4 systems

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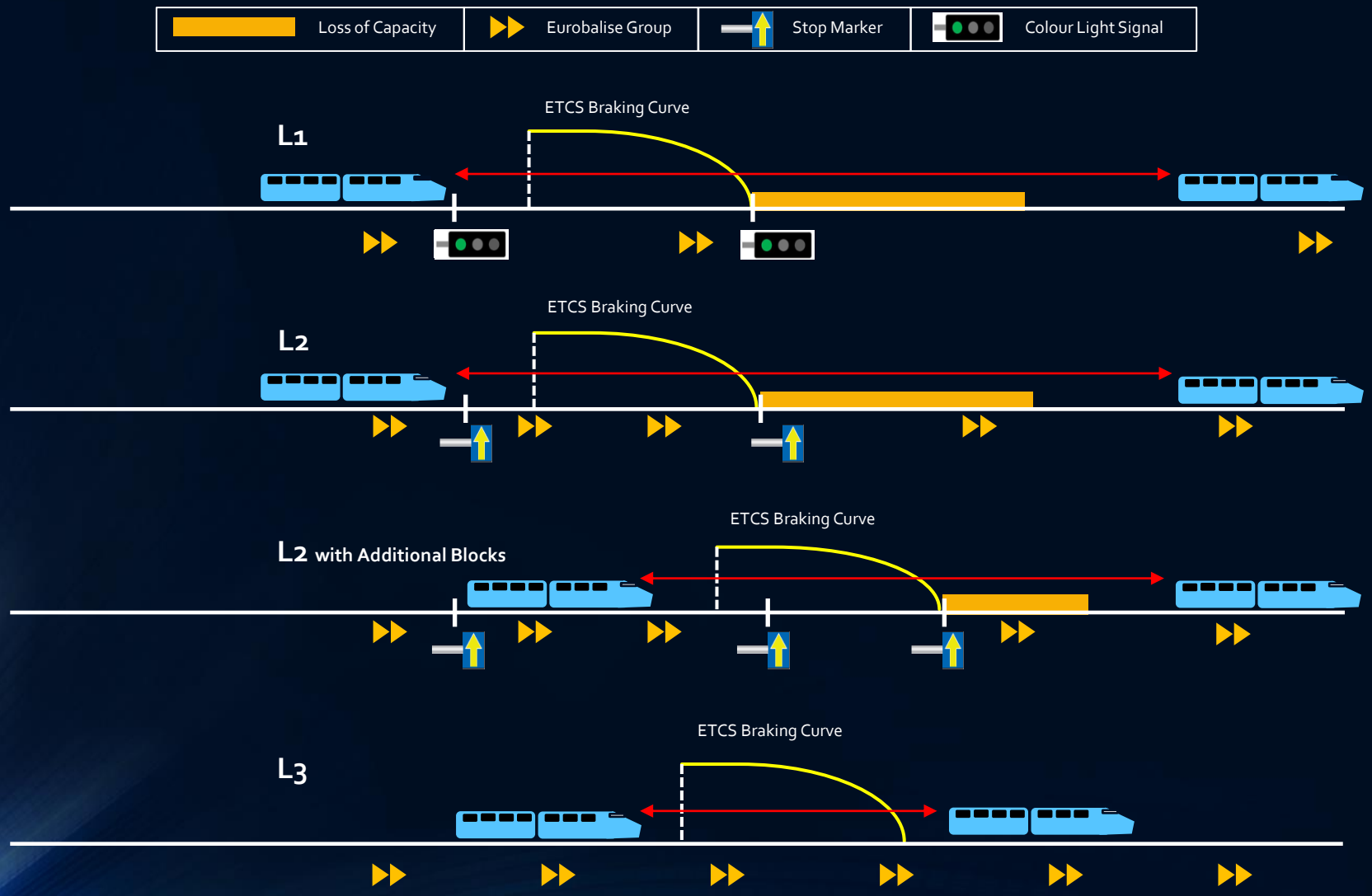
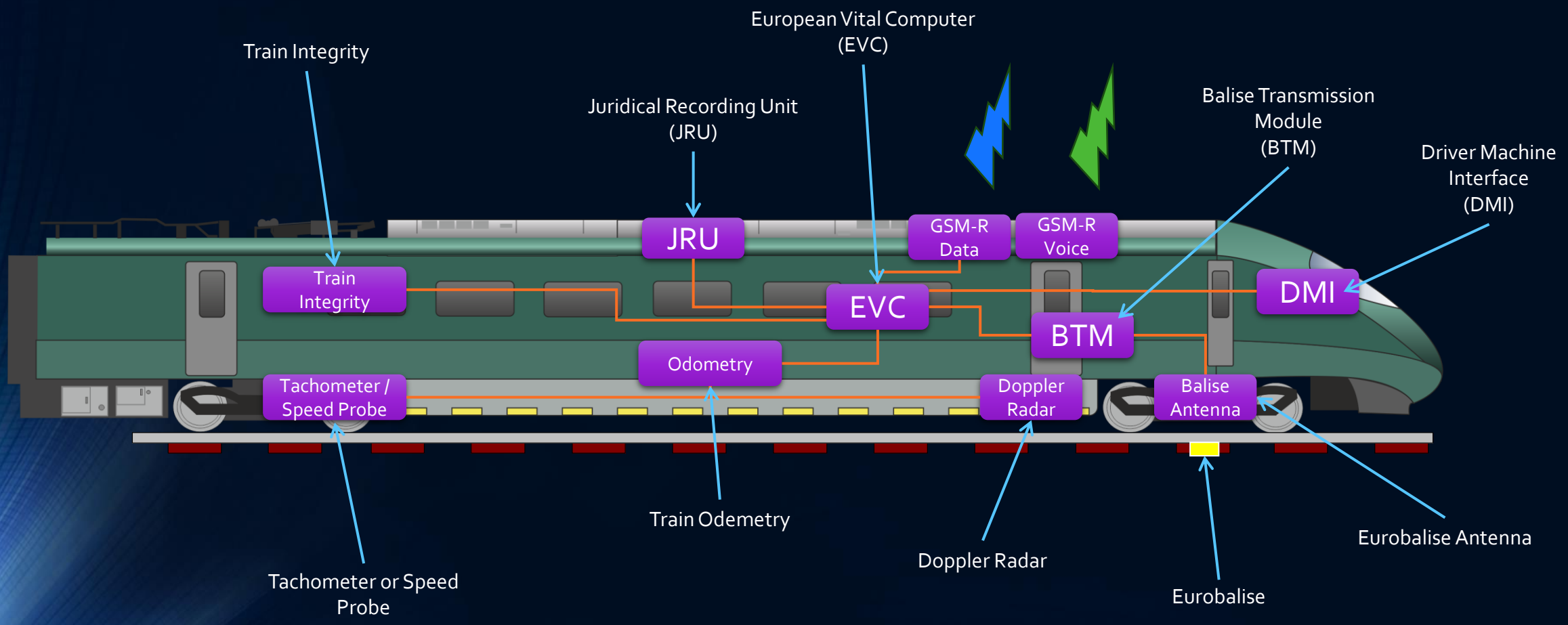
ETCS Levels 1,2 and 3



Onboard Equipment



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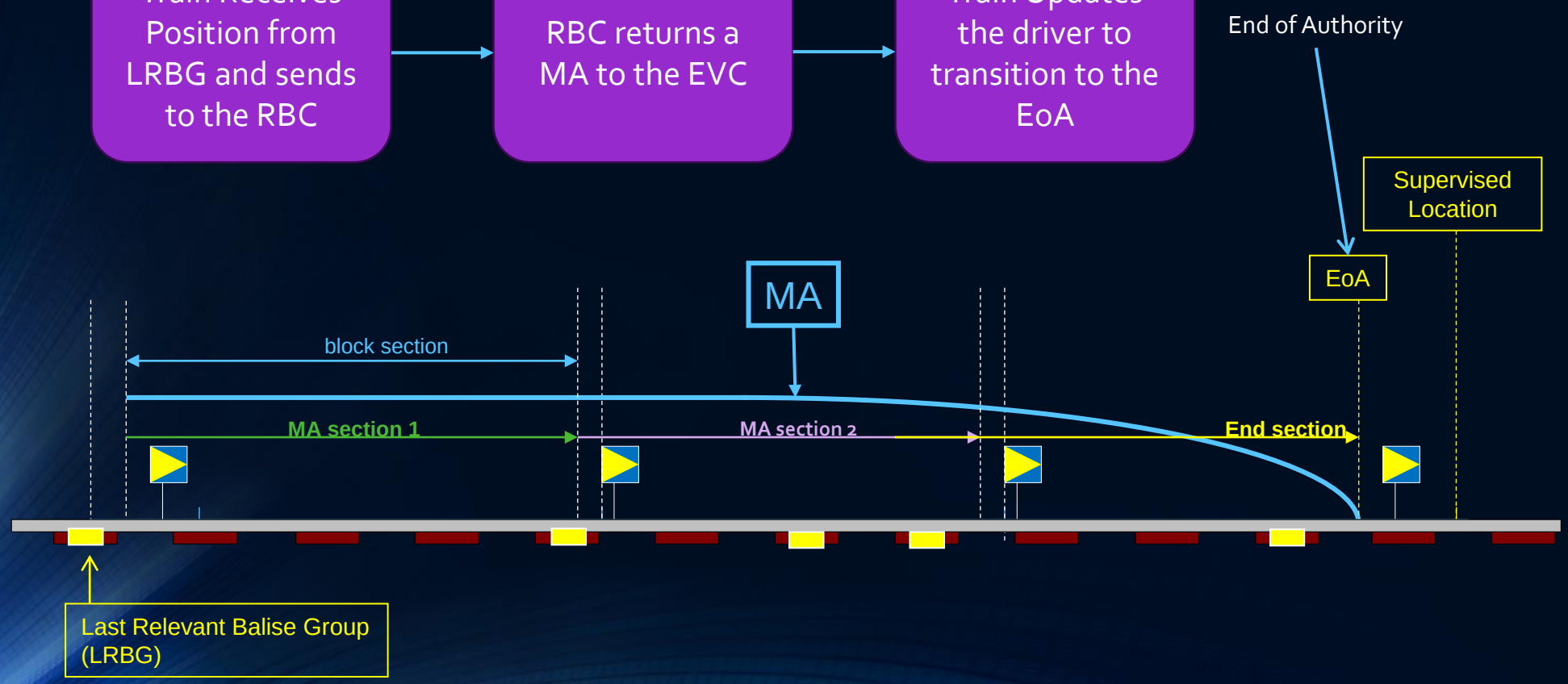
Movement Authority (MA)

The MA provides safety for train separation

Train Receives Position from LRBG and sends to the RBC

RBC returns a MA to the EVC

Train Updates the driver to transition to the EoA



Digital Machine Interface (DMI)

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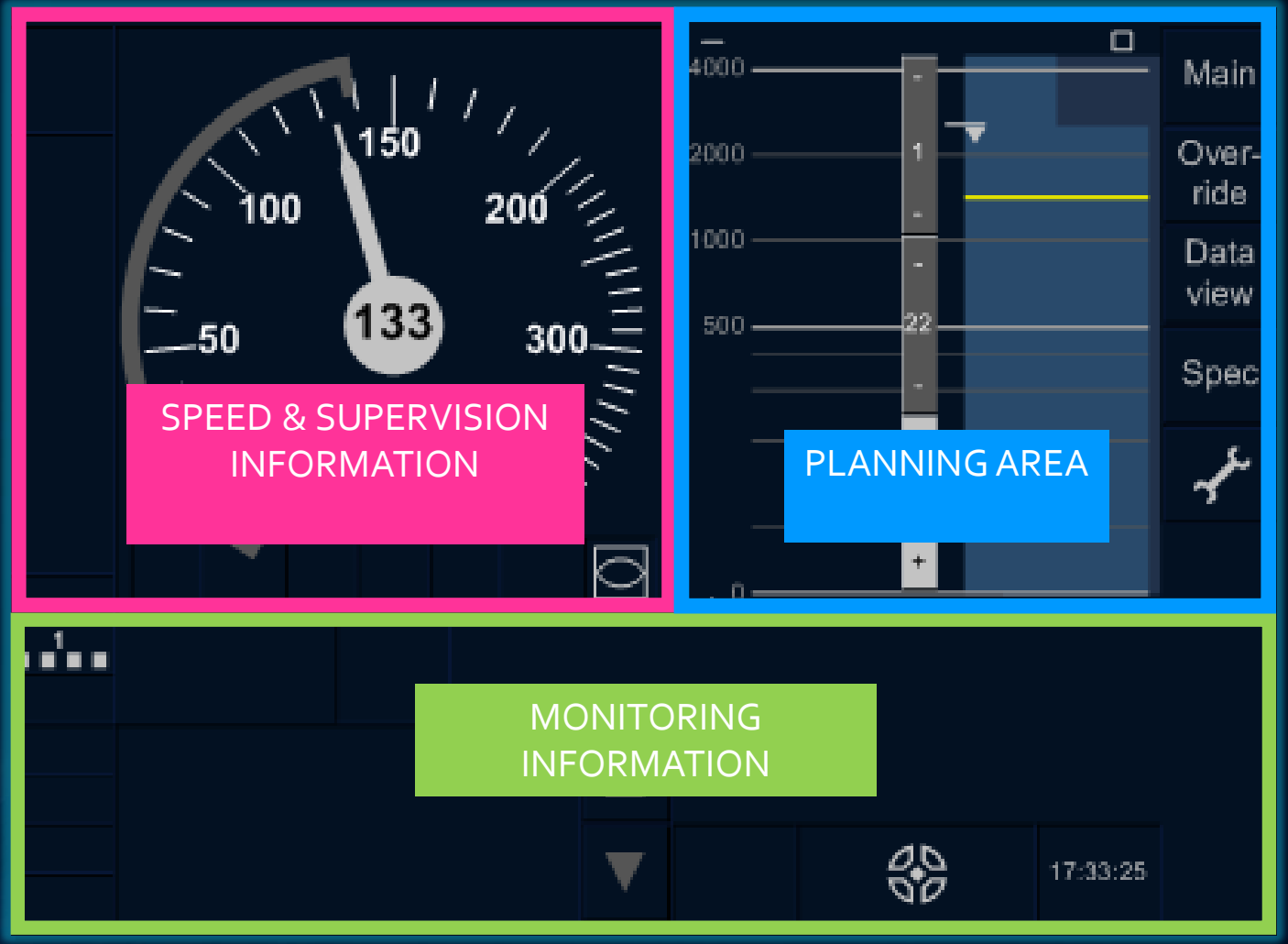
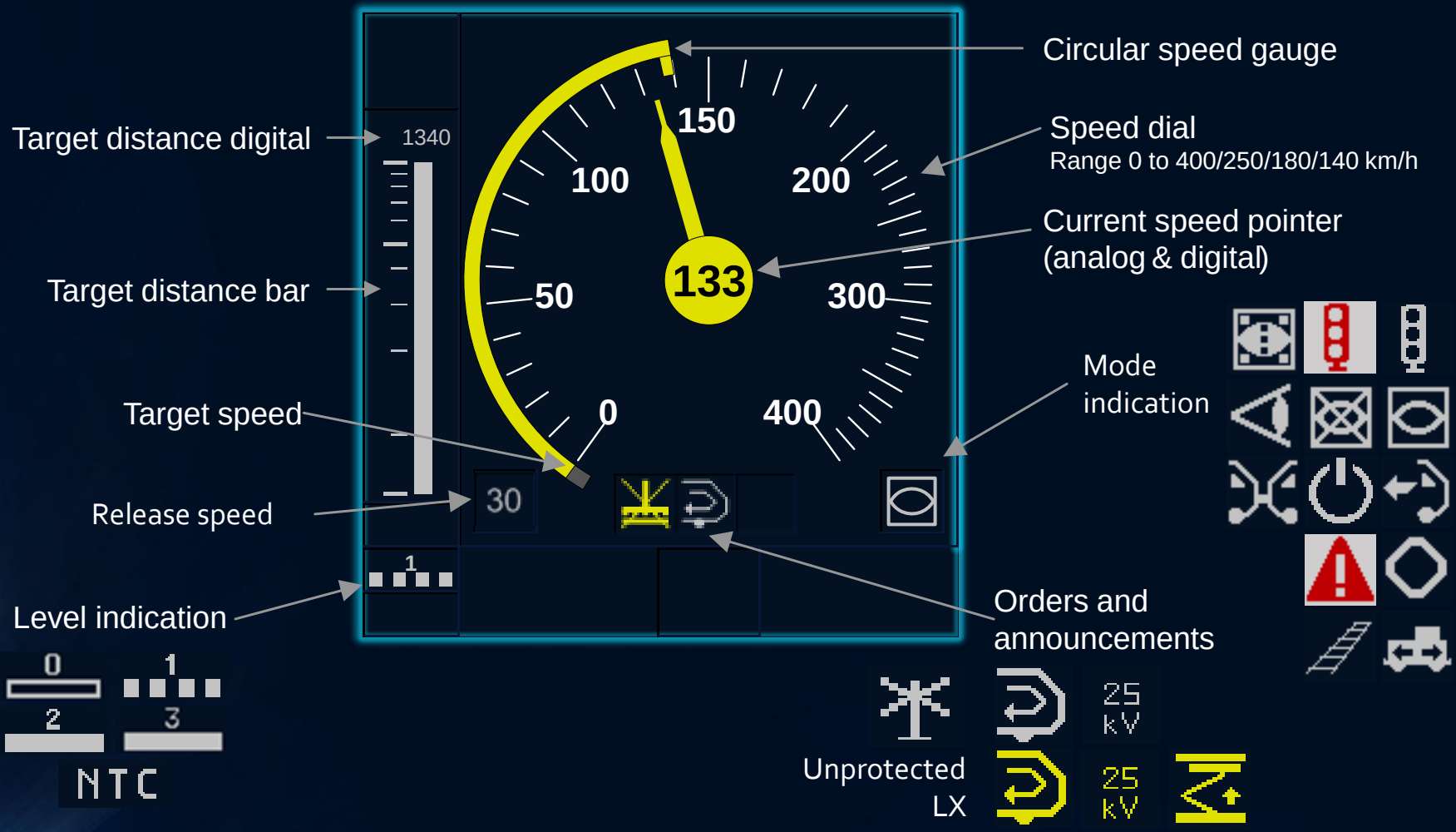
Digital Machine Interface (DMI)



DMI Speed & Supervision area



For symbols, refer to https://www.era.europa.eu/system/files/2023-12/index006_-_ERA_ERTMS_015560_v400.zip, paragraph 13

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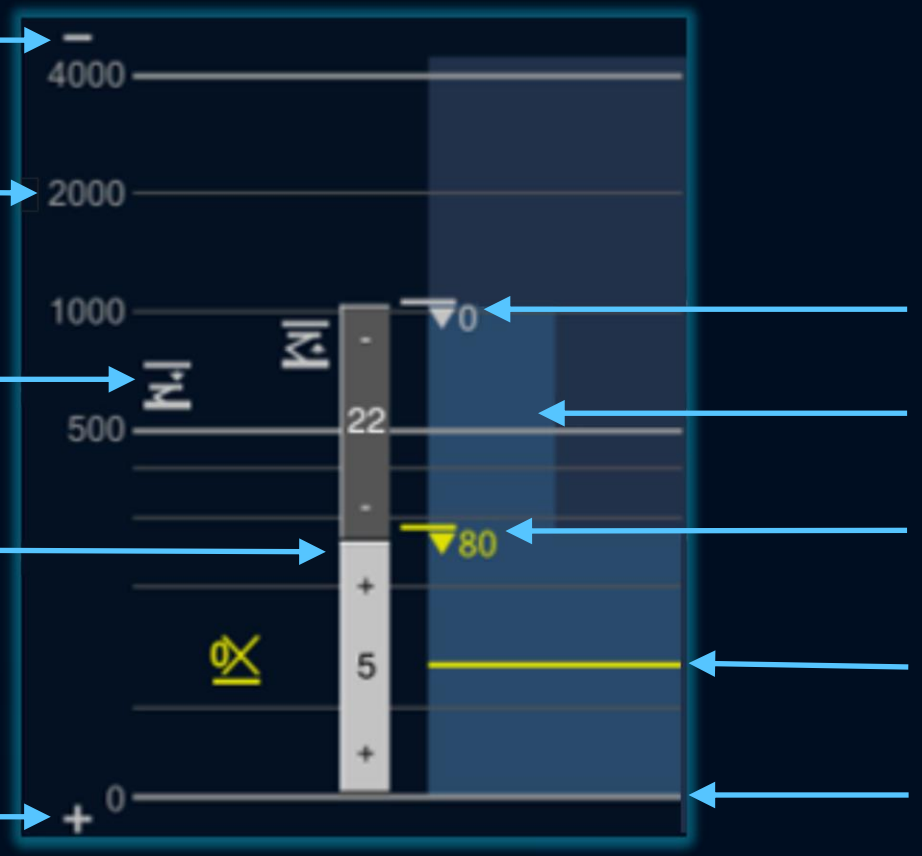
DMI Planning Area



Zoom Function

Distance Scale

Orders and Announcements Of Track Conditions

Gradient Profile

Zoom Function

Speed Profile Discontinuity (Zero)

Planning Area Speed Profile (PASP)

Speed profile discontinuity related to the indication marker

Indication Marker

Train Position

Braking Curves

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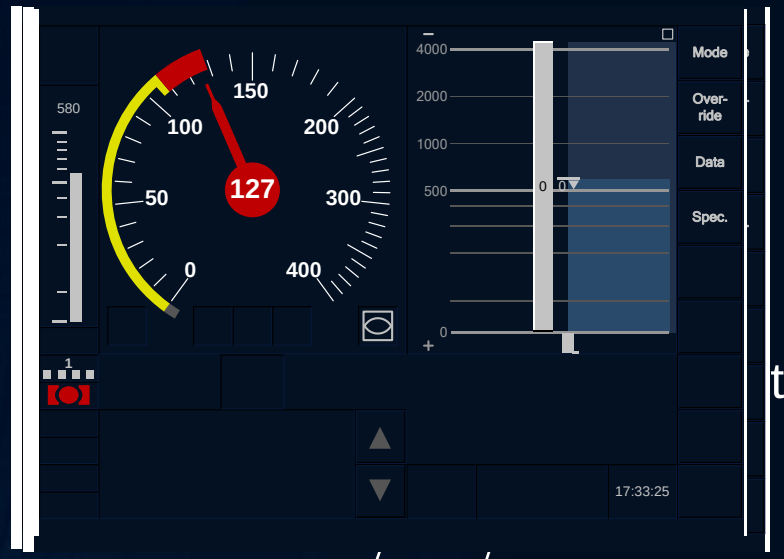
Braking Curves



Warning Curve

Service brake Intervention Curve

Emergency Brake Intervention Curve

End of
Authority

Supervised
Location

Speed
Profile

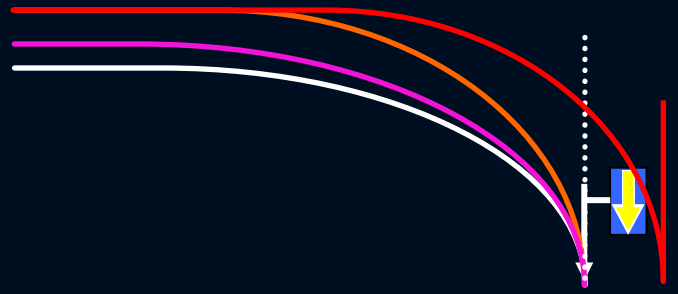
Permitted Speed

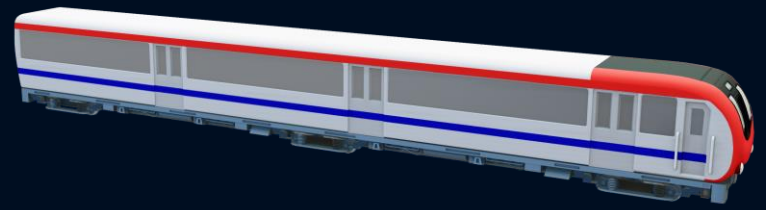
Distance to EoA

Balises
(position reference)

Stop marker

ETCS Braking Curve Calculations





Type of Brakes
Brake Percentage

Driver Data Entry

Onboard ETCS Model:
Deceleration Brake
Delay time etc

Guaranteed deceleration
Service Brake Deceleration
Emergency Brake Deceleration

Safety Margin

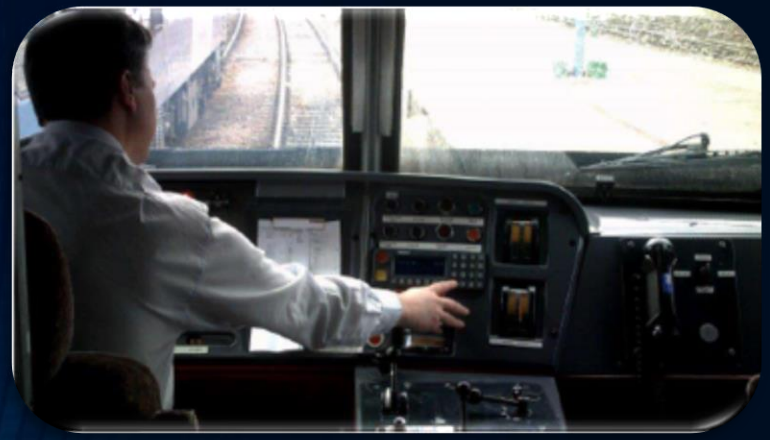
Gradient of the Line
Speed of the Line

Measured:
Max Deceleration
Service Deceleration
Brake Delay Time

Pre-programmed on-board ETCS

Telecoms

Global System Mobile Communication - Railway



Drivers GSM-R Unit

Signallers GSM-R

GSM-R Cell Tower

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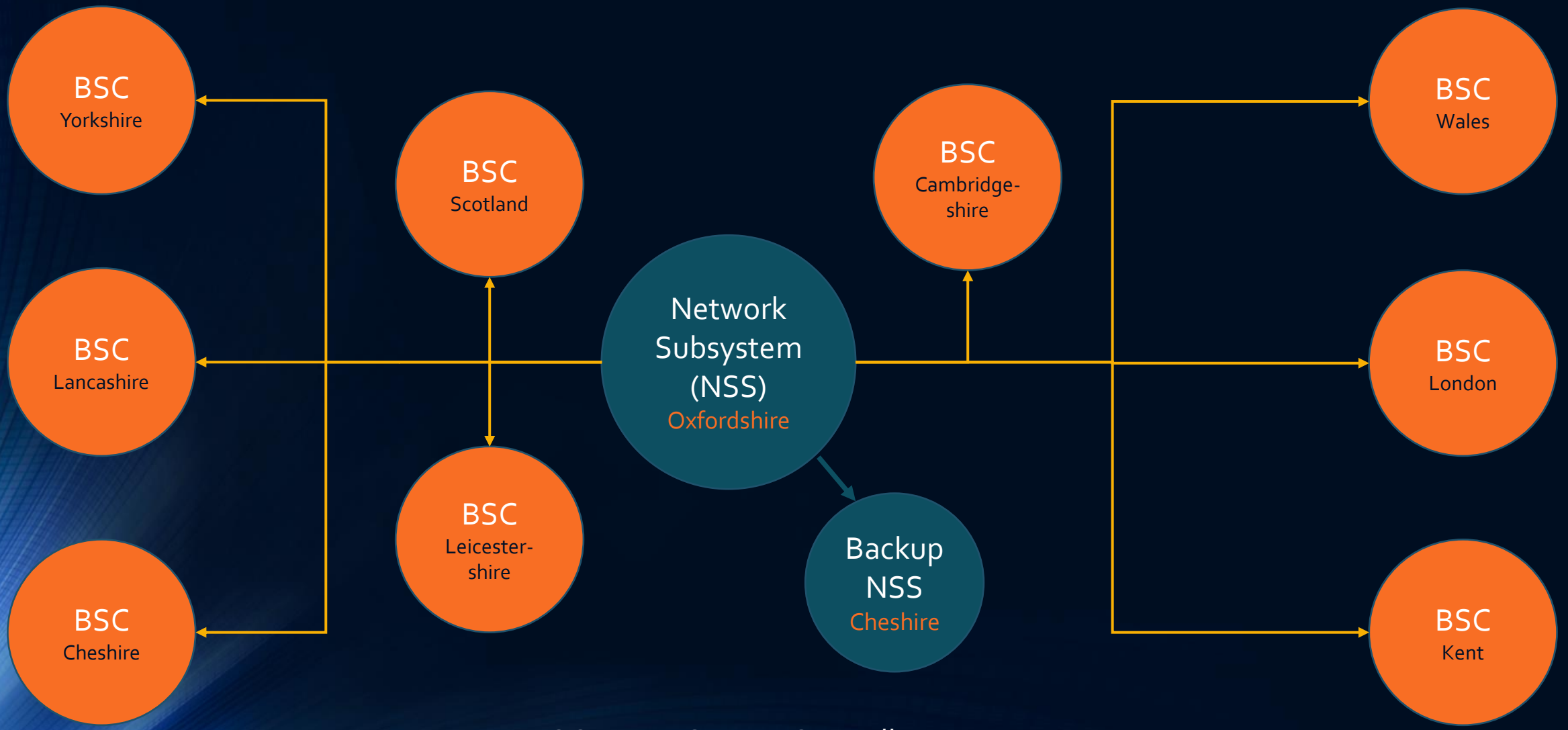
GSM-R Infrastructure



BSC = Base Station Controller

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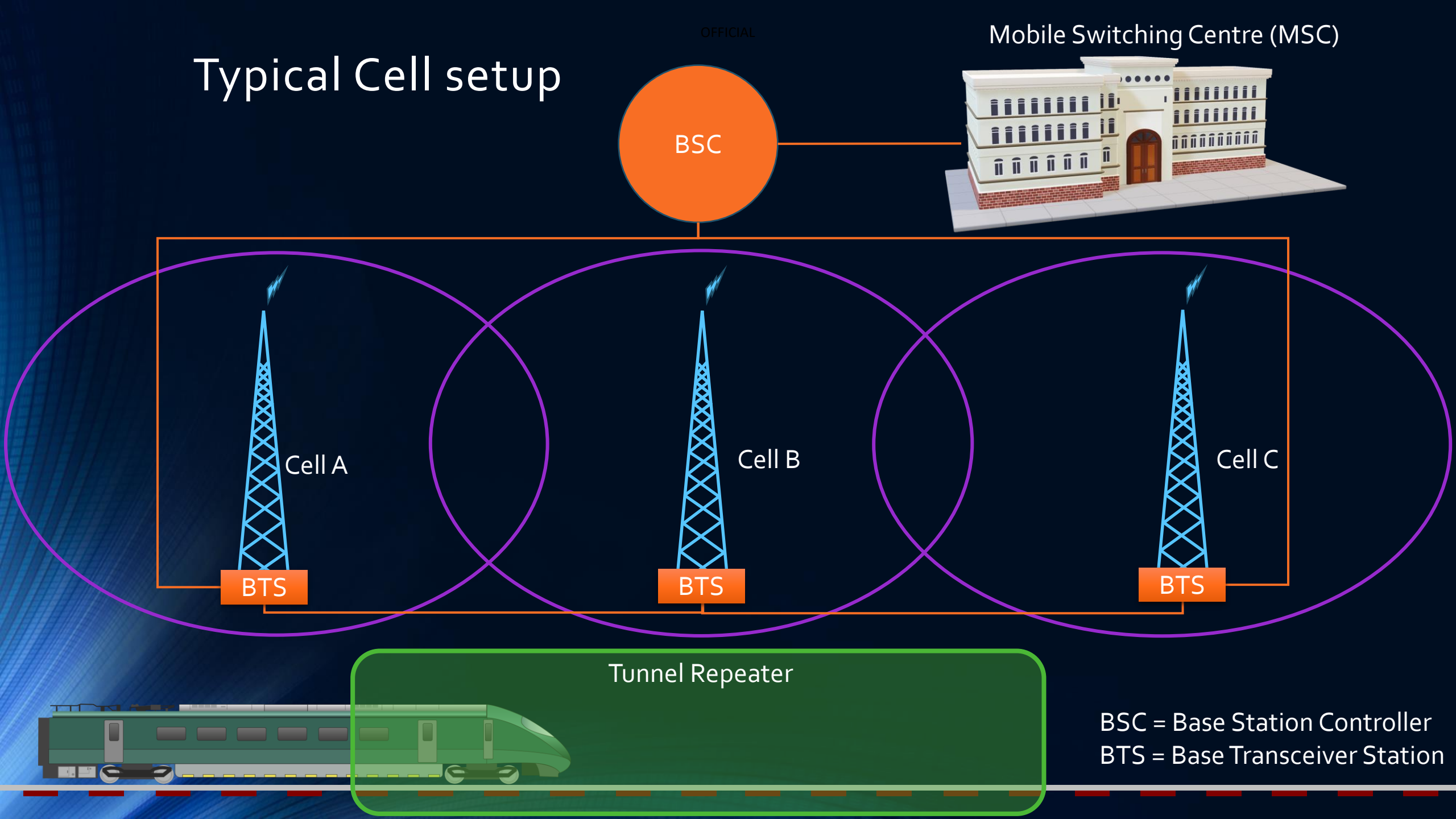
Typical Cell setup



BSC = Base Station Controller
BTS = Base Transceiver Station

Eurobalise

Eurobalise

Fixed Eurobalise

Switchable Eurobalise

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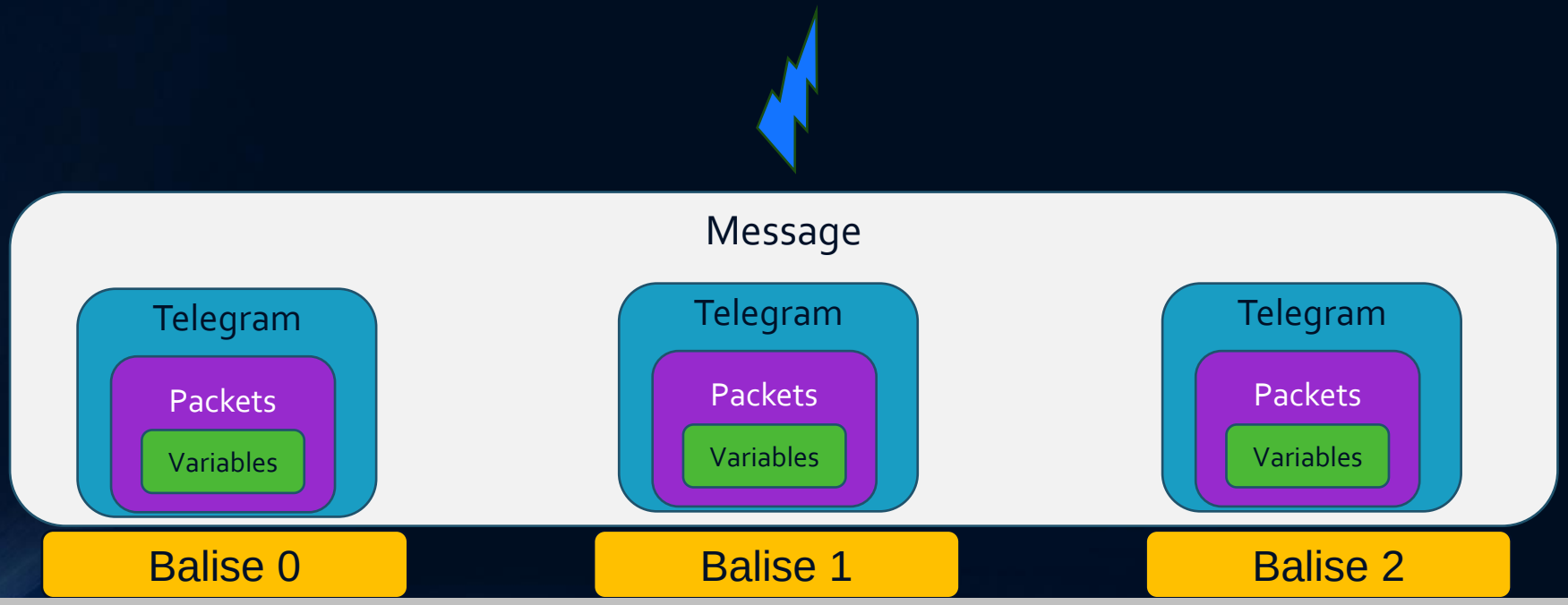
Eurobalise messages

A Eurobalise message is the information sent by a balise group (i.e. the message is composed of one or several telegrams, sorted by balise number in the group (telegram from balise number 0 first), each telegram is transmitted by a Eurobalise). A Eurobalise telegram contains one header and an identified and coherent set of Packets.



Balise Group (BG) with three Balise, can have up to eight Balise

Uses of Eurobalise

ETCS

TASS

ASDO / FASDO

APCo

Signage

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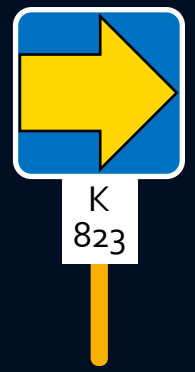
ETCS Signs

Approaching an ETCS area

Start of an ETCS area

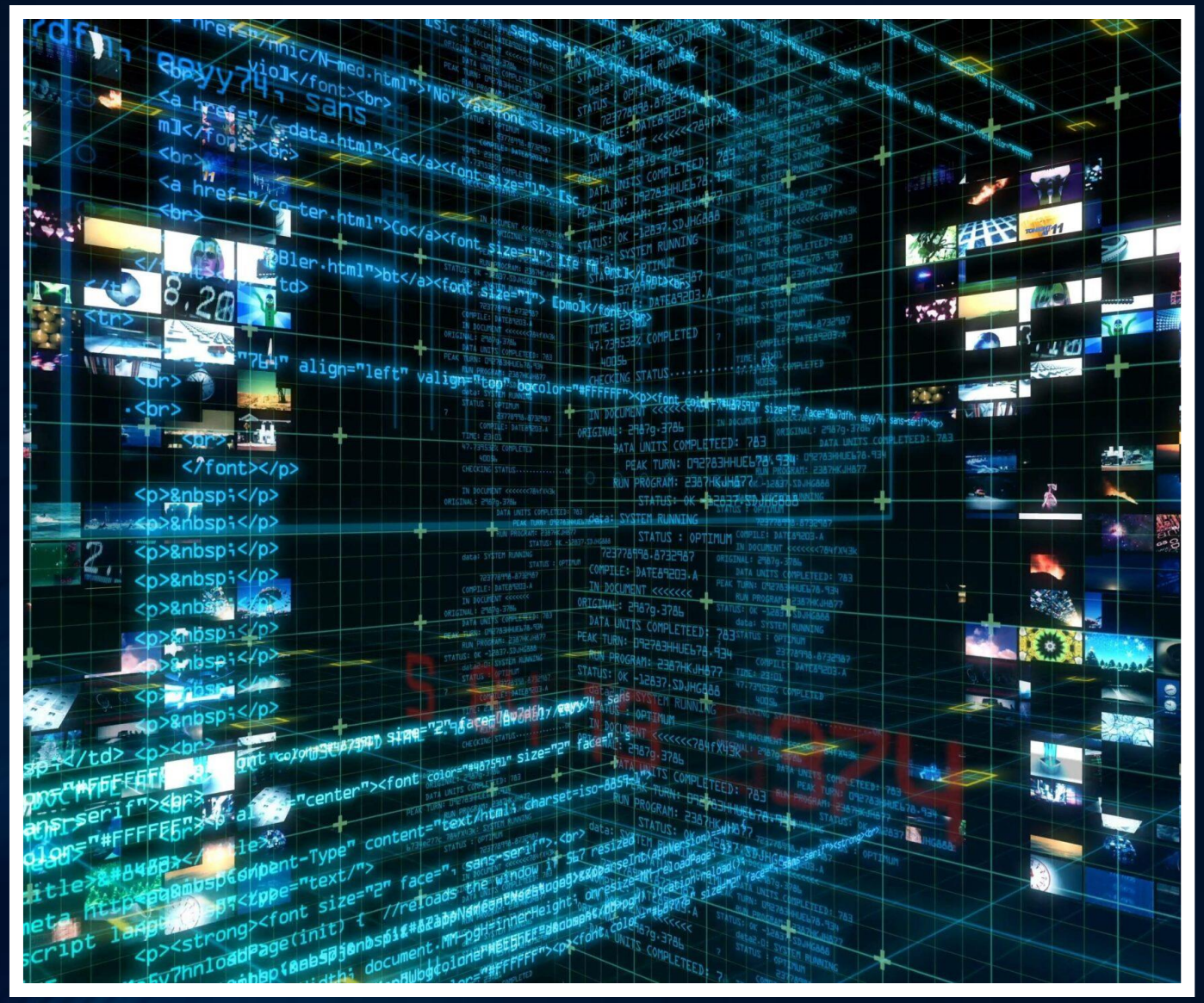


Stop Marker. It is a position marker with a unique identification plate that points towards the line it applies to.

Location Marker. It identifies a specific location to either reverse or communicate with the signaller.

End of ETCS and a return to conventional signalling (NTC) with TPWS/AWS.

ETCS Data



Log Files

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Timestamp   SequenceNo  Interface   Item    Value   LogType Crc16
GeoData : 6.0
2021-06-28T03:25:07.993 015CE824    RBCEcho RBC\TLK\Echo Info    DESC=Train Position Report,NID_MESSAGE=136,L_MESSAGE=25,T_TRAIN=95743026,NID_ENGINE=20794,PACKETS=1,PACKET=1,DESC=Position Report,NID_PACKET=0,L_PACKET=122,Q_SCALE=1,
2021-06-28T03:25:07.993 015CE825    RBCEcho RBC\TLK\Echo Info    unset   CommonAttributeChangeEvent  DB79
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2021-06-28T03:25:07.994 015CE827    RBCEcho RBC\TLK\Echo Info    unset   CommonAttributeChangeEvent  1457
2021-06-28T03:25:07.999 015CE828    RBCEcho RBC\TLK\Echo Info    DESC=Train Position Report,NID_MESSAGE=136,L_MESSAGE=25,T_TRAIN=95743026,NID_ENGINE=20794,PACKETS=1,PACKET=1,DESC=Position Report,NID_PACKET=0,L_PACKET=122,Q_SCALE=1,
2021-06-28T03:25:08.000 015CE829    RBCEcho RBC\TLK\Echo Info    unset   CommonAttributeChangeEvent  F878
2021-06-28T03:25:08.000 015CE82A    RBCEcho RBC\TLK\Echo Info    DESC=Train Position Report,NID_MESSAGE=136,L_MESSAGE=25,T_TRAIN=95743026,NID_ENGINE=20794,PACKETS=1,PACKET=1,DESC=Position Report,NID_PACKET=0,L_PACKET=122,Q_SCALE=1,
2021-06-28T03:25:08.000 015CE82B    RBCEcho RBC\TLK\Echo Info    unset   CommonAttributeChangeEvent  1C1B
2021-06-28T03:25:09.711 015CE82C    RBCServer   RBC_heartbeat_OK    High    MnemonicChangeEvent 6118
2021-06-28T03:25:09.711 015CE82D    RBCServer   RBC\TLK Status=519280, RbcTime=528970481    CommonAttributeChangeEvent  156D
2021-06-28T03:25:11.710 015CE82E    RBCEcho RBC\TLK\Echo Info    DESC=General Message,NID_MESSAGE=24,L_MESSAGE=10,T_TRAIN=95743306,M_ACK=0,NID_LRBG=32775,PACKETS=0  CommonAttributeChangeEvent  AB72
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2021-06-28T03:25:11.911 015CE832    RBCServer   RBC_heartbeat_OK    High    MnemonicChangeEvent 98F9
2021-06-28T03:25:11.911 015CE833    RBCServer   RBC\TLK Status=519280, RbcTime=528970701    CommonAttributeChangeEvent  9899
2021-06-28T03:25:13.176 015CE834    RBCEcho RBC\TLK\Echo Info    DESC=Train Position Report,NID_MESSAGE=136,L_MESSAGE=25,T_TRAIN=95743545,NID_ENGINE=20794,PACKETS=1,PACKET=1,DESC=Position Report,NID_PACKET=0,L_PACKET=122,Q_SCALE=1,
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2021-06-28T03:25:13.183 015CE83B    RBCEcho RBC\TLK\Echo Info    unset   CommonAttributeChangeEvent  B586
2021-06-28T03:25:14.110 015CE83C    RBCServer   RBC_heartbeat_OK    High    MnemonicChangeEvent 33B9
2021-06-28T03:25:14.110 015CE83D    RBCServer   RBC\TLK Status=519280, RbcTime=528970921    CommonAttributeChangeEvent  8635
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2021-06-28T03:25:16.294 015CE83F    RBCServer   RBC\TLK Status=519280, RbcTime=528971141    CommonAttributeChangeEvent  9A20
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2021-06-28T03:25:20.493 015CE84A    RBCServer   RBC_heartbeat_OK    High    MnemonicChangeEvent 8A47
2021-06-28T03:25:20.493 015CE84B    RBCServer   RBC\TLK Status=519280, RbcTime=528971562    CommonAttributeChangeEvent  D95B
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Typical RBC Log File

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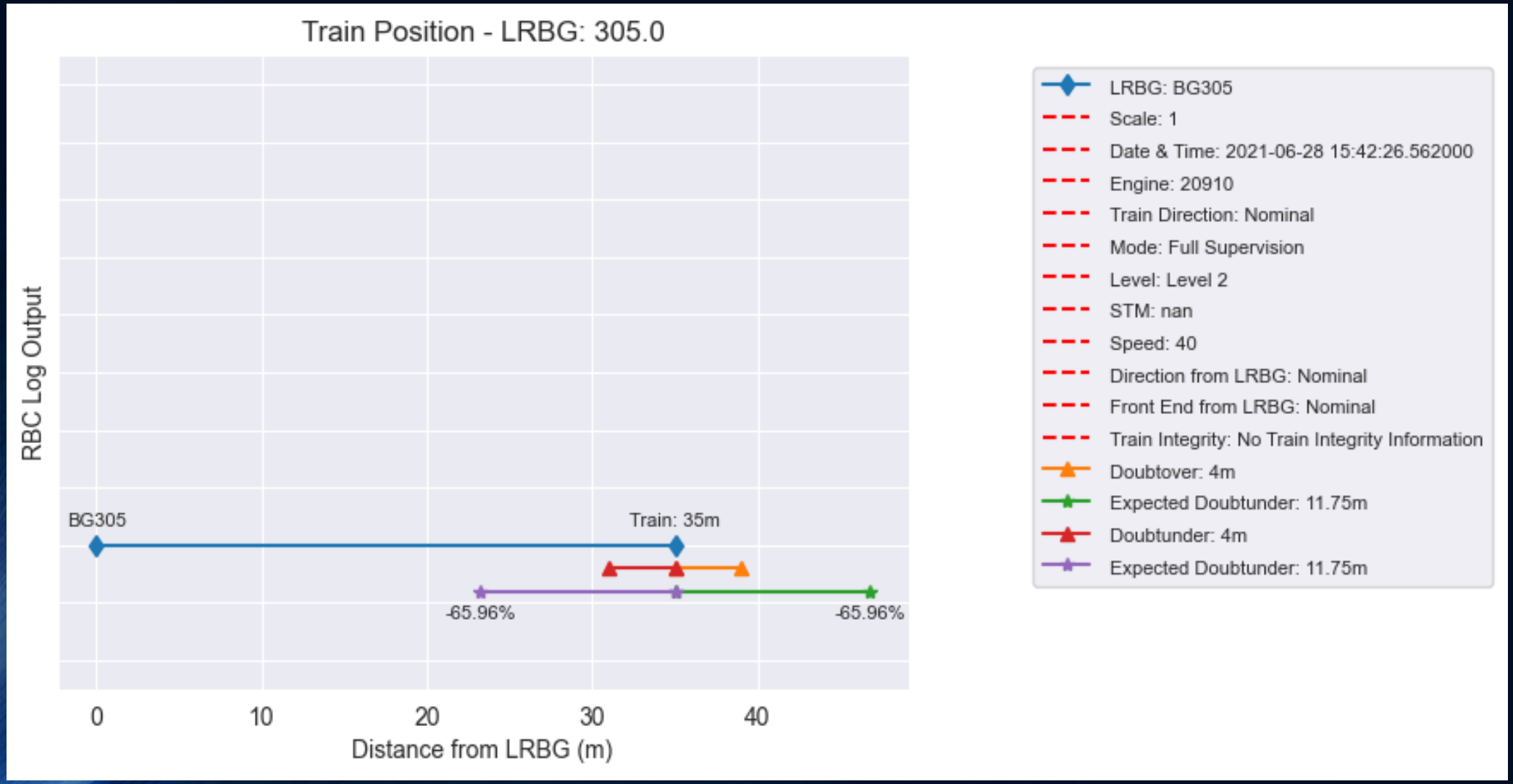
GENERAL MESSAGE
{
 NID_MESSAGE = 1
 L_MESSAGE = 39
 DATE
 {
  YEAR = 21
  MONTH = 6
  DAY = 26
 }
 TIME
 {
  HOU = 15
  MIN = 40
  SEC = 25
  TTS = 0 ms
 }
 TRAIN_POSITION
 {
  Q_SCALE = 1 '1 m scale'
  NID_LRBG
  {
   NID_C = 2
   NID_BG = 5355
  }
  D_LRBG = 30061
  Q_DIRLRBG = 0 'Reverse'
  Q_DLRBG = 1 'Nominal'
  L_DOUBTOVER = 1928
  L_DOUBTUNDER = 1523
 }
 V_TRAIN = 77 km/h
 DRIVER_ID = '2r47            '
 NID_ENGINE = 20910
 SYSTEM_VERSION = 33 0x21 'Reserved for future use (this is a valid value)'
 M_LEVEL = 1 'Level STM specified by NID_STM'
 M_MODE = 13 'STM National'
}
```

Typical JRU Log File

Automatic Translation – Position Report



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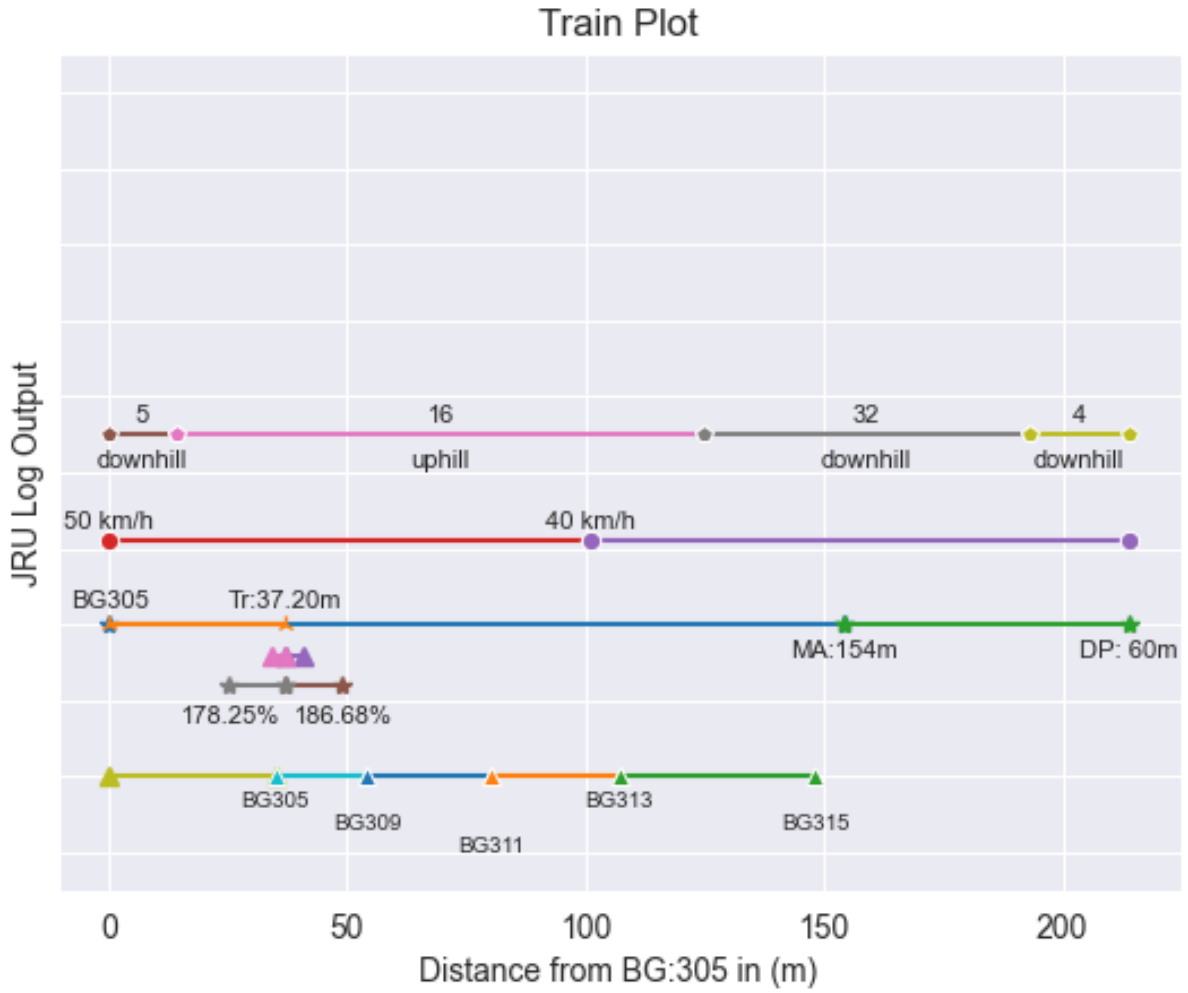
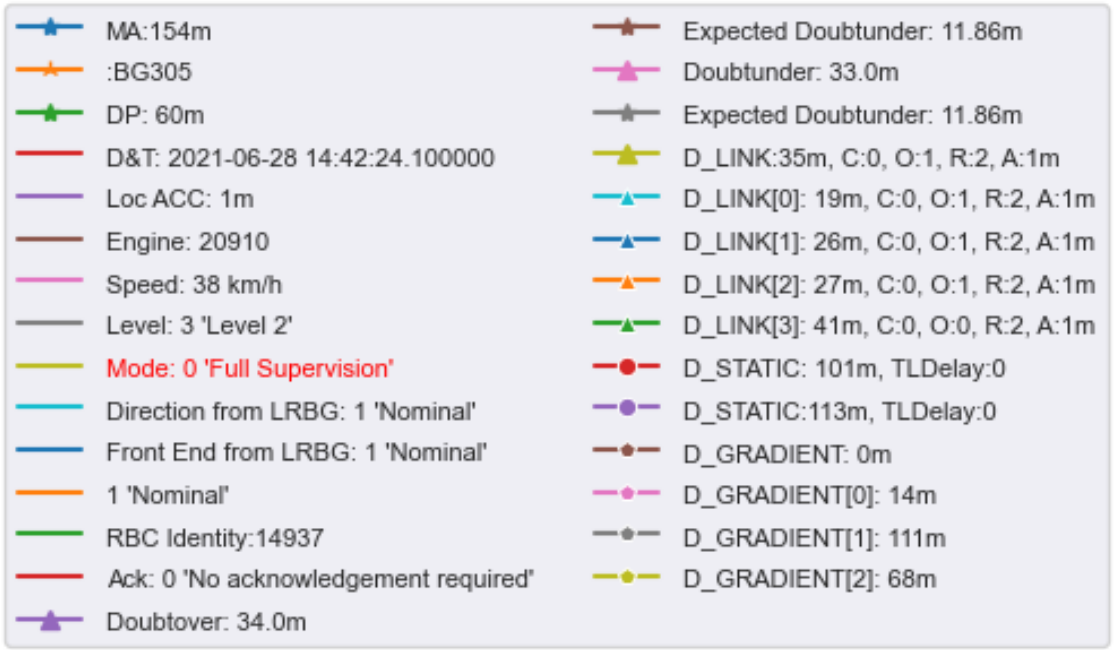
Automatic Translation – Movement Authority





Thank You, Any Questions?

Reference Material

European Rail Agency glossary of terms
https://www.era.europa.eu/system/files/2023-09/index003_-_SUBSET-023_v400.pdf

Safety Integrity Levels
https://webstore.iec.ch/publication/22273

Mandatory Specifications – Baseline 4
1. CCS TSI Appendix A – Mandatory specifications (ETCS B4 R1, RMR: GSM-R B1 MR1 + FRMCS B0, ATO B1 R1) | European Union Agency for Railways (europa.eu)

Digital Machine Interface
https://www.era.europa.eu/system/files/2023-12/index006_-_ERA_ERTMS_015560_v400.zip