3

Technology Overview

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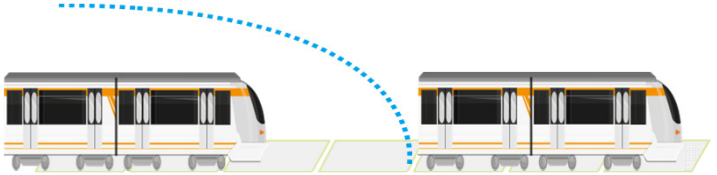
The objective of rail control systems...

...to guarantee the safe stopping of a train when required by track or traffic conditions

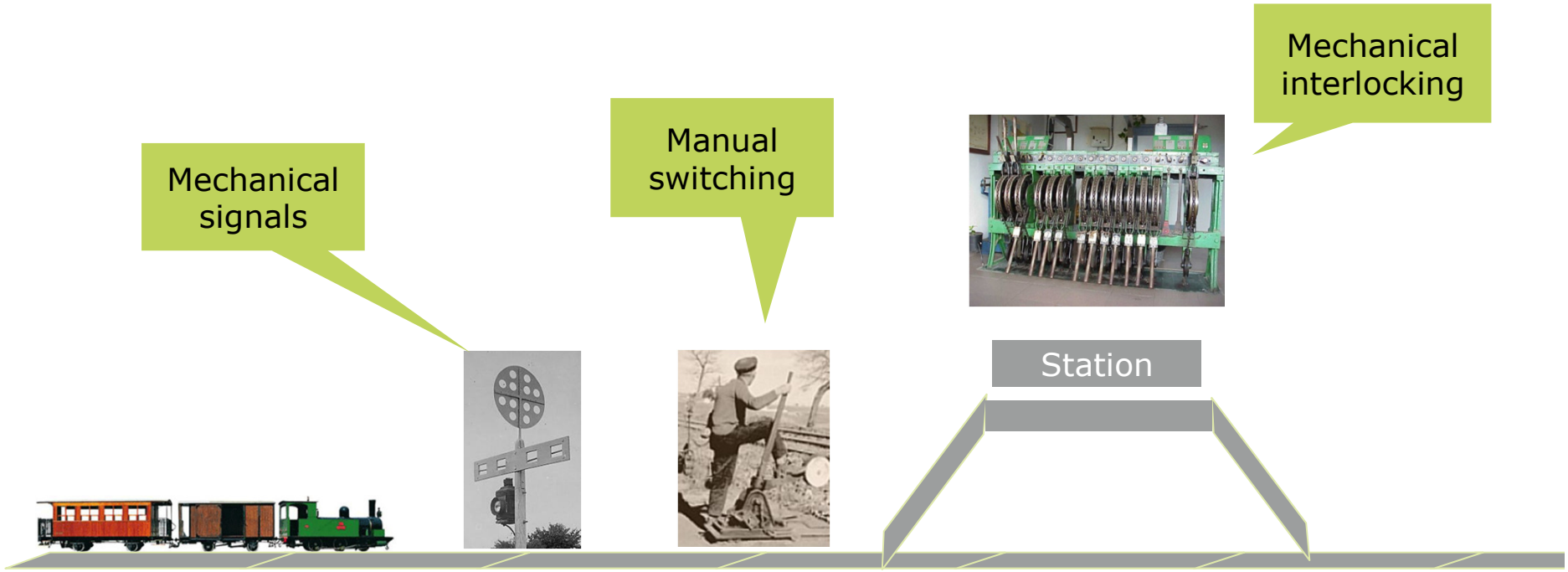
At the beginning...

Nowadays...



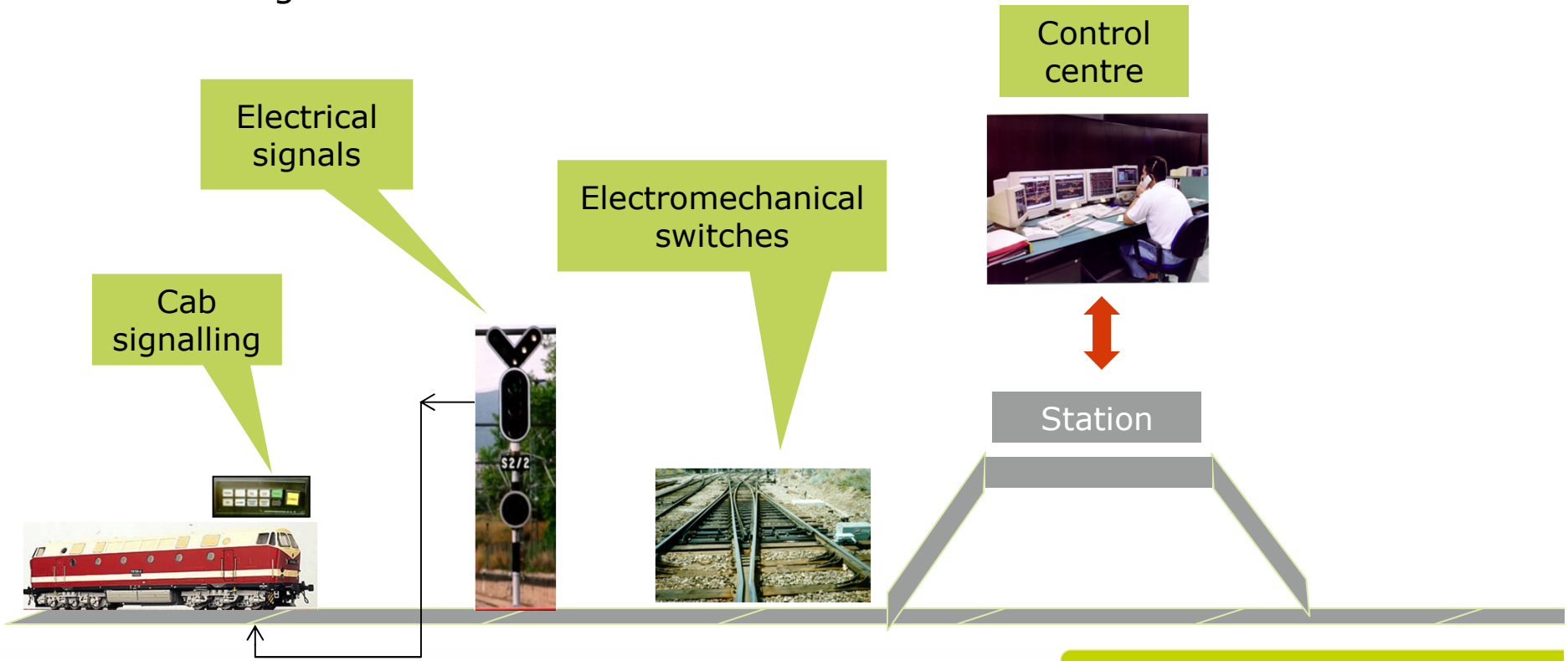
Railway signalling history (19th Century)

- The origin of railway signalling dates back to 1856 when John Saxby received the first patent for interlocking switches and signals



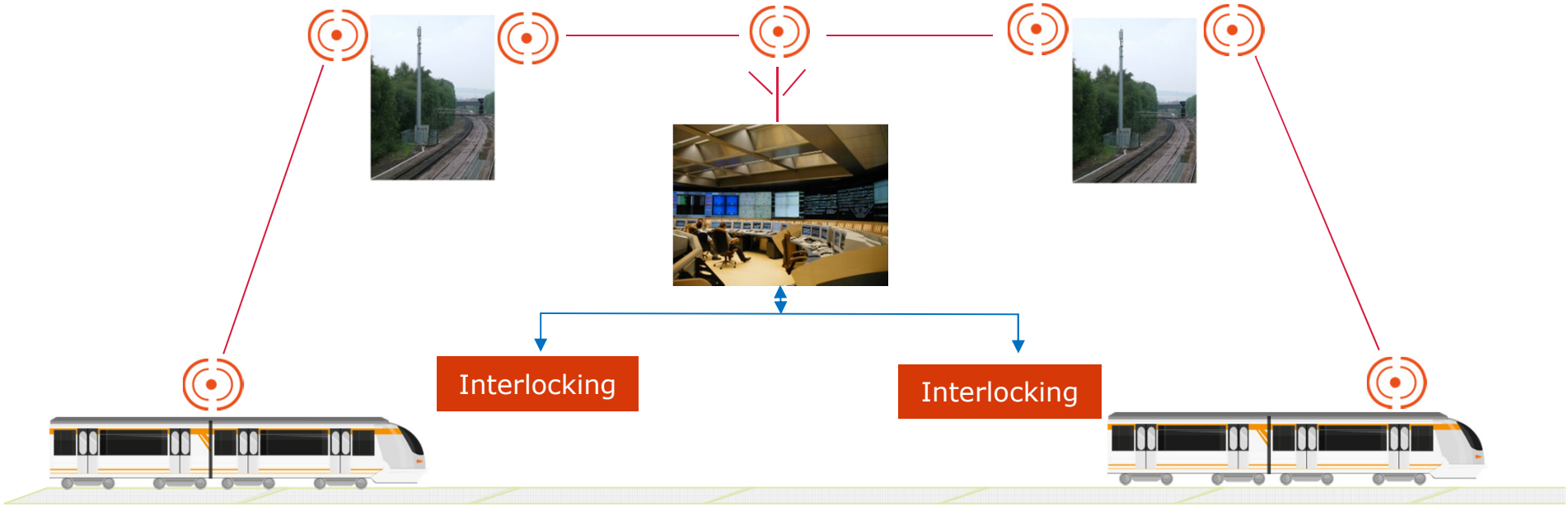
Railway signalling history (20th Century)

- Electrical-based solutions: train detection, signals, switching & interlockings
- Cab signalling systems for advanced signalling information onboard and for automatic train stops when passing red signals
- Traffic management from centralised control centre

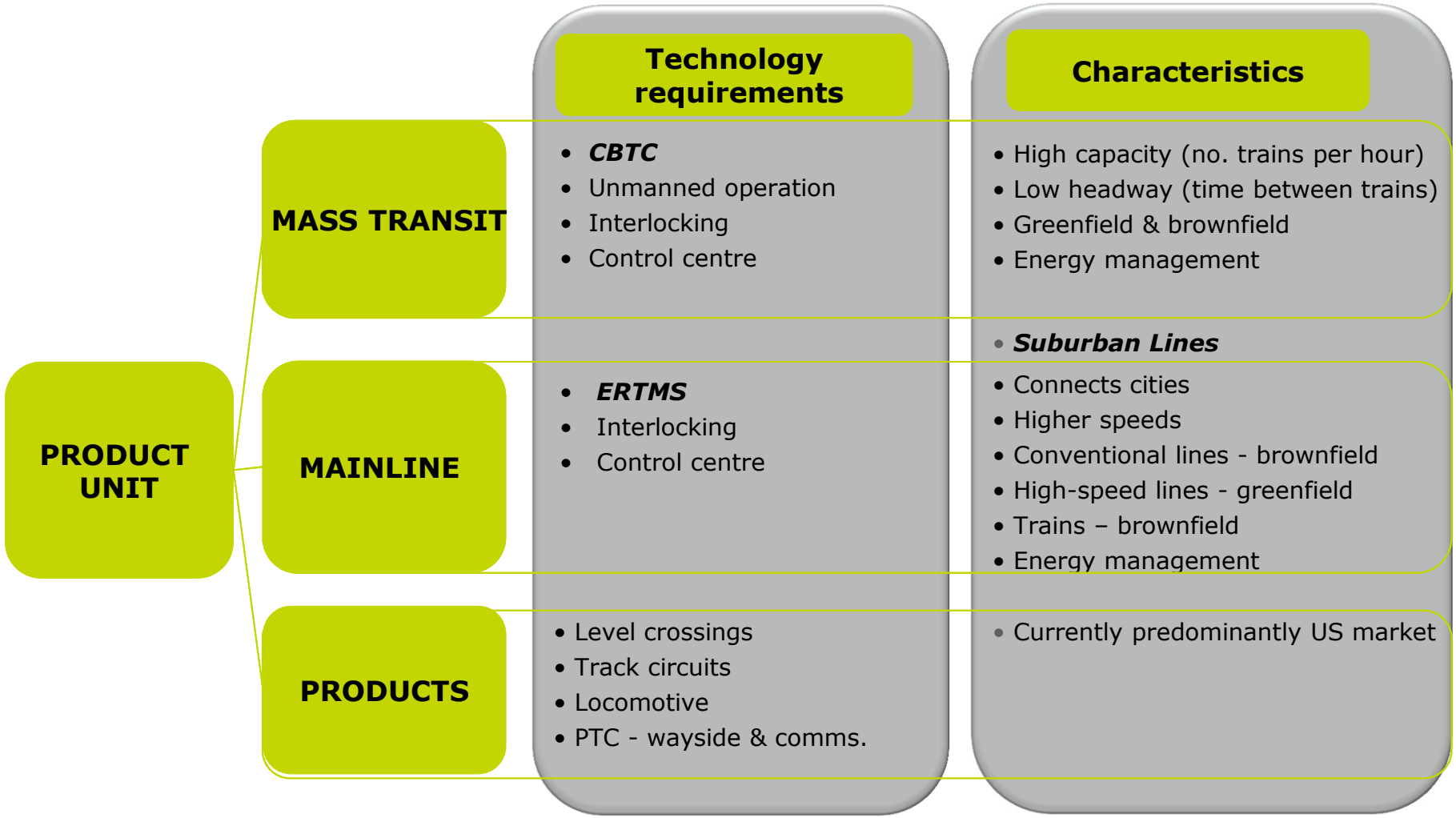


Railway signalling history (21st Century)

- Train position is reported to Operational Control Centre (OCC) by radio communication
- OCC calculates maximum speed dynamically and sends it back to the train
- Trackside equipment is reduced to minimum



Signalling technology driven by market requirements



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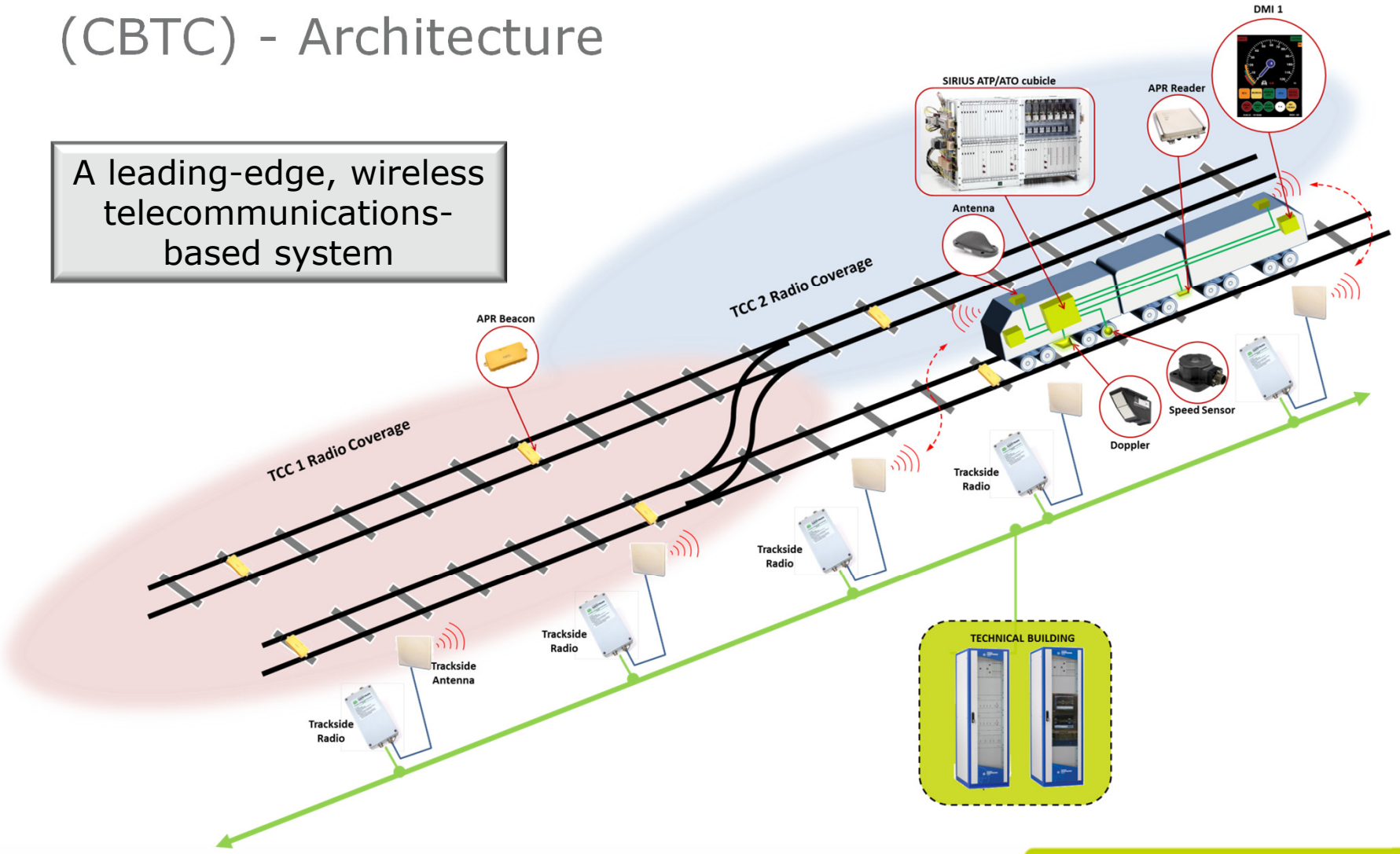
Mass transit: Communication Based Train Control (CBTC) - Architecture

A leading-edge, wireless telecommunications-based system



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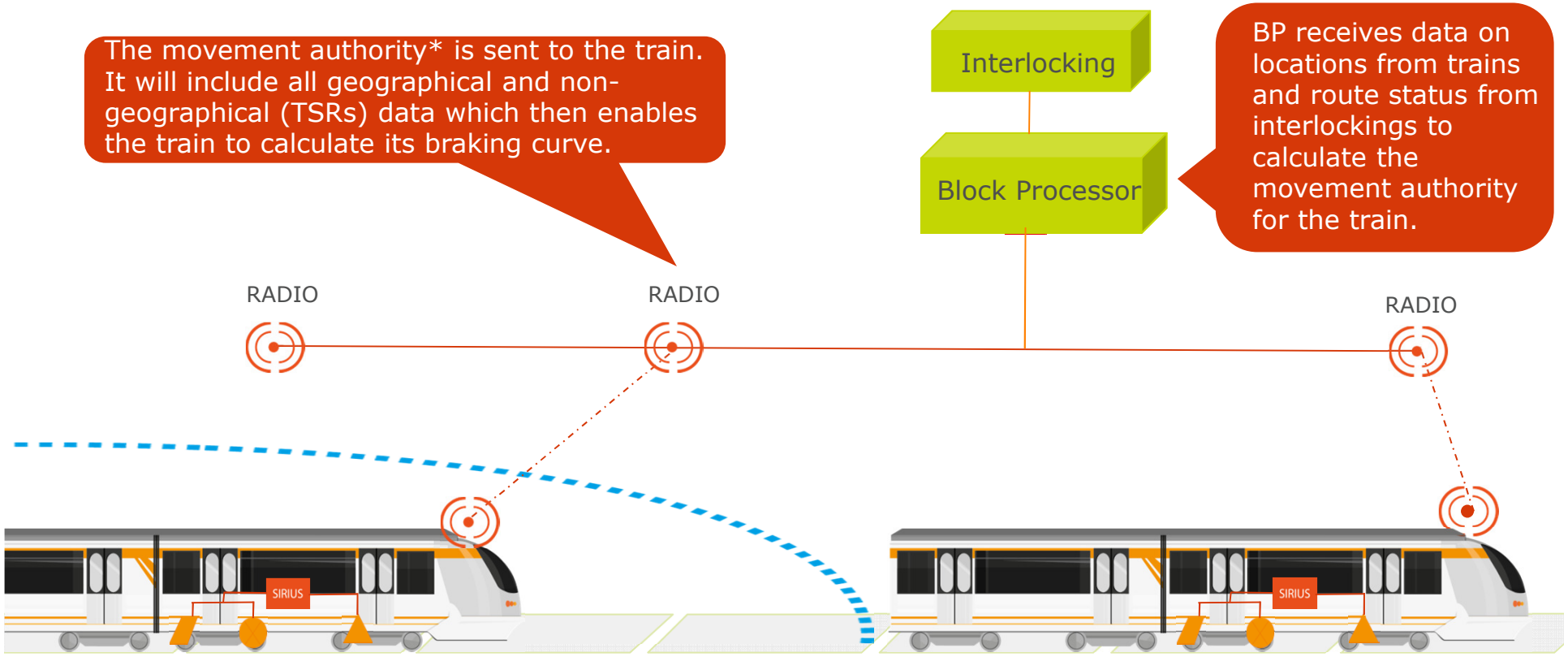
CBTC: Principles



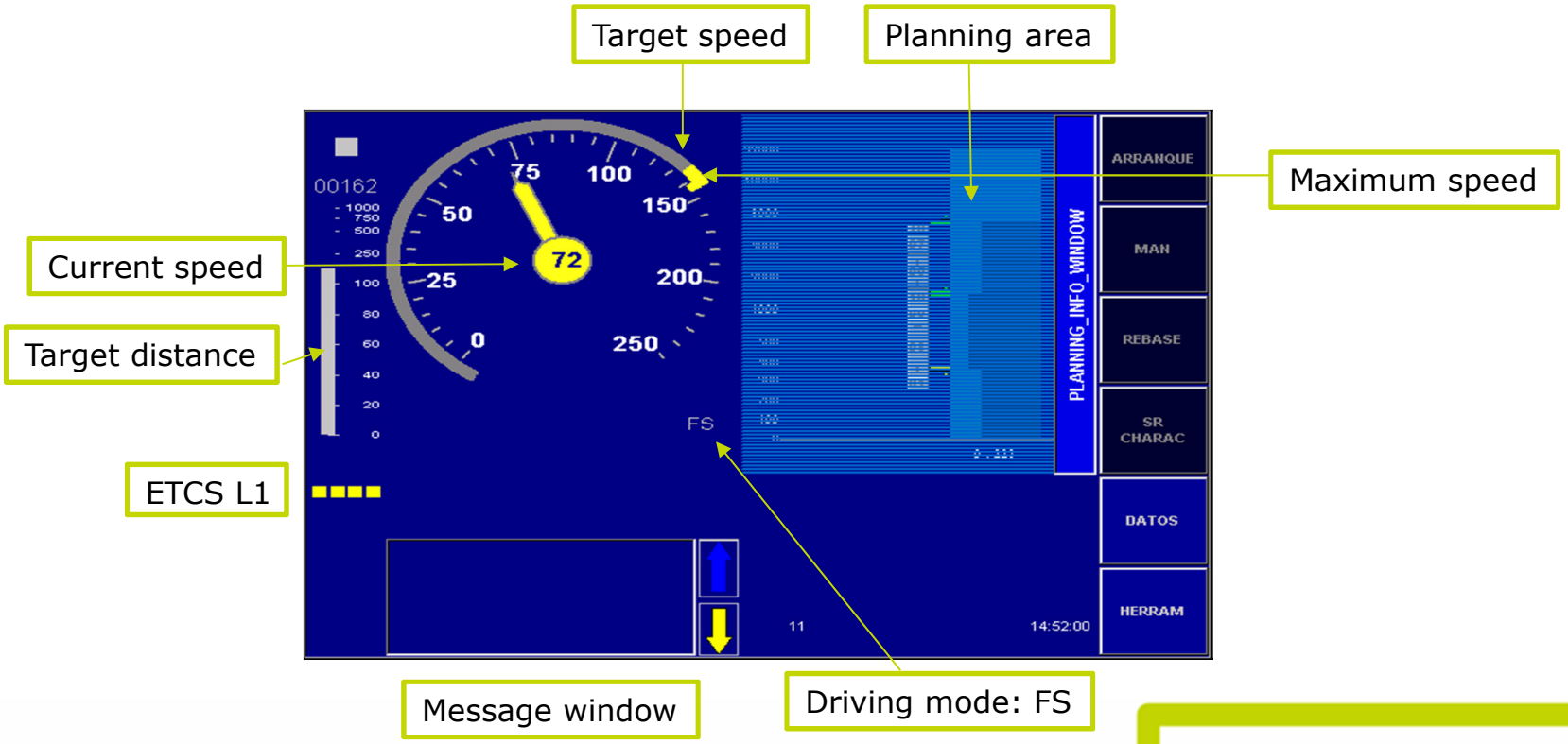
Main benefits:
- Increased capacity
- Reduced lifecycle costs (less track equipment)

The train calculates its location based on read APRs (balises) and sends it to the Block Processor through the onboard radio.

Note: The **movement authority** of the train is information about its location and where it is allowed to travel safely.*

Mainline: European Rail Traffic Management System (ERTMS) - Interoperability principle

- ERTMS onboard equipment from one supplier is able to operate with ERTMS trackside equipment from any other supplier
- Common system requirements/standards



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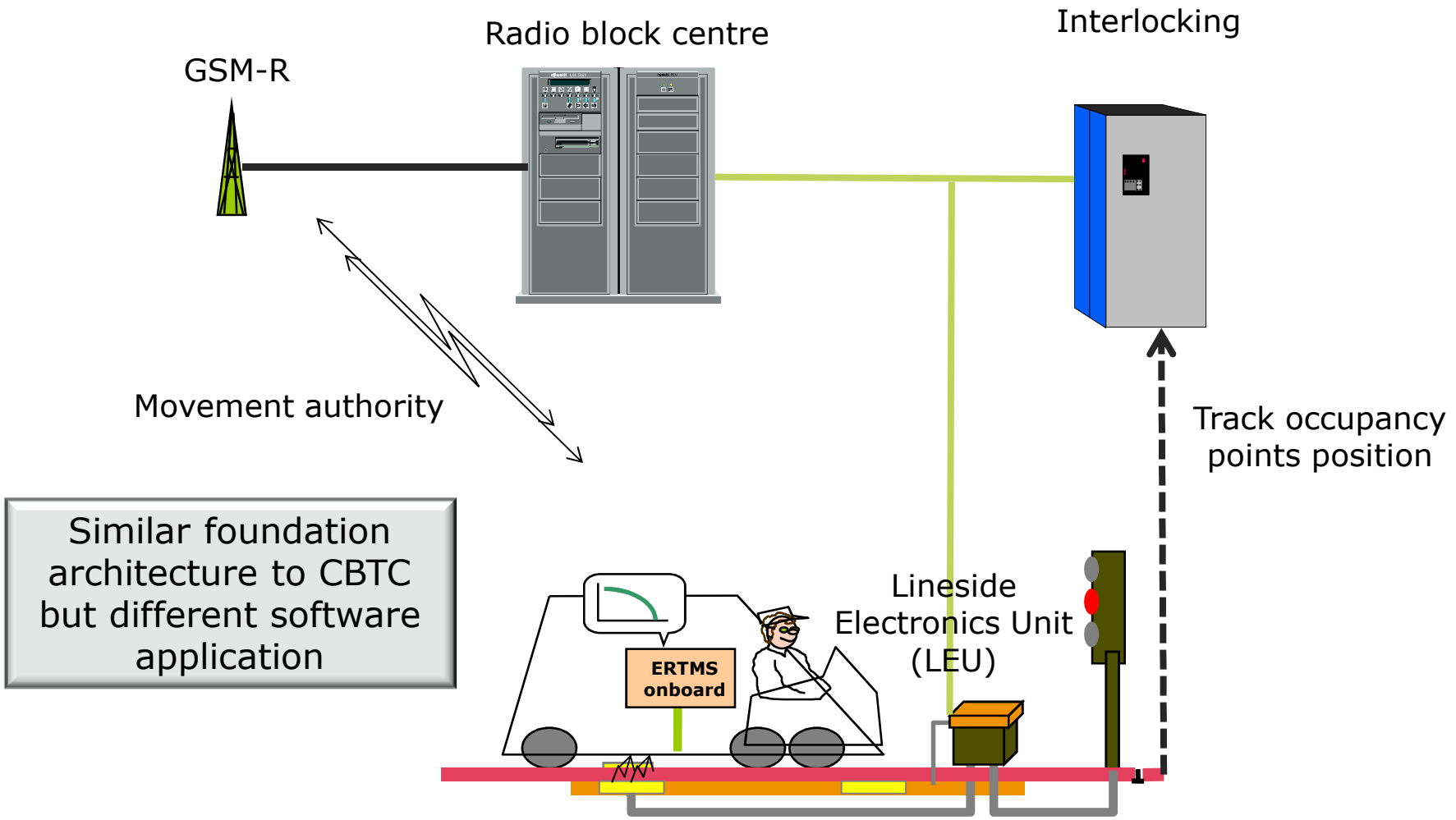
ERTMS: Architecture



ERTMS: Overview of different levels

- **ERTMS Level 1** is based on spot transmission from track-to-train (unidirectional). **Balises** transmit signalling information to the train (e.g. maximum speed, distance to travel,…)

- **ERTMS Level 2** is based on continuous transmission from track-to-train (bidirectional). It is based on **radio communications** (**GSM-R** - specific for railway applications) which allows ERTMS trackside equipment to transmit signalling information to the train. Trains can approach one another up to the following track section occupied

- **ERTMS Level 3** is an evolution of Level 2. Trains can approach one another up to the minimum physical distance (between the head of one train and the tail of the train in front of it). This ensures train integrity and removes the need for train detection systems (track circuits, axle counters,….)

The market for ERTMS Level 3 is currently unclear

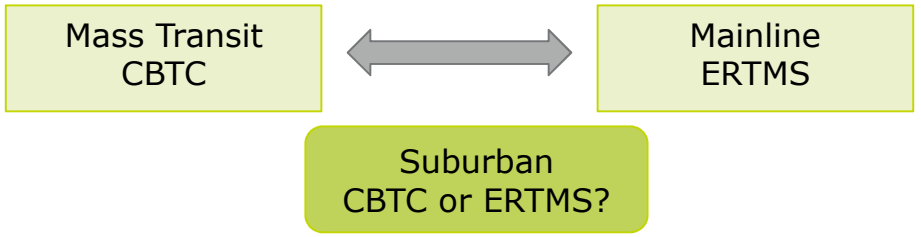
Signalling technology trends

- Signalling technology is standardising
  - Mass transit – CBTC
  - Suburban lines – CBTC & ERTMS
  - Mainline - ERTMS
- Technology gives the "right to play" but it is not a key differentiator between competitors given it is standards based
- ERTMS & CBTC need to be adapted to meet national/local requirements
- Competitiveness in services is now a key driver
- Safety developments – worldwide CENELEC* standards
- Engineering "elegance" offers value differentiation
- Optimisation of energy consumption

Note *: European Committee for Electrotechnical Standardisation

CBTC & ERTMS convergence

- ERTMS → requirement for ATO (Automatic Train Operation)
- CBTC → train positioning with EUROBALISE
- Invensys Rail uses same hardware & software platforms



Leading-edge technology to be deployed by Invensys Rail on Thameslink and Marmaray contracts

Suburban examples

Country	Details
Madrid, Spain	ERTMS
Thameslink, London, UK	ERTMS
Marmaray, Turkey	CBTC + ERTMS
CPTM, Sao Paulo, Brazil	CBTC

Research & development programme

- Future signalling technology will be judged by its operational value to a railway; it's no longer just about safety
- **ERTMS**
  - Update specifications ERTMS Level 1 & Level 2 (baseline)
  - Automatic Train Operation (ATO) (CBTC convergence)
  - Improvement design tools (application engineering)
- **CBTC**
  - Unmanned trains (UTO)
  - Adaptation to each local mass transit application (5-10% new functions)
  - ERTMS with Eurobalise (ERTMS convergence)
  - Improvement design tools (application engineering)

Research & development programme (cont)

- **Interlockings**
  - Core signalling capabilities
  - WESTRACE enhancements
  - WESTLOCK upgrades
- **LYRA**
  - New software and hardware platform for CBTC and ERTMS to lower total cost of ownership
- **Products**
  - New level crossing generation improving train prediction and crossing control
  - Track circuits and point machines update
  - New locomotive products - end of train, sensors, communications, ...
  - Positive Train Control (PTC) (United States) - a system of monitoring/controlling train movements to provide increased safety
    - Invensys Rail R&D focused on wayside (wayside vital controller and radio communication) where bulk of investment expected to be

China: Signalling technology

- Technology & standards
  - Mainly based on CENELEC (Europe) or AREMA (US) standards
  - Chinese technology similar to Western technology; however, they do not have the legacy/track record of the traditional Western signalling industry and operators
  - Chinese companies now have CBTC and CTCS technology with Western partners
- Invensys Rail partnerships in China based on CBTC/mass transit opportunities
  - Modification of CBTC for local standards/requirements
- Invensys Rail strategy for China export
  - Use existing CBTC/ERTMS technology as a subcontractor

Q&A