CBTC Report for vendor Bombardier, Thales and Ansaldo STS

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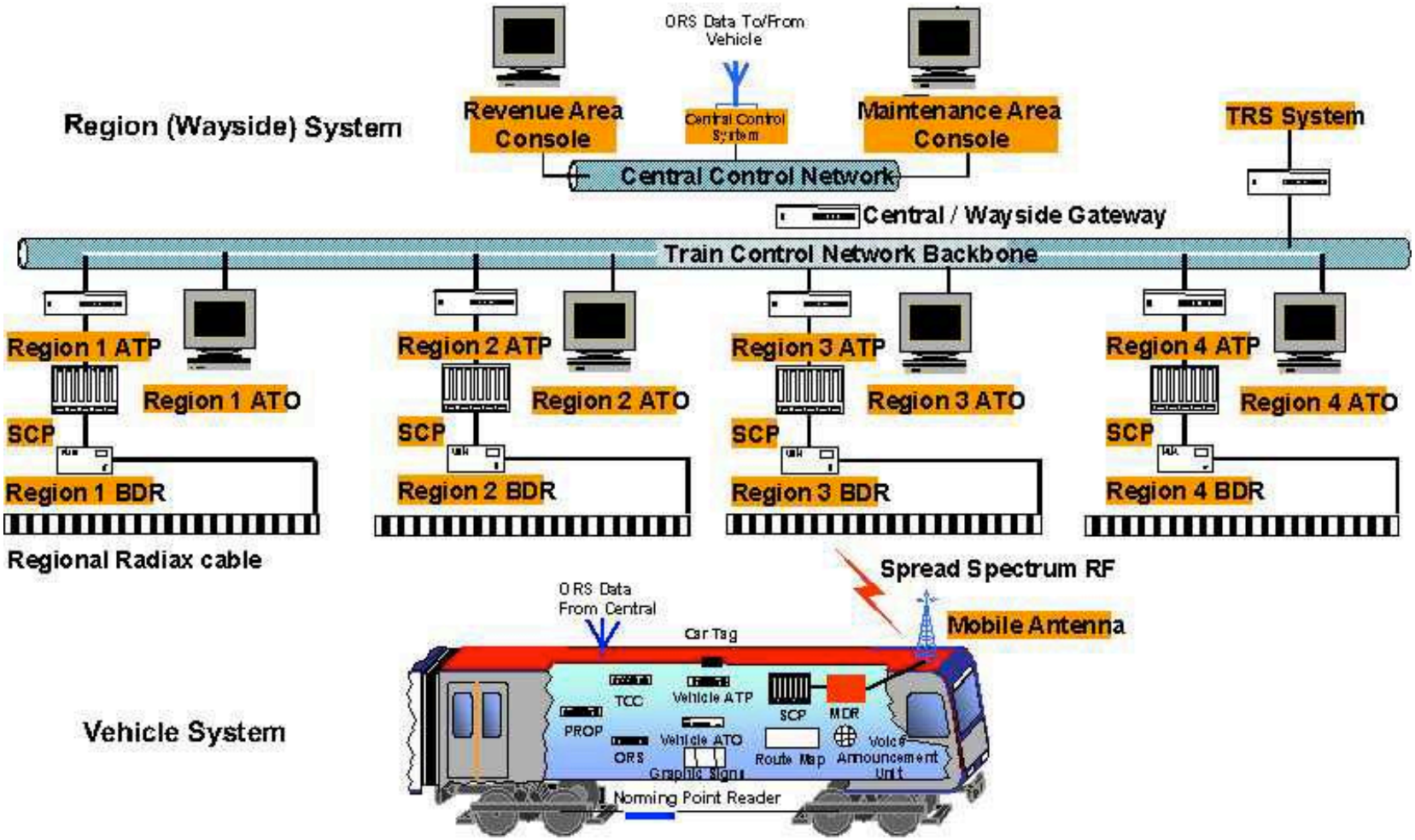
1. Bombardier
   - System architecture
   - Operating mode, Safety and failure management
   - Communication and Interlocking
   - ATS functions
   - Headway, Train speed and train location determination
   - Door management, ATO functions and Service-oriented facilities
   - Service-oriented facilities
2. Thales
   - System architecture
   - Operating mode, Safety and failure management
   - Communication infrastructure and protocol
   - ATS functions
   - Headway,
   - Train speed, train location determination,Door management, ATO functions
   - Service-oriented facilities

Bombardier System architecture



Operating mode management

CITYFLO 650 can also be used as an overlay train control system or resignalling

Safety and failure management

- **Full secondary signalling system using the conventional track circuits, interlockings and wayside signals.**
  The solution is based on the Bombardier EBI Lock 950 Computer Based Interlocking (CBI).
- CITYFLO systems allow a **cold start-up**

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- The RF communication uses either a leaky coaxial cable or Line of Sight (LOS) antenna network along the wayside that transmits data to the trains via their onboard mobile antennas.
- The train has also an internal communication network, which uses the IEEE-1473 protocol.

Interlocking and wayside information integration

- The CITYFLO 650 built-in interlocking function is **located with the regional wayside ATP**.
- The CITYFLO 650 solution can either use the **built-in interlocking function or add optional EBI Lock computer-based interlocking for fall-back system capability** or adherence to local norms.

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ATS functions

- Manual override requests (when the central operator substitutes the automatic system ATP or ATO)
- Management initiation and termination of service
- Management of train schedules including dwell and headway control
- Management of route assignments for normal operations and failure modes
- Train management (including skip station or station close)
- Remote set or reset of emergency brakes
- Voice communication with the train and supervision
- Control of any power distribution system (SCADA)

Headway

- CITYFLO 650 is capable of less than 75 second headway
- Metro Madrid Line 1&6: 101s/111s headway

Braking models and speed limit protection

No Information

Train speed and train location determination

- Tracks divided into entity called a "CITYFLO Segment" .
  For **example** suppose that a train was 25% through segment **R**1**S**4 in Moving Block Coordinate System is **R**egion 1, **S**egment 4, and Offset 25.
- A Norming Point is a **Passive Tag containing Location Data**.
- A **Conflict Point** is defined as the end of movement authority.
- Neihu-Muzha Line **maximum speed of 80 km/h**

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Door management

- Door control requests are issued by the ATO system (both onboard and wayside).
- The ATO system allows precision stopping by the train at stations with a typical accuracy of +/- 15 cm

ATO functions

- Each Region has an independent ATO.
- Ride Comfort Control, e.g. jerk limiting (VATO)
- Stopping accuracy (VATO)
- Speed profile (VATO)
- Door Control Requests (RATO and VATO)
- Onboard and Wayside PIDs and PA (VATO and RATO)

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Service-oriented facilities

- Passenger information displays (PIDs)
- CCTV (Closed Circuit TV)
- Public announcement (PA)
- Radio
- Telecoms

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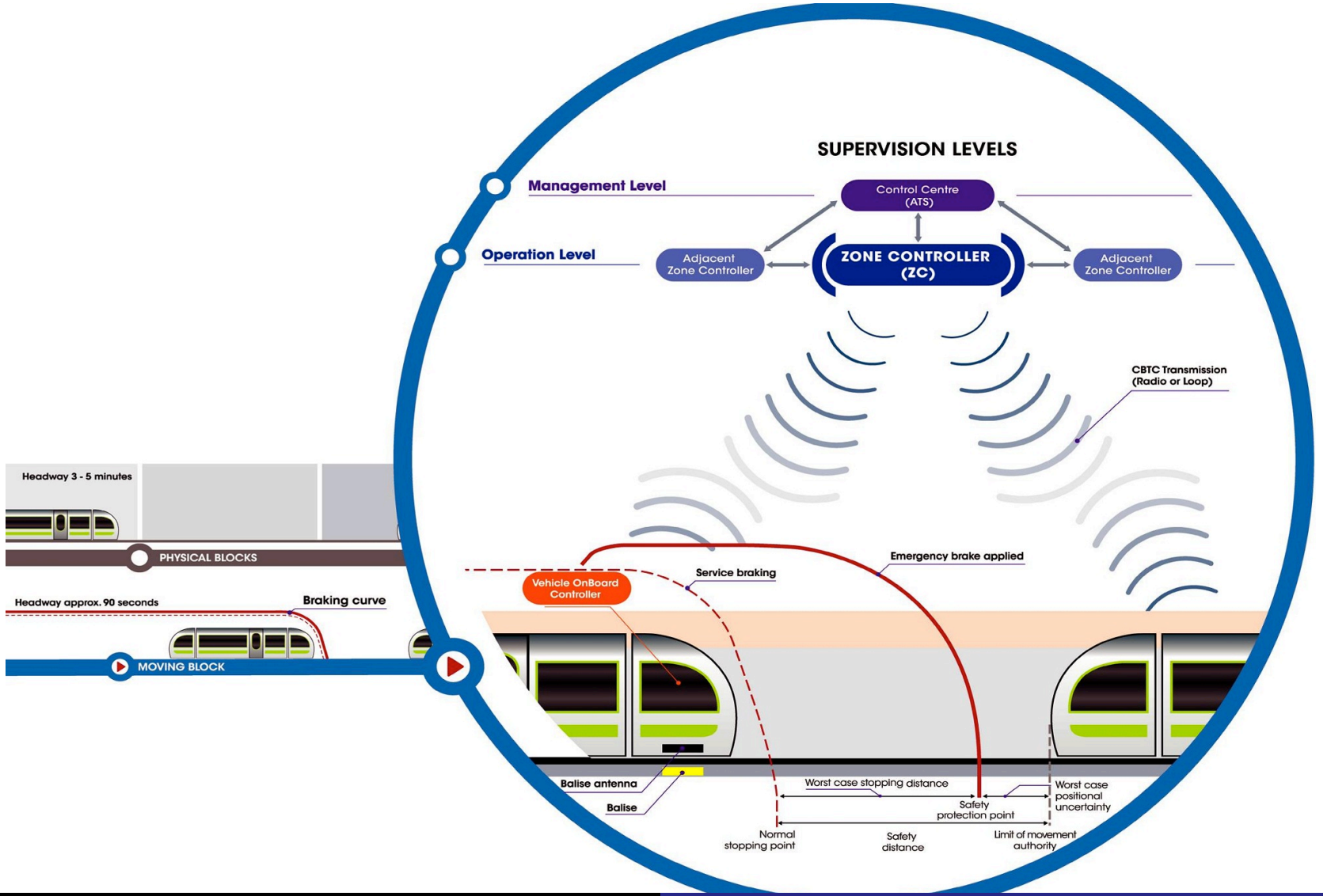
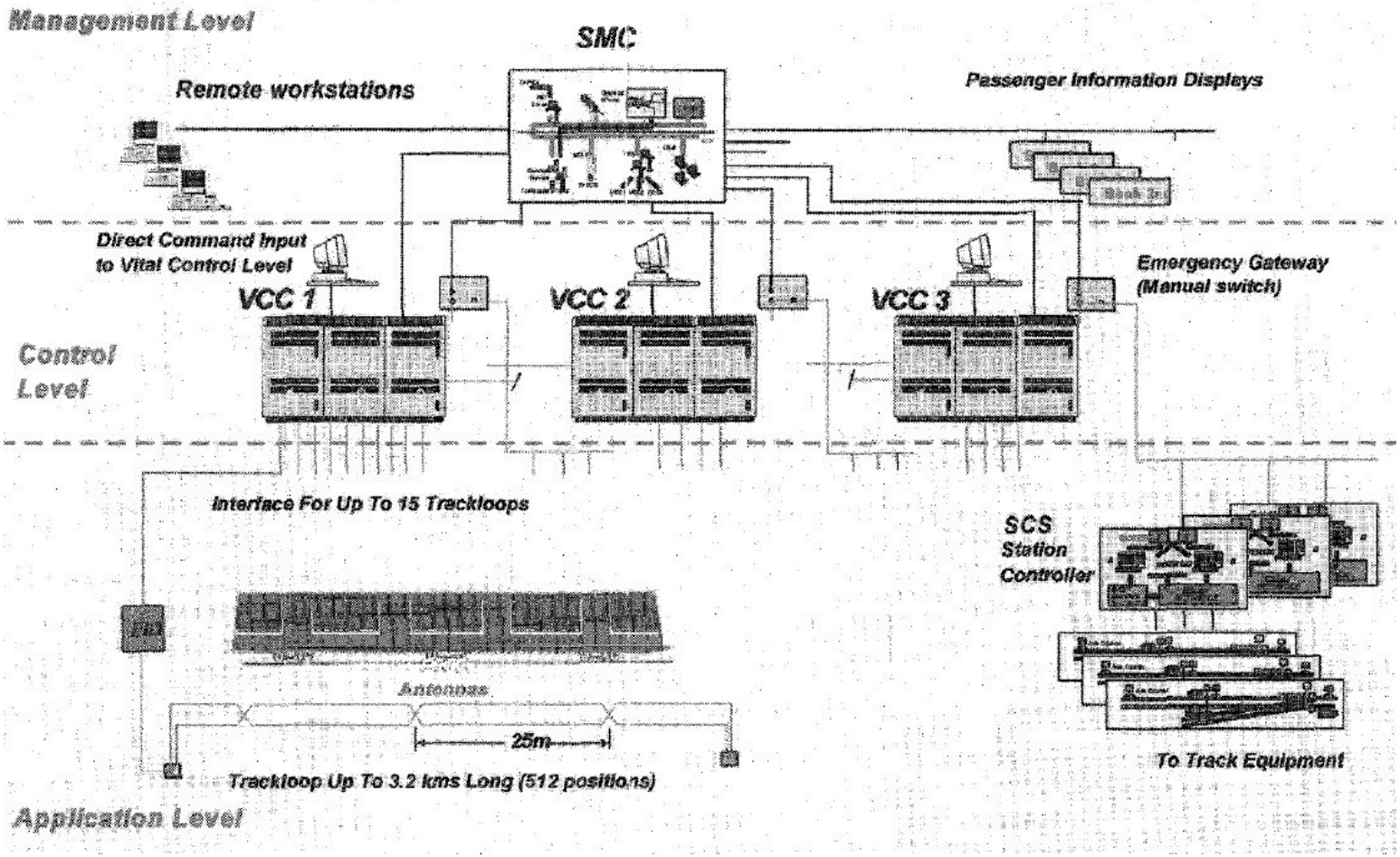
Thales System architecture

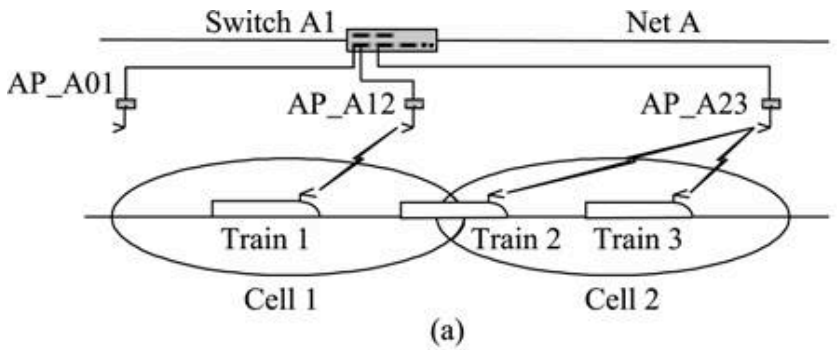


Thales System architecture Loop Inductive Version



SMC is Supervisory Control Level, VCC is Vehicle Control Computer, SCS is Station Controller Systems

Thales System architecture Radio Frequency Version



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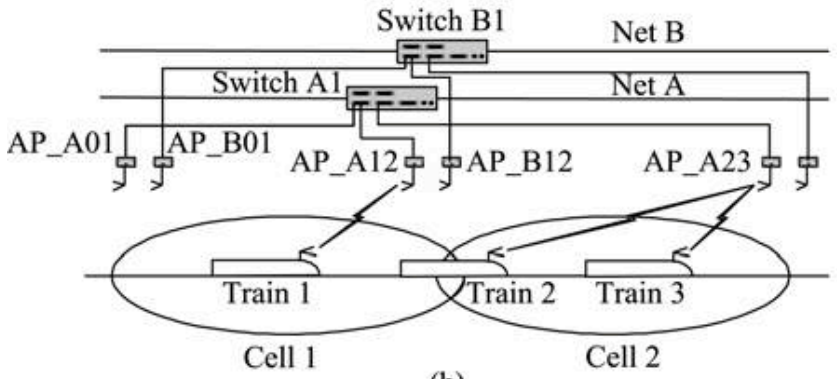

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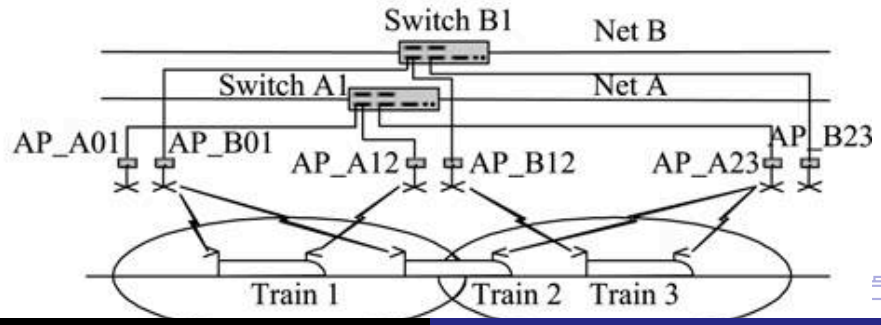

Operating mode management

Replacing or overlay existing signalling

Safety and failure management

Seltrac S40 uses fully redundant computer systems

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Communication infrastructure and protocol

- IL
  - Train-wayside protocol is Proprietary. VOBC antennas to receive data at 36 kHz and to transmit data at 56 kHz. The protocol used in Alcatel's loop communication has the VCC transmitting an 83-bit telegram to the VOBC at 1200 baud; the VOBC responds with a 43 bit telegram at 600 baud.
- RF
  - system are fully redundant.
  - Train-wayside protocol : IEEE 802.11
  - On Board Communication sub-system has two antennas, one on the front, and one on the rear of the train. Each onboard network device connected to the antenna is a modular component, with two IEEE 802.3 interfaces, as well as one CAN bus interface.

Interlocking and wayside information integration

The interlocking functions are provided by LockTrac 6131 ELEKTRA is an electronic interlocking system that provides the highest levels of safety and availability.

ATS functions

- Train departure, destination assignments and identification assignment.
- Train routing functions.
- Modification of the system operations parameters in response to system delays and Control Room commands.
- Data logging.
- Station platform information display (PID) control
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Headway and Braking model

- SelTrac has proven that it can deliver headways of under 60s.
- In Dubai Metro is configured for a minimum headway of 90s.

Braking models and speed limit protection

The system allows four service brake rates ranging from $0.4 ms^{-2}$ to $0.8 ms^{-2}$.
The brake rate for a specific train or track section can be adjusted manually from the control center.
Safety calculations are based on an emergency brake rate of $0.9 ms^{-2}$

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Train speed and train location determination

- With IL for speed determination use a tacho-generators, used to measure speed, direction and distance in conjunction with an accelerometer. SELTRAC train position detection system provides a 6.25 meter resolution.
- With radio-based the system use the trackside transponder tags assist in train positioning
- Maximum speed of the trains will be 90 km/h.

Door management

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ATO functions

Control train movement with regard to speed, acceleration, deceleration, and jerk.

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- Passenger information displays (PIDs)
- CCTV surveillance
- Public announcement (PA)
- Audio and video recording
- Phone system and emergency
- Advertising information system audio / video
- Supervisory Control and Data Acquisition (SCADA)
- Emergency call points allow direct communication with passengers from centralised Operational control centre.
- Access control: used to detect and warn in the event of unauthorised access to particular areas of the network

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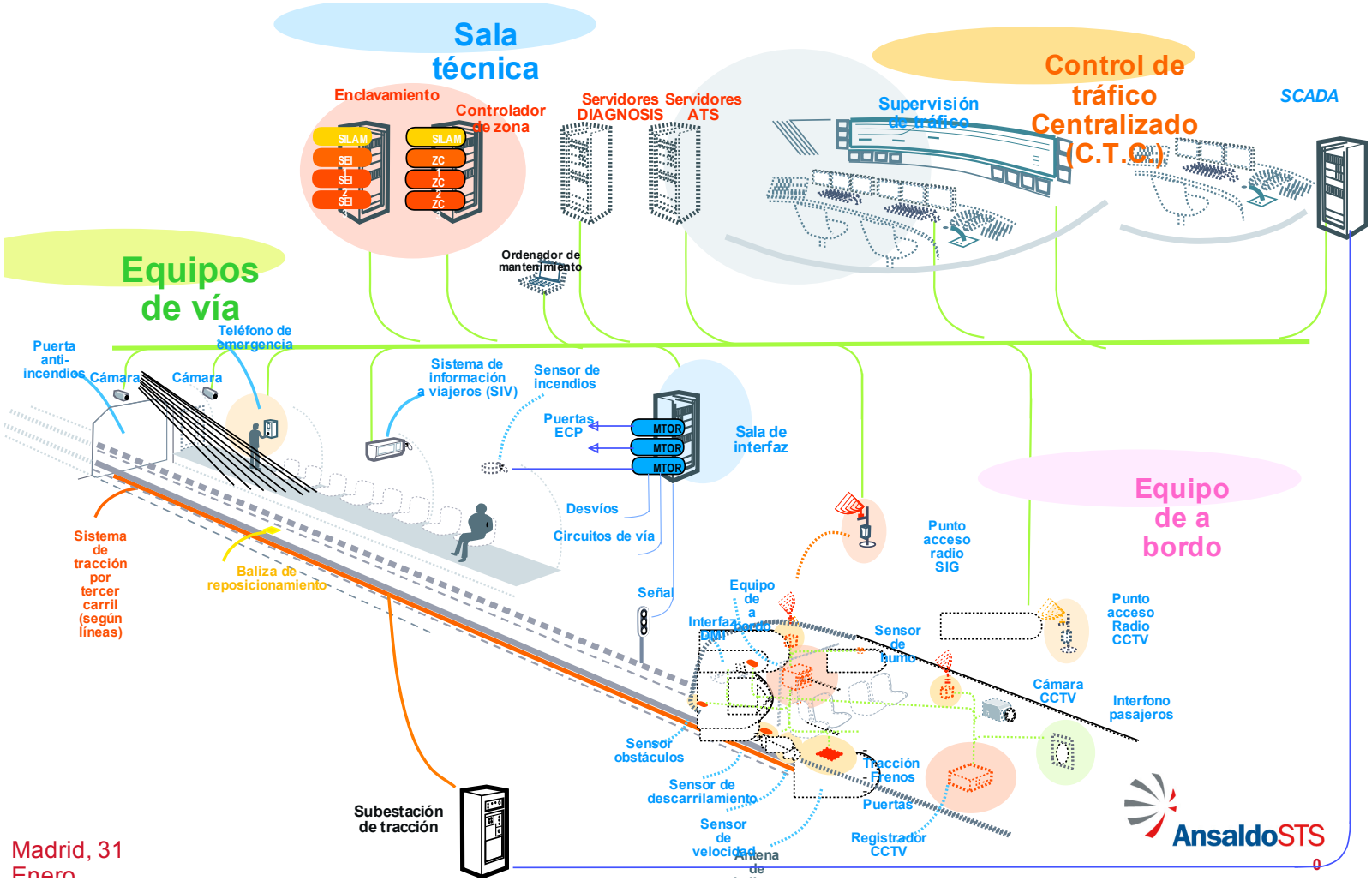

Operating mode management

simultaneous CBTC and non-CBTC equipped vehicles to share the same tracks

Communication infrastructure and protocol

- Train-wayside protocol Radio Frequency: IEEE 802.11
- Fully redundant configurations.

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- In brochures headway is declared down to 60 seconds.
- Copenhagen Metro 90s/100s minimum.
- Taipei Circular Line 90s minimum.

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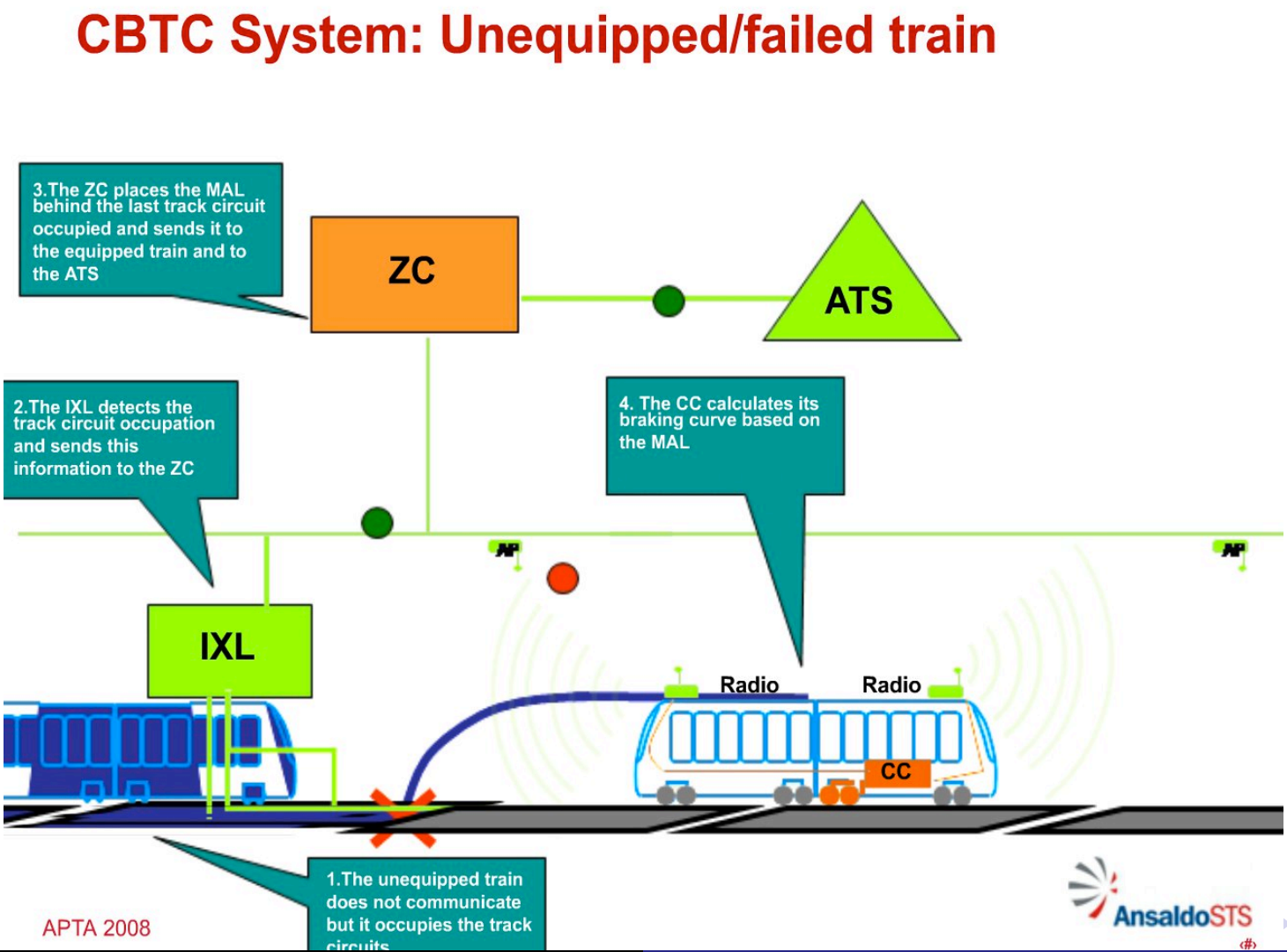

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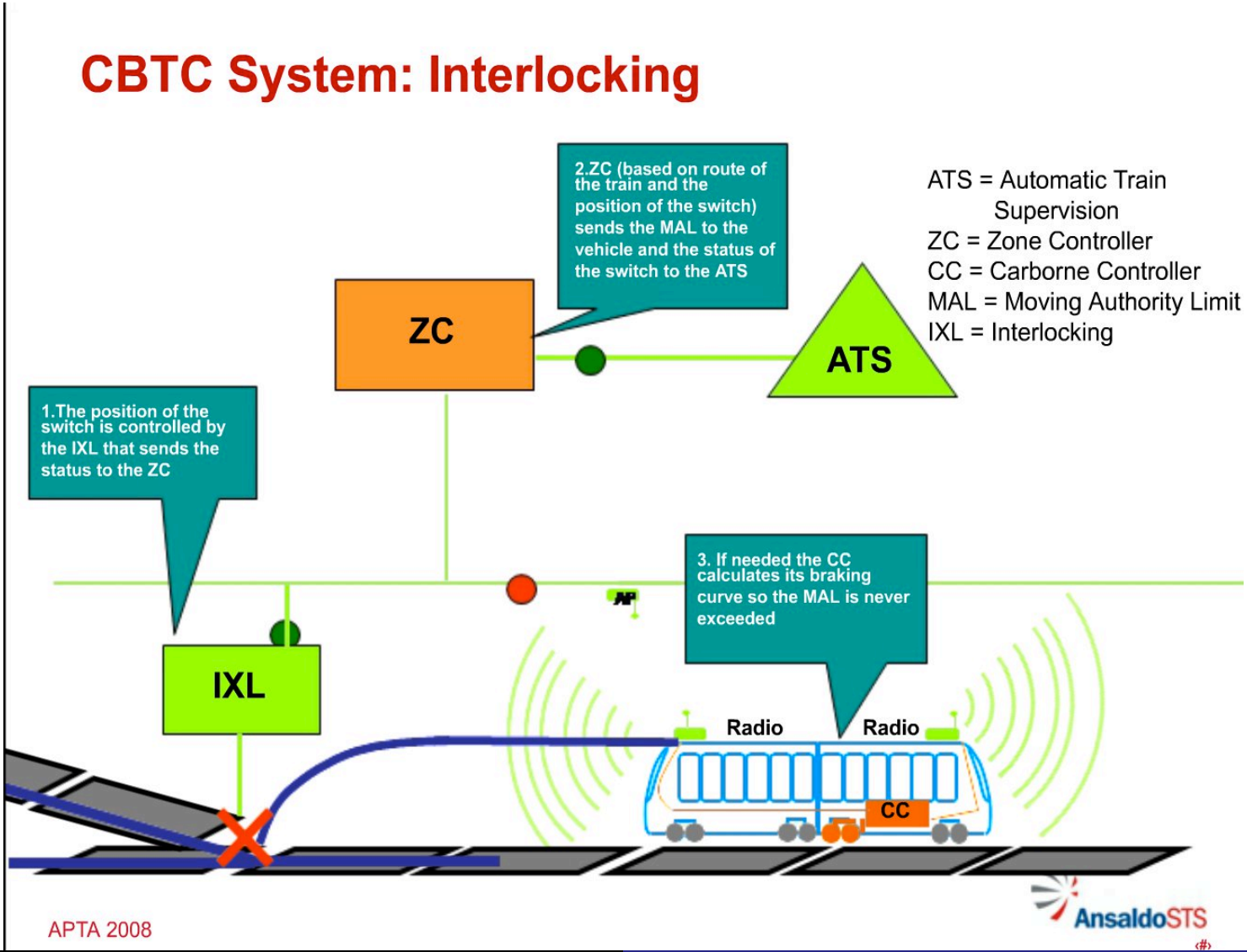

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- The ATO functions allows you to make small movements to center doors (Undershoot & Overshoot recovery)

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- Management of programmed stops
- Management of Platform Screen doors
- Skip Stop
- Management of overshoot ad undershoot
- Automated coupling & decoupling
- Energy consumption management and optimization

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- Loudspeakers in stations and trains.
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