Railway Signalling and Train Control: CBTC, ETCS, Interlocking and Headway Design

1 – 5 March 2027
Paris - Right Bank business hotel



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Introduction:

Railway signalling decisions taken at tender stage fix a line's capacity, safety case and upgrade path for decades, yet many project and maintenance teams still compare CBTC and ETCS offers on supplier claims rather than on headway, train detection, interlocking design and safety integrity evidence. This Core Concept course gives signalling engineers, project staff and O&M teams an engineering view of train control: block principles, interlocking, CBTC and ETCS architectures, headway calculation, RAMS under EN 50126, EN 50128 and EN 50129, and commissioning. Participants produce a Signalling System Selection and Headway Report for a metro or mainline scenario.

Course Objectives:

- Explain block working, train detection and interlocking logic well enough to review signalling design submissions and failure reports
- Compare CBTC and ETCS architectures, subsystems and grades of automation against the operating requirements of a line
- Calculate headway and line capacity from braking curves, train length, dwell time and fixed block or moving block separation
- Specify rail radio requirements for train control data, including the transition from GSM-R to FRMCS
- Apply EN 50126, EN 50128 and EN 50129 to RAMS targets, SIL allocation, safety cases and commissioning evidence
- Plan the migration or overlay of a new train control system on an operating railway with staged testing and cutover

Target Audience:

- Signalling and train control engineering functions that design, review or maintain interlockings and train protection
- Rail systems integration functions responsible for interfaces between rolling stock, radio and wayside equipment
- Signalling project delivery functions that manage tenders, contractors and commissioning programmes
- Operations and maintenance functions that fault-find signalling and train control assets on metro and mainline networks
- Safety assurance functions that review hazard logs, safety cases and RAMS evidence for signalling changes

Course Outline:

Day 1: Signalling Principles, Train Detection and Interlocking Logic

- Block Working Principles: One Train per Block, Overlaps, Sighting and Braking Distances
- Track Circuit Operation: Train Shunting, Relay De-Energisation and Rail Insulation Issues
- Axle Counter Evaluation Sections: Count-In, Count-Out, Reset Procedures and Disturbances
- Relay Interlocking: Route Locking, Flank Protection and Entrance-Exit Route Setting
- Computer-Based Interlocking: Software Data Preparation, Redundant Hardware and Change Control

Day 2: CBTC and ETCS Train Control Architectures

- Fixed Block Versus Moving Block: Safe Zone Calculation Behind Each Train
- CBTC Subsystems: Onboard ATP and ATO, Wayside Zone Controller and Data Communication System
- Automatic Train Supervision Functions and Grades of Automation GoA 2, GoA 3 and GoA 4
- ETCS Level 0, Level 1 and Level 2 Operating Principles with NTC and STM Fallback
- ETCS Trackside and Onboard Components: Eurobalise, LEU, RBC, EVC, BTM and DMI

Day 3: Rail Radio, Braking Supervision and Headway Calculation

- GSM-R Voice and Data Bearers and the FRMCS 5G Successor at Overview
- CBTC Radio Coverage Design: Frequency Bands, Redundant Networks and Handover
- Movement Authority, Speed Profiles and Odometry Error in Braking Supervision
- Headway Calculation Worksheet: Braking Curve, Safety Margin, Train Length and Dwell Time
- Line Capacity Comparison: Fixed Block Signal Spacing Versus Moving Block Separation

Day 4: RAMS, Safety Integrity, Testing and Migration Risks

- RAMS Life Cycle Under EN 50126: Hazard Log, Apportionment and Availability Targets
- SIL 1 to SIL 4 Allocation and Software Assurance Under EN 50128
- Safety Case Structure and Independent Assessment Under EN 50129
- Testing and Commissioning: Factory Tests, Site Integration, Dynamic Train Tests and Trial Running
- Brownfield Migration: CBTC Overlay, Dual-Fitted Fleets and Staged Cutover Planning

Day 5: Signalling System Selection and Headway Case Study

- Metro Upgrade Case: CBTC Versus Upgraded Fixed Block Option Scoring
- Mainline Corridor Case: ETCS Level 1 Versus Level 2 Trade-Off Matrix
- Headway Workbook Build for a Terminus Turnback and Peak Service Pattern
- Degraded Mode Review: Radio Loss, Axle Counter Failure and Restricted Manual Driving
- Signalling System Selection and Headway Report Drafting and Peer Challenge

Skills You Will Gain:

- Train Detection Fault Diagnosis
- Interlocking Design Review
- CBTC Architecture Assessment
- ETCS Level Selection
- Headway and Capacity Modelling
- Safety Integrity Allocation
- Signalling Commissioning Planning
- Brownfield Migration Planning

Why Attend This Course:

- Return with a Signalling System Selection and Headway Report built on a realistic metro or mainline scenario
- Question supplier capacity and availability claims with your own headway figures and RAMS reasoning
- Anticipate the testing, degraded mode and cutover issues that delay signalling upgrades on live railways
- Exchange signalling practice with engineers from metro, mainline, freight and light rail organisations

Conclusion:

Railway signalling choices hold up when train detection, interlocking, train control architecture, radio, headway and safety evidence are judged together. The course moves from block principles, track circuits, axle counters and interlocking, through CBTC and ETCS architectures, to rail radio, braking supervision and headway calculation, then to RAMS, safety integrity, testing, commissioning and migration on live lines. The final day applies these methods to metro and mainline cases and produces the Signalling System Selection and Headway Report.