Digital Railway Education Day

Presented by RDG’s ‘New Technology Introduction Team’

Today’s speakers are:
Chris Masson & Andrew Graham

Rail Delivery Group
Welcome to the Education Day

House Keeping:
• Fire Evacuation
• Toilets
• Lunch & Break Times
• Finish Time

Today’s Agenda:
• An overview of the current system
• What is the Digital Railway?
• ERTMS Legislation & Interoperability
• New Technology Systems Overviews, including:
  • GSM-R
  • ETCS, incorporating fleet fitment, infrastructure changes and operational considerations
  • Traffic Management
  • Driver Advisory Systems
  • COMPASS
  • Customer Information Systems
About the Education Days

• Delivered 60+ session since 2011
• Attended by people from across the industry
• Will support training before deployment of Digital Railway technology
• Help develop an informed view on Digital Railway and its systems
• We are here to answer your questions

It’s your day!
Things to think about:

• Digital technology is now commonplace on railways around the world
• Normally fitted to ‘green field’ roll outs
• Cambrian - one of the few retro-fitted routes in the world
• ERTMS was designed to standardise European network
• Route Signalling vs. Speed Signalling
• Timetable planning and delivery challenges
• Changes to the philosophy of how we operate the railway
Current System (Simplified)

- Coloured Light Signals
- Analogous Voice Radio
- Control Centre (e.g. ROC)
- TPWS
- AWS
- Analogue Voice Radio
- Train Detection (e.g. axle counters)
An Idealised Digital System

Control Centre (e.g. ROC)

Coloured Light Signals

Analogue Voice Radio

Train Detection (e.g. axle counters)

Train Detection + Signalling

Digital Voice Radio

Intelligent Train In-cab Signalling Speed Advisory

TPWS Balise AWS
New Technology Summary

- **GSM-R**: Global System for Mobile Communications - Railway
  - Radio based communications for voice & data – already functioning across the network

- **ETCS**: European Train Control System
  - Signalling control & train protection system using the GSM-R radio system developed by the European Union

- **ATO**: Automatic Train Operation
  - Automatic operation of train acceleration and braking, generally without human interaction

- **TM**: Traffic Management
  - Signalling & operations management tool connected to a number of different systems. ‘Plan Re-plan’ is the core of the system

- **S&C**: Stock and Crew
  - Combines data from the train service, its actual running diagram, resource information and their associated rolling stock allocations and crew rosters.

- **C-DAS**: Connected Driver Advisory System
  - Advisory system connected to TM. Calculates optimum speeds to meet timetable and use least amount of energy

- **COMPASS**: Combined Position & Alternative Signalling System
  - Alternative in-cab signalling system to provide limited service during signal failures (via GPS)

- **DRACAS**: Defect Recording Analysis & Corrective Action System
  - An information sharing framework for all command, control and signalling shared systems
New Technology Summary

**New Technologies**

- GSM-R
- ETCS
- ATO
- TM
- S&C
- C-DAS
- COMPASS
- DRACAS
- Incident Management
- Rules & Procedures

**People & Process**

- Radio based communications for voice & data
- Signalling control & train protection system using the GSM-R radio system developed by the European Union
- Signalling & operations management tool connected to a number of different systems. 'Plan Re-plan' is the core of the system
- Advisory system connected to TM. Calculates optimum speeds to meet timetable and use least amount of energy
- Alternative in-cab signalling system to provide limited service during signal failures (via GPS)
- An information sharing framework for all command, control and signalling shared systems
- Combines data from the train service, its actual running diagram, resource information and their associated rolling stock allocations and crew rosters.
- Automatic operation of train acceleration and braking, generally without human interaction
Digital Railway

Rail Delivery Group
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Toolkit First Thoughts

People:
- Culture Change
- Org Design
- Competencies
- Training
- Simulation

Operating processes & procedures

Data:
- Systems & standards

Safety Regulations

Network Code

Security & Cyber-security

Programme management & Business Change

Benefits

Costs

GSM-R ETCS C-DAS TM COMPASS

Implementation standards, templates, specifications, commissioning...
Digital Railway:

Strategic Outline Business Cases (SOBCs)

Early Contractor Involvement (ECI)

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SOBCs and ECI

SOBCs:

- Strategic Outline Business Cases targeted at 5 routes for CP5/6/7 delivery via Route Steering Boards
  - Anglia
  - LNE
  - South Eastern
  - Wessex
  - Western
- DfT & NR jointly considering Essex Thameside route options
- DfT leading Transpennine route investment cases may also include Digital Solutions for which the central programme are supporting
- TfL exploring an East London Line investment case with NR

ECI:

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<td></td>
<td>Customer Experience</td>
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Benefits of Digital Railway Technologies

• **More Trains:**
  
  With the right strategy, built for the digital age, the railway can achieve a step-change in capacity for both passenger and freight trains to run safely on existing track.

• **Better Connections:**
  
  Modernisation will create new choices for passenger and freight customers about how where, when and how fast trains travel.

• **Improved Performance:**
  
  Digital Traffic Management is boosting performance on leading railways. We need to apply these benefits to Britain’s national network.

• **Lower Costs:**
  
  Lower long term signaling costs with less lineside equipment.
“free movement of people and goods & services across members states”
• A pan-European open railway network with uniform standards based on a common set of requirements including:
  
  • Safety
  • Reliability
  • Availability
  • Technical compatibility
  • Technical Specifications for Interoperability (TSI)
    • Prepared by European Union Rail Agency (EURA)
    • A TSI is a common harmonised technical standard legally binding on member states
How does the European Union Rail Agency Work?

Sector organisations acting at European level:

- UNIFE (Euro rail ind assoc)
- CER (Comm of Euro Railways)
- EIM (Euro infra managers)
- UIP (Int union of wagon owners)
- UIRR (Int union of road/rail users)
- ERFA (Euro rail freight assoc)
- ETWF (European Transport Workers Federation)

National Safety Authorities’ Experts

Experts

- Working Party OPE TSI
- Working Party CCS TSI
- Working Party Energy TSI
- ETC...

Social Partners, Passengers & Customers

Recommendations

Commission

Committee on the Interoperability and Safety of the European Rail System (RISC)

Decision

* List established by Article 21 Committee on 22 February 2005
• European Interoperability Directive is transposed into national law, the Railway Interoperability Regulation (RIR) 2011, This would take time to repeal

• DfT asked RDG what options we would want to choose from the TSIs (i.e. faster approvals process in 4th Railway Package)

• There is also the benefit of the Single European Market, adopting a common standard means supplier solutions are more available and cheaper to implement
GSM-R:
Global System for Mobile Communications - Rail
GSM-R System Overview
GSM-R Architecture

Network Sub-System (NSS) - Didcot

BSC = Base Station Controller

- BSC Doncaster
- BSC Glasgow
- BSC Manchester
- BSC Nuneaton
- BSC Stoke
- BSC Peterbor.
- BSC Newport
- BSC London Victoria
- BSC Ashford
- Back-up NSS - Stoke

Location:
- Didcot
- Back-up NSS - Stoke

Urban Centers:
- Manchester
- Nuneaton
- Stoke
- Peterbor.
Cell Planning 101

4-8km (Typ)

BTS

Cell A

Cell B

Cell C

Tunnel repeater (cell B)

Cab radio

Signaller X

Signaller Y
Cell Planning 101

- In practice, a much more complex picture

- Odyssey Planning Tool Output:
  - Shows the spread of GSM-R signal from a mast – Not entirely directional!
  - Depends a lot on the environment and location
Radio Coverage and Behaviour

- Cab Radio spends 99% of time in ‘idle mode’
  - Seeks best serving cell for its position
  - Follows ‘neighbour’ list for next cell
  - Makes ‘cell re-selection’ as one cell’s strength fades and next increases
  - Cab mobile is making autonomous decisions

- During a call, cab radio in ‘dedicated’ mode
  - Receives instructions from the network to make ‘hand-over’ to next cell
Interference from Public Mobile Operators (PMO)

- O2 and Vodafone frequencies close to GSM-R
- This is in line with EU frequency allocation but there is some interference between the frequency ranges

- Mobile phones are entering the primary GSM-R band
Interference from Public Mobile Operators (PMO)

- Strong signals close to railway can overpower GSM-R signals
- There has been 200+ cases reported in UK and costs £150k per year just to manage it
- Network Rail Telecoms (NRT) are working with PMOs to address problem sites by turning down their output strength
- Additional GSM-R repeaters are used to boost GSM-R above PMO levels but this is a short term solution
• An **uprated Mobile Radio Module (MRM)** has been specified by the European Telecoms Standards Institute (ETSI), which is more resistant to bordering frequencies and PMO interference

• An uprated MRM has been developed on ETSI train no. 102903 for the Siemens radio

• The new unit will cost £35M+ nationally and it is unclear how this will be funded

• A fitment plan is being developed, new build trains and major modification projects should take advantage of the opportunity to upgrade
Roaming on PMO Networks

• As they have a similar radio spectrum it is possible to use public GSM networks as a fall-back solution where GSM-R has failed, this would require an agreement

• For some low traffic areas, public roaming can be used as a permanent solution instead of GSM-R

• This keeps most of the GSM-R functionality such as functional addressing but REC calls would be unavailable

• GB are considering public roaming as one fall-back option for voice and data
Packet vs Circuit Switching

• Packet and Circuit switching refer to how data transmissions are sent:

  • In **Circuit Switching**,  
    • one channel is attributed permanently and exclusively to a Mobile Station during the whole communication  
    • This delivers a high quality of service and is appropriate for communicating continuous and dense streams of data

  • In **Packet Switching**,  
    • the radio resource is only used when data is being exchanged and therefore can be more efficient for some applications  
    • This method is used for the General Packet Radio Switching (GPRS), which is widely used in public GSM networks  
    • Depending on configuration, GPRS can support several mobile stations interspersing their data on each channel, rather than Circuit Switching where one call is supported continuously
• Currently Circuit Switching is used for GSM-R
• GSM-R can use Packet Switching to increase the signalling centres / RBCs capacity
ETCS:
European Train Control System

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What does ETCS do?

- The train is told:
  - How far it can safely go
  - The line speed profile of the route
  - Other relevant information such as gradients
- The train ‘knows’ its own braking performance and maximum speed
- The train calculates how fast it can go such that it can stop within the specified distance
- The train advises the driver what the maximum speed is at an instant.
Driver Machine Interface (DMI)

- Speedometer
- Operating Mode
- Operating Level
- Text Message Display Area
- Planning Area
- Data Menu
What does ETCS do?

- Position Report
- Movement Authority
- RBC
- Speed Profile
- Balises (position reference)
- Distance to EoA
- Emergency Brake Intervention Curve
- Service Brake Intervention Curve
- Warning Curve
- Permitted Speed
- End of Authority
- Supervised Location
- Lineside marker
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Trains are fitted, trackside conventionally signalled but no underlying train protection/warning system.</td>
</tr>
<tr>
<td>NTC</td>
<td>Trains are fitted, trackside conventionally signalled. National train protection/warning systems are interfaced through an STM or can operate outside the ETCS system.</td>
</tr>
<tr>
<td>1</td>
<td>Movement Authority (MA) is passed to the train via balise or transmitter, repeating indication from existing line-side signalling.</td>
</tr>
<tr>
<td>2</td>
<td>MA is passed by radio from a Radio Block Centre (RBC) to the train. Provides intermittent update of train location and continuous update of MA. Can be installed with or without line-side signals.</td>
</tr>
<tr>
<td>3</td>
<td>Builds on Level 2, but enforces train separation using position data from the train, rather than trackside/on-track train detection. Provides continuous update of train location and MA.</td>
</tr>
</tbody>
</table>
ETCS Level 3

Signalling Control Centre

Interlocking
Worked points

Radio Block Centre (RBC)
Ground frames

GSM-R Mobile Switching Centre
Movement Authority

GSM-R BTS
Position & Status Reports

Train Integrity & Location
Train Interface Unit

Tachometer / Speed Probe

GSM-R Data JRU
EVC Odometry

GSM-R Voice
DMI
BTM
Balise Antenna

Doppler Radar

Balise
Balise
ETCS Operating Modes (17 in Total)

Operating Mode

- Full Supervision (FS)
  Levels: 1 2

- On Sight (OS)
  Levels: 1 2

- Staff Responsible (SR)
  Levels: 1 2

- Shunting (SH)
  Levels: 0 NTC 1 2

- System National (SN)
  Levels: NTC

- Non-leading (NL)
  Levels: 0 NTC 1 2

System State

- Trip (TR)
  Levels: 0 NTC 1 2

- Post-Trip (PT)
  Levels: 1 2

- Sleeping (SL)
  Levels: 0 NTC 1 2

- Standby (SB)
  Levels: 0 NTC 1 2

- Unfitted (UN)
  Levels: 0

- System Failure (SF)
  Levels: 0 NTC 1 2

- Isolation (IS)
  Levels: 0 NTC 1 2

- No Power (NP)
  Levels: 0 NTC 1 2

Not Used in UK

- Limited Supervision (LS)
  Levels: 1 2

- Passive Shunting (PS)
  Levels: 0 NTC 1 2

- Reversing (RV)
  Levels: 1 2
Compatibility

- ✓ OK
- ✓ OK
- Not recommended
- ✓ OK - Preferred
ETCS: Fleet Fitment

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What is fitted to the train?
Key Train Equipment

- European Vital Computer (EVC)
Key Train Equipment

- European Vital Computer (EVC)
- Driver Machine Interface (DMI)
Key Train Equipment

- European Vital Computer (EVC)
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Key Train Equipment

- European Vital Computer (EVC)
- Driver Machine Interface (DMI)
- Specific Transition Module (STM)
Key Train Equipment

- European Vital Computer (EVC)
- Driver Machine Interface (DMI)
- Specific Transition Module (STM)
- Balise Antenna and Balise Transmission Module (BTM)
Key Train Equipment

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Key Train Equipment

- European Vital Computer (EVC)
- Driver Machine Interface (DMI)
- Specific Transition Module (STM)
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- Odometery Equipment
- Juridical Recording Unit (JRU)
<table>
<thead>
<tr>
<th>Long Term Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Id</td>
</tr>
<tr>
<td>Vehicle Type</td>
</tr>
<tr>
<td>Vehicle Id</td>
</tr>
<tr>
<td>Equipment Id</td>
</tr>
<tr>
<td>Start</td>
</tr>
<tr>
<td>End</td>
</tr>
<tr>
<td>Distance</td>
</tr>
<tr>
<td>(mile)</td>
</tr>
</tbody>
</table>

![Graphical Journey Output](image-url)

- **Act_speed**
  - (miles/h): 130.00
- **Brake_cyl_press**
  - (bar): 7.00
- **(2 Min. Interval)**

- **Tract_notch_1**
- **Forward**
- **Occupied_cab**
- **Brake_code_1**
- **Emergency_brake**
- **Tract_notch_4**
- **AWS_pb_pressed**
- **AWS_clear**

- **Stop: Bognor, PBrake test**
- **Speed: 87.99mph**
- **Bamham**
- **59.89mph**
- **54mph**
- **3.50**
Key Train Equipment

- European Vital Computer (EVC)
- Driver Machine Interface (DMI)
- Specific Transition Module (STM)
- Balise Antenna and Balise Transmission Module (BTM)
- Odometer Equipment
- Juridical Recording Unit (JRU)
- GSM-R interface unit
Additional Components

- Power Supply
- Isolation Switch
- Soft Reset Switch (ERPIS)
- Train Interface Unit, including:
  - Direction
  - Cab Active
  - Service and Emergency Brake Demands
  - Traction Cut-Off
  - Tilt / TASS
  - Change of Traction Supply or Pan Up / Down
  - Selective Door Opening
  - Train Data from TCMS System
Installation Options – Modular Equipment

Single Unit or Distributed Equipment
One EVC or Two?

- A single EVC would suit shorter Multiple Units, whereas longer units would have a separate EVC at either end

- Loco Hauled Coaching Stock would have one EVC in the Loco and one in the Driving Van Trailer, if fitted

- The deciding factor for choosing the solution is train length; this is because of signal degradation through jumpers and cost
Examples of New Cab Fitments

Class 700

Class 374
Examples of New Cab Fitments

Class 345

Class 800
Examples of Cab Retro-Fitments

Class 97

Class 313

Class 158

Class 66 (Holland)
There are two Braking Models that the EVC can use to calculate the safe parameters:

- Gamma has 28 specific train characteristics and is loaded into the EVC as a pre-set when the Driver starts a mission.

- Lambda uses a Braked Weight Percentage entered by the Driver at the start – it is the sum of the braked weight of all vehicles divided by the total weight of the train.
On-board Maintenance Considerations
On-board Maintenance Considerations
• Technical Standards Interoperability (TSI)

• Some aspects of the TSIs are flexible, containing ‘Open Points’

• National Notified Technical Rules (NNTR) are GB Group Standards that are ‘Notified’ by GB to the EURA

• We combine the relevant TSIs and NNTRs to provide a GB ETCS Specification
Managing Heritage Stock on Mainline