



Modern Train Control Systems: Lessons from the United Kingdom

Q&A with Steve Knight, General Manager, Network Rail (UK)

Advanced train control systems can offer new opportunities for rail track owners and operators. The challenge for the industry, however, is how they can ensure they capitalise on new technology and ensure a successful rail network operation.

With this in mind, **Transport IQ** interviewed **Steve Knight, General Manager of Network Rail**, which is responsible for managing the United Kingdom's railway network. We've also attached his presentation that was conducted in March.

According to Steve, Network Rail is at the "leading edge of the technology front" when it comes to modern traffic management control systems.

Steve begun by setting the scene and describing his role and responsibilities at Network Rail:

"My role at Network Rail is currently General Manager. I look after the operational railway in Anglia and that responsibility is for the complete day to day operation of all the services that run on that part of the route.

Prior to this I led the development of the UK operating strategy, which determined how we were going to operate, signal and control the entire network. The strategy is funded and the elements of it are in the delivery phase.

Operating Anglia sees the day-to-day challenge of running a railway and planning for the future application of the operating strategy, including Crossrail."

Here is the *interview* with Steve discussing the emerging trends in the UK, and projects underway at Network Rail:

Transport IQ: What are the challenges the UK industry currently faces, and how are train control systems being utilised to play their part?

The main challenge that the UK industry faces right now is more capacity, and secondary to that is train performance and running trains on time. We are experiencing significant demand for rail services over and above what's ever been seen before.

Our capability to get more trains onto the network and to protect train performance whilst introducing extra service is the biggest challenge that we face.



Transport IQ: What emerging trends and developments can you share relating to train control systems in the UK?

There are probably three aspects that are worth talking about in that space. The first one is that we've got more than 800 operating locations around the network and we're moving to a position in which 14 centres run the network, so we're consolidating all of the signalling and control of the network into fewer locations, over a 15 year period.

The second one is we are introducing modern traffic management control systems - the system that will move the trains across the network and that the signaller or dispatcher will use.

We're at the leading edge of the technology front in that space and we're currently prototyping the technology that will deploy across the network with three suppliers. The third aspect is that we are deploying ETCS across the entire network and reducing the number of operator locations and introducing traffic management technology.

Transport IQ: Can you discuss how these developments have, and will deliver benefits for Network rail?

It's an aspiration. We currently have 10 of the centres built, with four more under construction. We have traffic management system prototypes being built by three suppliers. The first deployment of those systems will be in 2014 and we have the deployment of ETCS on the Cambrian line in Wales.

The benefits that we are seeing are the reduction of our costs and the ability to run significantly more trains on the network and to run them at an even greater degree of reliability than we were able to previously.

Without those three elements to our strategy we don't believe that we will be able to meet the challenge of running extra trains and keeping a credible service level.

Transport IQ: How do you perceive the future of train control systems improving the quality of service?

They should make trains more reliable and allow us to run more trains. They should also provide a better experience for the customer; aside from being more reliable they should provide better information to the customer about the journey.

If there is a disruption of any kind, then the information that's provided to people will be more timely, more accurate and more up to date. In a modern world where people demand much more information, immediately, I think it will help in that space.

Transport IQ: Can you offer some "top tips" to the Australian industry to avoid any common challenges?

One of the challenges around the strategy is where do you start? It's all interlinked it's important to foster a close relationship between the people that own and operate the trains and the people that own and operate the line-side infrastructure. That's probably the biggest lesson we've learnt.



To deploy ETCS across the network needs both the trains and infrastructure to be fitted. In the UK, where we've got different people that own the trains, different people that run the trains and different people that own the signalling assets, it's a complicated arrangement to achieve - so the simpler you can make the interface the simpler and easier your rollout of ETCS.

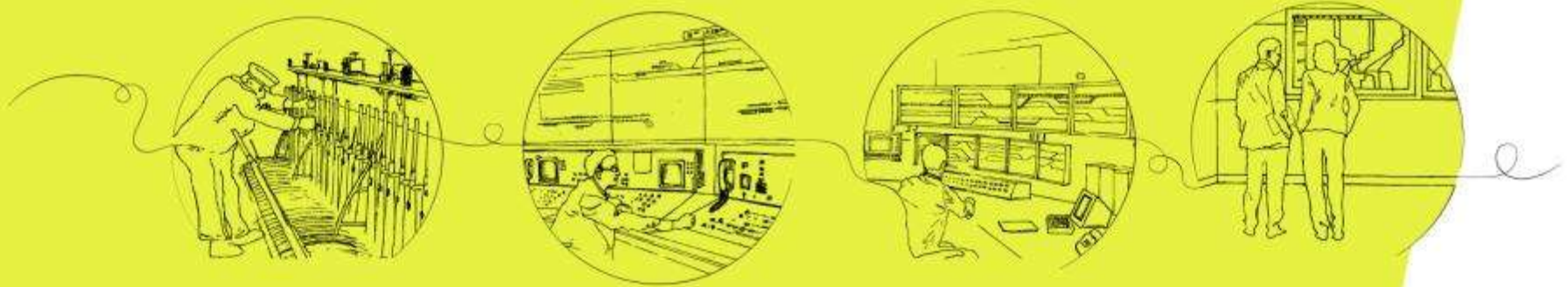
ETCS, at least in our experience, is still an evolving technology and if you want to go down that journey, then at this present moment in time you're going to find things that other people haven't yet found.

You need to be prepared and accept the fact that this is still a developing technology and its application, particularly when it's retrofitted to old railways, is still a significant challenge.

On a slightly different tack is the control system and management side. This is a key element of what the conference is focused on, and it is important we don't underestimate the kind of human impact of moving from an old and traditional way of working to a modern way of working.

This demands a more IT-literate generation of people rather than some of the people that we've already got in our organisation. The challenge of change management is probably greater than of any technical challenge. And we need to be very careful in terms of preparing for that change and not underestimate the time, effort and energy that will need to go into that.

International perspective – innovation within control systems



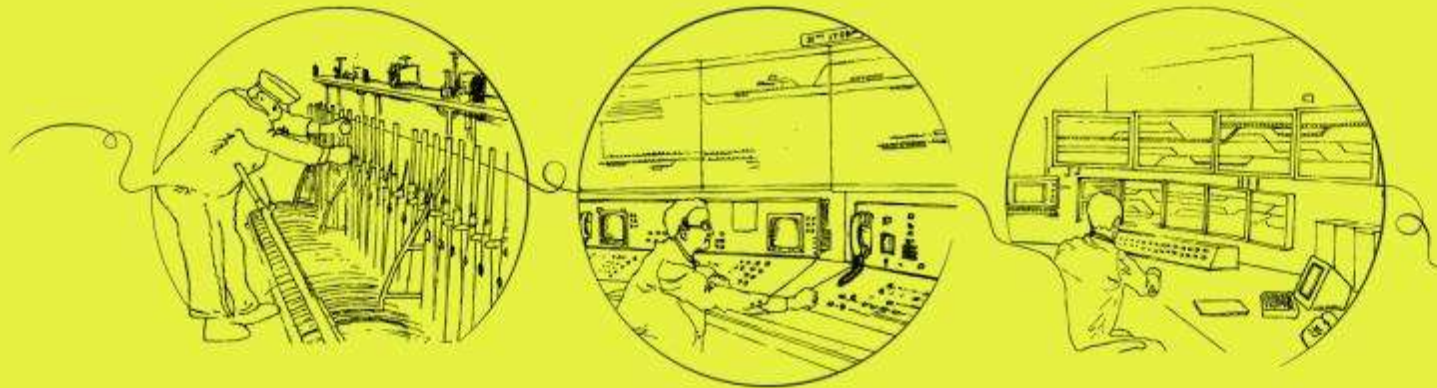
Steve Knight

Areas to cover



- 1. Introduction and context of Network Rail / Great Britain railways**
- 2. Challenges we are seeking to address**
- 3. Insights on control centres and systems**
- 4. Cambrian ETCS lessons learnt**
- 5. Thameslink ETCS / ATO**
- 6. Lessons learnt for Australia**

1 - *Introduction and context of Network Rail / Great Britain railways*



What is Network Rail?



We own and operate the GB rail infrastructure, including:

- 830 signal boxes
- 2,500 stations
- 8,200 commercial properties
- 6,500 level crossings
- 20,000 miles of track
- 40,000 bridges and tunnels
- Providing the infrastructure to enable 24,000 trains to run every day



What is Network Rail?



In the UK, Network Rail:

- is one of the largest private landowners
- is the biggest purchaser of electricity
- has the third largest telecoms network



The company has:

- 35,000 employees
- 5,000,000 neighbours



Our investment programme for 2009/14:

- is more than all 22 water companies combined; or
- is more than all electricity companies and National Grid combined

What does Network Rail do?



- We operate, maintain and renew the infrastructure
- We operate signals, set the timetable and measure how punctual trains are
- We organise access to the track for train and freight operators
- We are responsible for planning for the future of the railway in the short, medium and long-term
- We deliver projects to improve the railway for the people and companies that rely on it
- We offer a global consulting capability



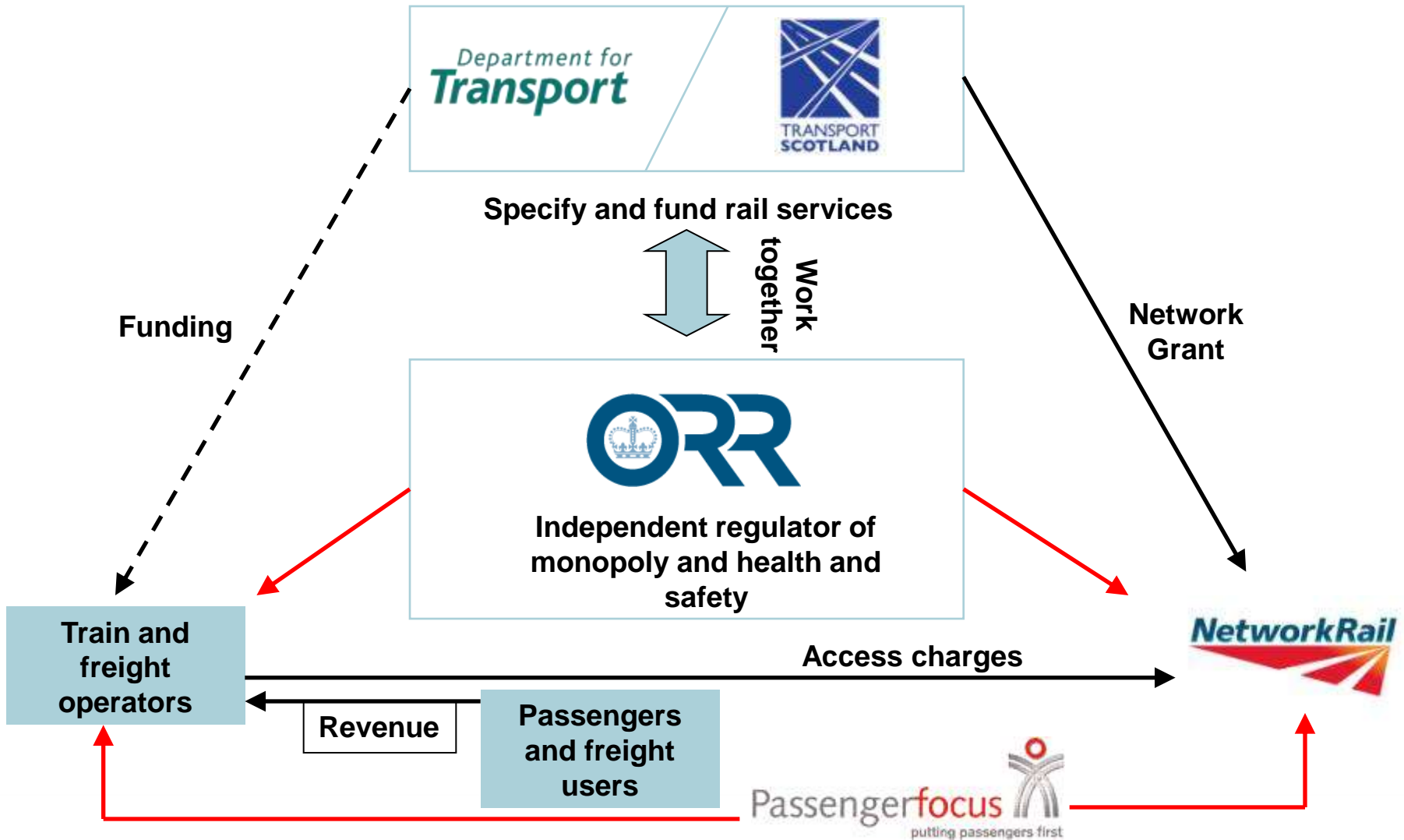
Our corporate structure



- As a company limited by guarantee, Network Rail Limited has members rather than shareholders
- Members have no financial interest in the company
- As a not for dividend company we reinvest any and all profits in the railway
- We do this by investing in the infrastructure or reducing debt



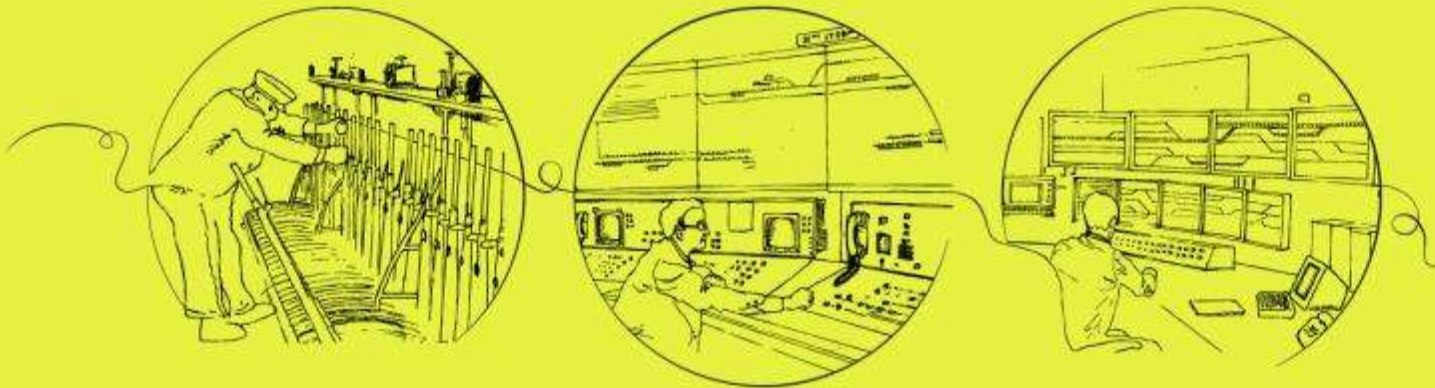
An overview of the industry



Background to me.....



2 - Challenges we are seeking to address



Challenges and our operating ambition



Today we carry almost 50% more passengers than ten years ago

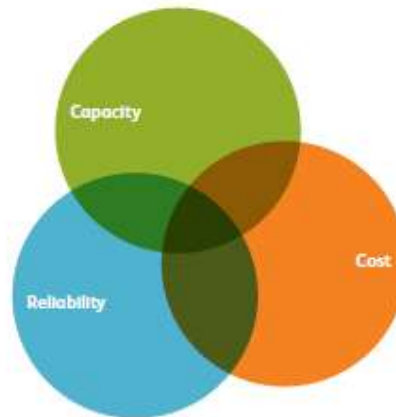


2002/03



2011/12

Competing priorities



400

Million more passenger journeys by 2020

By 2019, we will carry 30% more freight than today



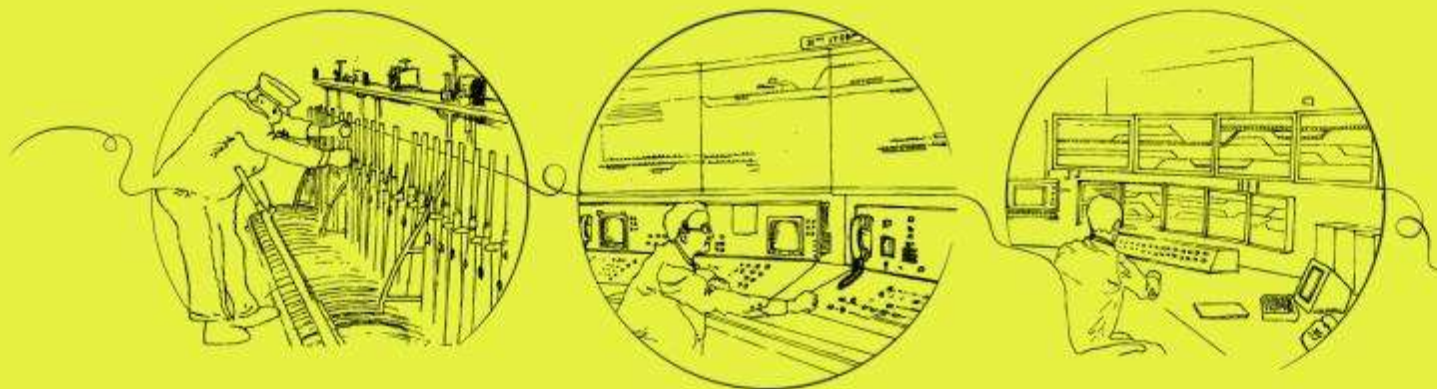
- We are committed to creating a modern, efficient railway for the future of Great Britain
- By modernising the way we manage train movements on the network, we aim to:
 - Create a **high performance railway** - among the best in the world
 - **Reduce delay** and **increase capacity** on an ever busier network
 - Make the railway **more affordable**

What is the Operating Strategy?



- **To move from >830 locations to 14 Rail Operating Centres (ROC's)**
- **Consolidate all elements of operational control (signalling, control, operators and electrical control) to the ROCs**
- **Deploy a Traffic Management solution to each ROC**
 - Highly automated to reduce repetitive tasks increasing productivity
 - Reduction and resolution of 'real-time' conflicts
 - Just in time planning
 - Reconfigurable control areas to manage disruptions
- **Future roles**
 - To work with stakeholders to develop the new roles required to support new ways of working
- **Accelerate renewal driven timescales to accelerate business benefits**

3 - Insights on control centres and systems



The current signalling estate provides varied working environments and signalling interfaces



Mechanical box



Brandon

Power Signal Box



London Bridge

Operating Centre



EMCC (Derby)

Built

19th Century

20th Century

21st Century

Approx Number

500+

200+

8 (with 6 more planned)

Interface/grade

Mechanical lever, typically lower grade

Panel, typically medium-upper grades

VDU, typically senior grades

Characteristics

Frequently single manned boxes located in rural areas.

Some single manned, many larger boxes. Staff engagement sometimes a challenge.

Modern ergonomically designed working environments. Generally high levels of staff engagement (although more work to do here).

In addition we have a separate control layer and electrical control rooms

We are developing 14 Rail Operating Centres (ROCs)



Centres built

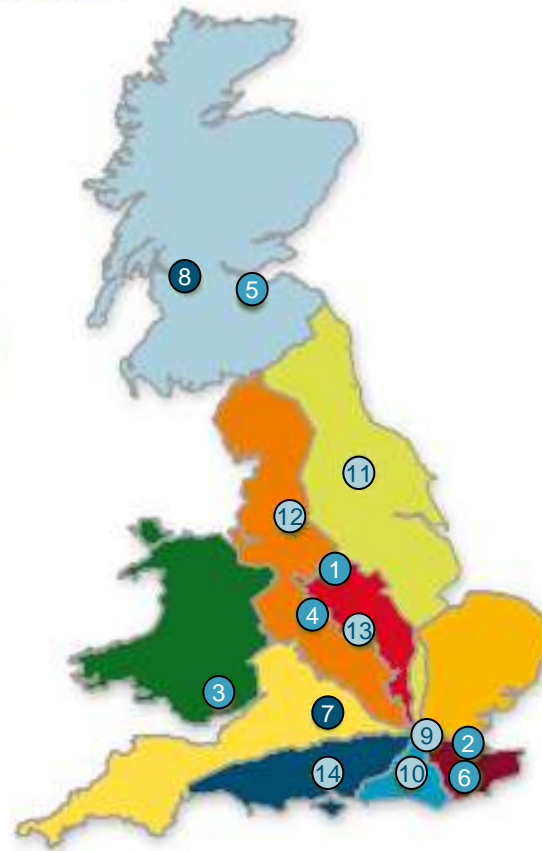
- 1 - Derby
- 2 - Gillingham
- 3 - Cardiff
- 4 - Saltley
- 5 - Edinburgh
- 6 - Ashford

Existing buildings undergoing investment

- 7 - Didcot
- 8 - Glasgow

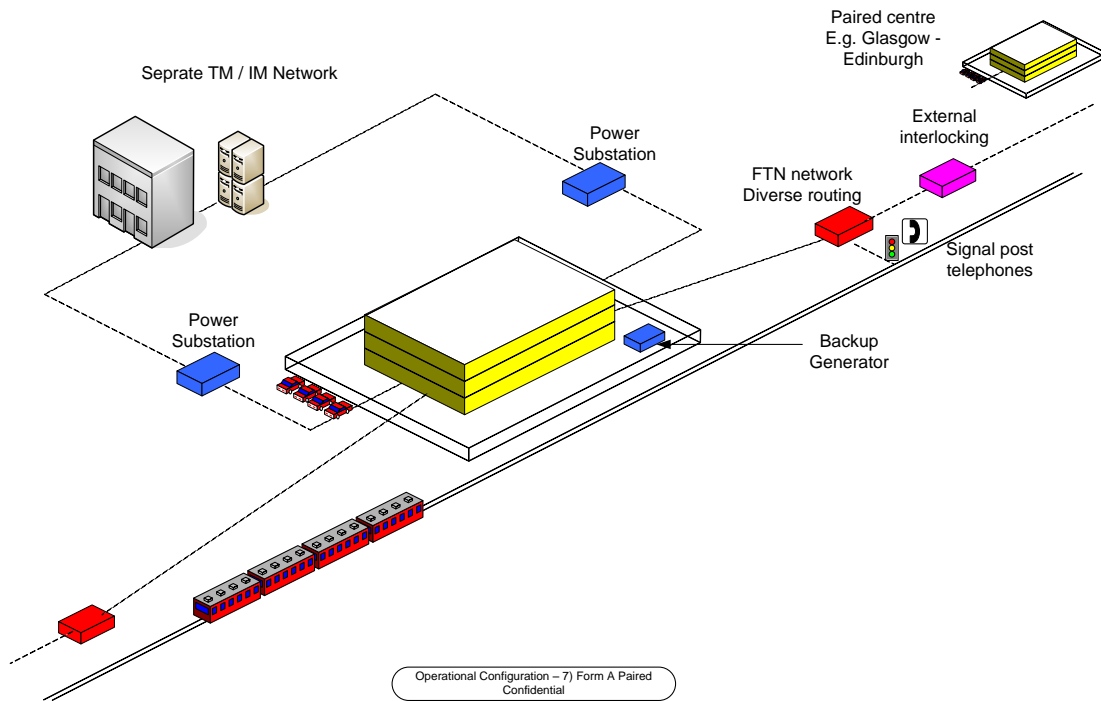
New buildings being built

- 9 - Romford
- 10 - Three Bridges
- 11 - York
- 12 - Manchester
- 13 - Rugby
- 14 - Basingstoke



The ROC working environment is comparable to world leading facilities

System resilience within of the buildings have had careful consideration



Form A Building - Paired

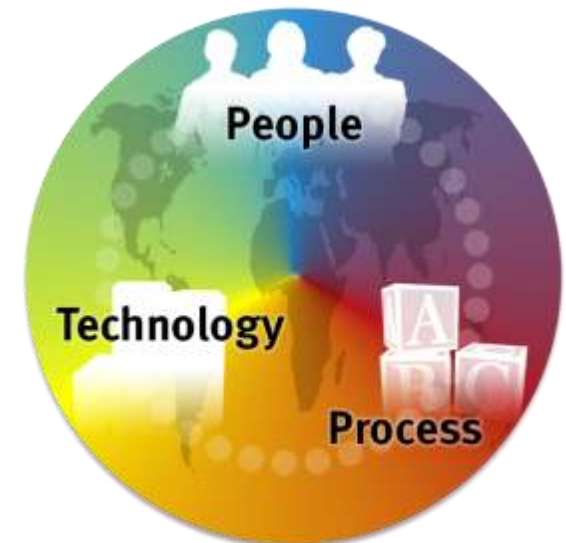
- 20m standoff
- 24/7/365 security
- External interlocking
- Government Security Clearance
- Two Power Supplies
- IT – Redundant Workstations + Server
- Two FTN connections
- National Systems Fully Redundant
- Paired centre – Fast recovery
- Number of staff low – Better IR mitigation
- Separate TM/IM network

Allowing business continuity with reduced locations has been a key factor

We are also developing traffic management to transform the way in which we operate the railway



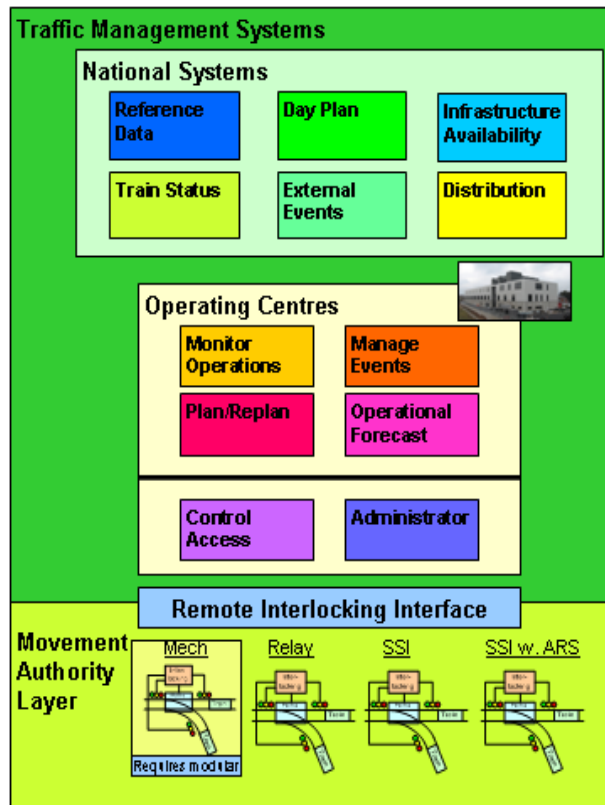
- Traffic Management (TM) combines proven software, recognised processes from across the world and will introduce a number of new operational roles
- Traffic Management will include:
 - **A single operational information system, providing real-time information to passenger and freight customers particularly during times of disruption**
 - **Decision support tools and real-time planning/prediction & resolution of conflicts**
 - **Reconfigurable control areas to handle disruption**
- TM will be highly automated largely running itself
- It will optimise the use of the existing infrastructure and enable more capacity without impacting performance
- TM technology and roles will be prototyped in new locations



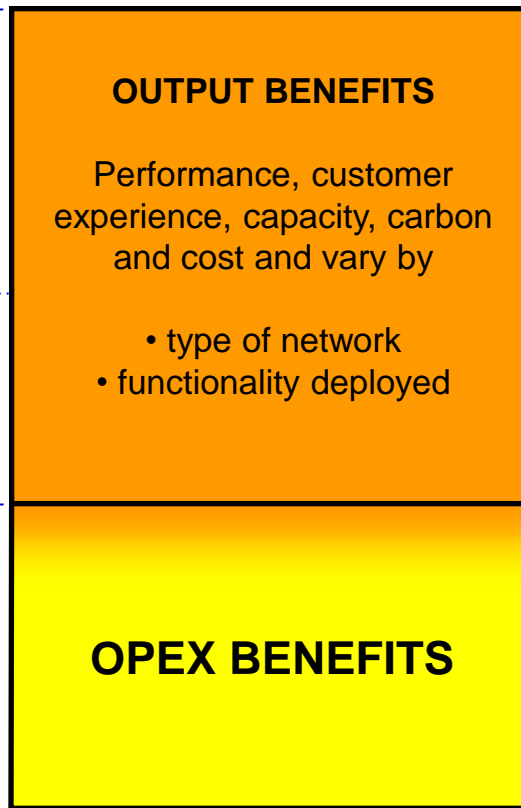
The traffic management control system will be deployed in each ROC and will enable output and opex benefits



System View



Benefit Areas



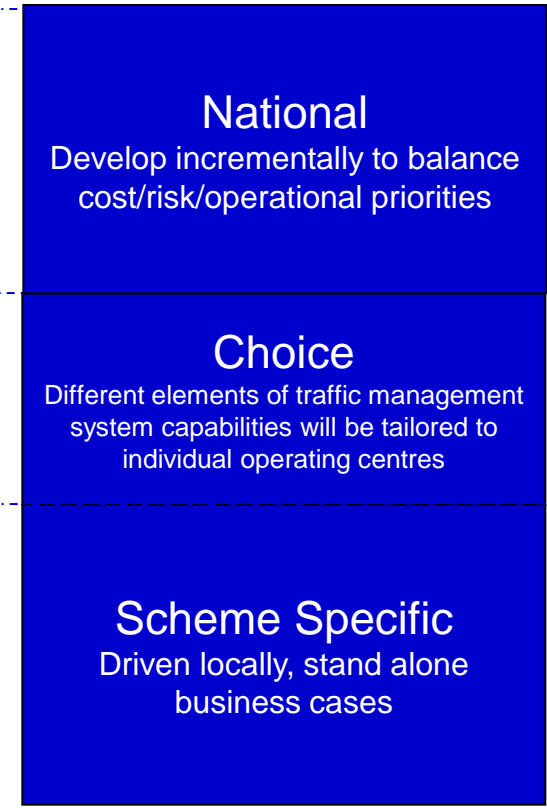
OUTPUT BENEFITS

Performance, customer experience, capacity, carbon and cost and vary by

- type of network
- functionality deployed

OPEX BENEFITS

Deployment choices



National

Develop incrementally to balance cost/risk/operational priorities

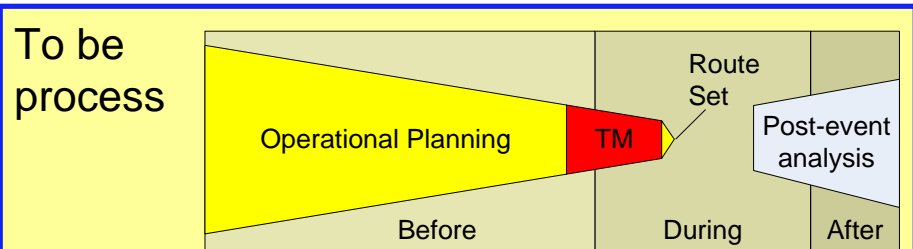
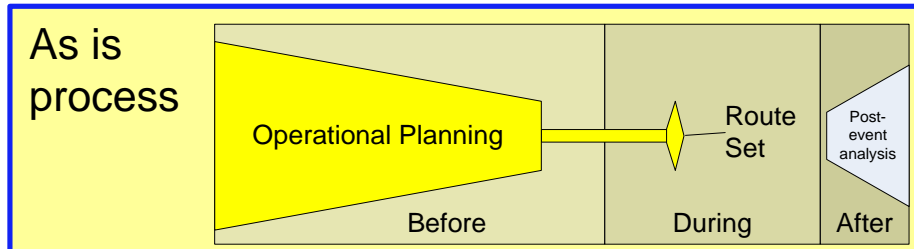
Choice

Different elements of traffic management system capabilities will be tailored to individual operating centres

Scheme Specific

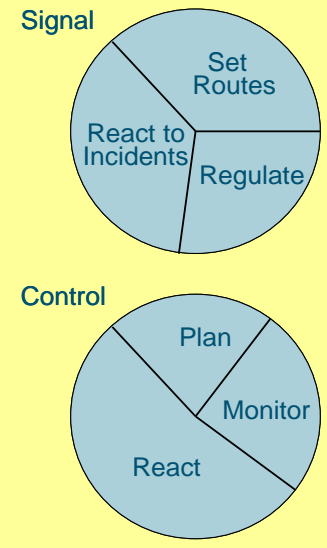
Driven locally, stand alone business cases

TM will allow us to more proactively manage the network and deal with the challenges



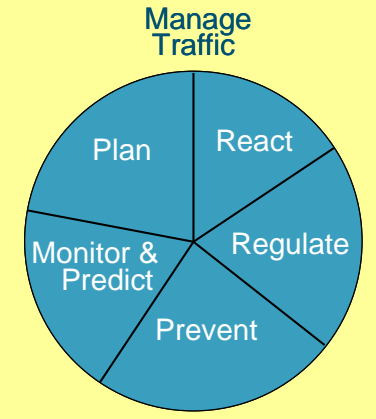
Current management systems

- National Systems
- Control Centres (x 14)
 - Monitor Operations
 - Manage Events
 - Replan
- Signalling control (>830)
 - Mechanical layers
 - VDU (w/ ARS)
 - NX panels
 - VDU with ARS (RECC)
- Bespoke Interlocking Interface
- Movement Authority Layer
 - Mech
 - Relay
 - SSI
 - SSI w/ ARS



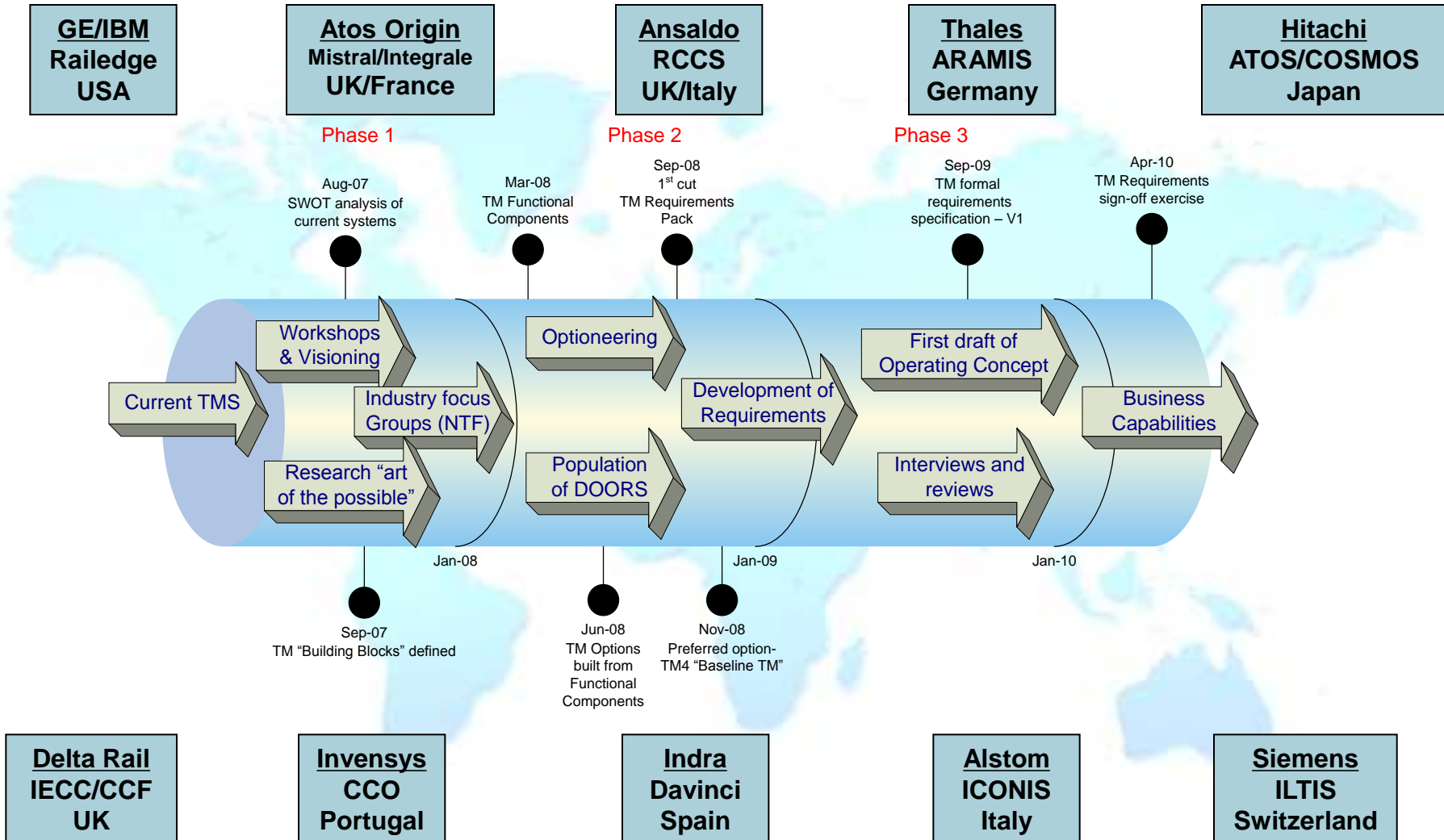
Traffic Management Systems

- National Systems
 - Business Data
 - Day Plan
 - Infrastructure Availability
 - Train Status
 - External Events
 - Distribution
- Operating Centres
 - Monitor Operations
 - Manage Events
 - Plan/Replan
 - Operational Forecast
 - Control Access
 - Administrator
- Remote Interlocking Interface
- Movement Authority Layer
 - Mech
 - Relay
 - SSI
 - SSI w/ ARS
- Trains & Drivers

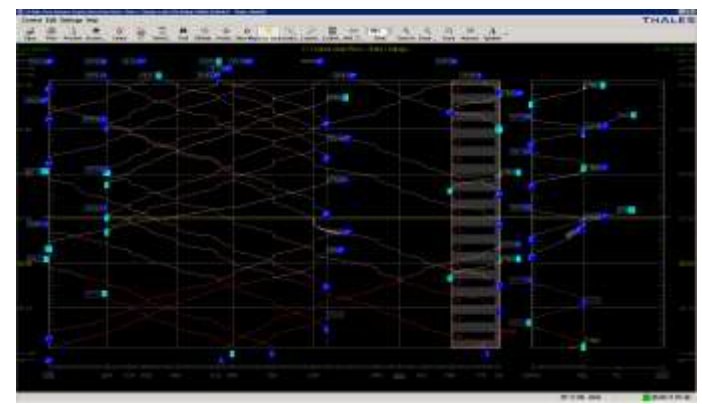
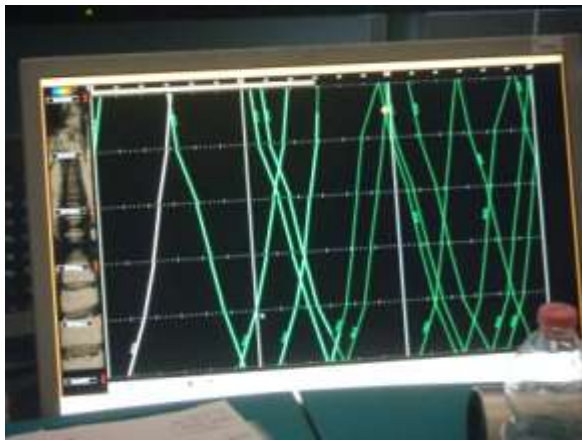


Traffic Management is projected to significantly improve our ability to manage the service when things go wrong

The early development of traffic management & example locations from around the world



Some samples of traffic management in action



We will introduce new roles to enable us to deliver the following high level objectives

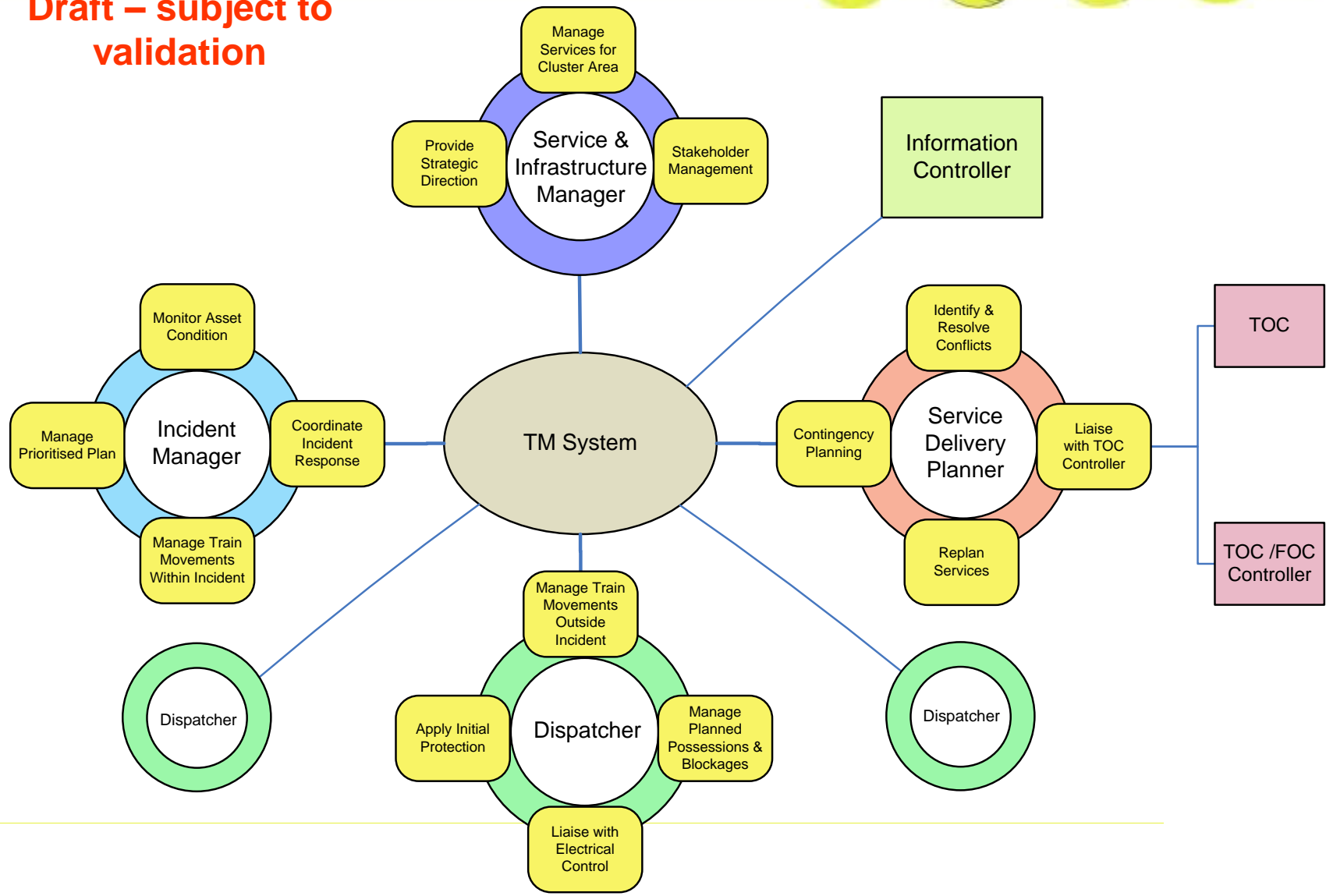


- True integration of signalling and control
- The opportunity to provide true management of incidents
- One role responsible for performance through ownership of the service plan
- The ability to separate safety from performance
- Reduction in communications
- All roles operate from the same suite of tools

Proposed traffic management roles



Draft – subject to validation



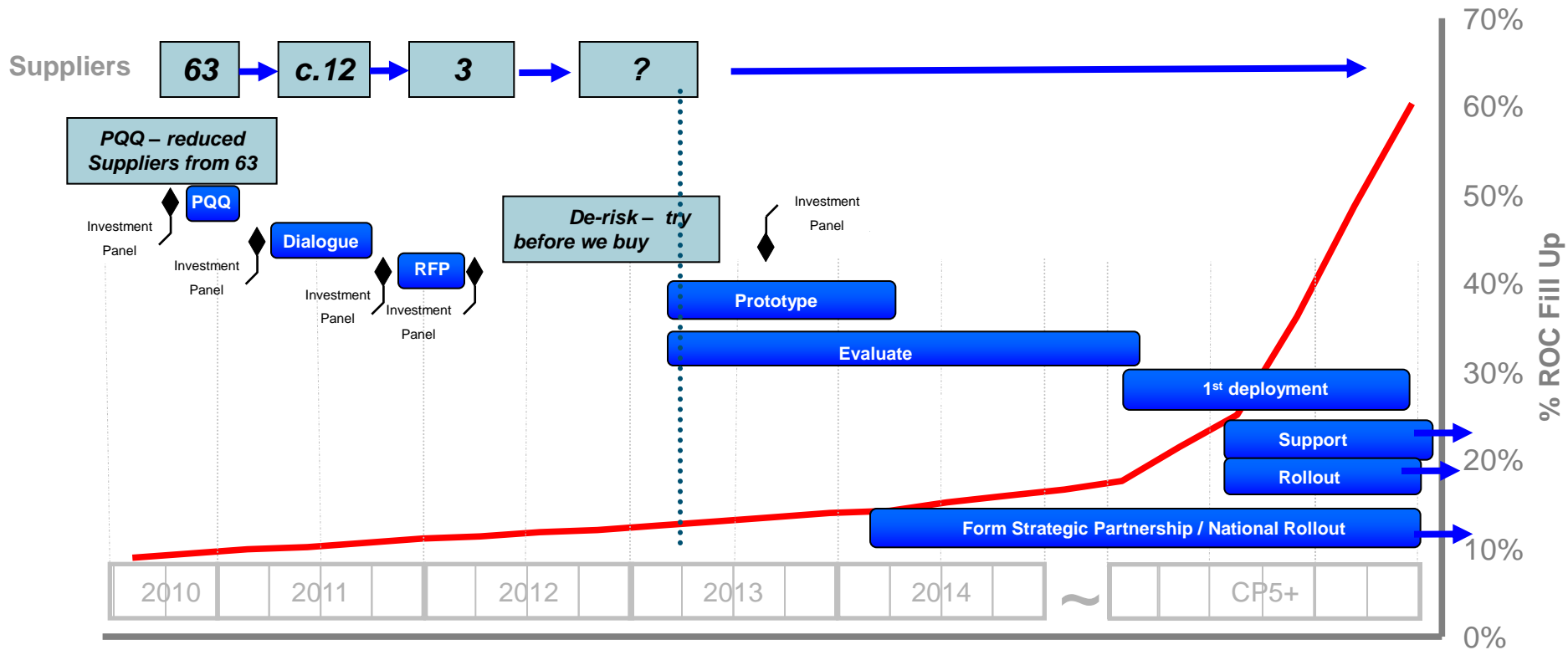
Other supporting roles



Draft – subject to validation

- **Level Crossing (LX) Controller** – This role will manage the safe operation of all level crossings
- **TOC Controller/TOC Interface Controller** – there is still debates about integration / seperation of the current TOC roles
- **ROC Manager** – Manages the activities of all roles within the ROC
- **Maintenance Technician** – Maintains the TM hardware / software and carries out fault finding
- **Configuration Manager** – Responsible for data changes within the TM system and testing those changes
- **Remote Condition Monitoring Technician** – Responsible for monitoring the reliability of infrastructure equipment
- **Trainer** – Manages the competence, assessment and training of the operator roles

High level timeframes for developing, procuring & implementing TM and future roles



We are working collaboratively with our 3 suppliers (Hitachi, Thales & SSL) to achieve this

Key areas of focus going forward on control centres and systems



- Finish the construction of the remaining ROCs
- Complete the prototype phase of traffic management technology, process and roles
- Develop our transitional plans to new technology and new ways of working
- Fill up the ROCs with all elements of operational control; this is not dependent on the signalling technology deployed (conventional or ETCS)

4 - *Cambrian ETCS lessons learnt*

Background to ETCS in Great Britain



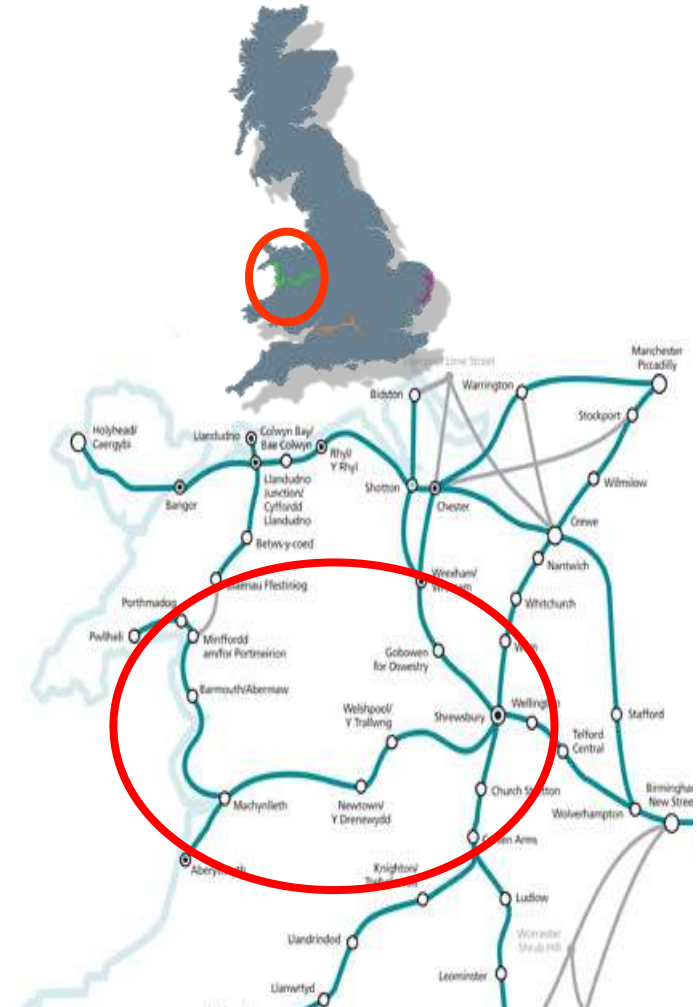
- UK Government & industry has committed to the implementation of ETCS
- Development of the UK application:
 - will present a range of technical, operational and cultural challenges
 - will require a co-ordinated cross industry approach
- Cambrian Lines identified as preferred route for first implementation :
 - Provides a learning environment
 - de-risks subsequent application of ERTMS
- A period of migration is required to make ERTMS the “Day Job” delivering:
 - a full operational rules set
 - confidence and reliability growth
 - market and product development
 - cost assessment
 - engineering and operational skills capability
 - ETCS readiness on key routes and rolling stock

Cambrian Pilot Route

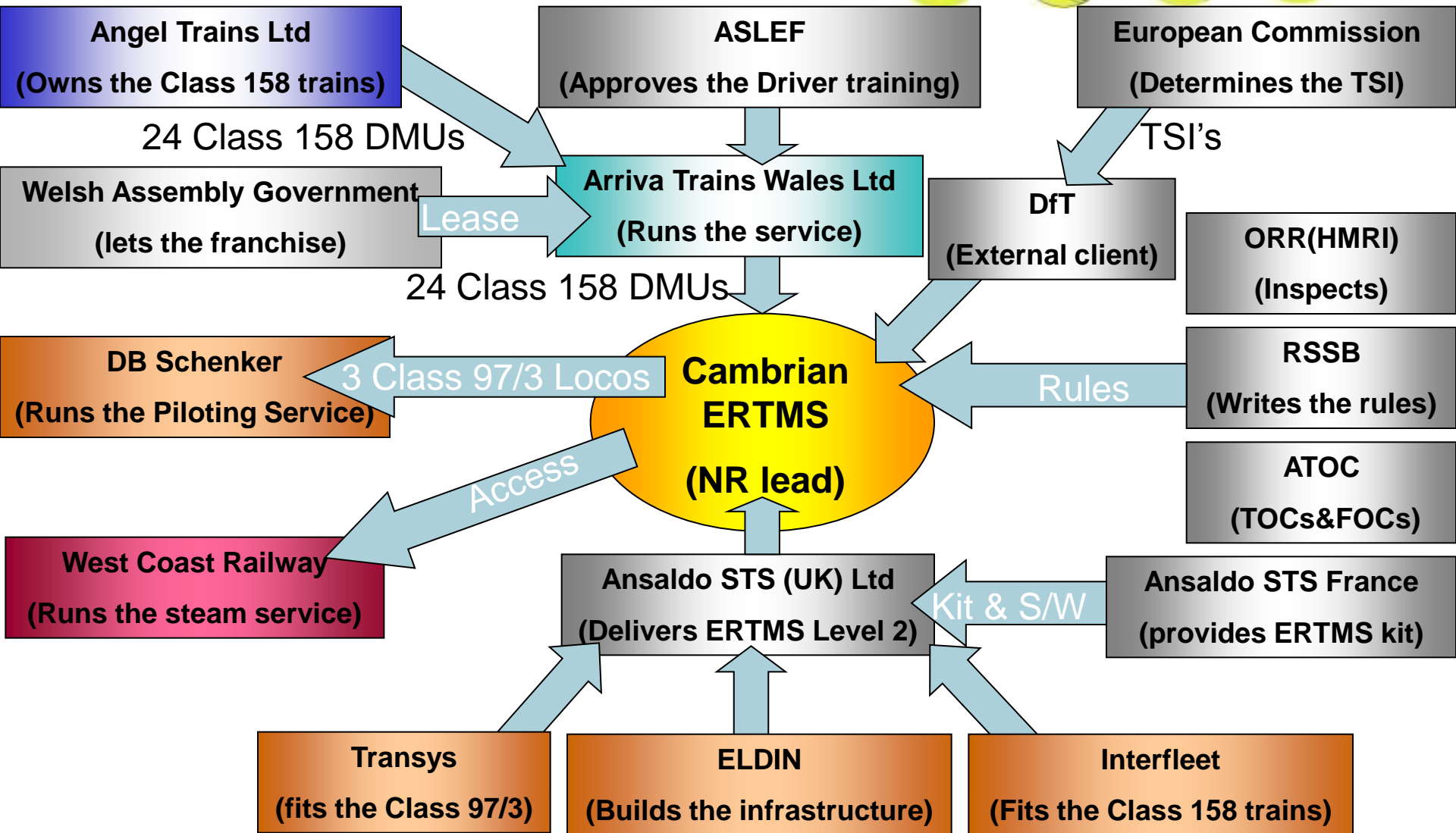


Project scope

- UK's pilot site for ERTMS Level 2:
 - Shrewsbury-Aberystwyth ('Cambrian main line' - TEN), and
 - Machynlleth-Pwllheli ('Cambrian Coast')
- ERTMS Level 2 (no line-side signals)
- 215 km of track
- 24 DMUs for passenger service
- 3 locos to pilot unfitted trains
- New control centre (Machynlleth)
- New axle counters & interlocking
- 2 Terminal stations
- Transition from semaphore to L2
- Depot for Class 97/3
- Single line: Replacing RETB + hydro-pneumatic points



Background – Organisational interfaces



Contracts & Procurement Strategy



- Procurement action established through:
 - OJEU Expressions of interest Mid 2005
 - Open tendering & BAFO Stage 1 Aug - Nov 2005
 - Contact Award Stage 1 - Ansaldo(UK) Dec 2006
 - STA negotiated tender for Stage 2&3 Sep – Nov 2007
 - Draft Contract placed Nov 2007
- Fleet Fit Agreement (FFA) with ATW complete 13 July 2009
 - *including side letter to Angel Trains Ltd*
 - *WAG & DfT required review and agreement*
- Finalisation of contract 11 Dec 2009
- Piloting service placed with Serco 3 Aug 2007

Key Milestones



- Project gained full financial authority from Network Rail – 8th August 2008
- First of Class 158 fitted June to September 2008
- Line-side Infrastructure (ex commissioning) completed April 2009
- Level crossing works (ex commissioning) completed May 2009
- Class 158 Fleet Fitment started June 2009
- ERTMS fitted to 3 Class 97 Locos July 2009
- Class 97/3 Dynamic testing July 09
- Level 2 ERTMS Rehearsal Pwllheli to Harlech February 2010
- Level 2 Passenger Service introduced Pwllheli to Harlech October 24 2010 under ROGS
- Full Service commissioned March 28 2011 under Railway Interoperability Regulations

What has been Achieved - Overall



- System Fully Commissioned under Railway Interoperability Regulations
 - ERTMS System 2 (No lineside signals)
 - SRS 2.3.0 plus
 - Normal passenger service provided through Arriva Trains Wales Class 158 fleet
 - Shrewsbury to Machynlleth, Aberystwyth and Pwllheli
 - A number of notable successes:
 - Implementation of terminal stations under ERTMS Level 2
 - Transition from traditional semaphore to ERTMS Level 2 (Sutton Bridge)
 - Passenger station operational under ERTMS Level 2
 - CCTV Level crossings operational under ERTMS Level 2
 - UK firsts include:
 - Operation of axle counters over FTN
 - Train control over GSM-R
 - ERTMS commissioned and in use on a passenger railway

What has been Achieved - Trains



• Class 158:

- 24 units fitted with ERTMS equipment
- Operational in Level 0 from Holyhead to Cardiff via Birmingham New St and Chester
- Operational in Level 2 from Shrewsbury to Aberystwyth and Pwllheli via Machynlleth
- Completed Technical file submitted & signed off by ORR



Arrival of first ERTMS fitted CI 158 at Machynlleth

• Class 97/3:

- Operational in Level 0 off Cambrian and Level 2 on Cambrian Route
- Completed Technical file submitted & signed off by ORR
- Carrying out piloting operations on Cambrian Route for:
 - Charter passenger services
 - Tampers, Rail Grinders, Auto-Ballaster, Rail weld vehicles
 - Track inspection coach, Radio survey train



Class 97 setting off for slip/slide tests (Machynlleth)



ERTMS fitted Class 97 at Shrewsbury

What has been achieved – Infrastructure



Trackside Infrastructure - Overview

- 116 axle counters installed and fully operational via FTN
- 3 MCB CCTV Level crossings commissioned as part of scheme
- 460 Euro-balises fitted
- 13 REBs installed and commissioned
- 18 sets (22 point ends) of train operated points converted to power operated and integrated with ERTMS
- 76 km of cabling laid and terminated
- 10 Ground Frames converted and fitted with detection
- 15 lineside telephones installed
- New loops at Welshpool, Talerddig and Dovey Junction commissioned



What has been achieved - Infrastructure



- **Signalling Control Centre**

- Fully operational East and West Desks
- Box Technician desk operational and in use
- Equipment room fully functional
- Power supplies (inc. UPS and standby generator) commissioned.

- **Coleham Depot**

- Coleham depot complete and in operation
- Handed over to DBS



Signaller West Desk

Box Technicians desk



Coleham Depot



What have we learned



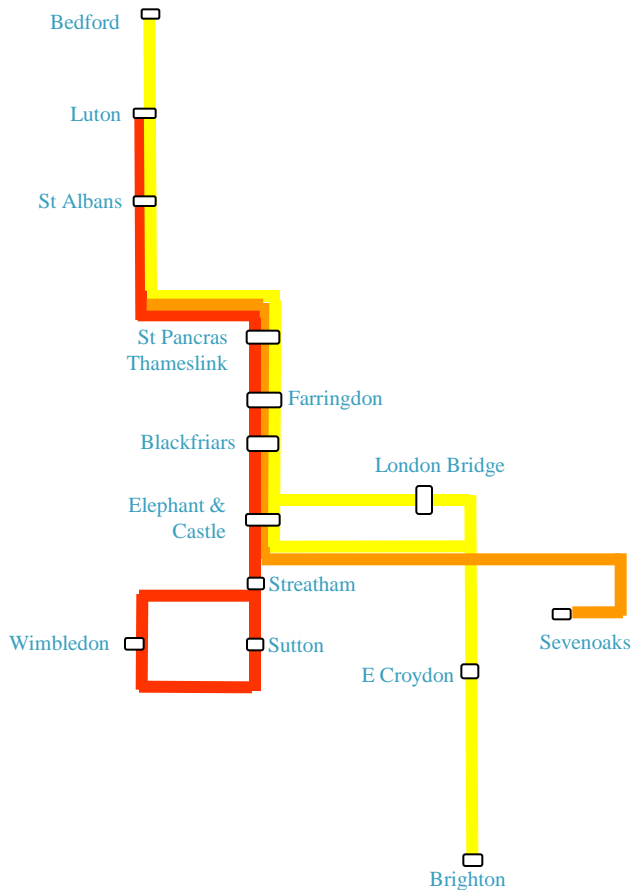
- Most European Countries have implemented ETCS on new, high speed lines and or have a test site to ease introduction and learning
- ETCS level 2 can and does work in the UK on a mixed railway
- Retro-fitting old trains adds significant complications
- The system operation and reliability in Level 0 is as important as Level 2 (the Class 158 trains spend most of their time in Level 0)
- Cambrian was a simple railway, but it has had to break many areas of new ground to operate ETCS
- Reliability was an issue, but has significantly improved
- Network Rail has caught up and in some areas is potentially at the forefront of ERTMS understanding in Europe
- Industry complexity affects the capability to roll out

5 - Thameslink ETCS / ATO

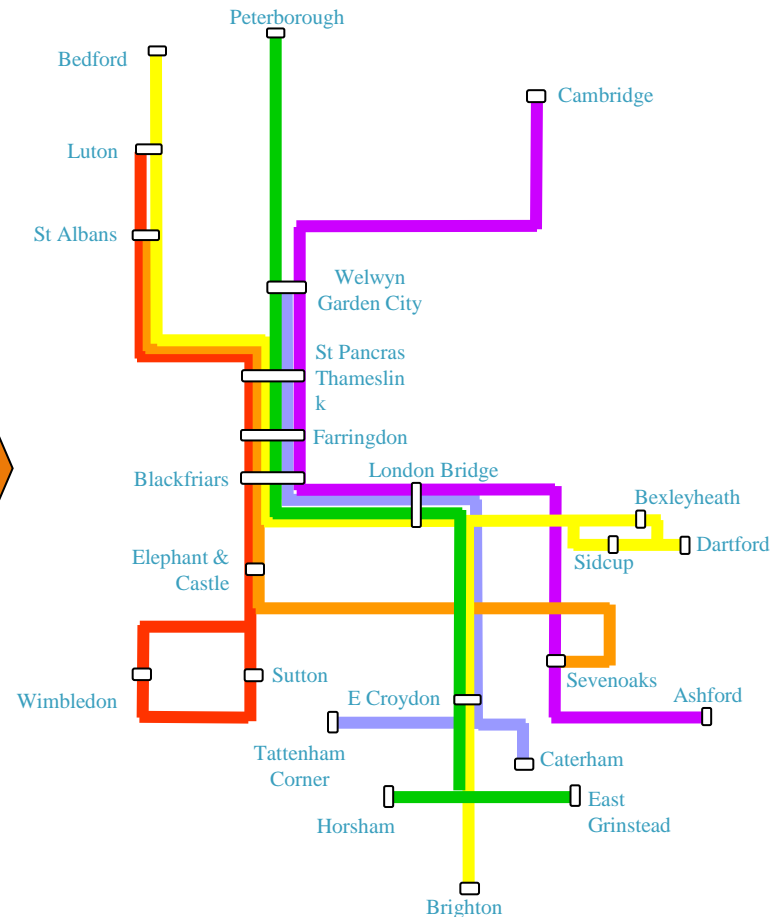
Thameslink seeks to significantly increase the capacity of the London network



Current service pattern



Service pattern post 2018



Solving the Capacity Challenge



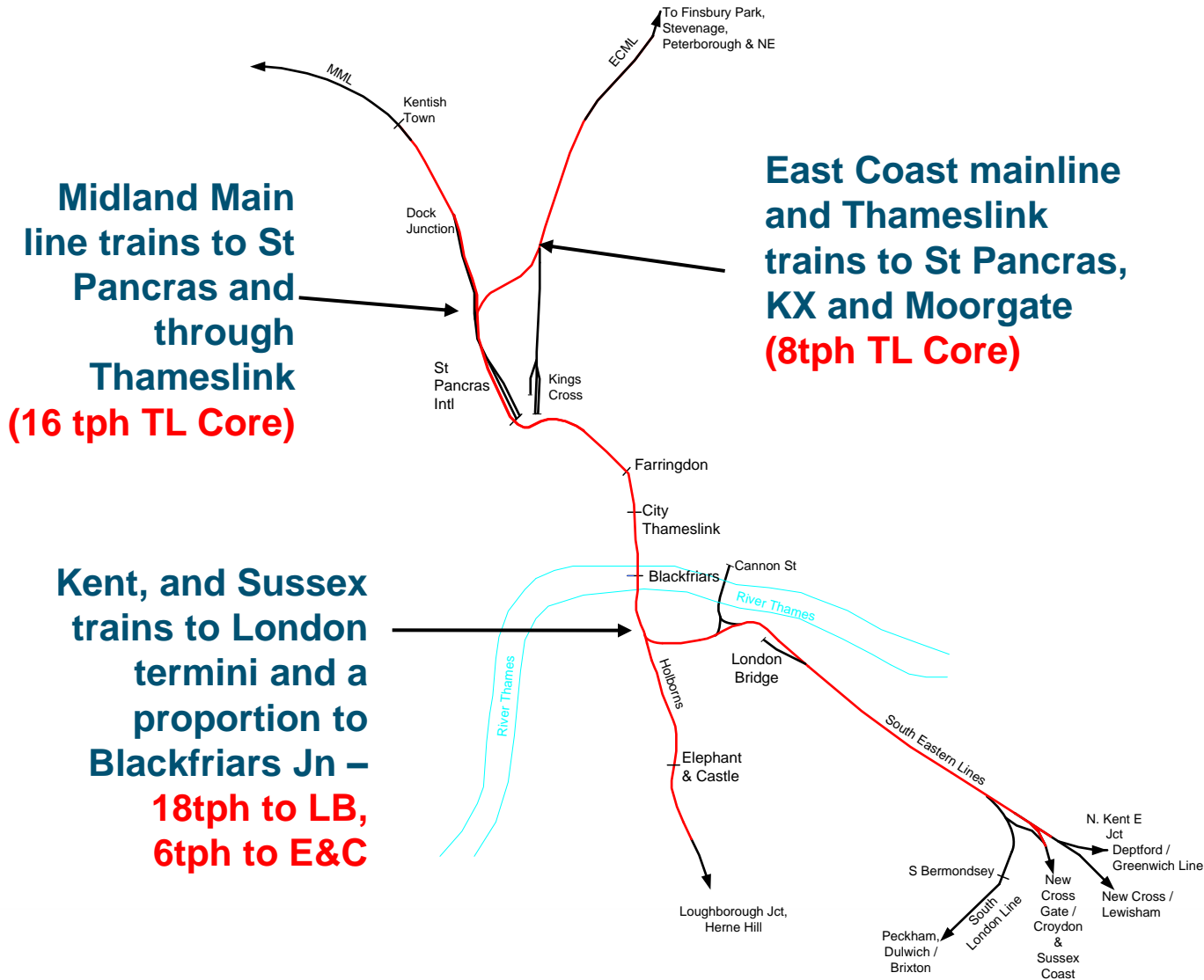
More train paths for longer trains North / South through London

- 13 tph 8 car trains in peak at start of project
- Key output 1 - 16 tph 8 & 12 car trains (delivered)
- Key output 2 - 24 tph 12 car trains
- Approx 250% increase in peak capacity

New Routes

- Link ECML to St Pancras International to take suburban trains away from Kings Cross

2018 24tph infrastructure

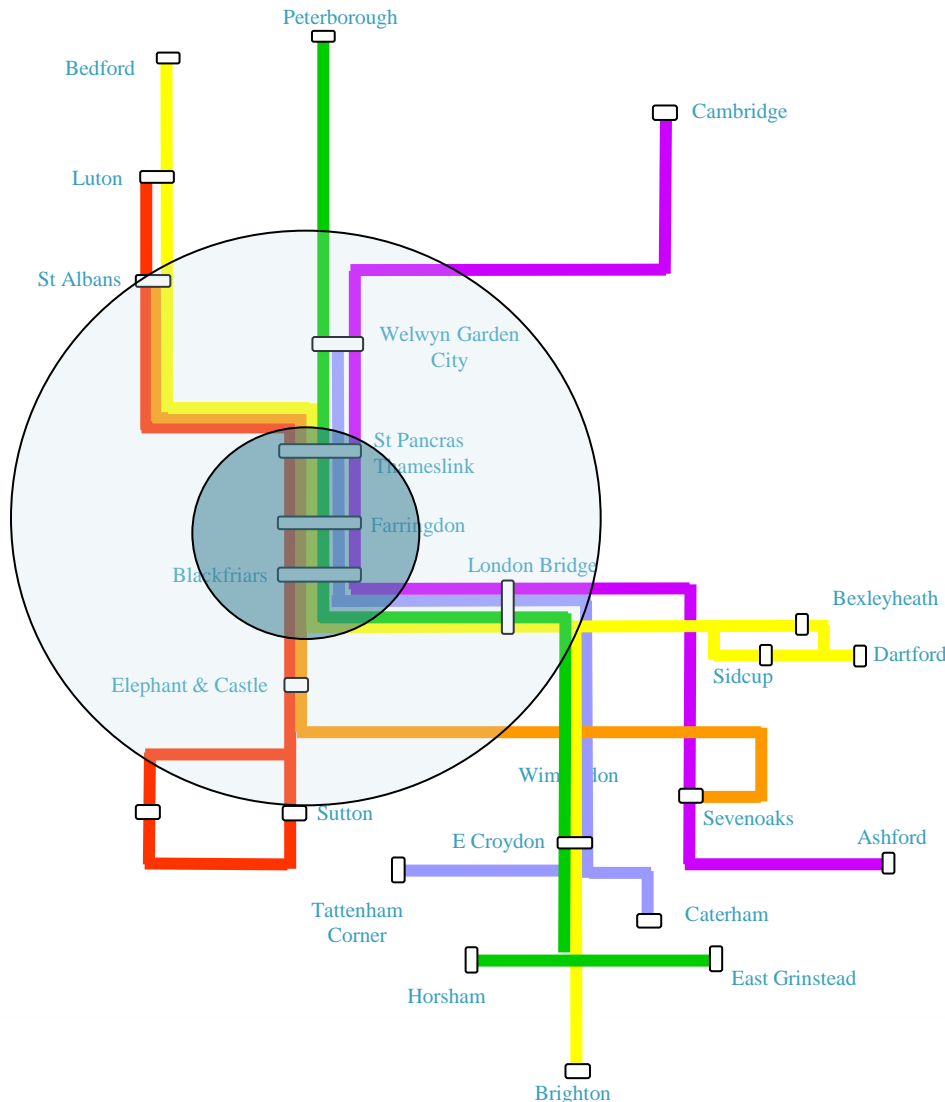


Cornerstones to Achieving 24 tph



- Cross industry ops & control strategy
- Integrated control & communications
- Timetable
- Dwell time management
- ATO over ETCS
- Systems engineering & integration
- Incremental implementation

Integrated Control and Communications



- It is a 60 mile network into a 2min 30 headways through the core
- The project investment is in the core
- The operating challenge is across the 60 mile network
- Approximately 35% of GBs trains will be impacted by the Thameslink 2018 service
- Currently Thameslink covers 6 signalboxes, 4 controls; we are consolidating into one of our ROCs (Three Bridges)

Our work on the timetable has shown challenges above 20 tph



20 tph

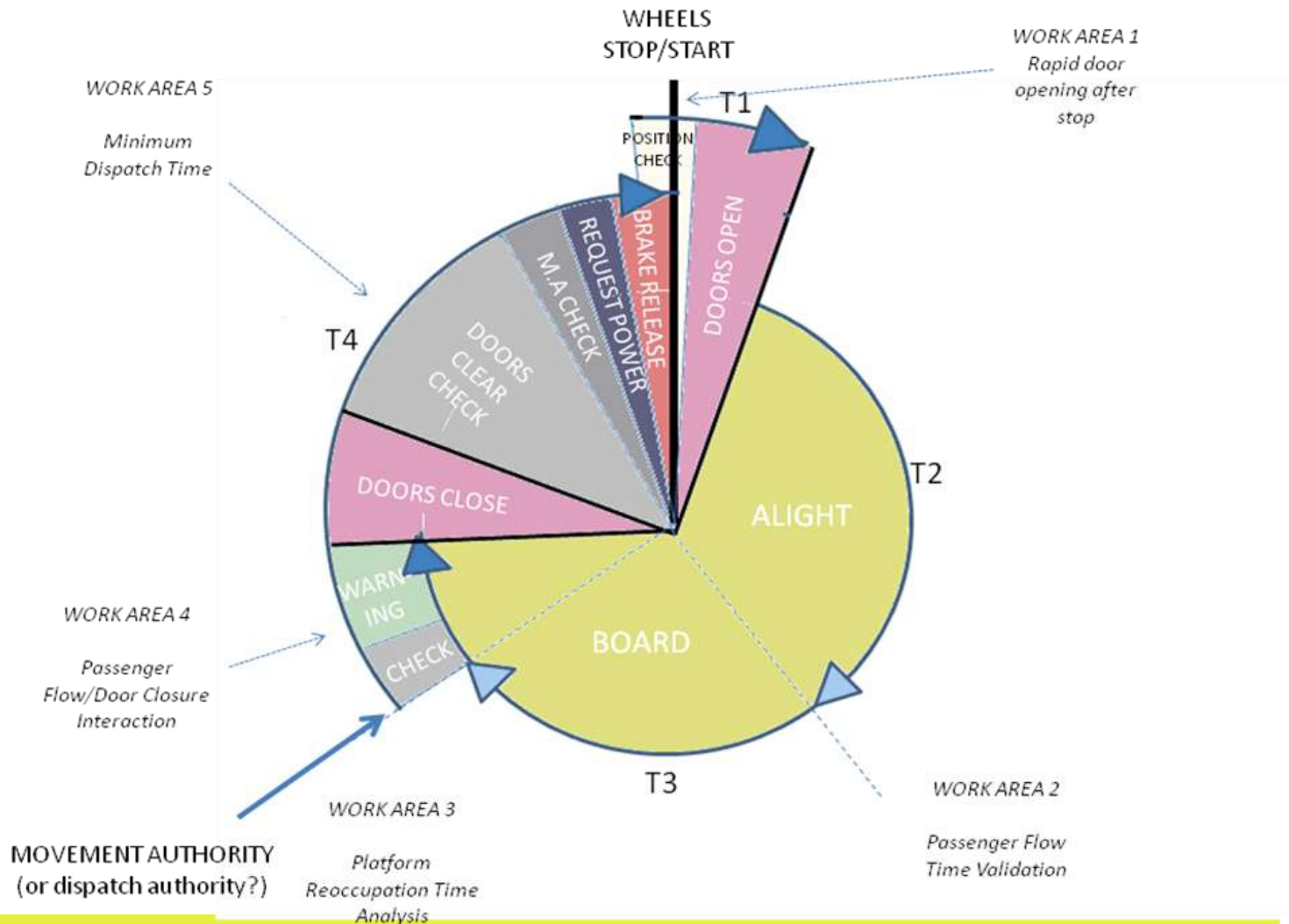
Modelling demonstrates that conventional signalling systems (with ARS) will achieve this if all goes to plan

24 tph

Modelling has shown that ATO will deliver a robust 24 tph (30 tph recovery) by:

- More consistent train performance – in the same circumstances, ATO will drive each train in an identical fashion
- ATO maximises use of the available safe speed profile
- ATO will stop accurately at stations
- ATO will help reduce dwell time in Core Area stations by automatically opening doors

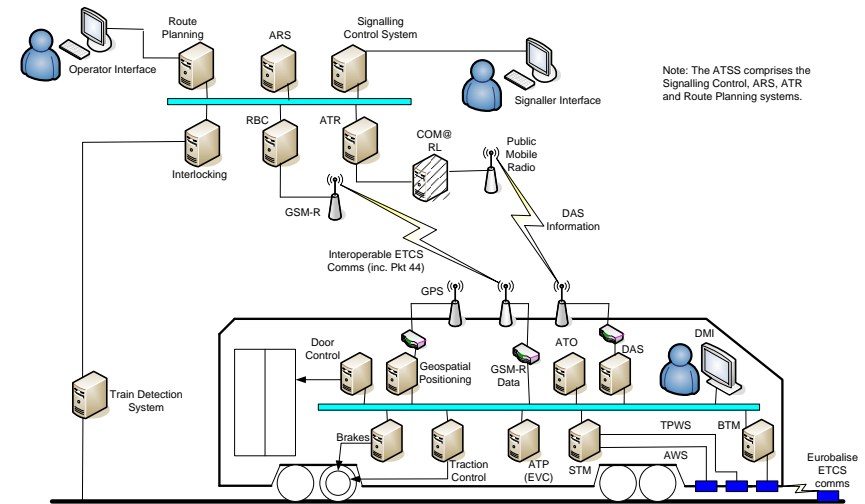
Dwell Time Management / Platform Management – the 45/60 second challenge.



ATO Concept – ETCS ATP Platform



- ATO on ETCS exists on high speed networks but Thameslink will be the first deployment in a metro style environment
- New trains are being procured for the Thameslink route so we will avoid retrofitment
- Simulation, laboratory testing and a test facility have been built to prototype and prove the technology and interfaces prior to deploying on the Thameslink route



Systems engineering and integration



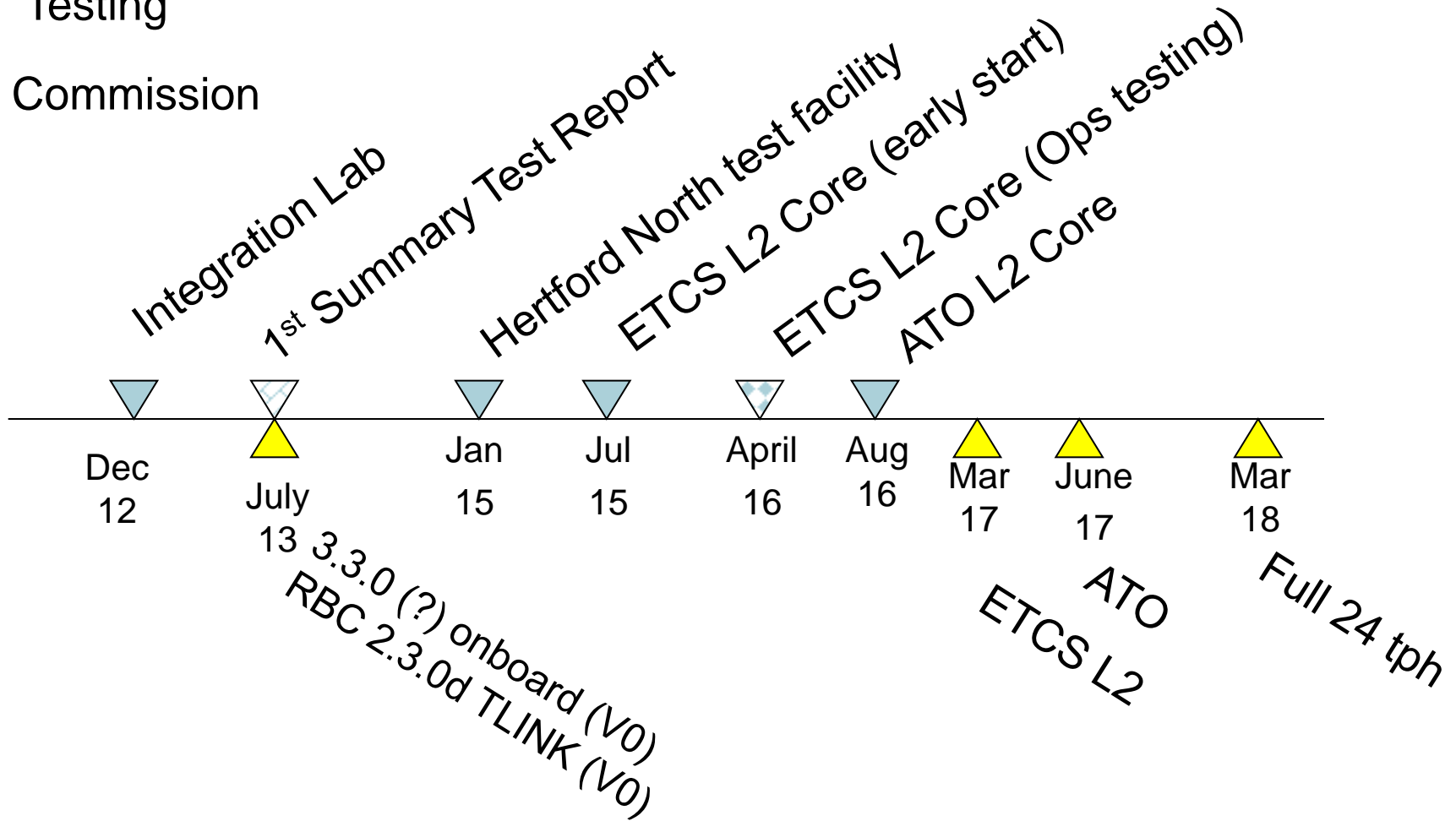
- Concept Simulator
 - Desktop simulation, ‘generic’ subset 26 (2.3.0d).
- Integration Laboratory
 - ‘Real’ RBC, OBU, IXL, simulated trackside
- Hertford Integration facility
 - Complete system, simplified infrastructure
- Thameslink
 - Complete system, ‘actual’ infrastructure.

System Testing Timeline



▼ Testing

▲ Commission

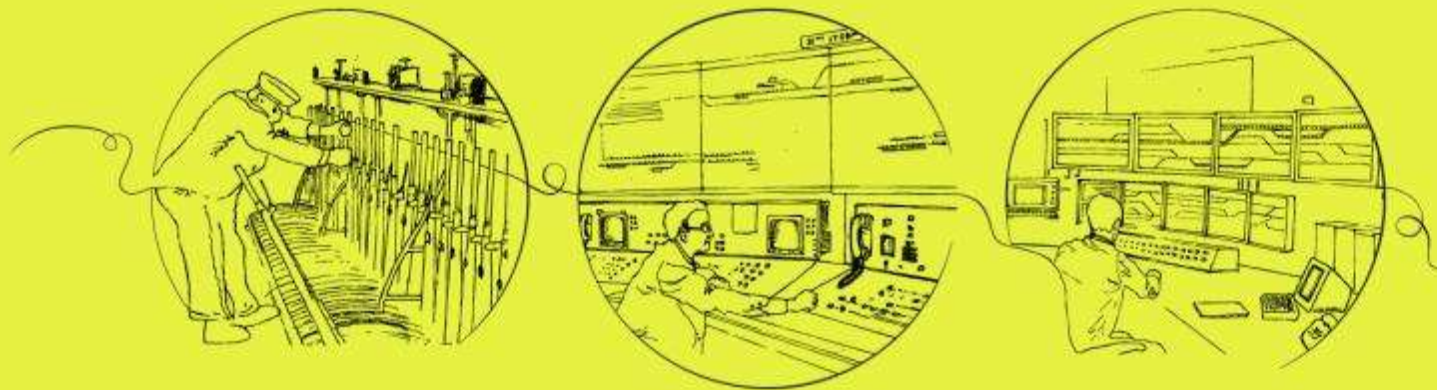


Incremental implementation



- Passive provision of intermediate blocks in KO1 ✓
- Development of Operational Rules using simulation ✓
- Core Route modelled by NR and Suppliers ✓
- System Integration using Static laboratory
- Proving of train and infrastructure systems integration at HNIF
- Testing of ETCS and ATO in Core using Bi-Di signalling
- Commission ETCS throughout route
- Transfer control to TM at Three Bridges
- Timetable proving and full ATO trial operations

6 - *Lessons learnt for Australia*



Lessons learnt for Australia (or anywhere!)



- 1. Be clear on your business challenges and vision – technology should enable them not lead their creation**
- 2. Technology requires development, testing and validation of readiness prior to deployment in your environment**
- 3. There will be resistance, obstacles and setback to the change**
- 4. Stakeholder management challenges are at least equal to any technical challenge**
- 5. It will take longer and cost more than you first thought**