Routes to Market Report

26 - Satellite Technologies for Rail Traffic Management

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CATAPULT
Satellite Applications

Contents

1. Introduction and Scope

Rail traffic management can include a variety of activities. For the purposes of this report the definition includes:

- Rail traffic planning (freight, passenger, maintenance)
- Operation system management
- Operation information for passengers
- Operation information for staff and contractors
- Maintenance support – including track maintenance, preventative maintenance due land movements, weather
- Driver only and driverless operations

A key requirement is the safety and integrity of the rail network. Any systems affecting monitoring or supporting the safety critical aspects require to be robust and accurate.

This report considers the opportunities for a variety of space related services including earth observation, global navigation, satellite systems and satellite communications. Consideration is given to additional space infrastructure requirements to increase the robustness and accuracy of any service. For example, the potential for delay time in signals passing to and from geo-stationary satellites, and 'line of site' issues for satellite communications.

The report will focus on the UK in the first instance, but also considers existing and future opportunities in Europe, Australia, North America and the developing networks in Africa.

Key stakeholders are identified and their supply chains. Barriers are highlighted as well as market dynamics that exist.

The report does not consider defence or national security issues. However, cyber security is a major issue for both infrastructure and user, and has been considered in this report.

2. Market Overview and Opportunities

2.1. UK Rail Market

UK Passenger numbers have doubled in the past 20 years. Despite planned improvements, demand growth is predicted to outstrip supply growth by 2020. Signal maintenance alone costs some £800m/year. Modernisation can bring new challenges – e.g. centralisation of signalling will mean that breakdowns will be more disruptive. In the UK and beyond, the industry is seeking solutions which, while maintaining safety standards, reduce the costs associated with traditional operating methods – examples are developing control systems which require less trackside equipment, or remotely monitoring the condition of infrastructure.

The market for some elements of train management systems is growing quickly; for example, the world market for signalling products is estimated to be growing at 6%/year.
The UK industry's Big Picture answer is the Digital Railway programme. This integrates a range of systems to control train movements, manage infrastructure, and improve communications, covering;

- traffic management
- implementation of the European Train Control System (ETCS)
- advice to drivers, and automatic control

- improved communication, including GSM-R
- backup systems to improve operation in “degraded mode” (e.g. if somebody steals the signal wire)

More purposeful project management has recently been injected into the programme, with a more ambitious timetable than was originally envisaged. The objective is to enable a comprehensive demonstrator to be available (in the Norwich/Yarmouth area) by March 2019, the end of the current Control Period (CP5). This may be overambitious but reflects a sense of urgency, which providers of new technical solutions can exploit.

International context for rail networks

The UK’s rail network does not feature in the world’s 10 longest rail networks. The following provides a brief overview (Ref: WWW.RAILWAY-TECHNOLOGY.COM):

- USA: 250,000km – 80% is freight lines. Plan to build 27,000km of high speed rail by 2030.
- China: 100,000km. Targeted to grow to 270000km by 2050. Rapid expansion of high speed network to 50,000km by 2020.
- Russia: 85,500km
- India: 65,000km. Six high speed corridors have been identified
- Germany: 41,000km
- Australia: 40,000km
- Argentina: 36,000km
- France: 29,000km
- Brazil: 28,000km
- Great Britain: 15,799km. UK has 108km of high speed track and HS2 will add 225km in the first phase (mid 2020s) and a total of 531km once the ‘Y’ network is completed in mid-2030s. (There is some political support for exploring the use of space applications in the new lines.)

Morocco will have Africa’s first high speed rail link due to open in 2018. At 200km it is expected to carry 10 million passengers per year. The project is a joint French Morocco venture using French engineering contractors and Alstom is providing the rolling stock.

2.2. Satellite Opportunities

Space applications have the potential to contribute to most elements of the ERTMS[1] (Europe) and Digital Railway[2] (UK) programmes. The industry has defined a range of challenges in developing its management systems, and has identified areas where innovation is to be sought. These are set out in the 2013 Rail Technical Strategy[3]. The European Space Agency (ESA) has identified major challenges, which fit in well with the Rail Technical Strategy (see Annex). So far, the engagement of space technologies appears marginal to many projects and there is no overarching structure to consider possible space applications in rail. Some specific attempts to develop joint rail/space industry solutions have produced worthwhile results but others haven’t worked well – e.g. the Innovate UK/NR challenge to space operators to develop applications to measure land movement. Nevertheless, projects over the past years have provided proofs of concept for potential space-based applications.

[1] ERTMS: European Rail Traffic Management System

[2] http://digitalrailway.co.uk/

[3] http://wwta2.networkrail.co.uk/publications/technical-strategy/

As regards to train management, the ESA funded IRISS[4] project (involving UK players – East Midlands Trains, Nottingham Scientific, Avanti…) provided a Proof of Concept for an integrated on-board management system involving a mix of terrestrial and space technologies. This has contributed to the Combined Positioning and Alternative Signalling System (COMPASS)[5] of which a demonstrator is planned as part of the Digital Railway Programme. Although designed as a back-up when core signalling systems are degraded, this could provide the foundation for a stand-alone core system.

Other elements of IRISS-type solutions have the potential for further development, such as a control system to facilitate more sensitive management of trains on blocked lines.

At European level, both elements of ERTMS (train control systems and track/train voice and data communications) are the focus of work, so far at a pilot level, to reduce costs using new technology, including space. If successful, such work could open major commercial opportunities. GSA[6] has been active in promoting the use of GNSS in rail systems. It has developed a roadmap that aims by 2020 to embody GNSS in the ERTMS specification. If this is successful, UK operators will be in a strong position because of the advances in developing COMPASS.

3. Customer and value proposition to the customer and end user

Satellite services will require engagement with an extensive rail value chain. A key weakness identified during the compilation of this report is the lack engagement of the whole value chain to develop solutions. It is important to get all the relevant 'players' throughout the value chain together, and not for suppliers to demonstrate what the can do, or for the rail industry to just set out a shopping list.

The value chain includes: satellite specific equipment manufacturers; system integrators; train manufacturers; train owners/operators; infrastructure managers.

Examples for each of these groups include: (Source GNSS Market Report Issue 4, March 2015)

Components Manufacturers (Receivers and others)

- Trimble
- Septentrio
- Navis
- Garmin
- Broadcom
- Furuno
- Hexagon (Leica Geosystems)
- U-Blox
- Infineon Tech

- System Integrators
- Ansaldo STS
- General Exlectric
- Alstom
- Siemens
- Thales
- Bombardier
- Telespazio
- Nottingham Scientific

Train Manufacturers

- Siemens
- Bombardier
- Alstom
- Hitachi
- China South Locomotive and Rolling Stock

[4] Intelligent Railways via Integrated Satellite Services - https://artes-apps.esa.int/projects/iriss

[5] RSSB Innovation Programme Solutions Catalogue (https://www.rssb.co.uk/innov-prog/Documents/2016-11-01-rail-technical-strategy-solutions-catalogue-projects.pdf)

[6] European Global Navigation Satellite Systems Agency

Train Owners / Operators

- Deutsche Bahn
- Trenitalia
- SNCF
- Arriva
- Colas
- RENFE
- Veolia
- Stagecoach
- ROSCOs[7]

Infrastructure Managers

- Network Rail (UK)
- Deutsche Bahn (DE)
- RFI (IT)
- SNCF (FR)
- ADIF (SP)

For private lines for mining companies or freight traffic, examples include:

- Vale (Brazil) has a logistics network integrating mines, railroads, ports and ships, in Brazil, Indonesia, Mozambique, Oman, Philippines and Argentina.
- FCAB (Antofagasta Chile): Copper ore/product rail network of 700km.

4. Market Competition

Space technologies can play a role in integrated systems involving several applications; in very few cases will satellite products be directly usable to meet the challenges identified. Many of the elements of current train management systems are intensive in investment and/or manpower, especially in difficult locations, or can involve disruption to commercial services, so the scope for improvement is potentially large. It is estimated that savings of up to 40% in signalling infrastructure costs could be achieved by replacing trackside equipment with remote systems.

New applications would respond to market growth in terms both of increased traffic and new lines.

The strongest possibilities are likely to be in:

- improved signalling and train control systems; for example, using satellite positioning and timing data to improve robustness, and ultimately to reduce the need for trackside equipment; a trial in Sardinia has enabled a satellite-based system to work in “full supervision” mode, and the roll out of the Digital Railway concept will put UK in a strong competitive position;
- integrating EO (Earth Observation) and GNSS for infrastructure and land hazard monitoring; for example, EO can itself detect potential hazards, together with smart sensors, and satellite based communications and improvements in data-handling can combine to provide improved analysis and data-sharing.

Targets for this could in the first instance be private rail lines used by mining companies in South America; or freight lines in Australia. In each case the ability to monitor large distances is not possible without using satellites as a primary driver of the service. Types of sensor groups that could be incorporated into any solution could be: earth observation (detection of very small land movements); weather; track temperature; vibration; rolling stock movements.

[7] ROSCOs: Rolling Stock Operating Companies

Examples where accurate earth observation combined with a wider view beyond just the track-side and weather data, may have been able to provide prior information on incidents such as the Hatfield landslip 2013, which resulted in line closure for 5 months. Landslips almost always occur when there has been heavy rainfall, and in this case the movement was due to a coal tip and weak sub-surface structure.[8]

- using satcoms and GNSS to support on-train condition monitoring (for example work being done by Huddersfield University).

Any offering must consider its cyber resilience.

The opportunity to use space technology is as a supplement to improve on terrestrial systems. The use of space applications as described in section 4 means:

- Better protection against land-based-hazards, as current systems are not good at detecting problems away from the track;
- More efficient signalling, with better back-up systems, without which improvements in capacity will be more difficult and the risk of disruption caused by breakdowns is greater;
- Asset monitoring with less of the disruption.

5. Role of UK Companies

The potential landscape is well-defined. UK companies clearly have the potential to contribute to effective hybrid services. Among big players, Inmarsat and Avanti have the technical capacity to deliver comprehensive services. The purposeful approach now being followed in the Digital Railway provides a potential firm foundation for the growth of UK operators. Smaller operators not currently involved in rail activity could also offer adaptable capacity. In the field of signalling, Ansaldo plays a dominant role; Hitachi Rail is now its majority owner and its management has a strong UK tone - so a new UK-focused player is emerging.

Where satellite EO data are required, CEMS is a leading resource with high accessibility; this makes the UK as well placed as any environment for the sharing and processing of EO data. New UK bodies (e.g. the Turing Institute, Institute for Environmental Analytics) are promising potential partners where big data processing is needed.

The Satellite Applications Catapult has been leading the way in facilitating access to earth observation data to enable UK companies to develop new solutions. This needs to be connected into the rail sector's supply chains to develop new solutions.

[8] Rail Accident Report: Class investigation into landslips affecting Network Rail infrastructure between June 2012 and February 2013

6. Revenue projections

	2016	2017	2020
Opportunity 1. Global rail asset management (Digital Railway & ERTMS)	€110m	€160m	€620m
Opportunity 2. Satellite Integrated Track Management Services	To be determined – market not yet present		

Global rail asset management using GNSS estimates is based on the European Global Navigation Satellite Systems Agency Report Issue 4 March 2015.

Obtaining any figures for the deployment of satellite related services for rail traffic management has not been possible. The figures above illustrate the growth in the asset management market.
ERTMS, European Railway Traffic Management System, is developing an international market. Outside Europe the biggest take up of ERTMS is in China, with about 7,500 km contracted to ERTMS. This followed by Saudi Arabia with 2500km. (Source: http://www.ertms.net/?page_id=58)

7. SWOT Analysis

7.1. Opportunity 1: Global rail asset management (Digital Railway & ERTMS)

Strengths	The requirement is mature. UK operators are engaged. UK companies, at least potentially, have good capacity. Strong academic sector.
Weaknesses	Big players have been reluctant to engage. There is no forum to bring together the players in the complex space/rail value chain. Deployment has been slow in the UK and in Europe. Non-European markets have been developing quickly.
Opportunities	Integration of satellite observation and communications as a more defined offering alongside terrestrially based systems. Non-UK or European markets may offer a quicker way to gain a foothold for UK businesses in this area.
Threats	Non-UK companies have been developing quickly. The UK is a difficult market to break into the supply chain. An engrained culture does not help bring forward new technologies.

7.2. Opportunity 2: Satellite Integrated Track Management Services

Strengths	The UK has a broad range of capabilities providing sensors along track-side through to satellite observation and data analysis. Organisations such as the British Geological Survey and the Met Office provide additional capabilities that start to put together a comprehensive view of factors impacting on the efficient running of a rail network.
Weaknesses	The UK's rail infrastructure is difficult to work with. The speed of developing trials is very slow, and the introduction of new technologies and innovations difficult. The rail supply chain is difficult to penetrate and the coherence of the offer is not clear.

Opportunities	The opportunities are to develop a stronger role for satellite based services in the Digital Railway and ERTMS programmes. The second opportunity is to provide a broader service offering that could initially be applied overseas on private rail networks.
Threats	ERTMS exists and is being sold around the world. This is dominated by European based systems integrators. However, there may be customers where a satellite system may be more appropriate due to geographical issues. Developing a wider service will require the development of a strong business case that will show the cost benefit of introducing a range of sensors/technologies to monitor the performance of a rail network.

8. Opportunity/Blockers/Enablers

In the UK, there are some significant barriers to the growth of innovative solutions for rail traffic management. These are:

- The intent from Network Rail and DfT is for a modern rail network using new technologies, however the culture is one of risk aversion, based on historical safety issues, and a slowness to engage with a new set of technology driven suppliers.
- The UK is not a free market model, and although there is a penalty / payment system – Schedule 8 - for non-performance against certain parameters this does not lend itself to incentivising the introduction of new technologies. However, the fund generated could be a source for developing trials once there is buy-in to a new technology.
- Network Rail is considered to be a major barrier to the introduction of new technologies and operating practices. This is driven by the paramount requirement for a safe network and the lack of emphasis on the passenger the ultimate beneficiary of the rail service. The governments funding periods, Control Periods, also provide a blockage to new technology introduction as there is reduced incentive on Network Rail to deliver.
- The visibility of the opportunity of space technologies aligned to the rail sector is not coherent, and the funding of trials to move from the feasibility stage to the demonstrator stage involving large end-users is not easy. (An example in an adjacent sector is the automotive sectors Advanced Propulsion Centre large-scale projects bringing OEMs together with technology providers in total project sizes of up to £100m.)

There are some key enablers to raising the satellite opportunity to rail traffic management:

- The promotion of 'the art of the possible' needs to be developed at a strategic level to DfT, ORR, NR, TOCs. This is less about technology push but more about how the rail network achieves its goal of moving more passengers more efficiently and with a better experience.

The development of Network Rail's investment plan for the next Control Period (CP6) due to start in 2019, provides an opportunity to integrate space solutions.

- The Satellite Applications Catapult, Transport Systems Catapult and the UK Space Agency all have a role in developing the case for integrating satellite technologies into delivering a modern rail network and passenger service.
- Network Rail is often seen as a major barrier for introducing new technology, but it is also seen as a global brand through its consultancy arm, which operates around the world. Cultivating a working relationship with Network Rail could be a means to illustrating the UK's satellite applications capability overseas.
- The UK Space Agency has many MOUs with their equivalents around the world, some in countries with expanding rail networks; e.g. Russia, China and South Africa. The development

of rail as a UK application specialism where joint projects are proactively developed would be a means of raising the UK's space sector profile.
- HS2 provides an opportunity to incorporate satellite derived services into the infrastructure from the design phase.

The following are suggested actions:

1. Develop a focused space/rail forum for clarifying opportunities, blockers, and remedies. As a start, this should be at a strategic level, to ensure the right cooperative links between UKSA, Innovate UK, DFT, NR and train operators.
2. Consider a large-scale demonstrator for the necessary technology on trains in the UK; ESA-supported activity elsewhere can provide pointers.

Action (1) could be led by the Catapults (SatApps and Transport Systems).

The introduction of new technology into rail services will necessarily involve many stakeholder groups, including regulatory; rail infrastructure providers; train operators; systems integrators; installation and maintenance companies.

The first issue to deal with is the lack of detailed understanding at a strategic level of the opportunity that can be obtained from joining differing sensor technologies to provide a more detailed, and real time understanding of the rail network.

The UK rail industry also does not operate within a free market. This makes the introduction of new technology difficult. There is no coherent way for the introduction of new technology into the rail network.

Key stakeholders include:
- Department for Transport
- The Office of Rail and Road (ORR)
- Network Rail (NR)
- Sympathetic TOCs (Train Operating Companies): e.g. C2C, SW Trains, Chiltern, East Midlands Trains
- Supply chain companies including: Babcock; Amey; Carillion; Colas.

There are two levels to engage with; there is the strategic level where the opportunity needs to be understood; and then the delivery level, which is probably through the system integrators.

9. Market Trends

Inevitably the rail market operates in the long term, with investment periods typically 5 – 30 years. Worldwide growth is likely to continue. Some of this is in countries where UK has good links. The UK space industry has a strong export record (for example as the largest exporter of satellite-based tools to the developing world) and if engaged could be well-paced to seize overseas opportunities

10. Annex

The European Space Agency (ESA) has established an initiative, SPACE4RAIL (http://space4rail.esa.int/), to raise the understanding in the rail industry of space related assets that can support the sector.

The following is a list of where space related technologies could provide support to the monitoring and control of mobile assets in the rail industry.

- Monitoring of freight (especially of sensitive cargoes), trains, rolling stock, personnel and equipment, e.g. on rural lines or those not well covered by terrestrial communications systems, or where track-based monitoring is sparse or too expensive to maintain or replace;
- Signal control systems based on the train rather than track side;
- Scheduling and information on journey progress for intermodal freight and logistics systems;
- Monitoring and maintenance of railway infrastructure;
- Identification and prediction of hot spots that are likely to cause service degradation; and, the enabling of early warnings and preventative action, including monitoring of structures (bridges, embankments, cuttings, etc);
- Data mining and management as applied to infrastructure monitoring, including the extraction of data from Earth Observation satellites for specific target locations;
- Erosion and flooding, by rivers or sea;
- Vegetation monitoring and growth prediction;
- Monitoring and maintenance of Overhead Line Equipment (OLE);
- Temperature monitoring of railway track and other infrastructure;
- Human activities (e.g. illegal waste dumping, trespassing, status of fences and boundaries, theft);
- Animals on or near the railway (including identification of indicative changes in land use);
- Security of critical infrastructure and overall integrity of the infrastructure.
- Autonomous Systems and Robots:
    - The use of such systems to improve efficiency and safety of train operations, infrastructure and maintenance. The aim is to reduce the need for personnel on the network, thereby reducing risks and costs with systems that are accurate and repeatable. It includes:
        - Driverless trains;
        - Unmanned Aerial Systems (UAS) as applied specifically to railways;