Routes to Market Report

05 - Satellite Technologies for Broadband to Trains

Innovate UK

beta

CATAPULT Satellite Applications

Contents

1. Introduction and Scope

This market opportunity analysis focusses on satellite broadband to trains. The report looks at the existing and developing market for broadband services to passengers, staff and contractors. There is increasing demand from passengers for good quality and reliable broadband connectivity. In the UK, Train Operating Companies (TOCs) are responding through the provision of Wifi, although the broadband service is not perhaps what is expected by passengers. Wifi is a marketing tool for TOCs, and the provision of on-board offerings such as movies may be a way around the broadband connectivity.

The potential of high speed trains, eg. HS2 in the UK, places significant technical demands on the communication infrastructure. The use of satellite communications will only be part of the solution.

The report considers a number of markets around the world where there is significant rail infrastructure. The initial focus is on the UK, and others considered include Europe, Australia, China, Russia, South America, and the quickly developing area of Africa.

The business model that will drive the commercial opportunity to provide good quality broadband to trains has to be developed. The use of satellites may be a way to provide both coverage and data transmission speeds. Existing broadband models such as used in aircraft and ships provide an indication of the type of broadband services that can be provided when travelling.

The infrastructure needs to be put in place from the design of the rolling stock through to the communications architecture from satellite to user. In most cases, the technology exists or is at a feasibility stage ready for demonstration.

Key stakeholders include the national rail regulators, rail network providers, train operating companies, rolling stock designers and lease companies, users of broadband such as advertisers, and the recipients of the service – passengers. For example, the global internet data and social media providers such as Google and Facebook are looking for new ways to access new clients in new geographies. The ability to have good connectivity of trains in emerging markets is an important source of new clients.

The expansion of rail networks around the world, as well as in the UK, have timelines over several decades providing the opportunity for longer-term solution development. Existing rail networks and providers are seeking new offerings to customers and therefore provides short-term solutions. The need to integrate solutions across communications platforms is apparent in order to service the broadband to train market. Potential and existing barriers to broadband to trains are presented.

The development of the 5G mobile communications platform will have an impact over the next 2-5 years as it develops. This may be a competing technology, but also an enabling one as part of an integrated offering. The 5G standards have not been agreed and the functionality may also be affected by some of the train carriage design issues such as metallised windows.

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.

Period – to 2030

2. Market Overview and Opportunities

2.1. Rail Market

The consumer market for internet based services on trains is potentially large - 1.7bn UK passenger rail journeys/year and 31bn passenger journeys were taken world wide in 2015[1]. This compares with 131m air passenger journeys where a more sophisticated broadband offering is being rolled out.

In Europe, the UK has the second highest number of passenger journeys at 1.7billion in 2015-2016[2]. Germany has the highest at 2.7billion in 2014[3]. Third is France with 1.2billion, and fourth is Italy with 0.8billion.
By comparison, in the USA, which has the world's longest rail network, the number of passenger journeys in 2015 was only 55 million.

The development of high speed rail lines in a number of countries around the world, will increase the demand for good quality broadband services to support passengers throughout their journey. In the UK the HS2, once fully completed, will add around 531km in the 'Y' configuration, with phase 1 due to be operational by 2026.
Other notable intentions to develop high speed lines are:

- USA: plan to build 27,000km.
- China: plan to increase high speed network to 50,000 km by 2020, and their overall rail network to grow by 270,000km by 2050.
- India has identified six high speed corridors.
- Morocco is due to open a 200km high speed line in 2018, which will carry 10 million passengers per year.

(Ref: www.railway-technology.com)

The current number of passenger carriages and trailers in Europe is approximately 99,000 and for the rest of the world is approximately 208,000[4].

2.2. Broadband Requirement

78% of global consumers have a smart phone, with texting and instant messaging being the favourite activity.[5] 4G is generally preferred as the main method of connectivity. The use of satellite broadband will need to improve significantly the experience that smartphone users currently receive on trains if on-board WiFi is to be commercially viable.

[1] International Union of Railways 2015 Synopsis
[2] Dept for Transport Rail Trends Factsheet January 2017.
[3] Eurostat: Railway passenger transport statistics - quarterly and annual data
[4] International Union of Railways Railway Statistics 2015

[5] Deloitte's Global mobile consumer trends: 1st Edition 2016

The recent McKinsey & Company Global Media Report 2015 states that: "Digital, consisting of Internet and mobile advertising, will become the largest advertising category by 2017, surpassing TV….and mobile will more than double its share of the digital ad market." The report tabulates that in 2014 the global spend on mobile data[6] was US$237bn and by 2019 is anticipated to be US$447bn.

2.3. Technology – State of the Art

Satellite data provision to ships and aircraft is relatively well-developed. This enables internet use by passengers (which generates income both in user fees and through advertising) and supports management systems (using eg 6000 sensors on an A380). INMARSAT is the major provider.

Unlike air or sea transport, trains are a hostile environment for communications technology. Opportunities arise from the "bearer-independent" combination of different technologies – cellular, satellite, Wi-Fi, track-side, and (supported by ESA (European Space Agency) in particular) such systems are emerging. The issue is not just about meeting passenger needs; meeting the major challenges in train management is likely to require better communications systems, and indeed this element is prominent in both ERTMS and the Digital Railway. Nevertheless, current enquiries from train operators reflect greater interest in content provision than in communications for train management.

New powerful satellites, and constellations, are coming on stream, capable for example of generating numerous signal beams. There are important technical challenges to meet in order to exploit the opportunities, particularly because it is physically challenging to equip trains with antennae with enough elevation to operate on UK tracks. (It is noteworthy that the current trial of a hybrid system is under way in Sardinia, but a proposed trial with Caledonian Sleepers could give pointers about the operation of such a system in UK conditions). The development of flat antenna panels is likely to be a key enabler.

2.4. Market Offering for Satellite Broadband to Trains

The sheer size of the potential market suggests that if technical, commercial and cultural barriers can be overcome, the provision of high-volume data services may represent a stronger and quicker opportunity for the space industry than those directly related to the network or with a safety implication.

The market offering is broadband to trains using satellites as the part of the solution for connecting to trains. Satellite transmission will need to be as part of a system that switches between satellite and terrestrial sources as required to provide coverage where line of site to the satellite is interrupted, eg. tunnels, cuttings, built up areas.
The opportunity is to provide:

- Electronically steerable antenna that are integrated into the construction of rolling stock, or can be retro-fitted whilst maintaining the compliance of the rolling stock within the geometries of the network;
- Broadband to WiFi solutions on board trains using existing technology;
- Initially the use of existing satellites;

[6] Consists of mobile broadband, mobile advertising, mobile video games, audio digital streaming,, daily newspaper, digital circulation spending, electronic consumer books and satellite subscription spending. Sources: McKinsey & Company, Wilkofsky Gruen Associates.

- Involvement in the specification of new satellites (or satellite constellations);
- Development of business models with service providers to create an attractive business proposition for the supply chain.

In order to supply broadband to trains the technical obstacles include:

(i) seamlessly integrating signals from different sources
(ii) providing train based antennae.

21net (Belgium) and INDRA (Spain) and ORBIT (USA), for example, have developed solutions to the first of these; they and Gilat in Israel have produced a design for antennae, and there are projects on-going to develop new flat and electronically steerable antennae. The antenna these companies have developed can be quite significant in size (INDRA) and may contravene the allowable geometries on the UK rail network in particular. A detailed technical understanding of these offerings will need to be developed.

The activity proposed will require the development of partnership working within the UK to realise a solution. This would provide a useful test-bed for enacting recommendations from the McNulty report of 2011[7].

3. Value Proposition to Customer and End-User

The ultimate customer and end user for consumer services is the passenger. On-board services exist on some rail services already in the UK and overseas, some on a fee-paid basis, some as an element of the offer to passengers. Passengers are more likely to find WiFi on long-distance trains.

Reliable provision of access to broadband will enhance the passenger's perception of the train journey and can be argued to enable greater productivity for business passengers and increased user experience for non-business passengers. Some UK TOCs are providing other WiFi services such as on-board movies.

Network Rail in the UK has a well developed and robust 2G mobile network that provides basic communication to train crews in particular drivers. The provision of enhanced broadband capability will allow the transmission of more data regarding the train performance and its environment to control centres.

The TOCs provide the service to the passengers and are the customer for communication systems to support management activity, eg to improve communications between trains and managers. Subject to consistency with regulatory requirements, communication systems, systems incorporating satellite communications could contribute to the upgrade of GSM –R. An EU-level study is expected to emerge soon on the evolution of GSM-R which will identify key topics for further work.
In both cases, end-user services are likely to depend on a mix of satellite and terrestrial technology; the seller is a system integrator.

[7] Realising the Potential of GB Rail. Sir Roy McNulty, 2011

Both Google and Facebook are looking to provide free WiFi to new large markets, particularly focussed on India and Africa. Google launched, in 2016, Railtel, which is a free WiFi service to a network of rail stations in India.

Facebook have also been looking at geographies where there is an infrastructure obstacle. Facebook have faced issues regarding their domination of service provision, but have signed up nearly half of the countries in Africa (about 635m) people to its free internet service.
Facebook has been partnering with Eutelsat Communications and Spacecom to establish a satellite to cover Africa. However this failed to launch last year.

According to GSMA there could be upwards of 700m smartphones in sub-Saharan Africa by 2020.

There is a clear customer demand for WiFi on trains, backed up by a requirement that new franchises must include plans for offering it.

Satellite-based consumer services need to demonstrate that they offer better capacity, convenience and robustness, than systems currently available and/or lower cost. This includes eg the removal of black spots, and greater bandwidth. Such systems are likely to be hybrids of terrestrial and satellite-based services.

Systems to support management activity are constrained by regulation, but hybrid systems could initially at least provide backup in the event of failure. If regulatory constraints can be overcome, worthwhile costs savings are possible in areas where infrastructure is weak. Regulatory requirements are less stringent on low-density lines and these may be particularly suitable testbeds for space-based systems.

4. Market Competitiveness

The alternative is to rely wholly on terrestrial systems. The appeal to customers depends on a proposition set out in the previous section.

Passengers are keen to access good quality WiFi on trains, and this is a UK government pledge and requirement of franchise licenses. The expectation of passengers has been raised as train operators advertise their WiFi provision; however, the reality is that the experience is less positive.

The development of new rolling stock and in particular the use of metallised film windows for climate control are affecting the performance of individual access to the cellular network.

Certainly, large cellular providers such as Vodafone, are looking at integrating their service to trains, and in the case of Vodafone they have patented an approach to “Providing Broadband to Trains”. This uses a mixture of mechanisms to provide a robust service, and although satellite is mentioned it is not their main mechanism. Vodafone have linked with Inmarsat.

The main alternative to broadband provided on trains is for passengers to link directly to the cellular network. This is potentially more intermittent as it tries to move from cell to cell. In addition the design of rolling stock may cause increased transmission attenuation due to their construction.

5. Role of UK Companies

The potential landscape is well-defined. UK companies clearly have the potential to develop effective hybrid services. Among big players, Inmarsat and Avanti have the technical capacity to deliver comprehensive services. The issue for them is the attractiveness of investment in this area. There are strong synergies in particular with Inmarsat's services to aircraft and ships. A number of smaller operators can contribute to the development process and are familiar with the rail environment; they are identified in for example the NR/RSSB "Solutions Catalogue" and include both SMEs like Nottingham Scientific and RDS and research/University bodies; and NR has a Strategic University Programme to interact with them. Operators working on new technologies for signal reception (eg Palliser) could also have a role as indicated above, there is a need for new disruptive technical approaches to receiving equipment.

There is ground to make up, exemplified by 21net; this started as an ESA/BNSC initiative, which has now migrated to Belgium.

6. Revenue projections

	2016	**2020**	**2030**
Opportunity 1. UK Broadband services to train passengers	1.7bn passenger journeys. No premium service.	1.95bn passenger journeys. Assume £0.5 per passenger per journey is included in the ticket price. Revenue: £975m pa.	2.14bn passenger journeys. Assume £0.5 per passenger per journey is included in the ticket price. Revenue: £1.07bn pa.
Opportunity 2. Global rail passenger digital advertising revenue	31bn passenger journeys world wide. Assume 0.1% have broadband at an additional ticket fee of £0.5 equivalent. Revenue: £1.55bn		
Opportunity 3. Provision of flat antenna arrays to carriages	Assume 0.01% of carriages world wide to be fitted with antenna. No. of antenna and associated systems: 3,070 systems.		

Calculation of figures:

Logic of revenue estimate, based on comparison with complimentary market, turnover of leading players, published reports etc. In the UK, train operating companies are providing WiFi on trains for free to passengers. There will be a cost to this provision and it has been assumed that the additional price included in the ticket for WiFi is £0.5 per passenger journey. The revenue stream will come from the additional passenger growth/ticket price increase through provision of an enhanced service. Additional revenue streams could come from specific advertising links. Assume an annual growth in UK passenger journeys of 3.5% upto 2020, based on ORR (Office for Rail and Road) figures for 2016/17. In the period 2021-2030 assume an overall passenger increase of 10%. The infrastructure would still need to be in place and therefore the broadband provider to the train will be able to gain revenue from the service provision to the train operating company. This would be recovered from the TOC through ticket prices. Revenues from passengers in 2016 was £9.3bn. If 0.5% was used to fund broadband services the opportunity would be £46.5m pa. The market size for equipment on to train carriages has been estimated. The value of this will depend on the value of the equipment to be installed.

7. SWOT Analysis

7.1. Opportunity 1. Broadband Services to Trains UK

Strengths	UK players well engaged in relevant activity. Outputs of NR/RSSB, and ESA, research and innovation can be built on.
Weaknesses	Reluctance of big operators to engage reflects doubts about the investments needed. While space solutions play a part in some identified solutions in the UK environment, national frameworks don't focus specifically on space, so efforts are diffuse. The UK space offering is not coherent to the rail sector – major systems integrators need to see and push the opportunity. SMEs in particular are not strong enough to break into the market.
Opportunities	Potentially a very large market. Rail operators are increasingly likely to feel compelled to offer services (including as a condition for new franchises)
Threats	Terrestrial systems could improve to the extent of making space investment not worthwhile; 5G could meet many requirements.

7.2. Opportunity 2. Broadband Services to Trains ROW

Strengths	UK has a number of organisations that could provide many elements of the solution. UK space industry export performance is particularly strong.
Weaknesses	Coherent offering in the ROW. Not engaged with other large markets to illustrate the UK capabilities.
Opportunities	Draw on the UK's capability and the profile of the Network Rail brand to gain market share. Use the UK Space Agency MOUs with countries to develop understanding of the UK's space rail offering.
Threats	Other non-UK technology companies. Historical links between other major supplier countries such as France and Spain with developing territories in Africa for example.

7.3. Opportunity 3. Satellite receiving antenna on trains

Strengths	Technology is being developed and the UK's capability in satellite design to understand the needs. Historic train design – Bombardier (Derby)
Weaknesses	Low engagement with train rolling stock designers. Technology yet to be proved. Lack of suitable UK test track for high speed evaluations
Opportunities	A significant amount of commuter and high speed track is to be commissioned. This will require new rolling stock and provides the opportunity to develop an integrated design. HS2 is the in-country opportunity.
Threats	Technical solutions have not been proven. A trial in Spain will give that consortium and edge.

8. Opportunity Blockers and Enablers

In the UK there are some significant barriers to the growth of broadband on trains. These are:

- The current funding model means there is no emphasis on what the passenger actually wants. The model is there to run a rail network safely. Passengers generally are captive, especially on the lucrative commuter lines where there is very limited alternative.
- 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.
- The role of the Rolling Stock Operating Companies (ROSCOs) may hinder the introduction of new technology. In some cases, new rolling stock is provided to TOCs by ROSCOs. ROSCOs are essentially a financing operation and the dialogue between the rolling stock manufacturer, the ROSCO and the TOC means that cost will inevitably be a key driver. The case for introducing new services such as broadband may not be well articulated.

- 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 governments funding periods, Control Periods, also provide a blockage to new technology introduction as there is no 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.
- UK government has stated that free WiFi should be available to all passengers by 2017, this however does not equate to the reliable broadband that most passengers might expect and there is an opportunity for the rail regulators to define a minimum expected broadband service, as has been defined for broadband to home.
- The UK is perceived to have a more restrictive route geometry. It is no worse than the German routes for example, but will not be as open as completely new geometries that do not need to use existing track systems.
- The development of the dialogue with rolling stock designers and manufacturers of what technology there is or could be developed to be integrated into new rolling stock.

There are some key enablers to raising the broadband opportunity to trains:

- The promotion of 'the art of the possible' needs to be developed at a strategic level to DfT, ORR, NR, TOCs, ROSCOs. 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 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 UKs satellite applications capability overseas.
- The UK Space Agency has a number of MOUs with their equivalents around the world, eg 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.
- New high speed lines are often established by system or project integrators. For example in Spain the project integrator Aicox (Spanish) has been contracted by the rail company Renfe. Aicox selected the Israeli satellite company Gilat to provide broadband connectivity to the high speed train.
- HS2 provides an opportunity to incorporate satellite derived services into the infrastructure from the design phase.

(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.
(3) could be led by the Catapults (SatApps and Transport Systems); lead on (2) could be considered within (1)

9. Market Dynamics

The introduction of new technology into rail services will necessarily involve a number of stakeholder groups, including regulatory; rail infrastructure providers; train operators; systems integrators; rolling stock manufacturers and providers; and internet groups such as advertisers and social media platforms.

The first issue to deal with is the lack of detailed understanding at a strategic level of the opportunity that can be obtained from broadband to trains. The passenger is not at the traditional front end of the rail systems thinking.
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.

Broadband to train can essentially have limited impact on the safe operation of the rail network. The main impact will be on the structure of the rolling stock and its impact on existing on-board electronic systems.

Key stakeholders include:

- Department for Transport – to help stimulate demand through initiatives such as “through electronic ticketing”
- The Office of Rail and Road (ORR)
- Network Rail (NR)
- Sympathetic TOCs (Train Operating Companies): eg. C2C, SW Trains, Chiltern, East Midlands Trains
- Advertisers – JC Decaux
- Mobile networks who would be part of any solution
- System integrators – eg. Hitachi

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

Examples of existing provision in the international market are:

- Existing international suppliers of broadband to train include Gilat (www.gilat.com) (Isreal)

- Passenger Rolling Stock manufacturers include Talgo (Spain); Siemens (Germany); Alstom (France). Talgo is actively illustrating a satellite antenna box on top of their trains. Bombardier (UK & Canada) also manufactures aircraft and has a satellite offering for planes.

- System / Project Integrators are important in specifying communications related equipment. For example Aicox (Spain) specified the use of the Gilat satellite system to Renfe (Spanish Rail company).
  Other examples of integrators include: Schneider Electric (previously Invensys Rail) (UK); Spirent plc (UK)

10. Market Trends

The UK rail market continues to grow at about 3.5% pa for passenger journeys. For the UK the Office of Rail and Road (www.orr.gov.uk) provides a set of statistics covering aspects such as passenger rail use, rail freight use etc. The statistics highlight changes in use and which particular rail franchises are increasing numbers. The data can be used to indicate trends in rail usage. Since 2006 the number of passenger journeys in the UK has increased by 48.9%.

According to Deloitte's report - Mobile Consumer 2016 - Four out of five adults now have a smart phone. In the morning rush hour 78% use a smartphone when using public transport; however this reduces to 9% when returning home from work on public transport.

There is the opportunity to use the smart phone in different ways at different times of the day – organising the day in the morning, shopping or browsing in the evening. The McKinsey Global Media Report 2015 shows an increasing trend of digital spend, which includes the use of mobiles.

In the UK, there is the introduction of new passenger rolling stock on the East Coast (866 carriages) and First Great Western and in Scotland over the next 2-4 years.
Beyond these, there will be the development of the HS2 rolling stock for first service in 2026. These all provide opportunities for integration of new integrated or retro-fit opportunities.

As illustrated above there are ambitious programmes to increase the rail network in China, India and Africa as well as South America. These all provide a growing trend for the need for on-board communications for passengers.

The introduction of 5G does have the potential to disrupt the opportunity. However there are issues over full rail network coverage and the interaction of mobile signals with the trains structure. A combined offering is where growth opportunities will exist.