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Thought leadership from Atos

white
paper

The Connected Train

Atos

All around the world Atos is bringing connectivity to places where it has never been envisaged, delivering benefit to both business and user. We make sure that people have access to the right information no matter what their activity or context. Global rail is a major research area led by our experience in the UK where we have significant heritage and 'on the ground' vision. With travelers, operators and nation states demanding high bandwidth to improve passenger experience and drive business efficiencies we are defining a new economic and technical model that gives passengers free WiFi without the rail industry carrying operational cost. Furthermore we are focused on the true business benefit to all parties in the rail industry; revenue and margin drivers are at the core of our proposition.

This paper outlines a blueprint for this service called The Connected Train. We examine the nature of the proposition by posing and answering a number of questions.

The Connected Train

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About the Authors

This white paper was developed by the members of the Atos Scientific Community: Simon Elliott, Alison Plant, Mike Smith, Dr Mark Young in collaboration with Giovanni Pau, Adj. Associate Professor at UCLA.

What is The Connected Train?

Enabling people to continue their online lives whilst travelling on the train, The Connected Train helps monetize high bandwidth Internet on a moving train where data and transactions are facilitated via a WiFi platform. This statement has a different meaning from the point of view of each of the organizations involved.
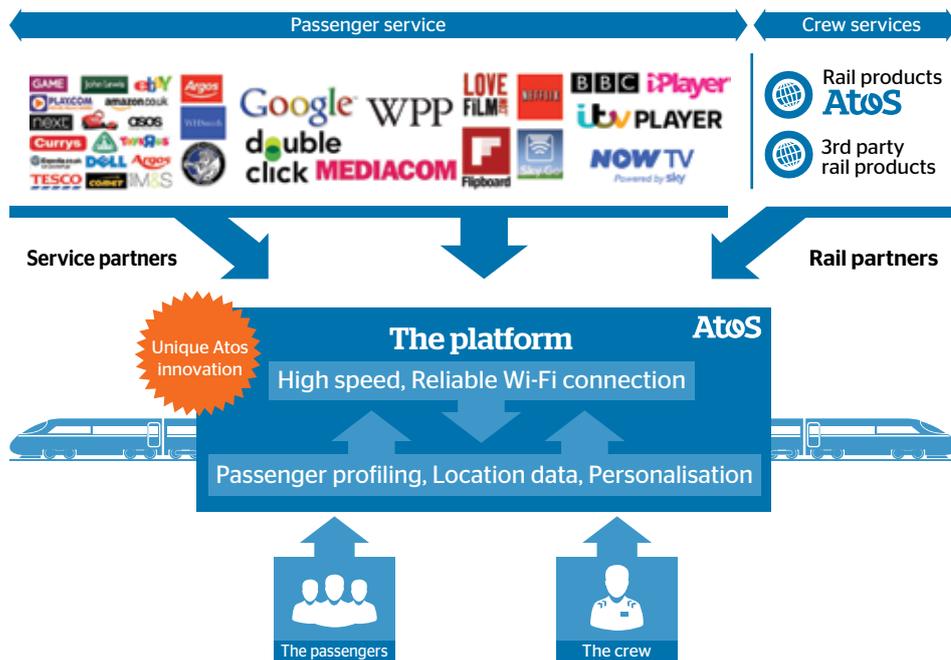
The passenger will be able to access high bandwidth free WiFi on the train, which includes high value special features. Additionally the crew will be able to access more information and perform actions regarding the train, the business or the passengers.

The service partner or rail partner will have more information to enable them to understand more about their customers; either passengers or crew.

These two groups are brought together in a multisided marketplace[i], united by the platform. We envisage that the platform stakeholders will be companies that will not only benefit from profit generated by the platform but it will also add value to their business models.

The rail infrastructure provider will gain valuable real time information relating to the performance of rail assets and be able to move into predictive analytics driving 'more informed' management.

The manufacturer or train maintenance company will be able to better plan maintenance cycles and drive up miles per failure, again through the data intelligence that comes from a connected train.

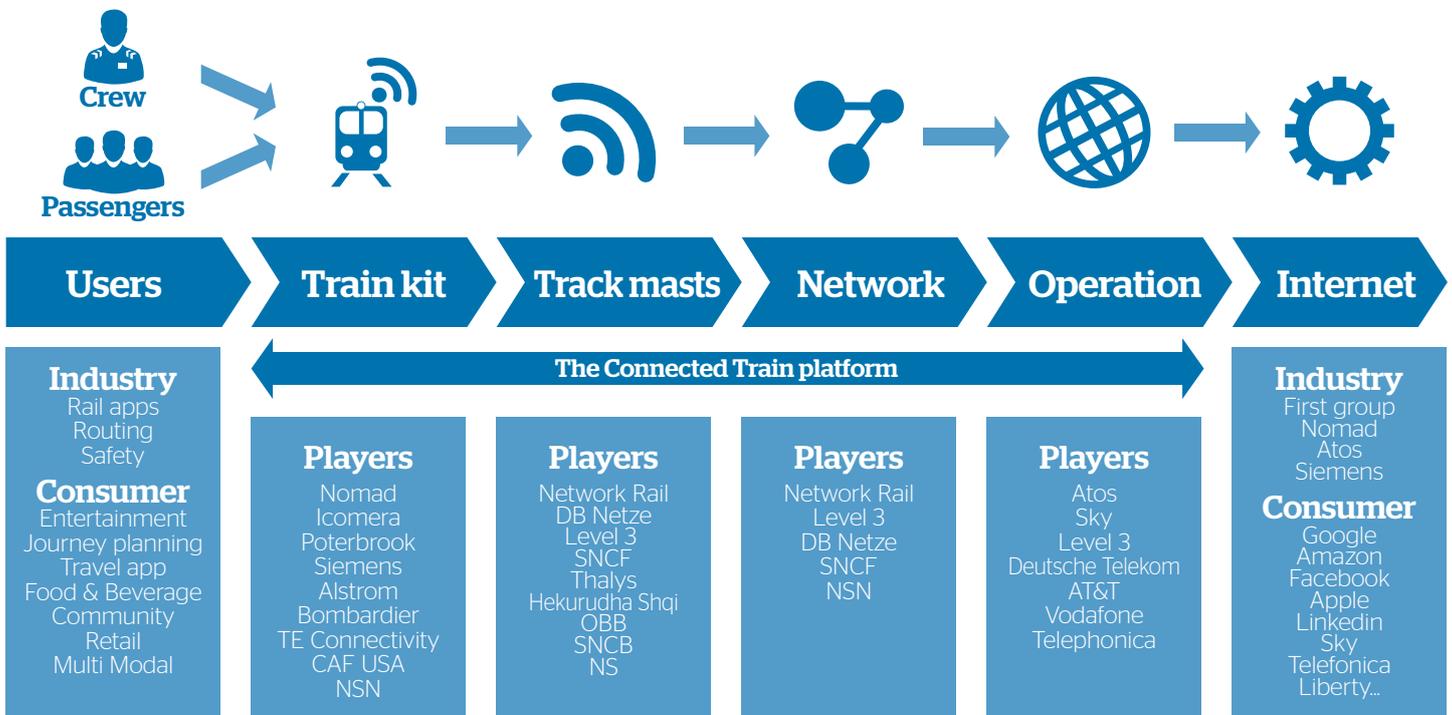**The owner of the train** will be able to better protect the asset value and derive better long-term value.

Finally to the platform provider(s), it's the ability to harvest and sell passenger data and facilitate business transactions that adds value.

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i Ascent White Paper "Economy of internet applications" – http://atos.net/en-us/home/we-are/ascent-thought-leadership.html

What is the value chain?

If you are traveling on a train with a smart device in your hand then the most bandwidth-intensive activity is streaming a movie. Video-based content and social networking rank very highly in the list of most visited websites[ii] . Popular online video services such as YouTube, BBC iPlayer and Netflix are bandwidth-intensive and tend not to operate well below 3Mb/s[iii] . This is a specific example of the phenomenon that hunger for bandwidth in general has been increasing exponentially[iv] as more and more sophisticated apps are launched and used.

If the rail industry plans to build an infrastructure that is future-proofed rather than one that satisfies merely today's needs then high bandwidth is paramount. The question is, who are the companies that need to collaborate to build this service, given that user expectation grows in accordance with Moore's law while trains typically have a 30-year obsolescence?

Users	Train kit	Track masts	Network	Operation	Internet

The Connected Train platform

| **Industry**
Rail apps
Routing
Safety

Consumer
Entertainment
Journey planning
Travel app
Food & Beverage
Community
Retail
Multi Modal | **Players**
Nomad
Icomera
Poterbrook
Siemens
Alstrom
Bombardier
TE Connectivity
CAF USA
NSN | **Players**
Network Rail
DB Netze
Level 3
SNCF
Thalys
Hekurudha Shqi
OBB
SNCB
NS | **Players**
Network Rail
Level 3
DB Netze
SNCF
NSN | **Players**
Atos
Sky
Level 3
Deutsche Telekom
AT&T
Vodafone
Telephonica | **Industry**
First group
Nomad
Atos
Siemens

Consumer
Google
Amazon
Facebook
Apple
Linkedin
Sky
Telefonica
Liberty... |

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ii http://en.wikipedia.org/wiki/List_of_most_popular_websites
iii http://iplayerhelp.external.bbc.co.uk/help/mobile_tablet/iPad_internetconnection
iv http://www.ispreview.co.uk/story/2010/06/10/cisco-forecasts-quadruple-jump-in-global-internet-traffic-by-2014.html

Why is connected train WiFi better than a cellular connection?

There are many challenges to connectivity whilst on a train: The metal body of the train blocks the signals, a lot of people on the same train are competing for the connectivity, phone towers flash past and tunnels block the signals. Therefore passengers will choose to connect to on-board WiFi to obtain very high bandwidth at zero cost and higher reliability. There are also unique features to enhance their travel experience; it is easy to register and users will subsequently join automatically.

They are willing to provide personal information in exchange for the extra functionality on the assumption that the data is treated with respect and the consequential impact on the user overall is positive. Of course all data will be subject to stringent data security and privacy controls.

To ensure that the platform is 'sticky' – i.e. to retain users, there will need to be passenger-specific benefits; perhaps an app to create a community among regular travelers. The choice of which services to offer might differ between train operating companies.

How does the platform generate money?

At any one time on our rail networks there are millions of people who currently do not have a decent connection. Increasingly, passengers will choose connected modes of transport over unconnected ones. In fact when connected, it may not matter so much when one is delayed. The act of providing a connection will also naturally generate business for companies like Amazon, Google, Sky and Facebook who rely on their customers being connected; and this will create value for those that provide the infrastructure to enable those companies to deliver their services.

The Connected Train platform has the concept of "Service Partner"; these are companies who invest in the platform via a membership fee to gain access to the connected passengers and therefore improve their business. In order for a passenger to obtain a free connection to The Connected Train platform they agree to give up some of their private data. This includes browsing behavior, information about their destination and point of origin and any loyalty information collected by the platform. This data is sold per transaction to the service partners who can use it to improve their business.

The total of all service partner membership fees and transactions for passenger data must exceed the platform cost for the platform to be profitable.

In addition the platform owners gain efficiency benefits as described in the first section.
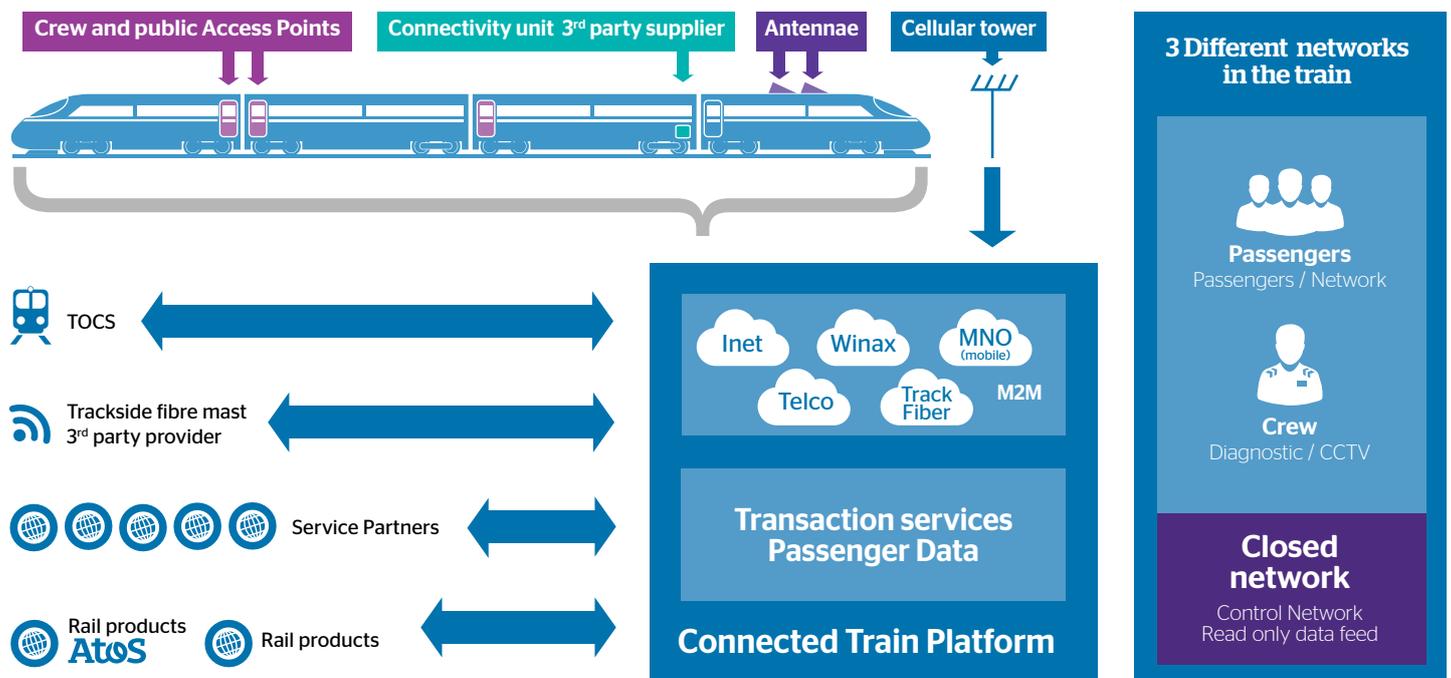
How does the platform work?

Whilst The Connected Train platform enables hundreds of different business models it can best be understood by examining use cases from different perspectives. Firstly let's look at the perspective of the passenger and their relationship to media advertising. Their experience will involve on-board facilities and concessions and access to loyalty schemes. In this use case our passenger simply wants to watch some television; the passenger browses to the Sky web site and starts to watch TV. There is a commercial break during the show and the passenger is presented with adverts. Because Sky is a service partner of The Connected Train the loyalty and travel details have been shared with them, they can, in turn, offer great deals on restaurants at the destination that he/she is traveling to. Our passenger has not yet booked dinner and accepts the offer. The 'magic' behind the scenes is that data associated with our passenger, or at least the key to unlock it, is shared with The Connected Train service partners; this allows them to provide better targeted services to the passenger. The more our passenger travels, the more detailed a picture we have about his/her behavior and therefore the more valuable it is to the service partner; and indeed for the passenger.

A second use case is from the perspective of the crew; their mission is to make the journey for the passenger as comfortable and predictable as possible. On a connected train the passengers will be interacting via social channels at the same rate or even more than in a home environment. Imagine if we could intercept, harness and present this information to the crew. For example our passenger could tweet that the heating is broken. The crew can be alerted via their smart device and immediately visit the passenger to help them with their problem. When the crewmember arrives they will have the complete loyalty history, social reach and sentiment analysis for the passenger enabling them to gauge the level of support to give the passenger.

What is the technology behind The Connected Train?

Inside a modern train there are three networks. The Control Area Network (CAN) sends safety critical messages between the different components of the train such as the brakes or doors. Additionally there is a network for the crew and separate network for the passengers. The crew and passenger networks may not have physical separation but instead may be virtual local area networks (VLAN). The crew and passenger network service is distributed around the cars using WiFi access points. Today we would expect this to be the IEEE802.11ac protocol, which should allow up to one gigabit per aggregate cell; this means that there is no constraint on data flow within the cars.

Crew and public Access Points

Connectivity unit 3rd party supplier

Antennae

Cellular tower

TOCS

Trackside fibre mast 3rd party provider

Service Partners

Rail products Atos

Rail products

Inet

Winax

MNO (mobile)

Telco

Track Fiber

M2M

Transaction services Passenger Data

Connected Train Platform

3 Different networks in the train

Passengers
Passengers / Network

Crew
Diagnostic / CCTV

Closed network
Control Network
Read only data feed

All of these networks come together at a 'connectivity unit'; this is the component of the train that connects via radio communications to a fixed infrastructure such as a mobile mast. Data that is emitted or consumed by the train flows through this connectivity unit. The connectivity unit only has read access to the CAN.

We are expecting that the connectivity unit will communicate to the Internet using a hybrid approach i.e. it will select multiple connection mechanisms depending on the network conditions at the time.

▶ **Mobile telephone networking 2G, 3G and 4G (LTE)**
The most common train connectivity in today's market is done by putting SIM cards into the connectivity unit and the train operating company constructing a deal with the Telco providers. There are several issues with this mainly that mobile telephony protocols tend to become less efficient when a high-speed object is using them (such as a car or train). Additionally there is significant contention at the mast as all the passengers are contending for the same spectrum as the train.
LTE has peak download rates of 300MBit/s and upload of 76Mbit/s and has base frequency of 1.8GHz or 2.6 GHz, LTE uses 20MHz of spectrum

▶ **GSM-R**
(Global System for Mobile Communications – Rail)
This is an international standard for rail connectivity that does not degrade at high speed. This uses towers based between 7 and 15km apart close to the track. The network is intended for use with voice and train control systems. In Europe GSM-R uses 880MHz for download 925MHz for upload. It is expected to deliver up to 100Mbit/s.

▶ **WiMAX or Wireless MAN (Metropolitan Area Network)**
This form of networking would see an SS (subscriber station) included within the connectivity unit. WiMAX offers a great solution for connectivity whilst the train is passing through a tunnel. WiMAX operates at 30-40Mbit/s and is part of the IEEE802.16 family of wireless network standards. WiMAX uses the 2.3 GHz, 2.5 GHz and 3.5 GHz spectrum allocation although this is not rigorously standardized and differs from region to region.

▶ **WiFi**
The train will naturally pass through stations and near fixed infrastructure that can emit a high-speed WiFi signal. WiFi uses the 2.4 GHz spectrum and consumes several channels. Whilst WiFi can deliver high Gigabit bandwidths it also has a reduced range and is only effective outdoors to 100m.
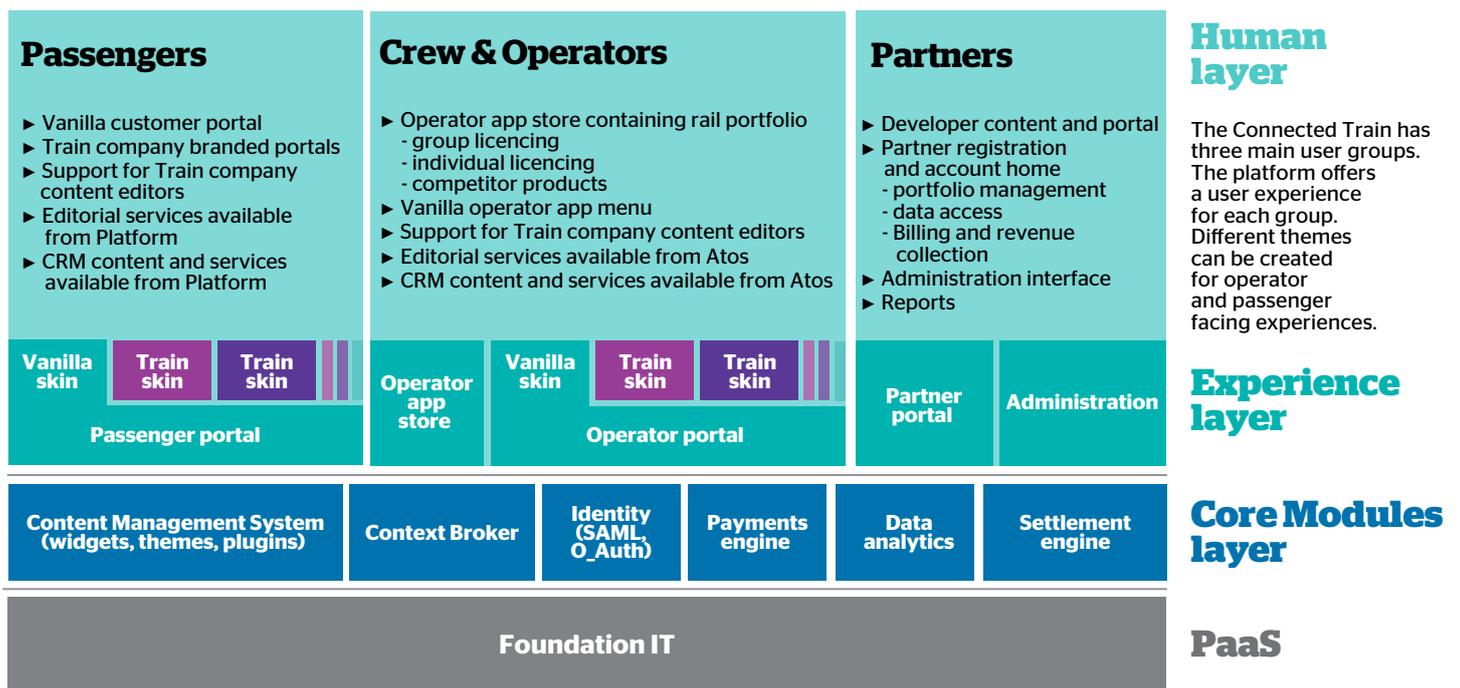
▶ **Bespoke wireless connectivity to trackside fiber**
By far the most attractive option is to use masts connected to the track side fiber optic network with a bespoke or mesh network. There are some considerations that need to be accounted for. Firstly does frequency need to be acquired? We feel that it may be possible to use whitespace spectrum channels with directional antennae to increase performance.

Train to infrastructure communications is still not the whole story. Data flowing from the trains will need to be routed to the Internet and this means acquiring bandwidth from the Telco operators. The glue between the infrastructure and the IP network is referred to as the "Machine to Machine" (M2M) component of the platform. It is important that this is considered as part of the platform as buying bandwidth in bulk will reduce costs for all of the members of The Connected Train platform. We also have to consider the provisioning and de-provisioning of trains, train operating companies and infrastructure, all of which generate work which will be carried out by the Network Operations Center (NOC).

When passengers or crew connect to the WiFi they will be presented with a user experience that acts as a gateway to all the features.

What is the technology behind The Connected Train?

Passengers

- ▶ Vanilla customer portal
- ▶ Train company branded portals
- ▶ Support for Train company content editors
- ▶ Editorial services available from Platform
- ▶ CRM content and services available from Platform

Vanilla skin	Train skin	Train skin	
Passenger portal			

Crew & Operators

- ▶ Operator app store containing rail portfolio
  - group licencing
  - individual licencing
  - competitor products
- ▶ Vanilla operator app menu
- ▶ Support for Train company content editors
- ▶ Editorial services available from Atos
- ▶ CRM content and services available from Atos

Operator app store	Vanilla skin	Train skin	Train skin	
	Operator portal			

Partners

- ▶ Developer content and portal
- ▶ Partner registration and account home
  - portfolio management
  - data access
  - Billing and revenue collection
- ▶ Administration interface
- ▶ Reports

Partner portal	Administration

Human layer

The Connected Train has three main user groups. The platform offers a user experience for each group. Different themes can be created for operator and passenger facing experiences.

Experience layer

Core Modules layer

Content Management System (widgets, themes, plugins)	Context Broker	Identity (SAML, O_Auth)	Payments engine	Data analytics	Settlement engine

PaaS

Foundation IT

The above software layer diagram visualizes how this architectural component works. At the bottom of the diagram is the infrastructure layer that provides the Platform as a Service (PaaS). Above this are generic architectural components that provide essential features such as identity management and security. Above this the platform is divided into the three main user experiences.

How much bandwidth does a passenger need?

To be able to determine how much bandwidth a passenger needs we will first have to think about what it is the passenger wants to do today and what you expect them to be doing throughout the lifetime of the infrastructure elements of The Connected Train platform.

Ideally passengers would like a seamless experience whilst traveling, just as in the office or at home. This means the ability to not only process their email and meeting requests, but to also consume media and engage with social networks. 50 or 100 Mbit/s is now commonplace in mainland European homes and can adequately service many devices simultaneously accessing the Internet.

Additionally, we expect smart device penetration to reach 90% by 2017[v] with many passengers having more than one active device. On commuter routes you often see passengers using their computers or tablets at the same time as other devices. We expect that each passenger will need to be able to access 8 Mb/s in order to achieve the experience they desire.

In 2018 the day-to-day technology of passengers will be very different. We can expect to see mass adoption of wearable computing, the Internet of Things, IPv6 and heads-up display technology (Google Glass). All of these new usages of the Internet will consume considerable bandwidth. Assuming that Moore's Law applies in order to meet passengers' demands The Connected Train must offer 12 Mb/s to each passenger.

[v] eMarketer Report published May 2013

How much bandwidth will a train need?

The bandwidth calculation is a complex one, not least because it depends on the nature of the traffic being consumed by the user. On the train today passengers use connectivity for their essential activities only, and with free access generally confined to business customers this funnels the activity to the checking of corporate email and browsing the Internet. The scarce resource is also controlled today to protect the quality of service for all.

The market demand and the services that we will provide in future will drastically change the type of traffic being consumed. Opening up free at the point of need, Internet access will change the demographic and therefore common applications in use. This will include highly interactive services with constant traffic, such as Facebook messaging, and high-bandwidth demand for video streaming from the likes of Netflix and YouTube.

On average there are 500 passengers on our trains; and we expect in future most will want to exploit the new platform of services that The Connected Train will enable.

Scaling up our previous passenger bandwidth estimates, this new world will cause a leap in bandwidth requirement to a range initially somewhere between 100Mb/s and 1Gb/s. However we also expect Moore's Law to apply in this field, causing bandwidth demand to double every two years.

Mapping the projected demand against prevailing and future mobile connectivity technologies leads to definitive technology inflection points in 2017 and 2021. At these times we will need to increase wireless uplink bandwidth (the limiting factor) to meet train demand as depicted in the diagram below.
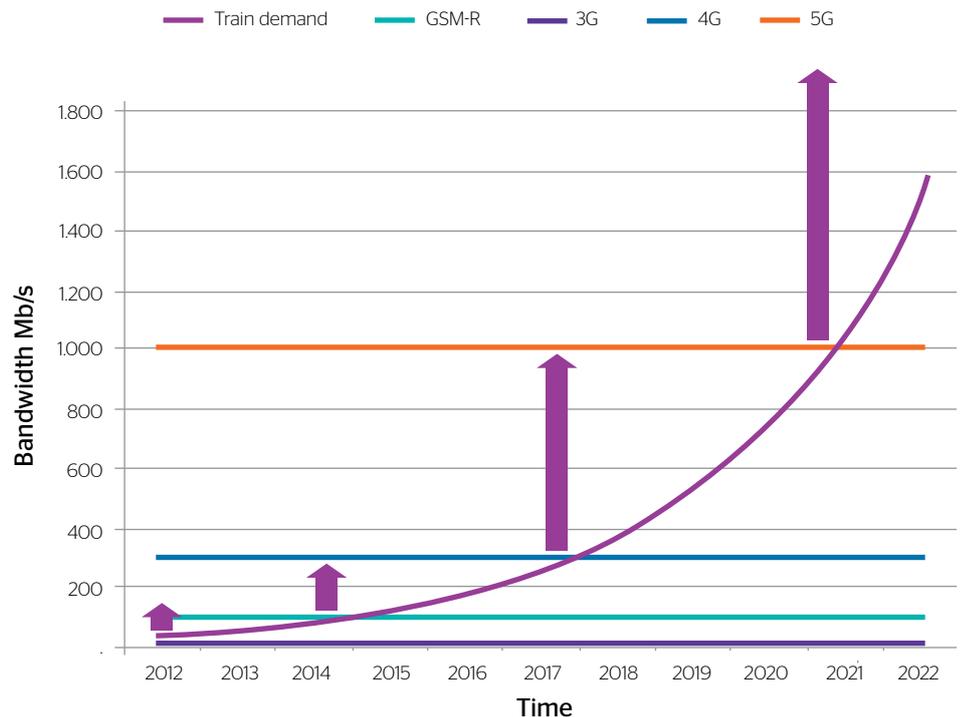
Passenger-driven demand of the type described above will result in bandwidth requirements that dwarf operational demand by crew and train systems. It will be important to ensure the technological solution addresses this, and to apply Quality of Service (QoS) to ensure the priority of the operational traffic.

Whilst the bandwidth to address the operational requirements of The Connected Train could be met by 3G technologies, we believe it will necessary to introduce 4G and higher technologies quickly as connected passengers drive up demand.

How is the experience different on The Connected Train?

The Connected Train offers far more to passengers than just bandwidth. The ConnectedTrain offers the potential for many other services. The attractiveness of these services is what makes the platform sticky, providing value to all the stakeholders. For example context information such as the status of the rail network or the current position and desired destination of the traveler can be used to improve the pre, post and travel experience. We have divided the features that are beyond Internet access into six categories.

Retail
In transit - food and beverage upgrades •
At station / Online - buyon line, collect at station •
Contextual advertising and pormotions •
Retailing networked multi modal products (e. g. car) •

Operational Efficiency
Internet of things for train maintenance •
Crew information and decision systems •
Data to support routing and configuration decisions •
Smart city integration i. e. multi modal decisions •

Safety and Security
Passenger assist •
Passenger alors •
Report / Find lost property •
Alert re broken facilities •

Infotainment
• Internet radio
• Social networking
• Large assets available over the train Wi-Fi
• Movies on the train

Connected Navigation
• Traffic - Understand delays at destination
• Journey planning / react to changes
• Live weather
• Events at destination

Community
• In transit - food and beverage upgrades
• At station / Online - buyon line, collect at station
• Contextual advertising and promotions
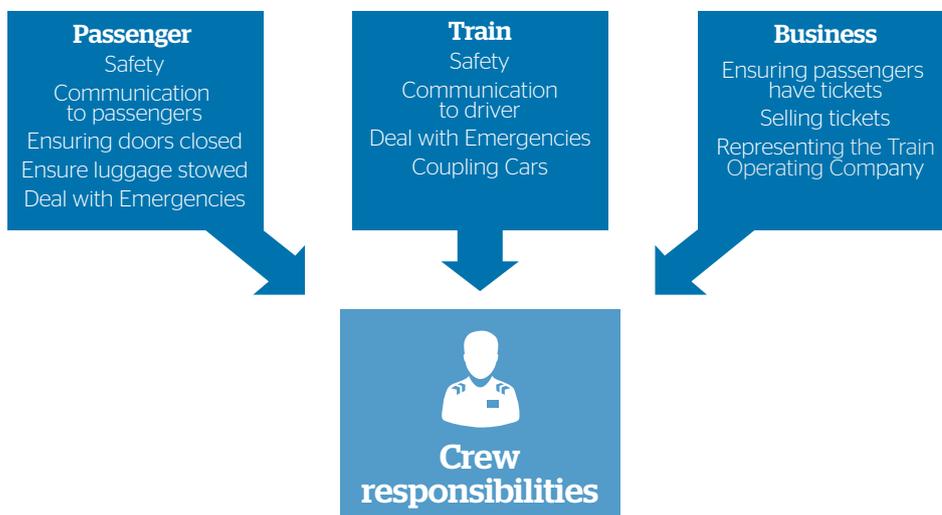• Retailing networked multi modal products (e. g. car)

The Connected Train

There are many new features that a connected train can offer. Passengers desire to be entertained and new forms of entertainment can be created that use their position or destination, a simple example is an I-spy game for a child's gaming device that asks them to identify the things they can see out of the window. Unlike any other form of transport a train is a social environment, take a look next time you travel and you will see people interacting and enjoying the ride. Technology has not yet penetrated this part of the rail travelers' experience - The Connected Train offers this opportunity.

What does The Connected Train mean to crew?

The train crew is an essential aspect of the operation of the railway. The Connected Train offers them technology solutions that can enhance their performance and effectiveness. The role of the train crew can be split into three: the performance of the train, helping the passenger and servicing the business of the train operating company.

Passenger	Train	Business
Safety	Safety	Ensuring passengers have tickets
Communication to passengers	Communication to driver	Selling tickets
Ensuring doors closed	Deal with Emergencies	Representing the Train Operating Company
Ensure luggage stowed	Coupling Cars	
Deal with Emergencies		

Crew responsibilities

Building on the concepts designed and delivered by the Atos connected car we are working towards a crew appstore which will offer a set of applications supplied from companies across and outside of the rail industry that have been certified for use in rail. This open market of crew applications will help to promote innovation and will provide a central transaction engine for ticket sales allowing small to medium enterprises to monetize their products.

Train crews have to give advice to passengers, often providing information on on connecting services, arrival times and selling tickets. The Connected Train offers them a deeper and richer set of information products to do this that can be context and passenger aware. This is also an opportunity to upsell products that fit into the train operating company service system such as parking or concessions. There is an opportunity to tell stations about trains which are overcrowded before they arrive. This gives passengers the knowledge on which to base a decision as to whether to get on this train or wait for the next one.

The Connected Train offers the possibility to provide the crew with complex real time information to a mobile device that can be used anywhere on the train.

Their duty to the train

The crew's primary responsibility is for the safety of the train. In an emergency situation they have to behave in the interests of all the passengers in the train and passengers in other trains that could collide with their train. Consequently communication with the driver and the network operator is essential and a high priority. The more operational aspect of their role is performing minor repairs to passenger areas of the train and the coupling and decoupling of rolling stock. A recent incident saw a train operating company being fined when the train had broken down and there was no good information given to passengers. The passengers phoned the infrastructure operator who kept telling them wrongly that there would be a rescue train along in 10 minutes. Simple communications in emergencies is a good use of The Connected Train.

Their duty to the passenger

The crew is also responsible for the communication with the passenger and performing checks such as making sure the doors are closed properly and that luggage is effectively stowed. Occasionally the crew will administer first aid to passengers and some have been known to deliver babies.

Their duty to the business

Ultimately the train operating company is a business and the crew is the embodiment of the brand to the passenger. They perform a role in checking that passengers have tickets or the right to travel and they can often sell tickets or related products such as food and drink. Connected stock management systems will increase retail performance.

In addition to access to the Internet The Connected Train can help the crew by providing social media information from the passengers or simple training videos to help them learn about their job. It also offers to help connect them with the wider crew online communities many of which offer advice and support to help them be successful in their job.

How should The Connected Train be branded?

Historically brands were trademarks ensuring quality (e.g. Kellogg's) then, after the advent of consumer advertising, brands became concepts promising emotional benefits (e.g. Marlboro) or inviting belonging (e.g. Virgin). Recently however a new kind of brand has emerged which enables people to take action (e.g. Amazon, Wikipedia, Google, YouTube, Facebook, Skype). The role of these so called 'platform brands' is to be useful to the user. They evoke a sense of taking part and the commercial benefit to the brand owner and the user experience for the consumer is enhanced by the network effect of having a large number of users[vi].

We believe that The Connected Train should be a platform brand as the benefits to the travelers and the platform owners are magnified by the network effect. In the UK this could be an ingredient brand beneath the brand of each train operating company or vice versa. Ideally the brand should be capable of being used globally. Consideration should be given to the benefits of using an existing brand (such as National Rail) versus a new brand (Intrainet?).

Conclusion

It is environmentally and politically advantageous to switch travelers into rail from other modes of transport. Increasingly passengers expect to be able to make use of their travel time whether to work, perform chores or be entertained. High bandwidth Internet is becoming a default expectation. Passengers cannot carry the cost of the connectivity through ticket price and the proposal to exchange individual's data for low cost access to Internet services is equitable and understood by the passenger, so long as it is treated with respect and trust established.

Rail connectivity will happen in the near future, the industry needs to decide what model to adopt and how ambitious to be. This paper argues that cross sector collaboration is the only way to meet passenger demand and that the companies that move now will seize the first mover advantage.

[vi] UEA 2013

About Atos

Atos SE (Societas Europaea) is an international information technology services company with 2013 annual revenue of € 8.6 billion and 76,300 employees in 52 countries. Serving a global client base, it delivers IT services through Consulting & Systems Integration, Managed Operations, and transactional services through Worldline, the European leader and a global player in the payments services industry. With its deep technology expertise and industry knowledge, it works with clients across different business sectors: Manufacturing, Retail & Transportation; Public Sector & Health; Financial Services; Telcos, Media & Utilities.

Atos is focused on business technology that powers progress and helps organizations to create their firm of the future. It is the Worldwide Information Technology Partner for the Olympic & Paralympic Games and is listed on the NYSE Euronext Paris market. Atos operates under the brands Atos, Atos Consulting, Worldline and Atos Worldgrid.

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