Keeping connected:

passengers' experience of internet connectivity on Great Britain's railways

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transportfocus

Contents

1. Executive summary

1.1 Research aims

This report covers research exploring passengers' experience of connectivity when travelling by rail in GB (England, Scotland and Wales). In using the term 'connectivity' the report refers both to the connection to the internet via any on-train Wi-Fi or passenger's mobile connection.

The research aimed to:

- measure the availability and quality of internet and voice connections available to passengers travelling on GB railways;
- explore passenger perceptions and experience of connectivity when travelling by train; and
- to attempt to establish a connection between the quality of the connection which is available and the passenger experience.

1.2 Report structure and methodology

The report is structured to address the research aims outlined using the following three, respective, approaches to data collection:

1. An overview of the current state of connectivity on GB railways is initially provided through an analysis of data which has been 'crowdsourced' by the consultants umlaut. umlaut crowdsourced data is passively collected from commonly used Android smartphone applications and without infringing on personal privacy. A cut of this data, covering those travelling on trains between December 2018 and May 2019, is used in the first part of the report.
2. An understanding of passenger perceptions of connectivity on trains is then provided through the analysis of data gathered via an online survey of Transport Focus' 'Transport User Panel'. 4,752 panellists completed this survey and results are weighted to the profile of those using GB trains.
3. Lastly an attempt to correlate passenger experience with actual connection quality is reported via an analysis of data gathered through a bespoke application designed by umlaut for this purpose. The application, which 252 Transport User Panellists downloaded to their devices, enabled the collection of data concerning both the quality of the connection that panellists received when travelling on trains, and how panellists were using their devices while travelling. Passenger perception of the quality of the connection received on train journeys was also collected via the application through the completion of weekly pop-up surveys.

1.3 Summary of findings

From the umlaut crowdsourced data:

- Based on the data that was collected, and the total amount of data traffic generated from the crowdsourced applications whilst passengers were travelling on trains, almost 96 per cent is carried over mobile network connections while only around 4 per cent is carried over the on-train Wi-Fi.

- Passengers receive a 4G connection for 78 per cent of the time that they are connected via a mobile network connection. This compares with 85 per cent of the time for consumers across GB more generally.

- However, the classification of these 4G connections by received signal strength is only classed as ‘good’ or ‘excellent’ approximately 75 per cent of the time. In effect passengers are only receiving a good or better 4G connection 58 per cent of the time. The overall quality of experience also falls short, when compared to GB-wide results, on metrics associated with average download throughput (i.e. data speeds) and network latency.

- The average internet download throughput of on-train passengers’ connections is 3.3Mbps (average of 3G and 4G data speeds) compared to 1.4Mbps for Wi-Fi connections. In comparison consumers achieve 6.8Mbps and 10.6Mbps respectively across GB more generally. Ofcom considers a minimum of 2Mbps is needed for a good experience.

- Those using on-train Wi-Fi networks also experience higher network latency compared to 4G connections, but have a higher probability of being able to connect to the internet. Both these are related to the design of the on-board Wi-Fi equipment and the equipment’s connectivity to the internet which uses multiple mobile operator connections simultaneously albeit having to serve all passengers connected to the on-train Wi-Fi.

- These findings support the generally-held view that passenger mobile and Wi-Fi internet connectivity is perceived as poor when travelling by train, as highlighted by the twice-yearly National Rail Passenger Survey conducted by Transport Focus.

From the Transport User Panel survey:

- The level of satisfaction with connectivity on trains is generally low, while the expectation of being connected is high. Most passengers also say that at least some of the journey that they most regularly make is affected by poor connectivity. Those travelling for business tend to be least satisfied and have the highest expectations when it comes to being able to make a connection on trains.

  These findings align with the evidence established in this report of poor passenger connectivity on GB trains.

- Being able to send emails, browse the web, send web-based messages and make voice calls are the connected activities which are most important to passengers.

- Three quarters of passengers believe that it is important to improve the connection available on trains. Similarly, most passengers believe that having information available to them regarding the quality of the connection on the trains that they use is important. Again, those travelling for business are more likely than others to take this view. This may be because they are more concerned than other types of passenger to be able to make use of the time that they spend travelling on trains.

From the bespoke application:

- While passengers say that they value being able to send emails and web-based messages, they spend disproportionate amounts of time browsing the internet or using social media when they are connected on trains. This suggests that a consistency of connection would be welcomed by passengers.

- An analysis of the data from the bespoke application provides some indication that passengers who experience faster download speeds and shorter network latencies are more likely than others to say that they were able to do all that they wanted to do on the train journeys that they made. It should be noted that this finding is drawn from a small number of panellists who downloaded the bespoke application.

- While satisfaction with the internet connection appears to some extent to be driven by the quality of the passenger experience, it is likely to be the case that the level of expectation of the individual passenger (travelling for leisure, business or commuting reasons) plays a major role. To draw stronger correlations between the level of connectivity available on trains and passenger experience more research of this type would need to be undertaken, with a commensurate increase in the sample size.

2. Methodological overview

2.1 Introduction

This report presents the findings of research undertaken by Transport Focus and umlaut on behalf of the Department of Transport to explore passengers' experience of 'connectivity' when travelling by train. In using the term 'connectivity' this report refers both to the connection to the internet via on-train Wi-Fi or through a cellular 'mobile' connection. While this report draws upon the work that umlaut has completed for this project, it does not present these findings in full; the full umlaut report is provided as an appendix to this document.

Below we provide an overview of the structure of the report in terms of how each section addresses the question of what connectivity is available to passengers on trains, and what are their related opinions and experience. Within this overview we have provided a short description of how the data which has been used to generate these findings has been collected. A more in-depth description regarding each of the methodologies which have been used is available within each of the relevant sections of the report.

2.2 Overview of the structure of this report

This report is set out in three parts:

- The first part concerns the current state of connectivity on railways in Great Britain (GB) and indicates the quality of the connection which is available to train passengers currently. This part of the report refers to data which umlaut have 'crowdsourced', or passively collected, from applications hosted on almost 80,000 passenger's Android mobile devices. This approach allows us to collect a large amount of information which can be analysed to provide a robust overview of the level of connectivity available to passengers in GB.

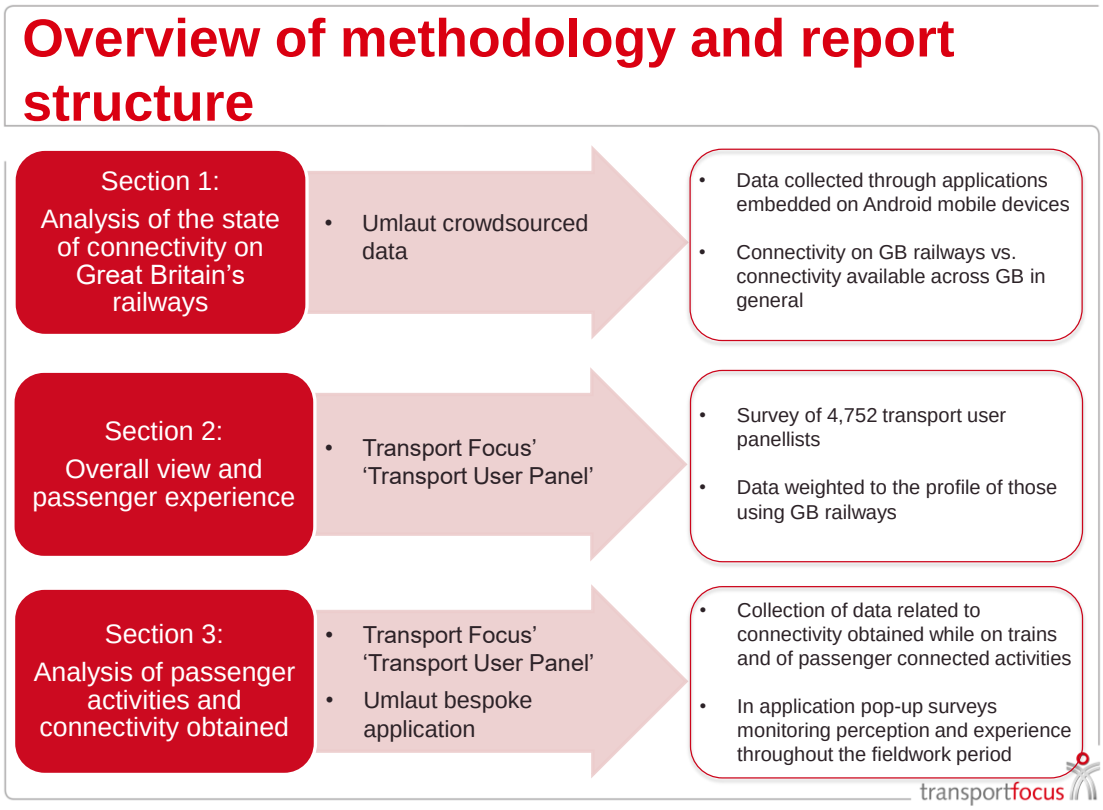
- The second part looks more closely at passengers' perceptions, experiences, and behaviours related to connectivity on GB railways. To generate these findings an online survey was undertaken with 4,752 members of Transport Focus' 'Transport User Panel who use trains no less than once every three months. Data used to generate the findings covered in this part of the report has been weighted to the profile of the Spring 2019 wave of the National Rail Passenger Survey[1].

- The third part concerns a pilot exercise where an attempt is made to correlate the level of connectivity available on trains (from part one), and the passenger experience and expectations (from part two). To do this the research made use of a bespoke application, loaded onto 252 Transport User Panellists' Android mobile devices, which collected information regarding what these

[1] https://www.transportfocus.org.uk/research-publications/publications/national-rail-passenger-survey-nrps-spring-2019-main-report/

passengers were doing on their devices as they travelled on trains, and data relating to the quality of the connection that they obtained. This information was enhanced by the collection of passenger experience data by the use of pop-up surveys which were generated from within the same application.

Fig. 1: Overview of methodology and report structure



3. Part one: current state of connectivity on Great Britain's railways

3.1 Overview

3.1.1 Introduction to the analysis of umlaut crowdsourced data

As indicated above, an analysis of the quality of the connectivity available to those using trains in Great Britain (GB: England, Scotland and Wales) has been derived though the use of umlaut 'crowdsourced' data. umlaut gathers this data by embedding a crowdsourcing solution into applications which are commonly downloaded on consumers' Android devices. This solution passively collects data from the device and only stops once the application is uninstalled by the device user.

The umlaut solution collects anonymised data which provides performance indicators relating to the end users' experience of the mobile network or Wi-Fi which is available; this data includes measures of the mobile coverage, the quality of the signal available and from which technology this connection can be made (whether 2G, 3G or 4G).

The crowdsourced data used for this research was passively collected from 220,000 individual Android devices used across GB during a six-month period from December 2018 to May 2019. The crowdsourced data was post-processed to geographically correlate the location and direction of travel information with GB rail routes. The resulting GB rail dataset represents data collected from 79,000 out of the 220,000 individual Android devices during this time.

3.1.2 Definition of key metrics analysed

The data provided by umlaut indicates the quality of connectivity available on GB railways in terms of several metrics: technology share, coverage quality, mobile network data service availability, download throughput, network latency, and voice call performance. A short description detailing each of these metrics is provided below.

Technology share: The technology share information gathered allows us to analyse the mobile technologies which are being used to access the internet, that is whether the connection is made through a 2G, 3G, 4G, or Wi-Fi connection. Using this information, a data network technology share metric is derived which reports the ratio of seconds per network technology used across all data sessions related to each of these technologies.

Coverage in terms of signal quality: While the amount of time that consumers access various network technologies is of interest, the quality of the signal which is received is of key importance to the consumer experience. In this report a metric for the quality of the coverage is derived by categorising 4G connections based on the received signal strength in decibels relative to

one milliwatt (dBm) and analysing the proportion of the 4G connections collected which fall into the 'good' or 'excellent' categories.

Availability of an internet connection: The data service availability performance indicator is a measure of a consumers' ability to connect to the internet at any given time. Periodically the umlaut solution on the consumers' device will check if it can make a connection to the internet via a mobile or Wi-Fi network. In this report we discuss the proportion of the time that the umlaut solution finds that a successful connection can be made.

Download throughput and consumption: Throughput, or download speed is a measure of the actual amount of data which is transferred during the time that a consumer makes a connection. This is measured in megabits of data transferred per second (Mbps), with the total data consumed measured in megabytes (MB) where eight bits equals one byte and one million bytes is a MB.

Network latency: Network latency or response time is defined as the delay between a consumer making a request to the network for information, and the network providing this information back to the user. This responsiveness is measured, and reported, in terms of milliseconds (ms) of time with lower speeds representing a better consumer experience.

Voice call performance: The umlaut solution also collects information on voice calls, in terms of the technology used to make the call (either via mobile network or through a Wi-Fi connection using mobile operators' 'Wi-Fi Calling' as opposed to voice-over-IP services such as Skype™), the duration of the call, and the a call success measure, which is related to the connection being made and ended by the passenger and not lost because of network issues. In this report we measure voice call performance by the proportion of the successful calls out of all calls which are attempted or made.

In the following section comparisons are made, as appropriate, between:

- 'GB-wide' data reflecting the applicable metric, such as the average availability of an internet connection, as experienced by consumers not travelling by rail such as at home, or in the office or elsewhere, or travelling by other modes of transport;
- 'GB mainline routes' data reflecting the applicable averaged metric as experienced by passengers travelling on a mainline as defined in Annex 1;
- 'Non-mainline routes' data reflecting the applicable average metric as experienced by passengers not travelling on a mainline;
- 'All rail routes' data reflecting the applicable averaged metric as experienced by passengers travelling on any rail route including mainlines.

3.2 Crowdsourced data findings

3.2.1 Introduction

As described, the findings reported here are crowdsourced from 220,000 Android mobile devices used across GB from December 2018 to May 2019. A cut of this data sourced from 79,900 Android devices is used to evaluate the consumer experience on the GB rail network over this time.

By aligning geographical data collected by the umlaut solution with the position of GB rail routes, we have been able to compare findings for mainline and all rail routes.

Of the 79,000 unique devices associated with rail travel during the data collection period, data was collected from 56,700 Android devices which had been used on mainline routes and 40,500 which had been used on non-mainline routes within the fieldwork period.

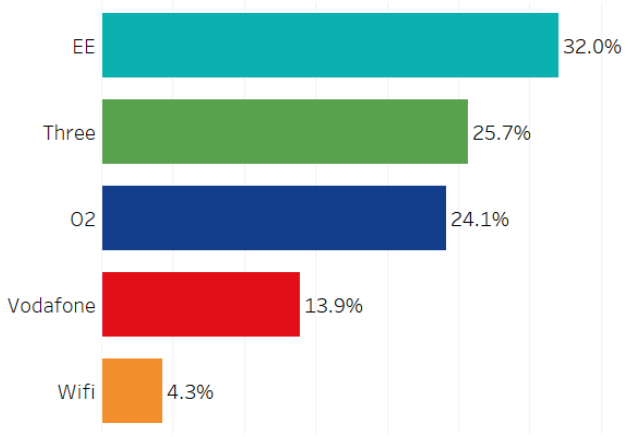
It should be noted that where analysis by mainline route is provided in this report, this should not be taken as an analysis of the specific train operating company's 'performance' as several companies may operate trains over the same routes.

3.2.2 Technology share

The analysis of the umlaut crowdsourced data highlights that almost 96 per cent of all data consumed by passengers during their rail journeys is carried over mobile network connections, with only 4 per cent carried over an on-board Wi-Fi connection (Fig. 2).

The figure also shows the percentage split by mobile operator; noting that the results presented reflect market share, as well as the average data consumption of their customers which varies considerably between mobile operators.

Fig 2: Percentage of total data consumed by passengers by mobile network operator and through on-board Wi-Fi whilst travelling on all rail routes

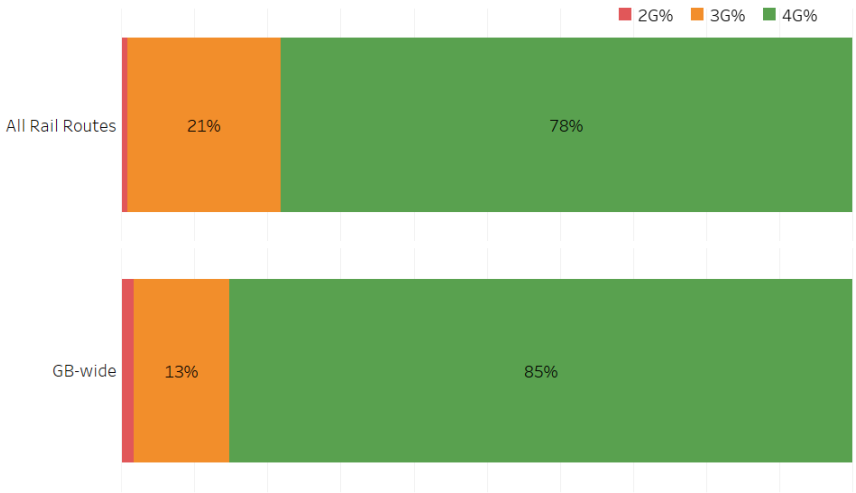


Those travelling by train, who are able to connect to their mobile network operator, are able to make a 4G connection for 78 per cent of the time that they are using a mobile network (Fig. 3).

This compares unfavourably with consumers across GB generally who are able to make a 4G connection for 85 per cent of the time when connected to a mobile network.

Those travelling by train receive a 3G connection for 21 per cent of the time that they are using a mobile network, whereas across Great Britain generally a 3G connection is received 13 per cent of the time.

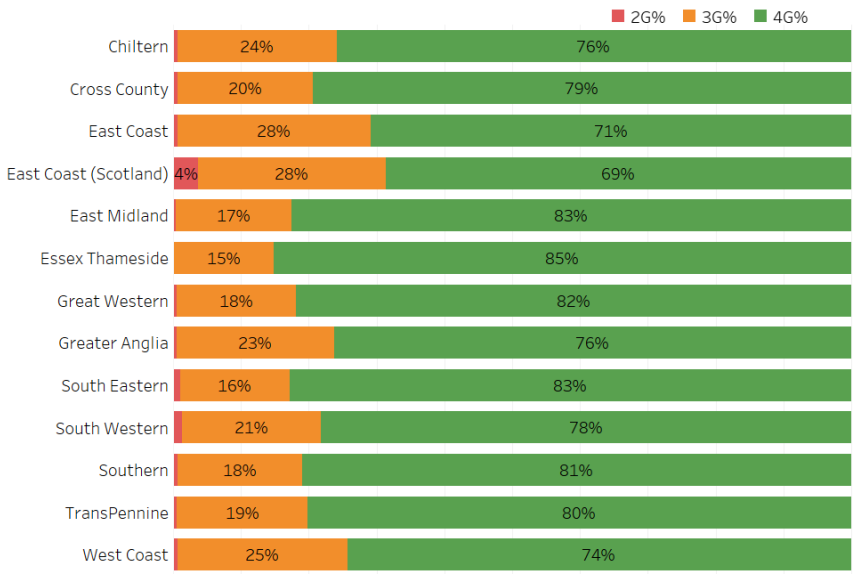
Fig 3: Percentage of time consumers are able to make a 2G, 3G or 4G network connection – All rail routes versus GB-wide



The percentage of time that those travelling by train are able to receive a 4G connection when using a mobile network varies by GB mainline route (Fig. 4).

Passengers travelling on the Essex Thameside mainline, East Midland mainline, Great Western mainline, South Eastern mainline, Southern mainline, and TransPennine mainline are able to connect to a 4G network for more than 80 per cent of the time. Conversely, those using the East Coast mainline are able to make a 4G connection for 71 per cent of the time, and among those using the East Coast (Scotland) mainline the ability to make a 4G connection falls to 69 percent.

Fig. 4: Percentage of time consumers are able to make a 2G, 3G or 4G network connection – GB mainline routes



Inferences

The findings show that the availability of a 4G signal tends to be worse when travelling by train than across GB generally, but passengers overwhelmingly use their mobile network operators' services.

Although not forming part of this research, possible reasons for the low usage of the on-train Wi-Fi may include:

- The perceived and actual poor quality-of-experience via the on-train Wi-Fi as highlighted in this research;
- Passengers switching their devices' Wi-Fi off to avoid the 'pop-up' message for known Wi-Fi access points, or not having Wi-Fi turned on by default;
- Passengers may have privacy concerns about using the public on-train Wi-Fi;
- The extra effort or time required to register and log onto the on-train Wi-Fi discourages use particularly on short journeys; or even
- Passengers forget to logon to the on-board Wi-Fi.

As described later in this document, passengers using the on-train Wi-Fi actually consume more data. Possibly because the availability of the on-train Wi-Fi's connection tends to be more consistent, albeit at lower speeds.

3.2.3 Coverage in terms of signal strength

The bars on mobile devices generally indicate the level of signal being received by the device – in effect the 'signal strength' or a proxy for the quality of the signal.

To undertake an analysis of the strength of the 4G coverage (assumed to be the service most likely to provide passengers with an adequate internet experience) all 4G connections derived from the crowdsourced data were categorised based on the connection's recorded signal strength measured in decibels relative to one milliwatt (dBm).

The categorisation assigning measured signal strength to one of five categories (ranging from 'Very Poor' to 'Excellent') is shown in the table below[2].

Table 1: Categorisation of 4G signal strength

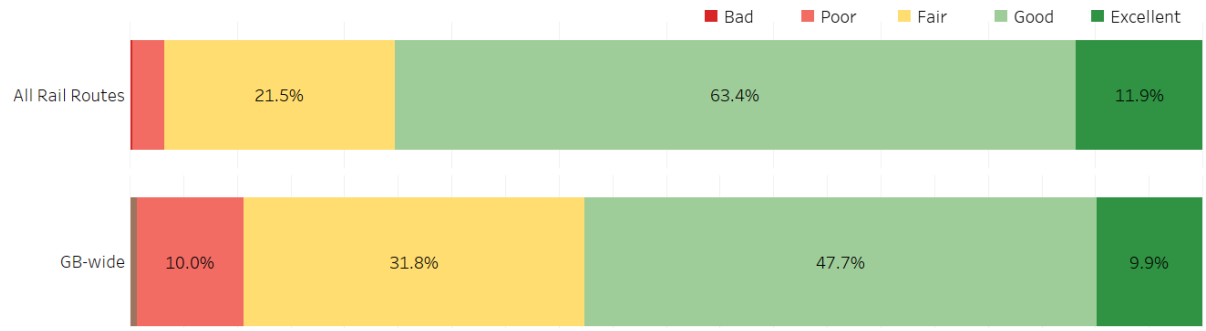
Categorisation	Very Poor	Poor	Fair	Good	Excellent
Between (dBm):	-139	-119	-109	-99	-84
And (dBm):	-120	-110	-100	-85	-45

Using this approach, Figure 5 shows that when connected to 4G the signal strength-based coverage available to those travelling on trains across all rail routes is actually higher than that available to consumers GB-wide.

Around 75 per cent of the 4G connections made on GB rail routes are rated as 'excellent' or 'good' compared with almost 58 per cent of the 4G connections made across GB as a whole.

[2] To note: this categorisation is based on umlaut's expertise. Ofcom considers the threshold for good outdoor coverage to be -105 dBm, and that other aspects, such as network congestion, can affect the 'quality' such that the categorisations do not necessarily reflect the actual end-to-end quality received.

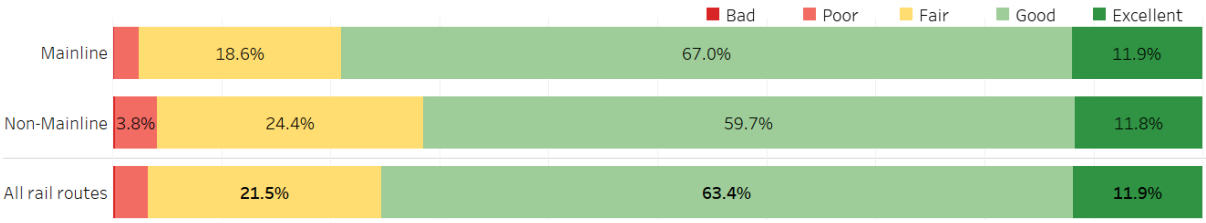
Fig. 5: Categorisation of 4G received signal strength – All rail routes versus GB-wide (noting that rail passengers can only connect to 4G 78% of the time compared to 85% GB-wide as per Figure 3)



The signal strength-based 4G coverage is higher on GB mainline rail routes than for non-mainline routes.

Around 79 per cent of 4G connections made on mainline routes are rated as excellent or good compared with 71 per cent of 4G connections made on non-mainline routes (Fig. 6).

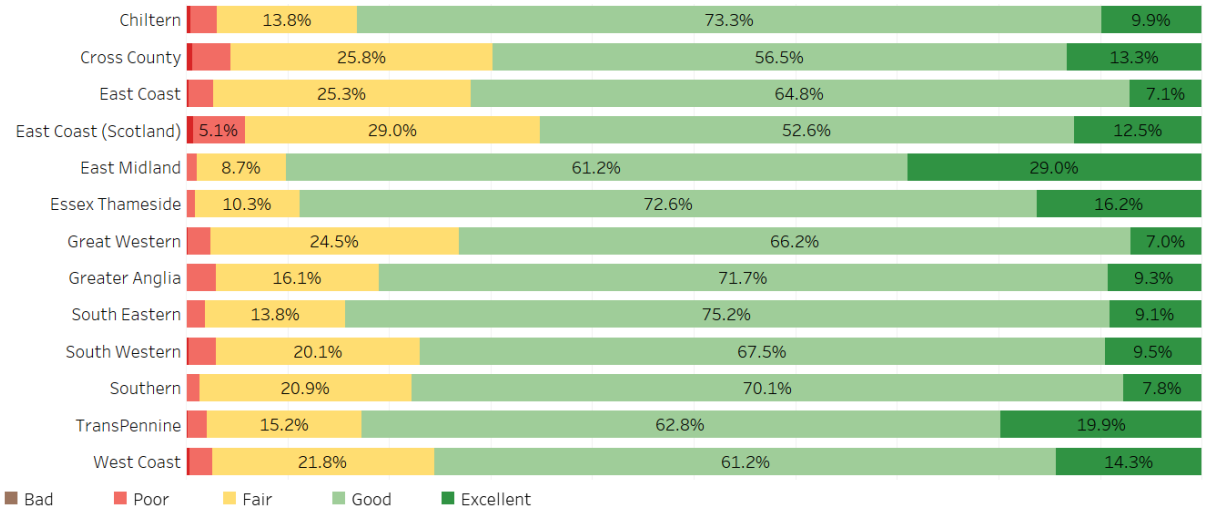
Fig. 6: Categorisation of 4G received signal strength – GB mainline routes versus non-mainline routes compared to all rail routes



As well as being among those mainline routes which offer the greatest 4G network availability, the East Midland mainline and the Essex Thameside offer the highest 4G signal strength based coverage (Fig. 7); around 90 per cent and around 88 per cent of the 4G connections made on each of these mainline routes respectively are rated as excellent or good.

Again, as with 4G network availability, the East Coast (Scotland) and East Coast mainline routes are among those offering the poorest signal strength based 4G coverage quality with 72 per cent and 65 per cent of 4G connections being rated as excellent or good for each of these mainlines respectively.

Fig. 7: Categorisation of 4G received signal strength – GB mainline routes



Inferences

As noted, on average passengers across all rail routes are only able to make a 4G connection 78 per cent of the time (Fig. 3) and actually receive a 4G signal rated as excellent or good approximately 79 per cent of the time (Fig. 5).

In effect therefore, on a GB all rail route basis, approximately 62 per cent of passengers actually receive a 4G signal rated as excellent or good.

Whilst the GB-wide equivalent is just 49 per cent – seemingly indicating that rail connectivity is significantly better – the GB-wide figure includes significant indoor measurements, as well as measurements from within vehicles and rural locations with poor coverage quality.

Although getting a decent signal is considered as a necessary condition to receiving connectivity from a mobile network, a signal strength measurement is an insufficient indicator of a good quality of experience.

Indeed, given a reasonable signal strength, the quality of the experience is largely affected by other factors such as the download speed offered by the network, network congestion and network-induced latencies (delay).

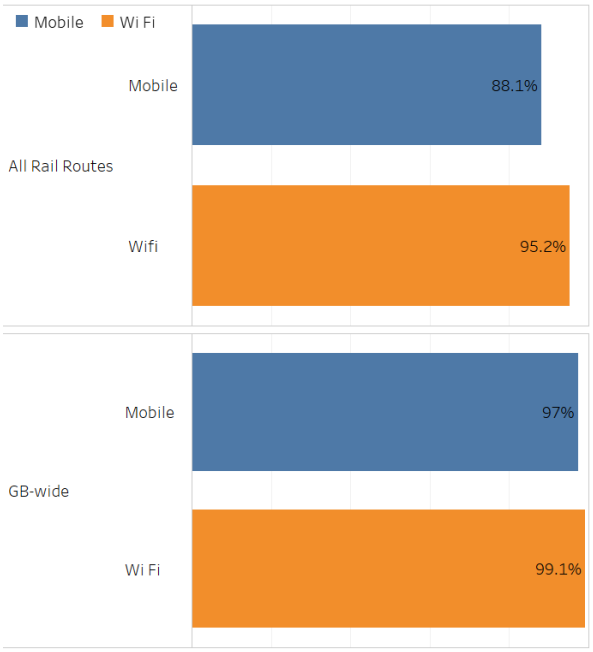
3.2.4 Availability of an internet connection

Overall, consumers receive a more consistent connection to the internet if they make this connection through a Wi-Fi network rather than through a mobile network.

Rail passengers are able to connect to the internet 95 per cent of the time if they make this connection through the on-board Wi-Fi compared to 88 per cent of the time via their mobile network operator connection (Fig. 8).

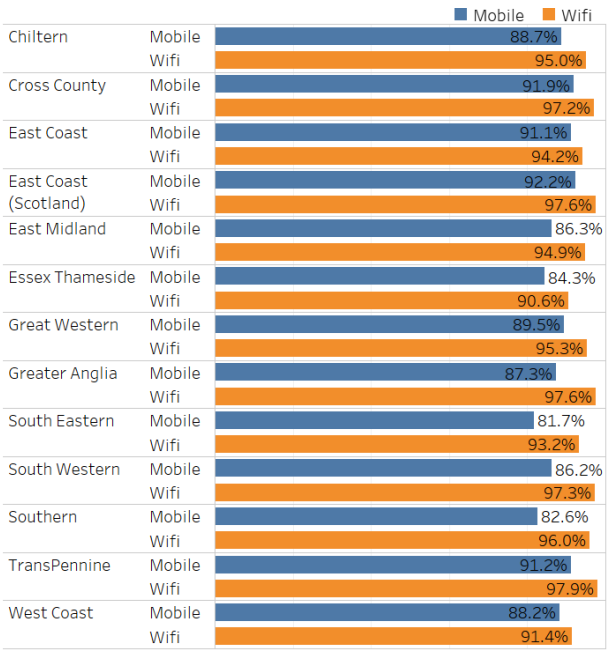
In comparison, consumers GB-wide generally are able to make a connection to the internet 99 per cent of the time if this connection is made through Wi-Fi and 97 per cent of the time when connected via their mobile network.

Fig. 8: Percentage of time that consumers can connect to the internet by technology type – All rail routes versus GB-wide



Passengers receive a more consistent connection to the internet over on-train Wi-Fi than they do when using a mobile network connection is true across most mainline routes (Fig. 9).

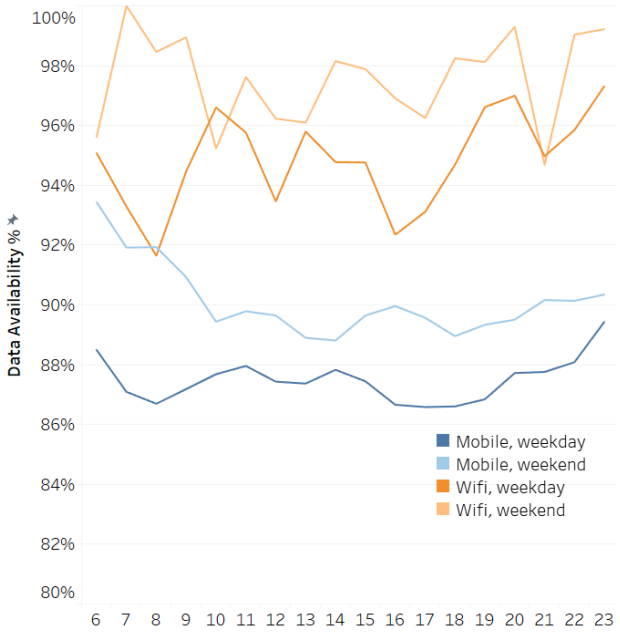
Fig. 9: Percentage of time that consumers can connect to the internet by technology type – GB mainlines



The percentage of time consumers are able to connect to the internet by hour by average week day and weekend day shows a pronounced difference between mobile network operator connections and those through the on-train Wi-Fi (Fig. 10).

The analysis also shows that the consistency of the connections to the internet during passengers' rail journeys, regardless of whether the connection is made via Wi-Fi or through a mobile network, improves at weekends.

Fig. 10: Percentage of time passengers are able to connect to the internet by time of day, by typical week day and weekend, by technology type – All rail routes



Inferences

The results show perhaps unsurprisingly that the percentage of time that it is possible to connect to the internet, even when a 3G or 4G signal is available, is worse when travelling by train compared to GB-wide equivalent metrics (derived from Fig. 8).

However the possibility of connecting successfully via a mobile connection improves at weekends compared to during the week (Fig. 10). This reflect earlier comments that signal strength alone is an insufficient indicator of the quality of a connection and other factors such as the number of passengers and network congestion play a role.

The generally higher availability of internet connectivity when passengers connect over the on-train Wi-Fi reflects the design of the on-train Wi-Fi service. The on-board Wi-Fi equipment uses multiple subscriptions with different mobile network operators to provide an aggregated connection to the internet and hence a higher likelihood of maintaining a constant connection between the train and the internet.

Whereas a passenger using their mobile operator subscription may find that the connection drops out in places where there is no external signal coverage, if they are using the on-board Wi-Fi the system's multiple different mobile operator connections is likely to mean there is at least coverage and internet connectivity via one of these connections. This also explains why, just like passengers mobile phones, the on-train Wi-Fi internet connection also does not work in longer tunnels as there is no connectivity at all.

When taken with the earlier calculation that approximately 62 per cent of the time passengers have an excellent or good 4G connection, the ability to actually connect

to the internet through a mobile connection is just 54 per cent (assuming that the figure of 88.1 per cent derived from Fig. 10 which is for both 3G and 4G connections applies proportionately for 4G connectivity).

3.2.5 Download throughput and consumption

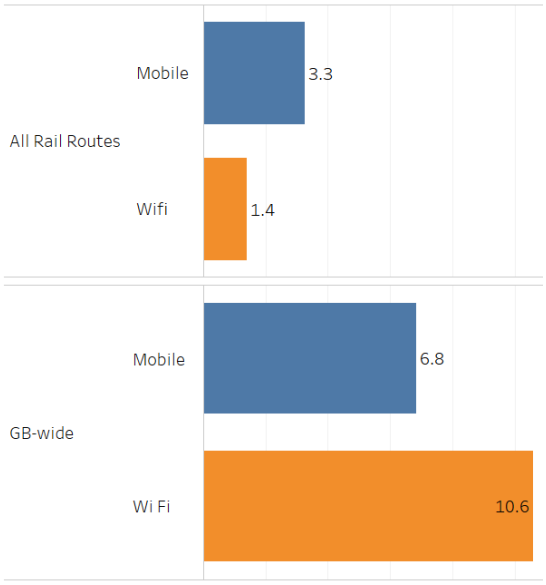
The download speed or 'throughput' experienced by those travelling on trains is significantly lower than that experienced by consumers GB-wide (Fig. 11).

On average passengers travelling by rail obtain download speeds of 3.3 Mbps when connected through their mobile network operator's 3G and 4G services and 1.4 Mbps when making an on-train Wi-Fi connection.

This compares with average download speeds of 6.8 Mbps for mobile connections, and 10.6 Mbps for Wi-Fi connections for consumers generally GB-wide.

Whilst consumers GB-wide generally experience a better download speed when connected to Wi-Fi than when making a connection through a mobile network, the situation is reversed for those travelling by train.

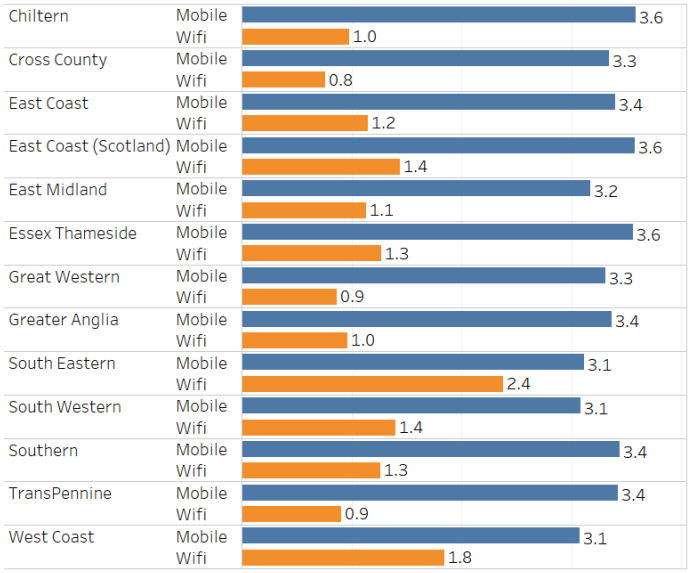
Fig. 11: Average download speed per passenger or consumer in Mbps by technology – All rail routes versus GB-wide



There is a significant disparity between the average download speeds available to passengers making a connection via the on-train Wi-Fi compared with those making a connection via their mobile network operator is consistent across all mainlines (Fig. 12).

In terms of Wi-Fi connection, passengers using the South Eastern mainline and those using the West Coast mainline receive better download speeds than passengers travelling on other mainline routes.

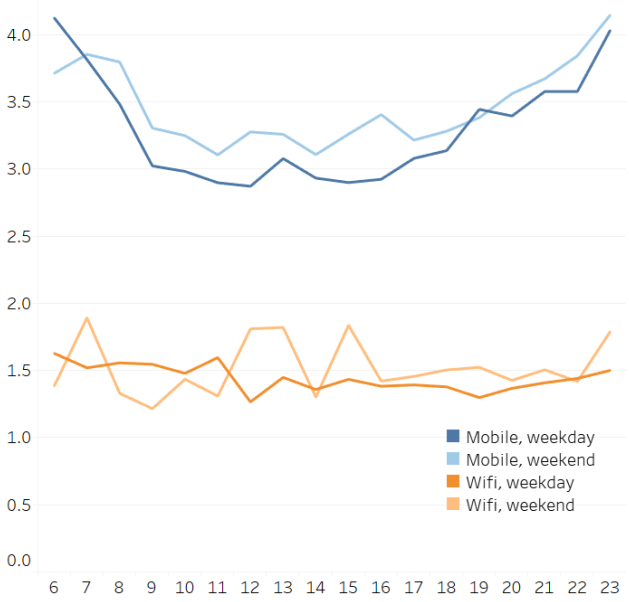
Fig. 12: Average download speed per passenger or consumer in Mbps by technology – GB mainline routes



Passengers generally experience better download speeds when travelling at the weekend than they do when travelling during the week (Fig. 13).

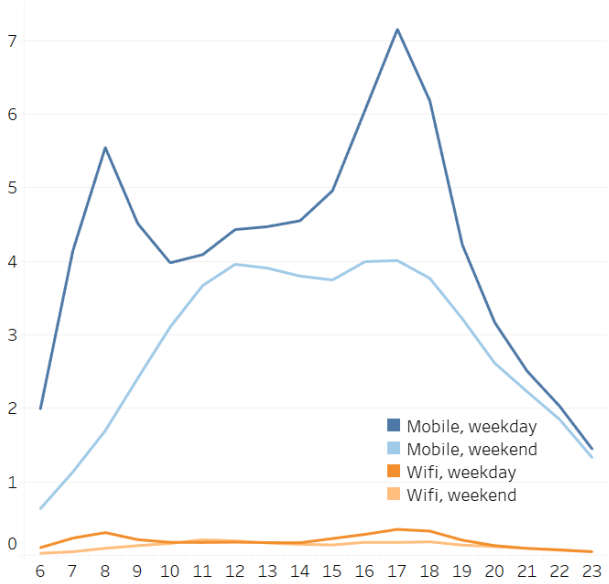
In terms of general performance, the average download speed available through the on-train Wi-Fi connection remains relatively stable throughout the day, whereas that available through a mobile network connection tends to degrade between 6am and 10am, remains consistent during the middle of the day, and improves after 7pm.

Fig. 13: Average download speed per passenger in Mbps, by time of day, by typical week day and weekend day, by technology – All rail routes



Peak periods of data consumption correlate with peak weekday travel periods, between 8 and 9 am and between the hours of 4 and 6pm (Fig. 14). These peak periods are less obvious at weekends and when a connection is made through the on-train Wi-Fi.

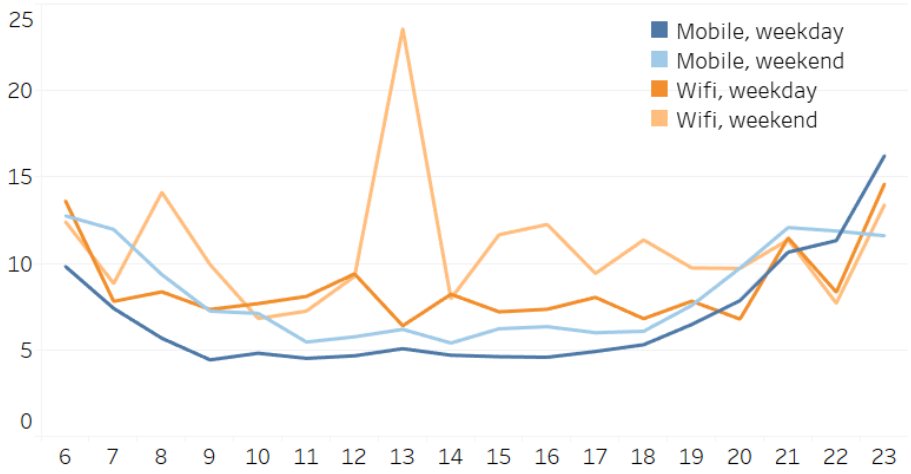
Fig. 14: Average hourly volume of samples in thousands by time of day, by typical week day and weekend day, by technology type – All rail routes



The typical weekday data consumption of a passenger varies significantly throughout the day (Fig. 16) with more than double the data consumption outside of busier periods.

Although the data traffic carried by the on-board Wi-Fi accounts for a small proportion of the overall data traffic, when a passenger connects to the on-board Wi-Fi the analysis shows that they tend to consume more data.

Fig. 16: Average data consumed in MBytes by a passenger during a session, by time of day, by typical week day and weekend day, by technology – All rail routes (note: the 'spike' in the weekend Wi-Fi data is an artefact of the analysis and sample size)



Inferences

The average download speeds are a good determinant of a passenger's likely experience of accessing the internet.

Ofcom considers a minimum of 2Mbps is needed to achieve a good customer experience[3], so these results highlight that the on-train Wi-Fi falls short (Figs 11, 12, 13).

As noted earlier, the design of the on-train Wi-Fi equipment is the key factor. Although there may be multiple mobile operator connections between the on-train Wi-Fi equipment and the internet (normally between three and four) these have to be simultaneously shared with all Wi-Fi connected passengers, as opposed to each passenger being able to make a connection directly.

Ultimately the congestion either happens at the on-train Wi-Fi equipment, or in the case of directly connected passengers at the mobile operator's base station cell site.

That average download speeds are generally better for consumers GB-wide, than they are for those travelling by train, reflects mobile network operators' focus on serving areas where people live, work and socialise, as well as the availability of 'good' Wi-Fi provided by home and business broadband services.

Perhaps the most interesting result is that the average data consumption of those passengers choosing to use the on-train Wi-Fi is generally higher than those using their mobile devices (Fig. 16). The higher general availability of the Wi-Fi connection

[3] https://www.ofcom.org.uk/data/assets/pdf_file/0022/111937/consultation-700mhz-coverage-obligations.pdf

(Figs 8, 9, 10) means that a slower more generally available connection may provide beneficial.

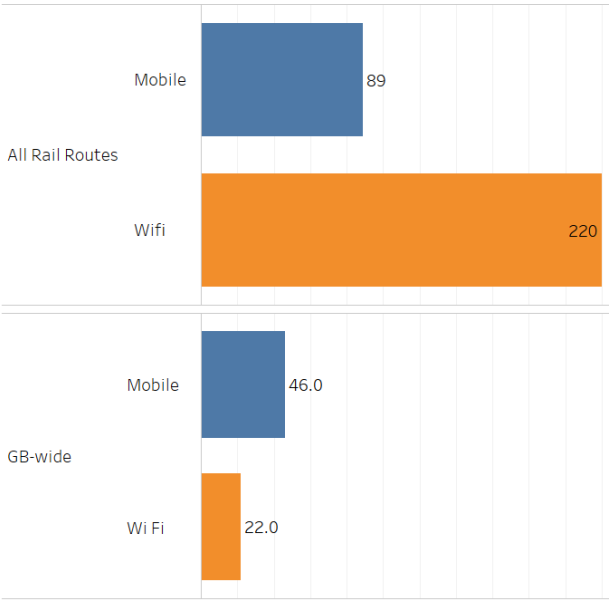
3.2.6 Network latency

In a network, latency measures the time it takes (delay) for data to travel across the network. It affects quality-of-experience when accessing the internet, e.g. download speed, responsivity, etc. It is generally measured in milliseconds (ms)[4].

When compared to GB as a whole, the average latency of the connections available on GB rail routes is relatively poor. This is particularly the case in relation to on-board Wi-Fi networks.

Across GB generally consumers can expect to experience an average network latency of 46ms when using a mobile network connection, and an average of 22ms when using a Wi-Fi connection (Fig. 16). This compares to average network latencies of 89ms and 220ms for the on-train mobile and Wi-Fi networks respectively.

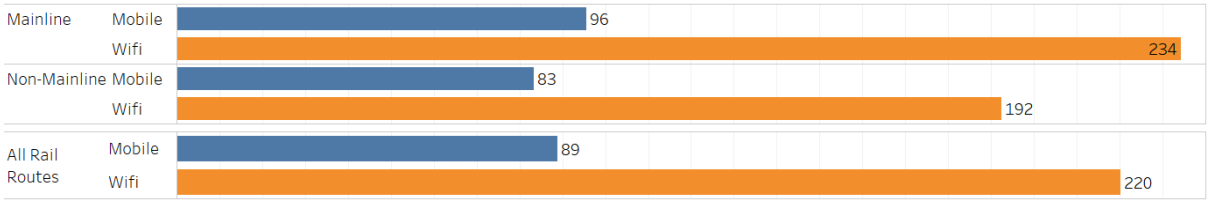
Fig. 16: Average network latency in milli-seconds by technology type – All rail routes versus GB-wide



Non-mainline rail routes show a marginally improved average network latency when compared to mainline rail routes (Fig. 17). Across all mainline routes average network latency is better for mobile connections than it is for Wi-Fi connections. Average on-board Wi-Fi network latency is worst on the East Coast mainline at 371ms.

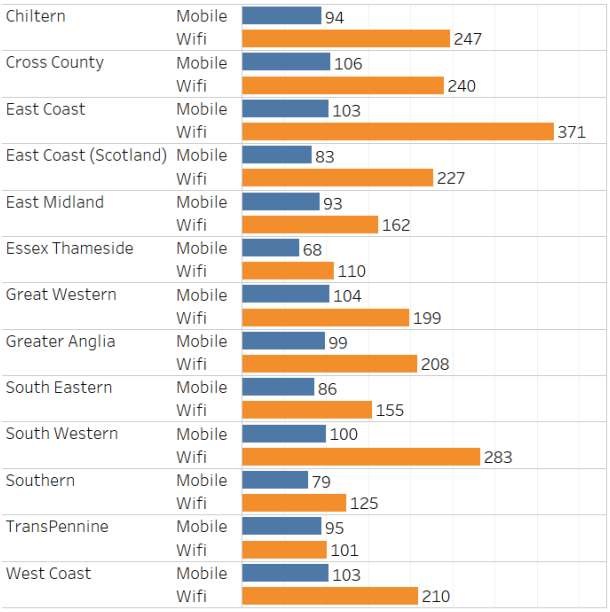
[4] One millisecond equals one thousandth of a second.

Fig. 17: Average network latency in milli-seconds by technology – Mainline routes, versus non-mainline routes versus all rail routes



These findings are also reflected in the individual mainline results (Fig. 18).

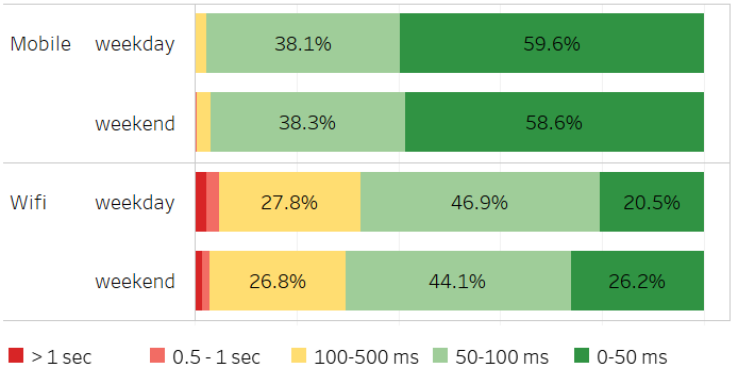
Fig. 18: Average network latency in milli-seconds by technology – GB mainlines



The poor average latency of the network connections available on rail routes is further demonstrated when latency is categorised by connection type and weekday vs. weekend period (Fig. 19).

Analysis of this type shows again that on-board Wi-Fi networks have a worse average latency than mobile networks, and also that performance is worse during weekdays as compared to weekends. During weekdays almost 33 per cent of the connections made through on-board Wi-Fi networks have an average latency slower than 100ms.

Fig. 19: Categorisation of average network latency, by typical week day and weekend day by technology type – All rail routes



Inferences

As with the earlier comments, the on-train wireless access points, Wi-Fi equipment and the multiple internet connection design all introduce additional latency.

The combination of the lower average data speed of on-train Wi-Fi connections coupled with higher latency will clearly impact passengers' experience of the service.

3.2.7 Voice call performance

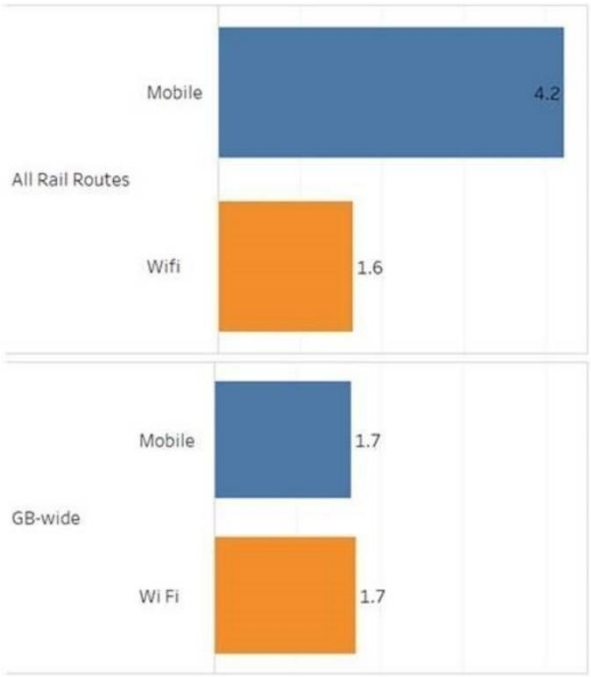
Overwhelmingly, passengers making voice calls on trains do so via their mobile network operator connection, rather than using their mobile operators' 'Wi-Fi Calling' feature (not to be confused with voice-over-IP services such as Skype™ or WhatsApp™) and the on-train Wi-Fi service.

From the analysis 98.3 per cent of voice calls made on trains are made via direct mobile network connections compared with 1.7 per cent of calls over Wi-Fi.

The average duration of a successful call made by rail passengers is 4.2 minutes for those making a call via their mobile network operator's connection, and 1.6 minutes for those making a call over Wi-Fi (Fig. 20).

This compares with an average duration of 1.7 minutes for calls regardless of whether connecting via their mobile network operator or Wi-Fi GB-wide.

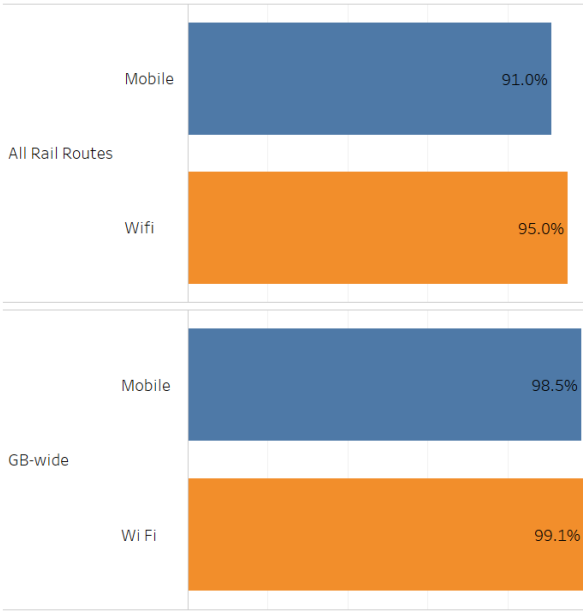
Fig. 20: Average call duration in minutes by technology – All rail routes versus GB-wide



Across GB generally (Fig. 21) only around one in a hundred calls made through either mobile network connections or Wi-Fi networks fail (99% call success).

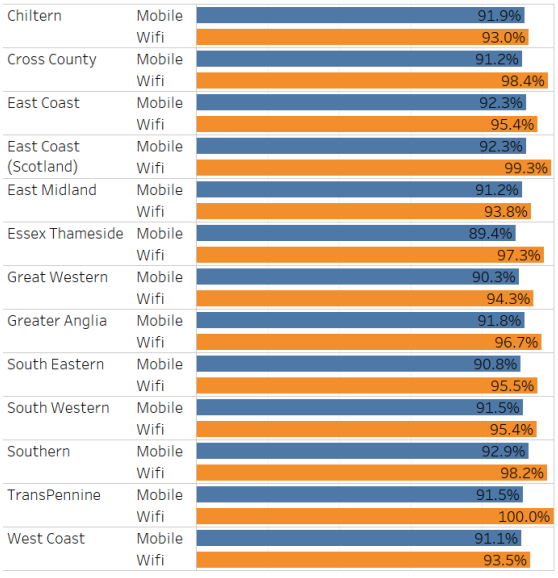
When voice calls are made on trains using a mobile network connection around one in ten calls fail (90% call success), while one in twenty calls fail if a call is made on a train using Wi-Fi calling (95% call success).

Fig. 21: Percentage of successful calls ('call success rate') by technology – All rail routes versus GB-wide



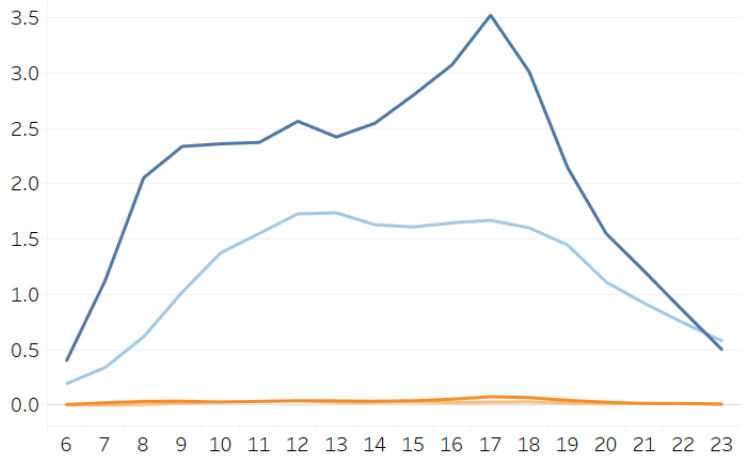
Across nearly all mainline routes a greater proportion of voice calls made over on-board Wi-Fi networks are completed successfully than those made via a mobile network connection (Fig. 22).

Fig. 22: Percentage of successful calls ('call success rate') by technology type – GB mainline routes



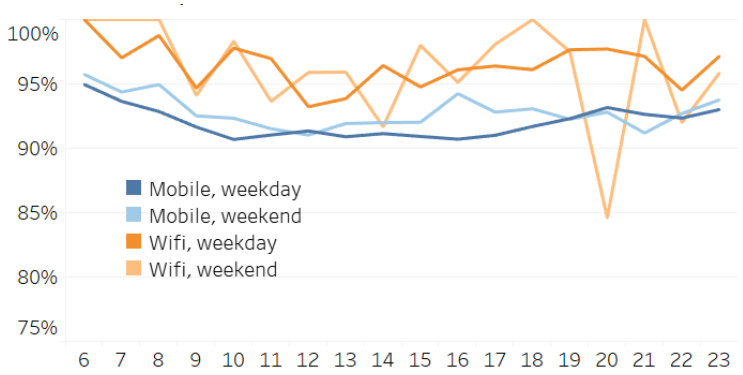
While the previous metrics tend to show an increased volume of data traffic generated by rail passengers during the week associated with the morning and afternoon peak periods, voice call volumes, particularly those calls made during the weekday using a mobile connection, peak at around 5pm.

Fig. 23: Successful call volume (in thousands) by time of day, by typical week day and weekend day, by technology – All rail routes



Analysis of the rate of successful calls made using both mobile and Wi-Fi networks increases over weekends compared with weekdays, with no significant variation in performance observed throughout the day.

Fig. 24: Percentage of successful calls by time of day, by typical week day and weekend day, by technology – All rail routes



Inferences

As noted, one in ten calls made by rail passengers using their mobile network operators' connections fail, though the average duration of such calls is approximately two and a half times the typical duration (Fig. 21).

If the distance travelled is taken into consideration the reason for the higher failure rates can be partially explained. During their 4.2 minute successful call a rail passenger on a mainline train travelling at 100mph (161kph) will have covered 7 miles (11.3km). A distance over which there needs to be an uninterrupted signal and good quality of connection.

The improved call success rate of Wi-Fi Calling services using the on-train Wi-Fi both reflects the shorter duration of these calls (akin to GB-wide figures) and that the on-train Wi-Fi from the analysis is more generally available.

The marginal increase in the call success rate of all types of mobile and Wi-Fi connections at weekends probably reflect the lower volume of calls generally and hence reduced congestion.

4. Overall view and experience of passengers on Great Britain's railways

4.1 The Transport User Panel

Transport Focus holds a database of people who, after undertaking research for the organisation, have indicated that they are happy to continue to receive transport-related surveys. These transport users provide email addresses to Transport Focus and are periodically invited to complete online questionnaires on a range of relevant subjects.

On 22 July 2019 11,547 panellists, who had previously told Transport Focus that they travel by rail, were emailed an online questionnaire concerning their experience of connectivity on trains in the UK. After a reminder email had been sent to those who had not responded in the initial weeks of fieldwork, the survey closed on 12 August 2019 having been completed by 4,752 panellists who indicated that they use a train at least once every three months.

To ensure Transport User Panel surveys reflect passengers' usage pattern across Great Britain's railways, it was necessary to 'weight' the final survey data. Panel responses are more often from male and older rail users who are more likely to be travelling for leisure reasons, so this weighting process adjusts on these criteria so that the weighted profile is closer to the proportions using the UKs railways. To estimate the proportions to weight to, we drew on the Spring 2019 wave of the National Rail Passenger Survey (NRPS)[5]. In each wave of this biannual survey Transport Focus samples around 25,000 rail *journeys* which can be used to provide a close estimation of the proportions on which to base a weighting of UK rail users.

Weighting as a process impacts on the effective sample size of a survey. For this survey, the efficiency at the overall level is 32 per cent and the corresponding 'effective' sample size of this survey is around 1,500. These values should be considered when interpreting results. The weighting efficiency of any subgroup within the overall survey will vary depending on its composition. We have not calculated the sampling efficiencies for each of the subgroups analysed as part of this report; though in each case they will be no smaller than 32 per cent of the unweighted base which is reported.

Figures 25 and 26 indicate the weighted profile of the sample; as indicated, this largely reflects the profile of those completing questionnaires for the Spring 2019 wave of the NRPS.

[5] https://www.transportfocus.org.uk/research-publications/publications/national-rail-passenger-survey-nrps-spring-2019-main-report/

Fig. 25: Weighted profile of panel sample by age and gender

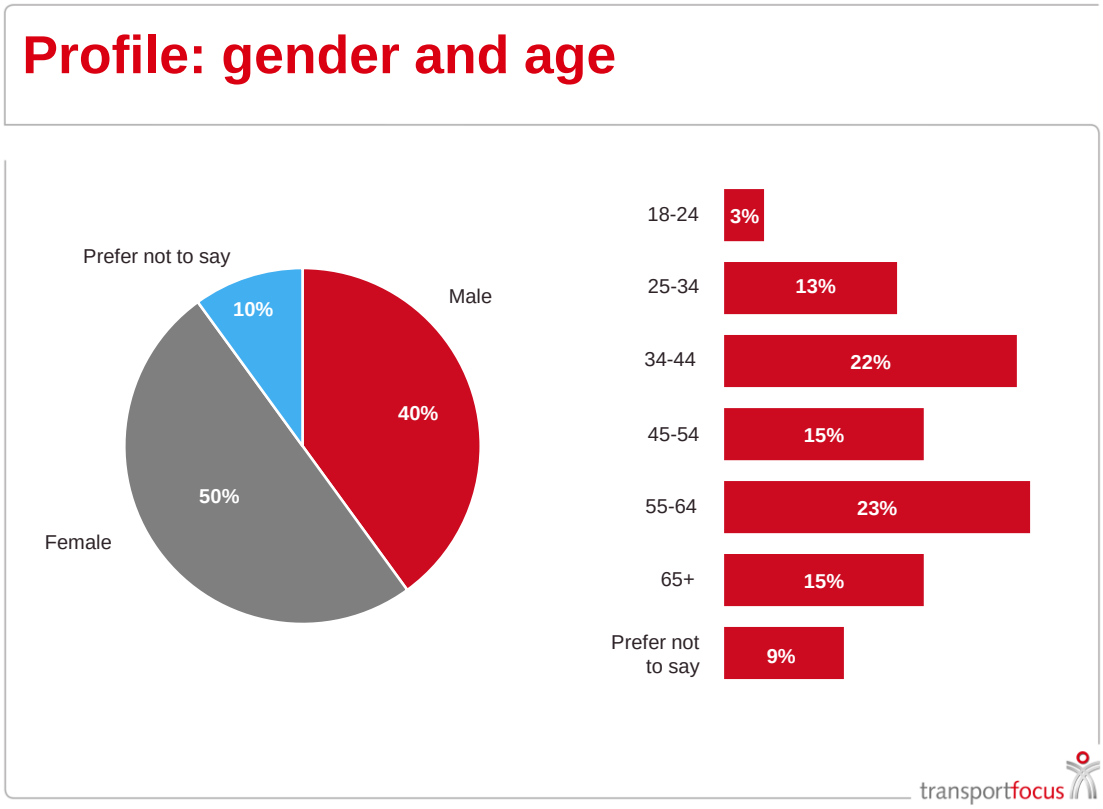
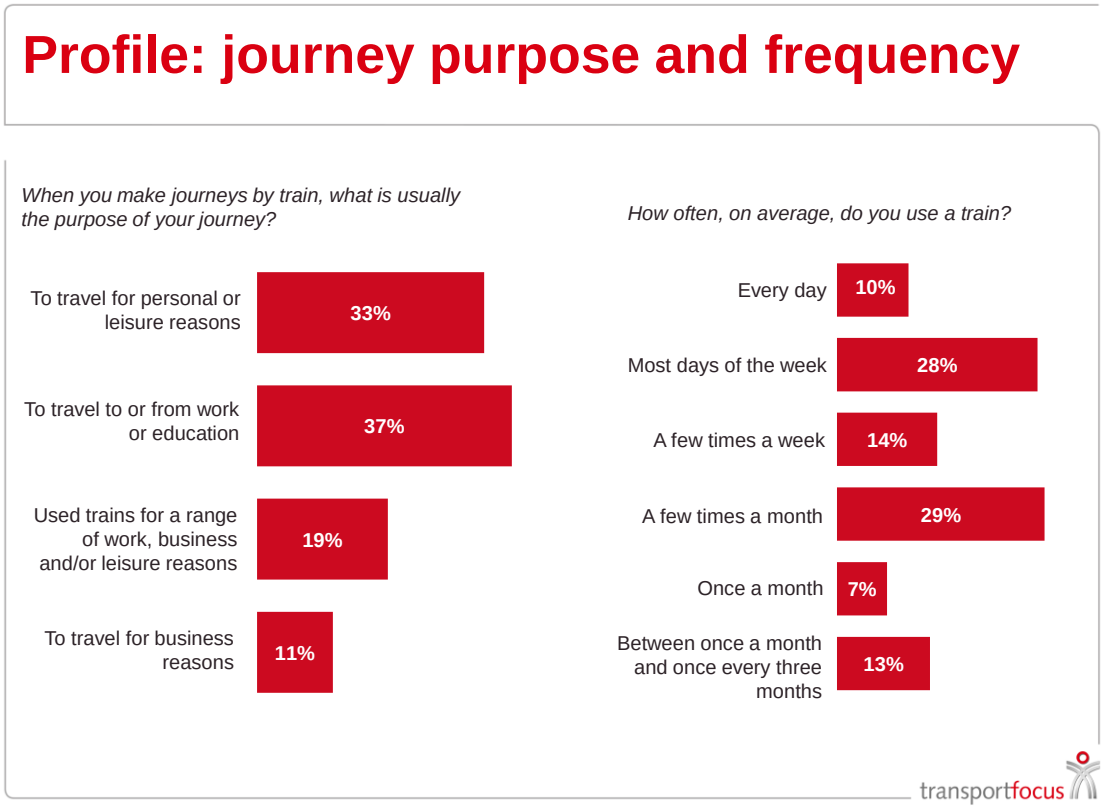


Fig. 26: Weighted profile of panel sample by journey purpose and frequency of rail travel

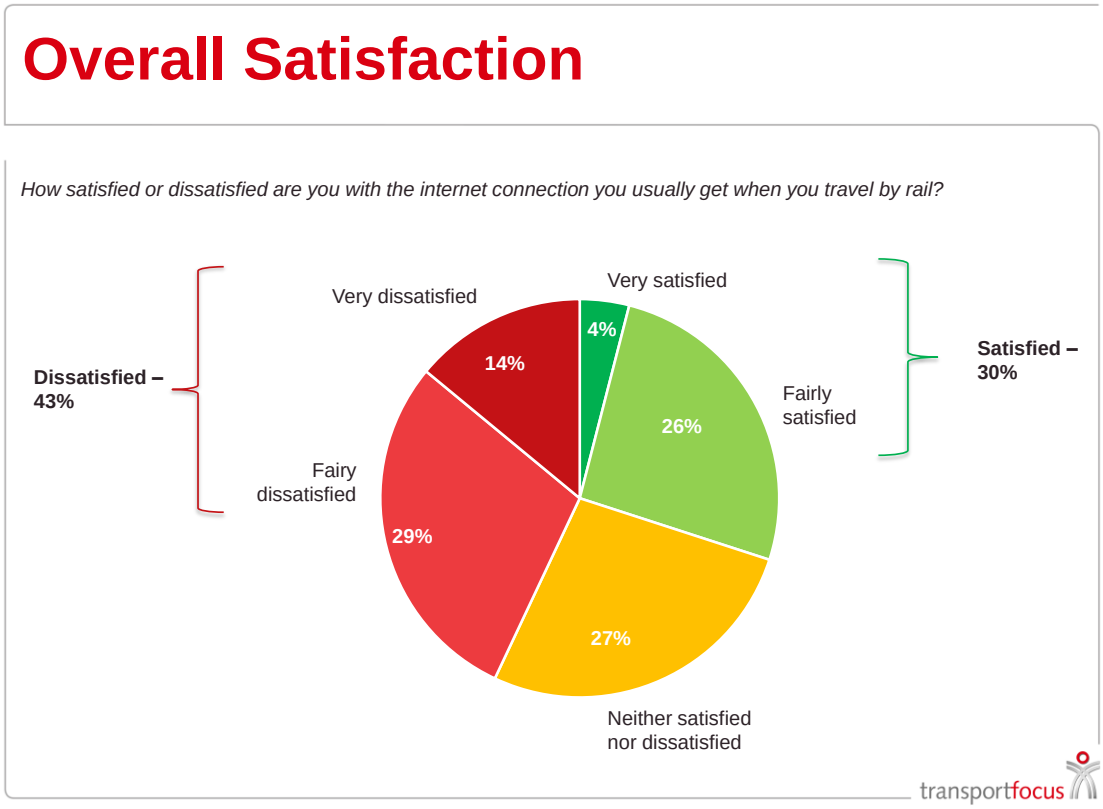


4.2 Passenger perceptions

4.2.1 Satisfaction with internet connection and expectation

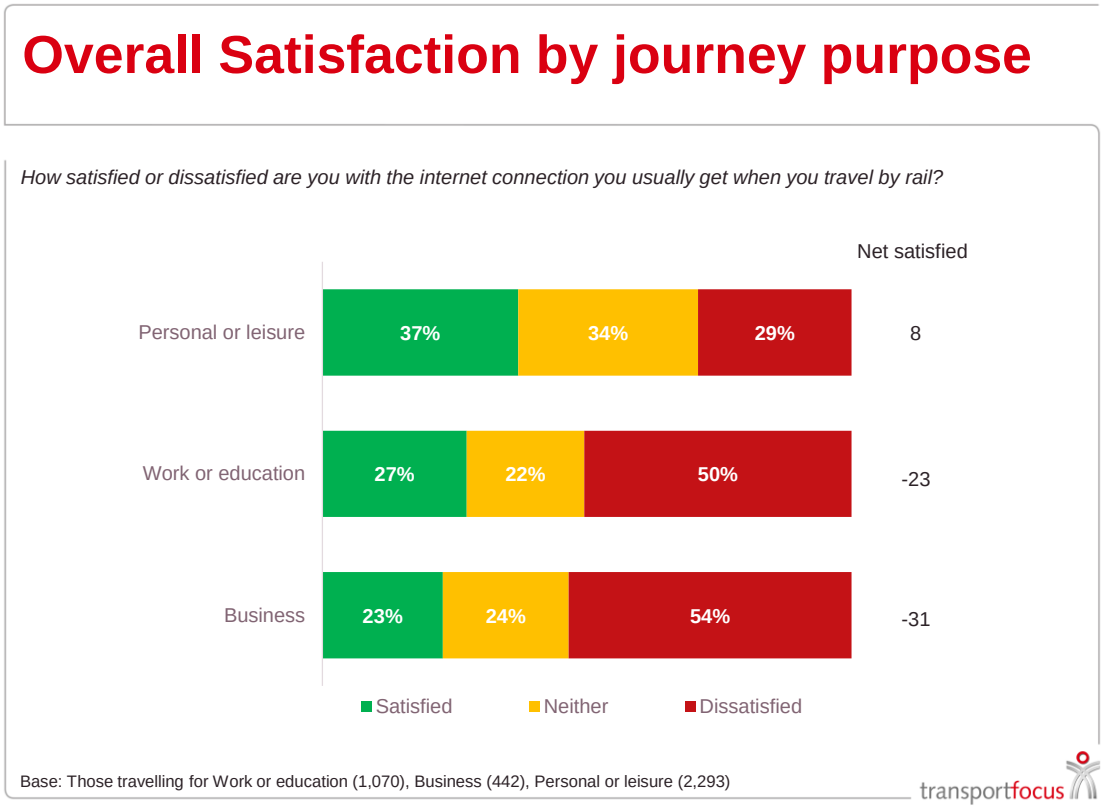
On balance rail users are generally dissatisfied with the internet connection that they usually get when they travel by train. Just over four in ten say this compared with three in ten who indicate that they are satisfied with the internet connection (Fig. 27).

Fig. 27: Overall satisfaction with the internet connection received on trains



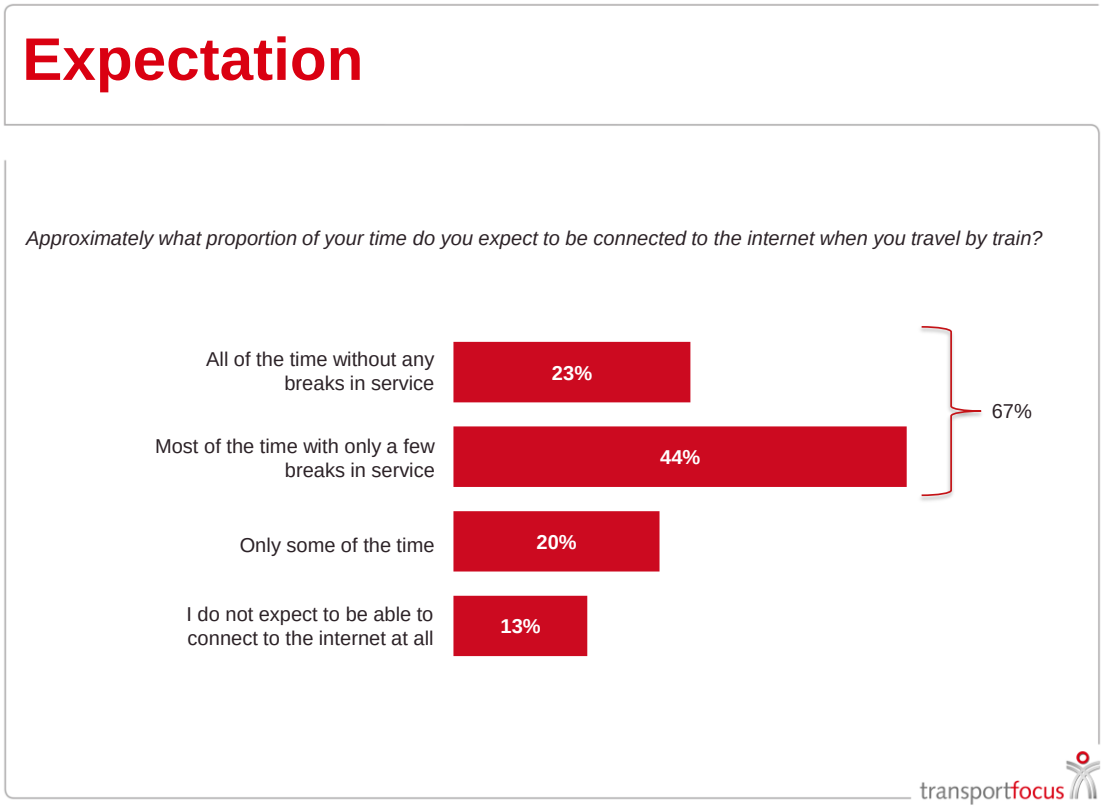
Those who tend to travel for personal or for leisure reasons tend to be more satisfied with the internet connection that they get while travelling by trains compared with other types of rail user (Fig. 28). Findings indicate that those travelling for business reasons are the least likely to be satisfied. In the chart below the difference in the balance of opinion between these subgroups is indicated by a 'net satisfaction' score. This figure is derived by subtracting overall dissatisfaction from overall satisfaction.

Fig. 28: Overall satisfaction with internet connection by journey purpose



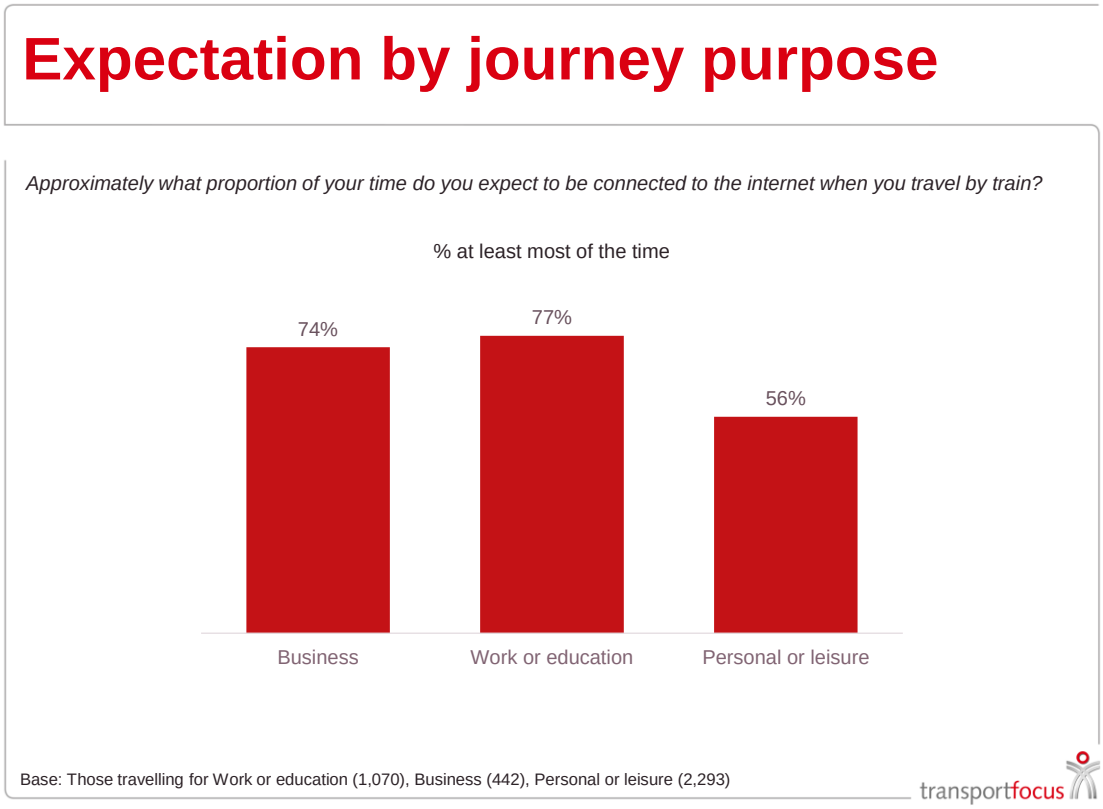
In terms of expectation, two thirds of panellists expect to be connected to the internet *at least* most of the time, with only a few breaks in service, when they travel by train; just under a quarter expect to be connected all of the time with no breaks in service at all (Fig. 29). 20 per cent expect to be connected only some of the time, while a little more than one in ten do not expect to be connected at all.

Fig. 29: Level of expectation of receiving an internet connection while travelling by train



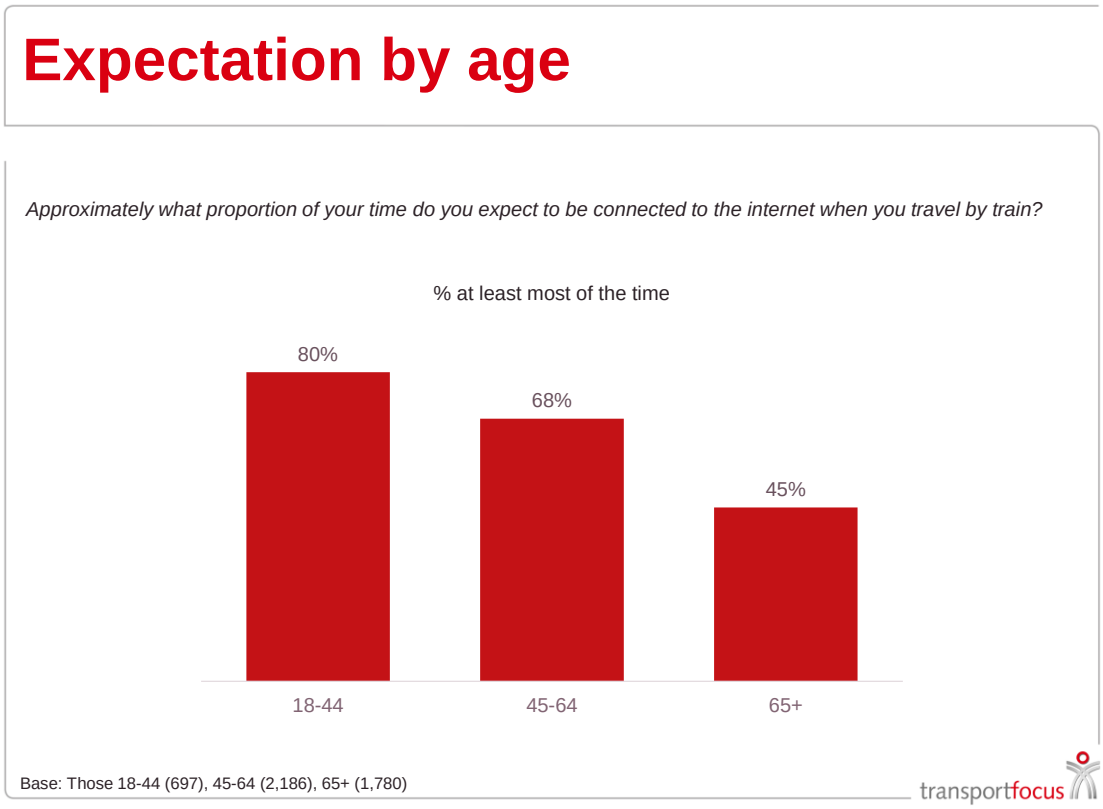
Expectation differs by both journey purpose and by age. Those who are commuting and those travelling for business reasons are more likely to expect to be connected at least most of the time than those who tend to be travelling for personal or leisure reasons (Fig. 30).

Fig. 30: Level of expectation by journey purpose



By age, those who are younger have a greater expectation of being connected when travelling by train than those who are older (Fig. 31). 80 per cent of those aged 18-44 say that they expect to be connected on their journey at least most of the time, while 68 per cent of 45-64 year olds and 45 per cent of those who are 65 or older say the same.

Fig. 31: Level of expectation by age

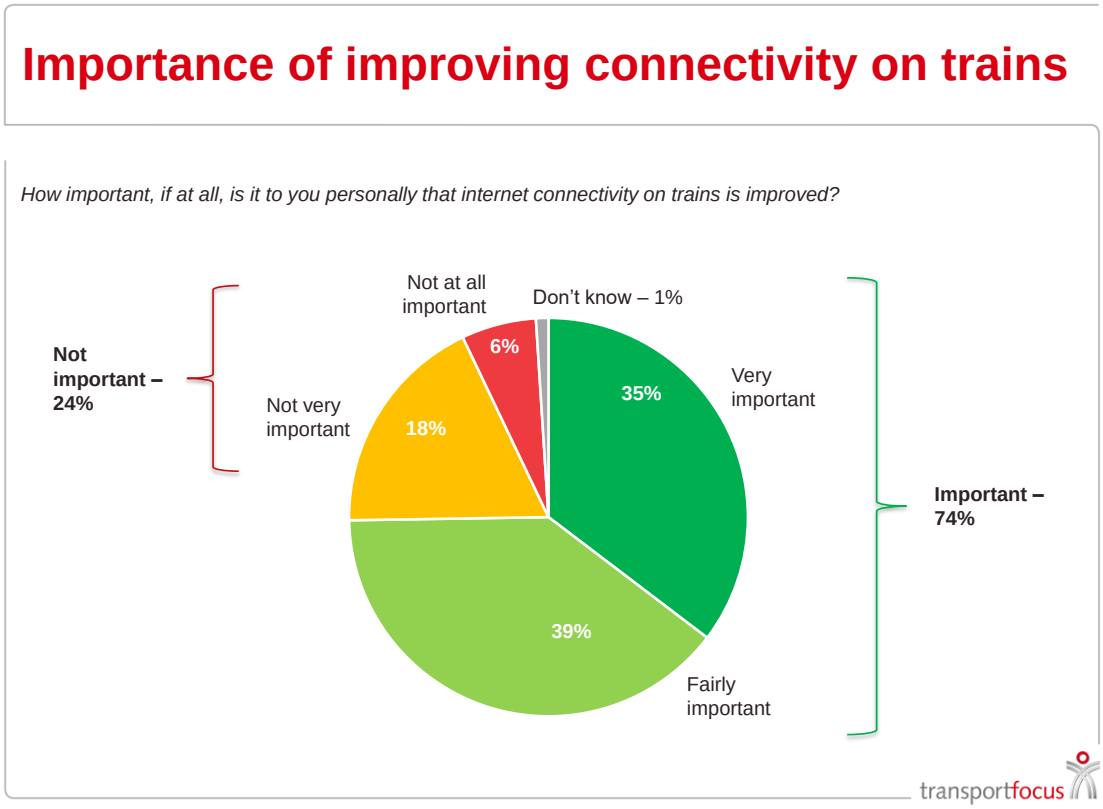


While it is possible that the level of expectation among the younger cohort could decrease as they get older, so that it then reflects the current expectations of the older cohort, it would appear to be likely that rail users' expectation of being connected when they travel by train will increase in the future. This therefore presents a challenge to train companies and mobile network operators.

4.2.2 Importance of improving connectivity

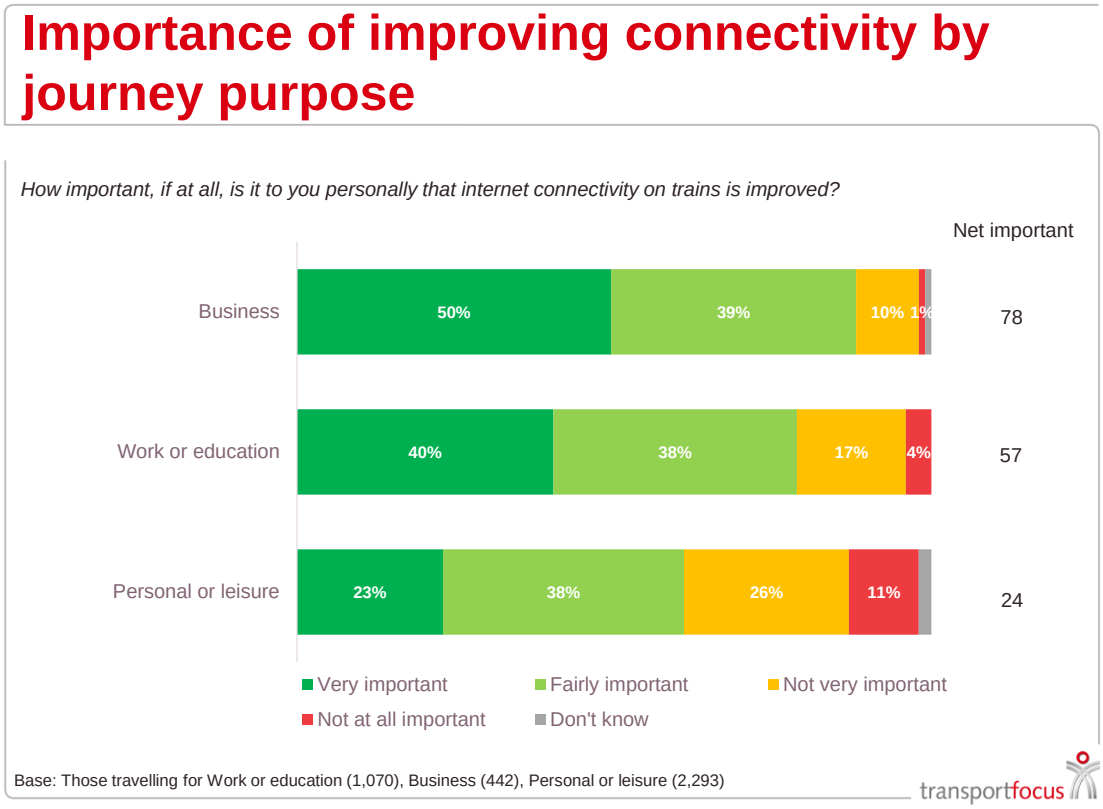
Around three quarters of train users generally say that they think it is important that internet connectivity on trains is improved; 35 per cent state that for them personally making improvements is very important (Fig. 32). This compares with 18 per cent for whom making improvements is not very important, and 6 per cent for whom it is not important at all.

Fig. 32: Level of importance ascribed to improving connectivity on trains



Those who mainly travel for business reasons are more likely than other train users to say that improving connectivity is important to them personally (Fig. 33). If the balance of opinion is derived by subtracting the proportion of those who say that improving connectivity on trains is not very or not at all important from the proportion who say that this is fairly or very important, those travelling for business give a 'net important' score of +78 per cent. This compares with a net important score of +57 per cent for those travelling for commuting reasons and a score of +24 per cent for those travelling for leisure.

Fig. 33: Importance of improving connectivity on trains by journey purpose



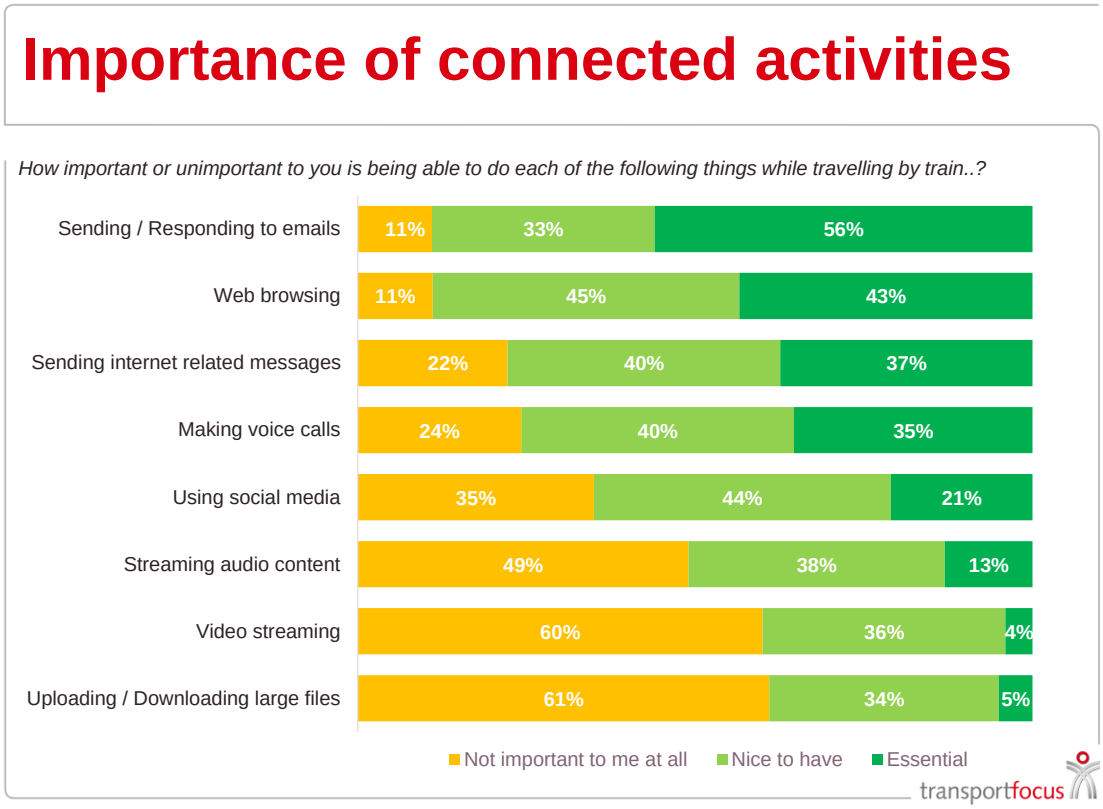
4.2.3 The importance of connected activities to rail users

Transport Focus' panellists were asked to rate several activities that they might want to undertake while travelling by rail in terms of their importance. The results of this question are shown at Figure 34. Sending or responding to emails and web-browsing were rated as similarly important with almost nine in ten rail users rating the ability to do these things while travelling by train as something that is, at least, nice to have. In relation to these activities 56 per cent rated sending / responding to emails as essential, while web browsing was rated as essential by 43 per cent.

Around three quarters rated the ability to send internet-related messages (such as WhatsApp or Facebook Messenger messages) and making voice calls as at least nice to have while travelling by train. 65 per cent say the same regarding the ability to use social media. In terms to which being able to do each of these things is seen as being essential, 37 per cent rated sending internet-related messages in this way, while 35 per cent said the same regarding the ability to make phone calls, and 21 per cent responded similarly with regards to using social media.

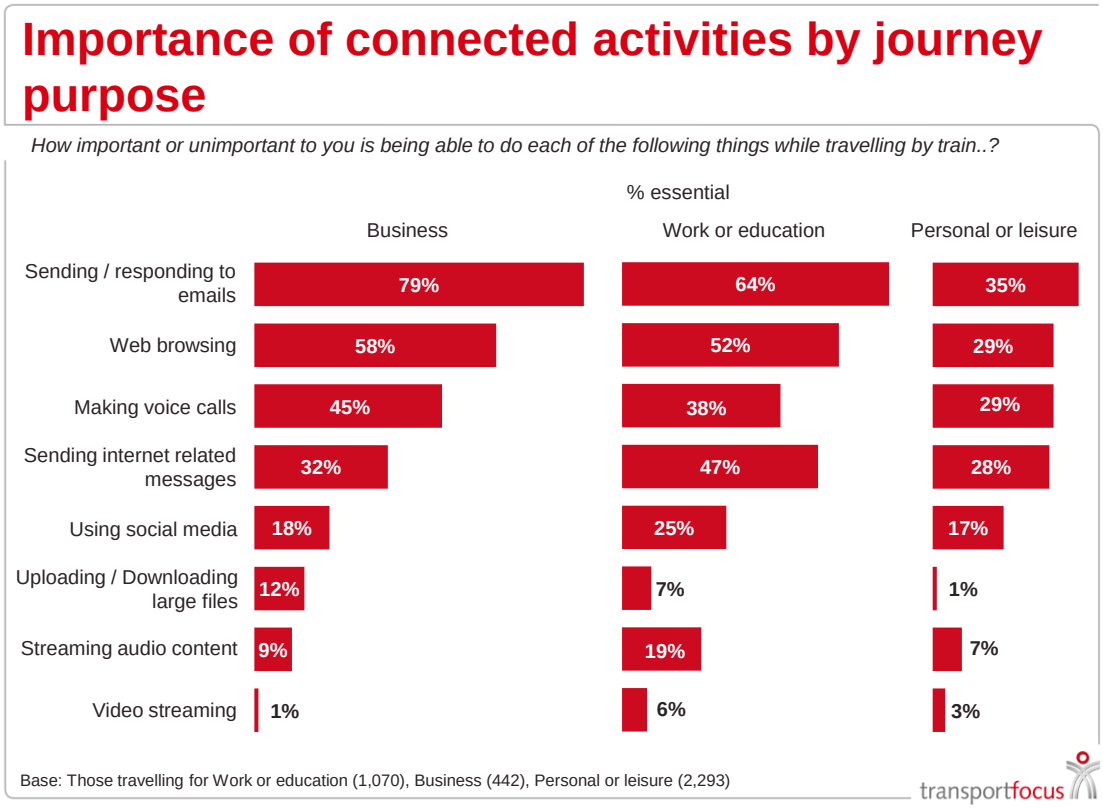
The ability to stream audio or video content and to upload or download large files is considered less important to rail users; in each case almost half or more stated that they consider having the ability to undertake these activities while travelling by train not to be important at all.

Fig. 34: Level of importance ascribed to different connected activities



Those who tend to travel by train for business reasons are more likely than other rail users to consider several of the activities as essential (Fig. 35). Particularly, 79 per cent of those travelling for business rated the ability to send or respond to emails as essential compared with 56 per cent of rail users overall. The ability to browse the web while travelling is also important to this group; 58 per cent of those travelling for business rate this activity as essential compared with 43 per cent of rail users overall.

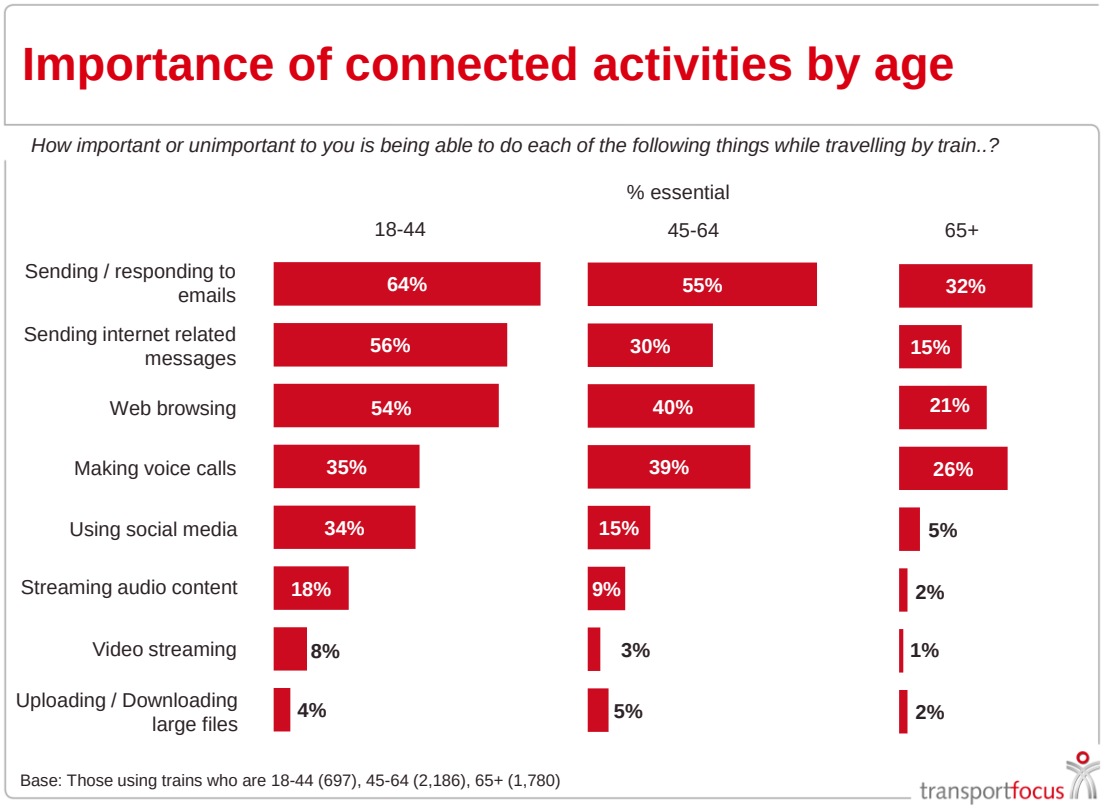
Fig. 35: Importance of connected activities by journey purpose



In general, the perceived importance of each of the connected activities decreases as the age of the train user cohort increases (Fig. 36). Differences between train users in general and those aged 18-44 are particularly marked in relation to sending internet-related messages, web browsing, and using social media. 56 per cent of those aged 18-44 consider the ability to send internet-related messages as essential, 54 per cent say the same regarding the ability to browse the internet, and 34 per cent feel similarly regarding the ability to use social media. This compares with 37 per cent, 43 per cent, and 21 per cent of rail users overall respectively.

Train users aged 65 or older are less likely than train users in general to rate each of the connected activities as essential.

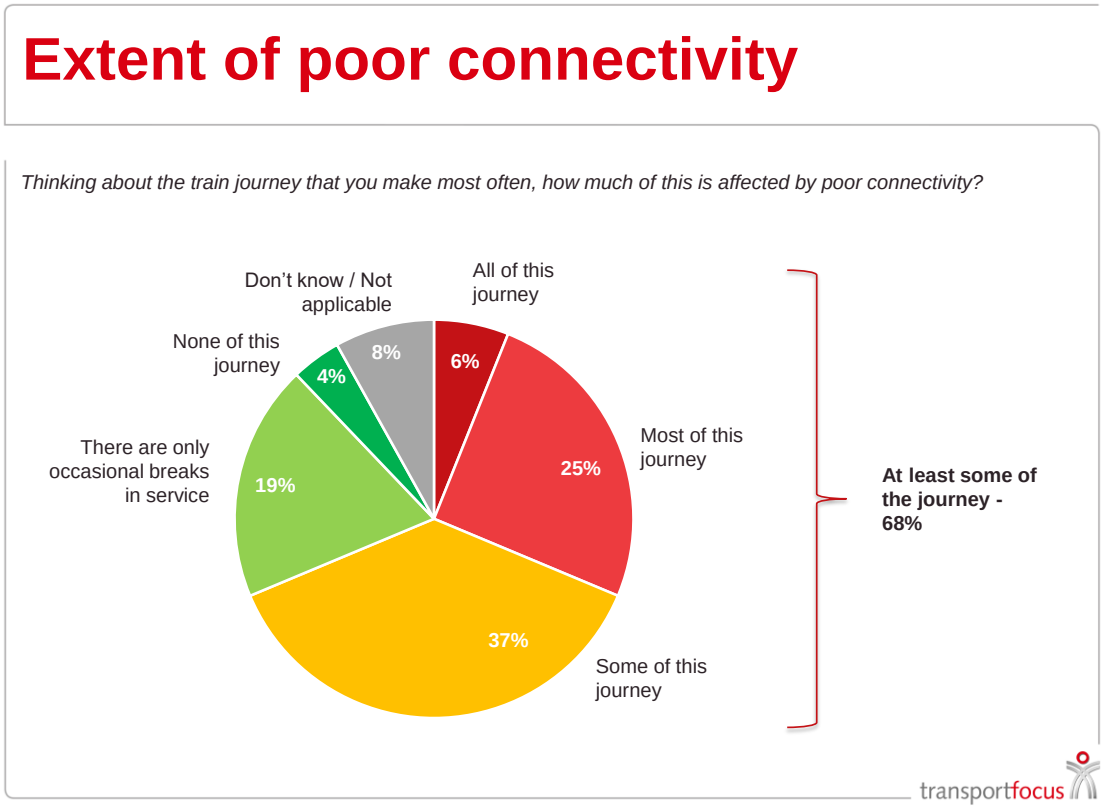
Fig. 36: Importance of connected activities by age



4.2.4 Perception and impact of poor connection on train journeys

In general train users perceive that poor connection has at least some impact on the train journeys that they make. When asked to think about the journey that they make most often, almost seven in ten rail users say that at least some of this journey is affected by poor connectivity (Fig. 37). A quarter say that most of the journey is affected, while fewer than one in ten say that all the journey is affected by poor connectivity.

Fig. 37: Perceived extent of poor connectivity on train journey made most often

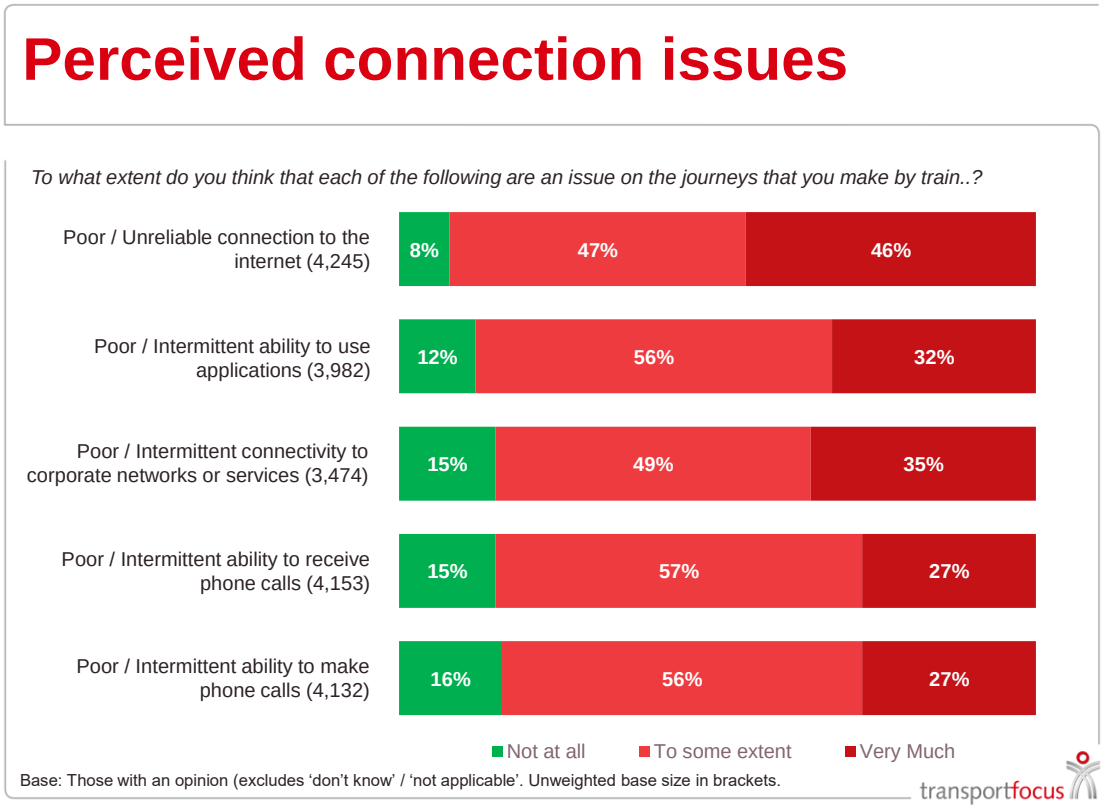


Train users were also asked to think about the journeys that they make in general and then to rate the extent to which they found each of several issues related to poor connectivity a problem. The results of this question are shown in Figure 38. In each case, among those who have experienced each of the issues, more than eight in ten felt that that issue was a problem at least to some extent on the journeys that they make by train.

93 per cent of train users who have experienced attempting to connect to the internet on trains indicate that a poor or unreliable connection is a problem at least to some extent on the journeys that they make, while just less than a half state that this is very much an issue. 88 per cent state that poor / intermittent ability to use applications is an issue at least to some extent, while a third note that this is very much an issue on the journeys that they make. Similarly, 84 per cent say that poor / intermittent connectivity to corporate networks or services is an issue at least to some extent, with 35 per cent saying that this is very much an issue.

As with the other issues, more than eight in ten report that the ability to make or receive phone calls is an issue on the journeys that they make by train; 84 per cent say this regarding receiving phone calls, while 83 per cent say the same regarding making phone calls. In each case around a quarter note that making or receiving phone calls is very much an issue.

Fig. 38: Perceived extent of connection issues experienced on train journeys

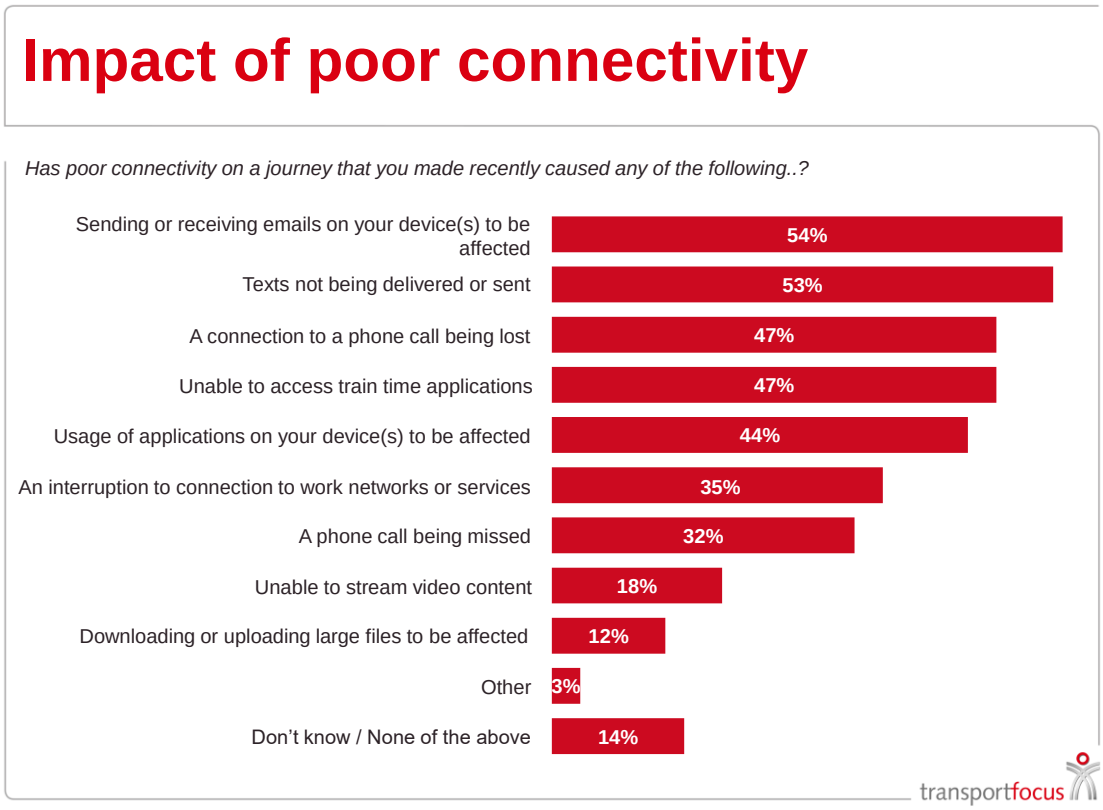


To further assess the perceived impact of poor connectivity on trains train users were given a list of potential issues and were asked to indicate which ones they had experienced on any journey by train that they had made recently. The results of this question are shown at Figure 39.

54 per cent say that they have experienced issues sending or receiving emails, while 53 per cent indicate that they have experienced issues with texts not being delivered or sent. Similar proportions note that they have experienced a connection to a phone call being lost and the inability to access train time applications; 47 per cent report these experiences in each case. Meanwhile 44 per cent say that they have experienced the usage of applications to be affected.

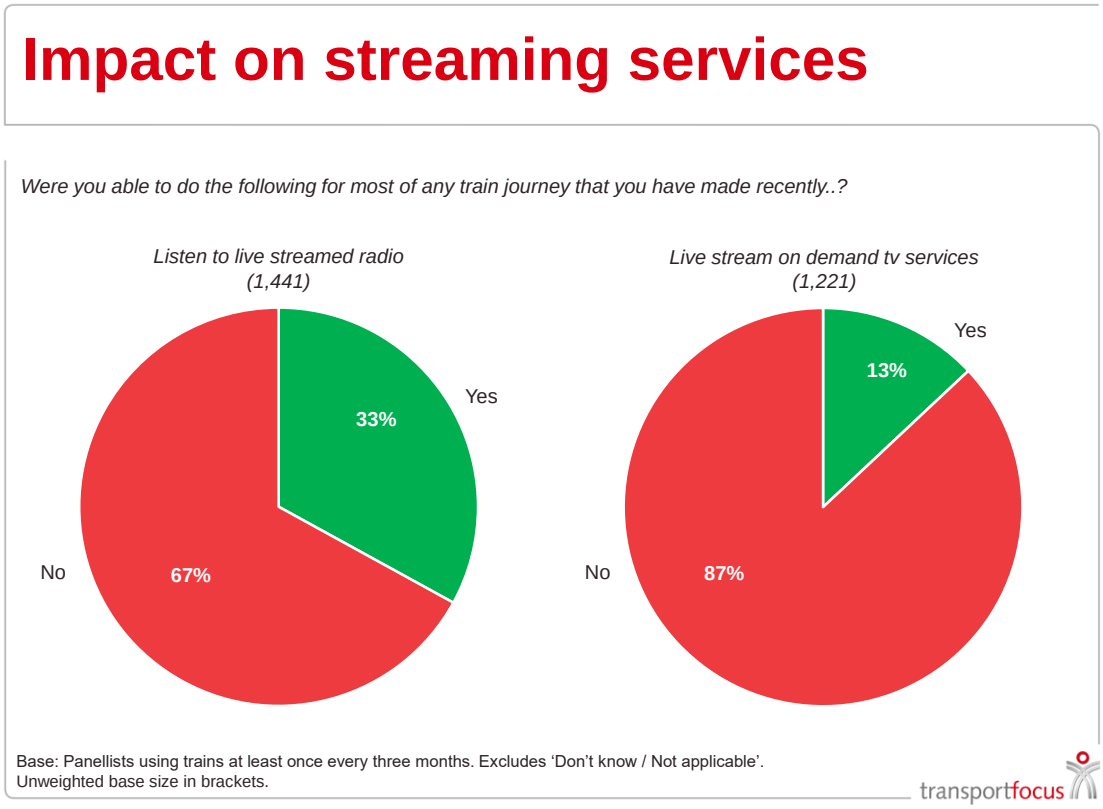
Smaller proportions report that poor connectivity has had other impacts. 35 per cent say that they have experienced an interruption to a connection to work networks or services, and 32 per cent say the same regarding a phone call being missed. Fewer report other issues such as the inability to stream video content and the ability to upload or download large files being affected.

Fig. 39: Perceived impact of poor connectivity on trains



In terms of the impact on live streaming services, (i.e. accessing content through a mobile or Wi-Fi connection rather than downloading it to a device in advance of travelling) 67 per cent of those who have attempted to listen to live streamed radio and 87 per cent of those who have attempted to live stream on demand TV services report that they have been unable to do this for most of any train journey that they have made recently (Fig. 40).

Fig. 40: Perceived ability to stream radio / on demand tv services[6] on trains



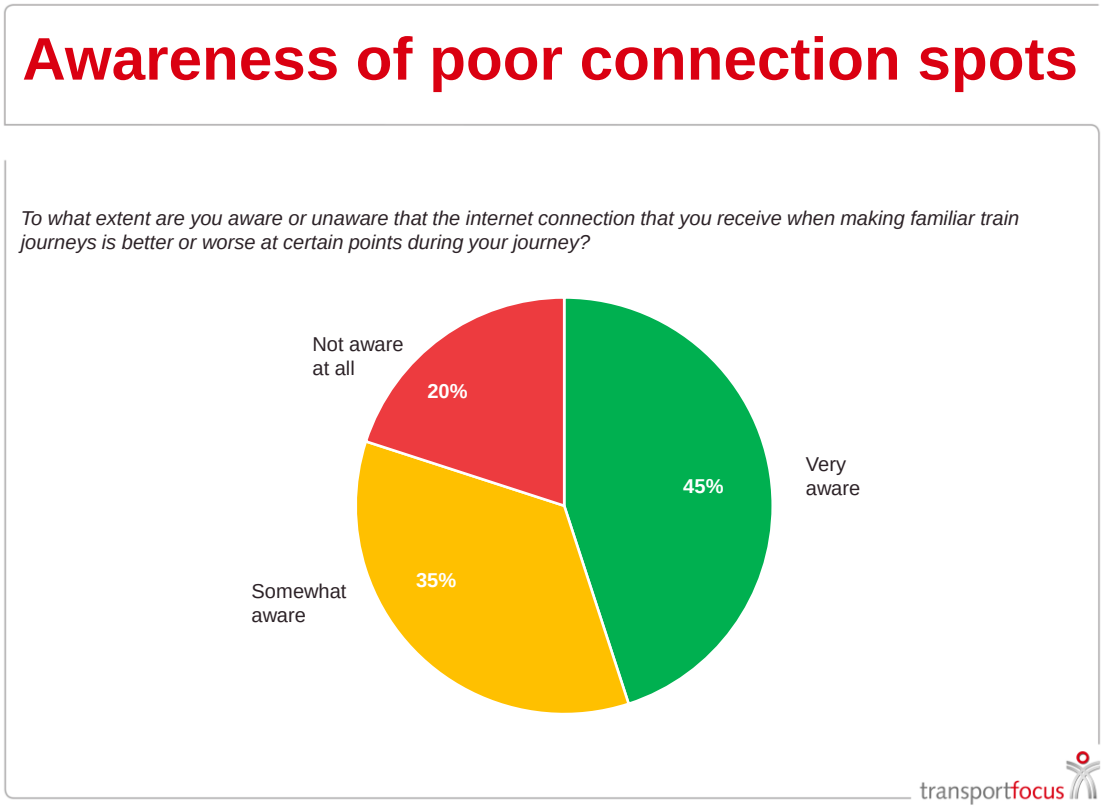
In each case two thirds of train users report that they have not attempted to live stream radio or on demand TV content. It would therefore appear that knowledge of the limitations on being able to do this may prevent train users from attempting these activities.

[6] To note: this may include on-demand TV, Netflix and other streaming services

4.2.5 Awareness of poor connectivity and related actions

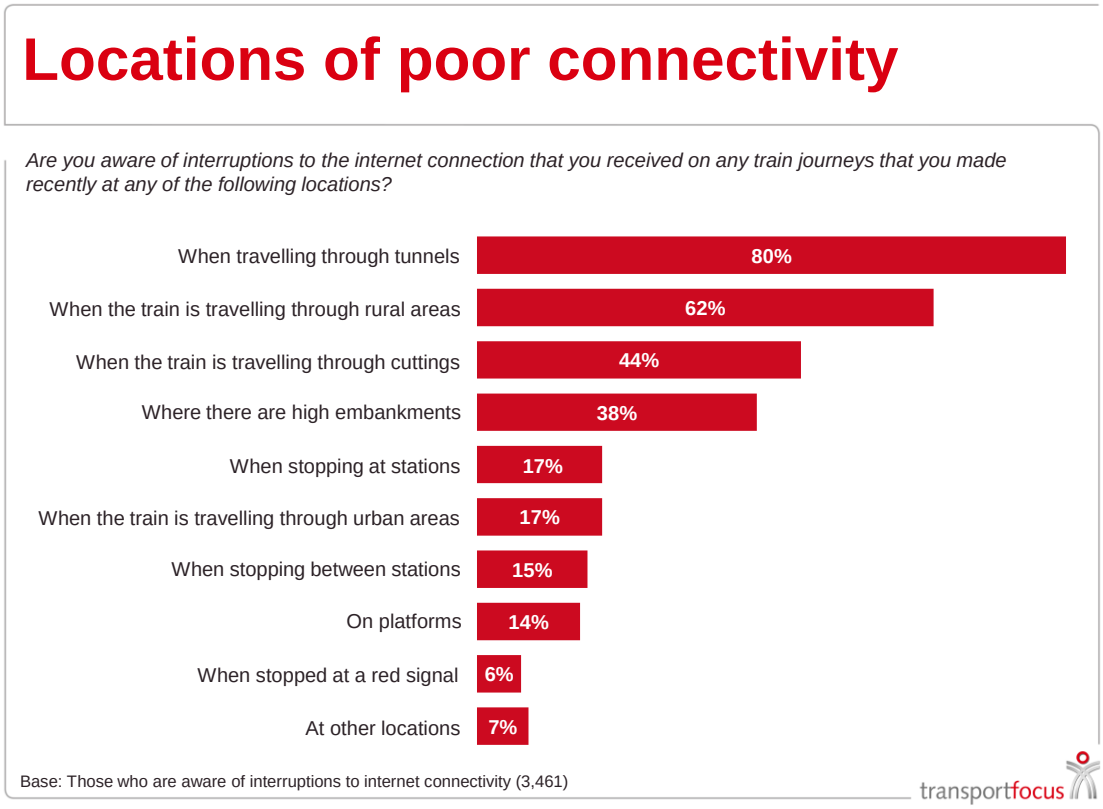
When asked about the extent to which they are aware that the internet connection that they receive when making familiar train journeys is better or worse at certain locations, 45 per cent report that they are very aware, 20 per cent say that they are somewhat aware, while 35 per cent indicate that they are not aware at all (Fig. 41).

Fig. 41: Awareness of poor connection spots on train journeys



Among those that are aware of locations where connection is poor 80 per cent note that on train journeys that they have made recently interruptions to the connection received have occurred when the train is travelling through a tunnel (Fig. 42). 62 per cent report that interruptions have occurred when the train is travelling through rural areas, while 44 per cent and 38 per cent respectively report the same when the train is travelling through cuttings or where there are high embankments.

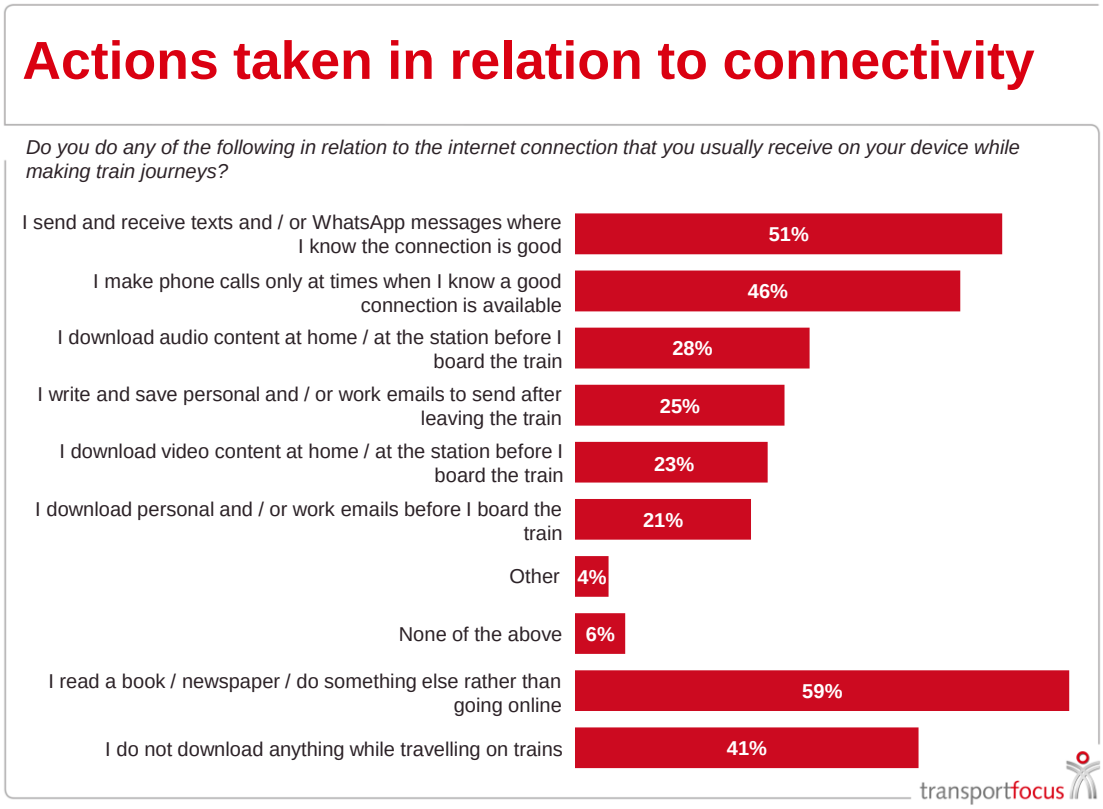
Fig. 42: Perceived locations of poor connectivity



As indicated previously in terms of the proportions of train users who say that they attempt to stream live radio or TV on demand services while on the train, it is likely that train users adopt certain behaviours in response to the relatively poor connection speeds available on trains. When asked around half say that they only try to receive texts and or WhatsApp messages when they know that the connection is good, while just fewer than half say that they make phone calls only at these times (Fig. 43).

28 per cent say that they download audio content at home or at the station before they board the train, while around a quarter or slightly fewer in each case report that they write and save personal and / or work emails to send after leaving the train, and that they download video content at home or at the station before they board the train. One in five state that they download personal and / or work emails before they board the train.

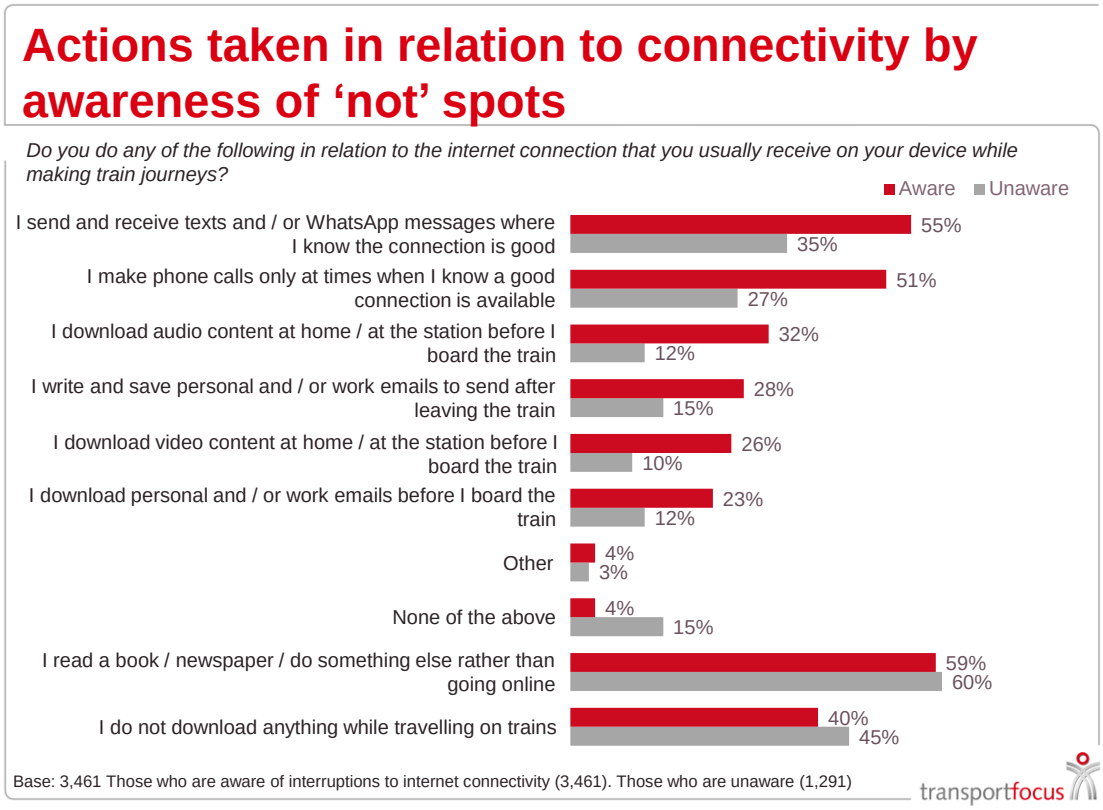
Fig. 43: Actions taken to mitigate against the impact of poor connectivity on trains



While it's clear that some train users take affirmative action to complete traditionally connected activities despite a less than satisfactory or intermittent connection on trains, others avoid using the internet altogether. 59 per cent say that rather than going online they read a book or do something else while travelling, while 41 per cent say that they do not download anything while travelling on trains.

Perhaps unsurprisingly those who are more aware of connectivity on trains, are generally more likely than those who are unaware to take mitigating actions to complete traditionally connected activities while travelling (Fig. 44). Conversely those who are unaware are more likely to be undertaking activities which do not require a connection, such as reading a book. This would suggest that a proportion of passengers are not aware of the quality of the connection simply because they have no need for it, rather than taking these actions because the connection is poor. Having said this 59 per cent of those who are aware of the quality of the internet connection read a book or do something else rather than go online, while 40 per cent of these train users do not download anything while travelling on trains.

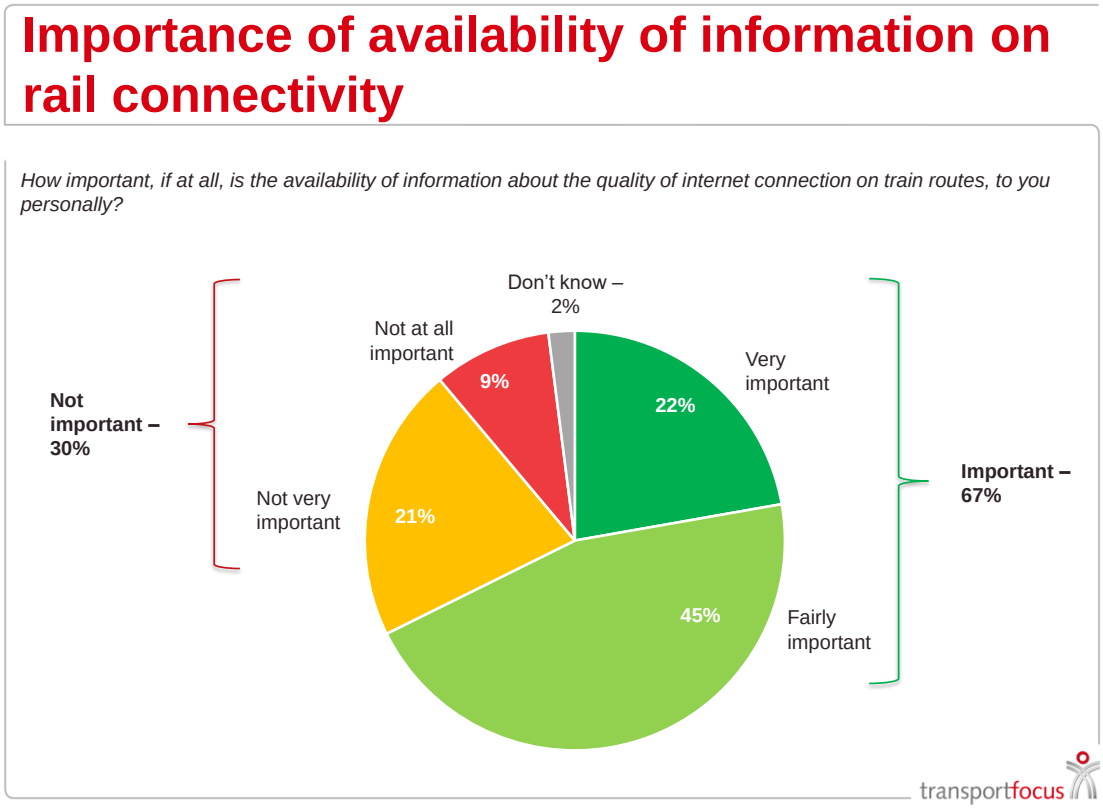
Fig. 44: Actions taken to mitigate against the impact of poor connectivity by awareness of 'not' spots



4.2.6 Information on connectivity

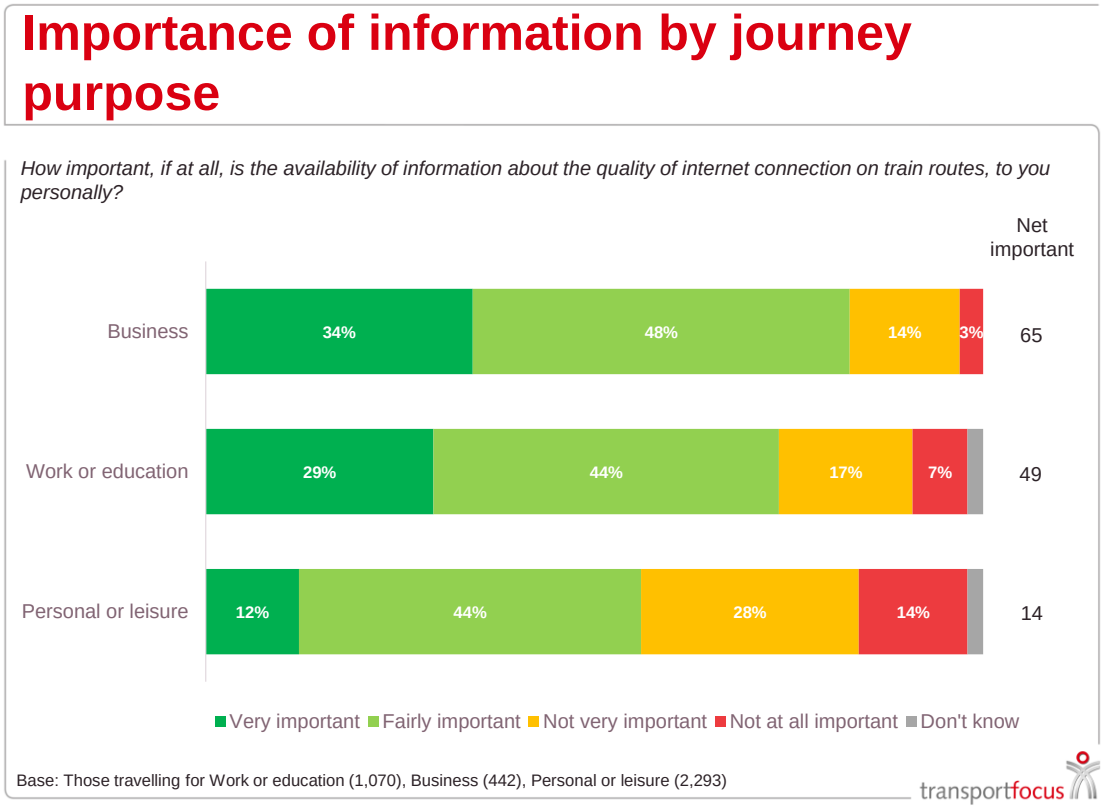
Almost seven in ten train users state that having information available about the quality of the internet connection on train routes is important to them personally (Fig. 45). This finding breaks down so that just under half say that this type of information is fairly important to them while 22 per cent state that having this information is very important. Conversely one in five say that this information is not very important, while less than one in ten say that it is not important to them at all.

Fig. 45: Perceived importance of availability of information on rail connectivity



By journey purpose those who tend to travel by train for business reasons are more likely than others to consider having information about the quality of the internet connection on train routes available to them as important (Fig. 46). If the balance of opinion is analysed by subtracting the proportion of train users who rate having information available as not very or not at all important, from those who rate this as fairly or very important, those travelling for business get a 'net importance' score of +65 per cent. This compares with a net importance score of +49 per cent for those travelling for commuting purposes, and +14 per cent for those travelling for leisure.

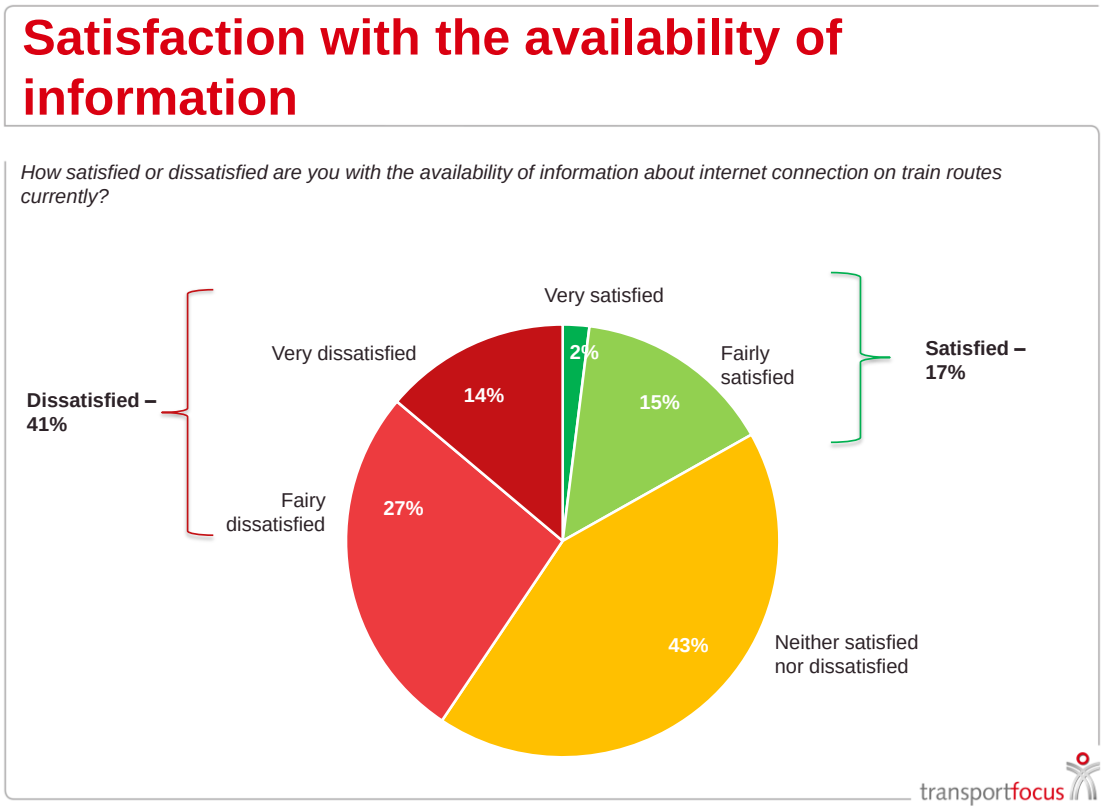
Fig. 46: Importance of information on rail connectivity by journey purpose



While a majority of train users think that it is important to have information about the quality of connectivity available on trains, a minority say that they are satisfied with the current availability of this type of information (Fig 47). 17 per cent say that they are satisfied with the availability of information related to the quality of connection on train routes compared with 41 per cent who say that they are dissatisfied.

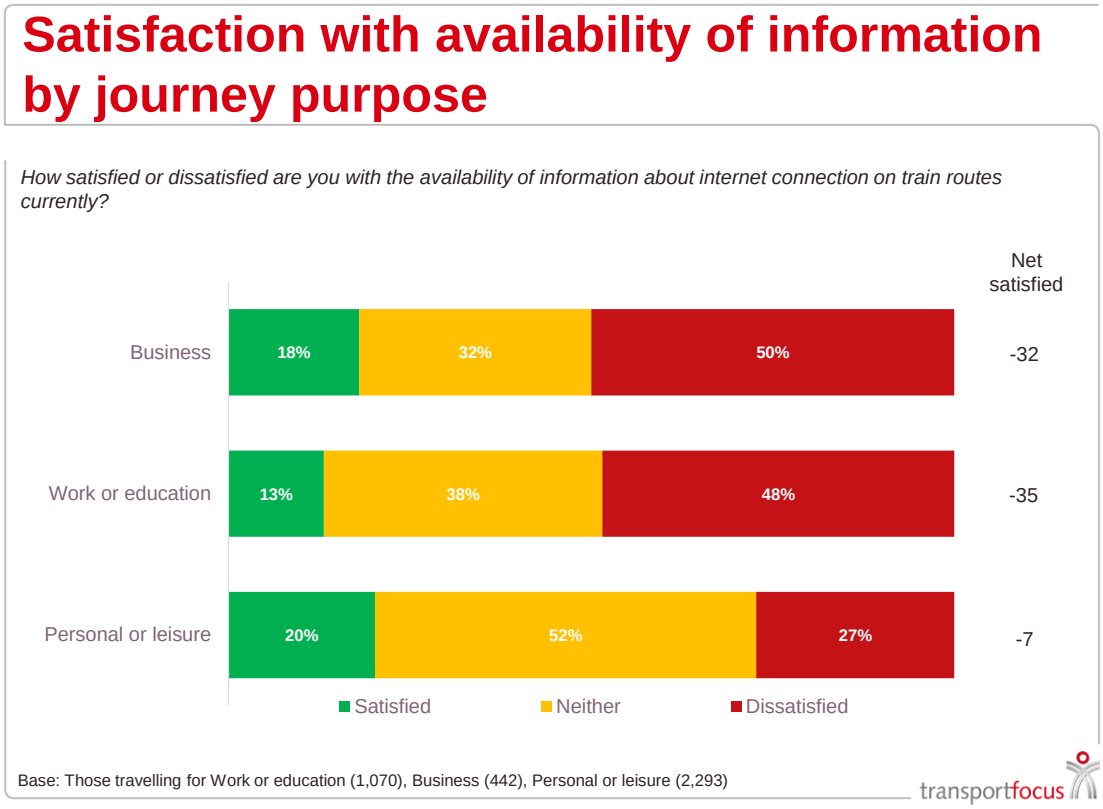
It is noteworthy that a large proportion, around two in five, are neither satisfied nor dissatisfied with the availability of information regarding connectivity on train routes. This finding is likely to reflect the fact that currently there is a general lack of this type of information.

Fig. 47: Overall satisfaction with the availability of rail connectivity information currently



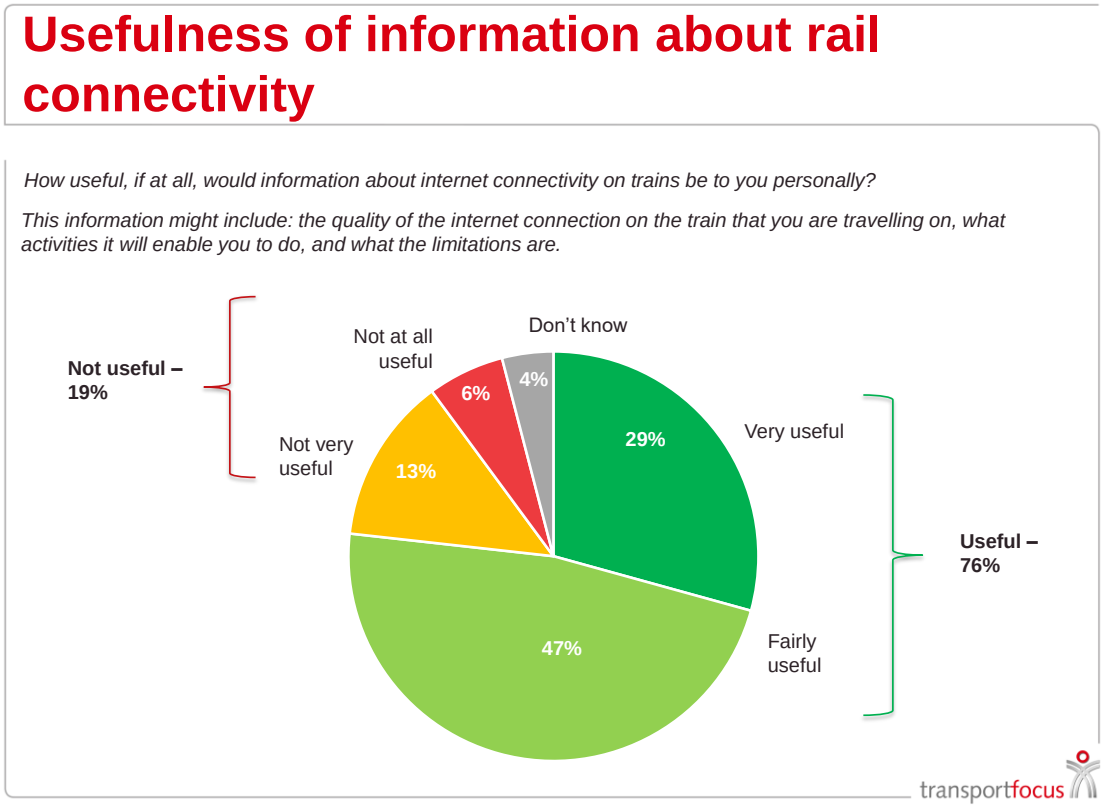
As with findings related to the importance of having information available, those travelling for business reasons are more likely than train users in general to be dissatisfied with the current availability of this type of information (Fig. 48). In this instance however, those who travel mainly for commuting purposes share this balance of opinion with those travelling for business. In terms of 'net satisfaction (those who are very or fairly satisfied minus those who are very or fairly dissatisfied) those traveling for business give a score of -32 per cent, and those commuting give a score of -35 per cent. This compares with a net satisfaction score of minus seven per cent for those travelling for leisure reasons.

Fig. 48: Satisfaction with the availability of rail connectivity information by journey purpose



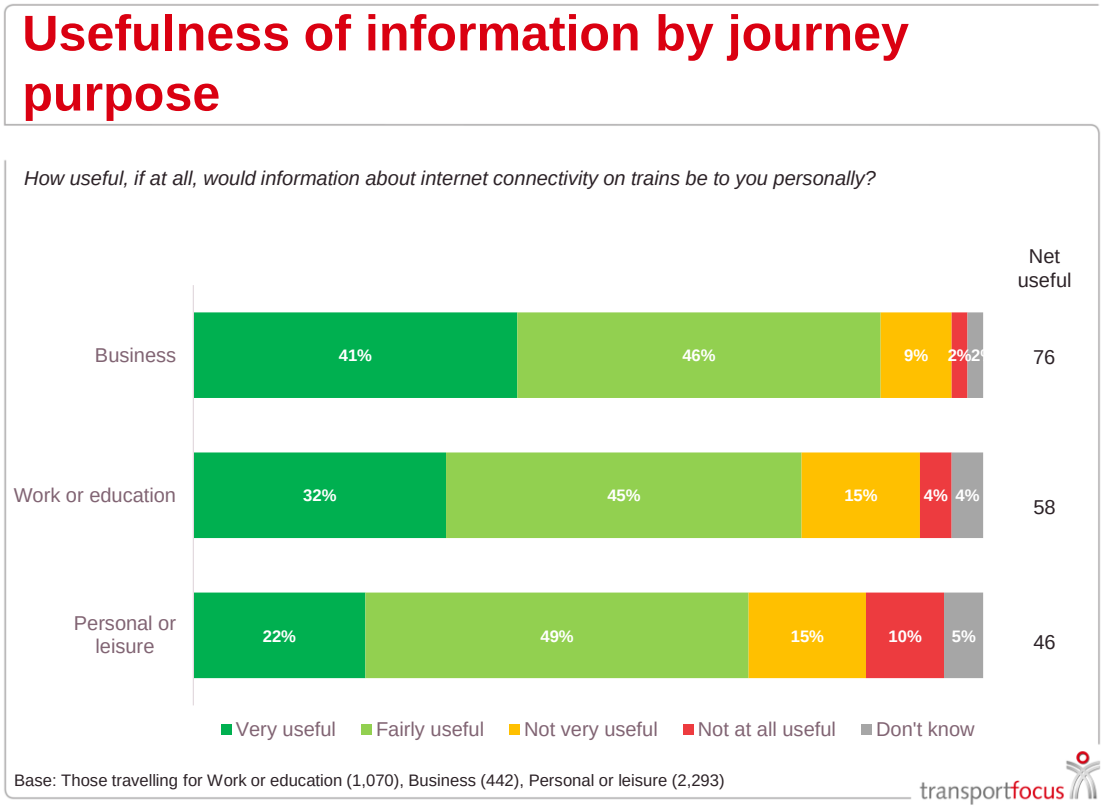
Reflecting the other findings relating to information, a majority of train users say that it would be useful to have more information about internet connectivity available to them (Fig. 49). In considering this proposition train users responding to the survey were asked to consider that this information might include the quality of the connection on the train that they are travelling on, what activities this will allow a passenger to complete, and what the connection speed's limitations are. 76 per cent state that this type of information would be useful to them, with 29 per cent saying that the information would be very useful. Conversely 19 per cent say that this information would not be useful to them personally.

Fig. 49: Perceived usefulness of information of about rail connectivity



Again, those who mainly use trains for business reasons are more likely than others to say that they would find the provision of information about connectivity on the trains that they travel on to be useful (Fig. 50). In terms of the balance of opinion these train users give a 'net useful' score of +76 percent, compared with a score of +58 per cent for those travelling for commuting reasons and a score of +46 per cent for those travelling mainly for leisure reasons.

Fig. 50: Perceived usefulness of rail connectivity information by journey purpose



In terms of findings about information as a whole, the general desire for more information regarding connectivity on trains is noteworthy, as is the particular desire among those who are travelling for business reasons. A reasonable interpretation of these findings would be that accurate information about the quality of the connection available on particular train routes, and indeed on specific sections of these routes, might be useful to business travellers as it would allow them to plan how they can be most productive when travelling during work time. In verbatim comments left at the end of the survey, many business travellers draw a connection between internet connectivity on trains and the need to be productive:

"*I choose to travel by train so I can work. On TPE services between Cleethorpes & Manchester this is often impossible due to poor connectivity and not just between Sheffield - Manchester.*"

"*When I travel on business by train I am usually on the train at least 3 hours each way. I need to make this 6-hour return journey as productive as possible and the internet connectivity on LNER trains is poor most of the time.*"

"*It is a real problem for me as I can spend up to 20 hours per week travelling by train. I can't afford to lose that much work time.*"

"Being able to work during my journey is very important. To do so effectively, I need to have a reliable internet connection"

"Being able to work while travelling is part of the justification for travelling by train. Not being able to work on the train destroys the argument for using the train in the first place."

5. Part three: analysis of train user activities

5.1 Background and methodology

5.1.1 Introduction

While survey data is useful for exploring the overall perception and reported experience of those who use trains, this methodology is less good at extrapolating actual behaviour, since a person's recollection is often partial and subject to bias. For this reason, it was not considered appropriate to ask the train users involved in the research to itemise the connected activities that they complete when travelling and to report their success in attempting to do these activities.

Relatedly the umlaut crowdsourced data does provide some indication of what types of connection speeds those travelling by train are likely to be getting and thereby we are able to make an informed interpretation of what train users are, and are not, able to do while they are on trains. However, as with survey data this data source does not allow us to understand exactly what it is that train users are trying to do while they travel.

To try to understand more about exactly what passengers are doing on their devices when they travel by train, Transport Focus and the Department for Transport worked in partnership with umlaut. umlaut were commissioned to design an application which would be downloaded by train users and would collect both the connection speeds that they were getting while travelling and monitor the activities which they carried out on their devices. This approach in many ways mirrors that adopted by Ofcom for research as part of their project exploring 'The Mobile Consumer Experience'[7], although it is applied to train travel only in this instance. While it was hoped that this element of the research would provide insights of benefit to the project as a whole, this part of the project was largely experimental in nature and therefore should be regarded as a pilot for a methodology which may be adopted, and built upon, in the future.

A more detailed description on how the 'bespoke application' was used as part of this research project, and an analysis of the information which was collected in this way is provided below.

5.1.2 Recruitment

Participants for the part of the research involving the bespoke application were recruited using Transport Focus' 'Transport User Panel'. As described above the panel is an online database of people who, after undertaking research for the organisation, have indicated that they are happy to continue to receive transport-related surveys.

[7] https://www.ofcom.org.uk/research-and-data/telecoms-research/mobile-smartphones/consumer-mobile-experience

In December 2018 an initial screening survey was emailed to 22,543 Transport User Panellists. This described in broad terms what the project would involve and asked panellists to indicate their interest in taking part. 2,592 panellists responded to this request with 1,919 saying that they were interested in being involved, or that they might be if provided with more information. 673 responded to say that they would not be interested in taking part under any circumstances.

The 1,919 panellists expressing an interest were then further screened for those who use an Android device when travelling by train. Because of restrictions that Apple places on collecting data from their products the umlaut application could only operate on Android devices and therefore users of Apple products had to be excluded from the project. After this screening stage 1,026 panellists remained who indicated that they possessed an Android device which they used when travelling by train.

In April 2019, 1,026 panellists were re-contacted and provided with fuller details concerning the bespoke application. They were given details on how they could download the application, exactly how the application would operate, and how the data generated would be shared (anonymously and securely) between the parties involved in the project. The panellists were given a fixed date for the end of the monitoring period and given details of an incentive payment that they would receive shortly after this time.

On 11 April 2019 the link to download the application was sent to 1,026 panellists and the monitoring period began. During this time 26 panellists contacted Transport Focus to formally opt-out of the project, leaving exactly 1,000 remaining. Of these 252 downloaded the bespoke application. On 30 June 2019 the monitoring period closed.

5.1.3 Initial profiling, in-app and post monitoring survey data

On downloading the application participants were asked to answer several profiling questions regarding their age, gender and typical journey purpose. They were also asked about their overall satisfaction with the internet connection that they usually get while travelling by train, their expectations in terms of connectivity, and to rate the importance of several connected activities.

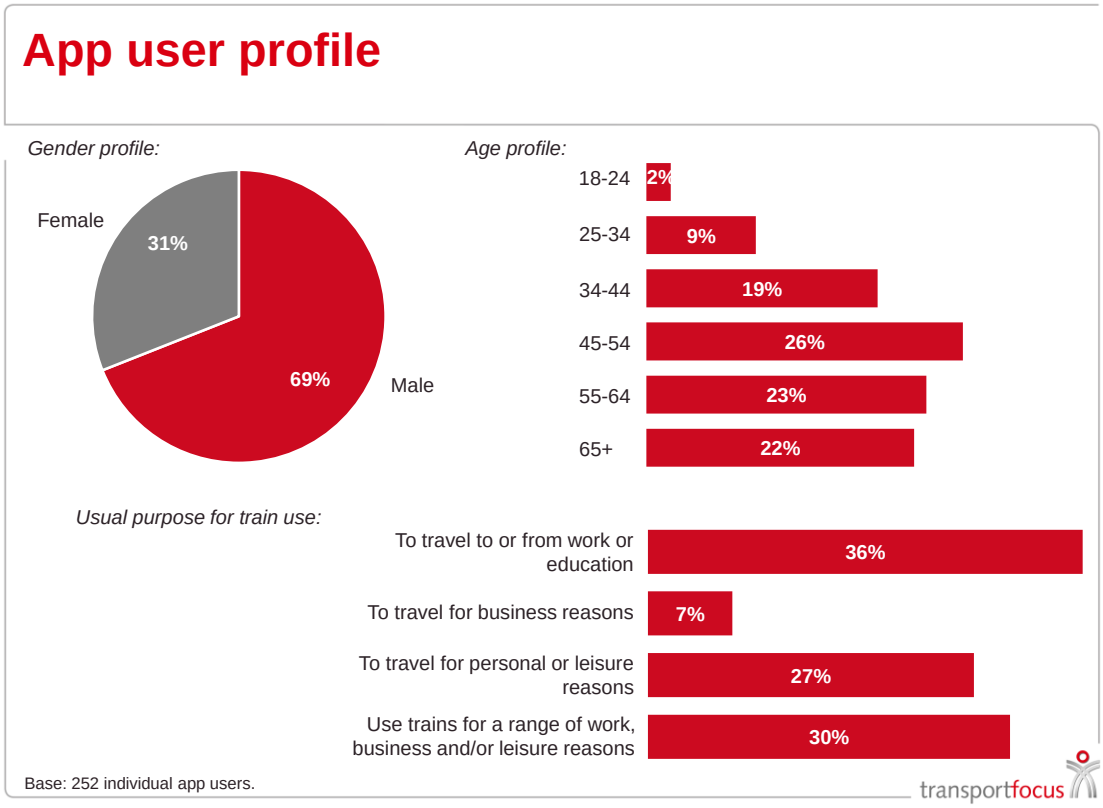
After collecting profiling information, the application continued to work on the background on participant's devices, collecting information regarding what activities participants were undertaking on devices, and passively monitoring the connection speeds that they were receiving while travelling on trains. During this monitoring period participants were sent weekly 'pop-up' surveys, generated from within the application itself, asking them to rate the connectivity they had received on any journeys that week and if they had been able to complete all the activities that they wished to carry out. By the end of fieldwork 870 in-app surveys had been completed by 170 individual application users. More details on the profile of these surveys is provided below.

At the close of the monitoring period on 30 June participants were sent an email indicating that this fieldwork stage had ended, and they should remove the umlaut application from their device. At this final stage participants were sent a final, 'post monitoring' survey which collected some general information regarding their perception of being connected while travelling by train. This final survey was completed by 221 of the 252 panellists who had downloaded the bespoke application.

5.1.4 Interpretation of bespoke application generated data

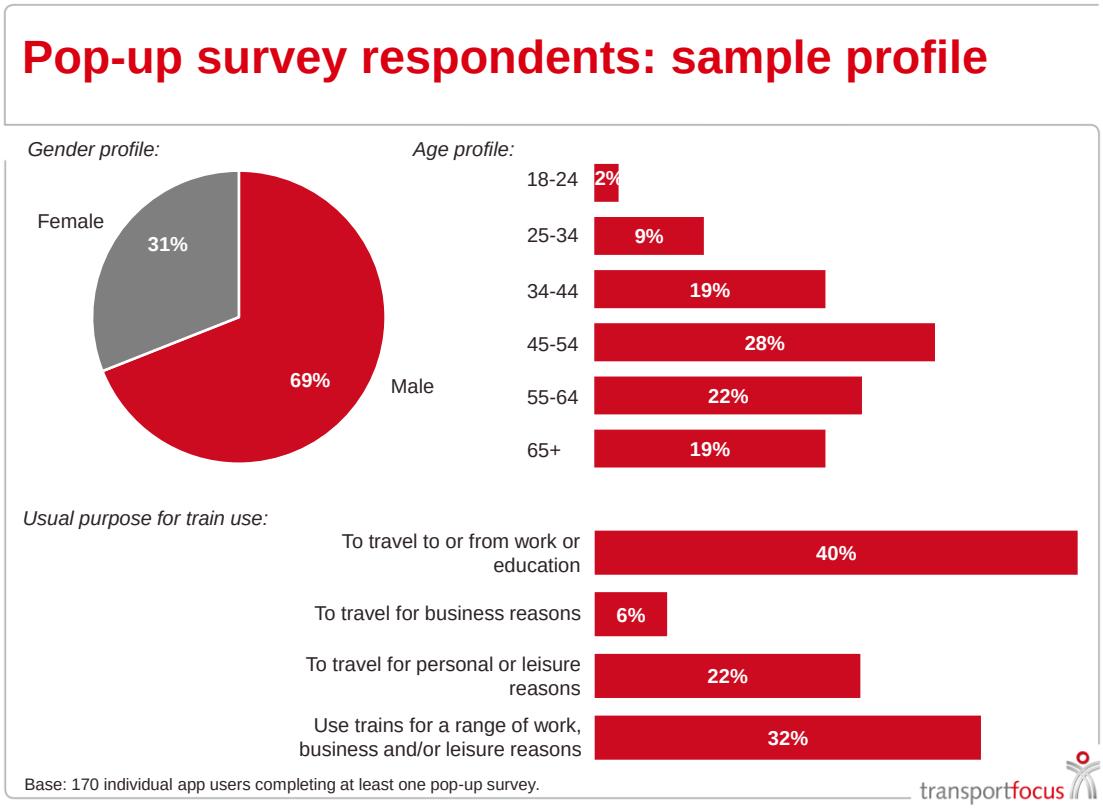
Since only a limited number of panellists downloaded the bespoke application, the findings reported below, which have been generated through this methodology, should be treated with some caution. Moreover, because of the impact of weighting, the data generated via the bespoke application has not been corrected to reflect the profile of UK rail users generally; rather the data more closely represents the profile of Transport User Panellists in that it tends to come from older and male train users (Fig. 51). For this reason, the findings should be seen to indicate train users' likely behaviour and not to give a very accurate reading of what passengers generally are doing on devices when travelling on trains.

Fig. 51: Profile of panellists who downloaded the bespoke application by age, gender, and journey purpose



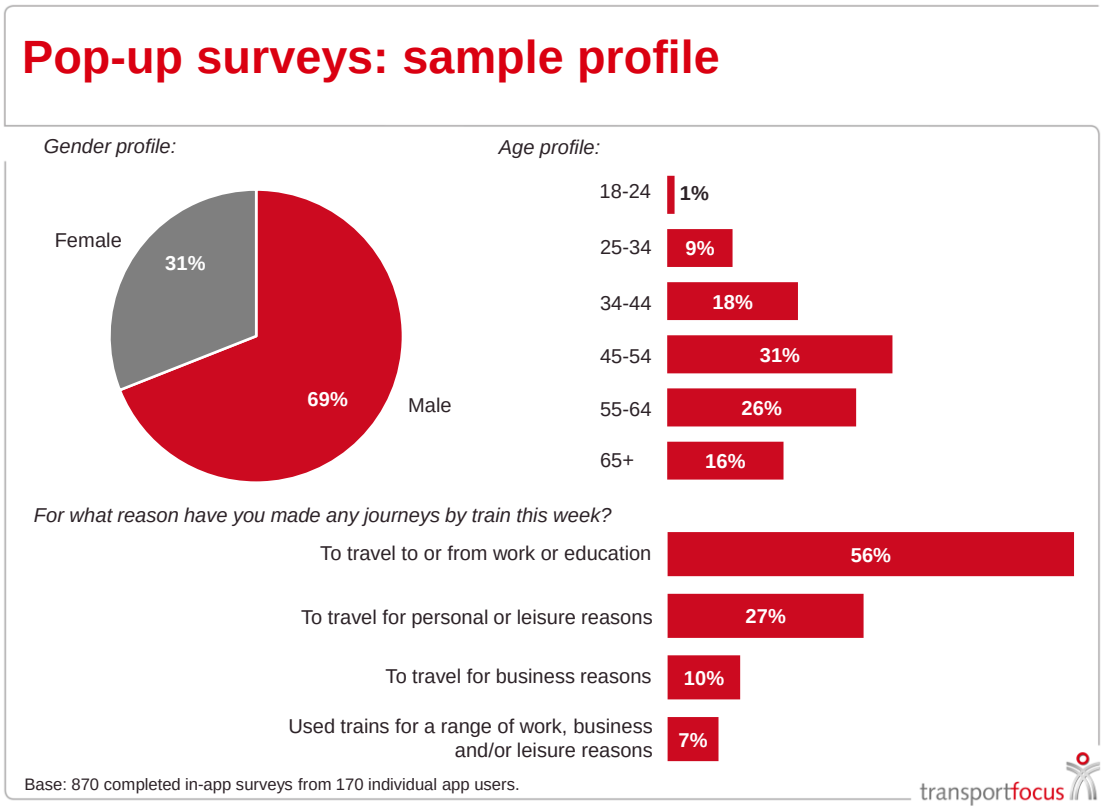
As with the profile of those who downloaded the application, the profile of those who completed at least one pop-up survey during the monitoring period largely reflects that of the Transport User Panel more generally (Fig. 52). However, those completing a pop-up survey are marginally more likely than those who downloaded the application to use trains generally to travel to or from work or education.

Fig. 52: Profile of panellists downloading the bespoke application who completed one or more pop-up surveys



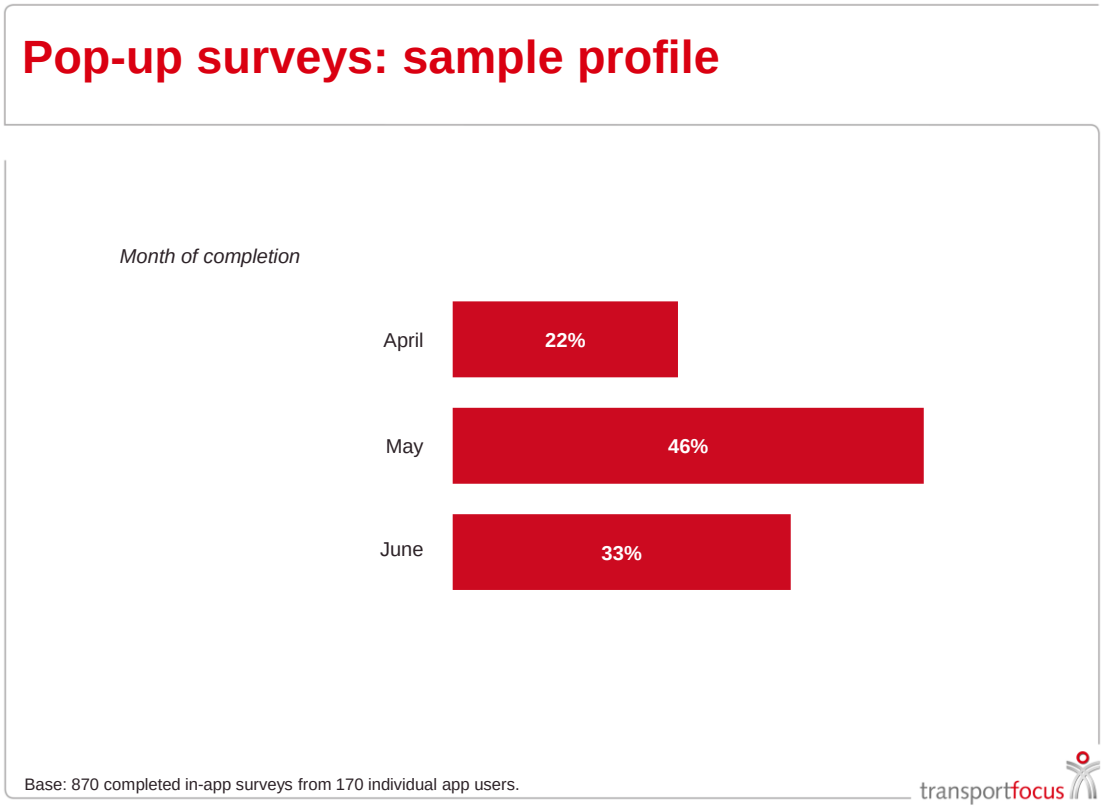
In terms of the profile of the pop-up surveys which were completed during the monitoring period, these share the over-representation of male train passengers which is consistent with the profile of those who downloaded the application generally (Fig. 53). However, a marginally greater proportion of pop-up surveys were completed in relation to journeys made for commuting or business travelling purposes. This is reflected in small increases in pop-up surveys completed by those in the middle-age brackets.

Fig. 53: Profile of the pop-up surveys completed within the monitoring period by gender, age and journey purpose



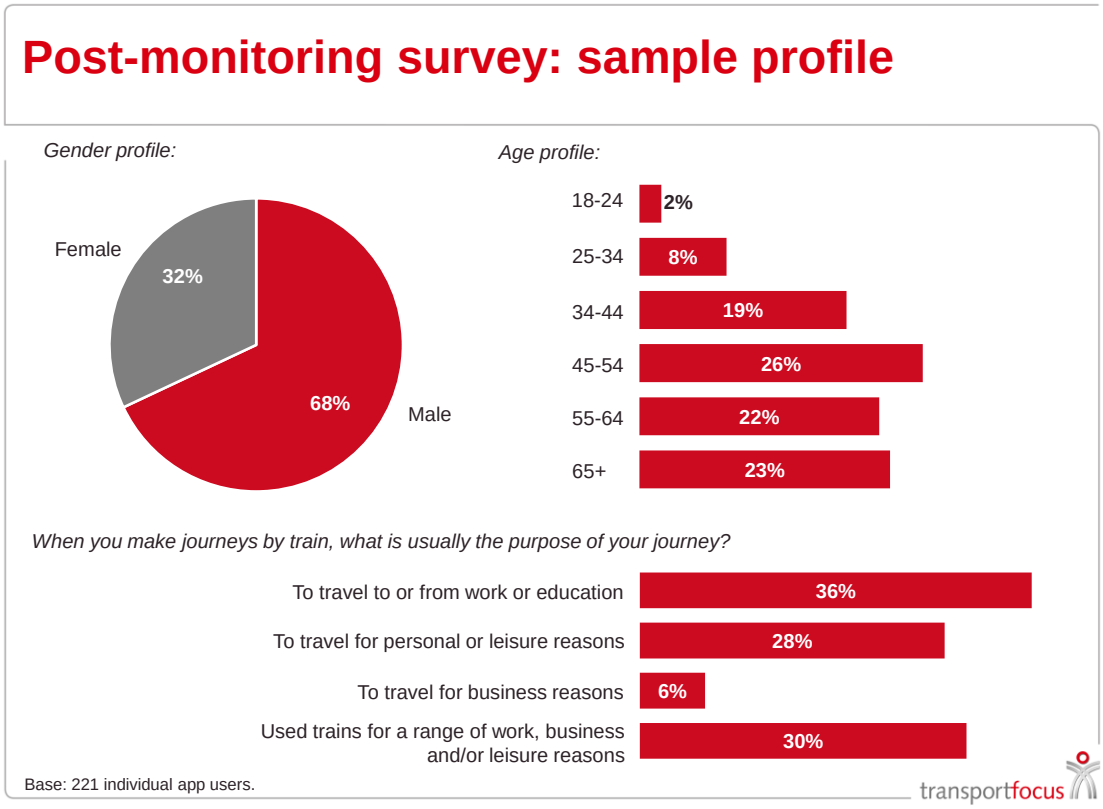
As indicated above 870 pop-up surveys were completed by 170 of those who downloaded the application throughout the monitoring period which ran between April and June 2019. In terms of how the surveys were distributed throughout this period 22 per cent were completed in April, 46 per cent in May and 33 per cent in June (Fig. 54).

Fig. 54: Profile of the pop-up surveys completed within the monitoring period by month of completion



At the close of the monitoring period, bespoke application users were asked to complete a final questionnaire regarding their general perceptions and attitudes towards connectivity on trains. This was completed by 221 of the 252 who downloaded the application; the profile of these responses shares that of those who downloaded the application generally (Fig. 55).

Fig. 55: Profile of panellists downloading the bespoke application who completed the post-monitoring survey



5.2 Perception of connectivity among those downloading the bespoke application

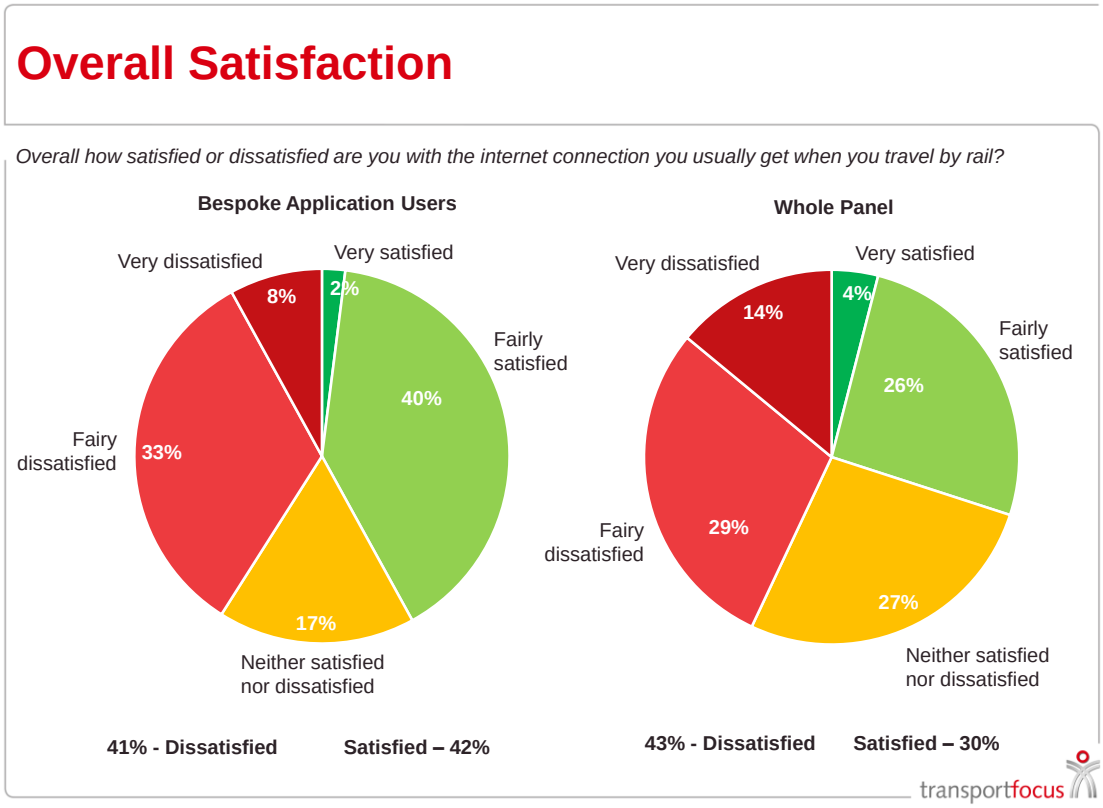
5.2.1 Pre and post monitoring period survey data

Though the profile of those who downloaded the bespoke application does not closely reflect the profile of train users generally, the attitudes and opinions of these groups regarding connectivity on trains is similar in many respects. Below we provide an analysis of the survey data which was collected initially when Transport User Panellists downloaded the application and survey data collected after the monitoring period. This is compared with the results from panellists in general, weighted to the overall profile of train passengers.

5.2.2 Satisfaction with internet connectivity and expectation

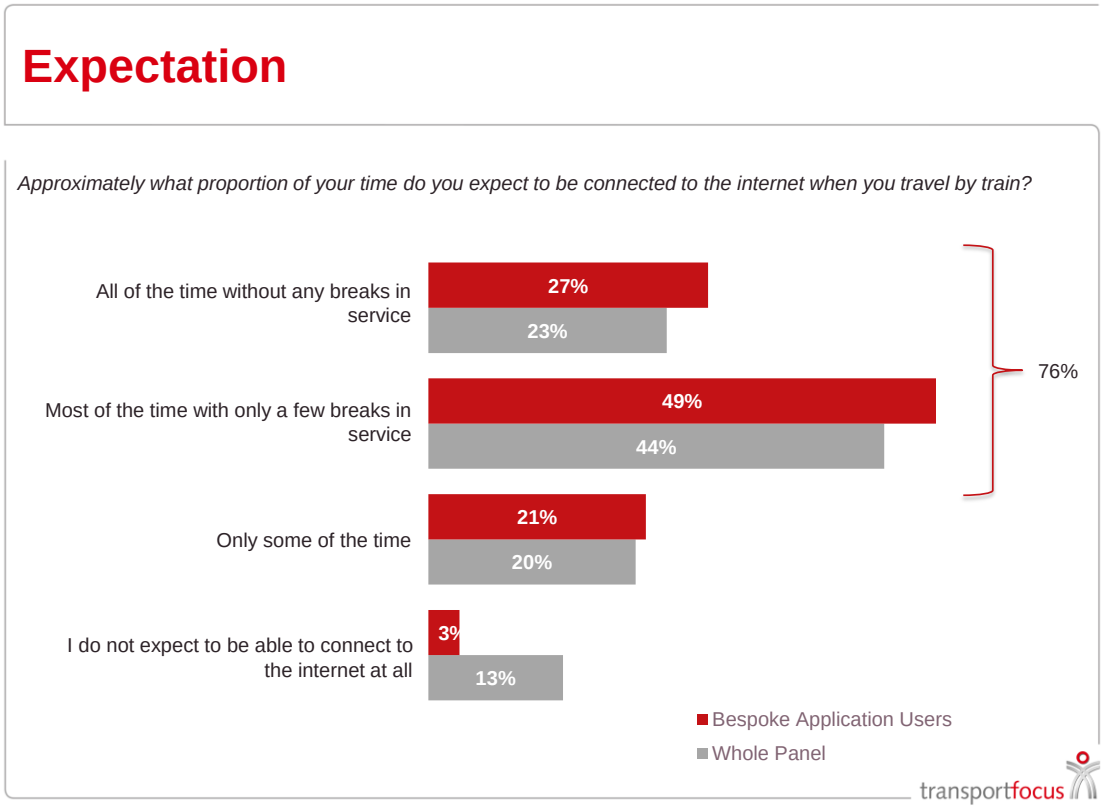
Those who downloaded the bespoke application are more likely than passengers in general to have an opinion regarding their level of satisfaction with the internet connection that they usually get when they travel by train (Fig. 56). However, while similar proportions are dissatisfied with the internet connection, those downloading the bespoke application are more likely to be satisfied with the internet connection that they usually get on trains.

Fig. 56: Overall satisfaction with the internet connection usually received when making train journeys. Panellists who downloaded the bespoke application vs. all panellists



While those using the bespoke application are generally happy with the internet connection, they tend to have a greater expectation in terms of the proportion of their journey time which should be 'connected' than train users generally (Fig. 57). Three quarters indicate that they expect to be connected at least most of the time compared with 67 per cent of passengers generally.

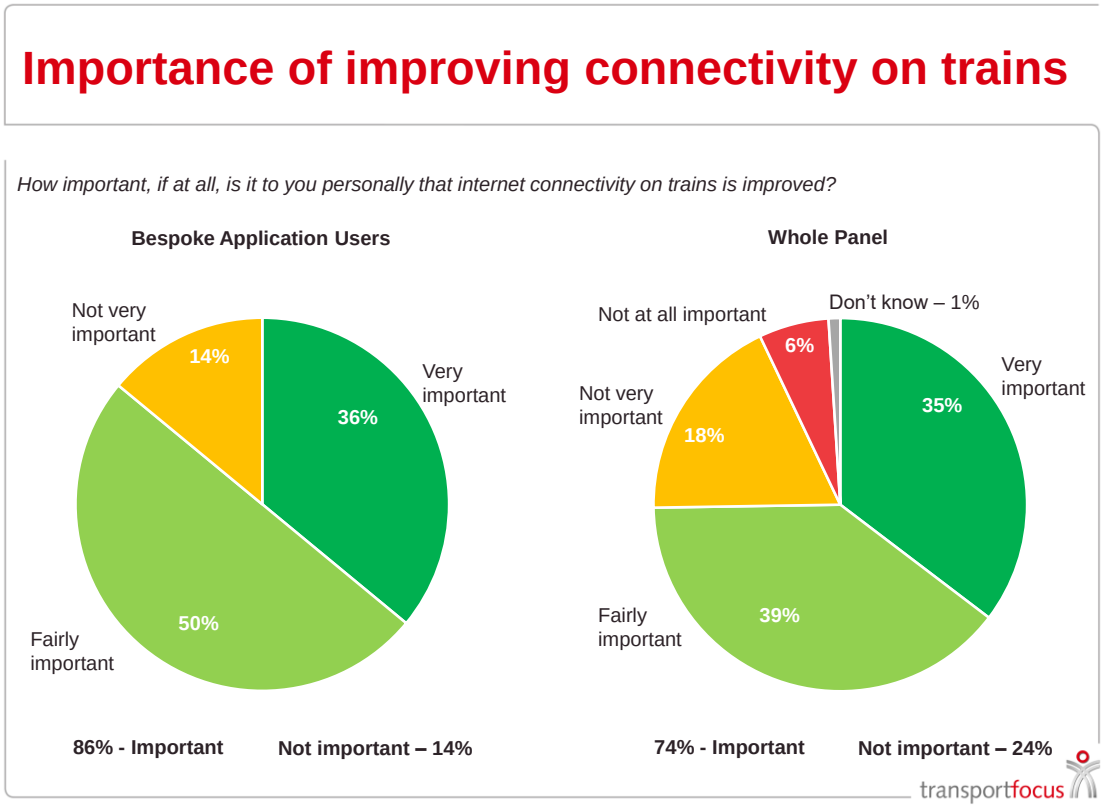
Fig. 57: Level of expectation of receiving an internet connection while travelling by train. Panellists who downloaded the bespoke application vs. all panellists



5.2.3 Importance of improving connectivity

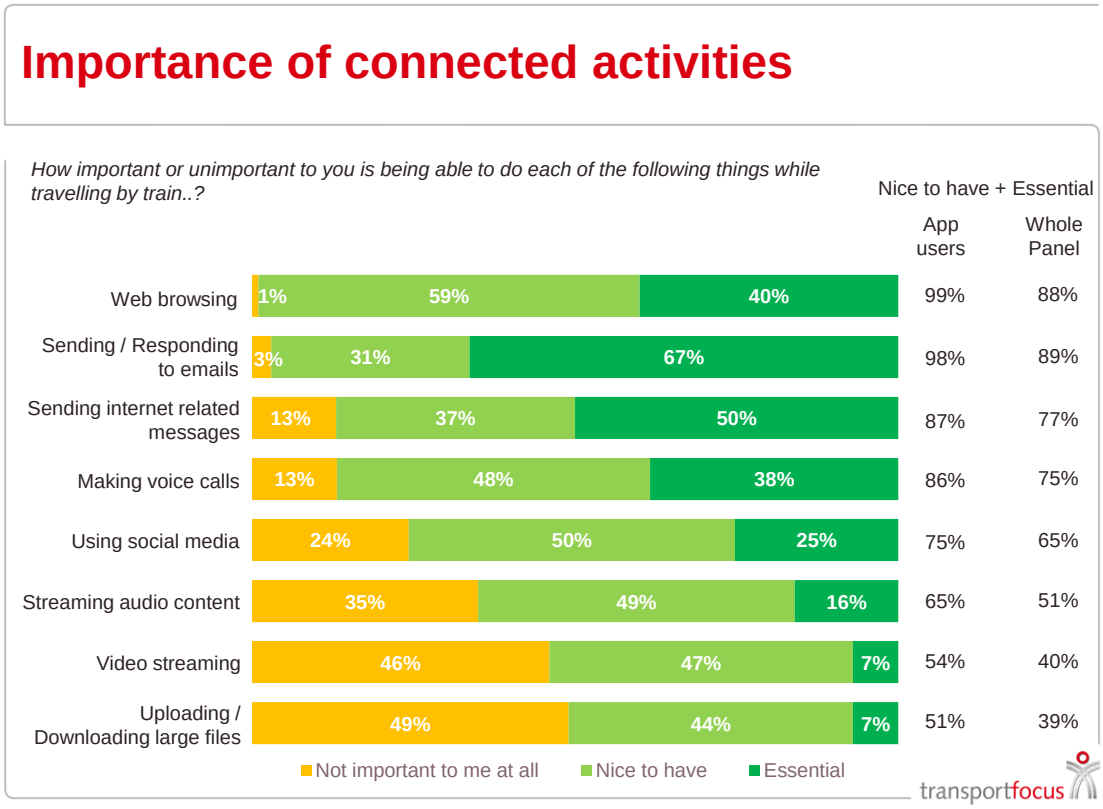
Those who downloaded the bespoke application are more likely than passengers generally to think that it is important to improve the level of connectivity on trains. 86 per cent say this compared with 74 per cent of passengers generally (Fig. 58).

Fig. 58: Level of importance ascribed to improving connectivity on trains. Panellists who downloaded the bespoke application vs. all panellists



When asked about different connected activities, those who downloaded the bespoke application tend to place these in a similar order of importance as train passengers generally (Fig.59). The ability to browse the web and to send and respond to emails is considered by this group to be particularly important, while the ability to download or upload large files, or to stream video or audio content, is considered to be less important.

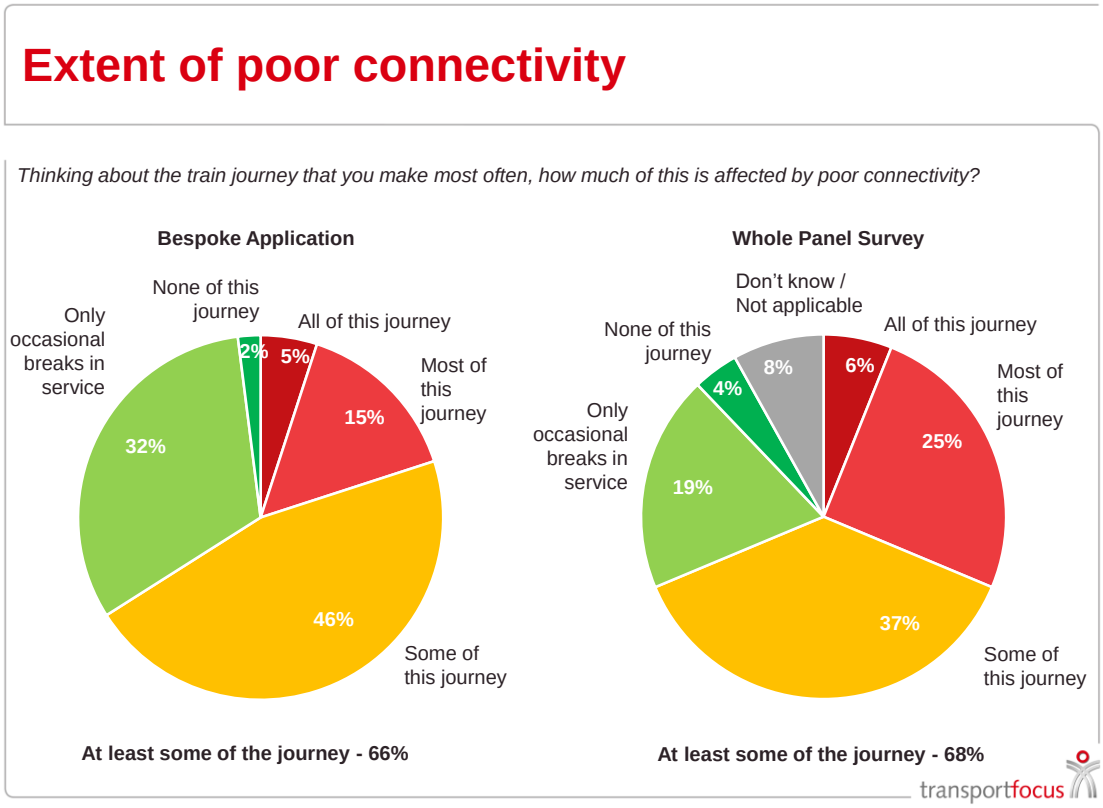
Fig. 59: Level of importance ascribed to different connected activities. Panellists who downloaded the bespoke application vs. all panellists



5.2.4 Perception and impact of poor connection on journeys

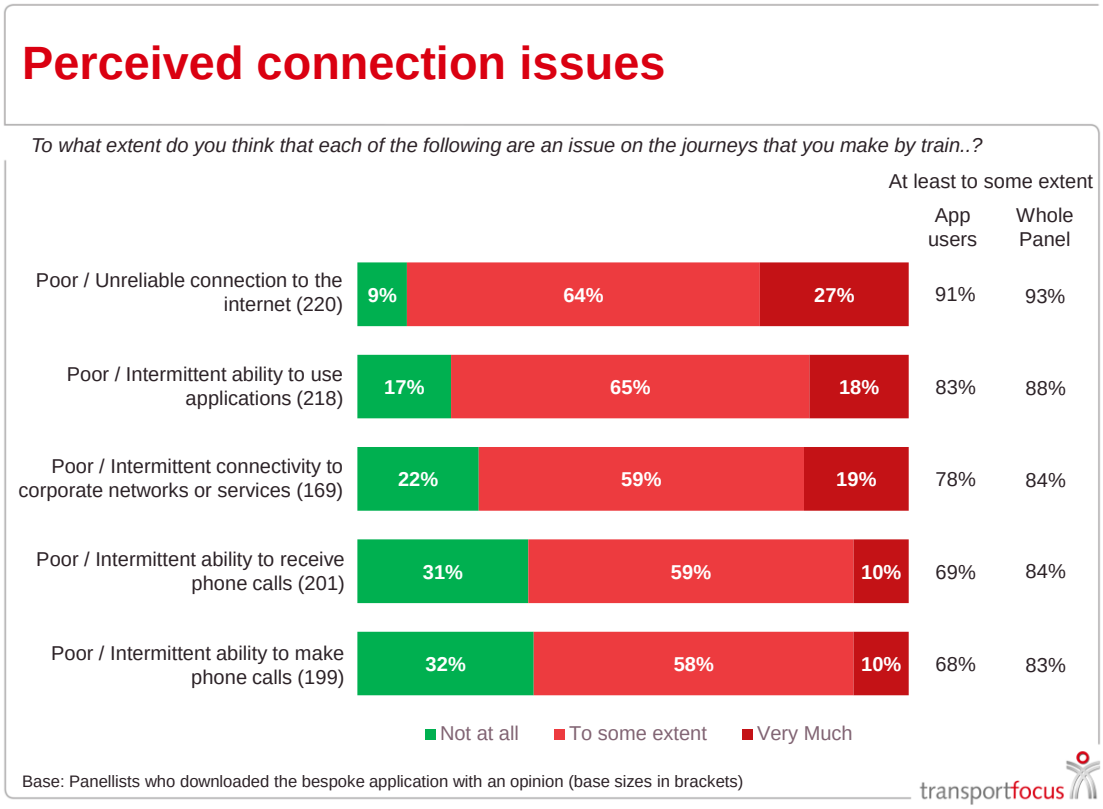
In broad terms those who downloaded the bespoke application share the views of train passengers generally regarding the extent of poor connectivity; 66 per cent of those who downloaded the bespoke application say that at least some of the journey which they take most often is affected by poor connectivity compared with 68 per cent of panellists overall (Fig. 60). While this is the case, smaller proportions indicate that most of their usual journey is impacted by poor connectivity and more say that there are only occasional breaks in service.

Fig.60: Perceived extent of poor connectivity on train journey made most often. Panellists who downloaded the bespoke application vs. all panellists



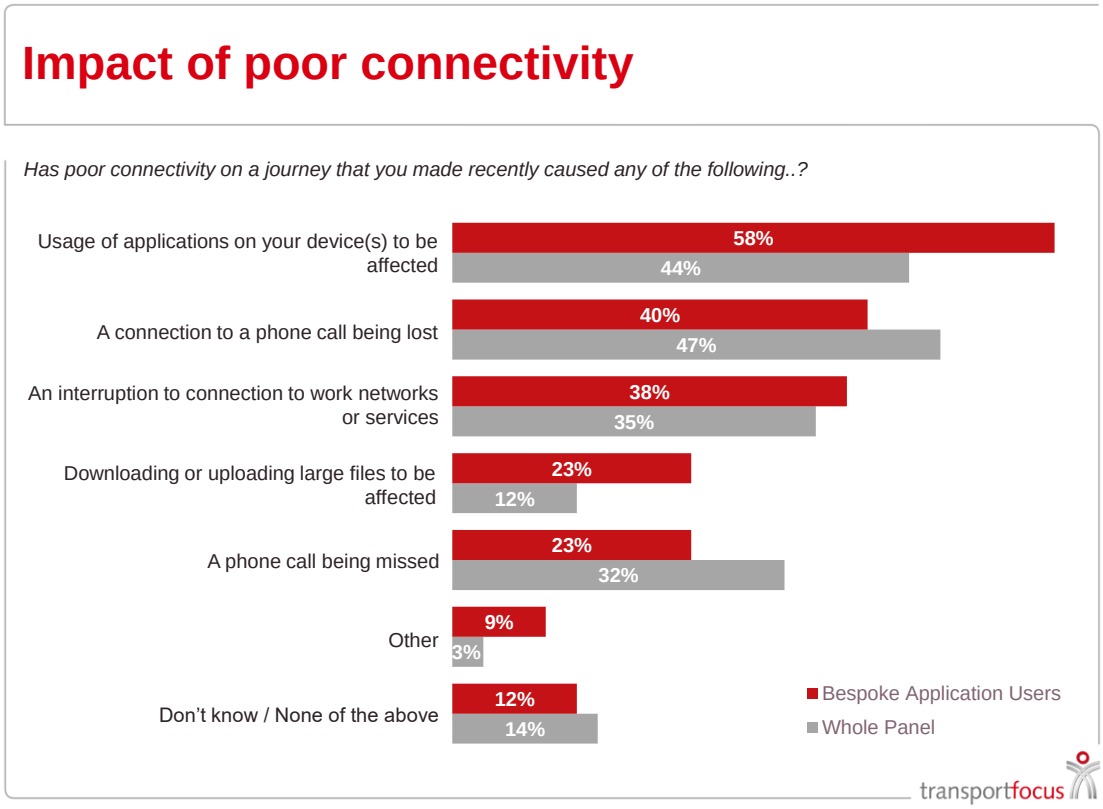
Those who downloaded the bespoke application perceive similar issues related to connectivity on trains as passengers more generally (Fig. 61). Nine in ten say that poor or unreliable connection to the internet is an issue at least to some extent on the journeys that they make by train, while around eight in ten say the same regarding poor or intermittent ability to use applications. As with passengers generally, the ability to make and receive phone calls is rated as less of an issue.

Fig. 61: Perceived extent of connection issues experienced on train journeys. Panellists who downloaded the bespoke application vs. all panellists



Bespoke application users are less likely than train passengers generally to indicate that a connection to a phone call being lost, or a phone call being missed has been an issue on a train journey that they have made recently (Fig. 62). Conversely, they are more likely than others to note that poor connectivity on a recent train journey has caused the usage of applications to be affected, an interruption to work networks or services, and the uploading or downloading of large files to be affected.

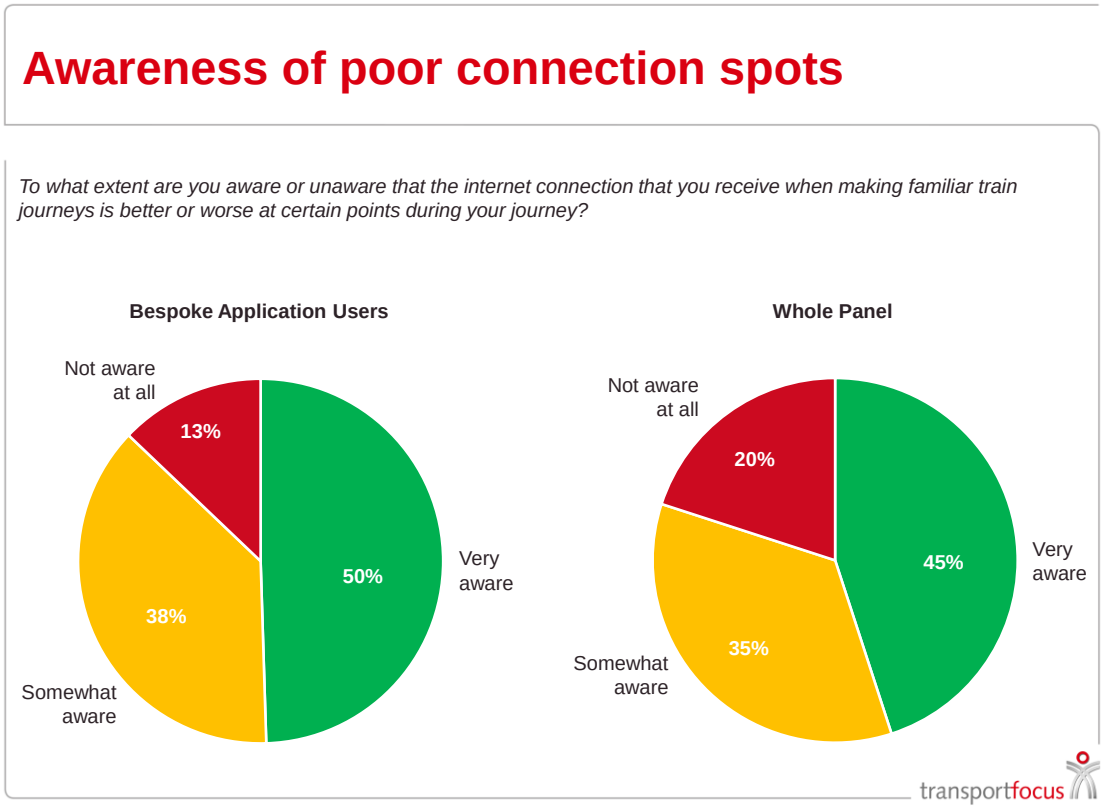
Fig. 62: Perceived impact of poor connectivity on trains. Panellists who downloaded the bespoke application vs. all panellists



5.2.5 Awareness of poor connectivity

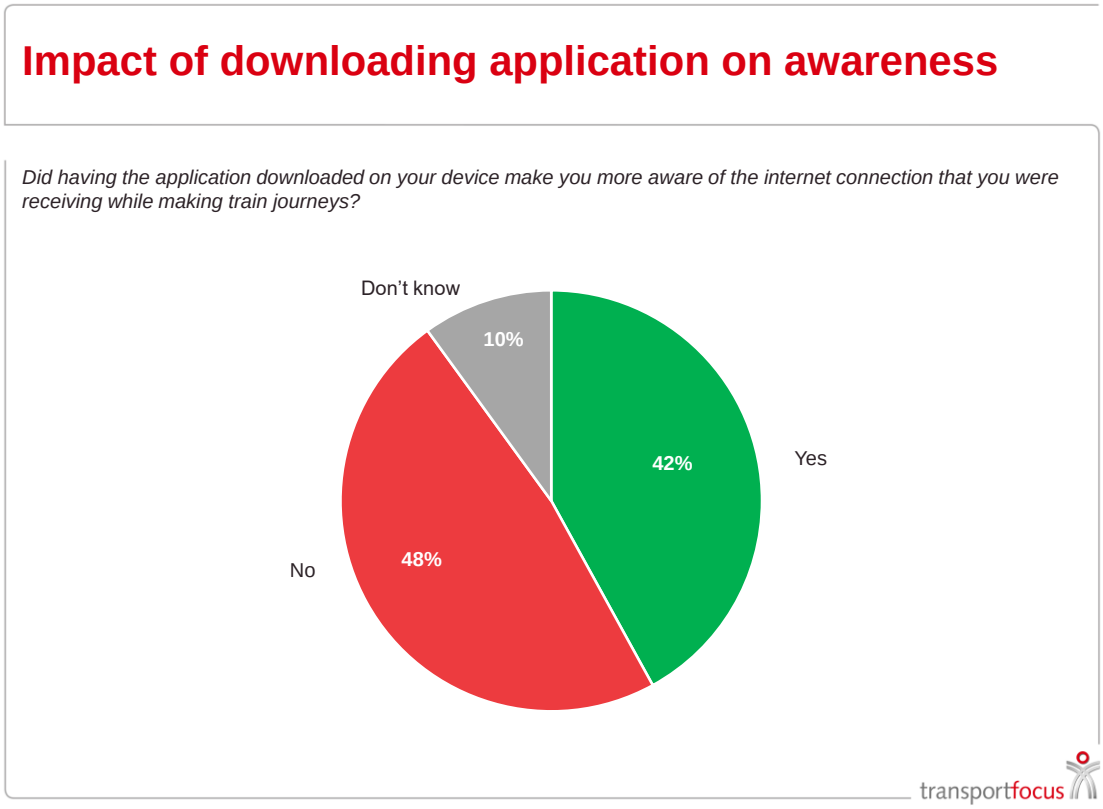
Users of the bespoke application are more likely than train passengers generally to say that they are aware that the internet connection that they receive is better or worse at certain points on a familiar train journey (Fig. 63). Half say that they are very aware of this, while 13 per cent are not aware at all.

Fig. 63: Awareness of poor connection spots on train journeys. Panellists who downloaded the bespoke application vs. all panellists



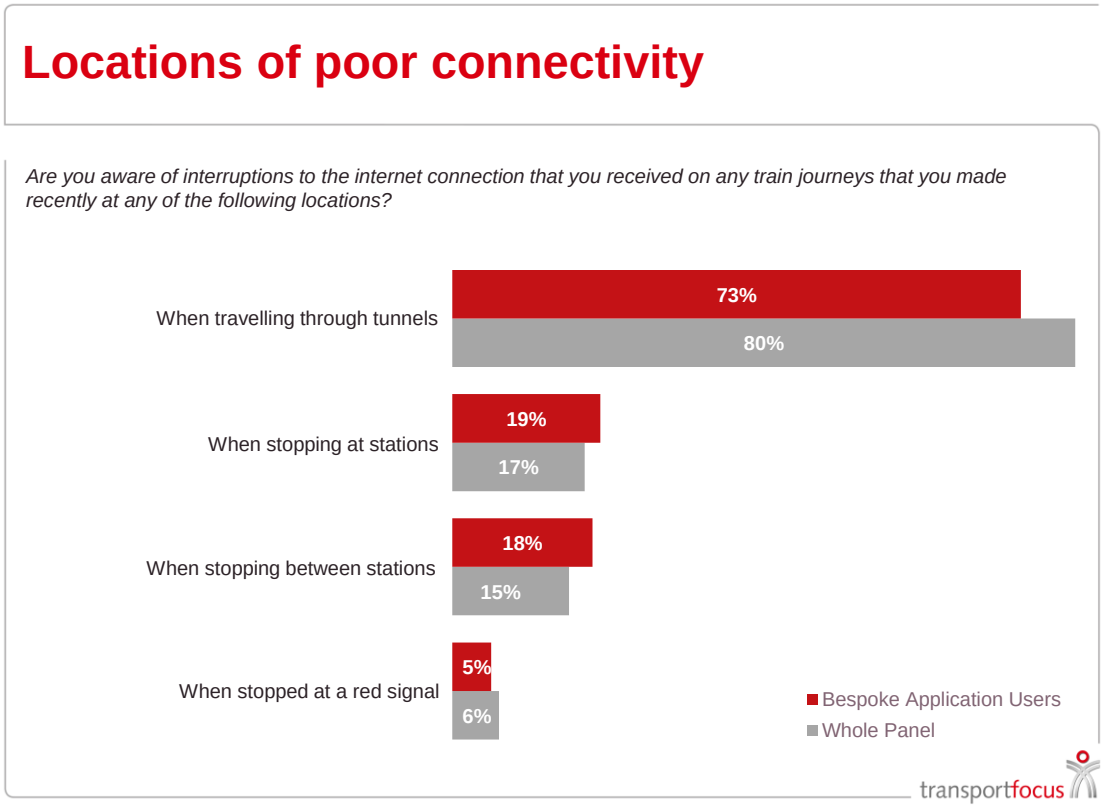
It is possible that the finding related to awareness of locations of poor connection among bespoke application users, which was collected after the monitoring phase of the research, is impacted by the process of the research itself. Indeed, 42 per cent of users noted that having the application downloaded to their device made them more aware of the connection speed that they were receiving when they made train journeys (Fig. 64).

Fig. 64: Perceived impact of downloading the bespoke application on awareness of the internet connection received when making train journeys



While those downloading the bespoke application may be more aware than others of locations of poor connectivity, like train passengers generally they perceive tunnels as being a place where internet connection tends to be interrupted during train journeys (Fig. 65).

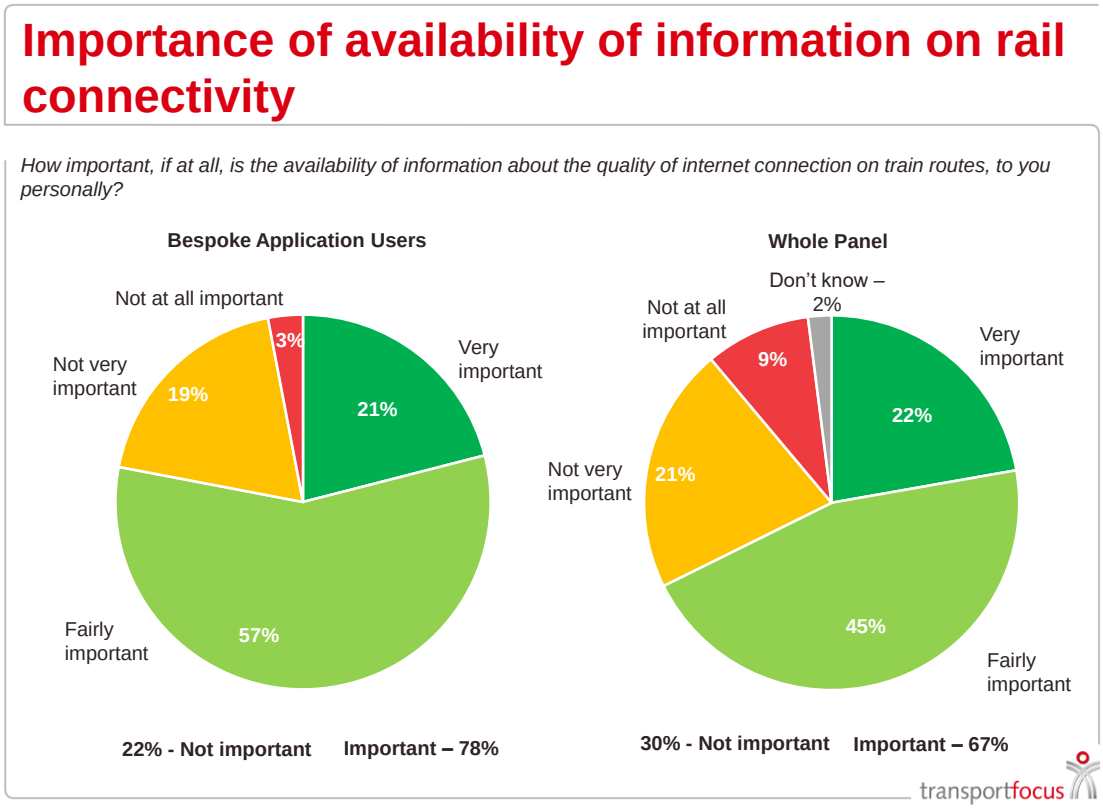
Fig. 65: Perceived locations of poor connectivity. Panellists who downloaded the bespoke application vs. all panellists



5.2.6 Information on connectivity

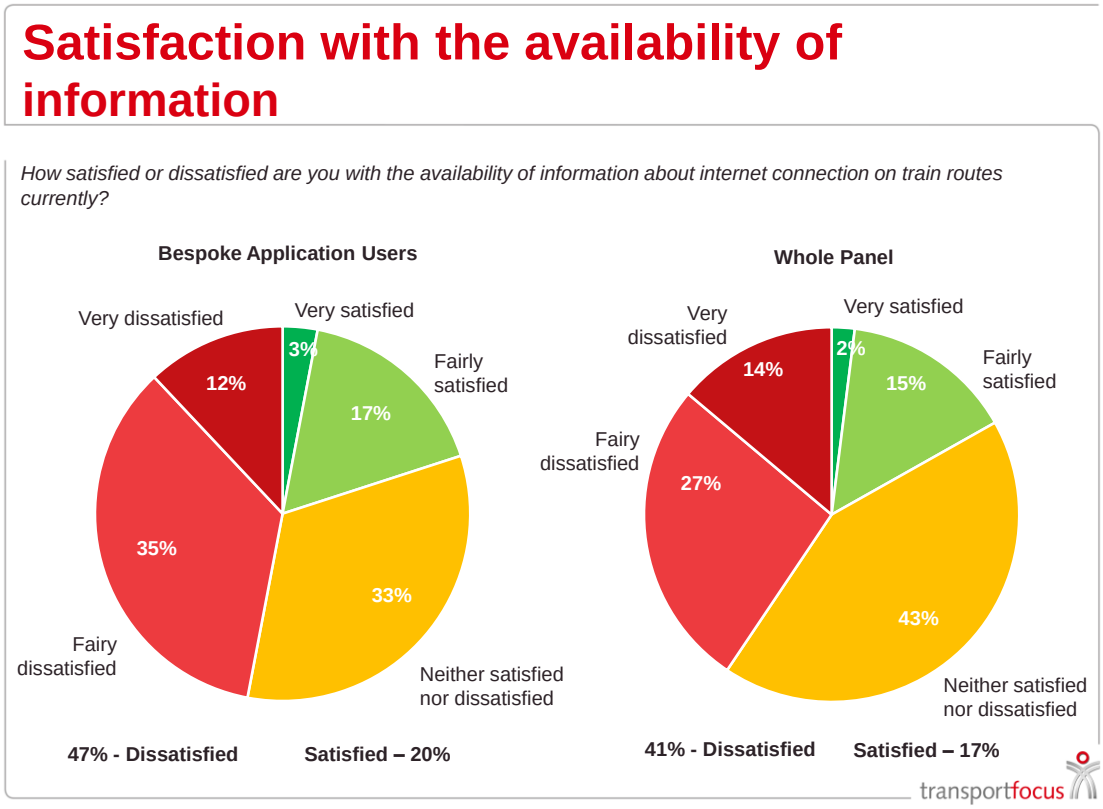
Transport User Panellists who downloaded the bespoke application are more likely than train passengers generally to think that it important that information related to connectivity on trains is made available (Fig. 66). 78 per cent of these train users say that the availability of this information is important compared with 67 per cent of passengers overall.

Fig. 66: Perceived importance of availability of information on rail connectivity. Panellists who downloaded the bespoke application vs. all panellists



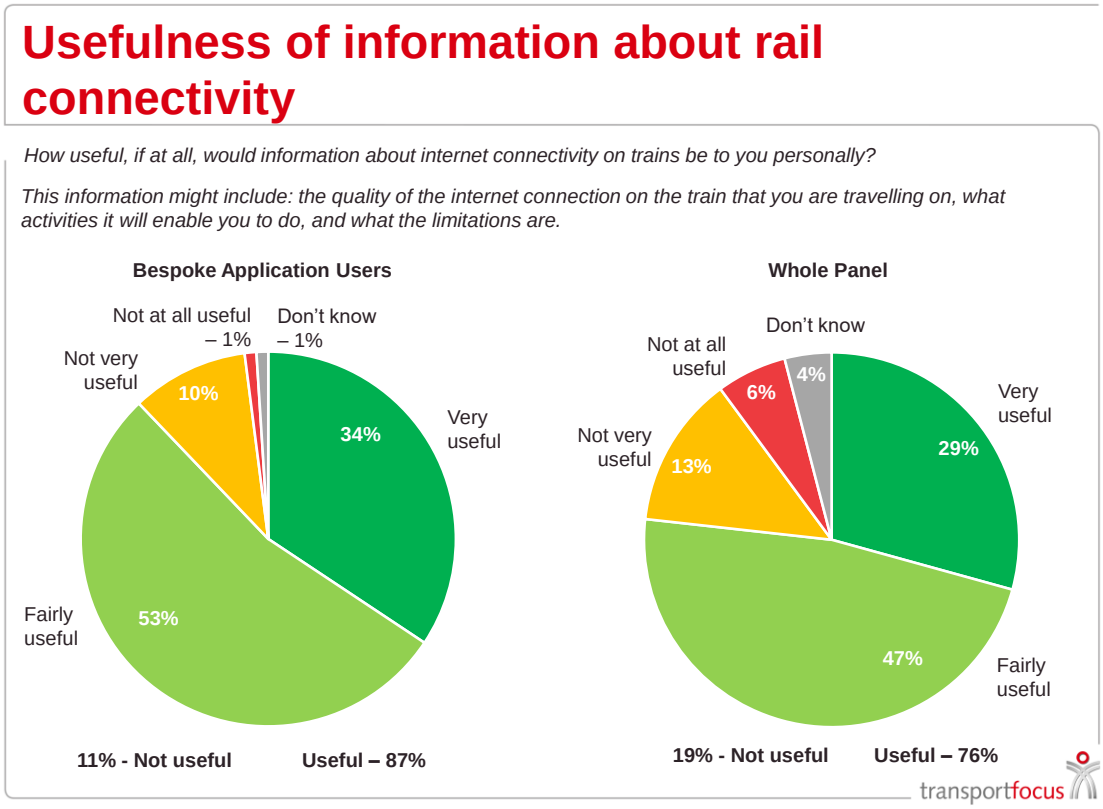
Those who downloaded the bespoke application are also marginally more likely than passengers generally to say that they are dissatisfied with the current availability of information about the internet connection available on rail routes. 47 per cent indicate dissatisfaction with the availability of information compared with 41 per cent of passengers overall (Fig. 67).

Fig. 67: Overall satisfaction with the availability of rail connectivity information currently. Panellists who downloaded the bespoke application vs. all panellists



Lastly, those who downloaded the bespoke application are more likely than passengers generally to say that they would find the availability of information about rail connectivity (such as the quality of the internet connection on the train currently travelling on) to be useful (Fig. 68). 87 per cent of these train passengers state that this information would be useful to them personally compared with 76 per cent of passengers overall.

Fig. 68: Perceived usefulness of information of about rail connectivity. Panellists who downloaded the bespoke application vs. all panellists



5.3 Passively collected bespoke application data and pop-up survey results

5.3.1 Introduction

As described above, the umlaut solution collected the same indicators of network performance among those who downloaded the bespoke application, as were crowdsourced among consumers more generally. However, because of the permissions provided by Transport User Panellists to the project team, the research reported here was also able to collect more in-depth information on the activities that these consumers engaged in while travelling on trains. This information was analysed together alongside feedback on perceived performance which panellists

gave by completing in app pop-up surveys close to the time that they made train journeys.

The findings which are reported here are based on data which was collected from 163 panellists using the bespoke application who were identified as using a train service within the monitoring period. This period ran from 11 April to 30 June 2019. The map at Figure 69 describes the locations of the samples collected by these panellists within this period.

Fig. 69: Train routes and locations of collected data samples from panellists who downloaded the bespoke application

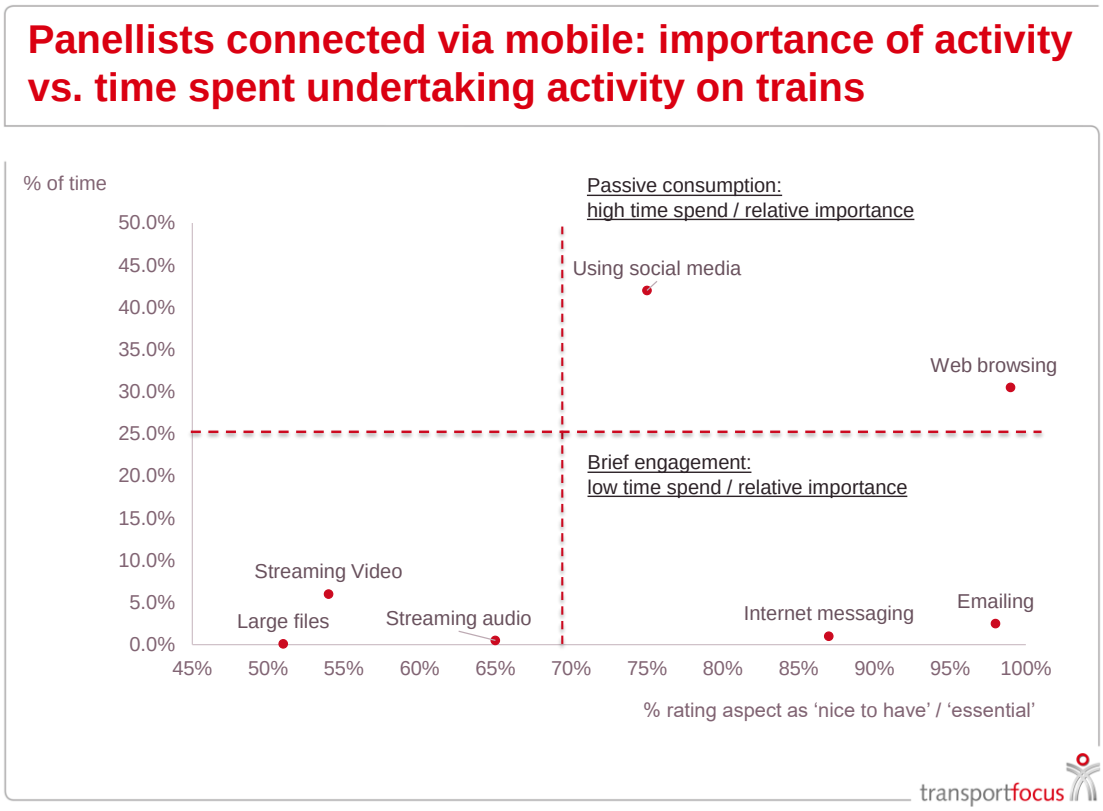
5.3.2 What are activities are passengers undertaking while on train journeys?

Those panellists who downloaded the bespoke application spent most of the time that they were using devices when travelling on trains undertaking three activities: browsing the web, using social media, and using tools (that is using things like mobile network operator customer care applications) and gaming. That these three activities are most prevalent is true for these panellists making connections on train or elsewhere in Great Britain and whether connections are made through Wi-Fi or through mobile networks. These activities are also those which account for the greatest amount of data traffic. While this is the case some differences do exist in terms of the ordering of the activities and in terms of the degree of disparity between them.

Differences also exist in terms of amount of time that panellists who downloaded the bespoke application spent undertaking different activities, compared with the degree to which they indicate that they consider these activities to be essential or nice to

have while travelling. This disparity is illustrated in Figure 70 which plots these variables against one another, taking into account panellists who made a mobile connection while travelling on trains (though the same general patterns are observable among those connecting via Wi-Fi). For example, while these panellists rate the ability to use social media as less essential or nice to have than they do other activities, it remains that activity where panellists spend greater proportions of their time. Similarly, while sending and receiving both internet-related messages and emails are considered to be important by more than 85 per cent of panellists who downloaded the bespoke application, these panellists spend relatively little time engaged in these activities.

Fig. 70: Panellist rating of importance of connected activities vs. time spent undertaking these activities (by mobile network connection)

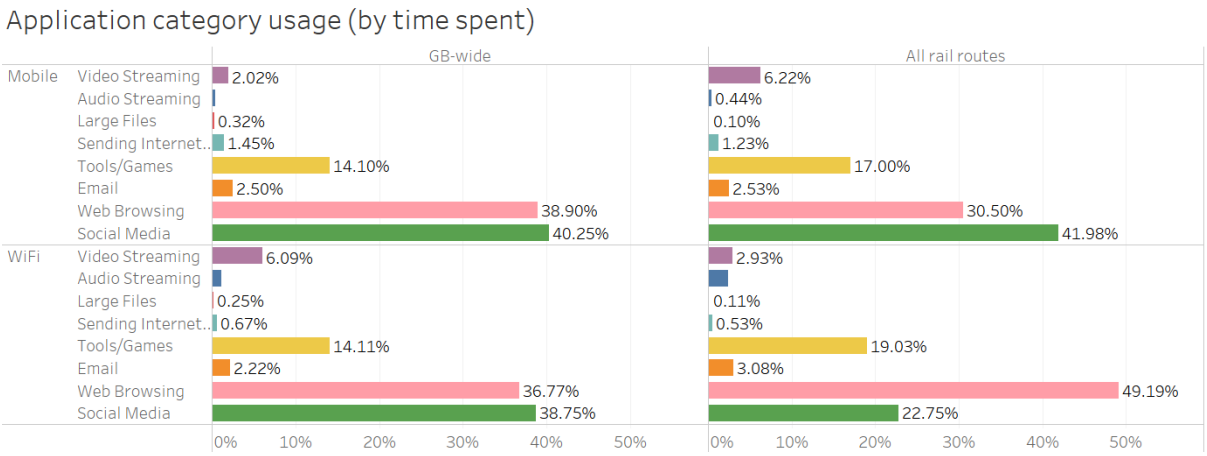


One might argue that given the nature of the activities, it is not necessarily surprising that the perceived importance of an activity is not reflected in the time in which people spend engaged in that activity. Similarly, it should be noted that passengers' previous experience will have an impact on their behaviour on trains. However, an analysis of this type does provide us with a holistic view of passenger attitude and behaviour and allows us to observe how the two aspects work in tandem. It would appear then that while passengers value the ability to undertake activities which take little time to complete, it is also relatively important to provide a consistent connected experience which allows for more passive, time-consuming activities.

Figure 71 illustrates the percentage of the total time that they were connected to the internet that panellists who downloaded the bespoke application spent undertaking several different activities. This information is broken down to offer a comparison between the amount of time the same panellists spent undertaking the same activities on trains or elsewhere, and when making connecting to the internet through a Wi-Fi or mobile network connection.

The bottom right quadrant of Figure 71 shows that when panellists who downloaded the bespoke application were connected to on-train Wi-Fi they spent around half of their time web browsing and 23 per cent of the time was spent using social media. While web browsing and using social media remain those activities where these panellists spent the greatest amount of their time when connected to Wi-Fi in places other than on trains (bottom left quadrant), there is much less of a disparity of time between them.

Fig. 71: Percentage of time spent undertaking connected activities by technology type – GB-wide versus all rail routes



Again, when panellists connect to a mobile network when travelling on trains (top right quadrant of Figure 71), web browsing and using social media remain the top two connected activities which are undertaken. However, while these panellists are more likely to spend time web browsing than using social media when using an on-train Wi-Fi connection (bottom right quadrant), this order is reversed when the same panellists make a connection through a mobile network. When connected to a mobile network while travelling on trains around 42 per cent of time is spent using social media, and 31 per cent of time is spent web browsing.

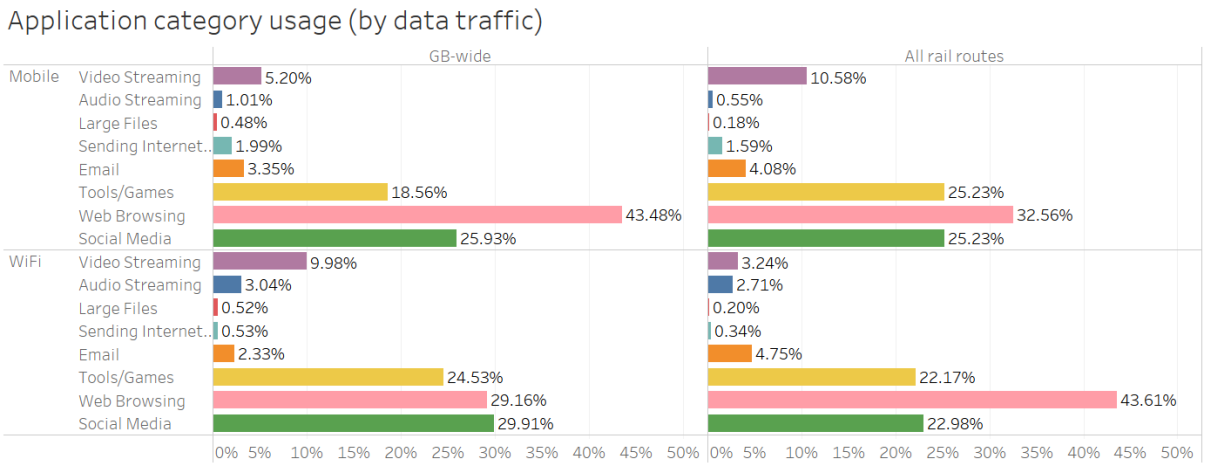
Panellists who downloaded the bespoke application spent around three per cent of their time video streaming when using on-train Wi-Fi (bottom right quadrant of Figure 71), while they spent six per cent of their time engaged in the same activity when connected to a mobile network while travelling by train (top right quadrant). This situation is reversed when the same panellists make connections in places other than on trains. When connected in places away from train routes these panellists

spent six per cent of their time video streaming when connected to Wi-Fi (bottom left quadrant), and two per cent of their time engaged in this activity while making a mobile network connection (top left quadrant).

Figure 72 again illustrates what panellists who downloaded the bespoke application were doing when making a connection on trains compared to when making a connection elsewhere, and when making a Wi-Fi on mobile network connection. However, in this case the chart shows the percentage of the total amount of data consumed which was spent in undertaking each activity.

Figure 72 shows that just as web browsing, using social media, and using tools and gaming are those connected activities that panellists spent most of their time undertaking while travelling on trains, they also account for the greatest proportions of data traffic generated. While video streaming accounts for a relatively small proportion of the time that panellists spent connected while on trains, the activity accounts for a greater proportion of data traffic. This is particularly the case among those panellists making a mobile network connection when on trains (top right quadrant of Figure 72) where almost 11 per cent of the data traffic generated is spent video streaming.

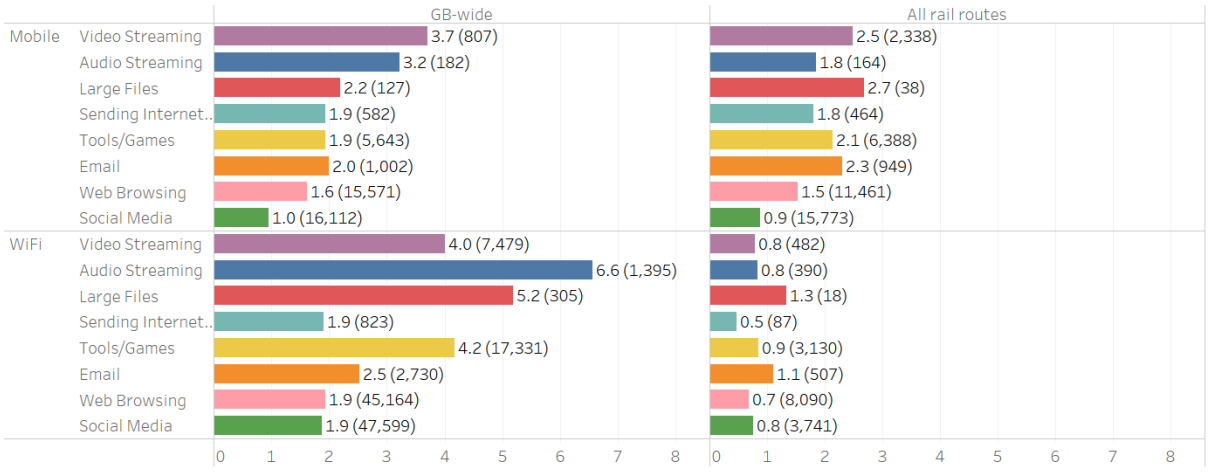
Fig. 72: Percentage of total data consumed undertaking connected activities by technology type – GB-wide versus all rail routes rail routes



An analysis of the throughput that those panellists who downloaded the bespoke application received while travelling on trains confirms that on-board Wi-Fi offers significantly reduced download speeds in comparison with mobile network connections (compare the top right quadrant with the bottom right quadrant in Figure 73). Similarly, the analysis shown at Figure 73 illustrates the disparity between the download speeds which are available on trains compared with those that are available elsewhere.

The disparity between the download speeds available on train and that available elsewhere is particularly obvious when considering those activities which use relatively large amounts of data. Among those panellists making a connection though on-board Wi-Fi (bottom right quadrant of Figure 73) an average download speed of 0.8 megabits per second (Mbps) was received for those engaging in streaming both audio and video content, while an average download speed of 1.3Mbps was received by those downloading large files. This compares with average download speeds of 4.0Mbps for video streaming, 6.6 Mbps for audio streaming, and 5.2 Mbps for downloading large files which are received when these same panellists make a Wi-Fi connection elsewhere (bottom left quadrant).

Fig. 73: Average download speed in Mbps received when undertaking connected activities by technology type – GB-wide versus all rail routes

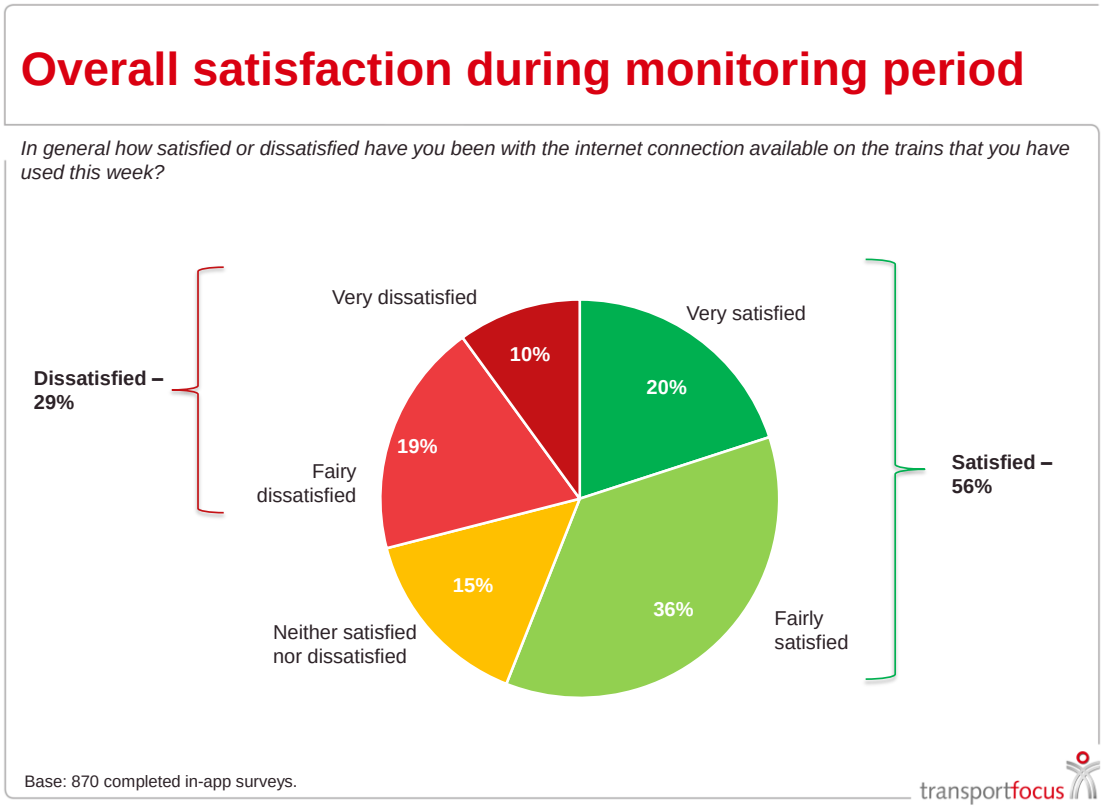


5.3.3 Passenger perception of connection speed

During the period in which the connection speeds received by those who downloaded the bespoke application were collected, the bespoke application sent users weekly pop-up surveys which encouraged them to report on their experiences in that week. Across the whole of this time 870 surveys were completed and returned.

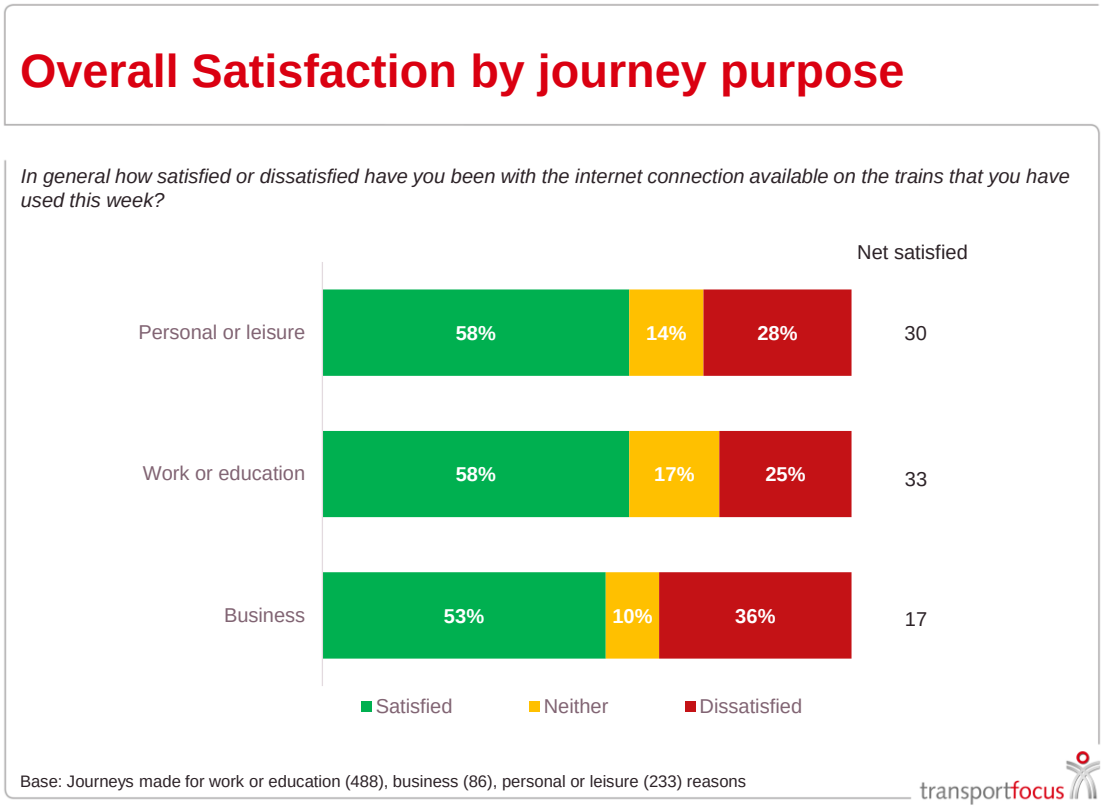
These surveys indicate that overall around 56 per cent of the journeys taken delivered a level of connectivity with which the application user was satisfied (fig 74). Conversely, the level of connectivity was felt to be dissatisfactory for 29 per cent of the journeys.

Fig. 74: Panellists' overall satisfaction with the internet connection available on trains used within the monitoring period



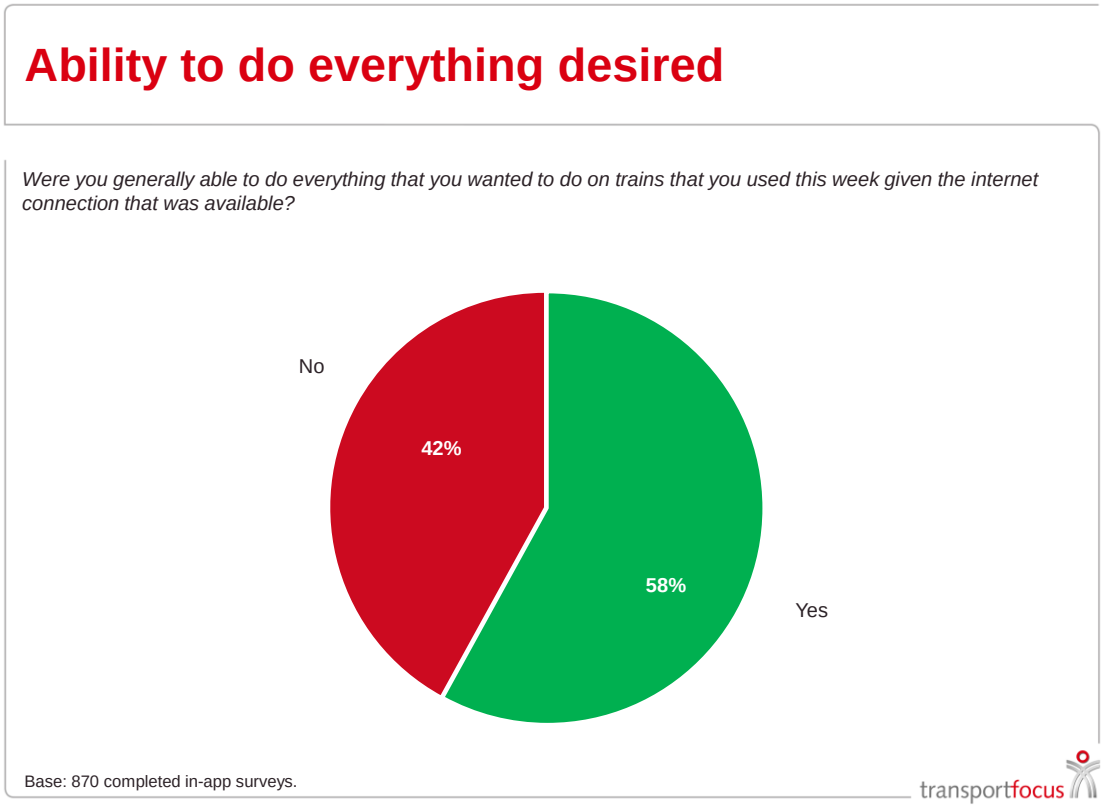
As is indicated elsewhere, findings from the pop-up survey indicate that those travelling for business reasons are less likely than others to find the connection speed that they received during their journey to be satisfactory. As illustrated in Figure 75, 53 per cent of the journeys taken by bespoke application users travelling for business were deemed to have delivered a satisfactory level of connectivity. This compares with 58 per cent of the journeys taken by those travelling for personal or for leisure reasons. If a 'net satisfaction' score is derived by subtracting the level of dissatisfaction from satisfaction for each journey purpose sub-group, this clearly shows the differences in the balance of opinion among each of these groups.

Fig. 75: Panellists' overall satisfaction with the internet connection available on trains used within the monitoring period, by main journey purpose



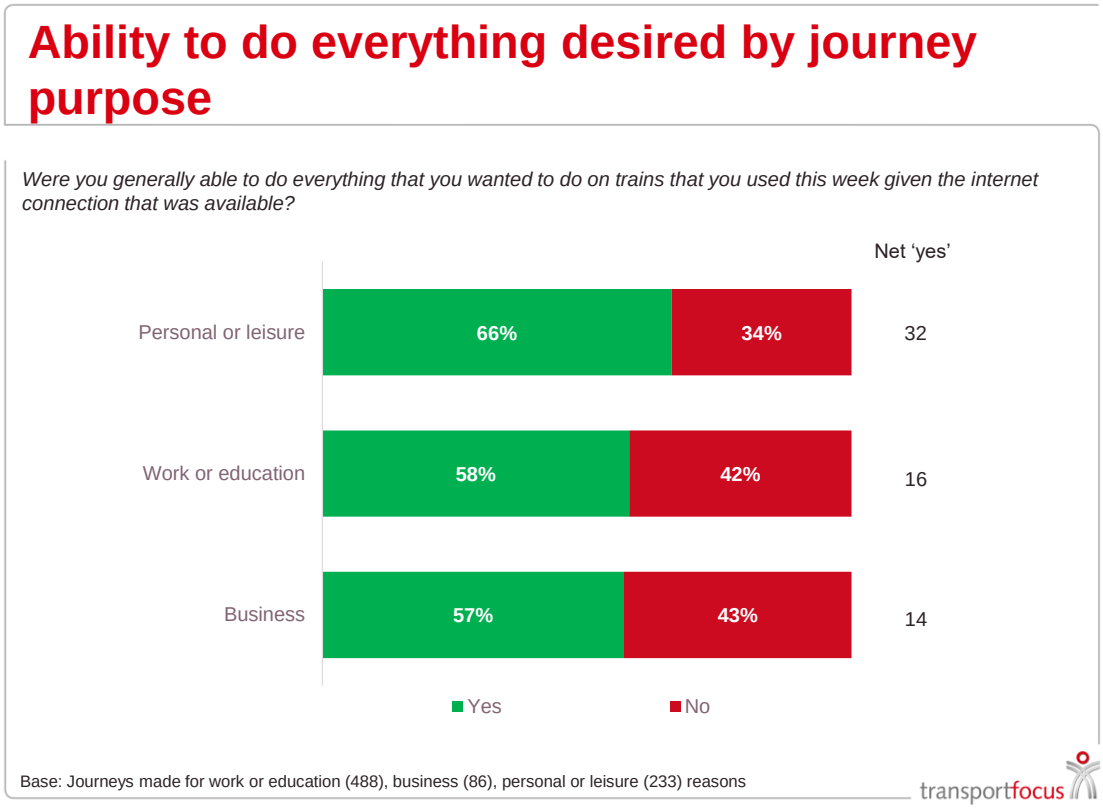
Bespoke application users indicate that during the monitoring period they were able to do everything that they wanted on their journeys on 58 per cent of occasions (Fig. 76). Conversely, the internet connection stopped these train passengers from completing activities 42 per cent of the time.

Fig. 76: Panellists' rating of their ability to 'do everything they wanted to do' on trains used in the monitoring period given the internet connection that was available



Again, findings indicate that those who are travelling for business reasons are less likely than others to find that they are able to do everything that they want to do while travelling on trains (Fig. 77). During the monitoring period bespoke application users travelling for this reason indicated that they were able to complete all activities on 57 per cent of the journeys that they made. This compares with 66 per cent of the journeys that were made by those travelling for personal or leisure reasons.

Fig. 77: Panellists' rating of their ability to 'do everything they wanted to do' on trains used in the monitoring period given the internet connection that was available by main journey purpose



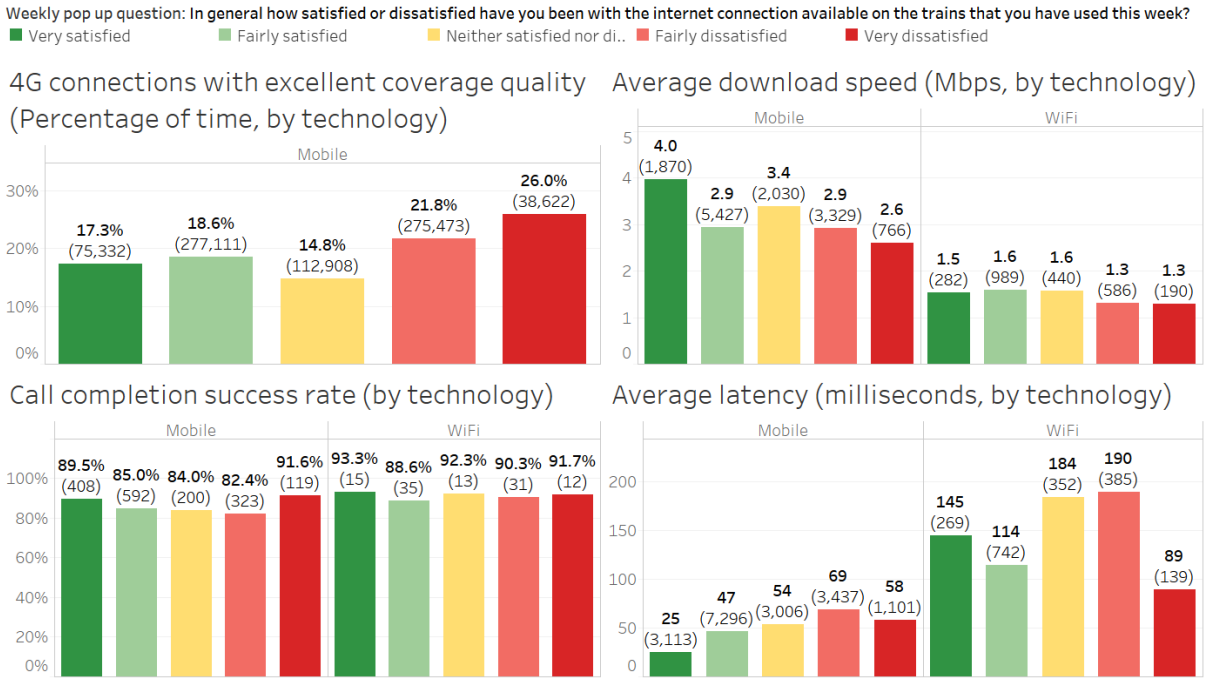
5.3.4 Correlating network performance and passenger satisfaction

To try to understand if improved network performance correlates with increased passenger satisfaction, data relating to the quality of the network connection which was collected through the bespoke application was correlated with the data provided by panellists via in app pop-up surveys. In particular this analysis concerned the responses to the questions that panellists answered relating to their satisfaction with the quality of the internet connection available on the trains that they had used that week, and also to the question of whether or not they were able to do all that they wanted to do on the trains on which they had travelled.

Analysis of this type provides some indication that panellists noticed when the quality of the connection that they received on trains was improved. This analysis, as it relates to the quality of the internet connection received and panellist rating of their overall satisfaction, is illustrated in Figure 78.

In terms of satisfaction with the quality of the internet connection, those making a mobile network connection appear to be generally more satisfied with the quality of the internet connection than others when average download speeds are increased (top right quadrant of Figure 78). This difference is not as marked among panellists making a connection through the on-board Wi-Fi, though as we have seen previously the quality of download throughput provided over on-board Wi-Fi fluctuates less often and provides a more consistent experience for passengers. This then is perhaps less likely to lead to differing levels of passenger satisfaction.

Fig. 78: Correlating panellists' overall satisfaction with the internet connection received on trains used within the monitoring period, with the quality of the internet connection which was available



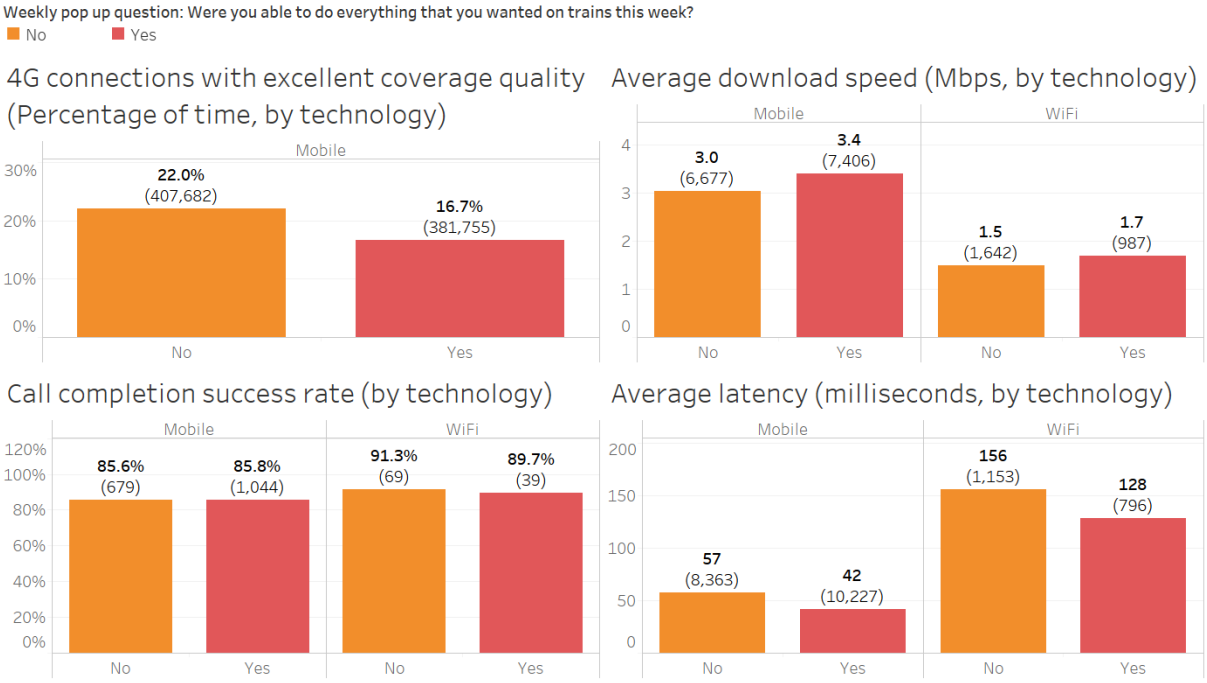
Similarly, data suggests that panellists using the bespoke application are more likely than others to report satisfaction with the quality of the internet connection available when average network latency is decreased (bottom right quadrant of Figure 78). Those using a mobile network connection, who reported that they were very satisfied with the quality of the internet connection that they received, experienced an average network latency of 25ms, compared with those who were fairly satisfied who received an average network latency of 47ms, and those who were fairly and very dissatisfied who received network latencies of 69ms and 58ms on average respectively.

In some ways attempting to correlate panellist experience of connectivity on trains with a measure of overall satisfaction will be limited, as the survey question does not concern any particular journey, but rather covers a range of journeys which will have been made in a single week. This is also the case with correlating experience with a question of whether a panellist felt that they were able to do all that they wanted to do on the journeys that that made, however the use of this question my confer some advantages. In particular, asking whether panellists felt that they could do all that they wanted to do provides a more direct measure of experience than a general feeling of satisfaction and also the question provides binary rather than graduated responses which are beneficial in terms of analysis.

The clarity of the question of whether panellists could do all that they wanted to do is, perhaps, visible in the results of the analysis (illustrated in Figure 79) which shows some indication of a correlation between panellist experience and quality of connection. In terms of download throughput (top right quadrant), panellists who accessed a mobile connection when travelling by train, who said that they were able to do all that they wanted to do, received an average download speed of 3.4 megabits per second (Mbps) compared with an average download speed of 3.0 Mbps among those who disagree.

For those making a connection through the on-board Wi-Fi the difference for those who said that they could do all that they wanted to do on trains compared with those who disagree is similar. Wi-Fi connected panellists who agreed that they were able to complete the tasks that they wanted to, received on average a download speed of 1.7 Mbps compared with 1.5 Mbps for those who disagree.

Fig. 79: Correlating panellists' rating of being able to 'do all that they wanted to do given the internet connection available' on trains used within the monitoring period, with the quality of the internet connection which was available



Results are again consistent when network latency is considered (see the bottom right quadrant of Figure 79). Panellists who made a mobile network connection and who said that they were able to do all that they wanted to do while travelling on trains received an average network latency of 42 milliseconds (ms) compared with an average latency of 57ms which was received among those who said that they were not able to complete tasks as expected. Among panellists who made a connection via the on-board Wi-Fi, those who said that they were able to do all that they wanted to do received an average network latency of 128ms, while those who disagree received an average network latency of 156ms.

While these findings are encouraging in terms of showing that making improvements to the level of connectivity on trains will be recognised in the passenger experience, some degree of caution is advised. The sample, in terms of numbers of individual passengers, used to generate these findings is small even if the number of individual 'samples', in terms of technical measures of the quality of the internet connection collected through the bespoke application, is larger. We know that Transport User Panellists are in some ways unlike those who use trains in general and so all results reported here should be seen as indicative rather than statistically significant. Overall our recommendation would be that more work of this type would need to be completed in order to provide more robust evidence of a correlation between the quality of on-board connectivity and passenger experience.

6. Conclusions

Technical measurements indicate that compared with their experience of making internet connections elsewhere, the experience of those travelling on GB rail lines is poor. This finding is mirrored by survey data which shows a low level of satisfaction among passengers, with satisfaction among certain types of passenger (such as those travelling for business reasons) being particularly low.

Findings do indicate that an improved quality of internet connection is noticed by those travelling on GB rail lines and that this leads to passengers reporting a higher rate of satisfaction. It is likely though that passenger perception is related to expectation which varies by passenger sub-group. Further research in this area would need to be undertaken using a larger sample size of passengers to unpick the complexities of this relationship.

7. Acknowledgements

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