Passenger experience of connectivity on GB's railways

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1 Introduction

This report summarizes the technical findings of the research project that umlaut performed for Transport Focus and the Department of Transport. The purpose of this project was to understand and evaluate consumer experience and satisfaction of mobile connectivity when using Great Britain's rail network.

The approach taken during this research, was to use and analyze data collected directly from consumers' smartphone Android devices.

In the following sections of this report we will explain in detail the methodology used for data collection in the project, present the different metrics used to assess consumer experience and finally publish the results of our assessment.

2 Data Collection Methodology

For the purpose of this project umlaut used data collected from two different sources. The first source was umlaut's crowdsourced data from Android devices across Great Britain during a 6 month period, from December 2018 to May 2019. The second source was from a bespoke application that umlaut developed for Transport Focus. This application was distributed to rail passengers by Transport Focus. The data collection period for this application was from 11th April 2019 to 30th June 2019.

In this section we will describe the above two data sources in more detail.

2.1 Data Collection using umlaut's Crowdsource Panel

The umlaut crowdsourcing solution is based on data collected from applications installed on consumers' smartphones devices and collects data passively in the background. Once one of these applications is installed on the end users' smartphone device, then the data collection is happening 24/7/365 seamlessly on this device. Data collection stops only when the application is uninstalled by the user. These applications will collect anonymized data of the mobile network and WiFi experience of the end users. The data includes metrics such as how good the mobile coverage is or if there is mobile signal available and from which technology (e.g. 3G 4G or 5G).

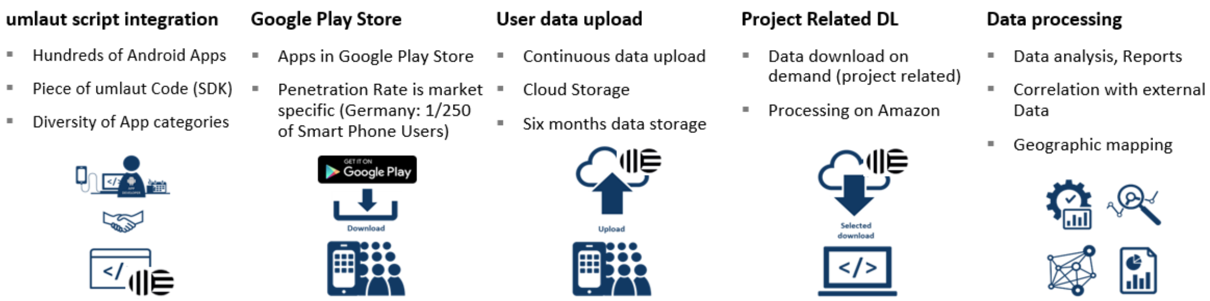


Figure 1: introduction to umlaut's Smartphone Application

This efficient data collection mechanism has allowed umlaut to create an extensive footprint in the UK, as shown in the figure below:

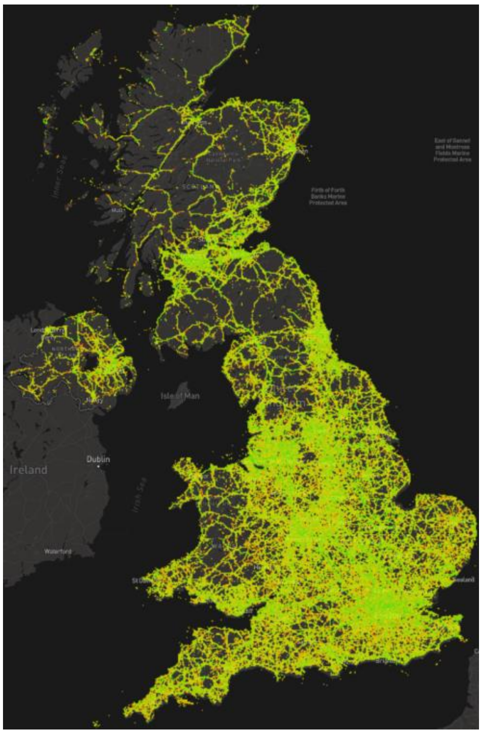


Figure 2: Coverage data collected in the UK over 30 days from umlaut crowdsource panel

The umlaut solution collects dozens of Performance Indicators that characterize consumer experience of mobile networks, many of them on a per second basis, including performance indicators for network coverage, data sessions and voice calls.

This solution is network agnostic which mean that the network type used by the end users (e.g. 2G/3G/4G or WiFi) is available for all collected samples. As such, comparative analysis on WiFi vs. mobile technology can be performed.

2.2 Data Collection using the Research App developed for Transport Focus

Using the same technology as described in section 2.1 above, umlaut developed a research app for Transport Focus, whose aim was to acquire more granular information on the mobile network experience of consumers while travelling on trains, while also collect detailed feedback about this experience.

The bespoke app, available on Android smartphone devices, was distributed to a panel of rail passengers by Transport Focus, and was used to collect measurements 24/7/365 seamlessly in the background and also to run at least weekly satisfaction surveys for the panellists to answer.

When opening the research app for the first time, a pop-up took users to their smartphone settings, where they are asked to add the app to the list of ‘apps with usage access’. This additional permission was required to ensure all of the application's functionality were properly enabled. The application then asked users to consent to the data collection and provided profiling information.

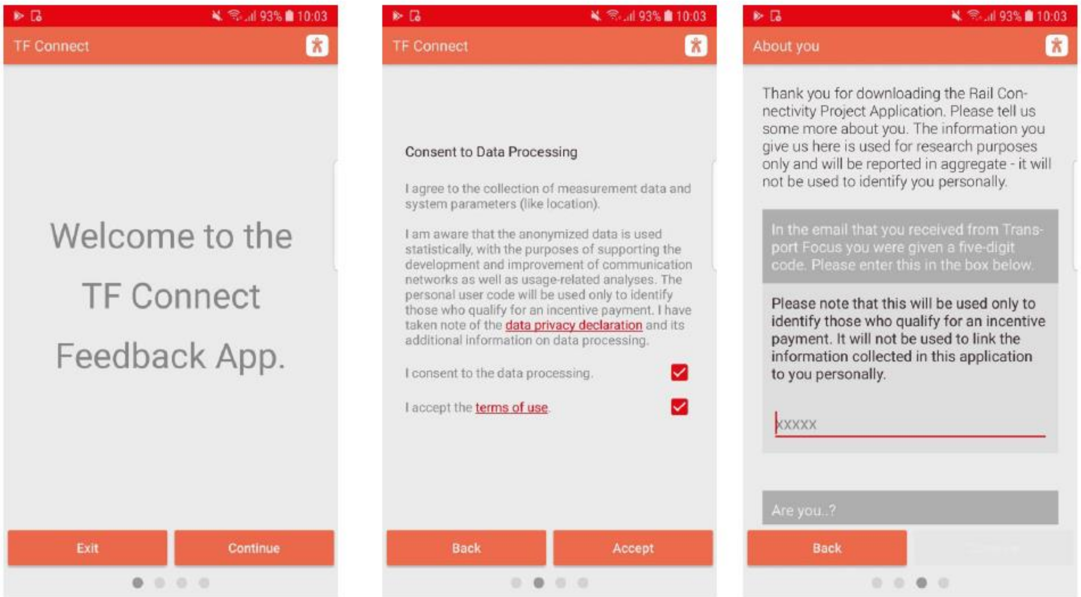


Figure 3: Transport Focus Application – Data Consent

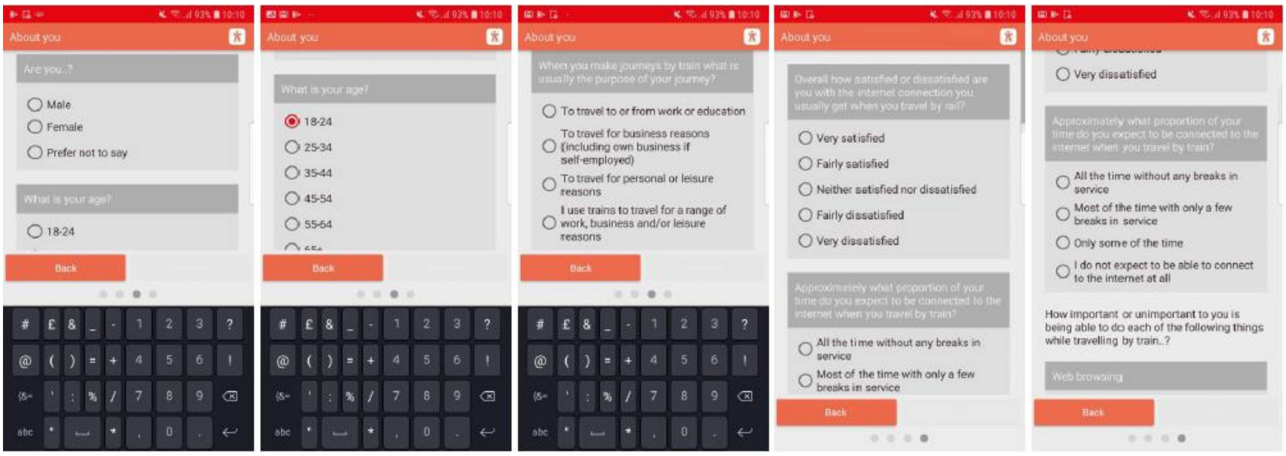


Figure 4: Transport Focus Application – Profiling Questions

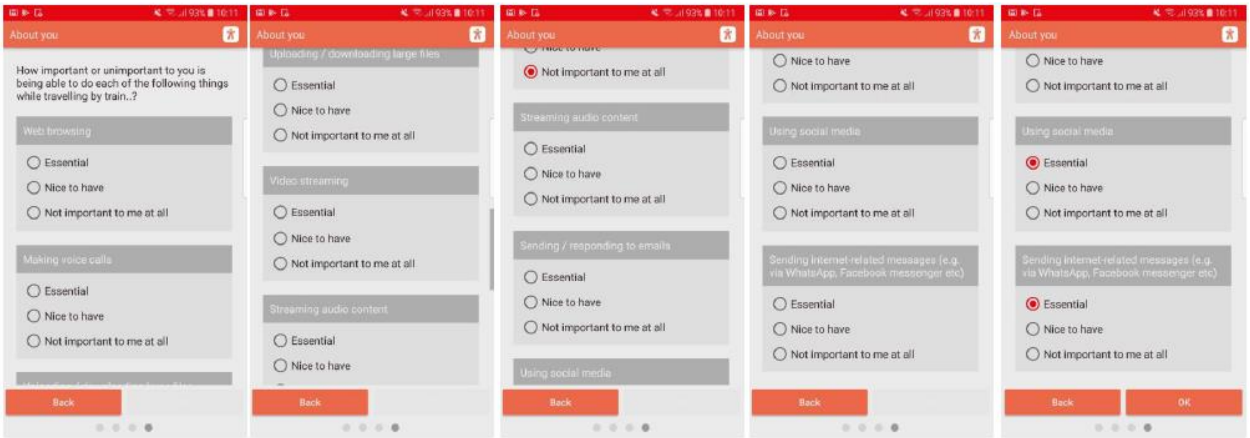


Figure 5: Transport Focus Application – Profiling Questions

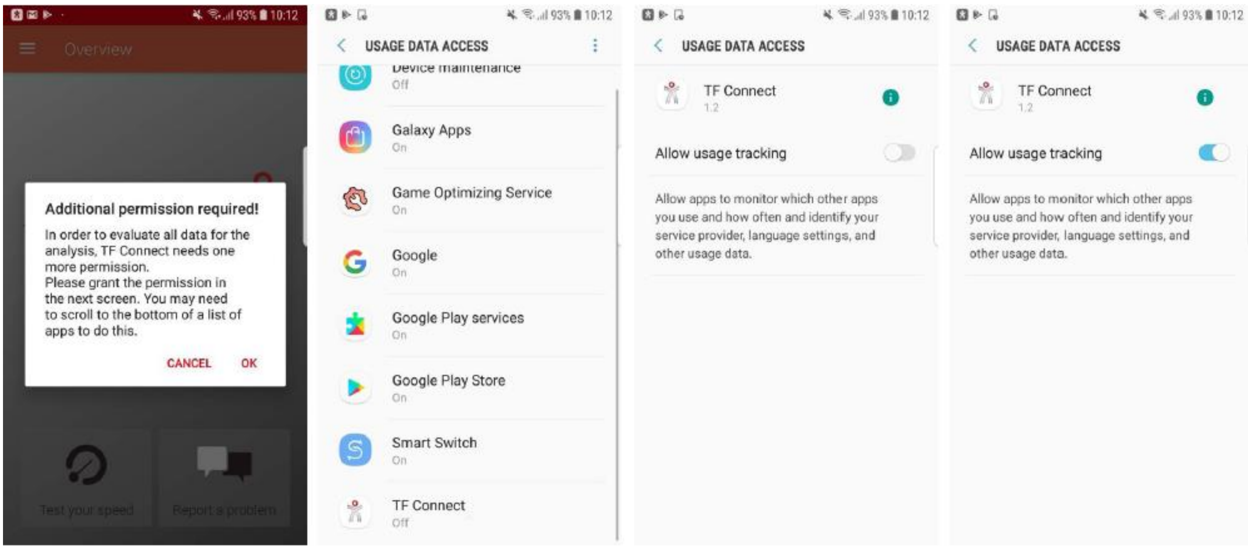


Figure 6: Transport Focus Application – Additional Permissions for App Usage Data Access

The application collected data passively, while people were using their phones, and did not require any further user interaction.

An important part of the research was to compare mobile network performance with customer satisfaction levels, so from time to time the application presented panellists with pop up questions.

umlaut's data collection framework is GDPR compliant and is designed to collect anonymised information only.

One major objective of this research method was to have minimal impact on the panellists' daily smartphone usage with particular focus placed on their battery consumption and mobile data use. The application was designed to use a minimum amount of data for use cases such as the active data connectivity tests and was limited on the amount of data it could transmit over a mobile network.

Data collection runs 24/7 and is interrupted only by phases when the device is switched off. Most data points are collected whenever the device is in active use; e.g. whenever the user is interacting with apps or making phone calls. In addition, an automated 'light-weight' connection test is attempted four times an hour to test the data service availability.

3 Customer Experience Performance Indicators

The data collected using the two approaches defined above, were used by umlaut to define the following customer experience performance indicators:

- Customer Experience Performance Indicators automatically collected
  - Technology Share
  - Coverage Quality - Categorisation of 4G Coverage
  - Mobile Network Data Service Availability
  - Download Throughput (i.e. data speeds) and Responsiveness (i.e. latency)
  - Network Latency (i.e. responsiveness)
  - Voice Call Performance
  - Behavioural and usage information
- Technical parameters
  - Mobile Subscription
  - Location information
  - Device and system parameters
- User generated input (e.g. from satisfaction surveys)

In this section we will define these metrics in detail, before presenting the findings of this research related to these metrics.

3.1 Technology Share

Consumers are accessing the internet by using their smartphones devices, through several different mobile technologies (i.e. 2G, 3G, 4G or WiFi). It was thus important to report, as part of this research, what network technology consumers and panelists were using while accessing the internet. The umlaut application is able to evaluate what technology consumers are using when accessing the internet and create a relevant metric called network share. The data network share metric establishes the ratio of seconds per network technology, across all data sessions, and hence expresses the time share on 2G, 3G, 4G or WiFi.

3.2 Coverage Quality - Categorisation of 4G Coverage

While availability of network technologies is important, another very important aspect of coverage is the quality of the received signal while those networks are being used by consumers. The Coverage Quality – Categorisation of 4G coverage metric is assessing the signal strength levels received by the consumers when they are using the 4G networks, providing a view on the amount of time consumers spend under each coverage quality category.

3.3 Mobile Network Data Service Availability

The data service availability performance indicator is a metric of the consumers' ability to connect to the internet using their smartphone device. Even when a consumer or panelist is not actively using their smartphone device to access the internet, the umlaut application will periodically check in the background if it can access a mobile or WiFi data network and connect to the internet. As a result, the data service availability metric, created for this report, provides a view on the success or failure to connect to the internet using a 2G, 3G, 4G mobile or WiFi network.

3.4 Download Throughput (i.e. data speeds)

As with the previous metrics, the data speeds that consumer get are also measured passively. For this metric, we evaluate the actual data amount transferred during users' data sessions as part of their everyday internet phone use. These passive throughput samples describe a customer centric view of speeds, as requested by consumers and as defined by their setup (i.e. mainly device capabilities and tariffs). It is important to highlight, that this speed metric reflects more accurately the actual user experience and may not reflect a network's capabilities to their full extent.

3.5 Network Latency (i.e. responsiveness)

Response time (referred to technically as network latency) is the delay between a consumer making a request to a mobile data network for information and the network providing this information to the device.

4 Findings from umlaut's Crowdsource Panel

As described in section 2, for the purpose of this project, umlaut used data collected from our crowdsource panel of Android devices across Great Britain during a 6 month period, from December 2018 to May 2019, in order to evaluate consumer experience of mobile networks in Great Britain's rail network. Furthermore, as part of this research, umlaut developed an algorithm that identified all data samples generated by consumers while travelling on Great Britain's mainline and non-mainline routes.

All measurements collected were then subjected to strict data cleansing rules to ensure only reliable data were used for any subsequent analysis.

4.1 Technology Share & Usage

The total number of consumers that were identified accessing the internet while travelling by train, during the data collection period, is shown in figure 7 below. The data is broken down by mobile operator (based on the user's SIM card) and technology (mobile vs. WiFi, whether a user has used the technology at least once). As such, a user that has used both technologies during the data collection period will be counted towards both categories.

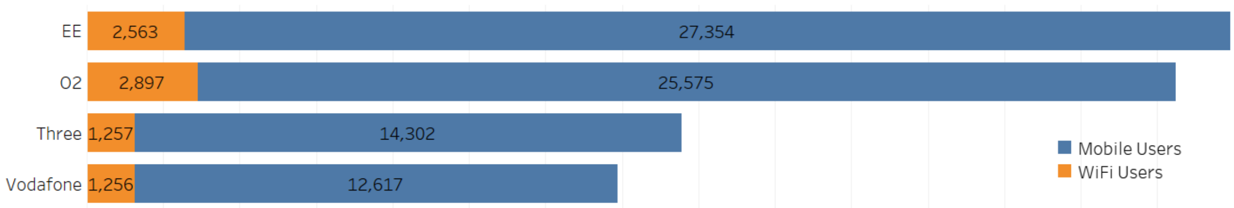


Figure 7: Unique user count (by technology and network operator) – Dec'18 to May'19

Figure 8 below is showing the total amount of data consumed across all mobile networks and WiFi. Only 4.3% of the data traffic generated during train journeys was carried over the trains' WiFi. The hourly trend (see figure 9) also reveals a distinct traffic pattern for weekdays and weekends. Hours between 00:00 and 05:00 have been excluded from the analysis due to the train services not running during this time and the subsequent low amount of user traffic generated. During weekdays the busiest hour seen is between 5pm to 6pm, with another peak seen also at 8am. These traffic peaks can be closely correlated to peak commuting times. On weekends, the traffic pattern is substantially different, with no significant peaks seen throughout the day.

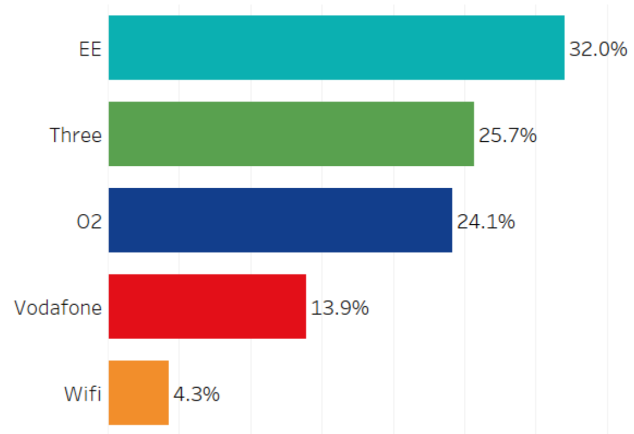


Figure 8: Percentage of data transmitted by mobile operator or WiFi

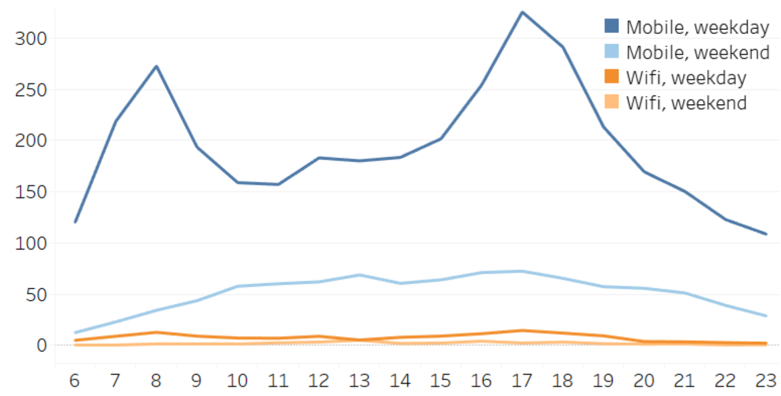


Figure 9: Total data transmitted over time (in GBytes)

Figure 10 below is showing the average amount of data consumed across all mobile networks and WiFi per consumer and time of day. Hours between 00:00 and 05:00 have been excluded from the analysis due to the train services not running during this time and the subsequent low amount of user traffic generated. The hourly trend for consumers using the trains' WiFi is fluctuating more due to the lower amount of consumers using the service.

More data is consumed on average, per user, when using the trains' WiFi. In addition, the data usage is slightly higher on weekends compared to weekdays.

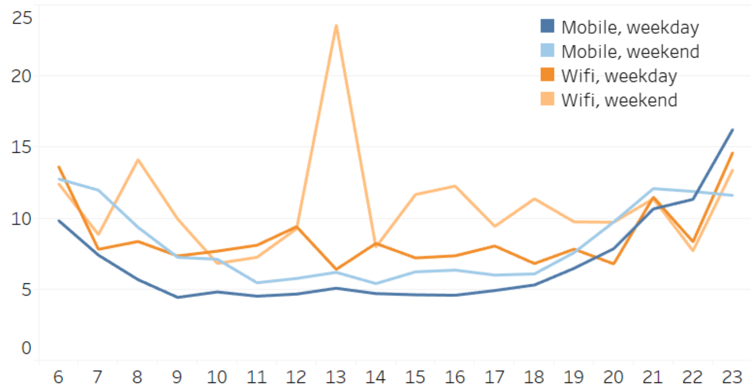


Figure 10: Average data transmitted over time per consumer (in MBytes)

4.2 Customer Experience Metrics

4.2.1 Technology Share

The figures below shows the crowdsource samples collected on train routes during the data collection period. 78% of the collected train samples occurred on 4G, while 21% were on 3G. The time consumers spent on a 4G network when travelling by train, was lower compared to the overall time consumers spent on a 4G network across Great Britain, where 85% of samples were on 4G.

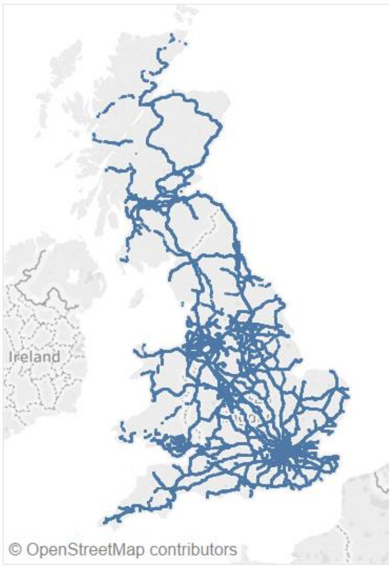


Figure 11: Great Britain Rail Routes within scope of the analysis

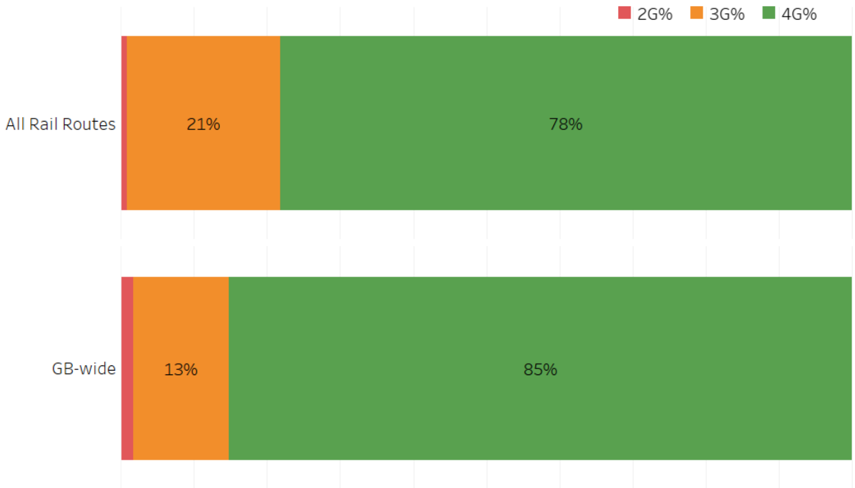


Figure 12: Percentage of time users were connected to a 2G, 3G or 4G network – Great Britain vs. travelling on rail routes

The time consumers spent on a 4G network was also analysed per mainline, in order to identify whether there are significant differences per route. Figure 13 below shows the crowdsource samples collected on mainline routes during the data collection period, while figure 14 shows the mobile technology split per mainline.

Figure 13: Great Britain Mainline Rail Routes within scope of the analysis

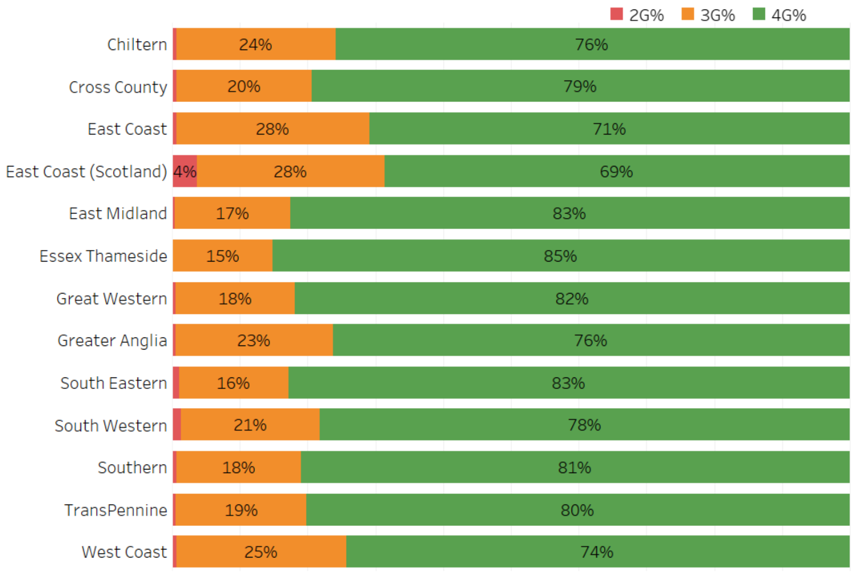


Figure 14: Percentage of time users were connected to a 2G, 3G, 4G network per mainline

The highest time spent on 4G was observed on the Essex Thameside mainline, with East Midland, Great Western, South Eastern, Southern and TransPennine all achieving time spent on 4G greater than 80%. The poorest performance seen on this metric was on the East Coast Mainline. The time consumers spent per mobile technology was also analysed to compare performance of mainlines vs non-mainlines, time of day and weekend vs. weekdays. No significant differences were observed.

4.2.2 Coverage Quality - Categorisation of 4G Coverage

While availability of a 4G network is important, the quality of the received 4G signal is also a very important parameter when assessing mobile coverage. As part of this research project umlaut categorised every signal reading recorded from a 4G network and mapped it to a coverage category, according to the following thresholds[1]:

[1] Coverage categories thresholds are based on umlaut's global best practice expertise

Technol-ogy	Bad	Poor	Fair	Good	Excellent
4G	-120…-139 dBm	-110…-119 dBm	-100…-109 dBm	-85…-99 dBm	-45…-84 dBm

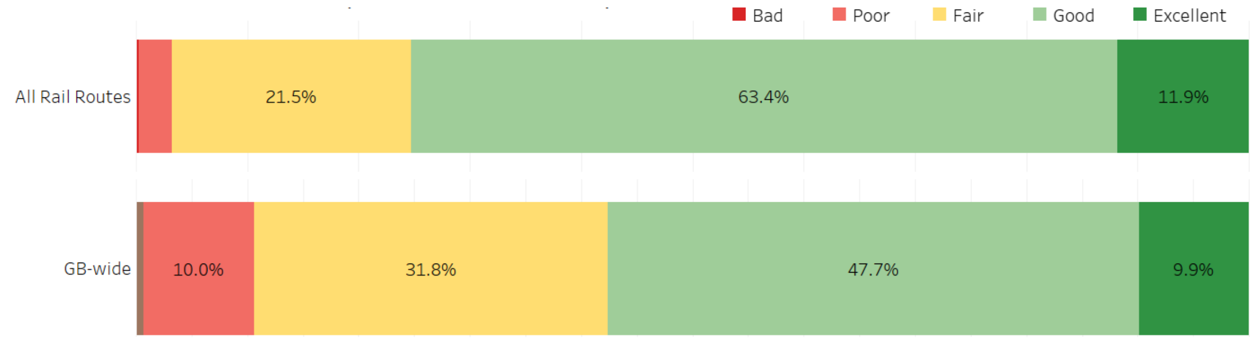


Figure 15: Quality of recorded 4G signal measurements – Great Britain vs. travelling on rail routes

As shown in figure 15, the quality of 4G coverage appears to be better across the GB train routes, compared to the overall Great Britain 4G coverage. A greater proportion of 4G samples were under bad or poor coverage conditions on a nationwide level. In addition, as shown in the figure 16 below, the 4G coverage quality is better on mainlines compared to non-mainline routes.

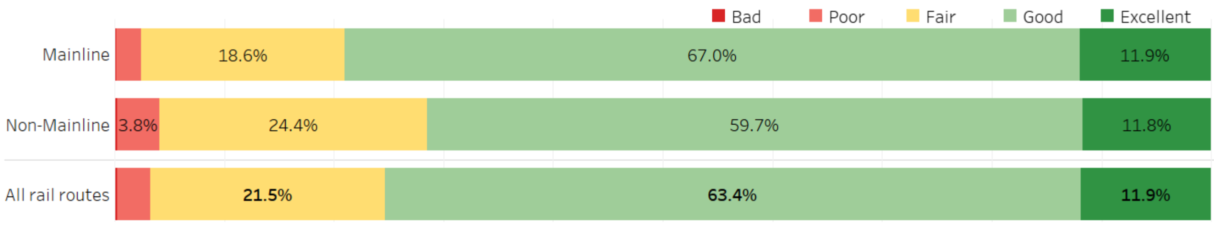


Figure 16: Quality of recorded 4G signal measurements – mainline vs. non mainline

The 4G coverage quality per mainline is shown in figure 17 below. The East Coast mainline is showing again a poorer performance with a low proportion of 'Excellent' samples and 27.8% of samples being in less than 'Good' radio conditions.

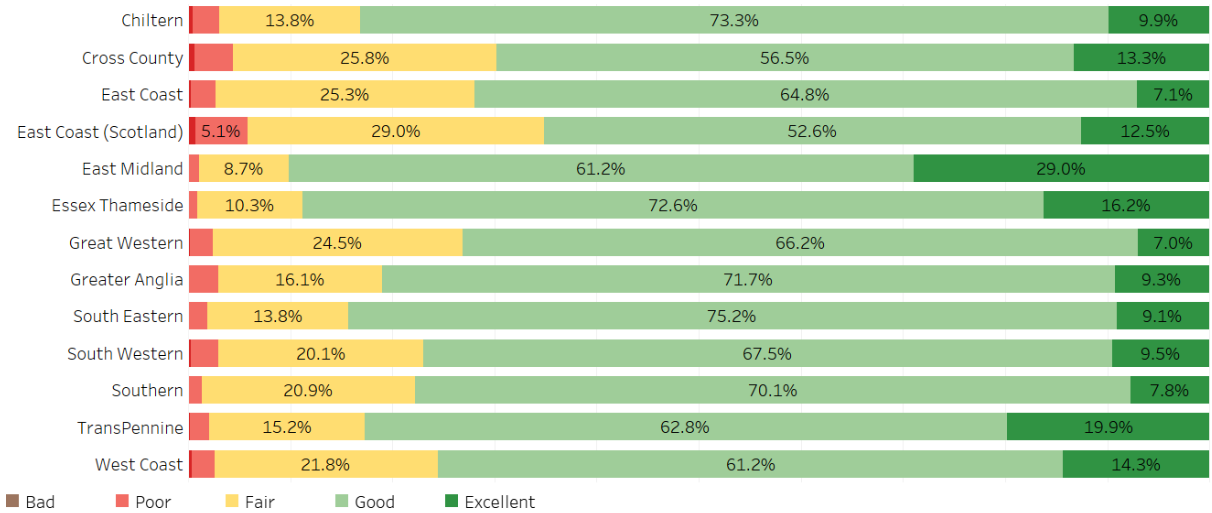


Figure 17: Quality of recorded signal measurements per mainline

4.2.3 Mobile Network Data Service Availability

As mentioned in section 3.3, the data service availability performance indicator is a metric of the consumers' ability to connect to the internet using their smartphone device.

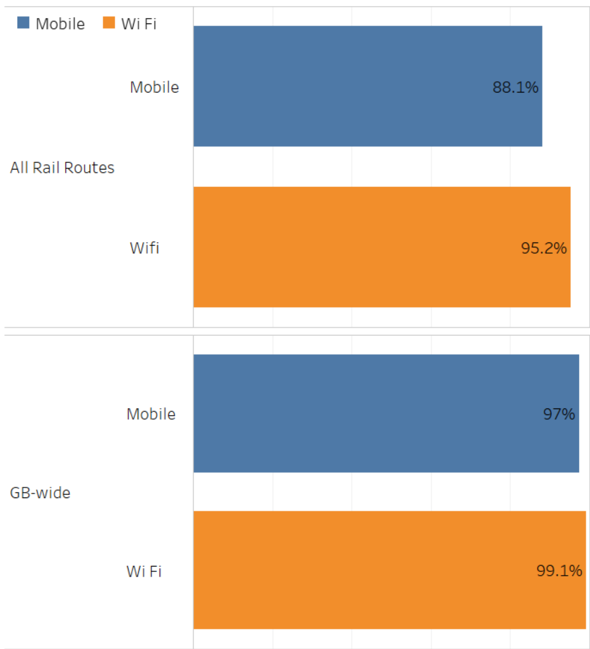


Figure 18: Ability to access the internet (as a % of time, split by technology) – Great Britain vs. travelling on rail routes

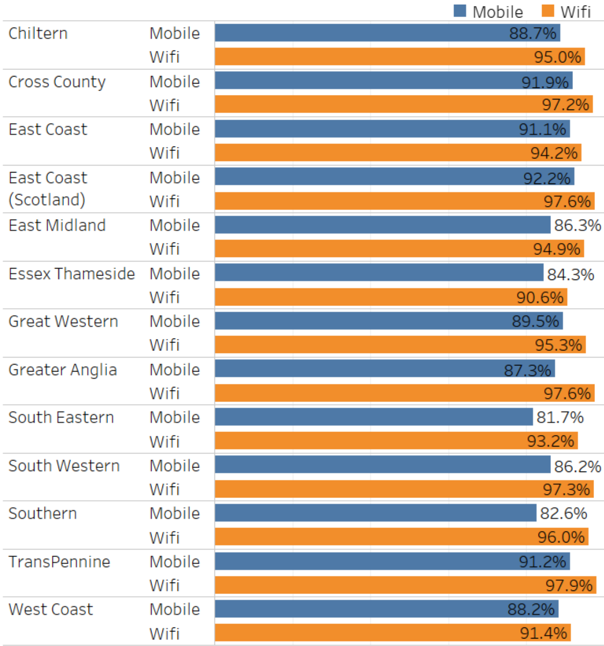


Figure 19: Ability to access the internet (as a % of time, split by technology) per mainline

As seen in figure 18, and in more detail by mainline in figure 19, the ability to access the internet while travelling by train appears to be significantly higher when using the onboard train WiFi. The metric drops to 88.1% when consumers are connected to a mobile network. Furthermore, the ability of users to connect to the internet while travelling by train is significantly lower when compared to the overall performance in Great Britain, for both WiFi and mobile services. Higher internet availability over WiFi is seen across all mainline routes. Only 4 mainlines achieve an ability to access the internet greater than 90% on mobile: Cross County, East Coast, East Coast (Scotland) and TransPennine.

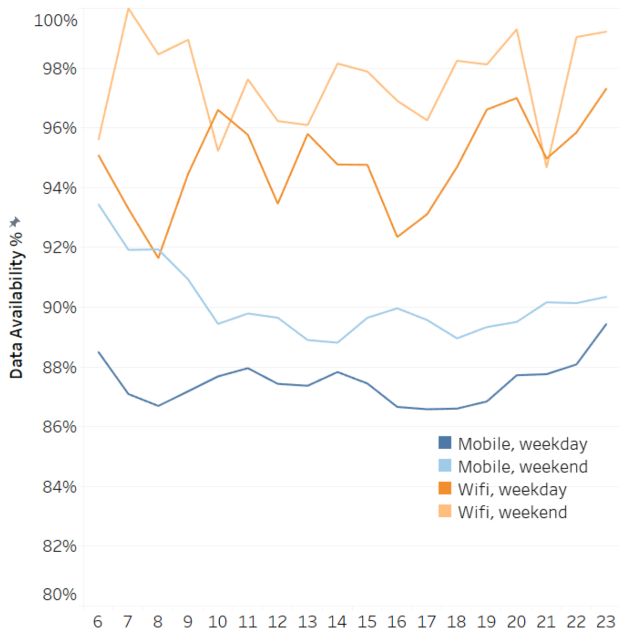


Figure 20: Ability to access the internet by time of day

When, as in figure 20, we breakdown the ability to access the internet by hour we see that performance is improved over the weekends for both WiFi and mobile. As mentioned above, the hours between 00:00 and 05:00 have been excluded from the analysis due to the train services not running during this time and the subsequent low amount of user traffic generated.

Figure 21 is showing the total amount of access samples, in thousands, by hour.

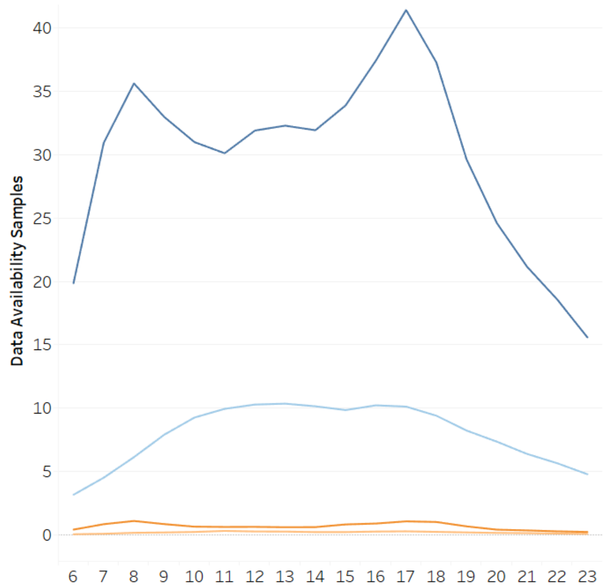


Figure 21: Ability to access the internet (volume of access samples, in thousands)

A performance comparison between mainline and non-mainline routes was also performed, with no significant differences observed.

4.2.4 Download Throughput (i.e. data speeds)

The data speeds experienced by consumers while travelling by train has been analysed and compared with the overall performance experienced by consumers across Great Britain. Further analysis was also performed to compare the speeds achieved per mainline.

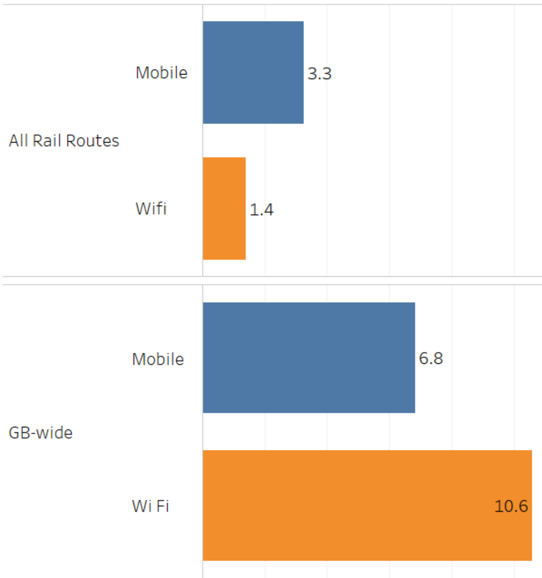


Figure 22: Average download speeds (in Mbps, per technology) – Great Britain vs. travelling on rail routes

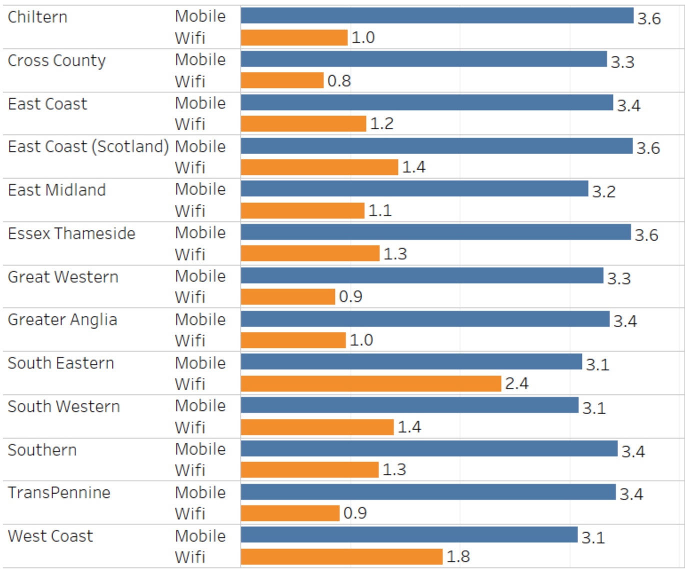


Figure 23: Average download speeds (in Mbps, per technology) per mainline

As seen in figure 22, and in more detail by mainline in figure 23, the average download throughputs experienced by consumers while travelling by train is significantly lower than the aggregate GB performance, both for mobile and WiFi. However, while users in general experience higher throughputs across GB when on WiFi compared to mobile, when travelling by train the situation is reversed. The average download throughput when travelling by train and using a mobile network is more than double, compared to that received when using the on board WiFi, with WiFi users achieving an average download throughput of only 1.4 Mbps. The download throughput performance per time of day, along with a weekend vs. weekday comparison is shown in figures 24 & 25 below.

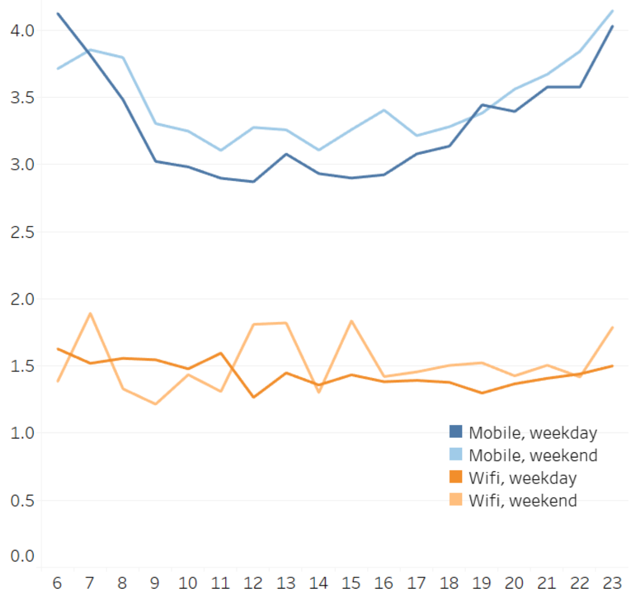


Figure 24: Average download speed per time of day (in Mbps)

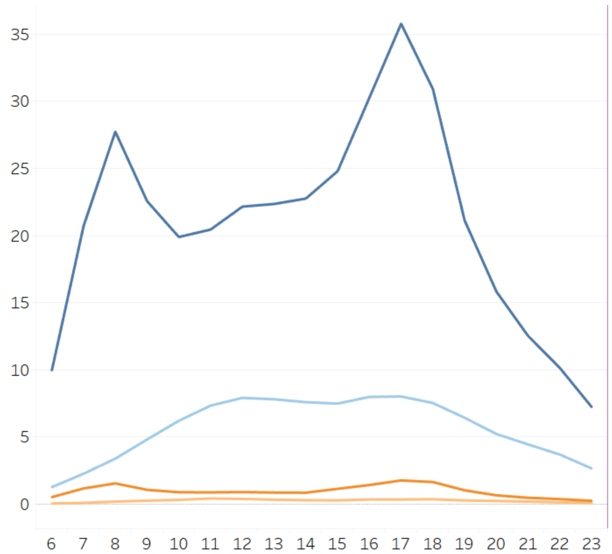


Figure 25: Average download speeds (volume of access samples, in thousands)

As seen with the Data Availability metric too, download throughput is improved over the weekends, for both mobile and WiFi networks. Hours between 00:00 and 05:00 have been excluded again from the analysis for the same reasons. Interestingly, the onboard train WiFi networks show a more stable performance throughout the day, while on mobile networks there is a significant degradation observed during the busier hours of the day. A comparison between mainline vs non-mainline performance was also performed, with no significant difference observed.

4.2.5 Network Latency (i.e responsiveness)

The network latency metric reflects the responsiveness of a network and is particularly important when consumers are browsing the web or for online gaming. The latency experienced by consumers while travelling by train and the overall performance in Great Britain is shown in figures 26 & 27 below, together with a breakdown of the performance by mainline:

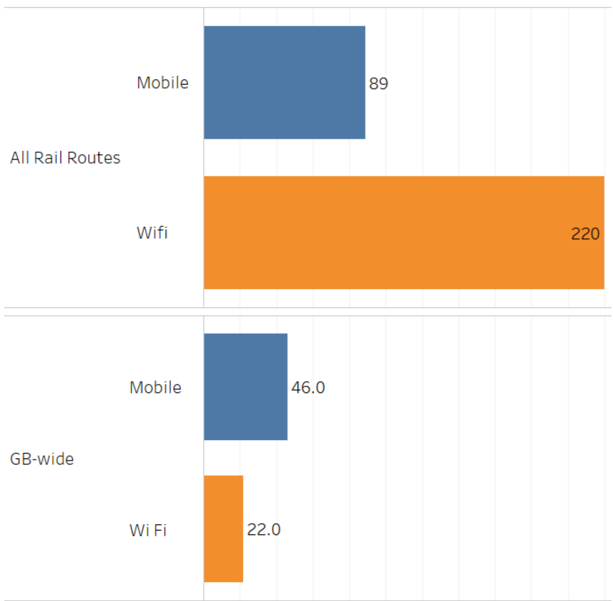


Figure 26: Average network latency (in milliseconds, per technology) – Great Britain vs. travelling by train

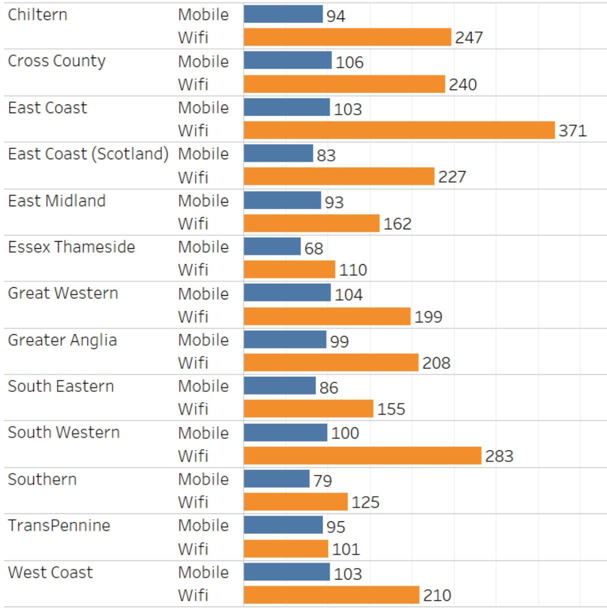


Figure 27: Average network latency per mainline (in milliseconds, per technology)

On board train WiFi networks show very poor performance, with an average latency of 220ms. Although, the latency experience by consumers while travelling by train is significantly improved to 89ms when using a mobile network, it is still at a sub-optimal level. Overall performance in Great Britain is drastically better than on trains, with WiFi showing the best results. When analysing the latency performance per mainline, it is clear that there is always a significant gap between mobile and WiFi. The East Coast Mainline shows the worse latency performance for WiFi at 71ms.

Non-mainline routes show a better performance compared to mainlines, as shown in figure 28 below:

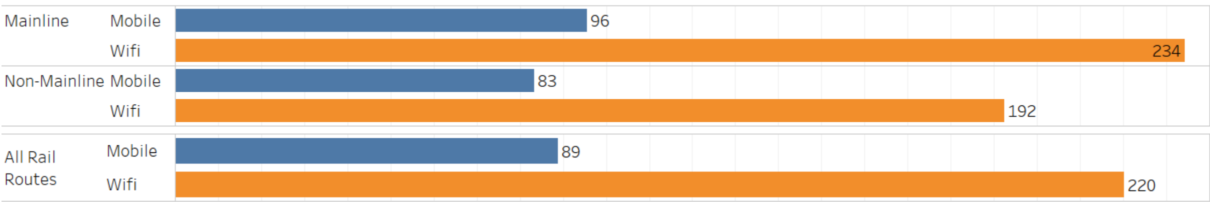


Figure 28: Average network latency mainlines vs. non-mainlines (in milliseconds, per technology)

In order to understand the differences seen in latency performance, further analysis on the distribution of the samples was performed and all the latency samples were grouped into the following categories:

- 0ms – 50ms
- 50ms – 100ms
- 100ms – 500ms
- 500ms – 1,000ms
- >1,000ms

Figures 29 and 30 below show that a high proportion of WiFi samples have extremely high latency. For example, during weekdays, 2.4% of the samples have latency greater than 1,000ms. In addition, performance is improved during weekends, for both mobile and WiFi.

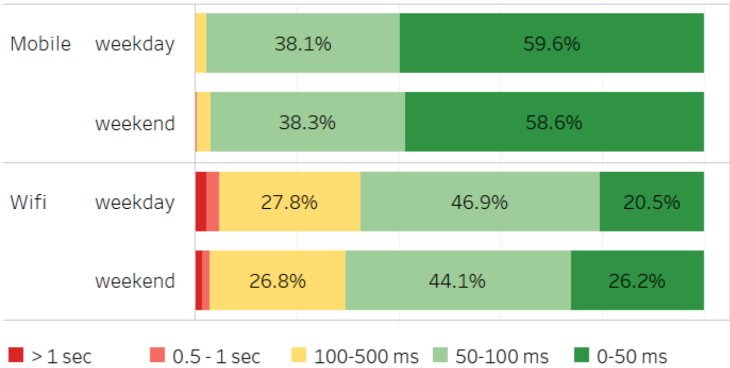


Figure 29: Average Latency broken down in categories (all rail routes)

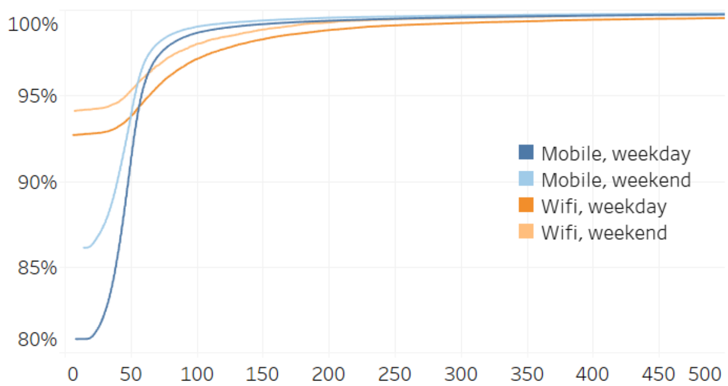


Figure 30: Cumulative Distribution Function of Network Latency

4.2.6 Voice Call Performance

As shown in figure 31, the vast majority of voice calls made by consumers while travelling on trains were over a mobile network, with only 1.66% of all calls made over WiFi (i.e. WiFi Calling).

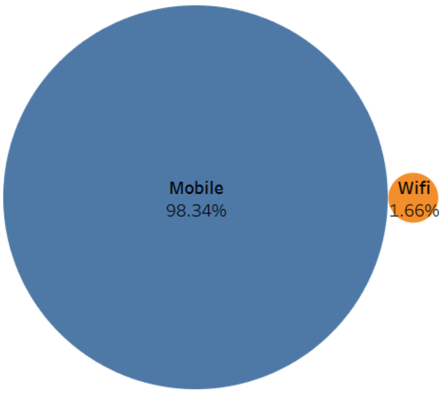


Figure 31: Percentage of voice calls split by technology

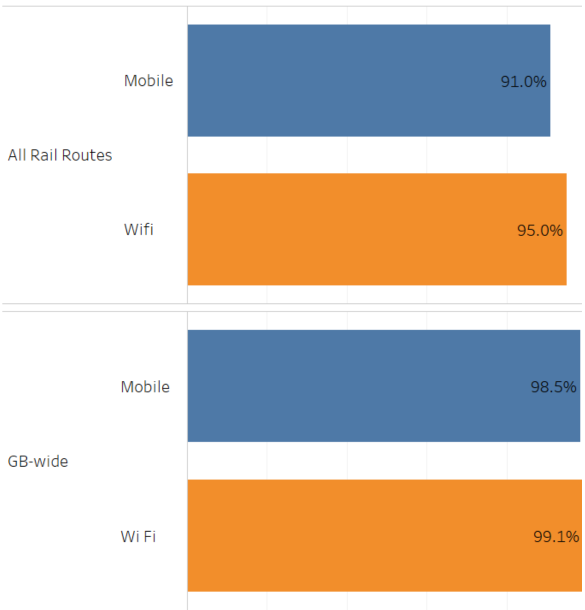


Figure 32: Percentage of successful voice calls (per technology) – Great Britain vs. travelling by train

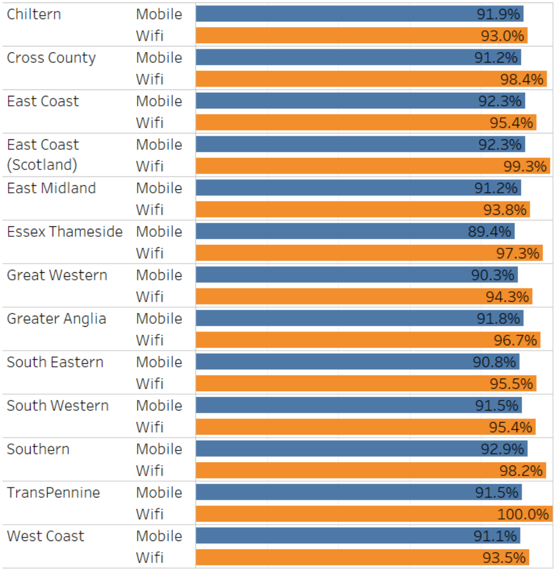


Figure 33: Percentage of successful voice calls per mainline (per technology)

The percentage of successful voice calls for consumers while travelling by train is particularly low. As shown in figure 32, only 91% of voice calls were successfully completed when using a mobile network, while the performance is improved to 95% for calls going over the on-board train WiFi. Both success ratios are significantly lower than the voice performance experienced by users across Great Britain.

When looking at individual mainline performance (see figure 33) we can see that WiFi performance is better on WiFi for all mainlines. Essex Thameside mainline has a success ratio lower than 90% for calls made over a mobile network and no mainline achieves a success ratio greater than 93% on mobile.

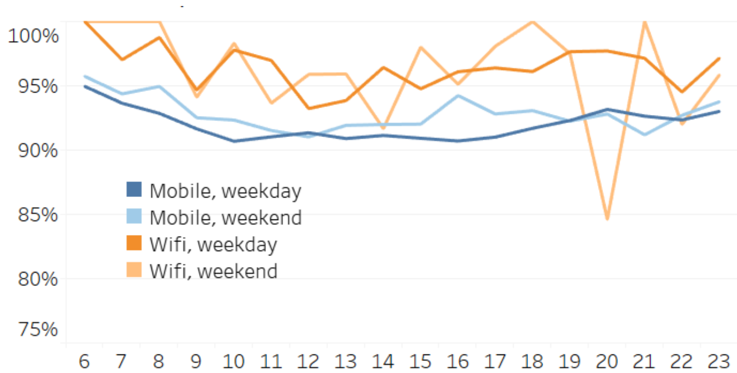


Figure 34: Percentage of successful calls by time of day (per technology)

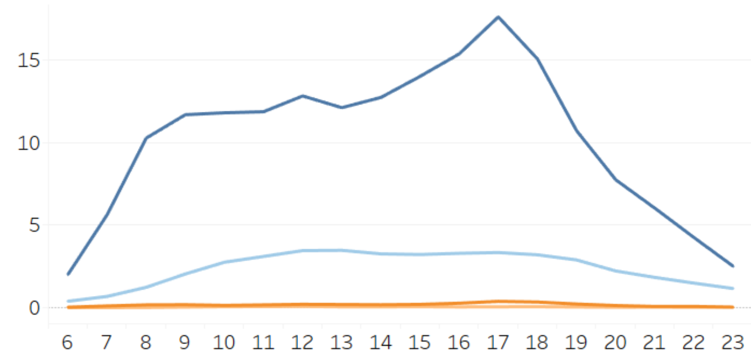


Figure 35: Successful calls by time of day (volume of samples, in thousands)

Performance over the weekend is generally better than weekdays (see figure 34) for both mobile and WiFi networks. No significant variation in performance is observed throughput the day. Hours between 00:00 and 05:00 have been excluded again for the reasons explained above. As shown in figure 35, the number of voice calls per time of day reveals a different pattern compared to the other customer experience metrics presented above. While all the other metrics show 2 spikes, one at 8am and the highest at 5pm, voice call volumes show a single spike at 5pm. A performance comparison between mainline vs non-mainline rail routes was also performed, with no significant differences observed.

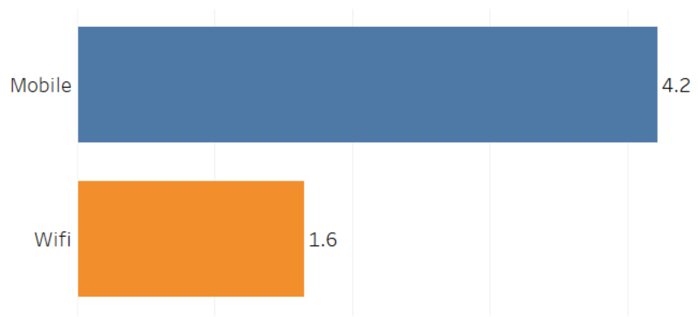


Figure 36: Average call duration per technology (in minutes)

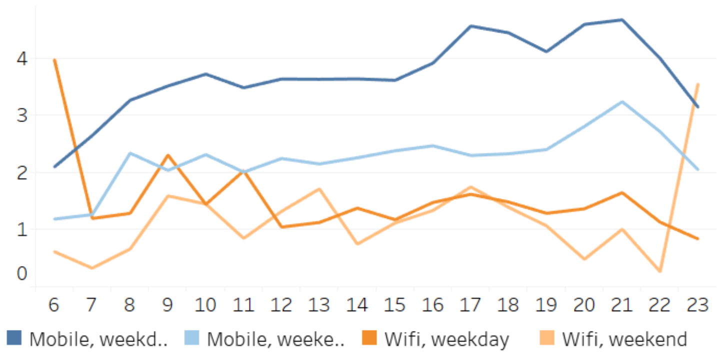


Figure 37: Average call duration by time of day and per technology (in minutes)

The average call duration seen on a mobile network when travelling by train is 4.2 minutes (see figure 36), which is significantly higher than that seen on WiFi networks. The daily and daytime trends show that calls on weekends are on average shorter than those on weekdays. In addition, the average call duration is increasing in the evening hours. Hours between 00:00 and 05:00 have again been excluded from the graphs for reasons already explained above.

With the above average call durations and considering the following average train speeds of:

- Mainline – 100 mph
- Suburban – 50 mph

The networks should be able to successfully sustain a voice call for the following distances:

Mobile

- Mainline – 100 mph x 4.2 mins = 7 miles
- Suburban – 50 mph x 4.2 mins = 3.5 miles

WiFi

- Mainline – 100 mph x 1.6 mins = 2.7 miles
- Suburban – 50 mph x 1.6 mins = 1.35 miles

5 Findings from the Transport Focus Research App

As explained in section 2.2 above, umlaut developed a research app for Transport Focus, whose aim was to acquire more granular information on the mobile network experience of consumers while travelling on trains, while also collect detailed feedback about this experience.

The bespoke app, available on Android smartphone devices, was distributed to a panel of rail passengers by Transport Focus, and was used to collect measurements 24/7/365 seamlessly in the background and also to run at least weekly satisfaction surveys for the panellists to answer.

All measurements collected were then subjected to strict data cleansing rules to ensure only reliable data were used for any subsequent analysis.

5.1 Data Collection

A total of 252 Transport Focus panellists downloaded the research app, with 163 of those identified as having used a train service at least once during the data collection period. The data collection period was from 11th April 2019 to 30th June 2019. The map in figure 38 below shows the samples collected from the research app panellists on train routes during the data collection period.

Figure 38: Train routes and locations of collected data samples

5.2 Panellists' Satisfaction vs Network Performance

The network performance metrics collected through the Transport Focus app were correlated with the feedback collected from the panellists during the trial period, in an attempt to establish whether there is any direct correlation between consumer satisfaction and perception, to network metrics. Figure 39 below shows the main performance metrics vs. the feedback collected from the panellists on the post-survey question: *"Overall how satisfied or dissatisfied are you with the internet connection that you usually get when travelling on train?"*

The number of samples for each category is shown in brackets, next to the performance metric. The satisfaction data do not appear to directly correlate with the technical performance metrics collected.

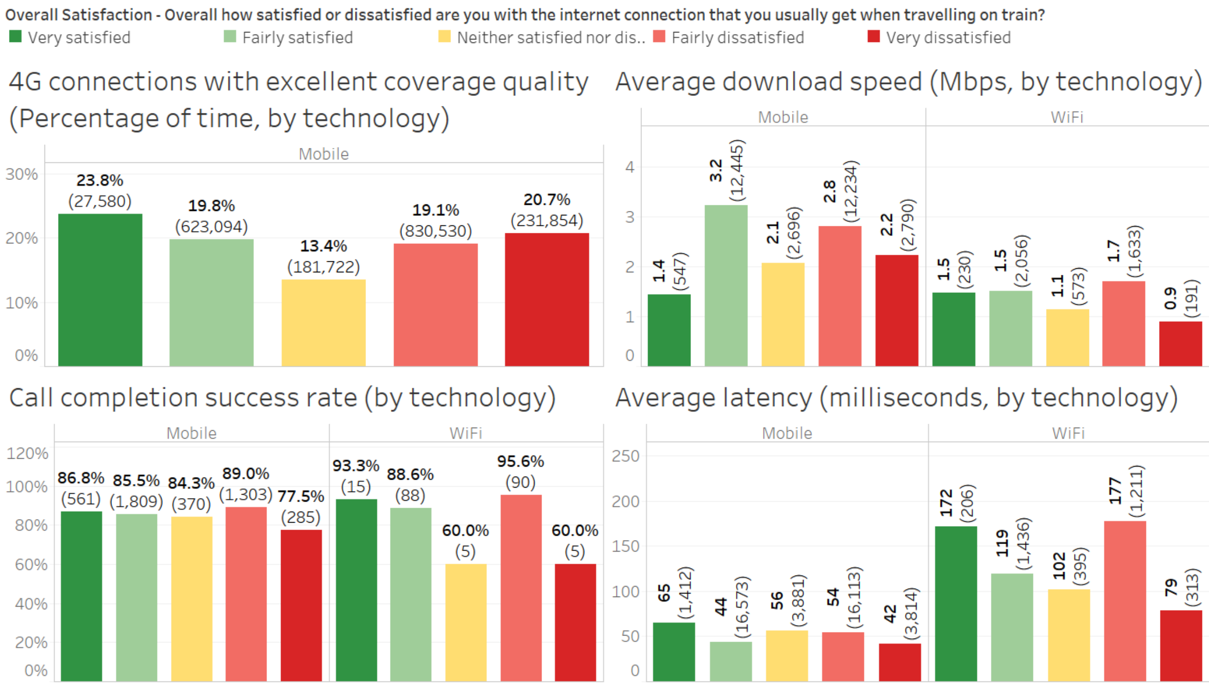


Figure 39: Correlating consumer satisfaction with network performance

The main performance metrics were also correlated against the weekly pop-up questionnaire (see figure 40) and in particular the question *"Were you able to do everything that you wanted on trains this week?"* This offers a more direct comparison between network performance and satisfaction, as consumer feedback is directly reflecting a particular time period. Samples collected from users during weeks when they didn't provide any response to the questionnaire, were excluded from the analysis.

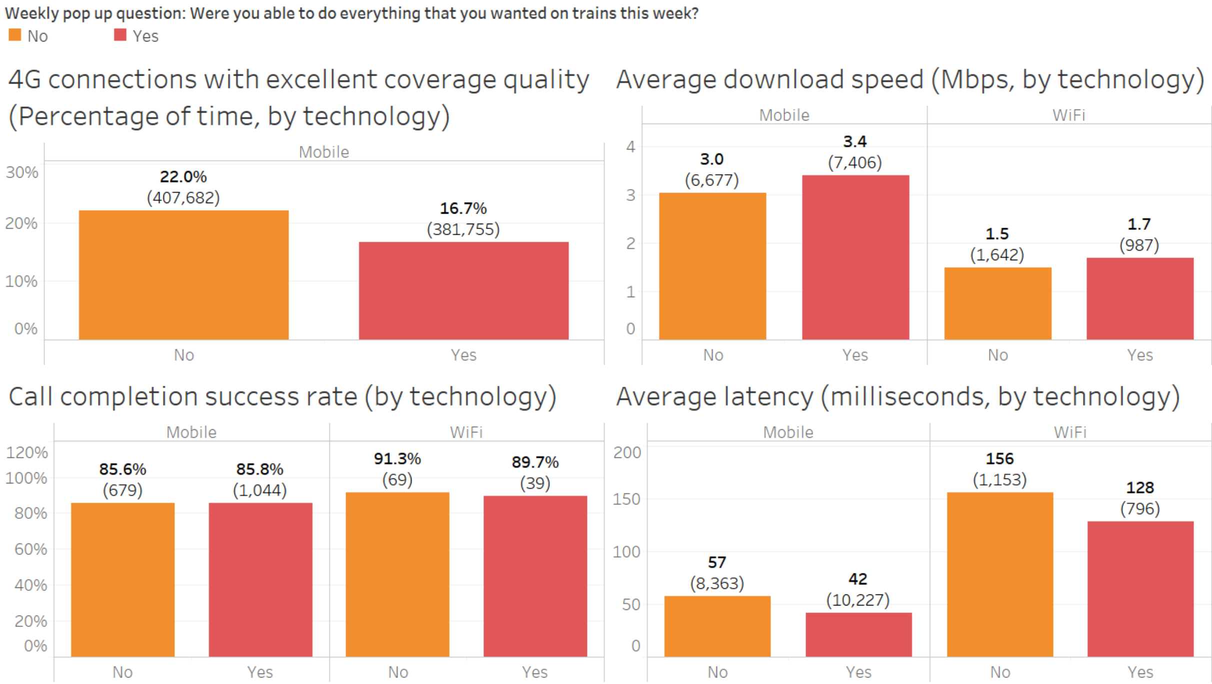


Figure 40: Correlating consumer satisfaction with network performance

5.3 Application usage while travelling by train

One of the objectives of this research and the application developed by umlaut for Transport Focus was to understand they different types of applications used by consumers while travelling by train. In order to present the results of this analysis in a friendly format, umlaut grouped the various applications used by the panellists into the following categories:

- Audio Streaming
- Uploading/Downloading Large Files
- Social Media
- Video Streaming
- Email
- Sending Internet Related Messages
- Tools/Games
- Web Browsing

Figure 41 below shows the different applications categories used by consumers, with breakdowns based on data traffic, time spent, whether the consumer was using a mobile network or the on-board WiFi and whether he was travelling by train or not.

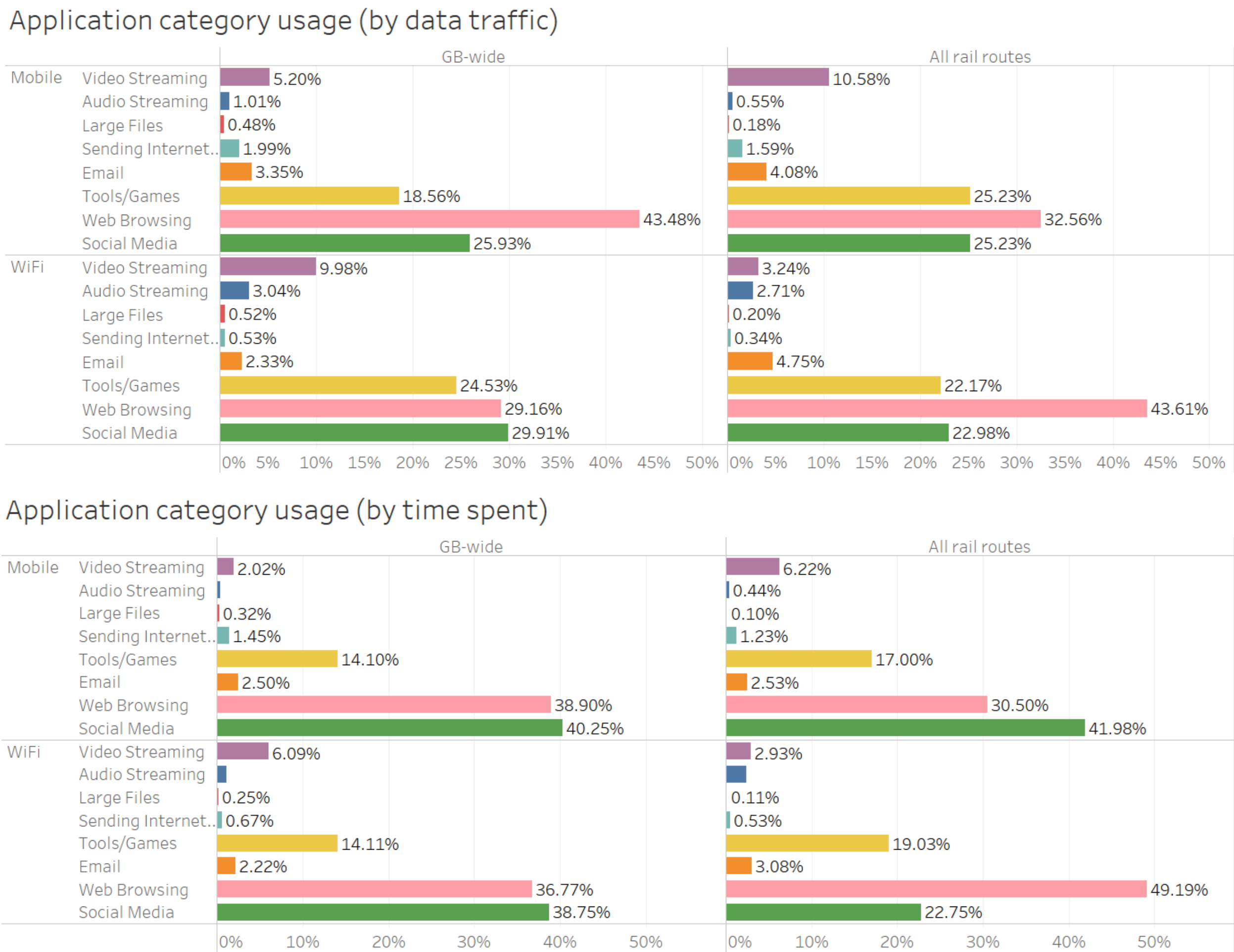


Figure 41: Internet application usage

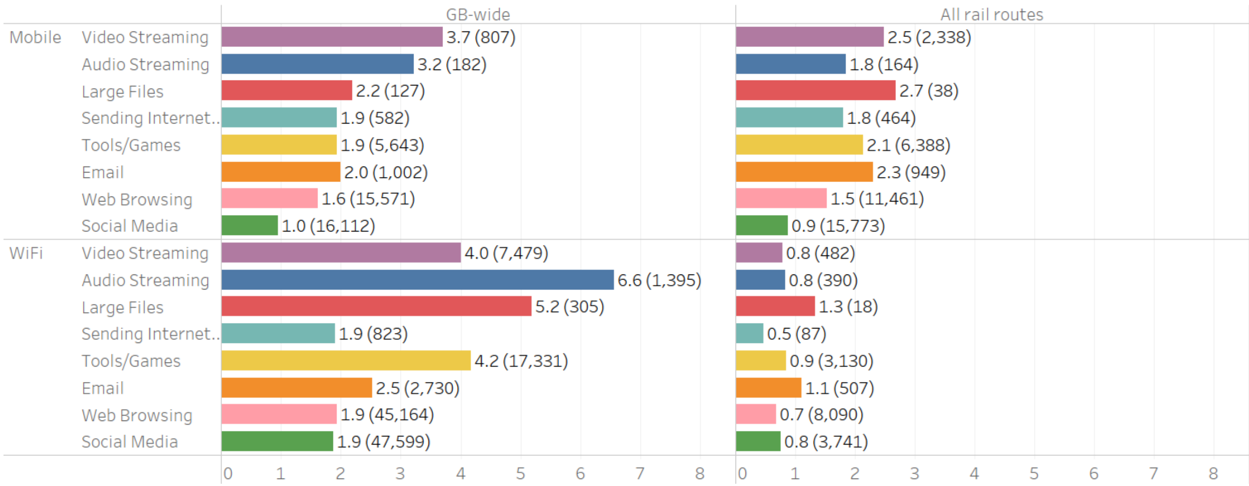


Figure 42: Average download speeds (in Mbps, per technology and app category) and amount of data sessions (per technology and app category)

When looking at average throughputs achieved per application (see figure 42), it is clear that the on-board train WiFi offers lower throughputs than those of non-train WiFi. While the WiFi speeds experienced on trains are particularly low, the download speeds for demanding applications like video or audio streaming on mobile are lower on trains than the overall Great Britain speeds. The total amount of data sessions per technology and app category is shown in brackets.

In order to understand the user behaviour on trains, the most used application category was identified per user. Figure 43 below shows the percentage of users that spending most of their time by a particular application category, while traveling by train.

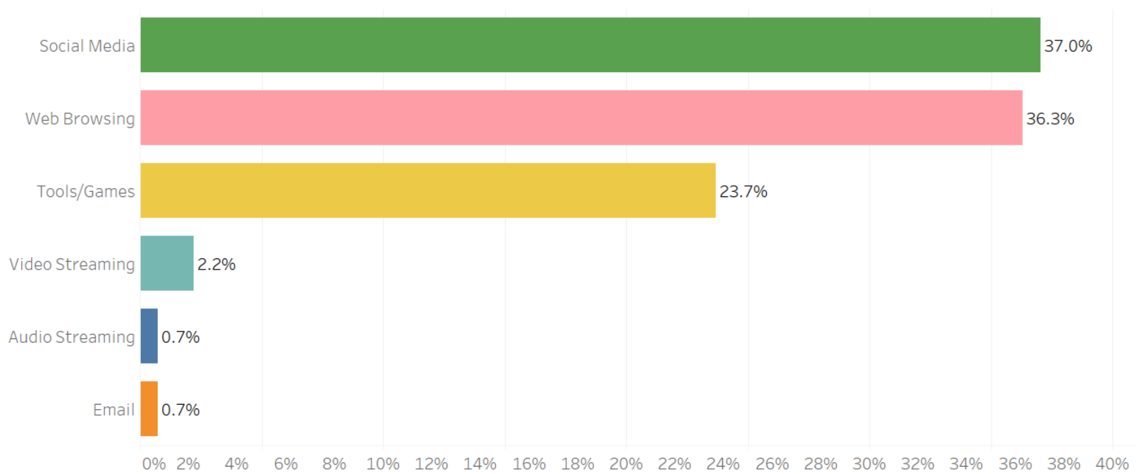


Figure 43: Percentage of panellists by most used application category

Over 73% of the Transport Focus panellists spent most of their time on their smartphone using social media or browsing the web. Panellists were mapped to an application category based on which activities they spent the majority of their time. The panellists' feedback on the post-survey question *"Overall how satisfied or dissatisfied are you with the internet connection that you usually get when travelling on train?"* is shown per application category in figure 44 below.

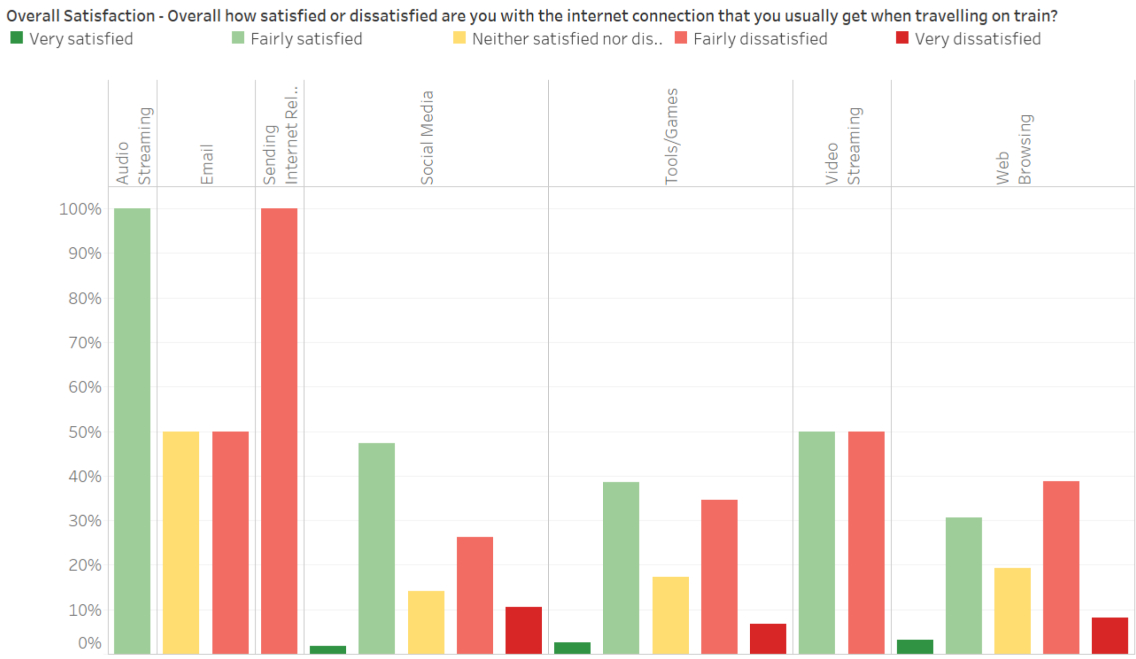


Figure 44: Overall satisfaction by most used app (Percentage of panellists)

5.4 Voice Analysis

The number of panellists that experienced connectivity issues during a voice call were also analysed by umlaut. Figure 45 below shows the percentage of panellists that had made voice calls while travelling by train and they also experienced at least one unsuccessful call.

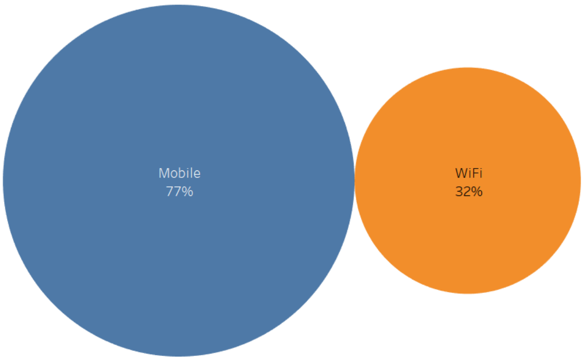


Figure 45: Percentage of panellists with at least one unsuccessful call (per technology)

Furthermore, the call completion success ratio per panellist while travelling by trains is shown in figures 46 and 47 below per technology.

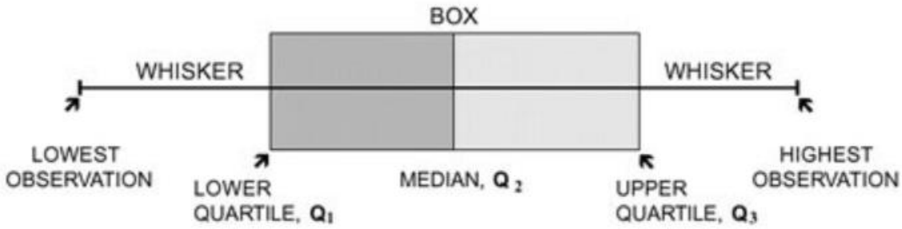


Figure 46: Definition of the box-and-whisker plot

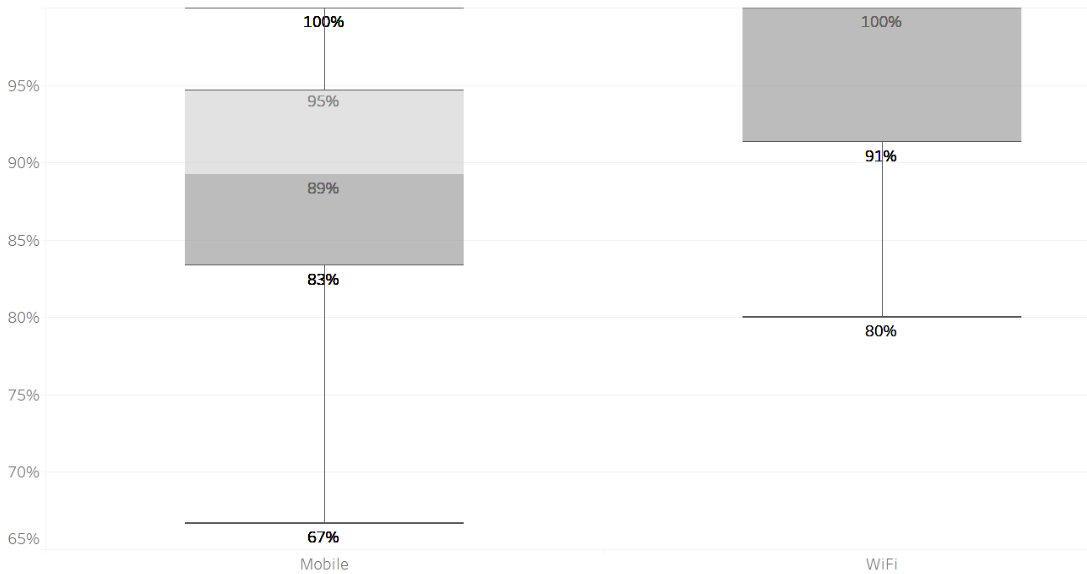
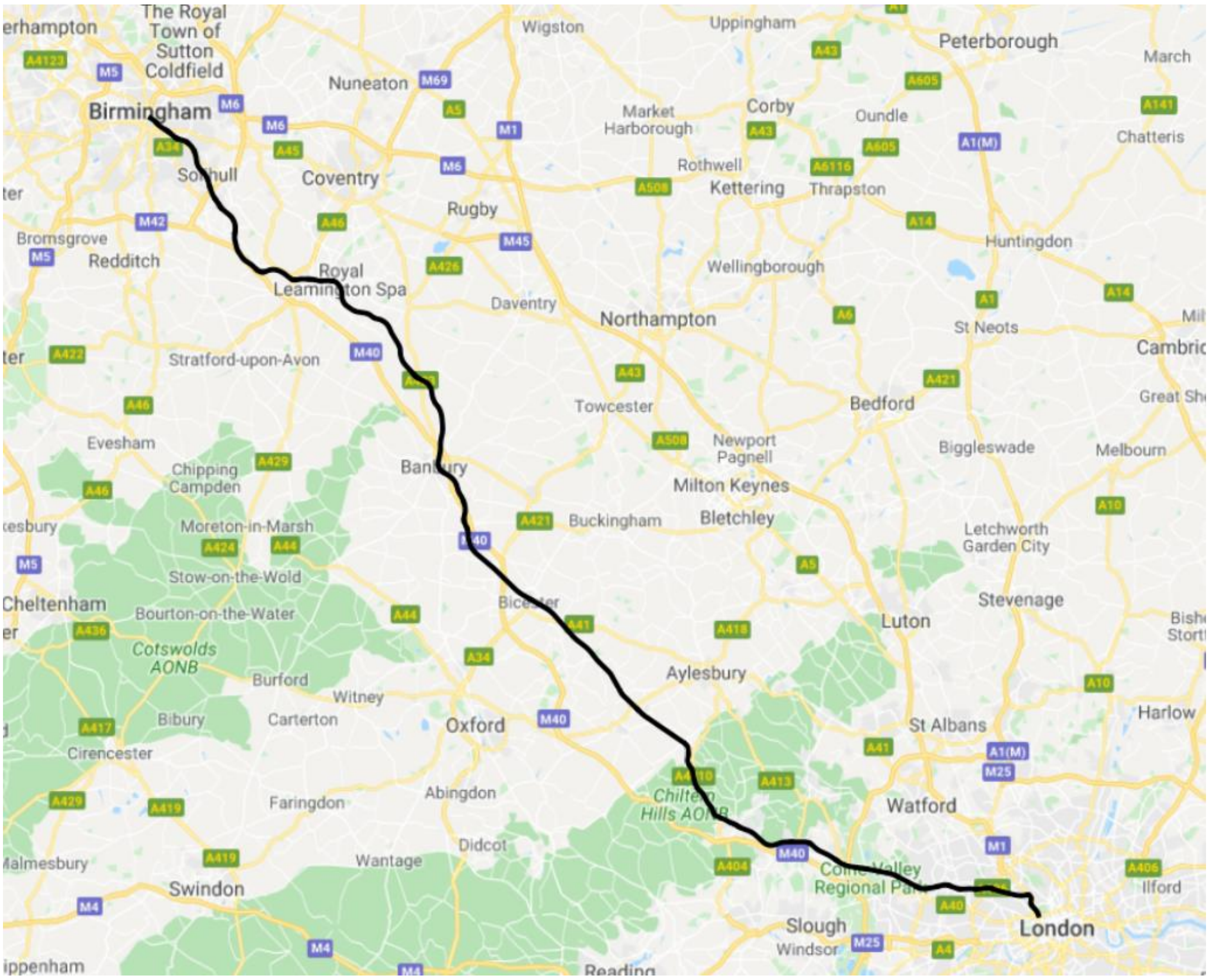


Figure 47: Call completion success ratio per technology

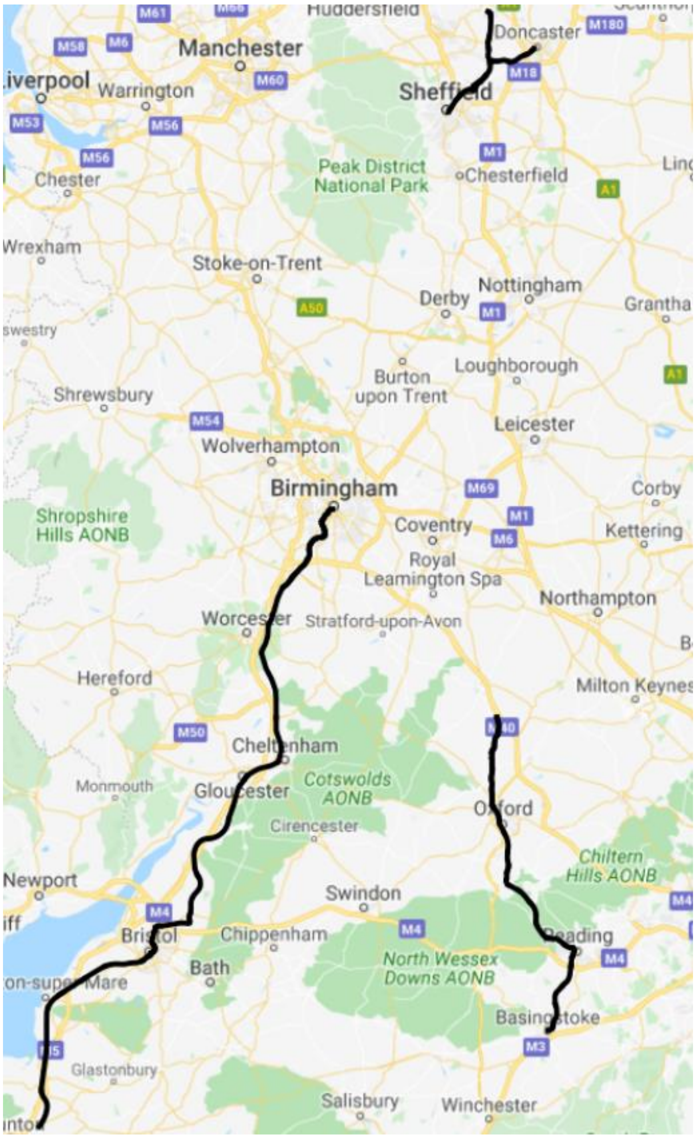
Figures 46 and 47 show the call completion success ratio experienced by users on mobile and WiFi networks while travelling by train. Confirming the results seen in the overall GB umlaut crowdsource data, the Transport Focus panel data is also showing higher success rates for WiFi. Voice call performance is particularly poor on mobile, with at least half of the panellists having experienced at least one unsuccessful voice call out of ten calls.

Annex A – Mainline routes maps

Chiltern



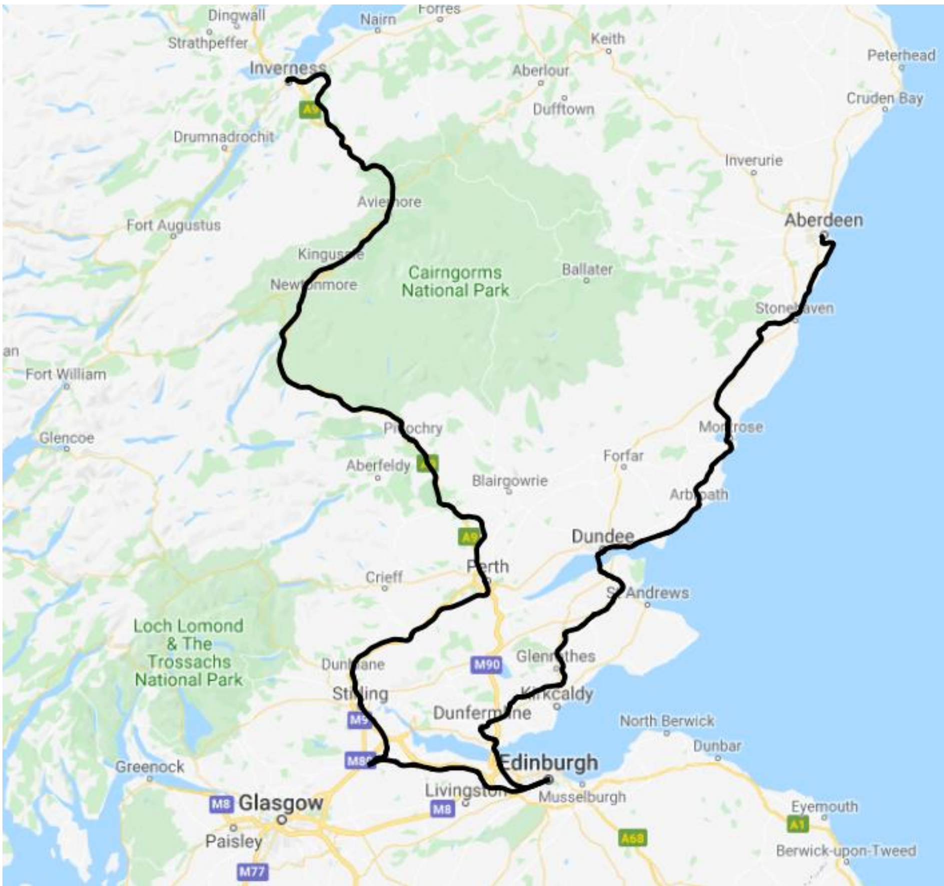
Cross Country



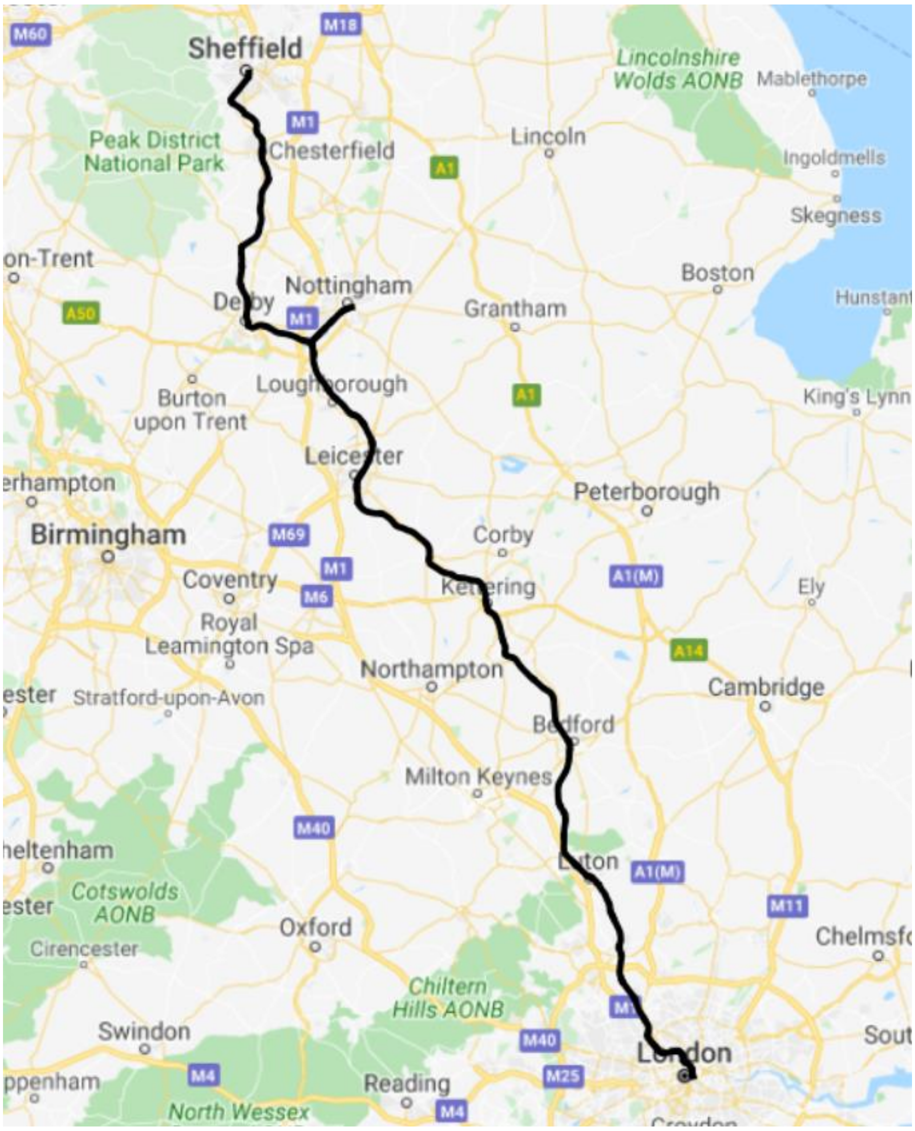
East Coast


Trossachs National Park
M90
Edinburgh
Glasgow
Paisley
M77
M74
Ayr
A74(M)
Dumfries
United Kingdom
Newcastle upon Tyne
Durham
North Pennines AONB
Middlesbrough
Lake District National Park
North York Moors National Park
Isle of Man
Yorkshire Dales National Park
A1(M)
York
Blackpool
Leeds
Hull
Great Britain
M61
M1
M18
Liverpool
M62
Sheffield
Chester
Peak District National Park
Snowdonia National Park
M6
Nottingham
M54
M6 Toll
Leicester
Peterborough
ENGLAND
Cambridge
WALES
M40
Colchester
Cotswolds AONB
Oxford
M11
Swansea
M4
Cardiff
Bristol
Swindon
Reading
London
M25
Southend-on-Sea
Bath

East Coast (Scotland)

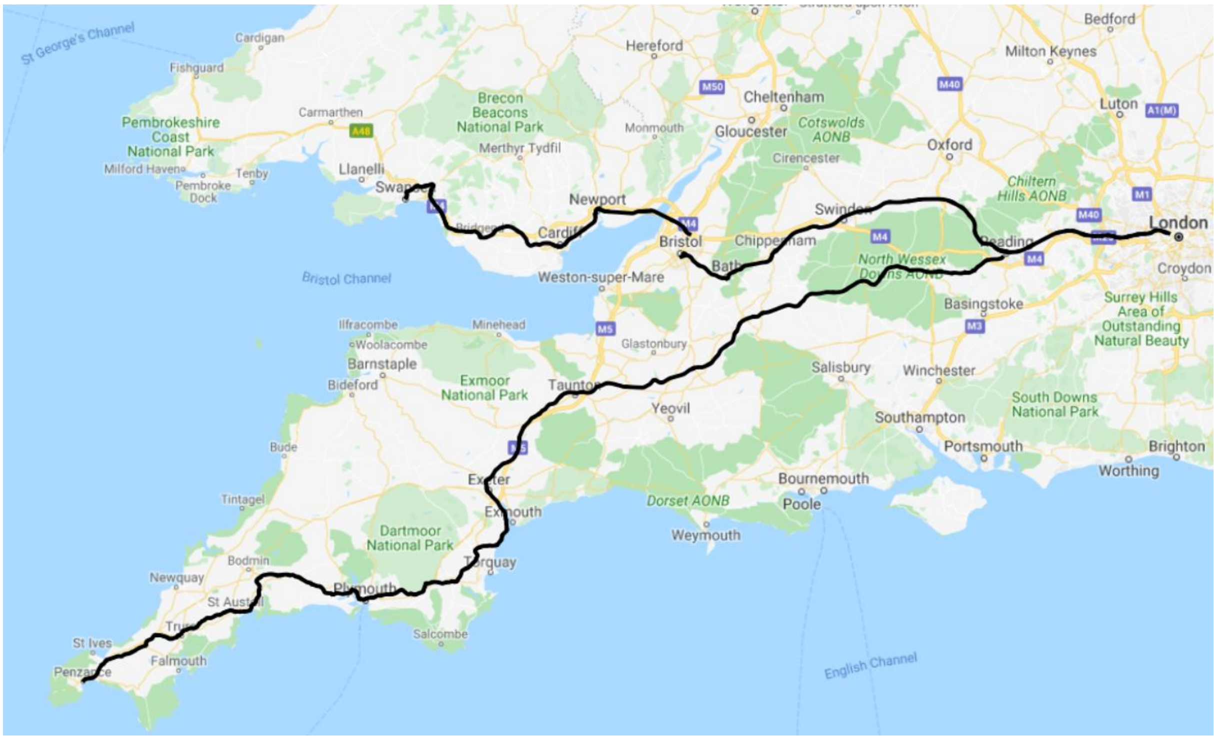


East Midland

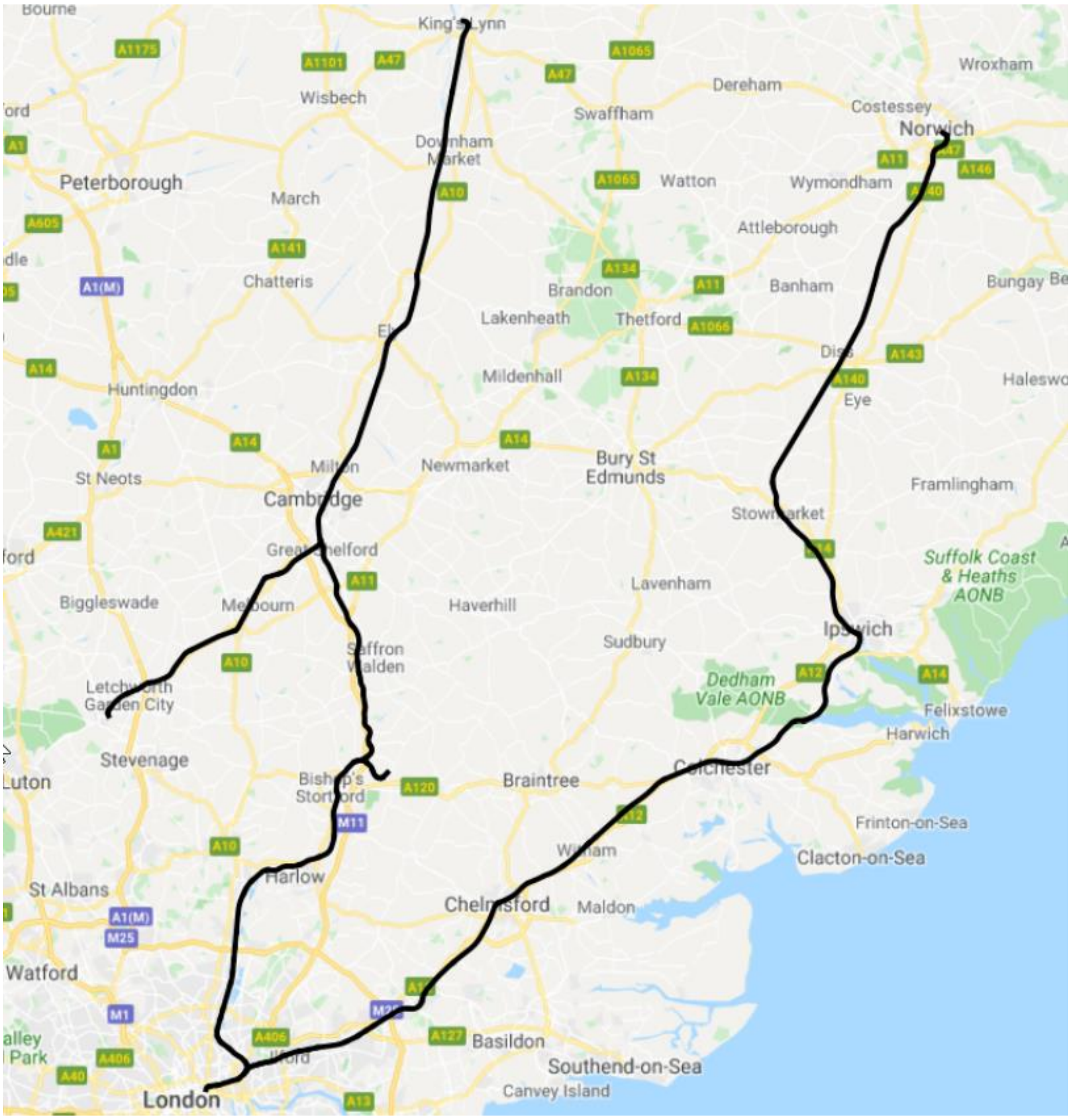


Essex Thameside

Great Western

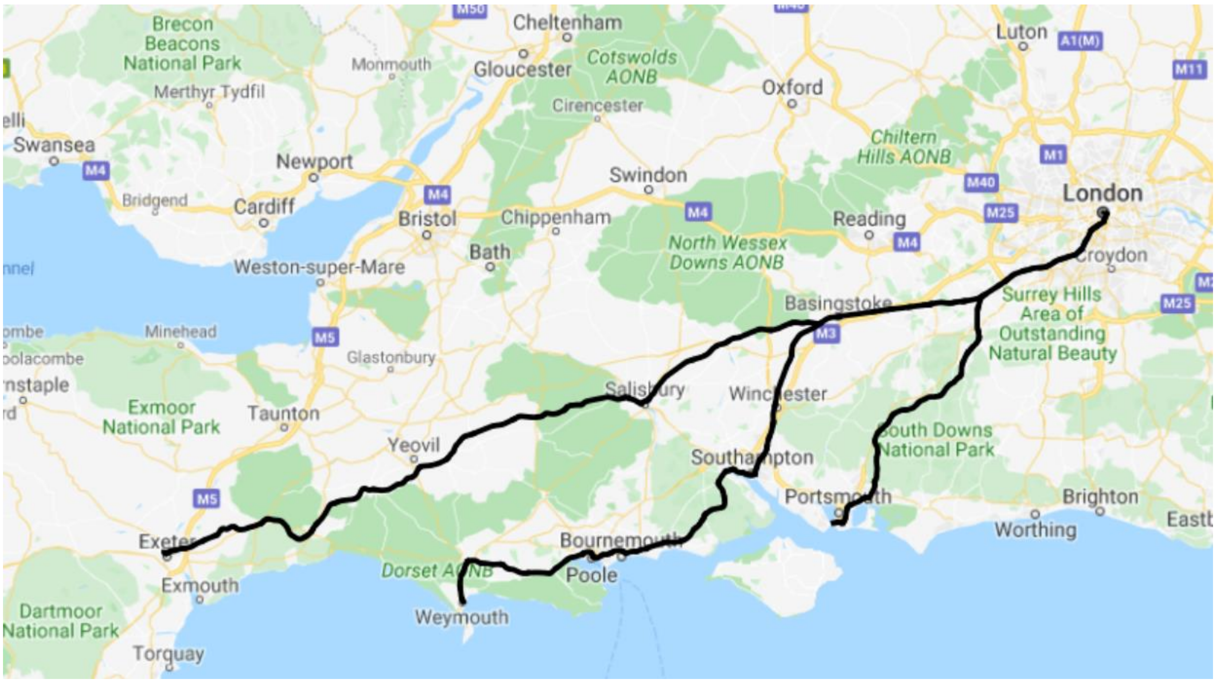


Greater Anglia

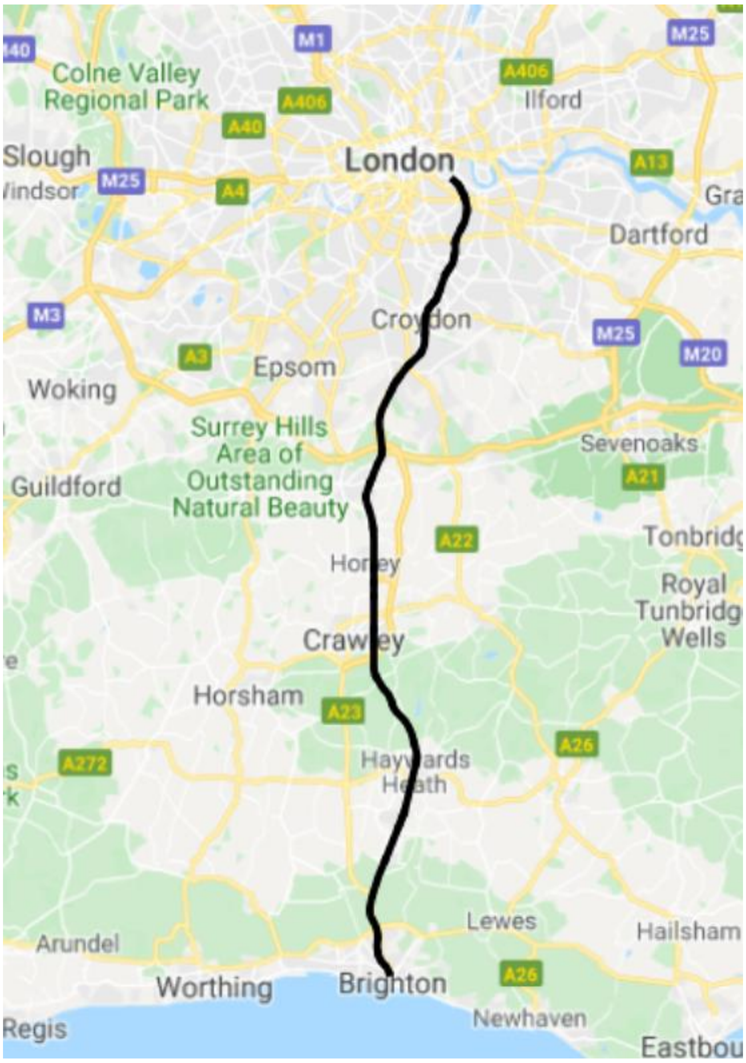


South Eastern

South Western



Southern


M1
M25
M40
Colne Valley Regional Park
A406
A40
Ilford
Slough
Windsor
M25
A4
London
A13
Dartford
M3
Croydon
M25
M20
A3
Epsom
Woking
Surrey Hills Area of Outstanding Natural Beauty
Sevenoaks
A21
Guildford
A22
Tonbridge
Horley
Royal Tunbridge Wells
Crawley
Horsham
A23
A26
A272
Haywards Heath
Lewes
Hailsham
Arundel
A26
Worthing
Brighton
Newhaven
Regis
Eastbou

TransPennine

West Coast