



H1 2024 - Claims Substantiation

Updated July 2024

Introduction to RootMetrics®

RootMetrics® is an independent mobile analytics firm that collects mobile network performance data to provide a unique and comprehensive view of the consumer mobile experience. As part of the RootScore® Report series, hundreds of millions of network performance data points are collected each year, with all tests designed to reflect the different ways people use their smartphones.

UK and Nation RootScore® Reports are based on a combination of results from testing in 16 large metropolitan markets, testing across the entirety of the UK, and within each of the four UK nations. Providing mobile network performance data and insights from nation to neighborhood, RootMetrics reporting can empower the mobile industry and consumers to make more informed mobile decisions.

The United Kingdom RootScore Report shows how the networks performed at a UK-wide level, while our England, Northern Ireland, Scotland, and Wales RootScore Reports provide a look at network performance at the nation level.

The goal of UK and Nation RootScore Reports is to provide an accurate and consumer-focused assessment of mobile performance on the networks of EE, O2, Three, and Vodafone for the entirety of the UK, as well as for nations within the UK.

Based on RootMetrics testing, RootScore Awards are granted to operators in the following performance categories: Overall, Reliability, Accessibility, Speed, Data, Call, Text, and Video. The Overall RootScore factors in results across data, call, text, and video testing. A good Overall RootScore means good overall performance and a good consumer experience. It's that simple.

The most important factors of a good mobile experience for consumers are reliability, accessibility, and speed. To address these consumer concerns, our Network Reliability and Accessibility RootScore Awards are based on a combination of results from data, call, and text testing, and the Network Speed RootScore Award is based on downlink and uplink speeds. These awards illuminate network performance from a holistic viewpoint.

The RootMetrics testing methodology represents the consumer experience of downloading and uploading files, downloading small files that represent web and app usage (secure and non-secure connections), making mobile-to mobile phone calls, and sending and receiving text messages. The details of this methodology are listed below.

Understanding RootScores®

RootScores offer a simple way to translate thousands or millions of complex data points into clear and easy-to-understand marks of performance. RootScores are designed to reflect a consumer's experience of network performance—the higher the score, the better

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the performance. For instance, the Overall RootScore reflects a consumer's everyday experience across data, call, text, and video usage. A good Overall RootScore means a good overall consumer experience and good overall network performance.

Using an educational analogy, think of RootScores like you would a final grade in a semester-long course: scores approaching the upper limit (100) indicate extraordinary performance, like receiving an "A" grade at the end of the semester. Scores approaching the lower limit (0) represent network performance that would be clearly unacceptable to everyday consumer usage, similar to receiving a poor grade at the end of the semester.

Just as a final grade in a semester-long course is a function of performance across multiple exams, no single test determines RootScore results for any performance category; RootScores are calculated from multiple tests that are weighted according to the impact to a consumer's experience.

RootScore® Rankings & Verifiability

After compiling thousands of test results in a market, we estimate each network's RootScore. Based on statistical principles, RootScores have uncertainty associated with them. Confidence intervals represent this uncertainty and reflect the distribution of possible RootScore values based on our sampling of network performance. More specifically, confidence intervals reflect the underlying statistical uncertainty associated with any estimate based on random sampling.

The number of samples available impacts confidence intervals; the greater the number of samples within a test location, the more precise the estimate and the smaller the confidence interval. Network rankings are determined through statistical comparison of RootScores; RootMetrics utilizes a bootstrap t-test at an achieved significance level of 0.1. Specifically, the t-test provides probabilistic evidence that two networks' scores are not equivalent to each other.

Through this process, networks with divergent scores are at times determined to be statistically indistinguishable and therefore receive the same rank, and networks with very close scores can receive different final rankings depending on the level of precision of the scoring.

For example, a Data RootScore might distinguish a clear ranking separation between 94.5 and 95.0, while a Call RootScore could result in a tie between scores of 93.0 and 95.0, based on observed differences in the uncertainty of the final RootScore.

RootScore® Reports

The United Kingdom RootScore® Report shows how the networks performed at a UK-wide level, while our England, Northern Ireland, Scotland, and Wales RootScore Reports provide a detailed look at network performance at the nation level.

The goal of UK and Nation RootScore® Reports is to provide an accurate and consumer-focused assessment of mobile performance on the networks of EE, O2, Three, and Vodafone for the entirety of the UK, as well as for nations within the UK. The RootMetrics testing methodology strives to provide an accurate, unbiased, and balanced assessment of operator performance.

UK and Nation RootScore® Reports are based on a combination of results from testing in 16 large metro areas as well as testing across the entirety of the UK and within each of the four UK nations. To provide an objective means of testing in areas where people live, the RootMetrics UK and Nation RootScore Report methodology uses results from tests conducted in 16 of the most populous Larger Urban Zones (LUZs) across the UK, as well as data collected in officially designated Built-Up Areas (BUAs) in England and Wales and officially designated Settlements in Scotland and Northern Ireland.

To ensure that sample collection provides a balanced and representative view of operator performance across different-sized communities, the UK and Nation RootScore Report sampling methodology targets small, medium, and large “places” that were not sampled for Metro RootScore Reports and are based on population size.

UK and Nation RootScore Reports consist of Overall, Reliability, Accessibility, Speed, Data, Call, Text, and Video RootScore Award winners at UK-wide and Nation levels.

RootMetrics pairs engineering expertise with statistical approaches to design operator performance tests, collect data on operator performance that reflects a consumer’s experience, and employ statistical techniques to determine results. This approach ensures that all operators are measured on a level playing field, without bias, allowing RootMetrics to provide real-world data that confirms or challenges mobile performance metrics that are otherwise only theoretical or based on ideal conditions.

Methodology

Measuring UK and Nation performance

Employees of RootMetrics called Scouters collect test samples. Mobile performance testing is conducted with our proprietary application that measures network performance across mobile network operators simultaneously. Our application is installed and runs on

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advanced off-the-shelf smartphones available to the public at the time of testing. A different mobile network operator services each device, and each device runs the application to test operator performance. Testing is conducted while driving and walking and at indoor locations.

To evaluate operator performance at a UK-wide level, all data contributing to each nation's calculation is factored into the UK-wide characterisation.

Data Collection

RootMetrics utilises a data collection strategy intended to reflect a consumer's mobile experience by testing where and when consumers are likely to use their phones, and all tests are designed to reflect real-world consumer mobile behaviours.

At the beginning of a shift, each Scouter is provided with a list of randomly selected test locations, which have been selected in advance using an algorithm. Mobile network performance is measured while driving and walking, and at indoor locations.

Before collecting samples, Scouters complete a pre-test checklist to ensure that all testing equipment is configured and operating correctly. All data is sent to secure servers at RootMetrics to be processed, aggregated, and analysed.

Drive tests are conducted along motorways, major routes, and residential roads where the population within a market generally lives and travels. Drive testing takes into consideration common traffic patterns. RootMetrics makes efforts, based on estimating common travel patterns for each market, to perform tests on routes that consumers would likely utilise on a daily basis.

Sample Design

RootMetrics uses a sampling scheme that:

- Is randomised to reduce spatial and temporal bias.
- Includes route optimisations that approximate estimated travel patterns common within markets that RootMetrics tests.
- Weights sample collection times to ensure that peak consumer usage and travel periods are well represented within each market.

Timing of the data collection period is scheduled to measure performance during representative usage periods. Therefore, testing is not conducted during major holidays, extreme weather, or during periods of significant population migration effects (e.g. Christmas Holiday).

Test equipment and data collection parity

To ensure that testing aligns with the latest consumer experience, RootMetrics makes efforts to select phones that support the most advanced network technology available at the time of selection (device models are evaluated twice per calendar year). Each smartphone is purchased with all recent operator updates, and the current operator-provided version of Android is installed.

Benchmarking smartphone models before testing helps remove limitations that can be caused by specific model/network interactions. All phones used for testing are configured identically and execute the same tests within each testing kit simultaneously. All phone times and schedules are synchronized for data collection. Testing has been structured to negate any testing effects that may impact network capabilities.

Mobile network performance is impacted by congestion. RootMetrics does not have information regarding the number of people within each test location or traffic on each of the networks at the time of testing. In H1 2024, the following devices were used:

- **EE** – Samsung Galaxy S23
- **O2** – Samsung Galaxy S23
- **Three** - Samsung Galaxy S23
- **Vodafone** - Samsung Galaxy S23

Data integrity controls

RootMetrics Field Operations Management has developed a procedural set of requirements for each Scouter to ensure that data collection is performed according to a specific data collection protocol. For instance, Scouters perform regular equipment checks, maintain progress notes, and record any procedural anomalies.

RootMetrics employs a sophisticated monitoring system that includes automatic alarms to identify any data integrity concerns during data collection. The alarm system allows RootMetrics to identify and solve problems while they occur.

Once data is collected and sent to the RootMetrics servers, the data is filtered through a series of algorithms designed to flag anomalies. If, during the RootMetrics quality control processes, any anomalies are found to have contributed bias to the results, the anomalous data is removed. Multiple software and human safeguards help to ensure data quality.

A flexible, evolutionary framework

RootMetrics regularly assesses and reviews all tests and methodologies with a high level of scrutiny. As consumer behaviour, technology, and the mobile industry changes, the










RootMetrics methodology will evolve to provide a current and representative measurement of the consumer mobile experience.

RootScore® Awards

RootScore® Awards are available in the following performance categories: **Overall (1), Network Reliability (2), Network Accessibility (3), Network Speed (4), Data (5), Call (6), Text (7), and (8) Video**. The top-performing network within each performance category earns the corresponding RootScore Award.

If two or more networks share the highest rank in the same category by recording statistically indistinguishable results, each network earns a RootScore Award in that category.

RootScores 1H 2024 - Metro and National components

	 Reliability (20% Call / 75% Data / 5% Text / 0% Video)	 Accessibility (10% Call / 85% Data / 5% Text / 0% Video)	 Speed (0% Call / 100% Data / 0% Text / 0% Video)	 Overall Performance (20% Call / 70% Data / 5% Text / 5% Video)
 Call (95%/5%/0%)	<ul style="list-style-type: none"> • Mobile-to-mobile blocked outgoing call • Mobile-to-mobile dropped outgoing call 	<ul style="list-style-type: none"> • Mobile-to-mobile call setup time 		
 Data (60%/15%/25%)	<ul style="list-style-type: none"> • Lite data secure access success • Lite data secure task success • Download/upload access success • Download/upload task success 	<ul style="list-style-type: none"> • Lite data secure access time • Lite data secure task time • Download/upload time to connect 	<ul style="list-style-type: none"> • Download speed (80%) • Upload speed (20%) 	
 Text (80%/20%/0%)	<ul style="list-style-type: none"> • Intra/inter-network text send failure rate • Intra/inter-network text receive failure rate 	<ul style="list-style-type: none"> • Intra/inter-network text delivery time by sender • Intra/inter-network text delivery time by receiver 		
+				
 Video (60/30/10)	<ul style="list-style-type: none"> • Stall Events (15%) • Median Stall Severity (5%) • Start Failures (40%) 	<ul style="list-style-type: none"> • Median Start Time (30%) 	<ul style="list-style-type: none"> • Median Bitrate (10%) 	<p>Notes:</p> <ol style="list-style-type: none"> 1. The Overall Award is updated in 2024 to include Video Scores. 2. Video scores are included in the Overall Award and are not included in Reliability, Accessibility, or Speed awards. 3. A scoring algorithm is applied to each test result (Call, Data, Text). In the case of speed components, appropriate weighting is applied to the median, as well as the 5th and 95th percentiles.

EE's H1 2024 Claims

- 1) **The UK's #1/Best Network**
 - **Across the UK, nations, and major metropolitan markets**
- 2) **The UK's #1/Best Network eleven years and counting**
- 3) **The UK's #1/Best Network twenty-two times in a row**
- 4) **The UK's Fastest Network**
- 5) **The UK's Most Reliable Network**
- 6) **The UK's Best Network for Mobile Gaming**
- 7) **The UK's Best Network for Video**
- 8) **UK's Most Reliable Network for Mobile Gaming**

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9) The UK’s Best Network for Video Performance

10) The UK’s Best 5G Experience

11) The UK’s Best Network for Calls

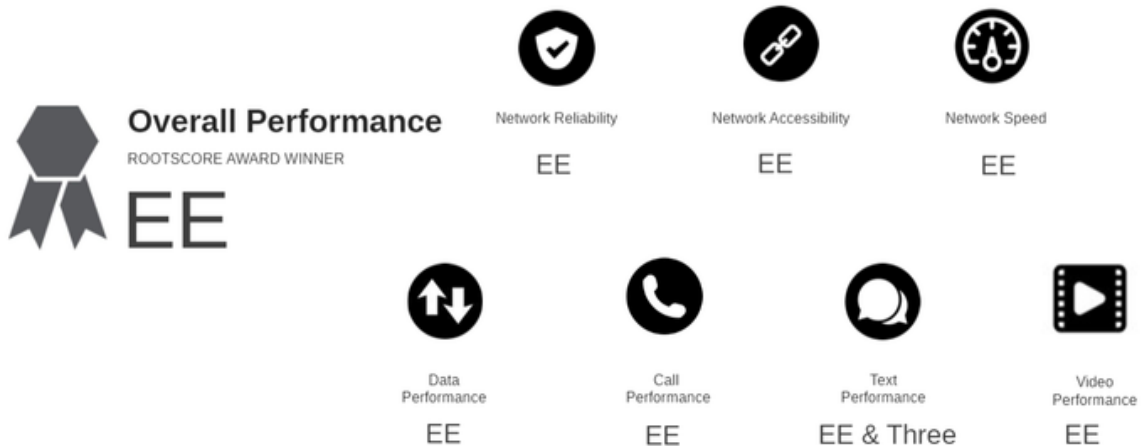
The UK’s Best Network – EE

As shown in the summary below, EE won outright or shared awards in all categories of [RootMetrics H1 2024 UK-wide testing](#). With this strong performance across subcategories, EE was announced as the winner of the Overall (Best) Network performance award in UK-wide testing. The first half of 2024 test period marked the 22nd consecutive time that EE has earned the UK Overall RootScore Award, a span of 11 years and counting.

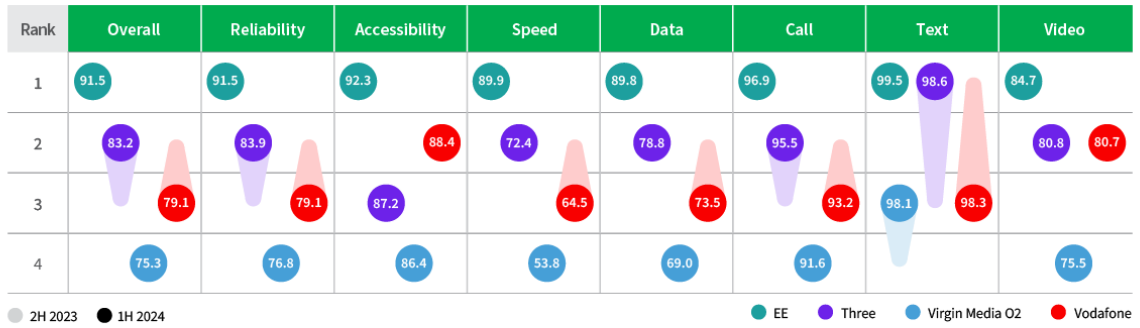
In addition, based on EE winning the Overall RootScore Award outright in all four nations, and in all 16 metros, EE is therefore eligible to make claims as the “Best Network” in the relevant metros and/or “Best Network” in England, Scotland, Wales, and/or Northern Ireland. EE is also eligible to claim the “Best Network in the UK’s 16 largest cities.”

UK Executive Summary

UK RootScore Results 1H 2024



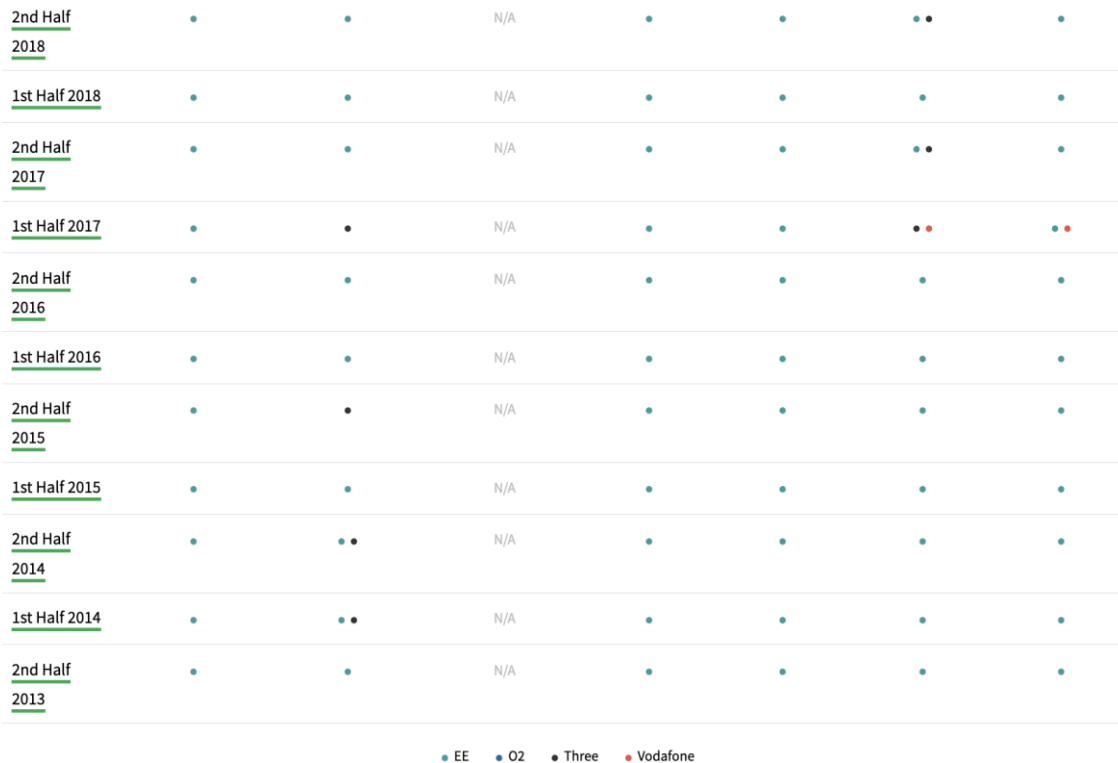
UK-wide RootScores 1H 2024



ROOTSCORE AWARD HISTORY

	Overall Performance	Network Reliability	Network Accessibility	Network Speed	Data Performance	Call Performance	Text Performance	Video Performance
<u>1st Half 2024</u>	●	●	●	●	●	●	●●	●
<u>2nd Half 2023</u>	●	●	●	●	●	●	●●	N/A
<u>1st Half 2023</u>	●	●	●	●	●	●	●	N/A
<u>2nd Half 2022</u>	●	●	●	●	●	●	●	N/A
<u>1st Half 2022</u>	●	●	●	●	●	●	●●	N/A
<u>2nd Half 2021</u>	●	●	●	●	●	●●	●	N/A
<u>1st Half 2021</u>	●	●●	●	●	●	●●	●●	N/A
<u>2nd Half 2020</u>	●	●	●●	●	●	●	●	N/A
<u>1st Half 2020</u>	●	●	●	●	●	●	●●	N/A
<u>2nd Half 2019</u>	●	●	N/A	●	●	●	●●	N/A
<u>1st Half 2019</u>	●	●	N/A	●	●	●	●●	N/A

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The UK's Fastest Network - EE

Based on EE winning the Speed RootScore Award at the UK-wide level, in all four nations, and in all 16 metros (with one tie in Southampton), EE is therefore eligible to make claims as the fastest network in the relevant metros or the fastest network in the UK, England, Scotland, Wales, and/or Northern Ireland. EE also recorded the fastest median download speed at the UK-wide level, in each nation, and in 14 out of 16 metros tested.

See below for Speed RootScore Award winners from UK-wide testing, testing across the nations, and in major metropolitan markets, as well as median download speeds for each location.

UK Speed RootScore Award winner – EE

UK-wide median download speeds 1H 2024



The speeds above show each operator's aggregate median download speed across the entirety of the UK.



- **England Speed RootScore Award winner: EE**
- **Northern Ireland Speed RootScore Award winner: EE**
- **Scotland Speed RootScore Award winner: EE**
- **Wales Speed RootScore Award winner: EE**

UK Nation aggregate median download speeds (Mbps) 1H 2024

Operator	England	Northern Ireland	Scotland	Wales
EE	80.1	72.2	81.6	75.3
Three	45.7	29.8	41.9	33.4
Virgin Media O2	23.9	27.7	20.6	14.4
Vodafone	44.8	39.8	30.6	29.2



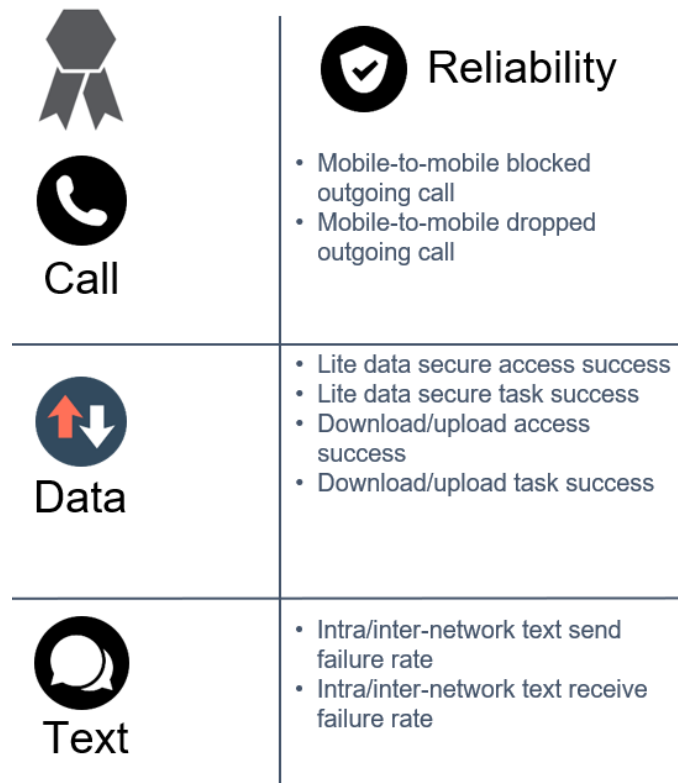
UK Metro Speed RootScore Award winners & scores H1 2024

City	Speed RootScore Winner	EE Speed RootScore	O2 Speed RootScore	Three Speed RootScore	Vodafone Speed RootScore
Belfast	EE	96.2	82.9	77.0	88.1
Birmingham	EE	95.2	75.3	82.2	81.4
Bristol	EE	88.9	43.9	76.7	82.8
Cardiff	EE	88.4	67.8	80.7	80.4
Coventry	EE	99.1	82.4	80.8	80.7
Edinburgh	EE	94.7	81.2	84.7	82.3
Glasgow	EE	99.7	67.5	83.4	89.5
Leeds	EE	95.9	78.5	82.1	78.3
Leicester	EE	91.4	85.5	81.2	85.3
Liverpool	EE	94.3	75.0	89.2	89.7
London	EE	96.7	76.7	81.3	82.5
Manchester	EE	99.5	76.6	92.3	91.1
Newcastle	EE	90.5	74.5	74.0	76.4
Nottingham	EE	97.9	75.2	79.7	73.7
Sheffield	EE	94.2	77.8	80.3	80.9
Southampton	EE & Vodafone	86.0	28.5	80.9	83.4

The UK's Most Reliable Network - EE

The RootMetrics Network Reliability category provides a holistic look at reliability performance across data, call, and text testing. The reliability category addresses the two questions most fundamental to a reliable mobile experience for consumers: can I access the network, and can I then stay connected to complete my intended task?

To answer these critical questions, RootMetrics assesses performance across the following key areas:



To evaluate downlink throughput performance, the RootMetrics testing application attempts to open and maintain 4 simultaneous HTTP connections to measure the total bytes transferred during the test period. Downlink throughput speed is measured during this testing.

Below are Reliability RootScore Award winners and Reliability RootScores for each operator in each metro, and market is linked to the relevant RootScore Report for reference.

EE won/tied for the Reliability RootScore Award in more markets than any other operator at 16 (15 outright wins and one shared win), allowing it to make claims in the metros it wins alongside making the national claim of the UK’s Most Reliable Network based on UK-wide results.

UK Metro Reliability RootScore Award winners & scores H1 2024

City	Reliability RootScore Winner	EE Reliability RootScore	O2 Reliability RootScore	Three Reliability RootScore	Vodafone Reliability RootScore
Belfast	EE	94.4	81.4	83.9	85.6
Birmingham	EE	93.3	72.6	89.7	82.1
Bristol	EE	92.9	71.9	83.2	88.1
Cardiff	EE	94.1	82.7	88.0	83.6
Coventry	EE & O2	91.3	91.0	87.1	89.1

Edinburgh	EE	94.5	84.1	86.4	83.6
Glasgow	EE	97.1	82.2	86.8	91.3
Leeds	EE	97.4	89.2	90.3	86.4
Leicester	EE	94.7	83.1	86.0	88.6
Liverpool	EE	94.1	81.0	91.5	88.1
London	EE	94.5	81.3	86.7	84.2
Manchester	EE	97.3	87.3	94.9	92.7
Newcastle	EE	92.8	79.2	78.1	78.1
Nottingham	EE	95.3	81.0	89.1	88.5
Sheffield	EE	94.3	87.4	88.6	87.2
Southampton	EE	95.7	72.4	91.5	89.3

Mobile Gaming Methodology

To determine which operator can provide the best real-world mobile gaming experience, RootMetrics developed a star rating system that offers a holistic and objective measurement of each network's ability to deliver a smooth real-world gaming experience based on the metrics that matter most to gamers.

To determine an operator's star rating, RootMetrics focuses on multiple key performance indicators (KPIs) that are critical to mobile gaming performance. All KPIs are recorded across all network technologies, including 4G LTE, any sub-4G LTE technologies, and 5G, when available.

When calculating ratings, each KPI is assigned a maximum number of stars an operator can earn, with a total possible rating of 5 stars across all included KPIs. For each KPI, an operator earns stars by exceeding a defined performance threshold. The KPIs used in our mobile gaming rating are:

- 1. Median Download Throughput Speed:** Minimum levels of download throughput that must be maintained for gameplay
- 2. LDRS Access Speed (Latency):** Low latencies required for smooth, reactive gaming experience
- 3. UDP Packet loss:** Packet loss can lead to missing information disrupting gameplay
- 4. UDP Jitter:** High jitter indicates inconsistent latency and can result in choppy or laggy gameplay

The above KPIs are used to analyze two major facets of the mobile gaming experience: (1) bandwidth and (2) latency and reliability. Bandwidth is represented in our ratings by using median download throughput speed, which we use as a proxy for bandwidth. Latency refers to the reliability of a user's experience and is represented in our ratings by LDRS access speed, UDP packet loss, and UDP jitter.

The thresholds in our mobile gaming ratings for **Median Download Throughput Speed**, a proxy for bandwidth, were determined using requirements published by popular cloud gaming platforms (i.e., Microsoft Xbox Game Pass, Polygon, GeForce Now, and others), game developers, and industry publications. For lower resolution gaming (ex., 720p), a 10 Mbps median download throughput speed threshold is referenced by Microsoft Xbox Cloud Gaming¹ and Polygon².

For higher quality gaming (ex., HD, 4k), speed thresholds ≥ 30 Mbps are defined by the organizations note above, with different gaming platforms recommending speeds ranging from approximately 25 – 35 Mbps for HD/4K gaming. Regarding bandwidth, more bandwidth (represented by faster median download throughput speeds) is an indicator of a connection's ability to potentially mitigate unforeseen network congestion that might affect a user's gameplay. A user may not need their full bandwidth all at one time, but it may offer the capacity required to recover from moments of latency spikes, packet loss, or inconsistent and/or high jitter. The ability for bandwidth to alleviate potential latency or reliability issues is the reason for the higher potential star accumulation for median download throughput speeds in our ratings, when compared to our latency and reliability KPIs (LDRS access speed, UDP packet loss, and UDP jitter).

Latency and reliability are also critical for gamers, which is why we have divided our latency measures into three categories worth a total of 3.5 stars.

LDRS access speed: most consumers would understand this KPI simply as “latency.” We have allocated 1.5 of the 3.5 stars available for latency and reliability to this KPI because it has a more noticeable impact on a user's gaming experience. High latency can disrupt (or even stop) a game in mid-stream, while low latency can provide smooth, buffer-free gaming. The latency results in this KPI are based on our secure web and app testing, which characterises use cases that require continuous data usage on a secure connection, which is the most common mobile cloud gaming experience. Microsoft Xbox Game Pass recommends latency below 60ms for optimal cloud gaming, and we've used that benchmark as a proxy for good cloud gaming on any cloud-gaming platform, both casual games in SD and online games in HD. Understanding that lower latency provides a better experience, we have determined that <30 ms is the next threshold for a smoother mobile gaming experience. Looking ahead at future 5G capabilities and the reality of wired in-home internet access as a benchmark, we've also included <10 ms as a final threshold for mobile gaming latency as this offers a true comparison to available gaming alternatives.

UDP Packet Loss: we measure packet loss during our UDP tests. Packet loss, which is a measure of reliability relating to latency, can lead to a frustrating gaming experience since, in effect, packet loss means that pieces, or packets, of game data are lost in transit to and from the user and cloud server. Packets can also arrive out of order, which could theoretically lead to a game that's unintelligible. Based on our initial research and information published by industry advocates and press outlets, we recommend packet

loss of below 3% for smooth casual gaming in SD; this metric was derived from the ICTP’s recommendation³ of between 2.5-5.0% for acceptable quality.

RootMetrics has selected a rounded metric on the lower end of this range to simplify the thresholds for easier comprehension while also keeping a reasonably high standard. Both ICTP and Cisco⁴ recommend packet loss of 1% or lower for activities such as video streaming and audio/voice communication which are critical for multiplayer online games in HD quality. In recent research, we have found several site developers who indicate anything above 1% packet loss is detrimental to the gaming experience.

UDP Jitter: we measure this KPI during our UDP tests. Jitter indicates that latency is inconsistent rather than stable. The effects of jitter are similar to those of latency: high jitter can lead to choppy or laggy gameplay and/or distorted audio and chat functionality, while low jitter can keep games running smoothly (as long as latency is also low). In short, the lower the jitter, the better. According to Cisco⁶, jitter below 30ms is ideal for streaming video and audio/voice communications. We have used this metric as a baseline for casual games in SD and, knowing that lower latency offers a better experience, jitter below 10ms for multiplayer online games in HD is required for a smooth mobile gaming experience.

The table below shows the KPIs with corresponding thresholds for the mobile gaming rating.

Metric Name	Performance Element	Max★	Units	Measure	0.5★	1.0★	1.5★
Download Throughput Median	Speed	1.5★	Mbps	≥	10	20	30
LDRS Access Speed	Accessibility (latency)	1.5★	ms	≤	60	30	10
UDP Packet Loss	Reliability	1.0★	%	≤	3	1	
UDP Jitter	Accessibility (latency consistency)	1.0★	ms	≤	30	10	
		5.0★					

To evaluate an operator’s ability to support gaming performance across the UK, data from testing in 16 metropolitan markets is combined with data from drive routes throughout each of the 4 nations. This data is weighted by the testing areas’ population consistent with other National awards given by RootMetrics. These UK-wide aggregate values are then compared to the KPI thresholds to determine each operator’s star rating. The operator(s) with the highest rating is able to make claims on gaming performance.

References:

- ¹ <https://support.xbox.com/en-US/help/games-apps/cloud-gaming/about-cloud-gaming#about-cellular-gameplay>
- ² <https://www.polygon.com/2020/10/14/21499262/cloud-gaming-setup-internet-router-how-to>
- ³ <https://web.archive.org/web/20131010010244/http://sdu.ictp.it/pinger/pinger.html>
- ⁴ <https://www.ciscopress.com/articles/article.asp?p=471096&seqNum=6>

H1 2024 UK Gaming Results

- **EE wins the UK’s Best Network for Mobile Gaming**
- **EE wins the UK’s Most Reliable Network for Mobile Gaming**

The table below shows the values of the relevant key performance indicators, stars earned for key performance indicator result, and a final gaming rating for each of the four major UK operators in the first half of 2024 population-based aggregation. EE had the highest score of any operator with a 3.5-star rating.

EE is also eligible for the claim of the “UK’s Most Reliable Network for Mobile Gaming.” UDP Packet Loss is a measure of reliability relating to the latency or responsiveness of a user’s gaming experience. EE had the lowest UDP Packet Loss among all operators in the UK at 1.8%, whilst the next operator in market achieved 3.9% UDP Packet Loss (Three).

When coupled with the Overall Reliability Award for EE’s mobile performance in the UK, EE is able to make the claim of the “UK’s Most Reliable Network for Mobile Gaming.”

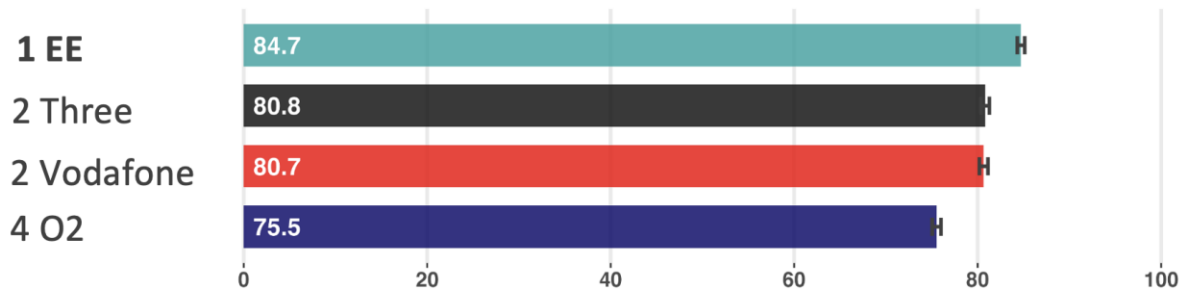
Operator	Median downlink throughput (Mbps)		Latency - median LDRS access speed (ms)		Packet Loss		Jitter (absolute ms)		Star Rating
	Value	Stars	Value	Stars	Value	Stars	Value	Stars	
EE	79.8	1.5★	50.8	0.5★	1.8%	0.5★	(0.03)	1.0★	3.5★
O2	23.3	1.0★	47.7	0.5★	4.8%	0.0★	(0.09)	1.0★	2.5★
Three	44.5	1.5★	44.7	0.5★	3.9%	0.0★	0.0	1.0★	3.0★
Vodafone	42.8	1.5★	55.6	0.5★	4.3%	0.0★	(0.16)	1.0★	3.0★

H1 2024 UK Video Performance results

- **EE wins the UK’s Best Network for Video Performance.**

As shown on the graphic below, EE recorded the highest Video RootScore score of any operator and earned the title of the UK’s Best Network for Video Performance.

Video Performance H1 2024



Key Video metrics factored into RootMetrics Video scoring:

- **Start Delay (ms):** Time to start playback from start of test
- **Average Media Bitrate:** Average bitrate of video playback
- **Stall Ratio/Severity:** Measure of stall relative to playback time
- **Start Failure Event:** Flag to denote failure to start playback
- **Stall Events (%):** The percentage of video samples where at least one stall event has occurred.

Video Testing Methodology

Our video testing measures streaming video performance in a typical consumer scenario such as a video playing on a web page or within a social media application, as well as to determine the maximum characteristics that their device and network connection are capable of when pushed to perform maximally.

This document is intended to provide transparency into the methodologies used to calculate and validate video test scores.

Methodology Overview

Video Scores are based on the adaptive bitrate stage of the Adaptive Bitrate (ABR) test, during which the video player controls the displayed resolution, while the application measures the time spent in various resolutions. Video Scores are composed of five components, each measuring a different aspect of consumer video experience. These components are evaluated and then scored on a scale of 0-100 for each eligible operator using scoring functions. Finally, scored components are combined in a weighted average to produce the final Video Score.

Process

The RootMetrics data analysis process consists of three main steps: collect, filter, and aggregate. The outputs of this process are then leveraged to determine Video Experience

Award winners.

Collection

The video test uses an Adaptive Bitrate (ABR) test, during which the video player controls the displayed resolution, while the application measures the time spent in various resolutions.

The purpose of the ABR stage is to measure the performance of streaming video in a typical consumer scenario, such as a video playing on a web page or within a social media application.

Data Quality Filtering and Sample Construction

To ensure that the data is accurate and reflective of actual consumer experience, each video test result is subject to RootMetrics proprietary data quality filters.

Video Score Construction

Video Scores are composed of five components, each measuring a different aspect of the consumer video experience.

Video Score Component	Description	Weight
Adaptive Start Failures (%)	The percentage of video samples where a start timeout or other failure occurs, causing the video not to start playback during the adaptive bitrate stage of the video test.	40%
Median Adaptive Start Time (s)	For each sample, the mean time spent waiting for the video to start playing during the adaptive bitrate stage of the test is computed as the “adaptive start time”. The median of these sample values is computed and used as a Video Score component. Measured in seconds.	30%
Median Adaptive Average Bitrate (Mbps)	For each sample, the average media bitrate observed during the adaptive bitrate stage of the video test is computed. The median of these sample values is computed and used as a Video Score component. Expressed in megabits per second (Mbps).	10%
Adaptive Stall Events (%)	During the adaptive bitrate stage of the video test, if a user experiences a stall (pause in playback for rebuffering) it is considered a stall event. “Adaptive Stall Events” is the percentage of video samples where at least one stall event has occurred.	15%
Median Adaptive Stall Severity (%)	Adaptive Stall Severity is the ratio of time spent rebuffering to time spent playing in the adaptive bitrate stage of the video test, given that a stall event has occurred (see Adaptive Stall Events). The median of these sample values is computed and used as a Video Score component.	5%

Video Score components are evaluated and then scored on a scale of 0-100 for each eligible operator. Each component is assigned a weight based on its importance toward creating a great overall video experience. For example, the Adaptive Start Failures (%) component is weighted heavily, because inability to start video playback is one of the more frustrating video experiences that consumers report. Component scores are then combined in a weighted sum to create the final Video Score.

Statistical Evaluation

Winners are earned by operators found to have the highest Video Score among competitors in the market, accounting for statistical uncertainty.

Best 5G Experience in the UK - EE

The end-user 5G experience in the UK comes down to two key pillars: availability and performance. It’s critical that both pillars be considered together—not in isolation—because the ideal 5G experience is marked by a combination of both widespread availability and strong speed, reliability, and latency performance.

In H1 2024, EE’s top combination of 5G availability plus performance allowed EE to earn the RootMetrics award for Best 5G Experience in the UK.

KPI’s behind UK’s Best 5G Experience

Operator	5 th Percentile Download Speed (Mbps)	Median Download Speed (Mbps)	Latency (ms)
EE	19.5	207.5	47.0
O2	5.3	79.7	48.5
Three	8.5	210.3	40.0
Vodafone	12.9	184.9	54.5

Operator	LDRS Access Success	LDRS Task Success	Percentage of Tests on 5G
EE	99.8%	99.8%	60.8%
O2	99.7%	99.2%	55.9%
Three	99.9%	99.2%	61.2%
Vodafone	99.7%	99.4%	47.2%

Fastest 5G in the UK results - no winner

To earn RootMetrics Fastest 5G award, an operator must deliver the fastest 5th percentile 5G download speed, the fastest median 5G download speed, and the fastest 95th percentile 5G download speed.

In H1 2024, no operator had the fastest 5G speeds across all three metrics. EE led for 5th percentile 5G download speeds, while Three recorded the top median and 95th percentile 5G download speeds.

5G download speeds (5th, median, and 95th percentile) H1 2024

Operator	5 th Percentile	Median	95 th Percentile
EE	19.5	207.5	709.0
O2	5.3	79.7	298.9
Three	8.5	210.3	879.0
Vodafone	12.9	184.9	458.6

Why are RootMetrics' results robust?

RootMetrics uses scientific methodologies to design tests, measure activities, and collect data about mobile network performance that are representative of a consumer's mobile experience within a given market. RootMetrics then employs statistical techniques to verify and validate the results. This approach ensures all operators are measured on a level playing field, removes unintentional bias, and allows RootMetrics to provide actual, in-the-field data that confirms or challenges performance numbers that are otherwise only theoretical or based on ideal conditions. Weighting and stratification methods ensure that test data correctly represents the overall national population distribution.

We measure network reliability, accessibility, and speed performance across the activities that consumers use their smartphones for on a daily basis, like browsing webpages, using apps, making calls, sending texts, and watching videos. Our methodology is designed to ensure that our tests measure performance across a wide range of real-world situations that consumers experience while using their smartphones on a daily basis. For example: we collect samples during periods of high and low congestion; we measure performance across variations in speed, from standing still to driving on the highway; and we perform tests whether coverage is poor or excellent or

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somewhere in between. We test each network head-to-head in these situations to make comparisons easy and assure all networks are measured on a level playing field.

Methodological facts and figures from RootMetrics' UK tests conducted between January and June of 2024:

- 625,047 tests across the UK
- 22,909 miles driven
- 4 nations visited
- 16 of the largest metropolitan areas (Eurostat 'Large Urban Zones' [LUZs]) included
- 795 indoors tested