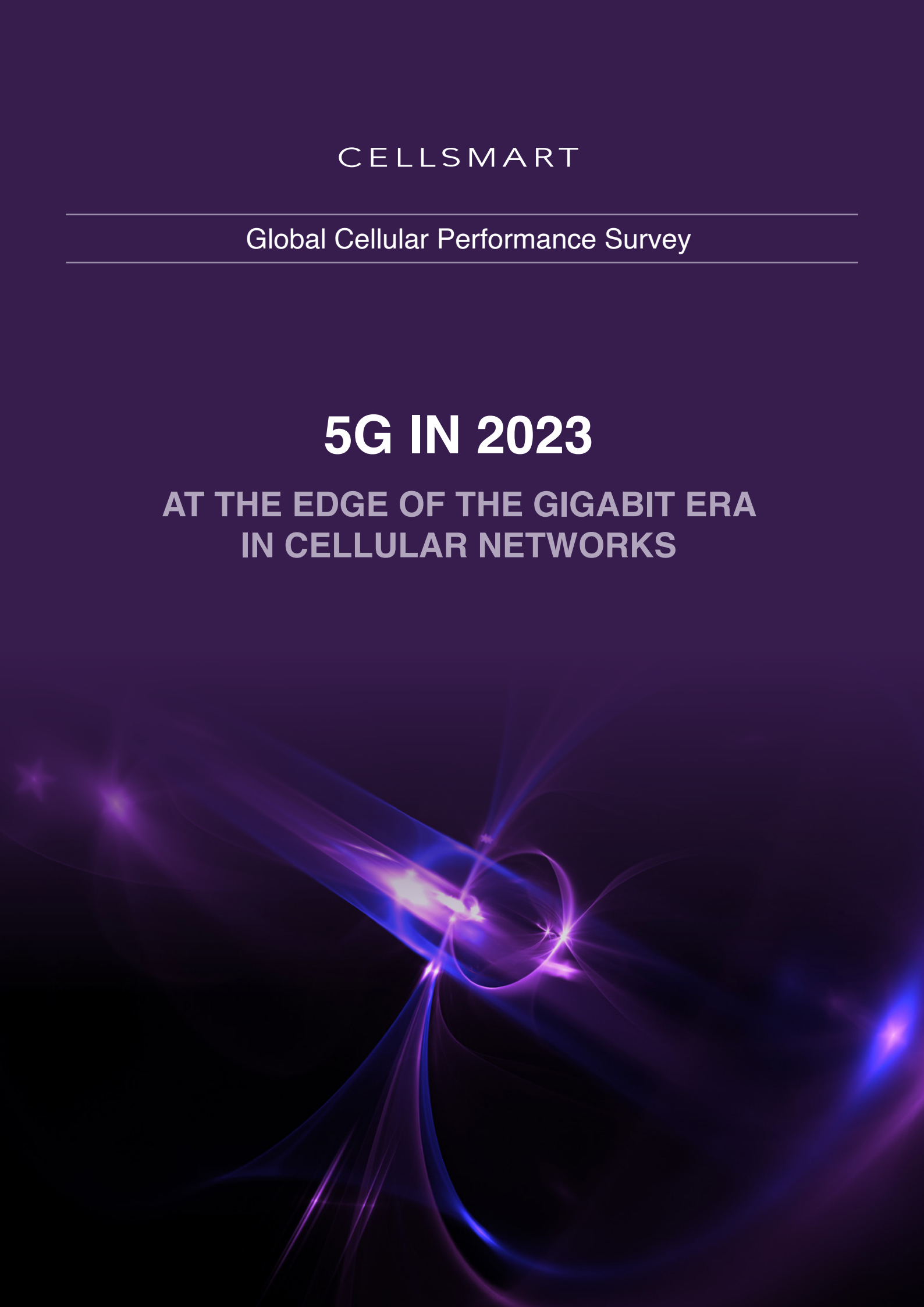
CELLSMART

Global Cellular Performance Survey

5G IN 2023

AT THE EDGE OF THE GIGABIT ERA IN CELLULAR NETWORKS



5G cellular network performance is evolving rapidly across the globe. Over a six month period, local performance testing has shown new levels of performance in both indoor and outdoor 5G networks. The survey results demonstrate that 5G is maturing and beginning to deliver on its promise of 1 Gbps download speeds.

While the mobile industry hasn't quite entered the gigabit era, the speeds recorded in indoor and outdoor settings are showing the potential to deliver enterprise-grade fixed wireless access solutions. Upload speeds are demonstrating greater peak performance while latency has fallen below 10 milliseconds (ms) indoors in several tests.

Cellular performance remains varied across the globe, but the overall trend is towards higher speeds, lower latencies, and greater resiliency in cellular networks. 5G is ramping up in 2023 and showing the viability of fixed wireless access as a simple, efficient, and reliable alternative to fibre or other terrestrial network infrastructure.

Research firm MarketAndMarkets expects the global 5G fixed wireless access market to be worth $29.4 billion in 2023 and will reach $153.0 billion by 2028, growing at a compound annual growth rate (CAGR) of 39.0% during the forecast period. It notes, "The growth of the 5G fixed wireless access market is expected to be driven by the increased wireless network capacity and high speed offered by high-frequency millimeter waves."

The challenge is that increases in capacity aren't evenly distributed and cellular network performance is hyper-localised. It requires intelligence and insights to find the best cellular options for fixed wireless access in each location. As cellular network performance changes month-by-month and year-to-year, it is critical to see the evolving landscape locally across the globe.

The CELLSMART survey provides real-world intelligence and is entirely based on speed tests run in the field. It represents the performance that an average user would experience in each location.

$153BN
BY 2028

$29BN
IN 2023

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KEY FINDINGS

5G network performance has come a long way over the last 12 months. Real-world testing shows new peak download and upload speeds on 5G networks. The industry is on the cusp of the gigabit era in cellular networks with these speeds moving from the lab to field in 2023.

1 Peak 5G download speeds are delivering nearly 1 Gbps with the top five download speeds exceeding 780 Mbps in outdoor tests.

2 Peak 5G upload speeds have increased by 35%, from 109 Mbps (Netherlands) to 146.75 Mbps (US) in outdoor tests.

3 Tests run in Norway and the Philippines had outdoor speed tests that showed latency of less than 10ms, followed closely by US (10ms), China (11ms) and France (11ms).

4 5G is still providing hyper-asymmetrical test results with an average outdoor download speed of 210.05 Mbps versus 26.78 Mbps outdoor upload speed.

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GLOBAL CELLULAR PERFORMANCE

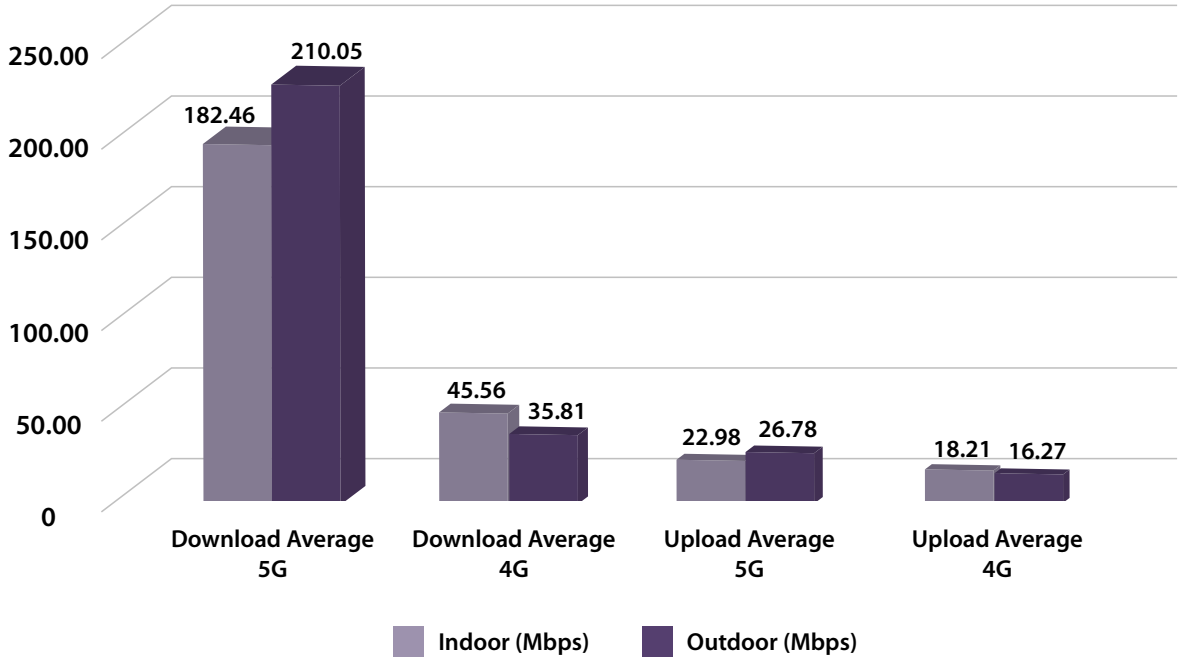
The survey results revealed the global average outdoor download speed for 5G is 210.05 Mbps, compared to 182.46 Mbps indoors. 5G download speeds show a significant improvement over 4G with an increase of 486.57% (outdoor) and 694% (indoor).

Average upload speeds continue to lag behind download speeds with almost no improvement from 4G to 5G in indoor tests. Both 4G and 5G upload speeds remain significantly lower than download speeds. 5G upload speeds as a percentage of download speeds is 17%, compared to 74% on 4G. Download and upload speeds remain hyper-asymmetrical in 5G, which needs to improve to support enterprise use cases.

The survey results also revealed how latency is impacted in indoor settings, with average 5G latency being 14.58ms lower indoors than outdoors. Average latency indoors was 15.32 higher on 4G than outdoors.

The CELLSMART Global Cellular Performance Survey sample size has increased by 745.39%. Greater global coverage and more tests has resulted in global 5G averages decreasing slightly compared to the previous report. As tests increase from 20,000 to 50,000, CELLSMART expects speeds to gradually increase as 5G rollouts and optimisation continues.

INDOOR GLOBAL AVERAGE DOWNLOAD & UPLOAD SPEEDS



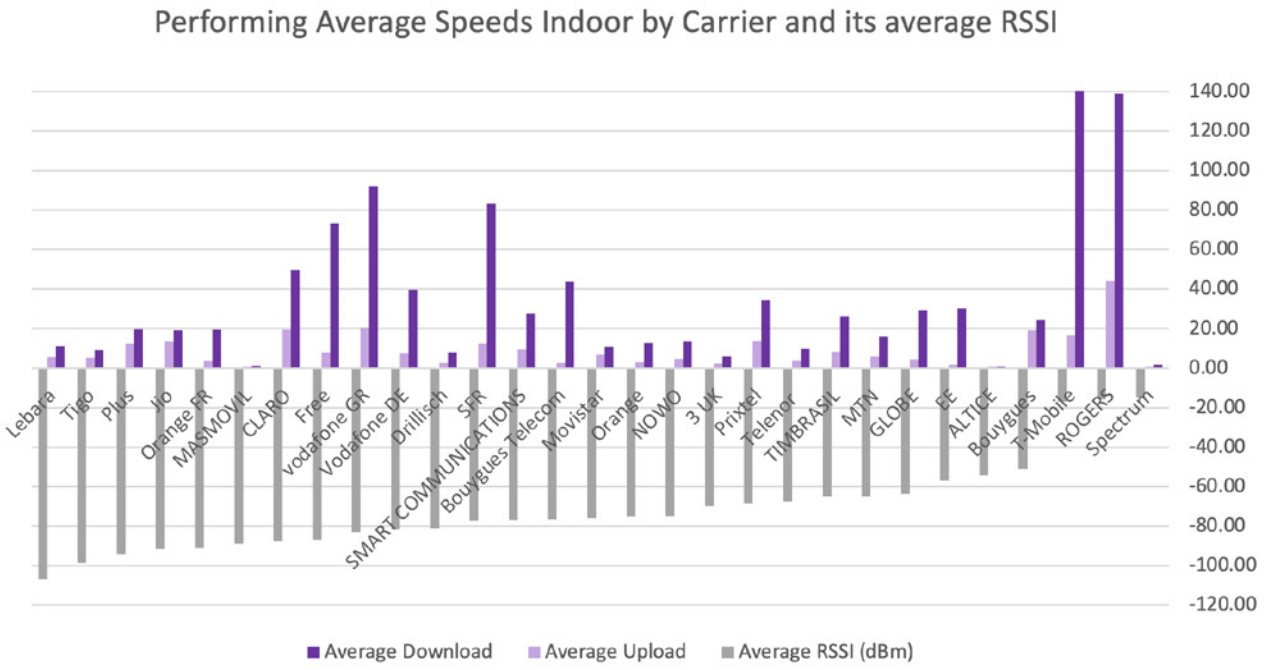
Latency Average 5G (ms)	Latency Average 4G (ms)
36.83 Indoor	47.59 Indoor
51.41 Outdoor	32.27 Outdoor

RADIO FREQUENCY STUDY:
THE CASE FOR 4G FIXED WIRELESS ACCESS

CELLSMART analysis shows the consistency of 4G networks around the world, in most cases achieving a higher Chanel Quality Indicator (CQI) than that determined by the environment. This shows the strength that 4G networks have today, with low error rates that allow for modulation adaptation.

We have been able to observe how the signal received by the device is lower indoors due to the effects of penetration between mediums, but even so we highlight operators with better results indoors compared to their competitors outdoors.

In terms of maximum speeds achieved, we can see how results of over 450Mbps in download and 65Mbps in upload have been obtained, which could even replace ADSL and fibre connections in certain homes and businesses with cellular networks, simplifying installation and start-up.



The graph shows how the different operators included in the study perform in indoor spaces. These are ordered according to the average power received by the devices. With this we can highlight how some operators, even with a lower average signal, have a better average development in terms of upload and download than other operators with a higher recorded signal. We can observe that the central/lower area has a rebound with a higher average speed, surpassing most of the operators ahead.

Leading the indoor download board, we see T-Mobile has the highest average download speed marked at 140.42Mbps followed by Rogers 138.9Mbps and Vodafone GR with 92.05Mbps. Robustness on Vodafone GR put it in third place having an average RSSI of -83dBm far from T-Mobile and Rogers with -18dBm and -16dBm respectively.

In terms of indoor upload speed, we find Rogers with 44Mbps average speed, Vodafone GR with 20.5Mbps and Claro with 19.49Mbps in this case as before, -16dBm for Rogers, -83dBm on Vodafone GR and -88dBm on Claro.

METHODOLOGY:

Based on around 8,300 tests performed on 4G connectivity. These samples include speed tests performed on Android mobile devices and routers with 4G connectivity with and without mobility. Those samples reflect an image of the reported signals by the device at the moment of the test.

LOCAL MARKET PERFORMANCE

North America continues to be the front runner in average download speed (172.02 Mbps) but is in the middle of the pack in upload speeds (25.20 Mbps). It is followed by Australia and New Zealand (95.15 Mbps) and Northern Europe (67.18 Mbps) in download speed. Australia and New Zealand are ahead of the US in upload speed (34.22 Mbps) while Northern Europe ranks behind (22.69 Mbps).

The highest average upload speed was seen in Western Asia, which includes high-performance cellular markets like the United Arab Emirates (UAE) and the Kingdom of Saudi Arabia (KSA). Southern Europe and Sub-Saharan Africa had the lowest average upload speeds with 5.04 Mbps and 4.72 Mbps respectively.

The general trend is incremental speed increases across all regions with average download and upload speeds varying dramatically around the world. Developed markets continue to lead the way while developing markets have plenty of growth opportunities in rolling out 5G.

Maximum 5G download speeds have doubled compared to previous survey results and show markets in Europe and North America continue to top country rankings. Test results from Norway (994 Mbps) and Spain (993.60 Mbps) show that peak 5G download speeds indoors and outdoors are rapidly approaching 1 Gbps.

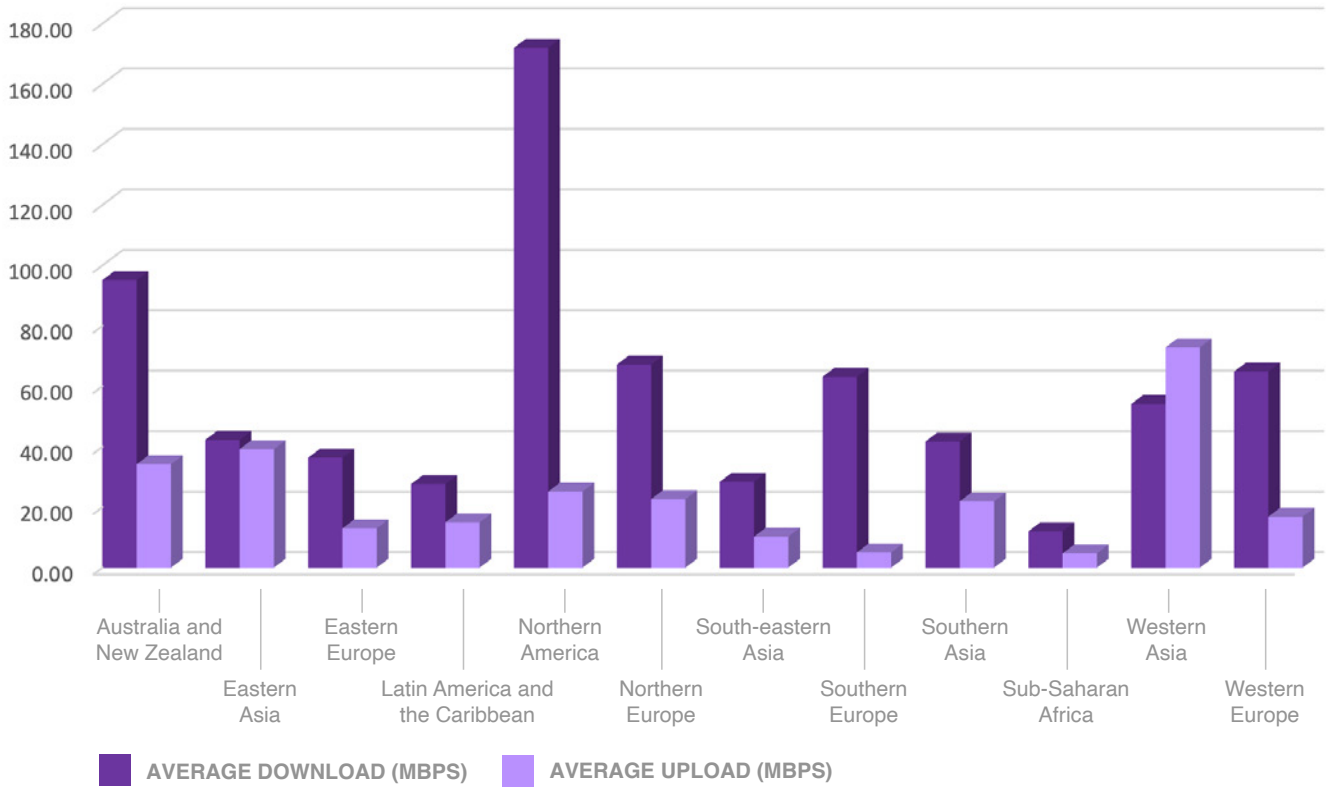
Both countries also led in average indoor 5G upload speeds with Spain ranking number one with 169.70 Mbps and Norway coming second with 145.00 Mbps. Across the country rankings Western Europe and North America dominate all five categories.

"The general trend is incremental speed increases across all regions with average download and upload speeds varying dramatically around the world

TOP 5 COUNTRIES

MAXIMUM DOWNLOAD SPEEDS **OUTDOOR**	MAXIMUM DOWNLOAD SPEEDS **INDOOR**	MAXIMUM UPLOAD SPEEDS **OUTDOOR**	MAXIMUM UPLOAD SPEEDS **INDOOR**
1. SPAIN - 993.00	1. NORWAY - 994.00	1. SPAIN - 169.70	1. USA - 146.75
2. USA - 966.00	2. FRANCE - 898.00	2. NORWAY - 145.00	2. NORWAY - 131.00
3. AUSTRIA - 921.10	3. SPAIN - 753.00	3. CANADA - 121.00	3. AUSTRIA - 128.20
4. FRANCE - 803.96	4. USA - 735.00	4. DENMARK - 109.32	4. SPAIN - 127.70
5. NORWAY - 789.00	5. GERMANY - 619.00	5. UK - 81.30	5. NETHERLANDS - 109.00

REGIONAL – AVERAGE CELLULAR PERFORMANCE



GLOBAL CELLULAR CARRIER RANKINGS

Telemovel in Portugal leads the rankings with 545.38 average download speed, across all network types. It is 138% greater average speed than 10th placed Mint Mobile in the US, showing how drastically different average performance can be even amongst the leading carriers.

Other than Singtel, all carriers in the top 10 are located in Western Europe or North America. Singtel is ranked number two in average download speed with 417 Mbps.

Average upload speeds across all network types shows even greater variation. Telstra Mobile in Austria leads with 103.30 Mbps average upload speed that is followed by Finetwork in Spain with 84.58 Mbps.

Average upload speeds are relatively similar and range from 103 Mbps and 47 Mbps. The top 10 list also includes mobile network operators (MNOs) from Canada (Eastlink), Bulgaria (Yettel), and Guatemala (Claro).

> Telemovel in Portugal leads the rankings with 545.38 average download speed, across all network types

LOCAL MARKET PERFORMANCE

TOP 10 CARRIERS
AVERAGE DOWNLOAD ALL NETWORKS (MBPS)

CARRIER	COUNTRY	DOWNLOAD MAXIMUM
Telemovel	Portugal	545.38
Singtel	Singapore	417.00
T-Mobile	USA	351.69
Meo	Portugal	350.52
Telia Norge	Norway	323.85
Orange France	France	292.19
3	UK	272.43
Skymobil	Norway	272.43
Oister	Denmark	248.00
Mint Mobile	USA	229.00

TOP 10 CARRIERS
AVERAGE UPLOAD ALL NETWORKS (MBPS)

CARRIER	COUNTRY	UPLOAD MAXIMUM
Telstra Mobile	Australia	103.31
Finetwork	Spain	84.58
O2-De	Germany	70.18
GTT	Guyana	64.01
Eastlink	Canada	60.17
Yettel	Bulgaria	51.73
Claro	Guatemala	49.87
Telia Norge	Norway	47.55
N Netcom	Norway	47.23

BEYOND THE GIGABIT ERA

CELLSMART believes it will register its first 1 Gbps download speed test in 2023. This will be a milestone for both 5G and the entire mobile industry. As download speeds continue to increase, we anticipate upload speeds to rise, especially as fixed wireless access becomes increasingly recognised as a revenue driver and margin opportunity. Overtime, there will be greater emphasis on the B2B opportunity in 5G and in turn upload speeds will become a greater priority.

Service providers in North America and Western Europe will be the first players to tap the opportunity in fixed wireless access based on the available cellular networks. This will quickly cascade across developed markets in Asia-Pacific and the Middle East.

As the industry enters the gigabit era, the cellular landscape is as diverse as it has ever been. Download speeds are showing new peaks while upload speeds still need to catch-up. The only thing that is certain is that cellular intelligence provides clarity in a rapidly changing market. Accurate local intelligence enables service providers to adopt and deploy the right solutions at the right time using the right local network.

METHODOLOGY

21.5K
NETWORK SPEED TESTS

67
COUNTRIES

1350
UNIQUE LOCATIONS

The CELLSMART Global Cellular Performance Survey presents out data captured in the speed tests and provides rankings of 5G upload and download speeds by country, metro area and MNOs as well as global analysis of the state of play in 5G deployments.

21,456 network speed tests were conducted in 67 countries and 1,350 unique locations to capture cellular network performance data. The speed tests were conducted by network engineers in the field, the CELLSMART team and interested parties using the CELLSMART mobile application.

Each test is run independently in the field with results submitted anonymously between March 22, 2022 and October 22, 2022. Data samples span Africa, Asia, Australia, the Americas and Europe. Data analysis was conducted by the CELLSMART team.

PARTICIPATE IN OUR RESEARCH

The CELLSMART Global Cellular Performance Survey has been opened to the wider community with the opportunity for you to share speed tests from across the globe. The goal of the survey is to provide accurate intelligence on cellular performance from a density of sites and carriers, so enterprises have access to mission-critical data about their cellular network options.

CELLSMART is continuously capturing new data from network engineers and its mobile application. Anyone can participate in the survey and download the mobile app for iOS or Android.

Each test is logged, mapped and used to advise organisations on local upload and download speeds and their suitability for use in fixed wireless access deployments. The launch of the mobile app opens testing capabilities to the public and enables anyone to get a snapshot of current wireless performance wherever they might be.

CELLSMART will be launching a growing number of initiatives that support new data capture across unique footprints across the globe. If you or your organisation would like to get involved, please reach via the CELLSMART website: www.cellsmart.io

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If you'd like to learn more about how you can get involved, look for updates on the CELLSMART website as we roll out the next phase of the CELLSMART Global Cellular Performance Survey.

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REVOLUTION

www.cellsmart.io