OPENSIGNAL

# THE 5G OPPORTUNITY

## How 5G will solve the congestion problems of today's 4G networks

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Opensignal active userbase:

| Total Devices | Total Measurements | Data Collection Period |
|---|---|---|
| 94,071,939 | 585,738,011,995 | Jan 1st – Dec 31st, 2018 |

Opensignal is the independent global standard for analyzing consumer mobile experience. Our industry reports are the definitive guide to understanding the true experience consumers receive on wireless networks.

# Key Findings

## Across 77 countries studied, 4G Download Speeds are between 31.2 Mbps and 5.8 Mbps faster at the best hour of day compared with the slowest hour of the day

Congestion on current 4G networks is holding back speeds highlighting the need for new 5G capacity to relieve pressure. Opensignal's* analysis uncovers that during the optimal time of day — usually when most users are asleep — networks are capable of enabling a significantly faster download experience than during awake hours.

## Across the day, 42% of countries experienced speed variation of two times or more

In the U.S., the best 4G Download Speeds were 1.9 times faster in the late hours of night — when networks are quieter and most users are offline — than during the day and evening leisure hours, when networks most need to offer a great experience for their users. India's best 4G Download Speed was 3.9 times faster than the speed experienced at the slowest time of day.

## 5G will add new capacities to help with these wide time-of-day speed variations

5G won't just deliver faster speeds. 5G will provide a blanket of capacity, built using new high-bandwidth, high-frequency spectrum bands that will help mitigate the daily cycle of congestion we see on today's 4G networks. These 5G services will support more simultaneous users at very fast speeds.

## Even the fastest 4G countries need 5G to counter big drops in speeds at busy times

In the fastest two countries in Opensignal's analysis, South Korea and Singapore, users experienced a speed gap of 13 Mbps between fastest and slowest hours, despite the two highest average 4G Download Speeds measured of 55.7 Mbps and 54.7 Mbps respectively.

## The slowest time of day tends to be in the evening, but varies between countries

While most countries experience the slowest speeds in the evening, between 9 p.m. and 11 p.m., there were notable exceptions. For smartphone users in Singapore and Norway speeds slowed much earlier at 6 p.m. and in the U.K. and the Netherlands the peak periods were even earlier, 5 p.m. and 4 p.m. respectively, overlapping the working day.

## Cities see the greatest speed swings, indicating daytime congestion 5G can relieve

Users in Paris experienced the greatest range of 4G Download Speeds, fluctuating between 21.5 Mbps and 51.4 Mbps in a 24-hour period, followed by Sydney and Santiago. Worryingly, New York's *fastest* hour for 4G speed of 40.8 Mbps was in a virtual dead heat with the 40.6 Mbps Seoul's inhabitants experience at their *slowest* hour of the day. But Seoul's slowest hour of day is still faster than the fastest hour of day in Taipei (38.2 Mbps), London (38.3 Mbps) and 21 other cities analyzed.

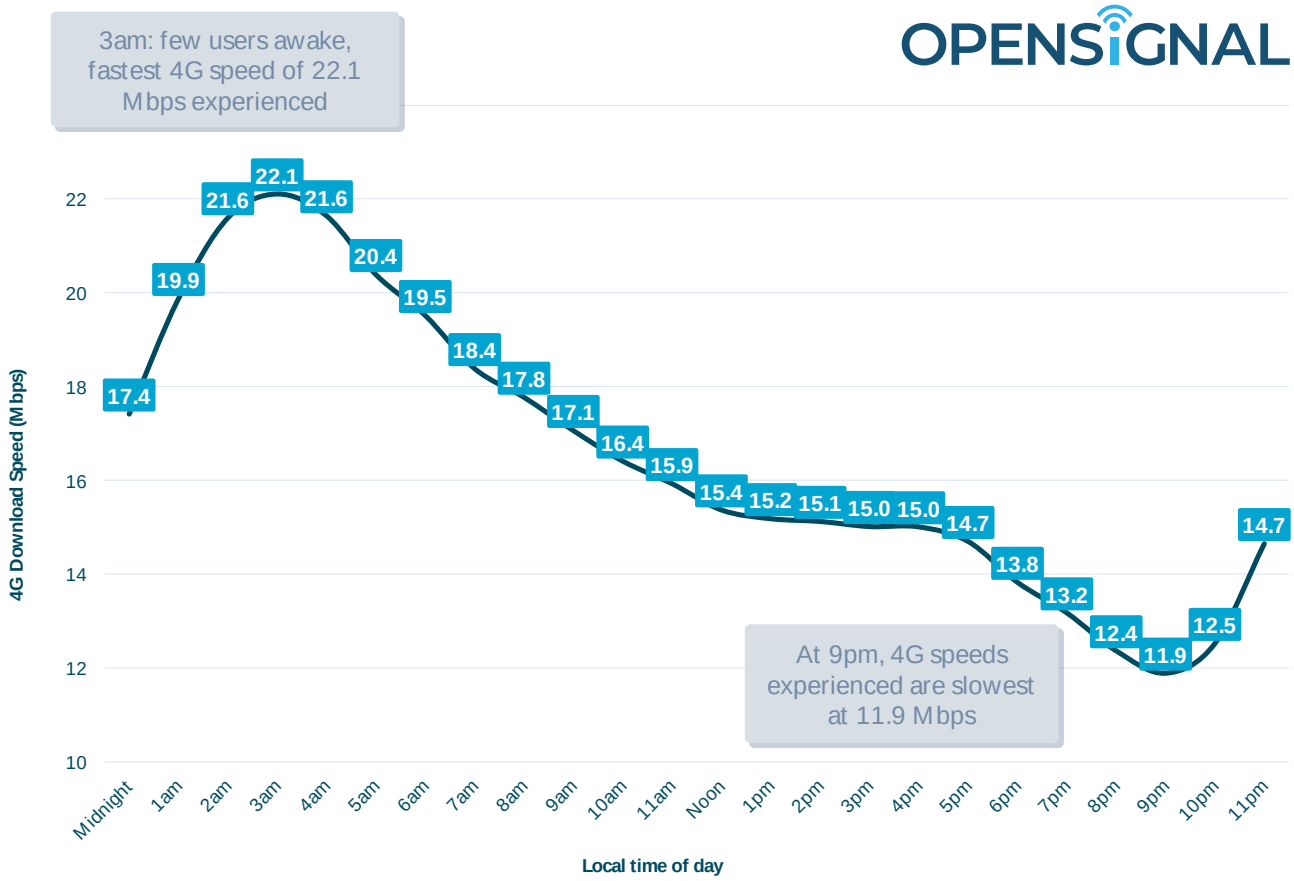
## Tremendous speed volatility is untenable for future mobile applications

To launch all the most demanding new applications, such as augmented reality or autonomous driving, operators and app developers must be able to break free from today's limitations where they are forced to create services and apps for the worst-case congestion conditions. The world needs new 5G networks to offer increased capacity, and more consistent speeds to sustain new innovations

***As of late February 2019, the correct spelling of our company name is Opensignal. OpenSignal is the correct spelling for our app.**

# World 4G speeds vary tremendously across the day showing the impact of congestion on daytime speeds

Chart 1




The 4G networks we enjoy today are light years beyond the 3G networks that kicked off the mobile data revolution at the turn of the millennium, but they have their faults. The biggest among them are inconsistency and congestion.

Across the hours of the day, Opensignal's analysis shows the enormous extent to which 4G speeds drop when most people are awake, using their smartphones and wanting a great mobile data experience. This fall in speeds indicates the pressure from millions of simultaneous users with which operators must cope.

By nature, cellular networks are shared networks. The more users there are vying for connections, the more a network's capacity gets sliced and diced among those users, which causes average speeds to fall. That produces massive inconsistencies in connection speeds throughout the

course of a day and ultimately can place severe restrictions on the type of applications and services consumers can access.

Opensignal has looked at those speed disparities in 77 countries across the world to show how big this problem truly is. We've also explored how 5G networks should be able to provide relief. 5G is usually touted because of its speed, but more significantly 5G will provide a solid foundation of capacity that will iron out the wild fluctuations we see in 4G speeds today.

## 4G is struggling to deliver a consistently good mobile experience

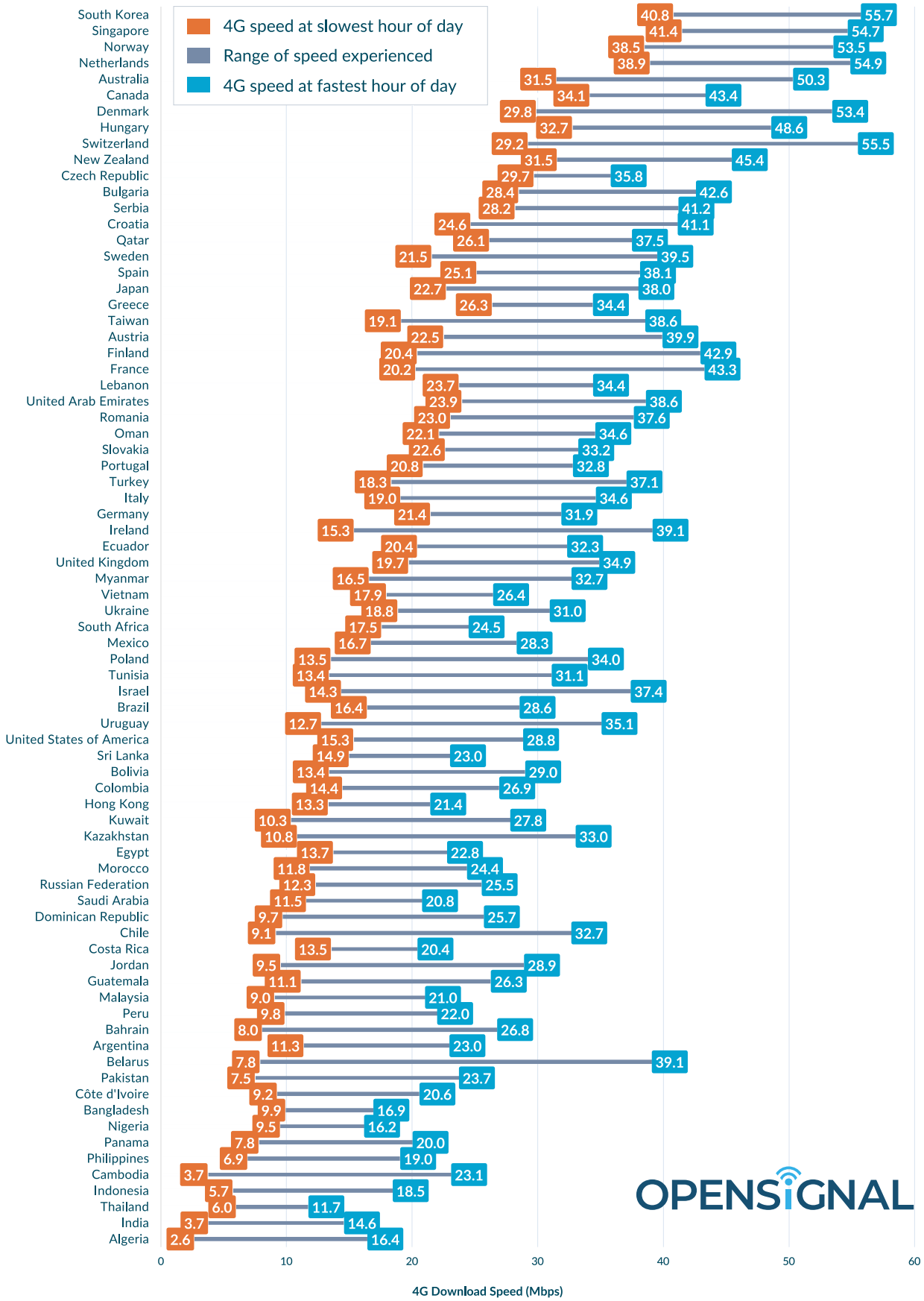
4G networks are very finicky creatures that can offer up different capabilities depending on their current loads. At peak times of day, demand for content and mobile capacity are greater, creating congestion on the network. That causes the average speeds for all users to fall. Conversely at non-peak times — often in the early hours of the morning — there are fewer users competing for network resources, allowing connections to open up, boosting speeds well beyond their normal levels.

Chart 2 provides a snapshot of the wide range of 4G Download Speeds we see throughout the day in different countries across the globe. For instance at the top of this chart we find South Korea, which had the fastest 4G Download Speed of the 77 countries in our analysis. But South Korea's average download of 47.1 Mbps isn't constant throughout the day. Depending on the hour, average speed rises as high as 55.7 Mbps or dips down to 40.8 Mbps. Even though there was a significant variation in their speeds hour by hour, South Korea and Singapore were the only countries where users averaged more than 40 Mbps at all times in our measurements, meaning they were always able to provide fast, if not consistent, connections.

The most extreme examples of hourly variation in speed were in Europe. In Switzerland average 4G Download Speed yo-yoed between 29.2 Mbps and 55.5 Mbps throughout the course of 24 hours in our measurements, while in Belarus that range was even bigger, seesawing between 7.8 Mbps to 39.1 Mbps.

# Users experience a wide range of download speeds at different hours

Chart 2



As the mobile internet evolves, these fluctuations in speed will become untenable. Consumers will expect the more consistent experience promised by 5G's proponents. Future mobile apps and services won't just demand fast speeds but will need consistent connections.

For instance, let's say a super-HD video or a 360-degree virtual-reality stream requires a minimum of 25 Mbps to perform optimally. If an operator has an average 4G Download Speed of 30 Mbps, you might assume it has plenty of connection power to support that content. But if in reality download speeds on that network fluctuate from 20 Mbps to 40 Mbps through the course of day — or across different locations — then we have a situation where users can consume that content only at certain times. What's worse, the times that content becomes unwatchable are precisely the peak times when more users want to consume it.

5G will not only provide extremely fast speeds but also a solid bedrock of capacity, to even out the consistency issues we are seeing with current 4G networks. As part of the 5G era, new high capacity and very high frequency radio bands will be usable for the first time by mobile technology, which will increase the networks' ability to support more simultaneous users and data at very high speeds.

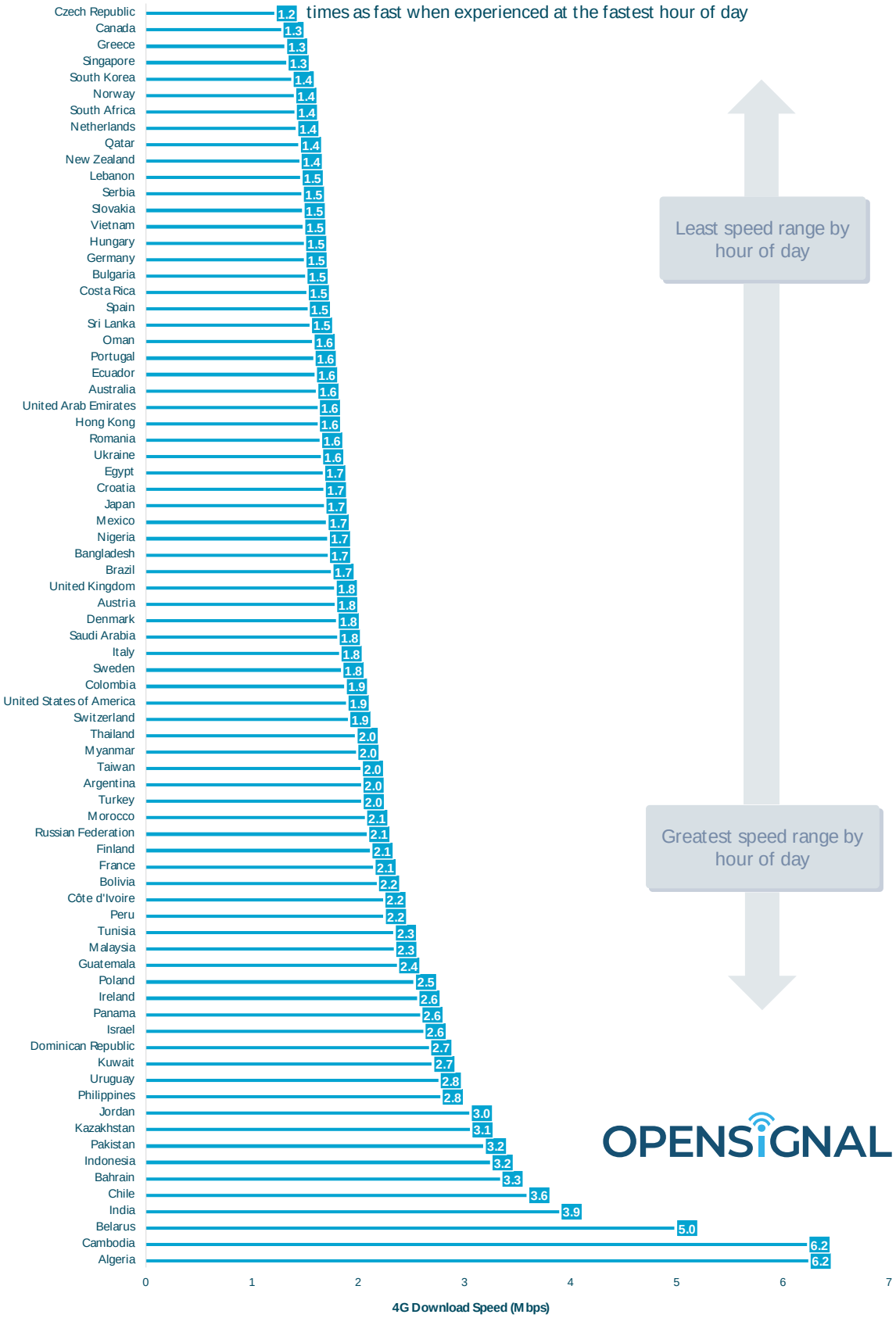
## Even the fastest countries have big swings in speed

Across the hours of the day, Opensignal has analyzed the difference between the time when smartphone users experience the fastest download speed and the time when speeds are slowest. The difference between the best and worst speeds indicates the speed a country's networks are able to deliver under both the most optimal and least optimal conditions depending on time of day.

Countries with a wide range likely have greater congestion pressure on their networks. Those countries with little difference between best and worst speeds most likely have networks that are lightly loaded.

# Difference in 4G Download Speed experienced between the fastest and the slowest hour of the day

Chart 3



Canada, the Czech Republic, Greece, the Netherlands, New Zealand, Norway, Qatar, Singapore, South Africa and South Korea all have little variation in speed despite being at varying stages of 4G development. This indicates a high degree of consistency in speed across the 4G networks in these countries regardless of the hour. The Czech Republic had the most consistent download experience of the 77 countries we analyzed. 4G Download Speed fell only 3.3 Mbps in the Czech Republic at the slowest time compared with an average speed of 33 Mbps experienced by smartphone users.

## Today's 4G networks are performing far from consistently

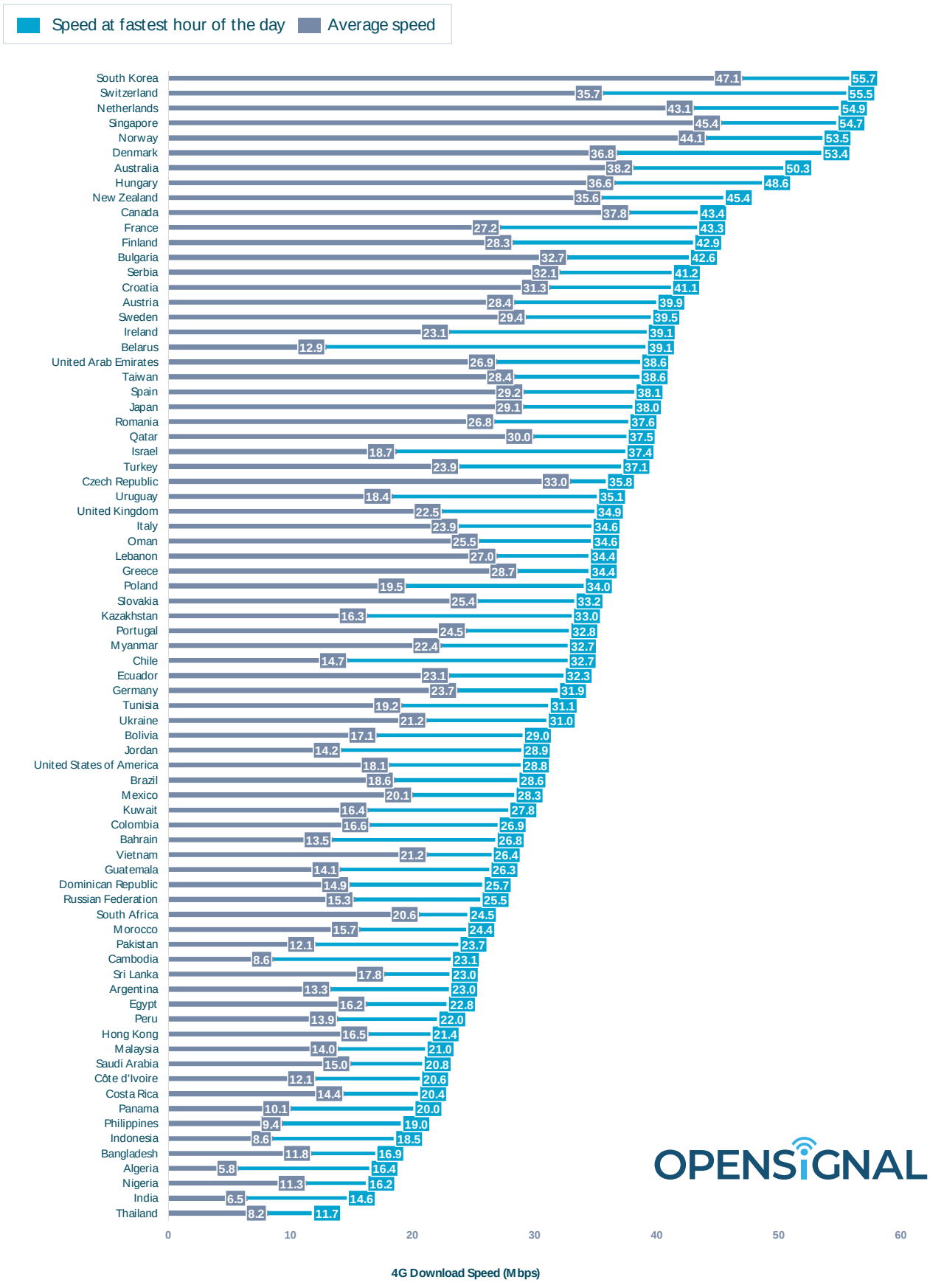
When we rank our 77 countries by off-peak speeds, we see yet another facet to the story. In Chart 4, the blue bars represent the 4G Download Speeds during the hour when speeds are fastest, when most users are offline, and there's likely the least data demand in each country.

This fastest speed during the quietest time of day indicates the true technical capabilities of a country's networks when unfettered by congestion. South Korea was at the top of that list, followed by several traditional 4G powerhouses: Switzerland, the Netherlands, Singapore, Norway, Denmark and Australia. But all seven of those countries have different average 4G Download Speeds across all hours of the day, as shown in the gray bars.

Some countries were better than others when it comes to delivering the full capacity of their networks to their customers on a consistent basis. We've already pointed out that Switzerland lags behind its peers on this front, but Denmark also demonstrates a huge gap between its best speed and average speed. In contrast, Canada does an excellent job delivering the full capabilities of its network from hour to hour. There was very little difference between Canada's most optimized connections and its average speed, putting it not only among the fastest countries in our analysis but also the most consistent.

# Countries' ranking by 4G Download Speed experienced at fastest hour

Chart 4



At the opposite end of the spectrum is India. India has low average 4G Download Speeds, but our analysis shows that its networks are a lot more powerful than their average speeds would indicate. India's optimized connection speed is more than twice as fast as its average connection speed. The mobile competitive landscape on the subcontinent is quite challenging at the moment. Competitive pricing pressure and cheap data bundling have caused 4G use and mobile data consumption to skyrocket, which is likely causing high levels of congestion on India's 4G networks and explains the big gap we see between peak-hour and average speeds.

Ecuador is the Latin American country with the fastest speed at its busiest time of day, though both Uruguay and Chile had faster top-line speeds than Ecuador when their networks were uncongested. When it comes to average speeds, though, Mexico (20.1 Mbps) and Brazil (18.6 Mbps) both came out ahead of Uruguay (18.4 Mbps) and Chile (14.7 Mbps), showing that even though their peaks are lower they're able to deliver a much more consistent speed experience throughout the day. In fact, Chile is the Latin American country with the greatest fluctuations in speed. 4G Download Speed at quiet hours in Chile (32.7 Mbps) is up to 3.6 times faster than at busy times (9.1 Mbps).

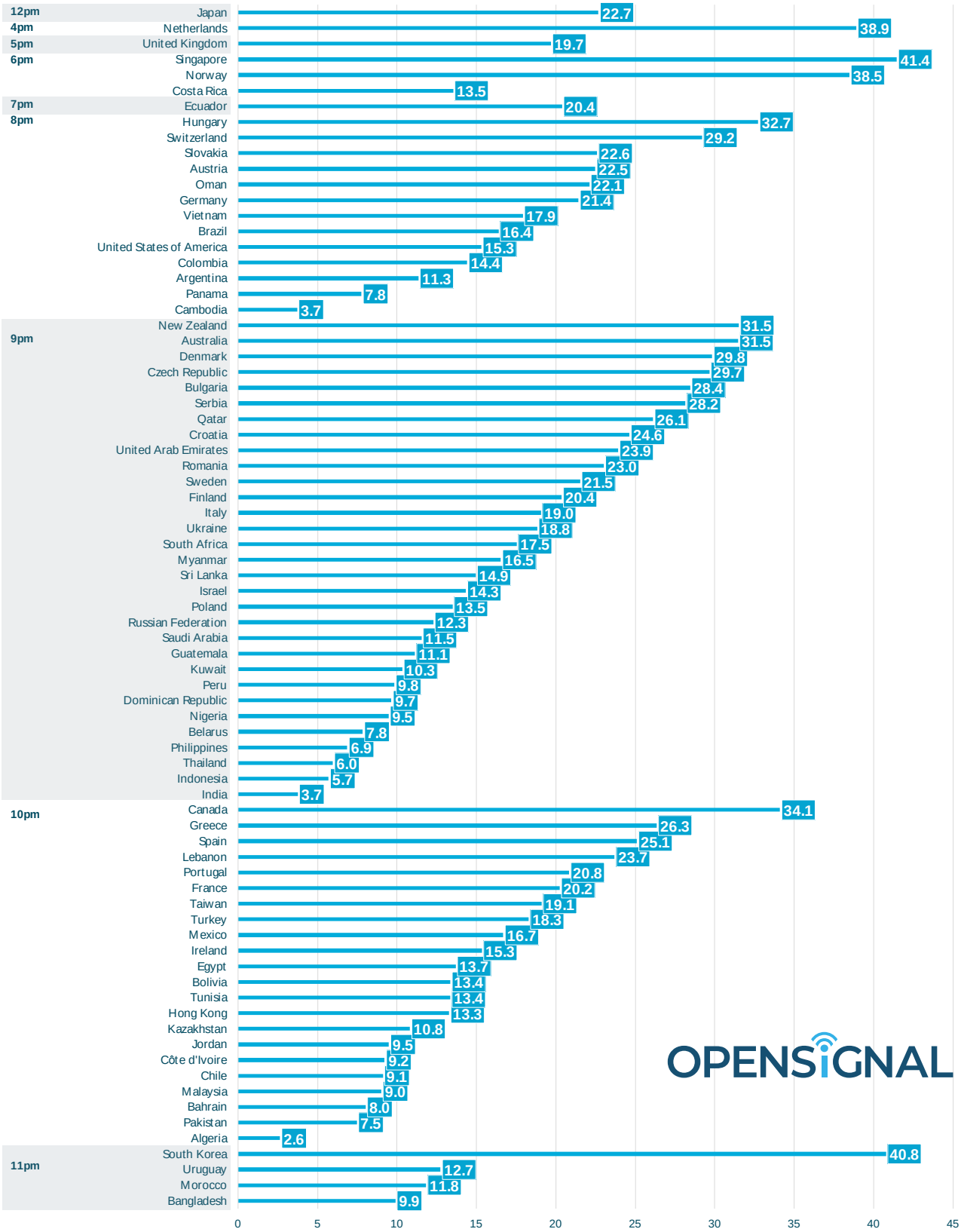
The U.S. will be an interesting bellwether of 5G's impact on congestion and speed consistency because it sits smack dab in the middle rank of countries for average 4G Download Speeds and in its range of speed variation by time of day. In the U.S. the distribution of 4G speeds throughout the day is neither particularly consistent nor particularly inconsistent, yet it will be one of the first countries to widely adopt 5G services. Any improvements we see in the U.S. mobile consumer experience due to 5G, we'll likely see reflected in many other parts of the world.

## Evening is slowest time of day most likely because of entertainment usage

We've discussed peak hours extensively, but these vary in different regions of the world, as we can see in Chart 5. For the vast majority of countries, the busiest hour — when demand is highest and speeds are slowest — falls in the evening between 8 p.m. and 11 p.m., after the business day concludes. In Japan, the networks get really hopping at midday, most likely as everyone starts watching mobile video at lunchtime.

# Time of day when 4G Download Speeds experienced are slowest

Chart 5



In the U.K. and the Netherlands, the most congested time comes far earlier, around 4 and 5 p.m., just as the business day is coming to a close. Smartphone owners are likely either still working, or using their phones while commuting, and most students have returned from school.

## Cities often experience the biggest speed swings of all

Comparing select cities around the world shows enormous variation in the speeds smartphone users experience. In Chart 6, Opensignal has analyzed how major cities stack up in both average 4G Download Speeds and the extent of variation in speed throughout the day.

It's clear that wild swings in speed are even more common at a city level than they are nationally. In Paris, our analysis showed that 4G Download Speed can climb as high as 51.4 Mbps one hour, but later in the day drop to 21.5 Mbps. While Paris offered up the most extreme example, all of the cities had big dips and spikes in their speeds over the course of a day.

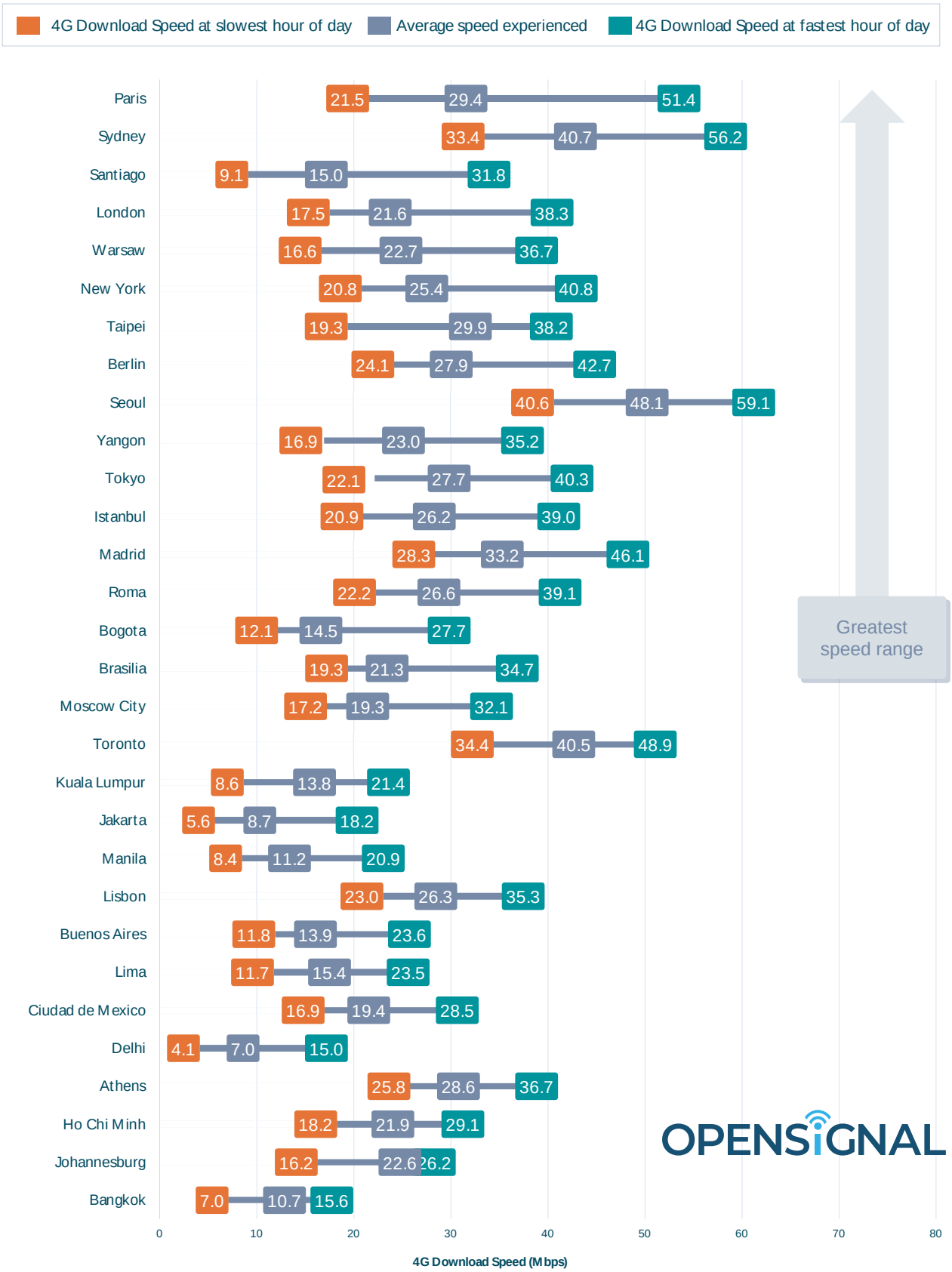
Cities often have the latest 4G technologies deployed and so should deliver the fastest speeds. And our measurements show they do, but only in the late hours night, when most users aren't seeking a fast mobile experience. During the day and evening, speeds drop dramatically, highlighting the failure of current 4G networks to deliver a consistent experience.

Many of the new 5G-only spectrum bands are ideally suited to cities — such as mmWave — because of their short range and extremely high capacities. In today's networks, typical bands held by an operator might be 5 MHz or 10 MHz wide in the lower frequencies or 20 MHz or 40 MHz wide on higher-frequency bands where most 4G networks operate today, but the new 5G bands will open up hundreds of megahertz of new extremely high frequency spectrum for mobile broadband use, delivering much greater capacity to minimize the effect of congestion.

Most operator 5G trials have been taking place in major cities because operators know this is where they need to add capacity the most. So analyzing where 4G speed variations are the greatest and networks are most congested, provides an excellent indicator of the locations where 5G should be deployed to provide the greatest benefit and an improved mobile network experience.

# Cities will benefit even more from new 5G capacity because users experience an even wider range of 4G speeds

Chart 6



# Our Methodology

## Opensignal measures the real-world experience of consumers on mobile networks as they go about their daily lives.

We collect over 3 billion individual measurements every day from tens of millions of smartphones worldwide. Our measurements are collected at all hours of the day, every day of the year, under conditions of normal usage, including inside buildings and outdoors, in cities and the countryside, and everywhere in between. By analyzing on-device measurements recorded in the places where subscribers actually live, work and travel, we report on mobile network service the way users truly experience it. We continually adapt our methodology to best represent the changing experience of consumers on mobile networks and, therefore, comparisons of the results to past reports should be considered indicative only.

For every metric we've calculated statistical confidence intervals and plotted them on all of the graphs. When confidence intervals overlap for a certain metric, our measured results are too close to declare a winner in a particular category. In those cases, we show a statistical draw. For this reason, some metrics have multiple operator winners.

## Confidence Intervals

For every metric we calculate statistical confidence intervals indicated on our graphs. When confidence intervals overlap, our measured results are too close to declare a winner. In those cases, we show a statistical draw. For this reason, some metrics have multiple operator winners.

In our bar graphs we represent confidence intervals as boundaries on either sides of graph bars. In our supporting-metric charts we show confidence intervals as +/- numerical values.

# Our Metrics

## 4G Availability

4G Availability shows the proportion of time Opensignal users with a 4G device have a 4G connection. 4G Availability is not a measure of coverage or the geographic extent of a network.

## Video Experience

Video Experience quantifies the quality of mobile video experienced by Opensignal users on real-world video streams.

To calculate Video Experience, we directly measure video streams from end-user devices, using an ITU-based approach to quantify factors such as load times, stalling and video resolution over both an operator's 3G and 4G networks. Video Experience for each operator is calculated on a scale from 0 to 100.

**4G Video Experience.** This metric quantifies the quality of mobile video for each operator on LTE connections as experienced by Opensignal users on real-world video streams.

**3G Video Experience.** This metric quantifies the quality of mobile video for each operator on 3G connections as experienced by Opensignal users on real-world video streams.

## Download Speed Experience

Download Speed Experience shows the average download speed experienced by Opensignal users across an operator's 3G and 4G networks.

It factors in 3G and 4G download speeds along with the the availability of each technology.

**4G Download Speed.** This metric shows the average download speed for each operator on LTE connections as measured by Opensignal users.

**3G Download Speed.** This metric shows the average download speed for each operator on 3G connections as measured by Opensignal users.

## Upload Speed Experience

Upload Speed Experience measures the average upload speeds experienced by Opensignal users across an operator's 3G and 4G networks.

It factors in 3G and 4G upload speeds along with the availability of each technology.

**4G Upload Speed.** This metric shows the average upload speed for each operator on LTE connections as measured by Opensignal users.

**3G Upload Speed.** This metric shows the average upload speed for each operator on 3G connections as measured by Opensignal users.

## Latency Experience

Measured in milliseconds, latency refers to the delay users experience as data makes a round trip through the network.

Our Latency Experience metric is calculated as an average of the individual 3G and 4G latency measurements based on the proportion of time Opensignal users spend connected to each network type. A lower score in this metric is a sign of a more responsive network.

**4G Latency.** This metric shows the average latency for each operator on LTE connections as measured by Opensignal users.

**3G Latency.** This metric shows the average latency for each operator on 3G connections as measured by Opensignal users.