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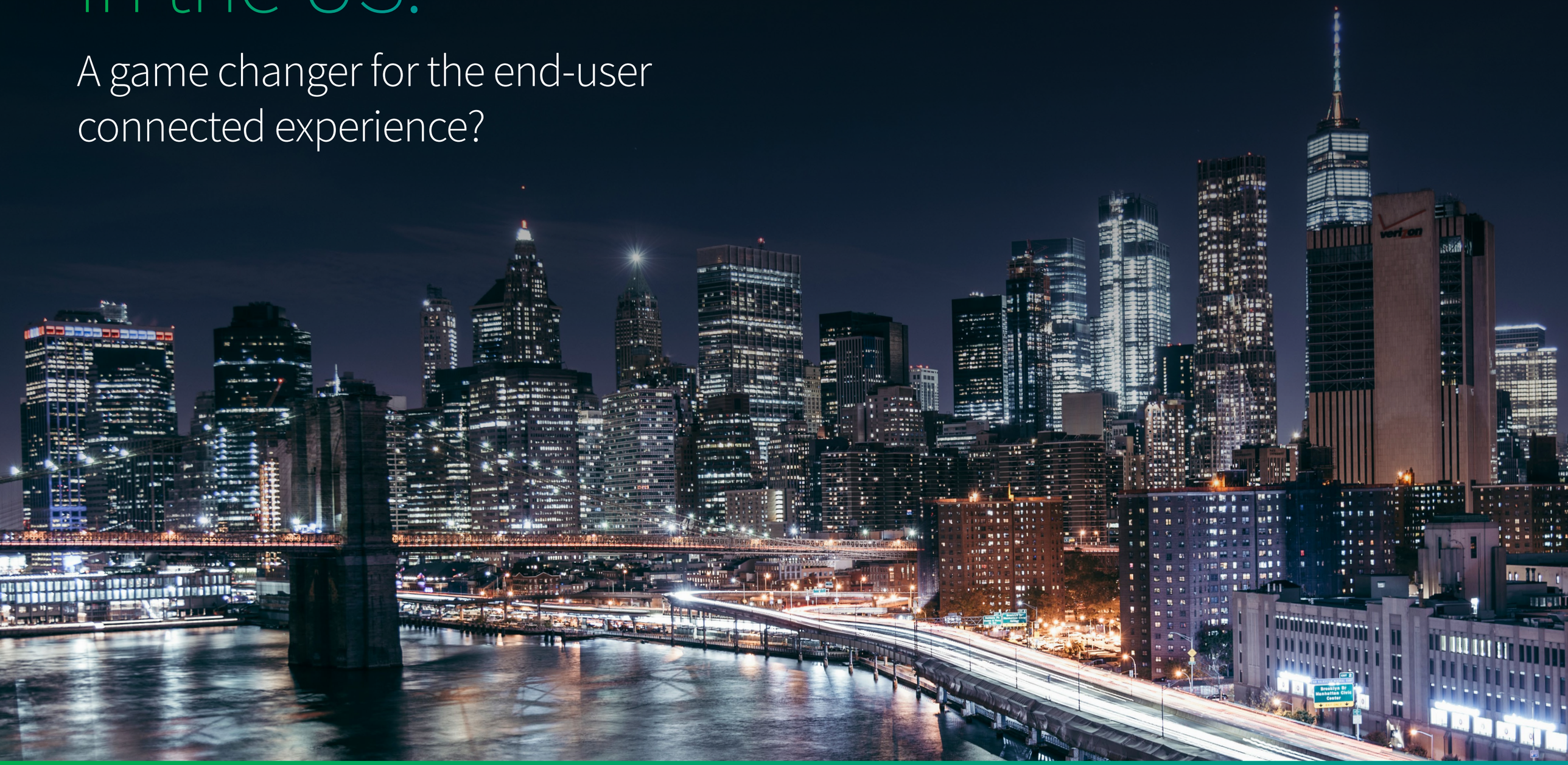
By IHS Markit

5G expansion in the US:

A game changer for the end-user connected experience?



5G is here and expanding. While 5G has the potential to fundamentally alter the connected experience for both enterprises and consumers alike, the transformative effects of 5G won't happen overnight. Instead, 5G will be implemented in a phased approach over the next few years, and that process has already begun for the carriers in various cities across the country.

We recently tested 5G in five major cities to see how the newly deployed low-band 5G networks of AT&T and T-Mobile compared to the mid-band 5G network of Sprint and Verizon's millimeter wave (mmWave) 5G. While 5G is still maturing in the US, our early testing showed that 5G is clearly capable of providing much faster speeds than current 4G LTE networks can support. This report shows what consumers can expect to find on different carriers' 5G networks and also highlights the unique traits of each network's 5G offering. Read on to see how the early 5G speed results we found during our testing across Chicago, Dallas, Indianapolis, Los Angeles, and Washington, D.C., can impact the end-user experience in the early stages of 5G deployments.

5G and spectrum

In a word, 5G can be complicated. There is no one-size-fits-all 5G solution and the end-user 5G experience can vary a great deal depending on what type of spectrum the carriers use for deployments. In the context of 5G, higher band spectrum above 6 GHz is considered millimeter wave (mmWave), while spectrum at 6 GHz or below can be separated into “low-band” or “mid-band” spectrum. It’s worth noting that low-and mid-band spectrum is also used for 4G LTE networks and isn’t intended solely for 5G.

There are two key considerations when it comes to spectrum:

- Speed performance
- Geographical coverage

Higher band spectrum such as mmWave can provide much faster speeds than its low- and mid-band counterparts, but mmWave signals can’t travel as far, cover large geographical areas, or penetrate solids or indoor locations as well as low- or mid-band spectrum.

With that general framework in mind, consider the three approaches that US carriers are currently adopting for 5G deployments. Understanding the different types of spectrum used by the carriers can give an indication of what consumers will actually experience on each network’s 5G.

Low-band spectrum 5G: AT&T and T-Mobile

Low-band spectrum: under 1 GHz: Low-band spectrum, which is also used for 4G LTE networks, can cover long distances and penetrate deep within buildings and other structures, but it doesn’t have the capability to provide high-end speeds as fast as those of mid-band or, especially, mmWave spectrum. For instance, the fastest 5G maximum download speed we recorded on the low-band 5G networks of AT&T and T-Mobile was AT&T’s 175.2 Mbps in Indianapolis, whereas Verizon’s mmWave 5G provided a blazing-fast 5G maximum download speed of 845.7 Mbps in Washington, D.C. That said, low-band spectrum can still offer fast speeds, and it can reach rural areas and other underserved communities well. It can also provide 5G internet for both cellular and home broadband where fiber installations are generally cost-prohibitive. With deeper penetration indoors, low-band spectrum can provide 5G in parking garages and other places where connectivity can be a challenge. Low-band spectrum will also help the growing IoT movement; 5G is expected to be the only technology that can support the myriad connected “things” across the vast IoT ecosystem, and the broad coverage and deep penetration capabilities of low-band spectrum should prove vital for the growth of the IoT.

Mid-band spectrum 5G: Sprint

Mid-band spectrum: 1 GHz – 6 GHz: Mid-band spectrum, which is also used for 4G LTE networks, is considered the sweet spot for 5G and has the potential to provide speeds faster than those of low-band spectrum, but not as fast as the high-end speeds of mmWave. For context, the fastest 5G maximum download speed we recorded on Sprint’s mid-band 5G was 249.9 Mbps in Chicago. While 249.9 is certainly impressive, it trailed the 5G maximum download speeds we recorded on Verizon’s mmWave 5G in multiple cities. In addition to allowing for strong speeds, mid-band spectrum provides additional capacity in areas with heavy congestion such as event venues, busy city centers, and other areas where finding strong mobile service can be a problem. Mid-band spectrum can provide stable, consistent connectivity and fast speeds (though not as fast as mmWave) in even heavily congested areas. Mid-band spectrum is typically reserved for government agencies, emergency services, the military, and other official entities, but Sprint was able to acquire its mid-band spectrum via auction.

High-band/mmWave spectrum 5G: Verizon

High-band/mmWave spectrum: 6 GHz+: In short, mmWave spectrum is fast. It offers the potential to deliver lightning-fast speeds theoretically as high as 5.0 Gbps or better and can provide broadband connectivity to busy office buildings and other densely populated areas of cities much more easily (and cost effectively) than wired broadband. Generally speaking, mmWave creates hot spots of 5G connectivity that can provide much faster speeds than low-or mid-band spectrum. Indeed, we recorded some incredibly fast 5G maximum download speeds on Verizon’s mmWave 5G, including a speed of 845.7 Mbps in Washington, D.C. While mmWave signals don’t travel more than about one city block and can be obstructed by architecture and other physical objects relatively easily, the upside is that mmWave can provide super fast speeds in areas of high congestion such as sections of busy city centers, stadiums, and concert venues. And in addition to offering blazing-fast connectivity, mmWave will ultimately be able to support the ultra-low latency (potentially below 1 millisecond) necessary for connected cars, remote real-time healthcare procedures, and other technologies that will reshape our world.

To learn more about spectrum, read our article Understanding spectrum.

Current spectrum usage in the US

The mobile performance landscape has always been fluid and constantly shifting, and 5G deployment strategies in the US have already shown signs of change.

While AT&T and T-Mobile initially launched 5G in the summer of 2019 with mmWave spectrum, both carriers have since shifted strategies and are now using low-band spectrum for their consumer-focused 5G deployments. AT&T still uses its mmWave spectrum holdings to provide 5G for some enterprise customers, and AT&T recently (early March 2020) began offering a consumer-focused mmWave 5G solution to coincide with the release of the Samsung Galaxy S20 5G, which supports both low-band and mmWave 5G.

Currently, AT&T and T-Mobile utilize low-band spectrum for 5G, Sprint uses mid-band spectrum 5G, while Verizon uses mmWave spectrum to provide 5G in targeted areas within select cities that require greater capacity. We're looking forward to testing AT&T's new mmWave 5G later in 2020.

It's also worth noting that while the US carriers have spectrum holdings across a variety of bandwidths, those spectrum allocations are not all necessarily active. The following table shows what spectrum is actively deployed for the four major US carriers for both 4G LTE and 5G.

Carrier	Low-band	Mid-Band	High-band/mmWave
AT&T	**5G 850 MHz 4G 700 MHz**	**4G 1.9 GHz, 2.1 GHz, 2.3 GHz**	**5G 39 GHz**
Sprint	**4G 800 MHz**	**5G 2.5 GHz 4.G 1.9 GHz, 2.5 GHz**	
T-Mobile	**5G 600 MHz 4G 700 MHz**	**4.G 1.9 GHz, 2.1 GHz**	**5G 28 GHz**
Verizon	**4G 700 MHz, 850 MHz**	**4.G 1.9 GHz, 2.1 GHz**	**5G 28 GHz, 39 GHz**

A note about latency results

The promises of 5G include much faster speeds and lower latency, and our testing looks at latency from multiple angles: download latency testing represents the most typical use case of downloading a file, while our web and app latency testing characterizes use cases that require continuous data usage such as with gaming, video, AR/VR.

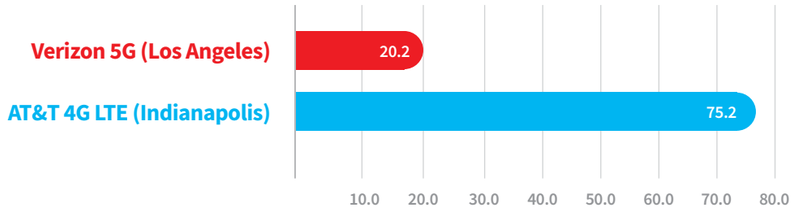
While our testing showed much faster speeds for some carriers on 5G, our latency results did not show a meaningful pattern of improvement on 5G compared to 4G LTE. That said, we expect to see latency improvements over time as the carriers continue to enhance their networks by utilizing more edge computing. As the carriers move applications closer to end users, they will be able to provide faster services than ever before, which could make things like zero-lag gaming and buffer-free video streaming standard elements of the everyday connected experience. We will continue to keep a close eye on latency as 5G becomes more ubiquitous across the country (and the world).

5G in the real world: downloading a video could be much faster with 5G

Consumers looking for fast, buffer-free streaming or ultra-fast video downloads should be pleased to learn that 5G can fundamentally improve their mobile experience, even in the early stages of 5G rollouts.

For instance, at the fastest 5G median download speed we recorded across all five cities tested (Verizon's 247.0 Mbps in Los Angeles), downloading a 600MB movie from Netflix would take a little over 20 seconds. In contrast, downloading the same video at the fastest 4G LTE median download speed recorded across those same five cities (AT&T's 64.5 Mbps in Indianapolis) would take about 75 seconds.

Time required to download 600MB video (seconds)



Benchmarking what matters most

To provide a holistic view of each network's real-world 5G performance, we've included visuals showing 5G availability and speed results along with key insights for the end-user 5G experience. We've also included examples showing how long it would take to download a 600MB video from Netflix at various median download speeds on both 5G and 4G LTE. Finally, we've also taken a look at how consistently the carriers deliver download speeds across all network technologies to show the speeds end users are likely to experience on each carrier's network. Taken together, this complementary information provides a full picture of the current end-user experience on 5G.

5G median and maximum download speeds

End-users won't always access a 5G network as they move through a city, so we've removed all non-5G (4G LTE) test results to show what to expect when 5G is available. 5G maximum download speeds show what topline performance might be, while 5G median download speeds offer a closer look at "everyday" 5G performance.

4G LTE median and maximum download speeds

Since end-users won't access 5G all the time, we looked at speed results on 4G LTE to offer a comparison between purely 5G speeds and those occurring on 4G LTE. Median download speeds on 4G LTE represent typical performance, and 4G LTE maximum download speeds show what high-end 4G LTE performance looks like. Taken together, these 4G LTE median and maximum speeds help show just how different (or not) 5G performance is compared to a non-5G experience across the various spectrum bands the carriers are using.

Speed consistency across all network technologies

At the end of the day, consistency of speed performance has the most impact on the end-user experience. Our speed intervals bring together test results across all network technologies to show how often different speed thresholds were reached or surpassed.

5G results by carrier in five major cities:

Chicago, Dallas, Indianapolis, Los Angeles, and Washington, D.C.

Our recent 5G testing revealed somewhat of a mixed bag in terms of speed results across the five cities we tested. Verizon's impressive mmWave 5G speeds, for example, could profoundly change the end-user experience in some cities. On the other hand, T-Mobile's low-band spectrum 5G speeds were much slower, which wasn't necessarily a surprise given the different characteristics of each carrier's spectrum. That said, it's important to remember that new technologies always take time to expand and mature, and we should see both faster 5G speeds and greater 5G availability over time for all four carriers. All testing was performed in late 2019.

Top-end 5G results for each carrier

While 5G is clearly capable of offering much faster speeds than those of 4G LTE, it's important to remember that we are still in the early days of 5G deployments, and it will take time for 5G to reach its full potential. That said, we have seen encouraging 5G results from all four carriers. The following table offers a quick look at each carrier's top 5G results across the five cities we tested. Sprint and Verizon delivered especially fast 5G median download speeds, while the maximum download speeds of AT&T, Sprint, and Verizon were impressive and suggest faster speeds could be in store moving forward. T-Mobile, meanwhile, offered 5G on a relatively broad scale in most of the cities we tested. For more detailed results and insights, see the city-by-city breakdown of 5G performance below.

Carrier	Highest 5G availability rate (%)		Fastest 5G median download speed (Mbps)		Fastest 5G maximum download speed (Mbps)	
AT&T	9.5%	Indianapolis	47.1	Indianapolis	175.2	Indianapolis
Sprint	45.7%	Dallas	136.7	Chicago	249.9	Chicago
T-Mobile	57.1%	Washington, D.C.	34.0	Chicago	147.8	Chicago
Verizon	3.1%	Chicago	247.0	Los Angeles	845.7	Washington, D.C.

Prioritizing download speeds
Our testing in US indicates that initial 5G deployments are primarily focused on increasing download speeds, rather than improving upload speeds or data reliability. We observed a similar prioritization of improving download speeds during testing in the United Kingdom, South Korea, and Switzerland as well.

Carrier-by-carrier key takeaways

We've provided a city-by-city breakdown of 5G performance below, but at a high level, our testing showed:

AT&T

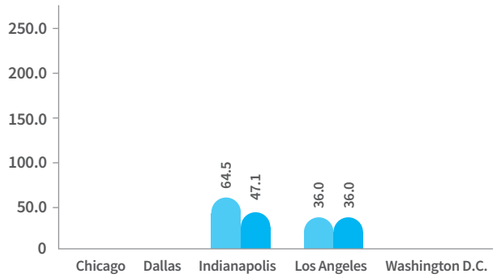
AT&T's 5G speeds have room to improve, but its 4G LTE offers strong service: AT&T's low-band 5G median and maximum download speeds were similar to or slower than its 4G LTE speeds in both Indianapolis and Los Angeles. However, given AT&T's spectrum resources and strong 4G LTE network, end users should still experience good performance and relatively fast speeds even when 5G isn't available. AT&T also launched a consumer-focused mmWave 5G solution in early March of 2020, so we'll be interested to see how it performs.

AT&T low-band 5G

4G LTE 5G

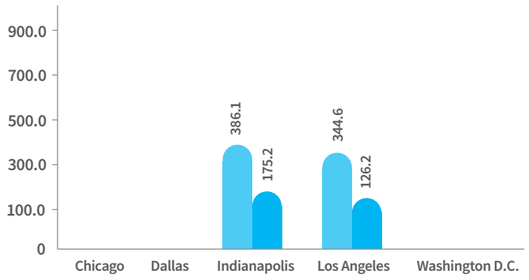
4G LTE & 5G median download speeds (Mbps)

Scale: 0–250 Mbps

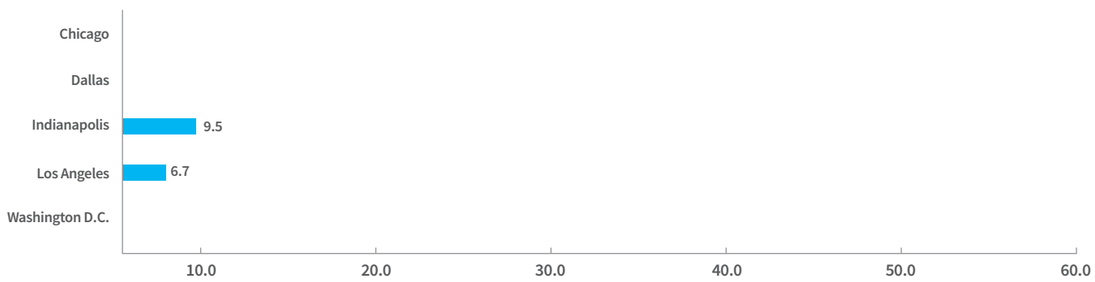


4G LTE & 5G maximum download speeds (Mbps)

Scale: 0–900 Mbps



5G availability(%)



*Because AT&T hadn't launched 5G in Chicago, Dallas, or Washington, D.C., we did not test its network at all in those cities (including 4G LTE performance) for this special report.

Sprint

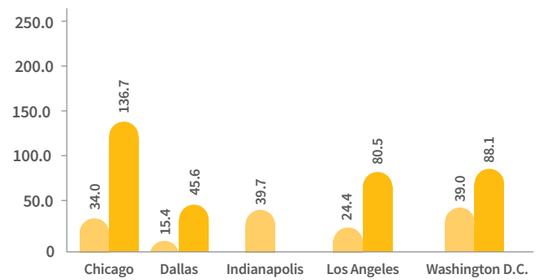
Sprint's 5G provides fast speeds and strong results: Sprint's 5G speeds were generally strong and much faster than its 4G LTE speeds in each city we tested. Sprint's 5G median download speeds were also faster than those of T-Mobile in each city, and Sprint's 5G speeds were similar to or faster than those of AT&T. Based on spectrum characteristics, Sprint's mid-band spectrum 5G could continue to provide faster speeds than the low-band spectrum 5G networks of AT&T and T-Mobile, but Sprint's speeds will likely trail the top speeds of Verizon's mmWave 5G.

Sprint mid-band 5G

4G LTE 5G

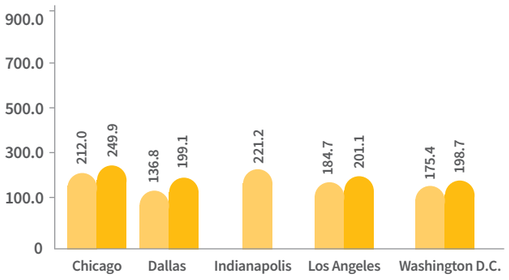
4G LTE & 5G median download speeds (Mbps)

Scale: 0–250 Mbps

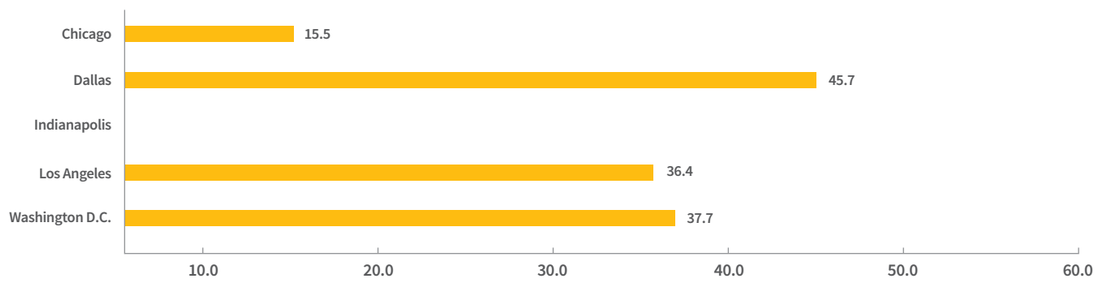


4G LTE & 5G maximum download speeds (Mbps)

Scale: 0–900 Mbps



5G availability(%)

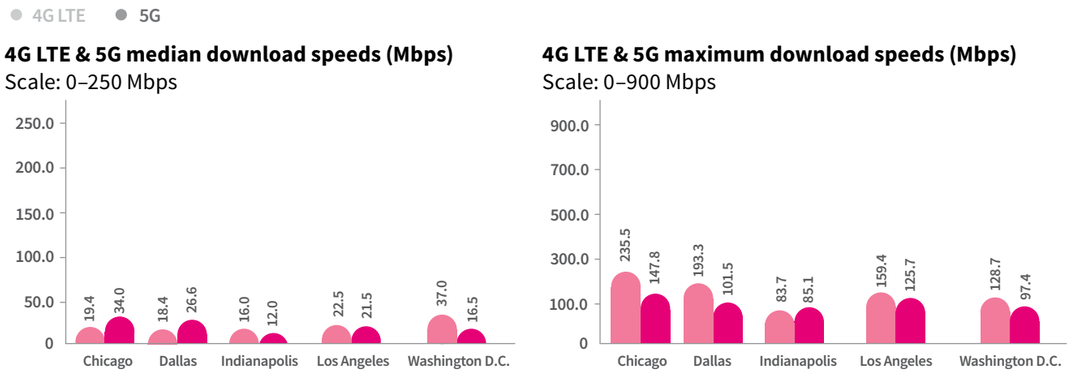


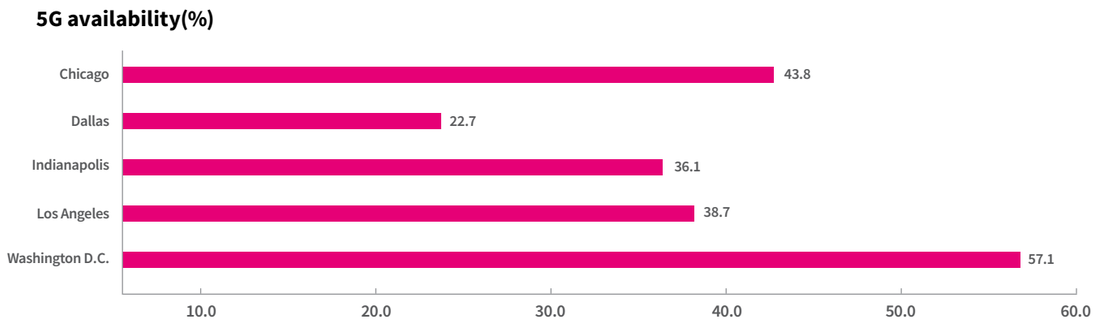
*Sprint hadn't launched 5G in Indianapolis at the time of our testing.

T-Mobile

T-Mobile offers wide 5G availability: The good news is that T-Mobile offered more 5G than any other carrier in four of the five cities we tested, and the carrier's 5G coverage was generally widespread in all five cities. On the other hand, T-Mobile's 5G median download speeds didn't exceed 34.0 Mbps in our testing, and in Indianapolis and Washington, D.C., T-Mobile's early 5G speeds were slower than its 4G LTE speeds. In short, our results suggest that, currently, T-Mobile's low-band 5G isn't performing much differently from its 4G LTE network. It's important to keep in mind, however, that the carrier's 5G network is still in its early stages (having launched in December of 2019), and we expect to see faster speeds in the future.

T-Mobile low-band 5G

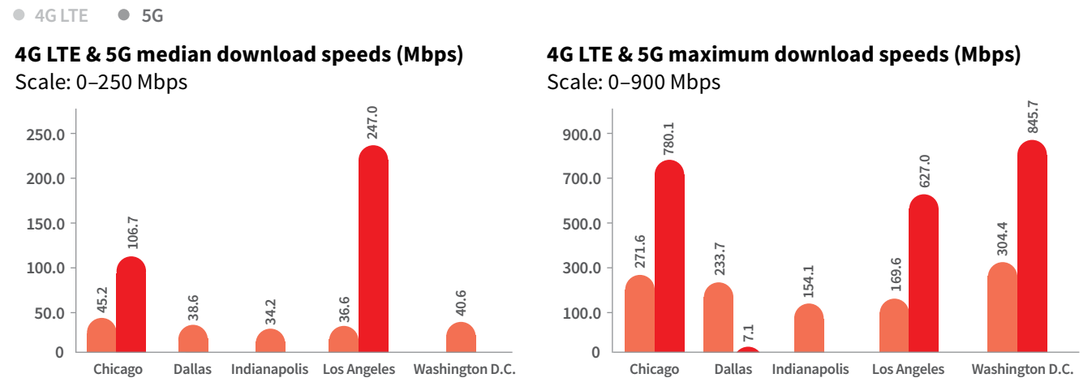


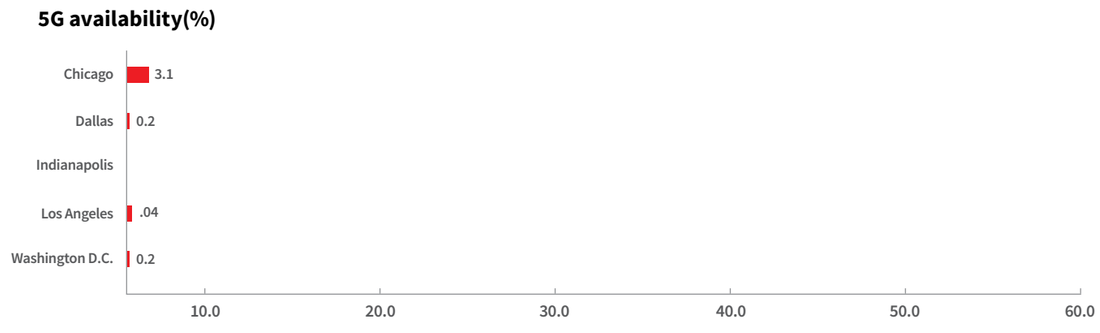


Verizon

Verizon's mmWave 5G was FAST and its 4G LTE continues to impress: Verizon's 5G median download speeds were incredibly fast, and its maximum download speeds were remarkable in Chicago, Los Angeles, and Washington, D.C. Verizon did show lower 5G availability than the other carriers, but that wasn't a surprise given the propagation characteristics of mmWave spectrum as well as Verizon's targeted approach to its 5G deployments. It's important to note, however, that Verizon's smaller mmWave coverage areas don't mean that Verizon customers have to miss out on top-notch performance. Indeed, Verizon's 4G LTE speeds were faster than the low-band 5G median download speeds of T-Mobile in each of the five cities we visited, and Verizon's 4G LTE median download speed in Los Angeles was nearly identical to AT&T's 5G median download speed in the same city.

Verizon mmWave 5G

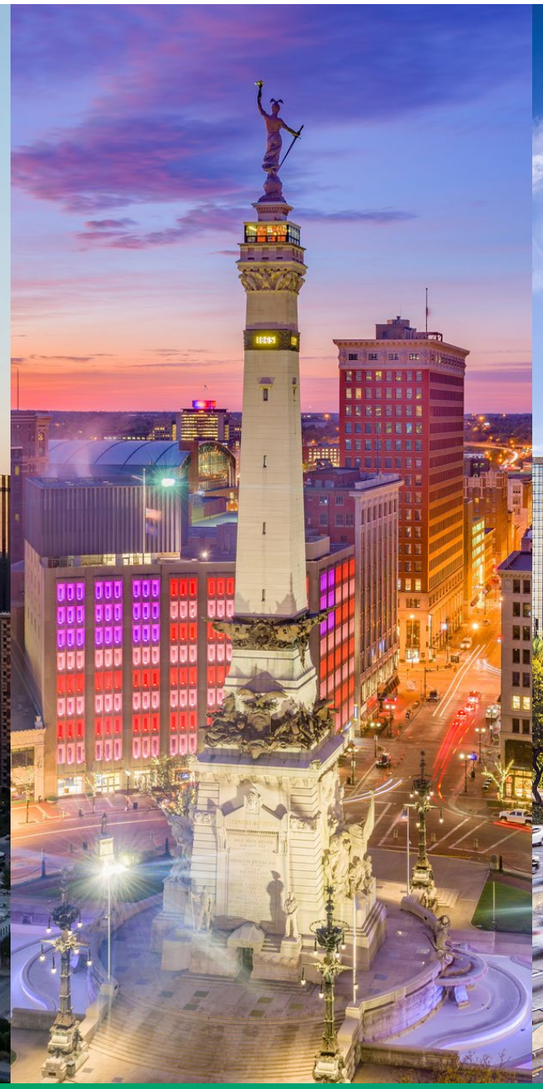
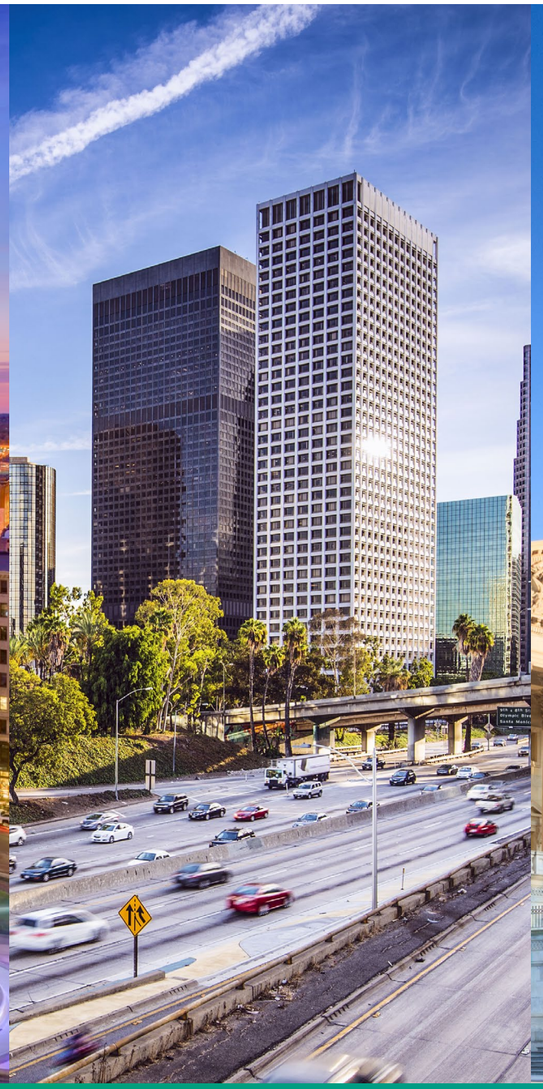




*Verizon hadn't launched 5G in Indianapolis at the time of our testing.
*Verizon's results in Los Angeles were based on a small sample size (7).
*Verizon's 5G sample sizes of 1 in Dallas and 4 in Washington, D.C., were too low to accurately characterize its median download speeds in either city.

5G results by city:

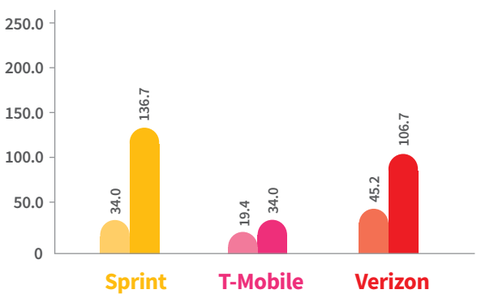
A look at 5G performance in the real world

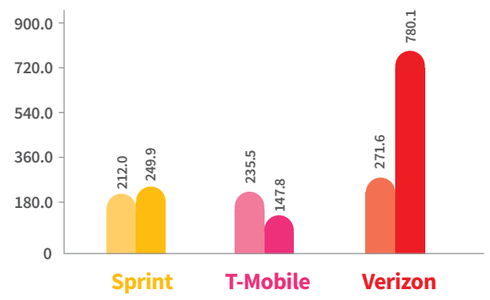

Chicago

Sprint and Verizon deliver impressive speeds, while T-Mobile offers the most 5G.

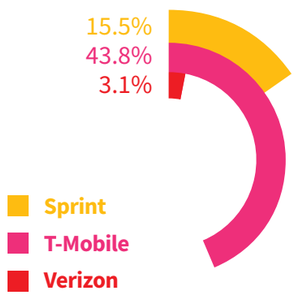
4G LTE & 5G median download speeds (Mbps)
Scale: 0–250 Mbps



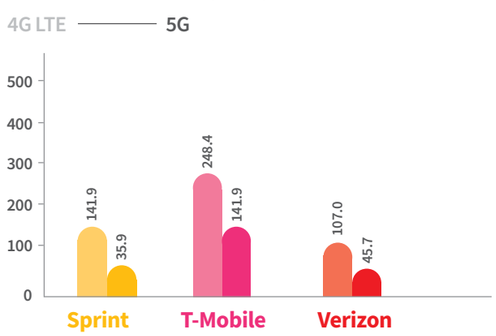
4G LTE & 5G maximum download speeds (Mbps)
Scale: 0–900 Mbps



5G availability (%)



Time to download a 600MB video on 4G LTE & 5G (sec)



*AT&T hadn't launched its low-band spectrum 5G in Chicago at the time of our testing.
*Times required to download a 600MB video are based on the 4G LTE and 5G median download speeds shown above.

Sprint and Verizon particularly fast in Chicago: Good news for Sprint and Verizon customers in Chicago. Sprint's mid-band spectrum 5G network delivered a blazing-fast 5G median download speed of 136.7 Mbps in the Windy City, and Verizon was on Sprint's heels with a 5G median download speed of 106.7 Mbps. T-Mobile's 5G, meanwhile, wasn't as fast as either Sprint or Verizon, but we do expect T-Mobile's 5G to provide faster speeds going forward.

T-Mobile offers the most 5G in Chicago: T-Mobile's low-band spectrum 5G was relatively widespread in Chicago, with 43.8% of our tests recorded on T-Mobile's 600 MHz 5G. However, T-Mobile's 5G speeds in Chicago weren't nearly as fast as those of Sprint or Verizon.

Verizon's mmWave 5G provides ultra-fast 5G maximum download speed: With maximum download speeds offering a look at a network's potential, Verizon customers should be pleased with the carrier's mmWave 5G. Verizon's 5G maximum download speed of 780.1 Mbps ranked among the three fastest 5G maximum download speed we've recorded in the US to date. In fact, Verizon also delivered the other two fastest 5G maximum download speeds we've found in the US, at 1.1 Gbps in Chicago in the Summer of 2019 and 845.7 Mbps during recent testing in Washington, D.C.

Speed consistency

The consistency of each carrier's speeds has the most impact on the end-user experience and reflects the true consumer experience regardless of network technology. In Chicago, Sprint and Verizon showed impressive speed consistency results, with both carriers clocking speeds of at least 50 Mbps (and 100 Mbps) far more often than T-Mobile. However, T-Mobile delivered topline speeds of 100 Mbps or faster during 3.4% of our tests (and speeds of at least 50 Mbps over 18% of the time), indicating that T-Mobile's 5G subscribers could at times experience very fast speeds. That said, T-Mobile also registered speeds between 0 – 20 Mbps a little over 46% of the time, easily the highest rate among all three carriers in the Windy City.

Looking at the lower end of our speed intervals also helps show the consistency with which Sprint and Verizon delivered fast speeds. Verizon, for instance, registered speeds below 10 Mbps just 7.4% of the time. And while Sprint delivered high-end speeds of least 100 Mbps nearly twice as often as Verizon, Sprint also registered speeds in the 0-10 Mbps and 10-20 Mbps ranges at higher rates than that of Verizon. In short, while both Sprint and Verizon were fast in Chicago, Verizon's consistency of delivering fast speeds was unmatched.

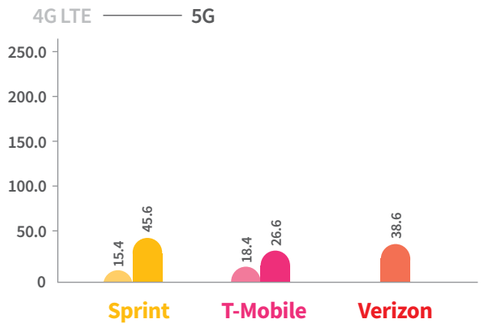
Carrier	0-10 Mbps	10-20 Mbps	20-50 Mbps	50-100 Mbps	100+ Mbps
Sprint	17.3%	13.1%	29.9%	23.2%	16.4%
T-Mobile	20.3%	26.1%	35.4%	14.7%	3.4%
Verizon	7.4%	10.2%	35.7%	37.0%	9.7%

*Speed consistency results reflect speeds across all network technologies (4G LTE and 5G).

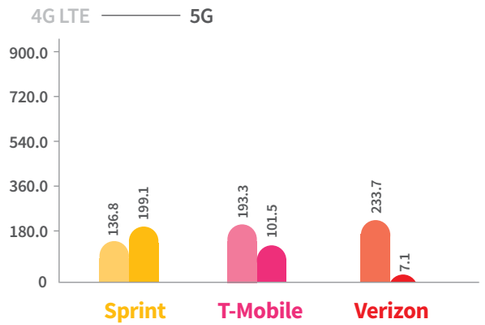
Dallas

Sprint delivers strong results with the most 5G.

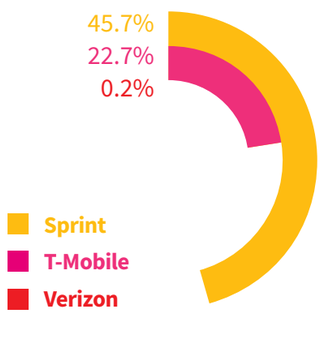
4G LTE & 5G median download speeds (Mbps)
Scale: 0–250 Mbps



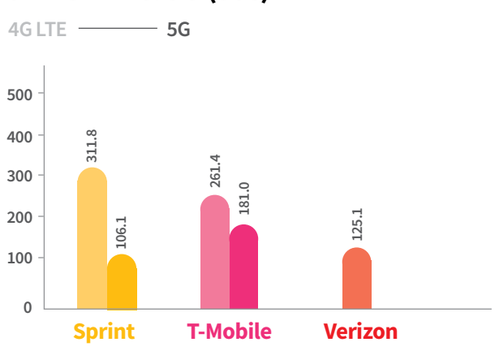
4G LTE & 5G maximum download speeds (Mbps)
Scale: 0–900 Mbps



5G availability (%)



Time to download a 600MB video on 4G LTE & 5G (sec)



*AT&T hadn't launched 5G in Dallas at the time of our testing.
*Verizon's 5G sample size of 1 in Dallas was too low to accurately characterize its 5G median download speed.
*Times required to download a 600MB video are based on the 4G LTE and 5G median download speeds shown above.

Sprint performs well in Dallas: Good news for Sprint users in Dallas. The carrier not only offered the highest 5G availability rate among all carriers, Sprint's 5G median download speed was much faster than that of T-Mobile. And while Sprint's 5G median download speed in Dallas wasn't nearly as fast as its speed in Chicago, Sprint performed quite well in general.

T-Mobile's 5G coverage relatively strong but has room to expand: Even though T-Mobile's 5G availability of 22.7% in Dallas was the lowest for the carrier across all five cities, it was still relatively widespread, especially given the early stage of the carrier's 5G deployment.

Sprint and T-Mobile offer mixed speed results: While we weren't able to collect enough test samples to accurately characterize Verizon's 5G median download speed in Dallas, the 5G speeds of Sprint and T-Mobile were somewhat uninspiring. The good news for Sprint users, however, is that Sprint's 5G median download speed was the fastest in Dallas and almost three times faster than its 4G LTE speed. While T-Mobile's 5G median download speed of 26.6 Mbps was slower than that of Sprint, it was quite a bit faster than T-Mobile's 4G LTE median download speed of 18.4 Mbps.

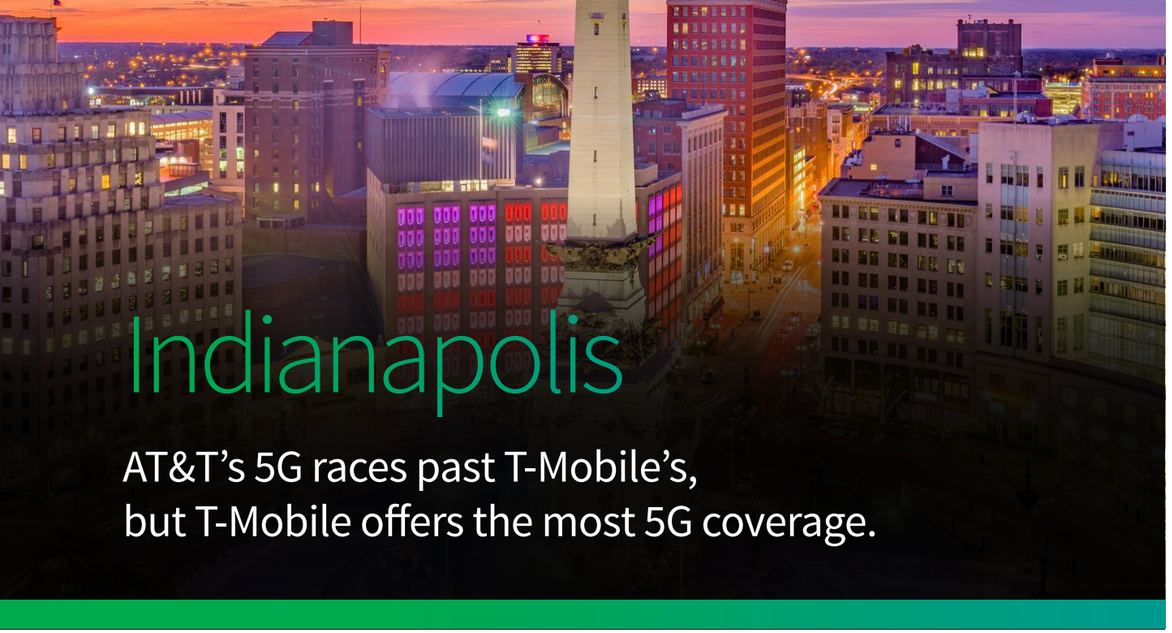
Speed consistency

At the end of the day, no matter what network technologies the carriers are using (or advertising), the most important part of the end-user experience revolves around the speeds that users actually experience. In that regard, Verizon shined in Dallas, even though the carrier's 5G availability was the lowest among all carriers and we didn't collect enough 5G samples to accurately characterize Verizon's 5G median download speed. The bottom line, however, is that Verizon was consistently fast, registering download speeds of at least 100 Mbps during 13.7% of our tests and speeds over 50 Mbps roughly 40% of the time. Neither Sprint nor T-Mobile came close to delivering fast speeds as often as Verizon.

The lower end of the speed intervals also showed Verizon's advantage when it comes to its consistency of strong speed results. Sprint, for example, registered speeds below 20 Mbps during about 48% of our tests, while T-Mobile did so around 54% of the time. Verizon, on the other hand, delivered speeds below 20 Mbps during roughly 32% of our tests, by far the lowest rate among all three carriers. In short, Verizon had the strongest speed results no matter how you look at the data: Verizon provided fast speeds (50 Mbps or faster) far more often than Sprint or T-Mobile, while also recording slower speeds (20 Mbps or below) far less often than the other carriers.

Carrier	0-10 Mbps	10-20 Mbps	20-50 Mbps	50-100 Mbps	100+ Mbps
Sprint	32.8%	15.0%	24.7%	18.8%	8.7%
T-Mobile	32.6%	21.5%	28.3%	14.8%	2.8%
Verizon	17.3%	14.5%	27.5%	27.0%	13.7%

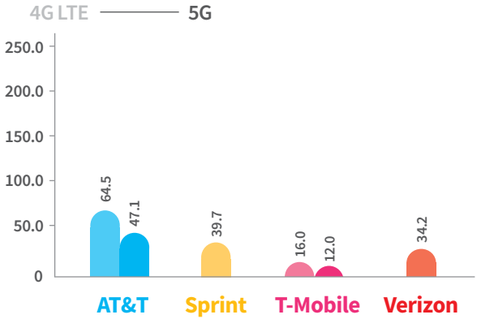
*Speed consistency results reflect speeds across all network technologies (4G LTE and 5G).



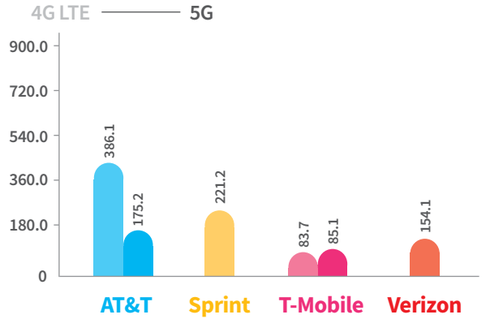
Indianapolis

AT&T's 5G races past T-Mobile's, but T-Mobile offers the most 5G coverage.

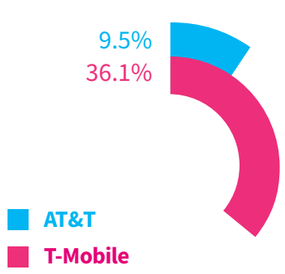
4G LTE & 5G median download speeds (Mbps)
Scale: 0–250 Mbps



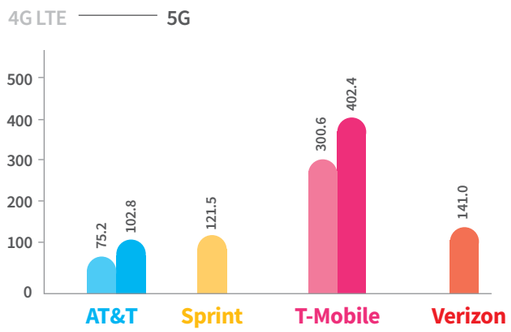
4G LTE & 5G maximum download speeds (Mbps)
Scale: 0–900 Mbps



5G availability (%)



Time to download a 600MB video on 4G LTE & 5G (sec)



*Neither Sprint nor Verizon offered 5G in Indianapolis at the time of our testing.
*Times required to download a 600MB video are based on the 4G LTE and 5G median download speeds shown above.

AT&T's 5G availability not as widespread as that of T-Mobile: In general, AT&T's low-band 5G wasn't as widespread as what we've seen from Sprint or T-Mobile in the two cities in which we tested AT&T's 5G—not yet, anyway. In fact, AT&T's relatively low 5G availability of 9.5% in Indianapolis was the highest rate we've recorded for AT&T across the two cities in which it offered 5G. However, we expect to see broader 5G coverage from AT&T going forward.

AT&T's 5G was solid but its 4G LTE was even faster: While AT&T's 5G median download speed of 47.1 Mbps wasn't as fast as some of the 5G speeds recorded across the five cities we visited, that speed was still nearly four times faster than T-Mobile's 5G speed in Indianapolis and remained fast enough to handle most typical end-user behaviors. AT&T also continued its trend of delivering fast 4G LTE speeds in major cities, clocking an impressive 4G LTE speed of 64.5 Mbps. With AT&T's 5G median download speed approaching 50 Mbps, the end-user experience on AT&T's' 5G should be a smooth one, and the good news is that even when 5G isn't available, AT&T's 4G LTE network offers strong performance.

T-Mobile's 5G speed lags behind the 4G LTE speeds of other carriers: T-Mobile's 5G median download speed of 12.0 Mbps was the carrier's slowest 5G speed across all five cities tested, and it was also slower than the 4G LTE speeds of the other carriers. In fact, T-Mobile's 4G LTE speed was faster than its 5G speed. That said, T-Mobile's 5G should get faster as the network matures and expands; in early December, we projected that T-Mobile has the potential to deliver a 5G median download speed of 87.3 Mbps in Indianapolis.

Speed consistency

AT&T's consistency of delivering fast speeds in Indianapolis was particularly impressive. While AT&T's 5G median download speed in Indianapolis was 47.1 Mbps, the carrier's speed results across all network technologies (4G LTE and 5G) showed that AT&T delivered speeds of at least 100 Mbps nearly 30% of the time, with speeds of 50 Mbps or better recorded during roughly 57% of our tests. Those results suggest that AT&T's 5G subscribers could experience game-changing speeds (100 Mbps+) in Indianapolis while also enjoying fast speeds when 5G isn't available. AT&T also impressed at the lower end of the spectrum, registering speeds between 0-10 Mbps and 10-20 Mbps during less than 18% of our tests, easily the lowest rate among all carriers.

Sprint and Verizon also showed strong results, especially since neither carrier offered 5G at the time of our testing. Sprint, for example, delivered download speeds of at least 50 Mbps during nearly 40% of our tests, with speeds over 100 Mbps recorded 12.1% of the time. Verizon, meanwhile, delivered download speeds between 50 - 100 Mbps 25.3% of the time and speeds of at least 100 Mbps during 6.7% of our tests. In contrast, T-Mobile was much slower, recording download speeds below 10 Mbps during nearly 50% of our tests without clocking any speeds of 100 Mbps or better.

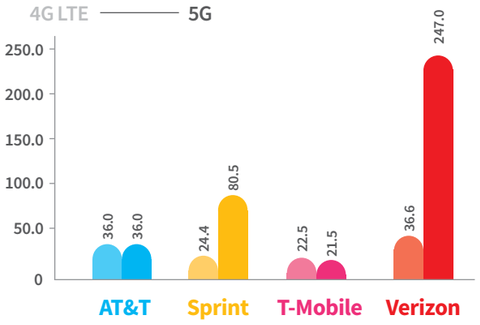
Carrier	0-10 Mbps	10-20 Mbps	20-50 Mbps	50-100 Mbps	100+ Mbps
AT&T	7.3%	10.3%	25.6%	28.0%	28.8%
Sprint	17.4%	12.7%	30.5%	27.3%	12.1%
T-Mobile	49.6%	25.7%	20.2%	4.5%	0.0%
Verizon	17.3%	15.3%	35.4%	25.3%	6.7%

*Speed consistency results reflect speeds across all network technologies (4G LTE and 5G).

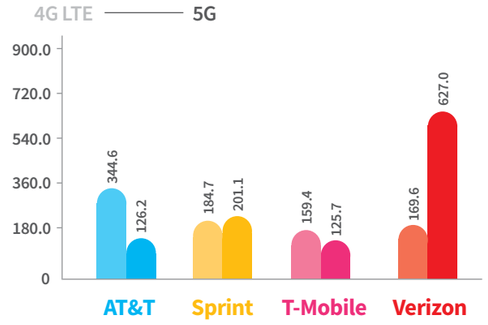
Los Angeles

Sprint and Verizon shine in LA.

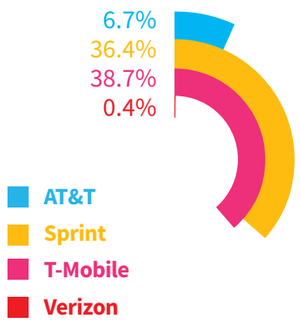
4G LTE & 5G median download speeds (Mbps)
Scale: 0–250 Mbps



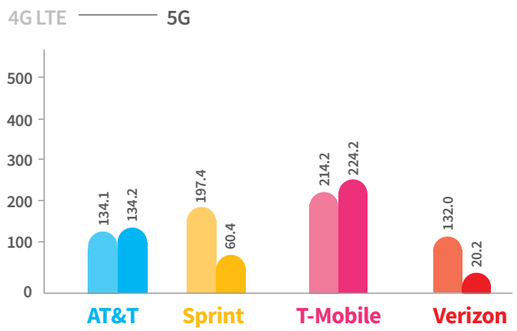
4G LTE & 5G maximum download speeds (Mbps)
Scale: 0–900 Mbps



5G availability (%)



Time to download a 600MB video on 4G LTE & 5G (sec)



*Verizon's 5G median download speed in Los Angeles was based on a small sample (7).
*Times required to download a 600MB video are based on the 4G LTE and 5G median download speeds shown above.

5G availability mixed in LA: While Sprint and T-Mobile offered 5G on a relatively broad scale in Los Angeles, the 5G availability rates of AT&T and Verizon were quite low. It's worth noting, however, that AT&T's 5G speeds were much faster than those of T-Mobile, and Verizon's low 5G availability in LA shouldn't come as a surprise given the characteristic of Verizon's mmWave spectrum and the carrier's targeted approach to 5G deployments. According to Verizon's website at the time of this writing, Verizon has launched its mmWave 5G in Downtown LA, Chinatown, Venice Beach, the Staples Center, and other congested areas of the city.

Sprint registers more strong results: Sprint's mid-band spectrum 5G network provided strong results in multiple cities during our testing, and that was certainly the case in Los Angeles as well. Though not as fast as Verizon's mmWave speeds, Sprint's 5G median download speed of 80.5 Mbps in LA was impressive and should provide Sprint customers with buffer-free online gaming, seamless video streaming, and quick file downloads.

Verizon delivers incredibly fast speeds: Verizon's sterling 5G median download speed of 247.0 Mbps was not only the fastest 5G median download speed we've recorded in the US to date, it was also faster than the 5G maximum download speeds of all other carriers in LA (and even in some of the other cities tested for this report). At 247.0 Mbps, Verizon's 5G customers can expect ultra-fast file downloads, seamless online gaming, and near-perfect music and video streaming. Verizon's 5G maximum download speed of 627.0 Mbps was likewise outstanding and hints at a strong future for Verizon's 5G. Keep in mind, however, that Verizon's 5G availability of 0.4% in LA indicates that Verizon customers will experience its blazing-fast speeds in only certain areas of the city. But even when Verizon's 5G isn't available, end users should still experience fast speeds on the carrier's 4G LTE network.

Speed consistency

AT&T's and Sprint's speed consistency results were particularly strong in Los Angeles, with both carriers registering download speeds of 100 Mbps or faster during at least 15.1% of our tests, with speeds of at least 50 Mbps recorded over 36% of the time. Verizon, meanwhile, delivered an incredibly fast 5G median download speed of 247.0 Mbps, and while the carrier's targeted 5G strategy focuses its 5G to certain areas of LA, Verizon continued to deliver strong speeds on its 4G LTE network, with the majority of Verizon's download speeds falling in the 20-50 Mbps and 50-100 Mbps ranges.

At the other end of the spectrum, T-Mobile customers could experience slower speeds than those of the other carriers, with T-Mobile registering download speeds below 10 Mbps during 38.7% of our tests, the highest percentage among all networks. T-Mobile also had the fewest tests recorded with speeds of at least 100 Mbps, doing so just 1.6% of the time.

Carrier	0-10 Mbps	10-20 Mbps	20-50 Mbps	50-100 Mbps	100+ Mbps
AT&T	12.6%	14.2%	36.5%	21.6%	15.1%
Sprint	24.0%	12.6%	22.2%	22.5%	18.7%
T-Mobile	38.7%	18.3%	30.0%	11.3%	1.6%
Verizon	16.0%	13.3%	34.7%	30.1%	5.9%

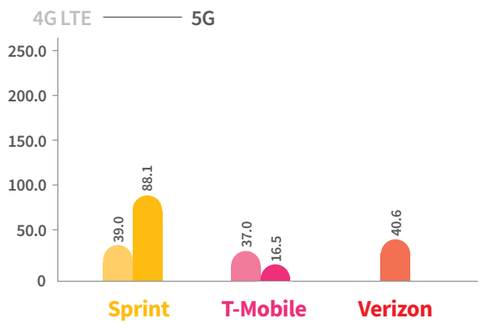
*Speed consistency results reflect speeds across all network technologies (4G LTE and 5G).

Washington, D.C.

Sprint provides top-notch results, while Verizon's maximum download speed dazzles.

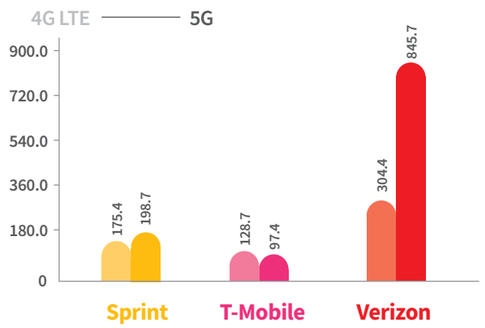
4G LTE & 5G median download speeds (Mbps)

Scale: 0–250 Mbps

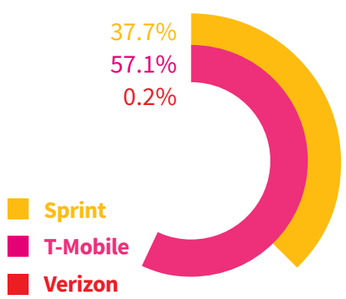


4G LTE & 5G maximum download speeds (Mbps)

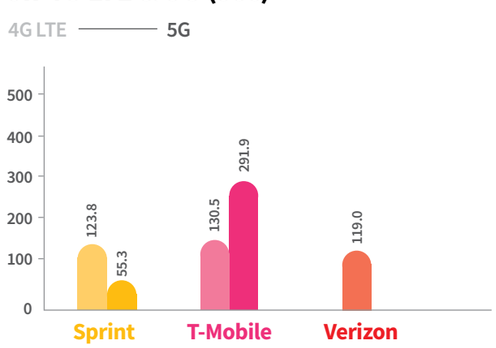
Scale: 0–900 Mbps



5G availability (%)



Time to download a 600MB video on 4G LTE & 5G (sec)



*AT&T hadn't launched 5G in Washington, D.C., at the time of our testing.
*Verizon's 5G sample size of 4 in Washington, D.C., was too low to accurately characterize its 5G median download speed.
*Times required to download a 600MB video are based on the 4G LTE and 5G median download speeds shown above.

Sprint customers in DC should be happy: Clocking in at an excellent 88.1 Mbps in Washington, D.C., Sprint registered its second-fastest 5G median download speed across all five cities. Sprint's mid-band spectrum 5G network impressed in more ways than one during testing in the nation's capital, providing its subscribers with relatively broad 5G availability (37.7%) and a 5G speed that was over twice as fast as its 4G LTE speed. Sprint's 5G median download speed was also over five times faster than that of T-Mobile.

T-Mobile's 4G LTE faster than its 5G: Similar to what we've seen elsewhere, T-Mobile's 5G median download speed in Washington trailed those of the other carriers and was slower than its 4G LTE speed in the same city. In this case, the difference between its 5G and 4G LTE speed was particularly stark, as T-Mobile's 4G LTE speed was over twice as fast as its 5G median download speed. That being said, T-Mobile's 5G speed in DC (and other cities) should improve as the network continues expand and make upgrades. For reference, in early December, right before T-Mobile launched its nationwide 600 MHz 5G service, we projected a potential 5G median download speed of 128.6 Mbps for T-Mobile's 5G in Washington, D.C.

Verizon's mmWave 5G delivers a remarkable maximum speed: With a 5G maximum download speed approaching 900 Mbps (845.7 Mbps), the future for Verizon's mmWave 5G in the nation's capital appears bright. While we didn't collect enough test samples to accurately characterize Verizon's 5G median download speed, the carrier's maximum download speed suggests that Verizon subscribers could experience very fast speeds going forward as the carrier's 5G network continues to expand.

Speed consistency

Sprint and Verizon were especially consistent at providing strong speeds in Washington, D.C., with both carriers clocking download speeds of 100 Mbps or better over 20% of the time during testing. Further, Sprint registered speeds of 50 Mbps or faster nearly 50% of the time, while Verizon delivered speeds of at least 50 Mbps during roughly 43% of our tests. While we didn't collect enough 5G test samples to characterize Verizon's 5G median download speed, the bottom line is that Verizon's 4G LTE download speeds were strong, and the 5G speeds we did record on Verizon's network were extremely fast.

T-Mobile's results, in contrast, weren't nearly as strong. While T-Mobile's 5G availability rate of 57.1% was quite broad and easily the highest in the city, T-Mobile delivered speeds of 100 Mbps or better during just 1.5% of our tests, a rate much lower than those of either Sprint or Verizon. And at the slower end of the speed spectrum, 44.1% of T-Mobile's speeds fell between 0-10 Mbps, whereas Sprint and Verizon had speeds in that range less than 14.3% of the time. While T-Mobile is clearly capable of providing fast speeds, the carrier's consistency of providing those speeds left room for improvement. That said, the good news is that we expect faster speeds are in store for T-Mobile's 5G network going forward.

Carrier	0-10 Mbps	10-20 Mbps	20-50 Mbps	50-100 Mbps	100+ Mbps
Sprint	14.3%	12.7%	24.1%	27.4%	21.6%
T-Mobile	44.1%	22.5%	26.0%	5.9%	1.5%
Verizon	11.8%	14.1%	30.8%	22.9%	20.3%

*Speed consistency results reflect speeds across all network technologies (4G LTE and 5G).

Conclusion

As the 5G era in the US continues to expand, we'll keep testing 5G performance in more and more cities across the country (and the world) to provide the most accurate picture of the end-user 5G experience available. While our early 5G speed results have been somewhat mixed, it's clear that some carriers are already providing extremely impressive speeds on 5G—speeds that in some cases far surpass those on 4G LTE. Indeed, Verizon's mmWave 5G could be a game changer for the end-user connected experience, with its median and maximum 5G speeds currently showing much more potential than what we've seen with low- and mid-band 5G. Our results suggest that it's important for consumers to understand what spectrum of 5G each carrier is using and what they are using it for. Low- and mid-band spectrum isn't new and initial results show speeds on low- and mid-band 5G that are currently not drastically different from 4G LTE. That said, if consumers are looking for a 5G signal that travels farther, low- and mid-band spectrum fit the bill nicely.

While all types of spectrum have differences in terms of speed and coverage, the good news is that regardless of 5G technology, we expect to see faster speeds on 5G as we move further into 2020 and beyond. In fact, we expect **5G to get a big boost** in the US after the release of the iPhone 5G (rumored to launch in the Fall of 2020), which could mark a watershed moment for 5G and mobile in general. Stay tuned to RootMetrics to learn more about real-world 5G performance and the mobile performance landscape at large.

How we test

We believe that real-world results come from real-world testing, and all RootMetrics testing is conducted from the consumer's point of view. Testing is performed indoors and while driving, and select markets include testing while walking within dense urban areas. For 5G testing in Indianapolis and Los Angeles, we used a Samsung Galaxy Note10+ 5G to test the 5G networks of AT&T, T-Mobile, and Verizon, and we used a Samsung Galaxy S10 5G to test Sprint's 5G. Testing was performed from December 17 through December 20, 2019.

During testing in Chicago, Dallas, and Washington, D.C., we used a Samsung Galaxy S10 5G to test Sprint's 5G network, and we used a Samsung Galaxy Note10+ 5G to test the 5G networks of T-Mobile and Verizon. Testing was conducted from December 9 through December 11, 2019.

We utilize random sampling techniques to ensure our results offer a robust characterization of performance in the places consumers most often use their smartphones, and all testing is focused on the activities for which consumers typically use their smartphones, including data, call, and text usage. To learn more about our testing, visit our **methodology**.

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