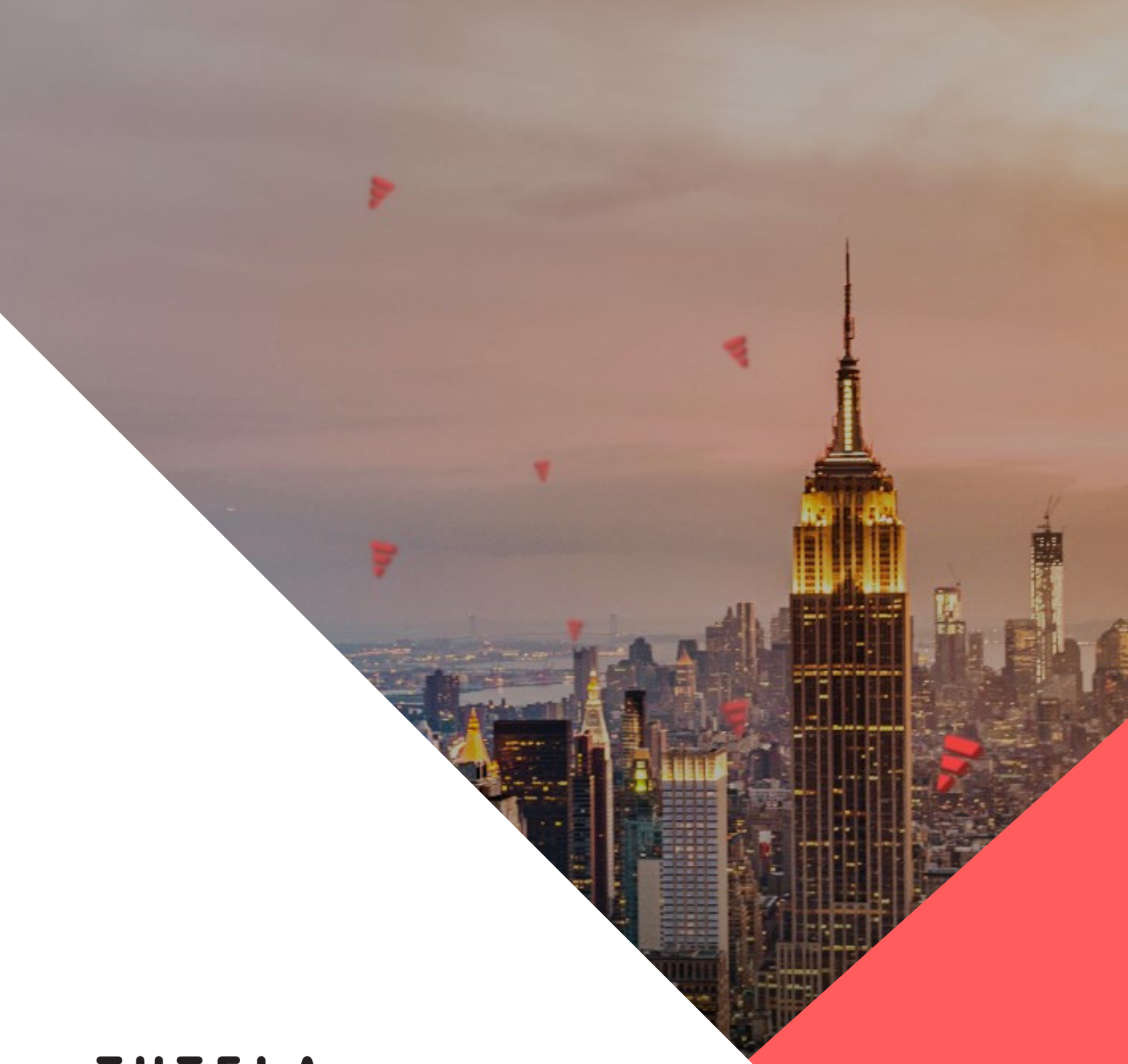


TUTELA

US Mobile LTE Network Quality 2018

Executive Summary

Reports on which networks have the fastest wireless speeds regularly flood the media, but often fail to tell the full story when it comes to carrier service quality. While fast top speeds are indicative of a strong network, reliable network quality is equally, if not more, important. After all, who cares whether you can occasionally hit gigabit download speeds if half the time you're struggling to load a Google search result?

That's why, in our 2018 report, Tutela is introducing a new primary metric: Consistent Quality.

Tutela uses the network and device data we collect from millions of mobile device owners every day to analyze which carriers reliably provide fast enough speeds to perform routine mobile tasks, like streaming a video on YouTube or using Google Maps.

For this 2018 report, Tutela analyzed over 240 billion network measurements collected from over 2.8 million handsets across the US between January 1st and August 31st, 2018. In total, we collected over 11 million speed tests and 240 billion data points to determine America's best LTE networks.

Tutela's 2018 report tests both speed and reliability to determine the US carrier with the most consistent quality.

Key findings

- Verizon delivered the highest level of consistent quality in the US
- T-Mobile's performance has improved rapidly as it builds its network at a rapid pace
- AT&T's consistent quality in urban areas lags behind both Verizon and T-Mobile
- Sprint has significantly lowered its latency but remains behind competitors
- Download speeds on MVNO networks are, on average, 23% worse than on the host operator

How Do We Define Consistent Quality?

When Americans are on their phones, chances are they're using one of the top 10 most popular apps in the country: YouTube, Facebook, Google Search, Google Maps, Facebook Messenger, Snapchat, Gmail, Google Play, Instagram, or Amazon.

With that in mind, Tutela has identified a set of five key performance indicators that show the minimum network requirements needed to run the most popular apps at a satisfactory level of operation. In other words, it's a network quality threshold. Any network performing at or above this level provides consumers with all they need to go about their daily digital routines. Anything below and consumers face slow-downs, freezes, and loading issues.

Note: In the interest of a fair comparison, we have limited the test to urban areas (since some operators have little or no coverage in rural areas). Results are thus primarily relevant to urban areas and urban clusters. As defined by the US Census Bureau, an urban area has a population of 50,000 people or above, while an urban cluster encompasses at least 2,500 people. Tutela's findings span 3,601 total urban areas and clusters.

Our key performance indicators

Download speeds > 4Mbps
Upload speeds > 2Mbps
Latency < 50ms
Jitter < 30ms
Packet loss < 5%

These performance indicators might not seem especially challenging for carriers to hit. That's because most popular apps are optimized to work under less-than-ideal conditions.

With this minimum level of performance, you can stream a 1080p HD video on YouTube, download the Facebook app (71.89MB) in about two and a half minutes or upload a 5MB picture to Instagram in around 20 seconds.

From the network tests that we have taken so far in 2018, we have calculated the percentage of the time that each operator exceeded the threshold — this is our consistent quality score. Below, we apply this rubric to America's largest carriers and see how they hold up.

Best Performing Networks 2018

TUTELA Best networks of 2018 - Tutela awards

Operator	Consistent Quality	Avg. Download speed	Avg. Upload speed	Latency	Packet Loss
verizon	🏆	🏆	🏆	🏆	🏆
T-Mobile			🏆		
AT&T					🏆
Sprint					

"Verizon has delivered the highest levels of consistency in network quality in 2018 in Tutela's extensive national testing"

Glossary - Breaking Down the Jargon

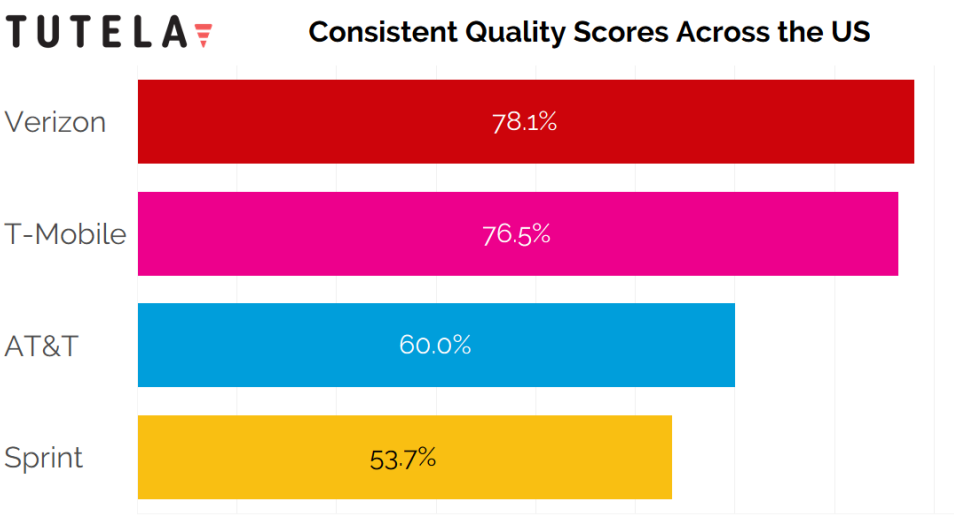
Latency
Any delay in data communication over a network, counted in milliseconds.

Jitter
A variance in time delay between data packets sent over a network — can result in data packets failing to arrive in the order they were sent. Also counted in milliseconds.

Packet loss
When a packet of data traveling through a network fails to reach its destination.

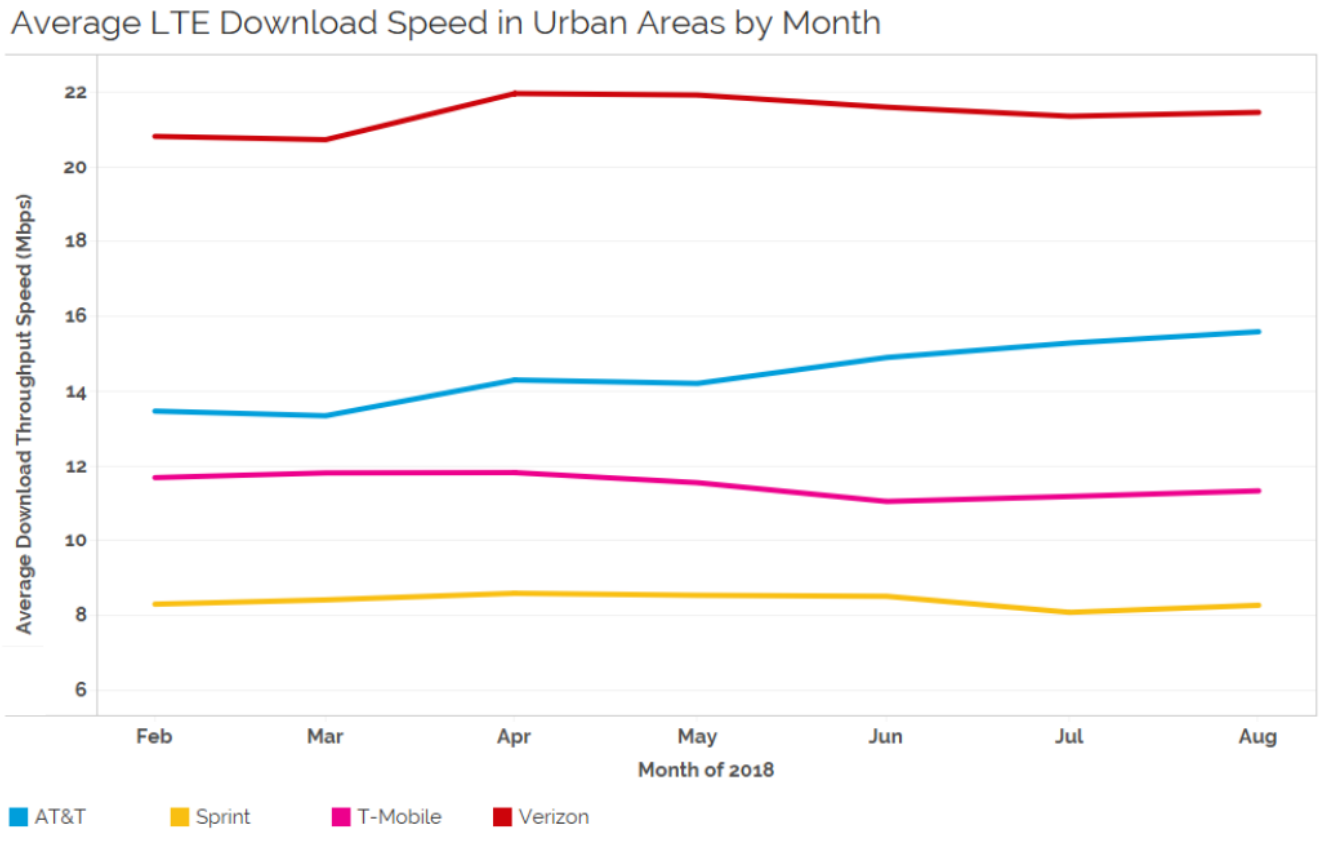
MVNO
Mobile Virtual Network Operator. A wireless reseller that purchases wholesale service from another operator or operators with physical infrastructure.

Analysis: All Operators

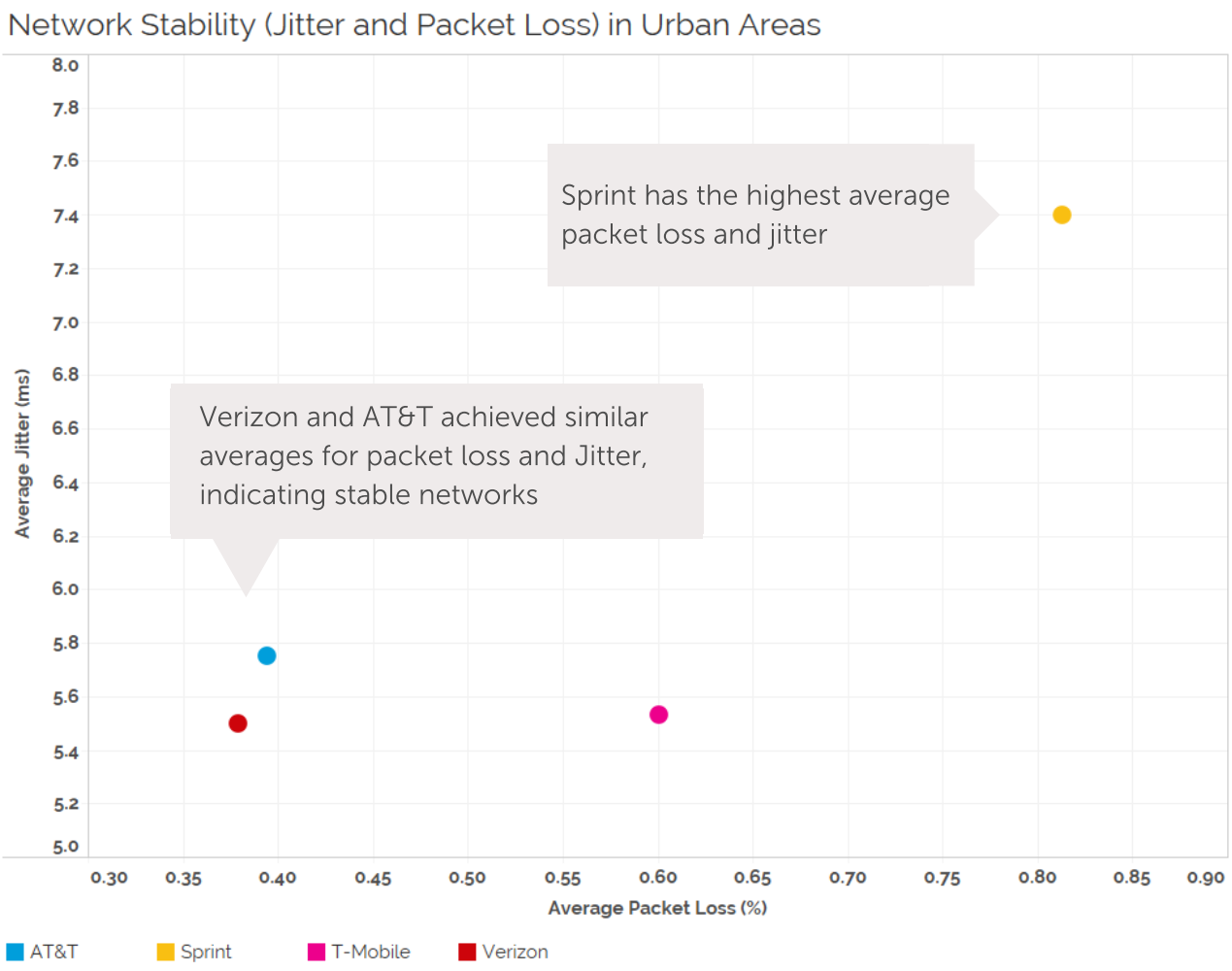


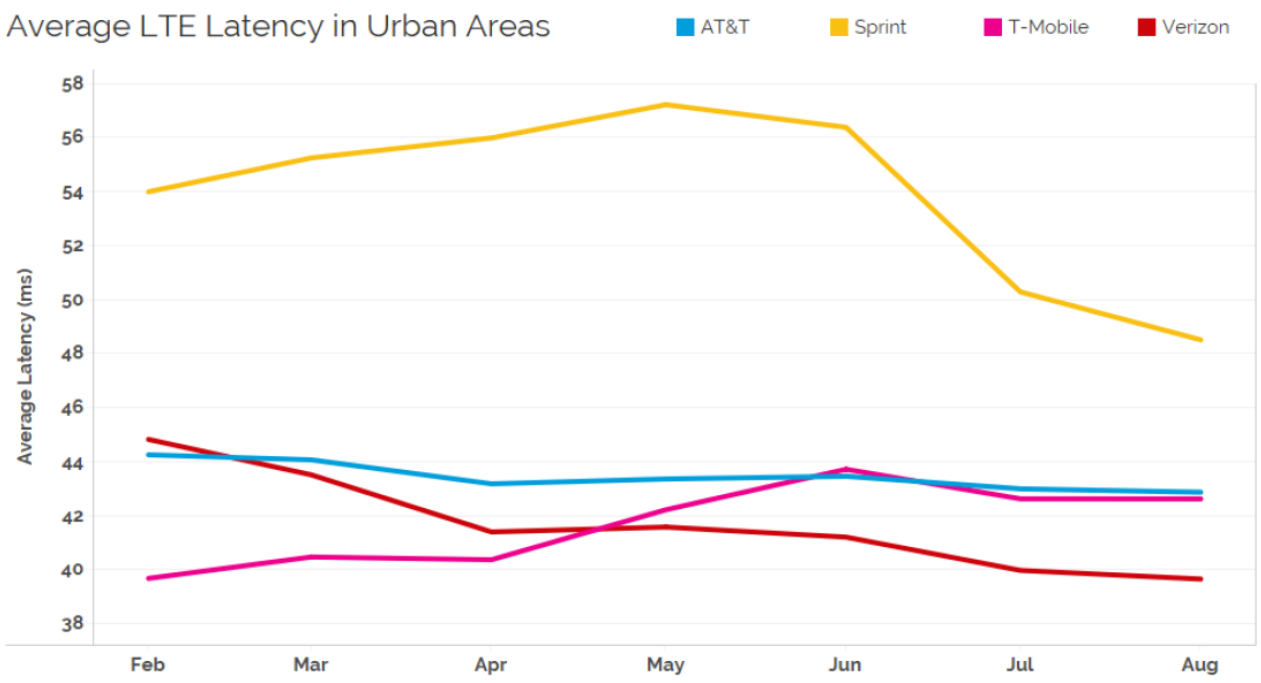
Verizon — the largest US carrier with over 152 million wireless customers — nabbed top honors for consistent quality. In 78.1% of tests in urban areas, the operator met or exceeded our network performance standards. But subscriber count doesn't necessarily translate to network performance — T-Mobile (~75 million subscribers) took home second place with 76.5%, while AT&T (over 147 million), slid into third with a significantly lower 60%.

When we look at average LTE download speeds, however, AT&T outpaces T-Mobile by an increasing margin, while still coming in well below Verizon. T-Mobile followed Verizon in having the second lowest jitter, while AT&T beat out the "uncarrier" for second place in lowest packet loss. Sprint, which T-Mobile is working to acquire, consistently came in last place across all tests.



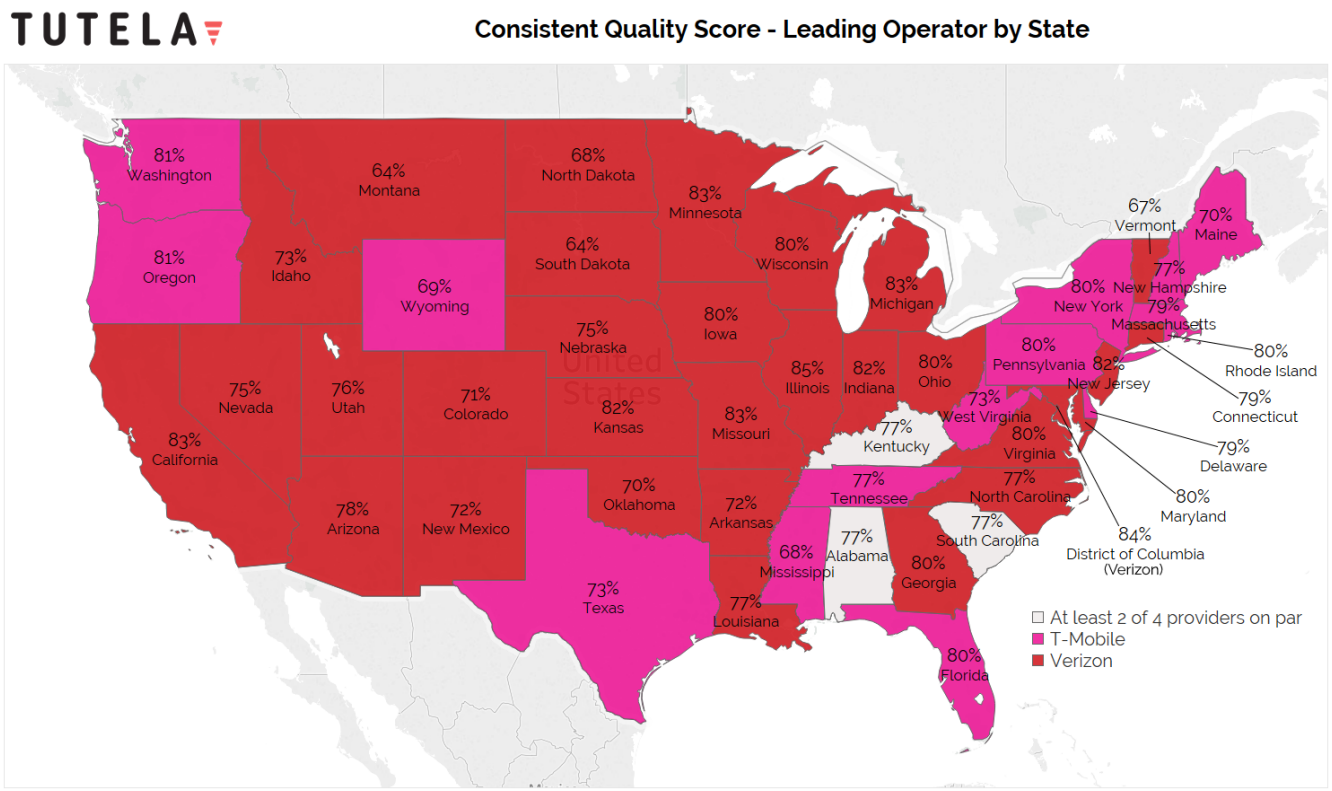
Analysis: All Operators

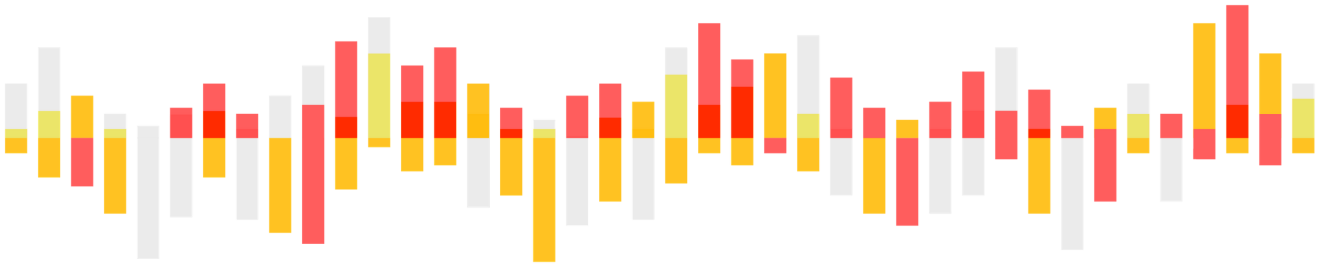




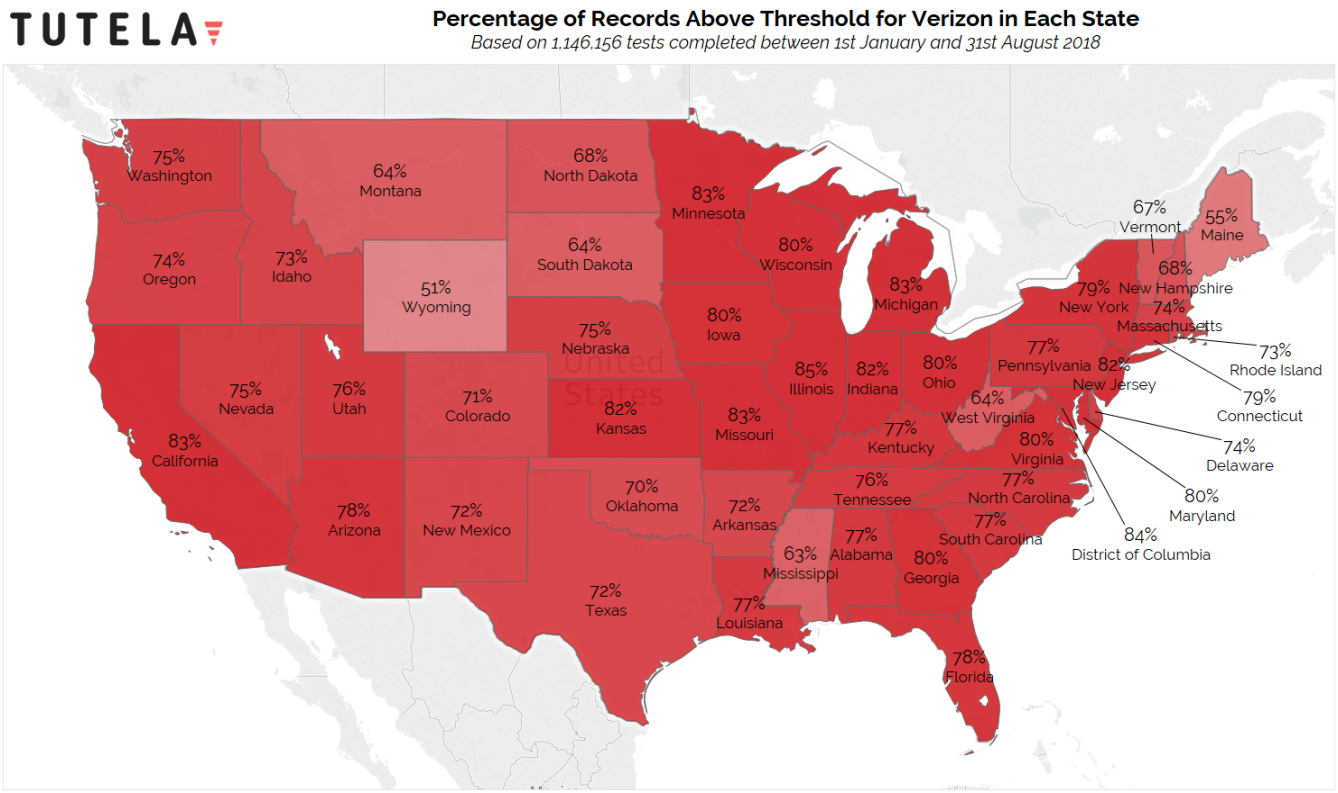
Analysis: All Operators

Breaking down the results geographically, Verizon came out ahead across most states in the contiguous US (31), while T-Mobile performed admirably, offering the highest level of consistent quality in 14 states.





Verizon



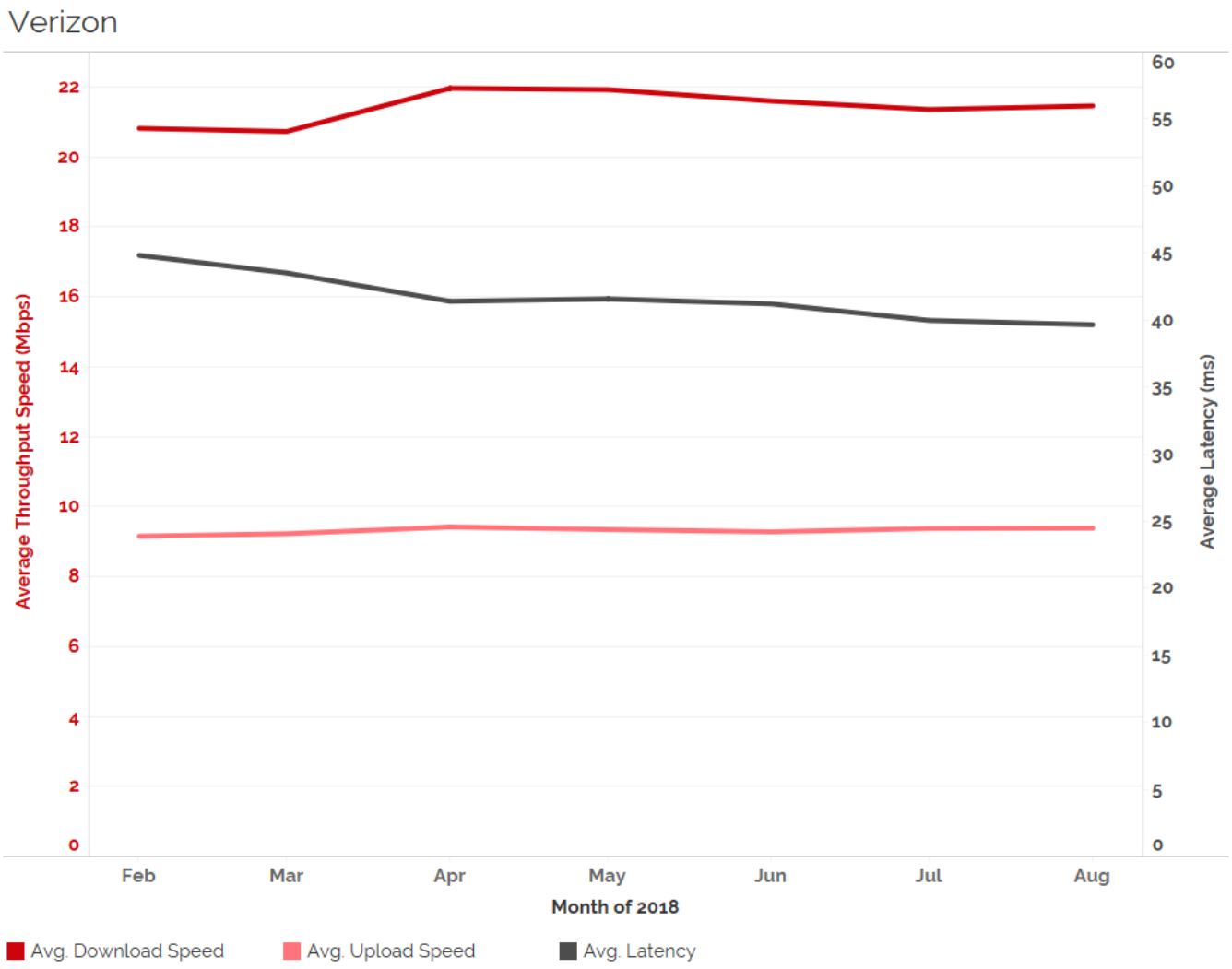
Throughout the year, Verizon's consistent quality score was high across almost all states. Verizon's lowest scores — in Maine (55%) and Wyoming (51%) — still provided customers with satisfactory performance of the most used apps around half the time. In the majority of states, the score was above 70%. Peeking behind the curtain, Verizon's spectrum holdings show the positive impact significant spectrum investment has on network performance.

Verizon has a large number of 700 MHz (Band 13) licenses, a mid-frequency band good at spanning long distances while still providing strong LTE speeds. Verizon relies on this frequency for rural and suburban coverage across the nation, but its 1700MHz AWS-1 spectrum (Band 4), carries the bulk of the weight in urban areas. Verizon made steady improvements to network performance during the year. In particular, there was a ~15% improvement to latency between February and August.

> "Verizon's consistent quality score was high across almost all states."

Verizon

Verizon made steady improvements to network performance during the year. In particular, there was a ~15% improvement to latency between February and August, indicating possible improvements to the core network. Latency saw its most significant drop in April (to ~40ms from ~45ms), around the same time that marked improvements in upload and download speeds appear.

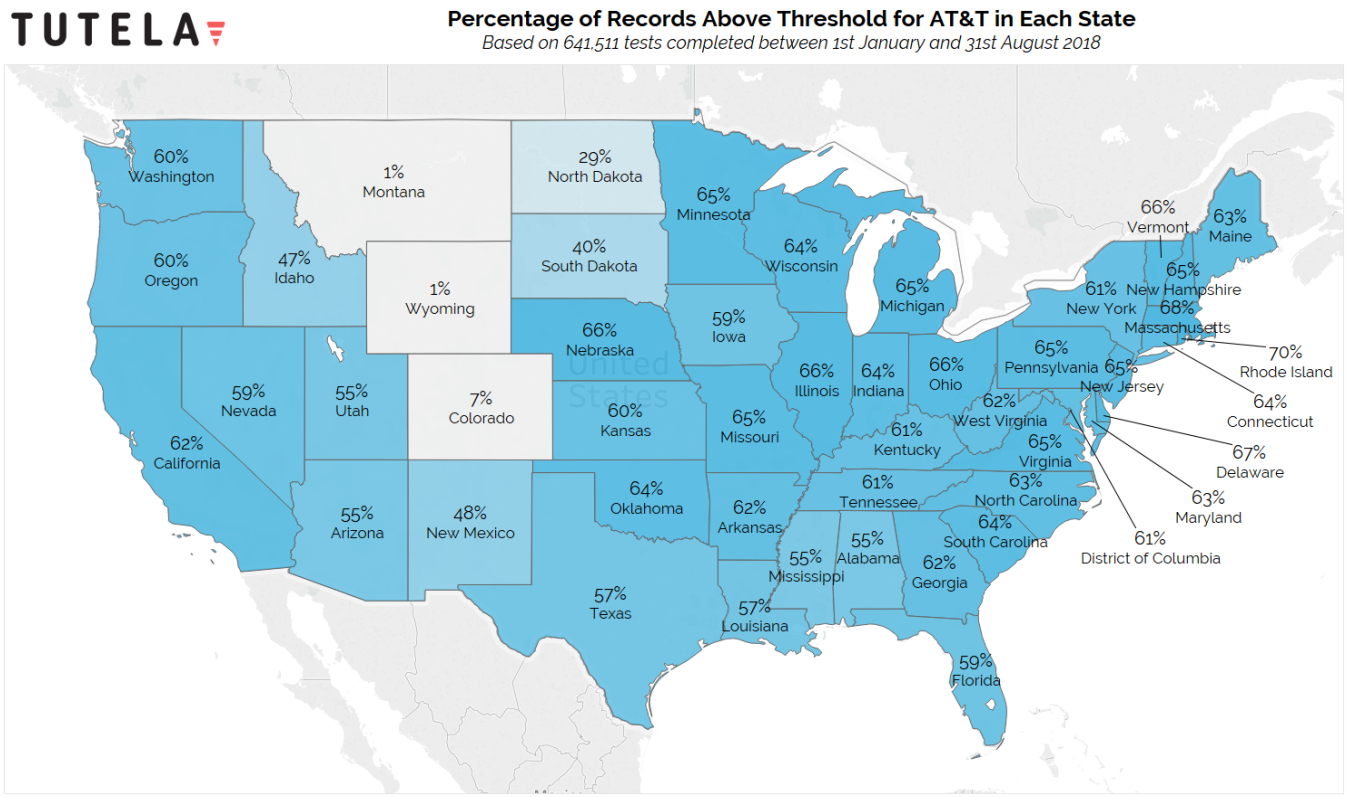


As for MVNO service, our tests show that Comcast's Xfinity, which operates on Verizon's network, provides roughly half the average data speeds in urban areas where Tutela conducted tests — 12.6Mbps in comparison to 24Mbps. The consistent quality score showed a 33.8 point disparity in Verizon's favor.

Verizon MVNO	MVNO Average download speed Mbps	Verizon Average download speed Mbps	MVNO consistent quality score	Verizon consistent quality score
Xfinity	12.6	24.0	48.6%	82.4%

For our MNO to MVNO comparison, we compared the operator and MVNOs based only on locations where both the MNO and MVNO recorded sufficient tests.

AT&T



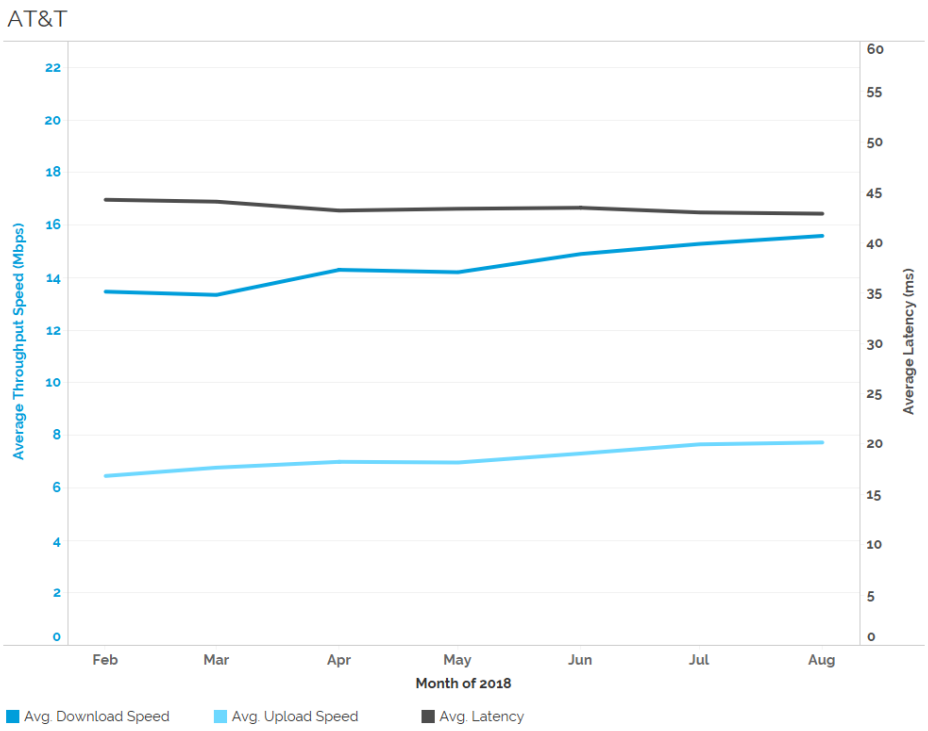
Just like its competitors, AT&T has been active in network improvements throughout 2018, however when we look at its consistent quality scores - the difference is stark, with the majority of states coming in under 70%, mainly due to more than a quarter of download tests scoring below our target threshold of 4Mbps. These speeds may be the result of speed throttling implemented during times of network congestion.

In Montana (1%), Wyoming (1%), and Colorado (7%), the scores for AT&T's network aren't even double-digit. Though the telecom company has substantial spectrum holdings, the bulk of it resides on the eastern half of the continental US. 1900 MHz (Band 2) is AT&T's most commonly used mobile band, though it relies more on 700 MHz AC (Band 12) for non-urban service.

> More than a quarter of download tests score below our target threshold of 4Mbps.

AT&T

Even with big differences in consistency, the national operator has seen larger download and upload speed improvements, comparatively, than Verizon. Average upload speed went from roughly 6Mbps to just under 8Mbps, while download speed went from nearly 14Mbps to just under 16Mbps. Both results lag behind Verizon but have been on a steady incline. Latency times, meanwhile, are on a slow decline, nearing 43 milliseconds from around 45ms in February.



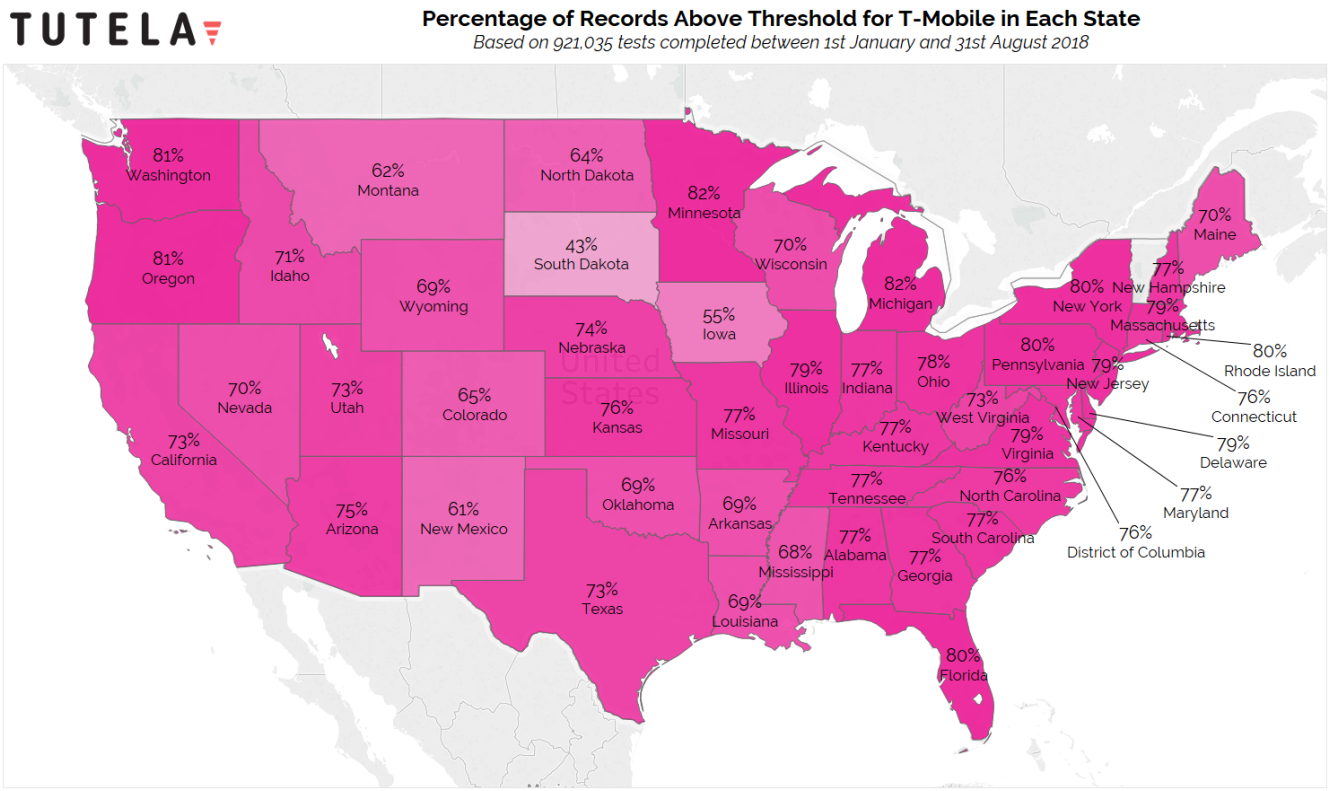
All of these results lag behind Verizon, but don't compare too poorly. In comparison to T-Mobile, AT&T actually wins on latency and average download speed, while just barely coming in behind on average upload speed.

In a performance comparison between AT&T and the MVNOs running on its network, the results are mostly unsurprising. Consumer Cellular, Cricket, and H2O all have download speeds that are around half what AT&T offers in the urban locations where Tutela tested both. However, H2O and Consumer Cellular both managed to achieve significantly higher consistent quality scores than AT&T. 72.8% and 71.5% respectively, compared to around 67% from AT&T. While we can't draw any absolute conclusions, one possible reason for this is superior core network elements (e.g. gateways and routers) on the part of those two MVNOs. Cricket, meanwhile, came in far lower with 40.8% compared to AT&T's 65.7%.

AT&T MVNO	MVNO Average download speed Mbps	AT&T Average download speed Mbps	MVNO consistent quality score	AT&T consistent quality score
Consumer Cellular	14.8	18.1	72.8%	67.0%
Cricket	7.2	17.9	40.8%	65.7%
H2O	10.7	18.2	71.5%	67.1%

For our MNO to MVNO comparison, we compared the operator and MVNOs based only on locations where both the MNO and MVNO recorded sufficient tests.

T-Mobile



In the majority of states, T-Mobile's consistent quality score is above 70 percent. In the lowest-scoring state, South Dakota, T-Mobile offered adequate service for popular app usage 43% percent of the time. No data exists for Vermont, where T-Mobile partners with AT&T for roaming.

With less low band spectrum than Verizon and AT&T, T-Mobile primarily uses higher frequency spectrum (Band 4, Band 2) — even for rural and suburban deployments that would benefit from greater range. The carrier has worked to address its lack of low band spectrum, however.

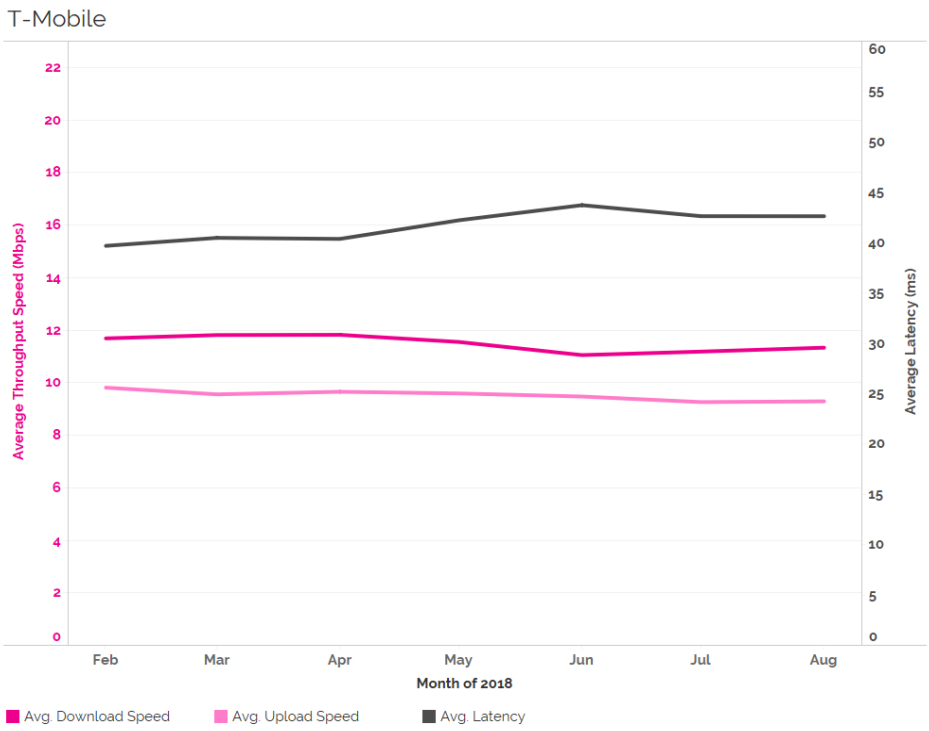
In 2017, it purchased a massive, nationwide chunk of 600 MHz spectrum at auction, which it is now deploying to boost its rural performance. Ultimately, though, it's the carrier's focus on urban areas that has given it an edge in this report.

While in possession of significantly fewer subscribers than AT&T and Verizon (around 74 million), T-Mobile has considerably built out their network. We took measurements from 68,086 T-Mobile LTE cell towers in regular use during 2018 — a 13% increase on the number of sites reported by the FCC in 2017.

> We took measurements from 68,086 T-Mobile LTE cell towers in regular use during 2018.

T-Mobile

T-Mobile's average latency has gone up slightly over the year, though it remains close to other competitors at approximately 43ms. The carrier's average upload speeds beat out the competition at roughly 9Mbps, but download speed came in far lower than Verizon and AT&T, staying relatively stable at just under 12Mbps.

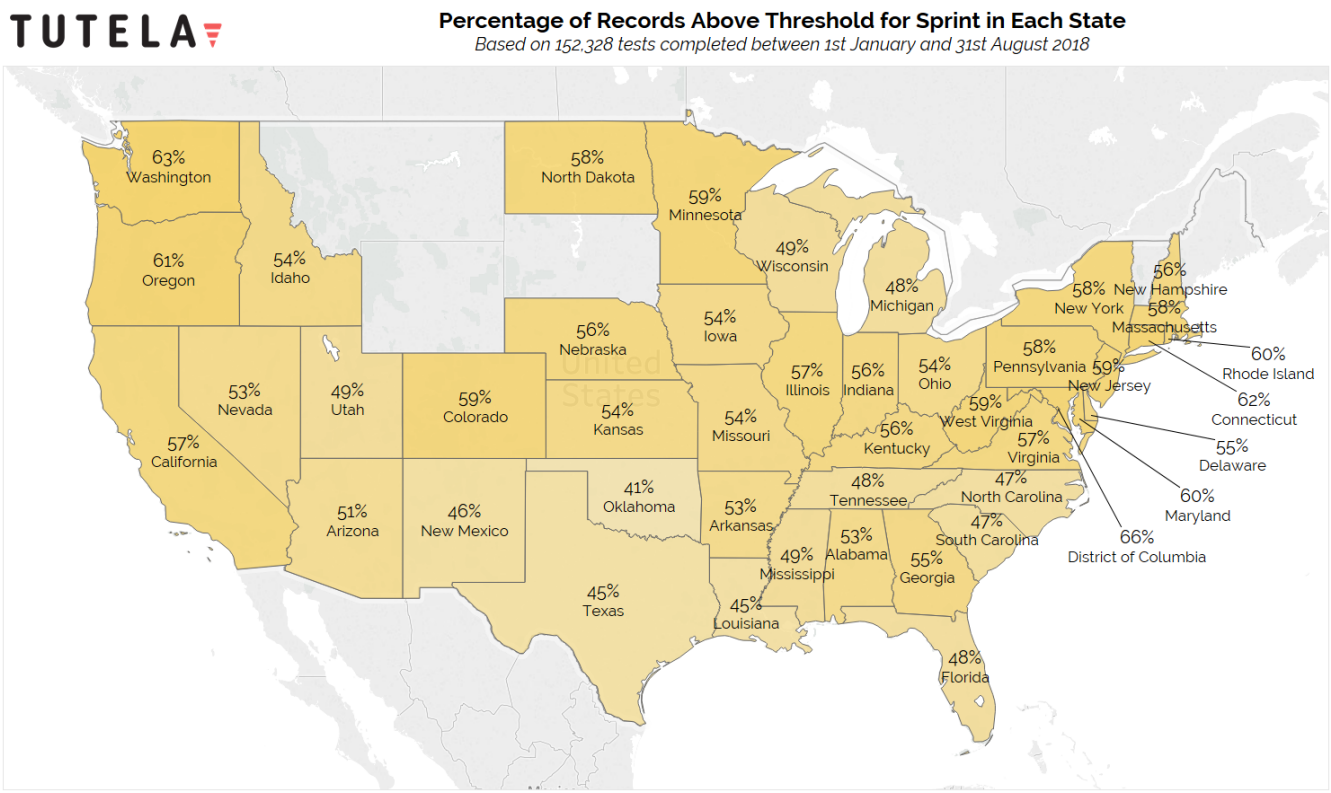


In our tests, Tutela found that the MVNO download performances of Consumer Cellular, LycaMobile, MetroPCS, and Ultra Mobile were remarkably similar to T-Mobile. However, MetroPCS' website states that its customers' data is "prioritized below data of some T-Mobile-branded customers at times and locations where competing network demands occur." Tutela's data reveals that at busier times MetroPCS customer experience lags further behind T-Mobile than at quiet times.

T-Mobile MVNO	MVNO Average download speed Mbps	T-Mobile Average download speed Mbps	MVNO consistent quality score	T-Mobile consistent quality score
Consumer Cellular	11.6	12.6	73.4%	81.6%
LycaMobile	11.3	12.8	74.4%	81.4%
MetroPCS	11.0	12.3	75.2%	80.5%
Ultra Mobile	11.3	12.9	76.1%	81.5%

For our MNO to MVNO comparison, we compared the operator and MVNOs based only on locations where both the MNO and MVNO recorded sufficient tests.

Sprint



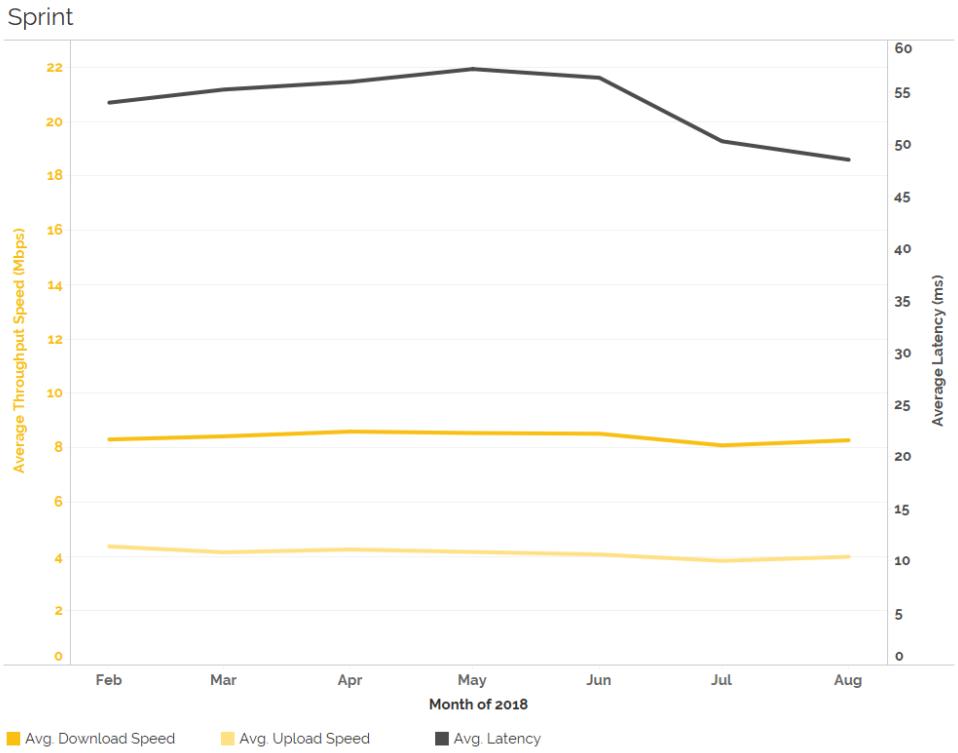
The fourth-largest carrier by subscriber count at around 53 million, Sprint lagged behind its competition in all tests. The wireless operator, which may soon merge with T-Mobile, clocked average-to-poor consistent quality scores across mainland US. Most states came in under 60 percent, with Montana, Wyoming, Maine, Vermont, and South Dakota omitted entirely. In large part, Sprint's unimpressive results seem tied to a lack of spectrum holdings, and, in particular, low-band spectrum.

In urban areas of the US, Sprint relies primarily on 2500 MHz (Band 41) spectrum, while 1900+ MHz (Band 25) is its main spectrum holding for suburban and rural areas — a slightly high-frequency band for practical long distance usage. What's more, it has substantially fewer spectrum holdings than its major competitors, clustered mainly on the two coasts.

> “Most states came in under 60 percent, with Montana, Wyoming, Maine, Vermont, and South Dakota omitted entirely.”

Sprint

From February to August, upload and download speed have held steady at approximately 4Mbps and 8Mbps respectively. Latency, however, improved significantly, dropping from a high of around 57ms to under 50ms. While each of these average metrics fit within Tutela's established data quality threshold detailed at the beginning of this study, consistency was an issue, leading to middling consistent quality scores.



The download performance of Sprint MVNOs Boost and Virgin Mobile is just under Sprint's average speeds, but the carrier has a better consistent quality score by about 10% in comparison to both resellers, which is an improvement on AT&T's network performance versus several of the wireless resellers on its network.

While Sprint's performance may not be inspiring in the context of this report, its spectrum holdings, infrastructure, and customer base will be a major boon to T-Mobile if the acquisition goes forward. The deal will immediately rocket the Bellevue, Washington-based company to a position of prominence on par with Verizon and AT&T.

Sprint MVNO	MVNO Average download speed Mbps	Sprint Average download speed Mbps	MVNO consistent quality score	Sprint consistent quality score
Boost	8.5	9.2	50.0%	59.0%
Virgin Mobile	8.4	9.5	51.5%	61.9%

For our MNO to MVNO comparison, we compared the operator and MVNOs based only on locations where both the MNO and MVNO recorded sufficient tests.

Methodology

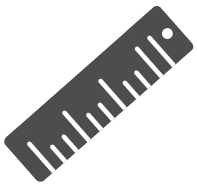
Tutela measures network quality based on the real-world performance of users in the field. Results in this report are based on a testing configuration to represent typical (not maximum) performance of users. We used a 2MB file to perform our download testing and a 1MB file to perform our upload testing. Tutela employs software installed on more than 3,000 partner apps and to complete frequent, lightweight tests of around 2MB.

Our results differ from other network testing companies who measure the peak performance of networks under ideal conditions (such as downloading a 500MB file).

In total, Tutela's software operates on over 250 million Android and iPhone devices globally, collecting over 10 billion mobile data measurements every day. Our data scientists analyze results for each country every month, and our analytics platform, Tutela Explorer, lets operators chart, map, and filter over 80 key performance indicators into customized dashboards to help them better understand industry performance and benchmark against competitors.

Report facts

The data in this report was taken from our crowdsourced data from mainland USA in 2018 between Jan 1 and Aug 31.



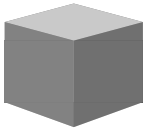
240 billion
Measurements

5.9 million
Download tests

5.5 million
Upload tests

300 million
Latency tests

300 million
Jitter tests



300 million
Packet loss tests

Discover Tutela Explorer

Explorer is Tutela's flagship analysis platform which combines Tutela's massive crowdsourced database with high-powered data visualisation and analysis, enabling you to analyse and drill down across every operator, device, state and street to find the insights you need in seconds with fully customisable views.

With Tutela Explorer you can:

- Analyse operator performance at country, state, street and cell level
- Identify cell tower locations, spectrum usage and performance
- Understand device mobile quality of experience and usage

Find out more:
www.tutela.com/explorer

About Tutela

Tutela is a mobile data and analytics company serving the mobile and telecommunications industry with software is embedded in over 3000 diverse mobile applications installed on over 250 million mobile Android and iOS handsets. Tutela continuously monitors network quality of experience all across the world. We collect more than 10 billion measurements every single day, and through our interactive toolset, enable our customers to turn those numbers into actionable intelligence for their businesses.

For more information, visit www.tutela.com or contact us at info@tutela.com