



**CFRA**

# Industry Surveys

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## Telecommunications: U.S.

AUGUST 2022

**Keith Snyder**  
Equity Analyst

**Siti Salbiah**  
Industry Analyst

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## Contacts

### Sales Inquires & Client Support

800.220.0502  
cservices@cfraresearch.com

### Media Inquiries

press@cfraresearch.com

### CFRA

977 Seminole Trail, PMB 230  
Charlottesville, VA 22901

## Contributors

### Raymond Jarvis

Senior Editor

### Atifi Kuddus, Geraldine Tan

Associate Editors

### Marc Bastow

Contributing Editor

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CFRA

977 Seminole Trail, PMB 230

Charlottesville, VA 22901

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## NEW THEME(S)



**What's Changed:** 2022 may be a turbulent year for the U.S. Telecommunications industry as it continues to be impacted by global component shortages. CFRA's financial projections for the industry are available on page 6.



**What's Changed:** Competition within the U.S. 5G space is heating up as it welcomes a new player, Dish. Head to page 15 for more details on the operator.

# EXECUTIVE SUMMARY

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CFRA has a neutral outlook on the Telecommunications industry. Here are the key themes we highlight for 2022.

## ***The Impact of the Covid-19 Outbreak Has Been Minimal***

The wireless industry has been surprisingly resistant to the effects of Covid-19. Beyond depressed equipment revenue due to store closures in 2020 and the beginning of 2021 and an overall pullback in consumer spending, customer net additions remained strong across the industry. Looking into 2022, CFRA expects the most significant headwind will be supply chain issues and ongoing component shortages. Many networking equipment vendors are reporting much longer lead times on high-end hardware, which could be an issue for 5G core deployments. In addition, antenna equipment could be hard to procure. Equipment prices are expected to continue to rise due to increased air freight costs and higher component costs.

## ***Consumer Handset Upgrades Will Continue to Slow***

CFRA expects equipment revenue to grow modestly in 2022, following the rebound in 2021 due to easy comps and pent-up demand. The phone upgrade cycle has been slowing for the past few years. Some of the slowdowns can be explained by rising prices, with flagship phones often costing more than \$1,000, but we note there have recently been a number of more moderately priced devices hitting the market. Lack of innovation is probably playing a role as well. Technical and feature advances between device generations have stalled in recent years and have mostly been limited to improving battery performance and installing better/more cameras. Device manufacturers had hoped 5G would solve this issue, but consumer interest in the technology has been fairly limited so far.

## ***Consumer Interest in 5G Phones Has Been Limited***

Many consumers will become 5G subscribers, not as an intentional purchasing decision but rather as a byproduct of their normal smartphone upgrade cycle. 5G is rapidly becoming the standard in an increasing number of smartphones across all price points. According to IDC, by 2025, 98% of smartphone shipments will be 5G-enabled, and 5G services should be a standard offering on the majority of wireless service plans. The main issue currently facing service providers when trying to convince customers to upgrade to 5G is that the majority of smartphone applications are neither bandwidth nor latency-sensitive, and there have yet to emerge 5G-specific applications that leverage the technology's key features.

## ***T-Mobile Will Continue to Capture Market Share***

T-Mobile has led the industry in net customer additions and postpaid phone net additions for the majority of the last eight years. We have no reason to believe that this trend will stop in 2022. The company's trove of low-band and mid-band spectrum it received in the merger with Sprint is ideal for 5G networks, with the perfect blend of strong propagation and speed. CFRA expects T-Mobile's 5G network will be best in class, which will attract consumers while also enabling it to go after enterprise customers – an area that AT&T and Verizon have dominated. T-Mobile's 5G Ultra Wideband network currently covers 235 million people and approximately 87% of its customers, which is significantly ahead of Verizon's and AT&T's coverage. T-Mobile continues to be very aggressive with plan pricing, helping fuel subscriber growth.

## ***Rapid Growth in Data Traffic Will Continue***

Mobile data traffic has exploded in recent years as consumers devoured a greater amount of video on their devices. According to Cisco Systems, 79% of the world's mobile data traffic will be video by 2022, up from 59% in 2017. By 2022, the average smartphone will generate 11 GB of traffic per month, a four-and-a-half-fold increase over the average of 2 GB in 2017. In addition, there will be rapid growth in the number of connected devices, with 29.3 billion networked devices by 2023, up from 18.4 billion in 2018. Meanwhile, the average mobile connection speed is expected to increase over three-fold, to 43.9 Mbps from 13.2 Mbps. To cope with this traffic growth, service providers will continue to invest in fiber deployments, network capacity, and small cell antenna deployments.

## TELECOMMUNICATIONS: U.S.

Outlook: Neutral

## MARKET CAP BREAKDOWN\*

RANK NO.	COMPANY NAME	MARKET CAP (\$ billion)
1	Verizon	194.0
2	T-Mobile US	179.4
3	AT&T	134.4
4	Lumen Tech	11.2
5	Iridium	5.7
	Others†	9.3

\*Market cap as of July 31, 2022.

†Refer to the Comparative Company Analysis section of this survey for other companies in the industry.

Source: CFRA, S&amp;P Global Market Intelligence.

## BY THE NUMBERS

3.6

Networked devices per capita by 2023, up from 2.4 devices in 2018

7x

Increase in mobile data traffic between 2017 and 2022

\$304.2 billion

Global telecoms capital expenditure in 2021

5.5 billion

Worldwide IoT connections in 2027

18.9%

CAGR from 2021 to 2031 for number of small cell antennas deployed in North America

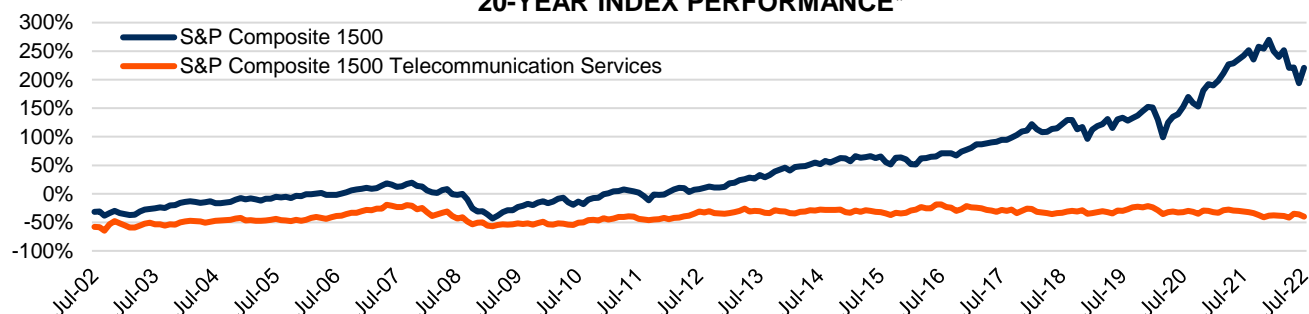
\$80.9 billion

Amount spent to acquire spectrum licenses in the C-Band auction

## ETF FOCUS

<b>XLC</b> Communication Services Select Sector SPDR	AUM (\$M) 9,372.5	Expense Ratio 0.12
<b>VOX</b> Vanguard Communication Services	AUM (\$) 2,741.5	Expense Ratio 0.10
<b>IYZ</b> iShares U.S. Telecommunications	AUM (\$M) 374.2	Expense Ratio 0.42
<b>IXP</b> iShares Global Telecom	AUM (\$M) 297.1	Expense Ratio 0.43
<b>XTL</b> SPDR S&P Telecom	AUM (\$M) 55.1	Expense Ratio 0.35

## 20-YEAR INDEX PERFORMANCE\*



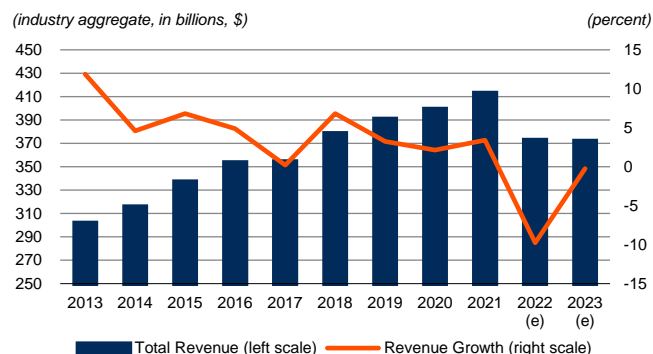
\*Data through July 31, 2022.

Source: CFRA, S&amp;P Global Market Intelligence.

# FINANCIAL METRICS

## Revenue

(industry aggregate, in billions, \$)

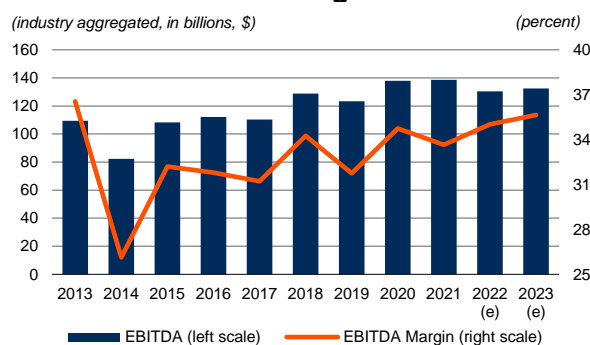


Source: CFRA, S&P Global Market Intelligence.

- ◆ Looking to 2022, we expect to see a shrink in revenue growth, impacted by ongoing component shortages that will affect equipment sales. The slower revenue growth can also be linked to a slowdown in phone upgrade rates as consumers hold on to equipment longer in response to the high price of new devices and the lack of significant new features between generations. We forecast revenue growth to reach -0.2% in 2023.
- ◆ While we are wary about declines in legacy wireline services and domestic video, we positively view growth in wireless and strategic services.
- ◆ In the second quarter of 2022, AT&T had total wireless net additions of 6.6 million, driven largely by connected devices with postpaid phone net adds of 813,000. Verizon reported a retail postpaid net loss of 215,000 in the consumer wireless business during the same period, while T-Mobile reported 1.7 million postpaid net adds.

## EBITDA & EBITDA Margin

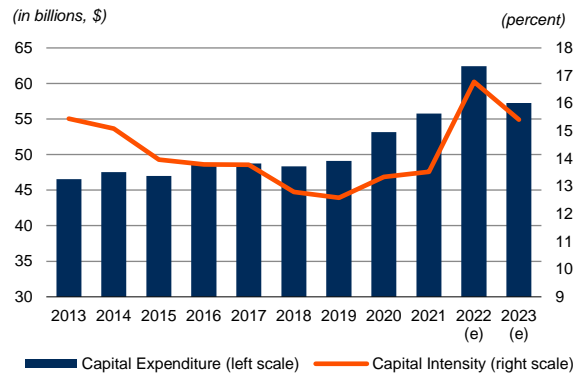
(industry aggregated, in billions, \$)



Source: CFRA, S&P Global Market Intelligence.

- ◆ We project EBITDA margin of 35.0% in 2022 and 35.6% in 2023, compared to 33.7% in 2021.
- ◆ In an effort to reduce debt, AT&T completed the sale of Time Warner to Discovery in April 2022 and concluded the spin-off of DirecTV to TPG in 2021.
- ◆ Meanwhile, we see stable wireline margins, as Verizon successfully achieved its \$10 billion savings target in 2021.

## Capital Expenditure and Intensity



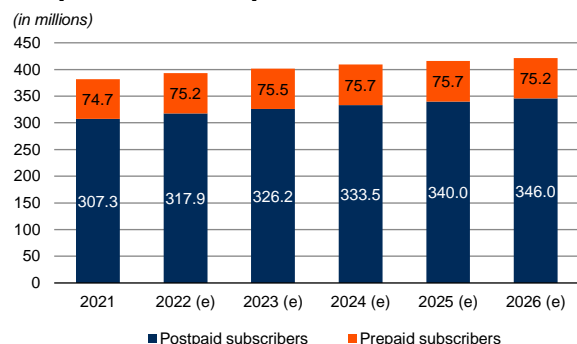
Source: CFRA, S&P Global Market Intelligence.

- ◆ CFRA expects capital expenditure to increase to 16.8% in 2022 but narrow to 15.4% in 2023, driven by looming headwinds on cash generation in a weak economic environment.
- ◆ We think the overall capital intensity levels will remain stable over the coming years as companies will deploy more fiber, spectrum deployments, and additional cell sites to expand their 5G rollouts.



# KEY INDUSTRY DRIVERS

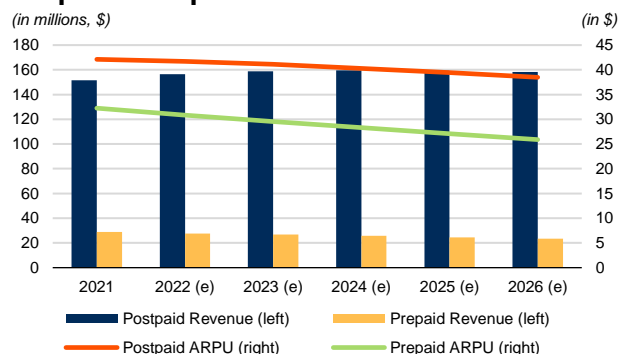
## Prepaid and Postpaid Subscribers



Source: IDC, May 2022.

- ◆ IDC expects U.S. wireless subscriber base to grow to 421.2 million by 2026 from 382 million in 2021, a 2% CAGR.
- ◆ The number of postpaid subscribers in the U.S. is projected to expand to 346 million by 2026 from 307.3 million in 2021, a 2.4% CAGR, according to IDC.
- ◆ Prepaid subscribers are projected to increase to 75.2 million in 2026 from 74.7 million in 2021.

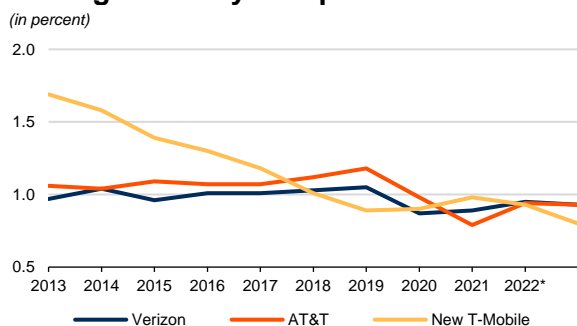
## Prepaid/Postpaid Revenue and ARPU



Source: IDC, May 2022.

- ◆ For mobile network operators, a postpaid subscriber is more desirable than a prepaid subscriber due to a higher average revenue per user (ARPU) and stronger brand loyalty.
- ◆ Meanwhile, the number of wearables computing devices will expand at 7.3% CAGR to 801.7 million by 2026 from 547.3 million in 2021, according to IDC.
- ◆ These devices typically carry lower ARPUs compared to smartphones, which helps explain the expected decline in postpaid ARPU between 2021 and 2026; IDC projects postpaid ARPU will decline from \$42.1 in 2021 to \$38.5 by 2026.

## Average Monthly Postpaid Churn



\*As of Q2 2022.

Source: Company reports, CFRA, S&P Global Market Intelligence.

- ◆ We observe a change of trend in postpaid churn in the second quarter of 2022, particularly for Verizon and AT&T from 2021, as consumers are now more likely to switch plans, bucking the trend from the pandemic, as store closures limited consumers' ability to cancel plans and sign up for new ones.

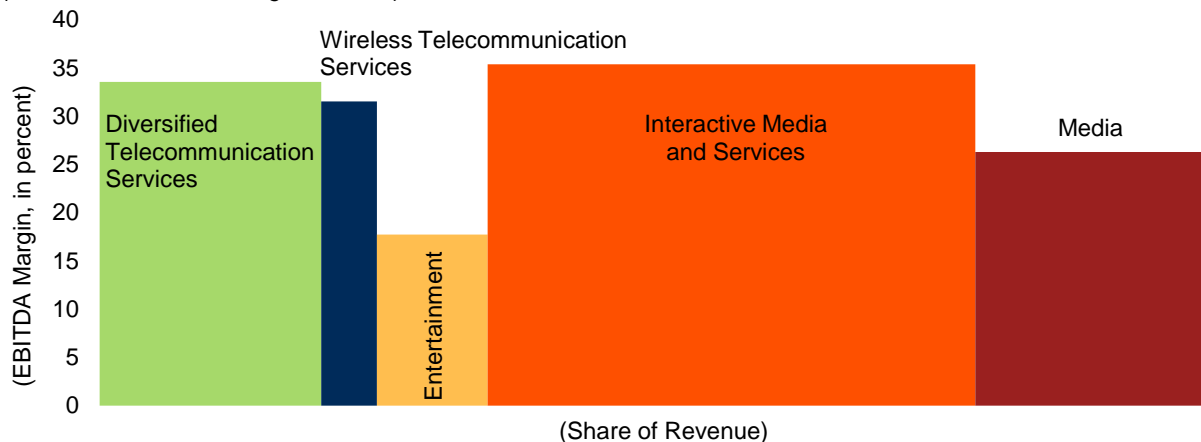


# INDUSTRY TRENDS

## Competitive Environment

### PROFIT SHARE MAP OF U.S. COMMUNICATION SERVICES SECTOR

(last twelve months through Q2 2022)



Source: CFRA, S&P Global Market Intelligence.

In the Communication Services sector, the Interactive Media and Services industry has the largest share of revenue at 44%, followed by the Diversified Telecommunication Services (20%). In terms of EBITDA margin, the Interactive Media and Services industry registered the highest EBITDA margin at 35.4%, followed by Diversified Telecommunication Services at 33.6%.

## Porter's Five Forces

Below, we use the Porter's Five Forces framework as a tool to analyze the competitive environment of the U.S. Telecommunication Services industry.

Porter's Five Forces Analysis	
<b>Threat of New Entrants or New Entry (Low)</b>	Unsurprisingly, the biggest barrier to new entrants in this capital-intensive industry is access to capital. Due to the high fixed costs of operating and building an extensive network infrastructure to provide fixed-line and wireless services, potential newcomers typically require a lot of cash. The level of threat depends on the accommodativeness of capital markets; when markets are generous, the threat of new entrants escalates, and vice versa. The fact that telecom companies are required to own a telecom license to operate represents another barrier to entry. Even an emerging telecom company needs to obtain the FCC's approval and licensing. There is also only a limited amount of "good" radio spectrum applicable to mobile voice and data applications. Finally, solid operating skills and management expertise are scarce, keeping the threat of new entrants low.

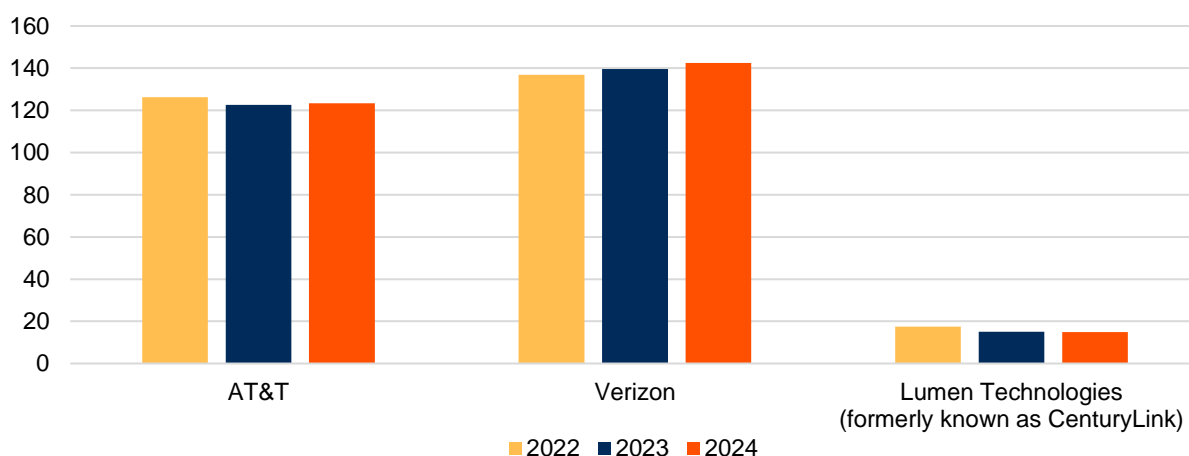
<b>Bargaining Power of Suppliers (Moderate)</b>	The bargaining power of suppliers in the telecommunications space is mixed. Some might think that telecom equipment suppliers have substantial bargaining power over telecom operators, as equipment such as high-tech broadband switching gear and fiber-optic cables are necessary for operators to transmit voice and data from place to place. However, there is actually a sufficient number of large equipment makers to materially dilute that bargaining power. In addition, given the scarce talent pool for professionals proficient in the latest technologies, equipment makers are in a weak position in terms of hiring and salaries.
<b>Bargaining Power of Customers (Low to Moderate)</b>	The power of customers increases as they get more choices of telecom products and services. Basic services are becoming like a commodity (there are not many differences at all between telephone and data services provided by the companies), so customers seek the lowest prices and sign up with the telecom provider that offers the most reliable services. However, the power of customers differs somewhat between market segments. The switching costs for a residential customer are relatively low compared to larger business customers, especially if those enterprises depend on customized products and services.
<b>Degree of Rivalry/Competition (High)</b>	In the telecommunication services industry, competition is cutthroat. The wave of deregulation in the industry coupled with the accommodative capital markets in the late 1990s opened the floodgates for many new entrants. A raft of new substitute services is being created thanks to technological advances. The saturation of mobile devices and broadband internet is forcing firms to fight for market share by lowering prices and investing in infrastructure to provide more exciting services. We think the high exit barriers of the industry (you can't turn off part of a network or reduce the variable costs easily) will force the major telecom companies to continue to operate, even in times of stress, keeping the competitive pressure strong.
<b>Threat of Substitutes (High)</b>	Telecom operators face serious threats of product and service substitutes from non-traditional telecom industries. Cable TV and satellite operators compete with telecoms for customers with their own direct lines into homes, broadband internet services, and satellite links. Railway and energy utility companies are building high-capacity telecom networks alongside their tracks and pipelines. On top of that, as cut-rate or even free internet voice calls and video chat services like Zoom, Microsoft Teams, and RingCentral become more reliable and more widely adopted by enterprises, telecoms will continue to lose their core voice revenue share.

## Wireless Segment

Over the years, the U.S. wireline business has shrunk to three dominant players: AT&T Inc., Verizon Communications Inc., and Lumen Technologies (formerly known as CenturyLink), along with a host of mid-sized regional carriers. The rest of the telecommunications industry comprises mid-sized independent local carriers, which over the years have acquired smaller wireline telecommunications companies (telcos) that were not part of the AT&T monopoly; as such, they are exempt from certain regulations.

### REVENUE FORECAST

(\$, in billions)



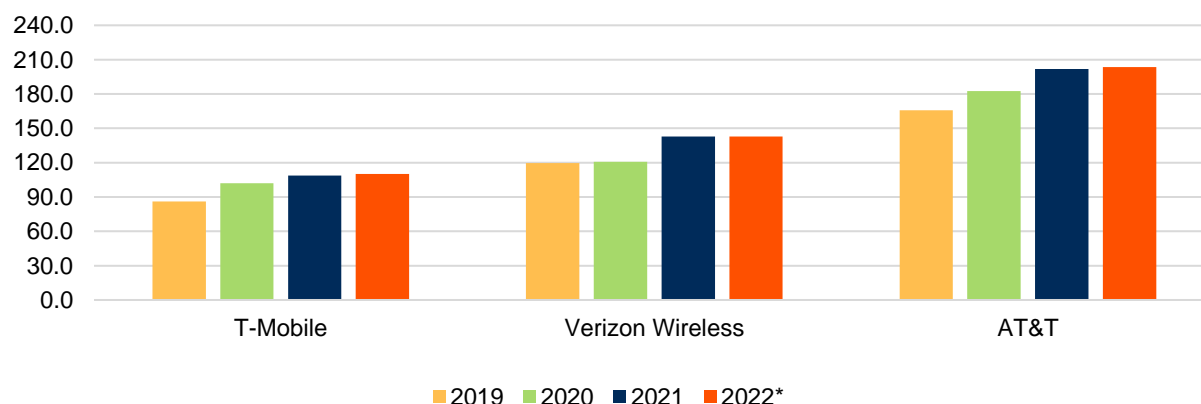
Source: CFRA, S&P Global Market Intelligence.

As of the second quarter of 2022, Verizon and AT&T led the U.S. wireless industry by wireless subscribers. Between them, the two carriers had 346.2 million subscribers in the U.S., or more than two-thirds of all U.S. subscribers. Competition has grown fierce as wireless telecommunications service providers fight to attract subscribers from each other to sustain revenue growth.

All telecom carriers can differentiate their services via pricing, network performance, customer services, as well as the diversity of offerings. T-Mobile had the fastest 5G download speed with an average of 150 Mbps, followed by Verizon and AT&T with 56.2 Mbps and 49.1 Mbps, respectively, according to independent mobile analytics firm Opensignal.

### NUMBER OF U.S. WIRELESS SUBSCRIBERS

(in millions, from 2019 to 2022)



\*As of Q2 2022.

Source: Company Filings.

◆ **Verizon.** As of the second quarter of 2022, Verizon reported wireless subscribers base of 142.8 million, an increase from 121.3 million in the same period in 2021. Verizon has been consistently investing in wireless and fixed-line technology to improve its network quality. Verizon's strong position in the wireless business will likely produce stable revenue and cash flow, by CFRA estimates. Verizon is relentlessly pushing forward in its core business, expanding its fiber-optic network, and deploying 5G wireless technology. On January 19, 2022, Verizon expanded its 5G network to 1,700 cities with 5G Ultra Wideband coverage on high-band spectrum. On June 14, 2022, Verizon announced that its users will observe an increase in capacity and speed on its 5G Ultra Wideband network, which will be running over the Citizens Broadband Radio Service (CBRS) spectrum.

◆ **T-Mobile US.** As of the second quarter of 2022, T-Mobile added 1.8 million wireless subscribers – 1.7 million of which were postpaid additions. Combining the additional postpaid subscribers with the addition of Sprint's customer base gave T-Mobile a total of 110 million subscribers as of the second quarter of 2022.

T-Mobile is poised to secure a sustainable lead in 5G, in CFRA's view, by leveraging its mid-band spectrum advantage. As of May 2022, T-Mobile's Extended Range 5G serves more than 315 million Americans and is anticipated to cover 99% of Americans by 2023. T-Mobile also tops its competitors in terms of geographic coverage. T-Mobile users can get a 5G signal more often than customers on any other network – 2.7-3.1 times as often as AT&T and Verizon, according to Opensignal.

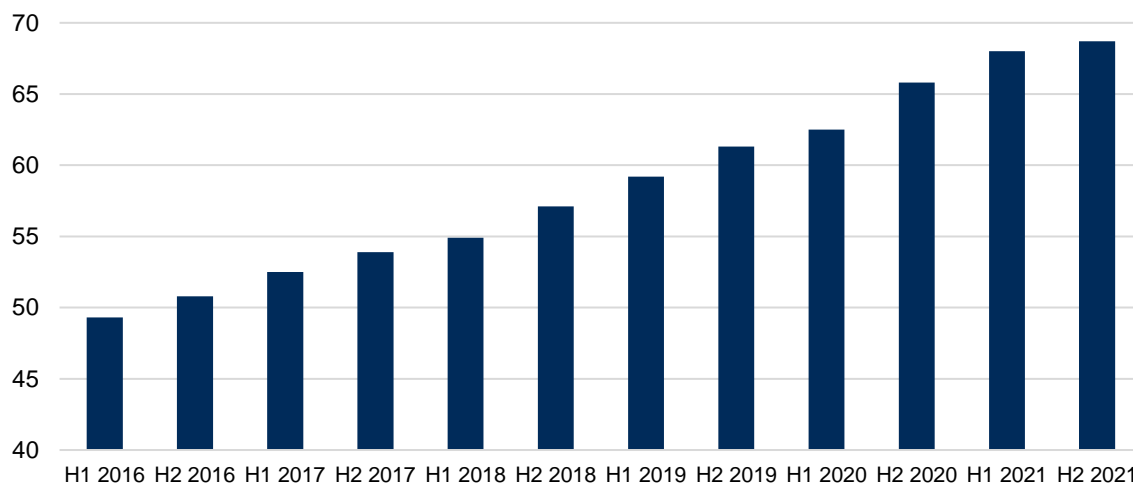
◆ **AT&T.** AT&T added 6.6 million wireless subscribers in the second quarter of 2022, serving a total of 203.4 million customers. The company is the third-largest wireless provider in the U.S. by its prepaid and postpaid wireless subscribers base of 101.8 million. Unlike Verizon, which connects fiber lines directly to homes, AT&T primarily uses a fiber-to-the-node (FTTN) deployment. Despite getting a late start on its rollout, the company completed the first wave of its planned buildout in less time and, overall, it has required less invested capital than a fiber-to-the-premises (FTTP) overbuild. AT&T's 5G deployment plans remain on track despite the Covid-19 outbreak. As of July 2022, AT&T's 5G coverage expanded to 14,000 cities and towns in the U.S.

### **Wireless Substitution Has Affected Wireline Voice and Broadband**

For the past few years, wireless has been one of the growth areas for the telecommunications industry. While wireless has been a highly profitable component for carriers like AT&T and Verizon that own their wireless operations, it has also hurt companies with traditional wireline businesses. With wireless plans offering unlimited minutes that can be used for local or long-distance calls along with unlimited internet connections, and the increased popularity of prepaid wireless service without a contract, this should not be surprising. Every wireless carrier offers a bundle of unlimited voice, web surfing, email, and text messaging. Mobile internet users on touchscreen smartphones consume vastly more data than those on traditional wireless phones.

The main driver of gains in average revenue per user (ARPU) for carriers has been data revenue growth. In addition to voice minutes shifting to wireless, the wireline carriers are losing access lines as some customers, particularly members of younger generations, use only mobile phones. When they move into new homes or apartments, these early adopters of wireless often forgo landline connections in favor of mobile phones. In the second half of 2021, approximately 68.7% of households were wireless-only, up from 68% in the first half of 2021, according to the National Center for Health Statistics.

#### PERCENTAGE OF WIRELESS-ONLY HOUSEHOLDS\*



\*Latest data released in May 2022.

Source: National Center for Health Statistics.

#### Competition from Cable Over Broadband Extending to Wireless Services

Cable companies are the industry leaders in broadband connections. The challenge for both telecom and cable companies is that penetration rates of their customers' bases are relatively high and so revenue growth needs to stem from faster connections.

In addition to broadband service, cable companies are also competing with telcos via their Voice over Internet Protocol (VoIP)-oriented cable telephony offerings. VoIP turns the human voice into digitized units, which are bundled into packets that can stream over a network at high speeds. At the receiving end, the packets are reassembled into an analog voice signal.

In addition to DISH's Boost Mobile business, Comcast, Charter Communications, and Altice Mobile have all launched mobile virtual network operator (MVNO) services in recent years, with the most recent being Altice in September 2019. The three cable operators have reported strong net adds during 2020, despite the pandemic. All three have benefited from entrenched enterprise clients that use their broadband offerings.

In May 2017, Comcast and Charter agreed to collaborate on their respective wireless business plans, particularly to accelerate their entry into the wireless market. Then, in July 2017, Charter announced that it intended to launch a wireless service in 2018 through the MVNO agreement with Verizon. In April 2018, Charter and Comcast announced that they had formed a 50/50 joint venture to cost-effectively develop and design back-end systems that support Comcast's Xfinity Mobile and Charter's Spectrum Mobile offerings. The operating platform will also serve as the systems interface for current and any future MVNO partners.

Comcast introduced its new wireless service using a hybrid of the cable operator's Wi-Fi hotspots and Verizon's network – Xfinity Mobile – in April 2017 and completed its nationwide rollout in August 2017. Xfinity Mobile, available to Comcast's Internet customers, provides a 4G LTE network for up to five lines with unlimited nationwide talk and text, no line access fees, and access to 18 million Xfinity Wi-Fi hotspots nationwide.

As of July 2022, each Xfinity Mobile customer can choose between paying only for the data used starting from \$15 per GB but with speeds reduced after 20 GB of usage, or unlimited data for \$45 per line. Comcast claimed that most consumers could save up to \$400 a year with Xfinity Mobile compared to other providers. In the first quarter of 2022, Xfinity Mobile added 318,000 new wireless subscribers.

### **The Emergence of Phone Leasing and Upgrade Programs Amid Demise of Subsidies**

Handset subsidies, or wireless operators' practice of shouldering some of the costs of selling flagship smartphones to reduce the initial sticker price of the phones to \$200 or less, provided carriers with significant customer additions but harmed their margins. Large subsidies are needed to pay for high-end smartphones, which also bring in high ARPU and low-churn subscribers, whose two-year contracts and payments allow carriers to recover the costs.

In the past few years, wireless operators have dropped their two-year contracts and the device subsidies that come with plans. T-Mobile eliminated subsidies in 2013, and now offers customers a choice of bringing in their own smartphones, paying the total cost upfront, or financing the smartphones over a two-year period. AT&T stopped offering two-year contracts in January 2016, while Verizon was the last major carrier to formally end phone subsidies after eliminating two-year contracts in January 2017.

All major U.S. wireless carriers have programs for phone upgrades, which involve leases and trade-in options for smartphones. As of July 2022, AT&T has a phone upgrade plan called AT&T Next Up, which allows customers to trade in their old devices and upgrade to a new device by spreading the cost of a device over 36 monthly installments. Customers who opt for the AT&T Next Up plan could trade in their phone for a newer model after paying 50% of the device price.

Verizon also started offering upgrades to iPhone models and Android phones, allowing for a phone upgrade after 30 days, provided that 50% of the phone's retail price has been paid. T-Mobile's JUMP! On Demand, which launched in June 2015, offers an 18-month leasing plan, with the option to upgrade the device once every 30 days. At the end of the lease term, customers can choose to upgrade, return, or purchase the device via a single payment or nine monthly payments.

## Operating Environment

Over the past few years, telecom companies have increasingly been forced to compete on price due to nearly identical products offered by each company (as the network performance gap closes, customers are increasingly less concerned about coverage and reliability). Telecom companies have high fixed costs and low marginal costs, which also naturally leads each to compete on price as it incentivizes companies to cut prices below their average total cost and near the marginal cost to win customers. These price wars have been harmful to the industry as they transfer profits directly from the industry to consumers.

However, we do see other forces beginning to stabilize the industry. We think the threat of entry is low given the economies of scale in the business. Any competitor would have to come in at scale, building a multi-billion-dollar broadband and/or wireless network. We think the recent merger and acquisition activity is indicative of the maturing industry and will strengthen the competitive positioning of the major players.

### **The Covid-19 Crisis Has Placed Unprecedented Demand on Communication Networks**

The Covid-19 pandemic accelerated many trends that were already underway. For example, work-from-home and social distancing policies generated a surge in remote work and media consumption. To cope with the significant traffic increases, network operators and governments across the globe are working to ensure that connectivity and communication services operate in a reliable and stable manner. Fixed and mobile broadband operators, as well as media content providers, have successfully maintained their networks to accommodate changes in utilization patterns with the peak period being stretched out during the day.

Mobile operators have responded by offering free data and services to their users, while also benefiting, in some cases, from access to additional spectrum resources to manage increased traffic volumes. In the U.S., AT&T, Verizon, and T-Mobile were granted approval from the regulator, the Federal Communications Commission (FCC), to reach a commercial agreement with satellite TV provider Dish, to borrow the company's unutilized wireless spectrum to add capacity to overcome congestion created by the Covid-19 lockdown. To help meet the increasing demand for Wi-Fi, FCC also granted network operators temporary access to spectrum in the 5.9 gigahertz (GHz) band to meet increased rural broadband demand. On November 18, 2020, the FCC also adopted new rules to make new spectrum for unlicensed uses, such as to improve automotive safety.

### **Taking 5G Network to the Next Level**

While some of the standards for 5G are still being established, all of the major U.S. carriers are fully focused on their 5G strategy, with AT&T, T-Mobile, and Verizon launching 5G networks and aggressively expanding those networks in 2022.

As of July 2022, AT&T's 5G network became available nationwide, expanding into 14,000 markets, covering 250 million Americans. Alongside this milestone, on July 23, 2020, AT&T announced plans to expand 5G access to prepaid customers. Starting on August 7, 2020, AT&T added 5G access to postpaid customers on its 5G unlimited plan. Although AT&T's nationwide footprint places it ahead of Verizon in the 5G market, it remains behind T-Mobile due to limited spectrum holdings. Being the highest bidder of the 3.45 GHz spectrum (under Auction 110) announced in January 2022, AT&T's acquisition of 3.45 GHz spectrum with 1,624 licenses won will help to strengthen its competitiveness in the market.

Most 5G networks were built upon the foundation of 4G networks in a type of 5G mode called non-standalone (NSA). This means that the mobile devices need to have both 4G and 5G signals to work in order to save time and money, leveraging 4G core infrastructure. T-Mobile is the first global mobile carrier to launch a standalone 5G network with nationwide coverage. T-Mobile's standalone 5G network is built upon the foundation of the company's low-band spectrum (600 MHz) 5G rollout, which started in 2019 with non-standalone, but also leverages the company's mid-band spectrum (2.5 GHz) and high-band



spectrum (28 GHz or mmWave). Notably, T-Mobile gained the mid-band spectrum with the acquisition of Sprint, which has roughly 160-200 MHz of that spectrum nationwide. This will allow the carrier to offer 5G's full feature set, including ultra-high download speeds, low latency, high connection densities, and network slicing capabilities. CFRA thinks this may allow T-Mobile to acquire new consumers before rivals have a chance.

Verizon has massively expanded its 5G network in 1,700 cities, while its fixed wireless 5G home product is currently available in 900 cities. This vast expansion was primarily contributed by its large win in Auction 110 for C-band spectrum, which has helped to enhance its mid-band portfolio.

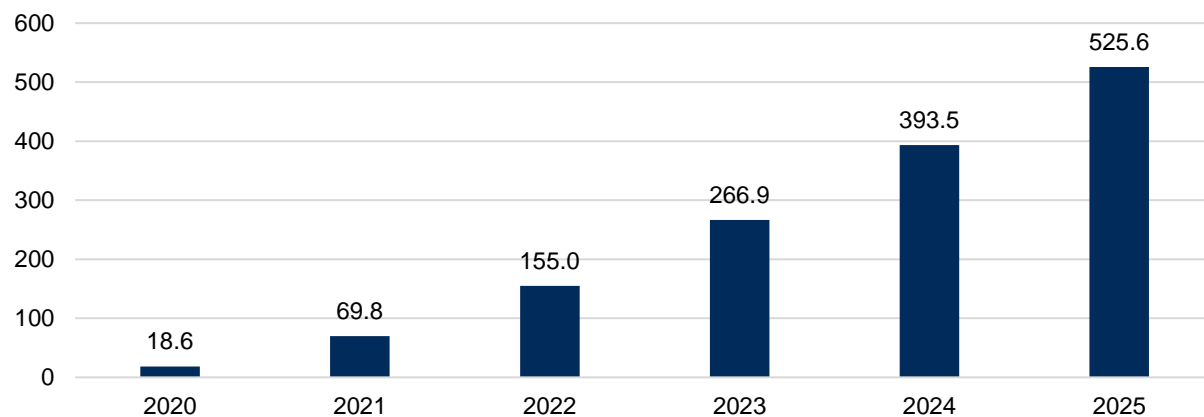
Another new rival, Dish, has finally managed to meet its deadline with FCC to launch its 5G services on June 14, 2022. The operator has also launched its services in more than 120 cities across the U.S. with coverage of over 20% of the U.S population, as of June 14, 2022. In addition, Dish has also expressed its intention to utilize the 12 GHz spectrum it already owns for its 5G services. Nevertheless, SpaceX, which heavily depends on the 12 GHz spectrum to provide internet from its Starlink satellites, is opposing the proposal to allow the operation of 5G services under the 12 GHz spectrum. In early July 2022, SpaceX began recruiting its fans to sign petitions by sending a pre-written message to the FCC and U.S. lawmakers to eradicate Dish's proposal to use the 12 GHz for terrestrial 5G. As a result, the FCC's public comment system has been flooded with more than 70,000 messages to preserve the Starlink satellite system. SpaceX also claimed that the proposal would disrupt its satellite internet service, whereas Dish reiterated that Starlink and ground-based 5G are able to work cohesively.

While 5G C-band deployments are on track to be activated by wireless carriers, the aviation industry expressed concerns in January 2021 on potential major interference to the aviation industry from the 5G implementation. The 5G rollout discussion between wireless and aviation industries has been ongoing since November 2021, where the two parties initially agreed on a 30 additional days delay for the rollout until January 5, 2022. On June 18, 2022, according to *Wall Street Journal*, AT&T and Verizon announced that they target to gradually lift self-imposed limits on their 5G network expansion near some airports over the next year. The companies also said that the timeline would suffice for airlines to retrofit aircrafts. This has unfortunately caused the aviation industry's issues with 5G rollout to resume, as major airline companies claimed the new timeline was reckless. The agreement enacted in January 2022 between the two parties expired on July 5, 2022. In addition, the Federal Aviation Administration (FAA) also said that the aviation industry has established the next course of action to protect commercial air travel and cellphone services over the coming year. AT&T and Verizon also aim to turn on their enhanced 5G services surrounding more airports in phases within the same period. However, the largest U.S. passenger airlines, Airlines for America expressed its concern about the timeline to the FAA and is seeking to upgrade other sensitive radar altimeters by July 2023.

With 5G mobile service coming to market beginning in late 2018 up to now, IDC projects U.S. mobile 5G subscribers will grow to 525.6 million in 2025 from 18.6 million in 2020 (latest available), representing a CAGR of 95.1%.

### U.S. 5G MOBILE SUBSCRIBERS FORECAST, 2020-2026\*

(in millions)



\*Latest available data.

Source: IDC, October 2021.

### New Unlimited Wireless Plans

Low churn during Covid-19-related lockdowns offers an opportunity for U.S. mobile carriers to retain and engage their existing customers. The industry has kept unlimited wireless plan prices largely stable since June 2020, which we view as prudent, with consumers reluctant to switch carriers amid Covid-19. As shown in the table below, Verizon's unlimited wireless plan is still the priciest as compared to AT&T and T-Mobile. Verizon offers a number of wireless bundled deals, which include Disney+, Discovery+, and Apple Music. CFRA thinks the bundled contents will help to enhance the perceived value of Verizon's unlimited wireless plan. Nevertheless, AT&T has relinquished its HBO Max streaming services from bundled perks for new customers on its highest-tier unlimited wireless plan after the sale of WarnerMedia to Discovery.

T-Mobile Magenta seems to be the cheapest single plan as compared to the other two rivals and also provides savings for multiple lines where the carrier offers the third line for free. T-Mobile announced 1.7 million postpaid net additions in the second quarter of 2022. These impressive stats imply the company led the industry in subscriber adds once again, highlighting the brand's appeal.

### STANDARD UNLIMITED PLAN PRICES\*

Number of Lines	Verizon Play More Unlimited / Do More Unlimited	AT&T Unlimited Extra	T-Mobile Magenta
1	\$80	\$75	\$70
2	\$70	\$65	\$120
3	\$55	\$50	\$120
4	\$45	\$40	\$140
5	\$40	\$35	\$160

\*Data as of July 31, 2022.

Source: Company Websites.

### Wireless Price Wars Will Continue, but the Battle Will Shift to Additional Services

At this point, unlimited data plans are standard across the industry. This has led to rapid growth in mobile data traffic, which has forced operators to invest heavily in additional network capacity. All of the unlimited plans feature data caps to help control heavy data users, but these limits continue to grow as applications become increasingly data heavy. Competition in the space has shifted to additional services offered with these unlimited plans, with access to video streaming services being the most common. T-Mobile includes Netflix with its Magenta plans, and Verizon has partnered with Disney to offer a free year of Disney+ to its wireless customers. Meanwhile, AT&T has stopped including HBO Max on its higher-end plans after the sale of WarnerMedia to Discovery. We expect competition among the top three, as well as pressure from newer entrants, to continue to drive the price of wireless plans down for consumers.

### CONSUMER PRICE INDEX FOR ALL URBAN CONSUMERS: TELEPHONE SERVICES

(1997=100, monthly, not seasonally adjusted)



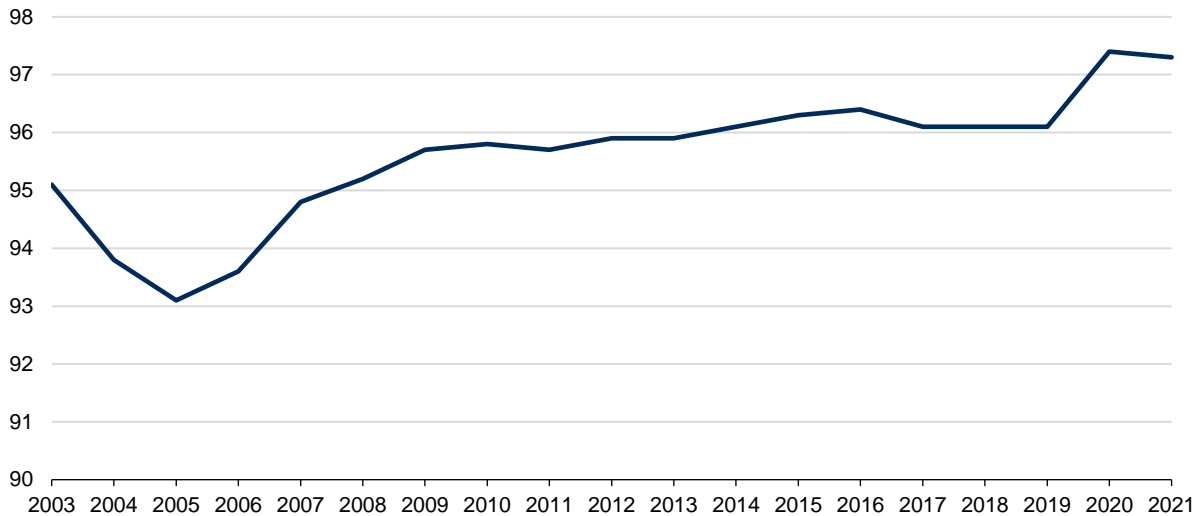
\*Data through June 2022.

Source: FRED.

### Growth in Wireline Broadband is the Key to Offsetting Voice Declines

Broadband has become a focus for telecom carriers. Hurt by regulators, innovators, and consolidators, the local voice telephone market has been under pressure, with access lines for telecom carriers declining, but the overall market has shown some signs of stability. Telephone penetration, defined as the percentage of U.S. households with access to telephone services (including cellphones), marginally declined to 97.3% in 2021 from 97.4% in 2020, according to FCC's "Universal Service Monitoring Report 2021".

## PERCENTAGE OF HOUSEHOLDS WITH TELEPHONE SERVICES\*



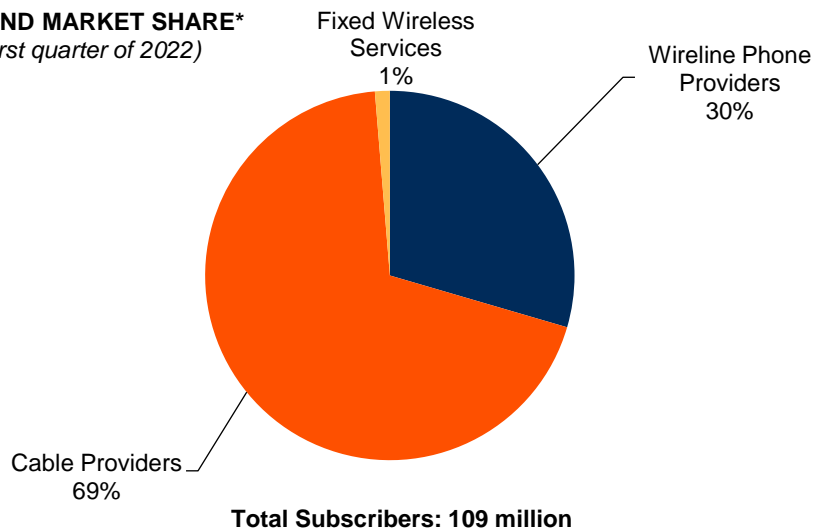
\*Data released on January 14, 2022.

Source: Federal Communications Commission.

The total number of landlines or access lines has been in decline across the telecommunications industry for many years because of competition from wireless and cable companies, and lower consumer spending. However, increased penetration of VoIP phone services has partially offset these access line declines. Importantly, monthly revenue per household served – the sum of revenues from voice lines, high-speed internet, and video services – is rising on an annual basis for many telecom carriers.

The largest cable and telecom providers in the U.S. – representing about 96% of the market – had about 1.07 million net additional broadband internet subscribers in the first quarter of 2022, compared to a gain of about 1.12 million subscribers in the first quarter of 2021, according to industry research provider Leichtman Research Group (LRG) Inc.

## BROADBAND MARKET SHARE\* (as of the first quarter of 2022)



\*Data released on May 18, 2022.

Source: Leichtman Research.

While the rate of growth has slowed due to high penetration rates, there is still room to grow as service is deployed to new markets. LRG reported that broadband subscribers in the U.S. totaled 109 million as of the first quarter of 2022, with top cable companies comprising 76 million broadband subscribers, top wireline phone companies and fixed wireless services accounting for 32 million and 1 million, respectively.

U.S. consumer fixed broadband services subscriptions are projected to increase at a compounded annual growth rate (CAGR) of 0.7% from 2021 to 2024, according to forecasts by IDC as of June 2022. As of the end of 2019 (latest available data), only 4.5% of Americans do not have access to both fixed terrestrial broadband at speeds of at least 25 Mbps/3 Mbps and mobile LTE at speeds of at least 5 Mbps/1 Mbps, according to the “2021 Broadband Deployment Report” by the FCC on January 19, 2021 (latest published).

In addition to benefiting as the overall broadband market expands, telecommunications carriers seek to take market share from local cable providers by presenting faster connection speeds and offering discounted service bundles with price security. Carriers compete on price and speed in markets where there is more than one provider. We have seen prices on lower speed plans decrease over the past few years, driven in part by a shift in consumer demand towards higher speed premium packages. We have seen strong consumer interest in gig-speed broadband packages, especially in 2020 as the pandemic forced many to work from home. In the past few years, telcos made investments aimed at more than doubling the broadband connection speeds available to households. The larger carriers also have extended fiber across a large portion of their respective service areas to bring high-speed broadband and video to subscribers. The small and mid-sized carriers have increased speeds as well.

In the coming years, we expect to see additional broadband competition from a number of new satellite operators. Satellite internet has been around for over 25 years, but the plans are often pricey, offer very slow speeds, and suffer from very high latency. These issues stem from the use of large, expensive satellites that are launched into geostationary orbit. This orbital plan sits 22,236 miles away from earth, which means that even at the speed of light, the round trip travel time for a signal is 240 milliseconds under ideal conditions. Most broadband service is able to achieve latencies under 40 milliseconds, while 5G networks expect to have sub-5 millisecond latencies. A new generation of satellite internet providers is beginning to emerge. SpaceX’s Starlink network is a constellation of low-earth orbit (210 miles) satellites to provide fast internet around the globe. It currently has over 2,400 satellites in orbit, with the approval for 12,000. Starlink is currently conducting a beta test of its service with 10,000 customers. Amazon is also planning to launch its own satellite constellation to provide high speed internet, although there are currently few details on its strategy. Given the speeds we are seeing from the initial deployments of this new breed of satellite internet, CFRA expects competition will further intensify.

U.S. broadband networks have managed to accommodate higher demand, particularly from the increase in home broadband usage during the pandemic, thanks to its fast network speeds compared to other developed nations. In the long term, CFRA thinks both wireless and wireline broadband speeds will likely continue to increase due to demand. Not only is content continuing to become richer and more data-intensive (such as high-definition video), but data that was previously consumed offline is moving online and requiring broadband. For example, storage and backups moving to the cloud, television and radio being delivered “over the top,” and even very large video games that were once delivered on disks are now being directly downloaded. Wireline broadband subscribership will likely also continue to grow due to a combination of faster speeds and the rise of in-home Wi-Fi usage to avoid extra data usage costs on capped wireless data plans. Increasing broadband speeds and coverage across the U.S. is a priority for the FCC. All in all, CFRA thinks broadband services will provide top-line growth for the U.S. wireline carriers, given that consumers will likely continue to pay a premium for faster home broadband connections.

## Regulatory Updates

### **Biden Administration Committed to Boost Infrastructure Spending**

On November 15, 2021, President Biden signed the Bipartisan Infrastructure Bill (Infrastructure Investment and Jobs Act) with a target of \$1.2 trillion in federal spending over the next five years. The bill comprises \$500 billion in new spending allocated for highways, bridges, broadband access, power grids, and more. The bill also includes a \$42.5 billion allotment for broadband equity, access, and deployment program to issue grants aiming to provide high-speed internet access to unserved and underserved communities. This is a major initiative as a part of the government's effort to make broadband more affordable to all Americans.

### **Spectrum Sale to Enhance Networks, M&A Potential for Industry**

The Auction 110 for mid-band spectrum in the 3.45 GHz band was concluded on January 4, 2022. The auction has made a mark to be one of the highest auctions in FCC's history, with a total of \$22.4 billion raised in net bids and \$22.5 billion in gross bids, coupled with 23 bidders winning a total of 4,041 licenses. AT&T was the biggest spender in the auction, with a total net bid of more than \$9 billion with a total of 1,624 licenses won. Dish Network, bidding under the name Weminuche LLC, came in second with total spending of \$7.3 billion and Verizon was surprisingly a no-show in the auction. The 3.45 GHz band combined with 3.5 GHz and 3.7 GHz represent 530 megahertz of mid-band spectrum, a stepping stone to deliver the promise of 5G that is fast, secure, resilient, and available across the nation.

The Auction 107, also known as the C-band spectrum, closed on January 15, 2021, with 280 MHz of licensed mid-band spectrum on the table. The auction raised \$80.9 billion in gross bids from dozens of bidders in the mobile, telecom, satellite, and fixed wireless space. On February 24, 2021, the FCC announced 21 bidders won all available 5,684 licenses with net winning bids of over \$81.1 billion and gross winning bids of \$81.2 billion, shattering records for being the world's most expensive mid-band 5G spectrum auction. Verizon led the pack with a total of \$45.5 billion gross winning bids with 3,511 licenses won, followed by AT&T spending \$23.4 billion with 1,621 licenses won, and T-Mobile spending \$9.3 billion with 254 licenses won.

The FCC's first big mid-band spectrum auction, Auction 105 for 3.5GHz CBRS licenses, ended in August 2020, and successfully raised a total of \$4.6 billion in bids. As widely expected, Verizon showed up at the auction in a big way, committing more than \$1.9 billion in bids and winning 557 licenses. Dish Network, bidding under the name Wetterhorn Wireless, showed up as the second largest total winning bidder, and made a total bid amount of \$912.9 million. Meanwhile, T-Mobile won only eight licenses with a total bid amount of \$5.6 million. T-Mobile is deploying 2.5 GHz mid-band spectrum acquired through the merger with Sprint, so it is not as desperate for this mid-band spectrum as Verizon. However, rival AT&T and U.S. Cellular were no-shows.

In March 2020, the FCC completed Auction 103, which made 3,400 MHz of mmWave spectrum available in the upper 37 GHz, 39 GHz, and 47 GHz bands. As seen in the table below, the auction had a total of \$7.5 billion in winning bids. Auction 103 comprised a total of 14,142 spectrum licenses. Bidding at Auction 103 was more fierce for 37 GHz and 39 GHz spectrum than for 47 GHz as the network operators face challenges to build 47 GHz spectrum outside of urban areas. The largest winner was Verizon, which won 4,940 out of 14,142 licenses. The second largest winner was AT&T, which won 3,267 licenses.

In early 2019, the FCC also held two mmWave auctions in a move to support the deployment of 5G wireless and Internet of Things (IoT) services. The first auction – Auction 101 of 28 GHz spectrum – offered a total of 2,965 licenses and generated around \$700 million in total winning bids. The second auction – Auction 102 of 24 GHz spectrum – comprised of 2,904 country licenses and generated a total of \$2 billion in winning bids.

AT&T was the bid leader with total bids of \$982 million, buying 49% of all the available licenses, while T-Mobile was in second place with \$803 million in total bids, buying 40% of all available licenses. Verizon spent the most in the 28 GHz spectrum auction, with total bids of \$506 million for the spectrum. Also, U.S. Cellular – a regional wireless network provider – was in second place in the 28 GHz auction, with a total of \$129 million in winning bids.

As seen in the table below, there were a couple of surprises in the auctions. Under the 24 GHz spectrum auction, Verizon made the lowest bid of only \$15 million in total winning bids. Verizon has made clear its intention to build 5G in mmWave spectrum by bidding 28 GHz licenses through its purchase of XO and Straight Path.

#### AUCTIONS 102, 103, 107 & 110 BY CARRIERS

(total net bids in \$, millions)

Bidder	Auction 102: 24 GHz		Auction 103: 37 GHz, 39 GHz, and 47 GHz		Auction 107: C-Band 3.7 GHz		Auction 110: 3.45 GHz		Total	
	Total Net Bids Amount	Number of Licences Won	Total Net Bids Amount	Number of Licences Won	Total Net Bids Amount	Number of Licences Won	Total Net Bids Amount	Number of Licences Won	Total Net Bids Amount	Number of Licences Won
AT&T	\$982.5	831	\$2,379.1	3,267	\$23,406.9	1,621	\$9,079.2	1,624	\$35,847.6	7,343
T-Mobile	\$803.2	1,346	\$931.6	2,384	\$9,336.1	142	\$2,898.4	199	\$13,969.3	4,071
Verizon	\$15.3	9	\$3,417.1	4,940	\$45,454.8	3,511	-	-	\$48,887.2	8,460
U.S. Cellular	\$126.6	282	\$146.3	238	\$1,282.6	254	\$579.6	380	\$2,135.1	1,154
Others	\$95.2	436	\$695.8	3,313	\$1,634.1	156	\$9,861.1	1,838	\$12,286.1	5,743
<b>Total</b>	<b>\$2,022.7</b>	<b>2,904</b>	<b>\$7,569.9</b>	<b>14,142</b>	<b>\$81,114.5</b>	<b>5,684</b>	<b>\$22,418.3</b>	<b>4,041</b>	<b>\$113,125.4</b>	<b>26,771</b>

Source: Federal Communications Commission (FCC).



## M&A Environment

Over the last several years, demand for fast and reliable connectivity has grown exponentially. The telecommunications industry has experienced rapid convergence in order to appeal to the digital age and is expected to continue to benefit from the rapid development of mobile devices, the increased popularity of smartphones, and the Internet of Things (IoT). The telecommunications industry has undergone significant changes through consolidating merger and acquisition (M&A) activity.

As of July 2022, there have been several ongoing and completed M&A activities in the industry. On August 3, 2021, Apollo Global Management agreed to acquire the incumbent local exchange carrier business of Lumen Technologies for \$7.5 billion. As part of the deal, Apollo will acquire Lumen assets, including local fiber and copper networks, and broadband and voice for consumer, enterprise, and wholesale customers. On top of that, Atlantic Broadband Finance entered into a definitive agreement to acquire Ohio Broadband Systems of WideOpenWest for a deal of \$1.1 billion on June 30, 2021. The deal was closed on September 1, 2021. On April 8, 2021, GI Manager L.P, a leading U.S.-based investor in data infrastructure, also acquired ORBCOMM for \$1.2 billion. The investment by GI Partners will support ORBCOMM's strong momentum in the industrial IoT as it increases its investment in sales, marketing, and technology innovation.

### U.S. TELECOMMUNICATIONS SECTOR M&A ACTIVITY SINCE 2018

(deals of at least \$1 billion, as of July 31, 2022)

DATE ANNOUNCED	BUYER	TARGET	TRANSACTION VALUE (\$ million)	TRANSACTION STATUS	DATE CLOSED
08/03/21	Apollo Global Management	Incumbent Local Exchange Carrier Business in 20 States of Lumen Technologies	7,500	Announced	-
06/30/21	Atlantic Broadband Finance	Ohio Broadband Systems of WideOpenWest	1,125	Closed	09/01/21
04/08/21	GI Manager L.P	ORBCOMM	1,187	Closed	09/01/21
11/01/20	Stonepeak	Astound Broadband	8,100	Closed	08/19/21
09/14/20	Verizon	TracFone	6,900	Closed	11/23/21
08/27/20	Sprint Spectrum	Shenandoah Personal Communications	1,890	Closed	07/01/21
08/06/20	Liberty Broadband	GCI Liberty	12,494	Closed	12/18/20
01/24/20	Macquarie Infrastructure and Real Assets	Cincinnati Bell	2,934	Closed	09/07/21
07/26/19	DISH Network Corporation	Prepaid Wireless Business of Sprint Corporation	1,400	Closed	07/01/20
05/08/19	EQT Partners; Digital Colony Management; Delaware	Zayo Group	14,438	Closed	03/09/20
04/29/18	T-Mobile US	Sprint Corporation	83,649	Closed	04/01/20

Source: CFRA, S&P Global Market Intelligence.

## Wireline Competition Heats Up with Mergers

◆ **AT&T Inc.** On May 17, 2021, AT&T announced a deal targeting to be one of Hollywood's biggest studios alongside media giants Netflix and Disney, with the intention to combine its content unit WarnerMedia with Discovery. Under the agreement, AT&T will form a new media company with Discovery by unwinding its \$85 billion acquisition of Time Warner in 2018. The new publicly traded company of the combined entities is named Warner Bros. Discovery. AT&T received \$40.4 billion in cash and WarnerMedia's retention of certain debt. AT&T shareholders also received 1.7 billion shares of Warner Bros Discovery, representing 71% of WBD shares on a fully diluted basis. The deal was concluded in April 2022.

On June 14, 2018, AT&T completed its acquisition of media company Time Warner in a stock-and-cash transaction. The U.S. Department of Justice filed a lawsuit in November 2017 to block AT&T's bid to buy Time Warner, claiming the deal violates antitrust law, given AT&T's ownership of both DirecTV and Time Warner. However, in June 2018, the deal was approved by the federal judge with no major conditions imposed. The merger is deemed accretive to AT&T's adjusted earnings per share and free cash flow, according to the company. AT&T has leveraged the Time Warner assets to take on Disney and Netflix in the streaming space with the launch of HBO Max, which it has previously used on the mobile side as a customer retention tool.

◆ **Verizon Communications Inc.** On May 3, 2021, Verizon announced the sale of its media group for \$5 billion to private equity firm Apollo Global Management. The sale allows Verizon to offload properties from AOL and Yahoo, where the new company will be rebranded to just Yahoo, with Verizon keeping a 10% stake in the company. The transaction was completed in September 2021.

On November 23, 2021, Verizon completed its acquisition of TracFone Wireless Inc., a provider of wireless prepaid services, from America Movil SAB for \$6.9 billion. TracFone has about 21 million prepaid customers in the U.S. under its namesake as well as budget brands StraightTalk, Net10, SafeLink, and Simple Mobile. The move plunges Verizon deep into the prepaid market, a segment it has largely avoided, by catering to more lucrative customers to pay for wireless service after it is rendered. The acquisition comes as Verizon faces new pressure from T-Mobile U.S.

On December 14, 2017, Verizon completed the \$225 million purchase of certain fiber-optic network assets serving the Chicago market from WideOpenWest Inc., as part of Verizon's plan to accelerate the deployment of next-generation broadband services. On February 1, 2017, Verizon completed the acquisition of XO Communications, LLC (XO) fiber-optic network business for \$1.5 billion. The transaction granted Verizon access to XO's fiber-based Internet Protocol (IP) and Ethernet networks that better serve Verizon's enterprise and wholesale customers. In addition, the fiber facilities have helped Verizon densify its cell network.

In June 2017, Verizon completed the acquisition of tech company Yahoo Inc. for \$4.5 billion. The acquisition price was lowered by \$350 million in February 2017, from the initial \$4.8 billion, after Yahoo disclosed two massive cyber-attacks on its platform. Shortly after the acquisition, Verizon integrated both Yahoo and AOL into a new subsidiary company known as Oath, which was rebranded as Verizon Media in January 2019. Verizon Media is currently a diverse house of more than 50 media and technology brands that engage over a billion people around the world. Verizon acquired AOL Inc., a pioneer in dial-up internet access, in June 2015 for \$3.8 billion. The transaction helped expand the company into two key areas: mobile and video.

◆ **Lumen Technologies (formerly known as CenturyLink).** CenturyLink rebranded to Lumen Technologies on September 14, 2020. This move aligns with the company's strategy to tap growth in enterprise fiber services. The company has grown via acquisitions to become the fourth-largest telecom

provider in the U.S., offering services to both residential and business customers. On August 3, 2021, the company announced its intention to sell its incumbent local exchange carrier business, including its consumer, small business, wholesale, and mostly copper-served enterprise customers and assets, in 20 states to Apollo Global Management, Inc. The \$7.5 billion deal comprises assets acquisition of local fiber and copper network, broadband and voice for consumer, enterprise, and wholesale customers, coupled with fiber and copper connectivity to enabled buildings, connecting to tower sites, as well as central offices. The deal is expected to conclude in the second half of 2022.

In November 2017, the company acquired Level 3 Communications for about \$34 billion, including debt. We see the acquisition as positive, giving the combined entity a greater geographic footprint and economies of scale, as well as some cost synergies and higher free cash flow. However, Level 3 also faced some of the same structural declines and slowing growth as its acquirer.

# HOW THE INDUSTRY OPERATES

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## Multiple Technology Platforms

A technology platform refers to the equipment that transmits telecommunication signals in a wireless network. These platforms operate according to one of several electronic protocols, or standards, which determine how the network is configured and how signals are processed within it.

Many countries have adopted a single standard for nationwide use, but the U.S. market currently employs several standards. Nevertheless, different platforms are increasingly becoming compatible with one another. At present, most U.S. carriers use either global system for mobile (GSM) or code division multiple access (CDMA).

◆ **Global System for Mobile.** As the 2G standard adopted in the European Union (EU), Global System for Mobile Communications (GSM) is the most widely used wireless technology in the world. GSM uses 2G digital technology, TDMA transmission methods, and a digital encoder that emulates the characteristics of human speech. A very efficient data rate/information content ratio is achieved with this method of transmission.

◆ **Code Division Multiple Access.** The code division multiple access (CDMA) standard sends multiple signals using an encryption method based on the unique signal of each handset. It is also known as spread spectrum multiple access (SSMA) because each signal is spread across a broad segment of spectrum. Developed by Qualcomm Inc., CDMA was first introduced commercially in Hong Kong in 1995. It is currently used predominantly in China, India, Japan, South Korea, and North America.

When implemented in a cellular network, 2G CDMA technology offers numerous benefits to the cellular operators and their subscribers. It can increase capacity eight to 10 times that of an advanced mobile phone service (AMPS) analog system and four to five times that of a GSM digital system. Initially, CDMA did not fully live up to its promise of greater capacity, but ongoing improvements have been made.

### 4G Digital Systems

These platforms allow wireless operators to meet the booming demand for new services, such as high-speed data and multimedia services. There are two competing fourth generation (4G) technologies: Long-Term Evolution (LTE) and Worldwide Interoperability for Microwave Access (WiMAX).

◆ **Long-Term Evolution.** This technology is the latest standard in the mobile network technology tree that produced GSM/EDGE and UMTS/HSPA network technologies. Long-Term Evolution (LTE) has significantly improved end-user throughputs, with speeds of 100 Mbps on the downlink and 50 Mbps on the uplink. It is deployed by many of the national carriers in the U.S., including Verizon, T-Mobile, and AT&T.

◆ **Worldwide Interoperability for Microwave Access.** This is a wireless broadband access technology based on the 802.16 family and is intended to serve as an alternative to wire technologies. Worldwide Interoperability for Microwave Access (WiMAX) offers optimal future speeds of 100 Mbps for high mobility and up to 1 Gigabit per second (Gbps) for fixed or low mobility.

### 5G: Looking to the Future

While the deployment of 5G networks started in late 2018, commercial deployment of 5G networks is aimed at meeting the requirements for mobile communications beyond 2020. Rising mobile data consumption requires more support, a key objective of the 5G network.

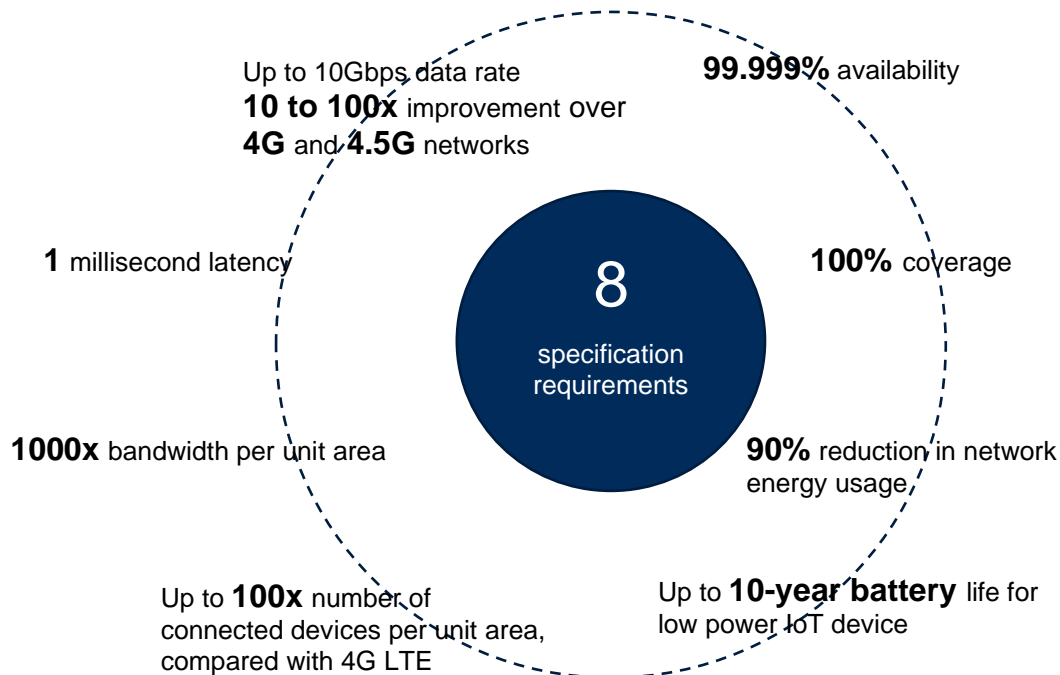
4G wireless technology provides the foundation for 5G. Unlike 4G, which requires large, high-power cell towers to radiate signals over long distances, 5G wireless signals are transmitted via large numbers of small cell stations located in places like light poles or building roofs. 5G uses a 5G New Radio interface, along with other new digital technology called massive multiple-input multiple-output (MIMO), to transfer more data over the air for faster speed, reduced congestion, and lower latency. 5G download speeds can reach 1,000 Mbps. Low-band 5G is more likely to be available for more rural locations with speeds up to 250 Mbps, while mid-band 5G is available in major urban areas with download speeds up to 900 Mbps.

Initially, 5G standards were associated with the International Telecommunication Union's International Mobile Telecommunications-2020 (IMT-2020) standard, which required a theoretical peak download capacity of 20 gigabits per second, along with other requirements. However, 3GPP, the industry standards group, proposed the 5G New Radio (NR) standard together with LTE as its submission to the IMT-2020 standard.

After initially delivering "Non-Stand-Alone" (NSA) NR specifications for 5G in late 2017, 3GPP worked on completing Release 15, which is the first full set of 5G standards. While initial specifications enabled NSA 5G radio systems to be supported by existing 4G infrastructure, Release 15 extends to cover "standalone" 5G, with a new radio system complemented by a next-generation core network. On July 2, 2020, 3GPP finalized Release 16, the second set of specifications for 5G New Radio technology. Release 16 is set to target enhancements for new capabilities and expansion into different verticals, including support for unlicensed spectrum, industrial IoT, and automotive applications. Looking ahead, 3GPP highlighted that Release 17 is expected to be completed in 2022.

WIRELESS TECHNOLOGY STANDARDS				
GENERATION		ACCESS TECHNOLOGY	TRANSMISSION SPEED	ADVANTAGES / DISADVANTAGES
2G		GSM cdmaOne (IS-95A)	14.4 kbps 14.4 kbps	Widely deployed, allows international roaming Stronger security features, longer handset battery life, more efficient use of bandwidth than GSM. Disadvantages include lack of global roaming capabilities, narrow deployment, fewer equipment suppliers, proprietary technology.
2.5G	For GSM	GPRS	64 kbps	"Always on" allows easier Internet browsing. Bandwidth shared with other users a disadvantage.
		EDGE	384 kbps peak, 140-160 kbps more likely.	Allows greater data rates per timeslot than GSM/GPRS.
	For CDMA	cdmaOne (IS-95B)	64 kbps peak, 14.4 kbps typical.	4 to 5 times capacity of GSM systems.
3G		WCDMA	2 Mbps peak, 400 kbps typical.	Faster data speeds and greater capacity than CDMA2000 1X. More expensive to deploy than CDMA2000 1X. Not compatible with earlier GSM networks.
		TD-SCDMA	2 Mbps peak, 1.2 Mbps typical.	Excellent for transmitting Internet data. Wide coverage area, more efficient use of spectrum for one-way transfer. Disadvantages include no commercial deployments, few equipment vendors.
		CDMA2000 1X(Relase 0)	307 kbps peak, 144 kbps typical.	Greater voice and data transmission capacity than cdmaOne using same bandwidth.
		CDMA 1X EV-DO (Evolution-Data/Optimized)	2.4 Mbps peak, 750 kbps typical.	Faster data speeds, handsets compatible with earlier CDMA networks.
		CDMA 1X EV-DV (Evolution-Data/Voice)	3.1 Mbps peak	Able to deliver real-time video streaming.
3.5G	For GSM/WCDMA	HSDPA (High-Speed Downlink Packet Access)	14 Mbps future potential, currently 3.6 Mbps	Delivers streaming video, interactive gaming, and multimedia music WCDMA tracks at speeds almost 3 times faster than WCDMA. Compatible with GSM/WCDMA.
	For GSM/W-CDMA	HSPA+ R8 (High-Speed Packet Access Plus)	Enhances rates up to 42 Mbps; future potential to 84 Mbps and beyond	Doubles data capacity over HSPA, more than doubles voice capacity over WCDMA. Enhances end-user experience, improved "always-on" experience.
	For CDMA	CDMA 1X EV-DO Revision A (Evolution-Data Optimized)	3.1 Mbps peak download speed, 1.8 Mbps upload	Revision A is an upgrade for CDMA 1X EV-DO. Compatible with CDMA networks.
4G	For GSM/WCDMA	LTE (Long Term Evolution)	100 Mbps peak download, 50 Mbps upload	Widely supported by equipment suppliers and wireless operators. Compatible with GSM/WCDMA.
		LTE-Advanced	1 Gbps peak download, 500Mbps upload	Compatible with GSM/WCDMA/LTE.
	For CDMA	UMB (Ultra Mobile Broadband)	288 Mbps peak download, 75 Mbps upload	Compatible with CDMA networks. Disadvantages on fewer equipment suppliers. Discontinued.
		WiMAX	128 Mbps peak download, 100 Mbps upload	High power consumption a disadvantage.
5G	For GSM	New Radio (NR)	Low-Band Spectrum (<1 GHz): 250 Mbps peak download Mid-Band Spectrum (1-6 GHz): 900 Mbps peak download High-Band Spectrum (>24 GHz): 2 Gbps peak download	Provide widest coverage among the spectrums. Lower data speeds as compared to mid-band and high-band spectrum. Provide wide coverage with high data speeds. Able to transmit very high volume of data at ultra-high speeds. Short range of coverage and cannot penetrate buildings.
Sources: CFRA, CDMA Development Group; GSMA Intelligence; S&P Global.				

## SELECTED 5G ATTRIBUTES AND CAPABILITIES



Source: Thales.

## The Network Buildout: Managing the System

Depending on the topography and population density of the area served, the radius of a rural cell, or service area, can be 10 miles or larger. However, in large cities, microcells (cells with a radius of 500 feet or less) are often needed to provide seamless coverage. Because handsets have trouble picking up signals inside buildings, dedicated transmitters/antennas are needed to provide indoor service to such locations as tall office buildings or underground garages. Ideally, coverage of a service area should be complete yet unduplicated; in reality, cells frequently overlap, and obstructions such as buildings can cause gaps in service.

As companies build and expand their networks, their focus will shift toward managing their systems. They will need to bill not only their own customers for using their service, but other wireless and wireline providers as well. When customers roam, signals can be handed off from one company's cell site to another's. When this occurs, a fee is charged, although these roaming charges have become less common in recent years, as carriers have consolidated or formed alliances to carry one another's traffic.

The transmission network of a telephony system is managed by an operations control center, which keeps track of performance, collects billing data, and picks up any alarms. Computer systems that are connected to switches, cell sites, and other network equipment monitor performance and relay detailed information about traffic patterns and bandwidth availability to the control center. Network employees can thus be made immediately aware of any equipment failures and often can correct potential problems before the customer experiences any decline in service.



Management networks—the total infrastructure for transmitting phone messages—must oversee equipment from many vendors deployed across a telephony system, while at the same time facilitate seamless connections with other carriers' systems. Software programs built into today's intelligent management networks can provide platforms for fraud control, customer interface, inter-network communications, and other complex administrative, maintenance, and operating functions. These programs are increasingly being loaded with marketing and strategic planning functions as well.

Wireless systems must be designed to connect with the landline infrastructure already in place, as this is where much traffic originates and terminates. In the U.S., where the existing infrastructure is extensive, carriers are attempting to create flexible wireless systems that can function across analog and digital platforms, low and high frequencies, and a variety of equipment from many vendors. Ideally, these new systems will be open to expansion, technological enhancement, and the convergence of voice, data, and video services.

## **Bandwidth is All the Rage**

In the wireless segment, coverage (the area a company serves) is king. However, bandwidth (the amount of data that can be carried by a channel, measured in bits per second) is close to the throne. Bandwidth determines the depth and level of the services that a company can provide, and today's high-speed, graphics-rich data transmissions require significantly more bandwidth than voice communications.

The amount of bandwidth a wireless network has is determined by the number of spectrum licenses the operator has in a given area. The frequency of the spectrum is also an important factor. Low-band frequencies have excellent propagation properties, given it is able to pass through most objects, but has limited data capacity. As frequency rises, propagation decreases while data capacity increases.

# HOW TO ANALYZE A COMPANY IN THIS INDUSTRY

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The health of the telecommunications industry can be determined by analyzing trends in prepaid and postpaid subscribers, but we note that analyzing this industry has grown more complicated as companies acquire media assets.

## Industry Drivers

◆ **Gross domestic product.** The broadest measure of aggregate economic activity, gross domestic product (GDP), is the market value of all goods and services produced by labor and capital in a country. The economy's growth is measured by changes in inflation-adjusted (or real) GDP. Consumption—spending by domestic households on final goods and services—accounts for approximately one-half to two-thirds of GDP across a broad spectrum of countries. Consequently, changes in GDP are an excellent measure of consumer markets.

The degree to which demand varies with GDP will depend partly on whether wireless service is perceived as a luxury or a necessity. This, in turn, varies according to demographics and wireline penetration.

◆ **Unemployment rate.** This rate measures the number of unemployed as a percentage of the labor force. As unemployment rises, the telecom traffic that an enterprise customer generates declines as fewer phones are used. Those unemployed workers may also restrict their own telecom spending, often dropping enhanced services.

◆ **Interest rates and inflation.** Because telephone companies are highly capital intensive, interest rates are an important factor, as they affect the cost of capital. Lower rates tend to stimulate investment unless the credit markets are as tight as they were in the second half of 2008.

Inflation is a further consideration: as inflation rises, so do interest rates. In the extreme, this has the potential to choke off investment spending. Lower levels of inflation, however, can aid capital-intensive businesses, as rising nominal cash flows can more easily pay off prior debt obligations. The key determinant of whether inflation is advantageous or harmful for a business is the company's relative pricing power. Given increasing levels of competition and a low capacity utilization level for broadband networks, the U.S. wireline industry does not have significant pricing power.

◆ **Demographics and housing starts.** Demand for telephone service is related to population growth. Having more people in a region or country tends to generate a greater need for telephones. Housing starts are a good measure of population density and can be an indicator of demand for new access line and broadband services.

◆ **Market penetration.** Market penetration is a measure of the subscriber base as a percentage of the total number of potential customers, or overall population. Calculated as a percentage, market penetration shows how deeply wireless service has entered a market and, thus, suggests how much growth potential remains in the subscriber base.

◆ **Average revenue per user.** A prime indicator of operating performance, average revenue per user (ARPU) gauges the average monthly revenue generated for each customer unit, such as a wireless phone, that is in service. Increases in minutes of use and in value-added services, including data, are considered drivers of ARPU growth.

◆ **Average revenue per account.** Similar to ARPU, average revenue per account (ARPA) is an indicator of operating performance for carriers with shared data plans. ARPA gauges the average monthly revenue

generated for each account rather than per user. Increases in data allotments and additional devices are drivers of ARPA growth.

◆ **Churn.** A metric used to monitor the stability of a customer base, churn is the percentage of subscribers that terminate wireless service with the carrier on a monthly basis—the lower the churn, the less pressure on a carrier to add new subscribers to generate revenues.

◆ **Net subscriber additions.** A prime indicator of the success of a carrier's marketing programs, net subscriber additions is the number of new customers added, less customers that terminated service with the carrier. It is typically calculated on a quarterly basis.

◆ **Cost per gross subscriber addition.** Cost per gross subscriber addition (CPGA) is an indicator of the average cost of signing a new subscriber. It is calculated by adding selling and marketing costs, as well as handset and accessory subsidy costs (excluding costs unrelated to initial customer acquisition) and dividing the total by new subscribers during the period (or gross adds).

◆ **Cash cost per user.** A benchmark used to measure the average monthly cost of serving subscribers. Cash cost per user (CCPU) is calculated as total operating expenses less equipment revenue, depreciation, and amortization expenses, and the costs of acquiring new subscribers, which is then divided by the average number of subscribers for the period. CCPU is commonly used within the industry as an indicator of the cash expenses associated with ongoing business operations, on a per handset basis.

◆ **Free cash flow.** This important liquidity metric is calculated as the net cash provided by operating activities of continuing operations, less cash payments for capital expenditures (capex) and other additions. Free cash flow provides useful information about how a company generates cash from operations after interest and dividends and how it funds debt maturities and other financing activities, such as debt refinancing or debt retirement and investments.

## Take a Hard Look at Cash Flow

Despite the differences among wireline telecommunication companies (telcos), they have some common characteristics. An important measure of any telco's financial health is growth in operating cash flow. The measure that historically has been used as a proxy for operating cash flows is earnings before interest, taxes, depreciation, and amortization (EBITDA). This figure can be calculated by adding back depreciation and amortization (D&A) charges to reported operating income.

EBITDA has gained widespread acceptance in the market because it eliminates some accounting problems that might arise, since most discretionary expenses come after EBITDA. It is also useful in analyzing new companies that are not profitable. It should be noted, however, that companies can and do manipulate EBITDA. Another drawback is the sizable amount of industry debt, and, therefore, sizable interest expense. A large part of cash flow is being eaten up by interest payments, which limits EBITDA's value as a measure of a company's profitability.

The trend in cash flow is an important indicator of where a company is in its business plan. If cash flows are not growing, it will be more difficult for the company to fund its capital spending or dividend payments. Questions that should also come to mind include: Where is the company investing? What are the chances of the investment being successful?



**Watch Out!** Companies record special charges for unusual or infrequent items, e.g., restructuring charges. Such charges are often excluded from non-GAAP earnings, and therefore provide dishonest management with the ability to enhance analysts' perception of its profitability through aggressive use of these special charges.



**Watch Out!** Companies can boost current earnings by shifting interest costs to the balance sheet by capitalizing these costs as part of fixed assets. To detect potential manipulation of capitalized interest, investors can analyze trends in capitalized interest relative to total interest costs as well as capitalized interest relative to total capital expenditures. If these ratios are increasing, a company may be manipulating earnings by capitalizing interest costs that are normally expensed.



**Watch Out!** Similar to the capitalization of interest, telecom service providers can capitalize operating costs incurred for the construction of an asset, and certain contract acquisition and fulfillment costs under the new revenue recognition standard. For example, labor costs may be capitalized if an employee is directly working on the construction of the network. Capitalized operating costs will be recorded on the balance sheet versus flowing through the current period income statement, providing a boost to current period income. In addition, cash flow from operations will be boosted as these capitalized costs are shifted to cash flow from investing from cash flow from operations. Once the network is completed, depreciation expense will include a portion of the capitalized costs.

## Valuation Methods

In gauging the attractiveness of an established telephone company's common stock, the enterprise value (EV)-to-EBITDA ratio is a key valuation tool. The multiple can be calculated by dividing the EV (market capitalization plus net debt) by next year's projected EBITDA. The company's multiple can then be compared with those of its peers. Telecom companies break out subscriber metrics and average revenue per user for the wireless business, the broadband business, and the media business, which enables the analysis of the health of each segment on its own.

Another technique is to calculate the company's intrinsic value. In general, a company's intrinsic value equals the present value of its future cash earnings, or free cash flows. Free cash flow consists of after-tax net income plus D&A, less capital expenditures (capex), plus increases in working capital (current assets minus current liabilities). These figures are available from a company's balance sheets and cash flow statements.

# GLOSSARY

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**2G**—A circuit-switched, digital wireless network that is voice-centric, although it may include some data capabilities such as text messaging.

**2.5G**—More feature-rich than 2G networks, but still not capable of full 3G services. Often an evolutionary step designed to help carriers raise new revenue from data services without full investment in, and deployment of, a 3G network.

**3G**—A platform that uses packets, as opposed to circuit switching, resulting in higher capacity and faster data transfer rates that can provide real-time video, high-speed multimedia, and mobile Internet access.

**3.5G**—An evolutionary step toward 4G, with faster transmission speeds and higher capacity; supports features such as streaming video.

**3<sup>rd</sup> Generation Partnership Project (3GPP)**—An umbrella term for a number of standards organizations that develop protocols for mobile telecommunications.

**4G**—A faster data rate than 3G services, up to 20 megabits per second (Mbps), compared with 2.4 Mbps for most 3G services; 4G transfers data at 100 Mbps while the user is moving and at 1 gigabit per second (Gbps) when stationary.

**5G**—The next-level network standard, which focuses on high-speed data connections over multiple devices, low latencies, machine-to-machine communications, and lower power usage. The first half of the 5G standard was finished by the 3GPP in December 2017, while the second half was finalized in June 2018, completing the overall standardization process.

**5G NR (New Radio)**—A set of standards that replace the LTE network 4G wireless communications standard.

**Access line**—A fixed or wireless local access connection between a customer's premises and a carrier's central office switch.

**Advanced mobile phone service (AMPS)**—Technological specifications for transmitting signals via analog cellular telephone.

**Analog**—Analog wireless telephone systems convert voice signals into electromagnetic waves, rather than the 1s and 0s of digital networks.

**Average revenue per user (ARPU)**—The average monthly bill per telecom customer; used in sequential fashion to measure price trends.

**Bandwidth**—The amount of data that can be transmitted in a fixed period of time. For digital devices, bandwidth is usually expressed in bits (or bytes) per second (bps). For analog devices, bandwidth is expressed in cycles per second, or Hertz (Hz). The bandwidth needed to send a given signal depends on the amount of information the signal contains. FM radio takes 10 times as much bandwidth per station as AM radio, a differential that explains FM's higher fidelity; a TV channel requires 33 times the bandwidth of an FM station. In telecommunications, bandwidth measures two characteristics of an electronic transmission: range and capacity. Range refers to the spectrum of electrical frequencies (from short to long waves) that a device can handle without distortion: the higher the bandwidth, the better the quality of the voice or data transmission. Capacity refers to the kinds of communications that can be carried on a channel (e.g., voice, data, video). A voice-grade bandwidth is four kilohertz.

**Base station**—The fixed device that intercepts signals sent by a mobile radio transmitter/receiver (or transceiver).

**bps**—Bits per second, a unit of measurement of the speed of data transmission.

**Broadband**—A bandwidth greater than four kilohertz (the minimum for transmitting voice communications), which can allow transmission of numerous voice, video, and data channels simultaneously.

**Broadband network**—A high-speed network that carries multiple transmissions over a single path, such as coaxial cable or fiber-optic lines.

**C-Band**—Refers to the portion of the electromagnetic spectrum allotted for satellite transmissions in the 4 GHz to 8GHz frequency range. C-Band can aid the transition from 4G to 5G by providing the non-line of sight (NLOS) spectrum mobile broadband (MBB) industry players need.

**Carrier**—A telephone company that owns and operates its own network and provides transmission services to other service providers through its facilities; also called a facilities-based carrier.

**Cell site**—The location of the wireless antenna and network communications equipment.

**Central office (CO)**—The area where customer lines terminate in switching equipment.

**Citizens Broadband Radio Service (CBRS)**—A band of radio-frequency spectrum from 3.5GHz to 3.7GHz that the Federal Communications Commission has designated for sharing among three tiers of users: incumbent users, priority licensees, and generally authorized, which is lightly licensed.

**Churn rate**—The percentage of a carrier's subscribers that terminate wireless service in a given month, or the average monthly rate for a given year.

**Code division multiple access (CDMA)**—A second-generation (2G) digital wireless technology that is used primarily in China, India, Japan, South Korea, and North America; also called CDMAOne. Invented by Qualcomm Inc., CDMA allows several users to share the same radio channel, providing up to 10 times the capacity of analog wireless. Its transitional (2.5G) version is 1xRTT. There are two advanced third generation (3G) versions: CDMA2000, based on the CDMA platform and wideband CDMA (WCDMA), based on GSM technology. (See 1xEVDO technology and Wideband code division multiple access.)

**Data Center**—A building, dedicated space within a building, or a group of buildings used to house servers and associated components, such as telecommunications and storage systems.

**Digital technology**—The use of a binary code to represent and transmit information from electronic equipment. In digital wireless telephony, sound and data are transformed electronically from analog signals into a digital pulse (an on-and-off series of coded ones and zeroes) that is transmitted via radio wave and reconverted into an analog signal at the point of reception. In contrast, analog technology relies on variable electrical signals—radio waves—that remain unchanged from origination to termination of a call and are more vulnerable to interference. Wireless telephony, which today is predominantly digital, transmits signals through the atmosphere rather than via copper wire or fiber-optic lines.

**Fiber-to-the-premises (FTTP)**—A technology that brings fiber-optic connections (rather than copper wire) directly into homes and businesses to enable a broad array of voice, data, and video applications.

**Global system for mobile communications (GSM)**—Functionally similar to TDMA, GSM is a second-generation digital technology that is mostly used for voice transmissions. It has been adopted by the European Union (EU) and is currently the most widely used digital cellular standard worldwide.

**Hertz (Hz)**—Cycles per second, a measure of radio frequency. Kiloherz (kHz) = thousands; megahertz (MHz) = millions; gigahertz (GHz) = billions; terahertz (THz) = trillions.

**Internet Protocol (IP)**—The set of rules that defines how information is packetized and addressed for delivery across the internet. Most networks combine IP with a higher-level protocol called Transport Control Protocol (TCP), which establishes a virtual connection between a destination and a source so that they can communicate with each other. VoIP technology uses the internet to transmit telephone calls.

**Internet service provider (ISP)**—A company that offers businesses and consumers access to the internet and other related services.

**Massive Multiple-input, Multiple-output (MIMO)**—An extension of MIMO – expands beyond the legacy systems by adding a much higher number of antennas on the base station. The industry sometimes also uses the term massive MIMO for analog beamforming with many antenna elements at millimeter-wave frequencies.

**Mobile Virtual Network Operator (MVNO)**—A wireless communications services providers that does not own the wireless network infrastructure over which it provides to its customers.

**Net Neutrality**—The principle that an internet service provider (ISP) must provide access to all sites, content, and applications at the same speed, under the same conditions without blocking or giving preference to any content.

**Net subscriber additions**—A growth metric that is equal to the number of wireless customers that add service during a period, minus those that terminate service.

**Non-standalone (NSA) 5G New Radio (NR)**—An early version of Standalone 5G NR, which uses an LTE RAN and core with the addition of a 5G component carrier.

**Population (POPs)**—A cellular industry term for customers or potential customers within a licensed area as surveyed by the U.S. Census. One POP is one member of the population.

**Roaming**—A service offered by most wireless providers that allows subscribers to use cellular service while traveling outside their home service area. Roaming requires an agreement between operators of technologically compatible systems in individual markets to permit customers of either operator to access the other's system. Roaming areas and costs vary by service provider.

**Smartphone**—A wireless telephone equipped with computer-enabled features such as wireless email, Internet access, and data transfer with other devices; also known as a converged mobile device.

**Spectrum**—The range of electromagnetic radio frequencies used in the transmission of sound, data, and television.

**Time division multiple access (TDMA)**—A first-generation digital cellular technology that offered a threefold increase in capacity over analog technology. Carriers with TDMA networks are in the process of switching to transitional GSM/GPRS platforms, after which they will upgrade to 3G via WCDMA.

**Traffic**—Electronic signals containing sound, data, or visual communications.

**Voice over Internet Protocol (VoIP)**—Internet telephony; refers to communications services (voice, facsimile, and/or voice-messaging applications) that are transported via the internet, rather than the public switched telephone network (PSTN).

**Wideband code division multiple access (WCDMA)**—A 3G technology that increases data transmission rates in GSM systems by using the CDMA air interface instead of TDMA.

**Wireless Fidelity (Wi-Fi)**—A wireless technology providing Internet access at speeds of up to 11 megabits per second. Also known as 802.11b, this radio technology has limited reach to connect laptops or portable devices with a Wi-Fi card to a Wi-Fi access node in the network.

**Worldwide interoperability for microwave access (WiMAX)**—A wireless technology providing broadband wireless connectivity to fixed and mobile users. It uses the 802.16 technology standard for two GHz to 11 GHz within a wireless metropolitan area network, has a service range of up to 50 kilometers, and provides data rates of up to 280 megabits per second per base station. WiMAX is the ultimate compliment to Wi-Fi, in our opinion, capable of being used to connect wireless hotspots and wireless LANs to the internet, provide campus connectivity, and create a wireless alternative to cable and DSL for last-mile broadband access.



# INDUSTRY REFERENCES

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## TRADE ASSOCIATIONS

### **3rd Generation Partnership Project (3GPP)**

3gpp.org

An organization formed by seven telecommunications standard development organizations to produce reports that define 3GPP technologies.

### **GSMA**

gsma.com

Dedicated to the development, deployment, and evolution of the Global System for Mobile Communications (GSM) standard for digital wireless technology and for the promotion of the GSM platform.

### **The United States Telecom Association (USTelecom)**

ustelecom.org

Association representing telecommunications industry service providers and suppliers. Provides updates on policy issues and industry news through daily and weekly newsletters.

### **WiMAX Forum**

wimaxforum.org

Nonprofit industry group working to facilitate the deployment of broadband wireless networks based on the IEEE 802.16 standard by helping to ensure the compatibility and interoperability of broadband wireless access equipment.

## RESEARCH FIRMS

### **GSMA Intelligence**

gsmaintelligence.com

Global database for mobile market information.

### **IDC Research Inc.**

idc.com

Provides market analysis for information technology and communications in the U.S. and worldwide.

### **Leichtman Research Group Inc. (LRG)**

leichtmanresearch.com

Provides research on broadband, media, and entertainment.

### **Opensignal**

opensignal.com

Provides crowdsourced wireless network coverage maps and quality reports.

## GOVERNMENT AGENCIES

### **Federal Communications Commission (FCC)**

fcc.gov

U.S. government agency that develops and implements policy concerning interstate and international communications.

### **Federal Reserve Economic Data (FRED)**

fred.stlouisfed.org

A database maintained by the Research division of the Federal Reserve Bank of St. Louis that has more than 816,000 economic time series from various sources.

### **International Telecommunication Union (ITU)**

itu.int

Leading United Nations agency for information and communication technology issues; coordinates global telecommunication networks and services, and organizes worldwide and regional exhibitions and forums.

### **National Center for Health Statistics**

cdc.gov

A principal agency of the U.S. Federal Statistical System, which provides statistical information to guide actions and policies to improve the public health of the American people.

### **U.S. Bureau of Labor Statistics**

bls.gov

A principal fact-finding agency for the U.S. government in the broad field of labor economics and statistics and serves as a principal agency of the U.S. Federal Statistical System.

## OTHER SOURCES

cisco.com

Designs and sells a broad range of technologies across networking, security, collaboration, applications and the cloud.

cnbc.com

A world leader in business news and real-time financial market coverage.

cnet.com

World's leader in tech product reviews, news, prices, videos, forums, how-tos, and more.

fiercewireless.com

Wireless industry's daily monitor that provides relevant and insightful information on the dynamic wireless market.

thalesgroup.com

An international digital security company providing software applications, secure personal devices such as smart cards and tokens, and managed services.

wsj.com

Online coverage of breaking news and current headlines from the US and around the world.

## COMPANY RESOURCES

### **AT&T**

<https://www.att.com/>

### **Lumen Technologies**

<https://www.lumen.com/>

### **T-Mobile**

<https://www.t-mobile.com/>

### **Verizon**

<https://www.verizon.com/>

# COMPARATIVE COMPANY ANALYSIS

		Operating Revenues																
Ticker	Company	Yr. End	Million \$							CAGR(%)			Index Basis (2013=100)					
			2021	2020	2019	2018	2017	2016	2015	10-Yr.	5-Yr.	1-Yr.	2021	2020	2019	2018	2017	2016
INTEGRATED TELECOMMUNICATION SERVICES																		
T	AT&T INC.	DEC	168,864.0	171,760.0	181,193.0	170,756.0	160,546.0	163,786.0	146,801.0	2.9	0.6	(1.7)	115	117	123	116	109	112
ATNI	ATN INTERNATIONAL, INC.	DEC	602.7	455.4	438.7	451.2	481.2	457.0	355.4	8.7	5.7	32.3	170	128	123	127	135	129
CNSL	CONSOLIDATED COMMUNICATIONS HOLDINGS, INC.	DEC	1,282.2	1,304.0	1,336.5	1,399.1	1,059.6	743.2	775.7	13.9	11.5	(1.7)	165	168	172	180	137	96
VZ	VERIZON COMMUNICATIONS INC.	DEC	133,613.0	128,292.0	131,868.0	130,863.0	126,034.0	125,980.0	131,620.0	1.9	1.2	4.1	102	97	100	99	96	96
ALTERNATIVE CARRIERS																		
CCOI	COGENT COMMUNICATIONS HOLDINGS, INC.	DEC	571.3	553.0	531.3	507.7	474.3	437.8	400.6	6.5	5.5	3.3	143	138	133	127	118	109
IRDM	IRIDIUM COMMUNICATIONS INC.	DEC	614.5	583.4	560.4	523.0	448.0	433.6	411.4	4.8	7.2	5.3	149	142	136	127	109	105
LUMN	LUMEN TECHNOLOGIES, INC.	DEC	19,687.0	20,712.0	21,458.0	22,580.0	17,656.0	17,470.0	17,900.0	2.5	2.4	(4.9)	110	116	120	126	99	98
VG	VONAGE HOLDINGS CORP.	DEC	1,339.1	1,185.4	1,106.5	971.7	1,002.3	955.6	895.1	4.4	7.0	13.0	150	132	124	109	112	107
WIRELESS TELECOMMUNICATION SERVICES																		
SHEN	SHENANDOAH TELECOMMUNICATIONS COMPANY	DEC	245.2	220.8	206.9	192.7	612.0	535.3	342.5	(0.2)	(14.5)	11.1	72	64	60	56	179	156
SPOK	SPOK HOLDINGS, INC.	DEC	142.2	148.2	160.3	169.5	171.2	179.6	189.6	(4.8)	(4.6)	(4.1)	75	78	85	89	90	95
TMUS	T-MOBILE US, INC.	DEC	80,118.0	68,397.0	44,998.0	43,310.0	40,604.0	37,490.0	32,467.0	14.5	16.4	17.1	247	211	139	133	125	115
TDS	TELEPHONE AND DATA SYSTEMS, INC.	DEC	5,329.0	5,225.0	5,176.0	5,109.0	5,044.0	5,155.0	5,210.0	0.3	0.7	2.0	102	100	99	98	97	99
OTHER TELECOMMUNICATIONS CARRIERS																		
ALSK																		
CCI	CROWN CASTLE INTERNATIONAL CORP.	DEC	6,340.0	5,840.0	5,763.0	5,370.0	4,255.0	3,921.0	3,663.9	12.0	10.1	8.6	173	159	157	147	116	107
SBAC	SBA COMMUNICATIONS CORPORATION	DEC	2,308.8	2,083.1	2,014.6	1,865.7	1,727.7	1,633.1	1,638.5	12.7	7.2	10.8	141	127	123	114	105	100
USM	UNITED STATES CELLULAR CORPORATION	DEC	4,122.0	4,037.0	4,022.0	3,967.0	3,890.0	3,990.0	4,031.0	(0.5)	0.7	2.1	102	100	100	98	97	99

Note: Data as originally reported. CAGR-Compound annual growth rate. []Company included in the S&P 500. †Company included in the S&P MidCap 400. §Company included in the S&P SmallCap 600. #Of the following calendar year.  
Source: S&P Capital IQ.

		Net Income																
Ticker	Company	Yr. End	Million \$							CAGR(%)			Index Basis (2013=100)					
			2021	2020	2019	2018	2017	2016	2015 #	10-Yr.	5-Yr.	1-Yr.	2021	2020	2019	2018	2017	2016
INTEGRATED TELECOMMUNICATION SERVICES																		
T	AT&T INC.	DEC	20,081.0	(5,176.0)	13,903.0	19,370.0	29,450.0	12,976.0	13,345.0	17.7	9.1	NM	150	(39)	104	145	221	97
ATNI	ATN INTERNATIONAL, INC.	DEC	(22.1)	(14.1)	(10.8)	19.8	31.5	12.1	16.9	NA	NM	56.6	(131)	(83)	(64)	117	186	71
CNSL	CONSOLIDATED COMMUNICATIONS HOLDINGS, INC.	DEC	(107.1)	37.0	(20.4)	(50.8)	64.9	14.9	(0.9)	NA	NM	NM	12,155	NM	2,314	5,770	NM	NM
VZ	VERIZON COMMUNICATIONS INC.	DEC	22,065.0	17,801.0	19,265.0	15,528.0	30,101.0	13,127.0	17,879.0	24.8	10.9	24.0	123	100	108	87	168	73
ALTERNATIVE CARRIERS																		
CCOI	COGENT COMMUNICATIONS HOLDINGS, INC.	DEC	48.2	6.2	37.5	28.7	5.9	14.9	4.9	20.4	26.4	675.2	984	127	766	586	120	305
IRDM	IRIDIUM COMMUNICATIONS INC.	DEC	(9.3)	(56.1)	(162.0)	(13.4)	233.9	111.0	7.1	NA	NM	(83.4)	(131)	(787)	NM	(188)	3,283	1,559
LUMN	LUMEN TECHNOLOGIES, INC.	DEC	2,033.0	(1,232.0)	(5,269.0)	(1,733.0)	1,389.0	626.0	878.0	13.5	26.6	NM	232	(140)	(600)	(197)	158	71
VG	VONAGE HOLDINGS CORP.	DEC	(24.5)	(36.2)	(19.5)	35.7	(33.9)	13.2	22.7	NA	NM	(32.4)	(108)	(160)	(86)	158	(150)	58
WIRELESS TELECOMMUNICATION SERVICES																		
SHEN	SHENANDOAH TELECOMMUNICATIONS COMPANY	DEC	998.8	125.7	55.5	46.6	66.4	(0.9)	40.9	54.4	NM	694.8	2,444	308	136	114	162	(2)
SPOK	SPOK HOLDINGS, INC.	DEC	(22.2)	(44.2)	(10.8)	(1.5)	(15.3)	14.0	80.2	NA	NM	(49.8)	(28)	(55)	(13)	(2)	(19)	17
TMUS	T-MOBILE US, INC.	DEC	3,024.0	3,064.0	3,468.0	2,888.0	4,536.0	1,460.0	733.0	NA	15.7	(1.3)	413	418	473	394	619	199
TDS	TELEPHONE AND DATA SYSTEMS, INC.	DEC	156.0	226.0	121.0	135.0	153.0	43.0	219.0	(2.5)	29.4	(31.0)	71	103	55	62	70	20
OTHER TELECOMMUNICATIONS CARRIERS																		
ALSK																		
CCI	CROWN CASTLE INTERNATIONAL CORP.	DEC	1,096.0	1,056.0	860.0	622.0	366.0	357.0	1,521.0	20.4	25.1	3.8	72	69	57	41	24	23
SBAC	SBA COMMUNICATIONS CORPORATION	DEC	237.6	24.1	147.0	47.5	103.7	76.2	(175.7)	NA	25.5	885.8	(135)	(14)	(84)	(27)	(59)	(43)
USM	UNITED STATES CELLULAR CORPORATION	DEC	155.0	229.0	127.0	150.0	12.0	48.0	241.0	(1.2)	26.4	(32.3)	64	95	53	62	5	20

Note: Data as originally reported. CAGR-Compound annual growth rate. [Company included in the S&P 500. †Company included in the S&P MidCap 400. §Company included in the S&P SmallCap 600. #Of the following calendar year.  
Source: S&P Capital IQ.

Ticker	Company	Yr. End	Return on Revenues (%)						Return on Assets (%)						Return on Equity (%)					
			2021	2020	2019	2018	2017	2016	2021	2020	2019	2018	2017	2016	2021	2020	2019	2018	2017	2016
INTEGRATED TELECOMMUNICATION SERVICES																				
T	AT&T INC.	DEC	11.9	NM	7.7	11.3	18.3	7.9	3.6	NM	2.5	3.6	6.6	3.2	11.8	NM	7.6	11.9	22.4	10.8
ATNI	ATN INTERNATIONAL, INC.	DEC	NM	NM	NM	4.4	6.5	2.6	NM	NM	NM	1.8	2.6	1.0	NM	NM	0.2	4.2	6.0	3.1
CNSL	CONSOLIDATED COMMUNICATIONS HOLDINGS, INC.	DEC	NM	2.8	NM	NM	6.1	2.0	NM	1.1	NM	NM	1.7	0.7	NM	10.1	NM	NM	17.4	7.1
VZ	VERIZON COMMUNICATIONS INC.	DEC	16.5	13.9	14.6	11.9	23.9	10.4	6.0	5.6	6.6	5.9	11.7	5.4	29.7	27.8	33.7	32.3	88.9	65.0
ALTERNATIVE CARRIERS																				
CCOI	COGENT COMMUNICATIONS HOLDINGS, INC.	DEC	8.4	1.1	7.1	5.6	1.2	3.4	4.9	0.6	4.0	3.9	0.8	2.0	NM	NM	NM	NM	NM	NM
IRDM	IRIDIUM COMMUNICATIONS INC.	DEC	NM	NM	NM	NM	52.2	25.6	NM	NM	NM	NM	6.2	3.2	NM	NM	NM	NM	15.9	8.6
LUMN	LUMEN TECHNOLOGIES, INC.	DEC	10.3	NM	NM	NM	7.9	3.6	3.5	NM	NM	NM	1.8	1.3	17.7	NM	NM	NM	7.5	4.6
VG	VONAGE HOLDINGS CORP.	DEC	NM	NM	NM	3.7	NM	1.4	NM	NM	NM	2.8	NM	1.4	NM	NM	NM	7.1	NM	3.2
WIRELESS TELECOMMUNICATION SERVICES																				
SHEN	SHENANDOAH TELECOMMUNICATIONS COMPANY	DEC	407.3	56.9	26.8	24.2	10.8	NM	112.1	6.2	2.9	3.1	4.7	NM	1.3	0.3	0.4	0.5	20.6	NM
SPOK	SPOK HOLDINGS, INC.																			
TMUS	T-MOBILE US, INC.	DEC	3.8	4.5	7.7	6.7	11.2	3.9	1.5	1.5	4.0	4.0	6.4	2.2	4.5	5.8	13.0	12.2	22.2	8.4
TDS	TELEPHONE AND DATA SYSTEMS, INC.	DEC	2.9	4.3	2.3	2.6	3.0	0.8	1.2	1.8	1.1	1.4	1.6	0.5	3.0	4.9	2.7	3.4	3.3	1.1
OTHER TELECOMMUNICATIONS CARRIERS																				
ALSK																				
CCI	CROWN CASTLE INTERNATIONAL CORP.	DEC	17.3	18.1	14.9	11.6	8.6	9.1	2.8	2.7	2.2	1.9	1.1	1.6	13.1	10.6	7.8	5.2	3.7	4.9
SBAC	SBA COMMUNICATIONS CORPORATION	DEC	10.3	1.2	7.3	2.5	6.0	4.7	2.4	0.3	1.5	0.7	1.4	1.0	NM	NM	NM	NM	NM	NM
USM	UNITED STATES CELLULAR CORPORATION	DEC	3.8	5.7	3.2	3.8	0.3	1.2	1.5	2.4	1.6	2.1	0.2	0.7	3.6	5.4	3.2	4.2	0.4	1.4

Note: Data as originally reported. CAGR-Compound annual growth rate. []Company included in the S&P 500. †Company included in the S&P MidCap 400. §Company included in the S&P SmallCap 600. #Of the following calendar year.  
Source: S&P Capital IQ.

Ticker	Company	Yr. End	Current Ratio						Debt/Capital Ratio (%)						Debt as a % of Net Working Capital					
			2021	2020	2019	2018	2017	2016	2021	2020	2019	2018	2017	2016	2021	2020	2019	2018	2017	2016
INTEGRATED TELECOMMUNICATION SERVICES																				
T	▮ AT&T INC.	DEC	0.7	0.8	0.8	0.8	1.0	0.8	50.3	45.9	42.5	47.1	47.3	48.6	NM	NM	NM	NM	NM	NM
ATNI	§ ATN INTERNATIONAL, INC.	DEC	1.1	1.6	1.9	2.0	2.1	2.4	31.5	8.4	9.3	9.5	14.9	15.1	3060.6	75.0	75.8	63.9	79.9	66.5
CNSL	§ CONSOLIDATED COMMUNICATIONS HOLDINGS, INC.	DEC	1.5	1.3	0.7	0.7	0.8	0.9	71.7	83.3	86.7	84.7	80.1	88.7	1486.4	2768.5	NM	NM	NM	NM
VZ	▮ VERIZON COMMUNICATIONS INC.	DEC	0.8	1.4	0.8	0.9	0.9	0.9	63.3	64.1	61.6	66.0	71.9	81.6	NM	825.4	NM	NM	NM	NM
ALTERNATIVE CARRIERS																				
CCOI	§ COGENT COMMUNICATIONS HOLDINGS, INC.	DEC	5.1	4.8	5.3	4.7	4.1	4.8	170.5	150.9	135.2	130.9	122.4	110.5	274.5	240.3	202.7	229.6	242.1	215.6
IRDM	† IRIDIUM COMMUNICATIONS INC.	DEC	3.9	3.1	3.0	1.5	1.9	6.2	55.7	53.5	55.1	57.0	53.0	55.2	506.4	687.4	775.5	1531.9	865.4	382.2
LUMN	▮ LUMEN TECHNOLOGIES, INC.	DEC	1.6	0.5	0.7	0.7	0.9	1.0	69.7	72.3	70.5	64.0	61.3	57.6	622.3	NM	NM	NM	NM	NM
VG	§ VONAGE HOLDINGS CORP.	DEC	0.8	0.9	0.7	0.6	0.7	0.5	41.4	45.6	46.7	48.7	31.3	40.7	NM	NM	NM	NM	NM	NM
WIRELESS TELECOMMUNICATION SERVICES																				
SHEN	§ SHENANDOAH TELECOMMUNICATIONS COMPANY	DEC	2.5	1.2	1.6	2.4	1.3	1.0	0.0	0.0	59.3	62.9	68.4	72.9	0.0	0.0	779.9	616.1	2145.4	NM
SPOK	§ SPOK HOLDINGS, INC.	DEC	1.7	2.1	2.3	2.9	3.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TMUS	▮ T-MOBILE US, INC.	DEC	0.9	1.1	0.7	0.8	0.8	1.6	49.8	50.5	46.4	50.8	53.1	59.1	NM	3049.8	NM	NM	NM	507.0
TDS	§ TELEPHONE AND DATA SYSTEMS, INC.	DEC	1.7	2.6	2.0	2.6	2.1	2.3	30.2	37.9	29.9	31.3	33.2	33.9	338.1	182.5	240.8	166.3	232.1	207.6
OTHER TELECOMMUNICATIONS CARRIERS																				
ALSK																				
CCI	▮ CROWN CASTLE INTERNATIONAL CORP.	DEC	0.6	0.6	0.6	0.8	0.9	1.4	71.1	66.7	62.9	58.6	56.2	61.5	NM	NM	NM	NM	NM	3321.2
SBAC	▮ SBA COMMUNICATIONS CORPORATION	DEC	1.0	0.8	0.3	0.3	0.9	0.4	175.1	176.8	158.4	160.1	138.8	132.4	NM	NM	NM	NM	NM	NM
USM	UNITED STATES CELLULAR CORPORATION	DEC	1.8	3.0	2.1	2.6	2.0	2.2	37.3	35.9	26.2	28.2	30.5	30.7	378.5	141.8	182.1	142.9	215.7	190.6

Note: Data as originally reported. CAGR-Compound annual growth rate. □Company included in the S&P 500. †Company included in the S&P MidCap 400. §Company included in the S&P SmallCap 600. #Of the following calendar year.  
Source: S&P Capital IQ.

Ticker	Company	Yr. End	Price/Earnings Ratio (High-Low)										Dividend Payout Ratio (%)						Dividend Yield (High-Low, %)																									
			2021	2020	2019		2018		2017		2016		2021	2020	2019	2018	2017	2016	2021	2020	2019	2018	2017	2016																				
INTEGRATED TELECOMMUNICATION SERVICES																																												
T	AT&T INC.	DEC	12	-	8	NM	-	NM	21	-	15	14	-	10	9	-	7	21	-	16	75	NM	107	69	41	91	10.6	-	5.2	9.4	-	6.4	7.8	-	5.1	6.9	-	5.1	6.0	-	4.6			
ATNI	ATN INTERNATIONAL, INC.	DEC	NM	-	NM	NM	-	NM	NM	-	NM	71	-	40	44	-	26	111	-	85	NM	NM	NM	55	61	173	2.1	-	1.4	1.8	-	1.3	1.8	-	0.9	1.3	-	0.8	1.4	-	0.8	2.5	-	1.1
CNSL	CONSOLIDATED COMMUNICATIONS HOLDINGS, INC.	DEC	NM	-	NM	18	-	8	NM	-	NM	NM	-	NM	26	-	11	104	-	65	0	0	NM	NM	145	525	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	17.5	-	0.0	14.8	-	11.1	11.8	-	5.5
VZ	VERIZON COMMUNICATIONS INC.	DEC	11	-	9	14	-	12	13	-	11	16	-	12	7	-	6	18	-	14	47	57	52	63	31	71	5.5	-	4.6	5.1	-	4.1	4.9	-	4.0	4.5	-	4.0	5.1	-	4.0	5.4	-	4.2
ALTERNATIVE CARRIERS																																												
CCOI	COGENT COMMUNICATIONS HOLDINGS, INC.	DEC	77	-	55	671	-	400	80	-	54	89	-	66	411	-	291	130	-	91	312	2082	300	341	1390	457	6.3	-	4.2	5.2	-	3.9	5.4	-	2.9	5.3	-	3.8	4.8	-	3.7	4.6	-	3.4
IRDM	IRIDIUM COMMUNICATIONS INC.	DEC	NM	-	NM	NM	-	NM	NM	-	NM	NM	-	NM	6	-	4	11	-	6	0	0	NM	NM	2	14	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0
LUMN	LUMEN TECHNOLOGIES, INC.	DEC	8	-	5	NM	-	NM	NM	-	NM	NM	-	NM	12	-	6	28	-	19	53	NM	NM	NM	105	186	10.4	-	7.3	10.3	-	6.5	11.6	-	6.6	15.3	-	6.6	15.6	-	9.0	15.9	-	7.9
VG	VONAGE HOLDINGS CORP.	DEC	NM	-	NM	NM	-	NM	NM	-	NM	97	-	54	NM	-	NM	118	-	64	0	0	0	0	0	0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0
WIRELESS TELECOMMUNICATION SERVICES																																												
SHEN	SHENANDOAH TELECOMMUNICATIONS COMPANY	DEC	3	-	1	23	-	16	46	-	27	54	-	32	30	-	19	NM	-	NM	94	13	25	28	18	NM	0.4	-	0.3	1.2	-	0.2	0.8	-	0.5	0.9	-	0.5	0.9	-	0.5	1.0	-	0.6
SPOK	SPOK HOLDINGS, INC.	DEC	NM	-	NM	NM	-	NM	NM	-	NM	NM	-	NM	NM	-	NM	31	-	23	NM	NM	NM	NM	NM	74	20.0	-	5.0	6.9	-	3.9	5.8	-	4.0	4.5	-	3.0	3.6	-	2.8	3.4	-	2.2
TMUS	T-MOBILE US, INC.	DEC	62	-	44	50	-	28	21	-	15	21	-	16	13	-	10	34	-	20	0	0	0	0	1	4	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0
TDS	TELEPHONE AND DATA SYSTEMS, INC.	DEC	26	-	17	13	-	8	35	-	21	30	-	20	24	-	18	81	-	54	76	35	62	53	45	151	4.8	-	3.3	4.1	-	2.7	4.5	-	2.6	3.0	-	1.7	2.7	-	1.8	2.5	-	1.8
OTHER TELECOMMUNICATIONS CARRIERS																																												
ALSK																					217	207	235	305	420	359	3.8	-	2.8	3.6	-	2.6	4.1	-	2.7	4.3	-	3.0	4.3	-	3.7	4.7	-	3.5
CCI	CROWN CASTLE INTERNATIONAL CORP.	DEC	81	-	58	74	-	50	83	-	59	95	-	82	141	-	105	108	-	82	107	862	57	0	0	0	1.0	-	0.6	1.0	-	0.6	0.9	-	0.5	0.7	-	0.5	0.0	-	0.0	0.0	-	0.0
SBAC	SBA COMMUNICATIONS CORPORATION	DEC	176	-	109	1496	-	997	207	-	123	423	-	355	199	-	119	193	-	139	0	0	0	0	0	0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0
USM	UNITED STATES CELLULAR CORPORATION	DEC	22	-	16	14	-	10	40	-	21	33	-	19	323	-	233	81	-	60	0	0	0	0	0	0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0

Note: Data as originally reported. CAGR-Compound annual growth rate. [Company included in the S&P 500. †Company included in the S&P MidCap 400. §Company included in the S&P SmallCap 600. #Of the following calendar year.  
Source: S&P Capital IQ.

Ticker	Company	Yr. End	Earnings per Share (\$)						Tangible Book Value per Share (\$)						Share Price (High-Low, \$)																	
			2021	2020	2019	2018	2017	2016	2021	2020	2019	2018	2017	2016	2021	2020	2019	2018	2017	2016												
INTEGRATED TELECOMMUNICATION SERVICES																																
T	AT&T INC.	DEC	2.76	(0.75)	1.89	2.85	4.77	2.10	(17.70)	(16.83)	(16.49)	(17.32)	(12.85)	(16.12)	33.88	-	22.02	39.55	-	26.08	39.70	-	28.30	39.29	-	26.80	43.03	-	32.55	43.89	-	33.41
ATNI	ATN INTERNATIONAL, INC.	DEC	(1.52)	(0.89)	(0.68)	1.24	1.94	0.75	26.03	29.59	32.37	33.44	32.70	34.62	52.65	-	37.51	79.64	-	37.01	79.52	-	50.48	88.78	-	49.34	87.82	-	49.50	84.29	-	62.70
CNSL	CONSOLIDATED COMMUNICATIONS HOLDINGS, INC.	DEC	(1.26)	0.47	(0.29)	(0.73)	1.07	0.29	(4.90)	(9.80)	(12.08)	(12.16)	(10.97)	(12.20)	9.89	-	4.72	8.81	-	3.47	12.10	-	3.24	14.23	-	8.51	27.88	-	12.07	30.23	-	17.76
VZ	VERIZON COMMUNICATIONS INC.	DEC	5.32	4.30	4.65	3.76	7.36	3.21	(25.28)	(15.09)	(16.33)	(18.24)	(20.77)	(24.59)	59.85	-	49.69	61.95	-	48.84	62.22	-	52.28	61.58	-	46.09	54.83	-	42.80	56.95	-	43.79
ALTERNATIVE CARRIERS																																
CCOI	COGENT COMMUNICATIONS HOLDINGS, INC.	DEC	1.03	0.13	0.81	0.63	0.13	0.33	(8.04)	(6.39)	(4.47)	(3.30)	(2.29)	(1.19)	80.50	-	56.38	92.96	-	53.20	66.67	-	43.96	57.65	-	35.75	54.85	-	37.85	43.61	-	29.65
IRDM	IRIDIUM COMMUNICATIONS INC.	DEC	(0.07)	(0.42)	(1.33)	(0.22)	1.82	0.89	9.47	10.25	10.73	13.84	15.75	13.54	54.65	-	32.85	39.95	-	16.87	28.24	-	17.79	24.35	-	10.75	12.90	-	7.80	11.15	-	6.14
LUMN	LUMEN TECHNOLOGIES, INC.	DEC	1.91	(1.14)	(4.92)	(1.63)	2.21	1.16	(10.86)	(14.52)	(16.17)	(17.57)	(18.48)	(19.36)	16.60	-	9.67	15.30	-	8.16	16.75	-	9.64	24.20	-	13.97	27.61	-	13.16	33.45	-	21.94
VG	VONAGE HOLDINGS CORP.	DEC	(0.10)	(0.15)	(0.08)	0.14	(0.15)	0.06	(1.04)	(1.23)	(1.34)	(1.59)	(0.42)	(0.66)	20.85	-	10.85	14.20	-	4.18	13.75	-	7.01	14.73	-	7.92	10.57	-	5.74	7.57	-	3.82
WIRELESS TELECOMMUNICATION SERVICES																																
SHEN	SHENANDOAH TELECOMMUNICATIONS COMPANY	DEC	19.97	2.51	1.11	0.93	1.33	(0.02)	11.06	9.43	7.73	(1.42)	(3.59)	(6.21)	61.53	-	24.44	59.93	-	38.35	51.18	-	29.61	51.41	-	29.93	41.80	-	25.35	42.66	-	19.18
SPOK	SPOK HOLDINGS, INC.	DEC	(1.14)	(2.32)	(0.56)	(0.08)	(0.76)	0.68	3.76	4.69	6.45	7.02	7.43	8.68	12.86	-	7.16	12.33	-	8.53	17.25	-	11.00	16.25	-	12.21	22.60	-	14.45	21.85	-	15.49
TMUS	T-MOBILE US, INC.	DEC	2.41	2.65	4.02	3.36	5.20	1.69	(32.36)	(27.30)	(11.34)	(15.22)	(17.11)	(13.11)	150.20	-	106.70	135.00	-	63.50	85.22	-	62.55	70.94	-	55.09	68.88	-	54.60	59.19	-	33.23
TDS	TELEPHONE AND DATA SYSTEMS, INC.	DEC	1.00	1.94	1.03	1.17	1.37	0.39	0.10	12.33	12.06	14.06	11.25	10.96	26.51	-	17.18	25.64	-	14.05	37.29	-	21.44	36.52	-	23.54	32.98	-	24.57	32.00	-	20.83
OTHER TELECOMMUNICATIONS CARRIERS																																
ALSK																																
CCJ	CROWN CASTLE INTERNATIONAL CORP.	DEC	2.53	2.35	1.79	1.23	0.80	0.95	(13.58)	(11.72)	(10.64)	(9.69)	(8.98)	(5.13)	209.87	-	146.15	180.00	-	114.18	149.47	-	104.22	117.60	-	98.85	114.97	-	83.96	102.82	-	75.71
SBAC	SBA COMMUNICATIONS CORPORATION	DEC	2.14	0.21	1.28	0.41	0.86	0.61	(74.22)	(72.67)	(65.25)	(59.66)	(53.22)	(46.72)	391.15	-	232.88	328.37	-	205.20	270.42	-	158.08	177.67	-	146.13	173.97	-	102.06	118.57	-	82.80
USM	UNITED STATES CELLULAR CORPORATION	DEC	1.77	2.62	1.44	1.72	0.14	0.56	5.34	20.72	20.07	21.76	17.11	16.21	39.96	-	28.53	37.37	-	23.91	59.74	-	30.74	58.44	-	32.06	46.01	-	32.29	45.87	-	32.72

Note: Data as originally reported. CAGR-Compound annual growth rate. [Company included in the S&P 500. †Company included in the S&P MidCap 400. §Company included in the S&P SmallCap 600. #Of the following calendar year.  
Source: S&P Capital IQ.

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