

December 22, 2020

**CLOUD AND COMMUNICATIONS**

## 2021 Outlook: Edge and 5G Companies Well-Positioned

**Top Picks: MSFT, TMUS, EGHT, and KLR**

### SUMMARY

Our 2021 top picks are MSFT, TMUS, EGHT and KLR. 5G and edge computing are two of the most important technology trends. They will both improve cloud computing, a once-in-a-century general-purpose technology. Cloud in turn supports three major new technologies: IoT to collect and act on data, blockchain to secure it, and most important AI to enable robotics, autonomous vehicles, genomics, and dozens of other services that will revolutionize our economy and way of life. We expect this to drive a very strong decade of growth, what we call "the new roaring '20s," similar to the impact electricity had on the 1920s and steam engines on the 1820s.

### KEY POINTS

- **Top Picks' Improving Fundamentals:** We believe we're entering the fourth compute cycle from centralized to decentralized cloud. Each of these companies is well-positioned to leverage unique infrastructure/customers for cloud/5G adoption during this transition with software. We see MSFT as better positioned than AWS/GOOG as we cross the cloud chasm. TMUS appears to be progressing well with the Sprint integration. EGHT and KLR benefit from improved cloud and 5g infrastructure and both should have strong 2021 results.
- **Cloud Entering the Chasm:** Two areas of growth in cloud that we are focused on in 2021 are: 1) edge computing (Fog); and 2) virtual workplace and communications software. Enterprise adoption of the public cloud is just now crossing the chasm; it is approximately 15-20% of the way through a \$500 billion target market, with \$100 billion of this edge-based. The first decade of public cloud was largely dominated by innovators and early adopters.
- **Wireless Innovation Accelerating:** Wireless fundamentals benefited from increased broadband usage during the pandemic. The wireless carriers reported strong 3Q20 results, supported by retail stores reopening, solid pricing, and a pickup in demand. To be competitive, wireless providers will need consistent high-quality broadband nationwide. Through 5G/Fog compute, we've identified four growth opportunities carriers can leverage: (1) fixed wireless, (2) private enterprise/organization wireless networks, (3) market share gains, and (4) higher ARPU for premium 5G services.
- **Economic Uncertainty Remains:** Macro risks linger and COVID cases are increasing. This and major new disruptive technologies are the largest risks. The unemployment rate edged down to 6.7% in November (from double digits in early summer), but there are still tens of millions of Americans out of work and many more underemployed (hours/wages cuts). The pandemic has exacted a significant toll on the economy, with reverberations likely to be felt for years.
- **Bottom Line:** COVID-19 has accelerated cloud adoption, and we see 2021 as a very strong year for our cloud infrastructure food chain. The sector outperformed the market by over 500bps last year on average, with most of the outperformance coming from new cloud application companies. We are also upgrading TMUS to Outperform (see separate note published this morning) with a \$160 PT based on 10.5x our 2022 EBITDA and supported by our DCF attached.

**Timothy Horan, CFA**  
212-667-8137  
[Tim.Horan@opco.com](mailto:Tim.Horan@opco.com)

**Matt Wilson, CFA**  
212-667-6360  
[Matthew.T.Wilson@opco.com](mailto:Matthew.T.Wilson@opco.com)

**Noah Herman**  
212-667-7119  
[Noah.Herman@opco.com](mailto:Noah.Herman@opco.com)

Disseminated: December 22, 2020 07:06 EST; Produced: December 22, 2020 07:06 EST

**For analyst certification and important disclosures, see the Disclosure Appendix.**

Table of Contents for 2021 Outlook Report

**WE FAVOR COMPANIES WELL POSITIONED FOR 5G AND  
EDGE ..... 3**

    OTHER KEY TRENDS ..... 9

**UPGRADING TMUS TO OUTPERFORM FROM PERFORM, TOP  
PICK FOR 2021 .....10**

    CLOUD ADOPTION ACCELERATING ..... 14

**WIRELESS AND WIRELINE – DAWN OF 5G.....16**

    WIRELESS FUNDAMENTALS: COMPETITION HEALTHY ..... 17

    DATACENTER OUTLOOK 2021 OUTLOOK ..... 17

    WIRELESS TOWER 2021 OUTLOOK..... 18

**KEY QUESTIONS FOR 2021 .....19**

**2021 TOP INVESTMENT RISKS..... 22**

**SUMMARY OF RECENT WHITE PAPERS ..... 23**

**APPENDIX I: INDUSTRY MODEL UPDATES ..... 24**

**APPENDIX II: LIST OF INDUSTRY REPORTS 2016–2020 ..... 43**

## We Favor Companies Well Positioned for 5G and Edge

5G and edge computing are two of the most important technology trends. They will both improve Cloud Computing, which is a once-in-a-century General Purpose Technology (GPT). Cloud that in turn supports major new technologies: IoT to collect and act on data, Blockchain to secure it, and most important, AI to enable robotics, autonomous vehicles, genomics and dozens of other services that will revolutionize our economy and way of life. We expect this to drive a very strong decade of growth, what we call “the new roaring 20s,” similar to the impact electricity had on the 1920s and steam engines on the 1820s. COVID has accelerated cloud adoption and we see 2021 as a very strong year. The sector outperformed the market by over 500bps last year on average, with most of the outperformance coming from new cloud application companies.

Enterprise adoption of the public cloud is just now crossing the chasm; it is approximately 15% of the way through an estimated \$500 billion target market, with \$100 billion of this edge-based. The first decade of public cloud was largely dominated by innovators and early adopters. These cloud-native customers gained advantages that allowed them to disrupt a number of industries (retail, transportation, and lodging). Cloud adoption has just crossed the chasm; we believe ~ 20% of workloads are now on Cloud. COVID slowed adoption by a few months but it has since reaccelerated with a vengeance and should end up accelerating overall adoption by a few years. Andy Jassy, CEO of AWS, believes that only 5% of enterprise IT spend is on the cloud [keynote address AWS re:Invent conference]. Cloud is now materially better than on premise compute, and the advantage is increasing. AWS’ new Graviton 2 chip costs two-thirds less than Intel’s and is likely one-third more efficient, or more than 3x the productivity improvement. This is a game changer when combined with the low latency 5G they are building with VZ and best in class AI. The scale that AWS and Azure are operating at likely can’t be matched for a generation.

One of the new services we are very excited about is MSFT’s “Cloud PC,” which is a culmination of advanced networking and cloud computing technologies and is likely to be launched in 1H21. This will enable high-quality compute from very low-cost devices to be accessed almost everywhere. MSFT will bundle this hardware with a complete suite of software productivity/communication tools all running on its intelligent Edge Cloud, Azure, and maybe even a wireless device. We think this will have the ability to bring compute to the masses at much lower costs. It will also enable MSFT to dominate the virtual workplace through its Teams platform. We see TMUS as an important supplier to this ecosystem, as it has a couple of years’ lead on 5G wireless coverage/capacity, and should gain share for the next few years. EGHT and KLR bring unique communication applications that are set to improve from new state-of-the-art network and cloud/fog infrastructure.

High-quality networking is the foundation of cloud and will enable the “Cloud PC.” Spectrum is the concrete and steel that makes this foundation. One of the largest spectrum auctions ever—the C-band—is being conducted as of this writing. This auction will likely sell \$40-50B worth of critical 280 MHz of mid-band spectrum, or \$0.50 per Mhz/Pop, and will be the spectrum that new 5G networks will be built on. The only 5G network in the US today is built by TMUS on mid-band spectrum; it saw an 8x increase in speed and capacity. Other mid-band spectrum deployments globally have also seen great performance. 5G will require continued major investments in wireless, datacenter and fiber infrastructure.

To be competitive wireless providers will need consistent high-speed, high-quality broadband nationwide. Through 5G/Fog compute, we've identified four material growth opportunities wireless carriers can leverage: (1) fixed wireless, (2) private enterprise/organization wireless networks, (3) market share gains, and (4) higher ARPU for premium 5G services. Wireline providers play an important role in supporting households and SMB, the consumers of next-gen 5G applications. Positively, Tower and Neutral datacenter stocks are at the low end of their relative valuation ranges and should see improved results in 2021 as cloud adoption accelerates, 5G builds begin in earnest, and Dish enters the market. Dish is looking to leverage existing cloud and core networking infrastructure to deploy new virtualized technologies (O-RAN), which have their genesis in cloud technologies. If they announce a partnership with one of the major FANG companies (Amazon?), as we expect, it could pressure the wireless and cable stocks. US prices for these services are well above the European average, although US quality is much better. Dish could be disruptive on prices with an Amazon-like partnership.

In the meantime we expect strong broadband fundamentals to carry over from 2020 to 2021, as the pandemic has increased the need for fast, reliable internet services. The cable providers have been clear beneficiaries, taking 100%+ flowshare in home broadband in 2020, and we expect this trend to continue in 1H21. Momentum is on Cable's side. CMCSA delivered a quarterly record for broadband customer additions (633K) in 3Q20, CHTR followed with its own strong quarter (537K). Cable is winning due to network quality and ease of self-installation (1 Gbps speeds in some areas)—at the expense of copper/DSL. However, fixed wireless is seeing major quality and cost improvements and we expect it to be a real competitor in 2H21.

Wireless fundamentals have benefited from increased broadband usage during the pandemic as well. All three wireless carriers reported strong results for 3Q20, supported by retail stores reopening, solid pricing, and a pickup in demand. Broadband demand for wireless and wireline (VZ FiOS was notably strong) continues to be strong and a required utility for consumers and businesses alike during COVID-19. Importantly, Apple announced that all iPhone 12 models support 5G mmWave, so a major inflection point in 5G marketing has begun. 2021 will be the year for 5G marketing, but with slightly varying strategies. AT&T's promo is an effort to reengage with its customer base and migrate customers to higher-priced, unlimited tiers bundled with HBO Max. VZ is going to market with its strong network quality and its mix & match 3.0 plan to shift customers to its higher-tier unlimited plans. TMUS is successfully integrating Sprint's 2.5 GHz spectrum and customer base into its network. Its 5G network is now covering 270M PoPs on low-band and it expects to reach 100M on 2.5GHz this year. Importantly, we think margins should be safe and carriers are focused on making their customer base stickier.

Pricing has been stable and customers continue to move up to higher-priced plans, driving solid ARPU. Promotional activity is focused on handset subsidies and, while a bit higher than normal, is in line with recent trends. The wireless companies are looking to bundle fixed wireless/video/mobile and expand fiber to grow ARPU. Over time they want to converge their two separate networks to one. VZ is on track to deploy 5x the number of small cells this year compared with 2019 in aid of its fixed wireless ambitions, and AT&T will add over 1M fiber connections this year. T-Mobile launched an OTT video service (TVision) and will double its 5G mid-band coverage to 200M pops next year and be positioned to do fixed wireless in 2022. The lines between wireless and wireline are blurring, which could lead to heightened promotional activity and greater competition with cable in 2021. Fixed wireless is becoming a reality as more spectrum is deployed and wireless infrastructure is built. We believe it's an important technology to focus on next year as 5G proliferates.

Fixed wireless is an important way for the carriers to fight back against cable domination in home and SMB broadband. We expect fixed wireless households to grow from 6 million to at least 30 million by 2027 (with 12 million mobile broadband-only homes and 70 million mobile voice-only today). In addition, many consumers require only mobile broadband,

with all applications over the top (OTT). This creates pressure on the legacy paid TV business, which we expect to decline from 60% of households to 40% over the next five years. This means a greater opportunity for AT&T (HBO Max) and TMUS (TVision) to bundle-in their OTT video offerings, and for VZ to continue to partner (e.g., Disney+, YouTube TV, Discovery+) on OTT and wireless bundles.

We think fixed wireless offerings will become more prevalent in 2021/2022—with marketing and uptake. VZ has positioned itself purely to have the best fixed wireless broadband solution by focusing exclusively on its 5G network. Costs for fixed wireless are 20% below those of cable and can be self-installed by customers. Importantly, the base station that serves mobile customers can also be utilized to deliver 5G fixed wireless access. Using the same equipment with limited marginal cost for incremental revenues fits right into our horizontal segmentation thesis—driving higher asset utilization. VZ is rolling out CPEs embedded with new chipsets that will enhance its fixed wireless coverage using mmWave spectrum. T-Mobile is also making investments in 5G fixed wireless broadband as it deploys Sprint's 2.5GHz spectrum nationwide. This requires minimal incremental cost to turn on and compete once the wireless infrastructure is deployed.

### Exhibit 1: Fixed Wireless Expect to Reach 30M+ Households in Seven Years

Data Usage In Home vs Cellular											
	2017	2018	2019	2020E	2021E	2022E	2023E	2024E	2025E	2026E	2027E
Total U.S. Broadband Households (In Millions)	89,314	91,656	93,816	98,267	101,247	103,272	105,337	107,444	109,593	111,785	114,021
Fixed Wireless Households (In Millions)	1,786	3,666	6,098	8,844	11,137	13,425	16,538	20,414	24,658	29,623	34,206
Fixed Wireless % of Households	2%	4%	7%	9%	11%	13%	16%	19%	23%	27%	30%
Average Home Fixed Wireless Data Usage (GB/Mo)	4	9	18	31	46	66	97	141	197	271	356
Overall Volume Growth		150%	103%	70%	49%	43%	46%	45%	40%	38%	31%
Average Mobile Usage per Home (GB/Mo)	12	17	24	33	46	63	87	119	164	222	300
Overall Volume Growth		40%	40%	40%	39%	38%	38%	37%	37%	36%	35%
Total (GB/Mo) Wireless	16	26	42	64	92	130	184	260	360	494	657
Overall Volume Growth		65%	62%	53%	44%	41%	42%	41%	38%	37%	33%
Average Home Wireline Data Usage (GB/Mo)	180	225	281	346	422	511	618	741	875	1,024	1,188
Overall Volume Growth		25%	25%	23%	22%	21%	21%	20%	18%	17%	16%
Total (GB/Mo) Wireless and Wireline	196	251	323	410	514	640	802	1,002	1,235	1,517	1,844
Overall Volume Growth		28%	29%	27%	25%	24%	25%	25%	23%	23%	22%
Mobile Data Usage %	6%	7%	7%	8%	9%	10%	11%	12%	13%	15%	16%
Cellular and Fixed Wireless Usage %	8%	10%	13%	16%	18%	20%	23%	26%	29%	33%	36%

Source: Company Reports, Oppenheimer & Co Inc.

**Private wireless networks are another hot topic in 2020/2021.** Enterprises and public/government entities require higher-quality broadband networks to enable their new IoT applications, reduce costs through automation, and increase utilization of scarce spectrum assets. This is paramount for mission-critical industries that have stringent network security requirements that can't rely on public network providers. Enterprises across all sectors have realized, especially through the pandemic, that they need high-quality networks to compete. As commercial demand for LTE and 5G use-cases grows, enterprises will be looking at the private wireless network space, driving a growing collection of different spectrum bands in the US to make available for enterprises, municipalities, and others beyond individual consumers. New applications can be tapped with improvements in latency as low as 1ms over 5G networks that can propagate effectively indoors using Sub-6GHz spectrum and new technologies (Massive MIMO, Beamforming, Network slicing, etc.)

**Exhibit 2: Shared Spectrum for Private Enterprise Networks**

Spectrum	Coordination	Status
3.5GHz CBRS	Exclusive and Shared Licenses	Available
5GHz	Unlicensed	Available
6GHz	Proposed Unlicensed	Under Evaluation
37-37.6GHz	Shared Spectrum; Local Licenses	Under Evaluation
57-71GHz	Unlicensed	Available
116-123GHz, 174.8-182GHz, 185-190GHz, 244-246GHz	Unlicensed	Approved; Effective Date TBD

Source: Heavy Reading, Qualcomm

Spectrum for private enterprise networks is typically based on small geographic areas to ensure access and reuse of spectrum by as many companies as need it. More enterprises with indoor facilities (industrial, healthcare, and entertainment) are looking to leverage this technology with cloud infrastructure provided by hyperscalers like AWS (Wavelength) and Azure. More unlicensed spectrum has been made available for enterprises to tap into for LTE networks, and this trend will likely continue. The CBRS auction saw a greater number of non-telco companies participate than in any other auction, signaling strong demand among enterprises for wireless capabilities. Many industrial applications are supported by LTE, but for users that have more demanding performance requirements (latency, availability, throughput, etc.), 5G will be better suited. The key service that operators can offer enterprises is network slicing, which allows operators to create end-to-end virtual networks designed for specific application use-cases. This requires a 5G network core, which carriers are beginning to deploy. Plus, 3GPP will complete Release 17 standards next year that provides a blueprint for network slicing.

The federal government has generally been supportive of wireless infrastructure and the pandemic has highlighted the digital divide. More than 18M Americans are still not connected to broadband, according to the FCC. The Biden administration could tighten some regulation, but we believe the government understands that world-class 4G/5G networks are a national economic and defense issue. We believe the administration will focus on a new infrastructure bill that includes subsidies for upgrading wireless/wireline infrastructure. The FCC has freed up an unprecedented amount of spectrum in the last four years, which is positive for the cloud infrastructure food chain (towers, neutral datacenters, fiber). The C-Band auction will conclude early next year and we expect Verizon will walk away with the most spectrum because it lacks mid-band. This will be critical for improving network quality and competing vs. T/MUS.

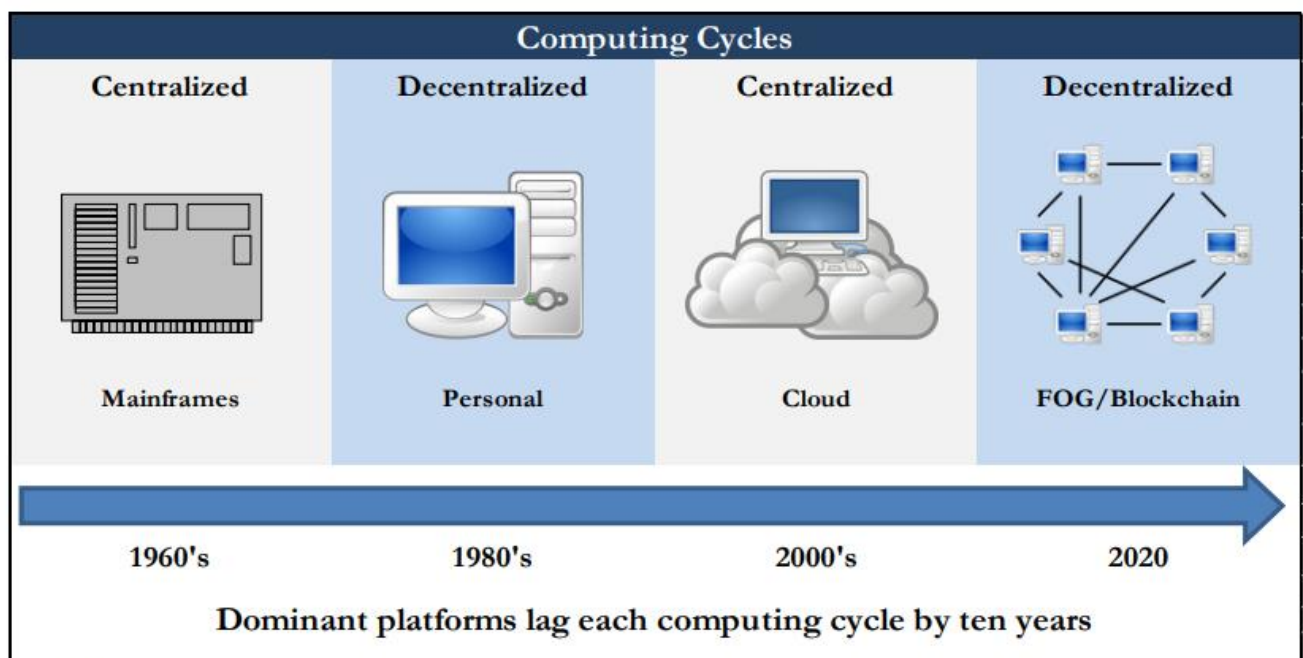
**Two areas of growth in cloud that we are focused on in 2021 are: 1) edge computing (Fog) and 2) virtual workplace and communications software.** The surge in remote work/play/learning due to the pandemic has driven demand for Fog infrastructure; we think this is an acceleration of a 20-year secular trend. Compute cycles shift between centralized and decentralized architectures based on need, and we believe Fog is the decentralization of public cloud computing. 5G, blockchain and IoT are all driving/enabling compute to be pushed to the boundaries, as close to the end user as possible. One of these low-latency applications is cloud-based communications, which is seeing record usage/adoption but also transforming how people work. Communications are being more engrained into workflows (with CPaaS) and applications. We see this as a major shift in the industry.



At its annual re:Invent conference, AWS announced that it is expanding its “Local Zones” edge infrastructure beyond Los Angeles to 15 additional cities by the end of 2021. AWS Local Zones are infrastructure deployments (compute, storage and database services) closer to end users in large cities and IT hubs. AWS announced two smaller appliances (form factors) for its Outposts suite of edge hardware, which will broaden appeal to smaller branch locations/offices/etc. AWS Outposts hardware allows customers to run AWS cloud in on-premise datacenters. MSFT is also investing in edge, along with market-leading hybrid services (Stack, Arc). Compute is cascading from the centralized cloud to the edge, where it can enable real-time processing for next-gen applications. This complements the cloud, and is also positive for our horizontally segmented cloud infrastructure names such as CDNs, datacenters and wireless towers.

A critical factor for FSLY is uptake of its Compute@Edge service in 2021. FSLY’s edge platform enables developers to access best real-time edge delivery of content and edge compute, in multiple languages. FSLY is investing heavily to build this platform, but it is seeing early success, evidenced by its millisecond purge times (vs. minutes for competitors) for content and applications. Traction in edge computing next year is likely to be key to maintaining FSLY’s valuation. Other CDN providers (AKAM and LLNW) have their own edge offerings. CDNs’ distributed architecture will be more valuable as it helps deliver content/applications from the centralized cloud to the edge efficiently. Low latency applications that enable people to work remotely (UCaaS, Video Conferencing, SaaS) and entertain themselves at home (Video and game streaming, social media, eCommerce) are seeing a surge in activity. However, we do worry about tougher comps in 2021, after the strong volumes during the pandemic/lockdown in 2Q and 3Q 2020.

**Exhibit 3: Compute Moving from Cloud to Fog (Edge)**

































Source: OPCO

Ultimately, both AWS and Azure are trying to become the next operating system of compute for the next 20 years. The cloud industry is far-reaching, commoditizing almost every other horizontal segment in IT as they themselves solidify their own horizontal positions. For example, we think the public cloud will continue to move up the stack into software. MSFT already sells Office and Dynamics 365 to cloud customers and AWS has its own business applications (Chime, WorkDocs, WorkMail, Alexa for Business, etc.). We think the market for high-value services and automation is 10x the basic infrastructure market (compute, networking & storage). The long-term risk to this dominance is blockchain, which could enable more peer-to-peer and customer-controlled services, but this will show up in the consumer way before it impacts enterprise applications.

Cloud-based communications is transforming rapidly, and the race is on to build the platform for remote work. MSFT is far ahead, but other large software/hyperscale companies could challenge (e.g., Google, CRM). Our UCaaS/CPaaS names are well-positioned to carve out a niche in a very large \$100B+ market and we view EGHT, VG and KLR as potential acquisition candidates. The COVID-19 pandemic and subsequent lockdowns have accelerated the migration of communication services and applications to the cloud and enabled convergence. A new service is developing, which we call a Virtual Workplace, that enables work from anywhere at any time. The Virtual Workplace integrates cloud-based communications (UCaaS, collaboration, conferencing, etc.) with applications and morphing into completely new formats, such as Microsoft's Together Mode (and future AR/VR formats, HoloLens, etc.).

**Exhibit 4: Eight SaaS Services Converging on One Virtual Desktop**

SaaS Pillars Converging							
UCaaS	Video Conferencing	Collaboration	CCaaS	CPaaS	CRM	ERP	Productivity Applications
 Microsoft Teams   	 Microsoft Teams   	 Microsoft Teams   	   	   	   	   	 

Source: Company Websites, Oppenheimer & Co.

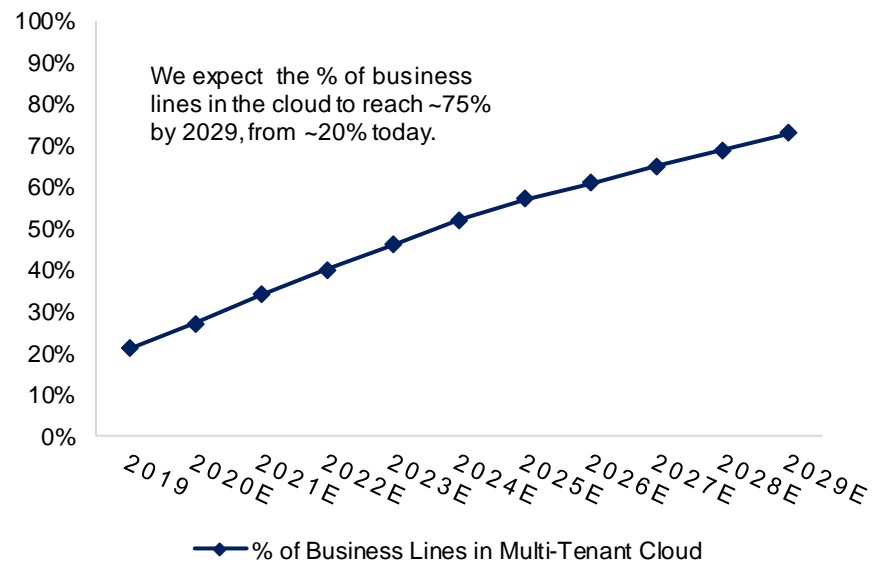
Microsoft is the only company in our coverage that has the disparate pillars to create a unified Virtual Workplace platform, and it has done so with Teams, leveraging its productivity software monopoly, Azure, and its great relationship with developers. Google is an emerging competitor, and has a good chance of success at the low end. Amazon will enable more à la carte offerings, as will other niche players but we see pricing pressure within certain applications. Companies with standalone products will have cost and distribution disadvantages. For this reason, we see standalone features as pillars in a larger, integrated platform. MSFT is spending \$20B a year on R&D and S&M, much of which is focused on cloud. While we are not certain as to exact amount, we would assume that MSFT is spending billions+ on its Teams communication platform and business productivity tools (Office & Dynamics). The scale and scope of MSFT can only be matched by other hyperscalers (Google, Amazon, Salesforce).

A major turning point is Salesforce's acquisition of Slack (announced in early December 2020). The acquisition positions Salesforce to defend its turf in CRM/ERP from fast-growing Microsoft Dynamics, which, integrated with the Teams platform, is a compelling alternative to Salesforce. Importantly, we think this is the inflection point that sparks a flurry of consolidation as companies rush to catch up to MSFT's lead in creating a global communication (Virtual Workplace) platform. M&A is needed to catch up to MSFT, and in theory EGHT, VG, and KLR could be possible acquisition candidates. Organic R&D is too slow in an industry that has seen a step function increase in adoption due to recent world events. One wild card is Zoom—will it be acquired despite its sky-high \$125B market cap or will it be a consolidator and build its own platform?



We are only about ~20% of the way through the migration from legacy PBX's to cloud-based communications on a global basis but far earlier in converging applications with communications. CPaaS was the start. It allowed applications to embed communication features (e.g., calling drivers in the Uber application). In our recent Virtual Workplace whitepaper, we believe that the market is \$100B+ for business communications, and new add-ons (Data, analytics) could increase potential revenue. 2021 will be a year of continued strong adoption, it won't see the rush that we experienced in 2020, but we have entered a strong, accelerated S curve adoption for cloud-based business communications.

#### Exhibit 5: Global Business Phone Lines are Shifting to Cloud



Source: Gartner, IDC, Oppenheimer & Co.

## Other Key Trends

**COVID accelerates secular trends.** 2020 was an unpredictable year given the COVID-19 pandemic. The pandemic accelerated a number of secular trends that we have been following closely over the past several years, including: 1) enterprise public cloud adoption, 2) adoption of cloud-based communication services (and now virtual work places), and 3) OTT video/gaming adoption, away from legacy linear TV. Reliable broadband service has become even more valuable to households in the age of work/play/learn-from-anywhere. We expect cable to continue to take share in home broadband, but the threat of fixed wireless offerings by wireless carriers is looming, as discussed above. On the other hand, cable is gaining traction in wireless with bundled packages. The lines between wireless and wireline are quickly blurring, and new competitive dynamics are evolving—which we expect to be a hot button issue for investors in 2021.

**Broadband pricing remains stable and volumes are surging.** Positively, pricing has been stable and volumes have been strong in 2020 for carriers, and cloud. CDN's are seeing record levels of traffic as consumers view more video over the internet. Pricing has been more difficult there for legacy services but has held up well for security/compute. New verticals (education) have leaned on CDNs extensively to support remote environments. We expect volumes to remain at elevated levels for the remainder of 2020 and in 1H21, but tough comps are coming for the summer months of 2021. We saw an uptick in promotional activity surrounding the new 5G-enabled iPhone, but pricing for wireless carriers remains mostly stable and competition has been healthy. We expect this

to continue in 2021, positive for ARPU and churn metrics. Carriers have successfully moved customers to unlimited plans, with higher-priced tiers available. Cloud pricing was seen as a risk entering 2020 as competition ramped: both Google and Oracle doubled down on cloud efforts. However, the surge in demand is helping alleviate price competition for the foreseeable future (~next 12 months).

**Macro risks linger and the pandemic is resurging.** The biggest risk for many of our names is the macro economy due to COVID. The unemployment rate edged down to 6.7% in November (from double digits in early summer) but there are still tens of millions of Americans out of work and many more underemployed (their hours/wages cut due to COVID-19). Several industry verticals have been more or less closed for business since March 2020 (airlines, hospitality, travel, leisure and restaurants). COVID-19 has exacted a significant toll on the economy and the reverberations will likely be felt for years. The main questions are: how severe is the recession and how long will it last? For many of our names, it may not matter: COVID-19 has increased demand for cloud solutions, for example. Other companies are more at risk due to lines of business (legacy TV, theatrical and theme parks), high debt loads, and companies pursuing asset sales. Treasury rates will drive the stock prices of our REIT infrastructure providers in the short term, but the direction of rates is difficult to call.

**Political risks have mostly subsided, but control of the Senate is a large uncertainty.** The political and associated headline risks are largely behind us at this point, but it is something to be mindful of heading into next year. The new Biden administration has its own put and takes—more likely to accomplish stimulus (infrastructure spending for broadband and cloud?) but heightened regulatory environment is also likely. The Senate is still up for grabs, and we believe a Republican majority reduces the probability of a tax increase. Interest rates have been lowered and appear stable heading into 2021, but this can flip in an instant. The REITs (datacenters and towers) are most susceptible to increasing rates, as are dividend payers. Volatile currency fluctuations are also a risk for a number of our companies.

**Blockchain is enabling the digitization of more industries—banking, finance, logistics, legal, etc. Emergence of decentralized finance (DeFi) in particular as a killer use case for Blockchain.** Crypto was the first major use case, and DeFi is the second and adoption has accelerated this year. Killer applications include payments and banking. Lending and bank deposits over cryptocurrencies are more peer-to-peer digital banking with lower intermediary fees. DeFi and Crypto trade in tandem, and both have had strong returns this year. Conditions are ripe for adoption. Investors are aware that recent government spending and other actions (Fiscal Stimulus, Fed monetary policy, looming recession, political uncertainty) could drive inflation, which tends to accelerate when it starts.

**Our top stock picks in 2021 are MSFT, TMUS, EGHT and KLR.** We see MSFT as better positioned than AWS/GOOG as we cross the cloud chasm, and it has a significant market opportunity in cloud-based communication and productivity software. Teams is now up to 115M DAUs (from 20M a year ago) and we think is on path to become the dominant communication platform and virtual workplace and even virtual IT of the cloud era. With over 1B+ Office seats, MSFT has much lower customer acquisition costs and easier roadmap to 1B+ users than our communication platform companies. MSFT has underperformed many of the other cloud-focused companies the last six months and now trades at a relative discount in our view.

TMUS appears to be progressing well with the Sprint integration and is successfully marketing its unique 5G service operating at 300 Mbps speeds. The company can take costs out of its business (already realized \$1.2B in synergies as of 3Q20, will likely double in 2021) through integration and new technology to virtualize networks/operations represent additional cost savings. TMUS is also coming off a strong 3Q20, when the company reported peer-leading, record postpaid subscriber additions of 1.98M with solid

pricing and better than expected churn. TMUS added a record 1.3M postpaid phone and 689K other postpaid subs last quarter, owing to solid execution. Churn was a low 0.9% and although standalone TMUS was a major factor, the lower churn is impressive as Sprint had ~2% churn last year and 15% of S's postpaid traffic migrated to the TMUS network. As for its 5G network, TMUS is seeing 7-8x LTE speeds or an average of ~300Mb/s with mid-band 2.5GHz spectrum and plans to have nationwide coverage in 2021, up from ~30M PoPs.

TMUS trades at a 10% and 20% discount to T and VZ on a wireless per subscriber basis, based on our estimates. TMUS' wireless firm value is ~\$230B vs. \$250B/\$320B for T/VZ and we expect this gap will shrink over the next two years. The company operates at much lower EBITDA margins than both, but should expand margins toward the 40%-range with \$6B in targeted annual synergies.

#### Exhibit 6: Estimated Per Subscriber Wireless Valuations:

(\$ in 000, Subs in 000)					
	<u>T-Mobile</u>	<u>T-Mobile w/ \$6 Bil. Syn</u>	<u>New TMUS Combined vs. 45% Margin</u>	<u>Verizon</u>	<u>AT&amp;T</u>
Postpaid Phone Subs	65,794	65,794	65,794	90,937	64,735
Prepaid Phone Subs	20,630	20,630	20,630	4,069	17,957
<b>Total Subscribers</b>	<b>86,424</b>	<b>86,424</b>	<b>86,424</b>	<b>95,006</b>	<b>82,692</b>
Est. Firm Value	\$235,071			\$357,002	\$360,006
Est. Wireless Firm Value	\$235,071	\$235,071	\$235,071	\$321,302	\$252,004
Total Wireless Revenue	\$74,270	\$74,270	\$74,270	\$92,890	\$71,239
Rev. Growth	5%	5%	5%	-1%	0%
Wireless EBITDA	\$21,743	\$27,743	\$33,421	\$43,844	\$31,067
<b>Est. Margin</b>	<b>29%</b>	<b>37%</b>	<b>45%</b>	<b>47%</b>	<b>44%</b>
EBITDA Multiple	10.8	8.5	7.0	7.3	8.1
Annual Rev. Per Subscriber/month	\$71.61	\$71.61	\$71.61	\$81.48	\$71.79
Total EBITDA Per Sub/month	\$20.97	\$26.75	\$32.23	\$38.46	\$31.31
<b>Valuation Per Total Subscriber</b>	<b>\$2,720</b>			<b>\$3,382</b>	<b>\$3,048</b>
Revenue Multiple	3.2	3.2	3.2	3.5	3.5
Avg. MHz Sub 6 GHz	306			116	166
MHz of Spectrum Per Subscriber	3.54			1.22	2.01
Annual Wireless CAPX	11,834			12,940	11,931
CAPX Per Subscriber Per Year	137			136	144

Source: Company reports, Oppenheimer & Co.

Note: Based on 2020 Wireless Revenue & EBITDA Estimates

Similar to Teams, EGHT should benefit from accelerated adoption of cloud-based communication services. EGHT uniquely has a complete suite of communication services (UCaaS, video meetings, collaboration, contact center and CPaaS) closely stitched together. Aggregating the communication data between these disparate pillars and using AI to uncover new insights is the next step. The company has had missteps in its go-to-market, but new management should improve execution. The company has the technology stack and quality of services to compete and take share with the right sales and marketing.

EGHT trades at a major discount to peers (Exhibit 11 - Pricebox), on our estimates, which could provide opportunities for investors. EGHT currently trades at 5.5x next-year revenue estimates, vs RNG and other leading cloud-based software communication companies trading at 20x+. Plus, it is possible that EGHT might become an acquisition candidate. Salesforce recently announced that it will acquire Slack, which could kick off a wave of consolidation.

KLR operates a trusted CPaaS service that is witnessing very strong growth and cloud communications and applications converge. KLR's experienced headwinds from the pandemic in both its Italy and India-based businesses. Despite these pressures the company is building momentum and diversifying its revenue base: Latin America, Healthcare vertical. CPaaS is a fast growing (30%+) and nascent market. Twilio is the market leader and MSFT will challenge with its newly announced Azure Communication Services. We see KLR carving out a niche in financial services companies; which require high level customer care, privacy and security that can help KLR appeal to other sensitive customers (Healthcare for example). The company has a road map to expand existing relationships: Mastercard in Latin America. K Lab has helped it win larger customers, and the company is seeing momentum with its go-to-market. Importantly, KLR trades at 1-2x next year's revenue vs. TWLO at 20x+ and Bandwidth at ~10x.

#### Exhibit 7: Past Top Picks: Companies with Unique, Virtualized Infrastructure

Company	Top Pick	New Technology Catalyst	Virtualized Asset	Revenue Growth
Comcast	2010-13	Docsis 3.1	Coax Cable And CPE Equipment, 25x speed increase	Cable revenue up 83%
T-Mobile	2013-16	Cheap LTE/Active Radios in Antennas	Virtualized Spectrum	Total revenue up 83%
Amazon	2013	Public Cloud	Virtualized Remote Compute	AWS Revenue up over 10x from 2013
Microsoft	2017-19	Hybrid Cloud	Virtualized Remote and On Premise Compute	Intelligent Cloud revenue grew 45%

Source: FactSet, Oppenheimer & Co.

## Cloud Adoption Accelerating—MSFT Best Fit For Enterprise

Now we are in the era of multi-year, hundred-million dollar enterprise contracts. The industry is approaching \$100 billion in run rate revenue, probably the fastest an industry has ever achieved this milestone. With the base so large growth rates are slowing—AWS Y/Y growth slowed to 29% in 3Q20 from 35% in 3Q19 and 46% in 3Q18—but incremental growth keeps increasing. AWS has added \$10B in incremental revenue over the past 12 months to achieve its 29% Y/Y growth rate. The rush is on to win enterprises, and host their respective data lakes which locks in these customers long-term. This is a critical period for market share gains for the three major cloud providers as whoever exits this period with momentum will likely dominate the sector for the next 20 years.

Microsoft, our top large cap pick for 2021, is still the best positioned cloud provider for enterprise adoption, for a variety of reasons. MSFT has a large installed base of enterprise customers with Office, Windows, etc., virtually every enterprise in the Western World is a MSFT customer in one way or another. MSFT also has decades of experience selling to enterprise, and one of the most extensive networks of partners and resellers in enterprise IT. MSFT also has leading hybrid cloud solutions (Arc, Stack) and is rapidly building an intelligent edge. Hybrid cloud is important because enterprises want an on ramp to the cloud, gradually shifting applications from on-premise to the public cloud as they see fit.

We expect MSFT to continue to chip away market share from AWS. Google is more competitive now and can become a major third player. The industry added almost \$22B billion in revenue in 2020, up from \$17B last year, and we expect it to only grow incrementally from here for the next few years. When we get over the chasm, we could see this grow at \$25 billion per year for the next decade. AWS's growth rate has dipped to 29%, but seems sustainable from here as we see very strong cloud demand over the next 24 months. The key is market share, we estimate that AWS has roughly 55% market share, down from 80% in 2015. In the same period, MSFT and Google have both doubled market share to 30% and 12%, respectively. AWS is wary of losing share to MSFT and GOOG; we think they will continue to invest aggressively in sales & marketing to accelerate growth.

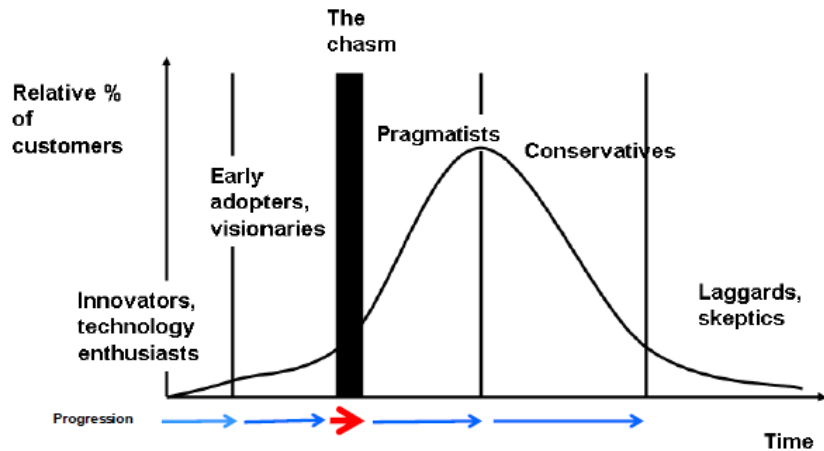
#### Exhibit 8: Cloud Revenue and Market Share Model

Last Updated: 12/20/2020	2018	2019	2020E	2021E	2022E	2023E	2024E
<b>Total Cloud Revenue</b>	<b>38,812</b>	<b>56,668</b>	<b>78,388</b>	<b>102,762</b>	<b>129,834</b>	<b>159,000</b>	<b>188,617</b>
Incremental Revenue	11,838	17,856	21,720	24,374	27,072	29,166	29,616
YY Growth	44%	46%	38%	31%	26%	22%	19%
<b>Total Adj. EBITDA</b>	<b>16,097</b>	<b>22,287</b>	<b>32,750</b>	<b>41,810</b>	<b>52,963</b>	<b>64,823</b>	<b>78,089</b>
EBITDA margin	41%	39%	42%	41%	41%	41%	41%
<b>Total Capex</b>	<b>26,852</b>	<b>31,525</b>	<b>35,576</b>	<b>39,491</b>	<b>42,988</b>	<b>44,625</b>	<b>47,318</b>
Incremental Revenue/Capex	0.44	0.57	0.61	0.62	0.63	0.65	0.63
YY growth	32%	17%	13%	11%	9%	4%	6%
<b>uFCF</b>	<b>(10,755)</b>	<b>(9,238)</b>	<b>(2,825)</b>	<b>2,319</b>	<b>9,976</b>	<b>20,197</b>	<b>30,771</b>
uFCF margins	-28%	-16%	-4%	2%	8%	13%	16%
<b>Cloud market share (Big 3)</b>							
AWS Share	66.1%	61.8%	57.5%	53.5%	50.2%	47.7%	45.9%
MSFT Share	25.6%	28.7%	30.6%	32.0%	32.9%	33.6%	34.0%
Google Share	8.3%	9.4%	11.9%	14.5%	16.9%	18.7%	20.1%

Source: Oppenheimer & Co., company reports

Cloud is still in early innings, with only about 15-20% of enterprise workloads hosted in the public cloud today. We think this number will grow to above 80% over the next decade, as it is a much better service and cheaper than on-prem IT. We believe the cloud market will grow from \$25B in 2017 to \$200B+ in 2025E. Winning share now is key to locking in customers with data lakes, and upselling higher value add services. It's a long journey, lift and shift will continue but the majority of growth will be net-new workloads, applications and use cases. COVID-19 has accelerated enterprise cloud adoption, at the beginning of the pandemic, cloud was already seeing a surge in usage. MSFT's Satya Nadella called out "two years' worth of digital transformations in two months" during its FY3Q (CY1Q) earnings.

Enterprise customers are much different than the developers and startups that dominated the first decade of cloud. Early adopters in cloud were innovators looking to build startups on the cloud and are characterized by shorter sales cycles and less hand holding than enterprises. Early adopters also have less negotiating power, which could explain relatively stable pricing in cloud the past 4-5 years. We are moving from early adopters, to pragmatists, which are more often enterprises that require complete solutions, SLAs and compliance and governance certifications. Enterprise customers move to the cloud to increase productivity, save costs and minimize risks.

**Exhibit 9: Cloud Adopting Moving to Early Majority (Enterprises)**

Source: Geoffrey Moore, *Crossing the Chasm*

MSFT has decades of experience selling to customers, relationships with channel partners and has a fully-built out enterprise sales force (30K+ employees). This will likely mean outsized investments by AWS/Google in sales and marketing to succeed with enterprise customers, and for MSFT in improved cloud services. MSFT has spent the past four decades building out an enterprise IT sales force, and it has an enormous head start. Although pricing has been stable the past ~five years, we think AWS could become aggressive as it tries to stabilize market share losses (now at ~55%, down from 80% in 2016). Google is also investing heavily in cloud and has a history of pricing aggressively. Oracle won notable contracts with communication software providers (Zoom Communications and 8x8 Inc.) in early 2020, partly by undercutting AWS and other providers. As a result, margins could be pressured over the next two years on slower growth; we think the Street underestimates these risks. Positively, we still believe cloud is a transformative technology that will revolutionize every industry in the next decade. Long-term (two-plus years), we are very bullish on MSFT and AWS.

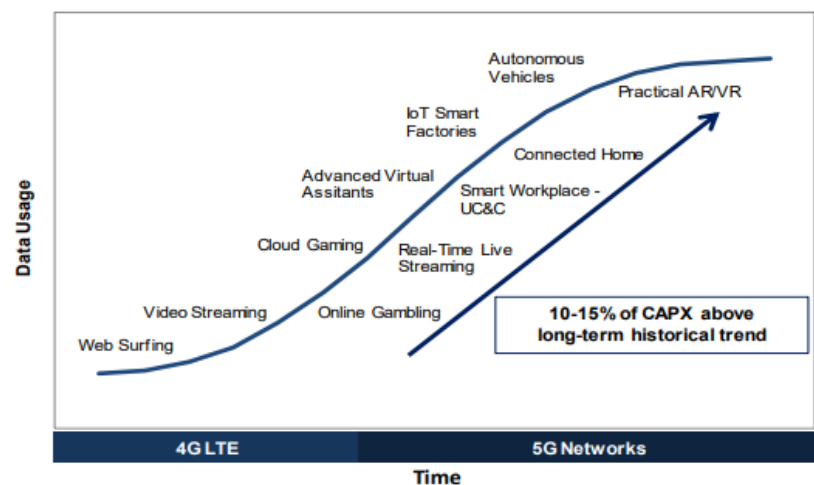
Horizontally segmented infrastructure is well-positioned for growth in cloud. The Fog is enabling new edge-based applications that are accessed by end-users on mobile devices; this is positive for AMT, CCI, and WIFI. Interconnection-focused datacenters, such as EQIX, are important for hybrid and multi-cloud deployments. Datacenter and tower fundamentals appear healthy heading into 2020; interest rates should be monitored though.



## Wireless and Wireline – Dawn of 5G

5G marketing was aggressive in 2020, but that was just the start. 5G networks/technology is still in its infancy, but will have profound impacts across the industry. 5G will increase wireless capacity 10x and reduce latency by 1/10th, while lowering operating expenses. 5G will drive wireless/wireline/cloud convergence and Fog as well as consolidation. The wireless addressable market should double to \$150B, driven by: 1) fixed wireless, 2) IoT/enterprise networks, and 3) higher usage/quality. The scale of cloud and wireless CAPX is unprecedented, and is helping drive more virtualized, compute, and networking in cloud datacenters. Better networks (5G) are good for cloud/hyperscale companies, whose business models require customers to have access to reliable internet connections.

### Exhibit 10: New Customer Use-Cases, Driving Data Usage on 5G Networks



Source: OFCO Research

We are seeing convergence between wireless and wireline and cloud and communication networks, and this will create a new edge-based Fog infrastructure. This will in turn drive lower costs and lower latency enabling virtually every application to run over the top. We believe converged and virtualized wireless and wireline network and go to market strategies could ultimately halve the opex/capex costs associated with two separate networks, particularly when leveraging virtualized/cloud based technologies. This is an area Verizon has particularly been focused on. This trend will only have a limited negative impact from COVID-19 in the short term (mostly from getting permits) but will actually be positive longer term. A single converged network can reduce costs and drive higher asset utilization, which is consistent with our 20-year investment philosophy. Convergence will be a competitive advantage for the wireless carriers as 5G becomes more prevalent.

As wireless captures more market share from wireline, it makes the underlying infrastructure more valuable—towers, neutral datacenters etc., and is driving hyperscale/telecom partnerships (AWS/VZ, T/MSFT). There are four drivers of this secular shift: 1) improved core technologies—semiconductors, optical components, antennas, batteries etc.—enabling mobile operators to see step-function increases in capacity; 2) incorporating this into equipment is being integrated into existing wireless infrastructure (MIMO/beam forming/aggregation/virtualization/fiber, etc.); 3) this enables 10x more spectrum to be deployed (700 MHz below 6 GHz and 7,000 new MHz above it); and 4) converging wireline/wireless networks through smaller cell sites/edge datacenters operated on one virtualized/cloud platform. 5G further ties this all together through an entirely new end-to-end network/cloud, by using AI, to enable 1/10 the latency, ~2-3 times the spectrum, ~2x the spectral throughput, and ~2x the number of cell sites, all enabling a 10x increase in traffic capacity in the next decade.

## Wireless Fundamentals: Competition Healthy

Wireless has seen strong postpaid phone-only net additions and customers shifting toward higher-ARPU unlimited offerings; we expect these trends will continue. Services revenues are growing in the 3% range, with EBITDA more like 5%. All the carriers began aggressively promoting unlimited plans with free OTT video streaming services. The new iPhone is positive for 5G adoption and is compatible with low, mid-, and high-band spectrum. Investors were initially concerned on aggressive promotions for the iPhone, but we actually think the industry's competitive intensity is declining and these aggressive 12-month promos are short lived. The other concern is increased spending on 5G, and Dish and cable competition impacting pricing, but that is probably two years out.

Wireless revenue growth troughed in 2Q20 during the height of the pandemic from lower roaming fees and store closures. As the pandemic headwinds subsided, revenues returned to low-single digits in 3Q20 mainly from a lift in lockdowns and carriers leaning on digital distribution. Phone sales were weak in 2019 as upgrade rates were at multi-year lows, but we expect this will improve with the new 5G iPhone and as carriers market/improve their networks.

We expect postpaid phone net additions will be down only 2% this year despite headwinds from the pandemic. Households relied much more on broadband during the height of the pandemic as working from home became the status quo. MVNOs used this opportunity to offer attractive mobile promotions and market aggressively. Year-to-date, MVNOs have taken ~54% of postpaid phone flowshare (vs. 33% last year), although this decelerated in 3Q to 26% (vs. 29% last year). Carriers will likely take back flowshare from cable through the iPhone upgrade cycle and as network quality improves. We expect competition with cable will increase in 2021/2022 as carriers begin rolling out 5G fixed wireless and other OTT video products. Verizon is well positioned to gain flowshare next year because it's focused on a pure play wireless strategy. The key for TMUS is handling Sprint churn as it begins migrating customers to its network.

## Datacenter Outlook 2021 Outlook

Datacenters are some of the most critical infrastructure for the era of Fog computing. We view networking datacenters as the central interconnectivity point of the new cloud/Fog, akin to the old telecom central offices. As the generation of data surges (Edge/IoT/5G), networks will need architectures that support movement and sharing of data. Enterprises can connect directly with their remote offices/customers/suppliers in these locations and major cloud providers (MSFT, AMZN, GOOGL), SaaS companies (CRM, ADBE, ADP, etc.) and network service providers (T, VZ). Such direct connection lowers enterprises' network costs (essentially an arbitrage between external network connections and within a datacenter) and enables lower latency applications in a more highly secure environment.

Equinix is the dominant interconnection focused datacenter platform, and only pure-play after Interxion was acquired by Digital Realty in early 2020. EQIX is making in-roads into new markets (Canada with Bell acquisition) and cross-selling new products to customer (i.e. bare metal services from Packet acquisition). EQIX is well-positioned as the only pure-play interconnectivity focused datacenter and rightfully demands a premium multiple. The key for EQIX is accelerating organic growth, partly through international expansion but also improving productivity of the Verizon assets. A critical question is how well and fast can EQIX integrate the Bell assets and ramp up their productivity.

The pandemic created some supply chain delays in datacenter deployments and headwinds in enterprise IT spending. The pandemic also accelerated the shift to cloud, positive for network-focused and hyperscale datacenter providers. This has created an imbalance in supply/demand that could benefit the industry over the next two years. Datacenters, like towers, have benefited from lower interest rates. Lower interest rates

help the companies invest organically and finance M&A for expansion in new markets and products. Rising rates are a risk, as is currency. EQIX now has over 50% of revenues exposed to foreign currency.

## Wireless Tower 2021 Outlook

Towers underperformed the S&P500 this year mainly from delays in catalysts that should materialize next year. Two key events causing this were Dish's decision to shift its network deployment into 2021 and the pandemic causing delay in spending/permitting. AMT and CCI saw organic revenue growth steadily decline this year, although we think this bottomed last quarter. TMUS is just beginning to aggressively spend on its 3-4 year network buildout that will bring in \$40B worth of investments. Further, we expect a stronger 2021 as 5G builds accelerate and as Dish begins to build out its network. The C-Band auction will finish early next year and this brings 280 MHz of new 5G spectrum to market. It appears that the Fed will keep interest rates low for the foreseeable future, positive for towers. We think the wireless environment is healthy and demand for towers remains strong driven by the annual 30%+ growth in mobile data traffic.

AMT closed on a 15-year master lease agreement with TMUS which is very positive and gives great visibility, including \$23B in incremental contractual revenue (total is now \$58B). Management's 2020 outlook was increased and now expects organic revenue growth will pick up next year. Positively, AMT is seeing strong growth in international markets and is expanding its tower footprint. On a gross basis, India is growing double digits and clarity around the adjusted gross revenue (AGR) Supreme Court ruling provides more visibility.

CCI issued 2021 guidance last quarter that suggests fundamentals will improve next year and we agree. Organic site rental revenue growth should be up 6% next year vs. ~5.5% this year, helped by 1% lower churn as a meaningful number of Sprint leases expire in 2023. Plus, Crown Castle will lease Dish space on up to 20K communication towers. The long-term agreement is a major win and should also help grow fiber related services. Investors would like to see small cell growth accelerate and more nodes deployed, although we are still in the early stages of this. Positively, collocation will account for ~40% of small cell activity next year, up from 20-30% and this will reduce capital intensity.

## Key Questions for 2021

### Cloud

- What does cloud growth look like in 2021? Is AWS ramping spend to accelerate growth? Can MSFT Azure and GCP continue to take share?
- Can cloud pricing remain stable? Does Google become more aggressive? AWS has wiggle room to get pricing down? To maintain market share.
- What new cloud services do the cloud providers focus heavily on in 2021? Serverless, Kubernetes, Edge, IoT, AI/ML, blockchain?
- Does Hybrid Cloud accelerate enterprise cloud adoption? We do see this as a stepping stone to true public cloud. Google is more of a competitor or not?
- CDN traffic volumes will have a tough comparison next year, as lockdowns end?

### Telco/Cable

- What price will the C Band auction go for?
- Will Dish look to disrupt Wireless?
- Will Cable start building wireless networks?
- What new revenue streams can 5G generate?
- Can wireless ARPU/Pricing continue to grow? This is probably the No. 1 factor for communication/cable stock performance.
- How will TMUS/S impact the industry? Will Dish be successful building out a 5G network from scratch?
- How much traction does private wireless networks get? Do they expand the wireless TAM?
- Will fixed wireless work? And if yes, when does cable face competitive pressures from fixed wireless?
- How much share will vMVPD services gain? Does targeted television advertising help this? Does Google's YouTube TV bundle this with other services?
- Why is business wireline growth coming in below expectations? Likely a secular shift to new technologies (SD-WAN), cloud and neutral datacenters. Will SD-WAN cannibalize the enterprise wireline market? We think SD-WAN is a large opportunity for CCOI and GTT and will accelerate the decline in revenue in the legacy enterprise wireline businesses of AT&T, VZ, and CTL.

### Infrastructure (Datacenters/Towers/Fiber/CDNs)

- Datacenters—does cloud continue to outsource? Supply and demand in key markets? Interest rates?
- Does TMUS begin decommissioning Wireless Cell Sites?
- Infrastructure M&A and private funds—next targets? GTT assets, AT&T, Boingo wireless?
- CDNs—can volumes persist after a very strong 2020? Will volume increases offset pricing declines?
- Do the hyperscale companies begin to sell their CDN capabilities more aggressively? Amazon and Microsoft have sound CDN technology. Google also going to market with its CDN offering.

- How will the slowing of Moore's Law impact datacenter demand and cloud? We view it as a positive long term.

### Cloud Communications

- Will we see further consolidation? We believe we will.
- Will demand continue? Can enterprise adoption continue to support high growth? How will Y/Y comps impact financials and investor sentiment?
- How competitive will MSFT be bundling in new services with Teams? What is their roadmap and how fast can they reach 1B users (if at all)?
- Are EGHT, VG and KLR acquired as large software and hyperscale players rush to create the next global platform for business communications?
- How will Salesforce/Slack merger impact industry? What are other large companies that could enter business communications?

Exhibit 11: Oppenheimer's Communications and Cloud Services Coverage Universe—Valuation Table (as of 12/21/2020)

Stock (Ticker)	Rating	Stock Price	Stock Perf.	Market Cap.	Firm Value	2021E Revs	2021E Rev. Growth	'21E Rev.	Normal EPS		P/E	Rel. To	Firm Value to '21E EBITDA		'21E FCF/ AFFO	'21E uFCF	'21E Net Debt/ EBITDA	Div. Yield
		12/21	Since YE19	(Mil.)	(Mil.)	(Mil.)	%YOY	Mult.	2021E		On 2021E		Consolidated					
		\$ Amt.	%YOY	EPS	S&P	EBITDA	Mult.	Yield	Margin	EBITDA	%							
Large Cap Communications																		
Altice USA (ATUS)	NC	\$35.6	30.0%	20,303	44,836	10,135	3%	4.4x	1.60	184%	22.2x	1.01	4,549	9.9x	9.0%	30.0%	5.4x	0.0%
AT&T (T)	O	\$29.1	(25.4%)	209,057	358,177	170,719	0%	2.1x	3.22	0%	9.1x	0.41	55,654	6.4x	12.9%	19.9%	2.7x	7.2%
ViacomCBS (VIAC)	NC	\$34.6	(17.6%)	21,400	39,804	27,699	7%	1.4x	4.19	(2%)	8.2x	0.38	4,884	8.2x	7.3%	9.2%	3.8x	0.0%
Lumen Technologies (LUMN)	O	\$10.0	(24.5%)	10,835	43,236	20,162	(3%)	2.1x	1.65	5%	6.0x	0.28	8,766	4.9x	28.4%	23.0%	3.7x	10.0%
Charter (CHTR)	P	\$656.2	35.3%	137,142	215,521	50,633	5%	4.3x	20.84	35%	31.5x	1.44	19,913	10.8x	6.1%	24.4%	3.9x	0.0%
Comcast (CMCSA)	P	\$50.5	12.4%	233,830	324,547	109,449	6%	3.0x	3.14	24%	16.1x	0.73	33,466	9.7x	5.9%	16.8%	2.7x	1.8%
DISH (DISH)	NC	\$29.8	(16.0%)	17,408	28,827	17,431	14%	1.7x	2.58	(2%)	11.5x	0.53	3,079	9.4x	5.0%	5.3%	3.7x	0.0%
Disney (DIS)	NC	\$171.4	18.5%	310,081	354,487	69,621	6%	5.1x	1.75	(13%)	98.0x	4.47	9,748	36.4x	0.3%	4.0%	4.6x	0.5%
T-Mobile US (TMUS)	P	\$130.4	66.3%	162,980	233,178	79,352	7%	2.9x	5.24	25%	24.9x	1.13	25,410	9.2x	4.5%	13.2%	2.4x	NA
Verizon (VZ)	O	\$59.6	(2.9%)	247,029	353,606	133,241	4%	2.7x	5.15	6%	11.6x	0.53	48,766	7.3x	8.2%	18.4%	2.2x	4.2%
Cloud Services																		
8x8 Inc. (EGHT)	O	\$31.9	74.5%	3,341	3,465	625	23%	5.5x	0.08	NM	NM	NM	20	NM	(0.9%)	####	5.2x	NA
Akamai (AKAM)	O	\$106.3	23.0%	17,694	17,030	3,498	9%	4.9x	5.63	8%	18.9x	0.86	1,532	10.1x	4.0%	21.2%	-1.4x	NA
Amazon (AMZN)	O	\$3,213.1	73.9%	1,625,812	1,640,257	456,780	20%	3.6x	62.29	22%	51.6x	2.35	71,056	22.1x	0.8%	3.2%	-0.8x	NA
Bandwidth (BAND)	NC	\$182.8	185.5%	4,420	4,417	452	38%	9.8x	0.35	(22%)	NM	NM	30	NM	0.1%	0.8%	-1.1x	0.0%
Cloudflare (NET)	O	\$85.0	398.4%	25,654	25,022	566	34%	44.2x	(0.09)	NM	NM	NM	34	NM	(0.2%)	46.1%	-19.5x	0.0%
Digital Turbine (APPS)	O	\$58.0	714.1%	5,576	5,562	375	53%	14.8x	0.85	70%	68.5x	3.12	89	62.4x	0.6%	8.6%	-1.2x	0.0%
Fastly, Inc. (FSLY)	P	\$101.7	406.9%	10,773	10,495	394	35%	26.6x	0.06	NM	NM	NM	30	NM	(0.2%)	(4.1%)	-10.4x	0.0%
Google (GOOG)	O	\$1,730.8	29.5%	1,187,071	1,082,017	214,843	21%	5.0x	61.66	19%	28.1x	1.28	77,644	12.9x	4.1%	22.7%	-2.4x	0.0%
Kaleyra (KLR)	O	\$8.8	3.4%	249	276	199	36%	1.4x	(0.38)	NM	NM	NM	9	29.8x	0.1%	0.3%	2.0x	0.0%
LimeLight Networks (LLNW)	O	\$4.2	3.7%	518	493	263	10%	1.9x	0.07	133%	60.4x	2.76	39	11.5x	4.2%	8.2%	-1.6x	NA
Microsoft (MSFT)	O	\$223.3	41.6%	1,705,418	1,630,993	164,699	9%	9.9x	7.01	10%	31.9x	1.45	82,714	18.7x	2.9%	30.3%	-1.9x	1.0%
RingCentral (RNG)	O	\$393.8	133.4%	35,113	35,831	1,434	23%	25.0x	1.16	21%	NM	NM	200	NM	0.2%	26.6%	2.6x	NA
Slack (WORK)	P	\$42.7	89.7%	24,329	23,659	1,143	29%	20.7x	(0.05)	NM	NM	NM	(21)	NM	0.3%	6.0%	NM	0.0%
Twilio (TWLO)	O	\$367.7	274.2%	54,238	51,602	2,189	31%	23.6x	0.10	(5%)	NM	NM	94	NM	(0.0%)	(0.9%)	-29.0x	0.0%
Vonage (VG)	O	\$13.5	81.6%	3,278	3,784	1,268	8%	3.0x	0.19	(5%)	70.8x	3.23	163	22.2x	1.5%	6.3%	2.1x	NA
Zoom Communications (ZM)	P	\$413.6	507.8%	123,765	121,667	3,502	36%	34.7x	2.97	2%	NM	NM	1,058	NM	1.0%	35.1%	-3.0x	0.0%
Cloud Infrastructure																		
American Tower (AMT) <sup>(c)</sup>	O	\$219.8	(4.3%)	98,051	121,103	8,656	9%	14.0x	4.52	4%	48.6x	2.22	5,535	21.9x	4.1%	48.1%	4.2x	2.0%
Boingo Wireless(WIFI)	O	\$12.6	15.3%	562	694	248	5%	2.8x	(0.29)	NM	NM	NM	40	17.3x	0.5%	4.2%	3.3x	NA
Cogent Comm. (CCOI)	P	\$60.2	(8.5%)	2,759	3,444	590	4%	5.8x	1.31	44%	46.0x	2.10	229	15.0x	3.3%	25.3%	3.0x	4.6%
CoreSite Realty (COR) <sup>(c)</sup>	NC	\$121.7	8.5%	5,160	7,026	654	8%	10.7x	1.92	1%	63.3x	2.89	348	20.2x	4.5%	28.5%	5.4x	3.9%
Crown Castle Intl. (CCI) <sup>(c)</sup>	O	\$153.2	7.8%	65,723	86,435	6,226	6%	13.9x	2.50	10%	61.3x	2.79	3,609	23.9x	4.4%	41.9%	5.3x	3.2%
CyrusOne (CONE) <sup>(c)</sup>	NC	\$70.8	8.1%	8,398	11,711	1,122	9%	10.4x	0.17	(5%)	NM	NM	589	19.9x	5.6%	(5.2%)	5.6x	2.7%
Digital Realty Trust (DLR) <sup>(c)</sup>	NC	\$133.3	11.4%	29,068	43,367	4,325	12%	10.0x	1.12	0%	NM	NM	2,366	18.3x	4.6%	27.8%	5.6x	3.2%
Equinix (EQIX) <sup>(c)</sup>	O	\$701.2	20.1%	62,771	72,522	6,650	11%	10.9x	10.76	28%	65.2x	2.97	3,159	23.0x	3.8%	10.2%	3.1x	1.5%
GTT Communications (GTT)	P	\$3.7	(67.2%)	213	3,407	1,627	(2%)	2.1x	(1.22)	NM	NM	NM	371	9.2x	53.0%	18.8%	8.6x	NA
QTS Realty Trust (QTS) <sup>(c)</sup>	NC	\$60.1	10.8%	3,705	5,401	600	12%	9.0x	0.16	92%	NM	NM	330	16.4x	4.4%	(36.9%)	5.1x	2.9%
SBA Comm.(SBAC) <sup>(c)</sup>	NC	\$277.2	15.0%	31,517	44,206	2,185	5%	20.2x	2.85	NM	97.2x	4.43	1,571	28.1x	3.7%	74.2%	8.1x	0.3%
Switch, Inc. (SWCH)	NC	\$15.9	7.0%	3,905	4,704	572	11%	8.2x	0.24	43%	65.3x	2.98	291	16.2x	2.1%	20.6%	2.7x	NA
Avg. Return Cloud & Communication Services																		
			82%															
S&P 500 (Cons. Ests.)		\$3,692	14%															
REIT Index		\$302	(12%)															
									168	22%	21.9x	--						

Note: Tim Horan provides Coverage of Companies that are Shaded, he Provides Co-Coverage of RingCentral and Amazon. TWLO/GOOG Covered by OpCO. (c) Using AFFO Yield versus FCF Yield. OPCO Ratings: O - Outperform, P - Perform, U - Underperform, NR - Not Rated, NC - Not Covered. \*Stock price results presented should not and cannot be viewed as an indicator of future performance. Return data excludes applicable costs including commissions and interest. See "Legal Disclaimer" section at the end of our reports for important disclosures, including potential conflicts of interest. Sprint's metrics are based on fiscal year, not calendar year.

Source: Company Reports, FactSet consensus, Oppenheimer & Co.



## 2021 Top Investment Risks

1. **Dish Entering Wireless with a FANG Partner.**
2. **Cable Building Out Wireless Networks, and Wireless Aggressively Attacking Fixed Wireless.**
3. **C-Band Spectrum Auction Raising More than \$50B.**
4. **In Cloud Google or Oracle Driving a Price War.**
5. **Over Supply of Datacenter and Fiber Capacity.**
6. **Deteriorating Macro Economic Conditions Cause Corporate Debt Spreads to Widen and Higher Customer Churn:** Trade wars and political uncertainty could lead to an economic downturn in the US. Europe has been weak and economic data in the US is mixed.
7. **Regulation.** The new democratic administration seems intent on bringing back net neutrality and likely other regulation on the industry. They may also try price regulation.
8. **Increased Competition as Cable/Wireless Converge, OTT Emerges:** Wireline cannibalization of voice and video could accelerate from both wireless and improved IP broadband speeds.
9. **Rising Interest Rates:** Interest rates increase debt/interest charge burden for our capital-intensive businesses.
10. **Price wars.** Wireless, broadband, CDN, networking, and cloud could all see aggressive price wars in 2021.
11. **FX volatility.** We expect volatility in the foreign exchange markets to impact results of companies with international exposure (AKAM, AMT, CCOI, EQIX, GTT, LLNW, MSFT, and VG are the most exposed).

## Summary of Recent White Papers

- Virtual Workplace White Paper: Communications and Applications Converge.** Business communications is converging with enterprise IT over the cloud, creating a winner-take-all, new virtual workplace. Teams is a once-in-a-decade new service/ platform that should win the race to serving a billion global virtual knowledge workers. We expect difficult-to-imagine services to evolve, which are sure to include AR, AI and Quantum Compute. This trend will expand the overall enterprise communications market and drive greater cloud/bandwidth usage. Teams, the dominant virtual workplace platform, has seen subscribers surge 10x in 1.5 years. Its platform enables network effects with partners and leverages its enormous Cloud, Applications and Distribution infrastructure, creating a positive flywheel. COVID-19 has accelerated this process by several years, and we see very strong growth in 2021 for Cloud Communications and Productivity Software as a whole. MSFT, EGHT, VG and KLR should continue to outperform the market. [Note here.](#)
- Blockchain White Paper: Token-Based Apps Drive New Collaborative Services.** Bitcoin has kick-started the infrastructure development that has enabled new blockchain-based applications, particularly in finance and logistics supported by tokens. These applications automate trust and with Tokens have created new community-based applications that were here-to-fore not possible, digital banking and farm-to-table food being two among dozens of others. We believe this will ultimately lead to a more distributed compute environment driving demand for key suppliers AKAM, MSFT, AWS, and EQIX to banking, payments, asset securitizations, and supply chain management, etc. We will focus on the investment potentials and impacts of Blockchain at our November 19th Virtual Blockchain Conference, as well as the developing ecosystem that could make blockchain a trillion-dollar market in the next decade. [Note Here.](#)
- 5G White Paper: Expect Stronger Revenue, CAPX, and Cell Site Growth.** 5G will increase wireless capacity 10x and reduce latency by 1/10th, while lowering operating expenses. 5G will drive wireless/wireline/cloud convergence and Fog as well as consolidation. The wireless addressable market should double to \$150B, driven by: 1) fixed wireless, 2) IoT/enterprise networks, and 3) higher usage/quality. We see a 10%-plus pickup in annual CAPX spending (excluding a potential \$80B in Federal broadband stimulus) and a doubling of cell site growth, helped by TMUS/S/ DISH. However, COVID-19 has caused new permitting and construction delays, short term. Other COVID-19 impacts are likely to last six months and could lower ARPUs, and, if last longer, CAPX. Regardless, 5G should accelerate wireless growth to 3% Y/Y in 2021, up from 1%. We detail each carriers' wireless strategy, with VZ the most aggressive. [Note Here.](#)
- CDNs Seeing Strong Growth; Secular Shift to OTT Video/ Gaming/Cloud Compute.** We have spoken with a dozen network and cloud infrastructure and CDN providers this week, and we hosted a conference call with LLNW management yesterday. The cloud infrastructure industry is seeing very strong volume growth from remote work/learning/entertainment. We see this as a permanent shift to a distributed cloud (Fog). CDNs are critical for Fog because they help deliver content/applications from the centralized cloud to the edge efficiently. We also believe this is positive for cloud infrastructure, datacenters/towers/fiber/cloud, as we discussed in our OTT whitepaper. For CDNs and networks, most of the increase in volumes is occurring off-peak with huge operating leverage for CDNs. In this regard, AKAM is also seeing strong demand for its relatively new suite of high margin enterprise security/network services (EAA). [Note here.](#)
- Cloud Asset Utilization Whitepaper:** It encapsulates our 20-year investment recommendations and more importantly how to make money over the next 20. Our approach has been to focus on companies that have unique assets that benefit from cloud growth, which is shifting to FOG/5G. These compute/network shifts have historically created major investment opportunities. We see GOOG, EGHT, FSLY, VZ, and a potential Dish/FANG partnership as well positioned in this shift. The best companies have unique assets and very low marginal costs on incremental revenues. This can take the form of infrastructure (AMT/EQIX/FSLY/VZ) software that leverages the cloud for provisioning, distribution, and sales (EGHT), or lowers sales costs through upselling multiple products. [Note Here.](#)

# Appendix I: Industry Model Updates

## Exhibit 12: Annual Wireline + Wireless Revenue/Capex Model (in millions)

						Y/Y Change				
	2019	2020E	2021E	2022E	2023E	2019	2020E	2021E	2022E	2023E
<b>Last Updated: 12/21/2020</b>										
<b>Revenues:</b>										
AT&T (T)	97,233	96,676	97,464	98,422	99,418	(1.0%)	(0.6%)	0.8%	1.0%	1.0%
Verizon (VZ) **	122,499	120,098	125,140	127,191	129,364	1.0%	(2.0%)	4.2%	1.6%	1.7%
New T-Mobile (TMUS)***	70,607	74,270	79,455	83,295	87,459	(5.9%)	5.2%	7.0%	4.8%	5.0%
Dish Network**		2,942	5,500	7,700	8,470			87.0%	40.0%	10.0%
Comcast (CMCSA)	58,082	59,742	61,719	63,571	65,478	3.7%	2.9%	3.3%	3.0%	3.0%
Charter Communications (CHTR)	45,764	48,037	50,633	53,165	55,823	4.9%	5.0%	5.4%	5.0%	5.0%
Lumen Technologies (LUMN)	21,458	20,708	20,162	19,759	19,462	(5.0%)	(3.5%)	(2.6%)	(2.0%)	(1.5%)
<b>Total</b>	<b>415,643</b>	<b>422,473</b>	<b>440,073</b>	<b>453,103</b>	<b>465,474</b>	<b>(0.3%)</b>	<b>1.6%</b>	<b>4.2%</b>	<b>3.0%</b>	<b>2.7%</b>
Growth YoY %	(0.3%)	1.6%	4.2%	3.0%	2.7%					
<b>Capital Expenditures:</b>										
AT&T (T)	22,685	19,448	19,000	18,000	18,000	(0.9%)	(14.3%)	(2.3%)	(5.3%)	0.0%
Verizon (VZ) **	16,081	17,562	17,393	17,536	17,812	9.1%	9.2%	(1.0%)	0.8%	1.6%
New T-Mobile (TMUS)***	10,900	11,834	14,699	14,993	15,305	7.5%	8.6%	24.2%	2.0%	2.1%
Dish Network**		297	2,000	2,500	5,000			NM	25.0%	100.0%
Comcast (CMCSA)	6,909	6,595	6,620	6,620	6,620	(10.5%)	(4.5%)	0.4%	0.0%	0.0%
Charter Communications (CHTR)	7,195	7,375	7,342	7,415	7,490	(21.2%)	2.5%	(0.4%)	1.0%	1.0%
Lumen Technologies (LUMN)	3,628	3,893	3,730	3,754	3,698	16.9%	7.3%	(4.2%)	0.6%	(1.5%)
<b>Total</b>	<b>67,398</b>	<b>67,004</b>	<b>70,784</b>	<b>70,819</b>	<b>73,924</b>	<b>(0.5%)</b>	<b>(0.6%)</b>	<b>5.6%</b>	<b>0.0%</b>	<b>4.4%</b>
Cap-ex as % of Revenues	16.2%	15.9%	16.1%	15.6%	15.9%					
<b>EBITDA</b>										
AT&T (T)	40,461	41,075	41,273	42,467	43,826	(0.5%)	1.5%	0.5%	2.9%	3.2%
Verizon (VZ)	47,972	48,653	49,240	50,434	51,673	(0.9%)	1.4%	1.2%	2.4%	2.5%
New T-Mobile (TMUS)***	20,479	21,743	24,284	26,132	27,439	6.2%	6.2%	11.7%	7.6%	5.0%
Dish Network**		37	1,100	1,925	2,541			NM	75.0%	32.0%
Comcast (CMCSA)	23,266	25,017	26,049	26,830	27,635	7.3%	7.5%	4.1%	3.0%	3.0%
Charter Communications (CHTR)	16,855	18,401	19,913	20,909	21,954	5.0%	9.2%	8.2%	5.0%	5.0%
Lumen Technologies (LUMN)	9,070	8,801	8,766	8,496	8,369	0.3%	(3.0%)	(0.4%)	(3.1%)	(1.5%)
<b>Total</b>	<b>158,103</b>	<b>163,727</b>	<b>170,625</b>	<b>177,193</b>	<b>183,437</b>	<b>1.9%</b>	<b>3.6%</b>	<b>4.2%</b>	<b>3.8%</b>	<b>3.5%</b>
EBITDA as % of Revenues	38.0%	38.8%	38.8%	39.1%	39.4%					
Growth YoY %	2.2%	1.9%	0.0%	0.9%	0.8%					
<b>Unlevered FCF</b>										
AT&T (T)	17,776	21,627	22,273	24,467	25,826	0.1%	21.7%	3.0%	9.9%	5.6%
Verizon (VZ)	31,891	31,091	31,847	32,898	33,861	(5.3%)	(2.5%)	2.4%	3.3%	2.9%
New T-Mobile (TMUS)***	9,579	9,909	9,585	11,139	12,134	4.8%	3.4%	(3.3%)	16.2%	8.9%
Dish Network**		(259)	(900)	(575)	(459)			NM	(36.1%)	(20.2%)
Comcast (CMCSA)	16,357	18,422	19,429	20,210	21,015	17.2%	12.6%	5.5%	4.0%	4.0%
Charter Communications (CHTR)	9,660	11,026	12,571	13,493	14,465	39.3%	14.1%	14.0%	7.3%	7.2%
Lumen Technologies (LUMN)	5,442	4,908	5,036	4,742	4,671	(8.3%)	(9.8%)	2.6%	(5.8%)	(1.5%)
<b>Total</b>	<b>90,705</b>	<b>96,723</b>	<b>99,841</b>	<b>106,375</b>	<b>111,513</b>	<b>3.8%</b>	<b>6.6%</b>	<b>3.2%</b>	<b>6.5%</b>	<b>4.8%</b>
UFCF as % of Revenues	21.8%	22.9%	22.7%	23.5%	24.0%					

Source: Company Reports &amp; OPCO Research Estimates

\* Includes wireless equipment sales.

\*\* Proforma for wireless/wireline acquisitions/dispositions

\*\* New T-Mobile Pro Forma Estimates

CLOUD AND COMMUNICATIONS

Exhibit 13: Quarterly Wireline + Wireless Revenue/Capex Model (in millions)

Last Updated: 12/21/2020	1Q19				2Q19				3Q19				4Q19				2019				1Q20				2Q20				3Q20				4Q20E				2020E				2021E				2022E				2023E				Y/Y Change																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

Source: Company Reports & OPSCO Research Estimates

\* Includes wireless equipment sales.

\*\* Proforma for wireless/wireline acquisitions/dispositions

\*\*\* New T-Mobile Pro Forma Estimates

## Exhibit 14: Annual Wireless Revenue/Capex Model (in thousands)

						Y/Y Change				
	2019	2020E	2021E	2022E	2023E	2019	2020E	2021E	2022E	2023E
<b>Last Updated: 12/21/2020</b>										
<b>Revenues*:</b>										
AT&T Mobility (T)	71,056	71,239	72,663	74,117	75,599	(0.4%)	0.3%	2.0%	2.0%	2.0%
Verizon Wireless (VZ)	94,223	92,890	98,944	101,912	104,970	2.7%	(1.4%)	6.5%	3.0%	3.0%
New T-Mobile (TMUS)***	70,607	74,270	79,455	83,295	87,459	(5.9%)	5.2%	7.0%	4.8%	5.0%
Dish Network**		2,942	5,500	7,700	8,470			87.0%	40.0%	10.0%
<b>Total</b>	<b>235,886</b>	<b>241,341</b>	<b>256,562</b>	<b>267,024</b>	<b>276,498</b>	<b>(0.9%)</b>	<b>2.3%</b>	<b>6.3%</b>	<b>4.1%</b>	<b>3.5%</b>
Y/Y	(0.9%)	2.3%	6.3%	4.1%	3.5%					
<b>Capital Expenditures:</b>										
AT&T Mobility (T)	13,611	11,931	12,350	11,700	11,700	(0.9%)	(12.3%)	3.5%	(5.3%)	0.0%
Verizon Wireless (VZ)	10,246	12,940	13,448	13,986	14,545	20.7%	26.3%	3.9%	4.0%	4.0%
New T-Mobile (TMUS)***	10,900	11,834	14,699	14,993	15,305	7.5%	8.6%	24.2%	2.0%	2.1%
Dish Network**		297	2,000	2,500	3,000			574%	25.0%	20.0%
<b>Total</b>	<b>34,757</b>	<b>37,002</b>	<b>42,497</b>	<b>43,179</b>	<b>44,550</b>	<b>7.4%</b>	<b>6.5%</b>	<b>14.9%</b>	<b>1.6%</b>	<b>3.2%</b>
Y/Y	7.4%	6.5%	14.9%	1.6%	3.2%					
Q/Q										
<b>Cap-ex as % of wireless Revenues</b>	<b>14.7%</b>	<b>15.3%</b>	<b>16.6%</b>	<b>16.2%</b>	<b>16.1%</b>					
<b>EBITDA</b>										
AT&T Mobility (T)	30,375	31,067	31,972	33,352	34,775	1.0%	2.3%	2.9%	4.3%	4.3%
Verizon Wireless (VZ)	43,095	43,844	44,525	45,861	47,236	1.3%	1.7%	1.6%	3.0%	3.0%
New T-Mobile (TMUS)***	20,479	21,743	24,284	26,132	27,439	6.2%	6.2%	11.7%	7.6%	5.0%
Dish Network**		37	1,100	1,925	2,541			NM	75.0%	32.0%
<b>Total</b>	<b>93,949</b>	<b>96,692</b>	<b>101,881</b>	<b>107,270</b>	<b>111,991</b>	<b>2.2%</b>	<b>2.9%</b>	<b>5.4%</b>	<b>5.3%</b>	<b>4.4%</b>
<b>EBITDA as % of Revenues</b>	<b>39.8%</b>	<b>40.1%</b>	<b>39.7%</b>	<b>40.2%</b>	<b>40.5%</b>					
<b>Unlevered FCF</b>										
AT&T Mobility (T)	16,764	19,136	19,622	21,652	23,075	2.6%	14.1%	2.5%	10.3%	6.6%
Verizon Wireless (VZ)	32,849	30,904	31,077	31,875	32,691	(3.6%)	(5.9%)	0.6%	2.6%	2.6%
New T-Mobile (TMUS)***	9,579	9,909	9,585	11,139	12,134	4.8%	3.4%	(3.3%)	16.2%	8.9%
Dish Network**	-	(259)	(900)	(575)	(459)			NM	(36.1%)	(20.2%)
<b>Total</b>	<b>59,192</b>	<b>59,690</b>	<b>59,384</b>	<b>64,091</b>	<b>67,441</b>	<b>(0.6%)</b>	<b>0.8%</b>	<b>(0.5%)</b>	<b>7.9%</b>	<b>5.2%</b>
<b>UFCF as % of Revenues</b>	<b>25.1%</b>	<b>24.7%</b>	<b>23.1%</b>	<b>24.0%</b>	<b>24.4%</b>					

Notes:

\* Includes equipment sales.

\*\* Dish Pro Forma Estimates

\*\* New T-Mobile Pro Forma Estimates

Source: Company Reports &amp; OPCO Research Estimates

CLOUD AND COMMUNICATIONS

Exhibit 15: Quarterly Wireless Revenue/Capex Model (in millions)

Last Updated: 12/21/2020

	1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E	2022E	2023E
<b>Revenues**:</b>													
AT&T Mobility (T)	17,363	17,292	17,701	18,700	71,056	17,402	17,149	17,894	18,794	71,239	72,663	74,117	75,599
Verizon Wireless (VZ)	22,700	22,682	23,569	25,272	94,223	22,565	21,742	22,640	25,943	92,890	98,944	101,912	104,970
New T-Mobile (TMUS)***	17,619	17,460	17,243	18,285	70,607	17,408	17,671	19,272	19,919	74,270	79,455	83,295	87,459
Dish Network**								1,342	1,600	2,942	5,500	7,700	8,470
<b>Total</b>	<b>57,682</b>	<b>57,434</b>	<b>58,513</b>	<b>62,257</b>	<b>235,886</b>	<b>57,375</b>	<b>56,562</b>	<b>61,148</b>	<b>66,256</b>	<b>241,341</b>	<b>256,562</b>	<b>267,024</b>	<b>276,498</b>
Y/Y	0.5%	(1.1%)	(2.2%)	(0.9%)	(0.9%)	(0.5%)	(1.5%)	4.5%	6.4%	2.3%	6.3%	4.1%	3.5%
<b>Capital Expenditures:</b>													
AT&T Mobility (T)	3,601	3,893	3,572	2,545	13,611	3,742	3,269	2,400	2,520	11,931	12,350	11,700	11,700
Verizon Wireless (VZ)	2,044	2,219	2,619	3,364	10,246	3,692	3,203	3,023	3,022	12,940	13,448	13,986	14,545
New T-Mobile (TMUS)***	3,080	2,978	2,623	2,219	10,900	2,675	2,257	3,217	3,685	11,834	14,699	14,993	15,305
Dish Network**								22	275	297	2,000	2,500	3,000
<b>Total</b>	<b>8,725</b>	<b>9,090</b>	<b>8,814</b>	<b>8,128</b>	<b>34,757</b>	<b>10,109</b>	<b>8,729</b>	<b>8,662</b>	<b>9,502</b>	<b>37,002</b>	<b>42,497</b>	<b>43,179</b>	<b>44,550</b>
Y/Y	8.6%	14.6%	6.5%	0.2%	7.4%	15.9%	(4.0%)	(1.7%)	16.9%	6.5%	14.9%	1.6%	3.2%
Q/Q	7.6%	4.2%	(3.0%)	(7.8%)		24.4%	(13.7%)	(0.8%)	9.7%				
<b>Cap-ex as % of wireless Revenues</b>	<b>15.1%</b>	<b>15.8%</b>	<b>15.1%</b>	<b>13.1%</b>	<b>14.7%</b>	<b>17.6%</b>	<b>15.4%</b>	<b>14.2%</b>	<b>14.3%</b>	<b>15.3%</b>	<b>16.6%</b>	<b>16.2%</b>	<b>16.1%</b>
<b>EBITDA</b>													
AT&T Mobility (T)	7,322	7,770	7,753	7,530	30,375	7,833	7,817	7,712	7,705	31,067	31,972	33,352	34,775
Verizon Wireless (VZ)	10,765	10,923	11,042	10,365	43,095	10,673	10,436	11,320	11,415	43,844	44,525	45,861	47,236
New T-Mobile (TMUS)***	5,352	5,461	4,933	4,733	20,479	5,249	5,596	5,779	5,119	21,743	24,264	26,132	27,439
Dish Network**								7	30	37	1,100	1,925	2,541
<b>Total</b>	<b>23,439</b>	<b>24,154</b>	<b>23,728</b>	<b>22,628</b>	<b>93,949</b>	<b>23,755</b>	<b>23,849</b>	<b>24,818</b>	<b>24,269</b>	<b>96,692</b>	<b>101,881</b>	<b>107,270</b>	<b>111,991</b>
<b>EBITDA as % of Revenues</b>	<b>40.6%</b>	<b>42.1%</b>	<b>40.6%</b>	<b>36.3%</b>	<b>39.8%</b>	<b>41.4%</b>	<b>42.2%</b>	<b>40.6%</b>	<b>36.6%</b>	<b>40.1%</b>	<b>39.7%</b>	<b>40.2%</b>	<b>40.5%</b>
<b>Unlevered FCF</b>													
AT&T Mobility (T)	3,721	3,877	4,181	4,985	16,764	4,091	4,548	5,312	5,185	19,136	19,622	21,652	23,075
Verizon Wireless (VZ)	8,721	8,704	8,423	7,001	32,849	6,981	7,233	8,297	8,393	30,904	31,077	31,875	32,691
New T-Mobile (TMUS)***	2,272	2,483	2,310	2,514	9,579	2,574	3,339	2,562	1,434	9,909	9,585	11,139	12,134
Dish Network**								(14)	(245)	(259)	(900)	(575)	(459)
<b>Total</b>	<b>14,714</b>	<b>15,064</b>	<b>14,914</b>	<b>14,500</b>	<b>59,192</b>	<b>13,646</b>	<b>15,120</b>	<b>16,157</b>	<b>14,767</b>	<b>59,690</b>	<b>59,384</b>	<b>64,091</b>	<b>67,441</b>
<b>UFCF as % of Revenues</b>	<b>25.5%</b>	<b>26.2%</b>	<b>25.5%</b>	<b>23.3%</b>	<b>25.1%</b>	<b>23.8%</b>	<b>26.7%</b>	<b>26.4%</b>	<b>22.3%</b>	<b>24.7%</b>	<b>23.1%</b>	<b>24.0%</b>	<b>24.4%</b>

Notes:

\* Includes equipment sales.

\*\* Dish Pro Forma Estimates

\*\*\* New T-Mobile Pro Forma Estimates

Source: Company Reports & OPCA Research Estimates

Y/Y Change												
1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E	2022E	2023E
0.0%	0.1%	(1.3%)	(0.4%)	(0.4%)	0.2%	(0.8%)	1.1%	0.5%	0.3%	2.0%	2.0%	2.0%
3.7%	1.0%	2.6%	3.5%	2.7%	(0.6%)	(4.1%)	(3.9%)	2.7%	(1.4%)	6.5%	3.0%	3.0%
(3.0%)	(4.7%)	(8.8%)	(7.0%)	(5.9%)	(1.2%)	1.2%	11.8%	8.9%	5.2%	4.8%	5.0%	5.0%
										87.0%	40.0%	10.0%
0.5%	(1.1%)	(2.2%)	(0.9%)	(0.9%)	(0.5%)	(1.5%)	4.5%	6.4%	2.3%	6.3%	4.1%	3.5%
2.2%	10.5%	1.4%	(19.7%)	(0.9%)	3.9%	(16.0%)	(32.8%)	(1.0%)	(12.3%)	3.5%	(5.3%)	0.0%
(13.6%)	34.5%	23.1%	43.6%	20.7%	80.6%	44.3%	15.4%	(10.2%)	26.3%	3.9%	4.0%	4.0%
43.5%	7.9%	(0.2%)	(14.7%)	7.5%	(13.1%)	(24.2%)	22.6%	66.1%	8.6%	24.2%	2.0%	2.1%
										574%	25.0%	20.0%
8.6%	14.6%	6.5%	0.2%	7.4%	15.9%	(4.0%)	(1.7%)	16.9%	6.5%	14.9%	1.6%	3.2%
1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E	2022E	2023E
1.0%	2.0%	0.9%	0.1%	1.0%	7.0%	0.6%	(0.5%)	2.3%	2.3%	2.9%	4.3%	4.3%
2.7%	1.8%	0.7%	(0.2%)	1.3%	(0.9%)	(4.5%)	2.5%	10.1%	1.7%	1.6%	3.0%	3.0%
21.1%	6.6%	(2.6%)	1.3%	6.2%	(1.9%)	2.5%	17.1%	8.2%	6.2%	11.7%	7.6%	5.0%
										NM	75.0%	32.0%
5.8%	2.9%	0.1%	0.2%	2.2%	1.3%	(1.3%)	4.6%	7.3%	2.9%	5.4%	5.3%	4.4%
(0.2%)	(5.3%)	0.5%	14.5%	2.6%	9.9%	17.3%	27.1%	4.0%	14.1%	2.5%	10.3%	6.6%
7.5%	(4.2%)	(4.7%)	(12.9%)	(3.6%)	(20.0%)	(16.9%)	(1.5%)	19.9%	(5.9%)	0.6%	2.6%	2.6%
0.0%	5.0%	(5.1%)	21.4%	4.8%	13.3%	34.5%	10.9%	(43.0%)	3.4%	(3.3%)	16.2%	8.9%
										NM	(36.1%)	(20.2%)
4.3%	(3.1%)	(3.3%)	0.2%	(0.6%)	(7.3%)	0.4%	8.3%	1.8%	0.8%	(0.5%)	7.9%	5.2%



## Exhibit 16: Annual Wireline Revenue/Capex Model (in millions)

						Y/Y Change				
						2019	2020E	2021E	2022E	2023E
<b>Last Updated: 12/21/2020</b>										
<b>Revenues*:</b>										
AT&T (T)	26,177	25,437	24,801	24,305	23,819	(2.4%)	(2.8%)	(2.5%)	(2.0%)	(2.0%)
Verizon (VZ)	28,276	27,208	26,196	25,279	24,394	(4.4%)	(3.8%)	(3.7%)	(3.5%)	(3.5%)
Lumen Technologies (LUMN)	21,458	20,708	20,162	19,759	19,462	(5.0%)	(3.5%)	(2.6%)	(2.0%)	(1.5%)
Comcast (CMCSA)	58,082	59,742	61,719	63,571	65,478	3.7%	2.9%	3.3%	3.0%	3.0%
Charter Communications (CHTR)	45,764	48,037	50,633	53,165	55,823	4.9%	5.0%	5.4%	5.0%	5.0%
<b>Total</b>	<b>179,757</b>	<b>181,132</b>	<b>183,511</b>	<b>186,078</b>	<b>188,976</b>	<b>0.6%</b>	<b>0.8%</b>	<b>1.3%</b>	<b>1.4%</b>	<b>1.6%</b>
Y/Y										
Q/Q										
<b>Capital Expenditures:</b>										
AT&T (T)	9,074	7,517	6,650	6,300	6,300	(0.9%)	(17.2%)	(11.5%)	(5.3%)	0.0%
Verizon (VZ)	5,835	4,622	3,945	3,551	3,266	(6.7%)	(20.8%)	(14.6%)	(10.0%)	(8.0%)
Lumen Technologies (LUMN)	3,628	3,893	3,730	3,754	3,698	16.9%	7.3%	(4.2%)	0.6%	(1.5%)
Comcast (CMCSA)	6,909	6,595	6,620	6,620	6,620	(10.5%)	(4.5%)	0.4%	0.0%	0.0%
Charter Communications (CHTR)	7,195	7,375	7,342	7,415	7,490	(21.2%)	2.5%	(0.4%)	1.0%	1.0%
<b>Total</b>	<b>32,641</b>	<b>30,002</b>	<b>28,287</b>	<b>27,640</b>	<b>27,374</b>	<b>(7.7%)</b>	<b>(8.1%)</b>	<b>(5.7%)</b>	<b>(2.3%)</b>	<b>(1.0%)</b>
Y/Y										
Q/Q										
<b>Cap-ex as % of wireline Revenues</b>	<b>18.2%</b>	<b>16.6%</b>	<b>15.4%</b>	<b>14.9%</b>	<b>14.5%</b>					
<b>EBITDA</b>										
AT&T (T)	10,086	10,008	9,301	9,115	9,051	(4.7%)	(0.8%)	(7.1%)	(2.0%)	(0.7%)
Verizon (VZ)	4,877	4,809	4,715	4,574	4,437	(16.9%)	(1.4%)	(1.9%)	(3.0%)	(3.0%)
Lumen Technologies (LUMN)	9,070	8,801	8,766	8,496	8,369	0.3%	(3.0%)	(0.4%)	(3.1%)	(1.5%)
Comcast (CMCSA)	23,266	25,017	26,049	26,830	27,635	7.3%	7.5%	4.1%	3.0%	3.0%
Charter Communications (CHTR)	16,855	18,401	19,913	20,909	21,954	5.0%	9.2%	8.2%	5.0%	5.0%
<b>Total</b>	<b>64,154</b>	<b>67,036</b>	<b>68,744</b>	<b>69,924</b>	<b>71,446</b>	<b>1.5%</b>	<b>4.5%</b>	<b>2.5%</b>	<b>1.7%</b>	<b>2.2%</b>
<b>EBITDA as % of Revenues</b>	<b>35.7%</b>	<b>37.0%</b>	<b>37.5%</b>	<b>37.6%</b>	<b>37.8%</b>					
<b>Unlevered FCF</b>										
AT&T (T)	1,012	2,491	2,651	2,815	2,751	(28.9%)	146.1%	6.4%	6.2%	(2.3%)
Verizon (VZ)	(958)	187	770	1,023	1,170	149.3%	(119.5%)	313%	32.9%	14.3%
Lumen Technologies (LUMN)	5,442	4,908	5,036	4,742	4,671	(8.3%)	(9.8%)	2.6%	(5.8%)	(1.5%)
Comcast (CMCSA)	16,357	18,422	19,429	20,210	21,015	17.2%	12.6%	5.5%	4.0%	4.0%
Charter Communications (CHTR)	9,660	11,026	12,571	13,493	14,465	39.3%	14.1%	14.0%	7.3%	7.2%
<b>Total</b>	<b>31,513</b>	<b>37,034</b>	<b>40,457</b>	<b>42,284</b>	<b>44,072</b>	<b>13.1%</b>	<b>17.5%</b>	<b>9.2%</b>	<b>4.5%</b>	<b>4.2%</b>
<b>UFCF as % of Revenues</b>	<b>17.5%</b>	<b>20.4%</b>	<b>22.0%</b>	<b>22.7%</b>	<b>23.3%</b>					

Source: Company Reports &amp; OPCO Research Estimates

## CLOUD AND COMMUNICATIONS

## Exhibit 17: Quarterly Wireline Revenue/Capex Model (in thousands)

Last Updated: 12/21/2020													Y/Y Change																									
Revenues:													1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E	2022E	2023E	1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E	2022E	2023E
AT&T (T)	6,478	6,607	6,503	6,589	26,177	6,332	6,374	6,340	6,391	25,437	24,801	24,305	23,819	(4.0%)	(0.6%)	(3.0%)	(2.1%)	(2.4%)	(2.3%)	(3.5%)	(2.5%)	(3.0%)	(2.8%)	(2.5%)	(2.0%)	(2.0%)	(2.0%)	(2.0%)	(2.0%)									
Verizon (VZ)	7,167	7,081	7,022	7,006	28,276	6,881	6,853	6,845	6,629	27,208	26,196	25,279	24,394	(4.6%)	(4.4%)	(4.1%)	(4.4%)	(4.4%)	(4.0%)	(3.2%)	(2.5%)	(5.4%)	(3.8%)	(3.7%)	(3.5%)	(3.5%)	(3.5%)	(3.5%)	(3.5%)									
Lumen Technologies (LUMN)	5,427	5,375	5,350	5,306	21,458	5,228	5,192	5,167	5,121	20,708	20,162	19,759	19,462	(5.1%)	(5.6%)	(4.8%)	(4.4%)	(5.0%)	(3.7%)	(3.4%)	(3.4%)	(3.5%)	(3.5%)	(2.6%)	(2.0%)	(1.5%)	(1.5%)	(1.5%)	(1.5%)									
Comcast (CMCSA)	14,280	14,450	14,584	14,768	58,082	14,918	14,428	15,000	15,396	59,742	61,719	63,571	65,478	4.2%	3.9%	4.0%	2.6%	3.7%	4.5%	(0.2%)	2.9%	4.3%	2.9%	3.3%	3.0%	3.0%	3.0%	3.0%	3.0%									
Charter Communications (CHTR)	11,206	11,347	11,450	11,761	45,764	11,738	11,696	12,039	12,564	48,037	50,633	53,165	55,823	5.2%	4.5%	5.1%	4.7%	4.9%	4.7%	3.1%	5.1%	6.8%	5.0%	5.4%	5.0%	5.0%	5.0%	5.0%	5.0%									
Total	44,558	44,860	44,909	45,430	179,757	45,097	44,543	45,391	46,101	181,132	183,511	186,078	188,976	0.5%	0.8%	0.8%	0.4%	0.6%	1.2%	(0.7%)	1.1%	1.5%	0.8%	1.3%	1.4%	1.4%	1.4%	1.6%	1.6%									
Y/Y	0.5%	0.8%	0.8%	0.4%		1.2%	(0.7%)	1.1%	1.5%																													
Q/Q	(1.5%)	0.7%	0.1%	1.2%		(0.7%)	(1.2%)	1.9%	1.6%																													
Capital Expenditures:																																						
AT&T (T)	2,401	2,595	2,382	1,696	9,074	2,015	1,760	2,062	1,680	7,517	6,650	6,300	6,300	2.2%	10.5%	1.4%	(19.7%)	(0.9%)	(16.1%)	(32.2%)	(13.4%)	(1.0%)	(17.2%)	(11.5%)	(5.3%)	0.0%												
Verizon (VZ)	1,733	1,110	1,310	1,682	5,835	1,319	1,144	1,080	1,079	4,622	3,945	3,551	3,266	3.6%	(5.6%)	(15.5%)	(9.3%)	(6.7%)	(23.9%)	3.1%	(17.6%)	(35.9%)	(20.8%)	(14.6%)	(10.0%)	(8.0%)												
Lumen Technologies (LUMN)	931	800	957	940	3,628	974	1,009	988	922	3,893	3,730	3,754	3,698	15.7%	3.8%	39.9%	11.4%	16.9%	4.6%	26.1%	3.2%	(1.9%)	7.3%	(4.2%)	0.6%	(1.5%)												
Comcast (CMCSA)	1,363	1,594	1,814	2,138	6,909	1,269	1,452	1,770	2,104	6,595	6,620	6,620	6,620	(19.4%)	(9.8%)	(6.8%)	(7.8%)	(10.5%)	(6.9%)	(8.9%)	(2.4%)	(1.6%)	(4.5%)	0.4%	0.0%	0.0%												
Charter Communications (CHTR)	1,665	1,597	1,651	2,282	7,195	1,461	1,877	2,014	2,023	7,375	7,342	7,415	7,490	(23.7%)	(33.2%)	(22.0%)	(6.2%)	(21.2%)	(12.3%)	17.5%	22.0%	(11.3%)	2.5%	(0.4%)	1.0%	1.0%												
Total	8,093	7,696	8,114	8,738	32,641	7,038	7,242	7,914	7,808	30,002	28,287	27,640	27,374	(7.0%)	(9.0%)	(6.2%)	(8.6%)	(7.7%)	(13.0%)	(5.9%)	(2.5%)	(10.6%)	(8.1%)	(5.7%)	(2.3%)	(1.0%)												
Y/Y	(7.0%)	(9.0%)	(6.2%)	(8.6%)		(13.0%)	(5.9%)	(2.5%)	(10.6%)																													
Q/Q	(15.4%)	(4.9%)	5.4%	7.7%		(19.5%)	2.9%	9.3%	(1.3%)																													
Cap-ex as % of wireline Revenues	18.2%	17.2%	18.1%	19.2%	18.2%	15.6%	16.3%	17.4%	16.9%	16.6%	15.4%	14.9%	14.5%																									
EBITDA																																						
AT&T (T)	2,446	2,632	2,481	2,527	10,086	2,381	2,595	2,507	2,525	10,008	9,301	9,115	9,051	(10.4%)	0.8%	(7.2%)	(1.5%)	(4.7%)	(2.7%)	(1.4%)	1.0%	(0.1%)	(0.8%)	(7.1%)	(2.0%)	(0.7%)												
Verizon (VZ)	1,455	1,367	1,222	834	4,877	1,376	1,405	1,232	795	4,809	4,715	4,574	4,437	(8.6%)	(8.6%)	(18.2%)	(35.4%)	(16.9%)	(5.4%)	2.8%	0.8%	(4.6%)	(1.4%)	(1.9%)	(3.0%)	(3.0%)												
Lumen Technologies (LUMN)	2,262	2,269	2,261	2,278	9,070	2,243	2,174	2,190	2,194	8,801	8,766	8,496	8,369	3.7%	(0.1%)	(1.1%)	(1.0%)	0.3%	(0.8%)	(4.2%)	(3.1%)	(3.7%)	(3.0%)	(0.4%)	(3.1%)	(1.5%)												
Comcast (CMCSA)	5,728	5,854	5,801	5,883	23,266	6,076	6,176	6,411	6,354	25,017	26,049	26,830	27,635	9.8%	7.4%	6.8%	5.4%	7.3%	6.1%	5.5%	10.5%	8.0%	7.5%	4.1%	3.0%	3.0%												
Charter Communications (CHTR)	4,055	4,185	4,086	4,529	16,855	4,396	4,489	4,639	4,877	18,401	19,913	20,909	21,954	4.2%	3.3%	3.4%	8.8%	5.0%	8.4%	7.3%	13.5%	7.7%	9.2%	8.2%	5.0%	5.0%												
Total	15,946	16,307	15,851	16,051	64,154	16,472	16,839	16,979	16,745	67,036	68,744	69,924	71,446	2.1%	2.7%	0.1%	0.9%	1.5%	3.3%	3.3%	7.1%	4.3%	4.5%	2.5%	1.7%	2.2%												
EBITDA as % of Revenues	35.8%	36.4%	35.3%	35.3%	35.7%	36.5%	37.8%	37.4%	36.3%	37.0%	37.5%	37.6%	37.8%																									
Unlevered FCF																																						
AT&T (T)	45	37	99	831	1,012	366	835	445	845	2,491	2,651	2,815	2,751	(88.2%)	(86.0%)	(69.3%)	82.8%	(28.9%)	709.8%	2,168.6%	347.7%	1.7%	146.1%	6.4%	6.2%	(2.3%)												
Verizon (VZ)	(278)	257	(88)	(848)	(958)	57	261	152	(284)	187	770	1,023	1,170	243.8%	(19.8%)	52.2%	50.1%	149.3%	(120.6%)	1.6%	(272.5%)	(66.6%)	(119.5%)	313%	32.9%	14.3%												
Lumen Technologies (LUMN)	1,331	1,469	1,304	1,338	5,442	1,269	1,165	1,202	1,272	4,908	5,036	4,742	4,671	(3.3%)	(2.1%)	(18.7%)	(8.2%)	(8.3%)	(4.7%)	(20.7%)	(7.8%)	(4.9%)	(9.8%)	2.6%	(5.8%)	(1.5%)												
Comcast (CMCSA)	4,365	4,260	3,987	3,745	16,357	4,807	4,724	4,641	4,250	18,422	19,429	20,210	21,015	23.8%	15.7%	14.3%	14.8%	17.2%	10.1%	10.9%	16.4%	13.5%	12.6%	5.5%	4.0%	4.0%												
Charter Communications (CHTR)	2,390	2,588	2,435	2,247	9,660	2,935	2,612	2,625	2,854	11,026	12,571	13,493	14,465	39.8%	55.9%	32.8%	29.8%	39.3%	22.8%	0.9%	7.8%	27.0%	14.1%	14.0%	7.3%	7.2%												
Total	7,853	8,610	7,737	7,312	31,513	9,434	9,597	9,065	8,937	37,034	40,457	42,284	44,072	13.6%	16.0%	7.6%	15.4%	13.1%	20.1%	11.5%	17.2%	22.2%	17.5%	9.2%	4.5%	4.2%												
UFCF as % of Revenues	17.6%	19.2%	17.2%	16.1%	17.5%	20.9%	21.5%	20.0%	19.4%	20.4%	22.0%	22.7%	23.3%																									
Source: Company Reports & OPCO Research Estimates																																						

Source: Company Reports &amp; OPCA Research Estimates

## Exhibit 18: Annual Wireless Subscriber Metrics

12/21/2020

OPCO Subscribers Ests (000s):	2018	2019	2020E	2021E
<b>Postpaid Phone Only Net Adds</b>				
Verizon	1,123	1,435	988	1,300
AT&T	194	482	1,107	600
New T-Mobile*	3,281	2,598	1,846	3,000
MVNO	987	1,834	2,310	2,375
<b>Total</b>	<b>5,585</b>	<b>6,349</b>	<b>6,251</b>	<b>7,275</b>
<b>Phone Only Churn</b>				
Verizon	0.79%	0.82%	0.74%	0.82%
AT&T	0.90%	0.95%	0.84%	0.95%
New T-Mobile	1.34%	1.32%	1.01%	1.00%
<b>Average</b>	<b>1.15%</b>	<b>1.18%</b>	<b>0.86%</b>	<b>0.92%</b>
<b>Postpaid Phone Only Flowshare</b>				
Verizon	20.1%	22.6%	15.8%	17.9%
AT&T	3.5%	7.6%	17.7%	8.2%
New T-Mobile	58.7%	40.9%	29.5%	41.2%
MVNO	17.7%	28.9%	37.0%	32.6%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
<b>Phone Only ARPU</b>				
Verizon	\$ 42.41	\$ 42.61	\$ 41.90	\$ 42.30
AT&T	\$ 54.72	\$ 55.61	\$ 55.21	\$ 56.50
New T-Mobile	\$ 48.23	\$ 48.09	\$ 48.14	\$ 48.28
<b>Average</b>	<b>\$ 48.45</b>	<b>\$ 48.77</b>	<b>\$ 48.42</b>	<b>\$ 49.03</b>
<b>Prepaid Net Adds</b>				
Verizon	(757)	(591)	(85)	21,000
AT&T	1,290	672	365	400
New T-Mobile	455	(241)	151	200
Dish Network			(362)	0
<b>Total</b>	<b>988</b>	<b>(160)</b>	<b>69</b>	<b>21,600</b>

Source: Company reports, Oppenheimer &amp; Co. Inc. estimates.

\*Includes Historical OPCO Estimates for New T-Mobile

Y/Y Change

2018	2019	2020E	2021E
45%	28%	(31%)	32%
(161%)	148%	130%	(46%)
(4%)	(21%)	(29%)	63%
160%	86%	26%	3%
<b>31%</b>	<b>14%</b>	<b>(2%)</b>	<b>16%</b>
2%	3%	(10%)	11%
5%	6%	(12%)	13%
(5%)	(1%)	(23%)	(1%)
<b>(1%)</b>	<b>3%</b>	<b>(27%)</b>	<b>7%</b>

(3.3%)	0.5%	(1.7%)	1.0%
NM	1.6%	(0.7%)	2.3%
(3.4%)	(0.3%)	0.1%	0.3%
<b>3.3%</b>	<b>0.7%</b>	<b>(0.7%)</b>	<b>1.3%</b>
NM	(22%)	(86%)	NM
50%	(48%)	(46%)	NM
(63%)	(153%)	(163%)	32%
		NM	NM
<b>(52%)</b>	<b>(116%)</b>	<b>(143%)</b>	<b>NM</b>

CLOUD AND COMMUNICATIONS

Exhibit 19: Quarterly Wireless Subscriber Metrics

12/21/2020

OPCO Subscribers Ests (000s):	2018	1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E
<b>Postpaid Phone Only Net Adds</b>												
Verizon	1,123	(44)	245	444	790	1,435	(68)	173	283	600	988	1,300
AT&T	194	80	72	101	229	482	163	(151)	645	450	1,107	600
New T-Mobile*	3,281	467	582	663	886	2,598	104	253	689	800	1,846	3,000
MVNO	987	347	389	495	603	1,834	547	485	568	710	2,310	2,375
<b>Total</b>	<b>5,585</b>	<b>850</b>	<b>1,288</b>	<b>1,703</b>	<b>2,508</b>	<b>6,349</b>	<b>746</b>	<b>760</b>	<b>2,185</b>	<b>2,560</b>	<b>6,251</b>	<b>7,275</b>
<b>Phone Only Churn</b>												
Verizon	0.79%	0.84%	0.76%	0.82%	0.86%	0.82%	0.82%	0.58%	0.69%	0.89%	0.74%	0.82%
AT&T	0.90%	0.93%	0.86%	0.95%	1.07%	0.95%	0.86%	0.84%	0.69%	0.95%	0.84%	0.95%
New T-Mobile	1.34%	1.31%	1.22%	1.34%	1.46%	1.32%	1.30%	0.80%	0.90%	1.05%	1.01%	1.00%
<b>Average</b>	<b>1.15%</b>	<b>1.16%</b>	<b>1.08%</b>	<b>1.18%</b>	<b>1.29%</b>	<b>1.18%</b>	<b>0.99%</b>	<b>0.74%</b>	<b>0.76%</b>	<b>0.96%</b>	<b>0.86%</b>	<b>0.92%</b>
<b>Postpaid Phone Only Flowshare</b>												
Verizon	20.1%	-5.2%	19.0%	26.1%	31.5%	22.6%	-9.1%	22.8%	13.0%	23.4%	15.8%	17.9%
AT&T	3.5%	9.4%	5.6%	5.9%	9.1%	7.6%	21.8%	-19.9%	29.5%	17.6%	17.7%	8.2%
New T-Mobile	58.7%	54.9%	45.2%	38.9%	35.3%	40.9%	13.9%	33.3%	31.5%	31.3%	29.5%	41.2%
MVNO	17.7%	40.8%	30.2%	29.1%	24.0%	28.9%	73.3%	63.8%	26.0%	27.7%	37.0%	32.6%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
<b>Phone Only ARPU</b>												
Verizon	\$ 42.41	\$ 42.54	\$ 42.75	\$ 42.94	\$ 42.22	\$ 42.61	\$ 42.26	\$ 41.31	\$ 42.15	\$ 42.14	\$ 41.90	\$ 42.30
AT&T	\$ 54.72	\$ 55.36	\$ 55.68	\$ 55.89	\$ 55.52	\$ 55.61	\$ 55.68	\$ 54.47	\$ 54.70	\$ 56.00	\$ 55.21	\$ 56.50
New T-Mobile	\$ 48.23	\$ 48.13	\$ 47.99	\$ 48.16	\$ 48.08	\$ 48.09	\$ 48.05	\$ 47.99	\$ 48.55	\$ 47.95	\$ 48.14	\$ 48.28
<b>Average</b>	<b>\$ 48.45</b>	<b>\$ 48.68</b>	<b>\$ 48.81</b>	<b>\$ 49.00</b>	<b>\$ 48.61</b>	<b>\$ 48.77</b>	<b>\$ 48.66</b>	<b>\$ 47.92</b>	<b>\$ 48.47</b>	<b>\$ 48.70</b>	<b>\$ 48.42</b>	<b>\$ 49.03</b>
<b>Prepaid Net Adds</b>												
Verizon	(757)	(176)	(213)	(81)	(121)	(591)	(84)	12	77	(90)	(85)	21,000
AT&T	1,290	96	341	227	8	672	(45)	165	245	0	365	400
New T-Mobile	455	39	(38)	(145)	(97)	(241)	(138)	133	56	100	151	200
Dish Network									(212)	(150)	(362)	0
<b>Total</b>	<b>988</b>	<b>(41)</b>	<b>90</b>	<b>1</b>	<b>(210)</b>	<b>(160)</b>	<b>(267)</b>	<b>310</b>	<b>166</b>	<b>(140)</b>	<b>69</b>	<b>21,600</b>

Source: Company reports, Oppenheimer & Co. Inc. estimates.  
\*Includes Historical OPKO Estimates for New T-Mobile

Y/Y Change											
2018	1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E
45%	83%	23%	51%	21%	28%	55%	(29%)	(36%)	(24%)	(31%)	32%
(161%)	(233%)	41%	46%	71%	148%	104%	(310%)	NM	97%	130%	(46%)
(4%)	(44%)	(19%)	(10%)	(11%)	(21%)	(78%)	(57%)	4%	(10%)	(29%)	63%
160%	77%	91%	99%	78%	86%	58%	25%	15%	18%	26%	3%
31%	(9%)	10%	26%	18%	14%	(12%)	(41%)	28%	2%	(2%)	16%
2%	5%	1%	3%	5%	3%	(2%)	(24%)	(16%)	3%	(10%)	11%
5%	11%	5%	2%	7%	6%	(8%)	(2%)	(27%)	(11%)	(12%)	13%
(5%)	(5%)	(2%)	(2%)	6%	(1%)	(1%)	(35%)	(33%)	(28%)	(23%)	(1%)
(1%)	0%	2%	1%	7%	3%	(14%)	(32%)	(36%)	(25%)	(27%)	7%

(3.3%)	1.6%	0.5%	(0.1%)	0.0%	0.5%	(0.7%)	(3.4%)	(1.8%)	(0.2%)	(1.7%)	1.0%
NM	3.7%	2.2%	0.4%	0.3%	1.6%	0.6%	(2.2%)	(2.1%)	0.9%	(0.7%)	2.3%
(3.4%)	(0.9%)	(0.1%)	(0.0%)	(0.1%)	(0.3%)	(0.2%)	0.0%	0.8%	(0.3%)	0.1%	0.3%
<b>3.3%</b>	<b>1.5%</b>	<b>0.9%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.7%</b>	<b>(0.0%)</b>	<b>(1.8%)</b>	<b>(1.1%)</b>	<b>0.2%</b>	<b>(0.7%)</b>	<b>1.3%</b>
NM	(47%)	(10%)	(16%)	34%	(22%)	(52%)	(106%)	(195%)	(26%)	(86%)	NM
50%	(60%)	(25%)	(60%)	(69%)	(48%)	(147%)	(52%)	8%	(100%)	(46%)	NM
(63%)	(90%)	(140%)	(790%)	155%	(153%)	(454%)	(450%)	(139%)	(203%)	(163%)	32%
						NM	NM	NM	NM	NM	NM
<b>(52%)</b>	<b>(114%)</b>	<b>(71%)</b>	<b>(100%)</b>	<b>106%</b>	<b>(116%)</b>	<b>NM</b>	<b>NM</b>	<b>NM</b>	<b>(33%)</b>	<b>(143%)</b>	<b>NM</b>

## Exhibit 20: Annual Broadband Subscriber Model

## Broadband Subscriber Model

12/18/2020

	2018	2019	2020E	2021E
<b>Total Broadband Subscribers</b>				
Major Cable	61,704	64,608	69,165	72,185
Telco	29,952	29,208	29,102	29,062
<b>Total Broadband Subscribers</b>	<b>91,656</b>	<b>93,816</b>	<b>98,267</b>	<b>101,247</b>
<b>Market Share</b>				
Major Cable	67.3%	68.9%	70.4%	71.3%
Telco	32.7%	31.1%	29.6%	28.7%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
<b>Total Net Adds (mil)</b>				
Major Cable	2,716	2,904	4,556	3,020
Telco	(374)	(744)	(106)	(40)
<b>Total Net Adds</b>	<b>2,342</b>	<b>2,160</b>	<b>4,450</b>	<b>2,980</b>
<b>Flowshare</b>				
Major Cable	116%	134%	102%	101%
Telco	(16%)	(34%)	(2%)	(1%)

Y/Y Change			
2018	2019	2020E	2021E
4.6%	4.7%	7.1%	4.4%
(1.2%)	(2.5%)	(0.4%)	(0.1%)
<b>2.6%</b>	<b>2.4%</b>	<b>4.7%</b>	<b>3.0%</b>
(3.0%)	6.9%	56.9%	(33.7%)
(102.7%)	NM	NM	NM
<b>(85.8%)</b>	<b>(7.8%)</b>	<b>106.0%</b>	<b>(33.0%)</b>

<b>Cable HSD Subscribers (000s):</b>				
Charter	25,259	26,664	28,993	30,403
Comcast	27,222	28,629	30,612	32,112
Cox	5,108	5,128	5,166	5,191
Altice	4,115	4,187	4,394	4,479
<b>Total U.S.</b>	<b>61,704</b>	<b>64,608</b>	<b>69,165</b>	<b>72,185</b>
<b>Major Cable HSD Subscriber Net Adds</b>				
Charter	1,271	1,405	2,329	1,410
Comcast	1,353	1,407	1,983	1,500
Cox	20	20	38	25
Altice	72	72	206	85
<b>Total U.S.</b>	<b>2,716</b>	<b>2,904</b>	<b>4,556</b>	<b>3,020</b>

5.3%	5.6%	8.7%	4.9%
5.2%	5.2%	6.9%	4.9%
0.4%	0.4%	0.7%	0.5%
1.8%	1.7%	4.9%	1.9%
<b>4.6%</b>	<b>4.7%</b>	<b>7.1%</b>	<b>4.4%</b>
(15.9%)	10.5%	65.8%	(39.5%)
15.8%	4.0%	40.9%	(24.4%)
(50.0%)	0.0%	90.0%	(34.2%)
(10.0%)	(0.4%)	186.8%	(58.8%)
<b>(3.0%)</b>	<b>6.9%</b>	<b>56.9%</b>	<b>(33.7%)</b>

<b>Telco DSL/Fiber Subscribers (000s):</b>				
AT&T	14,409	14,119	14,162	14,262
Lumen Technologies	4,812	4,678	4,528	4,398
Frontier Communications	3,735	3,513	3,385	3,255
Verizon Communications	6,996	6,898	7,027	7,147
<b>Total U.S.</b>	<b>29,952</b>	<b>29,208</b>	<b>29,102</b>	<b>29,062</b>
<b>Telco DSL/Fiber Subscriber Net Adds</b>				
AT&T	59	(290)	43	100
Lumen Technologies	(232)	(134)	(150)	(130)
Frontier Communications	(203)	(222)	(128)	(150)
Verizon Communications	2	(98)	129	120
<b>Total U.S.</b>	<b>(374)</b>	<b>(744)</b>	<b>(106)</b>	<b>(40)</b>

0.4%	(2.0%)	0.3%	0.7%
(4.6%)	(2.8%)	(3.2%)	(2.9%)
(5.2%)	(5.9%)	(3.6%)	(3.8%)
0.0%	(1.4%)	1.9%	1.7%
<b>(1.2%)</b>	<b>(2.5%)</b>	<b>(0.4%)</b>	<b>(0.1%)</b>
5.4%	(591.5%)	NM	132.6%
NM	NM	NM	NM
NM	NM	NM	NM
NM	NM	NM	(7.0%)
<b>(102.7%)</b>	<b>NM</b>	<b>NM</b>	<b>NM</b>

\*Note: We believe wireless internet service providers have 6M total broadband subscribers as of FYE 2019

Source: Company reports, Oppenheimer & Co. Inc. estimates.

## Exhibit 21: Quarterly Broadband Subscriber Model

## Broadband Subscriber Model

12/18/2020	2018	1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E
<b>Total Broadband Subscribers</b>												
Major Cable	61,704	62,550	63,035	63,814	64,608	64,608	65,722	66,981	68,217	69,165	69,165	72,185
Telco	29,952	29,930	29,741	29,489	29,208	29,208	29,104	28,890	29,042	29,102	29,102	29,062
<b>Total Broadband Subscribers</b>	<b>91,656</b>	<b>92,480</b>	<b>92,776</b>	<b>93,303</b>	<b>93,816</b>	<b>93,816</b>	<b>94,826</b>	<b>95,871</b>	<b>97,259</b>	<b>98,267</b>	<b>98,267</b>	<b>101,247</b>
<b>Market Share</b>												
Major Cable	67.3%	67.6%	67.9%	68.4%	68.9%	68.9%	69.3%	69.9%	70.1%	70.4%	70.4%	71.3%
Telco	32.7%	32.4%	32.1%	31.6%	31.1%	31.1%	30.7%	30.1%	29.9%	29.6%	29.6%	28.7%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
<b>Total Net Adds (mil)</b>												
Major Cable	2,716	846	485	779	794	2,904	1,114	1,258	1,236	948	4,556	3,020
Telco	(374)	(22)	(189)	(252)	(281)	(744)	(104)	(214)	152	60	(106)	(40)
<b>Total Net Adds</b>	<b>2,342</b>	<b>824</b>	<b>296</b>	<b>527</b>	<b>513</b>	<b>2,160</b>	<b>1,010</b>	<b>1,044</b>	<b>1,388</b>	<b>1,008</b>	<b>4,450</b>	<b>2,980</b>
<b>Flowshare</b>												
Major Cable	116%	103%	164%	148%	155%	134%	110%	120%	89%	94%	102%	101%
Telco	(16%)	(3%)	(64%)	(48%)	(55%)	(34%)	(10%)	(20%)	11%	6%	(2%)	(1%)

<b>Cable HSD Subscribers (000s):</b>												
Charter	25,259	25,687	25,945	26,325	26,664	26,664	27,246	28,096	28,633	28,993	28,993	30,403
Comcast	27,222	27,598	27,807	28,186	28,629	28,629	29,106	29,429	30,062	30,612	30,612	32,112
Cox	5,108	5,113	5,118	5,123	5,128	5,128	5,133	5,148	5,158	5,166	5,166	5,191
Altice	4,115	4,152	4,165	4,180	4,187	4,187	4,237	4,308	4,364	4,394	4,394	4,479
<b>Total U.S.</b>	<b>61,704</b>	<b>62,550</b>	<b>63,035</b>	<b>63,814</b>	<b>64,608</b>	<b>64,608</b>	<b>65,722</b>	<b>66,981</b>	<b>68,217</b>	<b>69,165</b>	<b>69,165</b>	<b>72,185</b>
<b>Major Cable HSD Subscriber Net Adds</b>												
Charter	1,271	428	258	380	339	1,405	582	850	537	360	2,329	1,410
Comcast	1,353	376	209	379	443	1,407	477	323	633	550	1,983	1,500
Cox	20	5	5	5	5	20	5	15	10	8	38	25
Altice	72	37	13	15	7	72	50	70	56	30	206	85
<b>Total U.S.</b>	<b>2,716</b>	<b>846</b>	<b>485</b>	<b>779</b>	<b>794</b>	<b>2,904</b>	<b>1,114</b>	<b>1,258</b>	<b>1,236</b>	<b>948</b>	<b>4,556</b>	<b>3,020</b>

<b>Telco DSL/Fiber Subscribers (000s):</b>												
AT&T	14,409	14,454	14,420	14,301	14,119	14,119	14,046	13,944	14,102	14,162	14,162	14,262
Lumen Technologies	4,812	4,806	4,750	4,714	4,678	4,678	4,667	4,638	4,563	4,528	4,528	4,398
Frontier Communications	3,735	3,697	3,626	3,555	3,513	3,513	3,480	3,440	3,415	3,385	3,385	3,255
Verizon Communications	6,996	6,973	6,945	6,919	6,898	6,898	6,911	6,868	6,962	7,027	7,027	7,147
<b>Total U.S.</b>	<b>29,952</b>	<b>29,930</b>	<b>29,741</b>	<b>29,489</b>	<b>29,208</b>	<b>29,208</b>	<b>29,104</b>	<b>28,890</b>	<b>29,042</b>	<b>29,102</b>	<b>29,102</b>	<b>29,062</b>
<b>Telco DSL/Fiber Subscriber Net Adds</b>												
AT&T	59	45	(34)	(119)	(182)	(290)	(73)	(102)	158	60	43	100
Lumen Technologies	(232)	(6)	(56)	(36)	(30)	(134)	(11)	(29)	(75)	(35)	(150)	(130)
Frontier Communications	(203)	(38)	(71)	(71)	(42)	(222)	(33)	(40)	(25)	(30)	(128)	(150)
Verizon Communications	2	(23)	(28)	(26)	(21)	(98)	13	(43)	94	65	129	120
<b>Total U.S.</b>	<b>(374)</b>	<b>(22)</b>	<b>(189)</b>	<b>(252)</b>	<b>(281)</b>	<b>(744)</b>	<b>(104)</b>	<b>(214)</b>	<b>152</b>	<b>60</b>	<b>(106)</b>	<b>(40)</b>

\*Note: We believe wireless internet service providers have 6M total broadband subscribers as of FYE 2019  
Source: Company reports, Oppenheimer & Co. Inc. estimates.

YY Change												
2018	1Q19	2Q19	3Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E		
4.6%	4.7%	4.5%	4.6%	4.7%	5.1%	6.3%	6.9%	7.1%	7.1%	4.4%		
(1.2%)	(1.3%)	(1.6%)	(2.0%)	(2.5%)	(2.8%)	(2.9%)	(1.5%)	(0.4%)	(0.4%)	(0.1%)		
2.6%	2.7%	2.5%	2.4%	2.4%	2.5%	3.3%	4.2%	4.7%	4.7%	3.0%		
(3.0%)	8.8%	(10.4%)	12.9%	6.9%	31.7%	159.4%	58.6%	19.4%	56.9%	(33.7%)		
(102.7%)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM		
(85.8%)	7.6%	(33.1%)	(4.9%)	(7.8%)	22.6%	252.7%	163.4%	96.5%	106.0%	(33.0%)		

5.3%	5.5%	5.4%	5.6%	5.6%	6.1%	8.3%	8.8%	8.7%	8.7%	4.9%		
5.2%	5.1%	4.9%	4.9%	5.2%	5.5%	5.8%	6.7%	6.9%	6.9%	4.9%		
0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.6%	0.7%	0.7%	0.7%	0.5%		
1.8%	2.0%	2.1%	2.1%	1.7%	2.0%	3.4%	4.4%	4.9%	4.9%	1.9%		
4.6%	4.7%	4.5%	4.6%	4.7%	5.1%	6.3%	6.9%	7.1%	7.1%	4.4%		
(15.9%)	16.6%	(3.4%)	23.4%	10.5%	36.0%	229.5%	41.3%	6.2%	65.8%	(39.5%)		
15.8%	(0.8%)	(19.6%)	4.4%	4.0%	26.9%	54.5%	67.0%	24.2%	40.9%	(24.4%)		
(50.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	200.0%	100.0%	60.0%	90.0%	(34.2%)		
(10.0%)	39.8%	37.9%	4.9%	(0.4%)	35.8%	437.4%	273.8%	328.6%	186.8%	(58.8%)		
(3.0%)	8.8%	(10.4%)	12.9%	6.9%	31.7%	159.4%	58.6%	19.4%	56.9%	(33.7%)		

0.4%	0.2%	(0.2%)	(1.0%)	(2.0%)	(2.8%)	(3.3%)	(1.4%)	0.3%	0.3%	0.7%		
(4.6%)	(3.6%)	(3.2%)	(2.7%)	(2.8%)	(2.9%)	(2.4%)	(3.2%)	(3.2%)	(3.2%)	(2.9%)		
(5.2%)	(5.1%)	(6.1%)	(6.5%)	(5.9%)	(5.9%)	(5.1%)	(3.9%)	(3.6%)	(3.6%)	(3.8%)		
0.0%	(0.4%)	(0.7%)	(1.1%)	(1.4%)	(0.9%)	(1.1%)	0.6%	1.9%	1.9%	1.7%		
(1.2%)	(1.3%)	(1.6%)	(2.0%)	(2.5%)	(2.8%)	(2.9%)	(1.5%)	(0.4%)	(0.4%)	(0.1%)		
5.4%	(45.1%)	(247.8%)	NM	(591.5%)	(262.2%)	NM	NM	NM	NM	132.6%		
NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM		
NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM		
NM	(428.6%)	NM	NM	NM	NM	NM	NM	NM	NM	(7.0%)		
(102.7%)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM		



## Exhibit 22: Annual Linear TV Subscriber Model

## Linear TV Subscriber Model

12/18/2020					Y/Y Change			
	2018	2019	2020E	2021E	2018	2019	2020E	2021E
<b>Total Linear TV Subscribers (mil)</b>								
Cable	51.05	49.31	47.17	43.99	-2.4%	-3.4%	-4.3%	-6.7%
Direct Broadcast Satellite	29.13	25.28	21.77	18.47	-7.5%	-13.2%	-13.9%	-15.2%
Telco Facilities-Based	9.34	8.69	8.00	7.39	-4.4%	-6.9%	-8.0%	-7.6%
<b>Total Legacy</b>	<b>89.52</b>	<b>83.27</b>	<b>76.93</b>	<b>69.85</b>	<b>-4.3%</b>	<b>-7.0%</b>	<b>-7.6%</b>	<b>-9.2%</b>
vMVPD	7.80	10.13	11.58	13.03	89.4%	29.9%	14.2%	12.5%
<b>Total Linear TV Subscribers</b>	<b>97.32</b>	<b>93.40</b>	<b>88.51</b>	<b>82.87</b>	<b>-0.3%</b>	<b>-4.0%</b>	<b>-5.2%</b>	<b>-6.4%</b>
<b>Linear TV Mkt Share (%) Inclu. vMVPD</b>								
Cable	52.5%	52.8%	53.3%	53.1%	(108 bps)	33 bps	50 bps	(21 bps)
Direct Broadcast Satellite	29.9%	27.1%	24.6%	22.3%	(231 bps)	(287 bps)	(246 bps)	(231 bps)
Telco Facilities-Based	9.6%	9.3%	9.0%	8.9%	(40 bps)	(29 bps)	(27 bps)	(12 bps)
vMVPD	<b>8.0%</b>	<b>10.8%</b>	<b>13.1%</b>	<b>15.7%</b>	<b>380 bps</b>	<b>283 bps</b>	<b>223 bps</b>	<b>264 bps</b>
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>				
<b>Total Linear TV Subscriber Additions (mil)</b>								
Cable	-1.24	-1.74	-2.14	-3.18	5.3%	41.1%	22.8%	48.4%
Direct Broadcast Satellite	-2.36	-3.85	-3.51	-3.30	39.5%	63.2%	-9.0%	-5.8%
Telco Facilities-Based	-0.43	-0.65	-0.69	-0.61	-54.1%	52.1%	7.1%	-12.4%
<b>Total Legacy</b>	<b>-4.02</b>	<b>-6.24</b>	<b>-6.34</b>	<b>-7.08</b>	<b>6.0%</b>	<b>55.2%</b>	<b>1.5%</b>	<b>11.7%</b>
vMVPD	3.68	2.33	1.44	1.45	56.7%	-36.7%	-38.2%	0.7%
<b>Total Linear TV Sub Adds</b>	<b>-0.34</b>	<b>-3.91</b>	<b>-4.90</b>	<b>-5.63</b>	<b>-76.5%</b>	<b>nm</b>	<b>25.2%</b>	<b>15.0%</b>
<b>Cable Video Subscribers (mil)</b>								
Comcast:	21.99	21.25	19.98	18.30	-1.7%	-3.3%	-6.0%	-8.4%
Cox:	4.04	3.90	3.67	3.41	-3.0%	-3.4%	-6.0%	-7.0%
Charter:	16.61	16.14	16.14	15.60	-1.4%	-2.8%	0.0%	-3.3%
Altice USA	3.29	3.18	2.98	2.78	-2.9%	-3.3%	-6.4%	-6.7%
Other	5.14	4.83	4.41	3.91	-7.2%	-5.9%	-8.7%	-11.3%
<b>Total</b>	<b>51.05</b>	<b>49.31</b>	<b>47.17</b>	<b>43.99</b>	<b>-2.4%</b>	<b>-3.4%</b>	<b>-4.3%</b>	<b>-6.7%</b>
<b>Direct Broadcast Satellite Video Subscribers (mil)</b>								
DirecTV	19.22	15.88	12.90	10.00	-6.0%	-17.4%	-18.8%	-22.5%
DISH	9.91	9.39	8.88	8.48	-10.2%	-5.2%	-5.5%	-4.5%
<b>Total</b>	<b>29.13</b>	<b>25.28</b>	<b>21.77</b>	<b>18.47</b>	<b>-7.5%</b>	<b>-13.2%</b>	<b>-13.9%</b>	<b>-15.2%</b>
<b>Telco Facilities-based Video Subscribers (mil)</b>								
AT&T-U verse	3.68	3.59	3.52	3.45	1.4%	-2.4%	-2.1%	-2.0%
Verizon	4.45	4.23	3.92	3.60	-3.6%	-5.0%	-7.3%	-8.1%
CenturyLink	0.16	0.04	0.03	0.03	-48.9%	-78.4%	-14.3%	0.0%
Frontier Comm.	1.04	0.83	0.53	0.31	-12.8%	-20.1%	-36.4%	-41.5%
<b>Total</b>	<b>9.34</b>	<b>8.69</b>	<b>8.00</b>	<b>7.39</b>	<b>-4.4%</b>	<b>-6.9%</b>	<b>-8.0%</b>	<b>-7.6%</b>
<b>vMVPD Video Subscribers (mil)</b>								
HULU Live	1.85	3.20	3.97	4.72	nm	73.0%	23.9%	18.9%
Sling TV	2.42	2.59	2.51	2.51	9.3%	7.2%	-3.2%	0.0%
AT&T TV Now	1.59	0.93	0.58	0.28	37.7%	-41.8%	-37.0%	-51.5%
YouTube TV	1.30	2.30	4.00	4.80	nm	76.9%	73.9%	20.0%
Playstation Vue	0.42	0.80	0.00	0.00	na	92.7%	-100.0%	na
FuboTV	0.23	0.32	0.52	0.72	88.0%	37.9%	64.3%	38.8%
<b>Total vMVPDs</b>	<b>7.80</b>	<b>10.13</b>	<b>11.58</b>	<b>13.03</b>	<b>89.4%</b>	<b>29.9%</b>	<b>14.2%</b>	<b>12.5%</b>

Source: Company Reports; US Census Bureau, Oppenheimer &amp; Co, Inc. estimates

Note: vMVPDs are OTT Video services that offer live-TV and are replacement for traditional cable/telco/satellite packages

## Exhibit 23: Quarterly Linear TV Subscriber Model

Linear TV Subscriber Model						Y/Y Change																		
12/18/2020	2018	1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E	2018	1Q19	2Q19	3Q19	4Q19	2019	1Q20	2Q20	3Q20	4Q20E	2020E	2021E
Total Linear TV Subscribers (mil)																								
Cable	51.05	50.69	50.22	49.79	49.31	49.31	48.59	47.95	47.58	47.17	47.17	43.99	-2.4%	-2.2%	-2.6%	-2.9%	-3.4%	-3.4%	-4.1%	-4.5%	-4.4%	-4.3%	-4.3%	-6.7%
Direct Broadcast Satellite	29.13	28.36	27.51	26.30	25.28	25.28	24.01	23.15	22.53	21.77	21.77	18.47	-7.5%	-8.9%	-10.2%	-12.1%	-13.2%	-13.2%	-15.3%	-15.9%	-14.3%	-13.9%	-13.9%	-15.2%
Telco Facilities-Based	9.34	9.12	8.97	8.82	8.69	8.69	8.54	8.33	8.16	8.00	8.00	7.39	-4.4%	-5.8%	-6.5%	-6.8%	-6.9%	-6.9%	-6.3%	-7.2%	-7.5%	-8.0%	-8.0%	-7.6%
Total Legacy	89.52	88.17	86.70	84.91	83.27	83.27	81.14	79.43	78.26	76.93	76.93	69.85	-4.3%	-4.8%	-5.5%	-6.3%	-7.0%	-7.0%	-8.0%	-8.4%	-7.8%	-7.6%	-7.6%	-9.2%
vMVPD	7.80	8.21	8.63	9.75	10.13	10.13	9.40	9.90	10.97	11.58	11.58	13.03	89.4%	71.5%	33.8%	33.0%	29.9%	29.9%	14.4%	14.7%	12.4%	14.2%	14.2%	12.5%
Total Linear TV Subscribers	97.32	96.38	95.34	94.67	93.40	93.40	90.54	89.33	89.23	88.51	88.51	82.87	-0.3%	-1.0%	-2.9%	-3.4%	-4.0%	-4.0%	-6.1%	-6.3%	-5.7%	-5.2%	-5.2%	-6.4%
Linear TV Mkt Share (%) Inclu. vMVPD																								
Cable	52.5%	52.6%	52.7%	52.6%	52.8%	52.8%	53.7%	53.7%	53.3%	53.3%	53.3%	53.1%	(108 bps)	(60 bps)	20 bps	28 bps	33 bps	33 bps	107 bps	100 bps	72 bps	50 bps	50 bps	(21 bps)
Direct Broadcast Satellite	29.9%	29.4%	28.9%	27.8%	27.1%	27.1%	26.5%	25.9%	25.2%	24.6%	24.6%	22.3%	(231 bps)	(252 bps)	(233 bps)	(275 bps)	(287 bps)	(287 bps)	(290 bps)	(294 bps)	(253 bps)	(246 bps)	(246 bps)	(231 bps)
Telco Facilities-Based	9.6%	9.5%	9.4%	9.3%	9.3%	9.3%	9.4%	9.3%	9.1%	9.0%	9.0%	8.9%	(40 bps)	(48 bps)	(36 bps)	(35 bps)	(29 bps)	(29 bps)	(3 bps)	(9 bps)	(17 bps)	(27 bps)	(27 bps)	(12 bps)
vMVPD	8.0%	8.5%	9.1%	10.3%	10.8%	10.8%	10.4%	11.1%	12.3%	13.1%	13.1%	15.7%	380 bps	360 bps	248 bps	282 bps	283 bps	283 bps	186 bps	203 bps	199 bps	223 bps	223 bps	264 bps
Total	100%					100%					100%	100%												
Total Linear TV Subscriber Additions (mil)																								
Cable	-1.24	-0.36	-0.47	-0.43	-0.49	-1.74	-0.72	-0.64	-0.37	-0.41	-2.14	-3.18	5.3%	-24.5%	77.5%	51.2%	nm	41.1%	97.6%	36.3%	-12.5%	-15.3%	22.8%	48.4%
Direct Broadcast Satellite	-2.36	-0.77	-0.85	-1.21	-1.03	-3.85	-1.26	-0.86	-0.62	-0.76	-3.51	-3.30	39.5%	nm	77.2%	67.2%	30.7%	63.2%	64.8%	1.7%	-48.8%	-25.9%	-9.0%	-5.8%
Telco Facilities-Based	-0.43	-0.22	-0.15	-0.15	-0.13	-0.65	-0.15	-0.22	-0.17	-0.16	-0.69	-0.61	-54.1%	nm	78.3%	17.4%	1.6%	52.1%	-33.0%	45.9%	11.0%	26.0%	7.1%	-12.4%
Total Legacy	-4.02	-1.35	-1.46	-1.79	-1.64	-6.24	-2.13	-1.71	-1.17	-1.33	-6.34	-7.08	6.0%	43.2%	77.4%	57.5%	46.6%	55.2%	57.8%	17.2%	-35.0%	-18.7%	1.5%	11.7%
vMVPD	3.68	0.41	0.42	1.12	0.38	2.33	-0.73	0.50	1.07	0.61	1.44	1.45	56.7%	-38.7%	-74.9%	27.4%	-18.9%	-36.7%	nm	20.4%	-5.1%	60.3%	-38.2%	0.7%
Total Linear TV Sub Adds	-0.34	-0.94	-1.04	-0.67	-1.26	-3.91	-2.86	-1.21	-0.10	-0.73	-4.90	-5.63	-76.5%	nm	nm	nm	93.5%	nm	nm	15.9%	-85.1%	-42.5%	25.2%	15.0%
Cable Video Subscribers (mil)																								
Comcast	21.99	21.87	21.64	21.40	21.25	21.25	20.85	20.37	20.10	19.98	19.98	18.30	-1.7%	-1.8%	-2.2%	-2.8%	-3.3%	-3.3%	-4.7%	-5.9%	-6.1%	-6.0%	-6.0%	-8.4%
Cox	4.04	4.00	3.97	3.94	3.90	3.90	3.80	3.73	3.70	3.67	3.67	3.41	-3.0%	-0.4%	-2.6%	-2.7%	-3.4%	-3.4%	-5.0%	-6.0%	-6.0%	-6.0%	-6.0%	-7.0%
Charter	16.61	16.46	16.32	16.25	16.14	16.14	16.07	16.17	16.24	16.14	16.14	15.60	-1.4%	-1.7%	-2.2%	-2.3%	-2.8%	-2.8%	-2.4%	-0.9%	-0.1%	0.0%	0.0%	-3.3%
Alice USA	3.29	3.28	3.26	3.22	3.18	3.18	3.14	3.10	3.04	2.98	2.98	2.78	-2.9%	-2.3%	-2.2%	-3.2%	-3.3%	-3.3%	-4.2%	-4.7%	-5.8%	-6.4%	-6.4%	-6.7%
Other	5.14	5.08	5.03	4.98	4.83	4.83	4.73	4.58	4.51	4.41	4.41	3.91	-7.2%	-6.5%	-5.7%	-4.8%	-5.9%	-5.9%	-7.0%	-9.0%	-9.5%	-8.7%	-8.7%	-11.3%
Total	51.05	50.69	50.22	49.79	49.31	49.31	48.59	47.95	47.58	47.17	47.17	43.99	-2.4%	-2.2%	-2.6%	-2.9%	-3.4%	-3.4%	-4.1%	-4.5%	-4.4%	-4.3%	-4.3%	-6.7%
Direct Broadcast Satellite Video Subscribers (mil)																								
DirectTV	19.22	18.72	17.95	16.81	15.88	15.88	15.00	14.14	13.57	12.90	12.90	10.00	-6.0%	-7.6%	-10.2%	-14.4%	-17.4%	-17.4%	-19.9%	-21.3%	-19.3%	-18.8%	-18.8%	-22.5%
DISH	9.91	9.64	9.56	9.49	9.39	9.39	9.01	9.02	8.97	8.88	8.88	8.48	-10.2%	-11.1%	-10.3%	-7.7%	-5.2%	-5.2%	-6.5%	-5.7%	-5.6%	-5.5%	-5.5%	-4.5%
Total	29.13	28.36	27.51	26.30	25.28	25.28	24.01	23.15	22.53	21.77	21.77	18.47	-7.5%	-8.9%	-10.2%	-12.1%	-13.2%	-13.2%	-15.3%	-15.9%	-14.3%	-13.9%	-13.9%	-15.2%
Telco Facilities-based Video Subscribers (mil)																								
AT&T-Uverse	3.68	3.64	3.63	3.61	3.59	3.59	3.58	3.56	3.54	3.52	3.52	3.45	1.4%	0.1%	-0.8%	-1.6%	-2.4%	-2.4%	-1.7%	-2.0%	-2.1%	-2.1%	-2.1%	-2.0%
Verizon	4.45	4.40	4.35	4.28	4.23	4.23	4.15	4.06	4.00	3.92	3.92	3.60	-3.6%	-4.3%	-4.7%	-4.8%	-5.0%	-5.0%	-5.8%	-6.5%	-6.5%	-7.3%	-7.3%	-8.1%
CenturyLink	0.16	0.10	0.07	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	-48.9%	-64.5%	-72.8%	-78.8%	-78.4%	-78.4%	-60.8%	-42.9%	-33.3%	-14.3%	-14.3%	0.0%
Frontier Comm	1.04	0.98	0.93	0.88	0.83	0.83	0.78	0.67	0.59	0.53	0.53	0.31	-12.8%	-15.4%	-17.2%	-18.9%	-20.1%	-20.1%	-20.3%	-27.8%	-32.9%	-36.4%	-36.4%	-41.5%
Total	9.34	9.12	8.97	8.82	8.69	8.69	8.54	8.33	8.16	8.00	8.00	7.39	-4.4%	-5.8%	-6.5%	-6.8%	-6.9%	-6.9%	-6.3%	-7.2%	-7.5%	-8.0%	-8.0%	-7.6%
vMVPD Video Subscribers (mil)																								
HULU Live	1.85	2.00	2.16	2.70	3.20	3.20	3.30	3.40	3.67	3.97	3.97	4.72	nm	nm	nm	nm	73.0%	73.0%	65.2%	57.6%	36.0%	23.9%	23.9%	18.9%
Sling TV	2.42	2.42	2.47	2.69	2.59	2.59	2.31	2.26	2.46	2.51	2.51	2.51	9.3%	5.3%	5.5%	13.3%	7.2%	7.2%	-4.7%	-8.8%	-8.5%	-3.2%	-3.2%	0.0%
AT&T TV Now	1.59	1.51	1.34	1.15	0.93	0.93	0.79	0.72	0.68	0.58	0.58	0.28	37.7%	2.8%	-25.9%	-38.4%	-41.8%	-41.8%	-47.7%	-46.3%	-40.3%	-37.0%	-37.0%	-51.5%
YouTube TV	1.30	1.53	1.81	2.14	2.30	2.30	2.71	3.20	3.70	4.00	4.00	4.80	nm	nm	nm	94.2%	76.9%	76.9%	76.9%	76.8%	73.2%	73.9%	73.9%	20.0%
Playstation Vue	0.42	0.49	0.58	0.80	0.80	0.80	0.80	0.00	0.00	0.00	0.00	0.00	na	na	25.3%	83.1%	92.7%	92.7%	na	na	na	na	-100.0%	
FuboTV	0.23	0.26	0.28	0.29	0.32	0.32	0.29	0.33	0.46	0.52	0.52	0.72	88.0%	44.5%	25.0%	15.2%	37.9%	37.9%	9.9%	19.0%	58.0%	64.3%	64.3%	38.8%
Total vMVPDs	7.80	8.21	8.63	9.75	10.13	10.13	9.40	9.90	10.97	11.58	11.58	13.03	89.4%	71.5%	33.8%	33.0%	29.9%	29.9%	14.4%	14.7%	12.4%	14.2%	14.2%	12.5%

Source: Company Reports; US Census Bureau, Oppenheimer &amp; Co, Inc. estimates

Note: vMVPDs are OTT Video services that offer live-TV and are a replacement for traditional cable/telco/satellite packages

## Exhibit 24: Cloud Revenue and Market Share Model

<b>Last Updated: 10/29/2020</b>	<b>2018</b>	<b>2019</b>	<b>2020E</b>	<b>2021E</b>	<b>2022E</b>	<b>2023E</b>	<b>2024E</b>
<b>AWS Revenue</b>	<b>25,656</b>	<b>35,026</b>	<b>45,071</b>	<b>54,958</b>	<b>65,125</b>	<b>75,870</b>	<b>86,492</b>
Incremental Revenue (sequential/annual)	8,198	9,370	10,045	9,887	10,167	10,745	10,622
Y/Y Growth	47%	37%	29%	22%	19%	16%	14%
Q/Q Growth							
Operating margin	33.1%	30.8%	34.7%	34.0%	33.5%	33.5%	33.5%
<b>adj. EBITDA</b>	<b>14,599</b>	<b>19,029</b>	<b>23,481</b>	<b>28,028</b>	<b>32,758</b>	<b>37,783</b>	<b>43,246</b>
Est. EBITDA margin	56.9%	54.3%	52.1%	51.0%	50.3%	49.8%	50%
<b>AWS Capex</b>	<b>9,783</b>	<b>13,060</b>	<b>14,250</b>	<b>15,938</b>	<b>17,584</b>	<b>18,209</b>	<b>19,028</b>
Capex as % of revenue	38.1%	37.3%	31.6%	29.0%	27.0%	24.0%	22%
incremental capex	591	3,277	1,190	1,688	1,646	625	819
Incremental rev/capex	0.84	0.72	0.70	0.62	0.58	0.59	0.56
<b>uFCF</b>	<b>4,816</b>	<b>5,969</b>	<b>9,231</b>	<b>12,090</b>	<b>15,174</b>	<b>19,574</b>	<b>24,218</b>
uFCF margins	19%	17%	20%	22%	23%	26%	28%
<b>MSFT Azure Revenue</b>	<b>9,945</b>	<b>16,291</b>	<b>24,004</b>	<b>32,885</b>	<b>42,750</b>	<b>53,438</b>	<b>64,125</b>
Incremental Revenue (annual or quarterly)	4,485	6,346	7,713	8,881	9,865	10,688	10,688
Y/Y Growth	82%	64%	47%	37%	30%	25%	20%
Q/Q Growth							
Gross margin	57%	59%	59%	61%	62%	63%	64%
EBIT margin	21%	25%	25%	33%	37%	40%	
<b>adj. EBITDA</b>	<b>1,790</b>	<b>3,258</b>	<b>8,881</b>	<b>12,825</b>	<b>17,528</b>	<b>22,444</b>	<b>28,215</b>
Est. EBITDA Margin	18%	20%	37%	39%	41%	42%	44%
<b>Azure Capex</b>	<b>9,480</b>	<b>10,439</b>	<b>11,624</b>	<b>12,076</b>	<b>12,014</b>	<b>12,277</b>	<b>12,825</b>
Capex as % of revenue	95%	64%	48%	37%	28%	23%	20%
Incremental capex	4,350	959	1,185	453	(62)	263	548
Incremental rev/capex	0.47	0.61	0.66	0.74	0.82	0.87	0.83
<b>uFCF</b>	<b>(7,690)</b>	<b>(7,181)</b>	<b>(2,742)</b>	<b>749</b>	<b>5,513</b>	<b>10,167</b>	<b>15,390</b>
uFCF margins	-77%	-44%	-11%	2%	13%	19%	24%
<b>Google Cloud Services Revenue</b>	<b>5,838</b>	<b>8,918</b>	<b>12,936</b>	<b>19,128</b>	<b>26,779</b>	<b>35,348</b>	<b>44,185</b>
Q/Q growth							
Y/Y growth	43.9%	52.8%	45.1%	47.9%	40.0%	32%	25%
<b>Google GCP Revenue</b>	<b>3,211</b>	<b>5,351</b>	<b>9,314</b>	<b>14,920</b>	<b>21,959</b>	<b>29,693</b>	<b>37,999</b>
Y/Y Growth	58%	67%	74%	60%	47%	35%	28%
<b>Total GCP EBITDA</b>	<b>(292)</b>	<b>0</b>	<b>388</b>	<b>956</b>	<b>2,678</b>	<b>4,595</b>	<b>6,628</b>
Est. EBITDA Margin	(5%)	0%	3%	5%	10%	13%	15%
<b>Total GCP capex</b>	<b>7,589</b>	<b>8,026</b>	<b>9,702</b>	<b>11,477</b>	<b>13,390</b>	<b>14,139</b>	<b>15,465</b>
Capex as % of revenue	130%	90%	75%	60%	50%	40%	35%
Incremental rev/capex	0.28	0.44	0.57	0.63	0.64	0.65	0.62
<b>uFCF</b>	<b>(7,881)</b>	<b>(8,026)</b>	<b>(9,314)</b>	<b>(10,520)</b>	<b>(10,712)</b>	<b>(9,544)</b>	<b>(8,837)</b>
uFCF margins	-245%	-150%	-100%	-71%	-49%	-32%	-23%
<b>Total Cloud Revenue</b>	<b>38,812</b>	<b>56,668</b>	<b>78,388</b>	<b>102,762</b>	<b>129,834</b>	<b>159,000</b>	<b>188,617</b>
Incremental Revenue	11,838	17,856	21,720	24,374	27,072	29,166	29,616
Y/Y Growth	44%	46%	38%	31%	26%	22%	19%
<b>Total Adj. EBITDA</b>	<b>16,097</b>	<b>22,287</b>	<b>32,750</b>	<b>41,810</b>	<b>52,963</b>	<b>64,823</b>	<b>78,089</b>
EBITDA margin	41%	39%	42%	41%	41%	41%	41%
<b>Total Capex</b>	<b>26,852</b>	<b>31,525</b>	<b>35,576</b>	<b>39,491</b>	<b>42,988</b>	<b>44,625</b>	<b>47,318</b>
Incremental Revenue/Capex	0.44	0.57	0.61	0.62	0.63	0.65	0.63
Y/Y growth	32%	17%	13%	11%	9%	4%	6%
<b>uFCF</b>	<b>(10,755)</b>	<b>(9,238)</b>	<b>(2,825)</b>	<b>2,319</b>	<b>9,976</b>	<b>20,197</b>	<b>30,771</b>
uFCF margins	-28%	-16%	-4%	2%	8%	13%	16%
<b>Cloud market share (Big 3)</b>							
AWS Share	66.1%	61.8%	57.5%	53.5%	50.2%	47.7%	45.9%
MSFT Share	25.6%	28.7%	30.6%	32.0%	32.9%	33.6%	34.0%
Google Share	8.3%	9.4%	11.9%	14.5%	16.9%	18.7%	20.1%

Source: Oppenheimer &amp; Co., company reports

**Exhibit 25: Hyperscale Revenue and Capex Model****Exhibit: Cloud/Hyperscale Revenue and Capex Model**

Last Updated: 8/13/2020

	2017	2018	2019	2020E	2021E	2022E	2023E	2024E
<b>Revenue:</b>								
Apple	238,399	264,229	263,166	281,370	309,732	321,683	328,172	341,911
Growth YoY %	8.8%	10.8%	(0.4%)	6.9%	10.1%	3.9%	2.0%	4.2%
Amazon	177,866	232,887	280,522	372,351	455,776	540,717	623,063	704,061
Growth YoY %	30.8%	30.9%	20.5%	32.7%	22.4%	18.6%	15.2%	13.0%
Alphabet	89,183	109,969	131,677	144,370	178,172	211,425	243,139	272,315
Growth YoY %	21.4%	23.3%	19.7%	9.6%	23.4%	18.7%	15.0%	12.0%
Microsoft	102,273	118,459	134,249	149,345	162,473	177,096	193,034	210,407
Growth YoY %	10.3%	15.8%	13.3%	11.2%	8.8%	9.0%	9.0%	9.0%
Facebook	40,653	55,838	70,697	79,913	99,085	119,409	138,871	160,268
Growth YoY %	47.1%	37.4%	26.6%	13.0%	24.0%	20.5%	16.3%	15.4%
<b>Total</b>	<b>648,374</b>	<b>781,382</b>	<b>880,311</b>	<b>1,027,349</b>	<b>1,205,238</b>	<b>1,370,330</b>	<b>1,526,279</b>	<b>1,688,963</b>
Growth YoY %	18.1%	20.5%	12.7%	16.7%	17.3%	13.7%	11.4%	10.7%
<b>Capital Expenditures:</b>								
Apple	12,668	12,603	10,031	9,558	12,051	10,974	8,655	8,754
Growth YoY %	(0.0%)	(0.5%)	(20.4%)	(4.7%)	26.1%	(8.9%)	(21.1%)	1.1%
% of Revenue	5.3%	4.8%	3.8%	3.4%	3.9%	3.4%	2.6%	2.6%
Amazon	23,716	25,219	31,645	40,546	50,247	58,640	66,773	70,406
Growth YoY %	73.7%	6.3%	25.5%	28.1%	23.9%	16.7%	13.9%	5.4%
% of Revenue	13.3%	10.8%	11.3%	10.9%	11.0%	10.8%	10.7%	10.0%
Alphabet	13,184	25,139	23,548	23,057	24,204	26,739	31,862	30,000
Growth YoY %	29.5%	90.7%	(6.3%)	(2.1%)	5.0%	10.5%	19.2%	(5.8%)
% of Revenue	14.8%	22.9%	17.9%	16.0%	13.6%	12.6%	15.0%	15.0%
Microsoft	11,138	15,800	18,000	21,103	21,957	22,668	23,164	23,145
Growth YoY %	22.2%	41.9%	13.9%	17.2%	4.0%	3.2%	2.2%	(0.1%)
% of Revenue	10.9%	13.3%	13.4%	14.1%	13.5%	12.8%	12.0%	11.0%
Facebook	6,733	13,915	15,102	15,692	18,676	19,859	19,310	20,482
Growth YoY %	49.9%	106.7%	8.5%	3.9%	19.0%	6.3%	(2.8%)	6.1%
% of Revenue	16.6%	24.9%	21.4%	19.6%	18.8%	16.6%	13.9%	12.8%
<b>Total</b>	<b>67,439</b>	<b>92,676</b>	<b>98,326</b>	<b>109,956</b>	<b>127,135</b>	<b>138,880</b>	<b>149,764</b>	<b>152,787</b>
Growth YoY %	34.6%	37.4%	6.1%	11.8%	15.6%	9.2%	7.8%	2.0%
% of Revenue	10.4%	11.9%	11.2%	10.7%	10.5%	10.1%	9.8%	9.0%
<b>Estimated Cloud-Based CAPX:</b>								
Apple	8,868	9,200	8,025	7,933	10,243	9,547	7,703	8,054
Amazon	9,190	9,783	13,059	14,250	15,938	17,584	18,209	20,030
Alphabet	9,229	15,083	16,484	16,832	18,879	22,193	28,676	28,500
Microsoft	7,240	10,270	12,240	16,249	17,566	19,041	20,848	21,988
Facebook	5,588	11,549	12,837	13,809	16,435	17,873	17,958	19,458
<b>Total</b>	<b>40,114</b>	<b>55,886</b>	<b>62,644</b>	<b>69,073</b>	<b>79,061</b>	<b>86,239</b>	<b>93,394</b>	<b>98,029</b>
Growth YoY %	47.1%	39.3%	12.1%	10.3%	14.5%	9.1%	8.3%	5.0%
% of Revenue	6.2%	7.2%	7.1%	6.7%	6.6%	6.3%	6.1%	5.8%
% of Total CAPX	59.5%	60.3%	63.7%	62.8%	62.2%	62.1%	62.4%	64.2%

AMZN, MSFT &amp; GOOG estimates are Oppenheimer's, AAPL and FB are sourced from FactSet

Capex numbers include consumer/retail focused capex

Source: OPCO, FactSet, Company Reports

## Exhibit 26: Cloud Server Analysis

Server Analysis (IDC's Forecast)	2015	2016	2017	2018	2019	2020E	2021E	2022E	2023E	2024E
Worldwide Server Install Base Units	32,896,000	34,249,000	35,418,000	36,519,000	37,550,000	38,300,000	39,171,000	40,139,000	40,941,780	41,760,616
yoy growth	2.1%	4.1%	3.4%	3.1%	2.8%	2.0%	2.3%	2.5%	2.0%	2.0%
Total Servers Shipped	9,707,900	9,556,507	10,167,400	11,762,500	12,130,300	12,638,700	13,178,200	13,925,500	14,621,775	15,206,646
yoy growth	5.1%	-1.6%	6.4%	15.7%	3.1%	4.2%	4.3%	5.7%	5.0%	4.0%
Windows Server Installed Base	22,893,000	23,286,000	23,103,000	22,669,000	21,937,000	20,926,000	20,024,000	19,169,000	18,480,780	17,802,810
yoy growth	-1.0%	1.7%	-0.8%	-1.9%	-3.2%	-4.6%	-4.3%	-4.3%	-3.6%	-3.7%
Market Share	69.6%	68.0%	65.2%	62.1%	58.4%	54.6%	51.1%	47.8%	45.1%	42.6%
Windows OS Servers Shipped	4,615,000	4,483,000	4,336,000	4,219,000	4,093,000	3,960,000	3,821,000	3,676,000	3,528,960	3,387,802
yoy growth	-1.6%	-2.9%	-3.3%	-2.7%	-3.0%	-3.2%	-3.5%	-3.8%	-4.0%	-4.0%
Market Share of Shipments	47.5%	46.9%	42.6%	35.9%	33.7%	31.3%	29.0%	26.4%	24.1%	22.3%
Linux Server Installed Base	9,344,000	10,444,000	11,904,000	13,514,000	15,327,000	17,122,000	18,917,000	20,753,000	22,961,720	25,355,289
yoy growth	13.3%	11.8%	14.0%	13.5%	13.4%	11.7%	10.5%	9.7%	10.6%	10.4%
Market Share	28.4%	30.5%	33.6%	37.0%	40.8%	44.7%	48.3%	51.7%	56.1%	60.7%
Linux OS Servers Shipped	3,343,900	3,661,000	4,362,000	4,882,000	5,435,000	6,013,000	6,580,000	7,167,000	7,812,030	8,593,233
yoy growth	12.8%	9.5%	19.1%	11.9%	11.3%	10.6%	9.4%	8.9%	9.0%	10.0%
Market Share of Shipments	34.4%	38.3%	42.9%	41.5%	44.8%	47.6%	49.9%	51.5%	53.4%	56.5%
Worldwide Server Equipment Market Revenue (000s)	63,700,000	62,100,000	70,600,000	90,300,000	91,000,000	94,400,000	97,300,000	104,200,000	109,825,000	114,858,000
yoy growth	8.9%	-2.5%	13.7%	27.9%	0.8%	3.7%	3.1%	7.1%	5.4%	4.6%
Average Selling Price Per Server	6,562	6,498	6,944	7,677	7,502	7,469	7,383	7,483	7,511	7,553
yoy growth	3.6%	-1.0%	6.9%	10.6%	-2.3%	-0.4%	-1.1%	1.3%	0.4%	0.6%
On-premise vs Off-premise (colocation datacenter, cloud)										
Off-premise spending	23,800,000	25,800,000	31,900,000	45,300,000	47,700,000	50,800,000	53,100,000	58,300,000	64,130,000	70,543,000
Y/Y growth	21.4%	8.4%	23.6%	42.0%	5.3%	6.5%	4.5%	9.8%	10.0%	10.0%
Off-premise shipments	4,157,800	4,364,100	5,063,400	6,330,500	6,769,200	7,200,400	7,569,700	8,176,200	8,993,820	10,073,078
Y/Y growth	17.1%	5.0%	16.0%	25.0%	6.9%	6.4%	5.1%	8.0%	10.0%	12.0%
average value of off-premise server shipped	5,724	5,912	6,300	7,156	7,047	7,055	7,015	7,130	7,130	7,003
On-premise Spending	39,900,000	36,200,000	38,700,000	45,000,000	43,400,000	43,500,000	44,300,000	45,900,000	45,695,000	44,315,000
Y/Y growth	2.6%	-9.3%	6.9%	16.3%	-3.6%	0.2%	1.8%	3.6%	-0.4%	-3.0%
On-premise shipments	5,550,100	5,192,407	5,104,000	5,432,000	5,361,100	5,438,300	5,608,500	5,749,300	5,627,955	5,133,568
Y/Y growth	-2.4%	-6.4%	-1.7%	6.4%	-1.3%	1.4%	3.1%	2.5%	-2.1%	-8.8%
average value of on-premise server shipped	7,189	6,972	7,582	8,284	8,095	7,999	7,899	7,984	8,119	8,632
Utilization Analysis										
AWS CAPX (000s)	4,681,000	5,193,000	9,190,000	9,783,000	13,059,000	14,626,000	16,726,000	18,843,000	19,764,000	19,028,196
AWS Server Spend (000s)	2,340,500	2,596,500	4,595,000	4,891,500	6,529,500	7,313,000	8,363,000	9,421,500	9,882,000	9,514,098
% of Server Spend	3.7%	4.2%	6.5%	5.4%	7.2%	7.7%	8.6%	9.0%	9.0%	8.3%
AWS Cost per server	4,745	5,088	5,541	6,432	6,417	6,458	6,418	6,563	6,655	6,717
AWS New Servers Added	493,243	510,317	829,264	760,547	1,017,547	1,132,435	1,303,018	1,435,490	1,484,933	1,416,412
% of Total Servers Shipped	5.1%	5.3%	8.2%	6.5%	8.4%	9.0%	9.9%	10.3%	10.2%	9.3%
Net Servers Added	310,492	223,676	347,222	267,304	507,229	303,171	542,471	417,943	352,498	113,394
AWS Revenue (000s)	7,880,000	12,219,000	17,458,000	25,656,000	35,026,000	46,096,000	57,676,000	69,787,000	82,349,000	95,524,800
AWS Total Servers	1,271,926	1,495,603	1,842,825	2,110,129	2,617,358	2,920,528	3,463,000	3,880,943	4,233,441	4,346,836
% of Total Servers shipped Globally	3.9%	4.4%	5.2%	5.8%	7.0%	7.6%	8.8%	9.7%	10.3%	10.4%
% of Total Enterprise Servers	4.4%	5.0%	6.1%	6.9%	8.5%	9.5%	11.3%	12.7%	13.9%	14.3%
Datacenter Level Analysis										
AWS Availability Zones	31	42	53	65	73	78	83	87	91	94
Adds in Year	2	11	11	12	8	5	5	4	4	3
Revenue per AZ (000s) (average)	262,667	334,767	367,537	434,847	507,623	610,543	716,472	821,024	925,270	1,032,701
At Scale Power Capacity Per Average AZ (MWs)	60	60	60	60	60	60	60	60	60	60
Total	1,860	2,520	3,180	3,900	4,380	4,680	4,980	5,220	5,460	5,640
At Scale Servers Per AZ (assumes 500 watts per Server)	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000
Watts per Server	500	500	500	500	500	500	500	500	500	500
sq. ft. per server	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Assumed sq. ft. per MW	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Total Servers	1,271,926	1,495,603	1,842,825	2,110,129	2,617,358	2,920,528	3,463,000	3,880,943	4,233,441	4,346,836
Y/Y growth	15%	24%	12%	15%	24%	12%	19%	12%	9%	3%
Estimated Constructed Sq. Ft.	3,815,779	4,486,808	5,528,474	6,330,386	7,852,074	8,761,585	10,388,999	11,642,829	12,700,324	13,040,507
Revenue per sq. ft. (average)	2,352	2,943	3,486	4,327	4,939	5,549	6,023	6,335	6,766	7,422
Estimated KW per sq. ft. design	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Estimated Utilized Power (MW)	636	748	921	1,055	1,309	1,460	1,731	1,940	2,117	2,173
Revenue per MW (average)	14,113,261	17,660,518	20,917,632	25,961,349	29,636,044	33,295,013	36,140,516	38,010,646	40,594,084	44,532,286
Datacenter per AZ	2.2	2.0	2.4	2.5	2.5	2.6	2.6	2.7	2.8	2.9
Total Estimated Datacenters	68	84	127	163	183	203	216	235	255	273
Estimated Servers per DC	18,650	17,805	14,488	12,985	14,342	14,401	16,047	16,522	16,615	15,946
Revenue per DC (000s)	115,543	145,464	137,248	157,883	191,923	227,298	267,266	297,092	323,191	350,421

Source: Oppenheimer &amp; Co., FactSet, Company Reports

## Appendix II: List of Industry Reports 2016–2020

**Please contact us for a copy of the industry reports we have published in the past ten years.** The industry reports we published last year (our key reports are listed below) support our views on capex growth in cloud and outline key trends in cloud and telecom.

### 2020

- Blockchain Summit Takeaways: Amazing Innovation and Institutional Adoption (11/23/20)
- Virtual Workplace White Paper: Communication and Applications Converge (11/20/20)
- Wireless Industry Update, Strong Growth, Concerns on iPhone Subsidies Overblown (10/22/20)
- Blockchain: Token-based Apps Drive New Collaborative Services (10/19/20)
- Cloud Industry 1Q20 Recap: Two Years' Worth of Cloud Adoption in Two Months (5/21/20)
- 5G White Paper: Expect Stronger Revenue, CAPX, and Cell Site Growth (4/15/20)
- COVID-19 Impacts and Thoughts On Our Coverage (3/27/20)
- CDNs Seeing Strong Growth; Secular Shift to OTT Video/Gaming/Cloud Compute (3/26/20)
- Cloud Enables New Business Models, Leveraging Assets to Drive High ROIC (3/3/20)
- TMUS/S Merger Expected to Clear, As We Predicted From The Original Announcement (2/10/20)
- Cloud 4Q Recap: Stronger than Expected Capex Efficiency, MSFT/GOOGL Taking Share (2/10/20)
- Communications 4Q19 Recap: Solid Wireless/Broadband Fundamentals, Very Weak TV (2/6/20)

### 2019

- Updated Cloud Thoughts: Early Innings Still, MSFT Well-Positioned (11/18/19)
- OTT the Third TV Wave—Catalyst for Cloud/Wireless Infrastructure (11/4/19)
- Cloud Set to Drive a New “Roaring 20’s”, Defined by Big Productivity Improvements (10/11/19)
- 2019 Tech Conference Takeaways: 5G/Cloud Builds Accelerating, FCC Is Supportive (8/12/19)
- Dish Networks' Impact on the Wireless Industry? (7/31/19)
- 2H19 Outlook: Despite Risks from TMUS/S Merger, FCF Will Remain the Focus (6/21/19)
- Wireless Disruption Coming as Industry Moves to Horizontal Segmentation (6/3/19)
- Wireless Industry Implications of Amazon Entry (5/31/19)
- Sprint/T-Mobile Merger: Negotiations Commence, We Expect Sprint to Be Flexible (5/14/19)
- Structural Separation Could Get Sprint/TMUS Approved (4/9/19)
- Artificial Intelligence: Driving the Next Century of Technology (4/1/19)
- Connected Cars' Impact on Wireless Revenue; AT&T Dominates the Segment (3/7/19)
- Highlights from Oppenheimer's First Annual Blockchain Summit (2/21/2019)
- Blockchain Ecosystem Developing Through Crypto Winter (1/16/19)

### 2018

- AWS re:Invent Preview: Enterprises Moving Up Stack to Premium Services (11/21/18)
- Datacenter White Paper—Interconnectivity and Hyperscale Dominate Growth (11/14/18)
- IBM/Red Hat Merger, Looking to Crash and Disrupt the Cloud Party (10/29/18)
- SEND Acquisition Highlights VG's/EGHT's Relatively Low Valuations (10/16/2018)
- 2H18 Telecom Outlook: Improving Wireless Trends Will Spur 2H Outperformance (9/20/18)

- The End of Television As We Know It (10/3/18)
- MSFT Ignite Recap: Uniquely Positioned to Drive Digital Transformations Through Hybrid Cloud/ Intelligent Edge (9/27/18)
- MSFT Investing for the Next 20-Year Wave of Computing—AI/Fog (7/27/18)
- Wireless Set to Transform Communications/Cloud (6/21/18)
- MSFT Acquires GitHub; Broadens Appeal to Developers (6/4/18)
- The Golden Age of Enterprise Communications (6/4/18)
- Blockchain Can Enable the Next Generation of Compute: FOG (5/31/18)
- Secular Changes Apparent in Telco/Cable Trends (5/11/18)
- AT&T/DoJ: Channel Checks Reinforce Our View T Will Likely Prevail at Trial (5/23/18)
- Cloud Bus Tour Highlights: Cloud Adoption Accelerating (5/19/18)
- Infrastructure Plan Supports Our \$20 Billion CAPX Growth/Year Est in 2018-20 (1/31/18)
- Nationalization of 5G Networks Is Illogical, But Government Support Is Helpful (1/29/18)
- MSFT Deep Dive: Cloud Growth/Margin Expansion Hitting Sweet Spot (1/9/18)

## 2017

- AWS re:Invent Focus on IOT, AI, Kubernetes, Alexa, Security, Database on Serverless—Increasing Target to \$1,330 (12/1/17)
- AWS re:Invent Preview, Expect Accelerating Innovation on Every Front (11/27/17)
- T-Mobile/Sprint Officially Off the Table (11/6/17)
- Sprint and Altice Form Creative MVNO; We Expect Comcast/Charter to Enter Also (11/6/17)
- Comcast Looks Inexpensive Despite Secular OTT Challenges (10/23/17)
- Cognizant Cloud White Paper—Driving the Next Economic Revolution (9/25/17)
- TMUS 14th Uncarrier Event: Netflix Free on Certain Family Plans (9/7/17)
- Verizon Wireless Tweaks Pricing Plans, But Pricing Remains High (8/22/17)
- Datacenter White Paper: Fundamentals Set to Improve (6/26/17)
- Telecom 2.0: Virtualization and Openness Driving a Network Revolution (6/7/17)
- Consolidation Driving Scarcity Value for Small-Cap Cloud/Comm (5/19/17)
- Spectrum Is Valuable and Gives Sprint/Dish Options (5/12/17)
- Switching from T-Mobile to Sprint as the New King Maker (4/24/17)
- Regulatory Update and Outlook (4/10/17)
- Update Wireless Industry Models, Lower Growth But TMUS Outperforming (4/4/17)
- Cloud Bus Tour Takeaways (3/16/2017)
- A Closer Look at VZ's Strategic Options (2/2/17)

## 2016

- Masayoshi Son Plans to Invest \$50B in the US, TMUS Likely in Play (12/7/16)
- Re:Invent—Updated Thoughts on New Market Entry, Particularly Communications (12/4/16)
- Post-Election Net Neutrality Update (11/23/16)
- The Public Cloud Race, and the March Up (and Down) the Stack (11/18/16)
- Updated Scenario: LVL Acquires CTL in a 1-for-2 Stock Exchange to Retain NOLs (10/30/16)
- Update on Recent FCC Proposals: Worst Fears Alleviated (10/10/16)
- Cloud Update: Machine Learning and AI Becoming Table Stakes (10/6/16)
- Appeals Court Rejects Challenge to Net Neutrality (6/14/16)
- Takeaways from Our Meetings with FCC, GTT and CCOI (6/12/16)
- Cloud Efficiency Drives Very High Returns and Disruption (6/7/16)
- Wireless Industry More Focused on Profitability (4/25/16)
- Multi-Cloud Architectures Blossoming (4/6/16)
- Ascending the Cloud S-Curve Adoption Cycle (2/2/16)
- Updated Implications of Weak Capital Markets (1/19/16)



**Stock prices of other companies mentioned in this report (as of 12/21/2020):**

IBM (IBM-NYSE, \$125.85, Not Covered)  
Dish Network (DISH-NASDAQ, \$30.49, Not Covered)  
General Motors (GM-NYSE, \$40.84, Not Covered)

**Price Target Calculation****TMUS:****Key Risks to Price Target****TMUS:****Disclosure Appendix**

**Oppenheimer & Co. Inc. does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision.**

**Analyst Certification** - The author certifies that this research report accurately states his/her personal views about the subject securities, which are reflected in the ratings as well as in the substance of this report. The author certifies that no part of his/her compensation was, is, or will be directly or indirectly related to the specific recommendations or views contained in this research report.

**Potential Conflicts of Interest:**

Equity research analysts employed by Oppenheimer & Co. Inc. are compensated from revenues generated by the firm including the Oppenheimer & Co. Inc. Investment Banking Department. Research analysts do not receive compensation based upon revenues from specific investment banking transactions. Oppenheimer & Co. Inc. generally prohibits any research analyst and any member of his or her household from executing trades in the securities of a company that such research analyst covers. Additionally, Oppenheimer & Co. Inc. generally prohibits any research analyst from serving as an officer, director or advisory board member of a company that such analyst covers. In addition to 1% ownership positions in covered companies that are required to be specifically disclosed in this report, Oppenheimer & Co. Inc. may have a long position of less than 1% or a short position or deal as principal in the securities discussed herein, related securities or in options, futures or other derivative instruments based thereon. Recipients of this report are advised that any or all of the foregoing arrangements, as well as more specific disclosures set forth below, may at times give rise to potential conflicts of interest.

**Important Disclosure Footnotes for Companies Mentioned in this Report that Are Covered by Oppenheimer & Co. Inc:****Stock Prices as of December 22, 2020**

Amazon.Com, Inc. (AMZN - NASDAQ, \$3,206.18, OUTPERFORM)  
 Apple Inc. (AAPL - NASDAQ, \$128.23, OUTPERFORM)  
 Adobe, Inc. (ADBE - NASDAQ, \$498.39, OUTPERFORM)  
 Akamai Technologies (AKAM - NASDAQ, \$105.98, OUTPERFORM)  
 American Tower Corp. (AMT - NYSE, \$219.78, OUTPERFORM)  
 Equinix Inc. (EQIX - NASDAQ, \$704.40, OUTPERFORM)  
 Facebook, Inc. (FB - NASDAQ, \$272.79, OUTPERFORM)  
 Twilio, Inc. (TWLO - NYSE, \$364.82, OUTPERFORM)  
 Verizon (VZ - NYSE, \$59.49, OUTPERFORM)  
 Cogent Communications (CCOI - NASDAQ, \$60.06, PERFORM)  
 Charter Communications, Inc. (CHTR - NASDAQ, \$654.69, PERFORM)  
 Crown Castle International (CCI - NYSE, \$153.26, OUTPERFORM)  
 8x8 Inc. (EGHT - NYSE, \$31.48, OUTPERFORM)  
 Microsoft Corporation (MSFT - NASDAQ, \$222.59, OUTPERFORM)  
 T-Mobile (TMUS - NASDAQ, \$130.22, OUTPERFORM)  
 Alphabet Inc. (GOOG - NASDAQ, \$1,739.37, OUTPERFORM)  
 Fastly, Inc. (FSLY - NYSE, \$101.21, PERFORM)  
 AT&T, Inc. (T - NYSE, \$29.01, OUTPERFORM)  
 Comcast (CMCSA - NASDAQ, \$50.37, PERFORM)  
 Limelight Networks (LLNW - NASDAQ, \$4.27, OUTPERFORM)  
 Salesforce.com (CRM - NYSE, \$226.47, OUTPERFORM)

Vonage Holdings Corp. (VG - NYSE, \$13.51, OUTPERFORM)  
 Kaleyra, Inc. (KLR - NYSE American, \$8.85, OUTPERFORM)  
 Zoom Video Communications (ZM - NASDAQ, \$408.97, PERFORM)  
 Oracle Corporation (ORCL - NASDAQ, \$64.48, PERFORM)  
 RingCentral (RNG - NYSE, \$393.25, OUTPERFORM)  
 Boingo Wireless, Inc. (WIFI - NASDAQ, \$12.71, OUTPERFORM)

All price targets displayed in the chart above are for a 12- to 18-month period. Prior to March 30, 2004, Oppenheimer & Co. Inc. used 6-, 12-, 12- to 18-, and 12- to 24-month price targets and ranges. For more information about target price histories, please write to Oppenheimer & Co. Inc., 85 Broad Street, New York, NY 10004, Attention: Equity Research Department, Business Manager.

#### Oppenheimer & Co. Inc. Rating System as of January 14th, 2008:

**Outperform(O)** - Stock expected to outperform the S&P 500 within the next 12-18 months.

**Perform (P)** - Stock expected to perform in line with the S&P 500 within the next 12-18 months.

**Underperform (U)** - Stock expected to underperform the S&P 500 within the next 12-18 months.

**Not Rated (NR)** - Oppenheimer & Co. Inc. does not maintain coverage of the stock or is restricted from doing so due to a potential conflict of interest.

#### Oppenheimer & Co. Inc. Rating System prior to January 14th, 2008:

**Buy** - anticipates appreciation of 10% or more within the next 12 months, and/or a total return of 10% including dividend payments, and/or the ability of the shares to perform better than the leading stock market averages or stocks within its particular industry sector.

**Neutral** - anticipates that the shares will trade at or near their current price and generally in line with the leading market averages due to a perceived absence of strong dynamics that would cause volatility either to the upside or downside, and/or will perform less well than higher rated companies within its peer group. Our readers should be aware that when a rating change occurs to Neutral from Buy, aggressive trading accounts might decide to liquidate their positions to employ the funds elsewhere.

**Sell** - anticipates that the shares will depreciate 10% or more in price within the next 12 months, due to fundamental weakness perceived in the company or for valuation reasons, or are expected to perform significantly worse than equities within the peer group.

Distribution of Ratings/IB Services Firmwide				
Rating	IB Serv/Past 12 Mos.			
	Count	Percent	Count	Percent
OUTPERFORM [O]	428	66.77	206	48.13
PERFORM [P]	212	33.07	70	33.02
UNDERPERFORM [U]	1	0.16	0	0.00

Although the investment recommendations within the three-tiered, relative stock rating system utilized by Oppenheimer & Co. Inc. do not correlate to buy, hold and sell recommendations, for the purposes of complying with FINRA rules, Oppenheimer & Co. Inc. has assigned buy ratings to securities rated Outperform, hold ratings to securities rated Perform, and sell ratings to securities rated Underperform.

Note: Stocks trading under \$5 can be considered speculative and appropriate for risk tolerant investors.

## Company Specific Disclosures

In the past 12 months Oppenheimer & Co. Inc. has provided investment banking services for FSLY and KLR.

In the past 12 months Oppenheimer & Co. Inc. has managed or co-managed a public offering of securities for FSLY and KLR.

In the past 12 months Oppenheimer & Co. Inc. has received compensation for investment banking services from FSLY and KLR.

Oppenheimer & Co. Inc. expects to receive or intends to seek compensation for investment banking services in the next 3 months from LVL, RNG and WIFI.

---

### Additional Information Available

**Company-Specific Disclosures:** Important disclosures, including price charts, are available for compendium reports and all Oppenheimer & Co. Inc.-covered companies by logging on to <https://www.oppenheimer.com/client-login.aspx> or writing to Oppenheimer & Co. Inc., 85 Broad Street, New York, NY 10004, Attention: Equity Research Department, Business Manager.

---

## Other Disclosures

This report is issued and approved for distribution by Oppenheimer & Co. Inc. Oppenheimer & Co. Inc. transacts business on all principal exchanges and is a member of SIPC. This report is provided, for informational purposes only, to institutional and retail investor clients of Oppenheimer & Co. Inc. and does not constitute an offer or solicitation to buy or sell any securities discussed herein in any jurisdiction where such offer or solicitation would be prohibited. The securities mentioned in this report may not be suitable for all types of investors. This report does not take into account the investment objectives, financial situation or specific needs of any particular client of Oppenheimer & Co. Inc. Recipients should consider this report as only a single factor in making an investment decision and should not rely solely on investment recommendations contained herein, if any, as a substitution for the exercise of independent judgment of the merits and risks of investments. The analyst writing the report is not a person or company with actual, implied or apparent authority to act on behalf of any issuer mentioned in the report. Before making an investment decision with respect to any security recommended in this report, the recipient should consider whether such recommendation is appropriate given the recipient's particular investment needs, objectives and financial circumstances. We recommend that investors independently evaluate particular investments and strategies, and encourage investors to seek the advice of a financial advisor. Oppenheimer & Co. Inc. will not treat non-client recipients as its clients solely by virtue of their receiving this report. Past performance is not a guarantee of future results, and no representation or warranty, express or implied, is made regarding future performance of any security mentioned in this report. The price of the securities mentioned in this report and the income they produce may fluctuate and/or be adversely affected by exchange rates, and investors may realize losses on investments in such securities, including the loss of investment principal. Oppenheimer & Co. Inc. accepts no liability for any loss arising from the use of information contained in this report, except to the extent that liability may arise under specific statutes or regulations applicable to Oppenheimer & Co. Inc. All information, opinions and statistical data contained in this report were obtained or derived from public sources believed to be reliable, but Oppenheimer & Co. Inc. does not represent that any such information, opinion or statistical data is accurate or complete (with the exception of information contained in the Important Disclosures section of this report provided by Oppenheimer & Co. Inc. or individual research analysts), and they should not be relied upon as such. All estimates, opinions and recommendations expressed herein constitute judgments as of the date of this report and are subject to change without notice. Nothing in this report constitutes legal, accounting or tax advice. Since the levels and bases of taxation can change, any reference in this report to the impact of taxation should not be construed as offering tax advice on the tax consequences of investments. As with any investment having potential tax implications, clients should consult with their own independent tax adviser. This report may provide addresses of, or contain hyperlinks to, Internet web sites. Oppenheimer & Co. Inc. has not reviewed the linked Internet web site of any third party and takes no responsibility for the contents thereof. Each such address or hyperlink is provided solely for the recipient's convenience and information, and the content of linked third party web sites is not in any way incorporated into this document. Recipients who choose to access such third-party web sites or follow such hyperlinks do so at their own risk.

This research is distributed in the UK and elsewhere throughout Europe, as third party research by Oppenheimer Europe Ltd, which is authorized and regulated by the Financial Conduct Authority (FCA). This research is for information purposes only and is not to be construed as a solicitation or an offer to purchase or sell investments or related financial instruments. This research is for distribution only to persons who are eligible counterparties or professional clients. It is not intended to be distributed or passed on, directly or indirectly, to any other class of persons. In particular, this material is not for distribution to, and should not be relied upon by, retail clients, as defined

under the rules of the FCA. Neither the FCA's protection rules nor compensation scheme may be applied. <https://opco2.bluematrix.com/sellside/MAR.action>

**Distribution in Hong Kong:** This report is prepared for professional investors and is being distributed in Hong Kong by Oppenheimer Investments Asia Limited (OIAL) to persons whose business involves the acquisition, disposal or holding of securities, whether as principal or agent. OIAL, an affiliate of Oppenheimer & Co. Inc., is regulated by the Securities and Futures Commission for the conduct of dealing in securities and advising on securities. For professional investors in Hong Kong, please contact [researchasia@opco.com](mailto:researchasia@opco.com) for all matters and queries relating to this report. This report or any portion hereof may not be reprinted, sold, or redistributed without the written consent of Oppenheimer & Co. Inc.

This report or any portion hereof may not be reprinted, sold, or redistributed without the written consent of Oppenheimer & Co. Inc. Copyright © Oppenheimer & Co. Inc. 2020.