

# *Michigan Wireless Association Presentation* – State of the Wireless Industry & What 5G Will Bring

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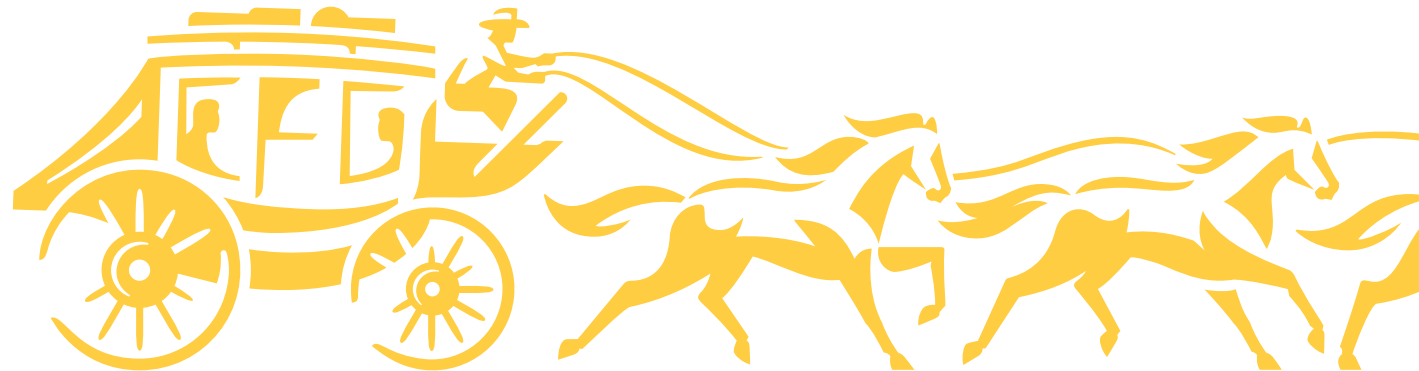
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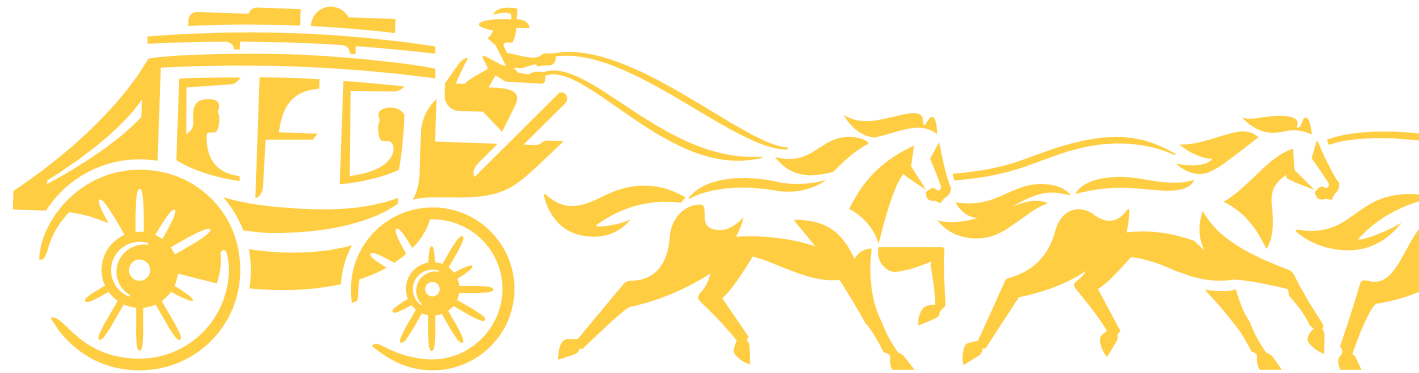
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# The Here and Now – What is Happening in Wireless



# Wireless Industry At A Quick Glance

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Wireless operators pursuing very divergent strategies

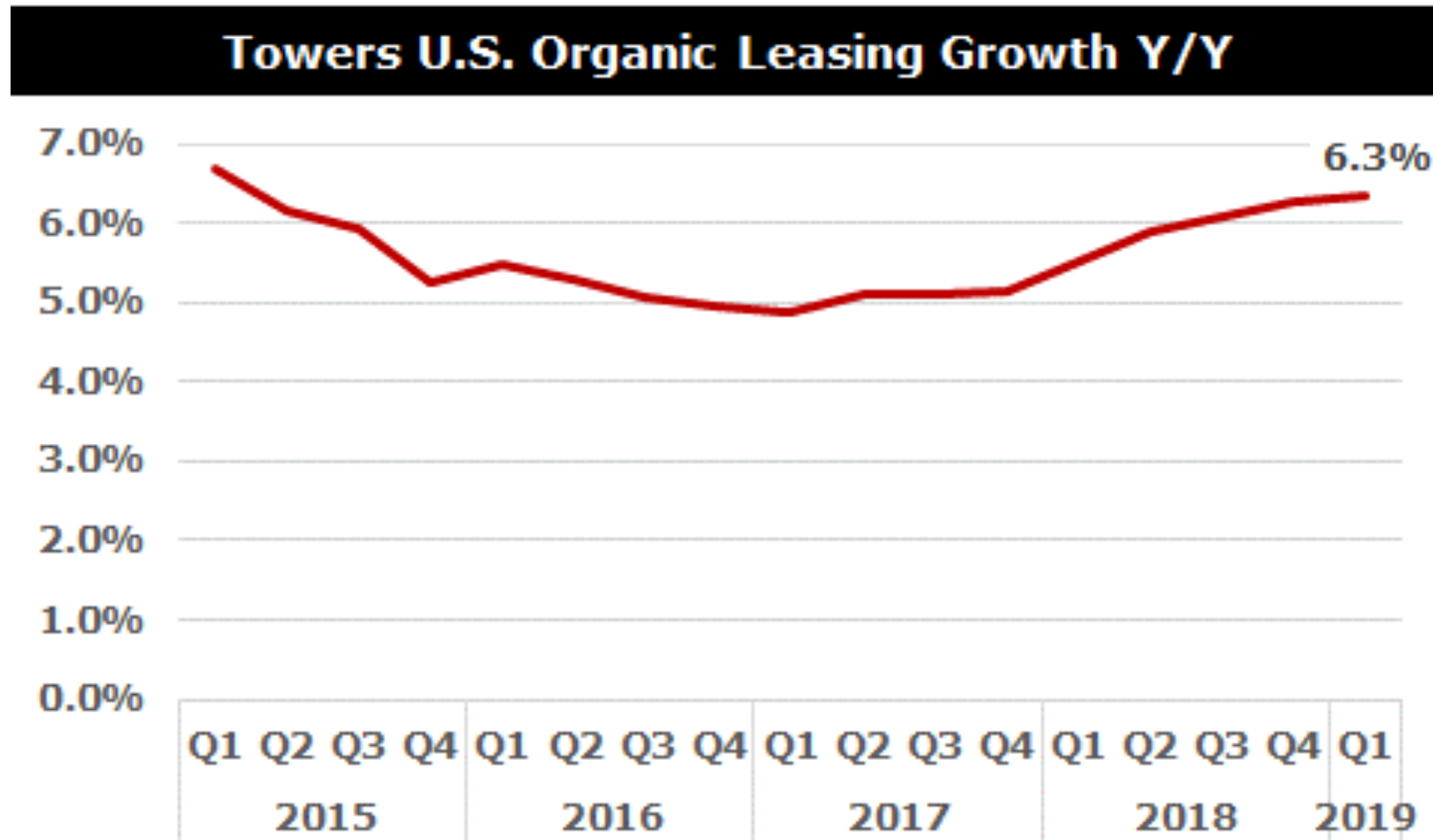
- **AT&T**: Integrating TWX assets and focused on growing WarnerMedia and its Advertising business; T's wireless strategy centered on a bundling approach to combine linear/over-the-top video, content and wireless services...more to come later this year with its own Direct to Consumer (DTC) video offer.
- **Sprint**: Advertising focused on narrowing gap between its network and other carriers (namely VZ) which charge higher prices; By S's own admission –is in much distress (financially & lacking scale) if the T-Mobile deal is not approved.
- **T-Mobile**: Continues to differentiate with consumer-friendly Un-carrier initiatives while expanding its geographic coverage; The focus of its promotions (55+ year-old consumers, military, family plans) centers on higher credit-quality consumers, primarily customers of T and VZ. If Sprint deal is not approved, they will need more mid-band spectrum, in our view.
- **Verizon**: Continues to price at premium based on its network quality vs. peers; Unlike closest competitor (T), VZ sees no near-term need to own linear content and prefers to be over-the-top video/content distributor; Only one of 4 national operators to NOT offer video bundle in its service plans. Fiber is full focus – most of 5G eggs in mmWave spectrum basket.
- **TMUS/S? (New T-Mobile)**: If the deal is approved, the “New T-Mobile” will have the most impressive spectrum assets of any of the three remaining players and a strong platform to compete with VZ/T in a 5G world. However, regulatory approval is no “lay-up,” particularly in light of recent suit brought against deal by 10 State AGs (hearing is scheduled for 12/9/19).

## But Can't Just Have Spectrum....Need to Spend Capital to Put this Spectrum to Use

<b>Big 4 Wireless Capex Trends (\$MMs)</b>						
	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019E</b>	<b>2020E</b>
AT&T	\$9,666	\$11,204	\$10,324	\$11,340	\$10,870	\$10,913
y/y %	-15.1%	15.9%	-7.9%	9.8%	-4.1%	0.4%
Verizon	\$11,725	\$11,240	\$10,310	\$8,486	\$8,788	\$9,008
y/y %	11.5%	-4.1%	-8.3%	-17.7%	3.6%	2.5%
T-Mobile	\$4,724	\$4,702	\$5,237	\$5,541	\$6,081	\$6,000
y/y %	9.4%	-0.5%	11.4%	5.8%	9.7%	-1.3%
Sprint	\$4,855	\$1,700	\$2,510	\$4,043	\$5,550	\$5,500
y/y %	-6.2%	-65.0%	47.6%	61.1%	37.3%	-0.9%
<b>Total</b>	<b>\$30,970</b>	<b>\$28,846</b>	<b>\$28,381</b>	<b>\$29,410</b>	<b>\$31,289</b>	<b>\$31,421</b>
y/y %	-1.3%	-6.9%	-1.6%	3.6%	6.4%	0.4%

- Source: Company data and Wells Fargo Securities estimates

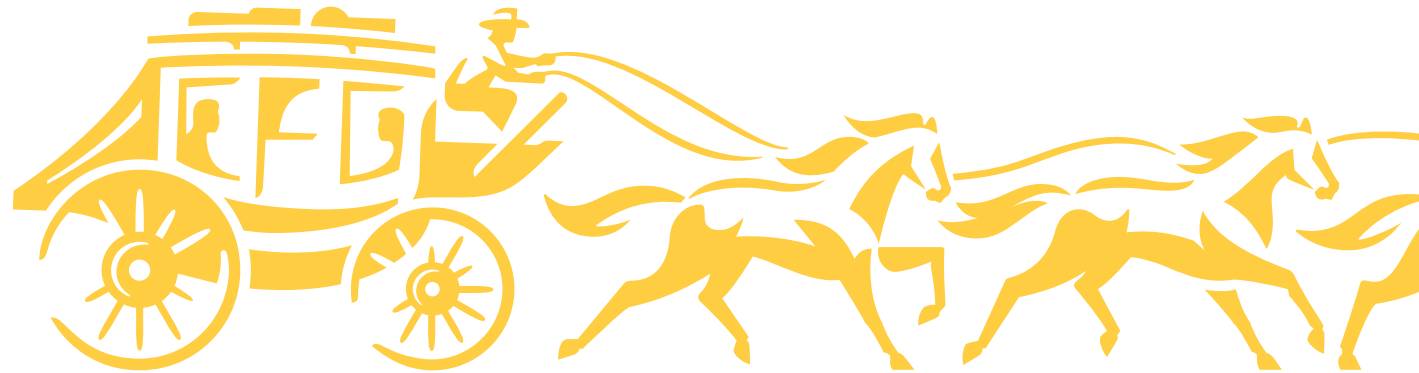
## And Towers Should Continue to Benefit from this Spend



- Source: Company data and Wells Fargo Securities estimates

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But What About that Thing Called 5G.....



# Big 4 Wireless Carriers' 5G Strategies

## Verizon

- Verizon's (VZ, Outperform, \$60.36, target: \$65) initial commercial launch of pre-standards-based fixed wireless 5G was completed in the second half of 2018 across 4 cities, delivering ~300 Mbps speeds; Verizon ultimately could scale its fixed wireless offering to ~30MM homes
- In April 2019, Verizon launched mobile 5G services in 2 cities (Chicago and Minneapolis), although across limited Moto handsets; Verizon plans to launch across 30 or more cities by the end of 2019
- VZ is leveraging its +1,100 MHz of mmWave spectrum for both fixed wireless and mobile 5G applications

## AT&T

- AT&T (T, Market Perform, \$37.84, target: \$36) currently has mobile 5G across 19 cities and plans to launch it nationwide in 2020
- AT&T has also been trialing 5G technologies with its "5G Evolution" launches across 23 major metro areas
- AT&T has been conducting fixed wireless 5G trials across multiple markets
- AT&T was a big winner in Auction 102 and now has ~630MHz of mmWave spectrum in total

## T-Mobile

- T-Mobile (TMUS, Outperform, \$78.77, target: \$98) was the first to commit to a nationwide 5G roll-out, with 30 cities expected to be launched in the second half of 2019 and a broader nationwide launch by 2020
- TMUS is dedicating a portion of its acquired 600MHz spectrum as a base for mobile 5G, and also recently acquired additional 369MHz of nationwide mmWave spectrum in Auction 102
- TMUS's 5G strategies also hinges on its planned merger with Sprint, which would give TMUS access to Sprint's significant 2.5 GHz spectrum holdings. Without Sprint, TMUS plans to use its 600MHz for 5G

## Sprint

- Sprint (S, Market Perform, \$6.17, target: \$6) currently has standards-based 5G deployed in select cities, with commercial service available in Chicago, Atlanta, Dallas and Kansas City on 5/31/19
- Sprint plans to launch in Houston, Los Angeles, New York City, Phoenix and Washington DC by end of 2019
- Sprint plans to "tri-band" its entire network over the next 2 years to enable a true mobile 5G experience, with 2.5GHz spectrum on ~80% of its macro towers

# Three Foundational Pillars of 5G

- 5G network deployments is a new mobile networking standard that is based around three foundational pillars:
  - **Enhanced mobile broadband:** Significant increases to peak data rates for applications such as video streaming, Web browsing and virtual reality
  - **Massive machine-type communications:** Under IMT-2020, peak data rates should be up to 20 Gbps (downlink), or a ~20x improvement from LTE (IMT-Advanced), with user-experienced data rates of 100 Mbps (~10x improvement
  - **Ultra-reliable and low-latency mobile communications:** This category should unleash latencies as low as 1 millisecond (1 ms) and provide satisfactory service to users traveling at speeds up to 500 km/hour

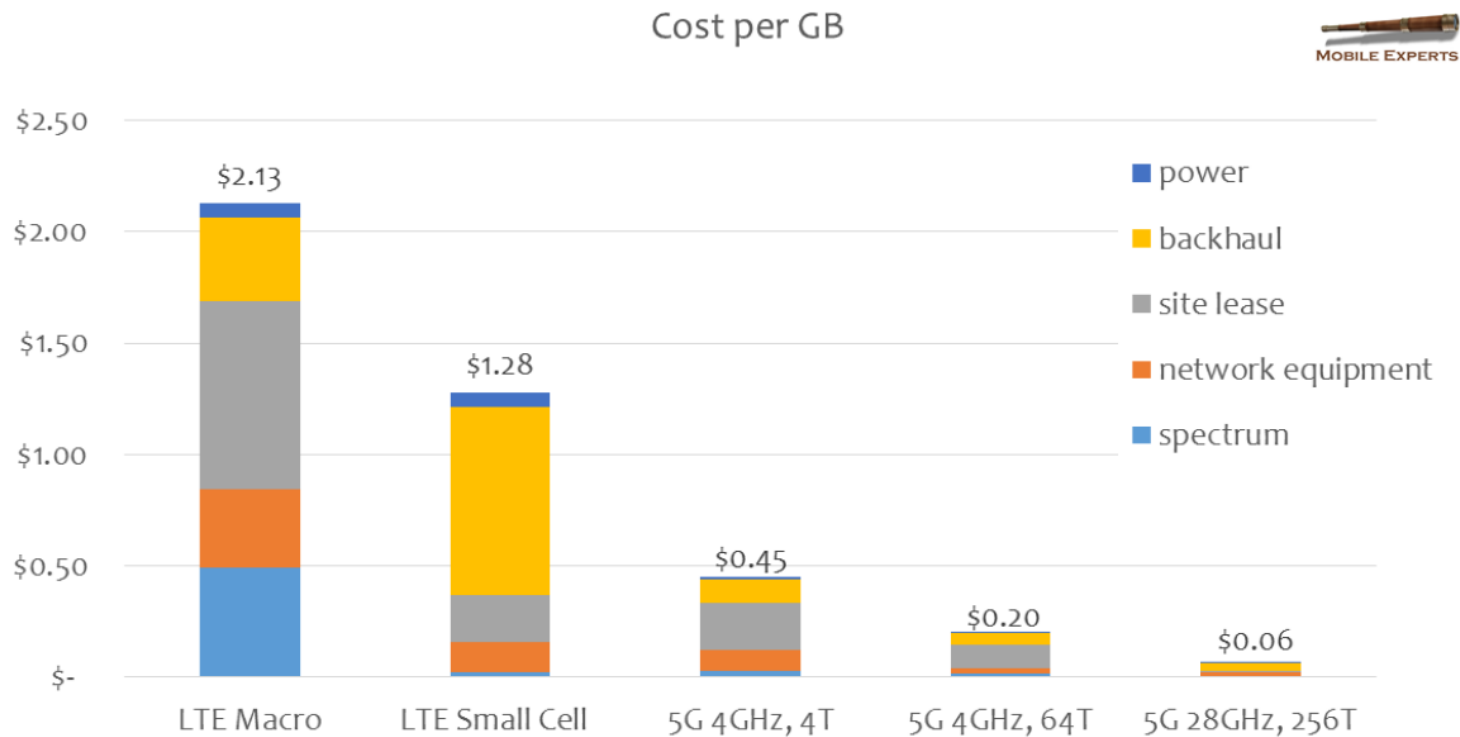
Overview of 5G Vs. Previous Mobile Network Standards			
	IMT-Advanced (4G)	IMT-2020 (5G)	5G Improvement over 4G
Peak Data Rate	DL: 1 Gbps	DL: 20 Gbps	DL: 20x
	UL: 0.05 Gbps	UL: 10 Gbps	UL: 200x
User-Experienced Data Rate	10 Mbps	100 Mbps	10x
Peak Spectral Efficiency	DL: 15 bps/Hz	DL: 30 bps/Hz	DL: 2x
	UL: 6.75 bps/Hz	UL: 15 bps/Hz	UL: 2.2x
Mobility	350 km/hour	500 km/hour	1.4x
User Latency	10 ms	1 ms	10x
Connection Density	100K/sq km	1MM/sq km	10x
Network Energy Efficiency	1 (normalized)	100	100x
Bandwidth	Up to 20 MHz/radio channel (100 MHz aggregated)	Up to 1GHz (single or multiple RF carriers)	

Source: Rysavy Research LLC and 5G Americas



# 5G Will Likely Dramatically Reduce Wireless Costs/GB

- A key driver of 5G deployments is around cost reduction, which initially could be larger than the revenue opportunity
- According to Mobile Experts, 5G can lower the cost to deliver 1 GB of data from \$2.13 in a LTE macro world to \$0.06 using a 5G 28 GHz standard with 256 transmitters



Source: Mobile Experts

# What are the 5G Use Cases?

## **Fixed Wireless Broadband**

- The first 5G use case, with deployments underway by Verizon and AT&T
- Fixed broadband-to-the-home replacement that leverages ultra high-band wireless spectrum and existing fiber to provide high home broadband speeds without the need to build fiber all the way to the premise

## **Enhanced Mobile Broadband**

- Broadband data access across a wide coverage area, including both indoor and outdoor locations
- Multi-user interaction and virtual/augmented reality are all components of these use cases
- Other use cases include hot spot/broadband access in densely populated areas, broadband access across public transport systems (i.e. high-speed trains) and “smart offices” in indoor environments

## **Massive IoT**

- Addresses the need for low-cost devices, extended coverage and longer battery lives for Internet of Things devices, such as sensors and cameras
- Applications could include industries such as transport and logistics (fleet management, goods tracking), utilities (smart metering, smart grid management), smart cities, industrial and agricultural

## **Ultra-Reliable Low-Latency Applications**

- Mission-critical applications with very high demands for performance, reliability and latency
- Applications could include connected vehicles to enhance safety applications, healthcare/remote surgery (i.e. remote patient diagnosis and treatment), robust communications in case of natural disasters and automated factories that enable time-critical factory automation

Source: 5G Americas and Wells Fargo Securities, LLC

# The “Chicken & Egg” 5G Dilemma

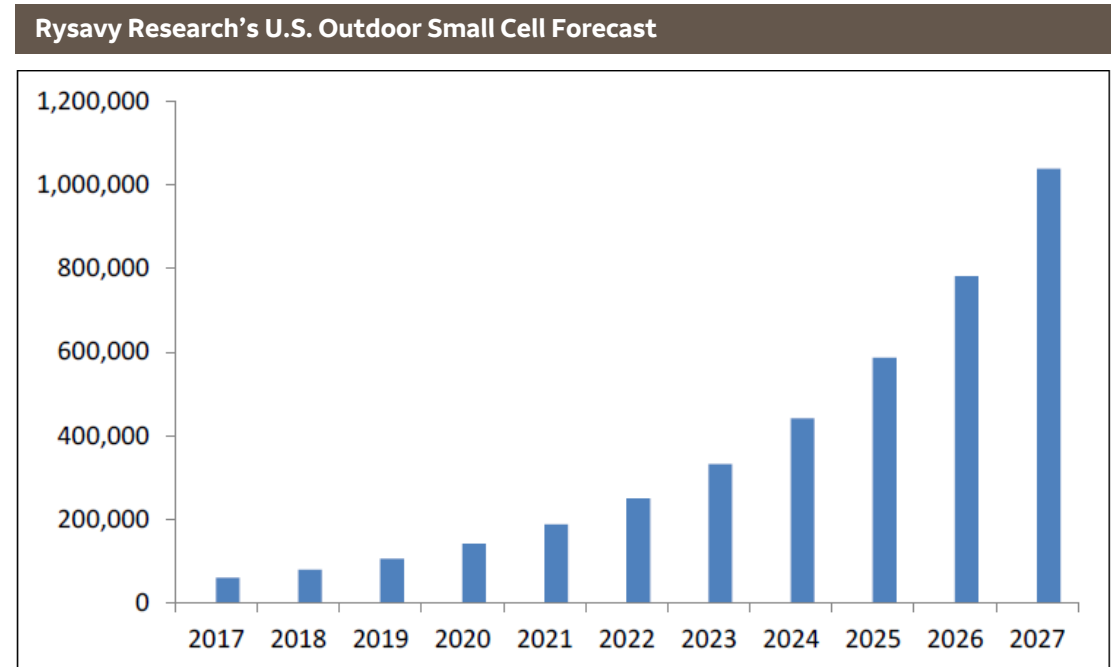
3 Critical Pieces of Infrastructure Needed  
Before Revenue Can Come

# Infrastructure Piece #1: Small Cells

- In our view, small cells will be an integral component of 5G network architectures and will need to scale materially to deliver the throughput and bandwidth promises of 5G
- Greatest need for small cells in dense, metro areas, where bandwidth consumption is the highest and where high-capacity mmWave spectrum is deployed
  - Rysavy Research estimates that 5G small cell inter-site distances will range from 100-300 meters
- Rysavy Research estimates that outdoor small cells could ramp from over 100K today to 200K by the end of 2021 and more than 1MM by 2027

Type of Cells and Typical Characteristics		
Type of Cell	Location	Description
Macro cell	Outdoors	Wide-area coverage; LTE supports up to 100 km in range, but typical distances of 0.5-5 km
Microcell	Outdoors	Covers small area, with typical ranges of 2 km
Picocell	Indoors or Outdoors	Deployed by operators to expand capacity; Typical range of 15 -200 meters outdoors and 10-25 indoors
Consumer Femtocell	Indoors	Ranges up to 10 meters (generally 4-6 users), often deployed by end users using own backhaul
Enterprise Femtocell	Indoors	Ranges up to 25 meters (generally 16-32 users) and usually deployed by operators
Distributed antenna system	Indoors or Outdoors	Same hardware can support multiple operators (neutral-host); Indoor deployments in large locations like airports; Outdoors for coverage/capacity expansion
Remote radio head	Outdoors	Uses broadband at macro site or centralized baseband equipment; If centralized, called C-RAN
Wi-Fi	Indoors or Outdoors	Provides capacity expansion, with neutral-host capability to enable multiple operators

Source: Rysavy Research and 5G Americas

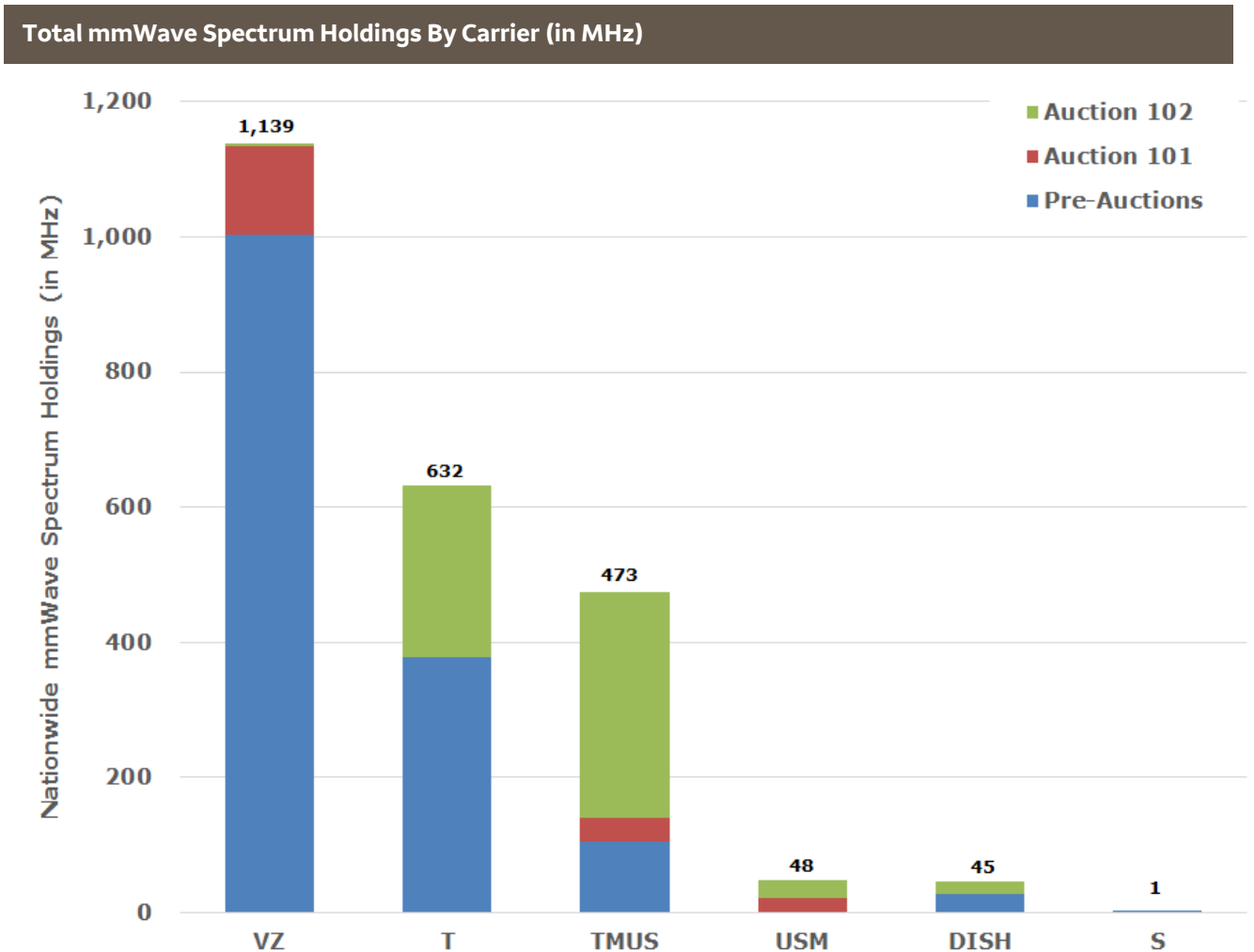


Source: Rysavy Research and 5G Americas

# Infrastructure Piece #2: Spectrum\*

(\*Not Tangible But Still Infrastructure)

- Carriers deploying mix of low-mid-high band spectrum for 5G services. Low-band spectrum still has propagation advantages but higher-bands will be needed for capacity demands, especially with low-latency 5G demands.
- VZ had an early lead owning ~1,000MHz of nationwide mmWave spectrum.
- T and TMUS were big winners in Auctions 101 (28GHz) and 102 (24GHz), adding 254MHz and 369MHz, respectively.



Source: FCC, Moise Advisory, Wells Fargo Securities, LLC

# Spectrum Remains The Lifeblood Of Wireless

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**Spectrum remains life-blood of wireless networks, in our view, as evidenced by increasing demand for ultra-high band** - Each wireless carrier is taking a slightly different approach in terms of spectrum deployment for mobile 5G, although we believe low, mid, high and (increasingly) ultra-high band spectrum will all be critical to next generation mobile networks

- **VZ:** Substantial holdings of low 700MHz (C Block), 850MHz, and AWS (purchase from cable consortium + \$10.4B from AWS-3 auction); Largest holder of mmWave spectrum, which it intends to leverage for mobile and fixed wireless 5G deployments
- **T:** Primarily 700MHz and 850MHz holdings and have been adding AWS and 2.1 GHz for capacity. Spent \$18.2B in AWS-3 auction , won the FirstNet award for 20MHz of 700MHz spectrum and was the highest bidder in mmWave Auction #102 (adding 831 new licenses)
- **S:** Substantial metro capacity with 2.5GHz spectrum (multiple 20x20 channels), along with 1900 and 800 MHz spectrum. Did not participate in AWS-3 , broadcast or mmwave.
- **TMUS:** Contiguous spectrum bands across the AWS, PCS and 700MHz frequencies. Spent \$1.8B in AWS-3 auction \$8.0B in broadcast incentive auction and \$802MM in mmwave Auction # 102. Would use 600MHz as base spectrum for 5G....but likely will change if Sprint deal gets done.
- **TMUS / S together in 2019?** The planned merger between S / TMUS (announced April 2018) centers around the 5G argument. With the deepest spectrum position of any of the Big 4 (IF approved!) – we believe this could be the 5G dark horse to watch....but the other Dark Horse (DISH) cannot be ignored. But there is a lot more legal hoops to jump through to get this ball over the goal line.

# What is Next on Spectrum Front?

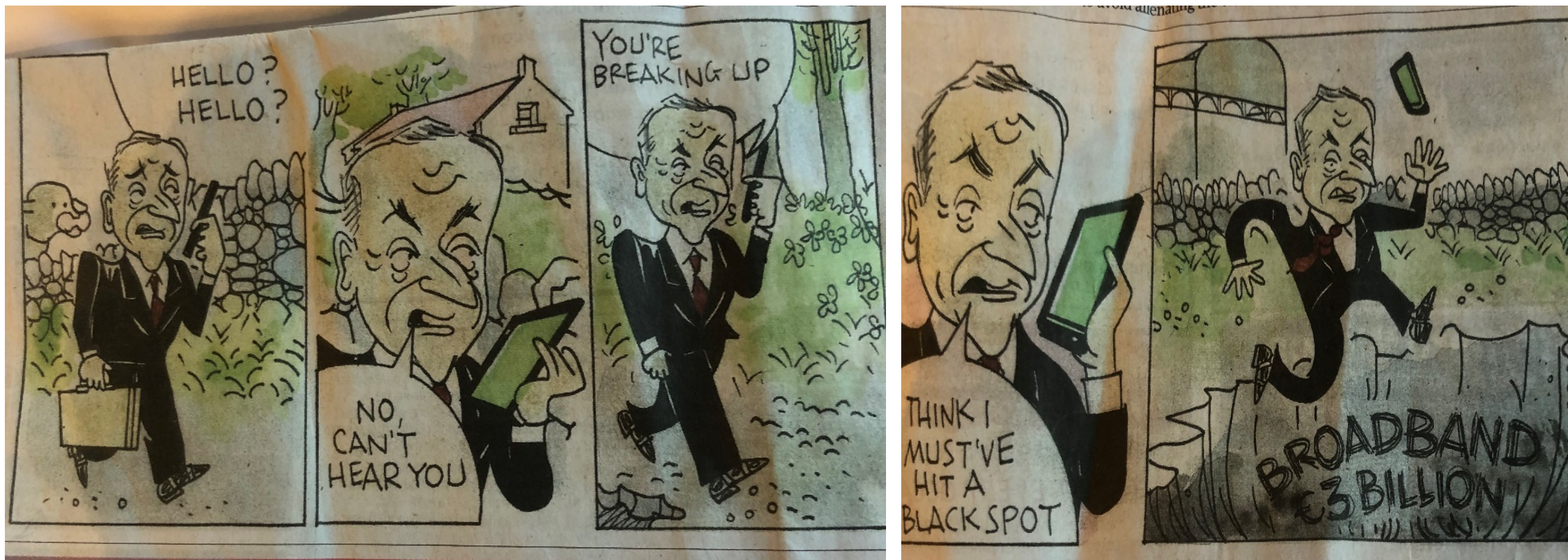
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- Watch what is happening on 3.5GHz CBRS scene (First commercial deployment happened in September)
- Don't forget about unlicensed spectrum (5GHz)
- C-Band also getting a lot of attention (satellite spectrum)
- More mmWave auctions coming. Auction 103 planned for December 2019, and will include 3.4GHz of spectrum in the 37 / 39 / 47GHz bands. Note this represents +3.8x what was auctioned off in Auctions 101 and 102 combined (on a population-weighted basis).
- DISH – If S / TMUS gets done – will Charlie Ergen be as disruptive as many think (he has lot of spectrum to work with!)
- Is Verizon really comfortable with their existing spectrum portfolio? (Especially post the February 2017 Unlimited Plan)....if they don't need more spectrum – they will need more cell sites!
- What is Cable's role....? Watch what Altice is doing in NY – taking a more infrastructure centric stance to MVNO partnership.

# Infrastructure Piece #3: Fiber - The Tie That Binds

- Deployment of fiber is a critical component of 5G networks, connecting macro towers, small cells, DAS networks and data centers/compute and processing nodes
- Given the bandwidth demands of 5G, macro towers and small cells will increasingly need to be fiber-based, as copper, microwave and other wired technologies do not have the bandwidth capabilities or scalability of fiber
- The proliferation of small cell nodes will, in most cases, require dedicated fiber pairs, with the cost of fiber ~80% of the total cost of small cell deployments
  - Next-generation wireless architecture will increasingly leverage C-RAN (cloud radio access networks), with fiber connecting centralized baseband units with remote radio heads (“fronthaul”)
- How much fiber will the U.S. ultimately need?
  - Rysavy Research estimates that 5G small cell inter-site distances will range from 100-300 meters
  - Deloitte Consulting survey in July 2017 estimated that the United States would need \$130-150 billion of total fiber investment over a 5-7 year period to support the use cases of 5G
  - The Fiber Broadband Association estimates that 5G networks will require 1.39 million miles of fiber cable in the top 25 metro areas, which represents 265K additional miles of fiber cable to cover 174K of the 3MM square miles of the United States
- In our view, owners and operators of dense metro fiber networks will remain in a strong position for years to come, including companies such as ZAYO (ZAYO, Market Perform, \$33.90, target: \$35), Crown Castle International (CCI, Outperform, \$139.01, target: \$142), CenturyLink (CTL, Outperform, \$12.48, target: \$14) and the cable companies (CMCSA,CHTR and ATUS)





Source: Dublin Gazette, Wells Fargo Securities, LLC

**Main Take-away:** Wireless and wireline capex lines get very blurry in 5G

And fiber is the long pole in the tent!

# 3 Key Questions For 5G:

- **Will 5G be embraced by Enterprise or Consumer first?**

- **Our View:** We believe Enterprise will be the first to embrace and benefit from 5G services. AT&T has claimed being an early leader in this space, providing dedicated 5G network services to different enterprise verticals. For example, providing Rush Hospital in Chicago 5G solutions for patient intake and ambulatory care, and Samsung's robotic manufacturing services in Austin. We believe these types of services will be the early applications of 5G, with mobile to follow as standards are set and handsets creep into the market.

- **Is 5G the Cable Killer?**

- **Our View:** The Moat is Very Wide - the staggering stat we just cannot get over is the amount of data / home cable is now seeing – and the growth that metric has seen in recent yrs. For example, CMCSA is now seeing the avg. home use ~ 300GB / month. But even more interestingly, the top 10% of the “power users” homes (as CMCSA calls them) are using ~ 600GB of data / month. While some may write this away as crazy users with 10 servers in their home, exploring the data history has shown us – is that for that last 20 years – the average base of users tend to follow these ‘power users’ over time.

- **The hype is very high! Can 5G live up to being the “4<sup>th</sup> industrial revolution” moniker?**

- **Our View:** Little if ever does the reality of a new “G” live up to the hype. We do believe it will get there but the tail will be very long (decade plus). Unlike past “G” upgrade, the underlying infrastructure of this G is vastly different than “traditional” wireless spending and includes a “wired” component.

# Conclusion: *The Initial Winners of 5G are the Infrastructure Owners...* And In Any 5G Discussion Towers Remain The Core Wireless Asset

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## ***Fundamental drivers intact for towercos, in our view.***

- A number of fundamentals remain intact, in our view, for the tower sector in 2019 which should drive U.S. carrier leasing activity up yr/yr
- Small cell and network densification are accelerating ahead of 5G services, with small cell RFPs up significantly yr/yr along with RFPs for dark fiber to cell sites
- With all 50 states opted into FirstNet, T has started its first wave of amendments, with the towercos providing conservative guidance on FirstNet's 2018 impact; T will deploy the 700MHz FirstNet spectrum along with its AWS-3 and WCS
- While Sprint and T-Mobile proposed merger is driven by network synergies, we believe the near-term will be positive for the tower cos. Irrespective of the merger, both carriers still have spectrum to light up – namely S's 2.5GHz spectrum and TMUS's 600MHz. Checks show S messaging to vendors implies steep ramp in spending related to Massive MIMO antennas and new site build. TMUS checks show no slow down in network investment since the merger announcement. It remains focused on clearing and lighting up its 600Mhz spectrum for deployment
- After several years of y/y decline in wireless capex spend, all 3 public tower companies poised to benefit from reacceleration of U.S. wireless capex in 2018 and 2019E.
- USM is in an interesting spot, in our view! #4 largest US tower owner – good place to be!



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