

5G is Coming. What is it and What will it Mean for Rural Telcos?

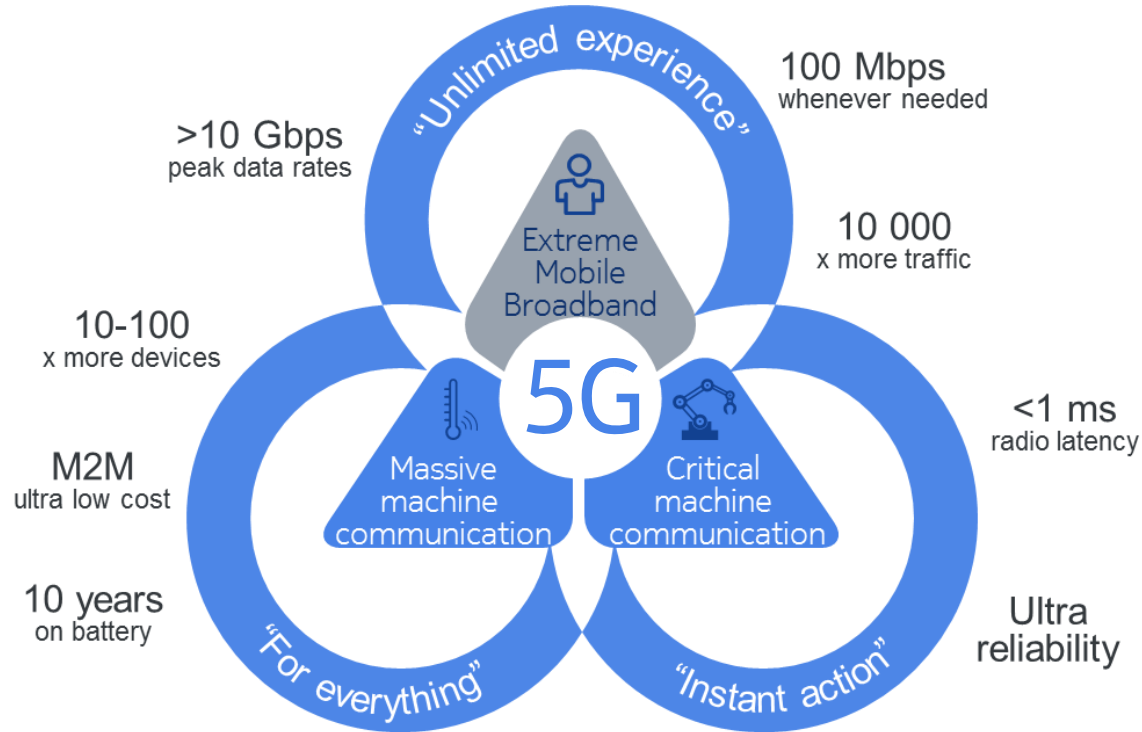
WTA 2017 – Hilton Head, SC

David Fritz – Sr. Consulting Engineer

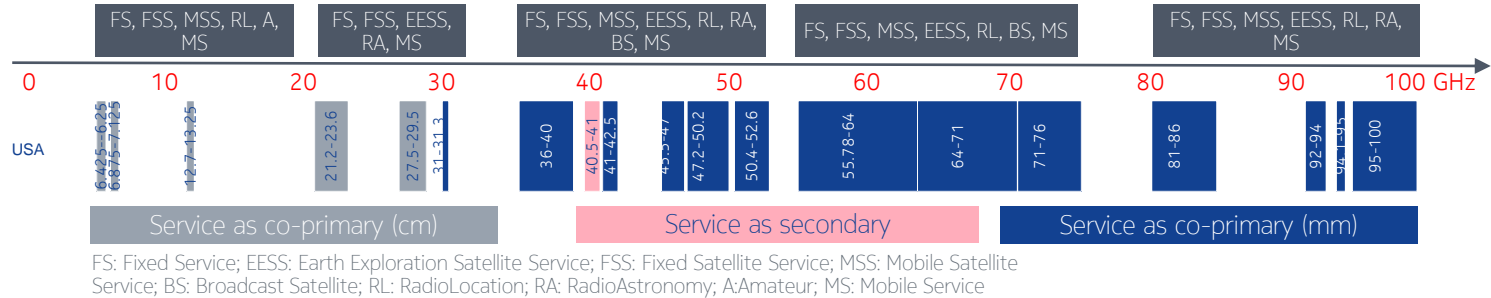
14 March 2017

What is 5G?

Nokia Corporate View



What Activities are Creating the 5G Buzz? - US Spectrum Summary



Below 6 GHz:

- 600 MHz (84MHz – Stage 4 Close)
- Current shared 3.5GHz (150MHz @ 3550-3700MHz)
- 2.5 GHz BRS/EBS (Sprint Push)

Future Targets:

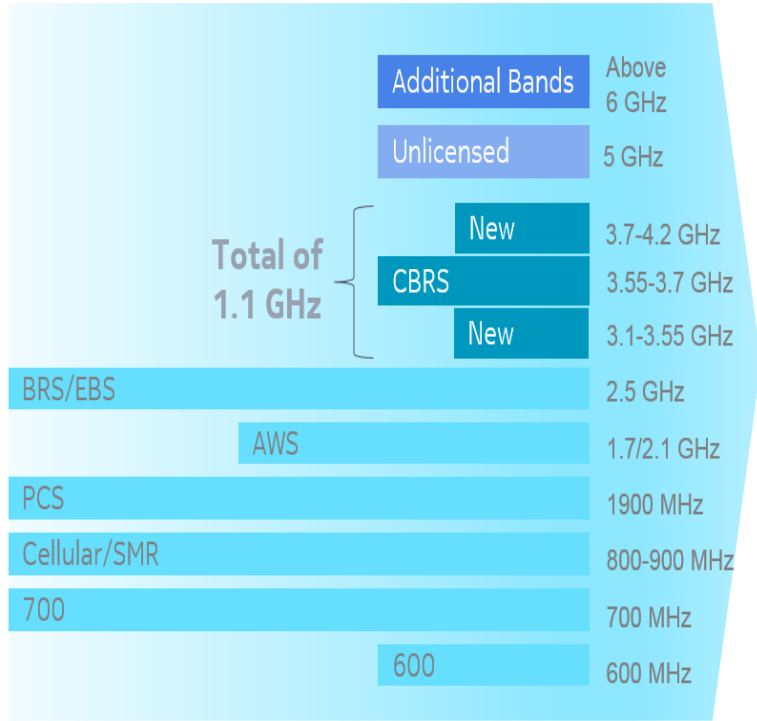
- Add 3700-4200MHz
 - 650MHz contiguous (3550-4200MHz). FSS incumbent.
- Consider also 3100-3550MHz
 - 1100MHz contiguous (3100-4200MHz). DoD incumbent.
- 1300-1390MHz (pair with spectrum above 1780MHz)
- ~~Additional 195MHz @ 5GHz~~
 - 5350-5470 MHz & 5850-5925 MHz, total 775MHz contiguous

FCC 5G mmWave Report & Order July 14

- 3.85 GHz of Licensed spectrum in the 28, 37 and 39 GHz bands
 - Flexible use spectrum, more than four times the amount of flexible use spectrum the FCC has licensed to date.
- 7 GHz of Unlicensed spectrum in the 64-71 GHz band
 - Doubles amount of high-band unlicensed spectrum to 14 GHz contiguous unlicensed spectrum (57-71 GHz)
- 600 MHz of Shared access spectrum in the 37-37.6 GHz band
 - Dynamic shared access between different commercial users, and commercial and federal users.
- Power Levels
 - Base Station Power: Adopt TX power limit of 75 dBm/100 MHz EIRP
 - Mobile Power: Adopt 43dBm EIRP transmit power
 - Transportable Power: Maximum power of 55dBm EIRP.

Is there 5G Spectrum for Rural Carriers?

Spectrum Tool Box



DoD Incumbent

• LMDS (28 GHz)

- Small Carriers Own Today
- Tier 1 Use Outside of Large cities?
- 28 GHz / 39 GHz Auction?

• Unlicensed 5.8 GHz

- Wifi Now
- LTE-U / LAA
- Multi-Fire

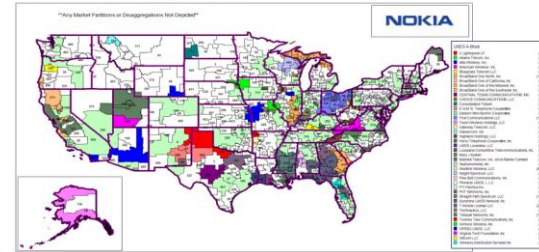
• CBRS 3.5 GHz

- Part 90, but Part 96 Transition
- LTE-U / LAA
- Multi-Fire
- 1.1 GHz Depth Future?

• 2.5 GHz

- Small Carriers Own Today
- Sprint Partnerships?

LMDS A-Block (FCC ULS 9/23/2016)



FCC/NextLink vs. All Markets:

License Name	Total BTAs Owned	A-Block	B-Block	Percent A	Percent B
FCC	597	296	301	60%	61%
NextLink Wireless, LLC	91	61	30	12%	6%

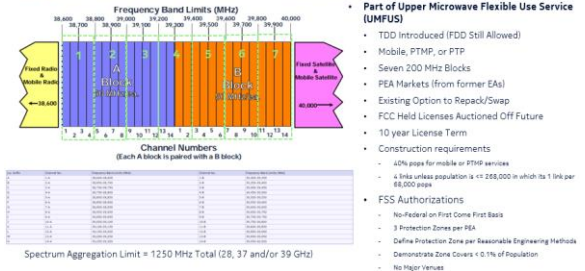
FCC/NextLink vs. Top 150 Markets:

License Name	Total BTAs Owned	A-Block	B-Block	Percent A	Percent B
NextLink Wireless, LLC	84	58	26	39%	17%
FCC	105	47	58	31%	39%

FCC/NextLink vs. Top 50 Markets:

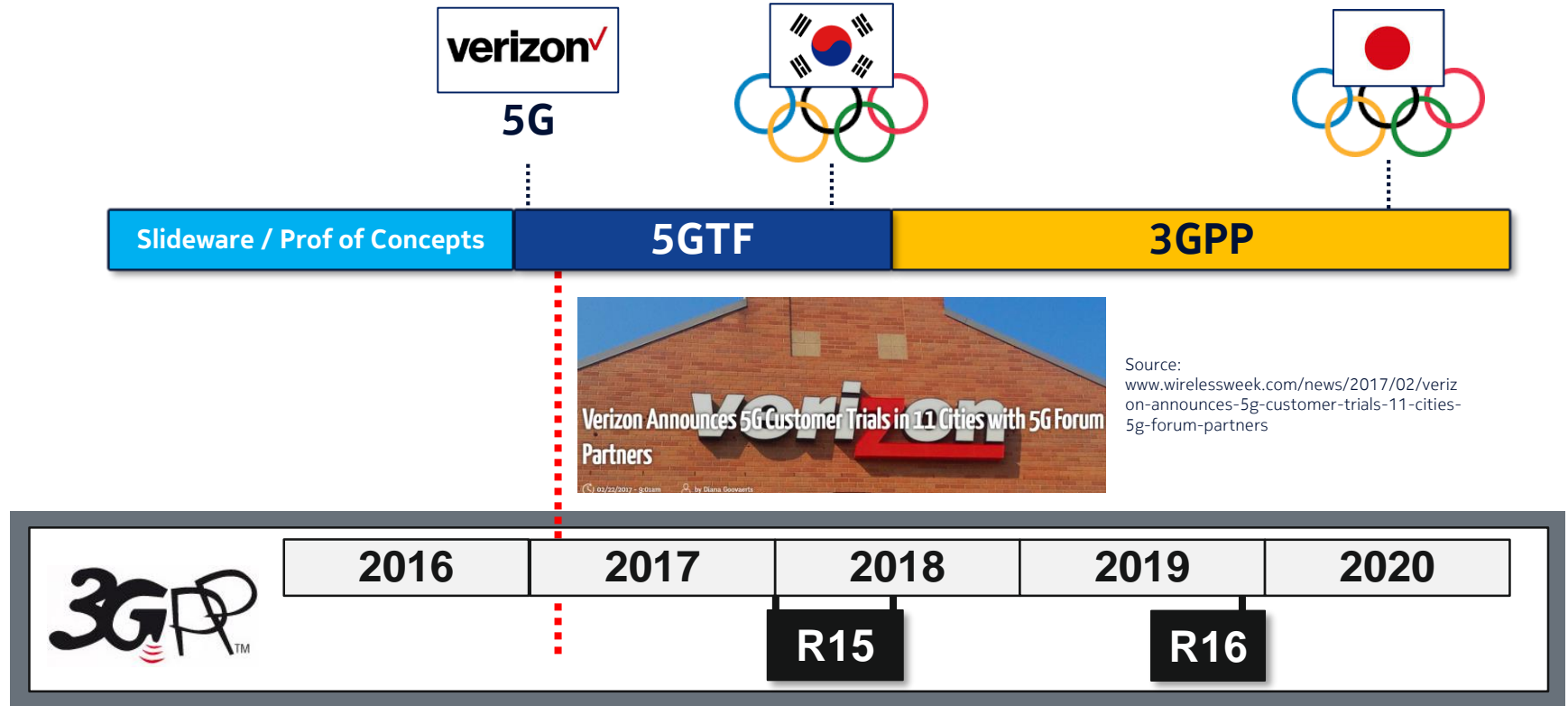
License Name	Total BTAs Owned	A-Block	B-Block	Percent A	Percent B
NextLink Wireless, LLC	56	36	20	72%	40%
FCC	13	13	0%	0%	26%

Legacy 39 GHz (Part 101) & New UMFUS (Part 30) Band Plans

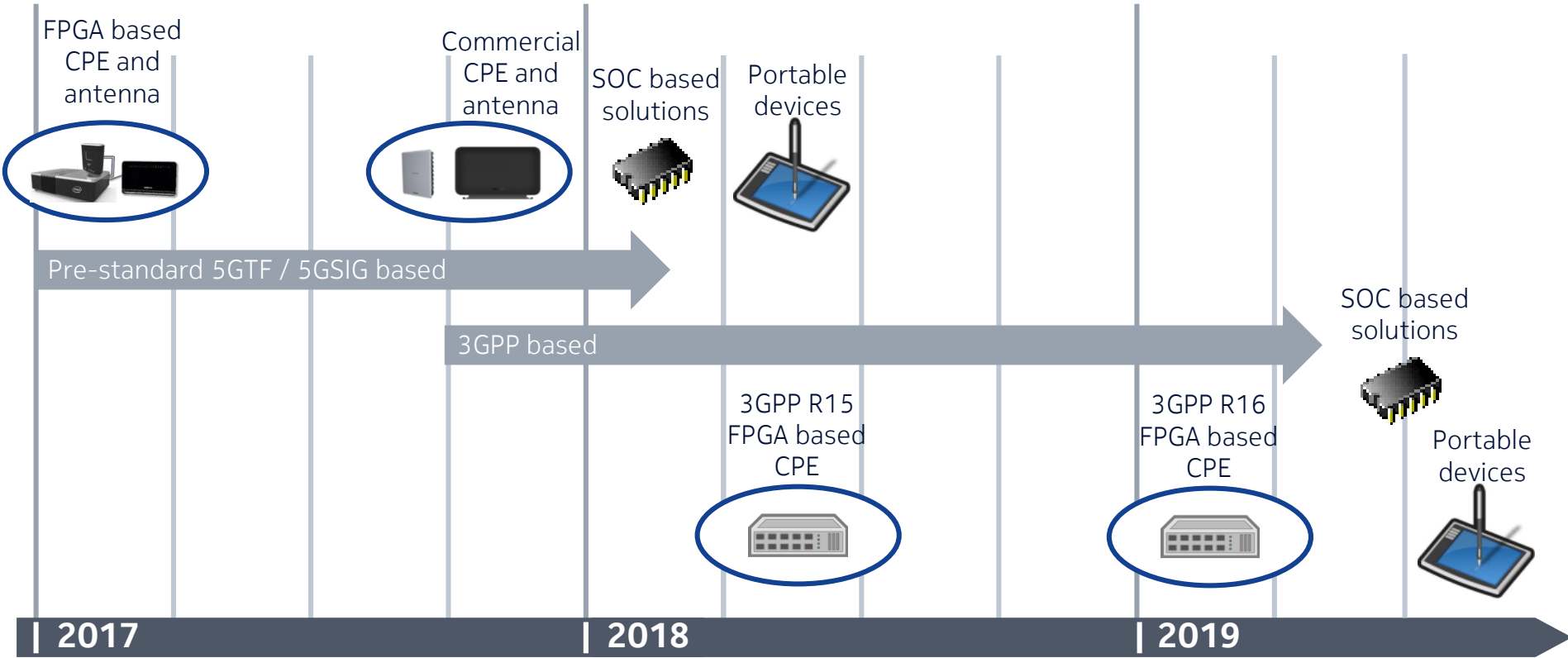


What are the Timelines and Mile Stones Driving the Standards?

Leading Mile Stones: Verizon, 2018 Winter Olympics, & 2020 Summer Olympics

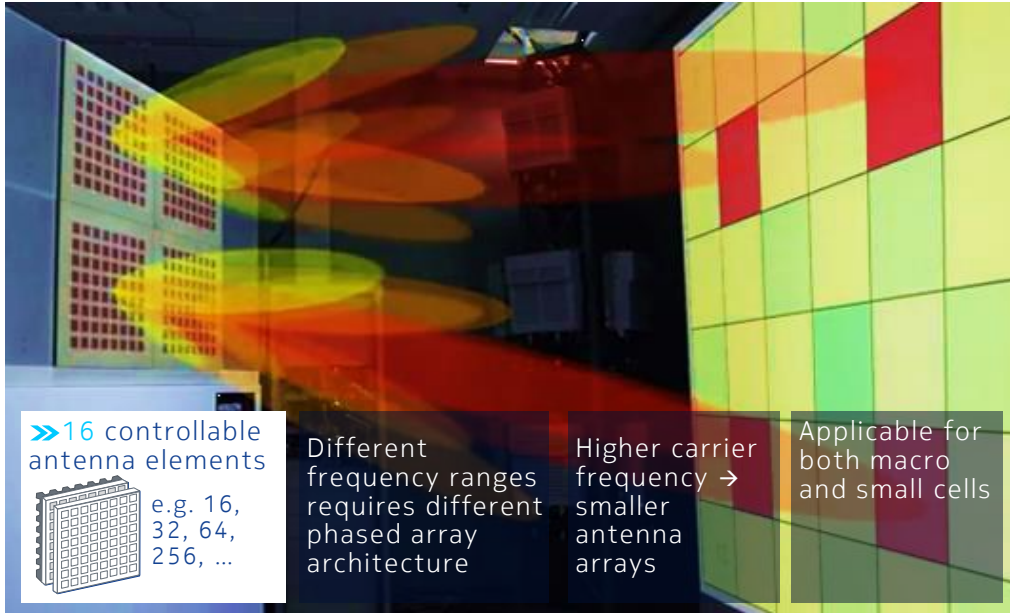


What is the Industry Timeline on 5G Chipset and Device Ecosystem?



What Does a 5G Ready Network Need to Evolve Into? - RAN

High Beamforming and/or Spatial Multiplexing Gain(s)



Two benefits

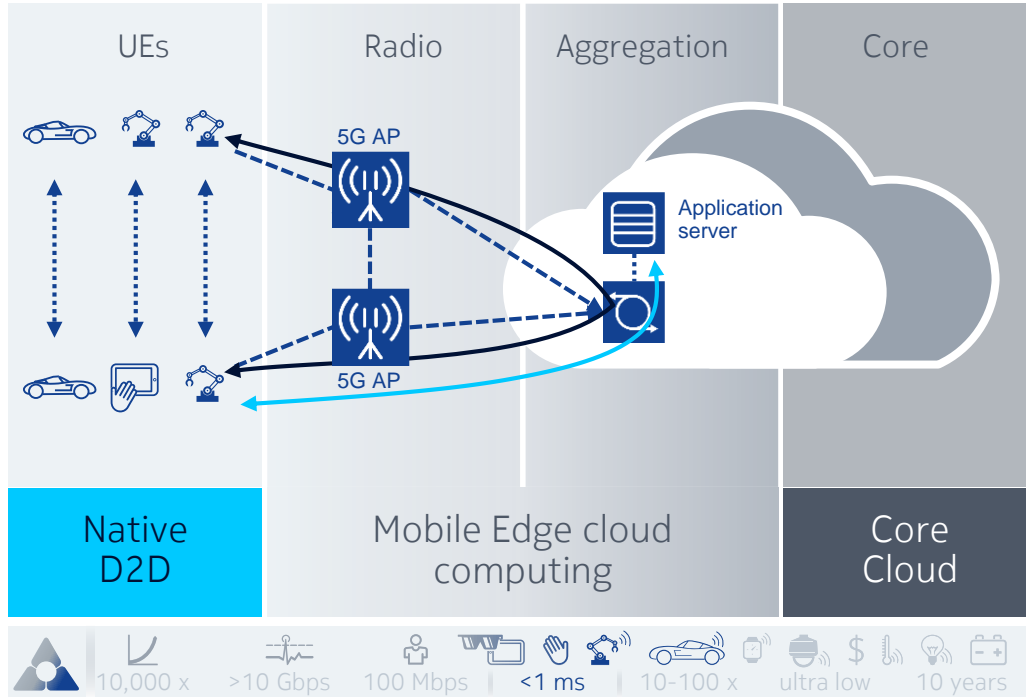
- SE improvement @ lower bands
- Compensating path loss with high antenna gain (using large number of antenna elements) @ high bands

Massive MIMO Gain: LTE @ 2 GHz

- **16 TXRU's, 2RX at UE**
 - ~ 200% gain in mean UE throughput
 - ~130% gain in cell edge over 8x2 (R12)
- **64 TXRU's, 2RX at UE**
 - ~ 60%-200% gain in mean UE throughput
 - ~ 90%-700% gain in cell edge over 16x2

What Does a 5G Ready Network Need to Evolve Into? - E2E

Low Latency / Computing on the Edge



Moving virtual networks

Mission-critical services, e.g. in V2X or industrial applications

Central cloud based	> 50 ms latency
Mobile Edge LTE	≈ 10 ms
5G Edge	≈ 2,5 ms
5G D2D	≈ 1 ms

Latency – 5G vs. Legacy

DL delay component	5G	LTE-A
eNB Processing	0.250	1.0
Frame Alignment	0.125	0.6-1.7
TTI duration	0.250	1.0
UE Processing	0.375	1.5
HARQ Re-transmission (10 % x HARQ RTT)	0.100	0.98-1.24
Total Delay	1 ms	5.2-6.2 ms

*Note 1: 5G now going to 200us TTI

What are Potential Rural Use Cases?

“Fritz Crystal Ball”

Use Case : 5GTTH

The Last “100” Feet



Network

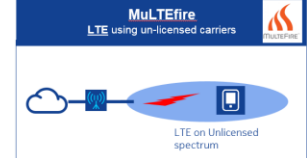
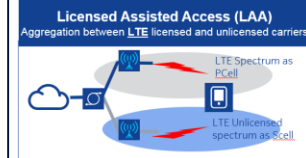
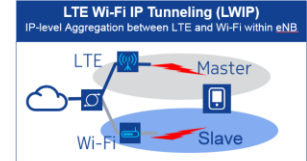
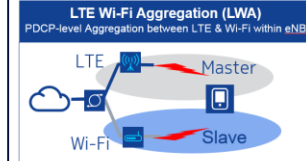
Use Case: High Density Venues

UHD 360° Video



5G
BTS

Use Case: Unlicensed Carrier Aggregation



Use Case: Location Gigabit Hotspot (Home / Enterprise)



What is 5G for Rural Carriers 2017/18?

Keep your Eye On Tier 1 Success and Failures!

Mobile World Congress 2017: 5 Major 5G Announcements (March 3, 2017)

“5G was one of the stars of the show at this year's Mobile World Congress (MWC) in Barcelona, even though the standard technically doesn't exist yet.”

Sprint strikes gooooooaaaaaaalllllll with 5G demo in Santa Clara (June 6, 2016)

“4K video . . . 73 GHz . . . Beamforming and low latency applications . . . VR headsets . . . Thanks to prototype provider Nokia”

AT&T: 5G mostly about fixed wireless for next two to three years (June 2, 2016)

“5G millimeter wave trial . . . start with 15 GHz in the summer . . . then go to 28 GHz at the end of the year”

AT&T's 5G trials could deliver speeds around 5 Gbps this year (May 25, 2016)

“5G trial with friendly customers by end of year . . . Trials in Austin”

Nokia wants to demonstrate 5G prototype gear at CSpire in July (May 9, 2016)

“helping the industry to adopt rules the rules on 5G deployment . . . Bands above 24 GHz”

Verizon's Shammo: 5G pilot in 2017 is all about fixed wireless (April 21, 2016)

“helping the industry to adopt rules the rules on 5G deployment . . . Bands above 24 GHz”



Nokia EVP Ricky Corker stands next to the Nokia base station that was used in Sprint's 5G demo

<http://www.fiercewireless.com/tech/story/nokia-5g-demo-copa-soccer-game-just-beginning/2016-06-05>



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