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2017 Fall Technical Forum
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READY OR NOT, 5G IS COMING: UNDERSTANDING THE BACKHAUL REQUIREMENTS FOR 5G

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The Intersection of HFC and 5G

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Agenda

2-way Engagement!

- Key Concepts in the 5G Physical Layer
- Mobility Evolution
- 5G Bandwidth Density Expectations
- Cellular Densification
- The PAC Conundrum (Power, Attachment, Connectivity)
- HFC Radio Overlay Possibilities
- Conclusion

Let’s get Physical….(Layer) in the Wireless Mobility Platform

Foundational Concepts to be focused on:

- Frequencies
  - Spectrum
    - Geographic Coverage

5G today is like Bigfoot:

Everyone is talking about it but no one has seen it!

5G – **What** is it?

5G – **Where** is it?

5G – **WHEN** is it?

5G – **How** will it be different for users and infrastructure?

5G – **Why** do we need it?

Let's go on a 5G Expedition!

Wireless Mobility Evolution

1G	2G	2.5G	3G	3.5G	3.75 G	4G	4.5G	5G
AMPS	GSM	GPRS	EDGE CDMA	EV-DO HSPDA	LTE Rel 8	LTE Rel 10	LTE Rel 13	3GPP
1981	1990	2000	2001	2006	2010	2010	2015	2020?

"Cells" appeared

TDMA
SMS

Data Connectivity

384 Kbps

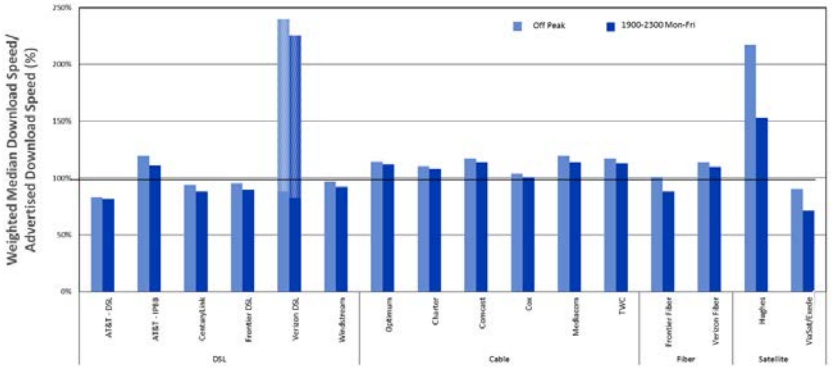
1 Mbps

10+ Mbps

Active Antennas
Beam Forming
Carrier Aggregation
Network Slicing
Cellular Densification

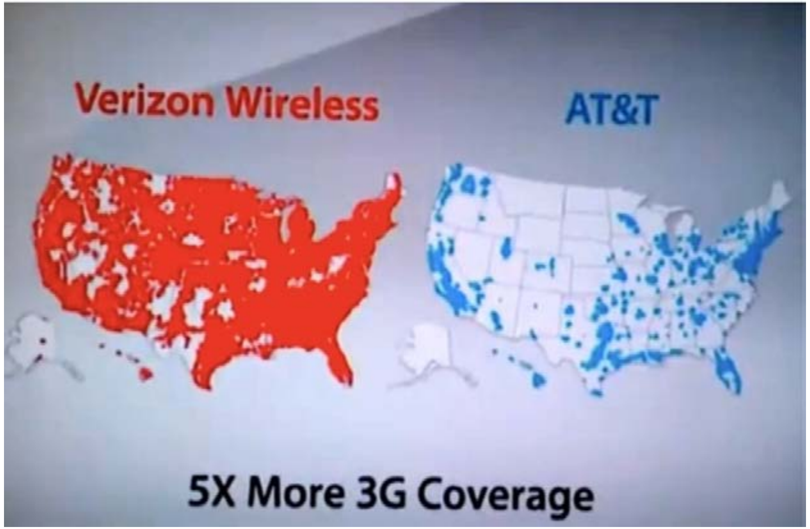
Mobility and Wireline Consumer Expectations

Wireline – Speed Focused



Graphic from FCC

Wireless – Coverage Focused



Graphic from Engadget.com

5G Capabilities

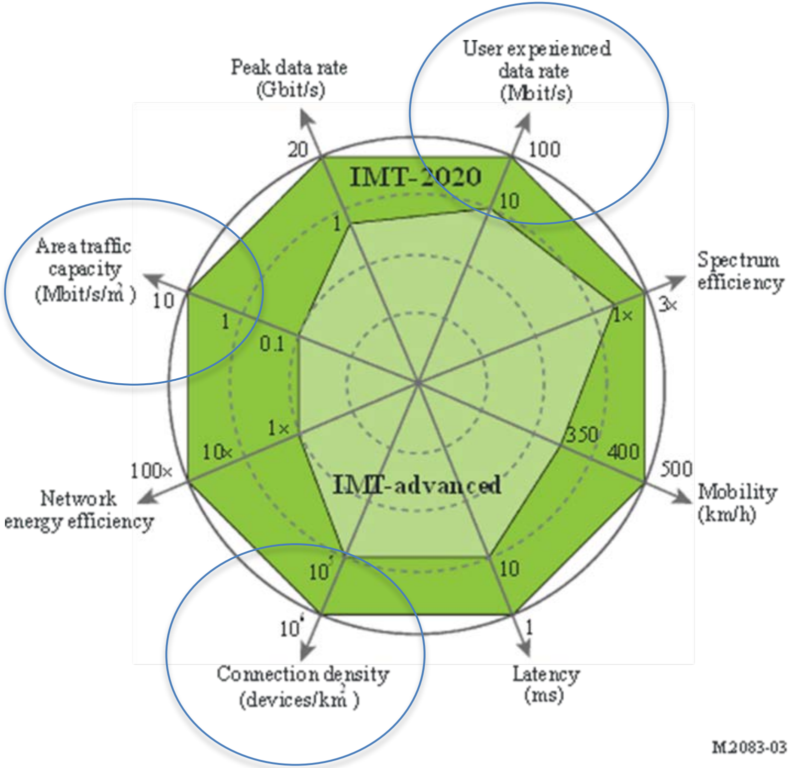
Connection Density

+

User experienced data rate

=

Area traffic capacity



Graphic from ITU-R

Where will the 10 Mbps per square meter come from?

Levers to Increase Bandwidth per Unit Area

- Obtain more spectrum
- Increase bits-per-hertz efficiency (modulation density)
- Enable re-use of spectrum through densification

5G will deploy all three, building on 4.5G capabilities such as Carrier Aggregation and Network Slicing

HFC and Cellular Bandwidth Augment Techniques

	HFC	Cellular
Spectrum	**220, 300, 400, 450, 550, 750, 860, 1000 MHz**	**Sub 1GHz, 1.6 – 2.1 , 2.3 -2.7, 3.5, 30, 39 GHz**
Efficiency	Analog, QPSK, 16 QAM, 64 QAM, 256 QAM	Analog, TDMA, CDMA, OFDMA, 16-256 QAM
Spectrum Re-Use	Narrowcast, Node de-combine, Node Split	Multi-sector cells, cell densification

Cellular Spectrum in the US

700 MHz:
- Block A: 698-704, 728-734 MHz (UHF Channels 52 and 57)
- Block B: 704-710, 734-740 MHz (UHF Channels 53 and 58)
- Block C: 746-757, 776-787 MHz (UHF Channels 60/61, 65/66)

Cellular: 824-849, 869-894 MHz

PCS:
- Block A: 1850-1865, 1930-1945 MHz
- Block B: 1870-1885, 1950-1965 MHz
- Block C: 1895-1910, 1975-1990 MHz
- Block D: 1865-1870, 1945-1950 MHz
- Block E: 1885-1890, 1965-1970 MHz
- Block F: 1890-1895, 1970-1975 MHz
- Block G: 1910-1915, 1990-1995 MHz

AWS: 1710-1755, 2110-2155 MHz

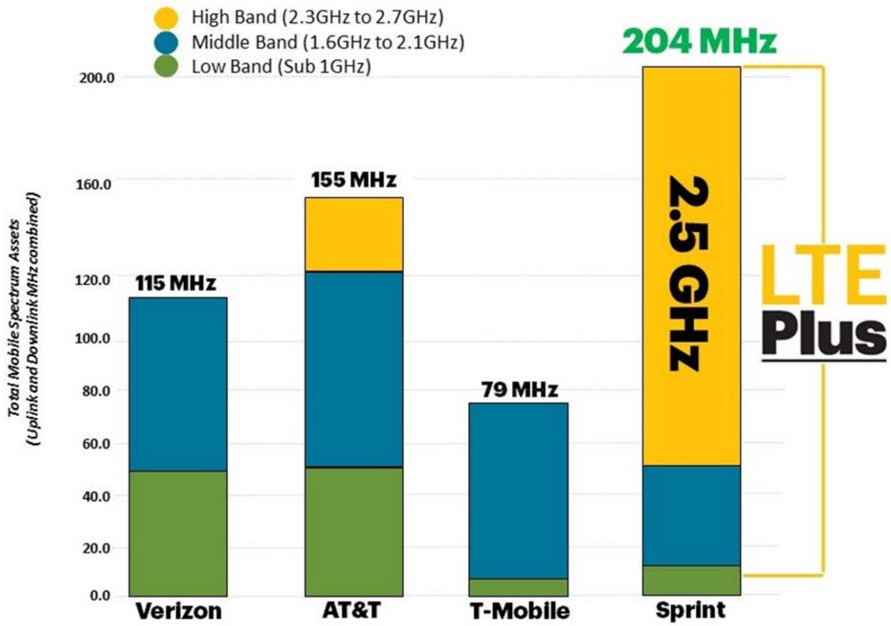
CBRS: 3550-3700 MHz

28 GHz: 27.5-28.35 GHz (850 MHz)

39 GHz: 38.6-40 GHz (1400 MHz)

Not in current use but proposed for 5G

Spectrum by US Carrier



Nationwide, population-weighted average spectrum assets as of 2/7/17. These numbers are national averages and do not represent the spectrum assets in any specific market.

Graphic from Sprint

cm/mm Wave Challenges and Opportunities

Calibration: 27.5-28.35 GHz = wavelengths of 1.09-1.057 **cm** (109-105.7 mm)
38.6-40.00 GHz = wavelengths of 77.7-74.9 mm

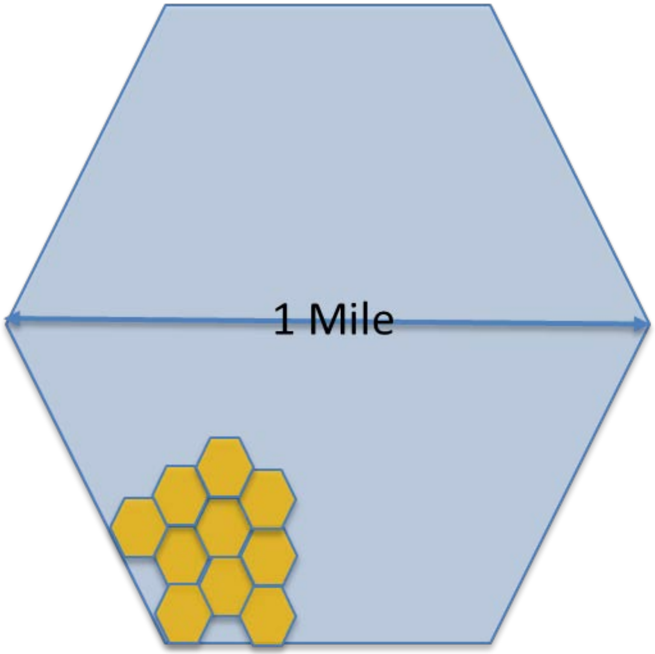
Opportunities	Challenges
LOTS of spectrum	Atmospheric Signal propagation poor
Small radius improves energy efficiency	Signals attenuated by walls (30dB), trees (7dB per..), ER glass (30dB)
Beam forming / MIMO	Multiple antennas and radios in handsets
Reflections can be used	Reflections from metal (cars, appliances)

- Power
  - Attachment
    - Connectivity

- Today - ~300,000 Macro cell sites in US

- 5G – 5,000,000 or more small/micro/pico/femto cells needed

- What does the US cable industry have that approximates a macro cell area?
  - HFC nodes (think outdoor Wi-Fi)



500 ft diameter versus
Macro 1 mile diameter

RAN Overlay in HFC Node Scenario

Power – 20 Watts per radio (for example) supplied by coax network (most nodes have spare power – limited by amp cascade)

Additional power supplies could be added if required

Attachment – to strand similar to Wi-Fi access point

Connectivity – embedded DOCSIS 3.0 or 3.1 modem

Example Deployment:

20 RAN locations
Peak RAN bandwidth 100 Mbps
20 Watts per radio @75 Volts
5.3 Amperes additional power
Modems provisioned at 100 Mbps (similar to residential)

- Macro site still exists
- RAN sites located where there is heavy bandwidth demand (e.g. bus stop) or poor signal from the Macro
- Data load would be incidental – most bits already travel through DOCSIS from home Wi-FI
- Other traffic short-duration as mobile device traverses 500 foot diameter – child in back seat streaming, jogger listening to Pandora
- DOCSIS Service Group adds the equivalent of 20 customers on top of the 200+ already in node

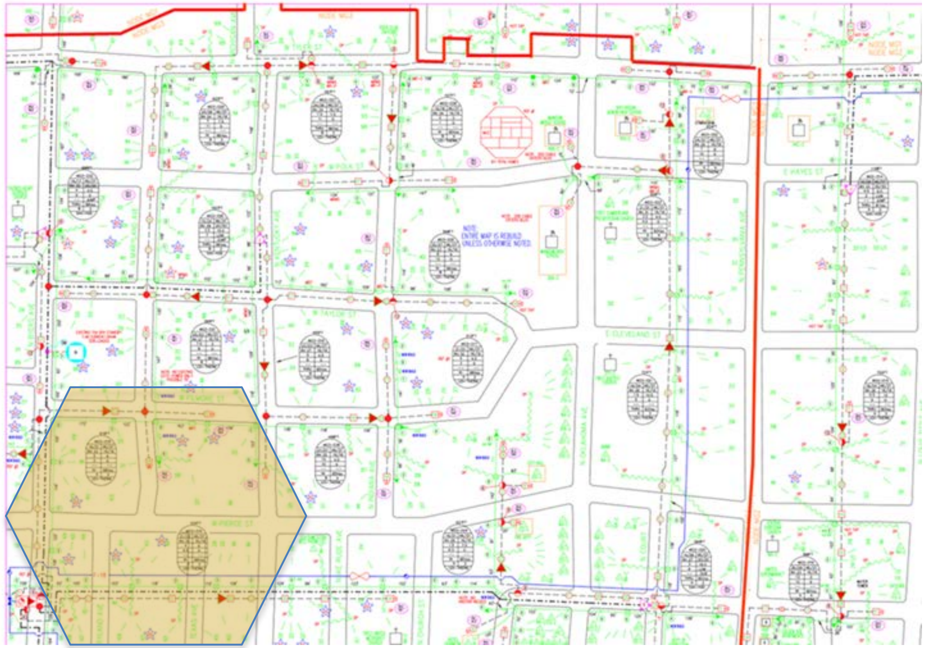
Key concept – 5G bandwidth will be different in different areas and applications – not every radio needs gigabits of bandwidth

HFC / Mini-Macro Overlay

Power – 100 Watts per radio (for example – 1500 ft radius) supplied by coax

Additional power supplies could be added if required

Attachment – to strand similar to Wi-Fi access point



Connectivity – LTE Gbps+ optical circuit from node or DOCSIS 3.1 RPD

If node not near desired location short fiber extension could be constructed

We have Bigfoot in our sight!

- 5G - **What** is it? – an exciting new set of standards for wireless communications, both mobile and fixed, that will dramatically increase connectivity speeds, support much denser end-device connections, reduce latency, and employ new licensed and unlicensed frequencies
- 5G- **Where** is it? – Nowhere, but just wait…
- 5G - **WHEN** is it? – 2020 - with some field trials before and mass scale by 2022
- 5G - **How** will it be different for users and the supporting infrastructure? – Higher connectivity speeds, lower power requirements, better support for machine-to-machine traffic, much denser cellular radio network
- 5G - **Why** do we need it? – to solve the insatiable demand for higher bandwidth for smartphones, overcome cellular spectrum challenges, enable exciting capabilities such as autonomous vehicles, and support the explosion of Internet-of-Things connected equipment
- **5G** – the Cable Industry opportunity lies in solving the **P**ower, **A**ttachment, and **C**onnectivity Conundrum for the Wireless Industry

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THANK YOU!

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