5G ➜ Road to Realization
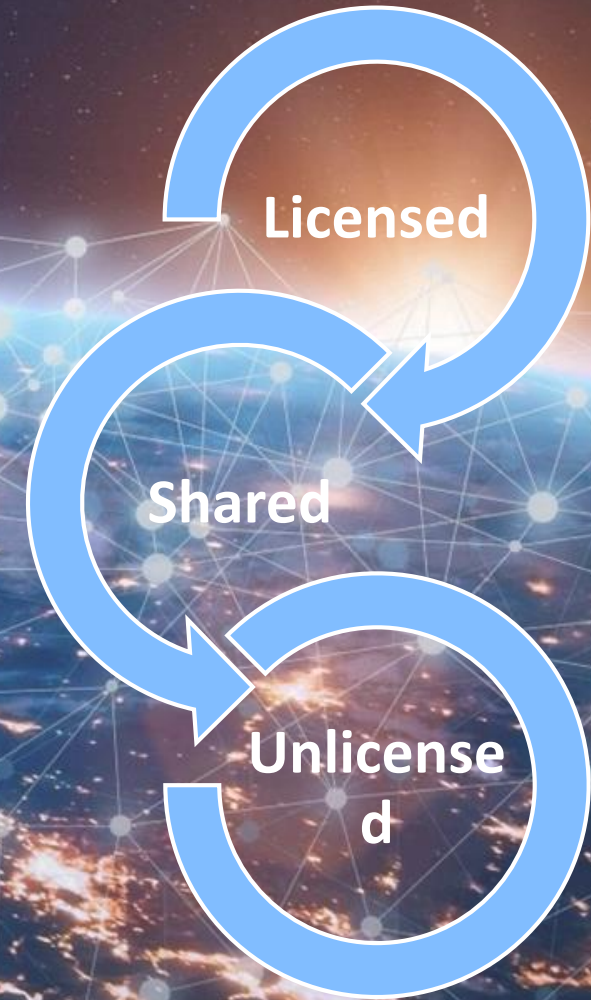
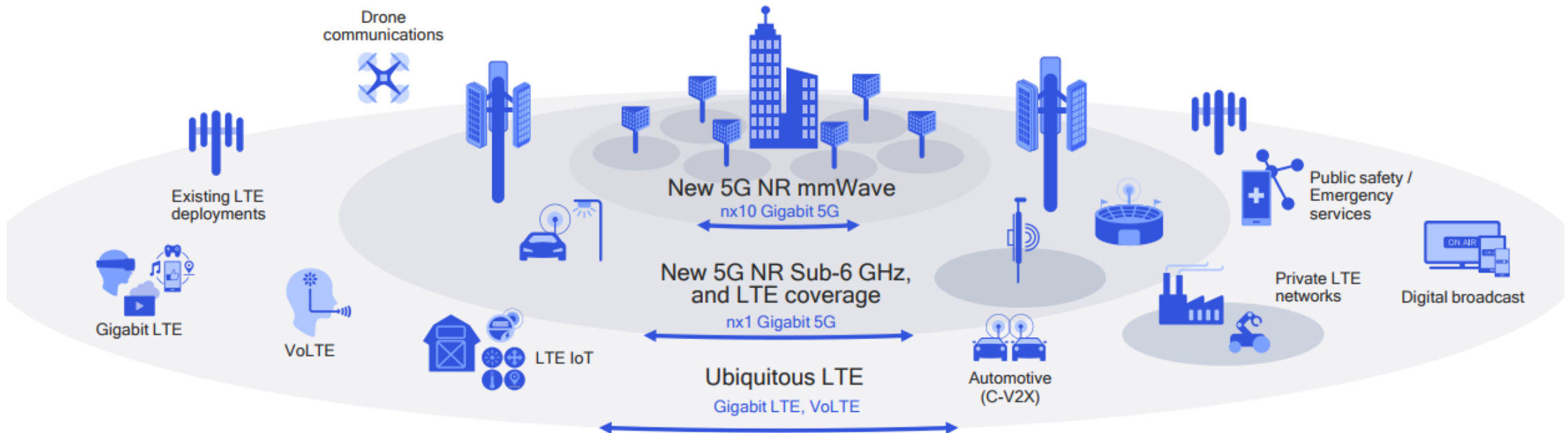## It is going to change the world….. Or is it?

5G Spectrum Segments

	Ultra High Capacity	High Capacity	Macro Footprint	Small cell Footprint	Fixed Wireless Access	Mobile Access
mmWave	●			●	●	
Mid-Band		●	●	●		●
Low-Band		●	●			●

Drone communications

New 5G NR mmWave
nx10 Gigabit 5G

Existing LTE deployments

Gigabit LTE

VoLTE

LTE IoT

New 5G NR Sub-6 GHz, and LTE coverage
nx1 Gigabit 5G

Ubiquitous LTE
Gigabit LTE, VoLTE

Automotive (C-V2X)

Public safety / Emergency services

Private LTE networks
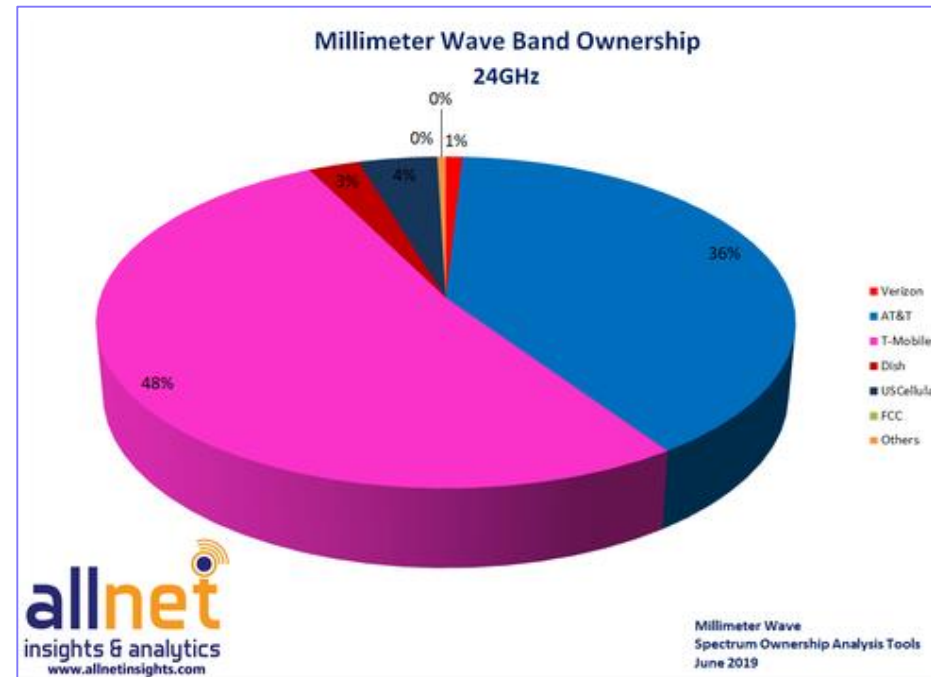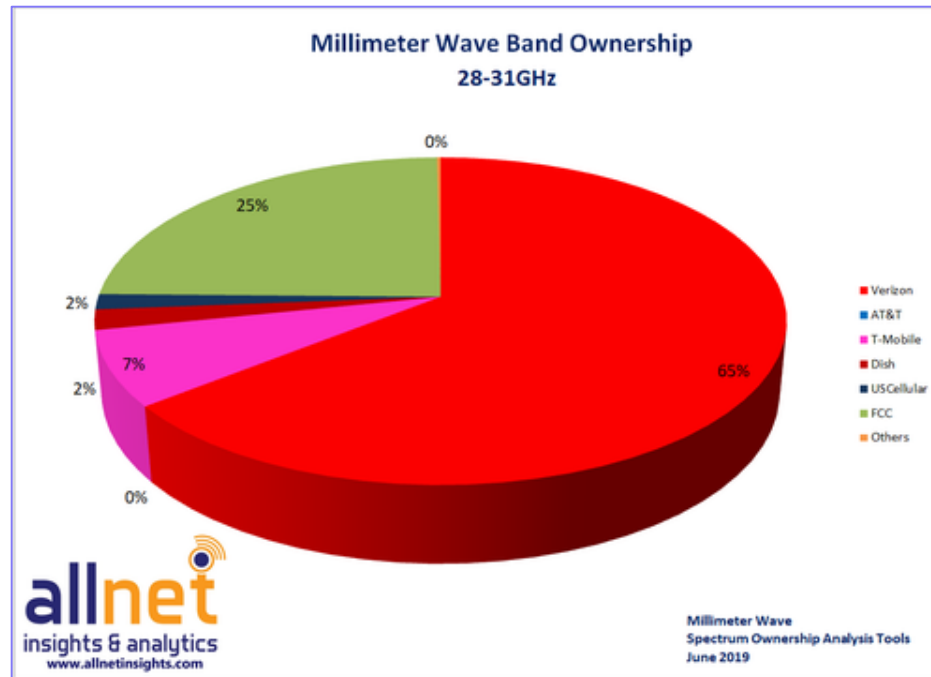
Digital broadcast

ON AIR

Source: Qualcomm Accelerating the mobile ecosystem expansion in the 5G Era with LTE Advanced Pro

5G Spectrum – Who owns what?

Bands	N41 2.5 GHz	N260 39 GHz	N261 28 GHz (US)
Verizon Wireless			TDD
AT&T		TDD	
Sprint	TDD		
T-Mobile			TDD

- Verizon owns most of 28GHz
- T-Mobile and AT&T won additional 24GHz spectrum in recent auctions
- Sprint owns in most of the market over 150MHz of Band-41 (2.5GHz)

Millimeter Wave Band Ownership
28-31GHz

- 0%
- 25%
- 2%
- 7%
- 2%
- 0%
- 65%

Verizon
AT&T
T-Mobile
Dish
USCellular
FCC
Others

allnet insights & analytics
www.allnetinsights.com

Millimeter Wave
Spectrum Ownership Analysis Tools
June 2019

Millimeter Wave Band Ownership
24GHz

- 0%
- 0% 1%
- 3%
- 4%
- 36%
- 48%

Verizon
AT&T
T-Mobile
Dish
USCellular
FCC
Others

allnet insights & analytics
www.allnetinsights.com

Millimeter Wave
Spectrum Ownership Analysis Tools
June 2019

https://www.phonearena.com/news/5G-bands-explained-Verizon-vs-AT-T-vs-Sprint-vs-T-Mobile-vs-World_id116781

5G – Latest Market Launches

Sprint's First 5G Markets

Atlanta · Kansas City · Chicago · Los Angeles · Dallas · New York City · Houston · Phoenix · Washington, D.C.

Current Markets — **5G** Ultra Wideband

- Atlanta
- Chicago
- Denver
- Detroit
- Indianapolis
- Minneapolis
- Providence
- St. Paul
- Washington, D.C.
- Phoenix

2019 Plan

- Boston
- Charlotte
- Cincinnati
- Cleveland
- Columbus
- Dallas
- Des Moines
- Houston
- Indianapolis
- Kansas City
- Little Rock
- Memphis
- San Diego
- Salt Lake City

AT&T

- Atlanta
- Austin
- Charlotte
- Dallas
- Houston
- Indianapolis
- Jacksonville
- Las Vegas
- Los Angeles
- Louisville
- Nashville
- New Orleans
- New York City
- Oklahoma City
- Orlando
- Raleigh
- San Antonio
- San Diego
- San Francisco
- San Jose
- Waco

T··Mobile·

- Atlanta
- Cleveland
- Dallas
- Las Vegas
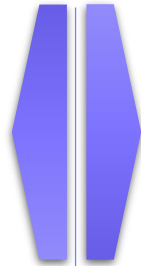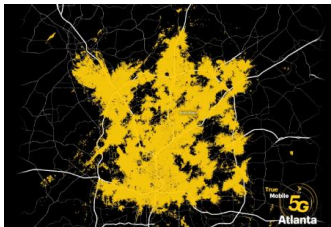- Los Angeles
- New York

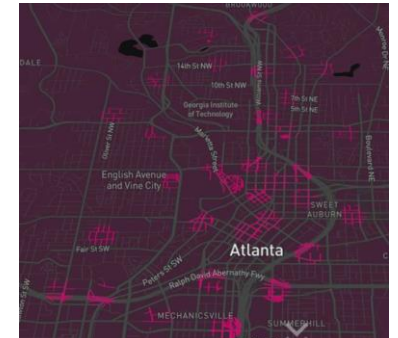**Average Speeds**

100Mbps +

300Mbps – 600Mbps

350Mbps +

600Mbps – 1Gbps

Coverage

Macro Type Covering Entire city

Limited Pop-Corn Hot-Spots

4

5G Market Segments

mmWave

Sub 6GHz

5G Fixed Wireless Access

Fiber- Backhaul

5G Site
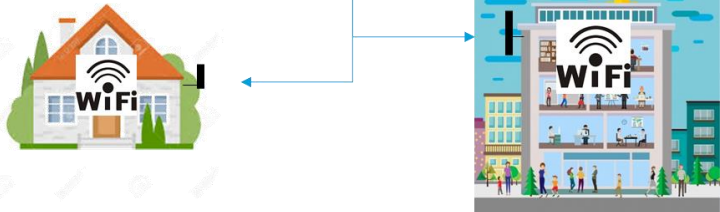
Ultra High Capacity

Short Range

5G Receiver

WiFi

WiFi

verizon✓

AT&T

T··Mobile·

5G Mobile Access

High Capacity

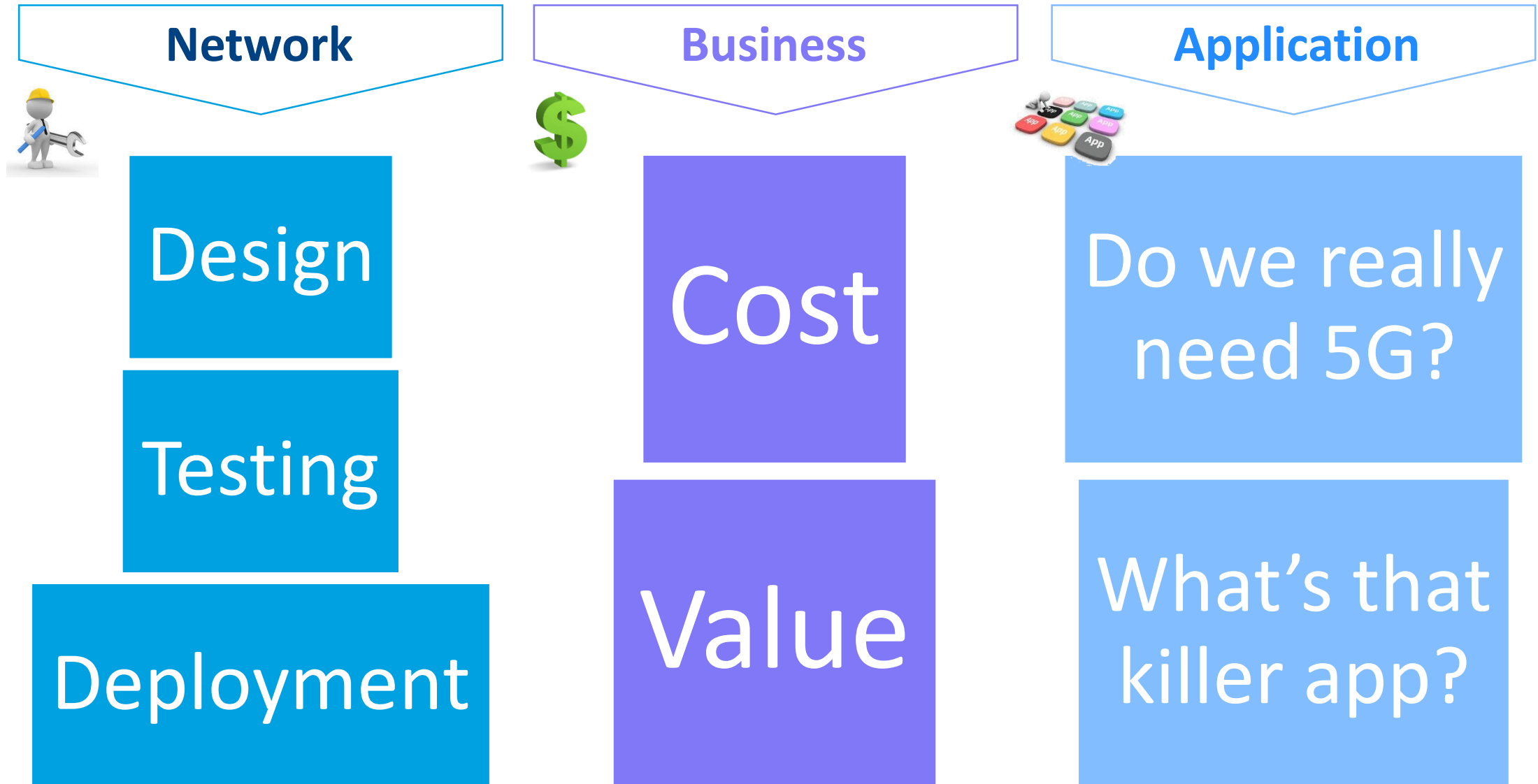4G Footprint

Sprint

Like todays LTE networks

Massive + Critical Machine Type Communications

Massive machine market is expected to start in 2022+

- Broader footprint of 5G and it will take time to get there
- Current IoT market space getting there slowly where 5G efficiency & performance will be needed like V2X, UHD content, AR/VR and Machine critical communications

5G Realization - Challenges

Network

Design

Testing

Deployment

Business

Cost

Value

Application

Do we really need 5G?

What's that killer app?

Applications

Current Video

- Typical video applications need around 3Mbps – 5Mbps for HD playback on cellular devices. This number is 15Mbps – 25Mbps for UHD videos.

VR/AR

- VR and AR are the new way we will consume video in the coming future. The content is out there and is limited, so is the access to these devices.
- Typical VR experience with retinal 360 video will need around 600Mbps.

  AR on the other will need much higher bandwidths for retina experience can reach out Gigabit speed requirements.

  Low resolution AR needs around 25Mbps

New Connectivity

- IoT although already there will expand in the future along with V2X and Machine to Machine type communication.

Per GSMA 75% of consumption will be video by 2020

$180 Billion industry By 2021

5G

25 Billion Connected Devices By 2020

5G

5G Realization Challenges - Network

Design

❑ From network design perspective the biggest challenge is the propagation characteristics for mmWave.
❑ Current design tools have been re-engineered and enhanced to accommodate and use ray tracing models but there are so many variables which can impact the quality of designed network.

Testing

❑ Another biggest challenge is the ability to test these networks due to ultra high speeds which need to be pushed through.
❑ There needs to be ways to test these networks without stressing backhaul, some at site data emulators which can generate massive demands for the test devices.
❑ Switch of mindset from network towards consumer behavior-based testing.

Deployment

❑ There are two aspect here for 5G deployment Sub-6GHz and mmWave
❑ Sub-6GHz due to propagation characteristics will have least challenge from deployment perspective.
❑ You can use same macro sites, need lesser small cells. A perfect example in US is Sprint.

❑ mmWave has short range and pretty much line of sight and if you have designed your network well you can leverage diffraction and reflection to get it beyond LOS but still very limited
❑ In order to provide good footprint you will have to deploy around 10X small cells and macro may not be of any value unless targeting MDU which is FWA play.
❑ Deploying these tens of thousands of small cells is logistically challenging.

1.9GHz   28GHz   39GHz   60GHz

Reflection · Transmitter · Receiver
Diffraction
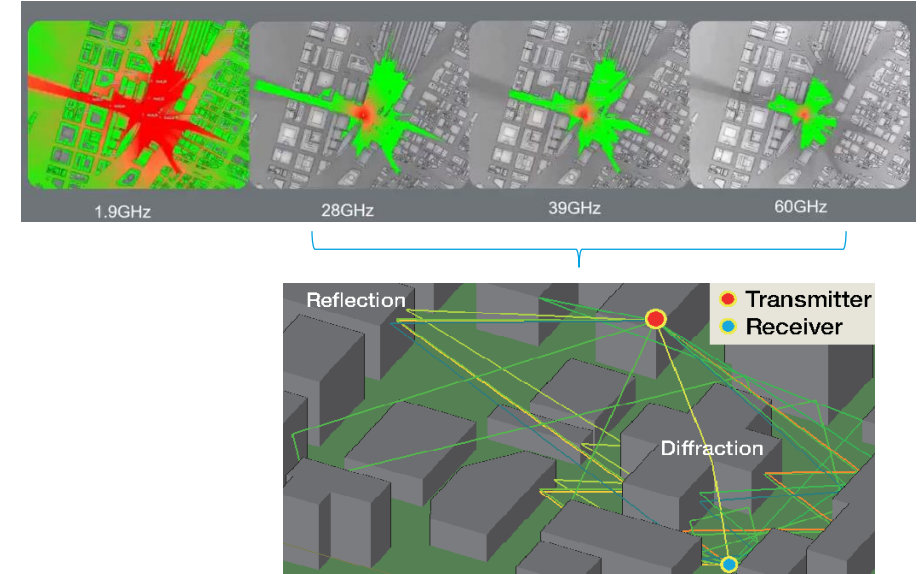
FC Federal Communications Commission   **VS**   **States**

STREAMLINE small cell deployment act

- Permits must be approved or denied on publicly available criteria that are reasonable, objective, and non-discriminatory.
- Small cell applications may be denied or regulated for objective and reasonable structural engineering standards, safety requirements or aesthetic or concealment requirements.
- Applications must be acted on no later than 60 days for requests to collocate equipment and 90 days for other requests.
- Flexibility and additional time is allowed for small municipalities (fewer than 50,000 residents).
- Empowers the FCC to grant flexibility by issuing a one-time 30-day waiver of the timeframes required for action upon a request by a state or local government.
- Fees must be publicly disclosed, competitively neutral, technology neutral, nondiscriminatory and based on actual and direct costs.

5G Realization Challenges

Business　　　　　　　　　　　　　**Application**

mmWave

Ultra High Capacity		Home or Business		Concern
• Where do we need it?	→	• Typical usage is on WiFi → 5G Fixed Wireless can enable this faster	→	• Most of the high demand areas are already connected

Per a recent study done on one of Tier-1 network provider it will cost 2X on average to connect a home using 5G mmWave.
- *Does this mean the real play for mmWave is high demand venues only ?*
- *For T-Mobile it makes sense as it can enable them to provide other service which Verizon and AT&T already have.*

Sub-6GHz

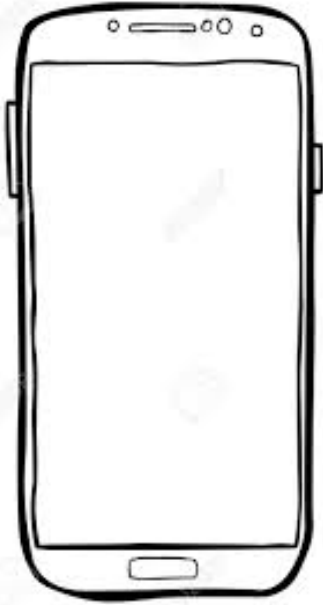| High Capacity		Everywhere		Concern
• Solves immediate capacity needs	→	• Provides relieve to current 4G network, device penetration will take time though.	→	• May not enough capacity to millions and millions of IoT and machine type communication

Killer App – For Me

The next evolution of communication where we don't need to hold a phone in our hands.

We wear it