5G mmWave Radiation Learning Session 3 — Field Experience with Safe & Sound mmWave RF Meter

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Introduction

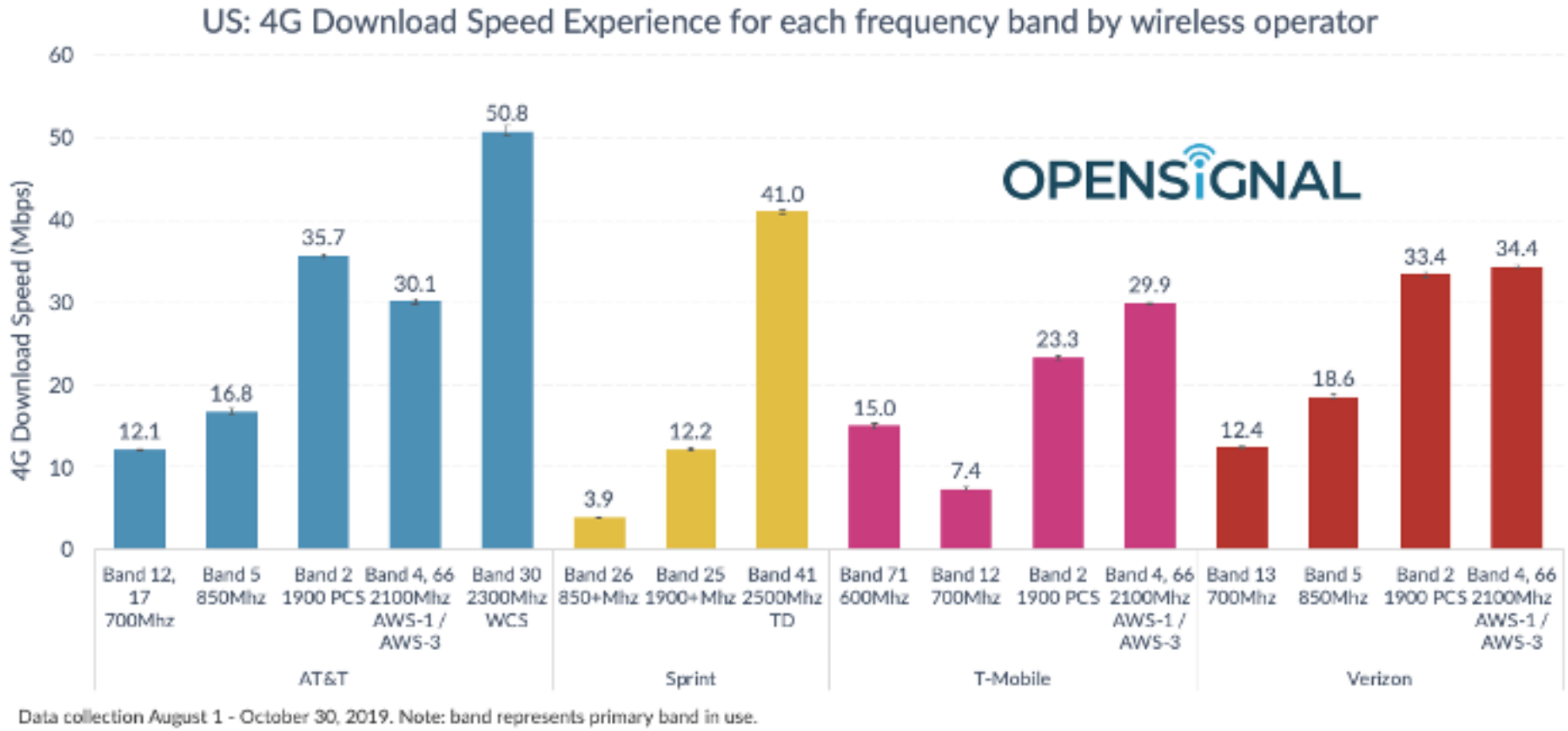
- Today's presentation contains a synopsis of my findings so far from field use since being a beta tester of the Safe & Sound mmWave 5G RF meter in Santa Monica and Los Angeles, California
- Most mmWave antennas found on busy boulevards
- Mostly Verizon 5G mmWave Antenna arrays
- Also noted 4G LTE and Verizon low band 5G antennas
- These findings are a snapshot in time in one location
- We look forward to input from colleagues in other locations

5G Coverage by U.S. Cell Carrier

- **Low band 5G** (600 MHz to 1 GHz) — *repurposed* 4G LTE:
- T-Mobile at 600 MHz for 200 million customers
- AT&T's "5GE" (5G Enhanced) at 850 MHz for majority of customers
- Verizon's "5G Nationwide" at 850 MHz for majority of customers
- **Mid band 5G NR** (1-6 GHz):
- T-Mobile at 2.5 GHz (inherited from Sprint with merger in April 2020)
- 3.4-3.5 GHz CBRS and 3.5-4.2 C-Band four carriers (Ver, AT&T, Dish, U.S. Cellular)
- Verizon's C-band service called "5G Ultra Wideband" (along with mmWave service)
- **High, mmWave band 5G NR** (28 & 39 GHz):
- Verizon's "5G Ultra Wideband" service — combined C-band and mmWave, >100 cities, 175 million people — began in Q1 2023, early full deployment Q2 2023
- T-Mobile's "5G Ultra Capacity" service — combined 2.5 GHz and mmWave
- AT&T "5G+" in 19 cities — mostly sports arenas, stadiums and airports

Characteristics of 5G Usage in U.S.

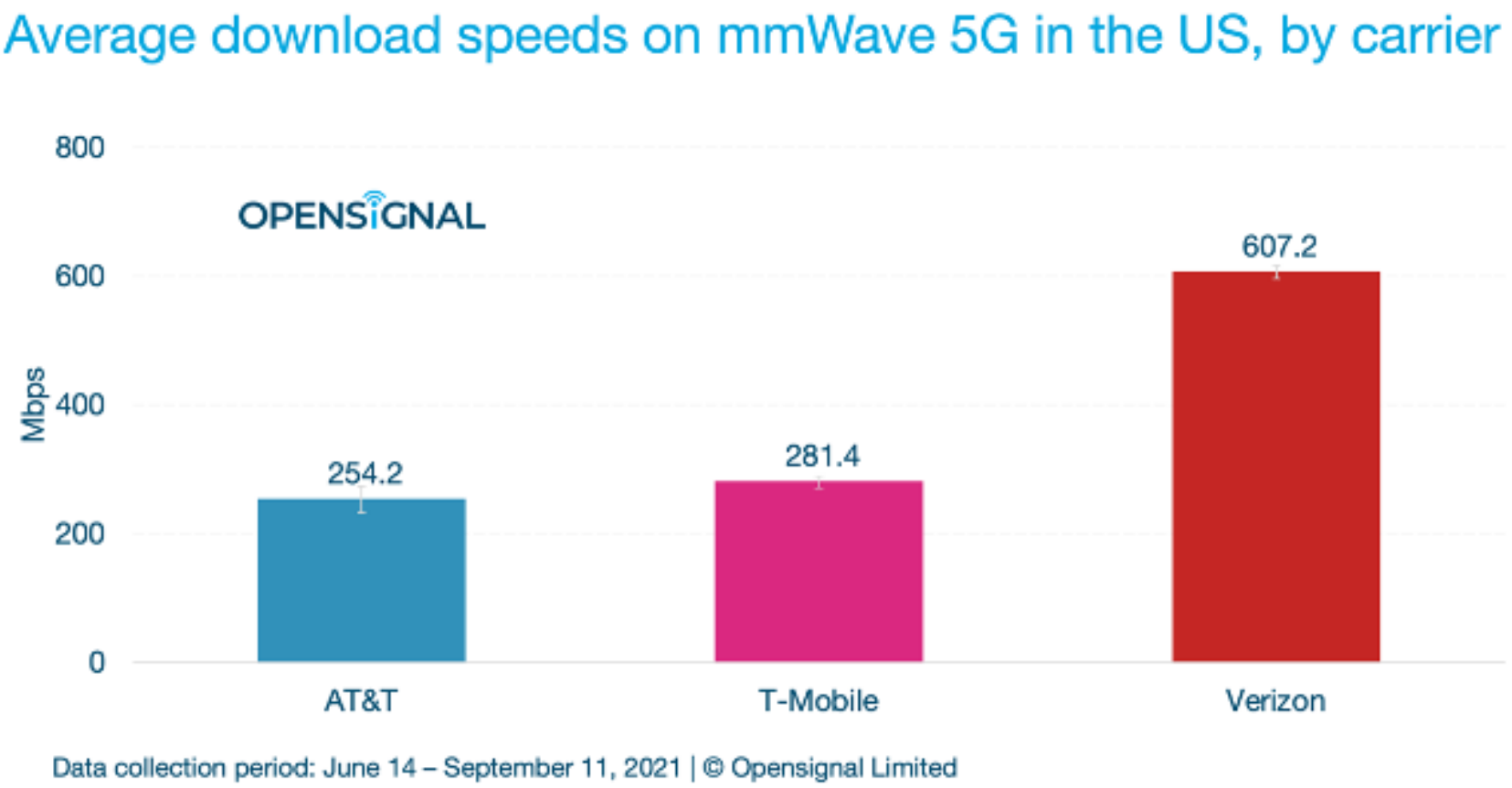
- Start with 4G LTE data download speeds
- Varies from roughly 12 to 50 Mbps
- T-Mobile merged with Sprint in April 2020



https://www.opensignal.com/2019/12/06/why-us-carriers-have-an-insatiable-appetite-for-new-spectrum

Characteristics of 5G Usage in U.S.

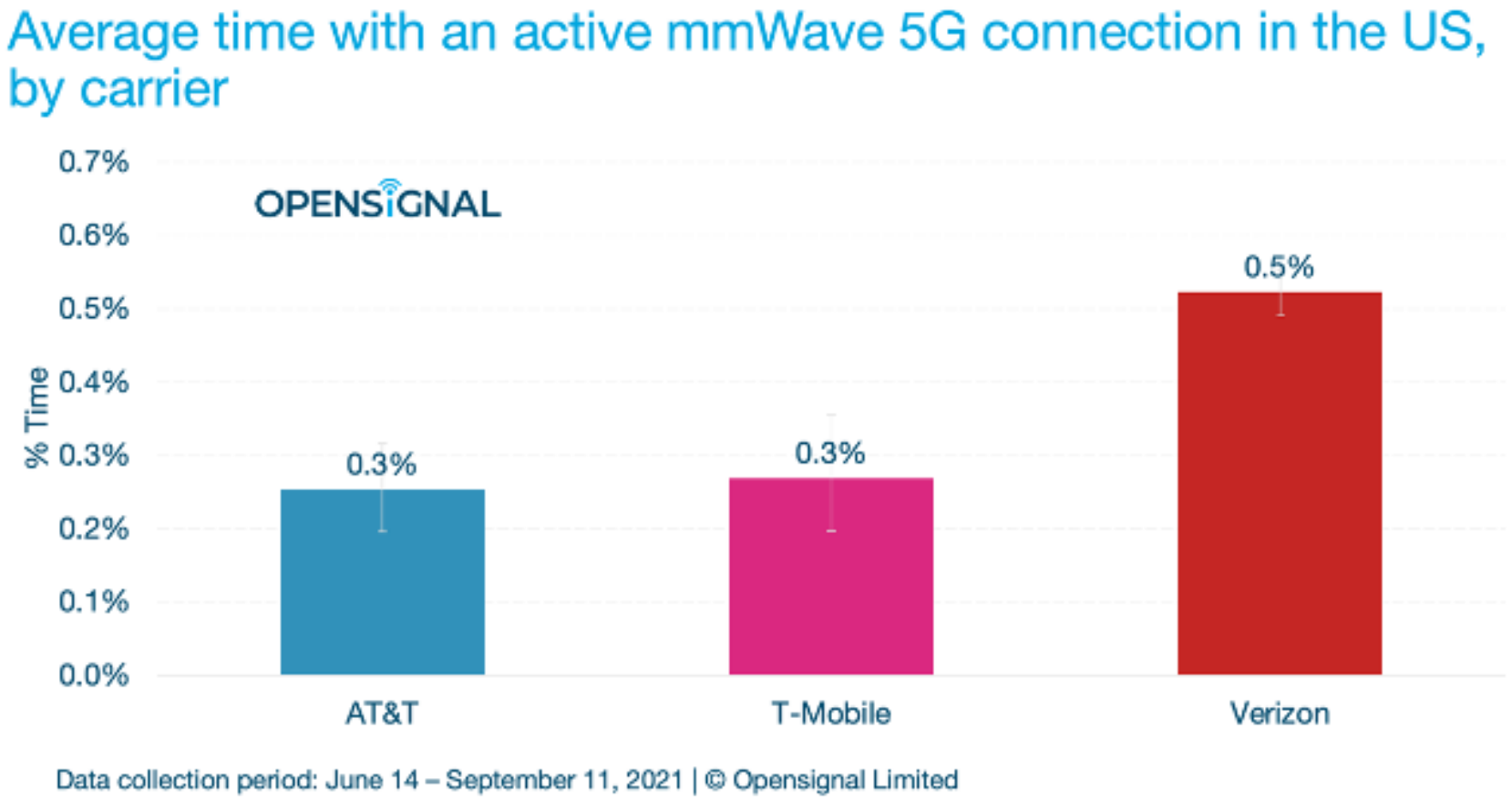
- mmWave download speeds 10-100 times faster than 4G LTE
- Verizon leads other carriers



https://www.opensignal.com/2021/10/14/quantifying-the-mmwave-5g-experience-in-the-us-october-update

Characteristics of 5G Usage in U.S.

- However, 5G mmWave service less than 1% of cellular connections
- mmWave 5G service only available in urban and suburban areas



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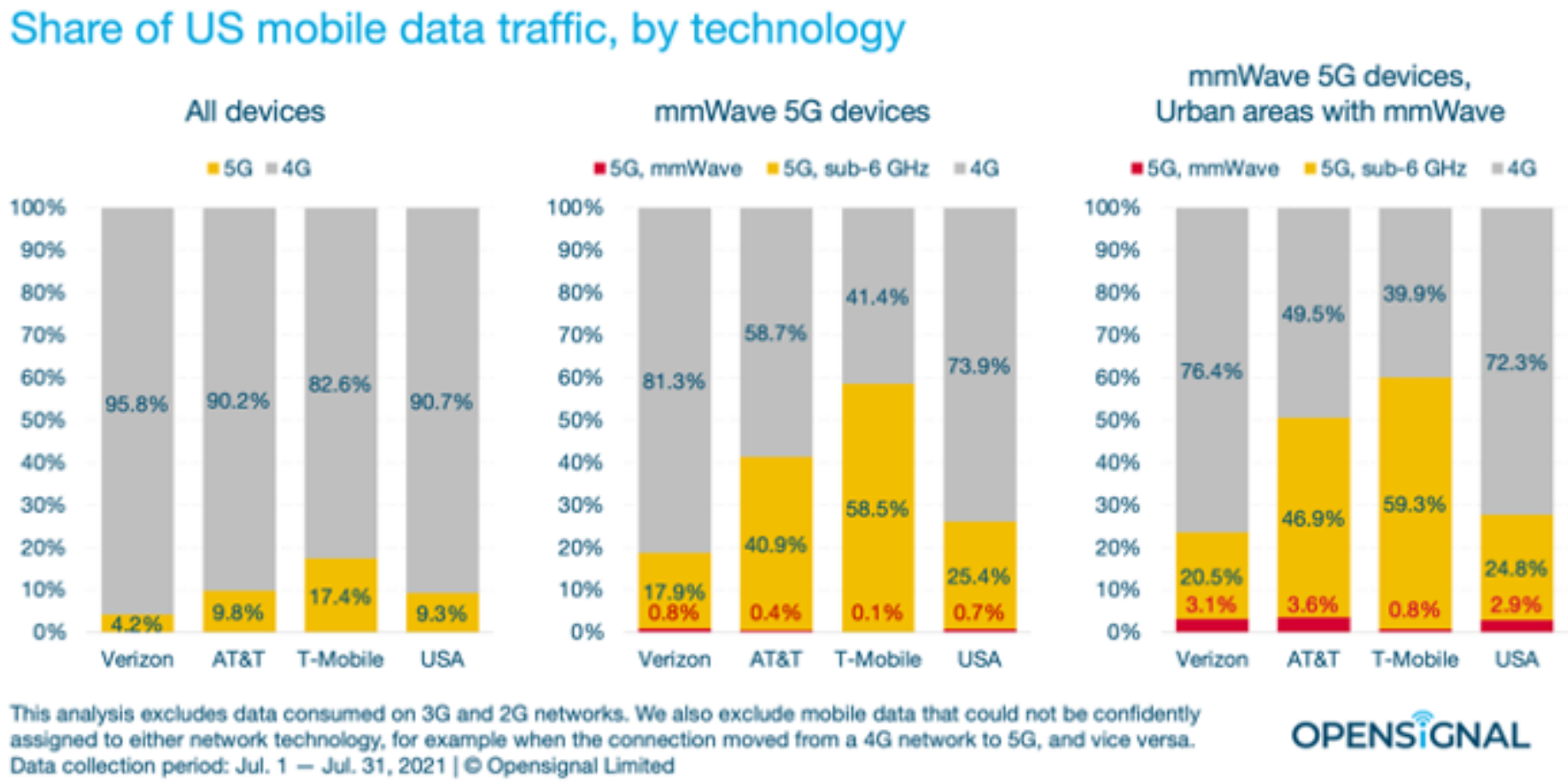
Characteristics of 5G Usage in U.S.

- 5G includes low, mid and mmWave band
- 4G LTE still dominates
- Most 5G is sub-6 GHz (low and mid bands)



https://www.opensignal.com/2021/09/22/mmwave-5g-provides-a-big-capacity-boost-to-us-users-in-high-traffic-areas

Details of Field Testing

- Beam-formed signals still on-demand as they initially were since early years of 5G starting in 2018
- Currently-measured mmWave antenna beacon signals are now always-on
- mmWave beacon signal is consistent in power flux density (PFD) across full 120 degree-wide transmission pattern side to side, just like 4G LTE and low and mid-band 5G
- Power density of mmWave beacon signal is *significantly* less strong than 4G LTE at same distance from antenna array
- Generally only 100-1,000 μW/m^2 vs. 10,000-250,000 μW/m^2 for 4G

Details of Field Testing

- mmWave beacon signals dissipate quickly with distance and were not measurable beyond one city block away from antenna
- Compare that to 4G LTE and low and mid-band 5G that travel at high power densities for one mile or more
- I am generally not measuring mmWave 5G signals in residential suburban neighborhoods
- mmWave 5G signals are so far confined to main boulevards with foot traffic and commercial and apartment buildings

Details of Field Testing

- mmWave 5G service is primarily an outdoor phenomenon, supplementing low and mid-band 4G LTE and 5G service
- mmWaves do not penetrate building walls well
- Shielding would be highly effective when used
- mmWaves do penetrate Low-E glass roughly 50-70%
- Film could be effective on and over windows and needs to be tested — metal mesh screen and RF curtains less so due to holes that mmWaves can pass through

Details of Field Testing

- mmWave antenna beacon signals *not* dependent upon cell phone
- Verizon mmWave antenna beacon signal present whether my Verizon iPhone had 5G enabled, disabled, or in Airplane Mode
- mmWave 5G beacon signal not strong in early 5G era, 2018-2021
- My Verizon iPhone triggered by beam-formed signal, emitted high RF levels >500,000 $\mu W/m^2$ only when engaged in data activity
- mmWave 5G signals from Verizon iPhone not present when my iPhone is not near a Verizon mmWave antenna — can be disabled
- Only phones from same carrier that installed mmWave antenna will have 5G transmissions from cell phone turned on by that antenna

Details of Field Testing

- I measured higher mmWave readings on my mmWave RF meter when passersby walked by, presumably with their Verizon cell phone triggered by Verizon mmWave antenna
- These high RF levels from cell phones may be a stronger health threat to user and those standing nearby than actual mmWave signals from 5G antenna
- mmWave signals from 5G antenna are beam-formed
- We do not know if RF from cell phones triggered by mmWave antenna are also beam-formed — needs to be confirmed

Value of Using mmWave Antenna

- Considering you will likely not see mmWave signals in suburban residential areas, mmWave RF meter is valuable for reassuring clients they do not have "5G" outside their house
- They are greatly relieved!
- Also see where mmWave service does exist in urban areas
- Show how strong and pervasive 4G LTE and low/mid 5G is with S&S Pro II and other RF meters in common use
- Also show how strong RF levels are from all portable wireless devices within client's personal space (cell phones, tablets, laptops)

Summary Points of mmWave 5G

- Conclusions by Mitch Marchand, BSc, EE, EMRS
- Beam-formed signal fairly significant from mmWave antenna
- Three separate effects when in proximity to mmWave 5G antenna:

1. 24/7 background level across full cone (120 degrees wide?)
2. Phone triggers beam-formed signal with data usage as "spot light" to phone or tablet, 3-4 feet wide, >31,600 $\mu W/m^2$
3. At same time, background exposure level across full cone elevates slightly, 100 $\mu W/m^2$, when a customer accesses data

Summary Points of mmWave 5G

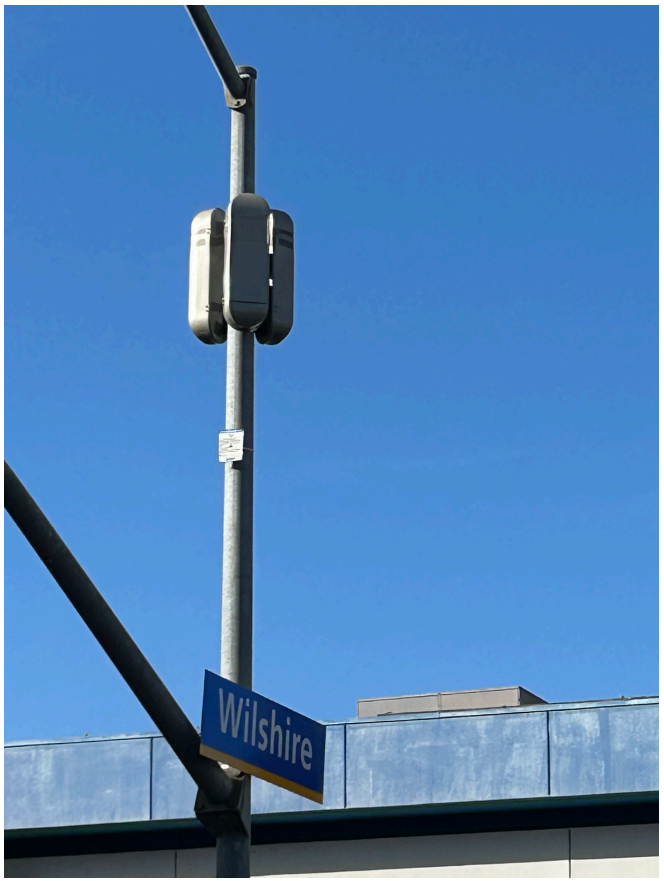
- Conclusions by Mitch and Oram to date
- Beam-formed signal fairly significant from mmWave antenna, triggered by phone from *same* cell carrier as mmW antenna
- Three separate effects in proximity to mmWave 5G antenna
- mmWave antennas still rare in residential neighborhoods
- mmWave signal blocked by solid walls, foil, paint
- mmWave signal *not* blocked by glass, fabric or mesh screen (signal can pass through holes in fabric or screen)

Summary Points of mmWave 5G

- Recommendations for further testing:
- Use cell phone from *same* cell carrier as mmWave antenna to trigger beam-formed signal from antenna
- Verizon predominates mmWave 5G service in U.S.
- Use attenuator when measuring with horn antenna, as signal from antenna and from phone will exceed rated capacity for horn antenna of 31,600 $\mu W/m^2$
- Note increase in Average value, indicating more dense antenna RF transmission (less time between pulses)

mmWave Antennas in California

- Verizon mmWave antennas in Santa Monica, California



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mmWave Antennas in California

- First, and only, mmWave 5G antenna array found in residential neighborhood
- Includes 4G LTE antenna at the top — See videos below

Click on images to start video

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mmWave Antennas in California

- Recap of finding of minimal mmWave antenna presence in residential neighborhood in Santa Monica, California

Click on image to start video

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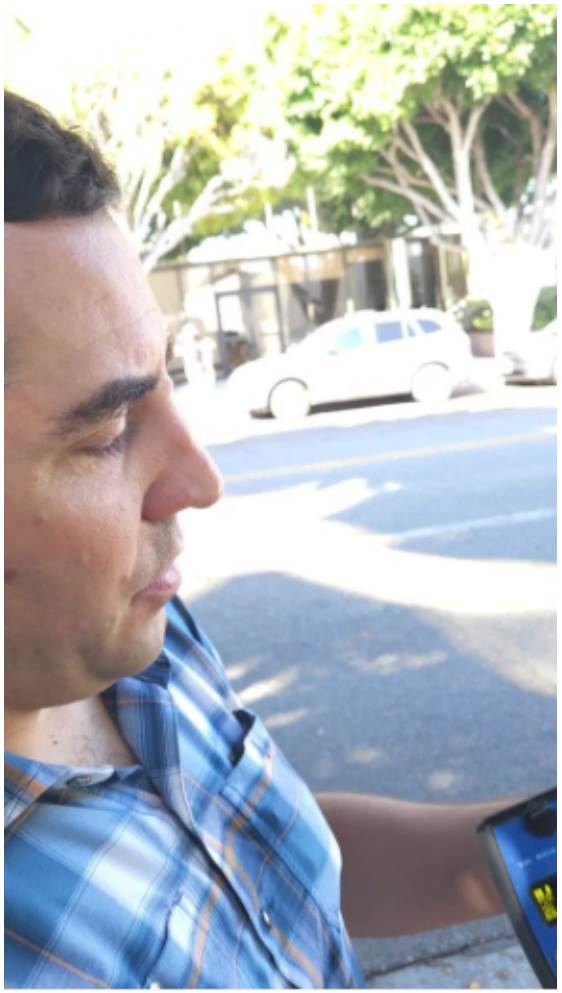
mmWave Antennas in California

- Summary of mmWave antenna activity and beam-formed signal by Mitch Marchand, EE, EMRS (see previous presentations for videos)

Click on image to start video



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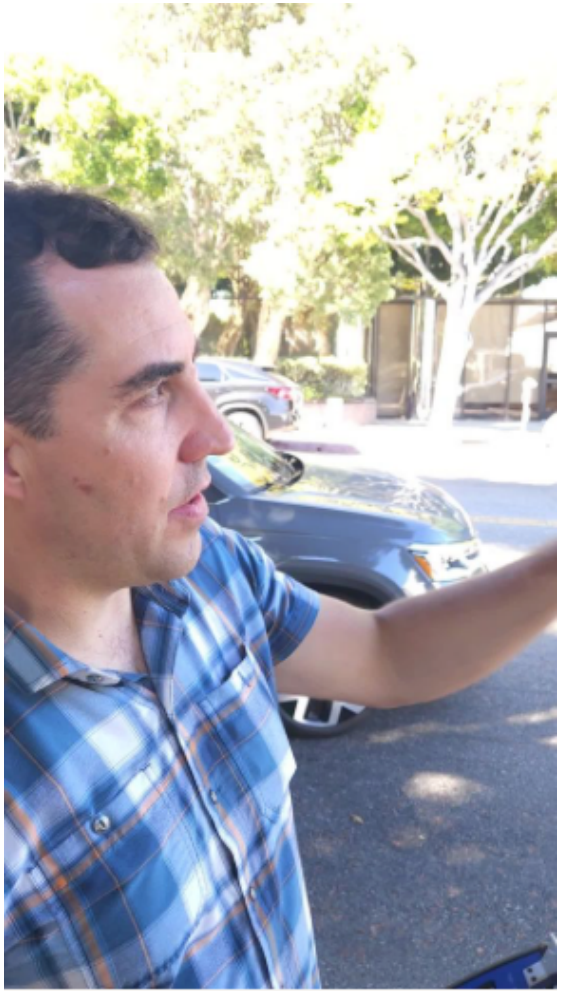
mmWave Antennas in California

- Further summary of mmWave antenna activity and beam-formed signal by Mitch Marchand

Click on image to start video



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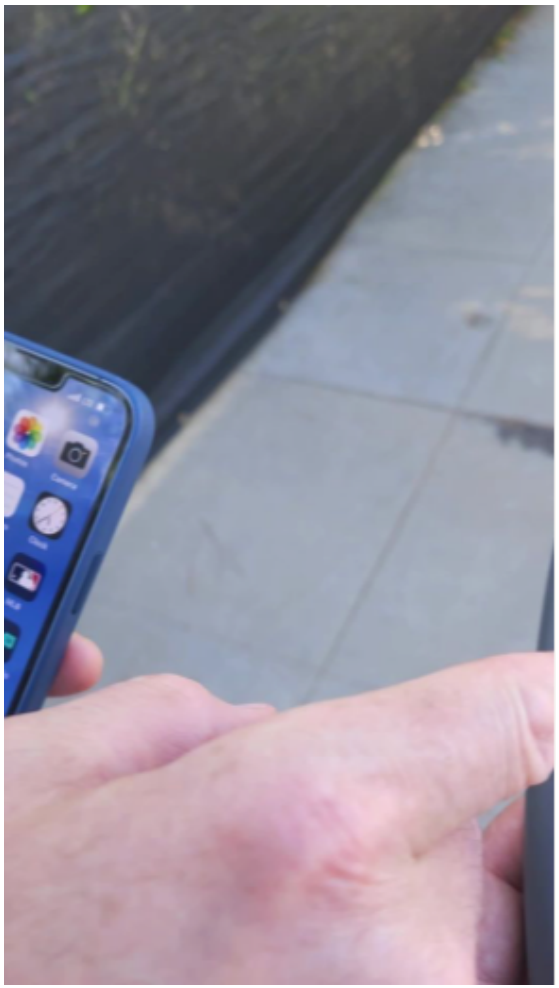
mmWave Antennas in California

- Triggering of Verizon beam-formed signal with Verizon cell phone data
- Summary of mmWave impact on nearby residents

Click on images to start video



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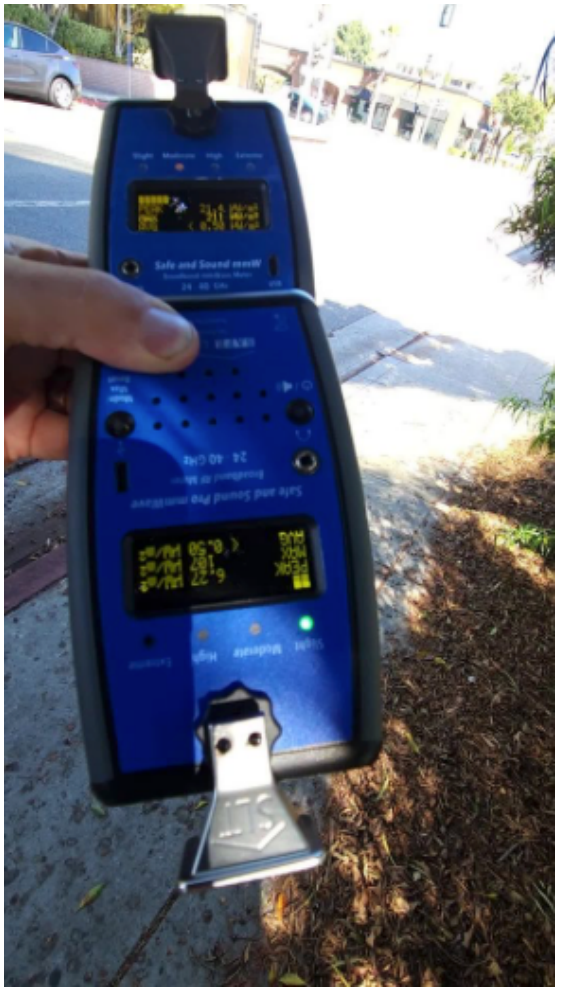
mmWave Antennas in California

- Verizon mmWave 5G antenna beam-formed signal triggered by data usage on Verizon cell phone (beam-formed signal from antenna, high RF signal from phone)

Click on images to start video



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mmWave Antennas in California

- mmWave 5G and 4G LTE antennas (not Verizon)

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mmWave Antennas in California

- mmWave 5G antenna, not Verizon
- Signal strength reduces turning in place

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