5G Spectrum Monitoring

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What is 5G? – It's a paradigm shift

1G ~1985

Transition from analog to digital…

2G 1992

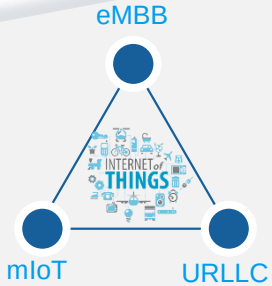
3G 2001

- *Define technology framework*
- *Find a use case*

4G 2010

5G 2020

- Define use case
- Analyze requirements
- Define technology



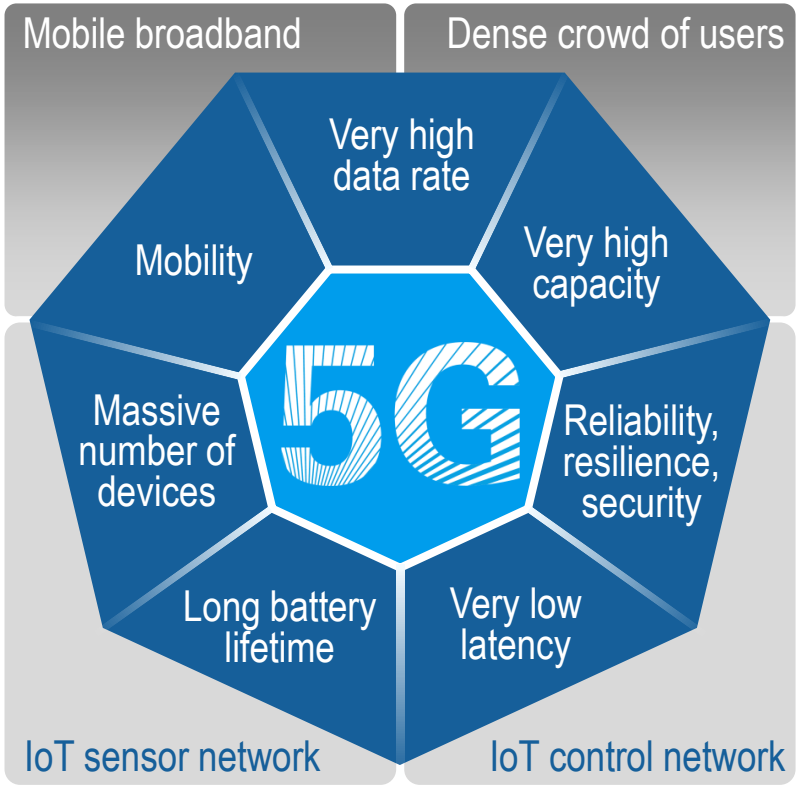
Use cases: Much more than only Mobile Broadband

Scenarios & Requirements

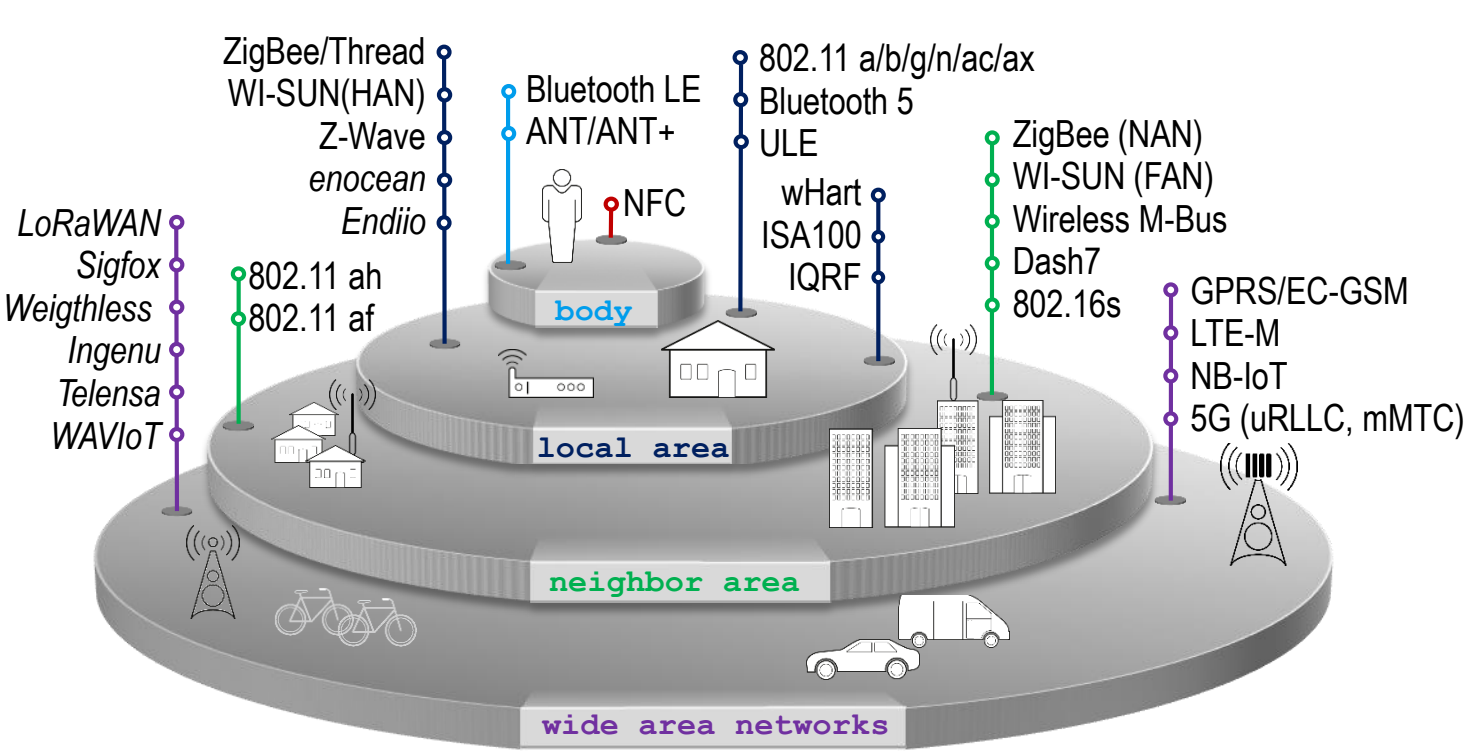
- **Mobile broadband / Dense crowd of users**
  Mobility, high data rates, high capacity and partly limited area.

- **Internet of Things – reliable and low latency**
  Low latency, high reliability, resilience and security; user case specific data rates/capacity.

- **Internet of Things – massive number of devices**
  The volume of devices and “things” will create new requirements.
  Battery life time expectation → years

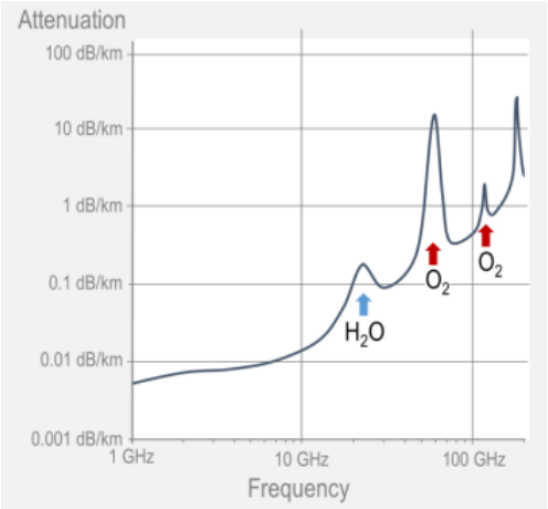


A plenty of radio technologies for the wireless Internet of Things



Technological framework
Frequency range

- Higher frequencies (up to 100 GHz) allow for larger bandwidths, i.e. higher peak data rates and system capacities
- Since path loss is significantly higher, highly directional beamforming will be required
- Oxygen and water absorption (e.g. rain or humidity loss) has to be taken into account for specific bands.
- The attenuation of most obstacles is stronger (e.g. even high foliage loss is present).
- Specular reflections are more common in mmWave.



Technological framework
Monitoring equipment

- Appropriate equipment has to be enhanced / developed
  - Frequency range
  - Bandwidth
  - Service specific parameters

- Wave propagation / micro cells
  - Mobile and portable equipment
  - Compact, autonomous systems
  - Easily deployable

- Coexistence of 4G (large coverage) and 5G (high data throughput)

Pre-rollout activities

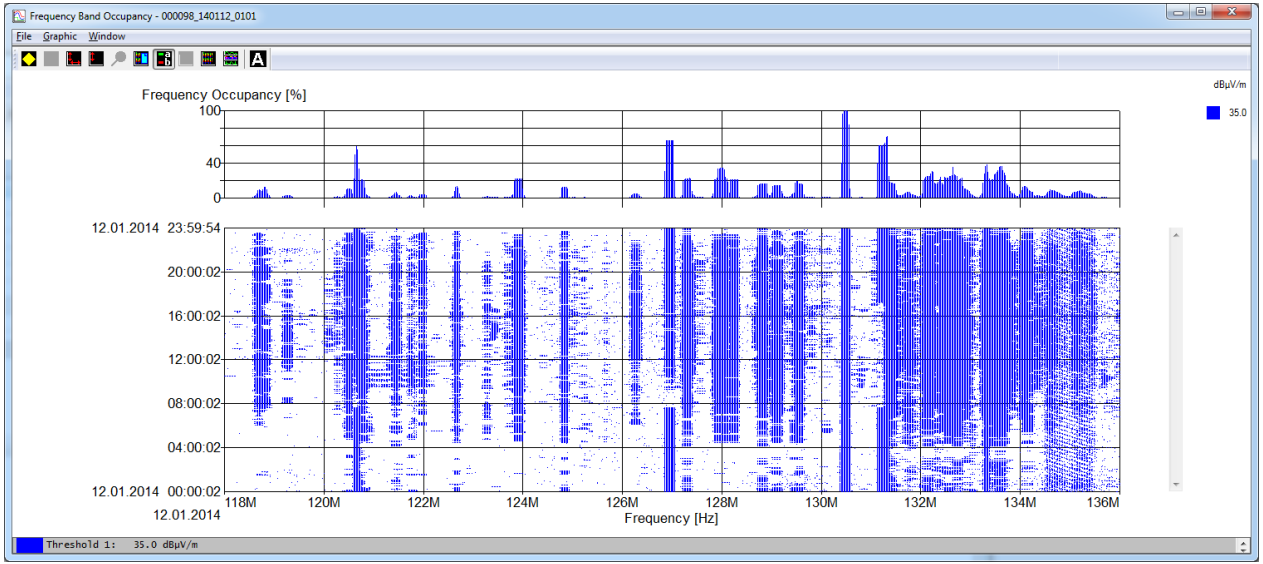
- Spectrum clearance and occupancy measurements
  - Verify that assigned frequency bands are really empty

- Device conformity
  - Assure that all devices operate without interference

Pre-rollout activities
Occupancy

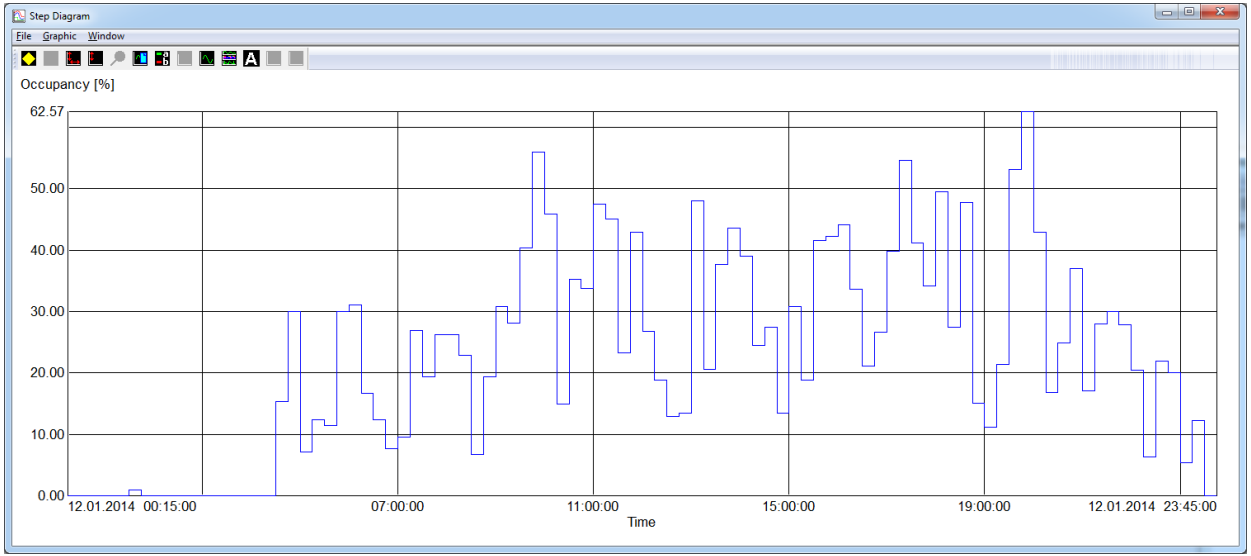
- Especially SHF / EHF frequencies often not in main focus of regulator
  -> real usage rather unknown
  -> situation in adjacent channels rather unknown

Pre-rollout activities
Occupancy



Frequency band occupancy

Pre-rollout activities
Occupancy

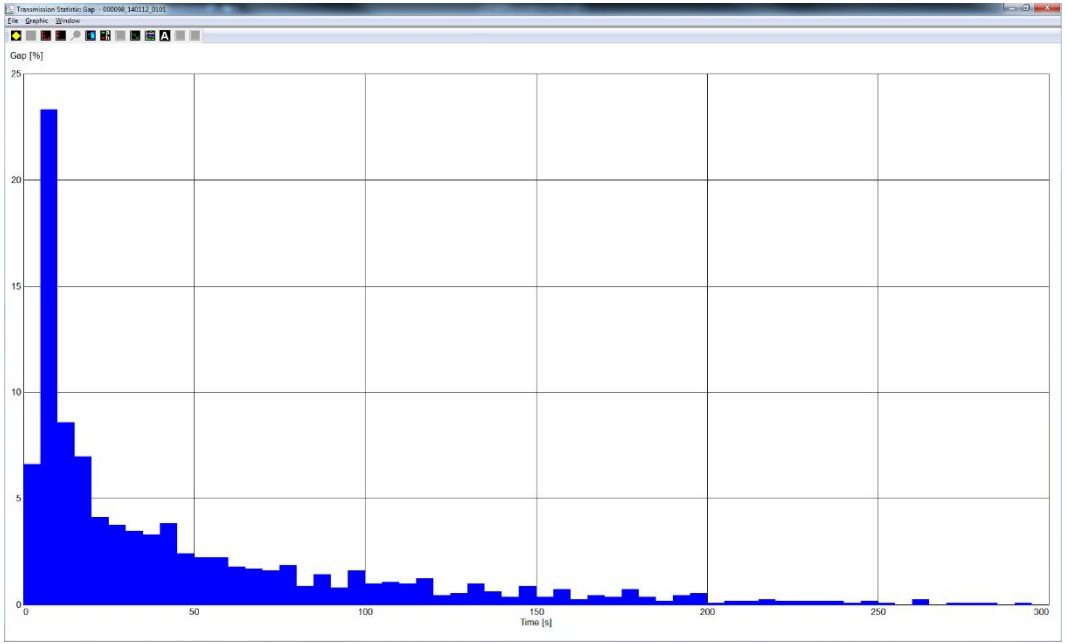


Frequency channel occupancy

Pre-rollout activities
Occupancy

Frequency channel occupancy, same channel but different users separated by level range

Pre-rollout activities
Occupancy



Transmission analysis shows that ~70% of all gaps are < 1min

Pre-rollout activities
Device conformity

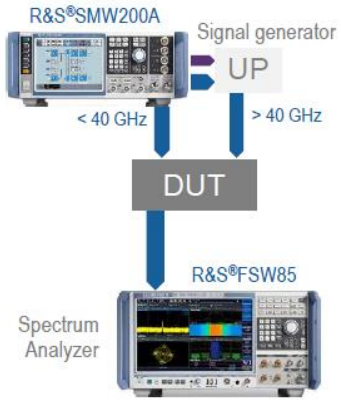
- New technologies pose very demanding requirements for all types of equipment

- Example: Massive MIMO / beamforming systems
  - Phase shifter tolerances
  - Thermal effects
  - Desired beam patterns
  - Frequency
  - Bandwitdh
  - …

- -> initial problems rather likely

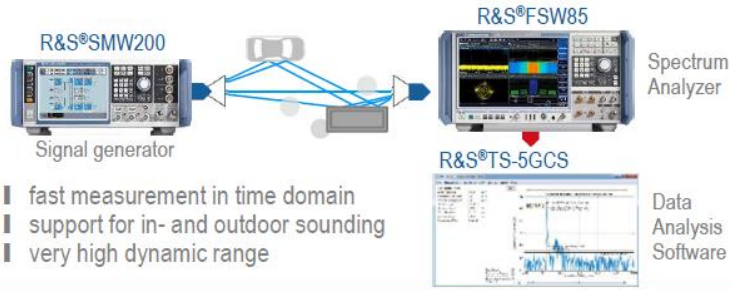
Pre-rollout activities
Device conformity

Wideband Signal Testing



- 40 GHz signal generation
- 90 GHz signal analysis
- 2 GHz bandwidth support
  (5G GHz with RTO2064 and B5000)

Channel Sounding Solution



- fast measurement in time domain
- support for in- and outdoor sounding
- very high dynamic range

Massive MIMO - Beamforming

- Phase-coherent RF generation
- Multi-port VNA

5GTF and 5G NR support

Component Characterization

Direct measurements up to 110 GHz

5G NR Device Testing

R&S®CMW100 (K06)

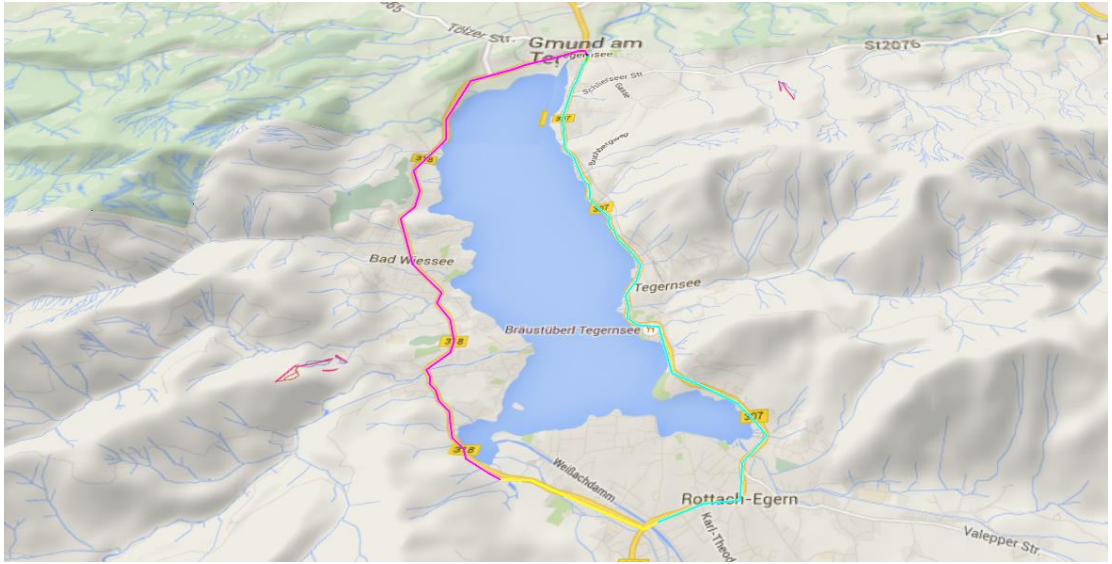
Testing of 5G NR sub-6 GHz devices in non-signaling mode

During and after rollout

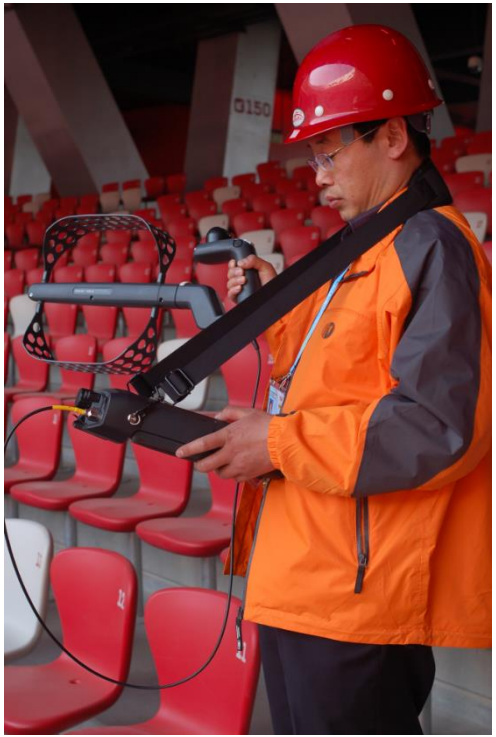
- Coverage
- Interference hunting
- Classical monitoring
  - Occupancy
  - Verification of license compliant operation
- Quality of service

During and after rollout
Coverage

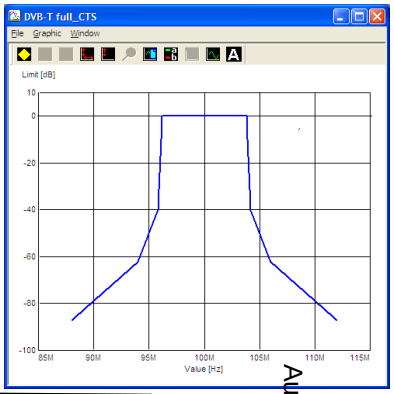
- How realistic are EHF propagation calculation tools?



During and after rollout
Interference hunting

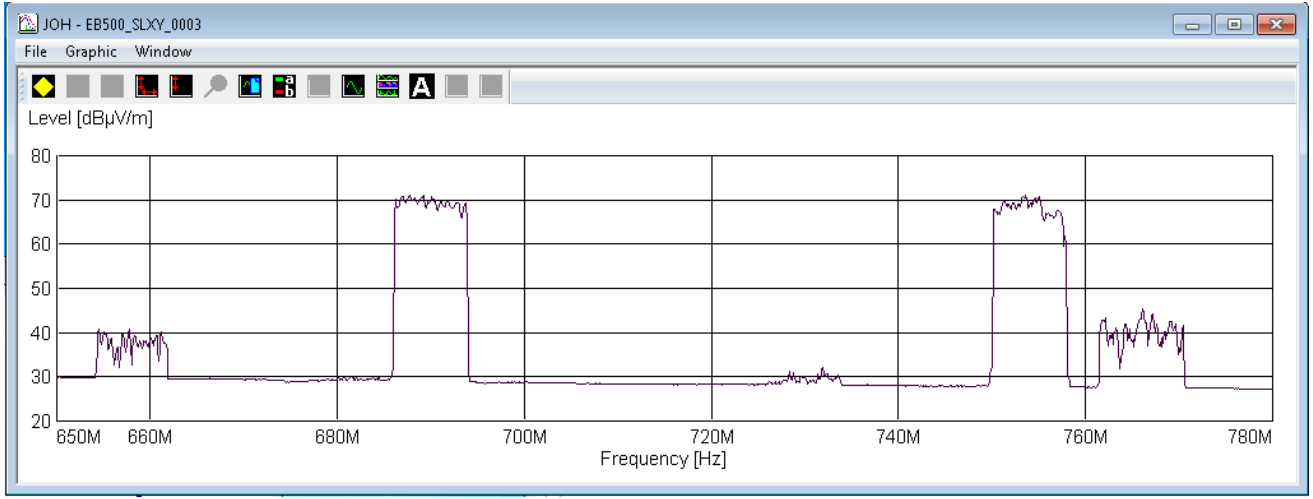


During and after rollout
Verification of license compliant operation



Automatic positioning on center frequency

Automatic positioning on peak level



During and after rollout
Quality of service

Drive test solution

Signals Research Group tested Verizon Wireless' 28GHz trial network

1.0 Executive Summary

Key Highlights from this Study

Signals Research Group (SRG) conducted what we believe is the industry's first independent benchmark study of a 5G commercial test network. We conducted tests in Houston, Texas where Verizon Wireless has a 28 GHz trial network that we believe is now supporting commercial traffic. Samsung is the infrastructure supplier in this market.

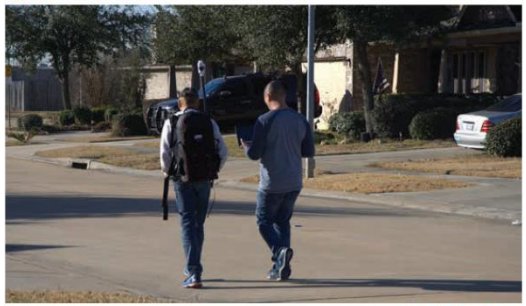
For this study, we used the Rohde & Schwarz TSMA autonomous drive test scanner to collect downlink performance metrics for the Beam Reference Signals (BRS), including RSRP, CINR, RSRQ, PCI, etc., of the 28 GHz millimeter wave radio signals. With this information, we could also estimate likely end-user data rates for the areas and locations we tested. Although Verizon is currently using the 5GTF specification, we believe the data we collected and the results we conclude from the analysis of the data are equally applicable to the 5G NR specifications, not to mention limited mobility use cases.

Based on numerous walk tests and stationary tests involving line-of-site (LOS), non-line-of-site (NLOS) and near-line-of-site conditions, we have a great appreciation for the promises of millimeter wave spectrum. To summarize, millimeter wave signals are far more resilient than we expected, even at distances exceeding several thousand feet. Tree foliage, passing school buses, buildings, parked cars, balding heads, and glass impacted the received signal, but the resultant signals were still capable of delivering meaningful data rates – thanks in part to the 400 MHz radio channel. Verizon can deploy 800 MHz channels in some markets. Who would have thought a millimeter wave signal in an area 100% blocked from the serving cell tower by the surroundings would still be capable of supporting good data speeds?

Verizon management is on record for "promising" Gigabit speeds to its serviced customers. We don't yet share this view with near-term deployments unless Verizon aggressively deploys 5GTF small cells (i.e., brings the consumer and the 5G access point closer together), and/or mounts CPEs in ideal exterior locations, and/or limits its customers to only those customers that it knows live in a location with suitable radio conditions that can support Gigabit speeds.

using R&S 5GTF backpack solution

Figure 2. SRG Walk Test



Source: Signals Research Group

Source: Signals Ahead, Vol. 14, Number 3 PREVIEW, Feb.20, 2018