

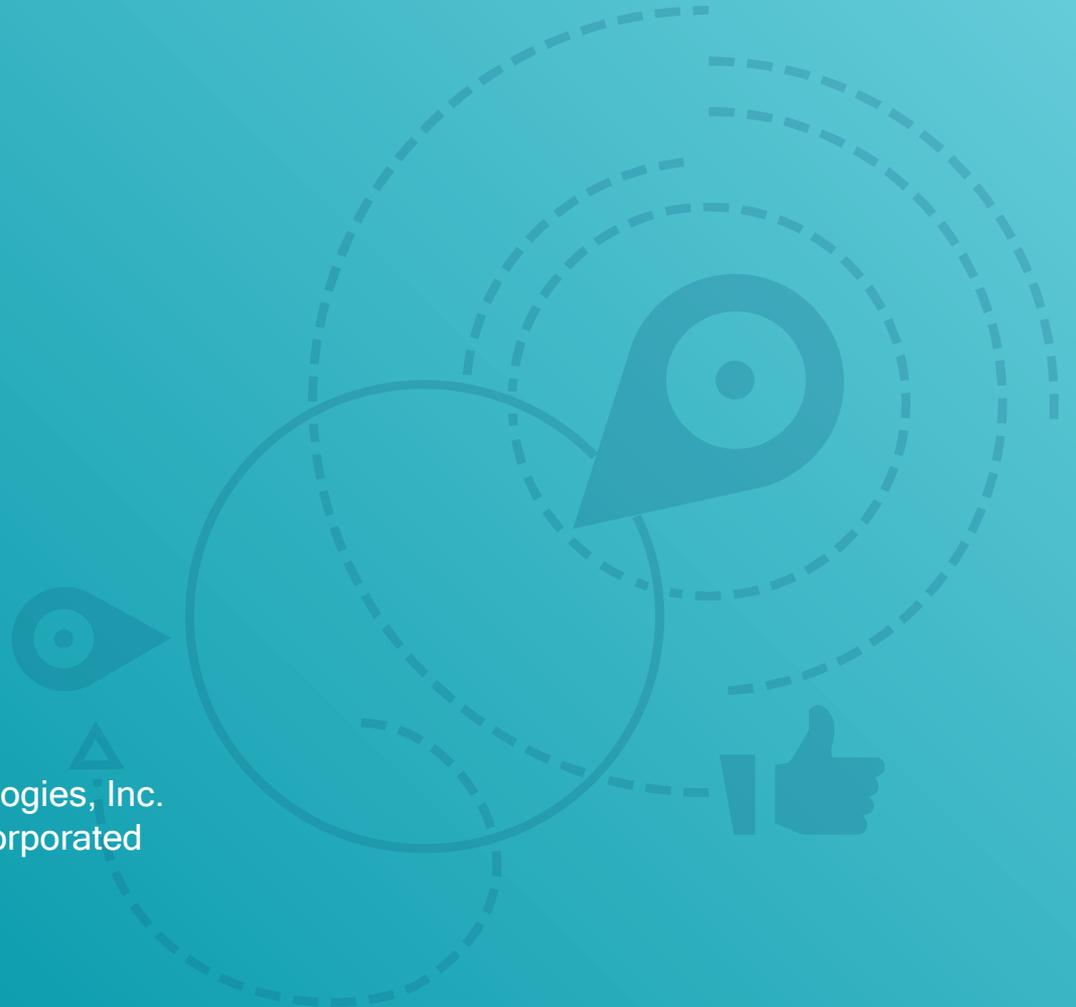


# Matt Grob

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March 2016



# A unified 5G design for all spectrum types/bands

## Addressing a wide range of use cases and deployment scenarios

### Licensed Spectrum

Cleared spectrum  
EXCLUSIVE USE

### Shared Licensed Spectrum

Complementary licensing  
SHARED EXCLUSIVE USE

### Unlicensed Spectrum

Multiple technologies  
SHARED USE

Below 1 GHz: longer range for massive Internet of Things

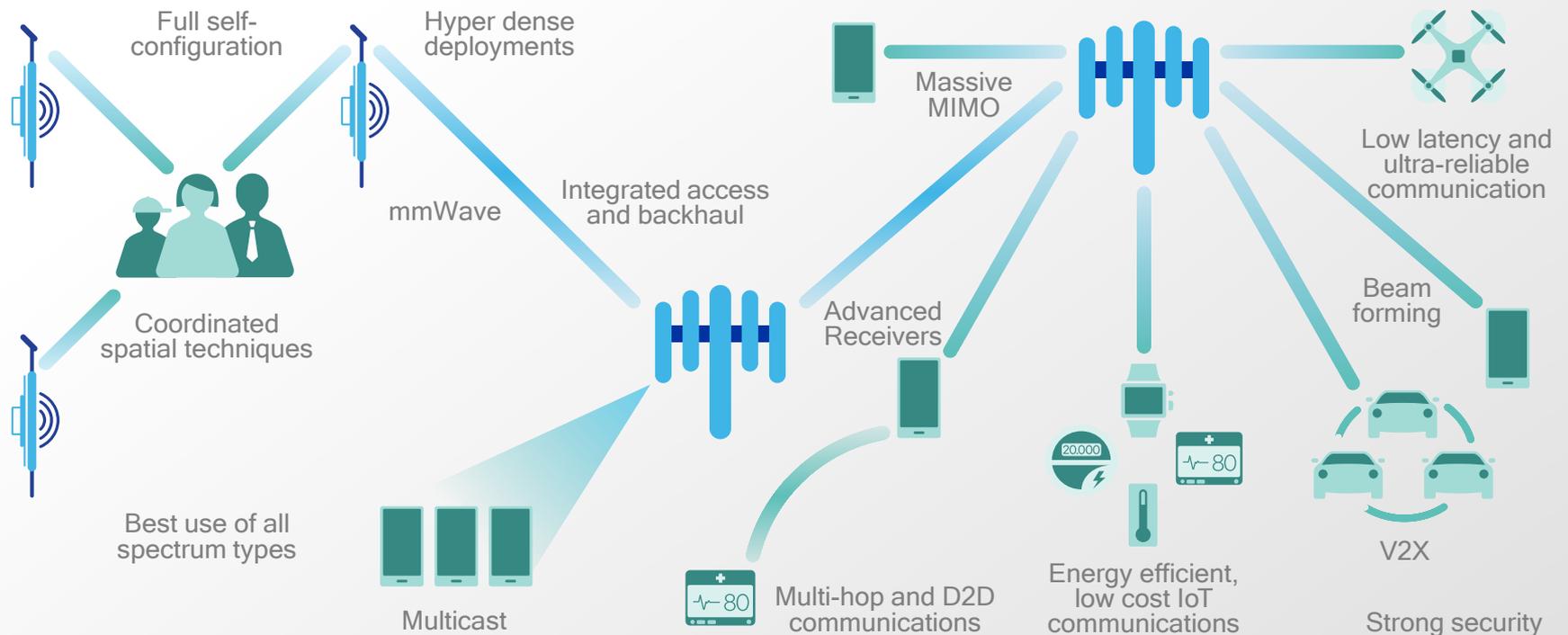
1 GHz to 6 GHz: wider bandwidths for enhanced mobile broadband and mission critical

Above 6 GHz, e.g. mmWave: extreme bandwidths, shorter range for extreme mobile broadband

From wide area macro to local hotspot deployments  
Also support diverse network topologies (e.g. D2D, mesh)

# Natively incorporate advanced wireless technologies

## Many technology enablers to meet 5G requirements and services



# Realizing the mmWave opportunity for mobile broadband

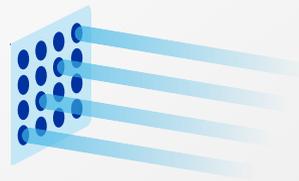
## The extreme mobile broadband opportunity

- Large bandwidths, e.g. 100s of MHz
- Multi-Gbps data rates
- Flexible deployments (integrated access/backhaul)
- High capacity with dense spatial reuse

## The challenge—‘mobilizing’ mmWave

- Robustness due to high path loss and susceptibility to blockage
- Device cost/power and RF challenges at mmWave frequencies

## 5G Solutions



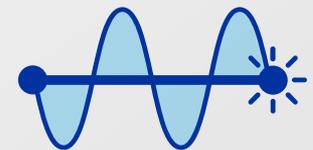
### Intelligent directional beam forming and beam tracking

Increase coverage and minimize interference



### Tight interworking with sub 6 GHz

Increase robustness and faster system acquisition



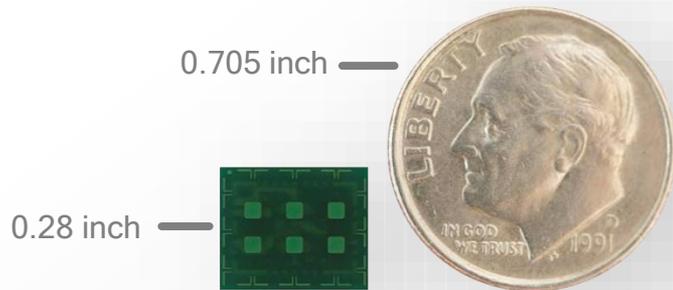
### Optimized mmWave design for mobile

To meet cost, power and thermal constraints

# Making mmWave a reality for mobile

## Qualcomm is driving 5G mmWave

60 GHz chipset commercial today for mobile devices



Qualcomm® VIVE™ 802.11ad technology with a 32-antenna array element

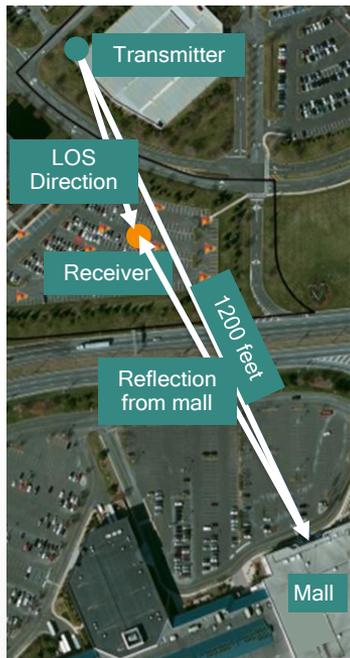
Developing robust 5G mmWave for extreme mobile broadband



Qualcomm Research 28 GHz end-to-end prototype system demonstrates beam forming and scanning to address NLOS scenarios, improve indoor/outdoor range, and provide robust mobility

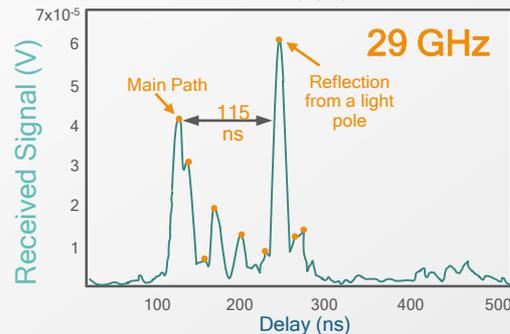
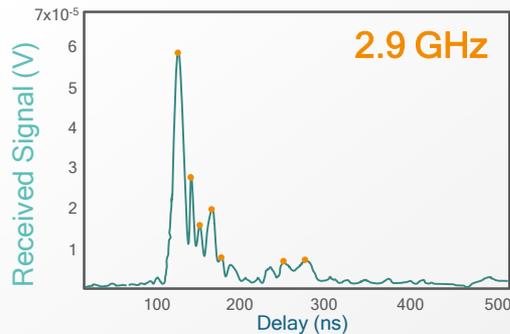
# Analyzing mmWave across various usage scenarios

## Outdoor example

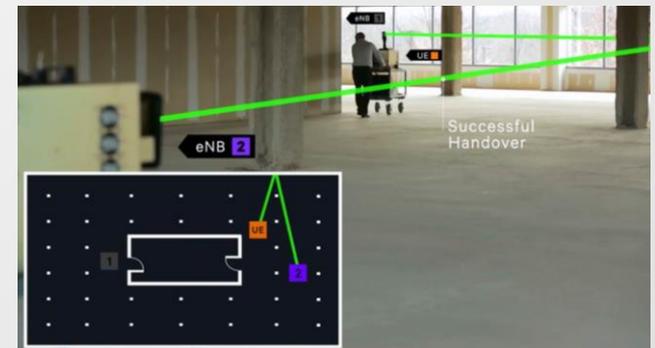
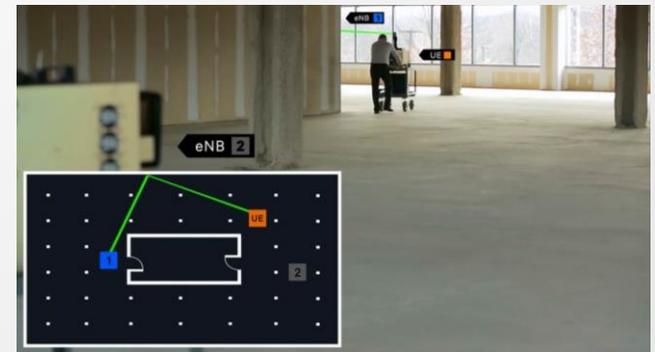


## Example measurement

Channel response from Omni-directional antennas



## mmWave prototype indoor demo



1 Due to easier diffraction around the objects at lower frequencies; 2 Non-line of sight path loss normalized to 1m antenna distance—actual path loss = [reference loss at 1m for a given frequency] + [normalized Propagation Loss]

# Driving 5G from standardization to commercialization

## Fully leverages LTE and Wi-Fi investments to enable a phased 5G rollout

### Qualcomm 5G activities

Designing 5G, e.g. OFDM-based unified air interface

Contributing to 3GPP, e.g. massive MIMO simulations, new LDPC code designs

Delivering advanced prototypes, e.g. 5G mmWave demo at MWC'16

Participating in impactful trials with industry ecosystem

2015 2016 2017 2018 2019 2020 2021 2022

5G study items

R15 5G work items

R16 5G work items

R17+ 5G evolution

### 3GPP 5G standardization

5G commercial launches

# Thank you

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