

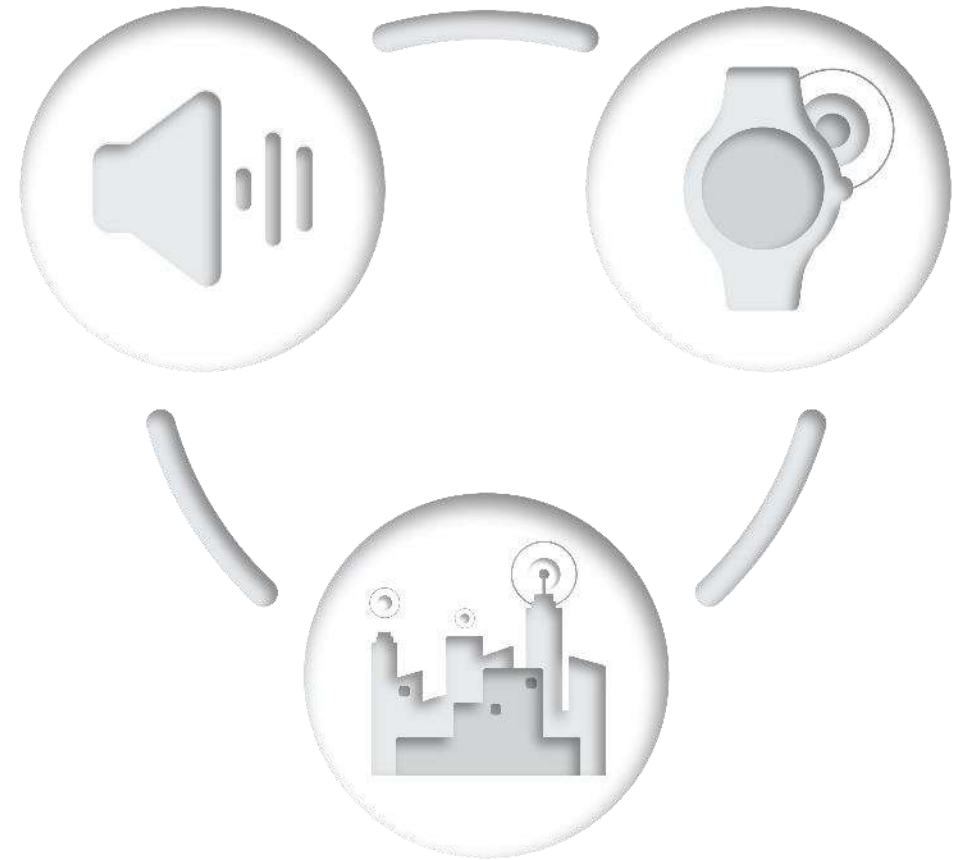
# 5G: New Adjacent and Vertical Markets

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Senior Vice-President Engineering  
Qualcomm Fellow  
Head Global Standards and Industry Organizations

March 27, 2018

# Outline

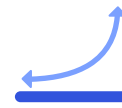
- 5G Vision
- Spectrum
- Some emerging markets



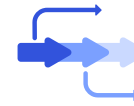


# 5G

## A new kind of network to drive innovation and growth



Significant connectivity upgrade



Smartphone tech is extending into many industries



Consumers want 5G smartphones

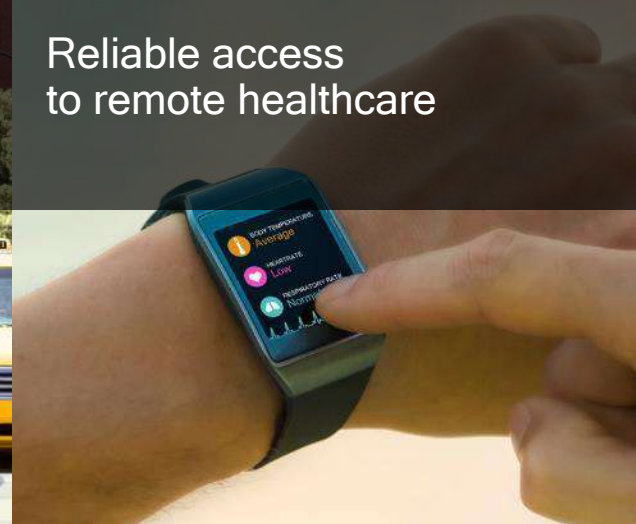
More autonomous  
manufacturing



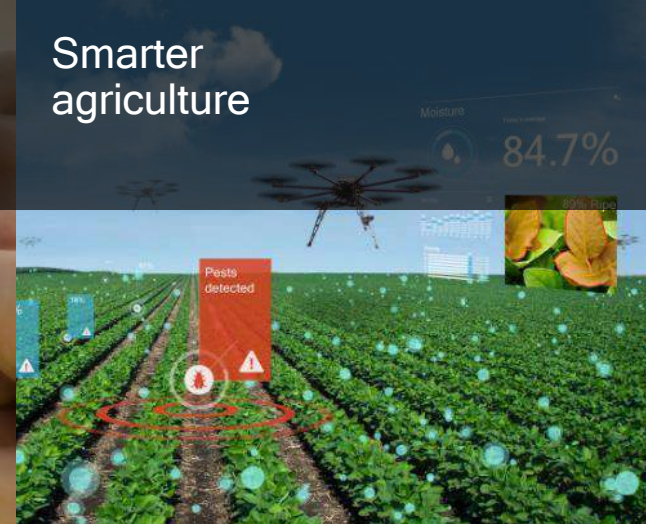
Safer, more autonomous  
transportation



Reliable access  
to remote healthcare



Smarter  
agriculture



More efficient use  
of energy and utilities



Improved public  
safety and security



Sustainable cities  
and infrastructure



Digitized logistics  
and retail



5G will expand the mobile  
ecosystem to new industries

\*The 5G Economy, an independent study from IHS Markit, Penn Schoen  
Berland and Berkeley Research Group, commissioned by Qualcomm

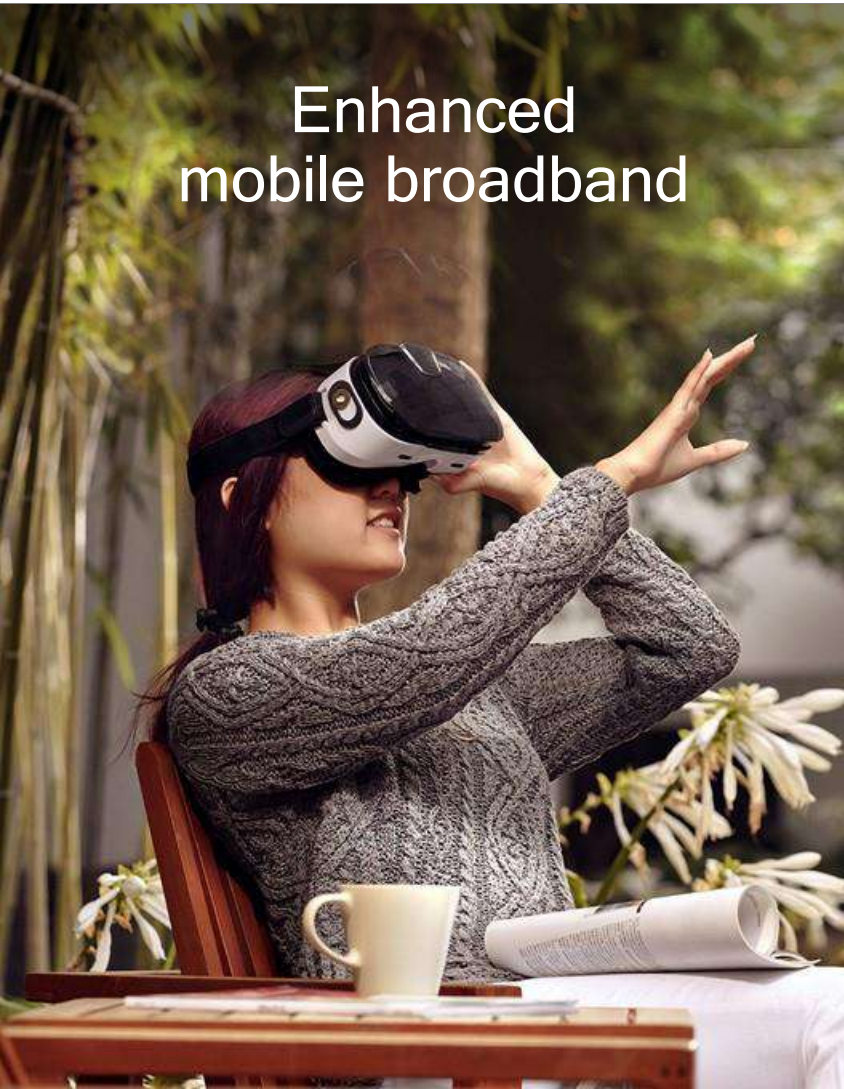
Powering the digital economy  
**>\$12 Trillion**  
In goods and services by 2035\*



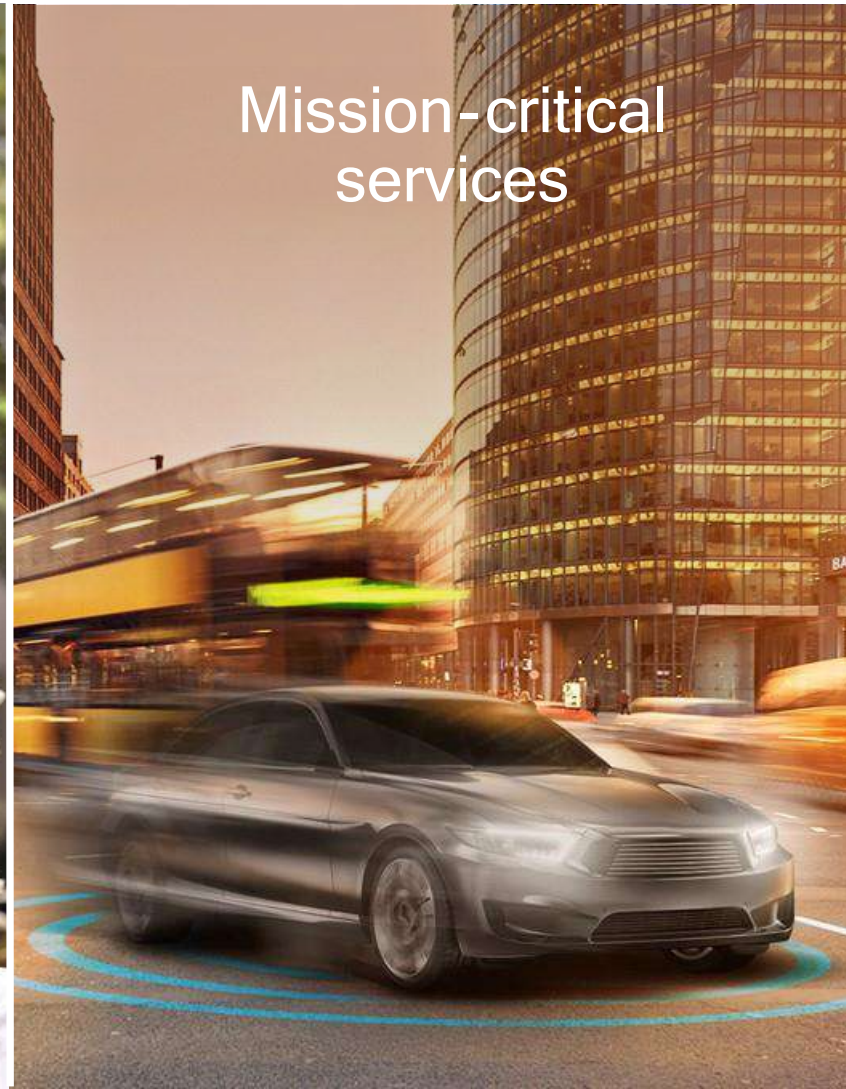
# 5G is foundational to what's next

And we're the foundation of 5G

Enhanced  
mobile broadband

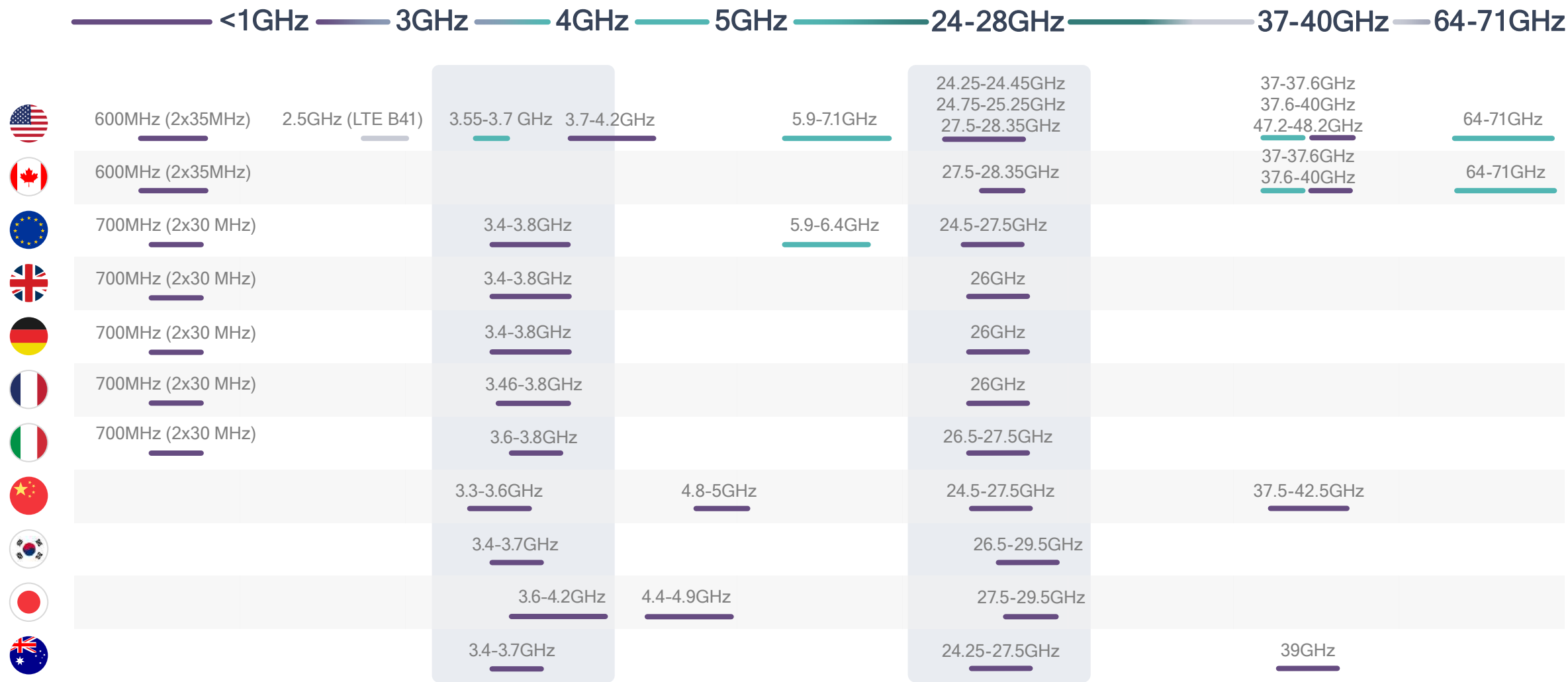


Mission-critical  
services



Massive  
Internet of Things





# Global snapshot of 5G spectrum

Around the world, these bands have been allocated or targeted

New 5G band

- Licensed
- Unlicensed / shared
- Existing band



# Realizing the mmWave opportunity for mobile broadband

## Extreme bandwidth opportunity

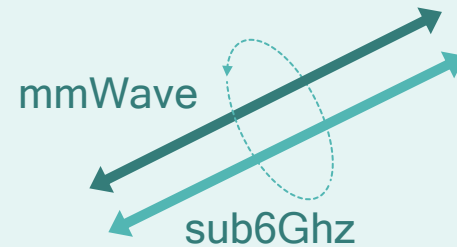
- Extreme bandwidths capable of Multi-Gbps data rates
- Flexible deployments (integrated access/backhaul)
- High capacity with dense spatial reuse

## Mobilizing mmWave challenge

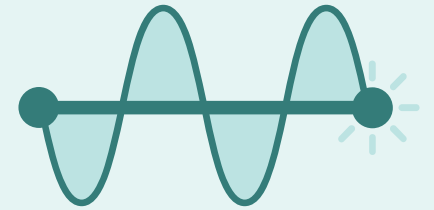
- Robustness due to high path loss and susceptibility to blockage
- Device cost/power and RF challenges at mmWave frequencies



Smart beamforming  
and beam tracking  
Increase coverage  
and minimize interference



Tight interworking  
with sub 6 GHz  
Increase robustness,  
faster system acquisition



Optimized mmWave  
design for mobile  
To meet cost, power and  
thermal constraints

Learn more at: [www.qualcomm.com/documents/promise-5g-mmwave-how-do-we-make-it-mobile](http://www.qualcomm.com/documents/promise-5g-mmwave-how-do-we-make-it-mobile)



5G

# Making 5G NR a commercial reality in 2019

**18**  
Operators

**20**  
OEMs



**Qualcomm**  
snapdragon  
X50 5G modem



# Using all available spectrum types and spectrum bands

## Licensed spectrum

### Exclusive use

Over 40 bands globally for LTE, remains the industry's top priority

## Shared spectrum

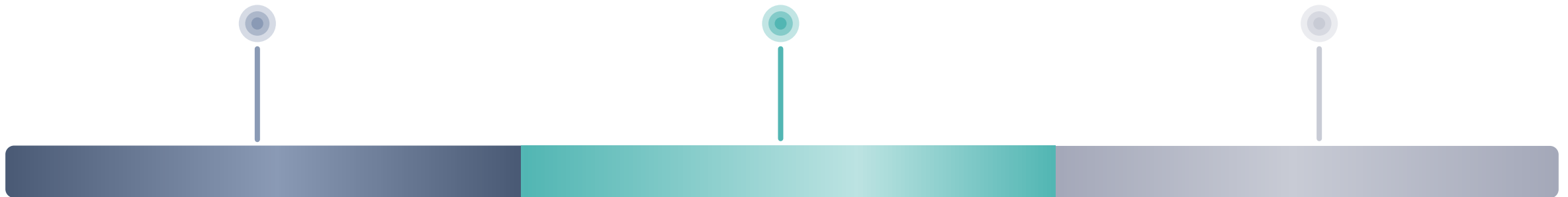
### New shared spectrum paradigms

Example: 2.3 GHz Europe / 3.5 GHz USA

## Unlicensed spectrum

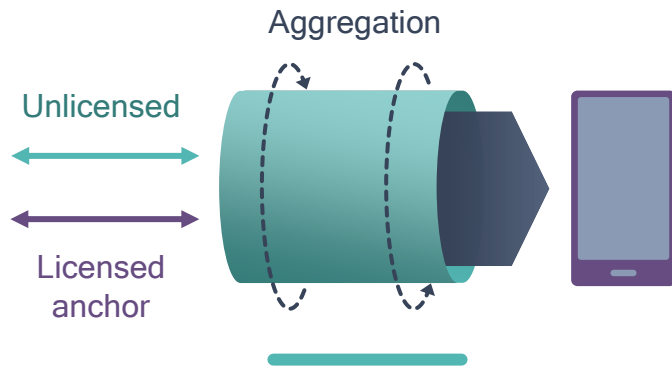
### Shared use

Example: 2.4 GHz / 5-7 GHz / 57-71 GHz global



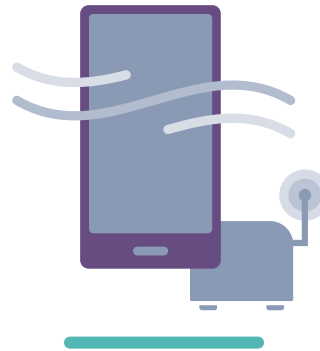
# 3GPP study on 5G NR operation in unlicensed spectrum

First time 3GPP studies cellular technology operating stand-alone in unlicensed<sup>1</sup>



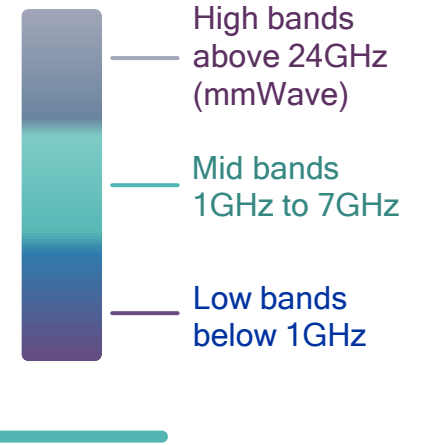
## NR-based LAA

NR in unlicensed aggregated with LTE (dual-connectivity) or NR (carrier-aggregation) in licensed spectrum



## Stand-alone unlicensed

NR operating standalone in unlicensed spectrum. This will become the MulteFire™ evolution path to 5G



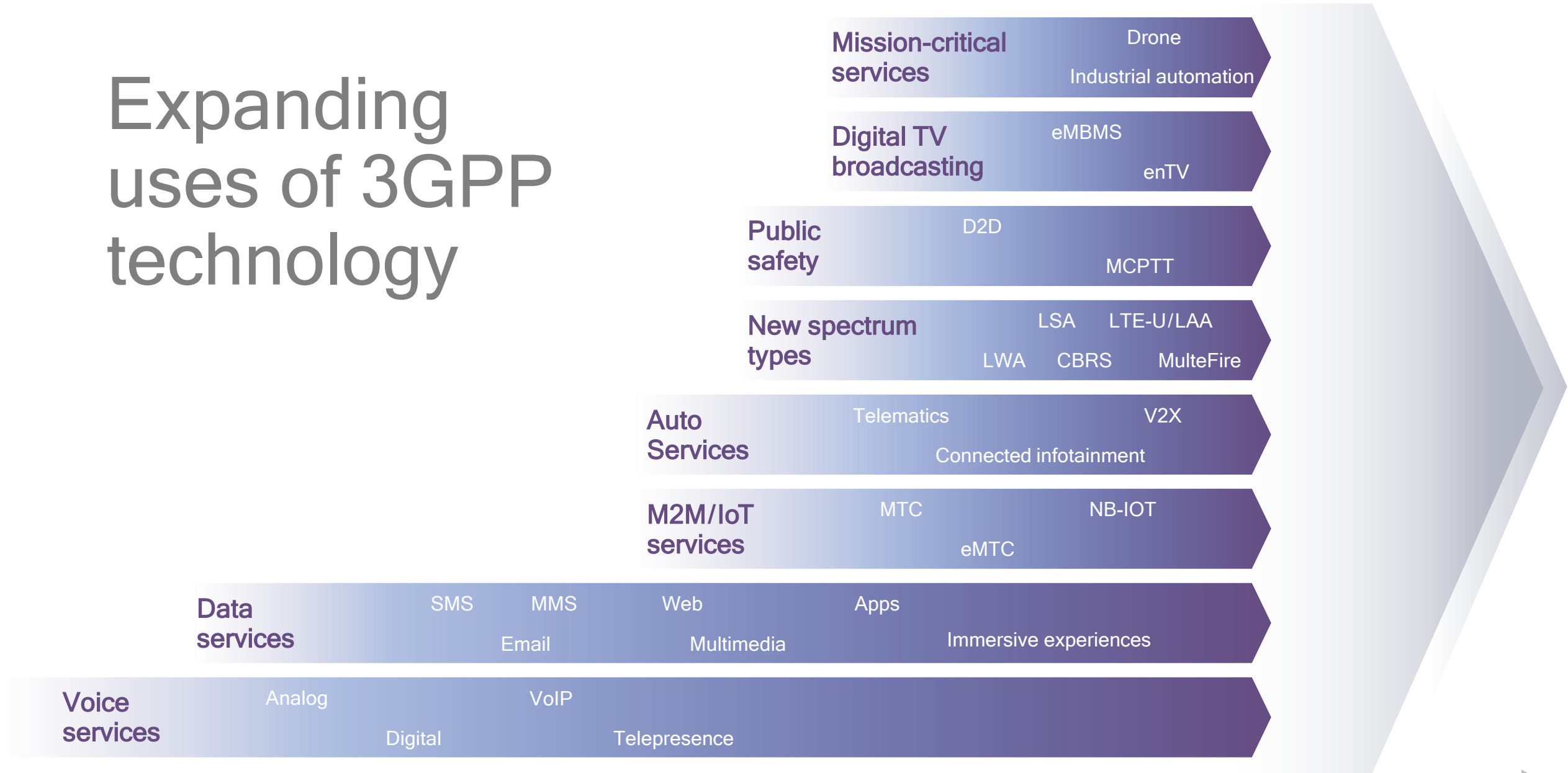
## Across spectrum bands

Both below and above 6 GHz, e.g., 5GHz, 37GHz, 60GHz\* (\*assuming no change to waveform)

Fair co-existence in any unlicensed spectrum: NR/NR, NR/LTE, NR/Wi-Fi

<sup>1</sup>.Study item in Rel.15 (RP-170828), which could be followed by a work item that is completed in Rel. 16.

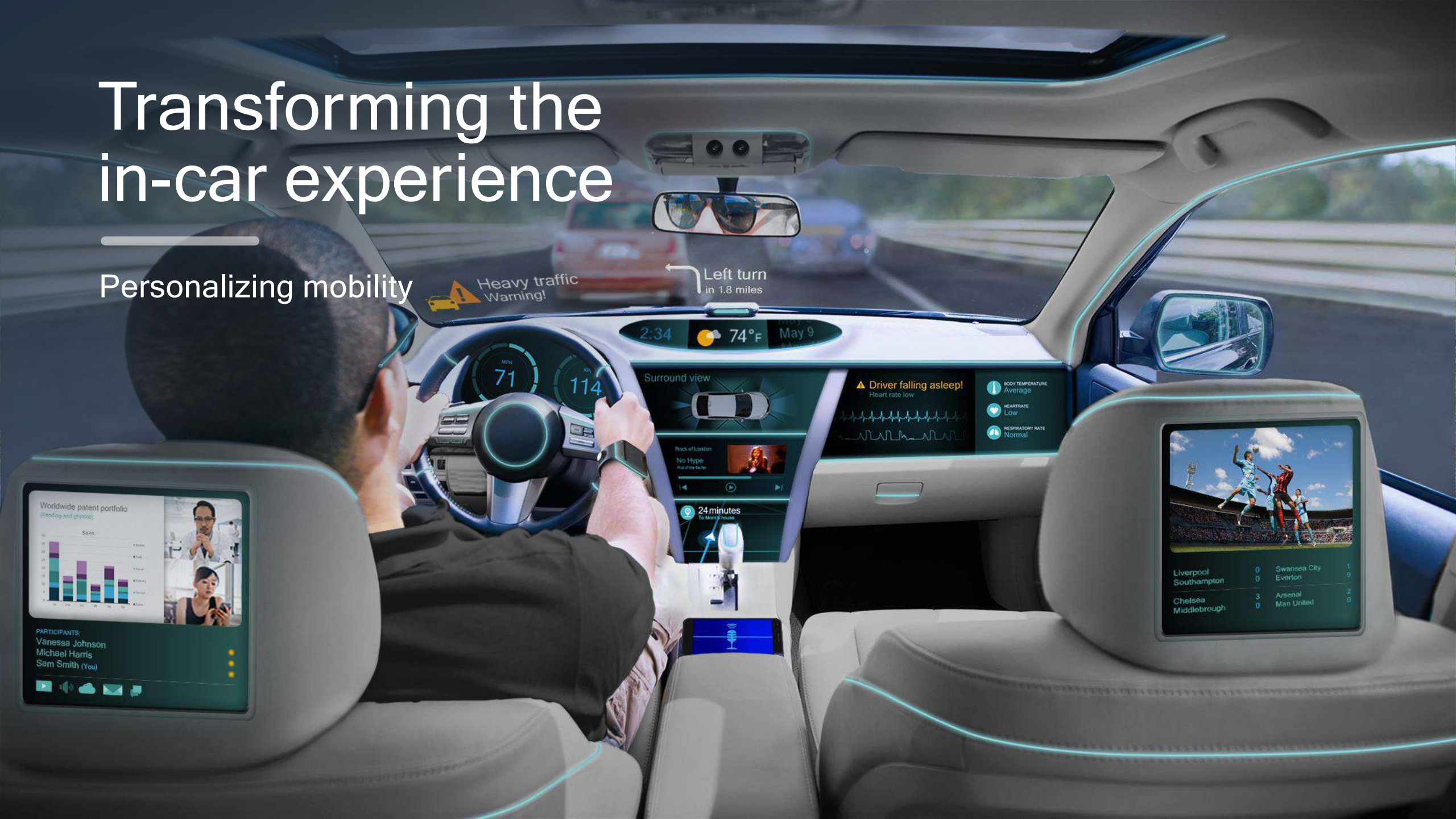
# Expanding uses of 3GPP technology





# Transforming the in-car experience

Personalizing mobility



Heavy traffic  
Warning!

Left turn  
in 1.8 miles

2:34 74°F May 9

Surround view

Rock of London

No Hype

Rock of London

24 minutes

To Home

Driver falling asleep!

Heart rate low

Body Temperature

Average

Heart Rate

Low

Respiratory Rate

Normal

Worldwide patent portfolio

(Pending and granted)

Sales

#Patents

#Patents

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PARTICIPANTS:  
Vanessa Johnson  
Michael Harris  
Sam Smith (You)



## V2V

Vehicle-to-vehicle  
e.g., collision avoidance safety systems



## V2I

Vehicle-to-infrastructure  
e.g., traffic signal timing/priority



## V2P

Vehicle-to-pedestrian  
e.g., safety alerts to pedestrians, bicyclists



## V2N

Vehicle-to-network  
e.g., real-time traffic/routing, cloud services



Enhanced range and reliability for direct communication without network assistance

# C-V2X

Establishes the foundation for safety use cases and a continued 5G NR C-V2X evolution for future autonomous vehicles



Release 14 C-V2X completed in 2017



Broad industry support – 5GAA

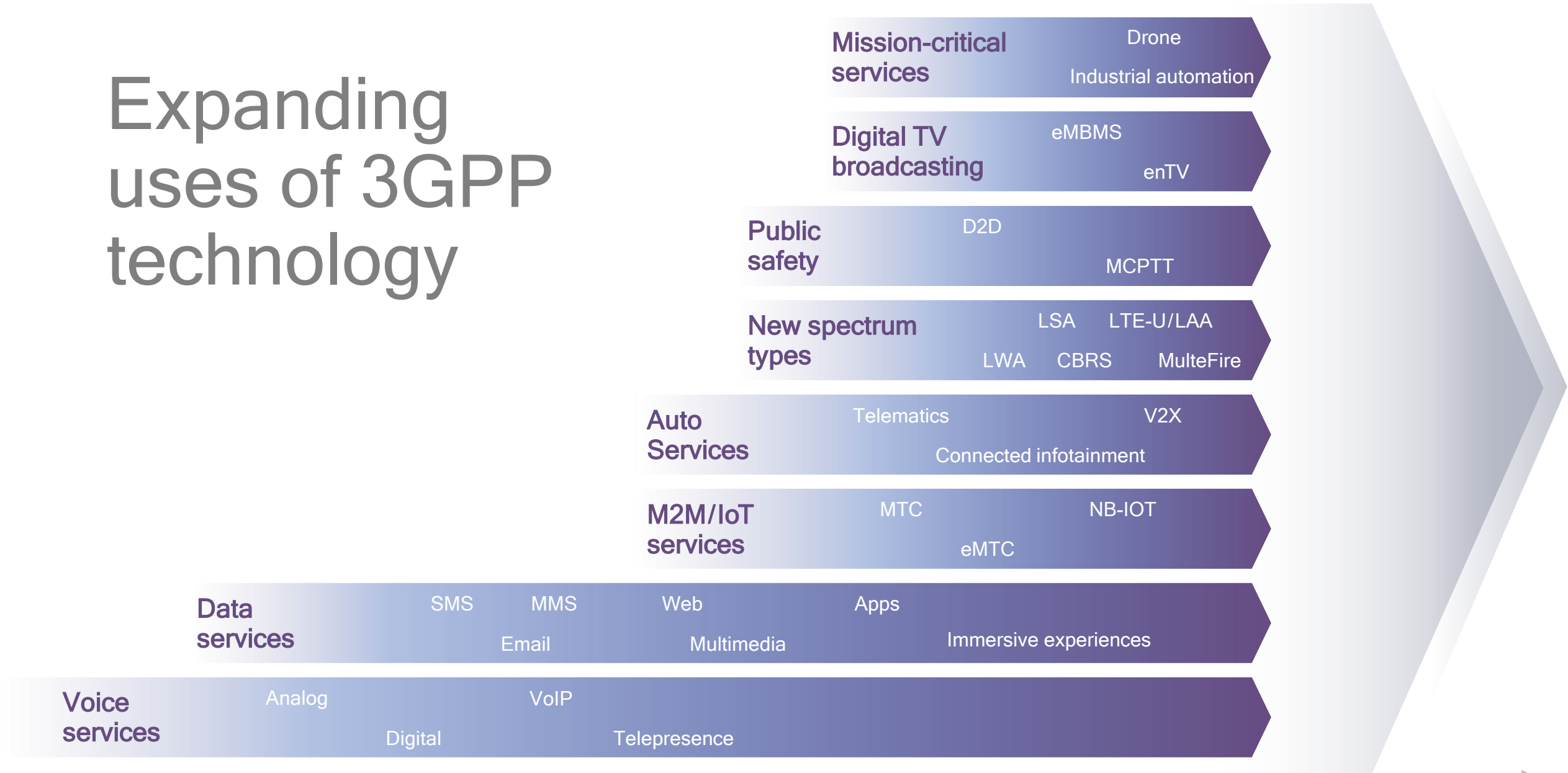


Global trials started in 2017



Our 1st announced C-V2X product in September, 2017

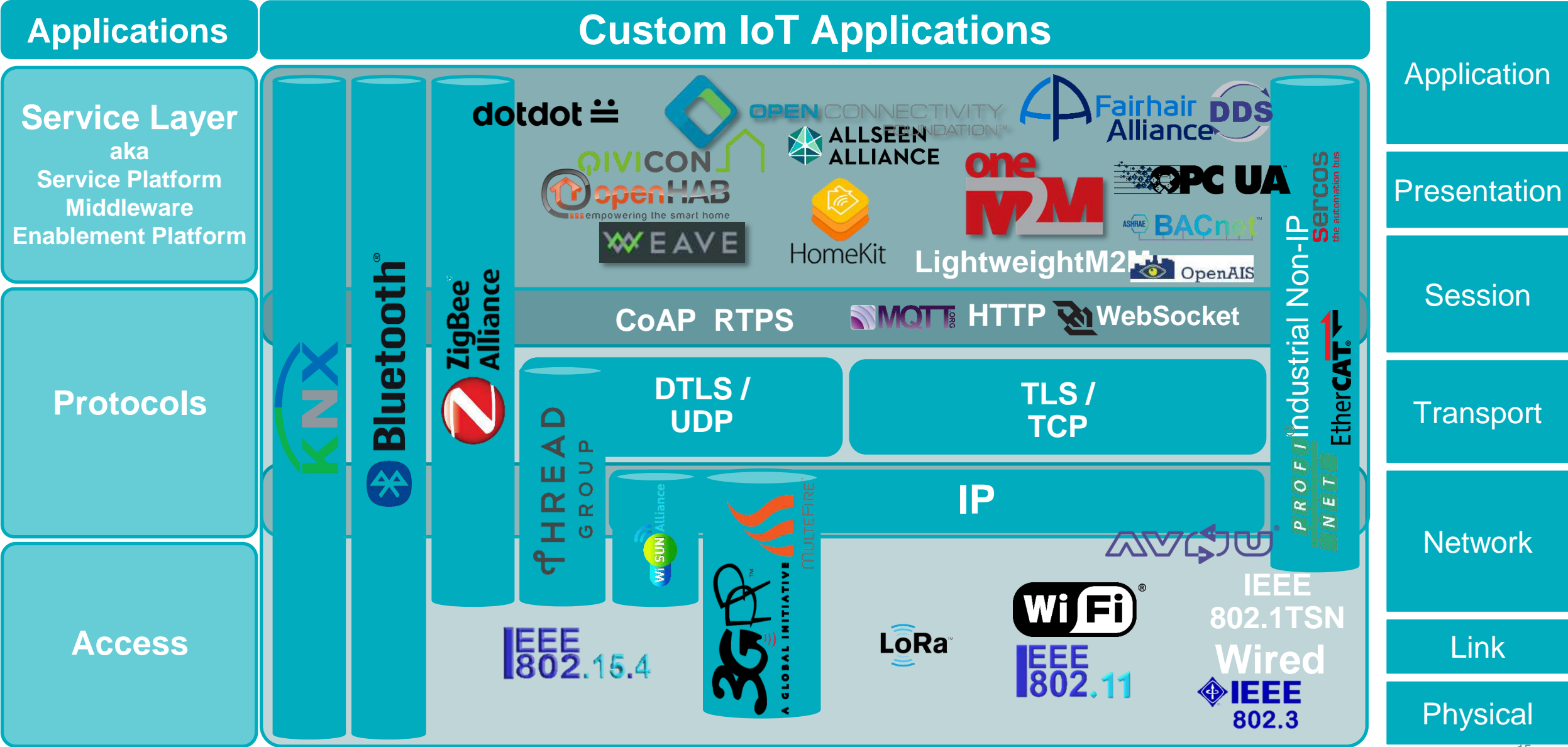
# Expanding uses of 3GPP technology





# Technologies in IoT Stack

“OSI equivalent”  
↓



# World's first tri-mode Wi-Fi / Bluetooth 5 / 15.4 SoC for the IoT

*To help address IoT fragmentation and software interoperability challenges*

## Tri-mode with advanced smart co-existence

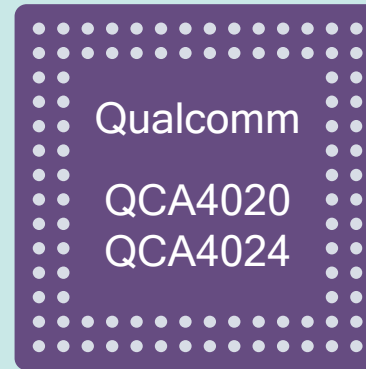
2.4 GHz / 5 GHz Wi-Fi  
802.15.4 ZigBee3.0 and OpenThread  
Bluetooth 5

## Dual-core processing

ARM® Cortex-M4 for apps  
ARM Cortex-M0 for connectivity

## Advanced HW-based security features

Secure boot  
Trusted execution environment  
Encrypted storage  
Key provisioning



## Hostless Architecture

300+ KB Internal RAM  
ARM Cortex-M4 up to 128 MHz

## Comprehensive set of peripherals





SPI, GPIOs, I2C, I2S,  
UART, PWM  
8-channel ADC

## Multiple ecosystems with pre-integration support for cloud services

Homekit  
Open Connectivity Foundation  
AWS IoT SDK  
Microsoft Azure IoT SDK



# Thank you

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