

# Unlocking New Spectrum Assets for 5G

IEEE DySPAN

March 9, 2017, Baltimore, MD

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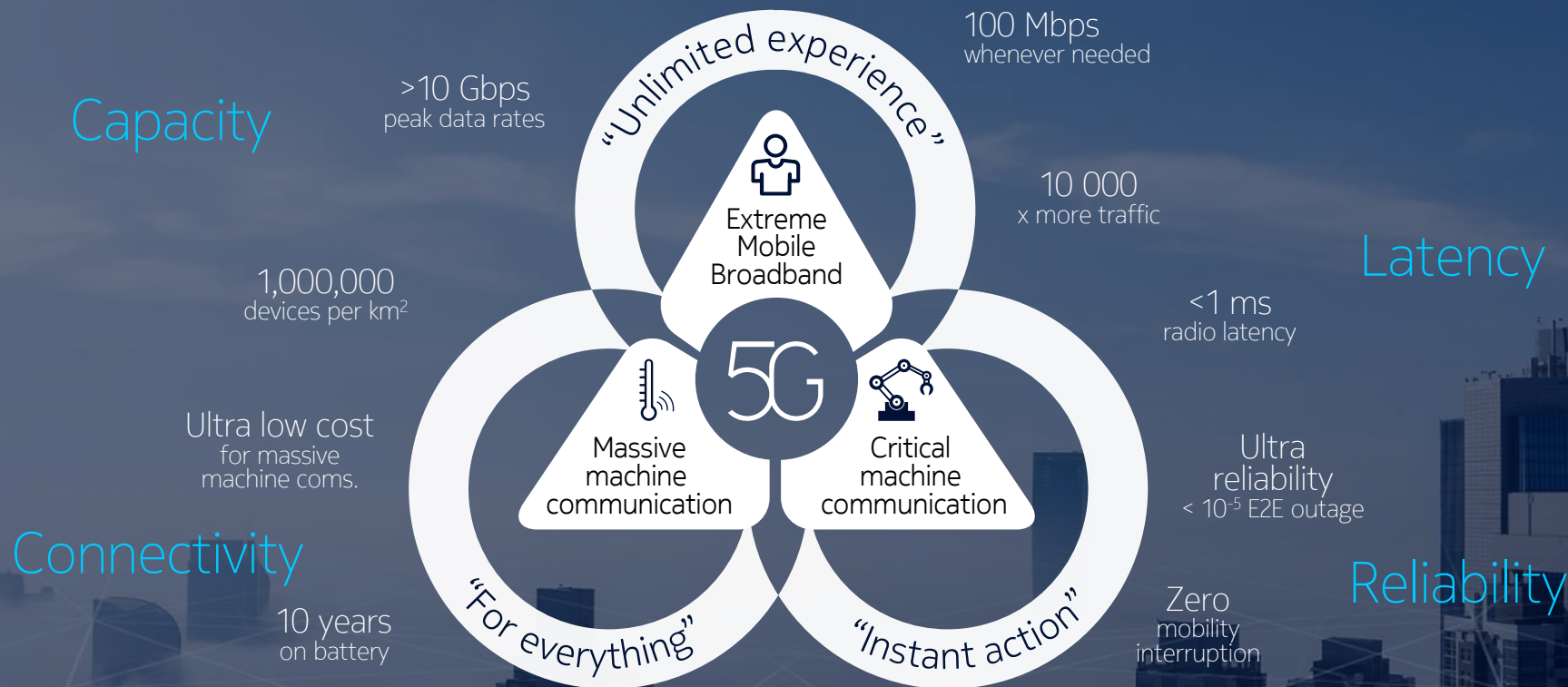
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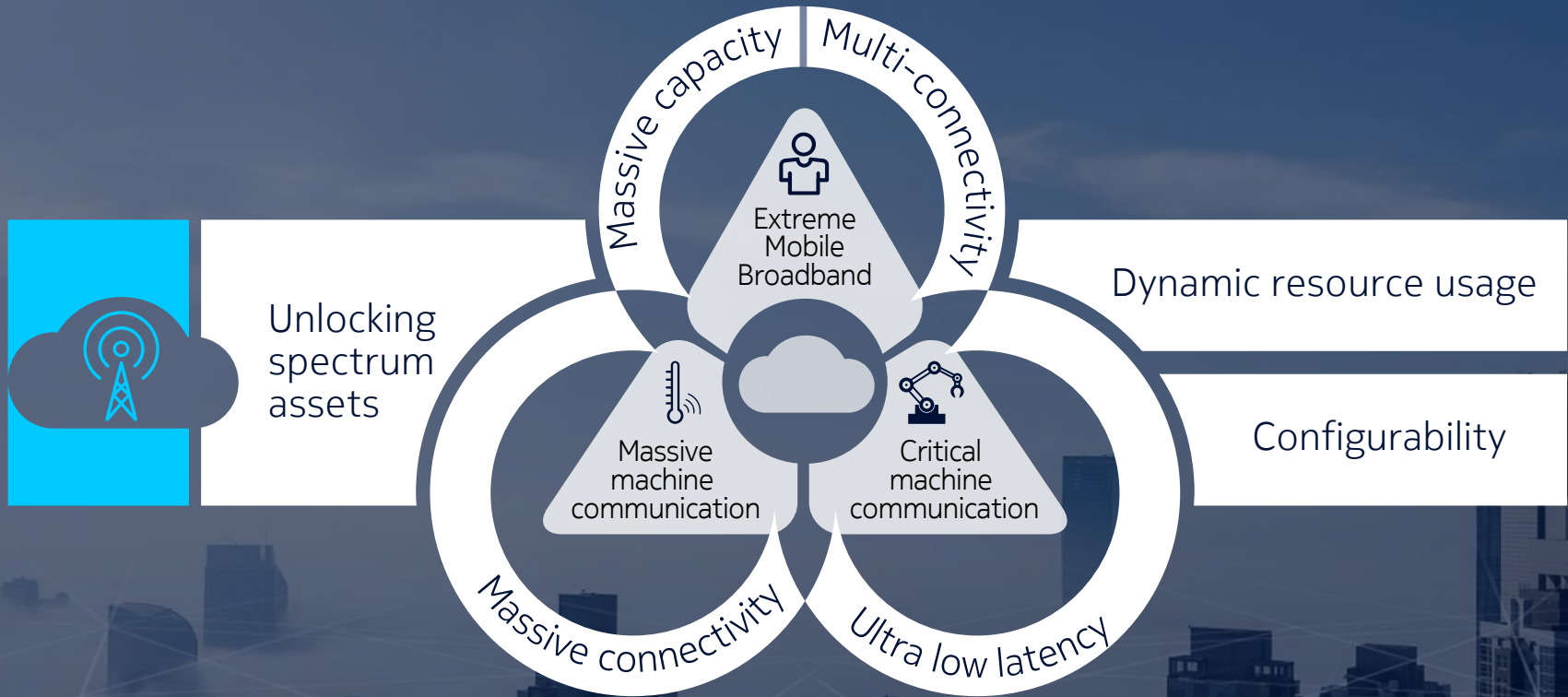
March 7, 2017, Baltimore, MD

- WHAT is 5G and WHY is it significant?
- WHEN can we expect 5G?
- WHERE and WHEN do we find spectrum for 5G?
- HOW can we take the 5G spectrum into use?

# The network will radically change



# The network will radically change







FUTURE OF ENTERTAINMENT

# 360-degree to Free Viewpoint

1s e2e

Streaming video  
start-up time



1s network RTT  
~ conventional 2D screen video

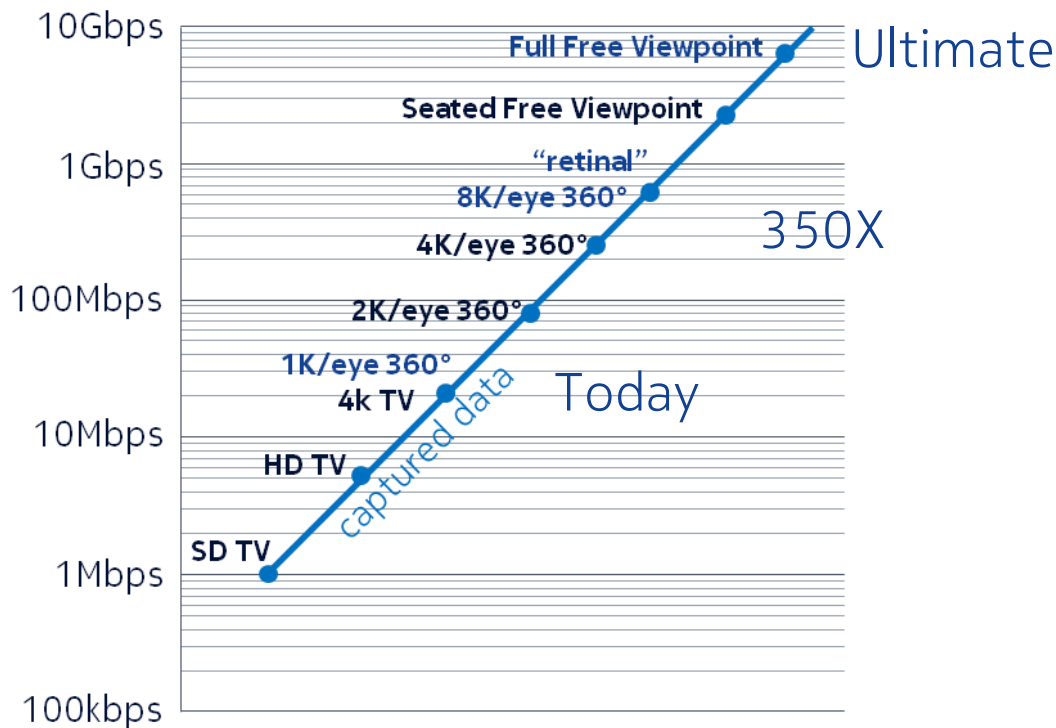
15 ms e2e

Motion-to-photon



Handled by local sensors and  
rendering GPU

## Bandwidth requirements



# 360-degree to Free Viewpoint

Bandwidth  
efficient  
MR video  
streaming



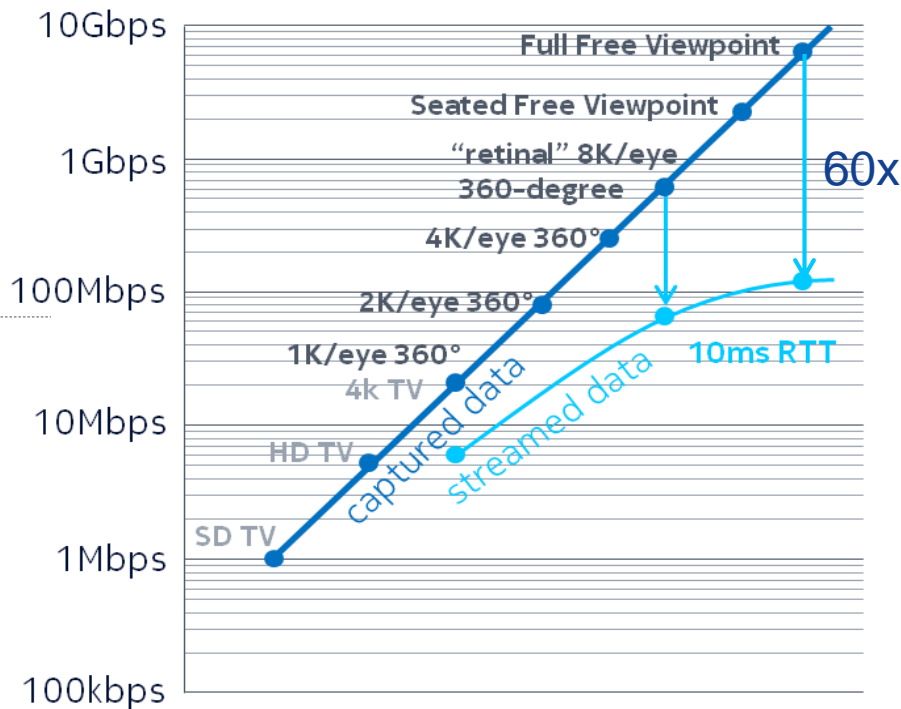
1ms to 100ms

15 ms e2e  
Motion-to-photon

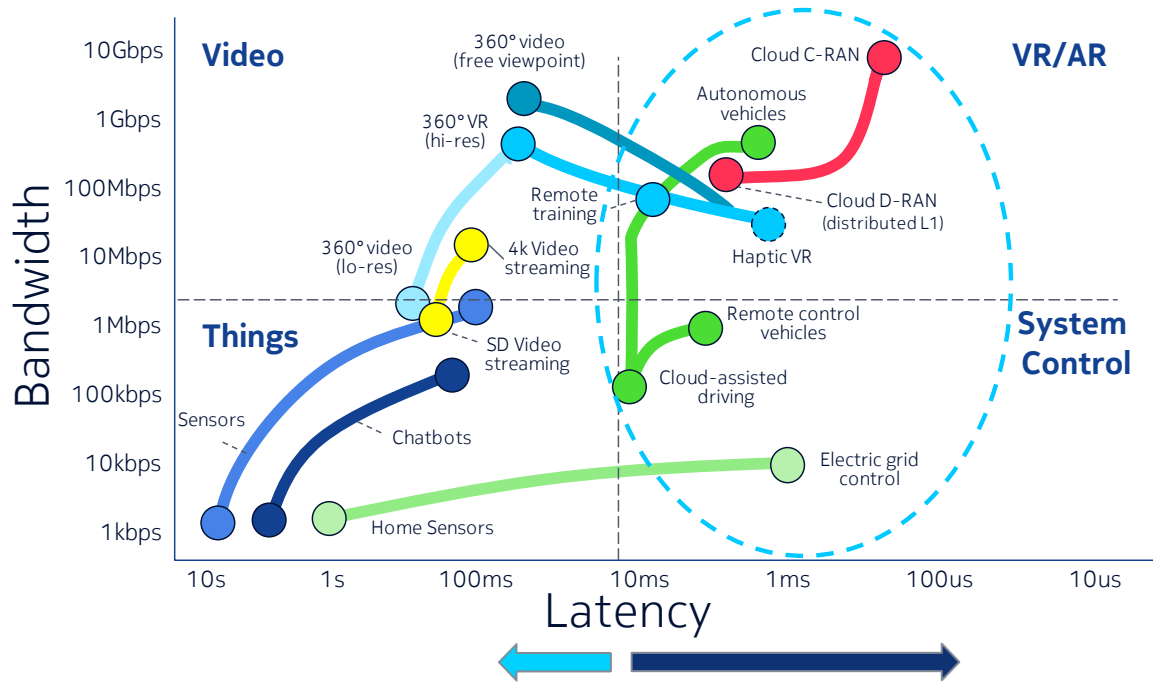


Handled by local sensors and  
rendering GPU

## Bandwidth requirements



# New applications redefine network requirements



## Low latency drivers

- Virtualized cloud access
- Interactively-intense AR/VR applications
  - virtual remote control
  - real time cloud rendering
  - haptic interaction
- Critical control systems
  - industrial/utility
  - vehicular automation



# 5G is happening NOW

## MWC 2017: Nokia, BT team to test virtual reality

Editor | 28 February 2017

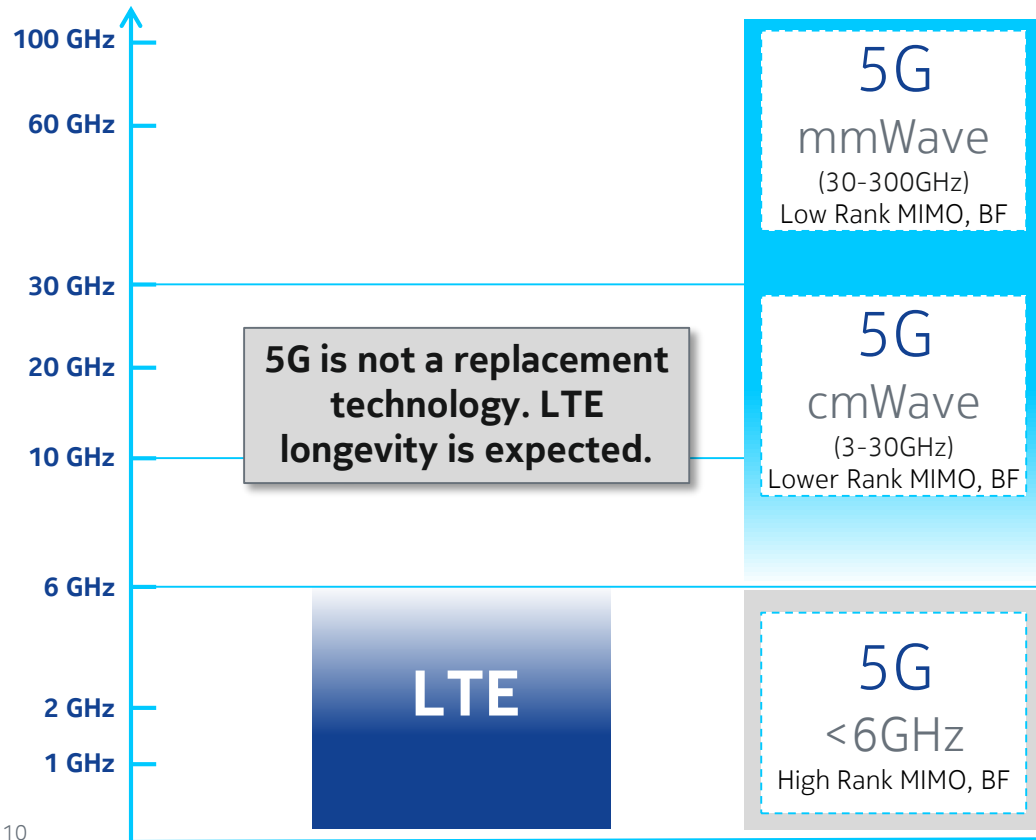
The development of virtual reality (VR) continues apace with BT and Nokia partnering to see how 5G networks can be used to maximise the experience of customers watching fully immersive live sport or entertainment in future high definition (HD) VR.

Nokia heralds 5G era with  
commercial end-to-end 5G  
FIRST #MWC17

Nokia at Mobile World  
Congress: Delivering on its  
strategy to lead in 5G, IoT and  
cloud, tap new growth markets  
#MWC17

Nokia and Sprint demonstrate  
massive MIMO at #MWC17

# Spectrum

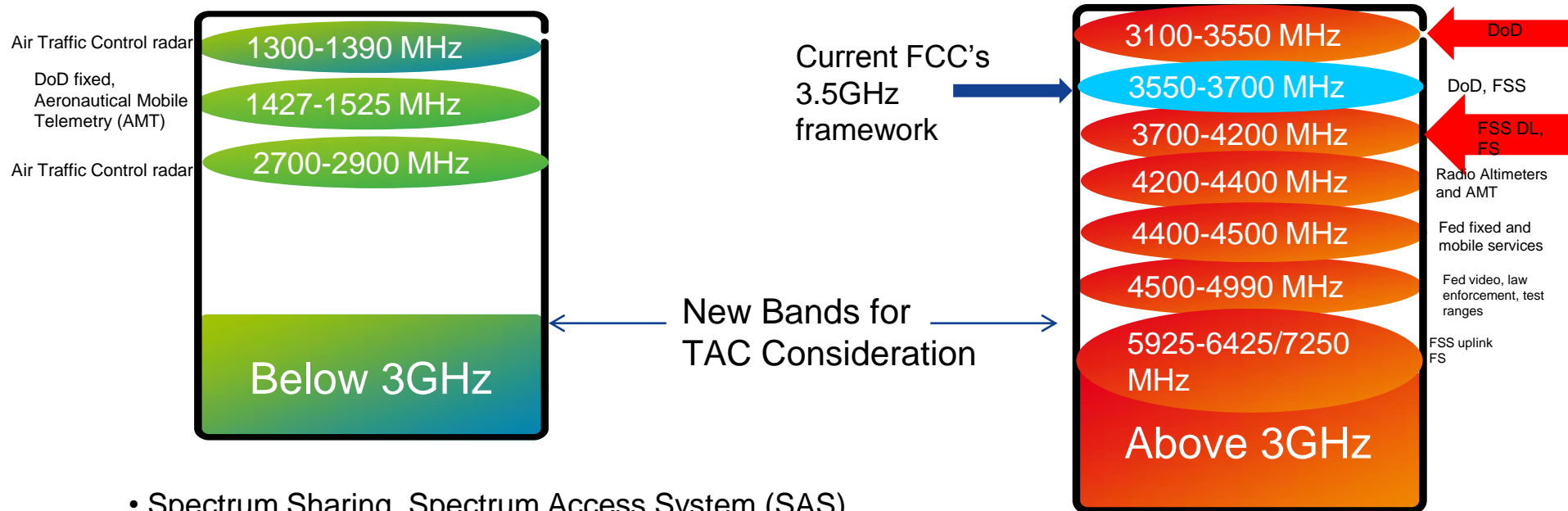


## Current Focus

- 39** US
- 32** Europe
- 28** Korea Olympics, US Fixed Access, Japan, EU
- 4.5** Japan Olympics, China
- 3.5** China, Europe, Korea, Japan
- 2.5** Europe, US
- 1.7, 1.8, 1.9, 2.1** China, US
- 900** China
- 700, 800** Europe
- 600** US

# US- Potential shared bands below 6GHz

## FCC Technological Advisory Council (TAC) Advanced Sharing WG



- Spectrum Sharing, Spectrum Access System (SAS).
- FCC to act on TAC Advanced Sharing WG findings just like Spectrum Frontiers WG led to 5G mmW Notice Of Inquiry (NOI).

# Incumbents



- Military ship-borne radar

- Operate in 3550-3650 MHz in coastal areas
- Only 17 ships with current-generation radar in the world; about 75% of this total are homeported in Norfolk, VA, San Diego, CA, and Seattle, WA



- Military ground-based radar

- Occasional in-band operations in 3650-3700 MHz at three sites: St. Inigoes, MD, Pensacola, FL, and Pascagoula, MS
- Below 3500 MHz radar operations at isolated military bases spread around U.S.



- Fixed-satellite service earth stations (receive-only)

- In-band: 35 sites around the U.S.; mostly coastal sites, limited to intercontinental international satellites
- Adjacent band (3700-4200 MHz): Thousands of sites around U.S.
- Protection criteria TBD (strict OOB limits adopted to help protect adjacent band)

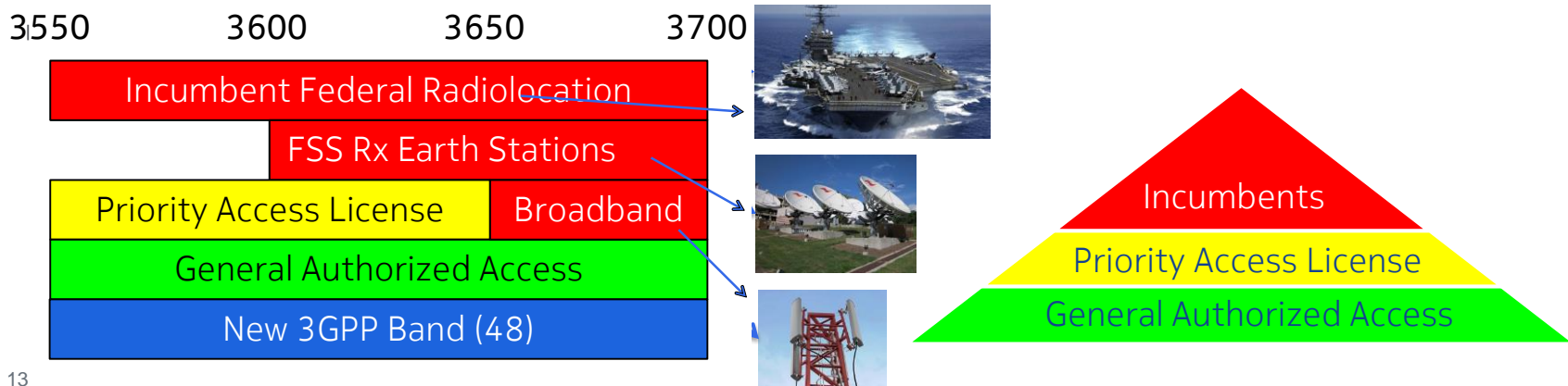


- Wireless Broadband Services (3650-3700 MHz)

- Many thousands around the country
- These stations will be transitioned to Tier 2 or 3 operation after 5 years

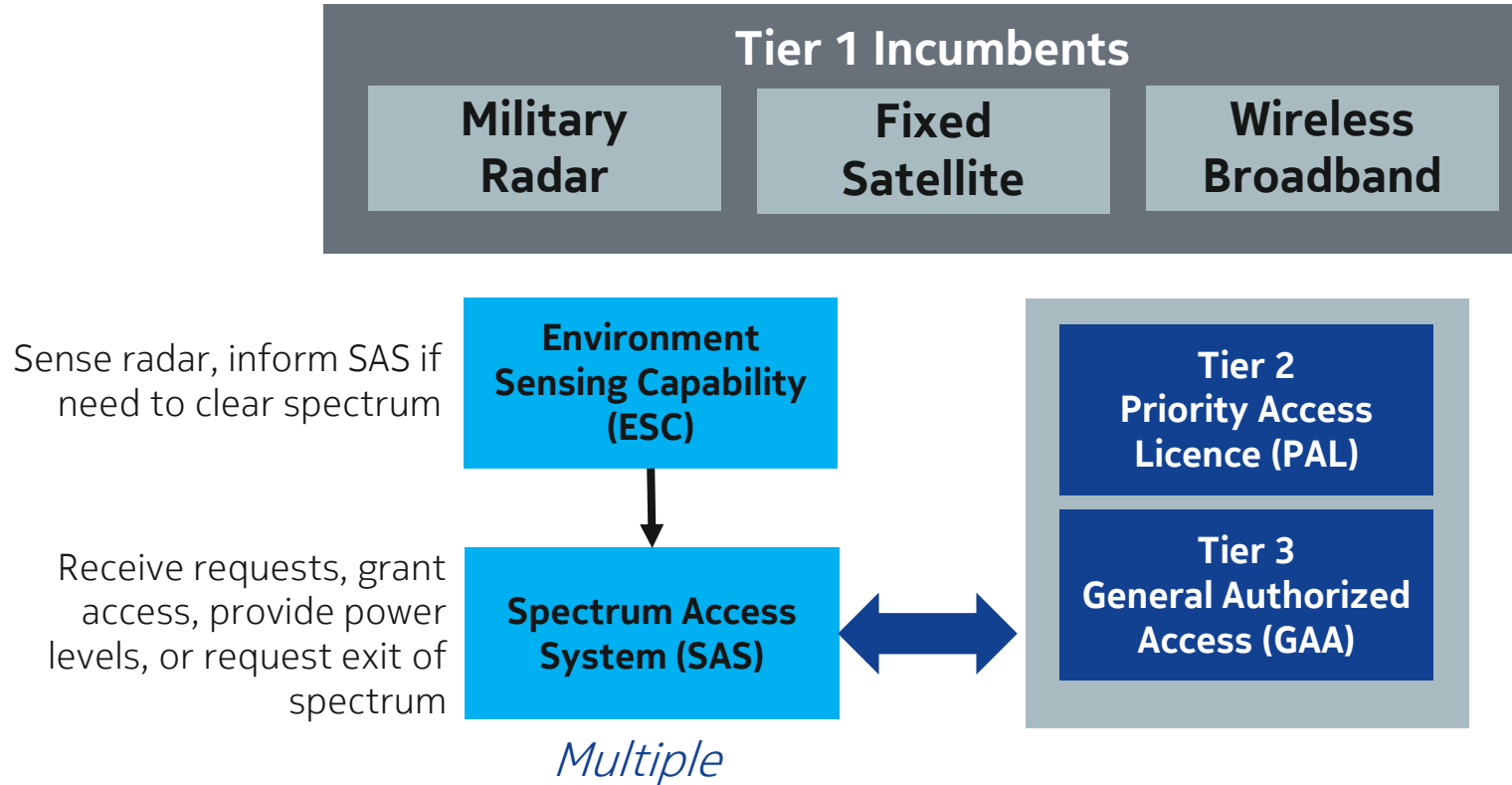
# FCC's 3.5GHz Sharing Framework

- Both GAA & PAL users must register and comply with Spectrum Access System (SAS)
  - PAL users will have “clean” exclusive use of spectrum
  - GAA users to share spectrum (non-exclusive)
- CAT-A CBSD restrictions on deployments (indoor use or outdoor use < 6 meters)
- CAT-B CBSD are limited to outdoor operations

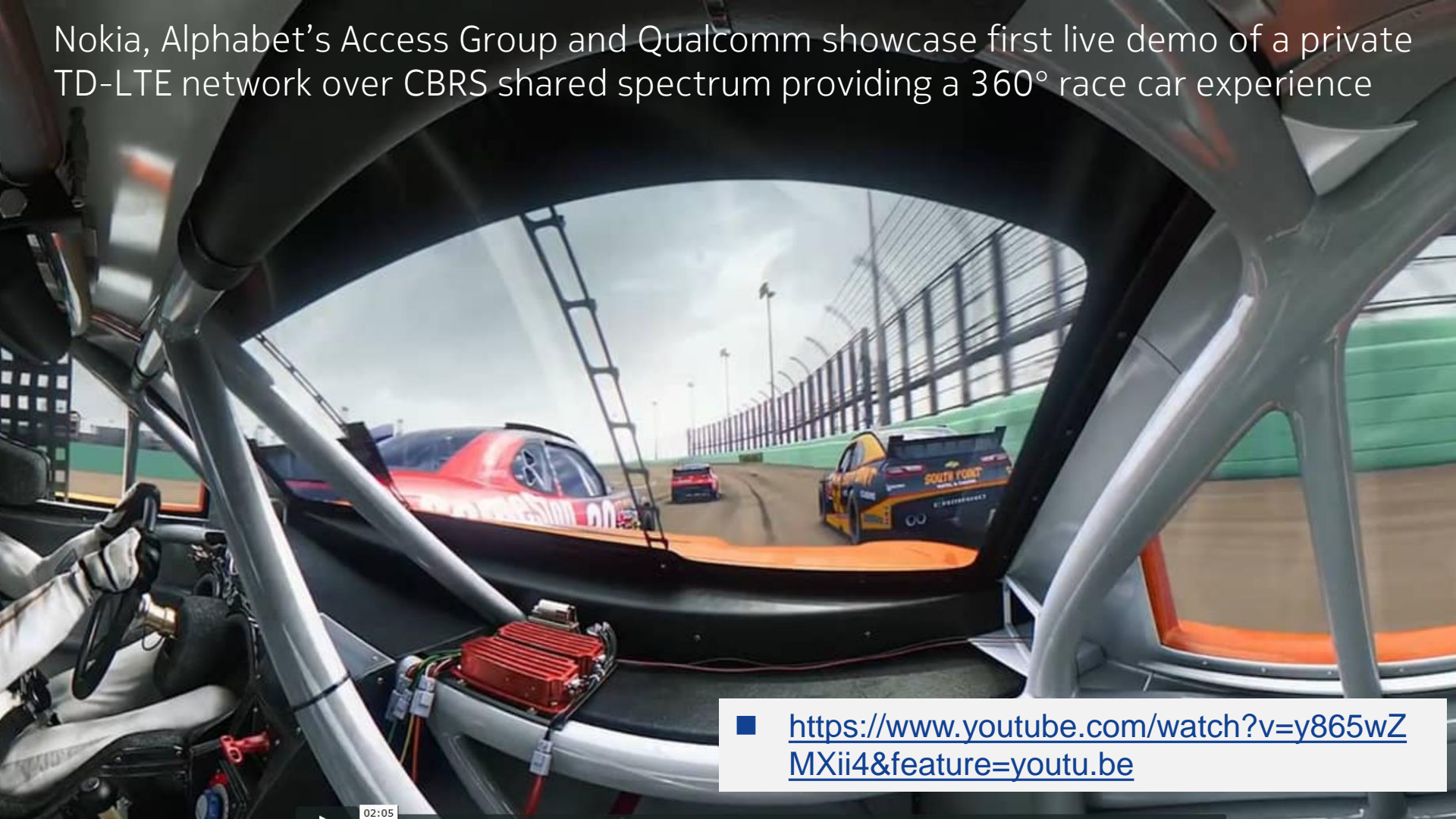




# Architecture



Nokia, Alphabet's Access Group and Qualcomm showcase first live demo of a private TD-LTE network over CBRS shared spectrum providing a 360° race car experience



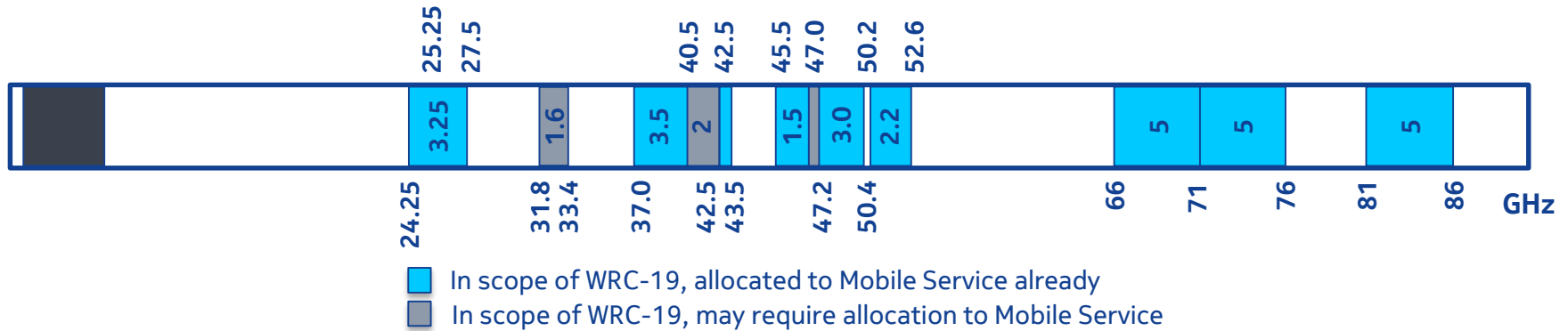
■ <https://www.youtube.com/watch?v=y865wZMXii4&feature=youtu.be>

# Above 6GHz



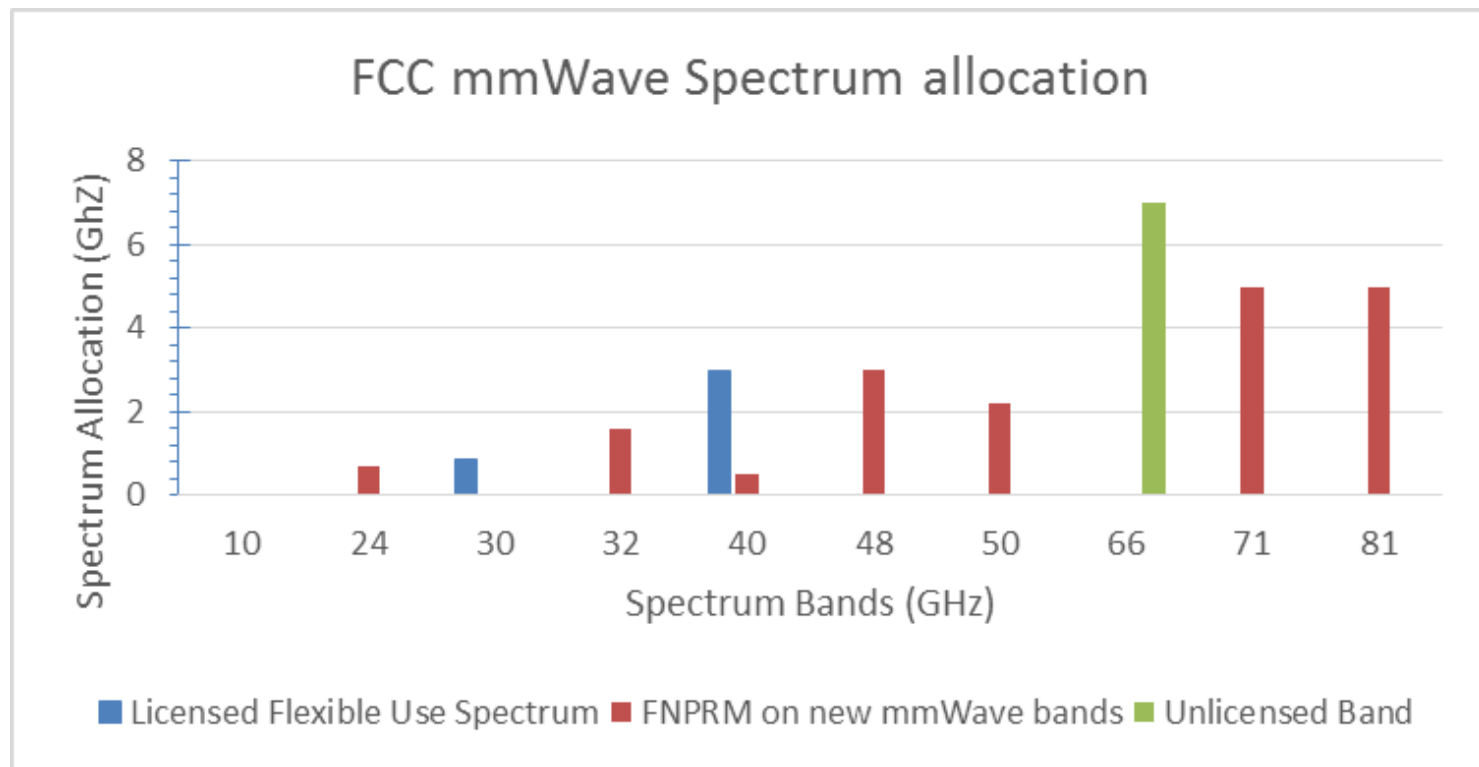
## Bands > 6 GHz under study for WRC-19

Opportunities at ~25 GHz and above based on WRC-15 decisions



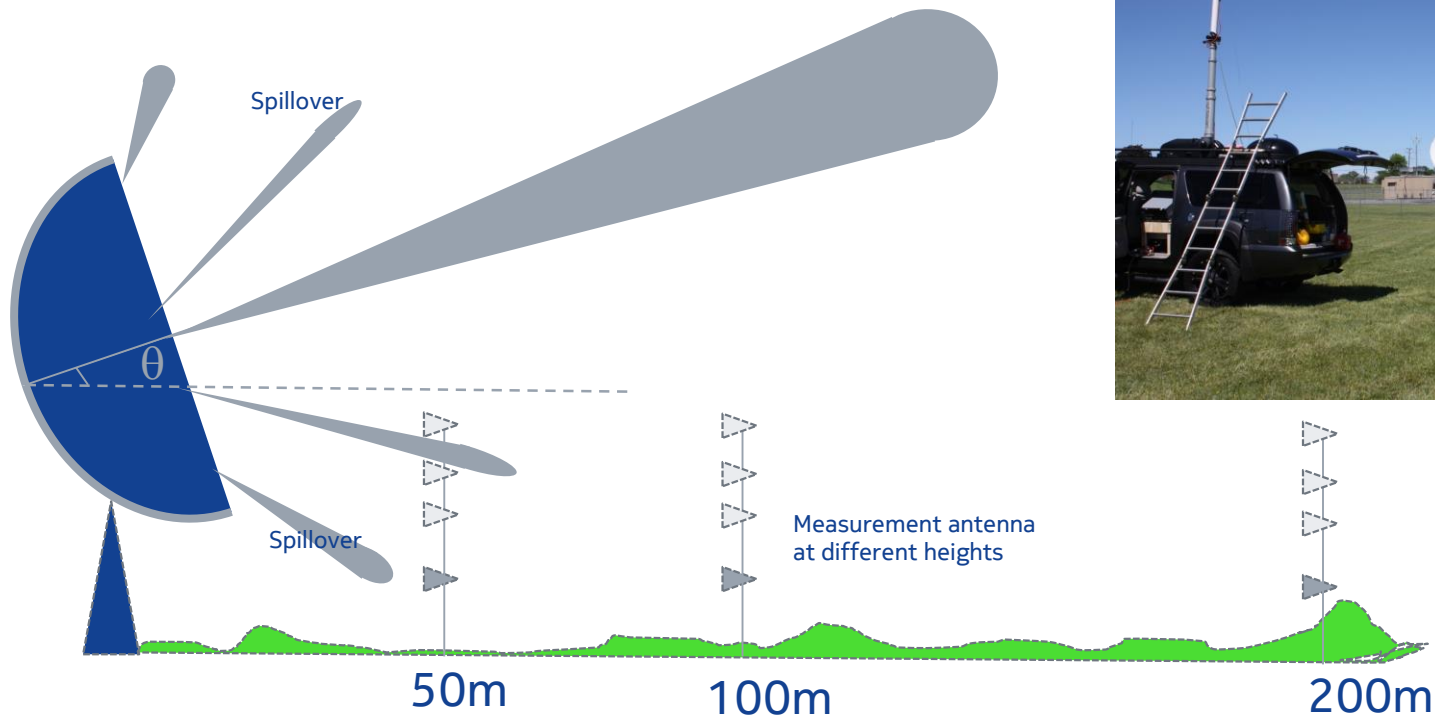
- **No band below 24.25 GHz is being studied for WRC-19**
- Bands between 24.25 GHz and 86 GHz are being studied for **WRC-19** (Agenda Item 1.13)
- New **spectrum needs** for IMT and **compatibility** with other services are being analyzed
- **Prioritization of bands**, considering global developments, is required to focus the studies on the most promising bands

## FCC R&O and FNPRM





# FSS co-existence



# Unlocking New Spectrum Assets for 5G

- 5G is a transformative technology
- 5G happens now and needs spectrum
- Spectrum sharing framework exists
- Sharing studies ongoing
- Roadmap to 5G spectrum

# THANK YOU!



