INTERNET 2 TECHNOLOGY EVALUATION CENTER

5G in Public Safety What Does It Mean?

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THE ROAD TO 5G

1G, 2G, 3G, …

- 1980s: 1G – AMPS
  - Analog radio signals
  - Circuit-switched voice only
- 1990s: 2G – Digital AMPS, cdmaOne, and GSM
  - Digital radio signals (different standards for different countries)
  - Circuit-switched voice
  - Intro of packet-switched* data (~ 40 Kbps – 384 Kbps)
- 2000s: 3G – CDMA2000 and UMTS
  - Digital radio signals (different standards for different countries)
  - Still circuit-switch voice
  - Faster packet-switched* data (~ 144Kbps – 20 Mbps)

Growing problem:

Increasing worldwide connectivity, economy

… but …

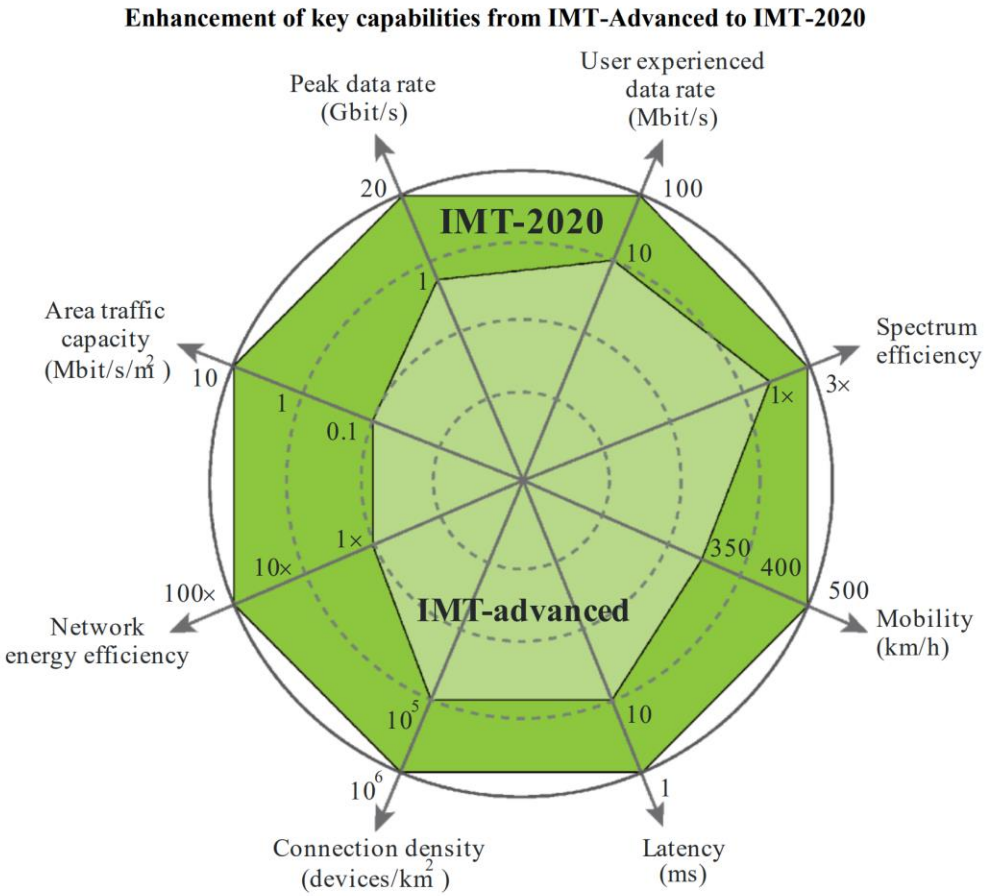
Disparate standards

AMPS = Advanced Mobile Phone System
CDMA = Code Division Multiple Access
GSM = Global System for Mobile Communications
UMTS = Universal Mobile Telecommunications System

International Alignment

- ITU – International Telecommunication Union
- 3GPP – 3rd Generation Partnership Program
  - Unified seven standards organizations across the world
- New functionality is published in “releases”
  - Release 08: Introduction of LTE (Long Term Evolution)
    - All IP, packet-switched network; VoLTE (Voice over LTE)
    - Based on ITU IMT-2000
  - Release 10: LTE Advanced
    - Based on ITU IMT-Advanced
  - Release 15: 5G NR (New Radio)
    - Based on ITU IMT-2020
  - Release 16: 5G SA, slicing, …
  - Release 17: under development …

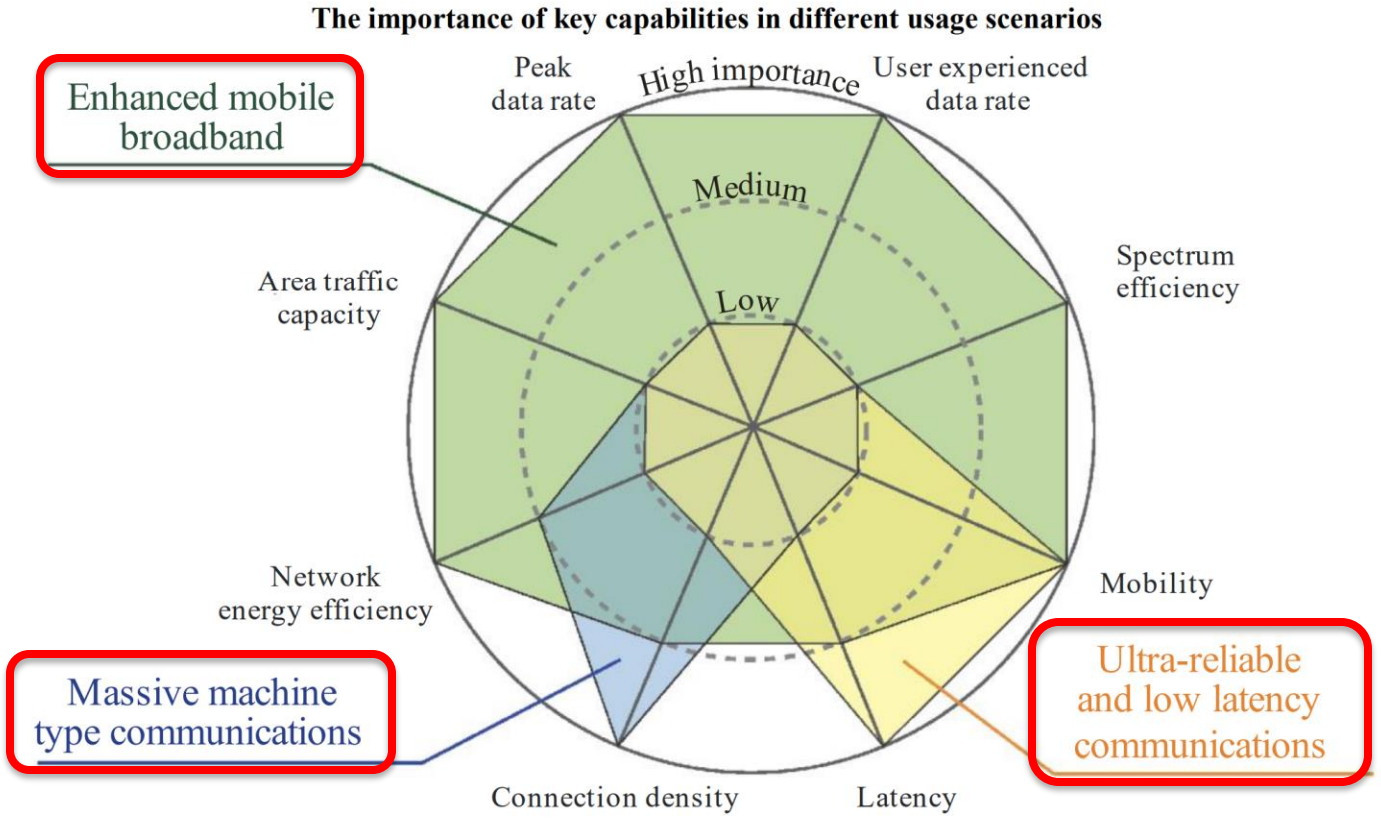
ITU 4G (Advanced) vs 5G Target



Source: Recommendation ITU-R M.2083

Characteristic	4G IMT-Advanced	5G IMT-2020
Peak Data Rate (Gbps)	1	20
User-experienced Data Rate (Mbps)	10	100
Latency (ms)	10-100	1 ms
Mobility (km/h)	350 km/h	500 km/h
Connection Density (dev/km$^{2)}$	100,000	1,000,000
Spectral Efficiency (bit/s/Hz)	10	30
Area Traffic Capacity (Mbit/s/m$^{2)}$	0.1	10
Network Energy Efficiency	1x	100x 4G Battery life = yrs

ITU IMT-2020 Primary Usage Scenarios



Source: Recommendation ITU-R M.2083

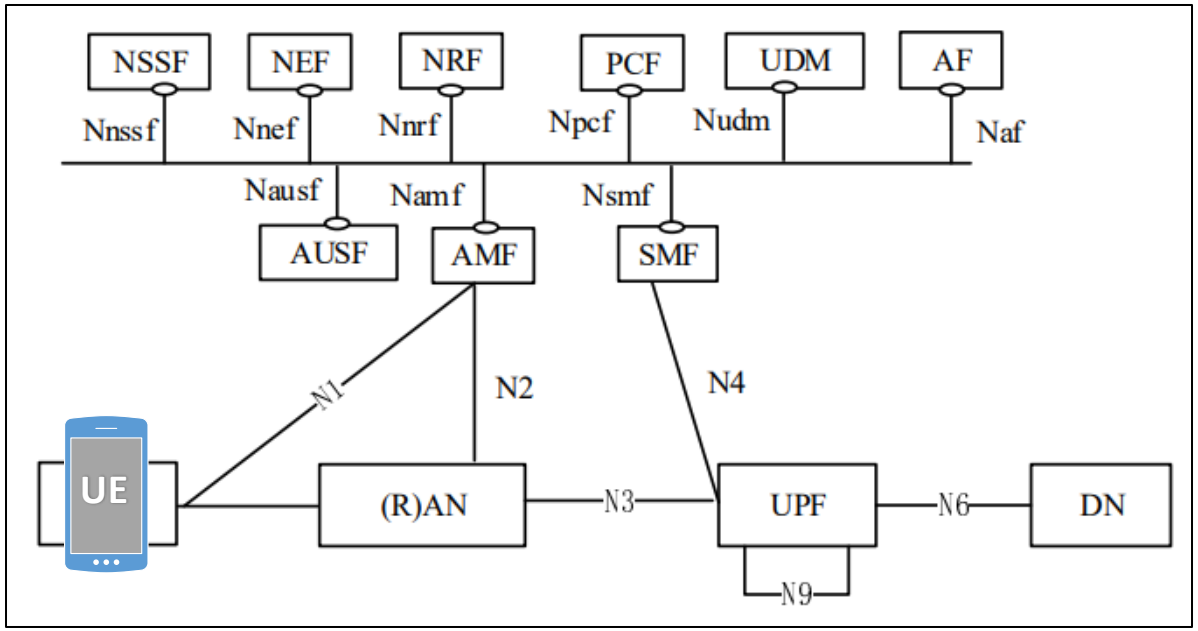
When you hear … think …

- **eMBB**
  - Broadband data & video
- **URLLC**
  - Mission critical
  - V2X (Vehicle to anything)
  - AR/VR feedback
- **mMTC**
  - IoT – Internet of Things

5G ARCHITECTURE

5G (Stand Alone) Architecture

- SBA - Service-based Architecture
  - Virtualized, containerized
- Scalable
  - Spin up additional services where and when needed
- Distributed
  - Control-plane / user-plane separation
  - Locate services where needed
- Resilient
  - Redundant NFs across machines and locations

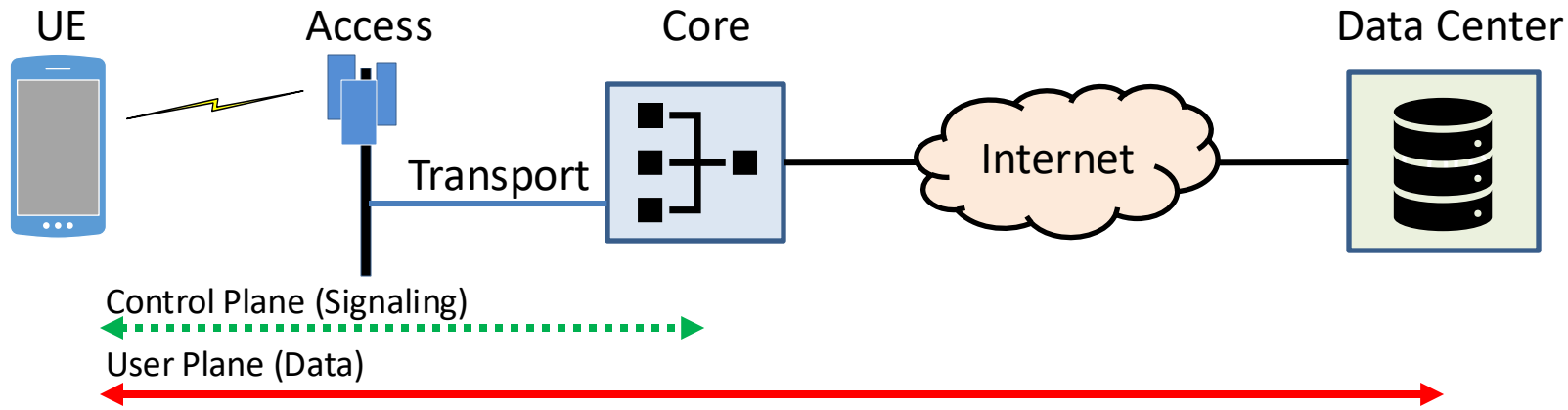


Overall: Flexibility of deployment options means greater ability to support emergency incident communications

Multi-access Edge Compute (MEC)

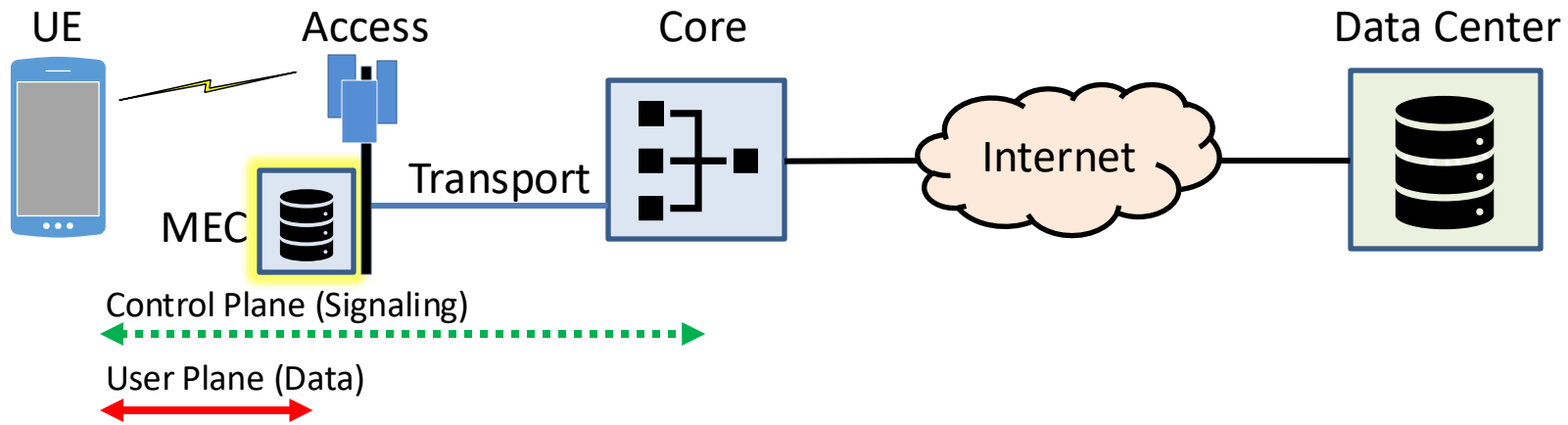
Traditional:

- Latency up to 100 ms (or more), depending on location of data



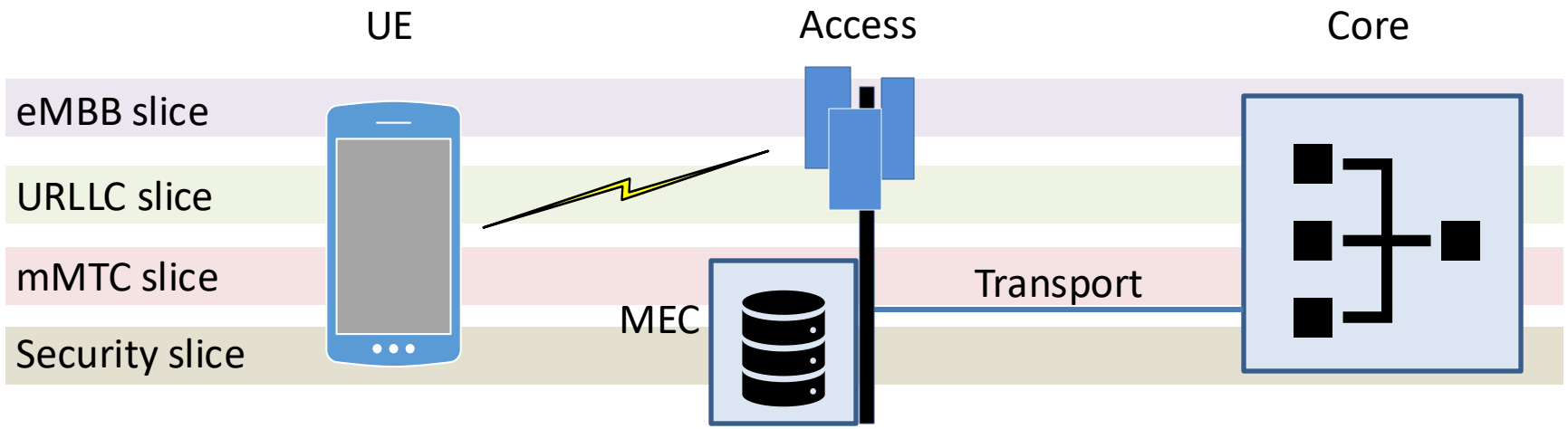
With MEC:

- Reduces latency
- Reduces backhaul load
- Improves reliability, deployability
- Ideal applications:
  - Data intensive
  - Latency sensitive



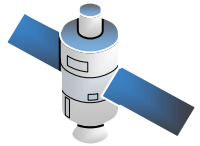
Network Slicing

- Partition / allocate network resources
  - Optimize each slice as needed for applications or security
  - Includes core, transport, RAN and MEC resources



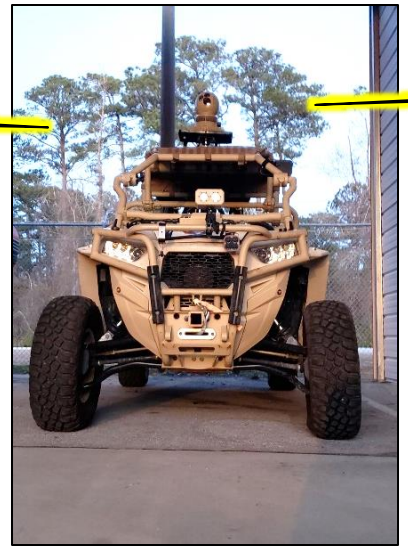
Deployable 5G Bubble

- 5G core, RAN, MEC provides local connectivity
- Integrated Access and Backhaul (IAB) can form a mesh

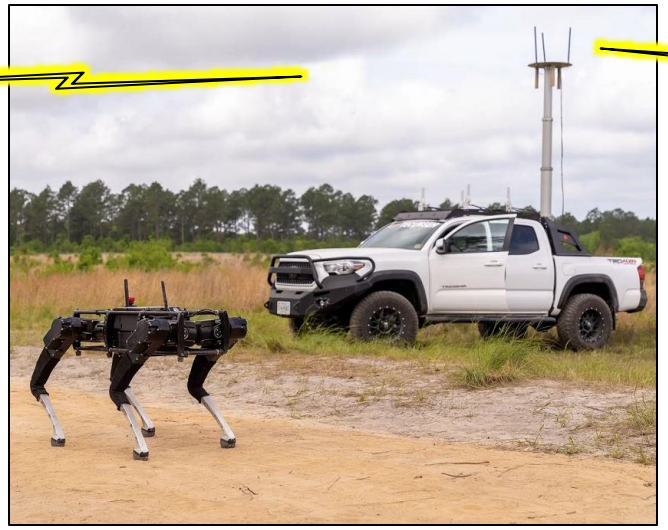


Add satellite for external connectivity

Cell on Light Truck (COLT)



All Terrain Vehicle (ATV)



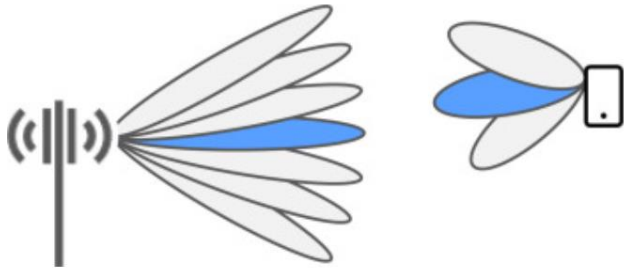
Ground-based drone

Manpack

RF Enhancements

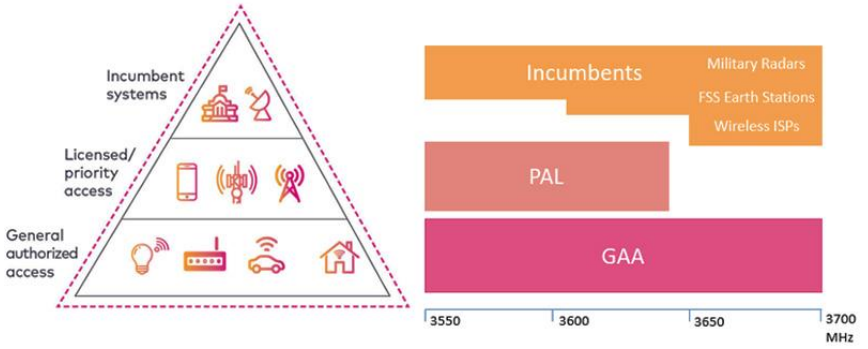
Massive MIMO and beamforming

- Demonstrated 10x (or more) improvement in capacity
- Directed energy improves coverage



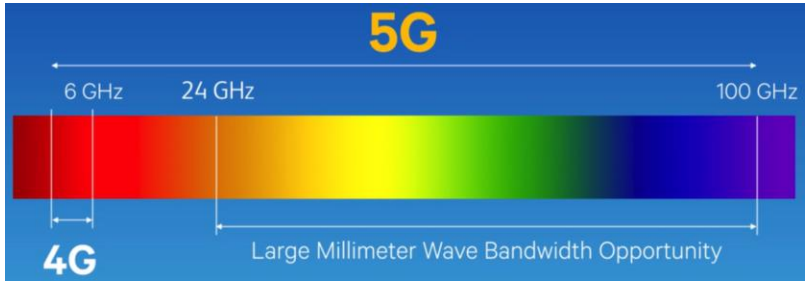
CBRS – Citizens Broadband Radio Service

- Enables private LTE and 5G networks
- Additional bands being investigated



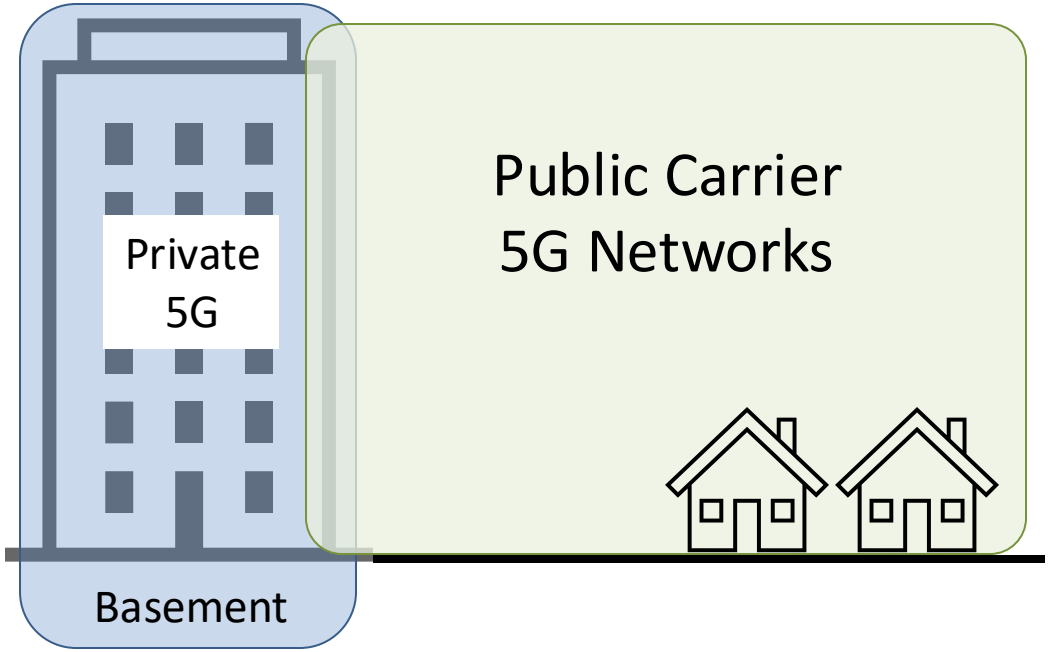
mmWave Spectrum (24 GHz+)

- Channel widths of 50, 100, 200, 400 MHz!



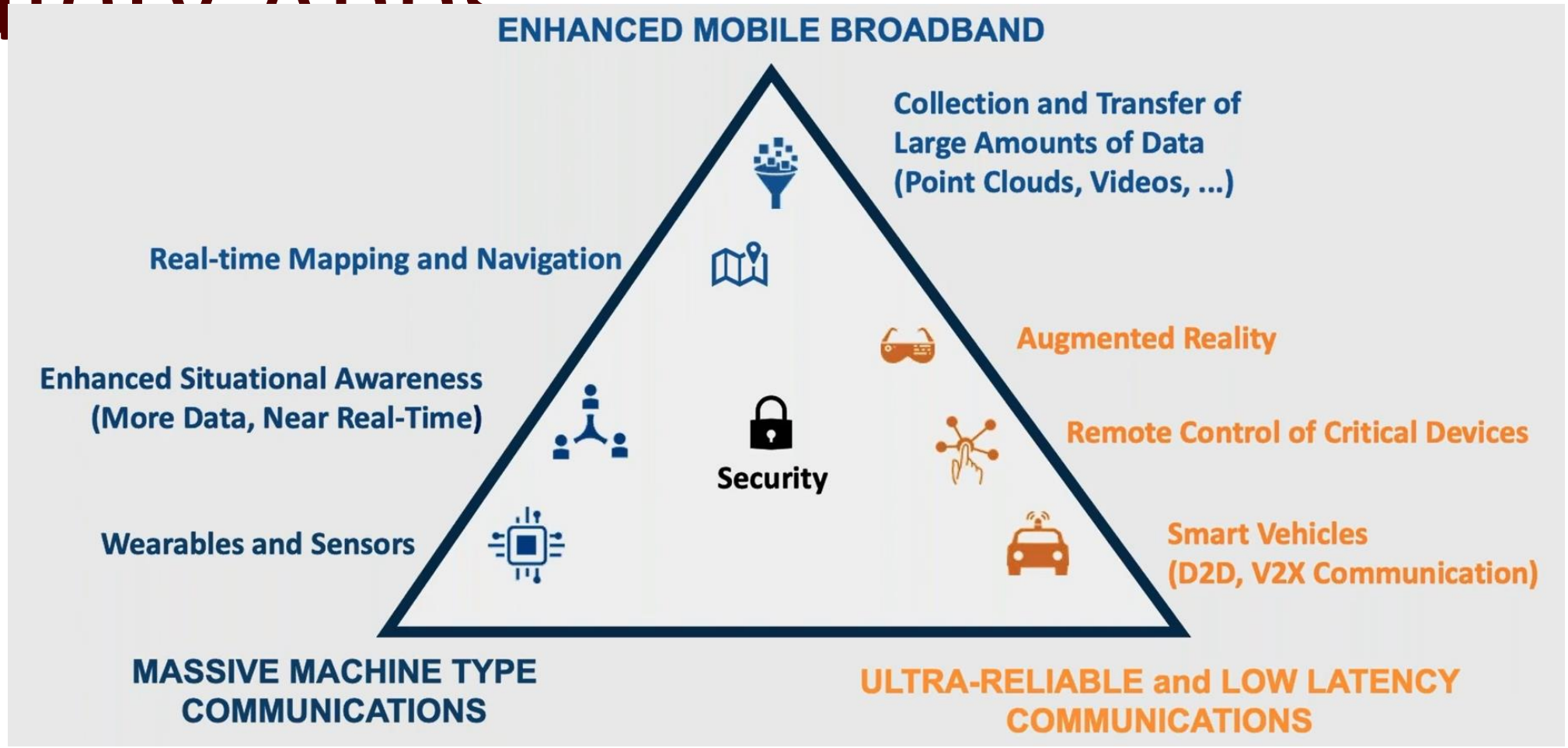
Public / Private 5G Interoperability

- Public 5G coverage may be limited in some commercial buildings
  - Especially with energy-efficient, reflective glass, and in basements
  - Especially high-bandwidth mmWave
- Private 5G networks can fill the gap
- Modern phones support both
  - Manually switch networks
  - Log in to all apps again!
- Need ability to walk into a building and switch network seamlessly
  - Especially First Responders



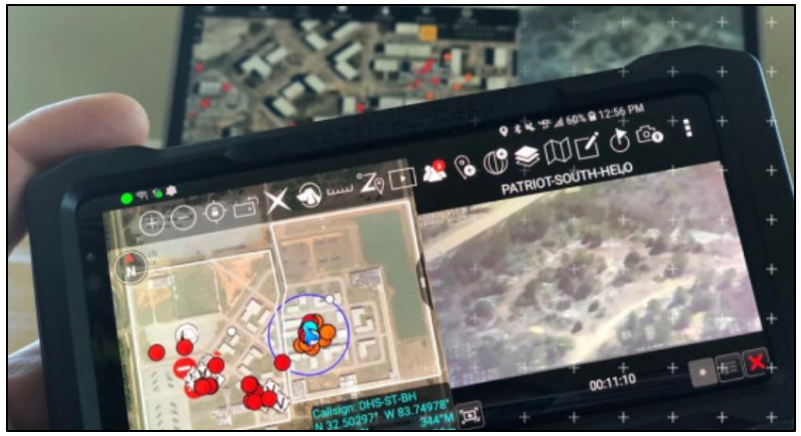
5G APPLICATIONS FOR PUBLIC SAFETY

ITU Usage Scenarios vs. Public Safety Apps



Source: NIST PSCR Webinar: 5G for Public Safety

Situational Awareness



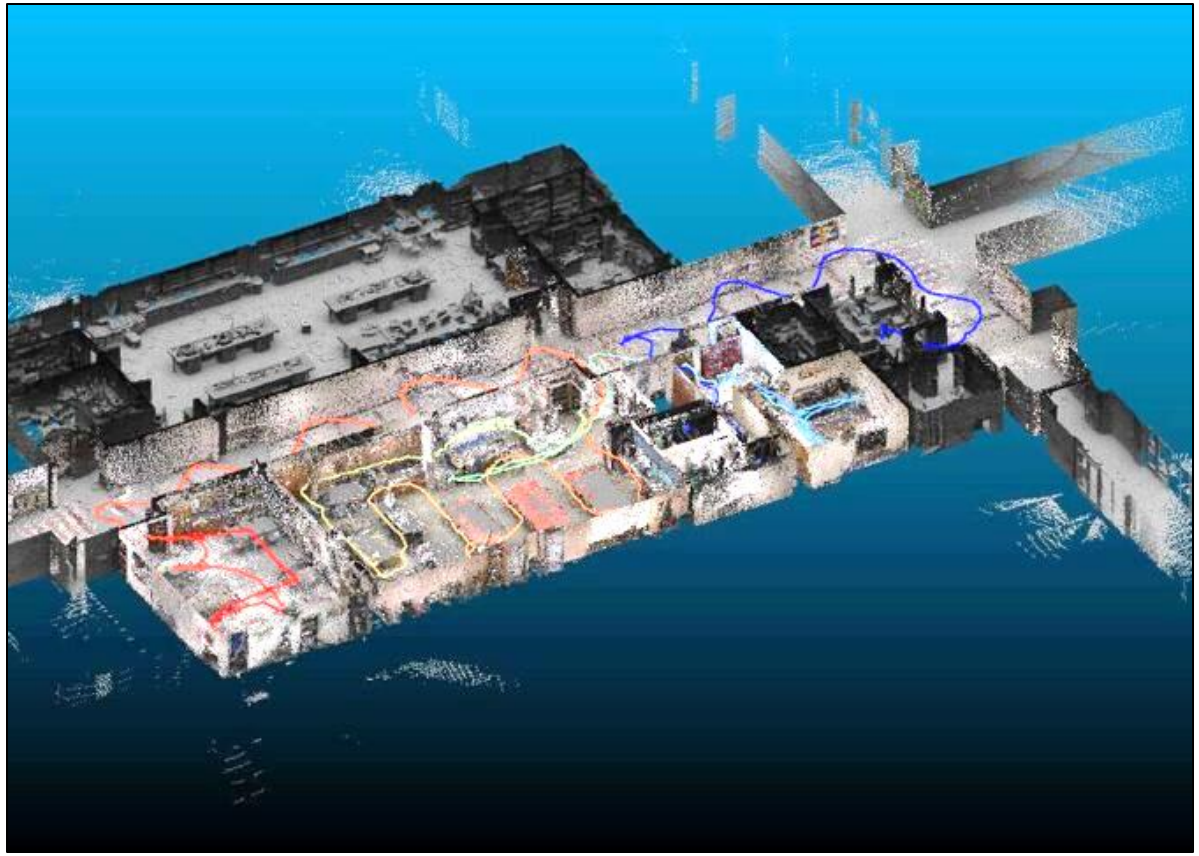
ATAK – Android Team Awareness Kit

- More mapping and coordination tools
- More video (much more!)
  - Local: body cameras, dash cameras
  - Surveillance: fixed, robot mounted, drone mounted
  - Higher resolution: 4K (or greater)
- Need to stream/share direct from the robot or drone
  - Old:
    - land the drone, download the SD card, upload to server
    - Issues: insufficient RF bandwidth, backhaul bandwidth
  - New:
    - stream direct from drone to UE(s)
    - Stream direct from drone to storage/distribution app, then to UE(s), ICP, EOC

- 5G: eMBB; mmWave spectrum (bandwidth); MEC (no need to backhaul)

Big Data

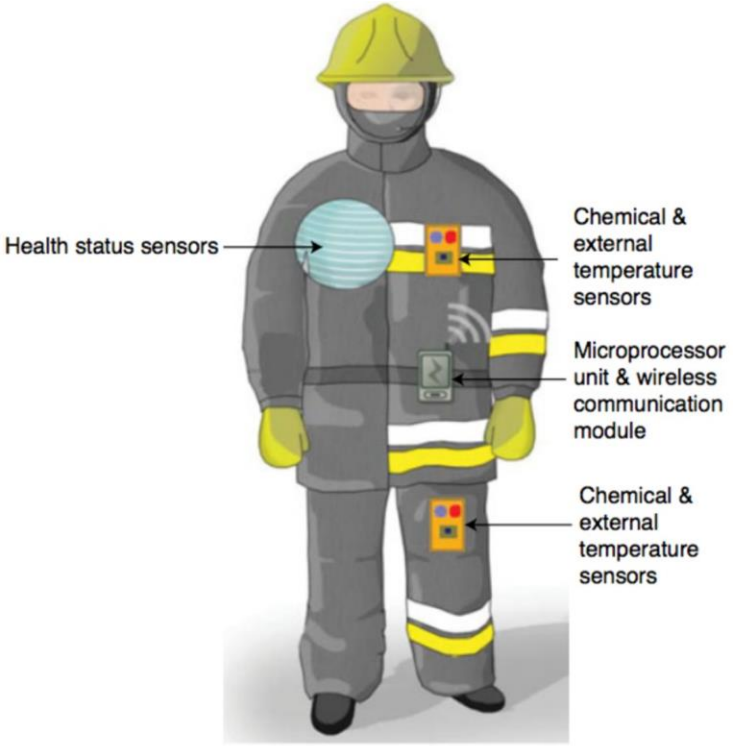
- LiDAR – Light Detection and Ranging
  - Remote sensing process; collect measurements for 3D models
  - Hand-held, tripod, backpack, robot, drone
  - Latest mobile phones have LiDAR scanners
- Point Clouds
  - Represent spatial data as a collection of coordinates
  - Can be rendered as pixels or converted to polygons for 3D representation of structures, objects
- Public Safety Examples
  - Indoor and outdoor mapping
  - Search path mapping
  - Escape route mapping
- 5G: eMBB, MEC



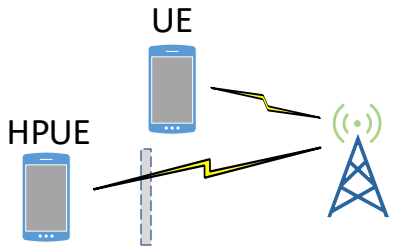
Source: National Institute of Standards and Technology

Wearables and Sensors

- Technology
  - Communications
    - Audio, video (body-cam, dash-cam, deployables, …)
    - Location tracking (X,Y and Z coordinates)
    - Telementoring (EMS)
    - AR/VR: search routes, escape routes, team locations, …
  - Heath status – Smart PPE
    - First responder: Body temp, heart rate, respiration rate, …
    - EMS: 12 lead electrocardiogram (ECG), blood pressure, pulse oximetry, …
  - External environment
    - Temperature; particulate; chemical, biological, radiological, nuclear (CBRN); shot spotter; …
  - Intrinsically safe!
- Non-technical issues
  - Legal, workplace, privacy, political, operational, …
- 5G: mMTC (sensors), eMBB (comms), URLLC (Mission Critical Services), MEC

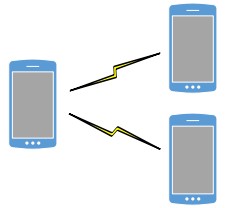


Mission Critical Enhancements



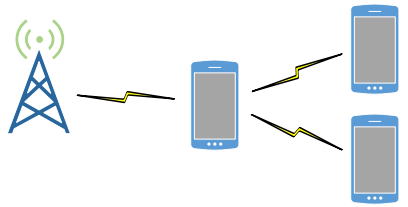
High Power User Equipment
- Band 14 Only
- Not directly 5G related, but useful for MCX

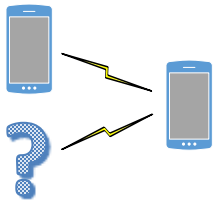
Off-Network MCPTT
- Mission-critical Push-To-Talk
- 5G enhancements: coverage and reliability; off-net too

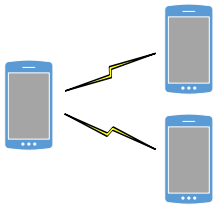


New Radio (NR) ProSe (Proximity Services)
- **Discovery:** Application and group member discovery between devices in proximity
- **Modes:** One-to-one and one-to-many

UE-to-Network Relay
Indirect access to network via another device

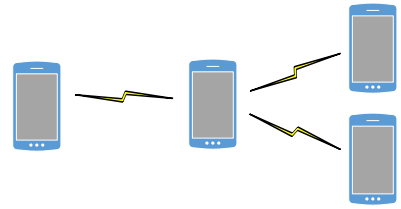




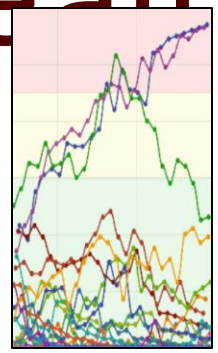


5G: URLLC

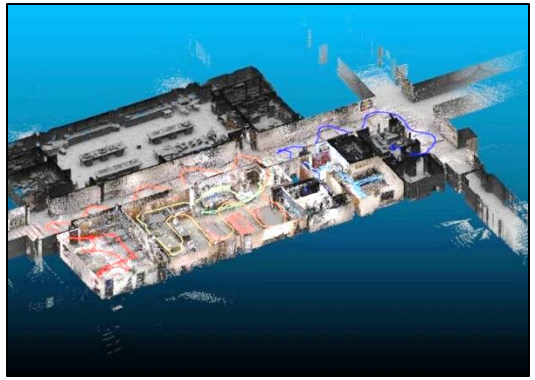
UE-to-UE Relay
Communication with a device via another device



Augmented Reality & Virtual Reality

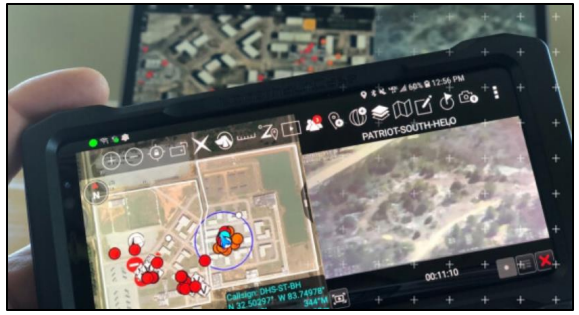


Sensor Data



Realtime mapping

5G: eMBB, URLLC, mMTC

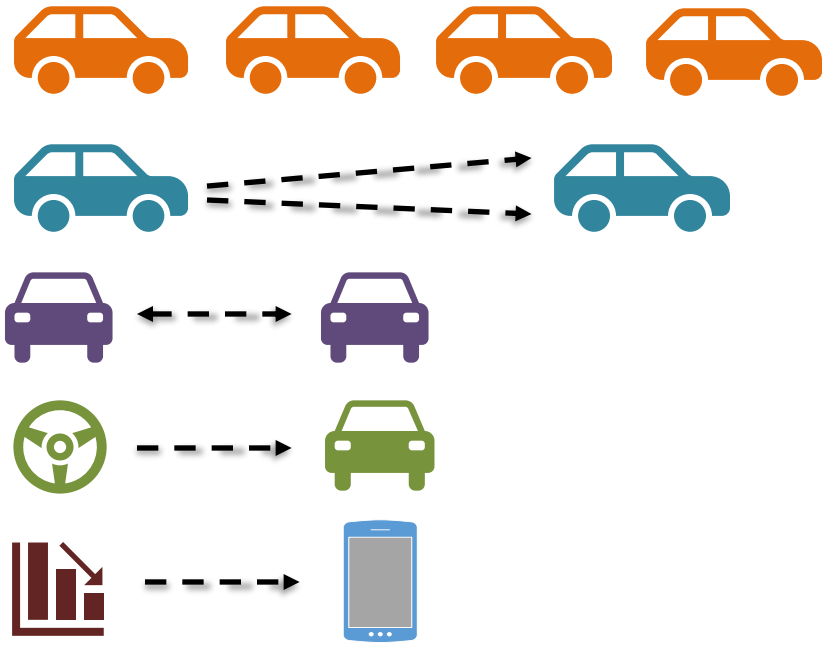


Situational awareness

Surveillance Video

Remote Control & Autonomous Vehicles

- 3GPP 5G NR V2X (Vehicle to X) Use Cases
  - Vehicle Platooning
  - Advanced Driving
  - Extended Sensors
  - Remote Driving
  - Vehicle QoS Support



- 5G: URLLC, mMTC

Conclusions

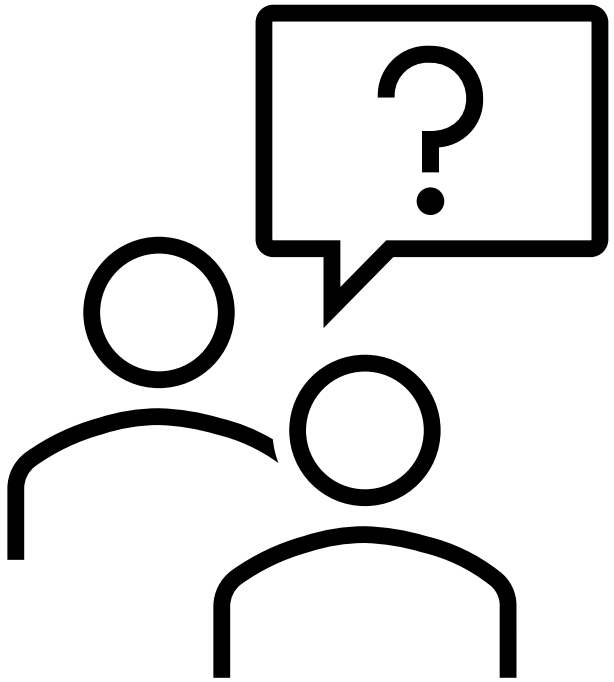
- By design, 5G will have direct benefits for public safety
  - Architecture, Security, Applications (many!)

- Application use cases will be a combination of
  - eMBB – Enhanced Mobile Broadband
  - URLLC – Ultra Reliable and Low Latency Communications
  - mMTC – Massive Machine-type Communications

- We know what it *CAN* do; what it *WILL* do is up to you
  - Experimentation, vendor partnerships, interoperability events

QUESTIONS?

LET'S TALK



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