



U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – C5ISR CENTER

Leveraging 5G Networks for Tactical Army Communications:
The Good, The Bad, and The Ugly

Jack L. Burbank
Senior Wireless Network Engineer
Sabre Systems, Inc.
Space and Terrestrial Communications Directorate (S&TCD)
Tactical Communications Division, Commercial Technology Evaluation and Integration Branch

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**Workshop on 5G Technologies for
Tactical and First Responder Networks**
October 7, 2019, 8:00 AM-6:00 PM
Johns Hopkins Applied Physics Laboratory, Laurel, Maryland
This workshop will be the catalyst to develop relevant use cases, drive standards,
and investigate deployment suitable for tactical and first responders.





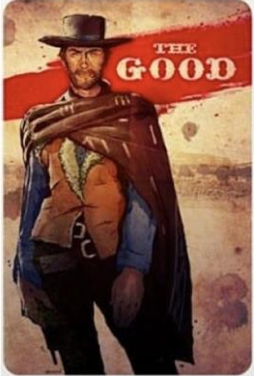
OUTLINE



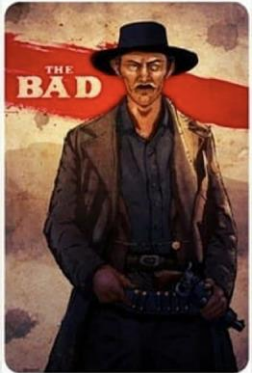
- **Introduction**
- **Benefits of 5G**
- **Key 5G Technology Enablers**
- **Potential 5G Use Cases**
- **Historical Challenges of Tactical Cellular**
- **Areas of Consideration for Tactical 5G**
- **Conclusions**



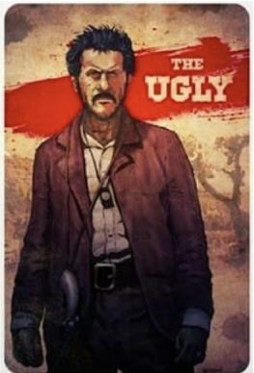
INTRODUCTION



- 5G technology is extremely exciting for the field of communications
- Has the potential to enable massive social and technical change
- Expected to become a disruptive set of technologies
- Tactical military community would naturally love to leverage these capabilities to better serve the Warfighter



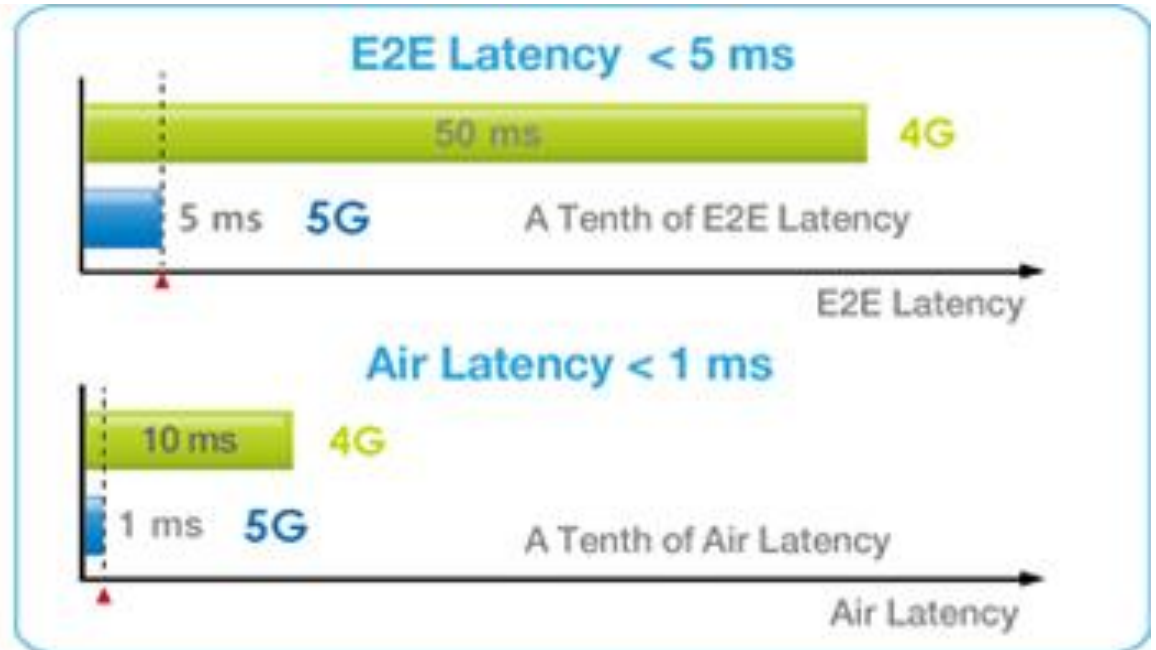
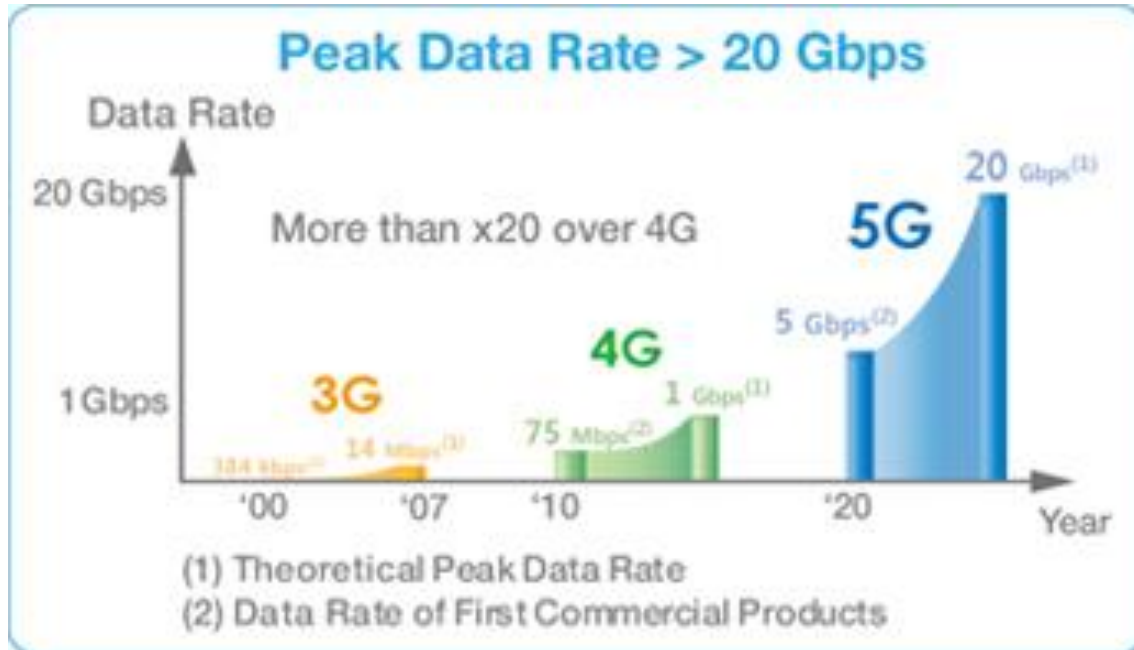
- Commercial cellular technologies have, to date, proven somewhat elusive in terms of adopting for tactical military usage
- Some key challenge areas that have persisted across many generations of cellular
- 5G expected to provide solutions to alleviate some of these challenge areas



- There remains multiple areas of consideration that likely requires technology and policy maturation before 5G can be effective as a tactical communications solution
- However, overall...5G holds great promise and should be explored more fully for tactical applications



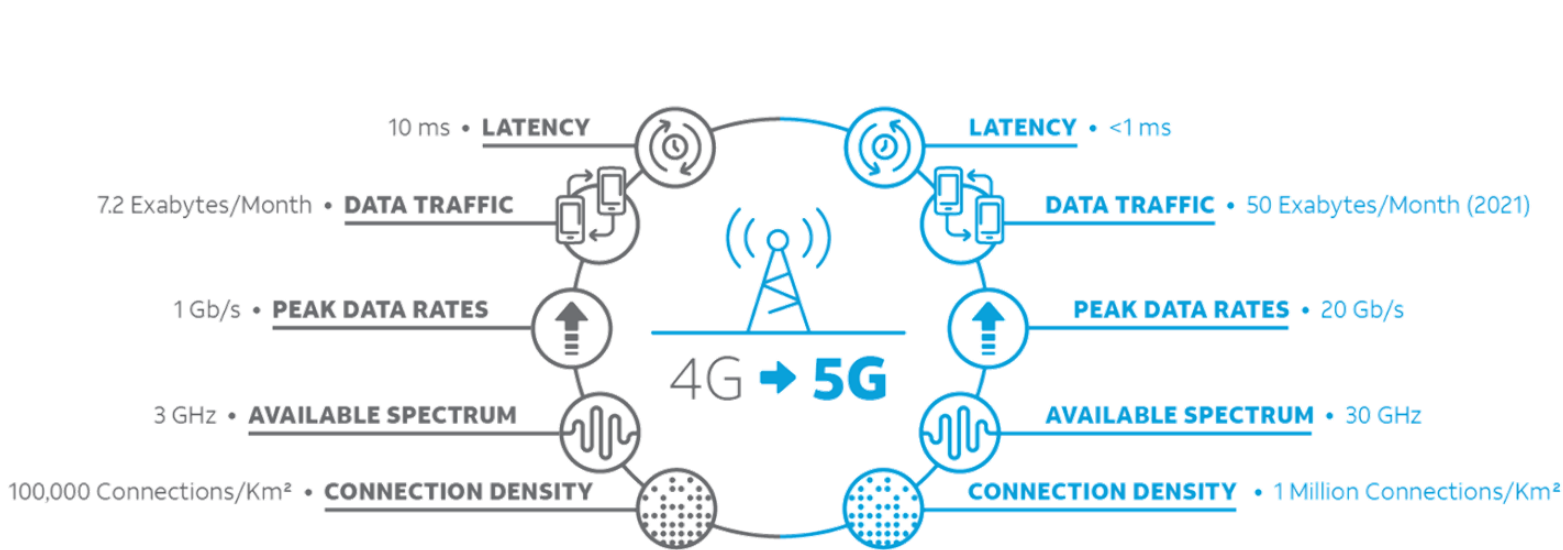
THE BENEFITS OF 5G: DATA RATE



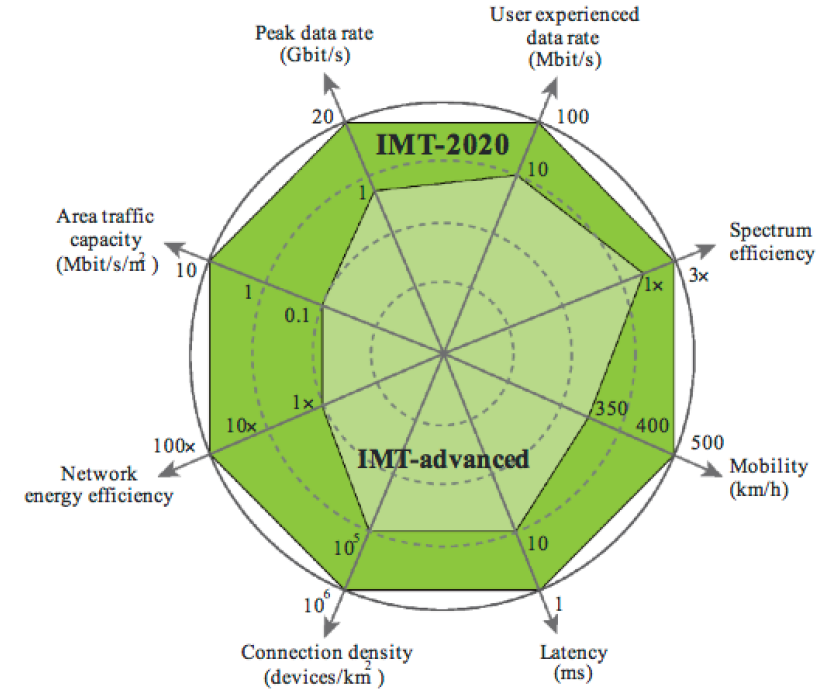
<https://developer.samsung.com/tech-insights/5G/5g-requirements>



THE BENEFITS OF 5G: A LOT MORE THAN JUST INCREASED DATA RATES



https://policyforum.att.com/wp-content/uploads/2018/11/5G_Competition_Based_Model_1.pdf



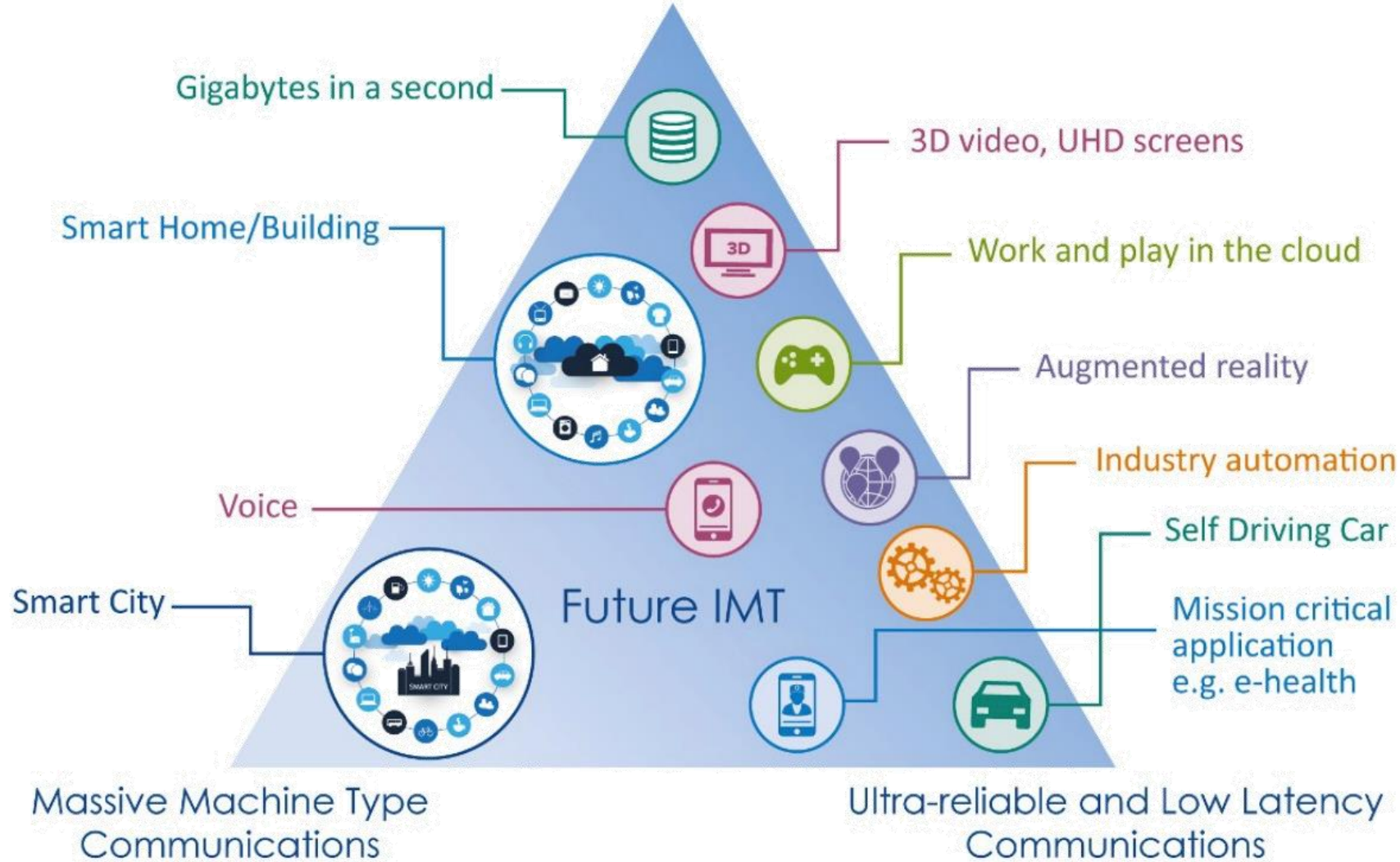
ITU-R M.2083-0, 09/2015



5G USE CASES



Enhanced Mobile Broadband



“Setting the scene for 5G: Opportunities & Challenges,” ITU Discussion Paper, July 2018.



SOME KEY 5G TECHNOLOGY ENABLERS



- **Spectrum**
 - New spectrum access enables higher data rates and more sophisticated networking approaches
- **Network Slicing**
 - The ability to virtualize the network
- **Small cell networking**
 - Using small cells for more than just filling in coverage
- **Mobile Edge Computing**
 - Pushing applications towards the edge
- **V2X**
 - Enabling advanced automotive networking concepts
- **Massive MIMO / Beamforming**
 - Advanced antenna technologies enabling 5G concepts

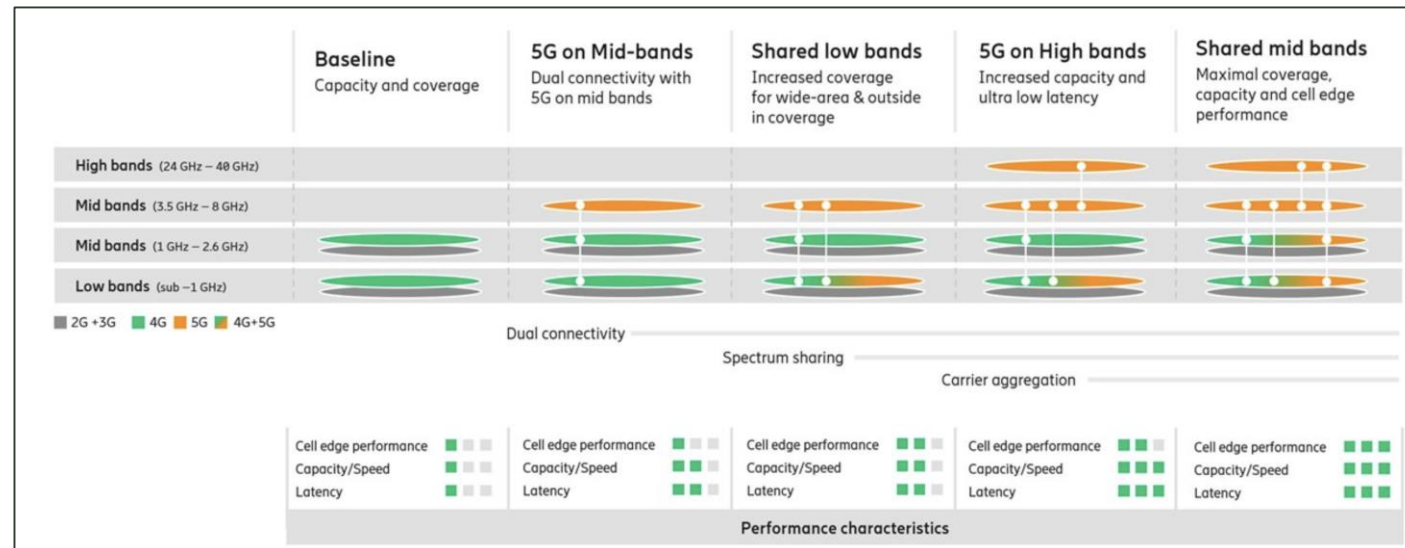
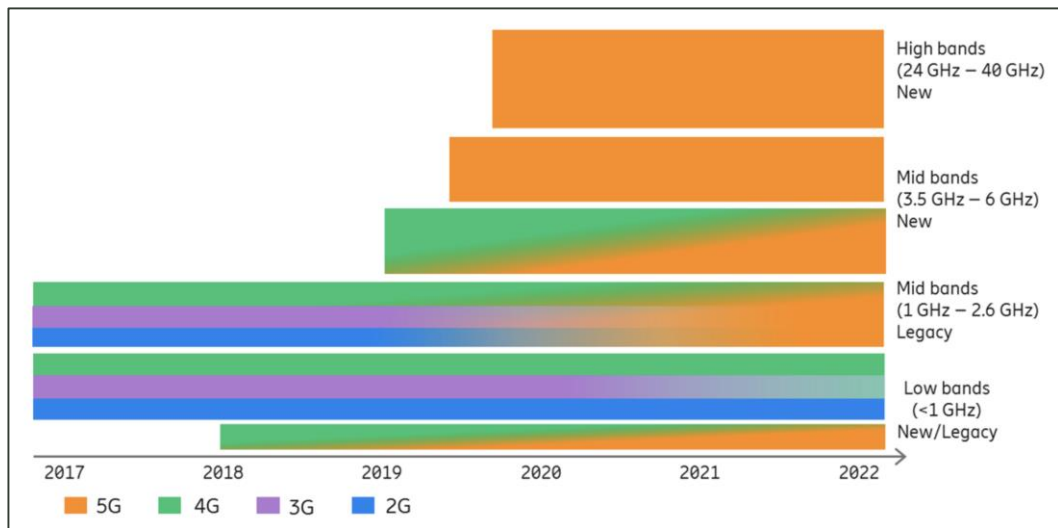
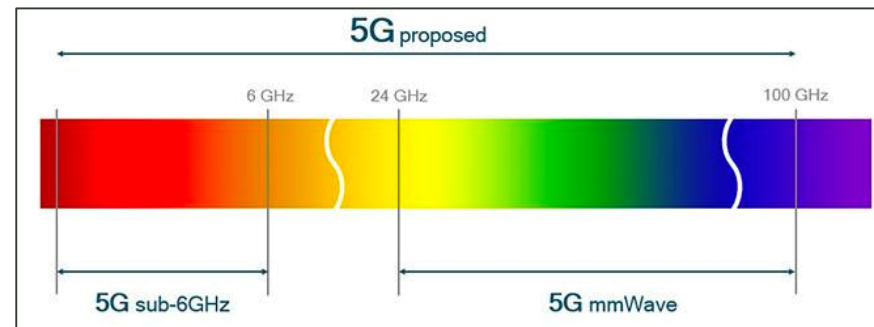


5G SPECTRUM



• New spectrum opportunities for 5G

- Millimeter wave (mmW)
- New sub-6 GHz opportunities



<http://www.ericsson.com/en/networks/trending/hot-topics/5g-spectrum-strategies-to-maximize-all-bands>



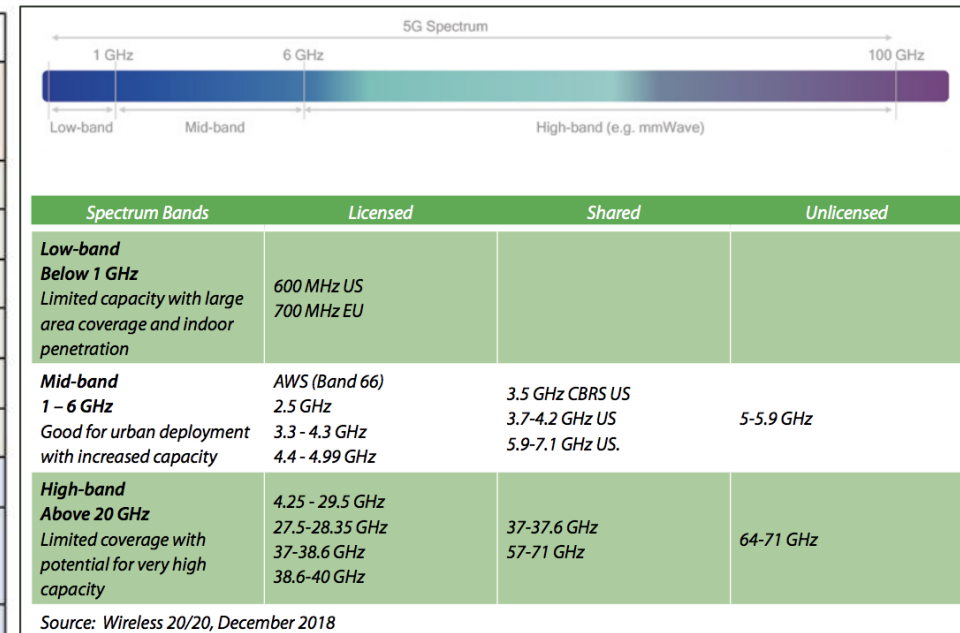
5G SPECTRUM (CONTINUED)



- New opportunities to share spectrum
- New unlicensed spectrum opportunities

Range	Band	Frequency Band	Bandwidth	Frequency Range
Low	71	600 MHz	81 MHz	617MHz - 698MHz
	44	700 MHz	100 MHz	703 MHz - 803 MHz
Mid	66	(AWS) 1700.2100 MHz	100 MHz	1710-1780 and 2110-2200 MHz
	40	2.3 GHz	100 MHz	2.3 – 2.4 GHz
	41	2.5 GHz BRS/EBS in US	194 MHz	2496 - 2690 MHz
	42	3.5 GHz	200 MHz	3400 - 3600 MHz
	43	3.6 GHz	200 MHz	3600 - 3800 MHz
High	C-band	4.4 GHz	590 MHz	4400 - 4499 MHz
	n258	24 GHz mmWave	3.25 GHz	24.25 - 27.5 GHz
	n257	26 GHz mmWave	3.00 GHz	26.5 - 29.5 GHz
	n261	28 GHz mmWave	850 MHz	27.5 - 28.35 GHz
	n260	37 GHz mmWave	1 GHz	37.0 - 38.6 GHz
	n260	39 GHz mmWave	2 GHz	38.0 – 40.0 GHz
	n257	47 GHz mmWave	1 GHz	47.2 - 48.2 GHz

Source: 5G Americas, 3GPP 5GNR NSA specification and Wireless 20/20, December 2018

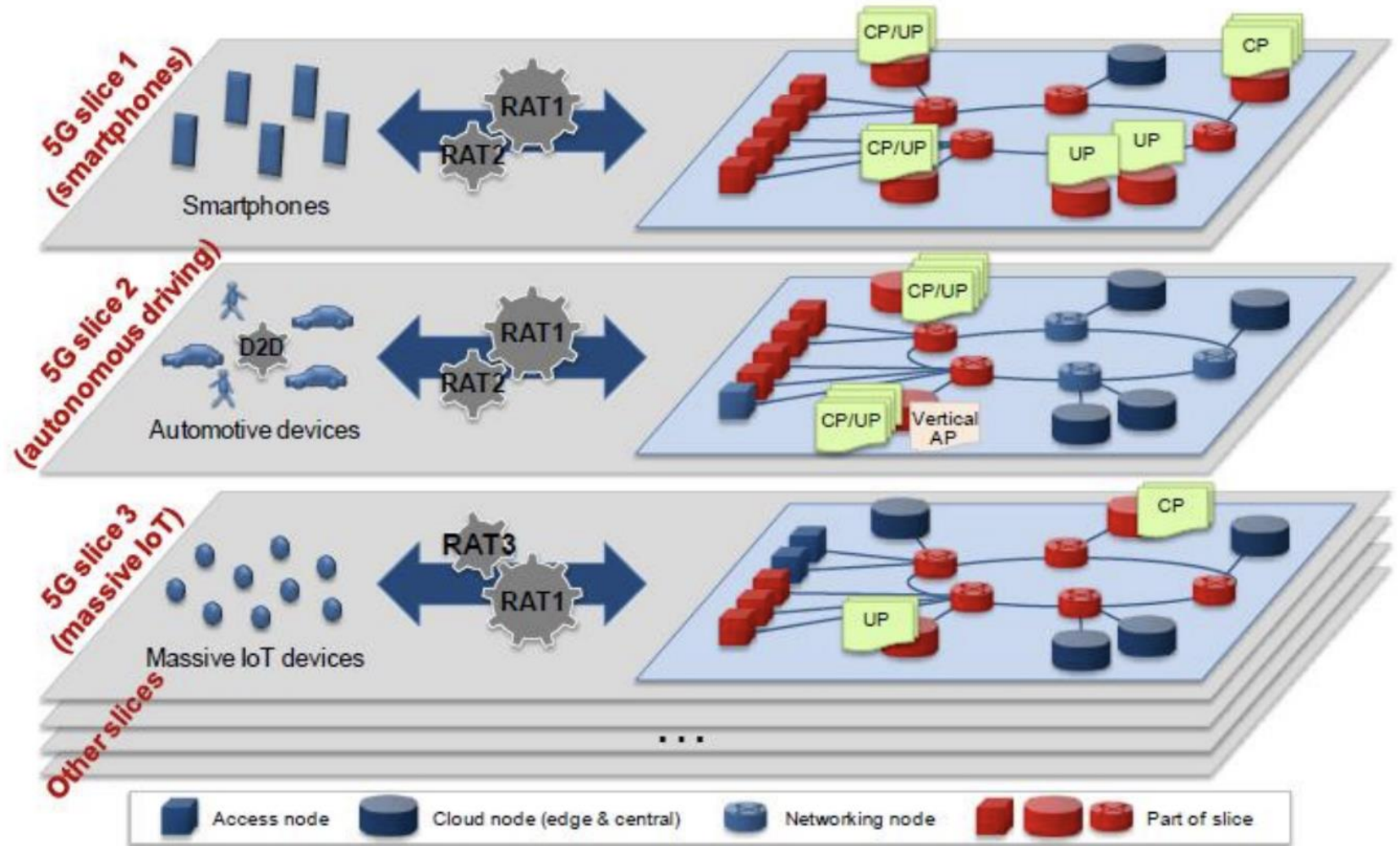




NETWORK SLICING



- “Providing dedicated virtual networks with functionality specific to the service or customers over a common network infrastructure”



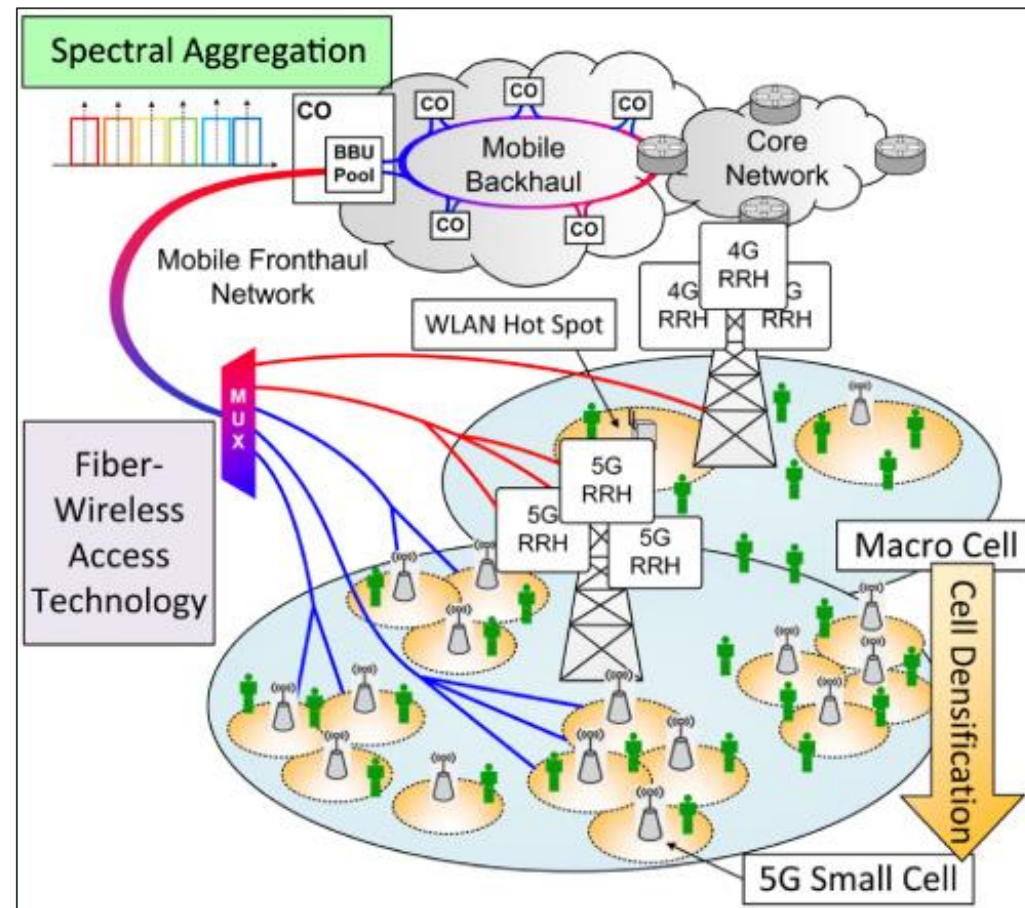
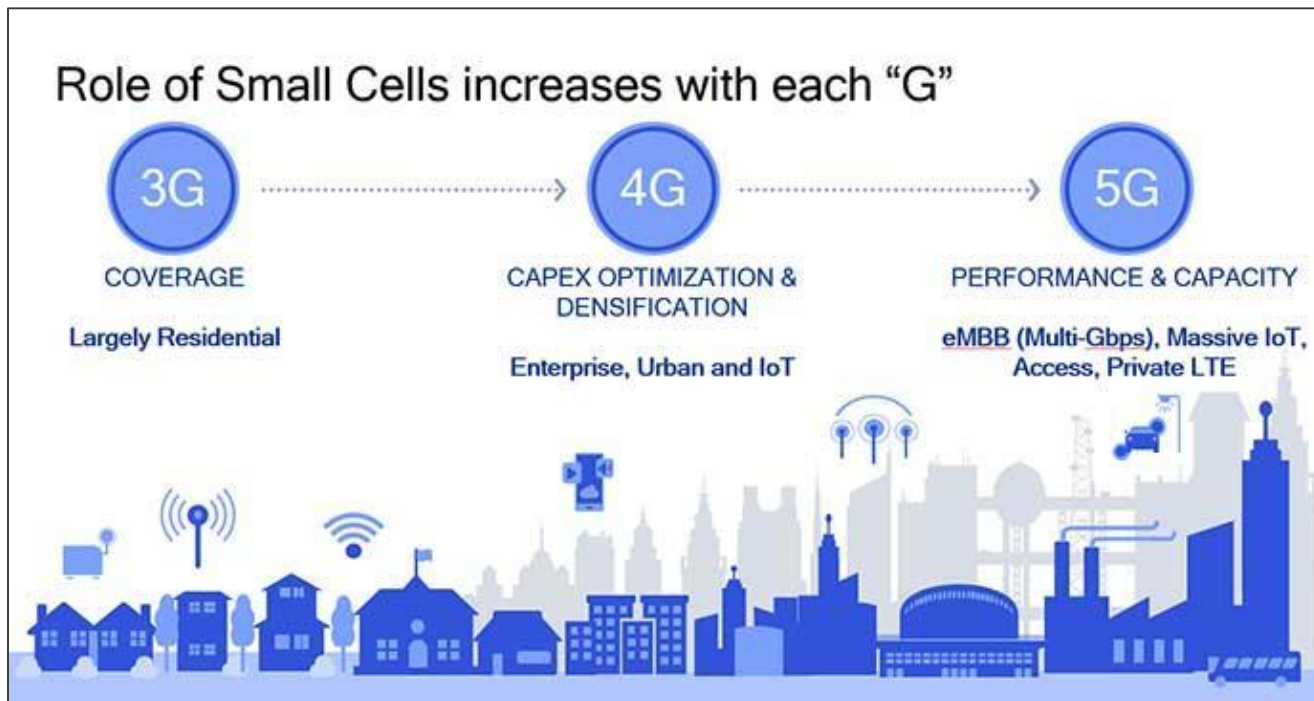
“TSN Profile for Network Slicing,” Huawei presentation, <http://www.ieee802.org/1/files/public/docs2018/new-tsn-wangtt-TSN-profile-for-network-slicing-0718.pdf>



SMALL CELL NETWORKING



- Small cell networking allows for densification of networks for improved performance and capacity



<http://qualcomm.com/news/onq/2018/10/15/ubiquitous-5g-experiences-small-cells>

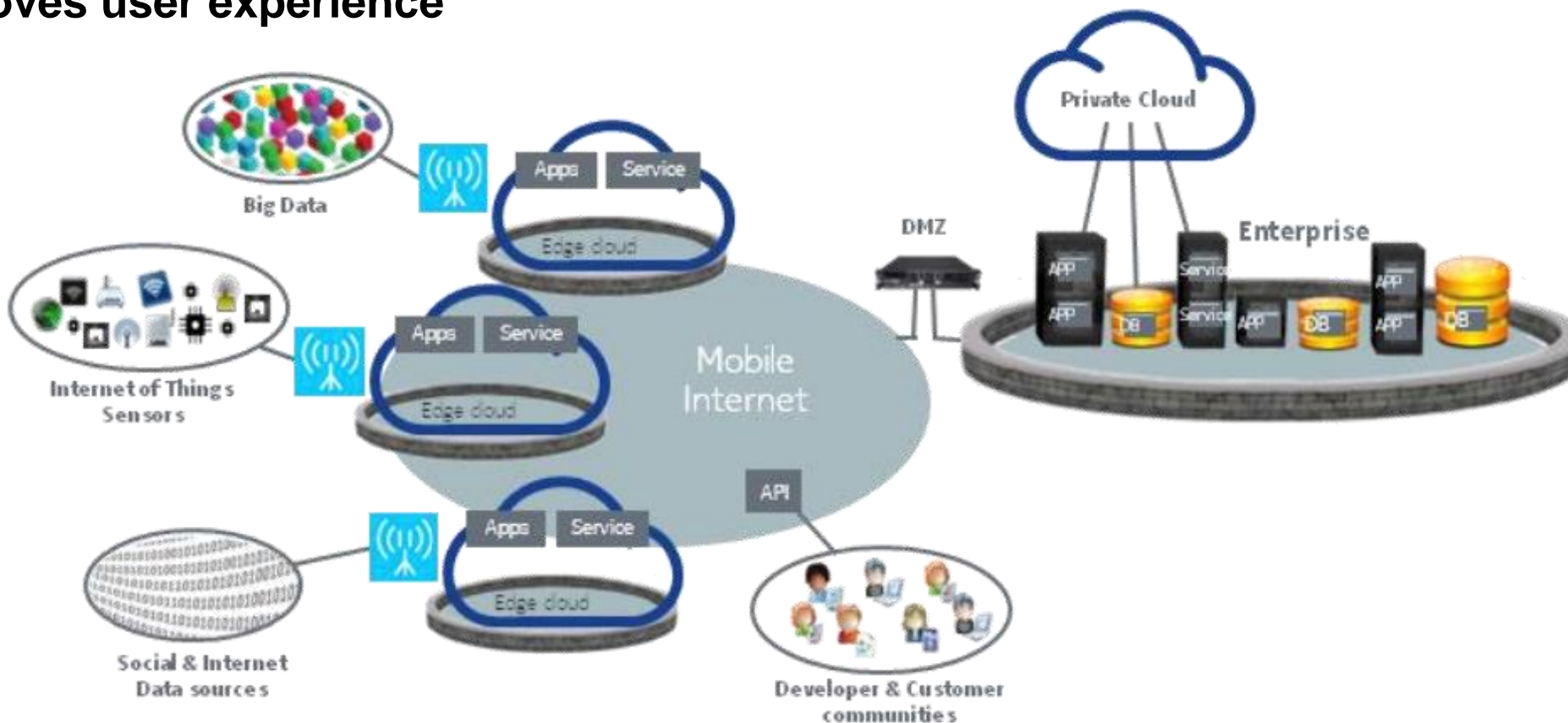
M. Xu et al., "Bidirectional Fiber-Wireless Access Technology for 5G Mobile Spectral Aggregation and Cell Densification," IEEE Journal of Optical Communications and Networking, Vol. 8, Issue 12, 2016.



MOBILE EDGE COMPUTING



- Moving applications closer to the edge (i.e. users)
- Improves E2E latency performance
- Improves user experience



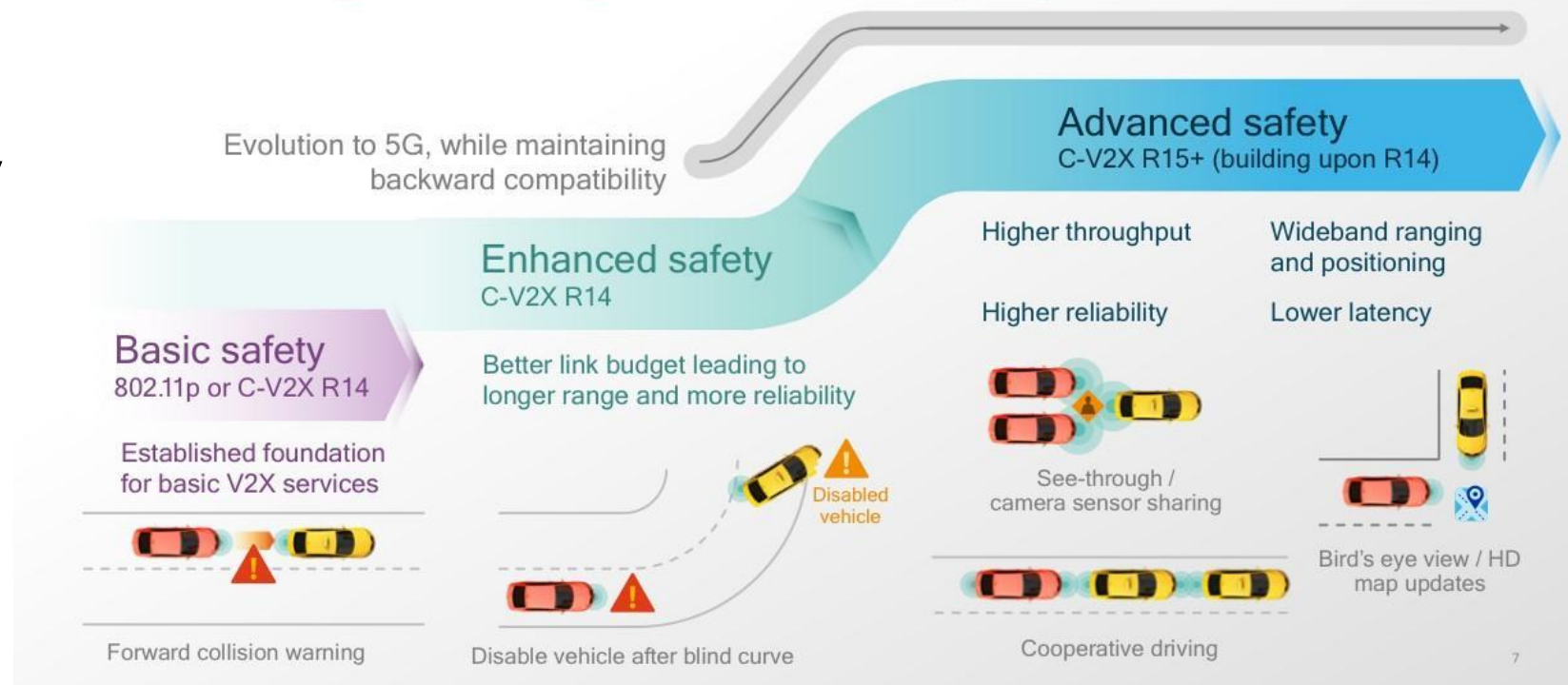


VEHICLE COMMUNICATIONS



- **V2X technology being developed to provide**
 - Improved throughput
 - Higher reliability
 - Lower latency
- **Key enabler for autonomous vehicles**

Continuous V2X technology evolution required
Accommodating ever-evolving use cases and safety requirements



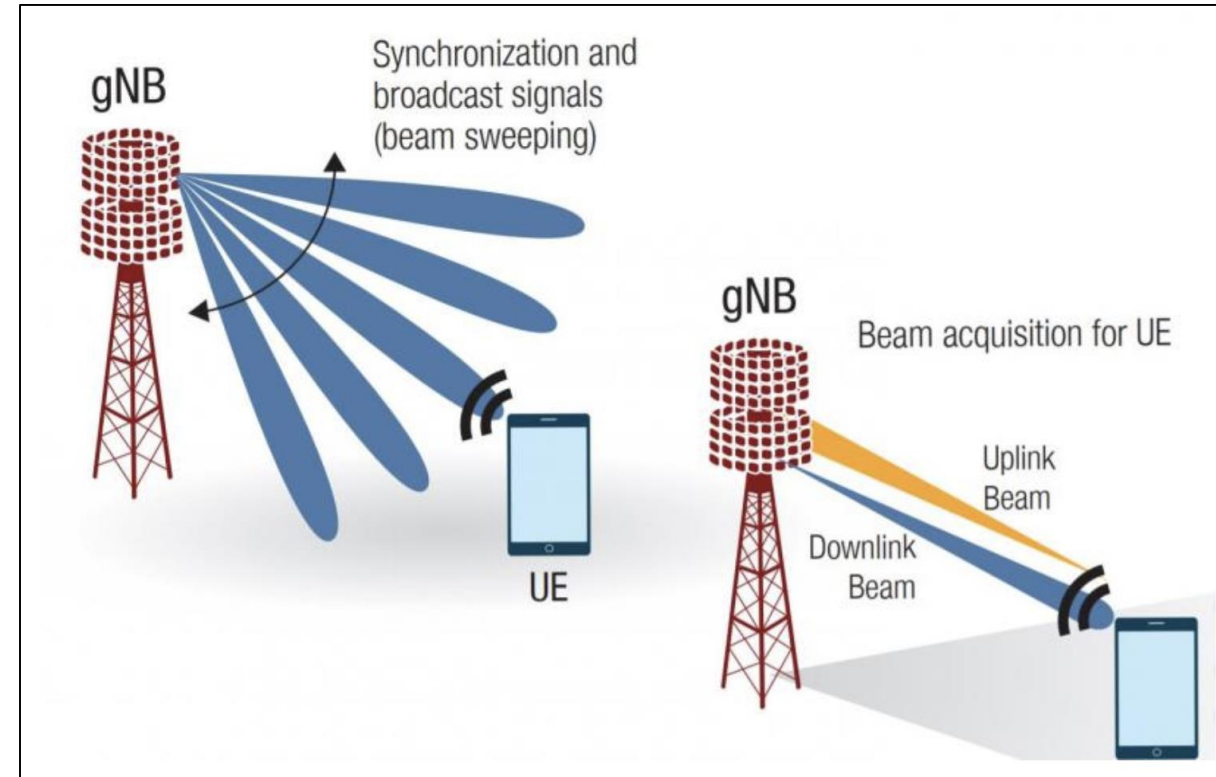
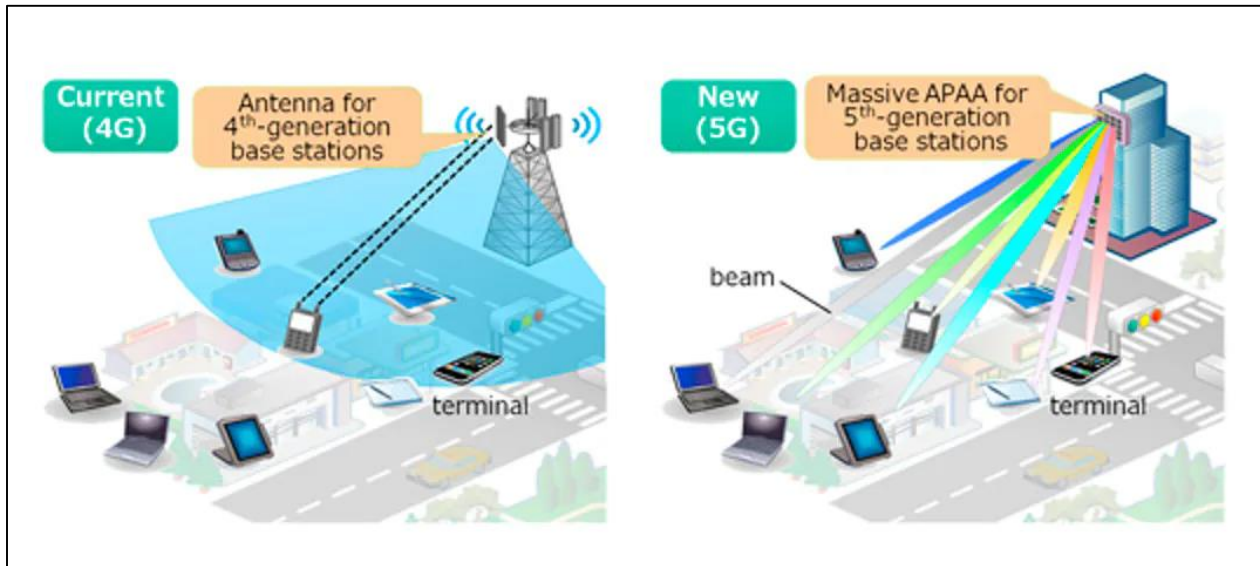
<http://qualcomm.com/news/onq/2017/02/24/accelerating-c-v2x-toward-5g-autonomous-driving>



ADVANCED ANTENNA TECHNOLOGIES



- Massive MIMO enables much higher data rates and RF link performance
- Beamforming provides opportunity for improved interference minimization



<http://www.ecnmag.com/article/2018/05/fact-or-fiction-whats-real-5g-new-radio>

<http://www.inverse.com/article/53624-do-cell-phones-cause-cancer-maybe-maybe-not>



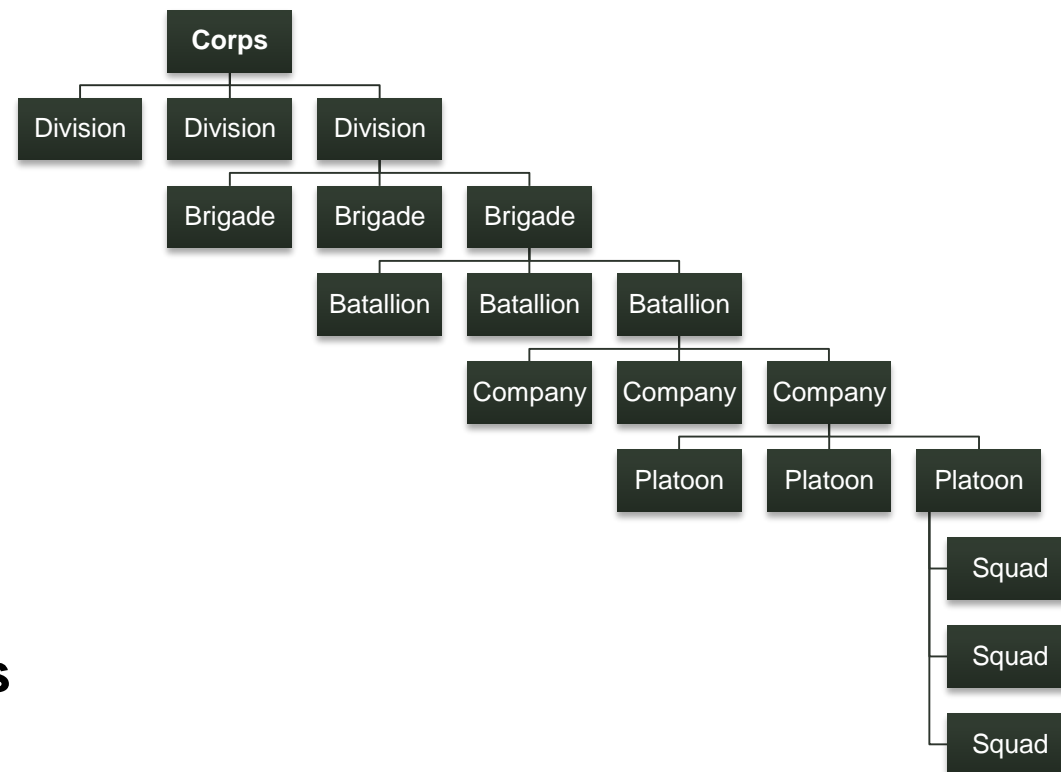
Applying 5G Technology to Tactical Networks



TACTICAL 5G – WHAT DOES THAT MEAN?



- **Multiple ways to use 5G cellular**
 - Use of existing commercial infrastructure
 - “Bring your own” private 5G networks
- **Challenges and requirements will generally vary by echelon**
- **Requirements and spectrum opportunities may vary by phase of fighting**
 - Training also important consideration

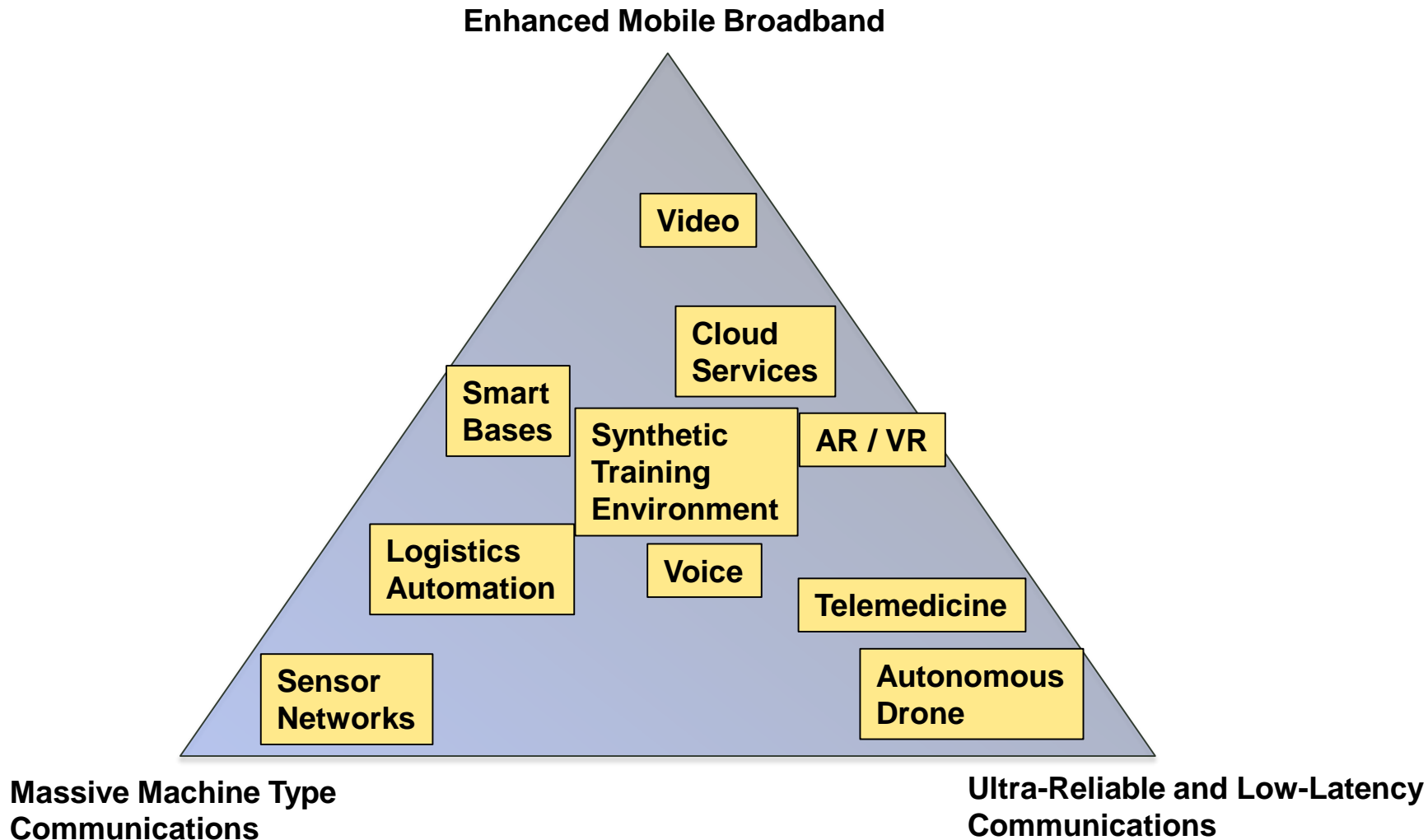




SOME POTENTIAL TACTICAL 5G USE CASES



- The envisioned capabilities of 5G could potentially be applied to a number of current and future tactical military use cases



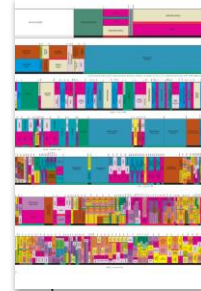


SOME HISTORICAL CHALLENGES OF TACTICAL CELLULAR



Security

- Electronic warfare
- Detection / Geolocation
- Over-the-air cyber attack
- CSfC challenges



Spectrum

- Access to commercial spectrum
- Not an over-abundance of tactical military spectrum available



Mobility

- Tactical mobility can prove challenging, especially at lower tactical echelons



Complexity

- At lower tactical echelons, technology must be push-button simple



Cell Site Installation

- Long timeframes associated with installations at permanent sites

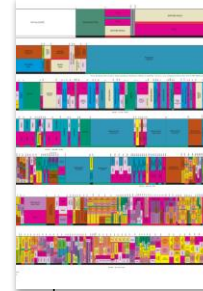


5G FOR TACTICAL: CONCERNS, CHALLENGES, AND CONSIDERATIONS



Security

- Over-the-air security may benefit from 5G beamforming
- Cyber attack may be partially mitigated by 5G protection mechanisms
- New mmWave bands may improve over-the-air security
- Network slicing may provide security benefits
- Supply-chain considerations



Spectrum

- Spectrum scarcity remains an issue
- Shared and unlicensed spectrum models may be attractive options



Mobility

- What if 5G infrastructure is on the move?
- How will beamforming work in tactical environments?
- How will interference management be affected by tactical mobility?



Complexity

- 5G is far more complex than predecessors
- How will it be made into a push-button black box?
- SON technologies may be key



Small Cell Networking

- Larger number of assets – can 5G solutions be made affordable?
- Permanent installations remain difficult

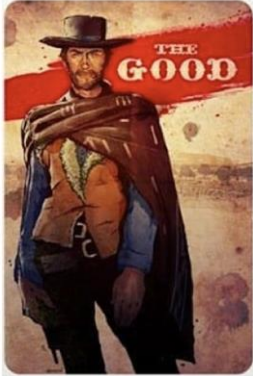


RF

- How will 5G ranges compare to tactical doctrine?
- Importance of reliable backhaul communications



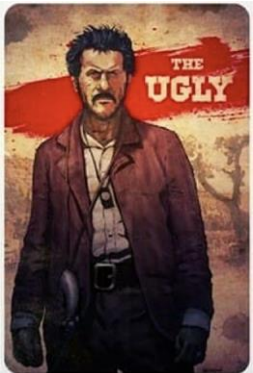
CONCLUSIONS



- **5G is an exciting technology with many possible tactical applications**



- **5G offers several attractive technology features that may help mitigate, at least partially, some historical challenges of employing cellular in tactical environments**



- **Several areas to track as 5G continues to mature**
 - Shared and unlicensed spectrum usage opportunities
 - Ease-of-use / ease-of-administration of 5G solutions
 - 5G security
 - SON in 5G

A night cityscape with glowing blue arcs representing 5G network connections. The arcs connect various points across the city, symbolizing a global or interconnected network. The city lights are visible in the background, and the overall color scheme is dominated by dark blues and bright whites from the network lines.

5G

THANK YOU