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CLE RELAY

Why Every Company is Now a Wireless Company: Making Our Way in a 5G World

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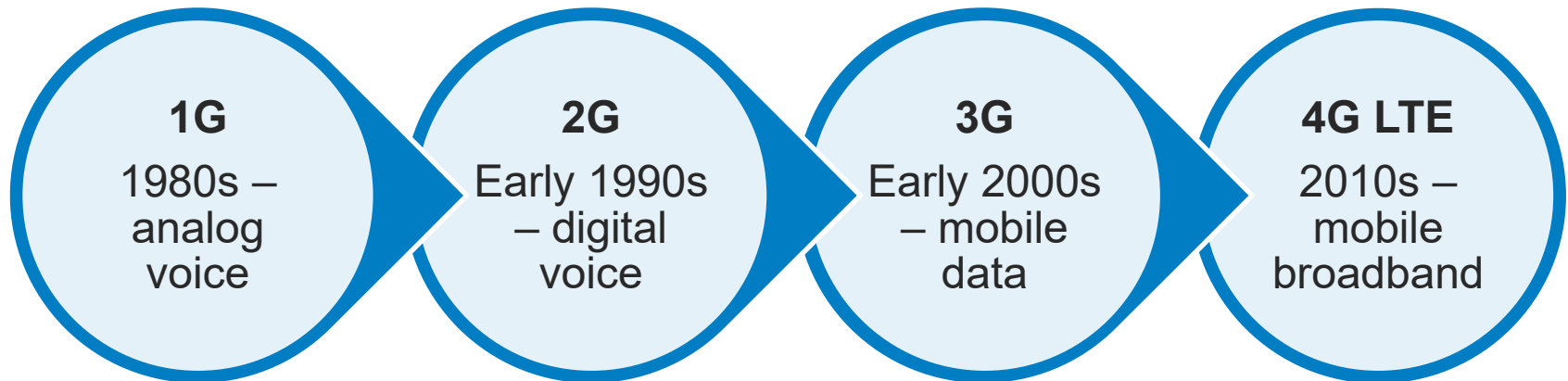
Agenda

- Background
 - What is 5G?
 - Why 5G?
- 5G Spectrum Regulations
 - What is spectrum and why is it important?
 - Spectrum management policies and principles.
 - Who manages spectrum use?
 - Licensed, Unlicensed, and Hybrid Spectrum.
- Engaging the 5G Economy

What is 5G?

- **5G = 5th generation mobile network technology standard**
 - OFDM technology (Orthogonal Frequency-Division Multiplexing)
 - 5G NR air interface
 - Wider bandwidth technologies

- The Road to 5G



How Have New Generations Brought Change?

1G:

- Simple voice service.

2G:

- Enabled the various networks to provide services such as text messages, picture messages, and MMS (multimedia messages).
- Internet surfing was possible for the first time, albeit slow and limited.

3G:

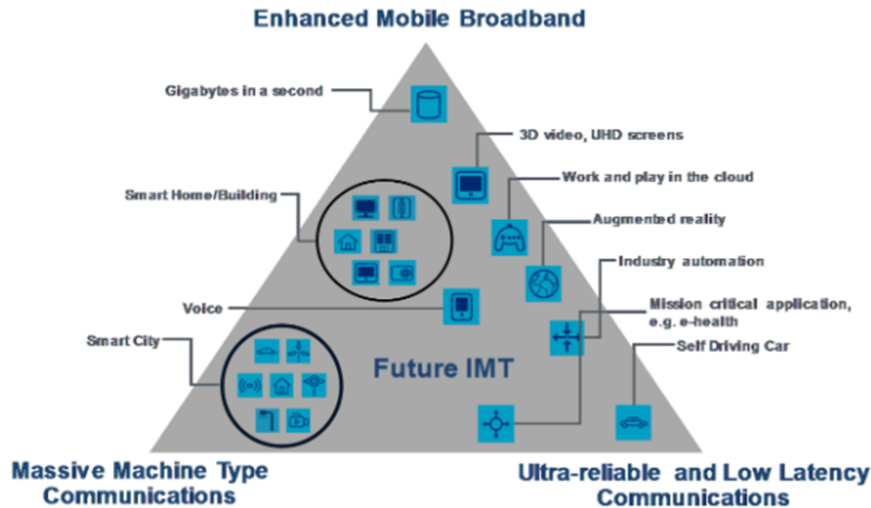
- Possible to conveniently surf the internet on a 3G network on the go with minimum hassle.
- Medical devices, fire alarms, ankle monitors used this network for accomplishing their designated tasks alongside mobile phone users.
- This network marked a first for a cellular communications network to be used in such a wide variety of tasks, kick starting the beginning of widespread usage of cellular networks.

4G:

- Data intensive interactive user services: Services such as online satellite mapping will now load instantly.
- Multiple User Video conferencing – subscribers can see as well as talk to more than one person.
- Apps like Uber, Instagram, and Snapchat can seamlessly play and update.

Why Do Businesses Care About 5G?

5G Usage scenarios



5G also focuses on advancements such as lower power consumption, virtualization, and Network Slicing

Faster

“eMBB”

Similar waveform to LTE but with advancements

Wider bandwidth channels

More Connections

“mMTC”

Eliminates IoT limitations of LTE

Low Latency

“URLLC”

Enables multiple mission critical use cases

Network Slicing

What is it?

- An end-to-end network management tool enabled by 5G that allows MNOs to create customized, independent virtual networks

What will it do?

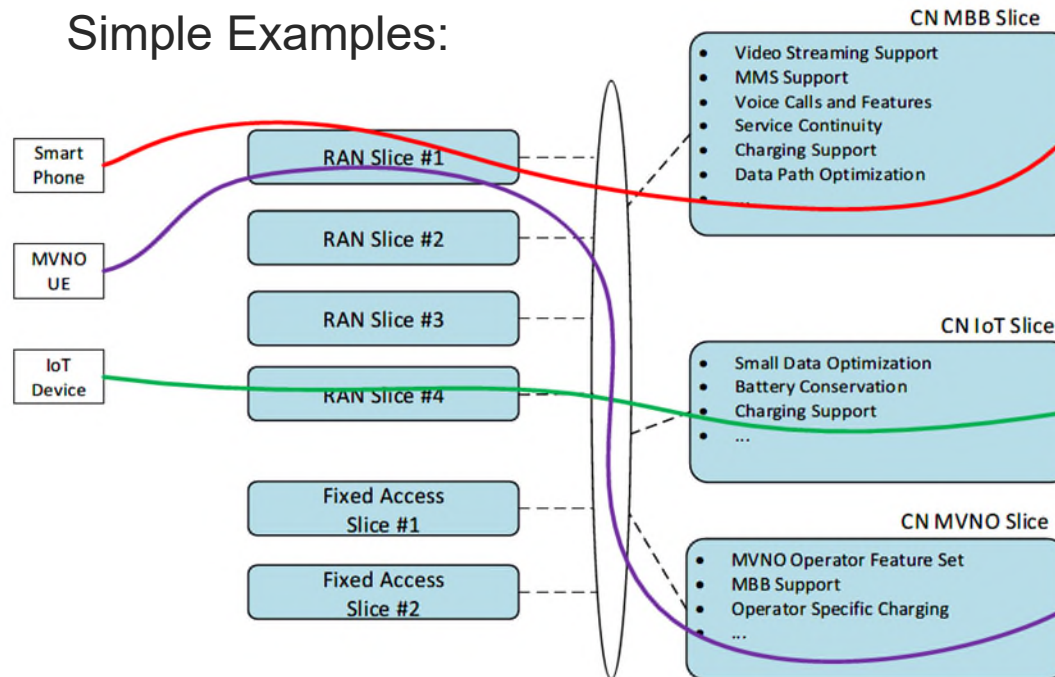
- Allow MNOs to create revenue-generating virtual end-to-end slices that serve different vertical markets and/or use cases, including secure private networks
- Each slice will optimally serve use case specific requirements independently of the requirements of other slices

Why do we need it?

- The myriad of use cases that 5G can support have very different network requirements (e.g., latency, bandwidth, security, reliability, QOS, etc.)
- Some of these requirements compete for network resources while others may only be applicable to specific use cases (e.g., security)
- Network slicing provides a way to ensure each use case optimally receives the network resources it requires without affecting the needs of other slices

Network Slicing

- Instead of all users sharing the entire network, network slicing lets users with the same requirements share a slice with each other
- This includes slices of the Radio Access Network's (RAN) resources (e.g., spectrum, backhaul, etc.) as well as slices of the Core Network (CN)



The RAN and CN slices do not necessarily align one-to-one, since some users/use cases may share the same RAN requirements but have different CN requirements

5G Spectrum Regulations

What is Spectrum Right?

Management Policies and Principles.

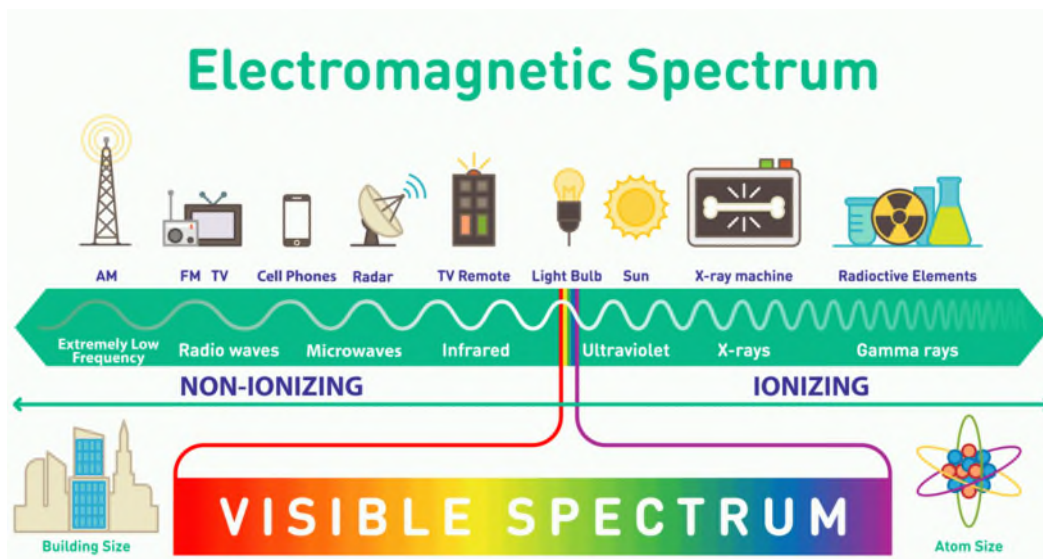
Who Manages Spectrum Use?

Licensed, Unlicensed, and Hybrid Spectrum.

What is Spectrum?

Spectrum license rights

- The right to exclude
- The right to transfer
- The right to use
- The right to retain



“It is the purpose of this chapter ... to maintain the control of the United States over all the channels of radio transmission; and to **provide for the use of such channels, but not the ownership thereof**, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license.” *47 U.S. Code § 301.*

Spectrum Management Policies and Principles

Allow	Allow for a diverse array of uses
Support	Support efficient investment and operations
Prevent or mitigate	Prevent or mitigate harmful interference
Promote	Promote competition
Encourage	Encourage innovation
Protect	Protect reliance interests
Lower	Lower barriers to entry
Support	Support technological neutrality

Who Manages Spectrum Use?

International

- International Telecommunication Union (ITU)

U.S.

- Federal Communications Commission (FCC)
- U.S. Department of Commerce (DOC)
 - National Telecommunications and Information Administration (NTIA)
- U.S. Congress

U.S. Spectrum Management - Licensed, Unlicensed, and Hybrid Spectrum

Licensed

- Exclusive use
- Licensees must comply with technical and service rules
- Geographic or site-based licenses
- Geographic licenses allocated through spectrum auctions in the U.S.

Unlicensed

- Not for exclusive use – operate on a non-interference non-protected basis
- Devices must be certified to meet technical and operating requirements
- Examples: Wi-Fi, Bluetooth, Ultra-Wideband (UWB)

Hybrid

- Sometimes called “lightly licensed”
- Users must be authorized to operate but do not hold an exclusive license
- Example: General Authorized Access (GAA) in the Citizens Broadband Radio Service (CBRS) band in the U.S.

Licensed Spectrum Allocation in the U.S. – Spectrum Auction

- FCC allocates geographically licensed commercial spectrum resources through spectrum auctions.
 - Pre-1993: comparative hearings and lotteries
 - Omnibus Budget Reconciliation Act of 1993 (P.L. 103-66) authorized the FCC to establish “a system of competitive bidding.”
 - The Balanced Budget Act of 1997 (P.L. 105-33) extended and expanded the FCC’s auction authority
 - Congress last extended the FCC’s auction authority via the 2012 spectrum law
- FCC’s auction authority is set to expire September 30, 2022, unless extended.

Licensed Spectrum Allocation in the U.S. – Spectrum Auction

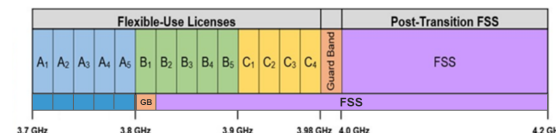
- “Mutually exclusive initial applications are subject to competitive bidding.” *47 CFR § 1.2102(a)*.
- Exceptions:
 - (1) Public safety radio services, including private internal radio services used by state and local governments and non-government entities and including emergency road services provided by not-for-profit organizations, that
 - (i) Are used to protect the safety of life, health, or property; and
 - (ii) Are not commercially available to the public;
 - (2) Initial licenses or construction permits for digital television service given to existing terrestrial broadcast licensees to replace their analog television service licenses; or
 - (3) Noncommercial educational and public broadcast stations described under 47 U.S.C. 397(6). *See 47 CFR § 1.2102(a)*.

Licensed Spectrum for 5G Case Study – 3.7 to 3.98 GHz C-Band (Auction 107)



- 280 MHz of prime spectrum for 5G – wide bandwidth with good propagation.
- Historically used for Fixed Satellite Service (FSS) for video and audio distribution, but use of the band for that service has been steadily declining.
- The FCC recognized an opportunity to pack remaining FSS into less spectrum and free spectrum for wireless broadband
- Two phase transition
 - 120 MHz cleared in 46 major markets by December 2021 – 100 MHz usable for wireless broadband
 - 300 MHz cleared by December 2023 – 280 MHz usable for wireless broadband

Licensed Spectrum for 5G Case Study – 3.7 to 3.98 GHz C-Band (Auction 107)



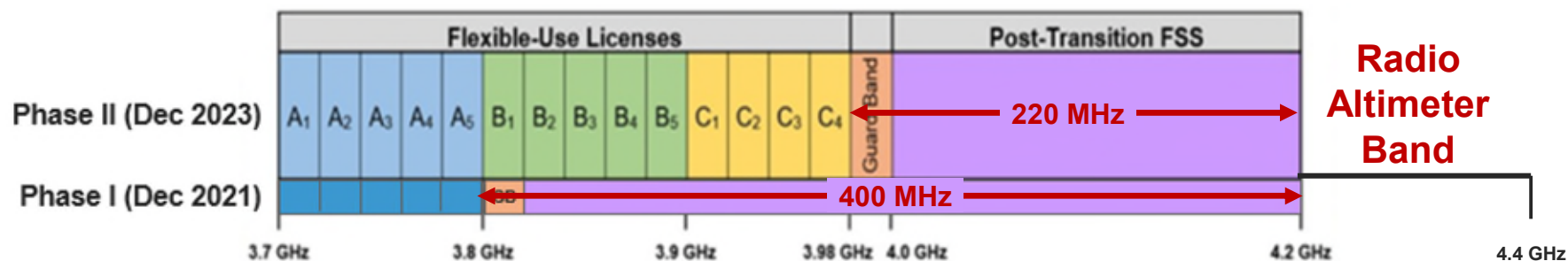
- **Licenses at Auction:** 5,684 new flexible-use overlay licenses in the 3.7–3.98 GHz band throughout the contiguous U.S. subject to clearing requirements.
 - License geography: Partial Economic Areas (PEAs)
 - 406 PEAs in the Contiguous U.S. (CONUS)
 - Not auctioned outside CONUS
- **Accelerated Relocation Payments:** New overlay licensees must pay a specified share of accelerated relocation payments and relocation expenses to reimburse incumbents for reasonable costs of transitioning out of the lower 300 megahertz of the band.
- **License Period:** Initial term not to exceed 16 years.

Bidders paid over \$81 Billion (with a 'B') and are additionally responsible for about \$13 Billion in clearing costs, so **\$94 Billion**

Licensed Spectrum for 5G Case Study – 3.7–3.98 GHz C-Band (Auction 107)

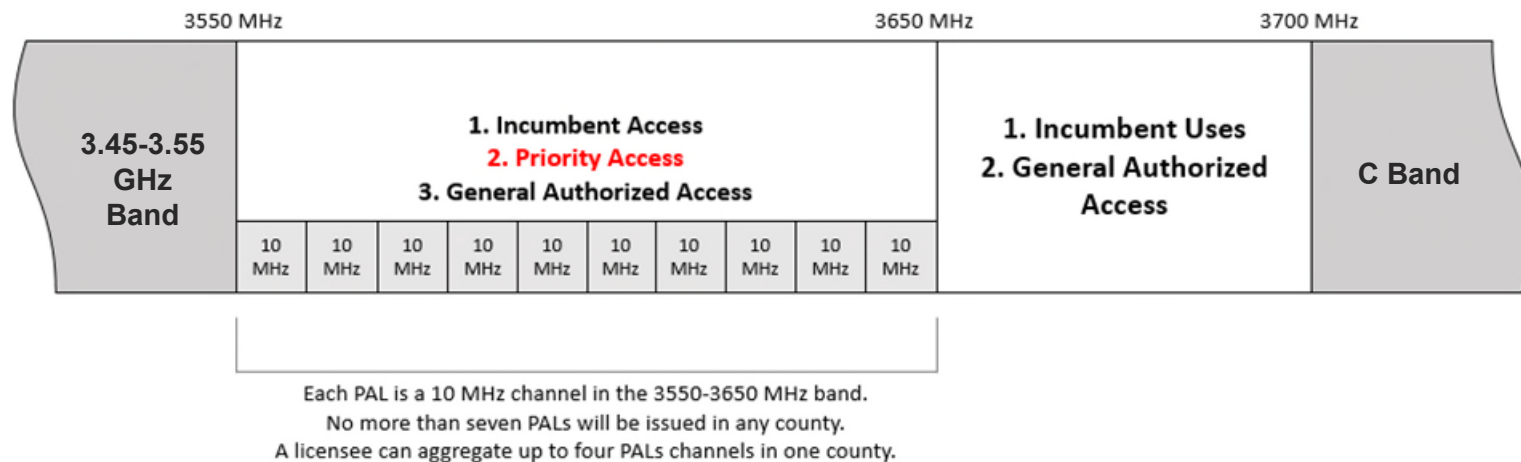
Table of Frequency Allocations			3500-5460 MHz (SHF)		Page 4
International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
(See previous page)	3500-3600 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile 5.431B Radiolocation 5.433	3500-3600 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile 5.433A Radiolocation 5.433	3500-3550 RADIOLOCATION G59 AERONAUTICAL RADIONAVIGATION (ground-based) G110 US108	3500-3550	
			3550-3650 RADIOLOCATION G59 AERONAUTICAL RADIONAVIGATION (ground-based) G110	US108 3550-3600 FIXED MOBILE except aeronautical mobile US105 US433	Citizens Broadband (96)
3600-4200 FIXED FIXED-SATELLITE (space-to-Earth) Mobile	3600-3700 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile 5.434 Radiolocation 5.433	3600-3700 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile Radiolocation	US105 US107 US245 US433	3600-3650 FIXED FIXED-SATELLITE (space-to-Earth) US107 US245 MOBILE except aeronautical mobile US105 US433	Satellite Communications (25) Citizens Broadband (96)
		5.435	3650-3700	3650-3700 FIXED FIXED-SATELLITE (space-to-Earth) NG169 NG185 MOBILE except aeronautical mobile US109 US349	
	3700-4200 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile		3700-4200	3700-4000 FIXED MOBILE except aeronautical mobile NG182 NG457A 4000-4200 FIXED FIXED-SATELLITE (space-to-Earth) NG457A NG182	Wireless Communications (27) Satellite Communications (25)

Licensed Spectrum for 5G Case study – 3.7–3.98 GHz C-Band (Auction 107)



- Late last year, the Federal Aviation Administration (FAA) sounded alarms that C-band spectrum deployments might endanger air travel by causing harmful interference to radio altimeters operating in the 4.2-4.4 GHz band.
 - Radio altimeters are critical aeronautical safety-of-life systems primarily used at altitudes under 2500 feet and must operate without harmful interference.
 - An agreement was reached to delay certain C-band deployments near airports
 - The FAA has moved to allow the airlines to avoid disruptions by providing an Alternative Method of Compliance (AMOC) – i.e., certifying that their altimeters can distinguish signals from adjacent-band 5G operations
- The upcoming Phase II release of additional C-band spectrum for wireless broadband at the end of 2023 will reduce the frequency separation between wireless broadband and radio altimeters from 400 MHz to 220 MHz.

Hybrid Spectrum – CBRS 3550-3700 MHz (3.5 GHz band)



- **Key Characteristics/Benefits:**
 - Unique three-tiered access structure
 - Lower power than other bands used for mobile broadband
 - Licensed by county (~3200 counties - affordable)
 - Lightly-licensed use (GAA)

Hybrid Spectrum – CBRS 3550-3700 MHz (3.5 GHz band)

- Three-tiered access to accommodate shared federal and non-federal use.
 - Tier 1 (incumbents): Authorized federal users in the 3550-3700 MHz band and Fixed Satellite Service (space-to-Earth) earth stations in the 3600-3650 MHz band
 - Tier 2 (PALs): Priority Access Licenses awarded on a county basis through competitive bidding.
 - Each PAL consists of a 10 MHz channel within the 3550-3650 MHz band.
 - Maximum seven PALs per county
 - Maximum four PAL per county per licensee
 - Tier 3 (GAA):
 - Licensed-by-rule to permit open, flexible access to the band for the widest possible group of potential users.
 - GAA users can operate throughout the 3550-3700 MHz band. GAA users must not cause harmful interference to Incumbent users or PALs and must accept interference from these users.
 - GAA users also have no expectation of interference protection from other GAA users.
- Interference protection of higher tiers is managed by Spectrum Access Systems (SASs) with input from an Environmental Sensing Capability (ESC).

Hybrid Spectrum – CBRS 3550-3700 MHz (3.5 GHz band)

- Spectrum Access Systems (SAS) manage access and operations to the spectrum among users.
 - The FCC authorized multiple SAS providers, and they must coordinate to ensure interference protection
 - SASs currently incorporate information from sensing networks called Environmental Sensing Capability (ESCs), which detect transmissions from Department of Defense radar systems and transmit that information to the SAS
 - The SASs then dynamically ensure that the incumbent operations are protected
 - The ESCs may be replaced in the future by Incumbent Informing Capability (IIC)
 - Incumbents would simply inform the SAS of the frequency, time, and geographic information to be protected, rather than having that information sensed by ESCs
 - NTIA is currently investigating the feasibility of IIC in the CBRS band as well as in other bands
- Due to lower power, CBRS users have potential interference concerns on both sides
 - The C-band above and the 3.45-3.55 GHz band below operate at much higher power
 - Synchronization of operations across the three bands would help mitigate interference, but it is not required and may prove difficult to implement
 - As operations in the C-band are relatively nascent, and operations in 3.45-3.55 GHz have not begun, the practical scope of the issue is not yet known

Unlicensed Spectrum



Both commercial and non-commercial entities use unlicensed spectrum to meet a wide variety of monitoring and communications needs.



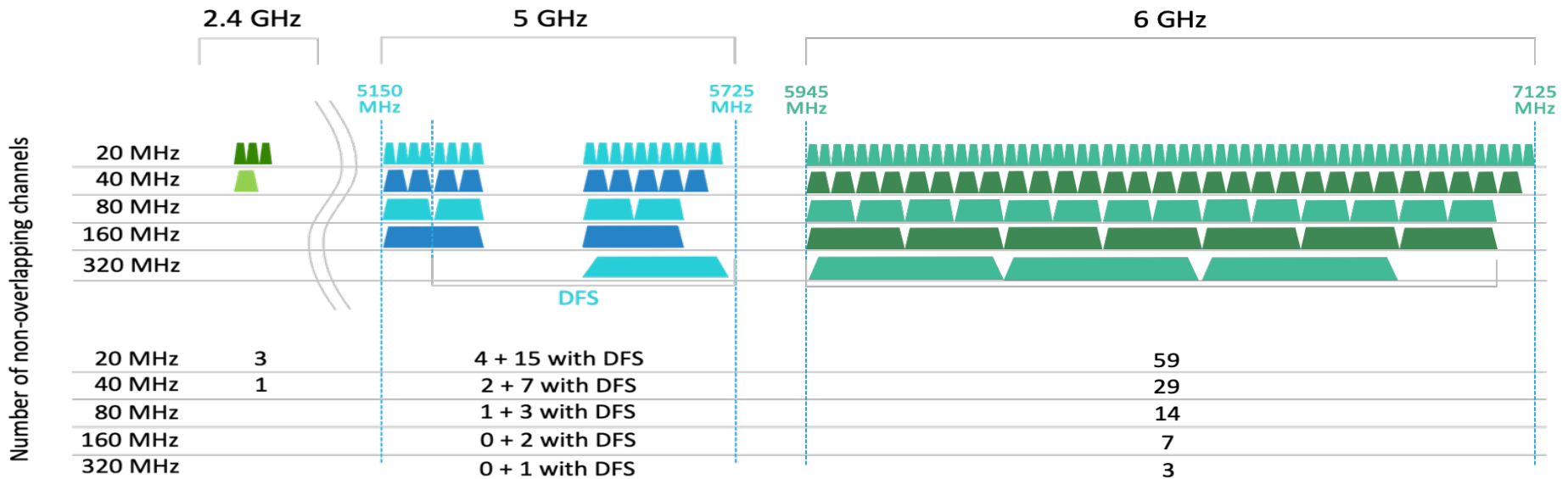
You use unlicensed spectrum everyday: WiFi; Bluetooth; baby monitors; PlayStation controllers.



Unlicensed spectrum is open to any use and by anyone, as long as devices follow certain technical rules.

Unlicensed Spectrum

- 902-928 MHz
- 2.4 GHz
- 5 GHz
- 6 GHz



Unlicensed Spectrum – Interference Control

- **Listen-Before Talk (LBT)**
 - Contention-based protocol
 - Devices “listen” before transmitting
 - Do not transmit if they “hear” others transmitting
- **Dynamic Frequency Selection (DFS)**
 - Devices dynamically detect signals from incumbent systems
 - Dynamically avoid co-channel operation with incumbent systems
- **Automatic Frequency Coordination (AFC)**
 - Unique to the 6 GHz band
 - Protects incumbent point-to-point microwave operations
 - Devices will consult a local AFC system to obtain list of frequencies and power levels at which they can transmit
 - The AFCs calculate the interference protection information based on the parameters of microwave receivers as listed in the FCC’s Universal Licensing Database (ULS)

Unlicensed Spectrum – Licensed Assisted Access (LAA) and 5G NR-U

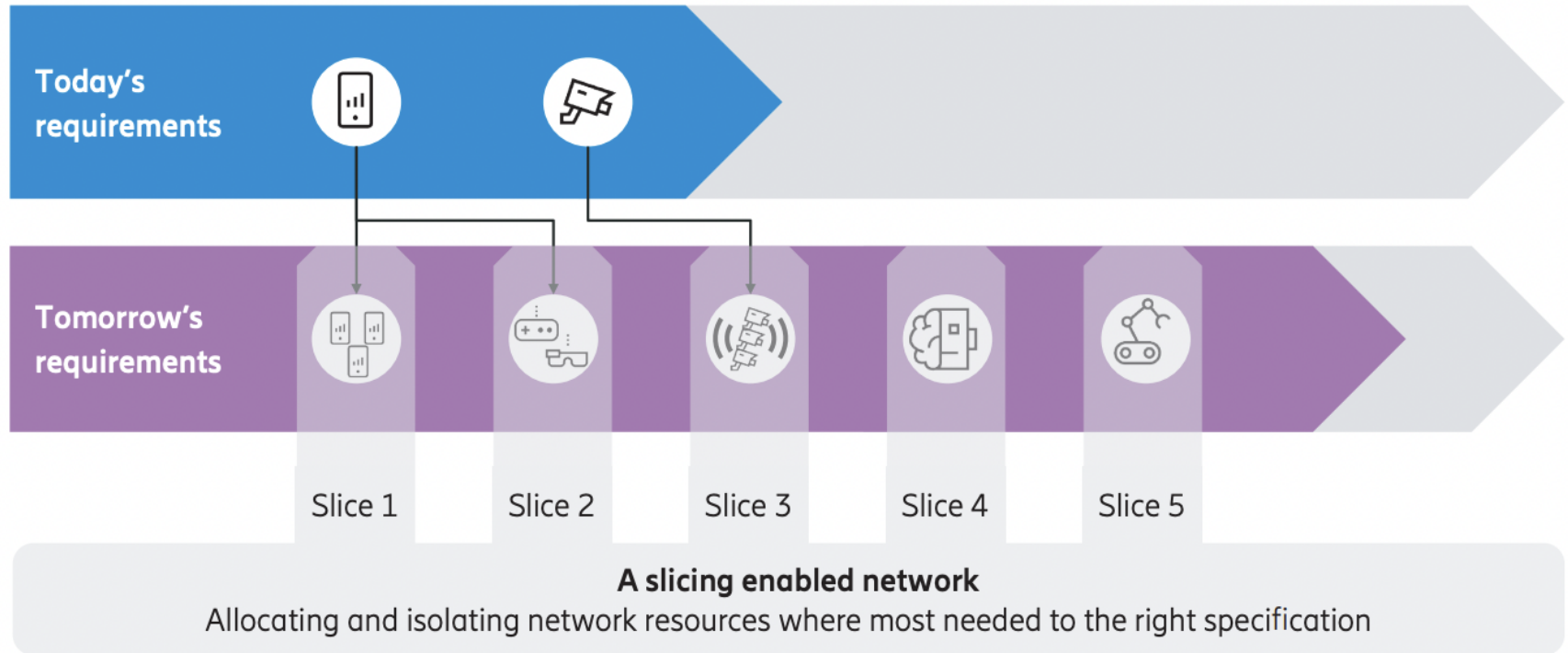
- LAA is an LTE feature that leverages the free 5 GHz unlicensed band in combination with licensed spectrum to deliver a performance boost for mobile users.
 - LAA allows mobile network operators to opportunistically use unlicensed spectrum to increase throughput and capacity.
 - By applying the fair sharing principle (LBT), LAA shares the spectrum fairly with no greater detrimental impact on Wi-Fi users than Wi-Fi would have.
 - Consumers benefit from increased access to spectrum.
- 5G includes a similar feature called NR-U (New Radio Unlicensed)

Build, Buy, or Lease?

- Businesses will have to decide whether to build a private 5G network, buy public 5G services from a mobile operator, or lease a 5G network slice.
 - Build a network
 - Spectrum
 - Core Network
 - Radio Access Network
 - Interconnection Infrastructure
 - Buy capacity
 - Lease a slice
 - A single network slice has all the functions needed to run a service.
 - No excess functions are supported, which minimizes complexity and cost.
 - Network slices are networks on-demand that can be created, deployed and destroyed dynamically.

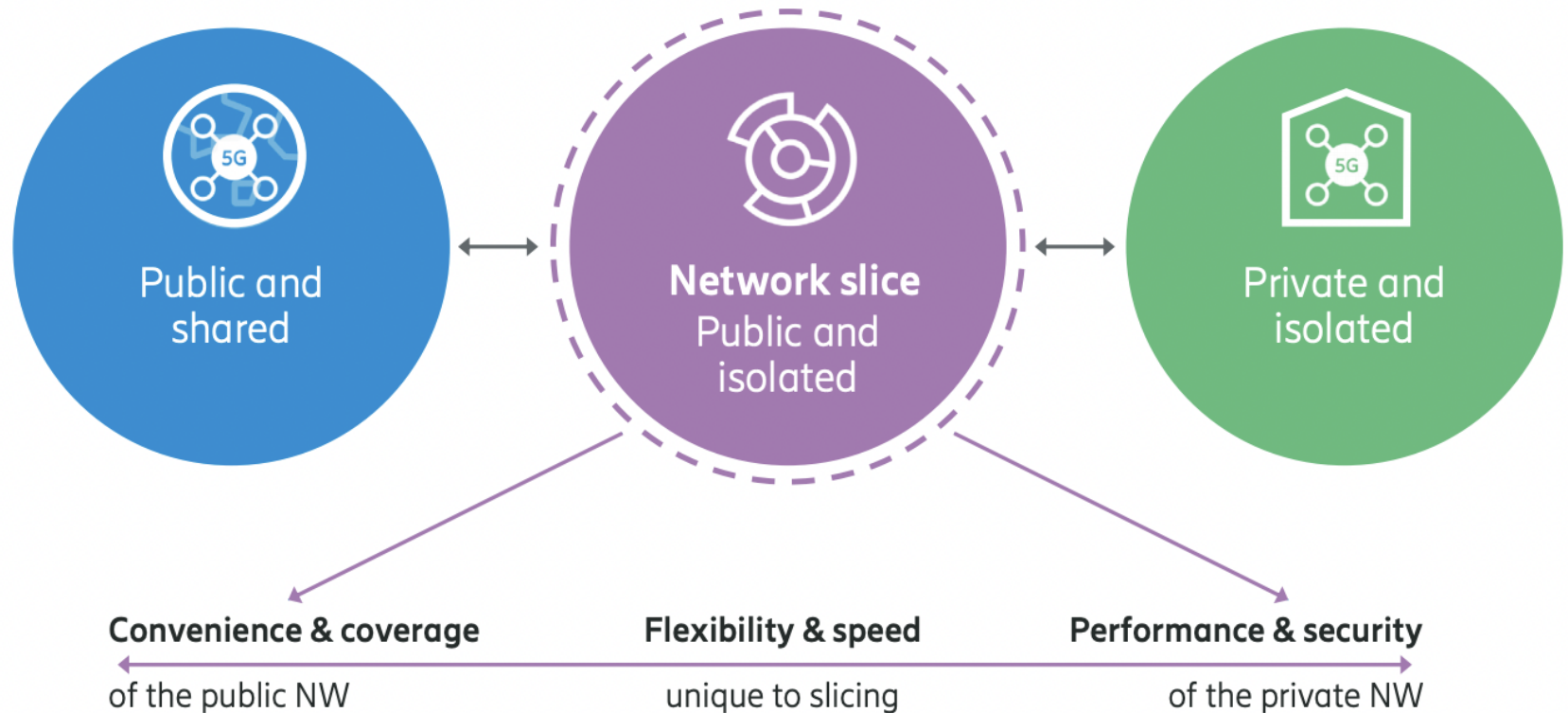
Engaging the 5G Economy

More Choice, More Performance ...



Engaging the 5G Economy

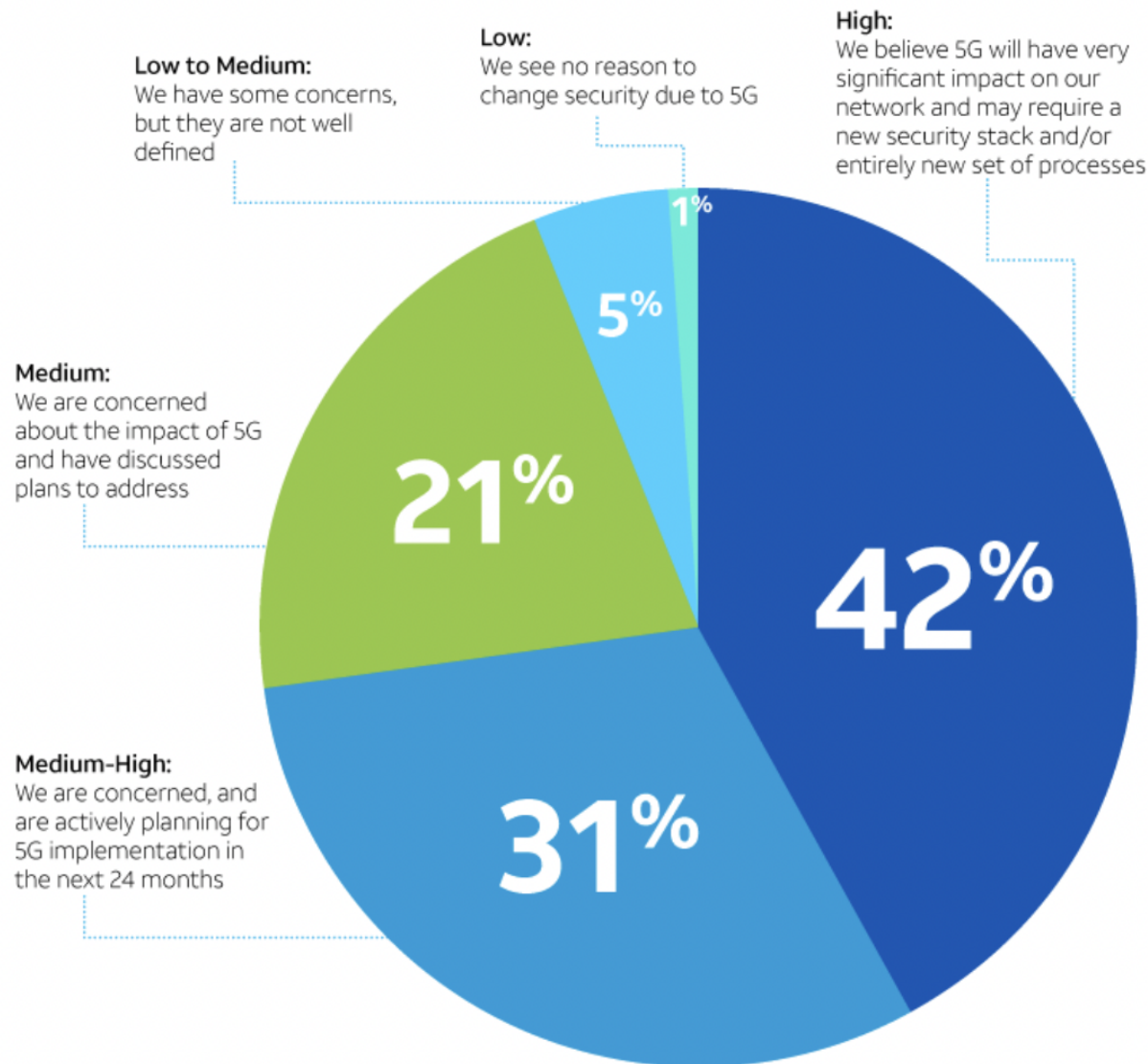
...More Flexibility, More Capacity, More Speed...



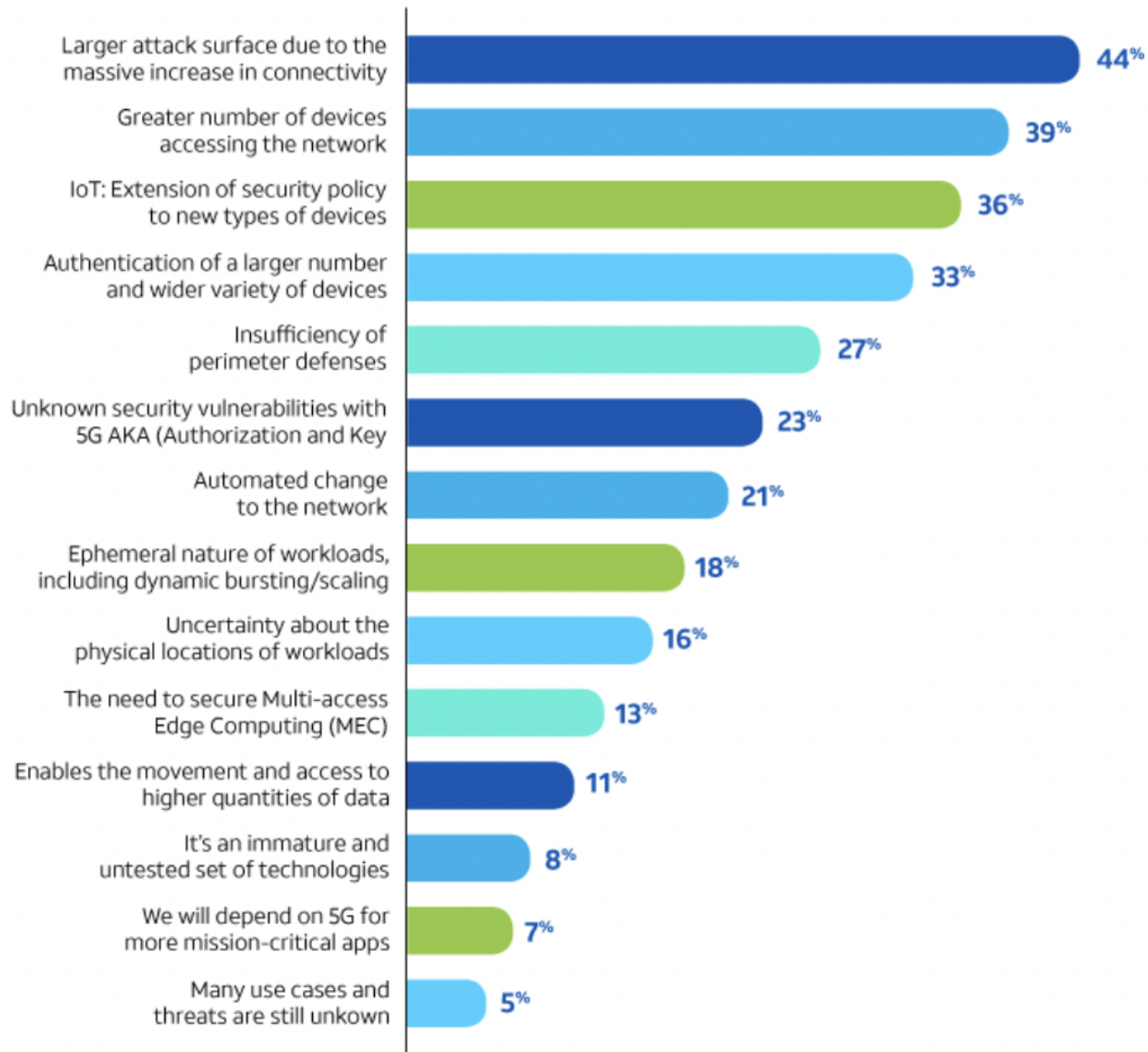
...And More Work for the Lawyers

- Broadband is no longer a commodity product, but rather a product with different unique feature sets, such as ultra-high data speeds, ultra-low latency, massive device connectivity, greater reliability, increased availability, or longer battery life.
- 5G creates the potential for options and features unique to the business, which can save costs and enhance performance.
- Service level agreements (SLAs) may prove critical to supporting 5G-enabled use cases, but will require documenting the unique characteristics of 5G networks as well as the roles and responsibilities of the different parties involved in service delivery and support

Security and 5G



Security and 5G



Commercial Considerations

Service Level Agreements

- Unique commercial terms tailored to a customer, service, or sector.
- Key considerations are likely to include:
 - (1) Quality of service metrics
 - (2) Maintenance and repair specifications,
 - (3) Performance monitoring process,
 - (4) Service level failures and indemnification clauses,
 - (5) Conditions of cancellation/termination,
 - (6) Periodic review,
 - (7) Modification procedures;
 - (8) Security,
 - (9) Privacy management,
 - (10) Environmental / site remediation
 - (11) Waiver
 - (12) Indemnification/Liability
 - (13) IP ownership



Appendix

ITU

- Geneva, Switzerland
- Specialized agency of the United Nations
- 193 countries and almost 800 private-sector companies and academic institutions
- Allocate and coordinate the global use of radio spectrum and orbits for satellite use
 - Develop International Mobile Telecommunications (IMT) standards.
 - World Radiocommunication Conference (WRC)

ITU – IMT Standards

- All mobile broadband systems (3G, 4G and soon 5G) are based on the ITU's IMT standards.
- IMT-2020 sets the requirements for 5G networks, devices, and services concluded. See Recommendation ITU-R M.2150-0 titled Detailed specifications of the radio interfaces of IMT-2020.

ITU – World Radiocommunication Conference (WRC) Process

- Under the terms of the ITU Constitution, a WRC can:
 - revise the Radio Regulations and any associated frequency assignment and allotment plans;
 - address any radiocommunication matter of worldwide character;
 - instruct the Radio Regulations Board and the Radiocommunication Bureau, and review their activities; and
 - determine questions for study by the Radiocommunication Assembly and its Study Groups in preparation for future Radiocommunication Conferences.

ITU – World Radiocommunication Conference (WRC) Process

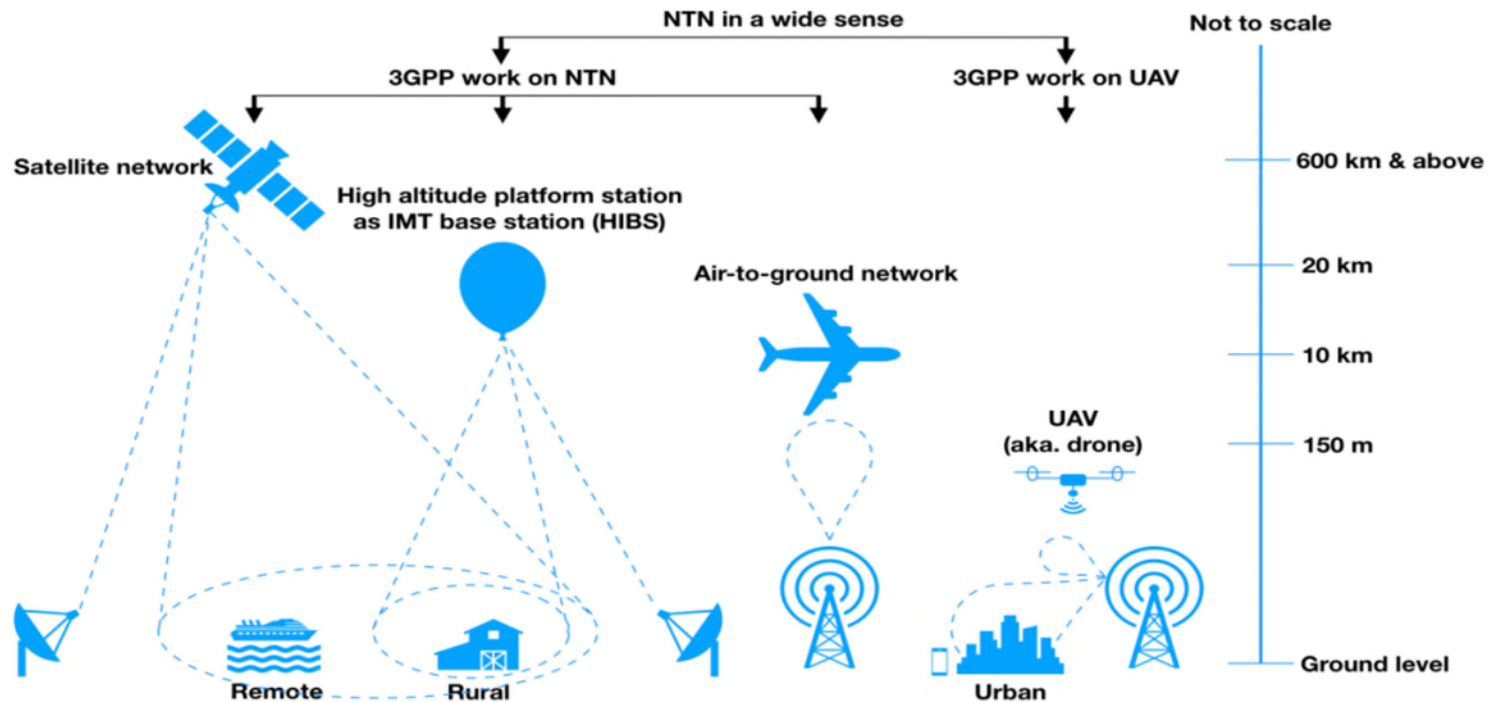
- The 2019 WRC identified additional frequency bands for 5G deployment.
 - 24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz.
- The 2019 WRC also identified a plan of studies to identify frequencies for new components of 5G.
 - *E.g.*, to facilitate mobile connectivity by High Altitude IMT Base Stations (HIBS).

ITU – World Radiocommunication Conference (WRC) Process

- 2023 WRC: November 20 to December 15, 2023
- WRC-23 5G Agenda Items
 - 1.1 – IMT in the band 4800-4990 MHz;
 - 1.2 – IMT in a number of bands including in the 3.5 GHz and 6 GHz ranges;
 - 1.3 – Mobile Allocation in 3600-3800 MHz in Region 1; and
 - 1.5 – Consideration of sub-1 GHz spectrum in Region 1.

Non-Terrestrial Networks (NTN)

- NTN delivers mobile and fixed wireless connectivity from space and the stratosphere, using 5G technology that is compatible with terrestrial 5G.
- A fully integrated 5G NTN can provide ubiquitous connectivity, service continuity, and network resiliency to existing terrestrial 5G networks.



Open Radio Access Network (Open RAN)

- Open RAN is an umbrella term for a set of industry-wide standards for RAN (Radio Access Network) that support interoperation and greater network flexibility.
- Today, RAN vendors generally offer equipment and software that is proprietary and non-interoperable.
- Potential benefits of Open RAN include more diverse network architectures, lower capital and operating expenses, and new services tailored to unique use cases and consumer needs.

