

INTEL INSIDE

SMART AND CONNECTED OUTSIDE

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**BUILD OUT
OF THE CLOUD**



**CONNECTED
THINGS**



**NEW
SERVICES**



NETWORK & CONNECTIVITY

NETWORK & CONNECTIVITY

NETWORK & CONNECTIVITY

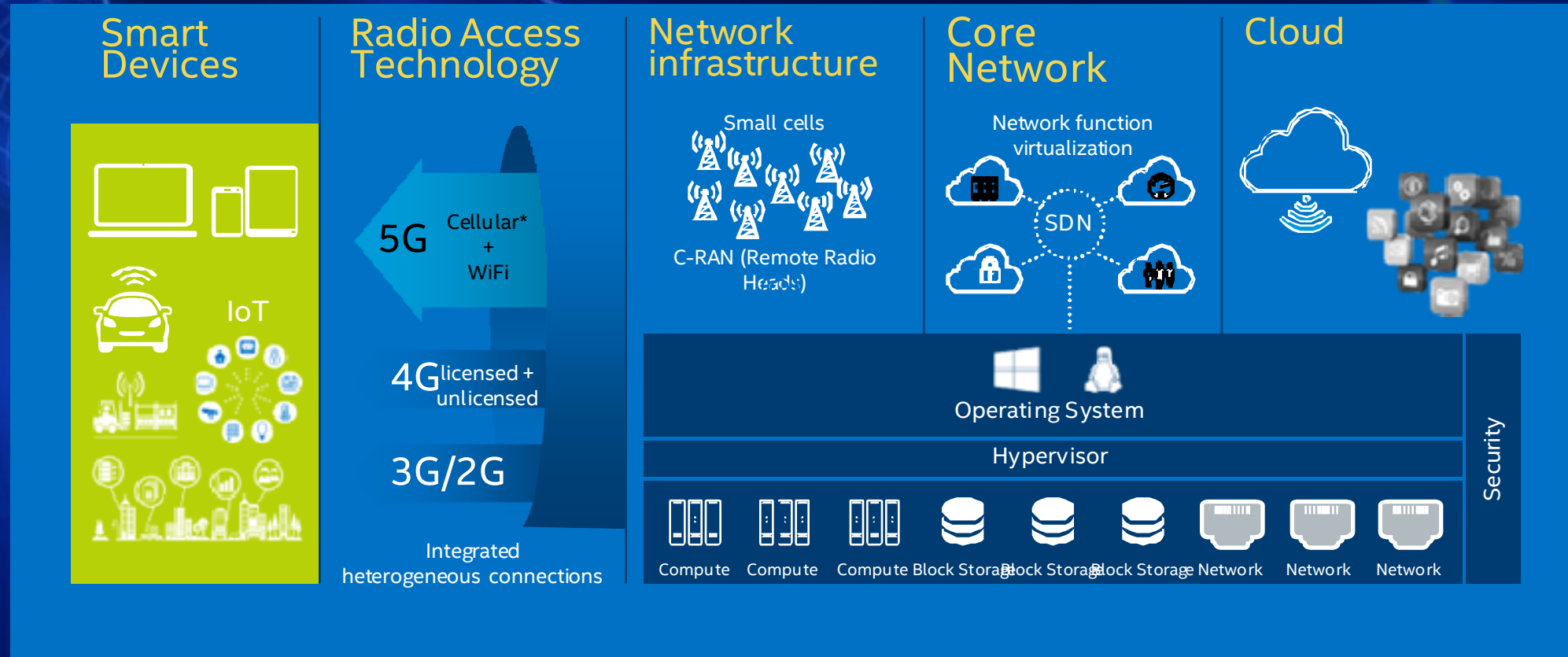


THE COMING 5G ERA

The text "5G" is rendered in a large, bold, sans-serif font. The letters are filled with a light blue color and have a subtle circuit-like pattern. The background of the entire image is a dark blue gradient with a complex, glowing white circuit board pattern that flows across the frame.

5G END-TO-END: NETWORK AND DEVICE TRANSFORMATION

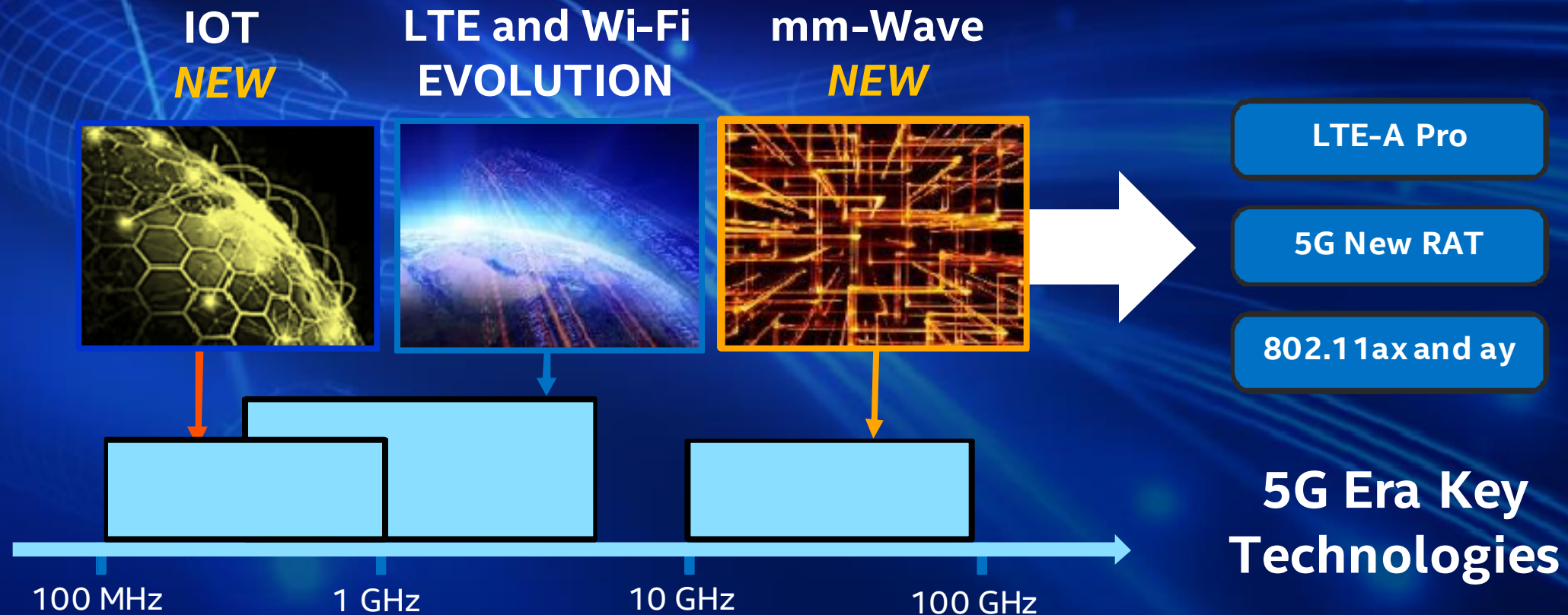
Intel Powers the end-to-end Network from Device to Cloud: Unleashing Tomorrow's Use Cases



Note: *licensed + unlicensed + cm/mmw; proprietary nodes and fixed appliances to co-exist with SDN/NFV

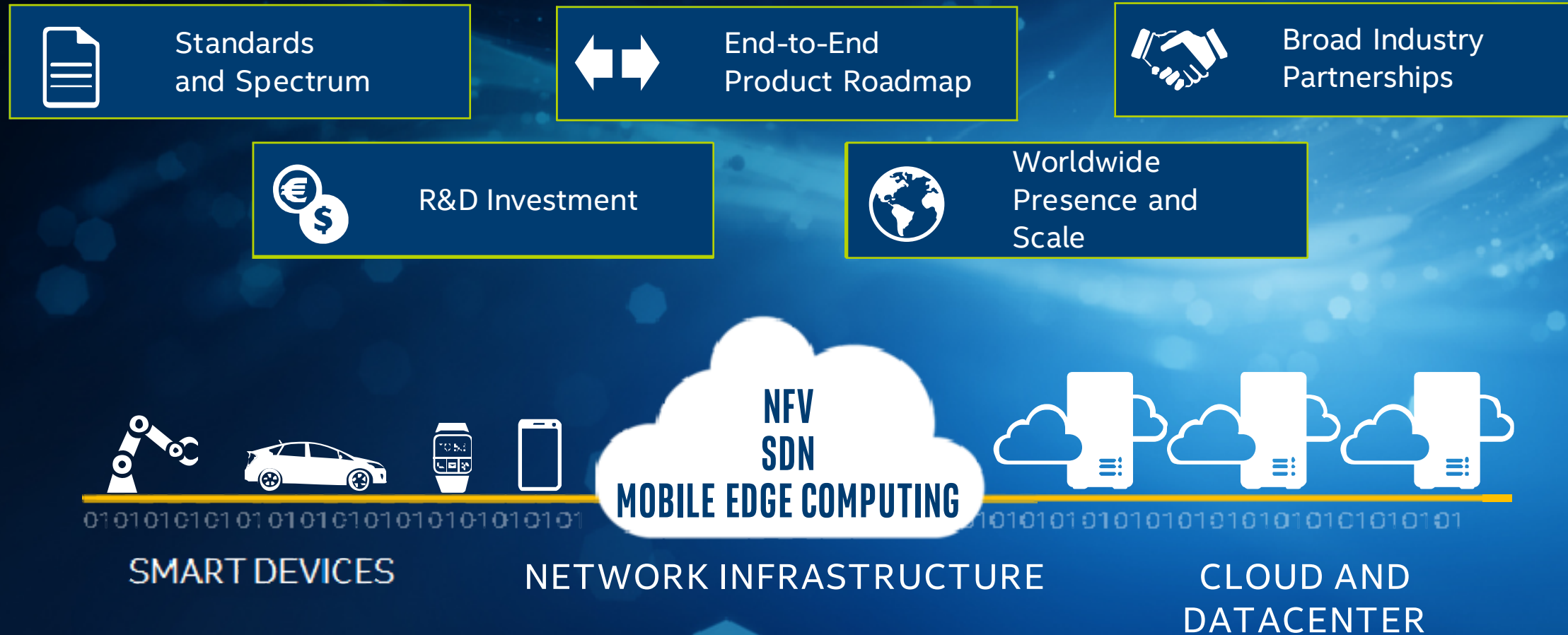
5G ERA – TECHNOLOGY TRACKS

5G Serves to an Extreme Range of Performance Requirements
(Data Rates, Latency, Battery Life, Coverage etc.)



Note: *licensed + unlicensed + cm/mmW; proprietary nodes and fixed appliances to co-exist with SDN/NFV

INTEL INNOVATING AND PARTNERING FOR THE 5G ERA



INTEL TRIAL ACTIVITIES IN SUPPORT OF **5G DEVELOPMENT**

Partnering with
AT&T* on its first
5G trials in 2016
and conducting
field trials for
wireless solutions
through the
Verizon* 5G
Technology Forum

Partnering with
KT* and **SKT *** in
Korea in
preparation for
5G trials for **2018**

In support of
**Japan 5G PoC and
Tokyo by 2020**

Participating
**China 5G
technology trial**
organized by
IMT2020* PG

INTEL 5G MOBILE TRIAL PLATFORM

Communications Stack

Powered by
Intel® Core™ i7 processor
Dual connectivity

Comms
Protocol
Stack



RF and
Antenna
Components



Baseband Signal
Processor

FPG
A

FPG
A

FPG
A

FPG
A

FPG
A

Radio Frequency Unit

Sub-6 GHz and 28GHz
cmWave

Four-stream MIMO

Baseband Processor

Five next-generation
Altera Arria 10 FPGAs

This device has not been authorized as required by the rules of the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained.

INTEL PROGRESS TO 5G

Intel is uniquely positioned to usher in the 5G era with end-to-end solutions that will integrate intelligence across the network, from the data center to the connected device and throughout systems in between.

MMWAVE PROTOTYPE

Active Research and development on mmWave technology and beamforming/beam steering

MOBILE EDGE COMPUTING

Applying network architecture concepts that enable cloud computing and IT service environment at the edge of the cellular network

C-RAN

Exploring CRAN architecture to create advance cost-effective, efficient infrastructure

MASSIVE MIMO

Creating massive antenna arrays to achieve large improvements in data throughput and energy efficiency

NB-IOT

Targeting deep indoor, wide area coverage, low device complexity and low device power consumption with NB-IOT



5G SPECTRUM

5G

EVOLUTION OF TECHNOLOGY AND SPECTRUM

2G	3G	4G	5G
VOICE 	+ SOME DATA 	+ LOTS OF DATA 	CONNECTED SOCIETY 
SPECTRUM			
Few MHz < 1 GHz	10s of MHz < 2 GHz	Several 10s of MHz < 4 GHz	Several 100s of MHz From < 1 GHz to > 70 GHz

SPECTRUM NEEDS OF 5G

Having access to sufficient spectrum in a variety of bands with economies of scale is key to success in 5G

5G applications drive technical requirements, including type and amount of spectrum

< 1 GHz – for wide area applications, e.g. sensor networks, etc.

< 6 GHz – for coverage/capacity trade-off, e.g. massive MIMO, outdoor-to-indoor

Higher – for apps needing ultra-wide channels, e.g. 4k/8k video, VR, etc.

Continuous flow of sufficient, adequate, new spectrum is key to:

Expansion of wireless market to 5G and beyond, and
Building a strong and healthy eco-system

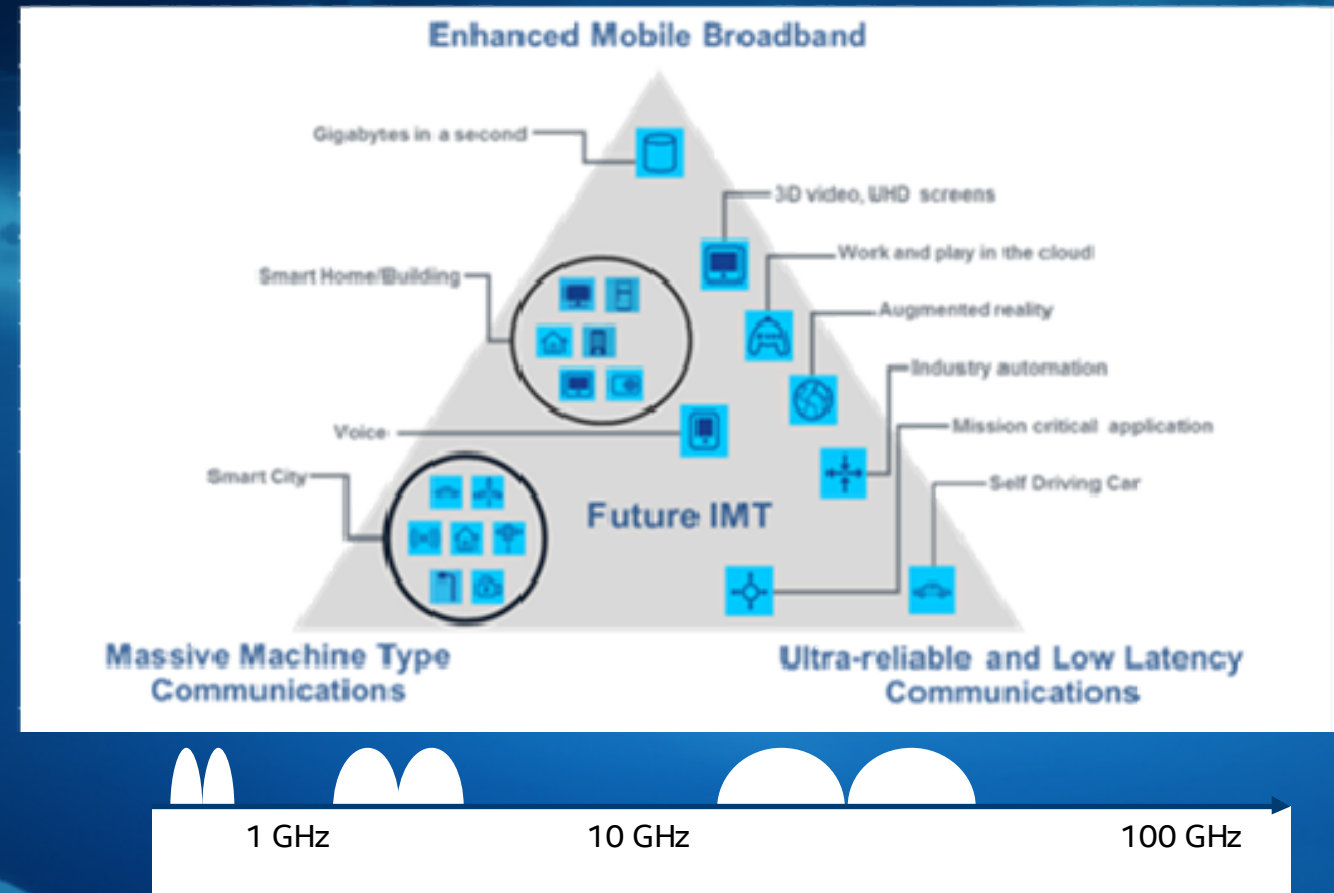
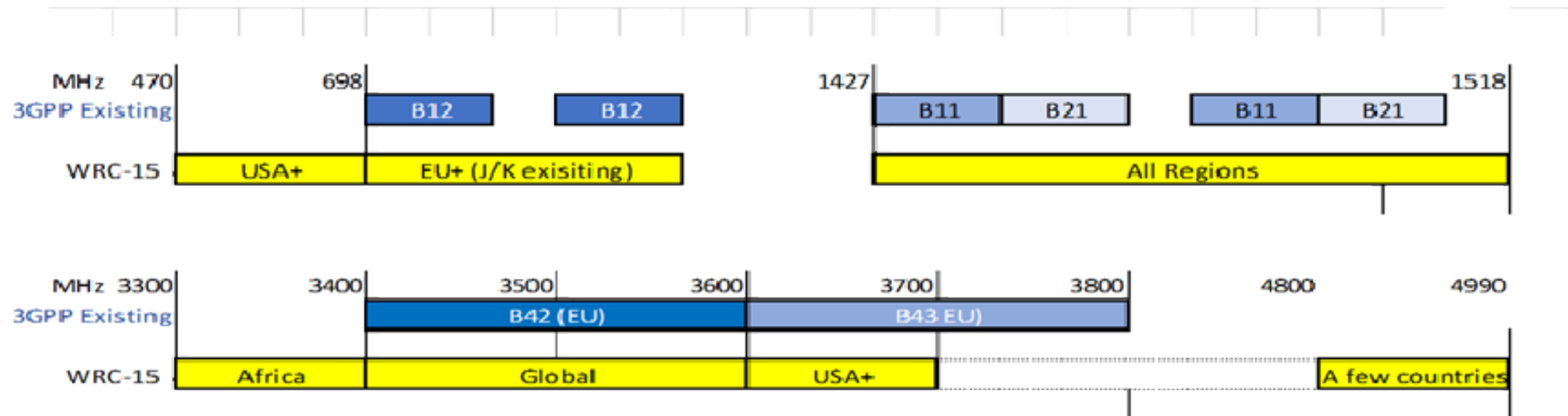


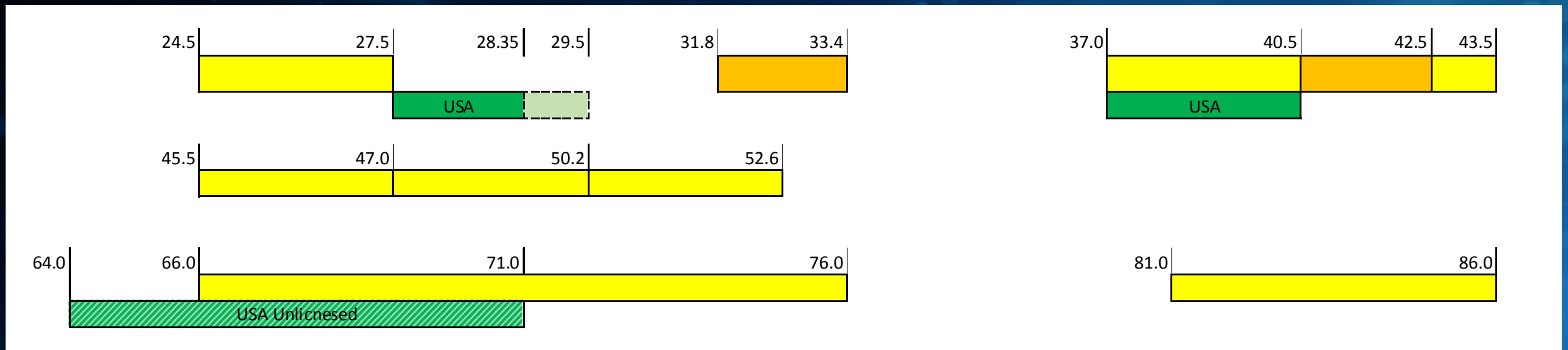
Image Source: Recommendation ITU-R M.2083 "IMT Vision - Framework and overall objectives of the future development of IMT for 2020 and beyond"

WRC-15 OUTCOMES BELOW 6 GHZ



Crucial to make sufficient spectrum sub 6 GHz available in a timely manner to enable 5G.

BANDS ABOVE 6 GHZ TO BE STUDIED TOWARDS WRC-19



Primary Mobile Allocation Exists

No Primary Mobile Allocation

FCC NPRM Bands

ITU-R will study the above several bands (yellow, orange) to prepare for WRC-19

If approved by WRC-2020, timeframe of availability ~2020

USA and some other countries are going forward with 28 GHz in 2016-2018 timeframe

Sharing conditions are expected to be difficult in some bands under study

US “5G”

Incentive auction of 600 MHz on track

“Frontiers” (mmW) Decision July 14

Mobile allocations for ~10 GHz of spectrum

Wide channel exclusive licenses

~28 GHz

~39 GHz

Existing licenses cover majority of population

Flexible performance rules

Satellite industry must rely on market mechanism for new growth

64-71 GHz--unlicensed

5G



ENABLING NB - IOT

5G

Narrowband IoT use cases: example of



NB-IoT Promises/KPI by technology definition

Complexity and cost reduction

- Plain NB-IoT, no legacy fall-back
- Limited number of RF bands supported, typically 1-2, savings in the RF front-end
- Half-duplex, cost savings in RF front-end and silicon design

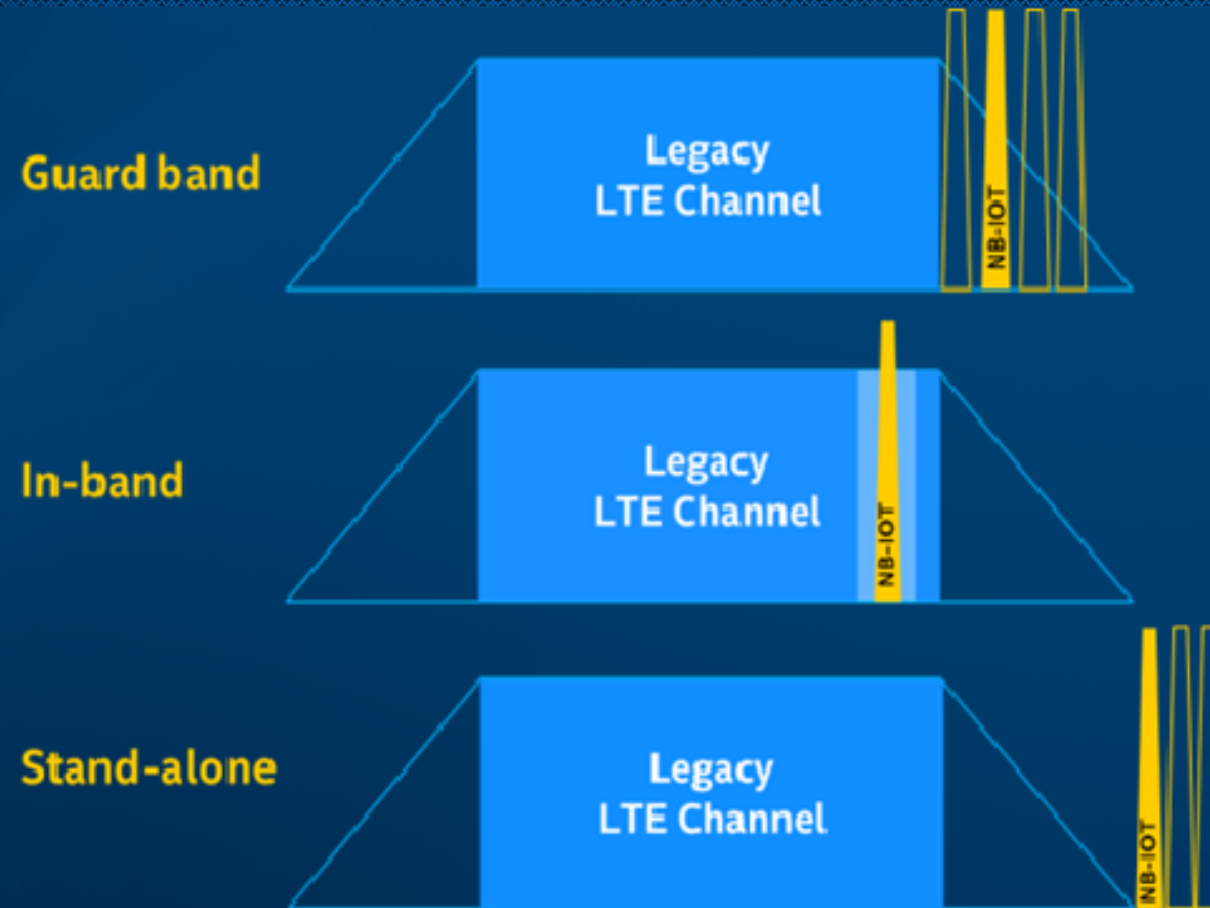
Deep indoor and wide area coverage

- + 10 dB extended coverage with moderate repetition factors
- + 20 dB extreme coverage combining high repetition factors and single-tone in uplink

More than 10 years battery life

- Rel.12 Power Saving Mode (PSM) for idle mode battery savings
- Rel.13 extended DRX (eDRX) for devices in connected or idle mode with irregular, sparse communication patterns

NB-IoT: guard band, in-band, stand-alone



- No use of LTE channel resources by NB-IoT
- No use of additional spectrum by NB-IoT
- **NB-IoT channels in guard band limited**

- **Use of LTE channel resources by NB-IoT**
- Trade NB-IoT channels vs. LTE capacity
- No use of additional spectrum by NB-IoT

- No use of LTE channel resources by NB-IoT
- **Use of additional spectrum by NB-IoT**

SUMMARY

5G offers dramatic jump in terms of not just speed but breadth of services.

Intel involved “end to end” in key SDOs/PPP and with partners to enable 5G.

5G will have both licensed (3GPP/IMT-2020) and unlicensed (IEEE 802.11) components: technical specifications being developed.

Having access to sufficient spectrum in a variety of bands with economies of scale is key to success in 5G

- Spectrum in sub 6 GHz should be made available quickly
- US moving forward in July with 28 GHz and 39 GHz. Other countries will need to also move quickly to enable 5G.

2G
also move quickly to enable
Other countries will need to
with 28 GHz and 39 GHz
US moving forward in July

5G

EXPANDING THE BOUNDARIES OF CONNECTIVITY



**AUTONOMOUS
VEHICLES**



**MEDICAL
MONITORING**



**SMART
CITIES**



**AUGMENTED
REALITY**



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