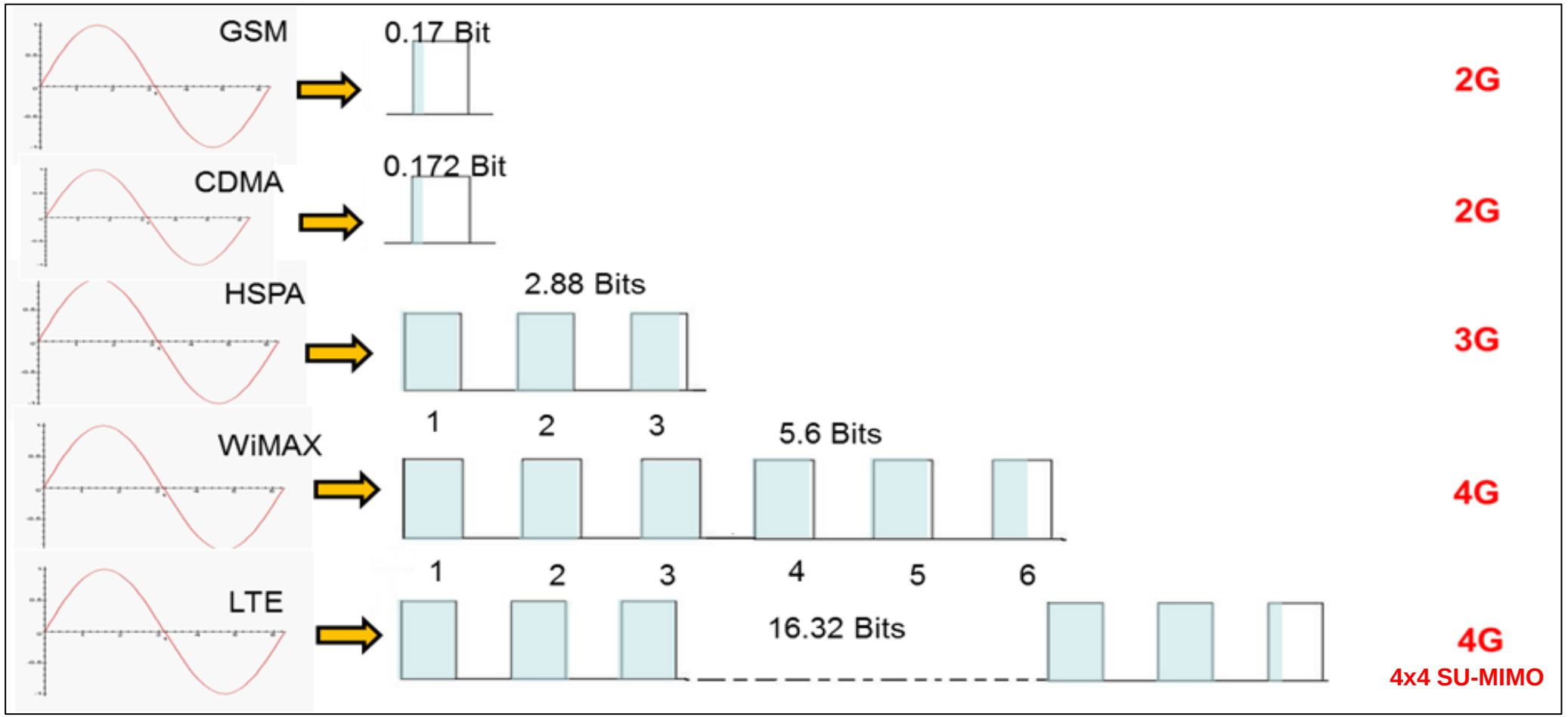
5G in India – Operators Perspectives

Reliance Jio

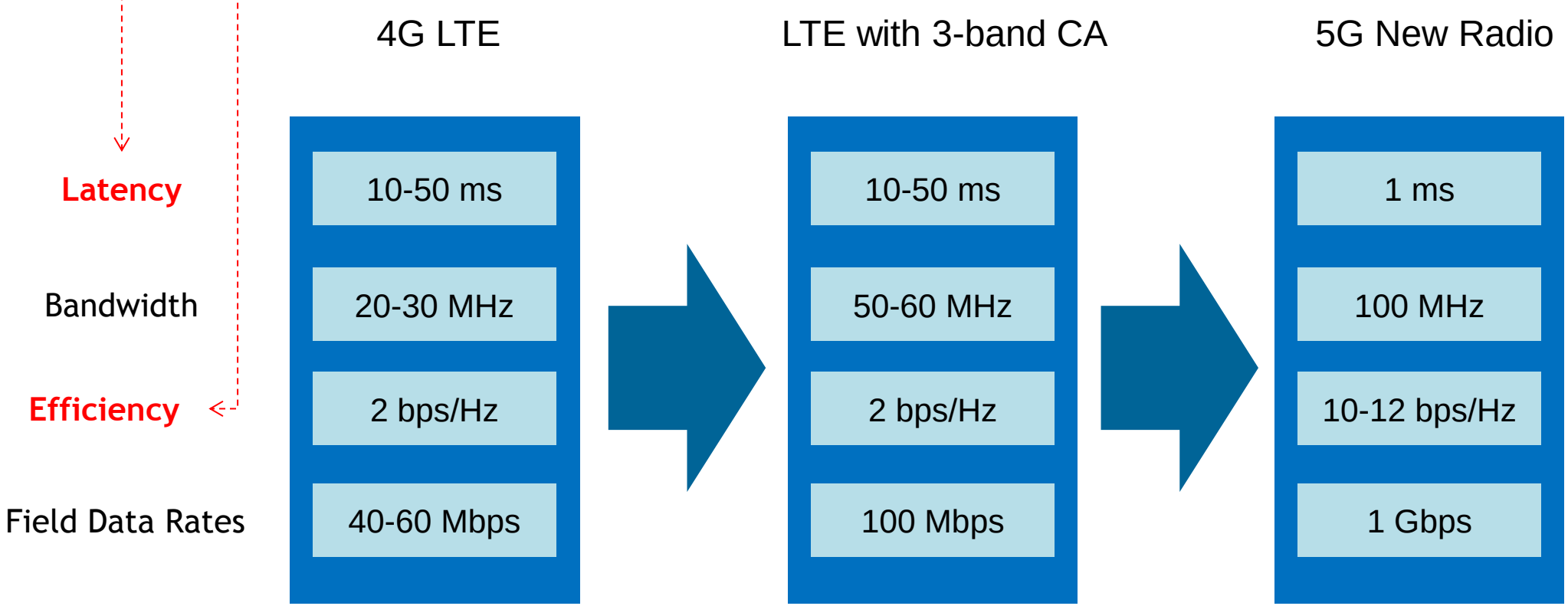
Spectral Efficiency – So far (Peak Data Rates).



- 5G in Sub-6 GHz would provide more than 8x gain.
- In addition to this gain, 5G can also provide 25% more efficiency in wider channel bandwidths owing to lower overheads for Reference Signals, Sync Signals, Broadcast Channel and Dedicated Control Channels

Generations of Cellular networks have spectral efficiency as the core objective.

The 5G architecture is characterized by both improved spectral efficiency, and reduced latency



Spectrum being a scarce natural resource should be used most efficiently, ***hence the need to move to 5G***

Low Latency opens up a whole world of new services

Exponential Growth of “Data on Mobile/Wireless” and in particular “Video based Applications”

Snippets from Cisco Visual Networking Index (VNI) Report

- Global **IP traffic** will increase nearly **threefold over the next 5 years**. It will grow at **CAGR of 24%**
- **Smartphone traffic will exceed PC traffic by 2021**. Traffic Distribution across devices in 2021 would be as follows:
  - **33% Data Traffic through Smart Phones** , 25% PCs, 42% - Others (Tablets, TV, M2M etc.)
- Globally, **mobile data traffic will increase sevenfold between 2016 and 2021**. CAGR of ~ 50%
- **82 % of all consumer Internet traffic** by 2021 will be **Video Traffic**
  - **Live Internet video** will account for 13 percent of Internet video traffic by 2021
  - **Internet video surveillance traffic** will increase **sevenfold** between 2016 and 2021. Globally, 3.4 percent of all Internet video traffic will be due to video surveillance in 2021
  - **Virtual Reality (VR) and Augmented Reality(AR)** traffic will **increase 20-fold** between 2016 and 2021, at a CAGR of 82 percent
  - **Internet video to Smart TV** will continue to grow at a rapid pace, increasing 3.6-fold by 2021. Internet video-to-TV traffic will be 26 percent of consumer Internet video traffic by 2021
  - **Consumer Video-on-Demand (VoD)** traffic will nearly double by 2021

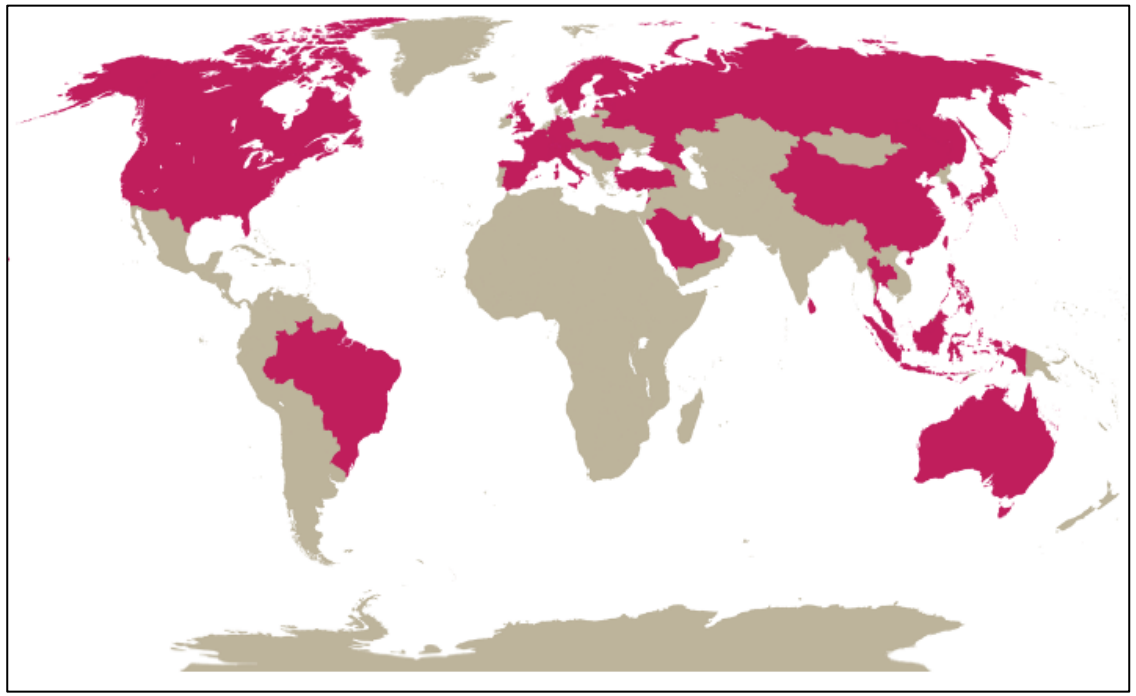
5G is a must to create sufficient capacities that can deliver video streaming bit rates to large number of mobile phones and other wireless devices

5G Spectrum - Globally

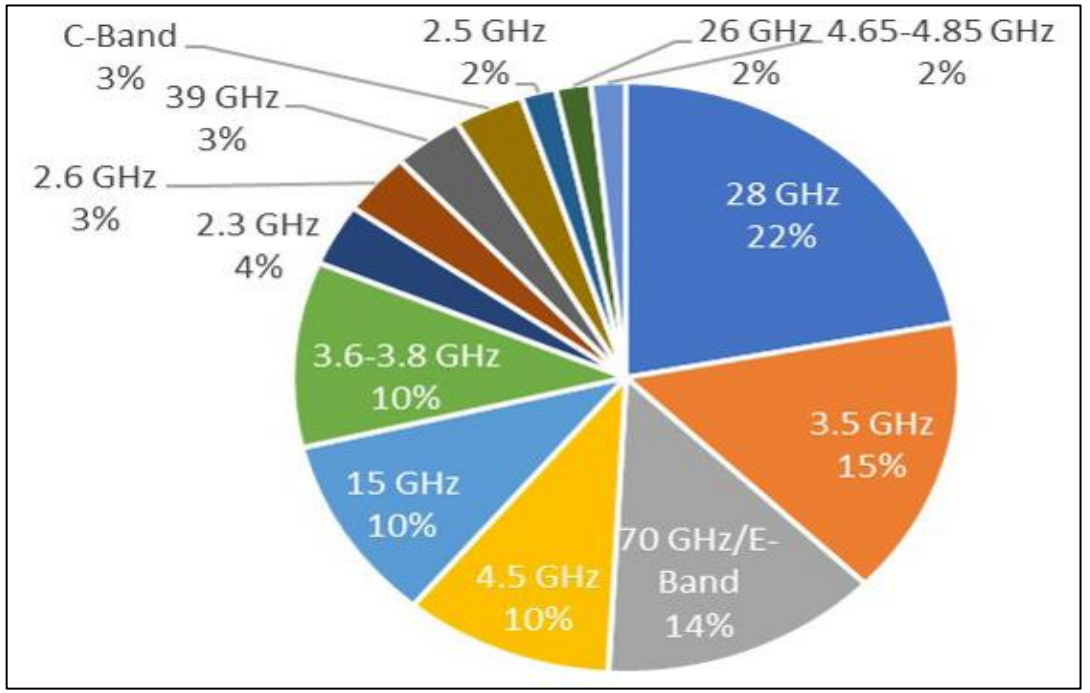
The Global trends for 5G spectrum allocation for trails indicate two broad categories:

1. **Sub 6 GHz Spectrum – primarily 3.5 GHz**
2. **> 6 GHz Spectrum – primarily 28 GHz and 70 GHz**

Global 5G Trial Landscape

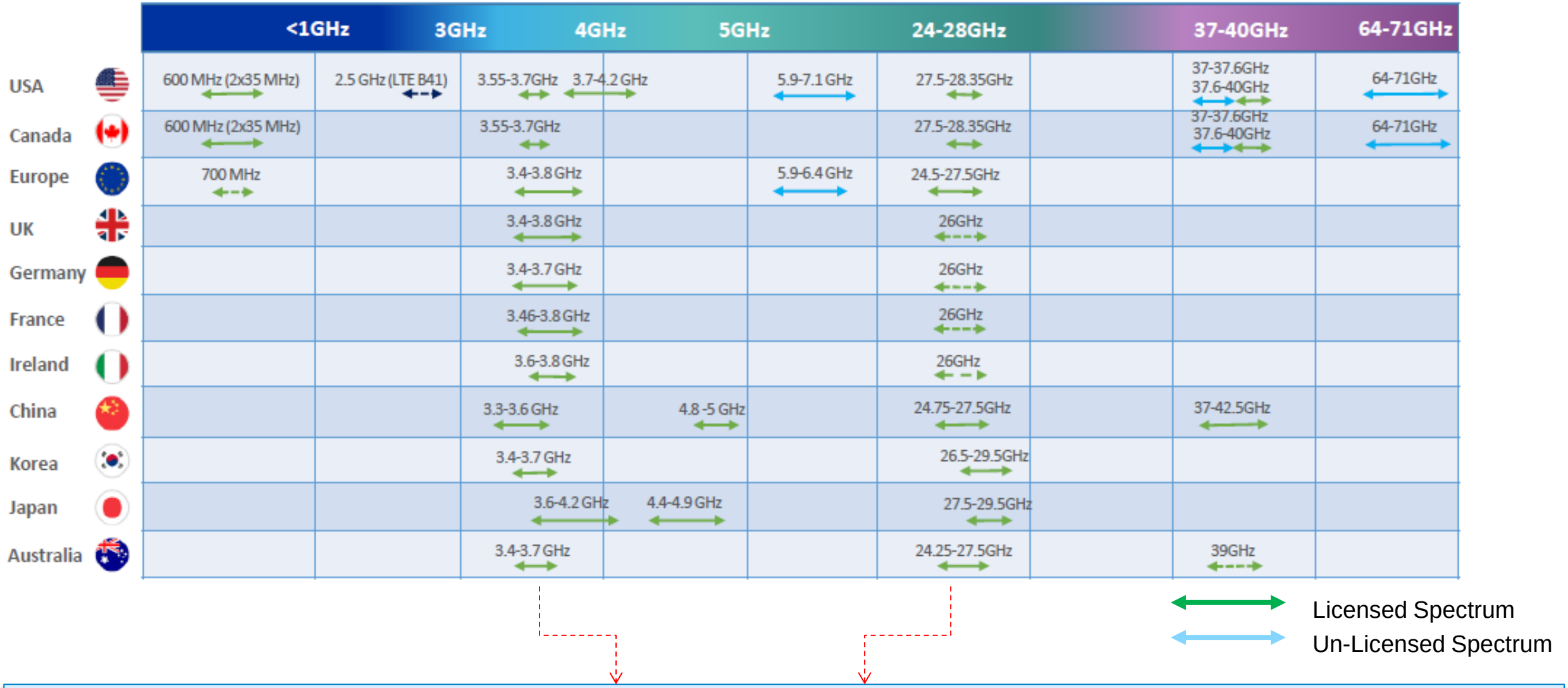


Spectrum bands used in over 50 trials:* *Source:GSA



3.5 GHz Spectrum Allocation in India would provide an excellent opportunity to provide improved Mobile Broadband to customers with reasonable capacity

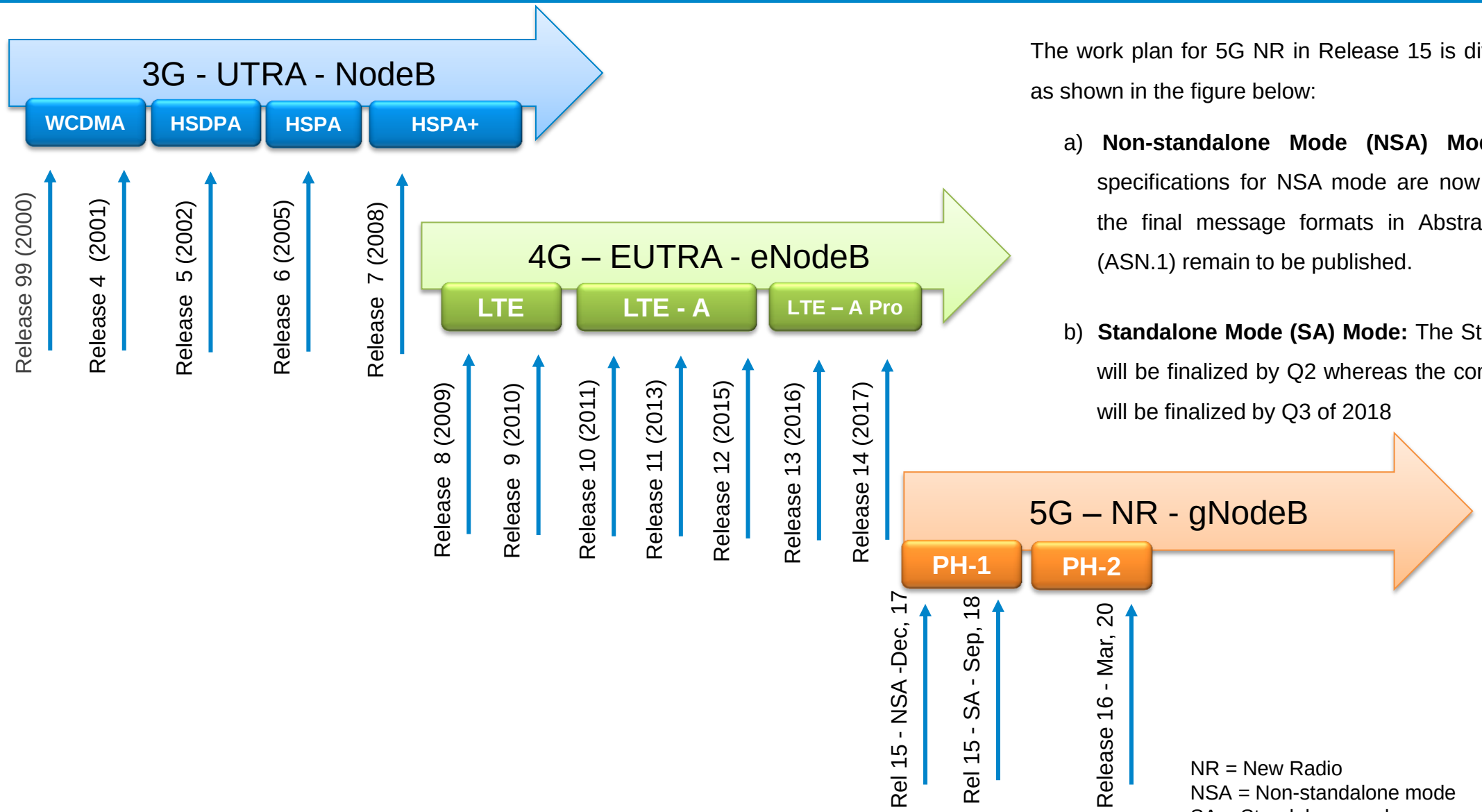
5G Spectrum – In Top Wireless Markets



3.5 GHz Band in Sub-6 GHz and 28 GHz in millimeter Wave are the most popular 5G bands globally

5G Standardization Timelines

Standardization moving ahead with a rapid pace to bring new services to market rapidly



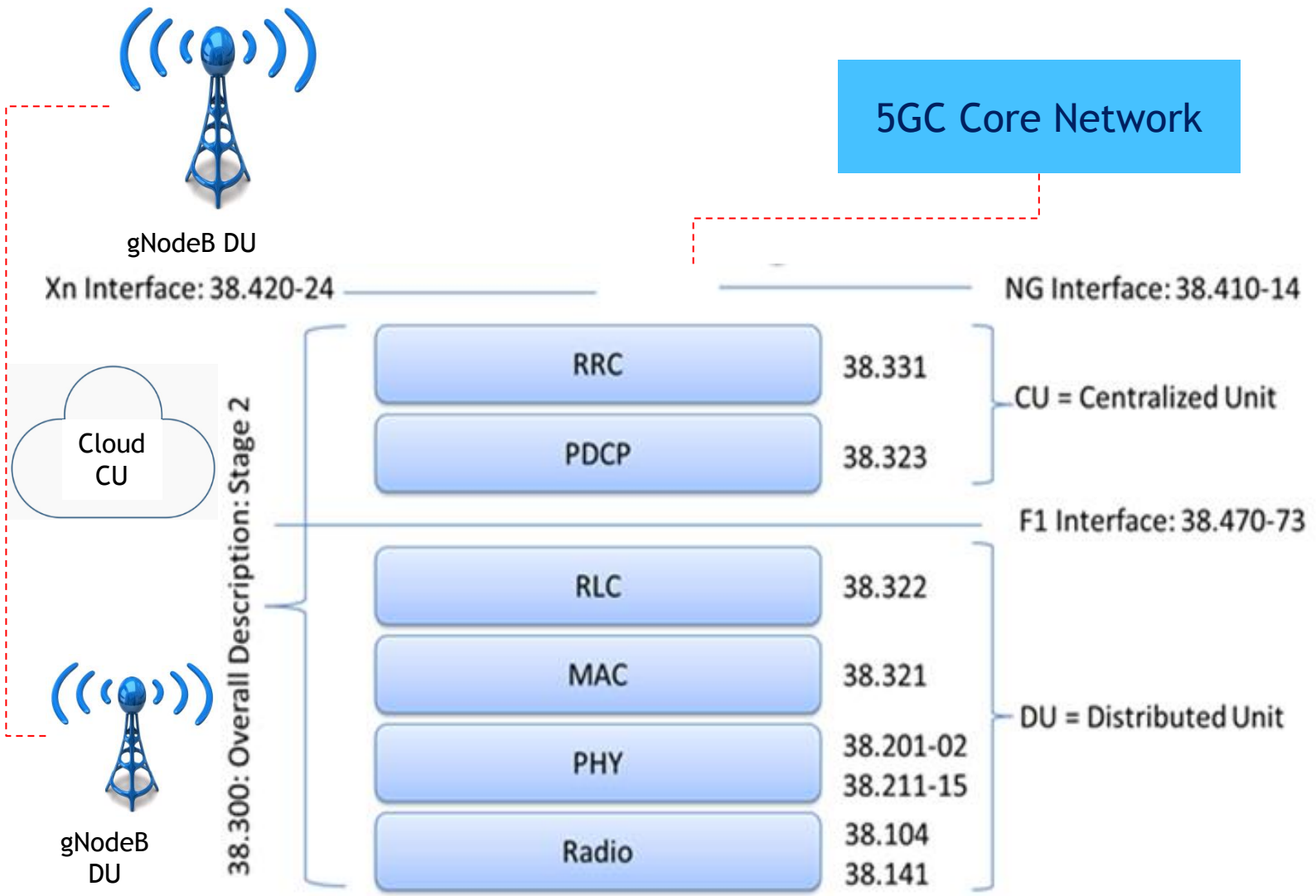
The work plan for 5G NR in Release 15 is divided into two parts as shown in the figure below:

a) **Non-standalone Mode (NSA) Mode:** The Stage 3 specifications for NSA mode are now complete and only the final message formats in Abstract Syntax Notation (ASN.1) remain to be published.

b) **Standalone Mode (SA) Mode:** The Stage 3 specifications will be finalized by Q2 whereas the complete ASN formats will be finalized by Q3 of 2018

NR = New Radio
NSA = Non-standalone mode
SA = Standalone mode

A pictorial view of key 3GPP Specifications for 5G and new Split Architecture of RAN



- 5G NR specifications are defined in a separate series called 38 series specifications. A pictorial view is shown.
- A major architectural difference in the 5G NR specification compared to LTE specification is that a “Split” in 5G NR Protocol Stack at the PDCP Layer is natively defined 5G RAN architecture.

The split is not mandated but the architecture provides an option to split the gNB into two parts: A Centralized Unit (CU) and a Distributed Unit (DU) with interface between them known as F1 Interface.

The F1 interface is also fully specified for both control plane as well as user plane.

Thus with F1 interface standardization, 3GPP has sowed the seeds of Virtualization in the RAN for the Centralized Unit (CU).

Four factors that further enhance Spectral Efficiency in 5G

- Since 5G NR can support very wide bandwidths, it can provide around **25% more throughput** than Multi-carrier Carrier Aggregation (CA) technology of 4G LTE.
- **The gain comes from the following factors:**
  1. Guard band on either side of the channel is around 50% less compared to 4G LTE. As a result more spectrums can be used to transmit 5G NR.
  2. Reference Signal is not transmitted across the entire bandwidth by default. It is transmitted only in allocated PRBs. This reduced overhead as well as interference
  3. Control Channel overhead is 2-5% less in 5G NR
  4. Overhead of Synchronization Signals as well as Broadcast Channel is also lesser in 5G NR

5G New Radio – Key Features

- Since initial deployments of 5G will be in higher bands such as 3.5 GHz and 28 GHz, coverage could be a key issue.
- Following features have been built into 5G radio to manage the coverage issue:

1. **Dual Connectivity:** Device connects to both 4G and 5G. Control signaling as well as uplink can be through 4G LTE in lower spectrums such as 850 MHz

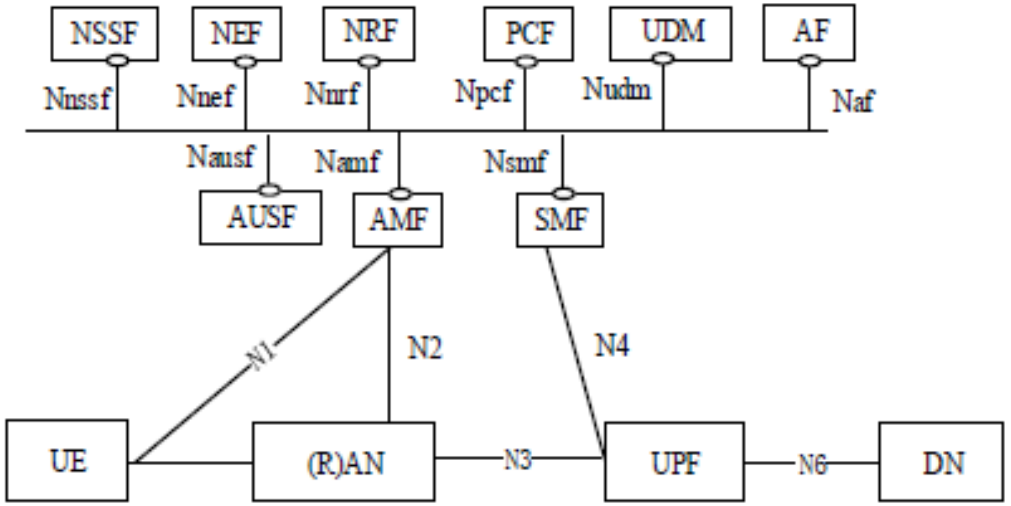
2. **Supplementary Uplink in 5G NR:** For example, in case of NR deployed in 28 GHz mmWave as well as 3.5 GHz band, the uplink can be sustained over 3.5 GHz only so that the coverage of mmWave is not limited by propagation losses of mmWave. Similarly, 5G NR in 700 MHz can also provide supplementary uplink for 5G NR in 3.5 GHz band

3. **Beam forming for Synchronization Signal as well as Broadcast Channel:** A narrow beam with high directional gain can be steered in the space and this increases the coverage of control channel

Using above features coupled with use of large antenna arrays (Massive MIMO), the end objective should be to achieve downlink coverage of 3.5 GHz that is identical to uplink coverage of 2.3 GHz / 1.8 GHz so that substantial downlink traffic can be offloaded from 4G to 5G when devices are available

5G Core Network: Designed based on Service Based Architecture

- Every Control Plane Function exposes its NF services through the service-based interface

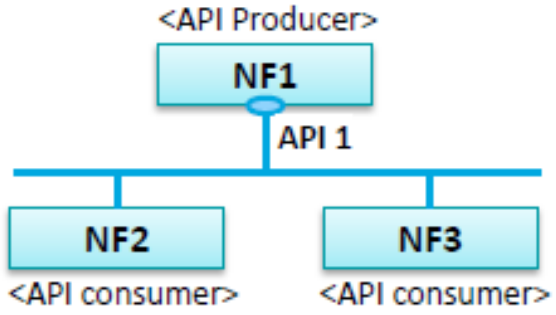


* 5G System architecture [TS 23.501]

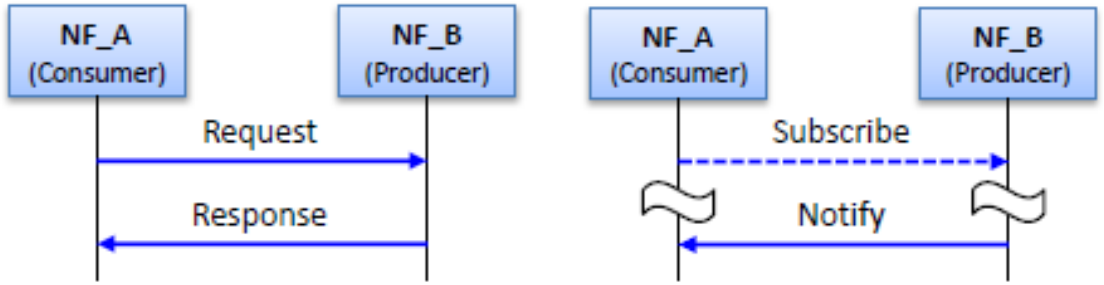
Network Functions	
AMF	Access & Mobility Management Function
SMF	Session Management Function
PCF	Policy Control Function
UPF	User Plane Function
AUSF	Authentication Server Function
UDM	User Data Management
AF	Application Function
NSSF	Network Slice Selection Function
NRF	Network Repository Function

Service-based Interface

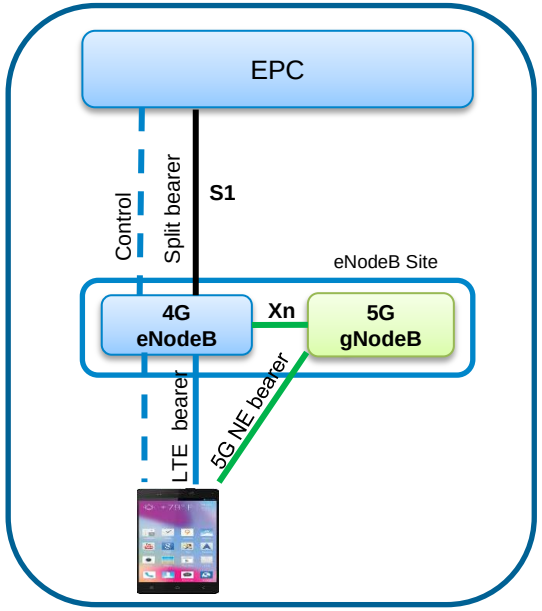
Single procedure is abstracted as single API



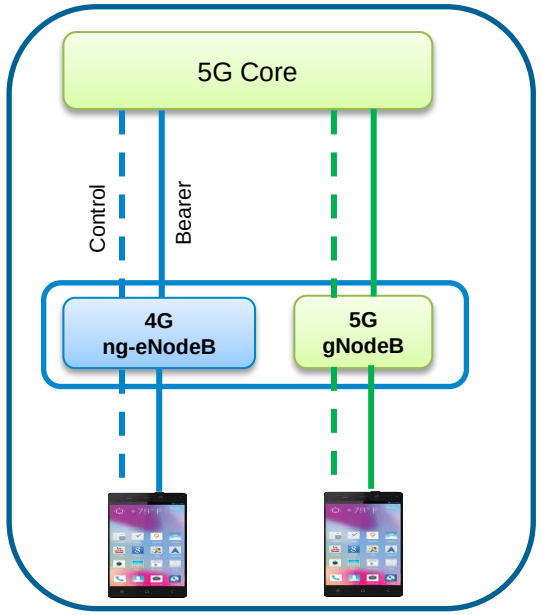
Protocol Primitives are Request-Response and Subscribe-Notify



5G Core Network: Two Deployment Options



Non-Standalone Mode



Standalone Mode

- The equivalent of LTE eNodeB in 5G is called gNodeB and the radio interface is termed as ‘New Radio’.
- 3GPP has created the specifications to allow phased deployments of 5G - starting with Non-Standalone (NSA) mode.
- In NSA mode, gNodeB will integrate with the existing LTE EPC. Therefore even as the gNodeBs are installed, they can be connected to the existing Jio EPCs. The NSA mode is depicted in the Left figure below.
- The gNodeB is shown to be connected to a neighboring or co-located 4G eNodeB which in turn connects to the EPC.
- The second phase is to move towards Standalone (SA) deployment of gNodeBs with the 5G Core (Next Generation Core – NGC) which will be the 5G counterpart of the current EPC.
- The 4G LTE eNodeB will also have to evolve to ng-eNodeB to integrate with 5G Core.

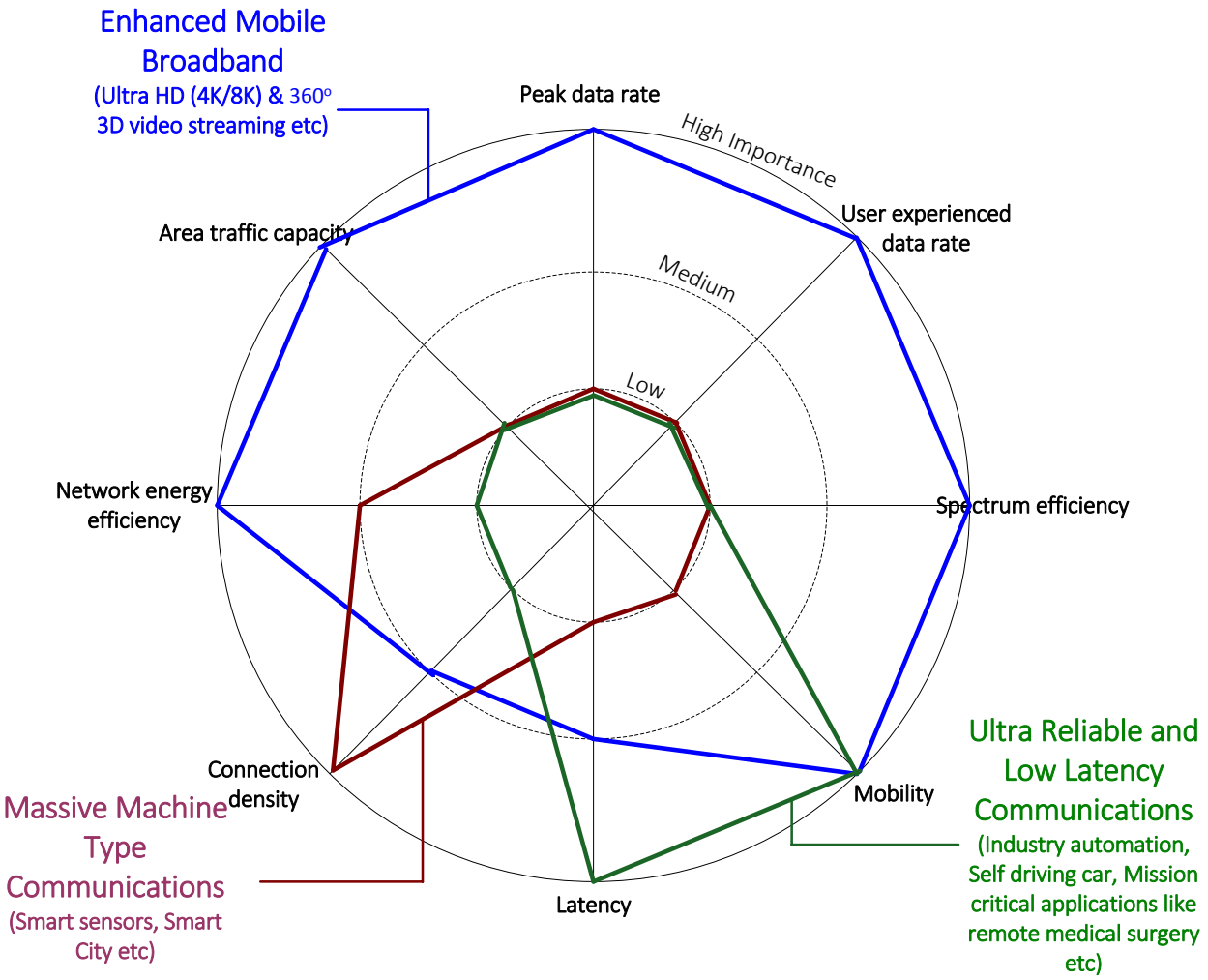
5G - One Technology that can satisfy a multitude of Parameters for Next Generation Services

5G should satisfy a variety of requirements for the following three broad category of services defined by ITU as part of IMT-2020.

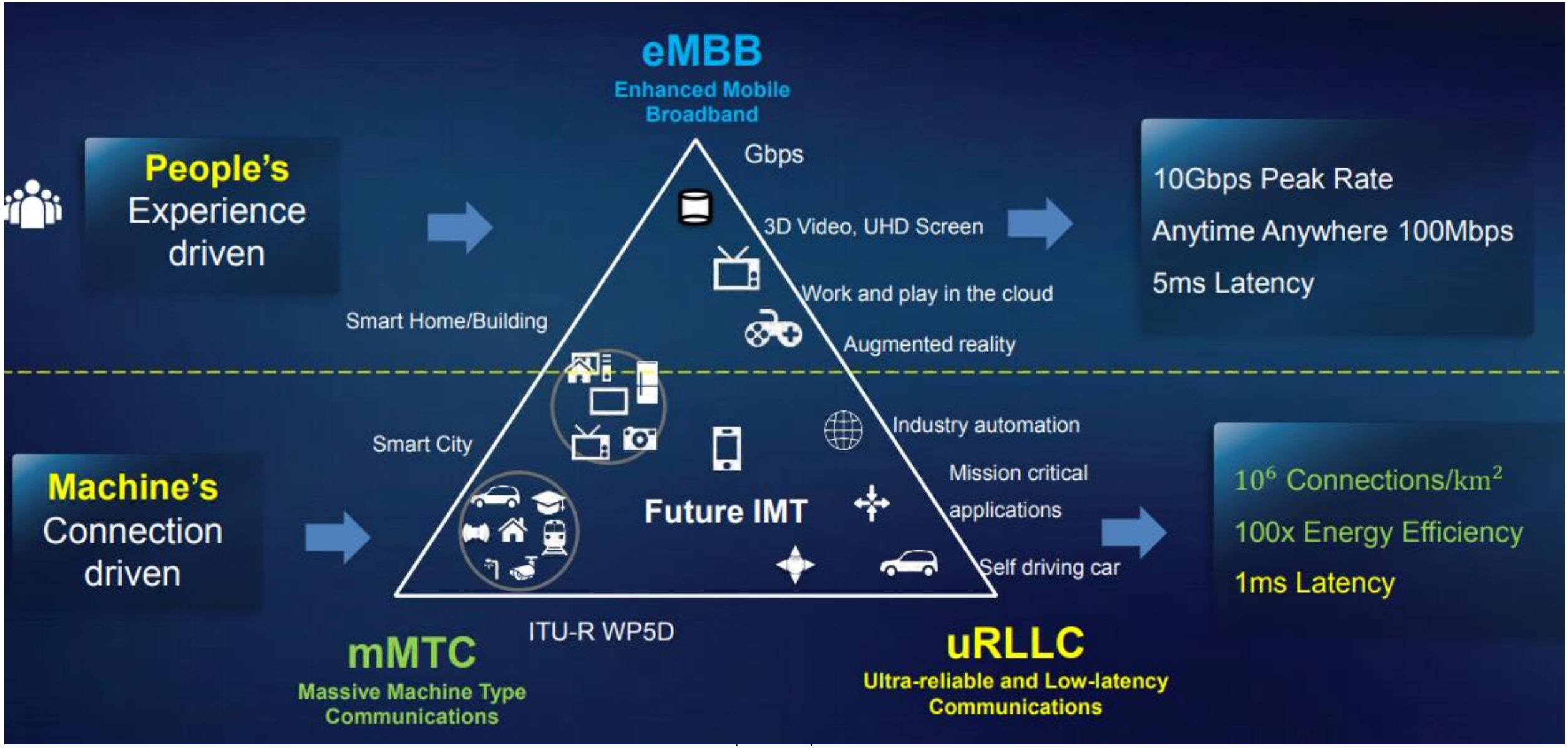
1. **Enhanced Mobile Broadband (eMBB)**
   - High Peak Data Rates & Spectral Efficiency
   - High User Data Rates
   - High Area Traffic Capacity
   - No compromise on Mobility

2. **Massive Machine Type Communication (mMTC)**
   - High Connection Density
   - High Energy Efficiency

3. **Ultra Reliable and Low Latency Communication (urLLC)**
   - Very Low Latency
   - No compromise on Mobility



5G Services – Another Illustration



New Innovative Services using LTE, 5G and NB-IoT

Limitless Possibilities by using Network As A Service (NaaS) concept

- LTE, 5G NR and NB-IoT will act as Enablers for connectivity
- Network will open up APIs for Developers of Apps and Services
- Variety of Devices will communicate to the Services over Radio Access Network

LTE Connected Classroom

EDU App

Wi-Fi

LTE Connected Village Hospital

ECG

SPO2

BP

Wi-Fi

Comm Device

Health App

IP Backhaul

IMS

EPC

Service Delivery Platform

APIs

Education Services

Health Care Services

Security and Surveillance Services

APIs

Agriculture Related Services

Fleet Management Services

Smart City Services

Connected Car Services

Client

5G enabled Cameras

NB-IoT Agriculture Sensors

Client/ App

Connected Car