



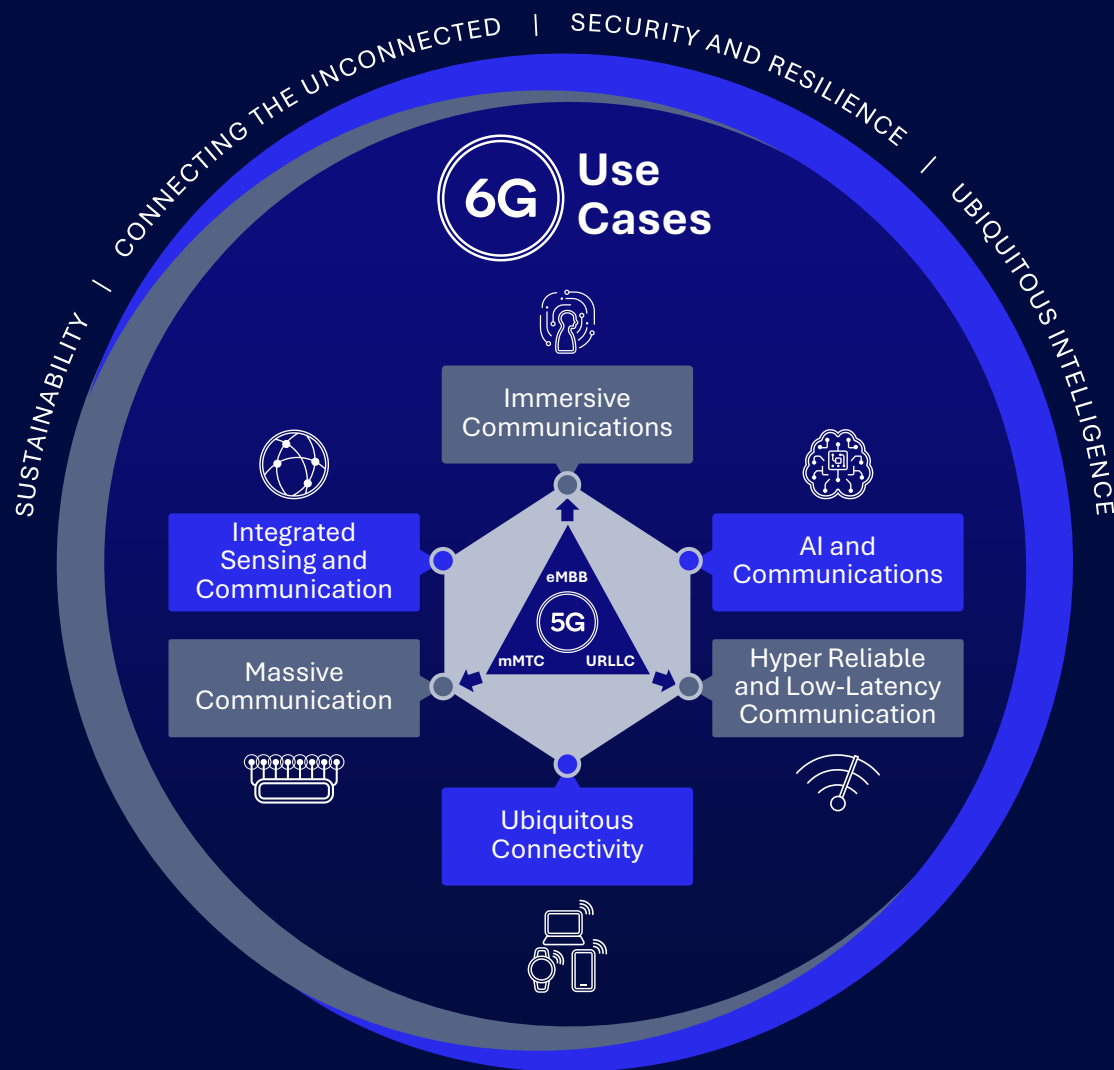
6G Spectrum Roadmap : Way to Shaping India's 6G Global Leadership

- Jitendra Singh

- Head Govt. Affairs (India) & Spectrum Strategy (APAC) Qualcomm



6G Framework - Usage scenarios and capabilities



Enhanced Capabilities

Security resilience	
Reliability	5G $1-10^{-5}$ 6G $\uparrow 1-10^{-5} - 1-10^{-7}$
Latency	5G 1 6G $\downarrow 0.1 - 1$ ms
Mobility	5G 500 6G $\uparrow 500 - 1,000$ km/h
Connection density	5G 10^6 6G $\uparrow 10^6 - 10^8$ devices/km ²
Area traffic capacity	
Spectrum efficiency	
User experience data rate	
Peak data rate	

New Capabilities

- Coverage
- Sensing-related capabilities
- AI-related capabilities
- Sustainability
- Interoperability
- Positioning (1-10 cm)



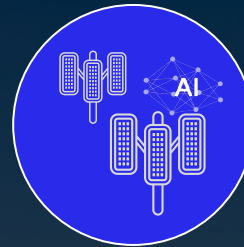


Pillars: Connectivity, Wide-area Sensing, AI Compute

INTELLIGENT DEVICES



6G RAN
+ RAN AUTOMATION



TELCO
EDGE CLOUD



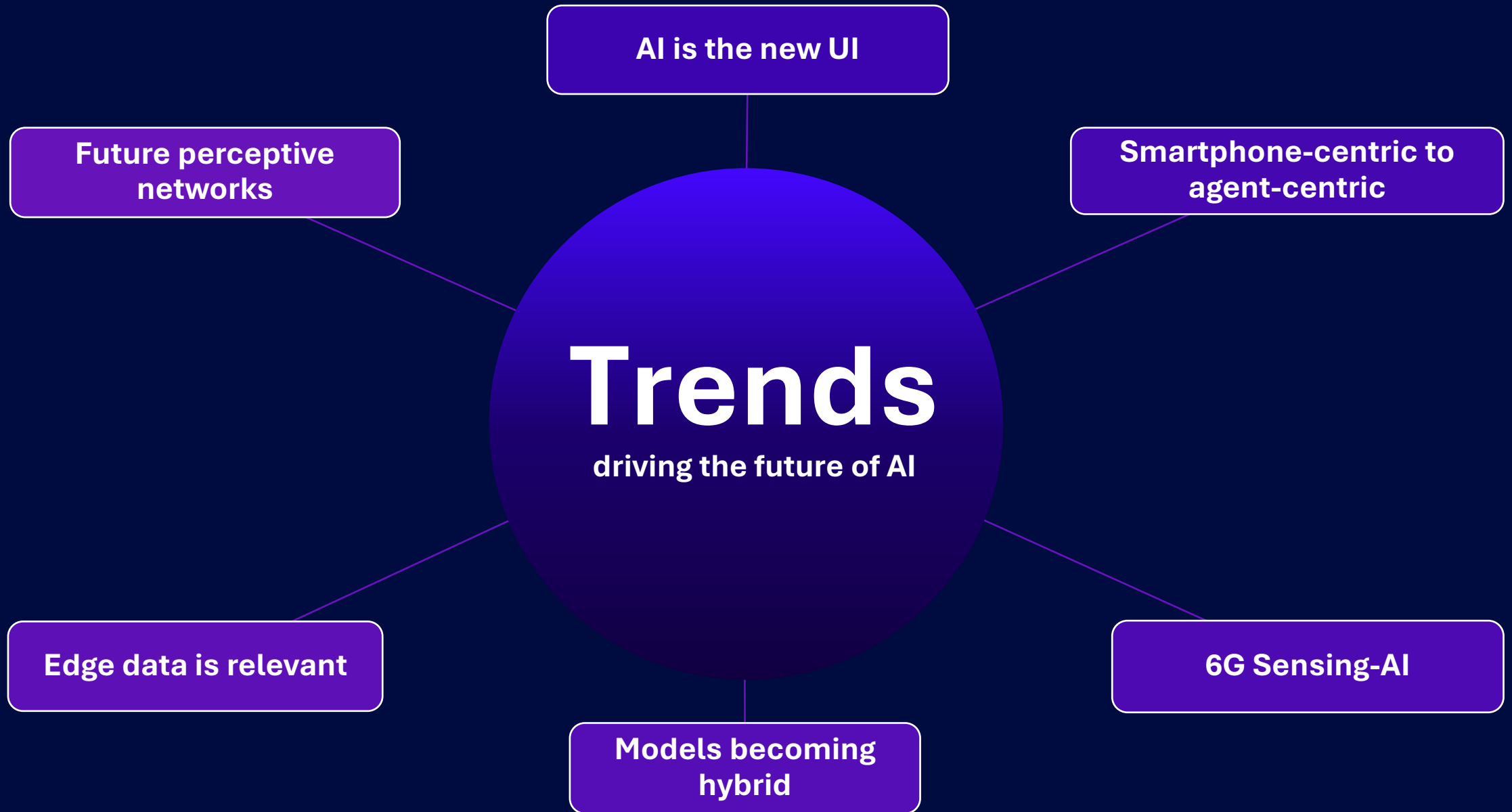
CENTRAL
CLOUD



CONNECTIVITY

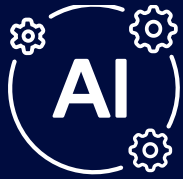
WIDE-AREA SENSING

AI COMPUTE



We stand at Edge of Intelligent Future

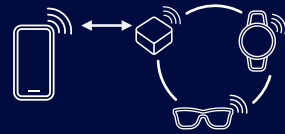
Changing consumer behaviors



Rise of AI agents

From app-based, user-initiated content consumption...

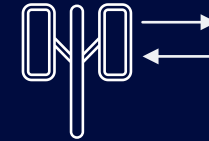
To persistent context-aware AI agents that observe, sense, and infer



Extension to new form factors

From smartphone only...

To an ecosystem of AI-enabled devices (watches, glasses, earbuds) working together for more natural interactions



Evolving usage patterns

From downlink-heavy traffic...

To sustained traffic growth, especially uplink, driven by AI agents continuously monitoring and sensing across IoT, robotics, AR glasses, ...

Today,
With smartphones...



2030+
Natural interactions
via watch, glass,
voice using AI
Agents



"Order a ride for two people to go to the mall and remind me what to buy!"



"Show my schedule and tell me about my next patient."



"Tell me the history of this building."

Value is created at the edge

6G and advanced wireless technologies are key to unlocking AI's full economic potential



Connected AI and compute enable new use cases for the merging physical, digital, and virtual worlds

AI-driven transformation of the 6G system

AI-native 6G
with adaptive intelligence

NETWORK



DEVICE



AI SERVICES ON RAN

OPTIMIZED PERFORMANCE FOR NEW USE CASES

- AI-driven applications including Chatbots, Gen AI, XR, gaming, etc.
- AI-enabled devices such as robotics, drones, etc.

AI-ENHANCED AND DRIVEN DEVICES

- AI-driven devices such as robots, self driving vehicles, etc.
- AI-enhanced devices such as smartphones, wearables, etc.



AI SOLUTIONS FOR RAN

AGENTIC AUTOMATION TO OPTIMIZE DEPLOYMENT

- Optimized performance such as energy saving for reduced TCO
- Adaptive user experience
- Improved resiliency through threat and anomaly detection

UE AGENTS

- Assist and work with network agents
- Leverage user experience and modem data to detect and potentially solve issues



AI-BASED ENHANCEMENTS IN RAN

AI-ENHANCED CU

- Mobility
- Traffic prediction

AI-ENHANCED DU

- Channel state feedback / prediction
- Beam management
- High PHY on an AI platform
- Positioning

AI-ENHANCED RU

- AI-driven RF power efficiency
- Channel estimation

CI / CD AND MLOPS

- Rapid deployment of new 6G features
- Lifecycle management of deployed models

VIRTUALIZED TELCO WORKLOADS ON CLOUD

- Leverage data centers in central/edge clouds to run telco workloads

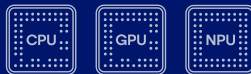
AI-ENHANCED PHY/MAC

- AI-native protocols for adaptive parameter selection
- On device AI to support RAN AI features

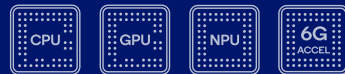


AI SERVICES AND RAN IN A SHARED PLATFORM

Central cloud



Telco edge cloud



Radio unit

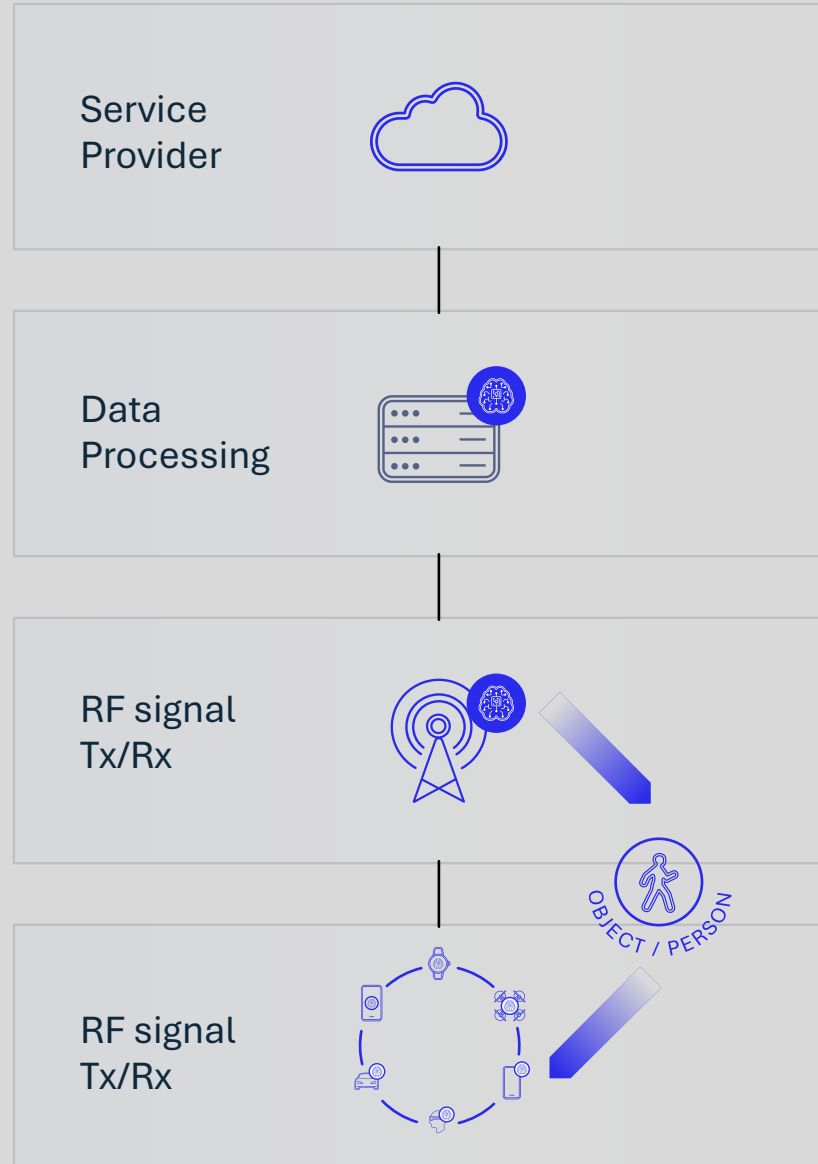




Wireless sensing

To utilize radio frequency (RF) signals from a wireless system to gain insights into the environment

Object does not contain active electronics or support device positioning



Types of wireless sensing use cases include:

- Presence detection and recognition
- Motion and gesture recognition
- Activity monitoring
- Environmental monitoring
- Vital signs
- Localization
- Occupancy counting
- Fall detection
- Sleep tracking
- Intrusion detection



Drone detection and tracking



Automotive detection and tracking



Immersive XR



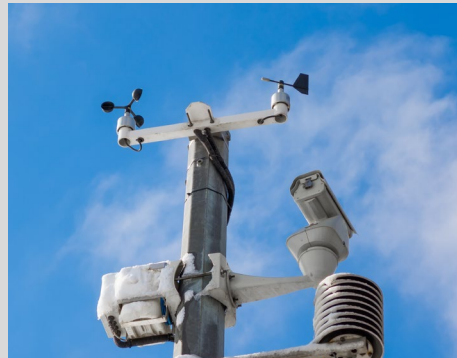
Automated guided vehicles (AGVs) detection and tracking



Digital twins



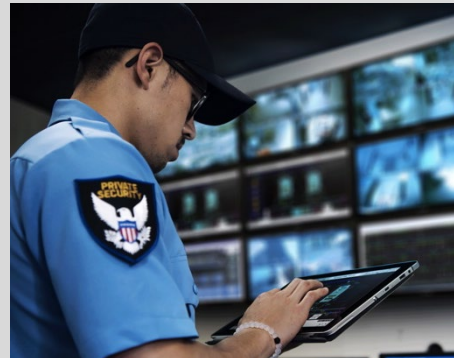
Pedestrian and obstacle monitoring on roads / railways



Weather monitoring



Health monitoring



Home intruder monitoring



Improving network performance and efficiency



Wireless sensing can support a variety of use cases across industries



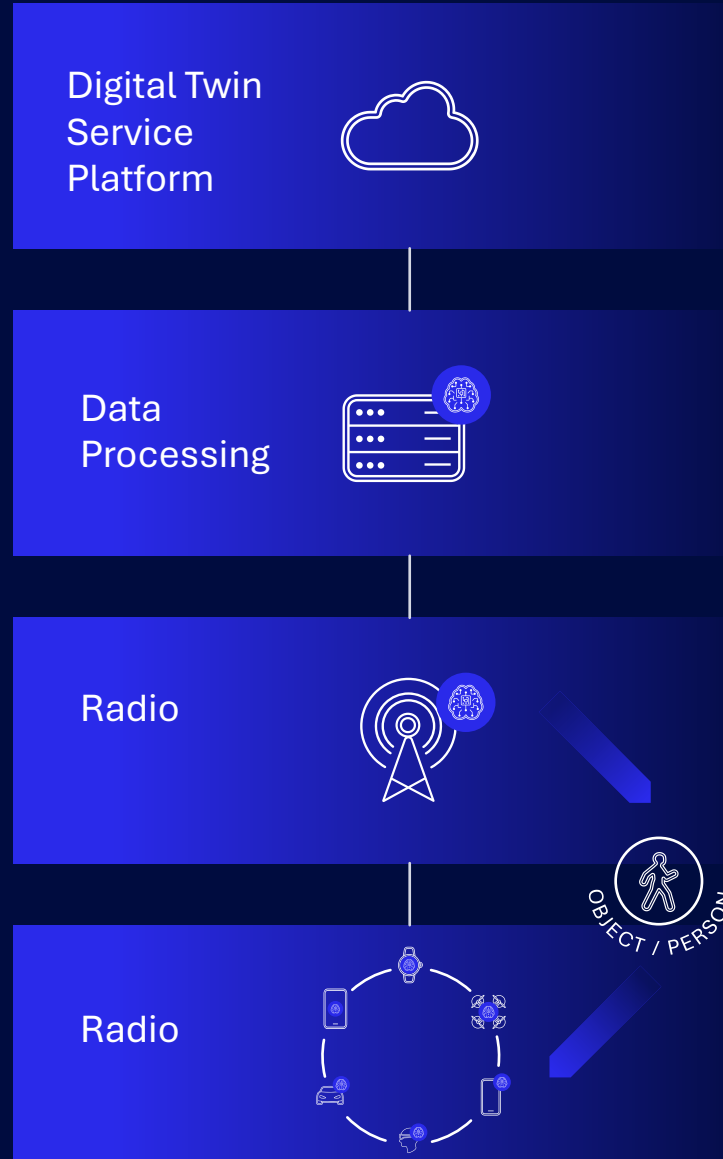
6G enables sensing as a service

Leverage existing network deployments

Incorporate 6G device feedback

Utilize 6G larger bandwidth and MIMO arrays to gain insights into real-time environment

Include other sensor inputs (e.g., vision)



Digital Twin Enabling diverse uses



Drone detection and tracking



Obstacle monitoring on roads/railways



Automated guided vehicles (AGVs) detection & tracking



Intruder Monitoring

Qualcomm



Digital Twin modeling for wide-area aerial sensing

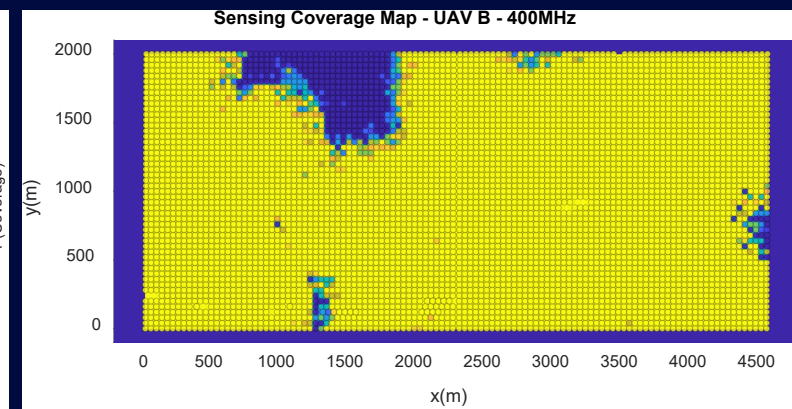
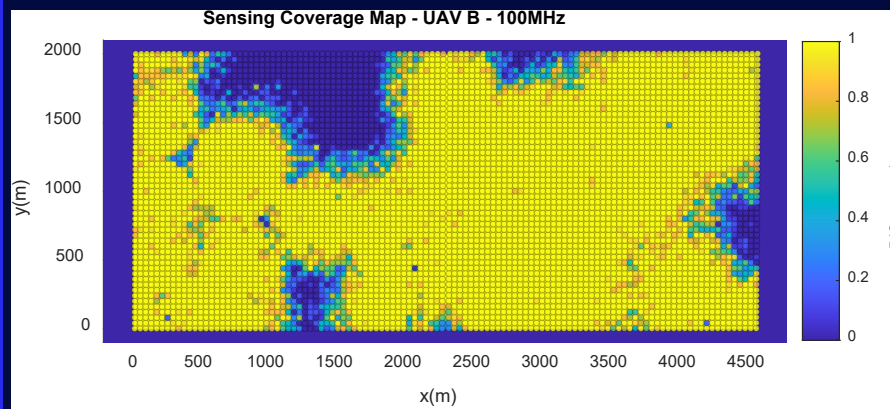
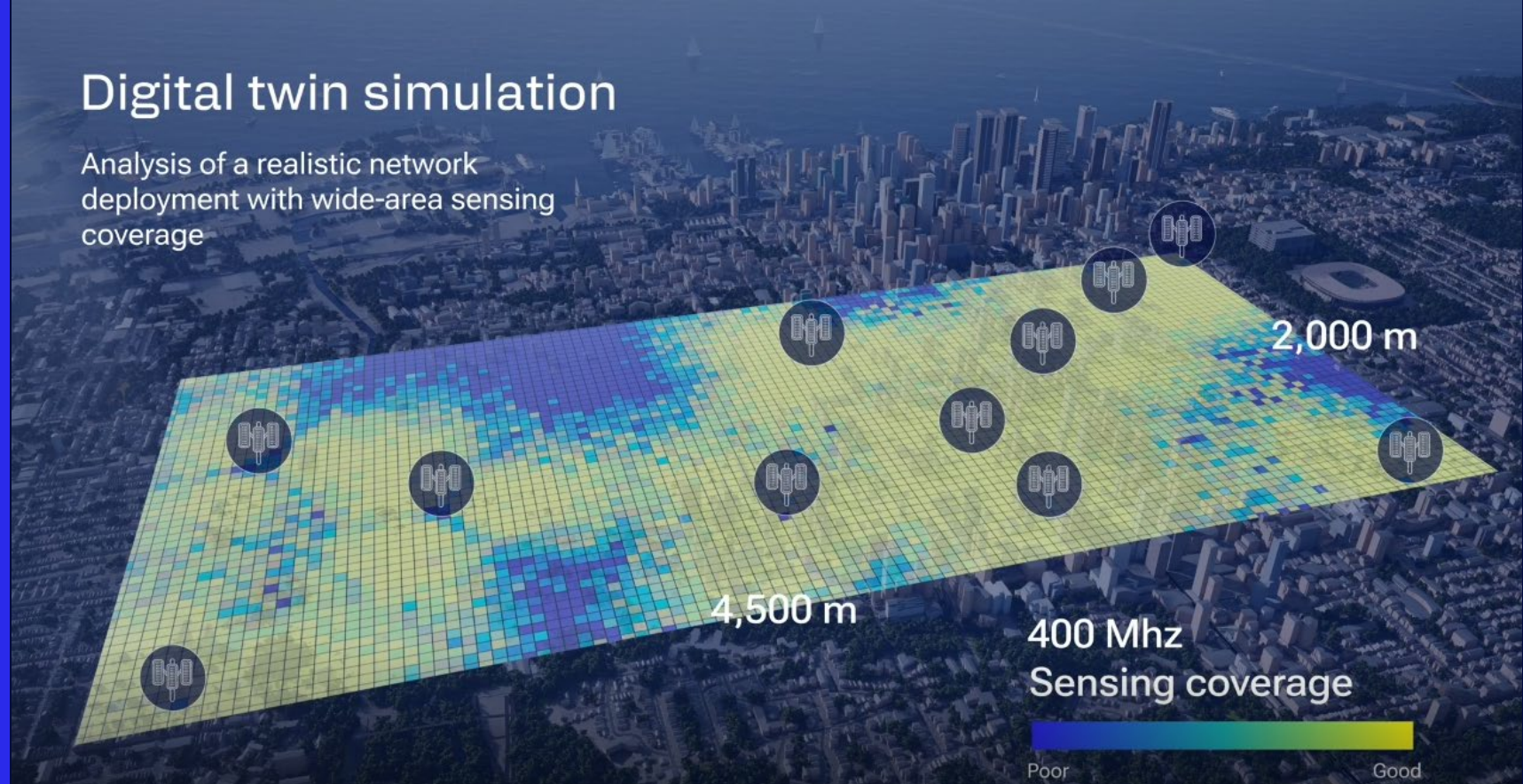
Digital twin creation for a 10km² area with 3D buildings

Realistic placement of cell site locations in digital twin

Drone sensing success rate seen to increase with 400MHz bandwidth, primarily due to higher EIRP

Digital twin simulation

Analysis of a realistic network deployment with wide-area sensing coverage

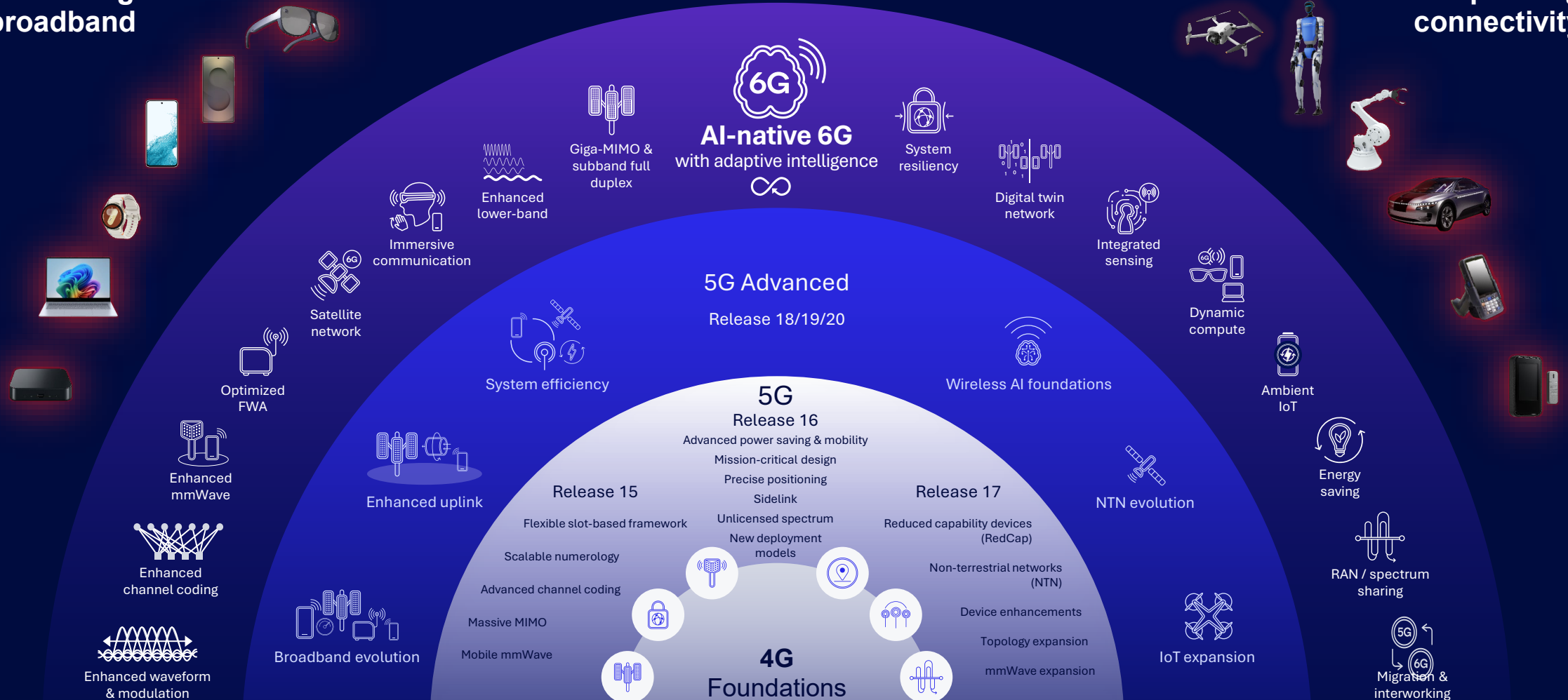


Our foundational innovations lead the path to 6G

Enabling new user experiences and technology applications

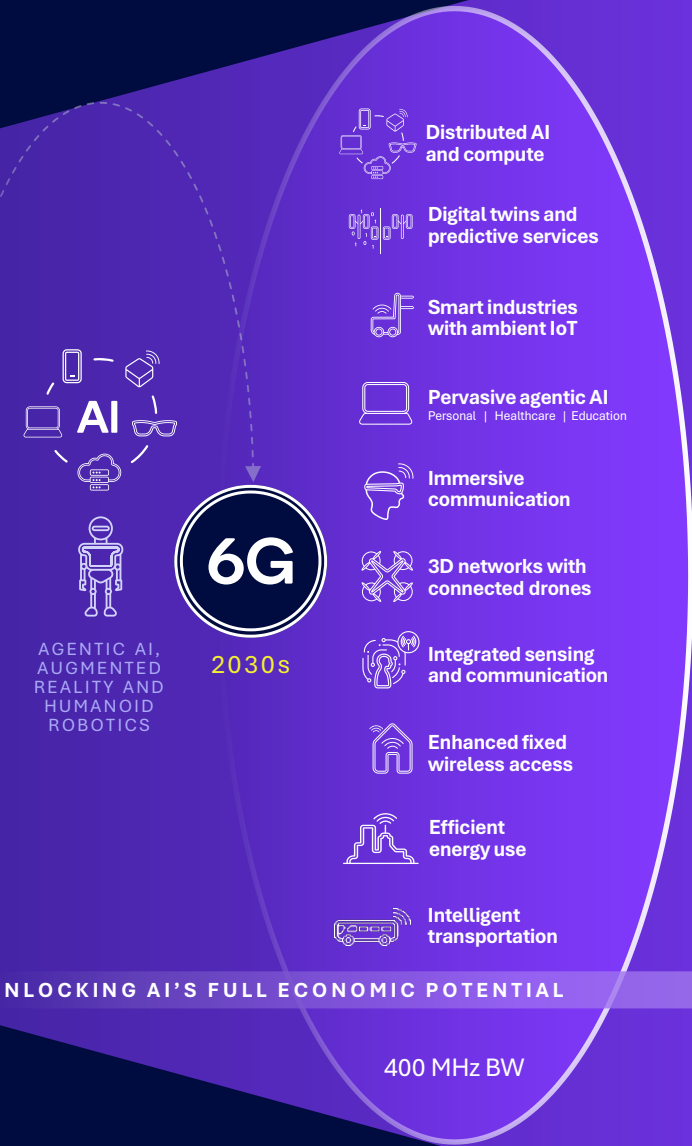
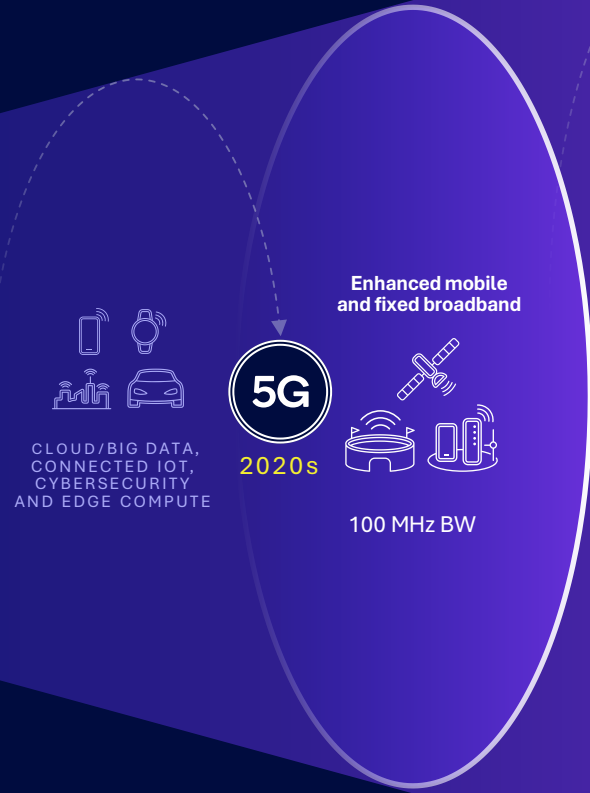
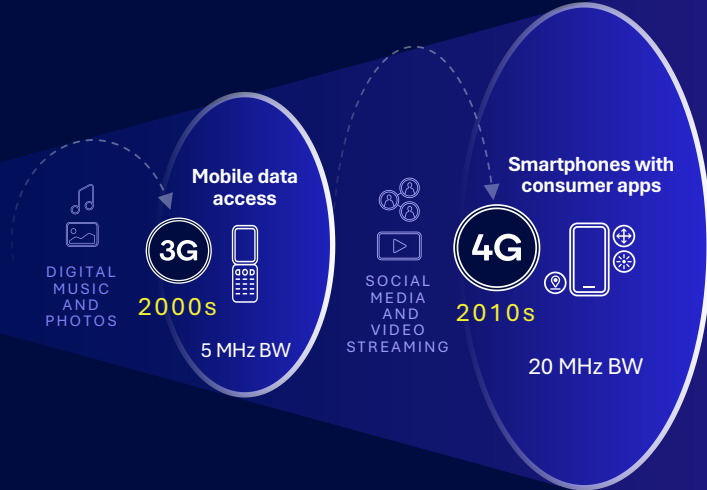
Enhancing
broadband

Expanding
connectivity



Increasing Spectrum Needs with Technology Evolution

Mobile transformations by Qualcomm



6G

NEXT-GEN WIRELESS

Innovation platform for the next decade and beyond

New user experiences and services at scale

AI-native for efficient and resilient operations

TECHNOLOGY REVOLUTIONS

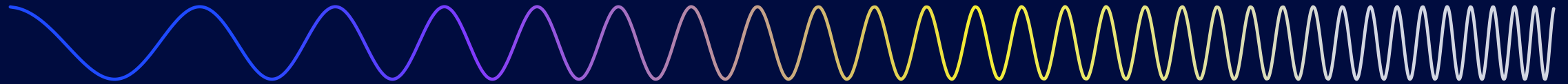
Driving capacity and coverage gains across all spectrum bands with 6G

LOW BANDS (FDD)
below 2 GHz (~20 MHz BW)

MID BANDS (TDD)
2 – 5 GHz (~100 MHz BW)

UPPER MID BANDS (TDD)
6 – 8.4 GHz (~400 MHz BW)

mmWAVE BANDS (TDD)
24 – 71 GHz (~800 MHz BW)



Wider Coverage ←

→ **Higher Capacity**



Low data rate coverage and low power IoT



Wide-area coverage layer, macro capacity layer, FWA, NTN, wide-area location



Macro capacity layer for 6G data, FWA, NTN, wide-area location & sensing



Capacity hotspots, venues, dense urban outdoor, FWA, local sensing

ENABLING RF TECH

FDD MIMO Scaling, Spectrum confinement

Massive MIMO at gNodeB, FDD/TDD bandwidth aggregation

Giga-MIMO at gNodeB, device antenna scaling, SBFD, RAN sharing

Unified transmission configuration indicator (TCI), beam management

Spectrum Bands Identified for IMT studies

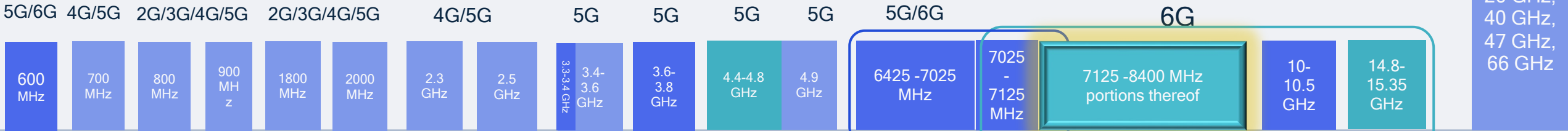
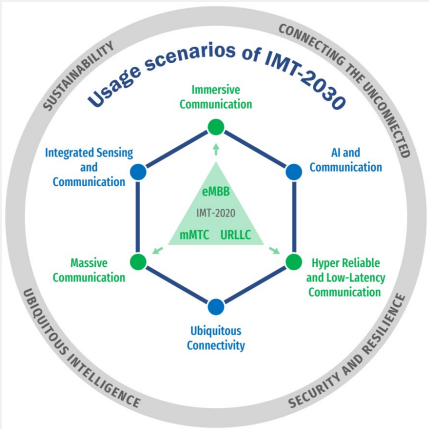
WRC-27 Agenda item 1.7

Administrations or Regions will study new candidate bands for use by 6G/IMT-2030, for decisions WRC-27.

Study Stage :

- 4 400-4 800 MHz
- 7 125-8 400 MHz
- 14.8-15.35 GHz.

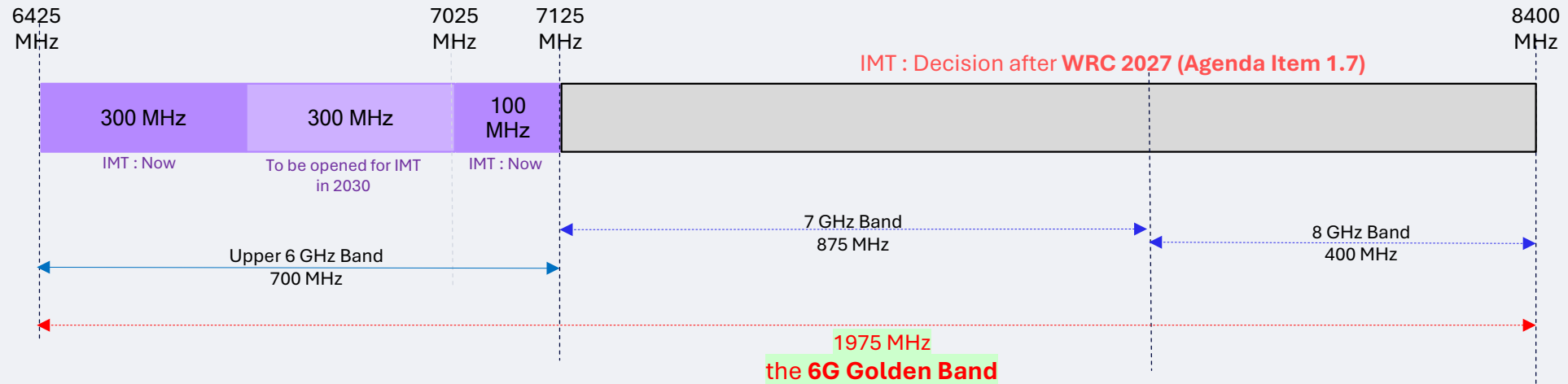
Additional contiguous broadband spectrum in FR3 range is required to support the immersive communication and high-resolution sensing in wide area coverage deployment.



Identification Stage :

- 4 400-4 800 MHz, or parts thereof, in Region 1 and Region 3;
- 7 125-8 400 MHz, or part thereof, in Region 2 and Region 3;
- 7 125-7 250 MHz and 7 750-8 400, or part thereof, in Region 1;
- 14.8-15.35 GHz, Global

India's 6G Spectrum Leadership



Spectrum requirements

- GSA – 400 MHz contiguous block per operator
- GSMA – 2 blocks of 200 MHz of contiguous blocks per operator
- 3GPP –
 - Downlink : 400 MHz
 - Uplink : 200 MHz

New Spectrum Bands for 6G

- Greenfield spectrum must for 6G
- Early identification of Greenfield spectrum must for initial pilots
- Existing bands to continue with 5G deployment till 6G gets stabilized
- 600 MHz band is an essential complimentary 6G band

Important : Management of Incumbents by 2028

- Spectrum in 7/8 GHz band be made available by 2028 for initial trials/pilots
- Essential to plan migration path and re-farming for incumbents in 7/8 GHz band

One India – One 6G Goal – Single alignment across all stakeholders including incumbents

Global Momentum for 6G is growing



ITU
IMT-2030 defines next-gen mobile system requirements for 2030 and beyond



3GPP
A GLOBAL INITIATIVE
The standards body responsible for global 6G technology standardization



United States
NextG Alliance



European Union
6G-IA (6G Smart Networks and Services Industry Association)



China
IMT-2030 PG



India
Bharat 6G Alliance



Japan
XG Mobile Promotion Forum



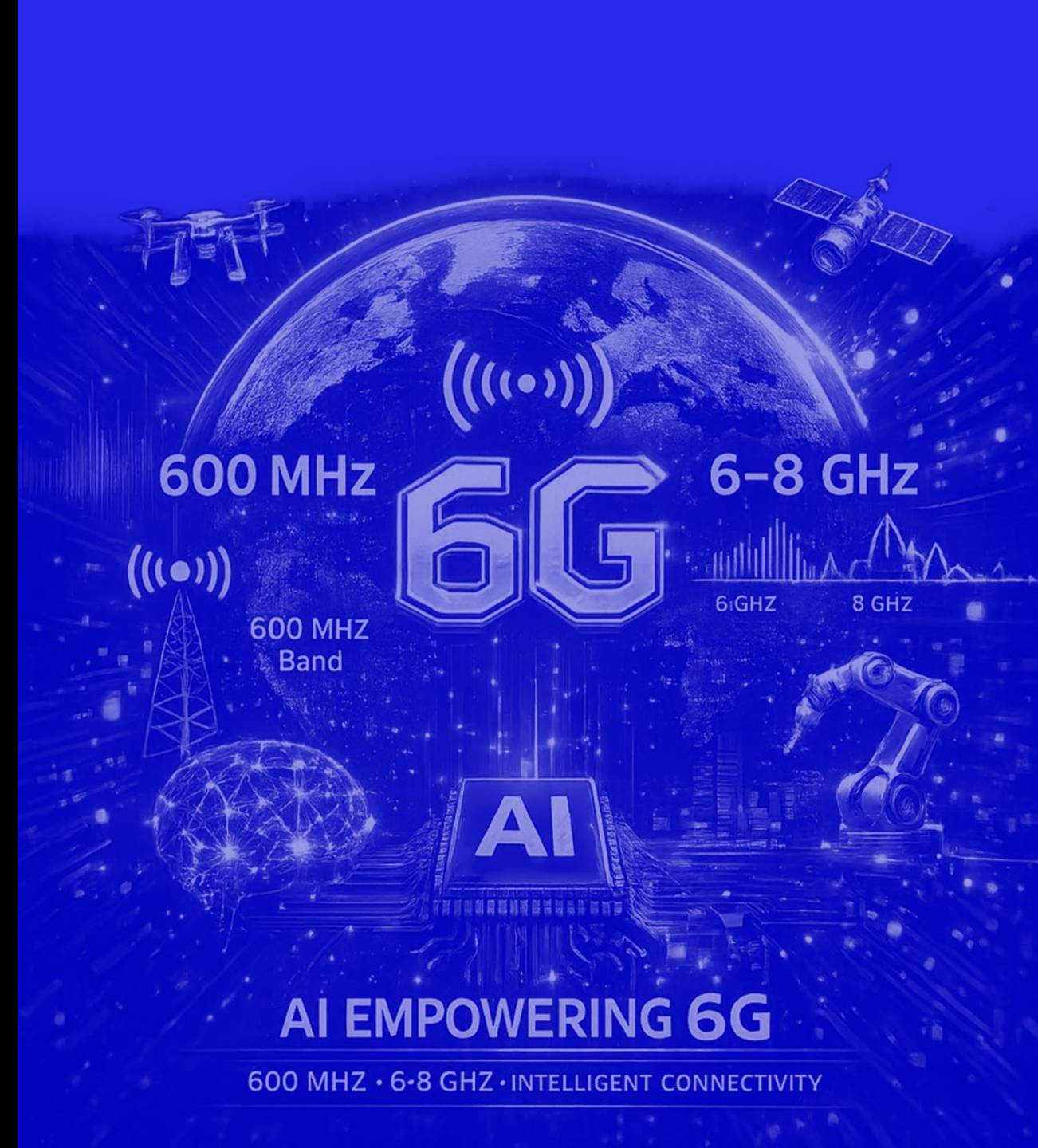
WRC-23
Setting the agenda for WRC-27 to secure new 6G bands

South Korea
6G Forum

- **New global strategic coalition** to accelerate development and commercialization of 6G
- **Targeting commercial** systems starting from **2029 onward**
- **Global operators**: Airtel, BT Group, Deutsche Telekom (via affiliates), KDDI, NTT DOCOMO, Reliance Jio, SK Telecom, Swisscom, T-Mobile, Telstra, TIM Group, Viettel, and others
- **Network & infrastructure vendors**: Ericsson, Nokia, NEC, Fujitsu/1finity, Siemens, Tejas Networks
- **Cloud, compute & platform players**: Amazon, Google, Microsoft, Meta, Dell, HP, HPE, Lenovo
- **Device & automotive ecosystem**: Samsung Electronics, LG Electronics, Motorola, Asus, Stellantis, Sharp

Key Takeaways

- AI is no longer a feature layer — it is now foundational
 - AI is here to stay — the real transformation has only just begun
- AI is the new UI
 - Changing consumer behaviors : “Shifting from “click and navigate” to “ask and collaborate.”
- Value getting created at the Edge
- AI-Native 6G networks
 - AI services on RAN, AI solutions for RAN, AI-based Enhancements in RAN
 - Telco edge cloud, Central Cloud
- 6G enables wireless sensing as a service
 - Can support a variety of use cases across industries
- Regional/global harmonization essential for spectrum & standardization
- India’s 6G leadership needs a clear spectrum roadmap for the Golden Band
- India’s focus on 6G leadership : Initial pilots in 2029
- One India – One 6G Goal – Single alignment



Thank you

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