6G: The Next Horizon

From Connected People, Connected Things, to Connected Intelligence

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Agenda

1 6G Technology Trend

2 6G Industry Progress

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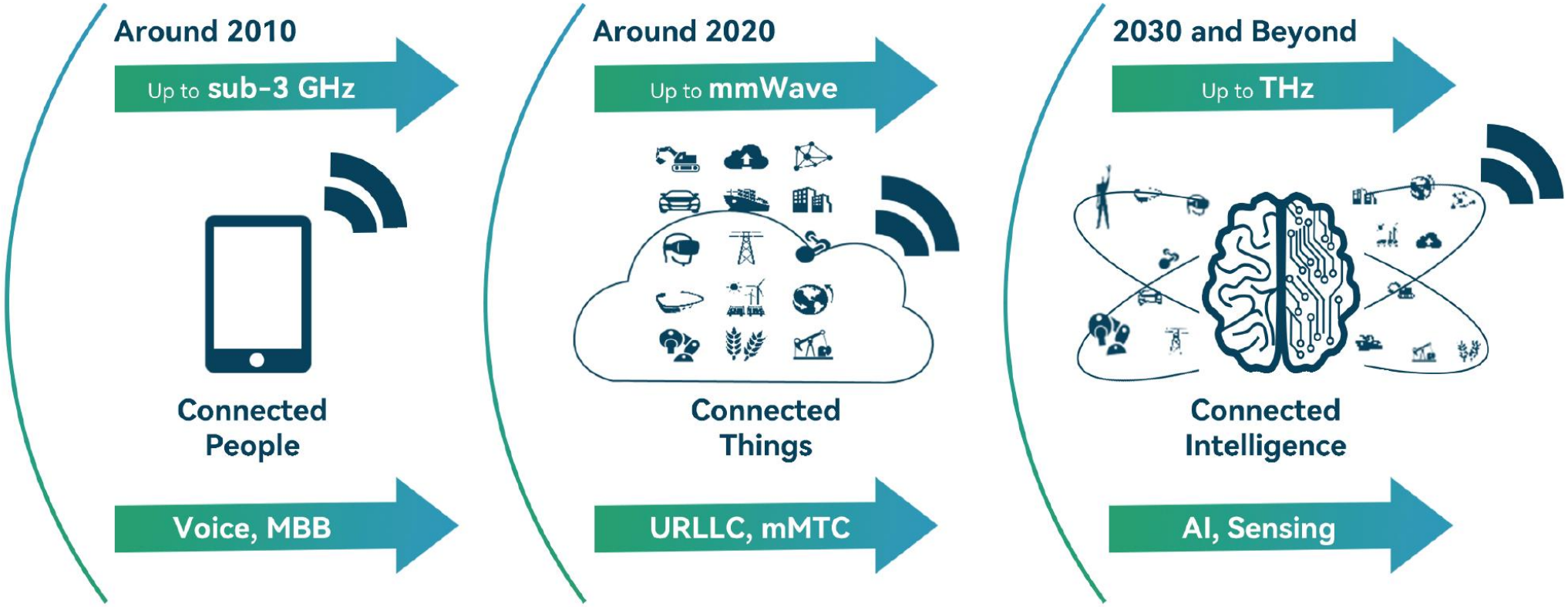
Mega-trends of mobile communications towards 2030 and beyond



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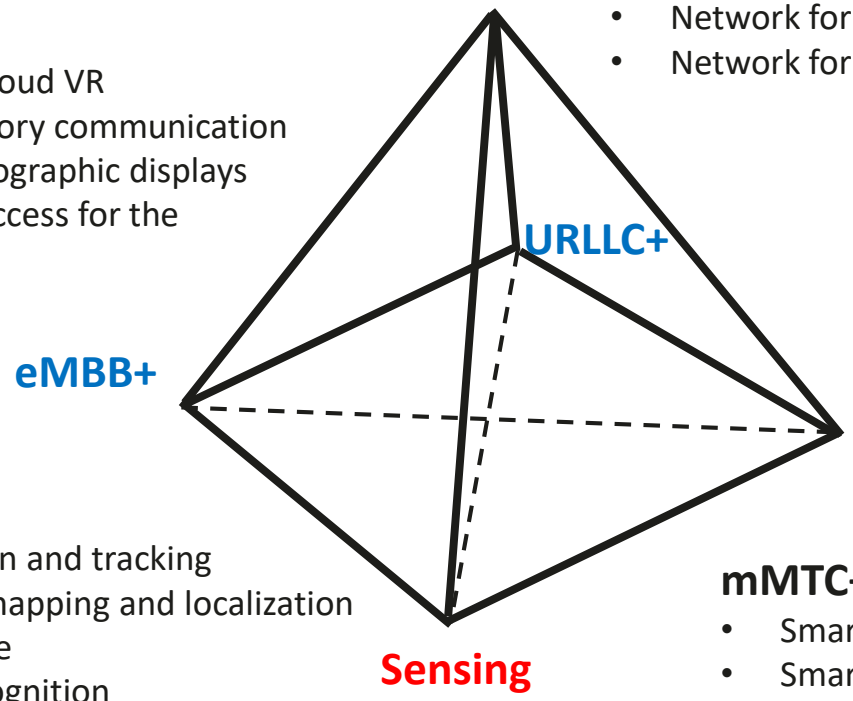
Overview of 6G use cases



AI
- AI-enhanced network automation
- Network for AI data/model transfer
- Network for distributed learning

eMBB+
- Ultimate immersive cloud VR
- Haptic and multi-sensory communication
- Glass-free 3D and holographic displays
- Broadband wireless access for the unconnected

URLLC+
- Factory of the future
- Motion control
- Collaborative robots in group
- From intelligent cobots to cyborgs

Sensing
- High-accuracy localization and tracking
- Simultaneous imaging, mapping and localization
- Augmented human sense
- Gesture and activity recognition
- High precision positioning and navigation
- Real-time earth observation and protection

mMTC+
- Smart transportation & autonomous vehicles
- Smart buildings
- Smart healthcare
- Smart services enabled by UAVs
- Wide-range IoT services in unconnected areas

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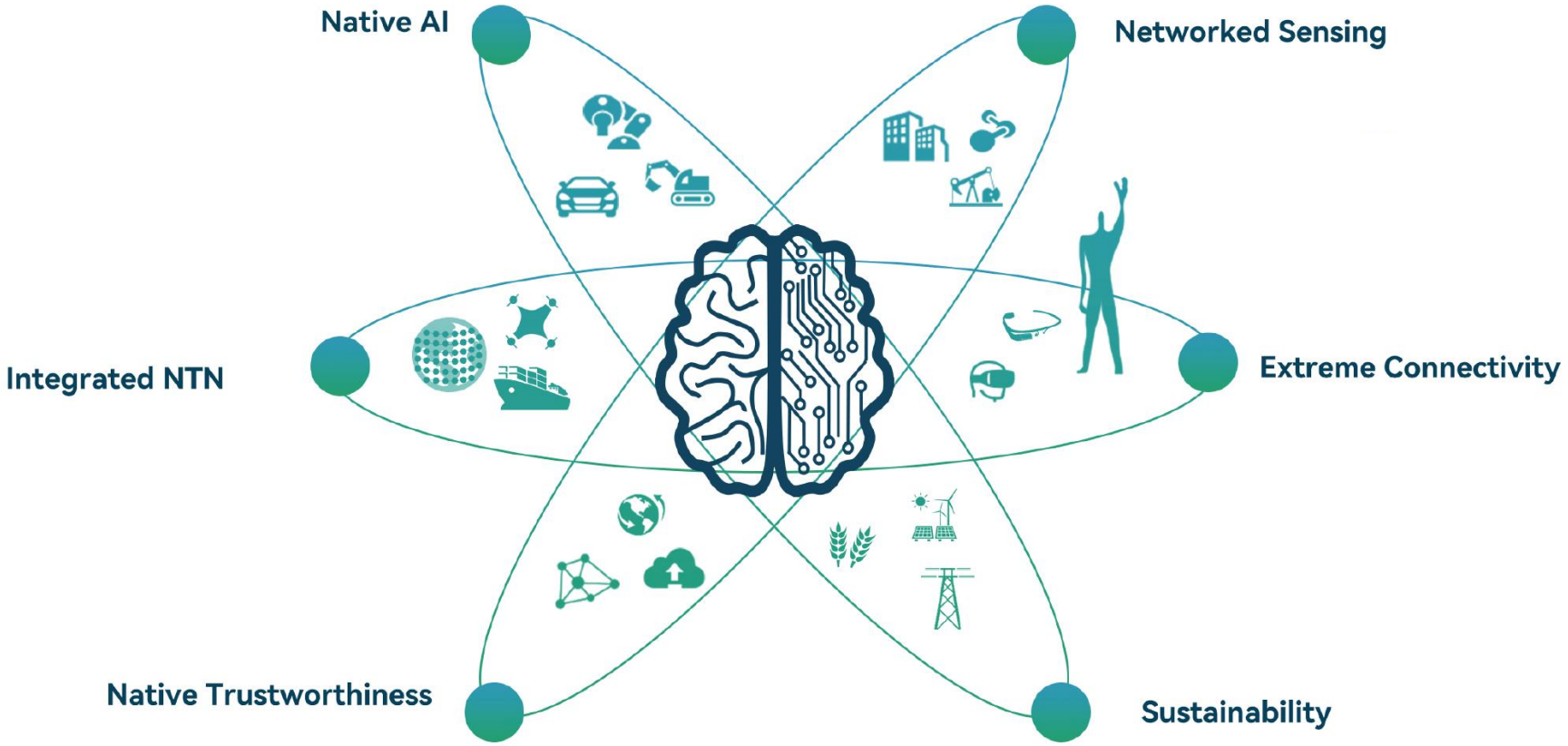
Six pillars of 6G key capabilities



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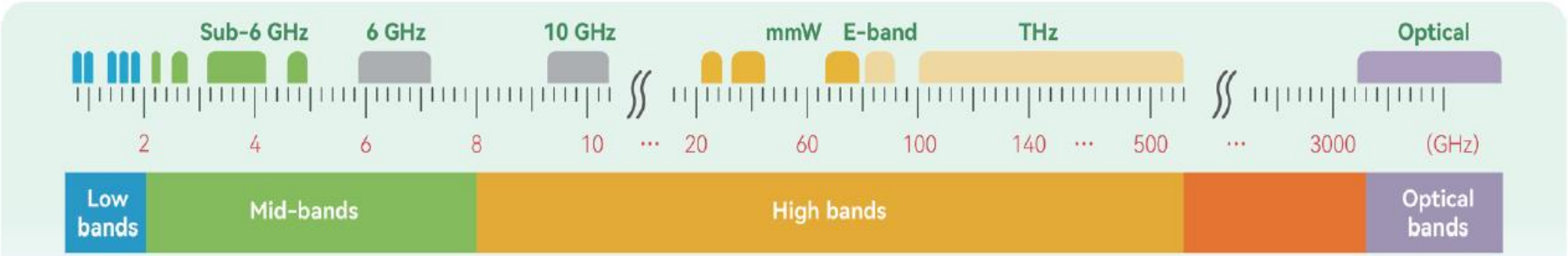
Multi-layered Frequency Band Framework



Low/mid-bands

Basic Coverage Layer

Mid-bands

Capacity/Coverage Layer

Ultra-high/high bands/high end of mid-bands

Ultra Experience Layer
(extremely high data rates, high-resolution positioning/sensing...)

Operating bandwidth of each generation follows the "five-times more" rule

2G: **200 KHz**
3G: **5 MHz**
4G: **20 MHz**
5G: **100 MHz**
6G: **500 MHz–1 GHz**

- **Low/mid-bands** remain the most cost-effective way for wide coverage
- **mmWave bands** become mature in 6G
- **THz bands** open new possibilities for sensing and communication

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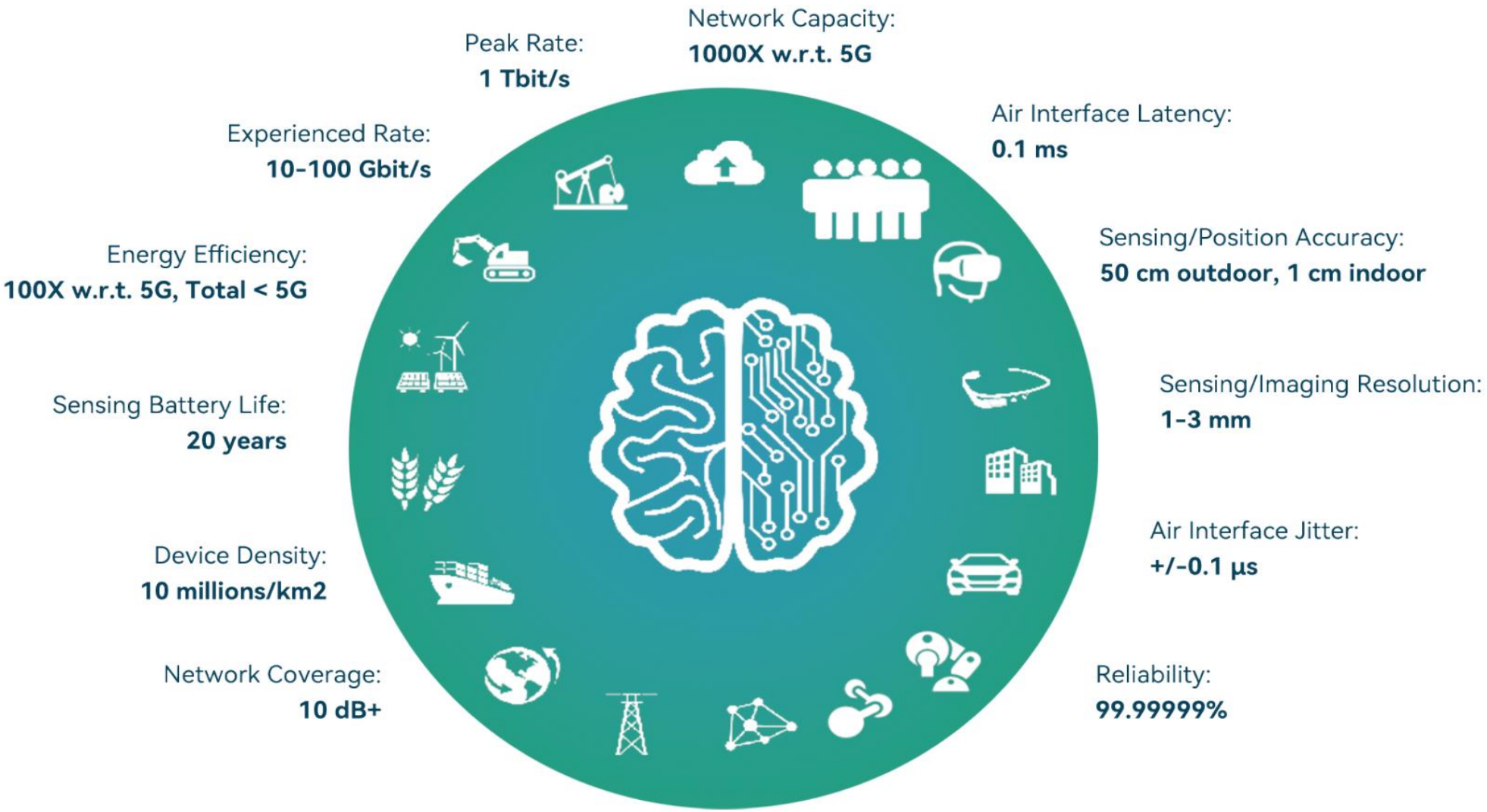
RAN KPIs for Extreme Connectivity



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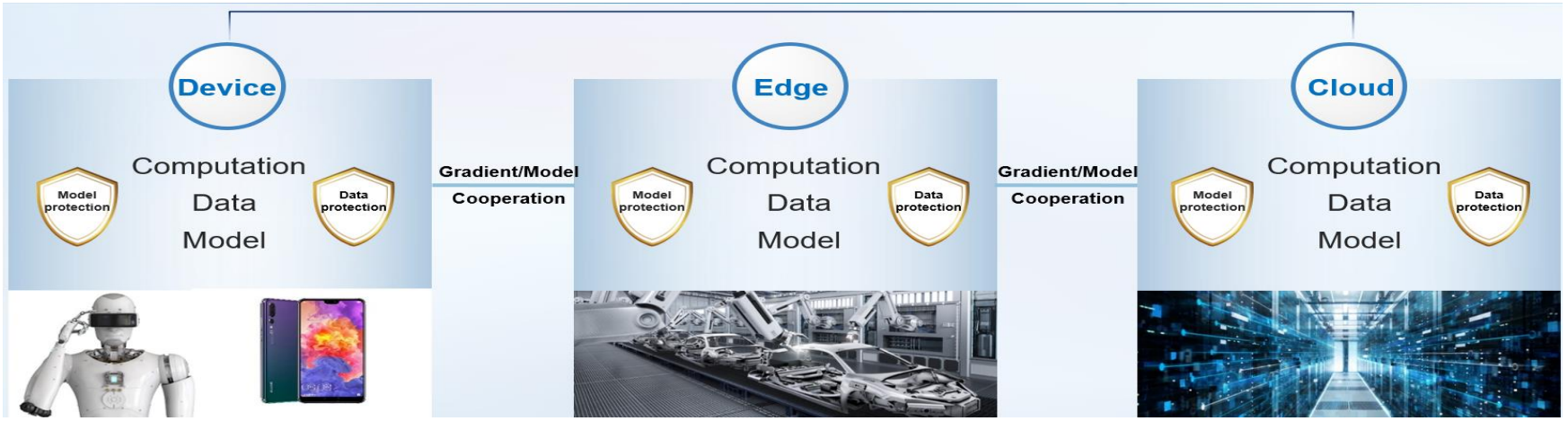
6G Networks

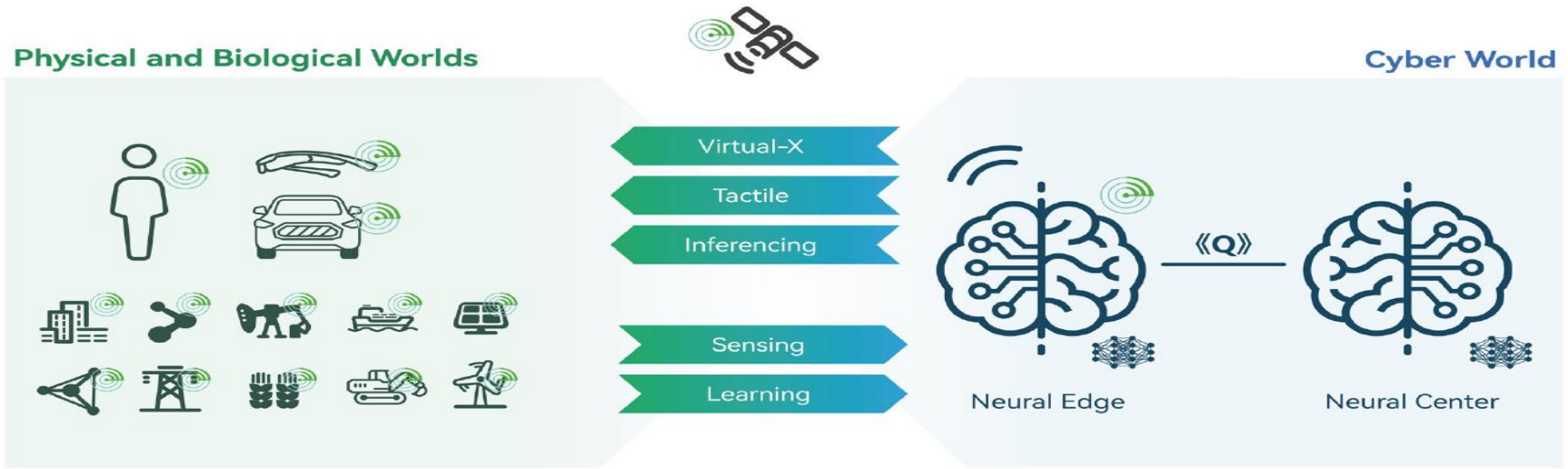
Today

On-demand cooperation across all scenarios: Higher resource efficiency and privacy protection



Tomorrow

Fusion of physical, biological, and cyber worlds



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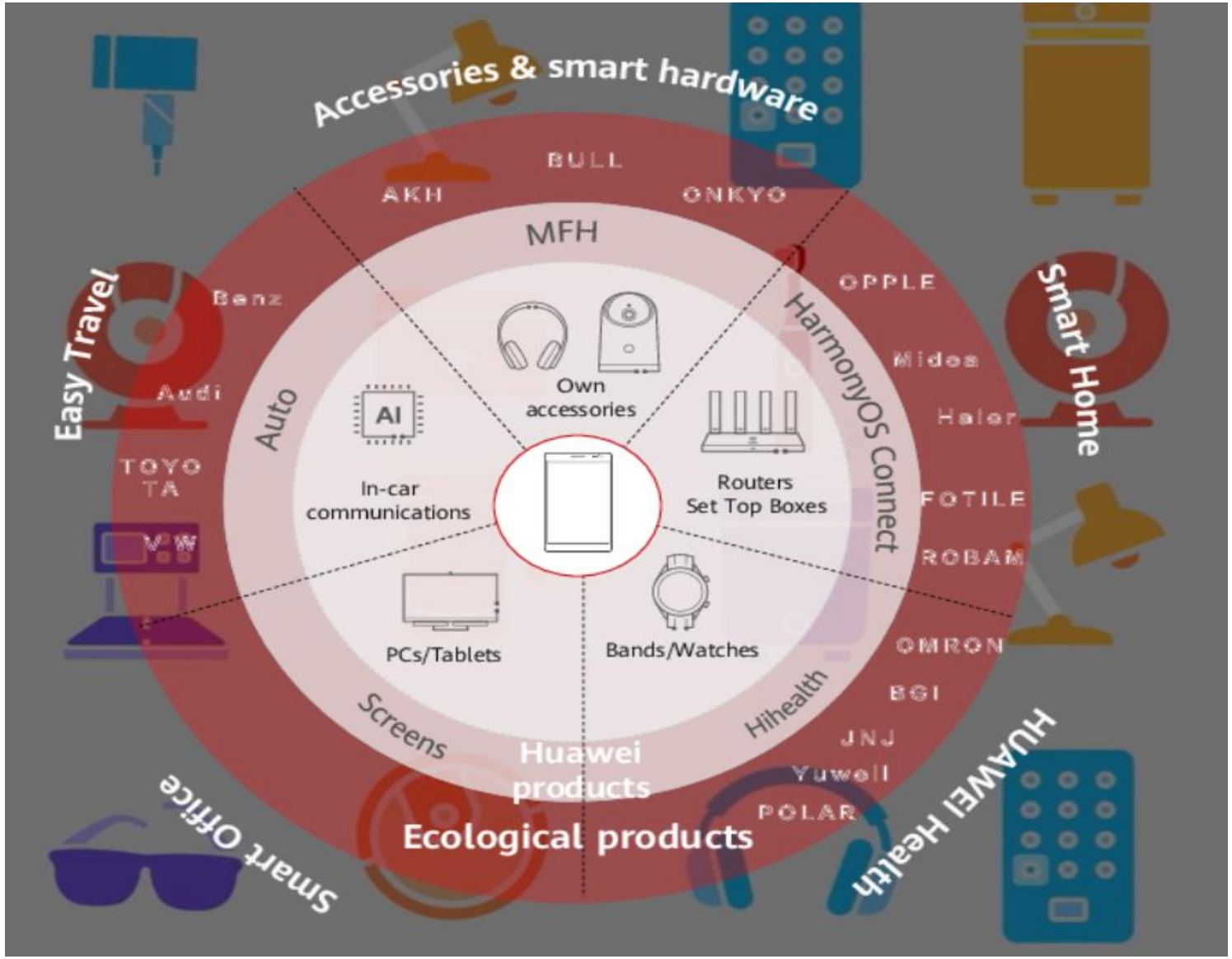
Future Terminals, The Key Trigger ?



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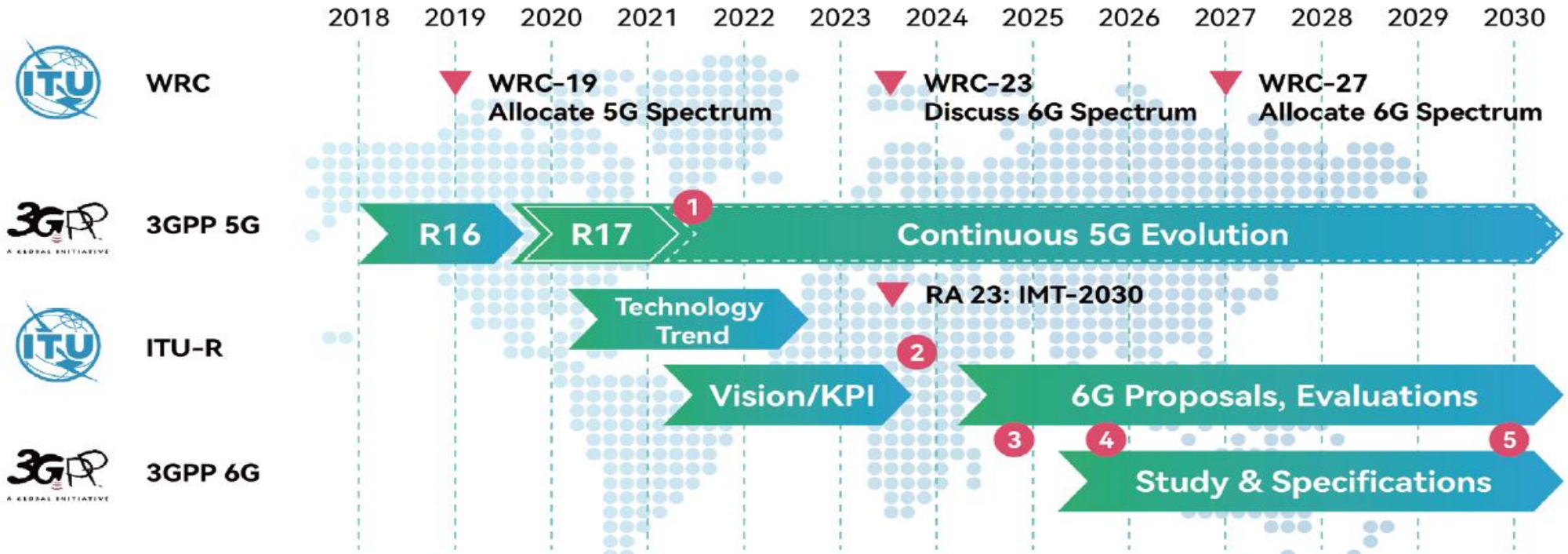
Expected Timeline of Standardization



1. R18 starts 5.5G standardization
2. 6G vision finished before WRC-23, vision workshop in June 2022
3. At the end of 2024, 6G workshop
4. At the end of 2025 or early 2026, 3GPP starts study of 6G (Requirement, SI, WI …)
5. First specification of 6G finished in 3GPP in 2030

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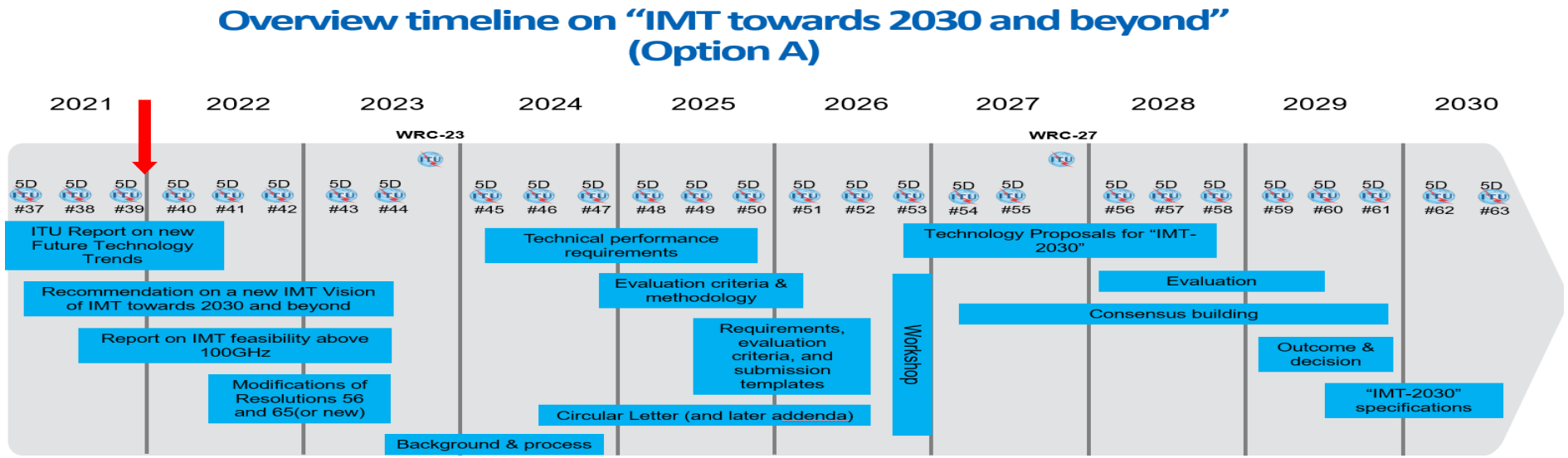
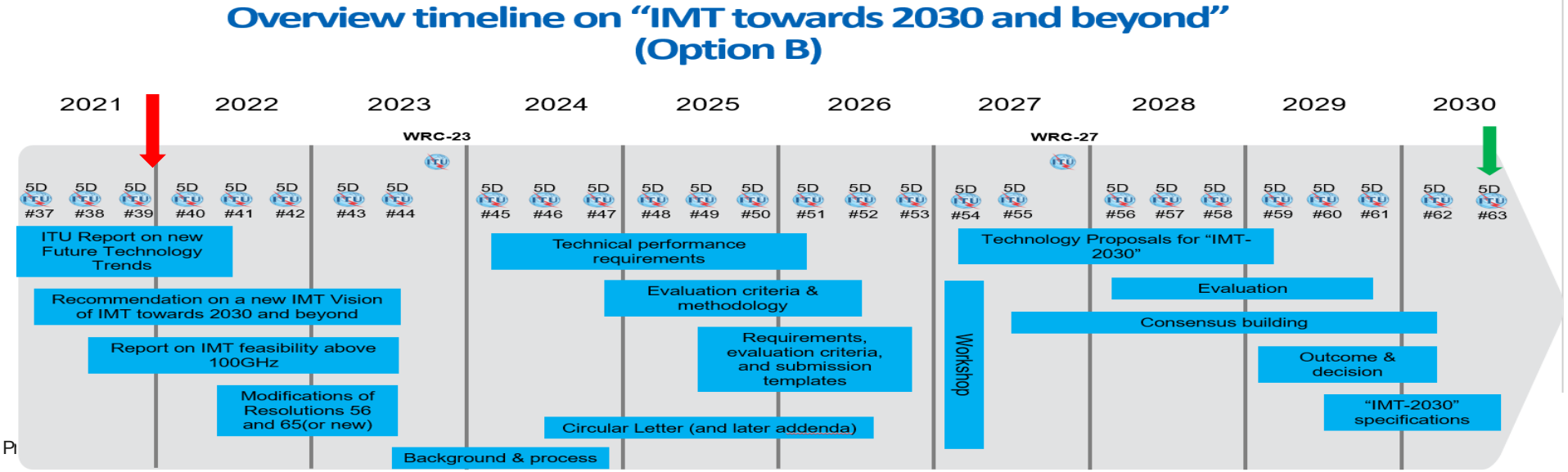
6G Timeline

- **Timeline proposal in the 39th meeting of ITU-R WP5D, Oct. 4-Oct. 15, 2021**





6G Vision and Use Cases

- **The discussion started from Feb. 2021, and the report will be ready in June 2023**
  - In the 39th ITU-R WP 5D meeting, external organizations are invited to share their views on 6G vision, including NGMN, WWRF, IOWN, ISO, Spark, T-Mobile, China, Japan, Korea, One6G, NGA, Hera-X, Ericsson

Contents of 6G vision report

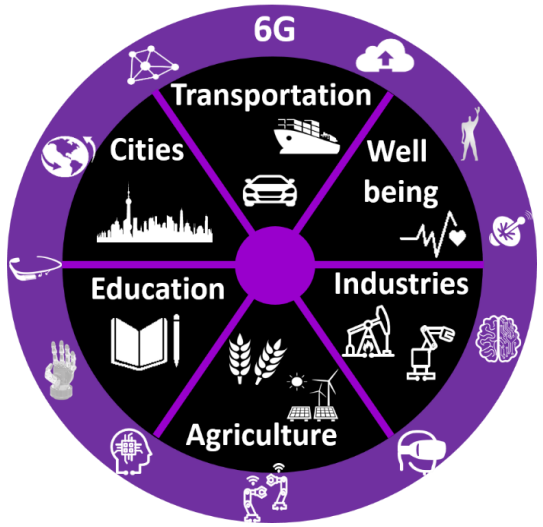
IMT Vision – Framework and overall objectives of the future development of IMT for 2030 and beyond

1. introduction
2. Trends of IMT for 2030 and beyond
   2.1 user and application trends
3. Evolution and role of IMT
4. Usage scenarios of IMT for 2030 and beyond
5. Capabilities
6. Framework and objective

Example view on applications (by China)

1. Supporting human-centric applications with ultra-low latency and ultra-high throughput
2. Supporting vertical applications with ultra-low latency and ultra-high reliability
3. Supporting ultra-massive connections
4. Supporting global seamless coverage
5. Supporting maintaining high quality communications at ultra-high mobility
6. Supporting high accuracy and resolution sensing applications
7. Supporting applications with pervasive intelligence
8. Supporting intelligent interaction
9. Supporting high quality interaction of virtual and reality
10. Task oriented applications with adaptive capabilities

Example view on use cases (by One6G)



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6G Capabilities and KPI

☐ 6G capabilities have also been discussed, but still at early stage

Some capabilities are still the same as 5G, but also many new capabilities proposed for 6G, e.g., AI and sensing related capabilities, trustworthiness

Proposed capabilities as of WP5D #39 Oct 2021

	Capabilities	M. 1645	M. 2083	Korea (614, 783)	T-Mobile (631)	IAFI (638)	SparkNZ (775)	WWRF (822)	China (867)	IOWN GF (771)
1	Peak data rate	O	O	O			O			
2	User experienced data rate		O	O			O			
3	Spectrum efficiency		O	O						
4	Latency		O	O						
5	Reliability			O					O	
6	Mobility	O	O	O			O			
7	Connection density		O	O			O			
8	Sustainability				O					
9	Portability of applications across devices				O					
10	Coverage			O		O			O	
11	End to end latency					O				
12	User plane latency						O			
13	Control plane latency						O			
14	Positioning			O					O	
15	Area traffic capacity		O	O						
16	Energy efficiency		O					O		O
17	Sensing resolution							O		
18	Localization accuracy							O		
19	Trustworthiness							O		
20	Availability								O	
21	AI-related capabilities								O	
22	Sensing-related capabilities								O	
23	Support for a ubiquitous intelligent mobile society					O			O	
24	Movement speed of mobile terminals					O			O	

Other capabilities	Spectrum and bandwidth flexibility		O
	Reliability		O
	Resilience		O
	Security and privacy		O
	Operational lifetime		O

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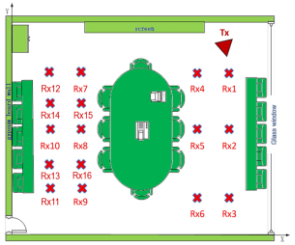
Study on the technical feasibility of IMT in bands above 100 GHz

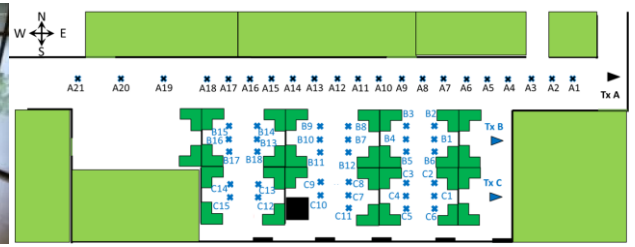
- **Initial study on technical feasibility of IMT in bands above 100 GHz**
  - **Radio wave propagation**
  - **Characteristics of IMT**
  - **Enabling technologies**
  - **Deployment scenarios and architectures**

The deployment of the channel measurement (by Huawei)



(a) Meeting Room

(c) Channel Sounder

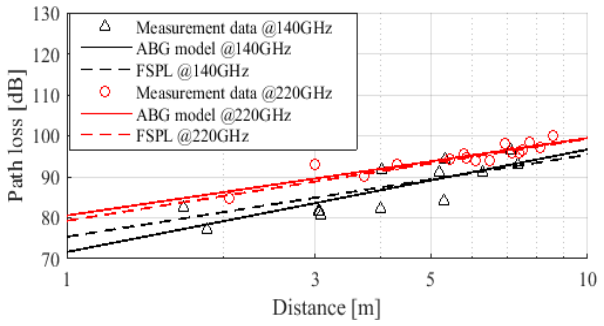


(b) Office Room

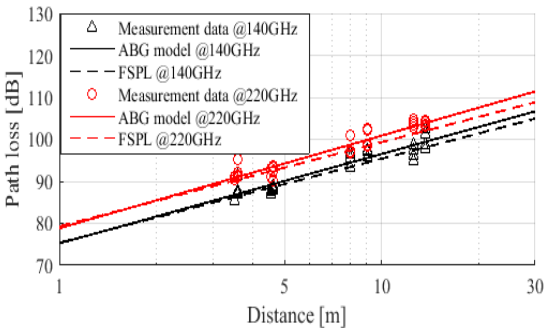
Some parameters of the measurement system

Parameter Value	Value	
Sounder frequency	140 GHz	220 GHz
Local oscillator	10.667 GHz	18 GHz
Start frequency	130 GHz	201 GHz
End frequency	143 GHz	209 GHz
Bandwidth	13 GHz	8 GHz

Path loss in the meeting room



Path loss in the open office area



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