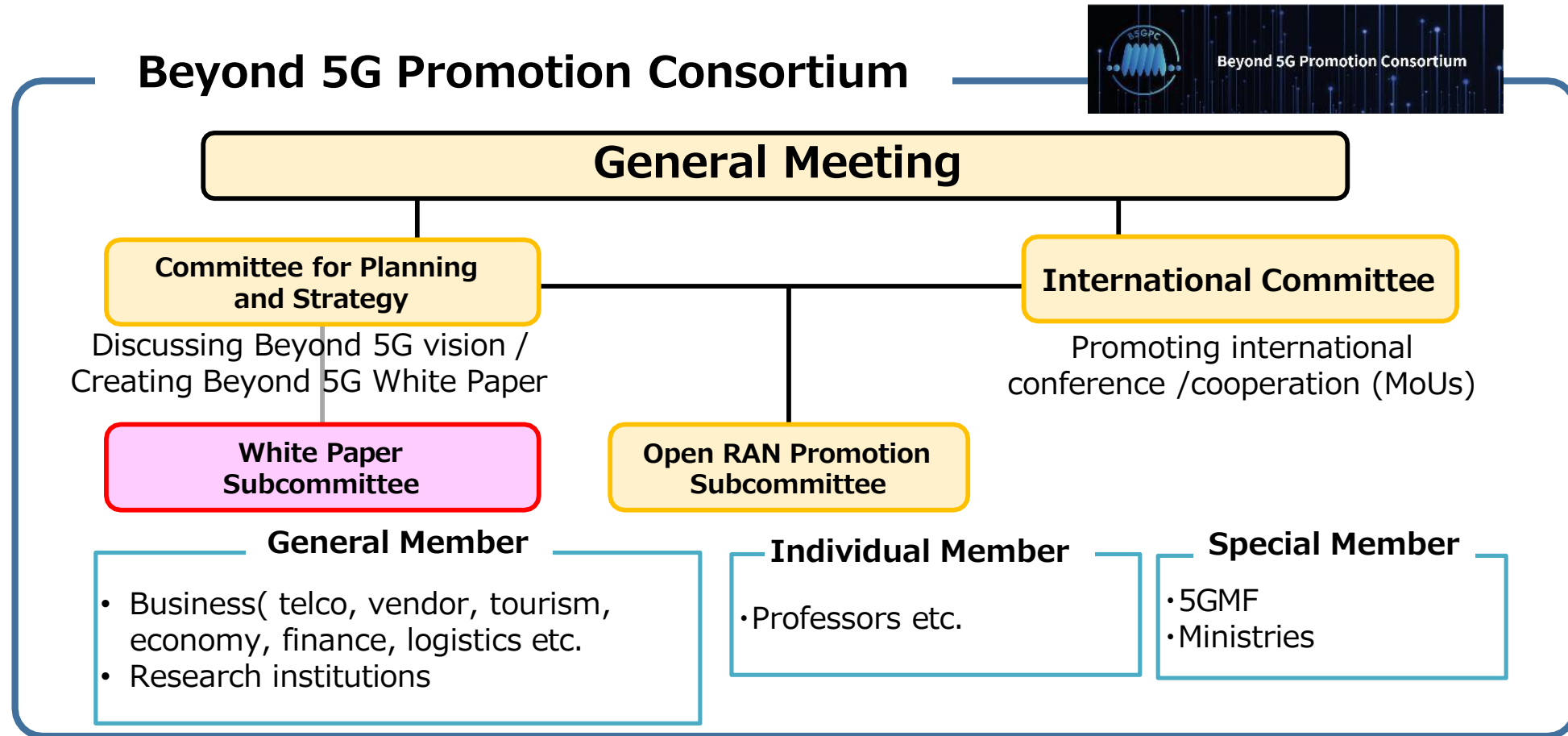


Beyond 5G White Paper (ver.2.0) **~Message to the 2030s~** **【Overview】**

Takehiro Nakamura
Chair of White Paper Subcommittee, B5GPC

- Established “Beyond 5G Promotion Consortium” to promote Beyond 5G Promotion Strategy through industry-academia-government collaboration.
 - International conference for international cooperation
 - Vision for Beyond 5G, White Paper etc.
 - Open RAN Promotion



Committee for Planning and Strategy

White Paper Subcommittee

Chair : Nakamura (NTT DOCOMO)

- Forecast strong and lively society expected in the 2030's and clarify use cases and requirements of Beyond 5G
- Take international leadership by developing concept of Beyond 5G early on and reflecting it to international standardizations including ITU
- Contribute to strengthen international competitiveness by capturing and reflecting views from various industries and developing meaningful concept of Beyond 5G for all industries

Vision Working Group

Leader : KONISHI (KDDI), Sub leader: NAGATA(NTT DOCOMO)

- Develop the vision part of the white paper with forecasting our society around 2030 and studying use cases and requirements of Beyond 5G

Technology Working Group

Leader : SAKUMOTO (FUJITSU), Sub-leader: SHIMONISHI(NEC)

- Develop the technology parts of the white paper with studying technology trends of Beyond 5G and clarifying roles and expectations of functions and values for users and markets

Spectrum Working Group

Leader : HONDA (ERICSSON JAPAN)

- Develop the spectrum related information with conducting survey on spectrum for Beyond 5G

WP5D Ad Hoc

Leader : AGATA (KDDI), Sub-leader: TAKETSUGU (NEC)

- Action planning and contribution to ITU-R WP5D based on studies in the subcommittee

Chapter 1. Introduction

Chapter 2. Traffic trends

- This chapter describes the trends in traffic from mobile applications and use cases of Beyond 5G that are predicted to arrive around the year 2030.

Chapter 3. Market trends in the telecommunications industry

- This chapter discusses market trends in the mobile communications sector, particularly changes in the share structure for smartphones, base stations, and other communication infrastructure equipment, and technical trends in components related to smartphones.

Chapter 4. Trends from other industries

- This chapter identifies the current challenges in all existing industries, provides suggestions for problem solving, and summarizes the visions and dreams that industries should aspire for, as well as the performance and capabilities that are expected of Beyond 5G.

Chapter 5. Capabilities and KPIs required in Beyond 5G

- This chapter identifies the unique use cases in the various industries discussed in Chapter 4 and summarizes the performance of Beyond 5G required for each use case, together with the symbol figure of Beyond 5G, the six usage scenarios and the target KPI (Quantitative and Qualitative).

Chapter 6. Technology trends

- This chapter examines the trends in technologies required for Beyond 5G and clarifies the functions and values it will provide, as well as the roles it will play and the expectations of the users and markets.

Chapter 7. Conclusion

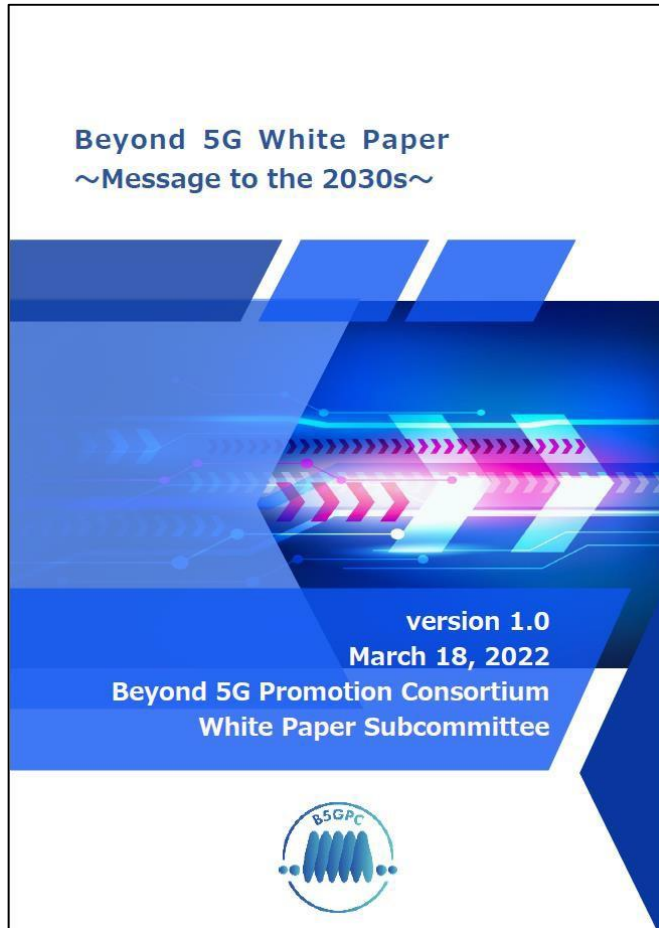


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<https://b5g.jp/en/output/>

1. Introduction
2. Traffic trends
3. Market trends in the telecommunications industry
4. Trends from other industries
 1. Finance
 2. Construction and Real Estate
 3. Logistics and Transportation
 1. Warehousing and Logistics
 2. Aviation
 3. Railway
 4. Telecommunications, IT
 5. Media industry
 6. Energy, resources and materials
 7. Automotive industry
 8. Machinery industry
 1. Machining Equipment
 2. Construction Machinery
 3. Agricultural Machinery
 4. Robots
 5. Shipbuilding (Ships)
 9. Electronics and precision electronics industry
 1. Electronics and precision electronics
 2. Semiconductors
 9. Living, food, agriculture industry
 1. Agriculture and fisheries
 2. Food
 3. Living and Cultural Goods
 10. Retail, wholesale, and distribution sectors
 11. Services, Public Services, Corporate Services
 12. Restaurant industry
 13. Entertainment, and Leisure
 15. Academic and others
 1. Space
 2. HAPS
 3. Society
5. Capabilities and KPIs required in Beyond 5G
 1. Capabilities required in Beyond 5G
 2. Conceptual figure of Beyond 5G and usage scenarios



<https://b5g.jp/output.html>

1. Introduction
 2. Traffic trends
 3. Market trends in the telecommunications industry
 4. Trends from other industries
 5. Capabilities and KPIs required in Beyond 5G
 1. Capabilities required in Beyond 5G
 2. Target Key Performance Indicators
 6. Technology trends
 1. Observations of technology trends towards Beyond 5G
 2. System Platform and Application
 3. Trustworthiness (Security, Privacy, and Resilience)
 4. Network energy efficiency enhancement
 5. Network coverage extension via non-terrestrial networks (NTN)
 6. Network architecture
 7. Wireless and optical
 7. Conclusion
- Abbreviation List**



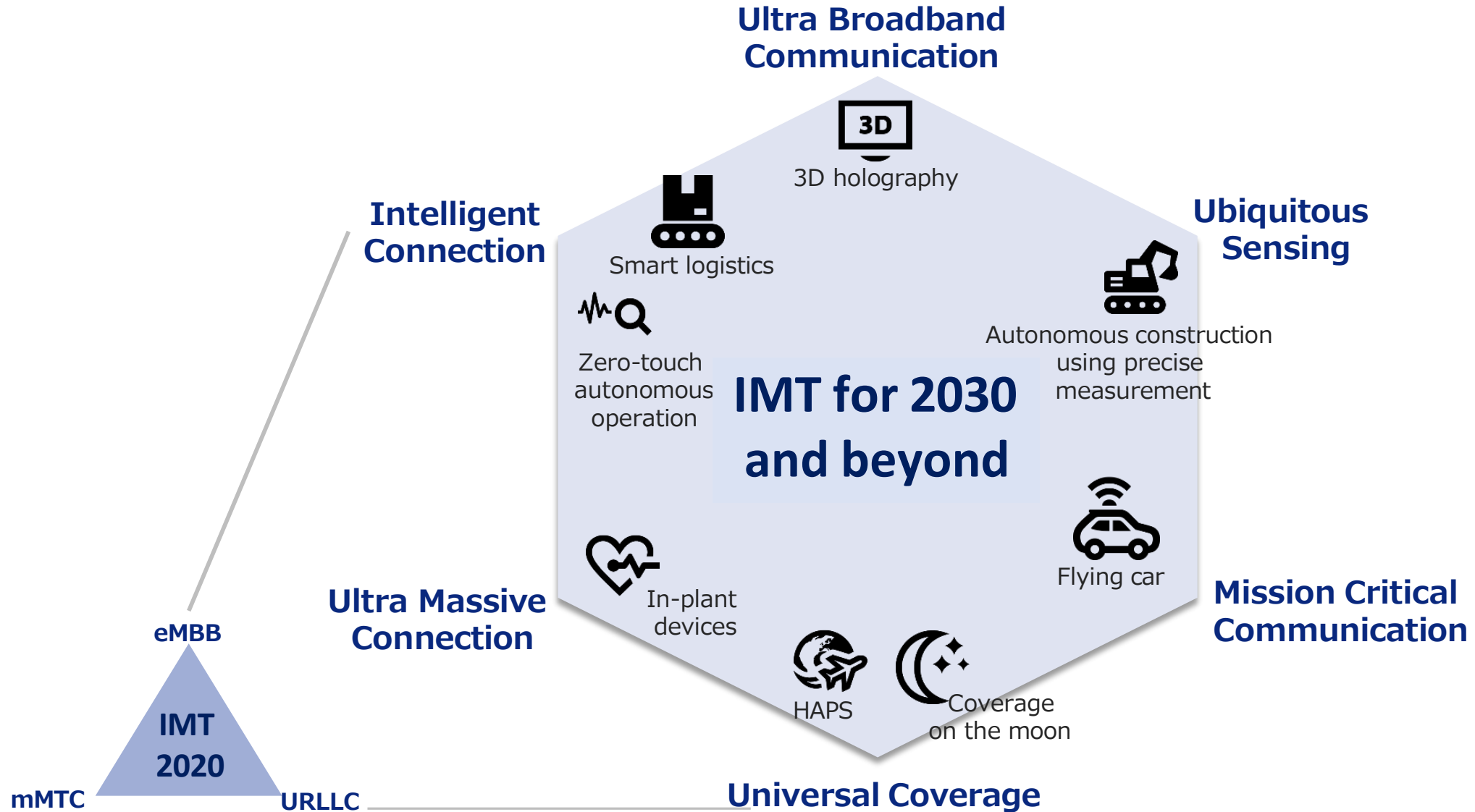
Summary in Sec. 5.1 "Capabilities required to Beyond 5G" (1)

Category	Requirements	Capabilities required by each industry
Quantitative requirements	Ultra-fast and large capacity	<ul style="list-style-type: none"> • 10 to 100 Gbps (Uncompressed transmission for holographic communications (Media)) • 50 Gbps (Remote monitoring and remote control (Automotive)) • 10 to 100 Gbps (Smart logistics (Retail and wholesale distribution)) • Several tens of Gbps (Remote surgery (Healthcare)) • 48 to 200 Gbps (Volumetric video) • Several tens of Gbps (Low to medium orbit (Space)) • 10 Mbps (Natural disaster prevention measures (Society))
	Ultra-low latency	<ul style="list-style-type: none"> • Order of milliseconds* (within the local network (Fully automatic operation of logistics facilities (Warehousing and logistics)) • Several milliseconds* (Emergency stops for super-high-speed trains (Railway)) • 100 ms* (Immersive remote-control system (Energy resources)) • 1 ms (Remote monitoring and remote control (Automotive)) • 100 micro sec* for local communications (Motion control (Machinery)) • 1 ms* (Robot remote control (Semiconductor)) • Motion-to-photon (MTP) 10 ms*, time-to-present (TTP) 70 ms* (Volumetric video) <p>* Including processing delay at application layers</p>
	Time synchronization accuracy	Time synchronization compatible with Precision Time Protocol (PTP) for the accuracy of internal clocks, including radio segments, (in microseconds) (Fully automatic operation of logistics facilities (Warehouse and logistics))



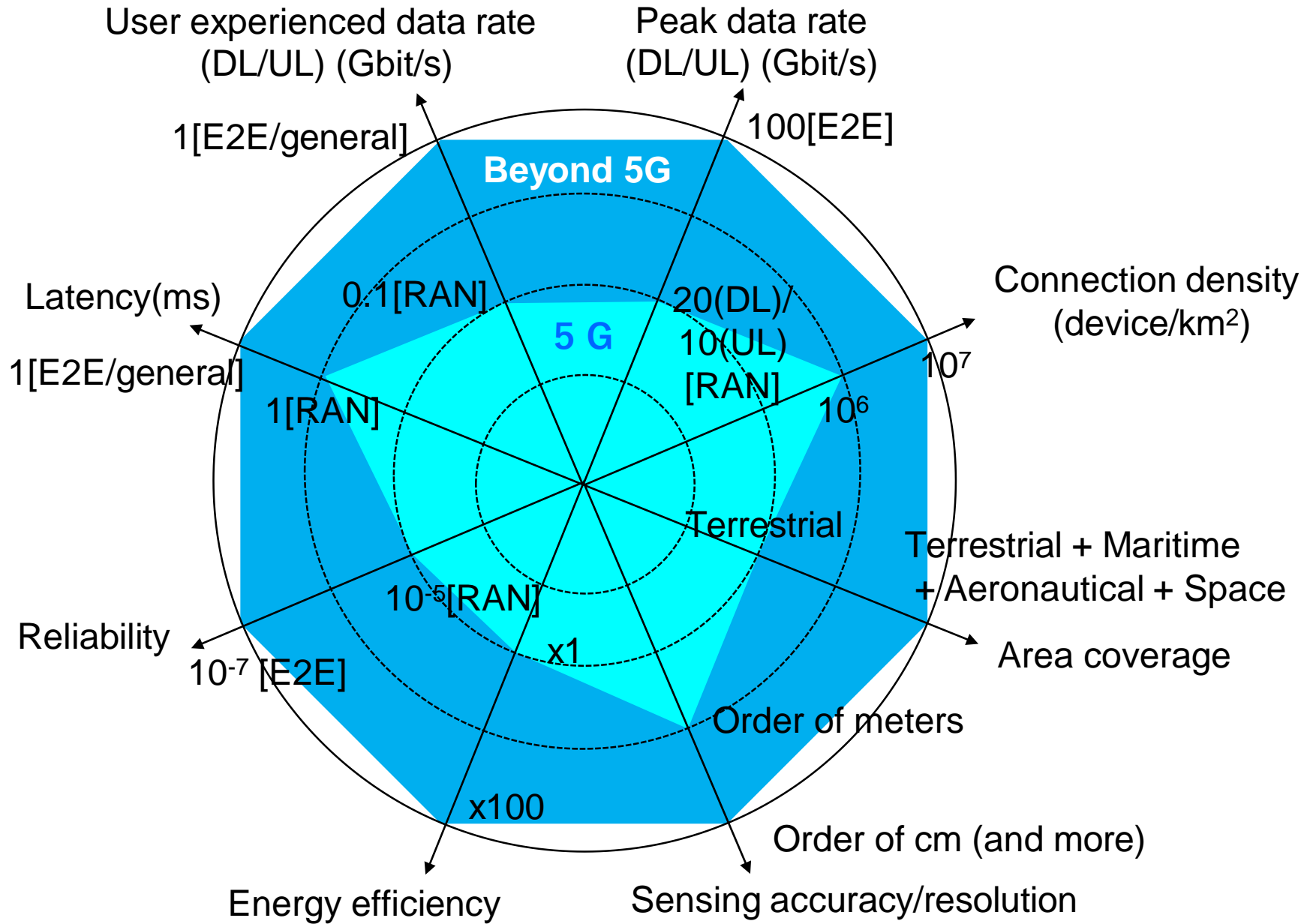
Summary in Sec. 5.1 “Capabilities required to Beyond 5G” (2)

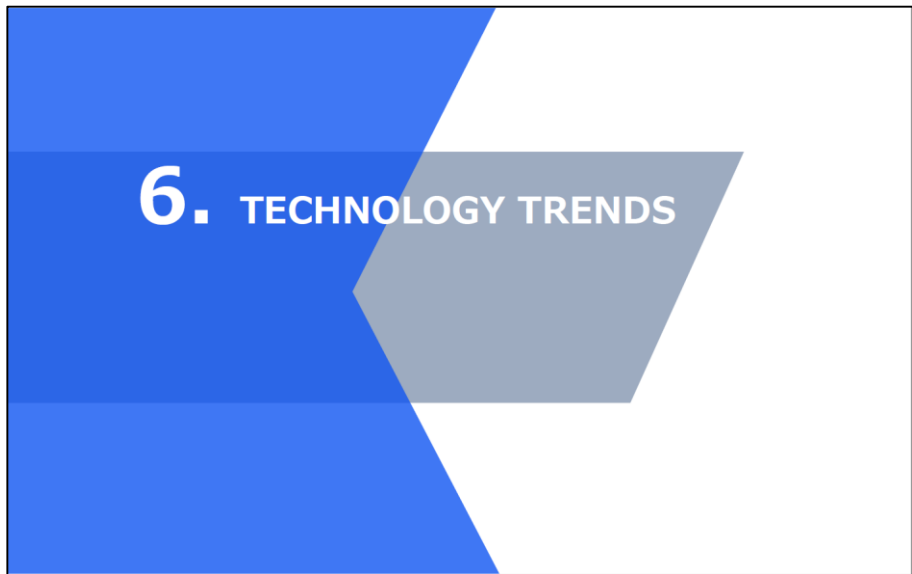
Category	Requirements	Capabilities required by each industry
Quantitative requirements	Ultra-security, resiliency and reliability	<ul style="list-style-type: none">• 10⁻⁶ (Remote monitoring and remote control (Automotive))• 10⁻⁷ (Remote surgery (Healthcare)) (unit: block error rate)
	Positioning and sensing	<ul style="list-style-type: none">• Positioning accuracy of 1 to 2 cm (Civil engineering (Construction and real estate))• Centimeter-level sensing accuracy (Vehicles traveling singly in rural areas or at night (Automobile))
	Ultra-massive connectivity	<ul style="list-style-type: none">• Several millions to tens of millions of devices/ km² (In-vivo devices (Healthcare))
	Universal coverage	<ul style="list-style-type: none">• Supersonic passenger aircraft flying at higher altitudes than current passenger aircraft, which is around 10 km, and coverage area at an altitude of more than 100 km in outer space (Aircraft)• 100% land coverage (Telecommunications and IT)• Coverage area in outer space and the moon (Space)• One HAPS aircraft covers tens to hundreds of kilometers in radius and a few kilometers above the ground (HAPS)





5.3.2 Target KPIs for Beyond 5G (Quantitative indicators)





6. Technology trends

1. Observations of technology trends towards Beyond 5G and overview of AI utilization, sensing application, and trustworthiness

1. Market demands

2. Deployment aspect

3. Technical aspect of radio spectrum

1. Trends in radio frequency resource utilization

2. Studies related to Radio Propagation

(1) Path loss of frequency band at 2 GHz, 26 GHz, and 300 GHz bands in urban microcell scenario

(2) Indoor line-of-sight and outdoor urban street canyon environments

(3) Path loss modeling using machine learning

(4) Design of ground to NTN communication using the 100 GHz band

(5) Indoor propagation characteristics in the 300 GHz band

A graphic with a blue background on the left and a white background on the right, separated by a diagonal line. The text "6. TECHNOLOGY TRENDS" is written in white on the blue background.

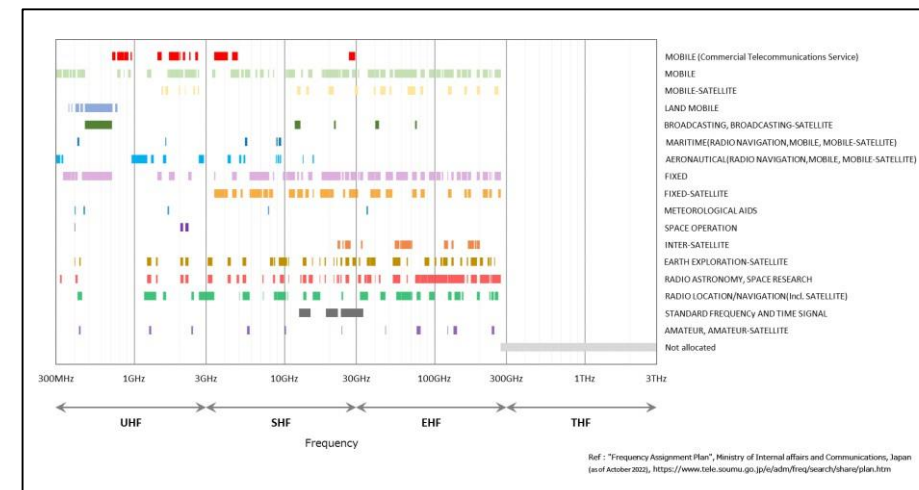
6. TECHNOLOGY TRENDS

6. Technology trends

1. Observations of technology trends towards Beyond 5G
2. System Platform and Application
3. Trustworthiness (Security, Privacy, and Resilience)
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Update Plan of The White Paper Ver. 3.0

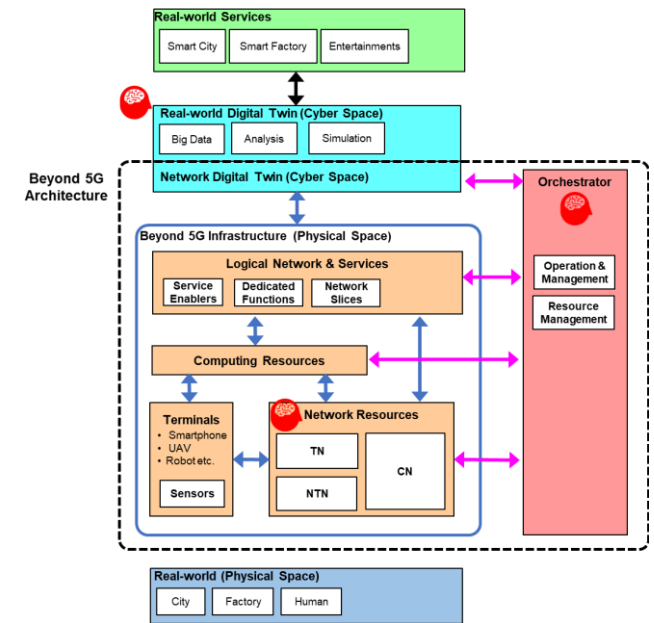
- Update spectrum aspects
 - Capture results of APG23-6 and WRC-23 for future IMT spectrum
 - Add survey of radio frequency on the range of 7125 MHz to 15.35 GHz in Japan
 - Evaluate existing radio systems, their level of usage, possibilities of contiguous and wider spectrum for IMT
 - Focus on 7125 – 8400 MHz and 14.8 – 15.35 GHz
 - Consideration for future actions





Update Plan of The White Paper Ver. 3.0

- Develop “Supplementary Volume” on 6G technologies
 - Summarize advanced technical study results on major technical topics for 6G in Japan
 - Contributed by both of industry and academia (**56** contributions)
 - Aiming global information sharing for discussion and contribution to standardization fora (Developed in English)
 - Supplementary volumes planned
 - Cell-Free Distributed MIMO
 - Radio technologies for higher frequency
 - Technologies on repeaters and reflectors
 - End-to-end network architecture
 - AI/ML
 - Sensing
 - Sustainability and Energy efficiency
 - NTN
- New Beyond 5G architecture will be presented



Beyond 5G architecture
(tentative)

- This white paper contains useful information which promote to study on new future business and solutions for social issues among all industries not limited to communication industry.
- It is expected that the white paper helps shape better future society and promote global activities including.
 - Collaborations among industry, academia and government
 - Collaborations among 6G research organizations
 - Support development of contributions to spectrum study and standardization activities in ITU and 3GPP
- Any related organizations are invited to give us an opportunity to exchange views on B5G/6G.

Thank you

