



# 6G Vision and Technology Trends

IMT-2030(6G) Promotion group

Vision of Future Communications Summit Workshop  
November 24, 2021





1 **6G Vision and Key Technologies**

2 **Introduction on IMT-2030(6G) Promotion Group**

# Overall vision towards 2030 and beyond



## Trends of society in the future

In 2030 and beyond, society will enter an era of intelligence. Balanced, high-quality social services, scientific, precise social governance, and green, energy-saving social development

## Technology trends

Communications integrating with sensing, computing, and control; achieving seamless global coverage, realizing reliable connections among people, machines, and things anytime, anywhere.



Ultimately realize the vision of an “intelligent connection of everything, digital twin” society.

## 6G services

6G will provide fully immersive interaction and support precise spatial interaction to meet the requirements for multiple senses, feeling, and mind communications. Communication for sensing and inclusive intelligence will realize the digitalization and intelligence of physical objects.

## 6G key capabilities

Ubiquitous connections among people, machines, and things and efficient interconnection of intelligent agents; incorporate new capabilities, including native intelligence, communication for sensing, digital twins, and native security.

# Driving Forces of 6G Development



## Changes in Social Structure

- Digital technologies are required to increase inclusiveness across unbalanced income levels;
- Demographic imbalance calls for digital technology to improve human capital and allocative efficiency;
- Change in the social governance structure necessitates modern governance



## High-Quality Economic Growth

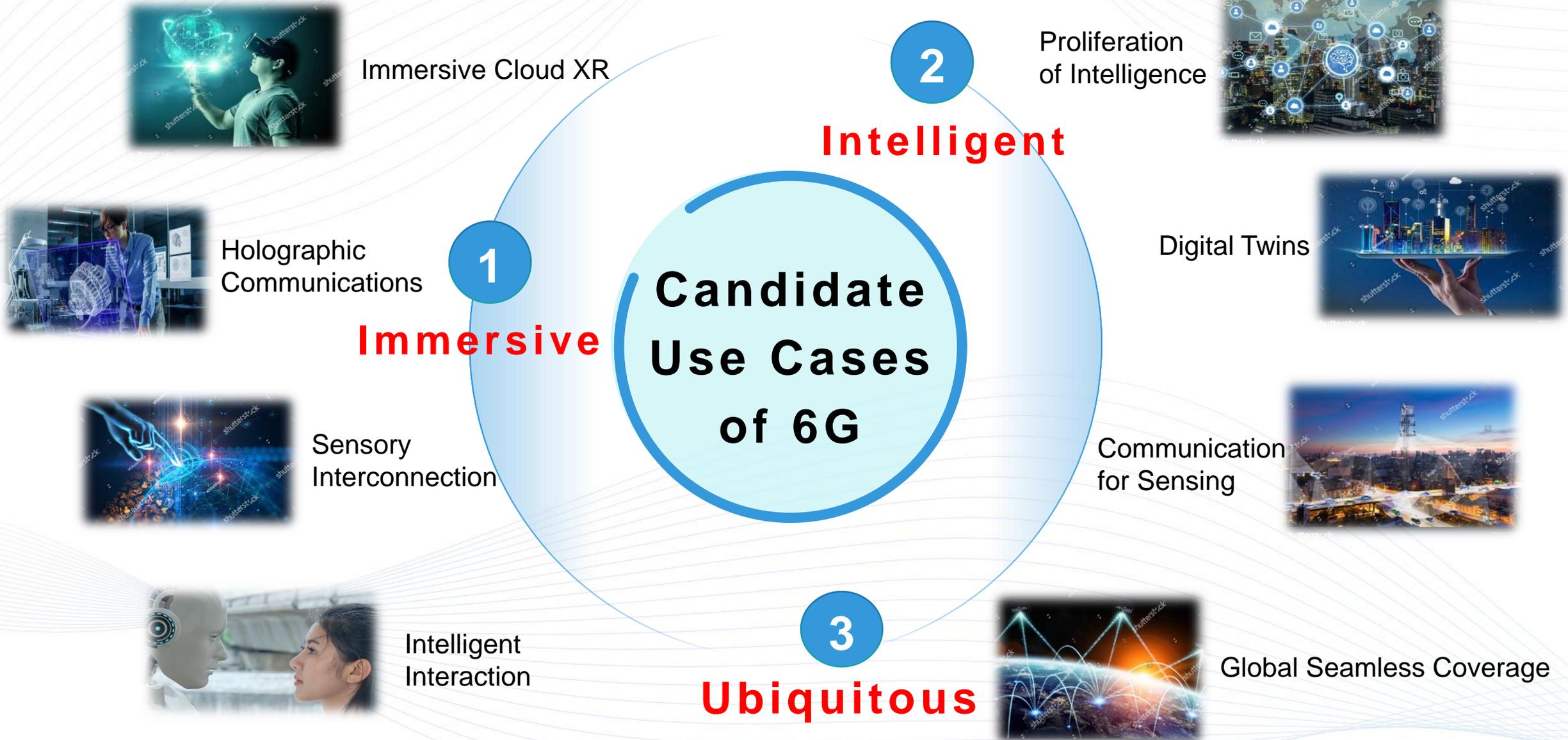
- Sustainable economic growth is fueled by the impetus brought by new technologies;
- The globalization of services requires lower cost in all-round information communications



## Environmental Sustainability

- Lower carbon emissions and carbon neutrality call for improved energy efficiency and green development;
- Extreme weather conditions and global emergencies require wider sensing and closer intelligent collaboration

# Potential 6G use cases: immersive, intelligent and ubiquitous



# Key Technologies 1: Extreme-MIMO



With the emergence of new materials and technologies, the scale of the antenna array will be further expanded to support new scenarios and services.

## Application scenarios



Macro coverage



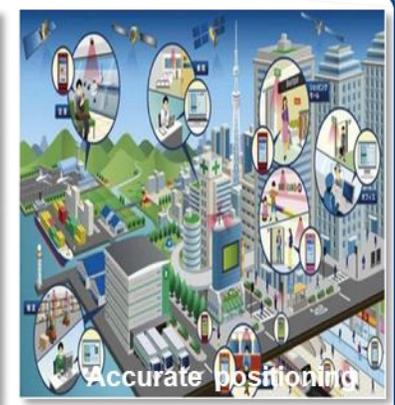
Hotspot coverage



3D coverage

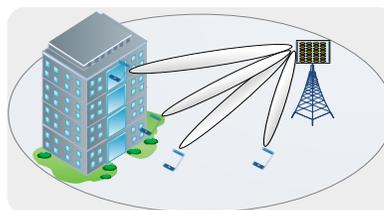


High-speed mobility



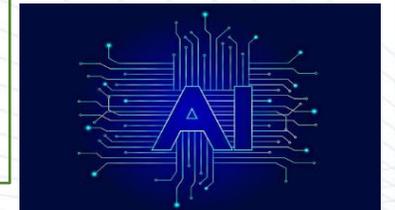
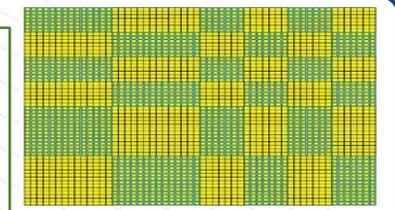
Accurate positioning

## Research directions



- **E-MIMO channel modeling**
  - Near-field model/continuous aperture/space-time non-stationary characteristics/ higher frequency band
- **Practical distributed E-MIMO solutions**
  - User-centric network structure
  - Low-cost, flexible deployment solution

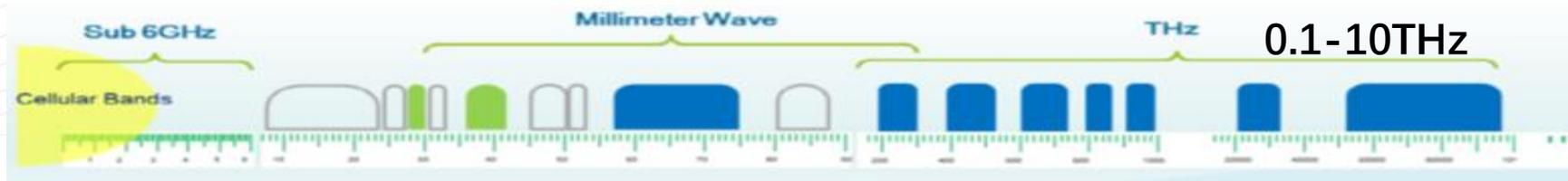
- **New antenna materials**
  - Integration of new antenna materials and system architecture
  - Efficient channel measurement scheme and feedback scheme
- **Intelligent E-MIMO**
  - E-MIMO AI theory
  - Data training on acquisition and interaction
- **Precise spatial positioning and perception**



# Key Technologies 2: Tera-Hertz (THz) Communications



Terahertz band has abundant spectrum resources and an extremely short wavelength, which can meet the needs of large-capacity and short-distance communication, as well as the ability in high-precision positioning and sensing.



## Application scenarios

- terrestrial communication, space communication, micro-nano-scale application scenarios, etc.

## Research directions

- **Channel modeling analysis:** indoor and outdoor channel modeling, spatial channel modeling, programmable material channel modeling
- **Key technologies:** terahertz communication + sensing, extremely narrow beam alignment and tracking, large bandwidth sampling and receiving technology, high-speed modulation coding and decoding technology, efficient networking and multiple access technology
- **Key components and chips:** mixers, frequency multipliers, oscillators, integrated circuit devices, etc.

# Key technologies 3: Integrated Sensing and Communications (ISAC)

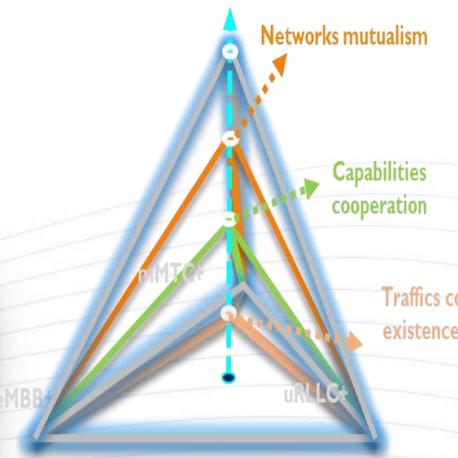


Leveraging wireless signals to realize wireless sensing and communications simultaneously. The 6G network will have native sensing capabilities to sense and better understand the physical world.

◆ **Scenarios:** a variety of wireless sensing capabilities (i.e., positioning, recognition, imaging, reconstruction, etc.) in the future smart life, industrial upgrade, social governance and other fields.

◆ **Technology evolution trends:** As the integration level of sensing and communication continues to increase, different stages will draw the technology roadmap of ISAC together.

Roadmap of ISAC towards 6G

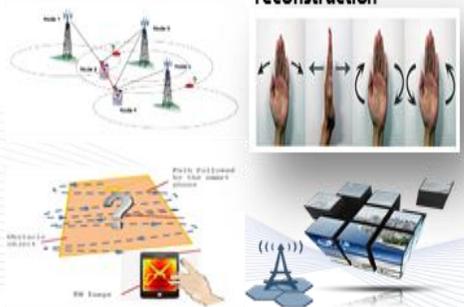


- Networks mutualism**
  - Deep information fusion
  - Multi-point sensing, network collaboration
- Capabilities cooperation**
  - Joint waveform design
  - Joint signal processing
- Function co-existence**
  - Shared spectrum/hardware
  - Interference management, hardware design

◆ **Key technologies:** Continuous breakthroughs are needed in fundamental theories, air interface, network architecture, networking schemes, hardware architecture, device design, etc.

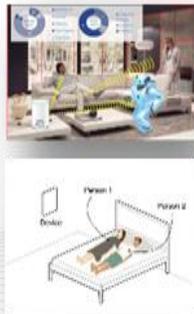
## Wireless Sensing Capability

- High-accuracy positioning
- High-resolution imaging
- Action recognition
- Virtual environment reconstruction



## Smart Life

- Smart home
- Medical and health



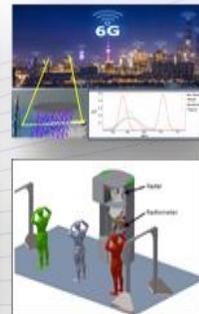
## Industrial Upgrade

- Smart factory
- Vehicle-to-everything



## Social Governance

- Environmental monitoring
- Public safety



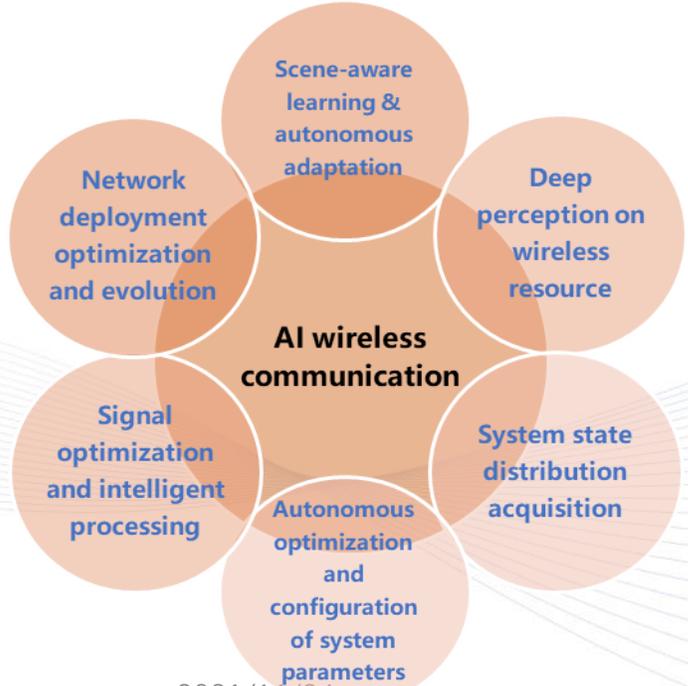
# Key Technologies 4: Wireless AI



Network intelligence is the development direction and important feature of 6G. **The combination of AI and wireless communication**, through the construction of a novel wireless AI network architecture and air interface protocol, can support 6G **full-scenario, full-dimensional, full-process** deep perception and learning, and significantly improve network intelligence.

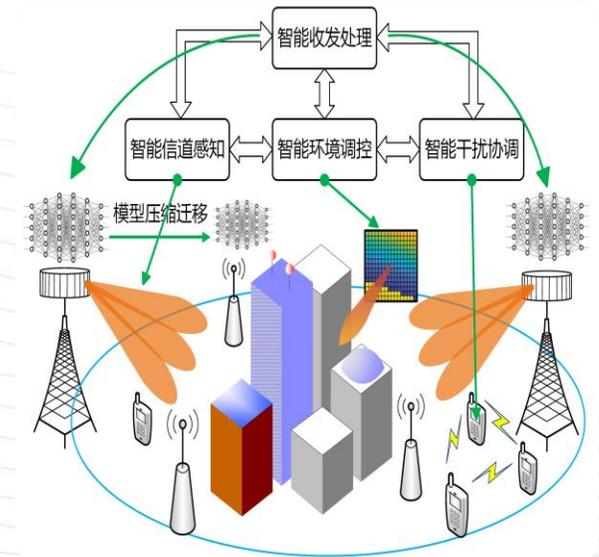
## Research directions

- A universal AI-native network architecture suitable for wireless environments, wireless resources, and wireless data
- New high-efficiency AI/ML algorithms at the physical layer/data link layer/network layer and system level
- The basic theory of wireless AI includes computing-storage-communication costs and performance limits
- Technology and industrialization development prospects supported by wireless AI



## Application Scenarios

- **AI for COM:** Realize **extremely intelligent communication**
- **COM for AI:** Support **smart distributed applications**
  - Distributed perception
  - Distributed control
  - Distributed computing



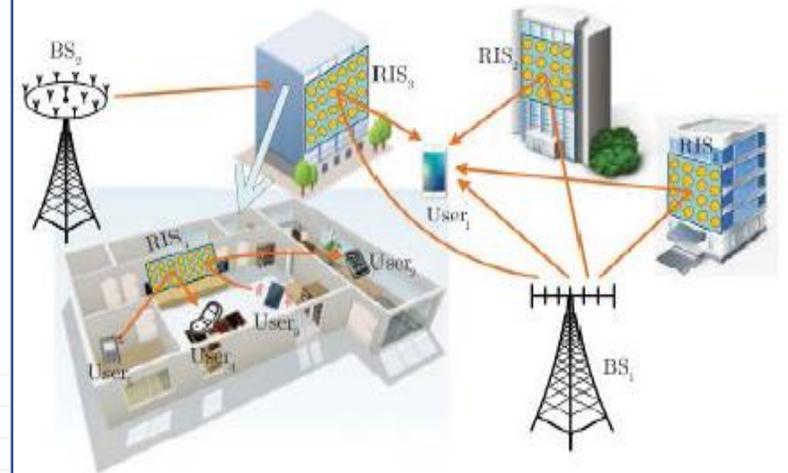
# Key Technologies 5: Reconfigurable Intelligent Surface (RIS)



By actively controlling the wireless propagation environment, RIS controls signal propagation direction, suppresses interference and enhances the signal, and builds a new paradigm of 6G intelligent programmable wireless environment.

## Application scenarios

- Overcome the limitation of NLOS, suitable for scenarios where the LoS path is blocked or the power is low
- Overcome the problem of local voids
- Serving cell edge users, solving multi-cell co-frequency interference
- Secure communication to prevent eavesdropping
- Applications in new scenarios such as positioning and sensing

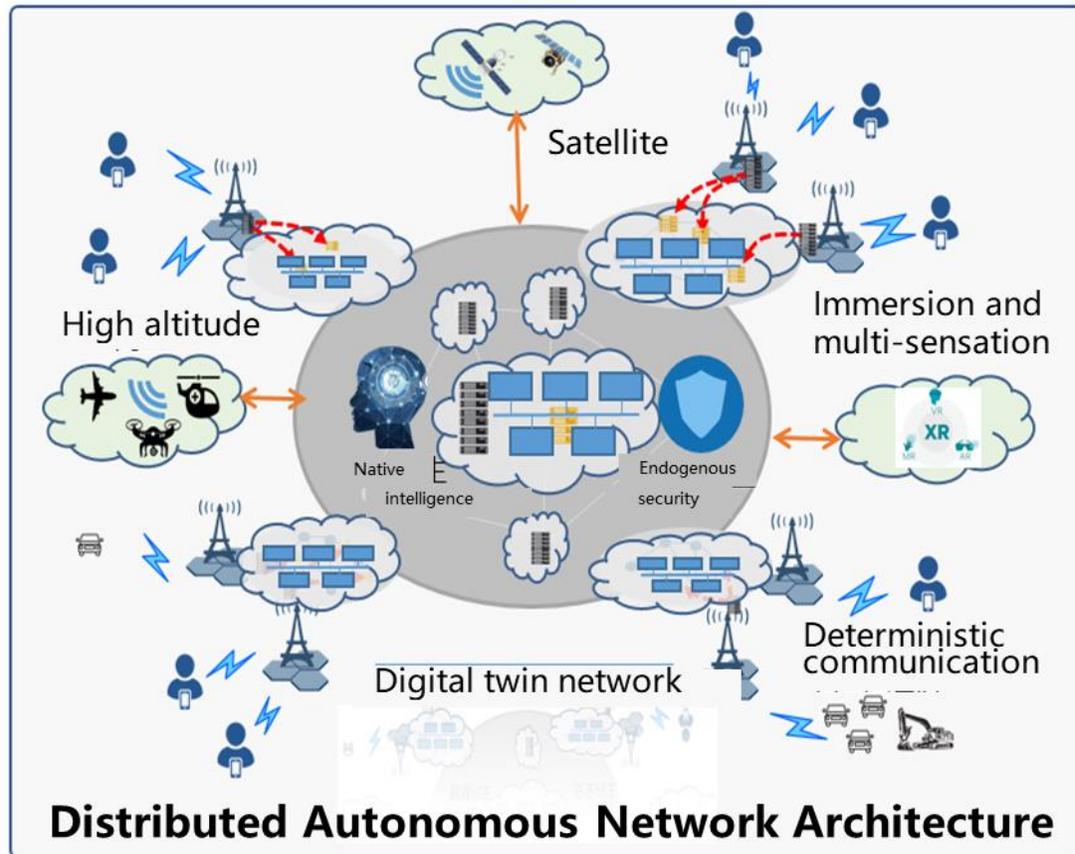


## Research directions

- **Basic theory and modeling research:** modeling and communication theory limit analysis, physical and electromagnetic compatibility model, channel measurement and modeling;
- **Technical solutions and algorithms:** channel estimation and feedback, beamforming design, passive information transmission, AI enabling design, networking design;
- **Hardware:** new materials, new ultra-surface system architecture and interfaces, etc.

# Key technologies 6: Network architecture

**Two principles: network compatibility, simple design. Four characteristics: native intelligence, native security, multi-domain integration, computing network integration**



**Six potential capabilities**

- Network programmability
- Communication awareness network
- Deterministic communication
- Data service
- Immersion and multi-sensation
- Semantic communication

**6G network architecture**

**Six potential architecture technologies**

- Distributed
- Air-Space-Ground integration
- Native intelligence
- Native network security
- Digital twin
- Computing network

## Four design principles

**From centralization to distribution**

**From heavy-duty incremental design to minimalist integration design**

**From plug-in design to internal design**

**From ground access to air-space-ground-sea-based access**

# Thoughts on 6G Development



01

**The Successful  
Commercial  
Deployment of 5G  
Will Lay a Solid  
Foundation for 6G**

02

**Efficient Use of  
High-, Medium-,  
and Low-  
Frequency Bands  
to Fulfill 6G  
Spectrum Needs**

03

**Native AI  
Intelligence  
Plays a Pivotal  
Role in 6G**

04

**Satellites Assist  
Cellular Terrestrial  
Networks to  
Achieve Full 6G  
Coverage**



1 6G Vision and Key Technologies

2 Introduction on IMT-2030(6G) Promotion Group

# Structure of IMT-2030(6G) Promotion Group



- In June, 2019, under the guidance of the Ministry of Industry and Information Technology(MIIT) in China, the IMT-2030 Promotion Group was established. It promotes the research of 6G and build an international view exchange platform.



## Expert Committee

Requirement WG

Wireless Tech. WG

Network Tech. WG

Spectrum WG

Standards & International Corp. WG

Economy and Society WG

There are 59 member units of the IMT-2030 promotion group, which are open to the world. Ericsson, Samsung, DoCoMo, etc. are all members of the promotion group.

**Research institution**

**Operator**

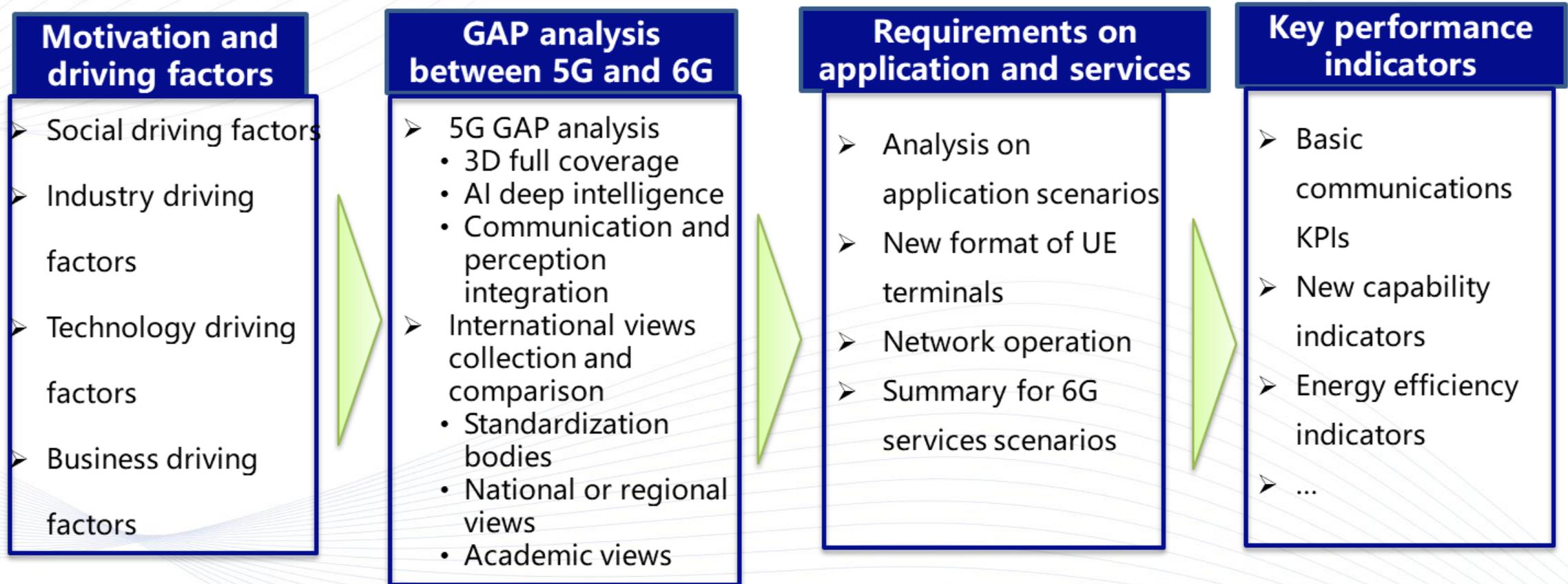
**System equipment provider**

**Chipset and terminal provider**

**University**

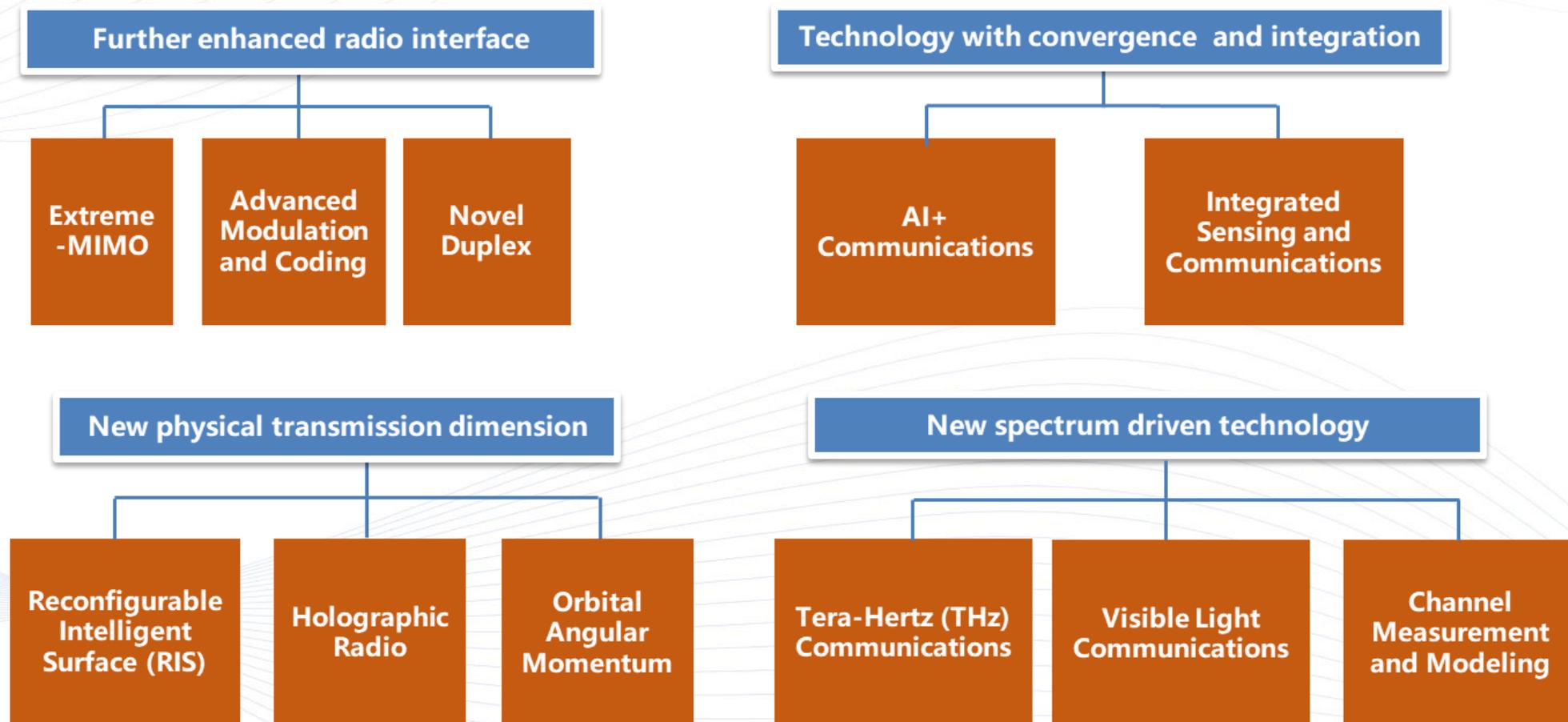
# Requirement WG

- **Focus on 6G vision and requirements, with the goal of proposing 6G overall vision, basic services, application scenarios and key capabilities**



# Wireless Tech. WG

- Explore a broad view of innovative wireless technologies.
- **WG structure is dynamic and flexible to include emerging technology aspects as needed.**



# Network Tech. WG



- Potential revolutionary technologies are emerging.
- The innovation of network architecture in the 6G era will be more important.

## '2+6' technology division with 8 task group

**Network architecture and requirement**

**Network security**



**Integration of terrestrial and non-terrestrial networks**

**Intelligent network**

**Deterministic network**

**Computing power network**

**Information central network**

**Digital twin network**

# Spectrum WG



- Research topic including 6G spectrum requirements, propagation characteristics on millimeter wave, terahertz, and visible light, new technologies for spectrum sharing, etc.

Spectrum requirement for 6G based on vision

Analysis on global spectrum strategy and policy

Exploring the 6G spectrum under ITU framework

Explore new frontier for 6G spectrum

Make good use of existing spectrum by exploiting sharing technology

- ✓ Traditional IMT frequency issues
- ✓ 6G "cross-border" topics, such as private network frequencies, satellites, intelligent transportation, high-altitude platforms, etc.
- ✓ Terahertz propagation characteristics and channel modeling
- ✓ Explore new technologies as spectrum sharing



- Promote international views exchanges and cooperation with the progress of 6G research in major countries/organizations around the world;

## Promote international cooperation

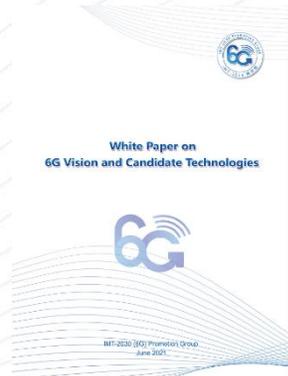
- Give full play to the channel role of international corporate members in the group and strengthen international communication and cooperation
- Promote to establish a liaison mechanism with foreign regional 6G organizations/alliances to reach consensus

## Output the research results to standardization organizations

- Carry out research work on 6G technology trends and vision for ITU and other international standardization organizations
- Coordinate the research needs and output of the working groups



# Publications from IMT-2030(6G) Promotion Group



White paper  
"6G Vision and Candidate Technologies"  
(\*with English version)



Technical report  
"Extreme MIMO"



Technical report  
"Integrated Sensing and Communication"



Technical report  
"Wireless AI"



White paper  
"6G network architecture vision  
and key technology outlook "



Technical report  
"Tera-Hertz (THz)  
Communications"



Technical report  
"Reconfigurable Intelligent Surface (RIS)"



Technical report  
"network security vision"

\*English version of white paper "6G Vision and Candidate Technologies" can be downloaded at [http://www.caict.ac.cn/english/news/202106/t20210608\\_378637.html](http://www.caict.ac.cn/english/news/202106/t20210608_378637.html)



# THANKS

