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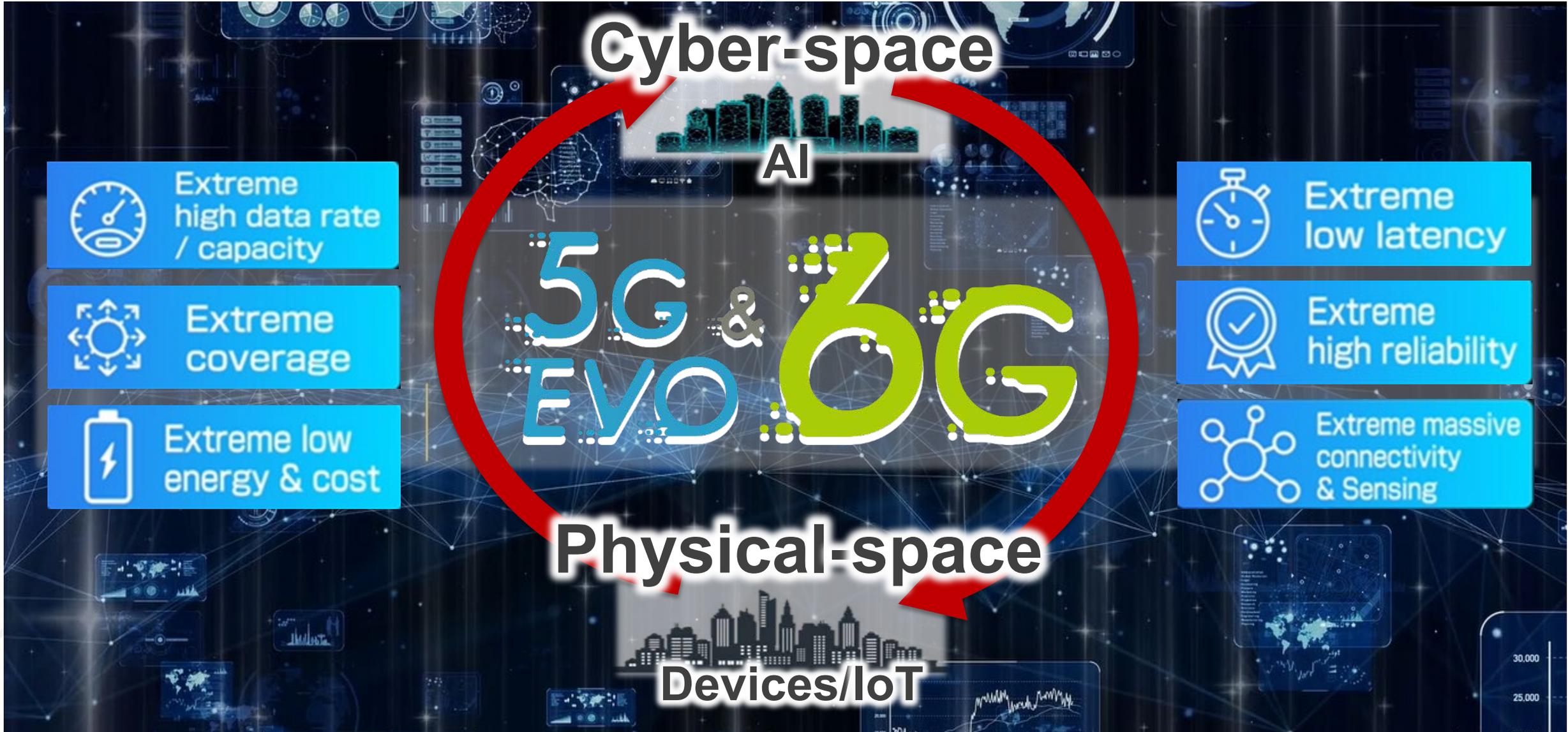
# 5G Evolution and 6G powered by IOWN

**NTT DOCOMO, INC.**

# 5G Evolution & 6G

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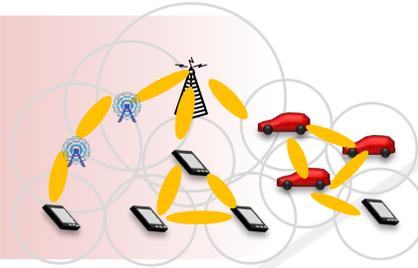
# Technologies for 5G Evolution and 6G

# Technological development and research areas

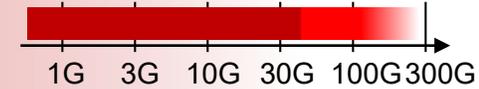
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Deployment of new radio network topology



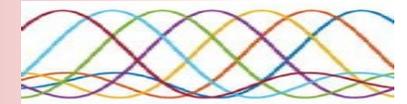
Broader frequency domain and advanced frequency utilization



Coverage extension, including non-terrestrial networks



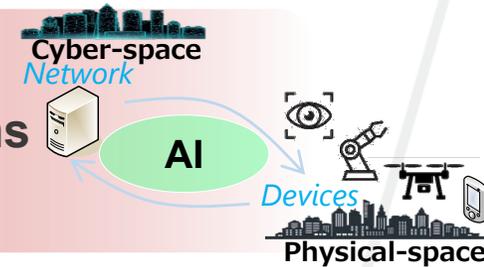
Advanced massive MIMO and wireless transmission



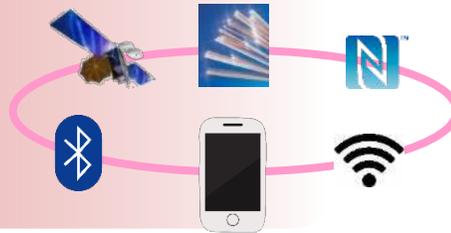
Ultra-reliable and low latency communications (URLLC) and industrial networks



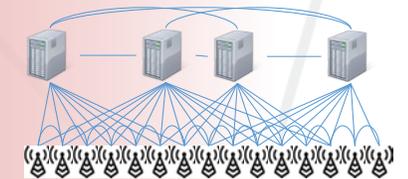
Multi-functionalization of wireless communication systems and utilization of AI technology



Integration of various wireless technologies



Advanced network architecture



# Technologies for coverage extension

- NTN/HAPS
- Underwater acoustic communications

# Coverage Extension with NTN

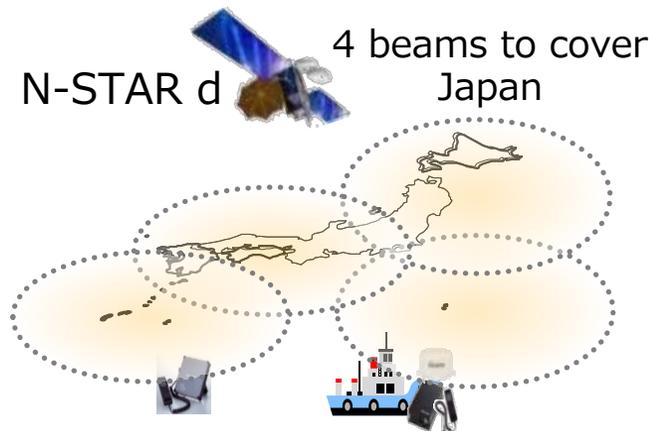
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	GEO	LEO	HAPS
Altitude (free space path loss)	36,000 km (191.9 dB)	1,000 km (160.7 dB)	20 km (126.8 dB)
Latency (one-way)	120 msec	3.3 msec	0.066 msec
Number to cover Japan	1	Many (need to support entire of earth)	Around 50



## (Example) Current DOCOMO's business case



Spectrum bands:  
2.5/2.6GHz (FDD)

Limited data rate  
Downlink: 384 kbps  
Uplink: 144 kbps

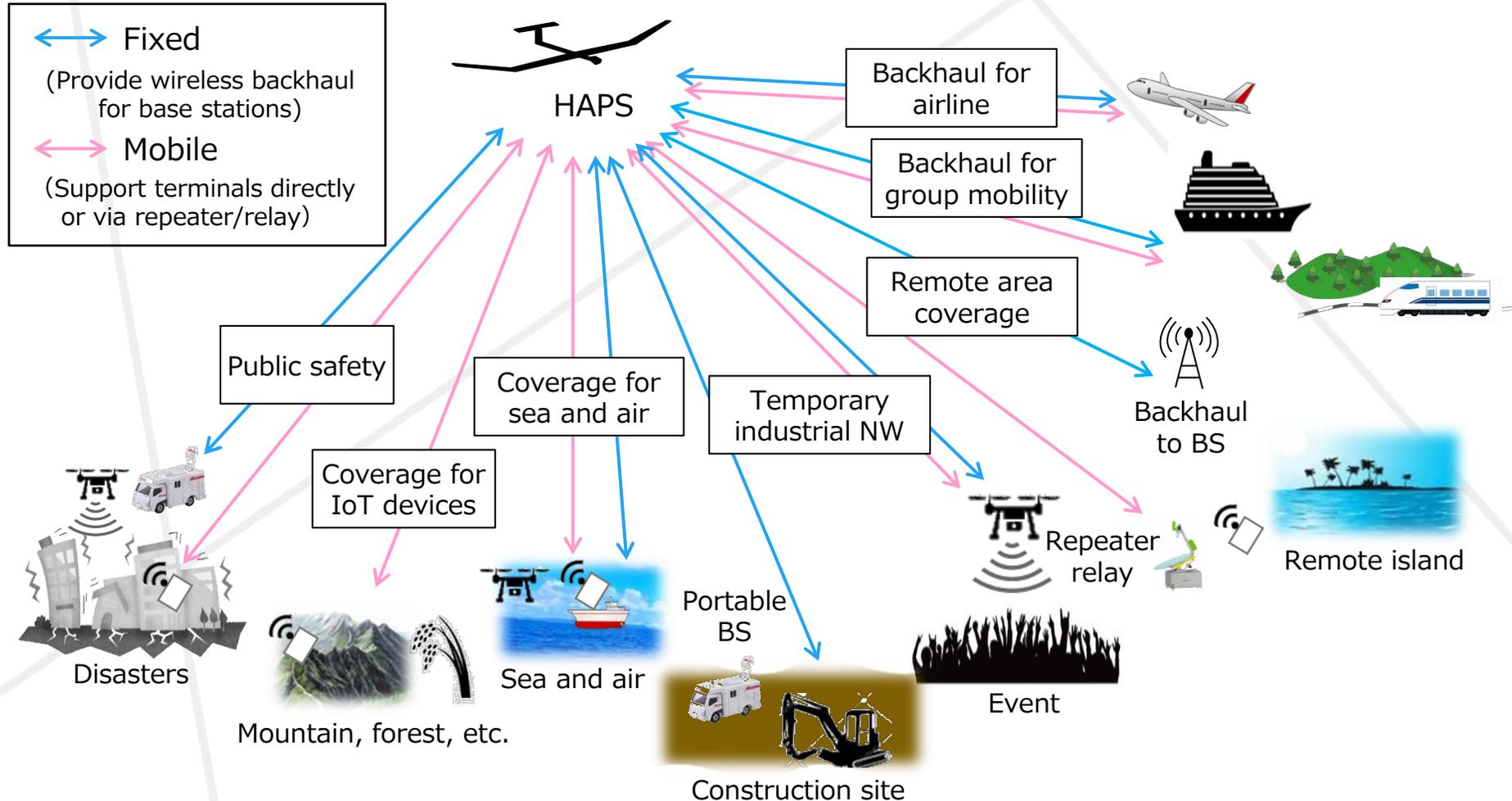
HAPS can support more business use cases with following benefits

- Higher data rate
- Lower latency
- Smaller terminals
- Flexibility of NW deployments



# Variety of Use Cases with HAPS

- Effective for many industrial use cases in 5G evolution & 6G as well as public safety



## Challenges of wireless technology

- Radio interface for long-distance communication
- Efficient frequency utilization scheme between HAPS and ground network
- Network design for efficient interworking between HAPS and ground network

# HAPS simulator

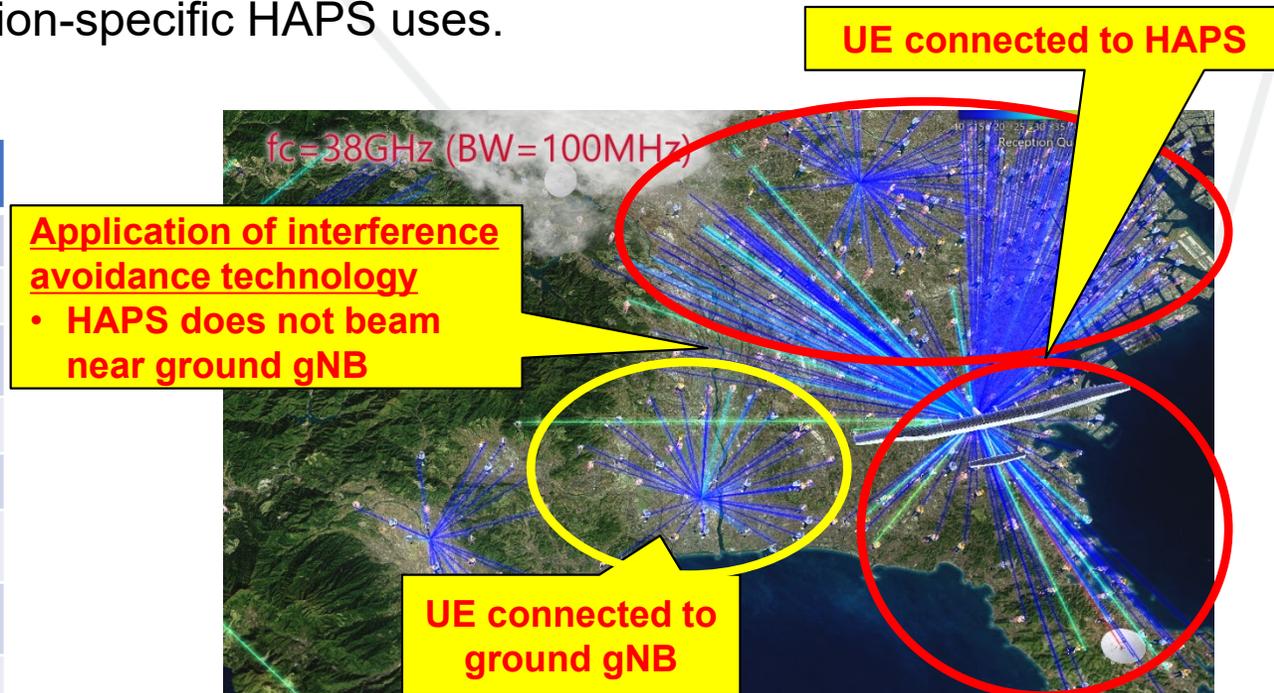
- HAPS simulator for airborne coverage
- Newly added functions for uplink, UE direct link, and interference reduction

## HAPS simulator for evaluating ultra-coverage performance

- After setting radio-communication parameters, the HAPS simulator calculates system capacity according to the communication environment on the ground.
- Communication parameters can be calculated for location-specific HAPS uses.

Simulator specifications (simplified version)

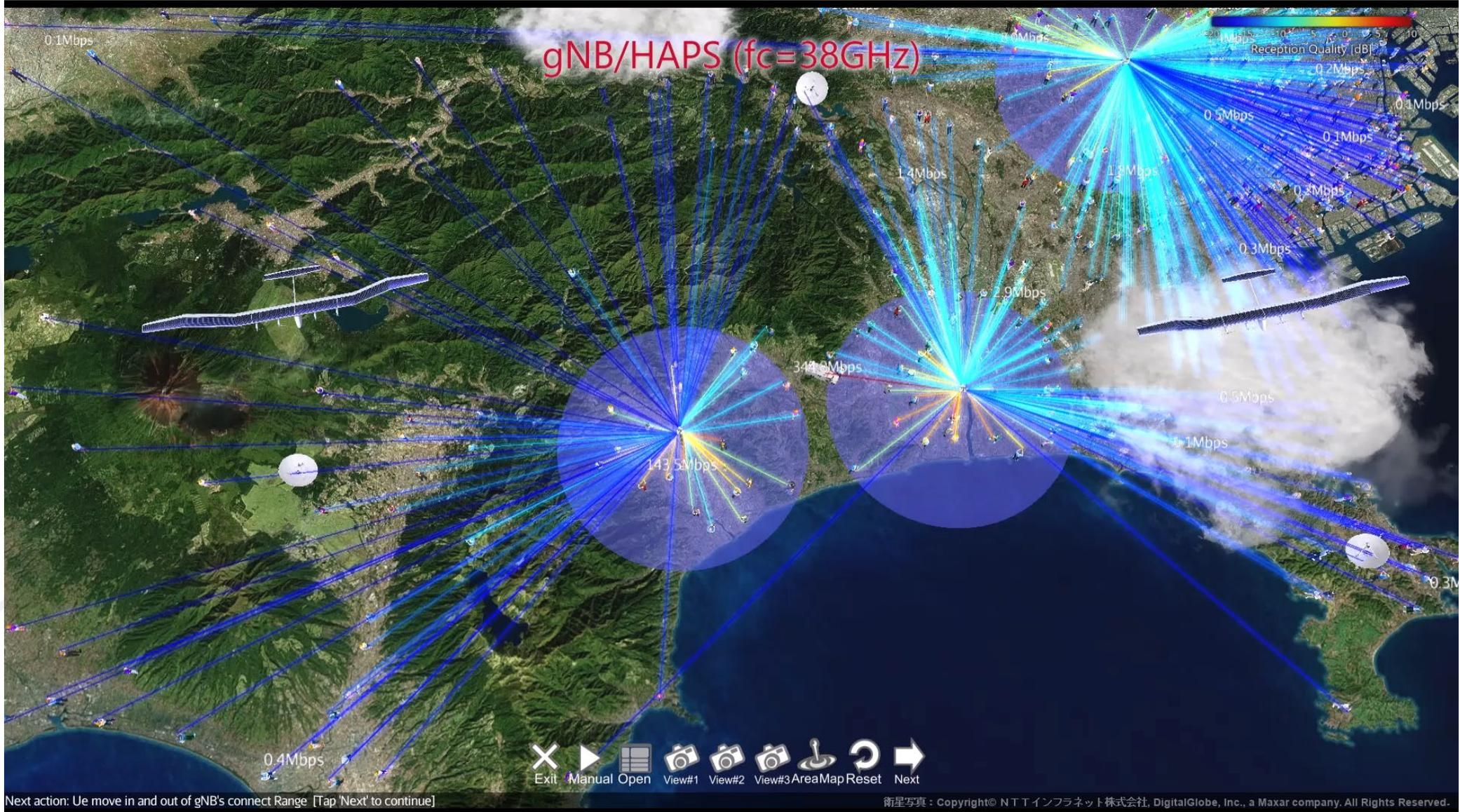
Parameter	Feeder link	Service link
Frequency	38 GHz	
Bandwidth	$\geq 100\text{MHz}$	
Transmission power	34 dBm	
Tx peak gain	50 dBi	30 dBi
Rx peak gain	30 dBi	
Pass loss model	Free space pass loss	
Rain attenuation	20 dB (if rainy)	
Atmospheric absorption loss	1 dB	



Simulated collaboration between HAPS and terrestrial gNB

# IHAPS simulator

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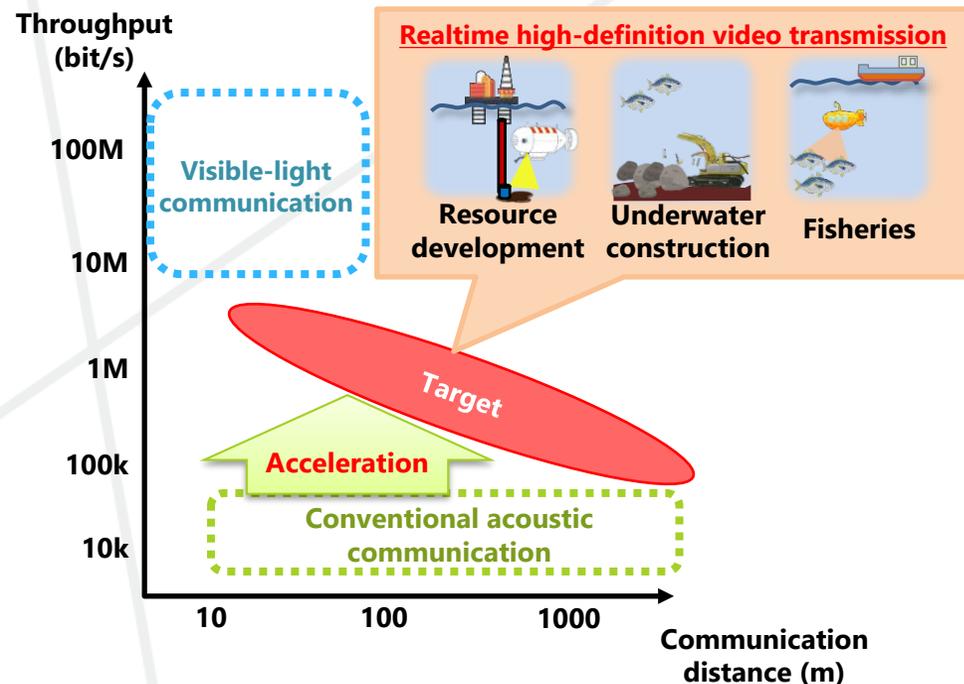
# High-speed underwater acoustic communication

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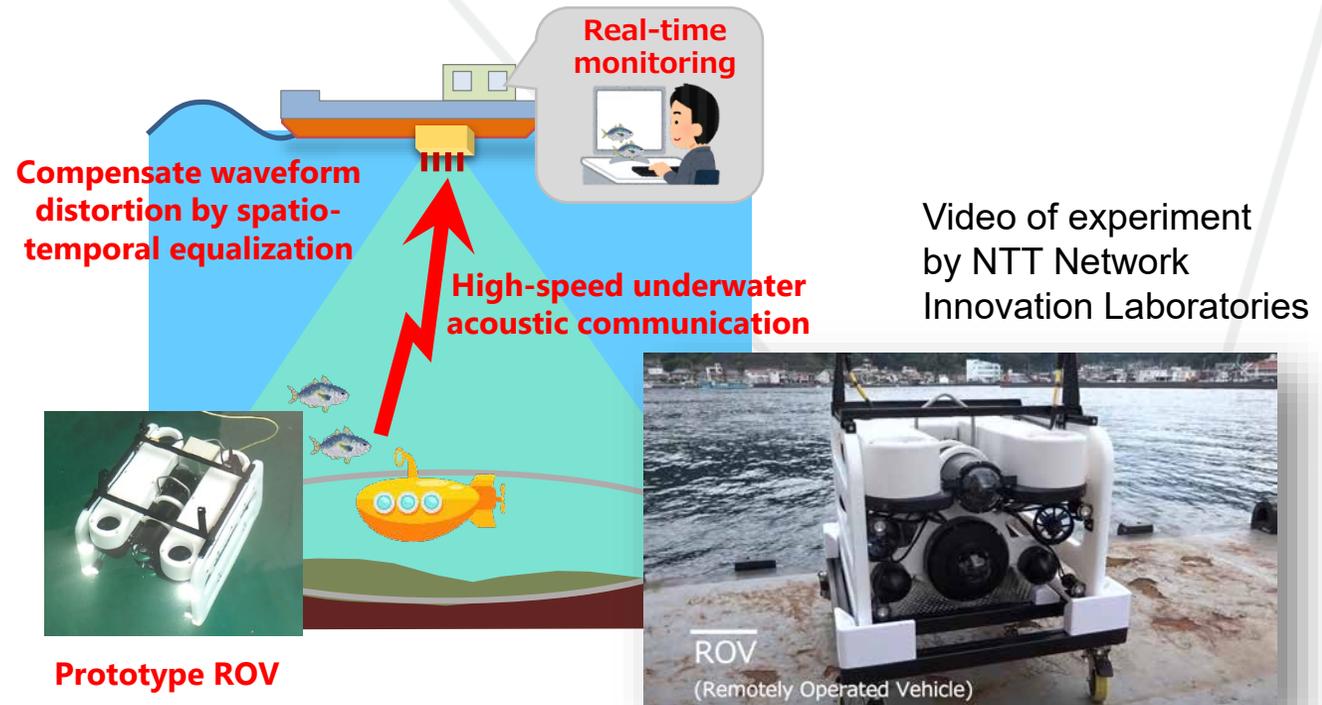


- Coverage will be extended to undersea areas unexplored for high-speed wireless communications.
- Spatio-temporal equalization technology that compensates for severe waveform distortion undersea has achieved underwater acoustic communications of more than 1 Mbit/s, enabling video transmissions from underwater drones.
- Current initiatives are focusing on bidirectional communication, improved stability and smaller, more power-efficient equipment, for achieving wireless remote control of underwater drones.

## Positioning of our technology



## Acoustic MIMO transmission



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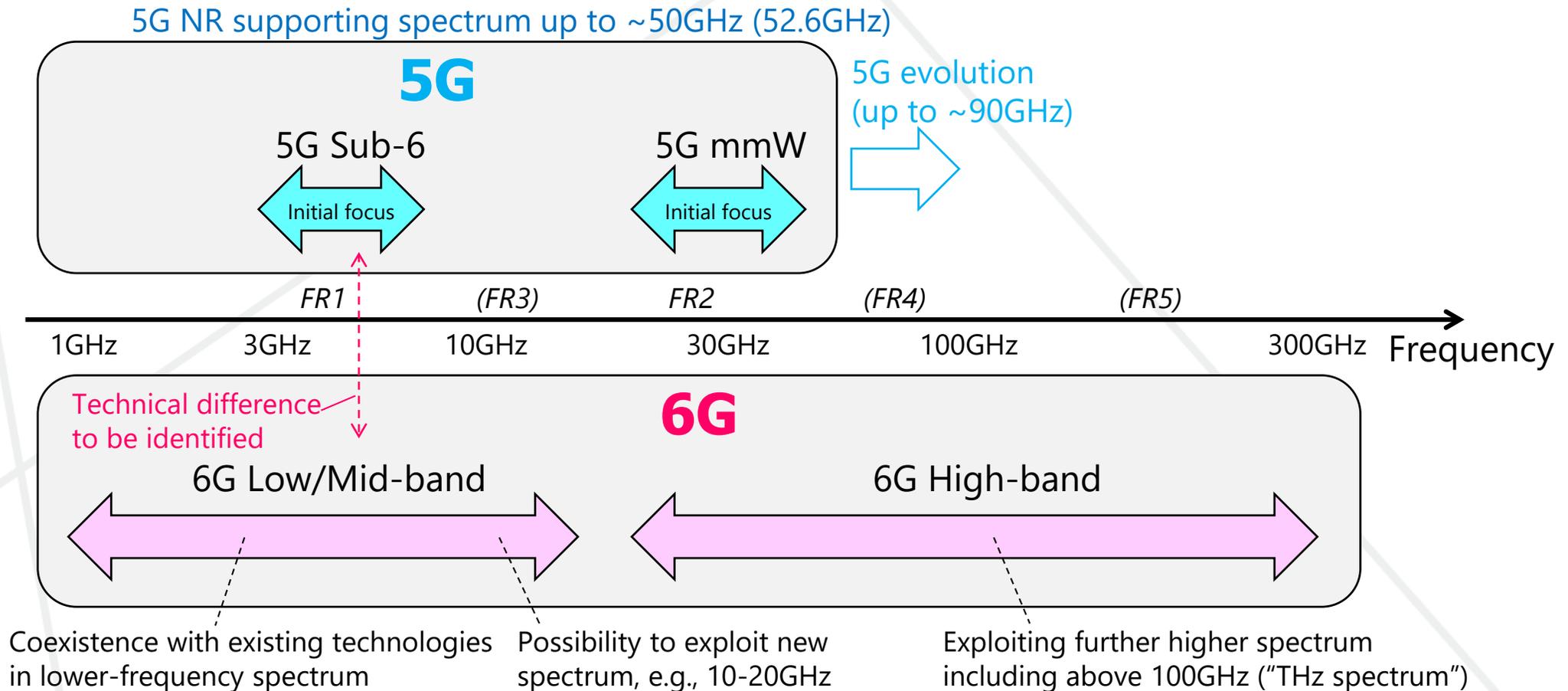
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# Terahertz frequency

■ **6G simulator**

# 6G Spectrum Extension

- 5G NR supports frequency bands up to 52.6 GHz, and extension to approximately 90 GHz for future release
- 6G exploits higher frequency bands than 5G such as “millimeter wave” and “terahertz wave” (~300 GHz), and remarkably wider bandwidth can achieve extreme high data rates exceeding 100 Gbps



# 16G simulator

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- Real-time system simulator for evaluating ultra-high-speed 100 Gbps 6G communication
- Will support use of terahertz frequency such as 100 GHz, in addition to sub-6 and millimeter waves
- User throughput above 100 Gbps achieved in factory-simulation test using 100 GHz

Center frequency	100GHz
Bandwidth	8000MHz
Base station elements	1296
Base station power	33 dBm
Mobile station power	23 dBm
TDD ratio	Changeable



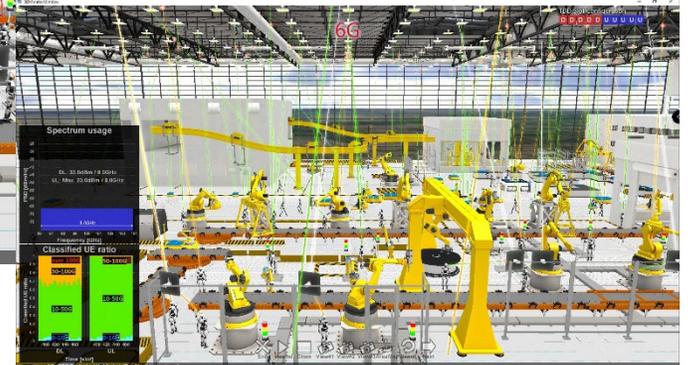
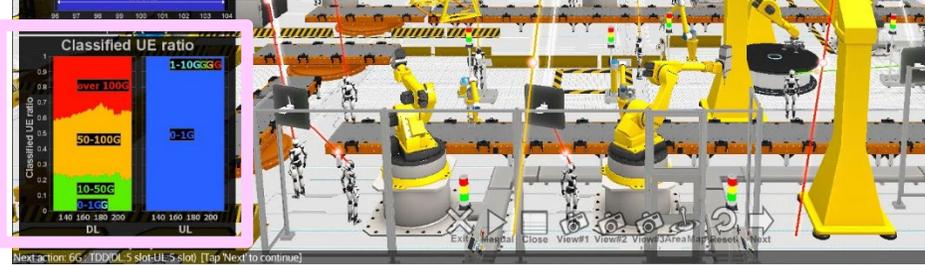
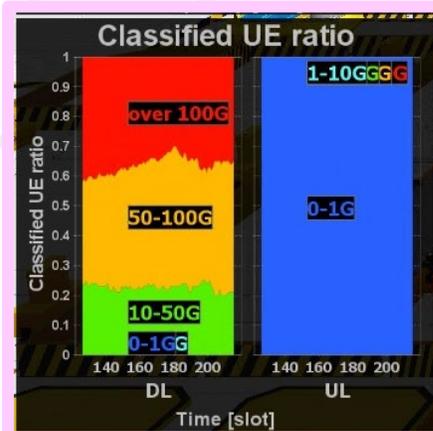
DL:UL = 10:0



DL:UL = 5:5



User throughput ratios (DL:UL)



# 6G simulator

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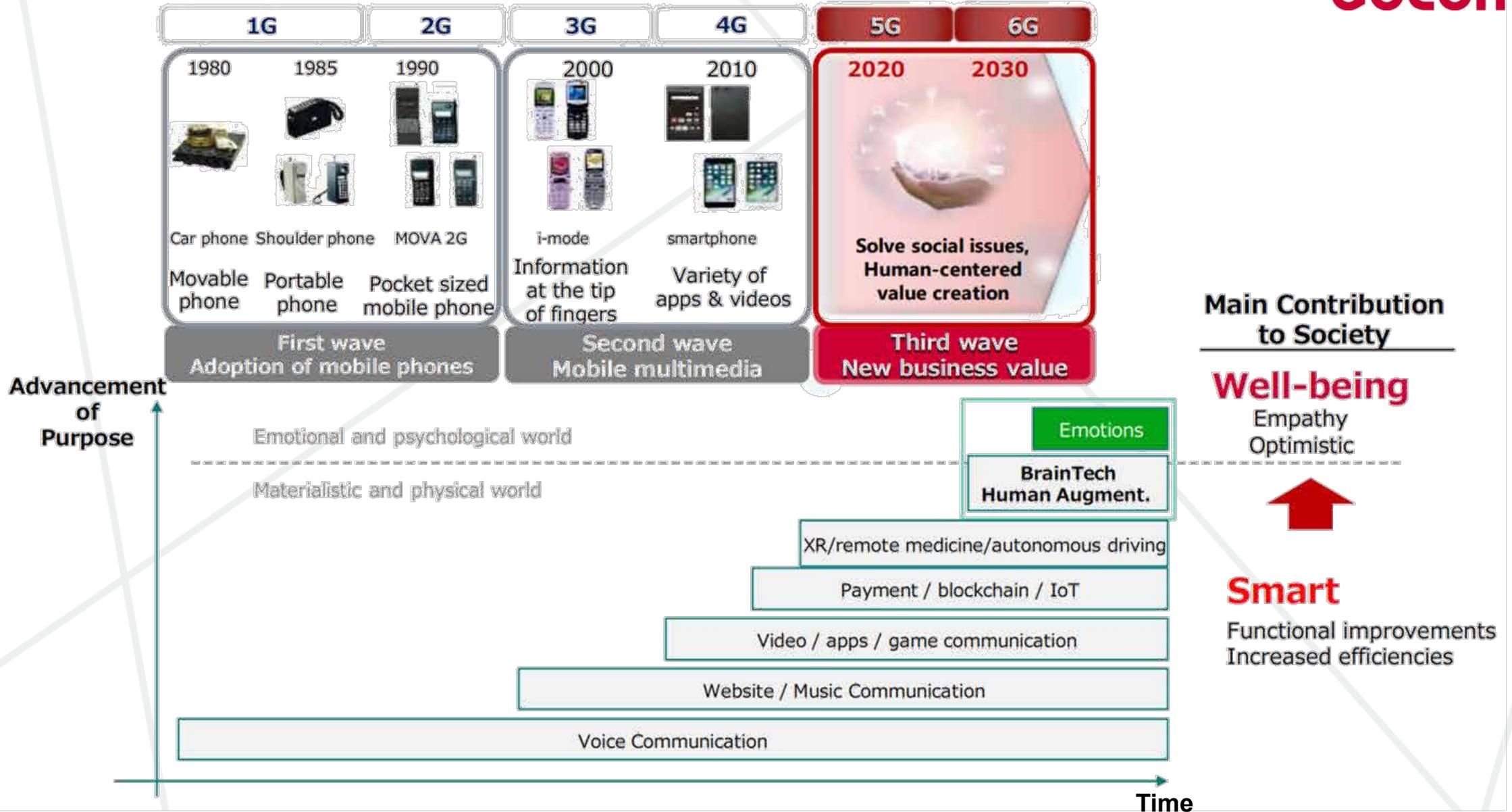
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# Innovative applications in 6G era

# Applications in 6G era

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# Human Augmentation through 6G NW!

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Ubiquitous body



Telepathy and telekinesis through the network



Network



Go beyond the constraints of space and time

Experience feeling



Superhuman

6G faster than nerve impulses!?

Share 5-Senses through the network!



# Human augmentation

## Sensing

### Electroencephalogram

EEG sensor



Electrical activity in brain

### Myoelectricity

Myoelectricity sensor



Hand and arm movement

### Physical movement replication

Piezoelectric sensor



Gripping force

### Embodied knowledge

Anthropometric sensors



Body movements

## Platform

### Human augmentation platform

Register sensor data

Reproduce sensor data

Interconnectivity

#### Database

Physical data

Mapping information

Sensor data

Operational data

## Application

### Robots



Robots

Control robot

### Myoelectricity



Myoelectricity actuator

Control prosthesis

### Physical movement replication



Myoelectricity actuator

Play instrument

### Embodied knowledge



Replicate physical movements while watching video

# Human augmentation demonstration (1)

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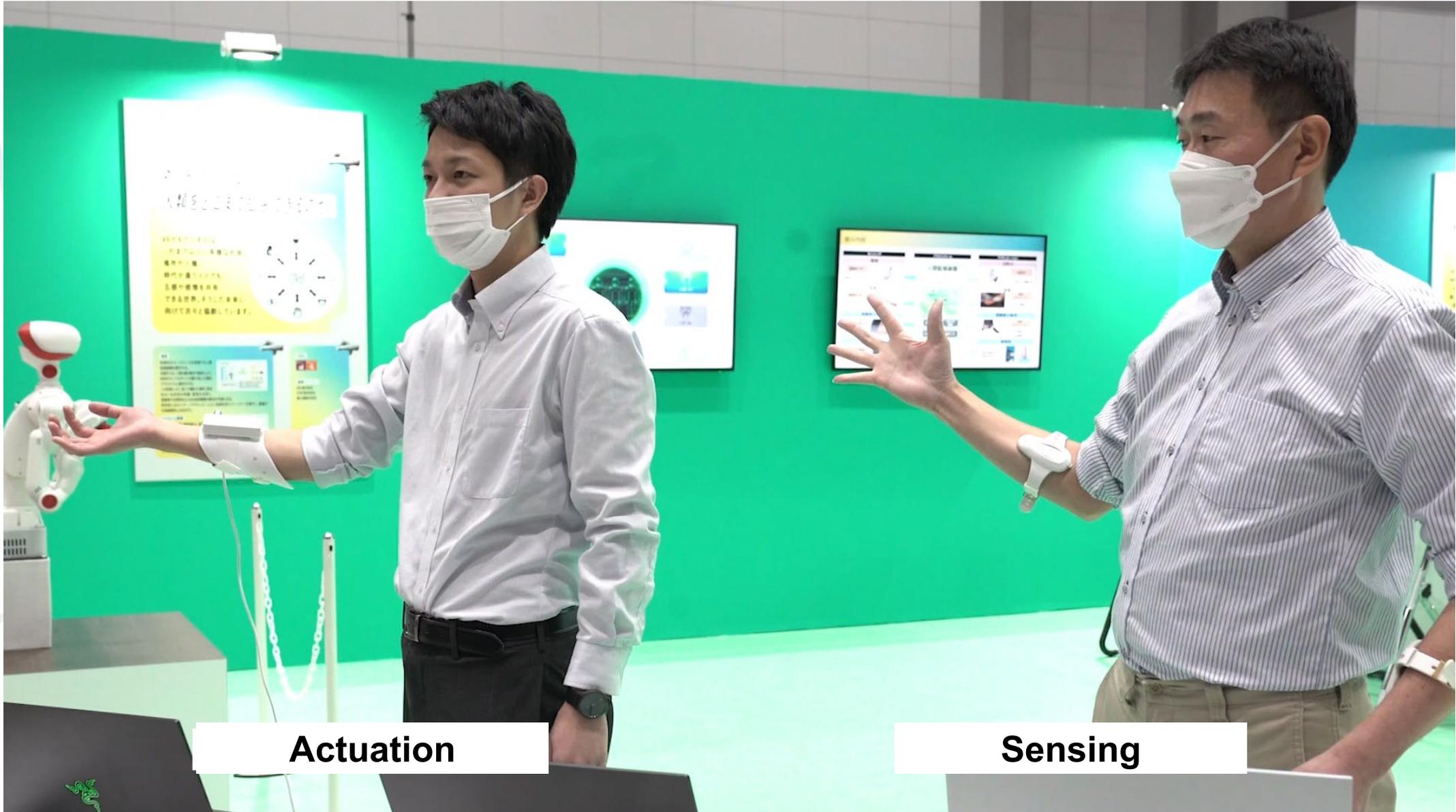


**Actuation**

**Sensing**

# Human augmentation demonstration (2)

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**Actuation**

**Sensing**

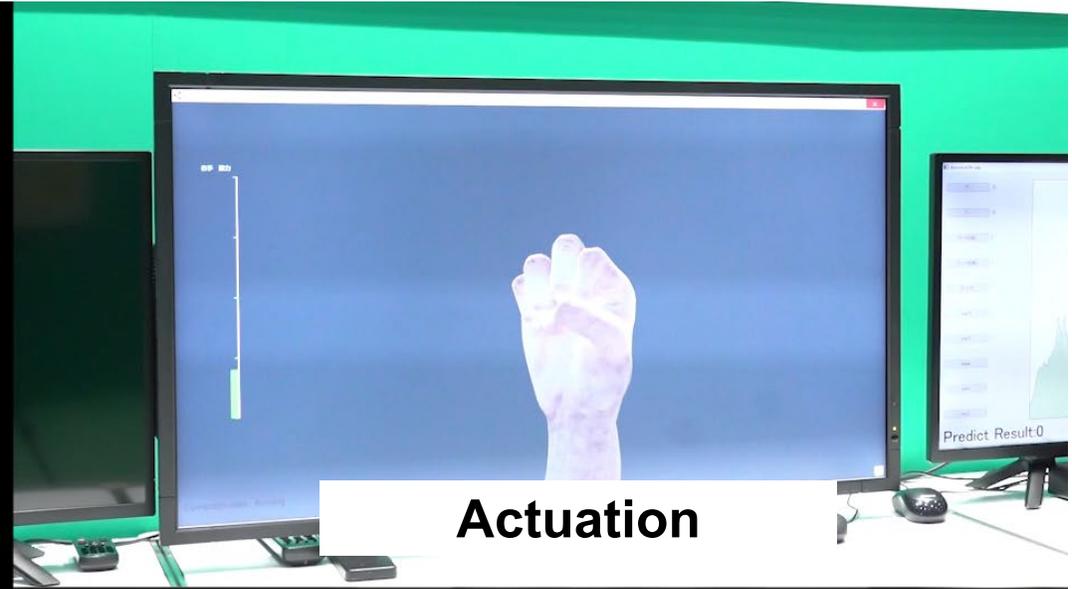
# Human augmentation demonstration (3)

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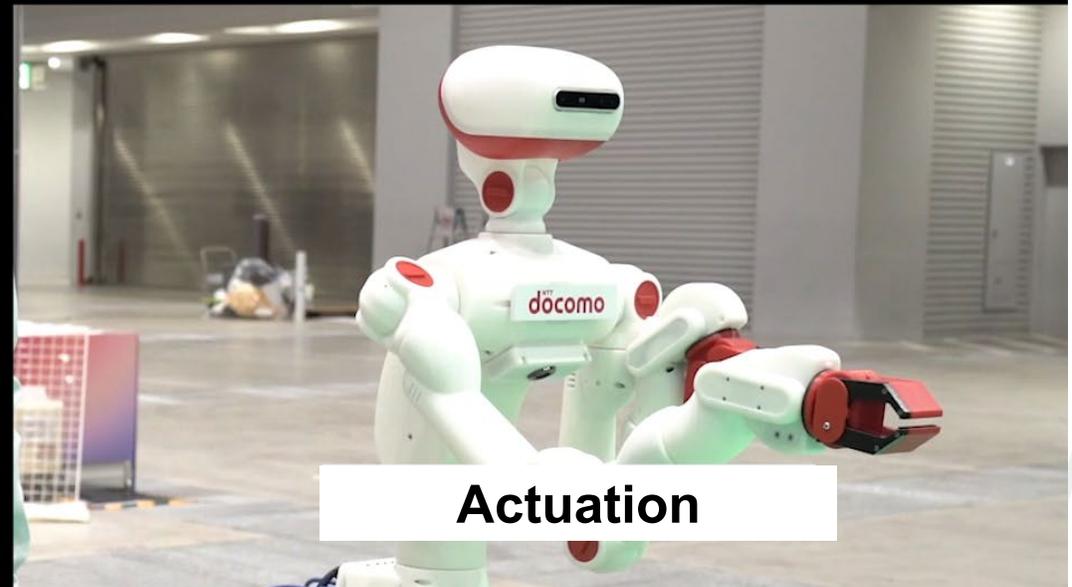
**Sensing**



**Actuation**



**Actuation**



**Actuation**

# **5G Evolution & 6G powered by IOWN**

**(Innovative Optical and Wireless Network)**

# 5G Evolution & 6G powered by IOWN

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5G Evolution and 6G mobile networks technologies can be combined with IOWN's ultra-high capacity, ultra-low latency and ultra-low power technologies based on breakthrough photonics, to further enhance the next generation ICT infrastructure, and respond to the pressing needs of society.

***Technology  
Elements***

**5G & 6G  
EVO**

**Powered by**

**IOWN**

Innovative Optical and Wireless Network

***Feedback toward  
commercial  
introduction***

# White paper: 5G Evolution and 6G (Ver. 4.0)

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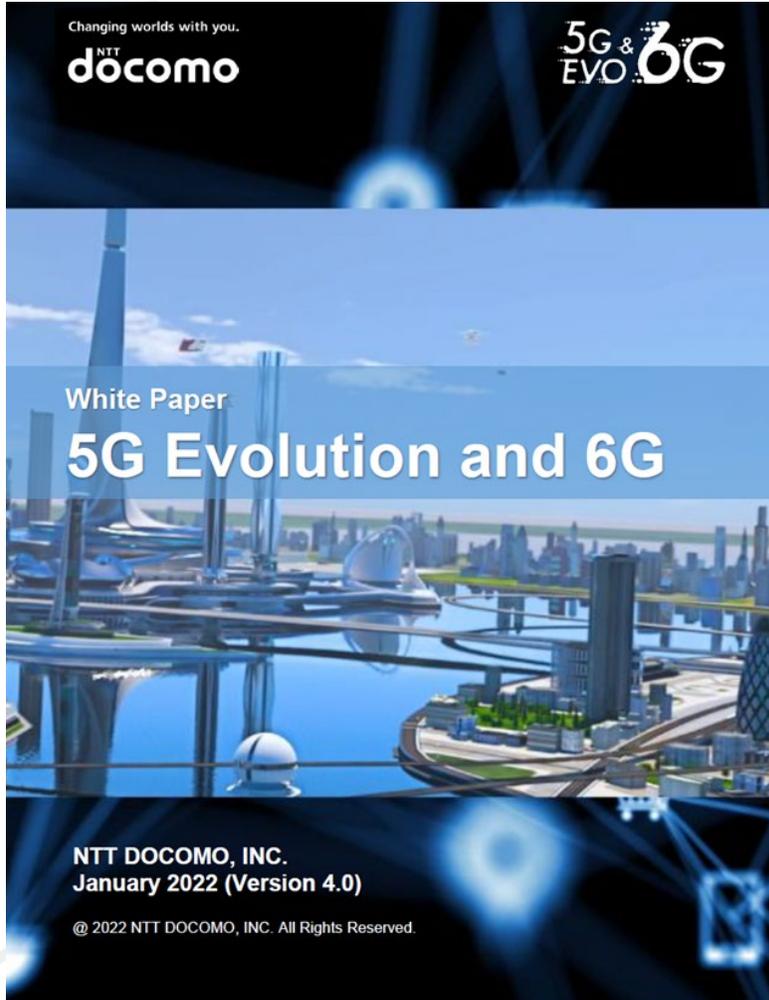


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## DOCOMO White Paper 5G Evolution and 6G

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See website for details:

DOCOMO 6G White Paper

Search

# Concept video: 5G Evolution & 6G powered by IOWN

*Introducing:  
Renewal by combining 5G Evolution & 6G  
and NTT's IOWN vision*

Please download this concept video:  
[https://www.nttdocomo.co.jp/english/corporate/technology/whitepaper\\_6g](https://www.nttdocomo.co.jp/english/corporate/technology/whitepaper_6g)





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