5G Evolution and 6G

− HAPS, metasurface lens and pinching antenna −

NTT DOCOMO, INC.

Progressing toward 5G Evolution and 6G

DOCOMO's White Paper

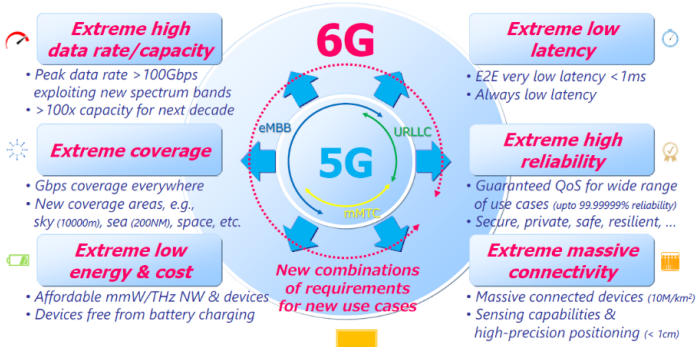
- 6G outlook
- Technical requirements
- R&D targets

Core R&D Initiatives

Improved coverage
- Metasurface lens
- Pinching antenna

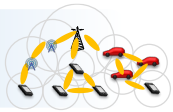
Extreme coverage
- High-altitude platform station (HAPS) systems

6G Requirements



Technology Developments

New radio network topology deployment in space



Coverage-extension technology including non-terrestrial networks

Extension of ultra-reliable and low latency communications (URLLC) and industrial networks

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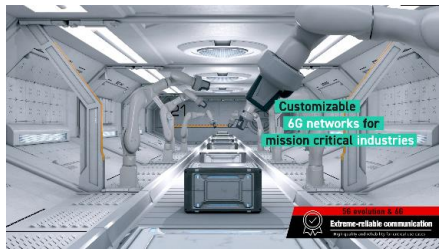
6G simulator

Line-shaped pinched antenna

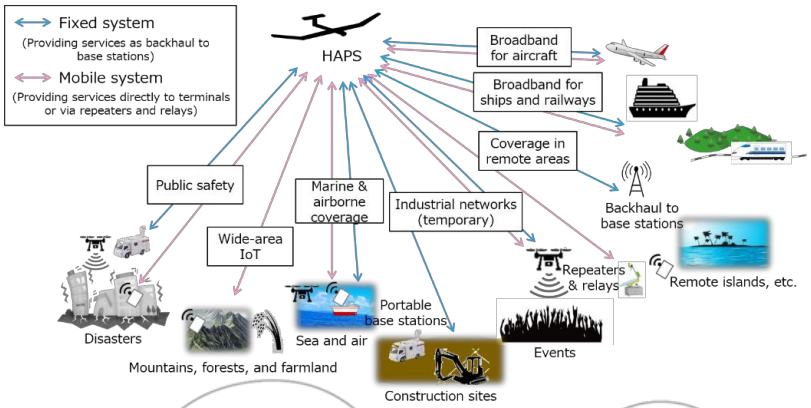
Current Deployments



Non-terrestrial Network using HAPS

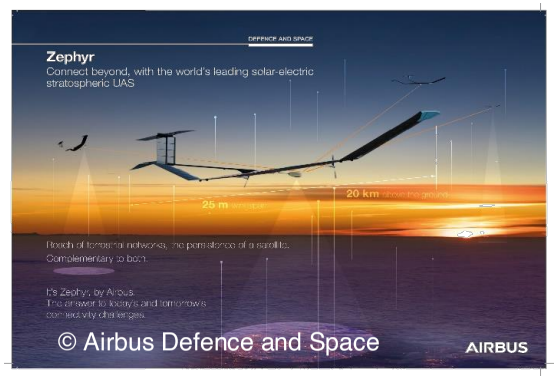
Non-terrestrial network (NTN) technology

Satellites and high-altitude platform station (HAPS) systems for coverage in mountainous, remote, marine and high-altitude areas.



Current HAPS aircraft

HAPS aircraft, such as Airbus's Zephyr, have dramatically improved flight capabilities and costs.

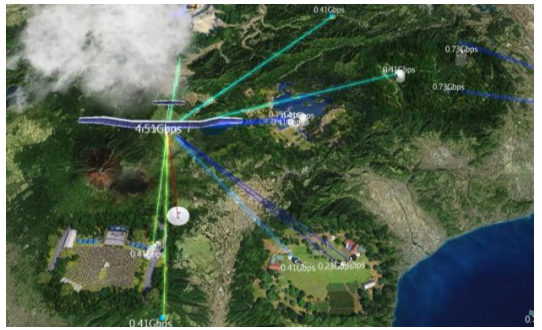


Collaboration partner

AIRBUS

HAPS simulator

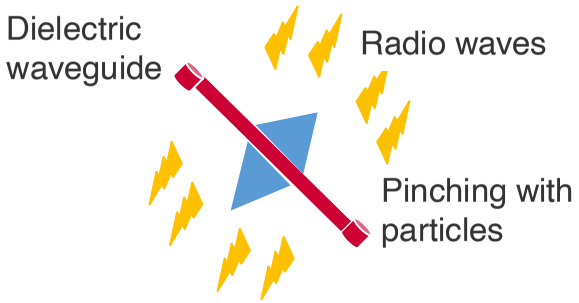
Visualize various use cases that are expected to be realized by HAPS. Based on the simulation, we implemented the evaluation of the expected throughput for each use case.



Pinching Antenna to Extend Coverage

Radio wave propagation via dielectric waveguide

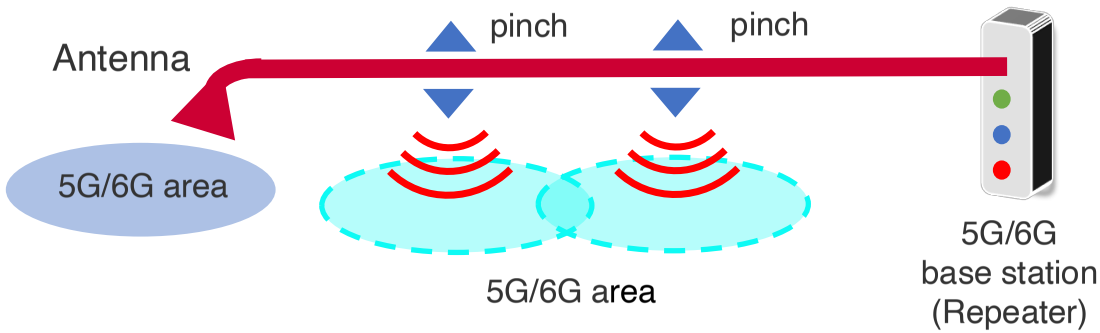
- Pinching a dielectric waveguide with small particles leaks (radiates) radio waves, creating a communication area around it.
- Additional pinches can create additional communication areas.



Practical demonstration

Pinching antenna has been verified to enhance propagation performance around a dielectric waveguide.

Applying the method to implement stable communication in factories, offices, etc. is being studied.



Future capabilities

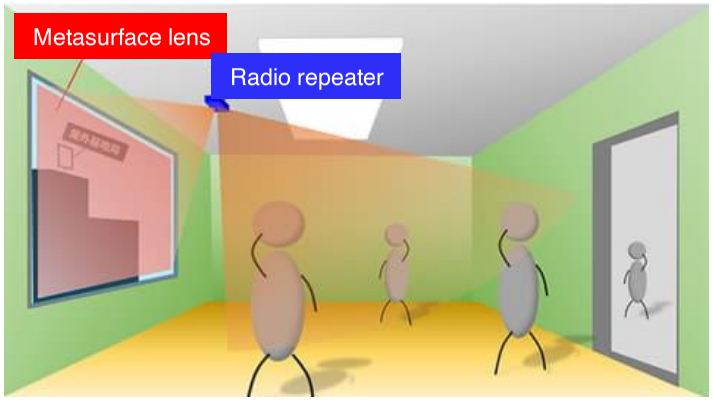
Pinching Antenna technology will be adopted for terahertz communications.

Metasurface Lens for Coverage Extension

Enhanced coverage indoors

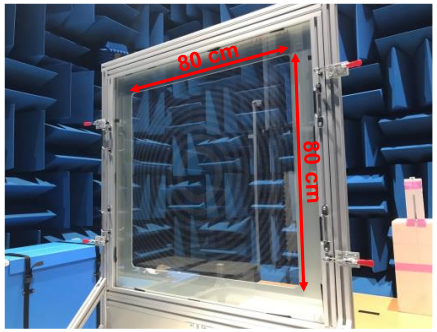
Millimeter waves from outdoors propagate to a focal point (metasurface lens) and then are amplified and transmitted indoors efficiently via a repeater.

Basic Concept



Development status of metasurface lens

Strength of signals received at metasurface-lens focal point can be increased 200-fold.

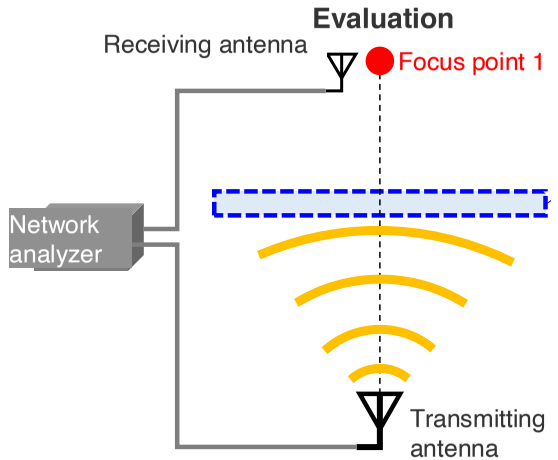


Metasurface lens

Verification results	
Normal glass	Metasurface lens
0 dB	>24 dB

Outdoor-to-indoor (O2I) verification

Currently, we are evaluating the performance of indoor coverage with metasurface lens and radio repeater.



Collaboration partner

AGC

(Transparent structure and microfabrication)

Testing support

DKK Co., Ltd. 電気興業株式会社

(5G relay station)

NTT docomo

For more information, please contact us at

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Pinching Antenna

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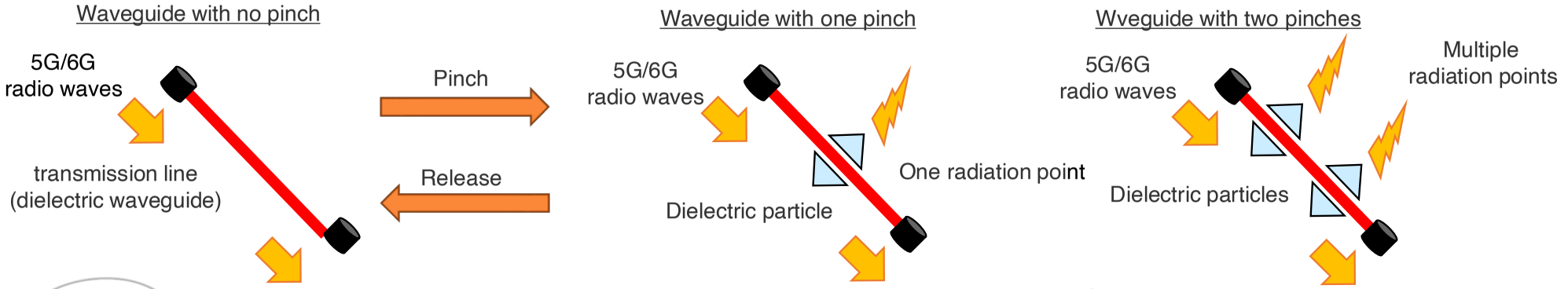
Pinching-antenna

A pinching antenna is the dielectric waveguide that works as a leaky-wave antenna by attaching other small dielectric particles on it

Features

- Radio waves are transmitted/received via (pinched) dielectric particles on a dielectric waveguide.
- The method deploys wireless communication areas around the dielectric particles.
- One or more transmission/reception points can be created anywhere along the dielectric waveguide.

Basic Concept



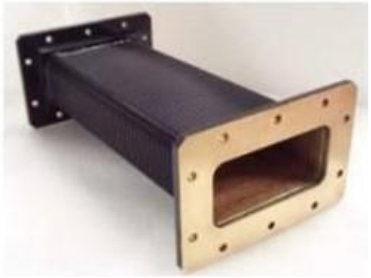
Dielectric Waveguide

Rod-shaped line made of fluorine resin or similar material

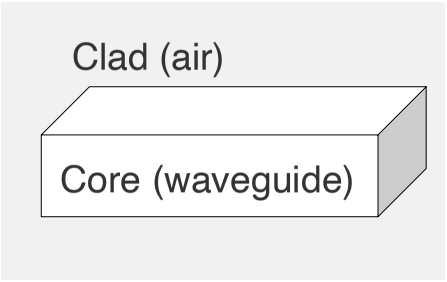
Features

- No core conductor, unlike coaxial cable
- Not covered with metal, unlike basic waveguide
- Consists of core (waveguide) and clad (air or other dielectric), same as optical fiber
- Capable of transmitting millimeter waves (28 GHz band and above)

Coaxial cable



Waveguide



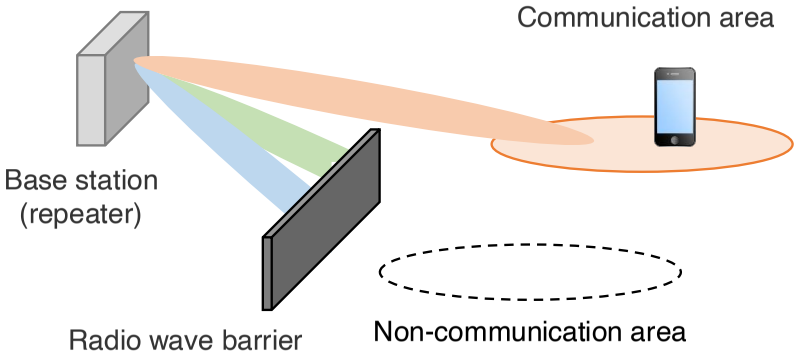
Dielectric waveguide

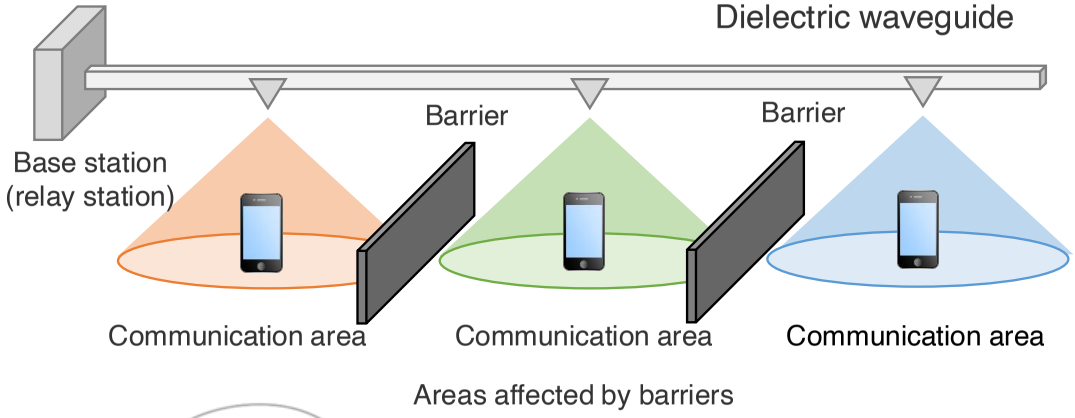
Sample waveguides

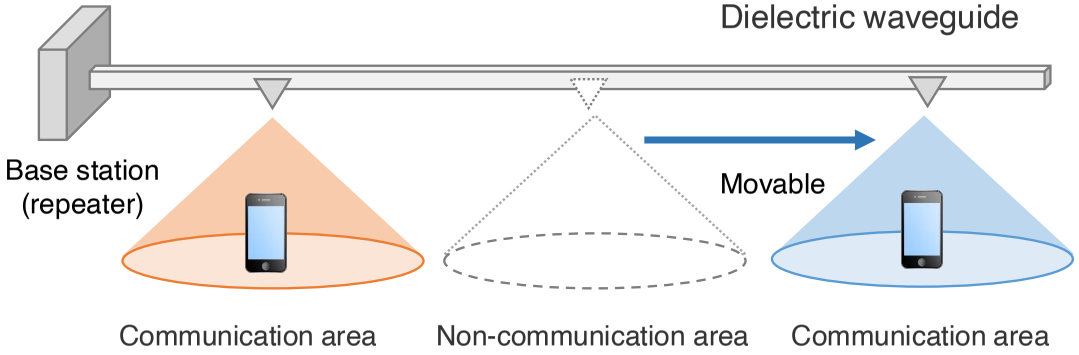
Wireless Communication in Hard-to-reach Areas

Method for overcoming radio-wave barriers

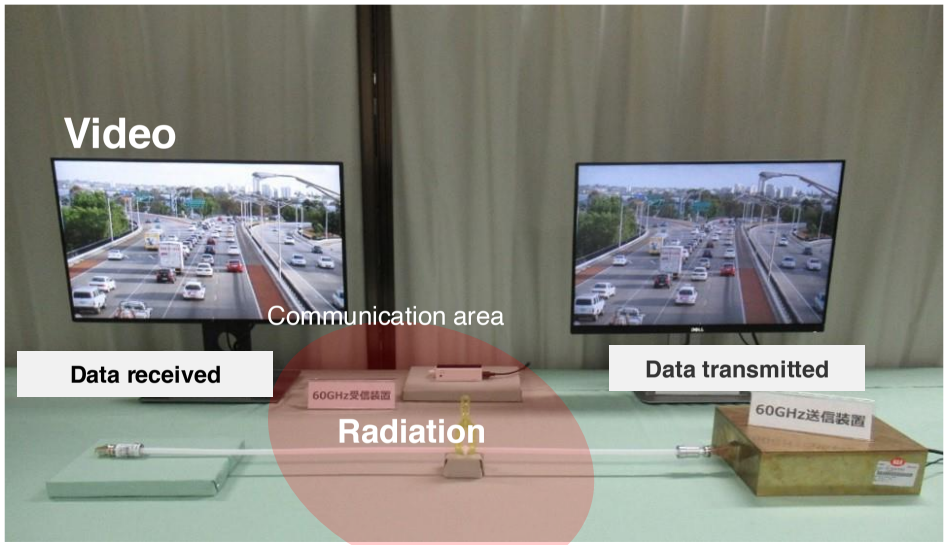
- Deploy wireless communication areas where radio waves from base stations are blocked by barriers.
- Achieve stable line-of-sight communication environments.
- Quickly deploy, move or shift wireless communication areas.

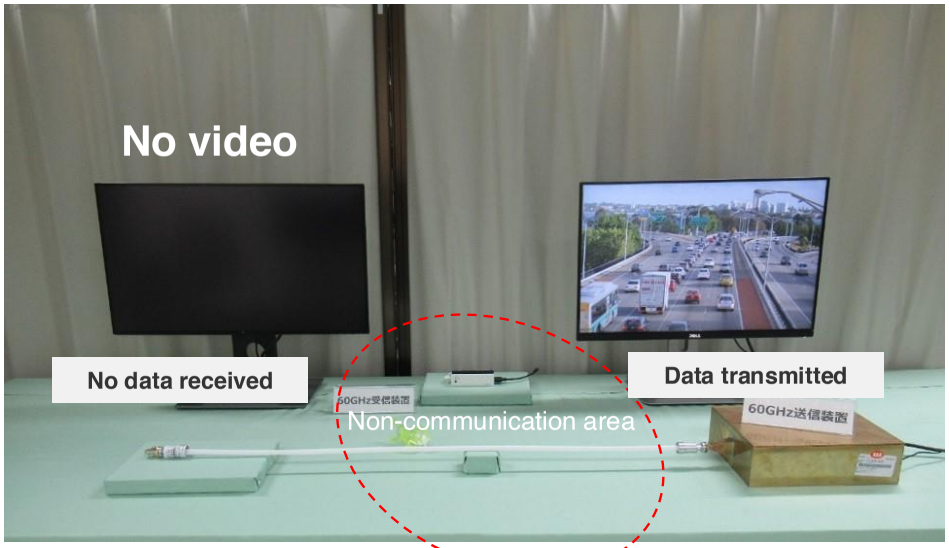


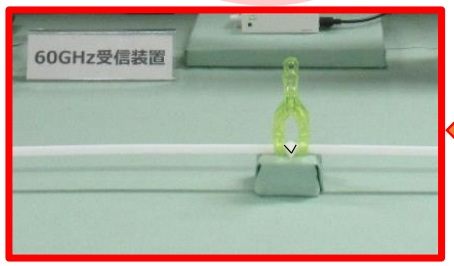




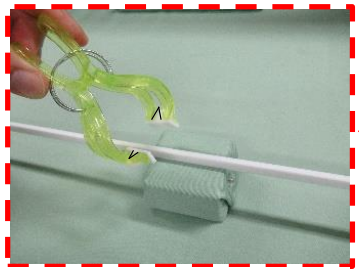
Data Transmission Test using 60GHz Band



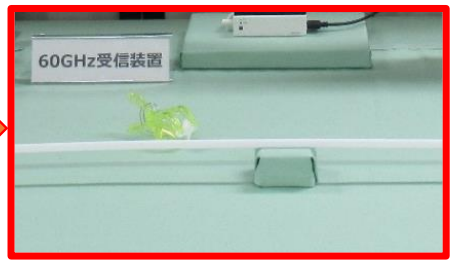




Pinching antenna



Antenna attached/released



No pinching antenna

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For more information, please contact us at

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