



# Inclusive Creation of Next Generation Cyber Infrastructure

OpenRIT 6G 2024

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- Special Advisor to the President of the University of Tokyo
- Director of Next Generation Cyber Infrastructure Institute, the University of Tokyo
- Member of Science Council of Japan
- Chairman of International Committee of Beyond5G Promotion Consortium
- Chairman of Network Architecture Committee of 5GMF
- Chairman of 5G/Beyond5G Committee of Space ICT Forum
- Community Informatization Adviser to the Ministry of Internal Affairs and Communications, Japanese Government
- Chairman of Local5G Promotion Research Group
- Founder of FLARE SYSTEMS

# B5G Related Projects in NakaoLab

## 7 National Projects

- **Super-Intelligent Computing Architecture** (FA: NEDO) KDDI, UTokyo
- **Ka-band HTS** enabling various use cases (FA: MIC) NICT, UTokyo, etc.
- **Satellite-ground communication integration** (FA: NICT) JRC, Skyperfect JSAT, UTokyo
- **IoT SoC and solution platform** enabling continuous evolution (FA: NICT) Sharp, UTokyo, etc.
- Synchronous **CPS computing platform** realized by Beyond 5G (FA: NICT) NEC, UTokyo
- **IoT ultra-coverage** with low earth orbit satellites (FA: NICT) UTokyo, Rakuten
- **Smart urban transportation infrastructure** technology (FA: NICT) Utokyo, etc.

## Social Collaborations

- Telecommunication Related Companies (NEC, KDDI, NTT East, NTT, Kyocera)

## Local Government

- Hiroshima Prefecture, "Smart Oyster Farming via 5G/AI/IoT"
- Yamanashi Prefecture, "Mt. Fuji DX: Secure and Safe Sightseeing"
- Iwate Prefecture, "Remote Education"
- Ehime Prefecture, "Citizen-driven Education"

## Industry Collaborations

10+ Industry partners

# Inclusive Creation of Next Generation Cyber Infrastructure

Objective:



In this research proposal, international collaborative research will be conducted **with an inclusive approach** where all stakeholders participate in the research to **establish fundamental technologies for next-generation cyber infrastructure even more robust as social infrastructure.**

Specifically, we will **promote "Local 6G,"** where **we promote local networks to drive various innovations locally and promote them to drive the evolution of the entire information and communication field** by quickly identifying and demonstrating the value of useful technologies through campus testbed collaboration.

We will **establish a sustainable top researcher network** by horizontally expanding the top researcher circle in this research field to like-minded countries, **with Japan and Finland as the core,** and vertically expanding them between generations.

Ultimately, we strategically focus on the **early experience of young researchers** in international collaborative research and **the formation of human networks** through participation in collaborative projects. The goal is to contribute to the **continuous cultivation of globally distinguished human resources** in the field of information communication in Japan.



# ASPIRE Project Structure

- WP1 Development of robust information and communication infrastructure through convergence of telecommunication computation and Wired/Wireless Softwarization (5 Tasks)
  - Task1.1 Fault-Tolerant Wired/Wireless Infrastructure with AI (ORAN RIC, AI-RAN)
  - Task1.2 Dynamic Frequency Sharing with AI (ORAN RIC, AI-RAN)
  - Task1.3 Robust Communication in Ultra Numerous Connectivity (Robust mMTC)
  - Task1.4 NTN and Terrestrial Integrated Communications (LEO+Local5G)
  - Task1.5 Advanced Security Utilizing Local 6G Base Stations
- WP2 Robust Campus Living Lab Testbed Collaboration
- WP3 Regional Development of Use Case Demonstrations (Mt. Fuji, Lapland, etc)
- WP4 Top Researcher Circle Management

# Global Supporters for our Projects

- Sorbonne U.(Professor Serge Fdida) SLICES RI
- FOKUS (Professor Thomas Magedanz) Open6GCore
- Virginia Tech U. (Professor Luiz Dasilva) O-RAN testbed
- U of Surrey (Professor Rahim Tafazolli) 6G campus test bed
- Eurecom U. (Professor Raymond Knopp) OAI project leader
- Clemson U. (Professor Kuang-ching Wang) FABRIC Testbed Leader
- NorthEastern U. (Dr. Manu Gosain) PAWR Project Director
- NYU(Professor Theodore Rappaport) Authority on high frequency wireless communications  
Participates in PAWR
- Karlsdad U.(Professor Andreas Kessler) Promoting research on communication and  
computation fusion applying AI to 5G
- Chalmers U.(Erik Ström ) Promoting research on 6G high frequency wireless communications,  
low latency and robust communications
- Many others...

# Professor Akihiro Nakao Appointed First Guest Professor at the University of Oulu

20 SEPTEMBER 2023



- **End-to-end slicing including first mile RAN**

Fusion of first-mile wireless and high-speed, high-capacity wired optical for on-demand, QoS-guaranteed end-to-end slicing

- **Support for mission-critical use cases**

Networks have been the excuse for mission-critical areas such as healthcare, mobility, and manufacturing. Network architecture with high availability, low latency, security, etc. to meet the demands of such fields

- **Verification of social acceptability of technology**

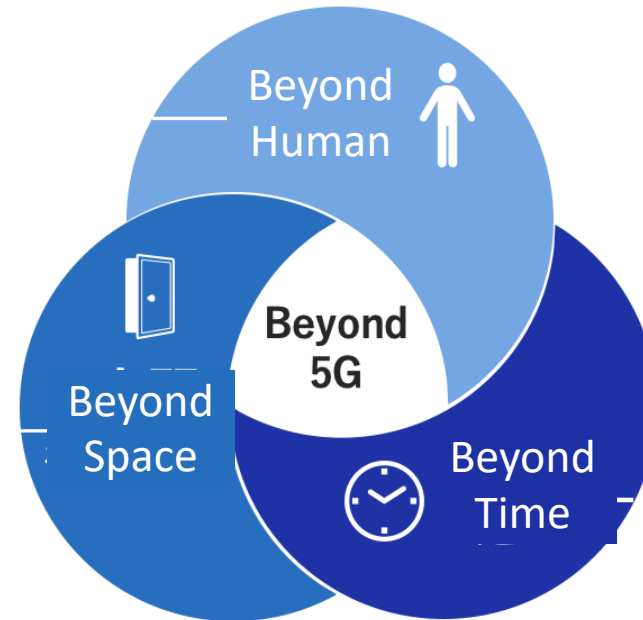
What is needed for superior technology to be accepted in the world?

- Deployment of an architecture in which robust and secure private network slices are dynamically constructed by utilizing IOWN/APN and local radios on campus to demonstrate use cases and confirm social acceptability
- APN + Private 6G model proposed at IOWN GF



## Co-created value and technology

New services and behavior change  
Real-time and high-capacity communication



Through the use of high-frequency band wireless communications and high-capacity communications, the limits and possibilities of human capabilities will be lifted, and new changes in behavior occur.

Secure and Fine-grained Controlled Communication  
ICT with ultra-high spatial resolution sensing

Real-time information associated with people and things  
Construction of communication area for safe and secure acquisition

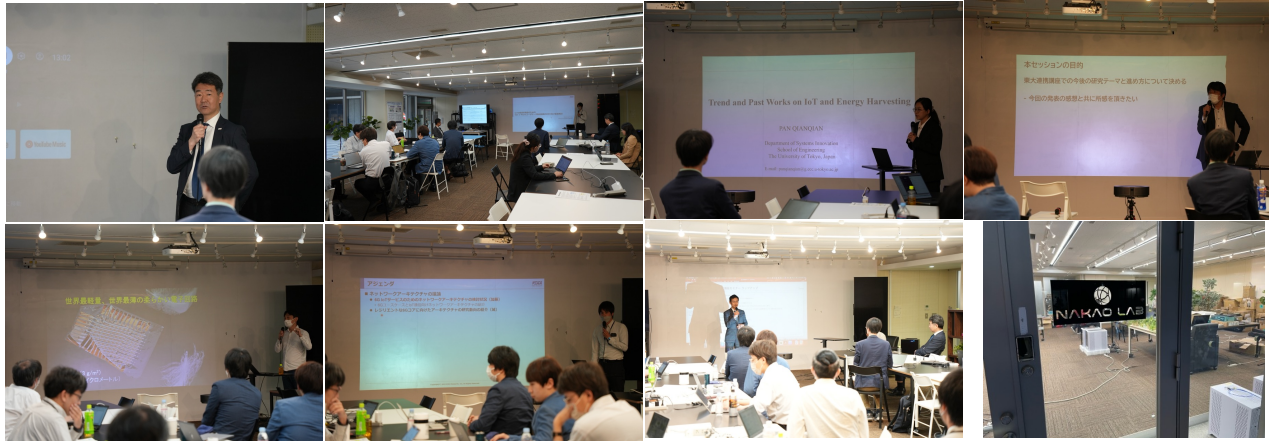
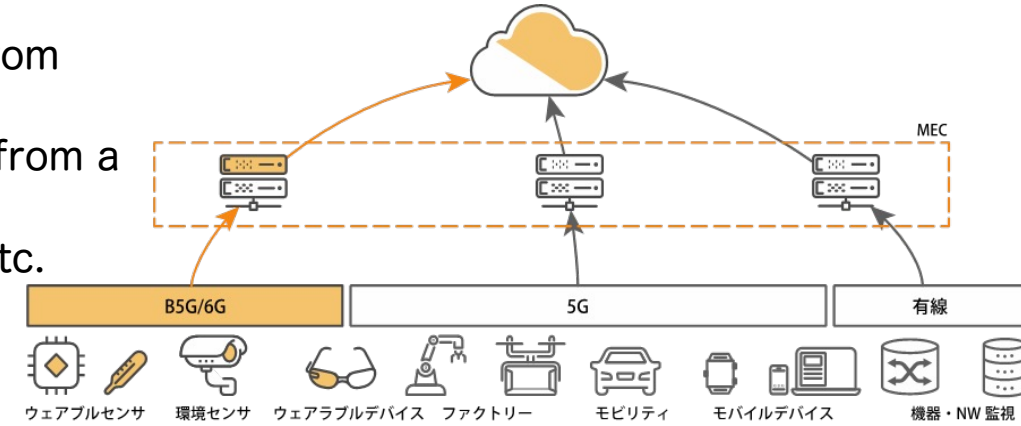
"Exponential Competitiveness in ICT Industry  
Technologies for rapid deployment

Software and Customized Hardware for Rapid Deployability  
Pursuit of Rapid Deployability  
Competitiveness beyond existing timeframes

# Social Collaboration of KDDI and UTokyo "Future Smart Society Research"

## Our Research Agenda

- Maintenance-free technology for devices and networks to collect data from physical space to cyber space
- Network technology to efficiently maintain and distribute data collected from a vast number of devices
- Data collection and processing technologies for data analysis using AI, etc.
- Automation technology to facilitate network operation using AI, etc.



## Social Collaboration Lecture Seminar Held

- Held at DevShowcase@NakaoLab, Hongo Campus,
- Introduced related research and discussed future research themes
- Extension of 5GC C-Plane User Data Transfer Function for MEC
- Trends in IoT and Energy Harvesting Research
- Network architectures for 6G IoT services
- Architectures for resilient 6G cores
- Skin-attached devices

## Status of Implementation and Plans for FY2023

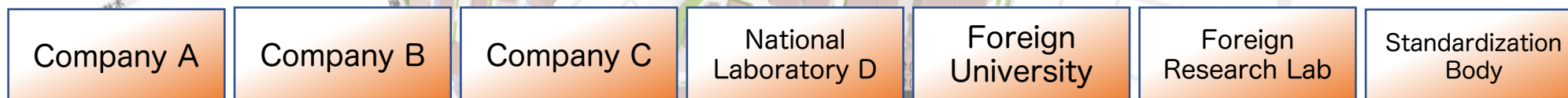
- Organize University of Tokyo Social Collaboration Course Seminars and Next Generation Cyber Infrastructure Workshops
- Publication of study results on the future vision of IoT (2030-2040)
- Collaboration on research related to sensing devices

# B5G Campus Testbed Concept

The strategy is to implement new ideas in society as quickly as possible and get feedback as quickly as possible.

- Testbed for **democratizing B5G network** technologies
- **Verification of social acceptability** of technology
- Human resource development and **industry-academia human resource circulation**
- Promote **interactive international collaboration** to attract outstanding human resources

Closed  
Competitive  
Domains



Open  
Cooperative  
Domain

B5G Campus Testbed Concept for Rapid Deployability First

NGCI: Collaborative Research Organization for Next-Generation Cyber Infrastructure



# DevShowcase@NakaoLab



NAKAO LAB

- Showcase for Industry-Academia collaboration
- For PBL education
- Local5G (Sub6-SA) License Obtained





# Project Based Learning Using Local 5G (Licensed) Environment







# Industry Collaboration Activities at “DevShowcase”

**Bsusiness Finland  
6G Local Public Networks seminar  
(2023/5/8)**



**Local 5G Promotion Working Group  
The 2<sup>nd</sup> Local 5G Interoperability Plug-Fest  
(2023/4/27)**







# Industry Collaboration Activities at “DevShowcase”

## NEC Internship (2023/8/28-)



## NEC Social Collaborations Workshop (2023/3/30)





# Local 5G

➤ Local 5G enables the following:

- ❑ Establishment of customized networks with flexible specifications that meet local needs
- ❑ Establishment of 5G systems prior to area coverage by mobile carriers
- ❑ Operation of networks less vulnerable to communication failures and disasters.

## Use cases of Local 5G

### Connected terminal



### Tele-medicine



### 4K/8K movie



### Smart construction



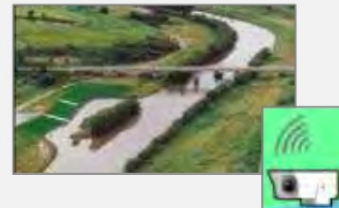
### Smart factory



### Remote work



### River monitoring



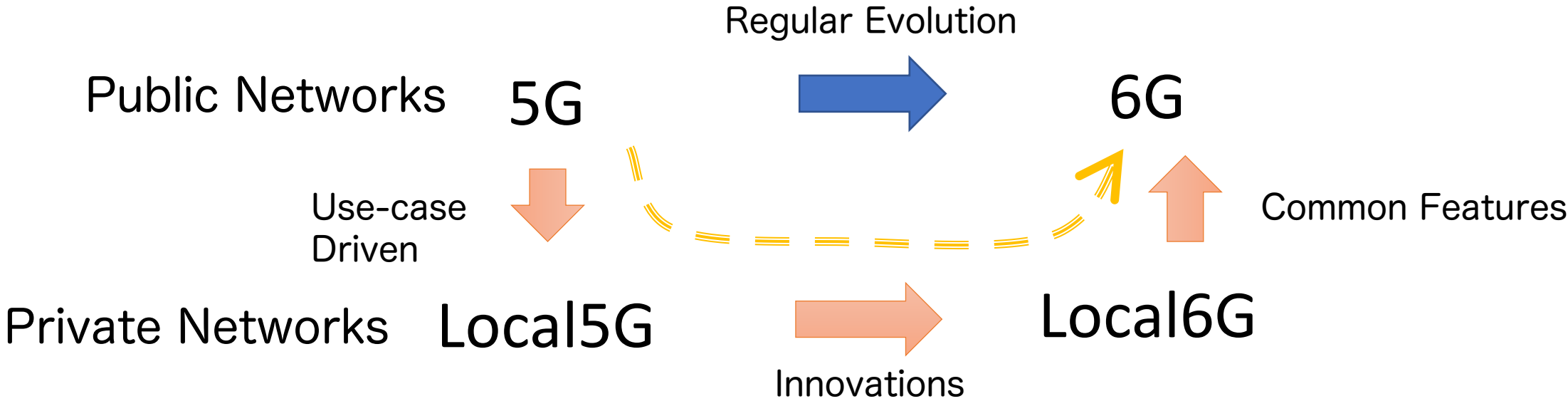
Sensor, 4K/8K

### Farming automation



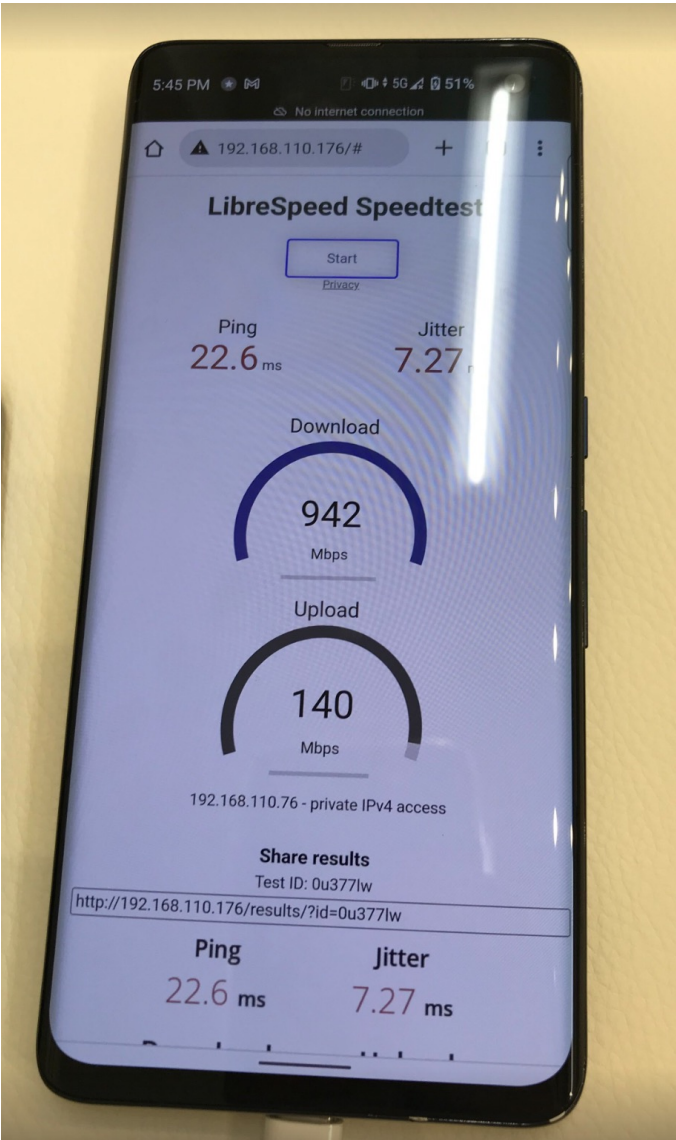


# Democratization: 6G will be driven bottom-up from Local6G / Private 6G



Various Innovations driven by “customizations”

# Softwarized Portable Local 5G Box

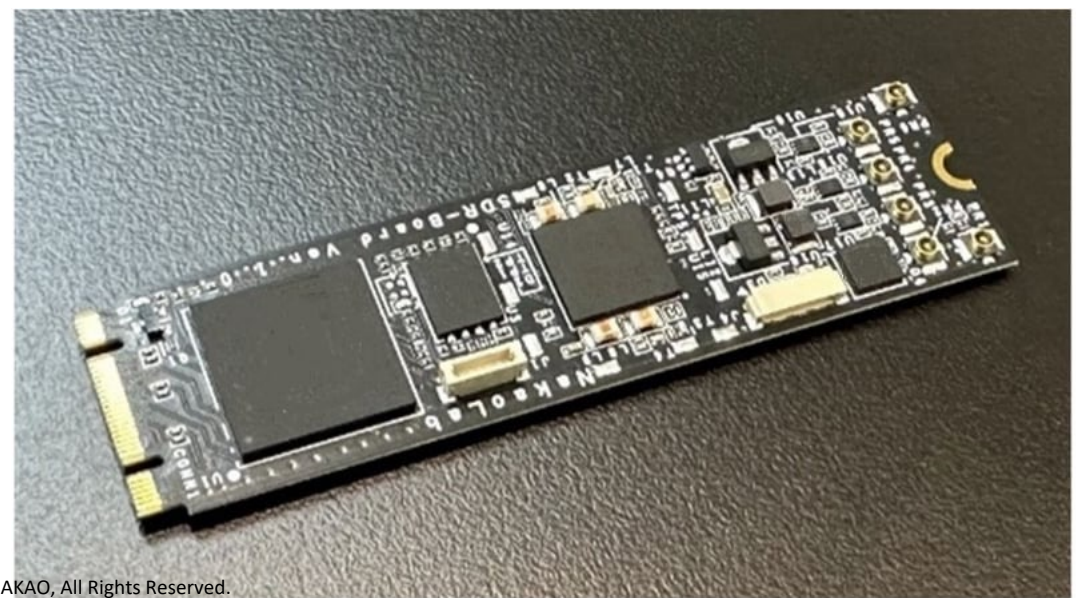


# Ultra-compact Software Defined Radio Board

- Accelerating Development of Programmable Base Stations Evolving with Software Expansion -

NICT B5G Fund Project “Research and Development of B5G IoT SoC and IoT solution Building Platform of Continuous Evolution”  
Grant #00801

- We have successfully developed an “ultra-compact” software-defined radio ( SDR ) board that supports the development of next-generation communication standards .
- We have developed a board that supports M.2 standard interface, ultra-compact size ( 80mm long, 22mm wide , 5mm thick (board thickness 0.8mm)) and can be programmed with 5G and next-generation communication protocols.
- We will accelerate the resolution of social issues, the exploration of latent needs, and the creation of value through confirmation and verification of usefulness in demonstrations using 5G/B5G communication equipment that utilizes SDR.



- ultra-compact: Compatible with M.2 standard.
- Height 80 mm, width 22 mm, thickness approx. 5 mm
- Flexibly add network functions through software
- Expand frequency bandwidth by daisy chaining multiple boards
- Confirmed to work as a 5G base station





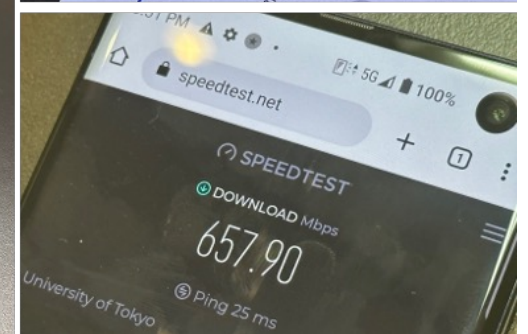
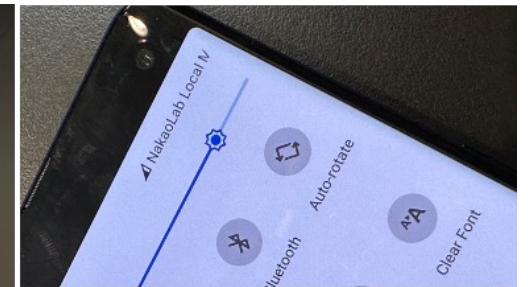
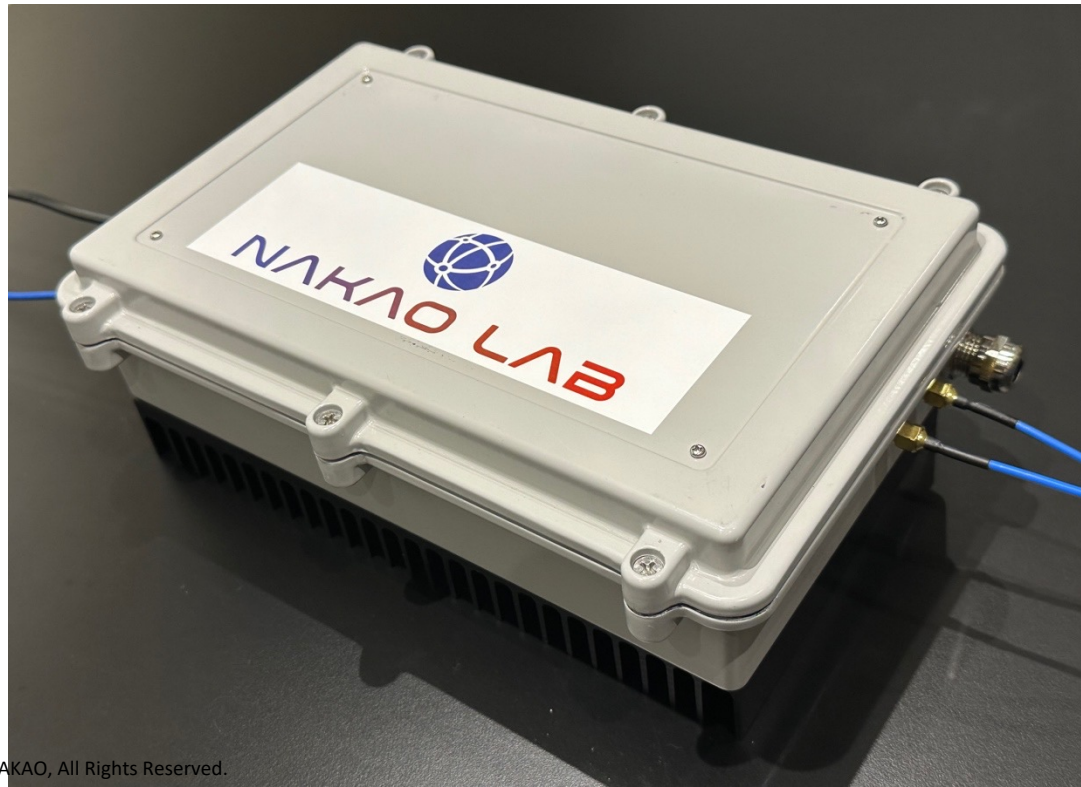
# Ultra Compact Local5G Softwarized System

2023/4/25 Press Released

NICT B5G Fund Project “Research and Development of B5G IoT SoC and IoT solution Building Platform of Continuous Evolution”

Grant #00801

- We have developed a **low-power** (W) integrated core and local 5G system that can **be quickly installed outdoors** with its **small form factor** (W) 173.2 x (H) 66 x (D) 274.2 mm (75% of A4 Paper Size)
- The recently announced development of an ultra-compact software-defined radio (SDR) board is embedded in a commercial general-purpose single-board computer to implement 5G functions, resulting in **lower cost and flexibility** in adding functions through software.
- We will accelerate the solution of social issues, search for potential needs, and value creation through confirming and verifying the usefulness in demonstrations using 5G/B5G communication devices.



4.7-4.9GHz /100MHz Sub6 5G 1W/ch total 2W  
2x2 MIMO, Low-Power (90W) TDD SemiSync 1,2,3



# Ready-to-use, compact, low-power, high-performance Internet Directly Connected Local 5G Demonstration System

Press Released 2023/3/31



NAKAO LAB

(Industry-Academia Collaboration  
among UTokyo, NEC, NEC Platforms)



Integrates local 5G base station, 5G core, and MEC  
Software-based, **quick functionality update** is possible.

**Quickly deployable** Indoor use (consult us for outdoor use)

**Space-saving, low power consumption**

- Output: 1 W × 4 ports (Total 4W)
- Size: (W)130 x (H)189 x (D)357 mm (excluding antenna)
- Weight: Approx. 6.2 kg
- Power consumption: Approx. 90 W

Supports semi-synchronous system (TDD1/2/3) (Note 3, 4)

**Flare Systems starts selling this unit TODAY!**

(Width)130 x (Height)189 x (Depth)357mm

Press Released 2023/4/25

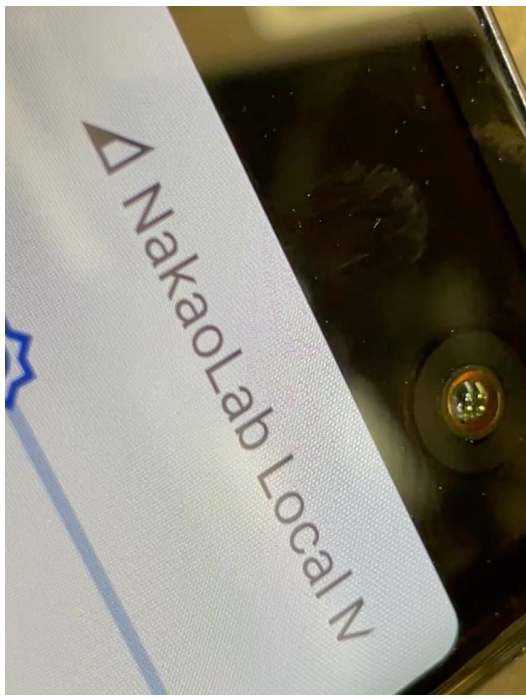
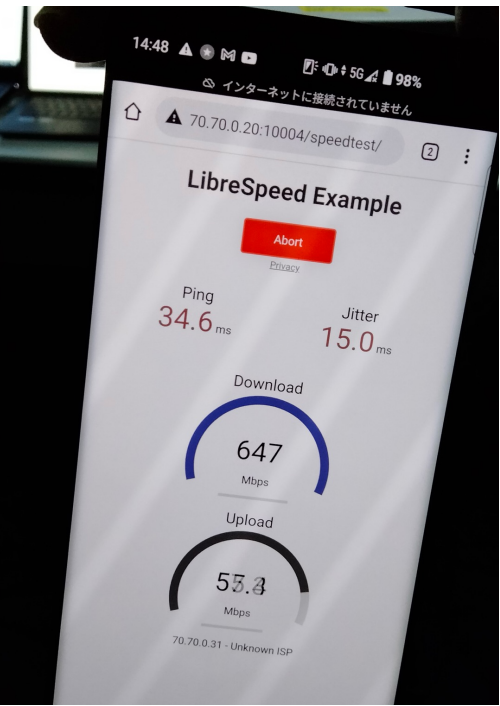
[https://jpn.nec.com/press/202303/20230331\\_02.html](https://jpn.nec.com/press/202303/20230331_02.html)



(Unit: bps)



# Democratizing 5G by Local5G “plugfest”



FLARE SYSTEMS L5G BS



NEC L5G BS



Apricia L5G BS



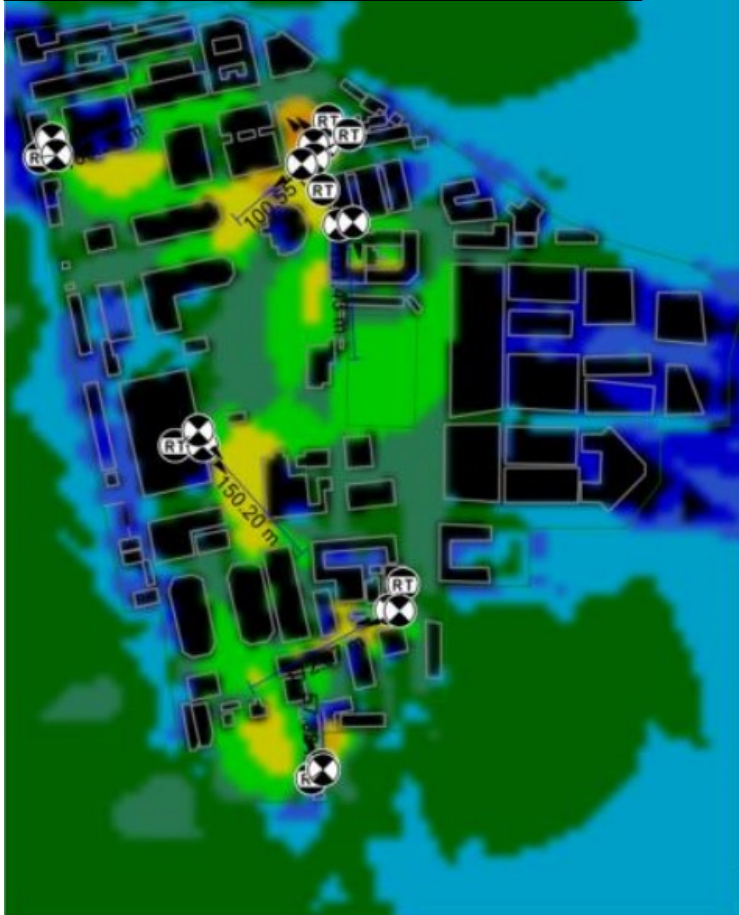
L5G UE/CPE



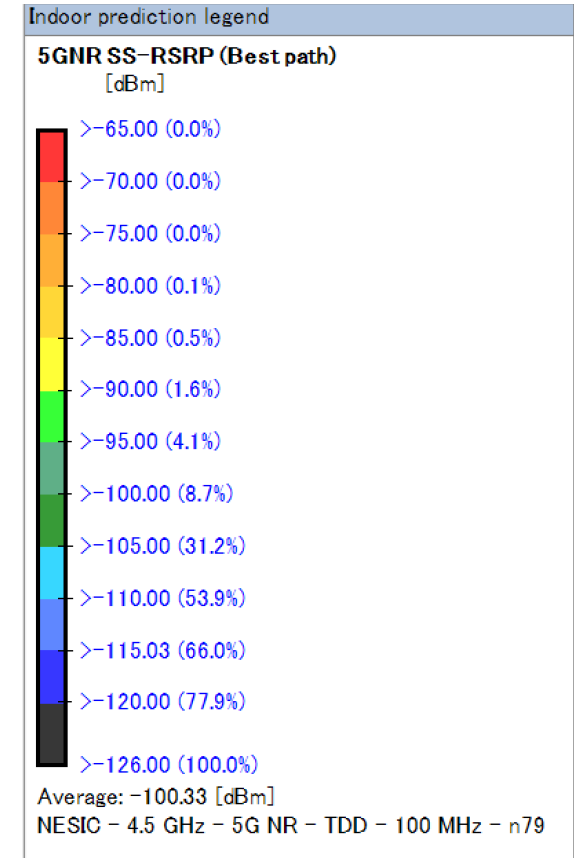


# Hongo Campus Deployment: Simulation Results

[Reference] The whole Hongo campus  
4W (36dBm) for all stations



After output adjustment



A weak field area exists at the edge of the site in the simulation.

→If the X65-3545FTD antenna is installed in the weak field area, there is a possibility of leakage outside the site because the beam width is 60° .

# A Local 5G Usecase : Enabling Local Government Revitalization



There are still more than 100 people facing climbing accidents every year



# Local 5G x NTN : Private5G and Satellite Internet Access Service for Disaster Countermeasures and Disaster Mitigation at Mt. Fuji for use in disaster countermeasures and disaster mitigation (Local Government Revitalization)

Press Released on 2022/11/25



NAKAO LAB



衛星インターネット  
アクセスサービス



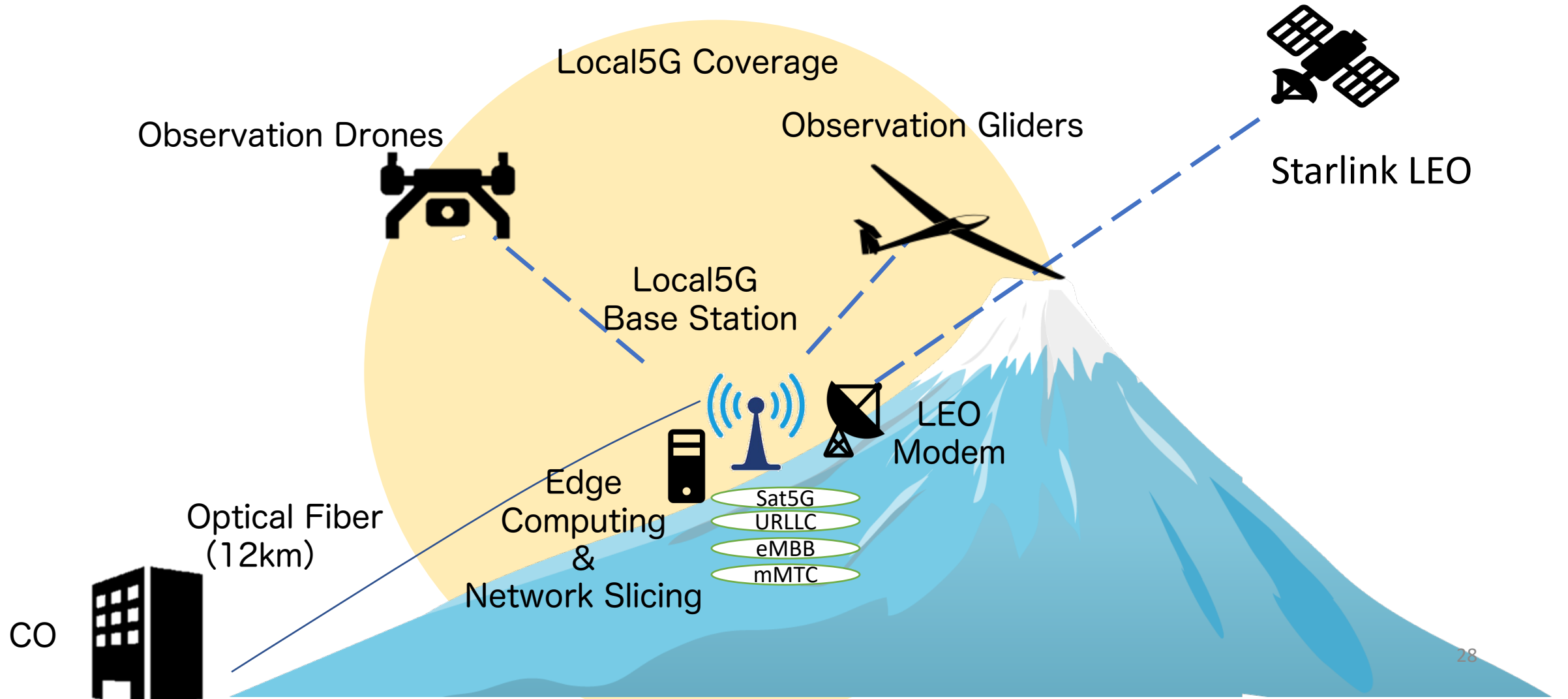






# LEO x Local 5G Use Cases at Mt. Fuji

Challenges: Harsh Environment (Windy/Stormy/Low Temp/No Electricity)  
Values: Surveillance / Security













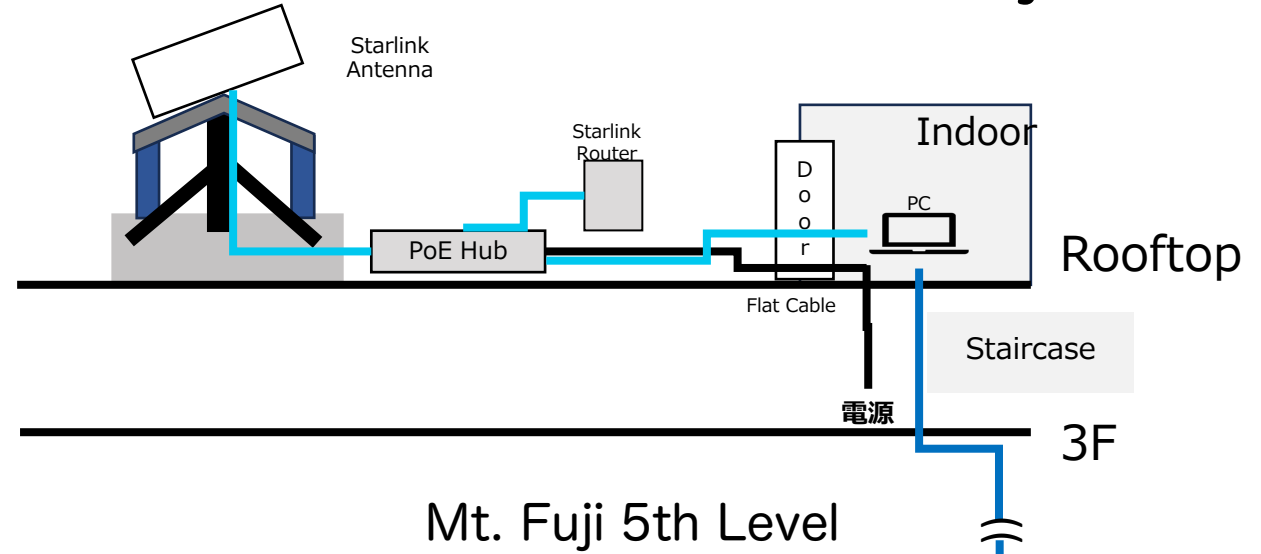
# LEO communication quality measurement environment at Mt. Fuji



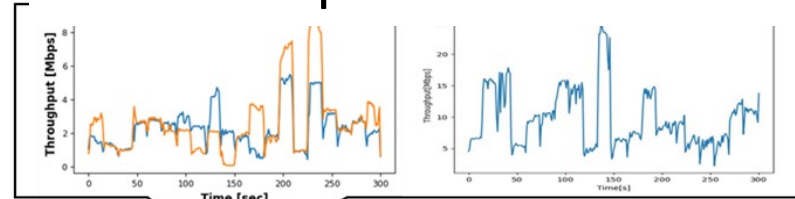
Mt. Fuji 5th Level



Measurement Gears on Rooftop



## LEO Throuput Measurement

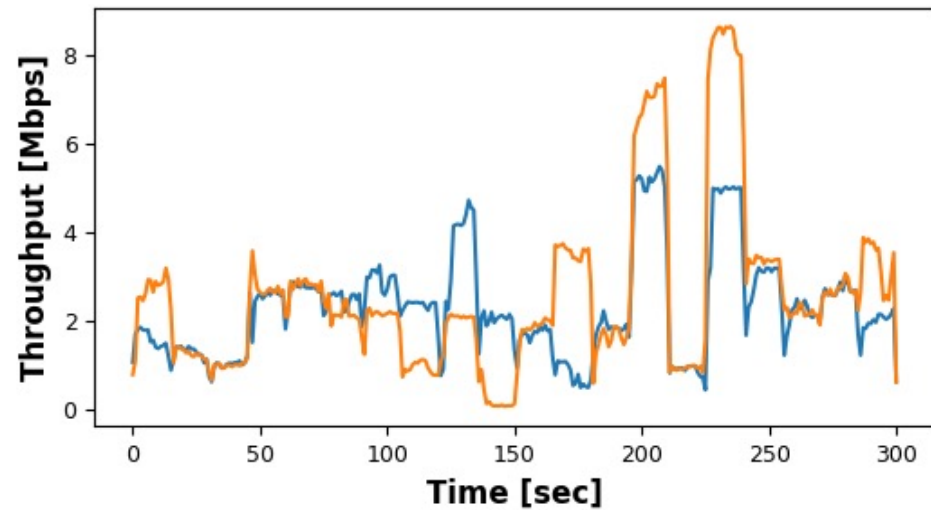


NakaoLab at UTokyo

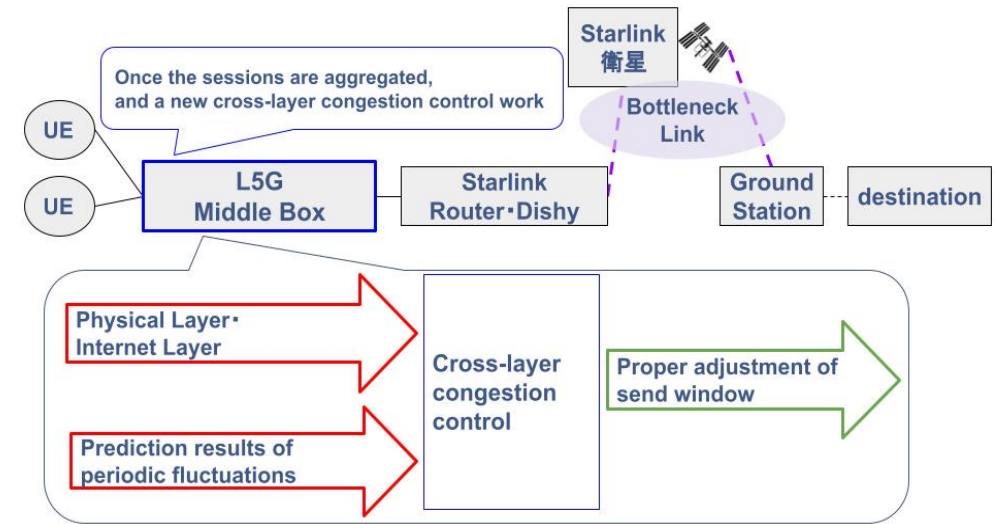
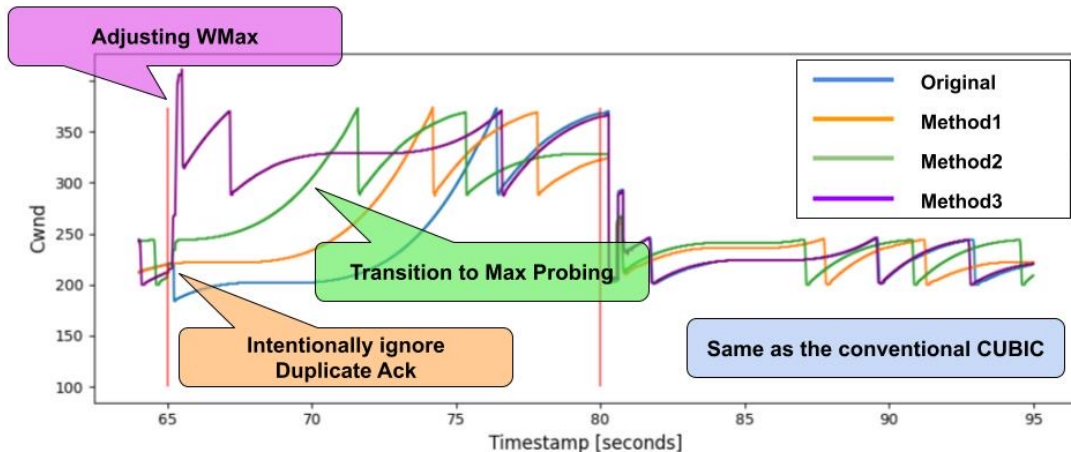
QoS control for effective interconnection of satellite communications, etc.  
Customization of mobile systems in local 6G for the purpose of  
Communication measurement and communication quality modeling



# End-to-end Architecture Optimization for New Radio (NR)



Throughput Fluctuation in Starlink LEO



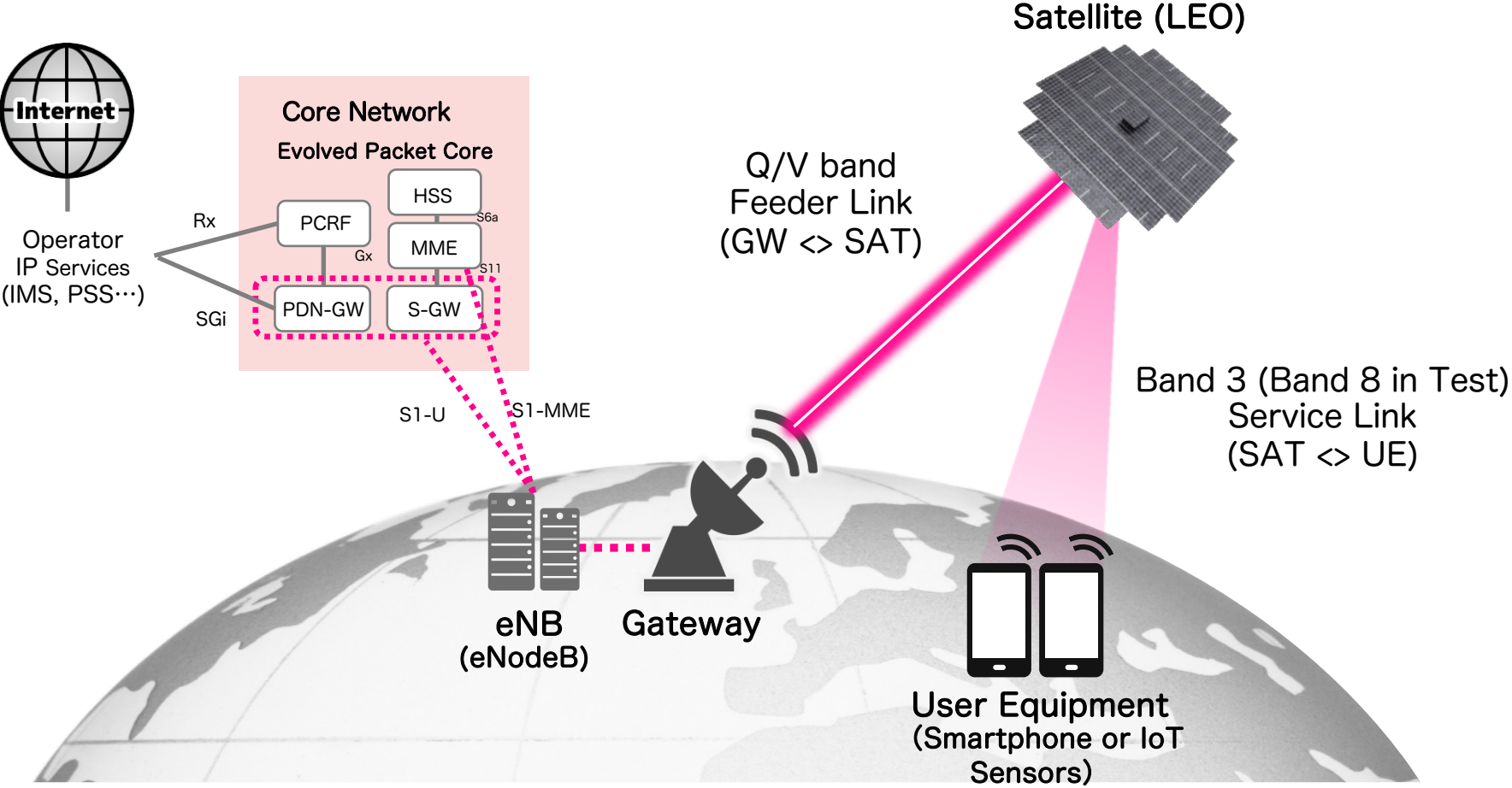
Local5G + LEO Integration Architecture

Proposal	1	2	3
Maximum Throughput Improvement Rate	15%	22%	<b>25%</b>
Capacity Nodes	3	5	<b>10</b>
Fairness (Jain's Fairness Index)	<b>More</b> than original		<b>Less</b> than original
Congestion Collapse	<b>NO</b> congestion collapse		
Prediction of Starlink status (Cross-layer information)	Increase or decrease		Rate of fluctuation

New Cross-layer Congestion Control achieves up to 25% throughput improvement!

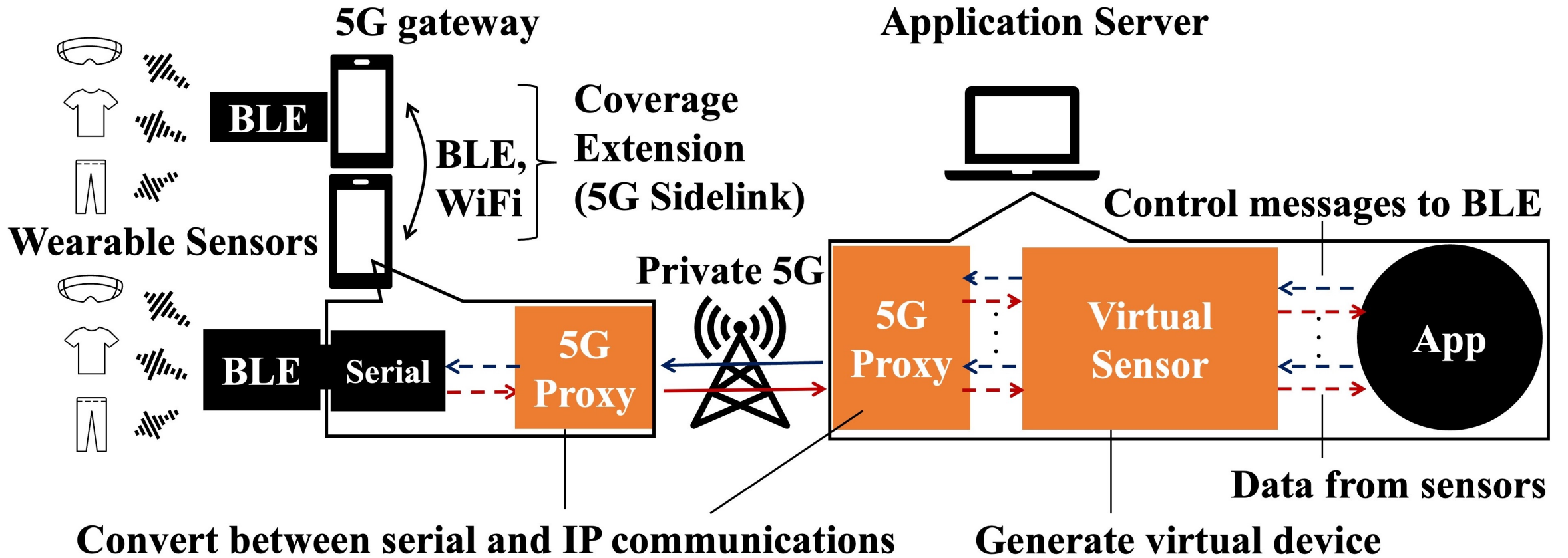
# “Mobile Direct” Project Rakuten/AST Mobile and UTokyo

- Base Stations and UE communicates **via Satellite**.
- Doppler shift and delay are processed on the ground so that **unmodified UE (User Equipment)** can communicate with each other **wherever they are!**





# Local5G Sidelink



REC 1482  
Reception: 100% (Good), Safety: 4% (Bad)

JOINT	ANGLE	POSE
Neck	12.22	
Shoulder	12.12	
Elbow	12.12	
Wrist	12.12	
Thoracolumbar	12.12	
Lumbosacral	12.12	
Pelvis	12.12	
Hip	12.12	
Knee	12.12	
Ankle	12.12	

