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Unleashing Imagination and Creativity

Power of Next Generation Network & Computing Infrastructure

June 15, 2023

Lund Connected Systems Workshop

Katsutoshi “Kats” Itoh
Head of Advanced Connectivity Technologies
Technology Development Laboratory
Sony Corporation - Tokyo, Japan

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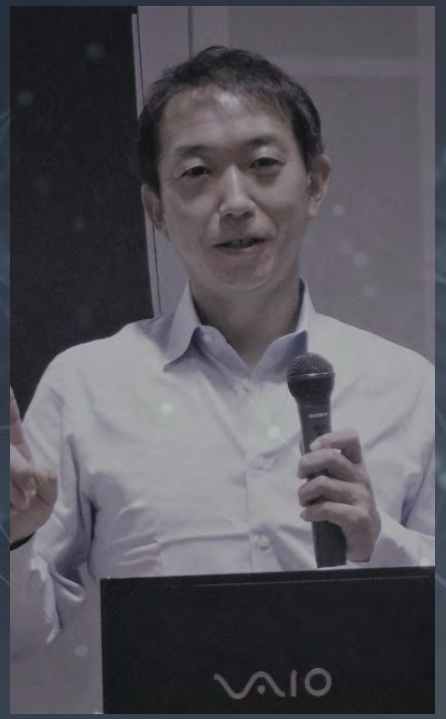
About myself… Katsutoshi “Kats” Itoh



Head of Advanced Connectivity Technologies,
Technology Development Lab, Sony Corporation

Joined Sony in 1999---started off with R&D in 3G-WCDMA

Current Responsibility:
-5G/6G/WLAN/LPWA/Optical Communication/mm-wave RADAR
-Chair, IOWN Global Forum, Use Case WG

Technical Background:
-Wireless System, Digital Signal Processing

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Outline of Today's Talk

1. Sony - Our diverse business portfolio
2. Connectivity Technologies from Sony's perspectives
3. Volumetric Video Creation and Delivery—Network & Computing Integration
4. Dynamic Spectrum Sharing—Spectrum is everything!
5. Sony in Lund – Connectivity Research
6. Q&A

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Who we are – Sony Group

Sony's Purpose

Purpose explains the reason for our existence, for Sony Group employees to work together along the same vector and create value from a long-term perspective; in other words, why we exist

Identity

Identity expresses how we want to be perceived from the outside; in other words, who we are

Corporate Direction

Corporate Direction sets out where we are headed

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Sony Group: Diverse Business and Technology Portfolio

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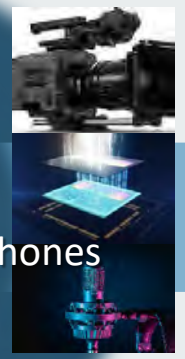
Network & Computing Infrastructure Connecting Sony's Strength

Real-Physical Space

Virtual-Cyber Space

Physical Sensing

Image Sensors
Multi-spectrum Sensors
Depth Sensors
Acoustic Sensors-microphones



3D Capturing Studio

Virtual Creation Studio

2D-3D Displays
360 Audio/Speakers
Haptics Control
Mobility Device

Physical Information

Analysis & Processing

3D Modeling/Creation
3D-Reconstruction
Anime Avatars
Metaverse
Digital Twin-Simulation/Prediction

Network Infrastructure

AI and Computing Infrastructure

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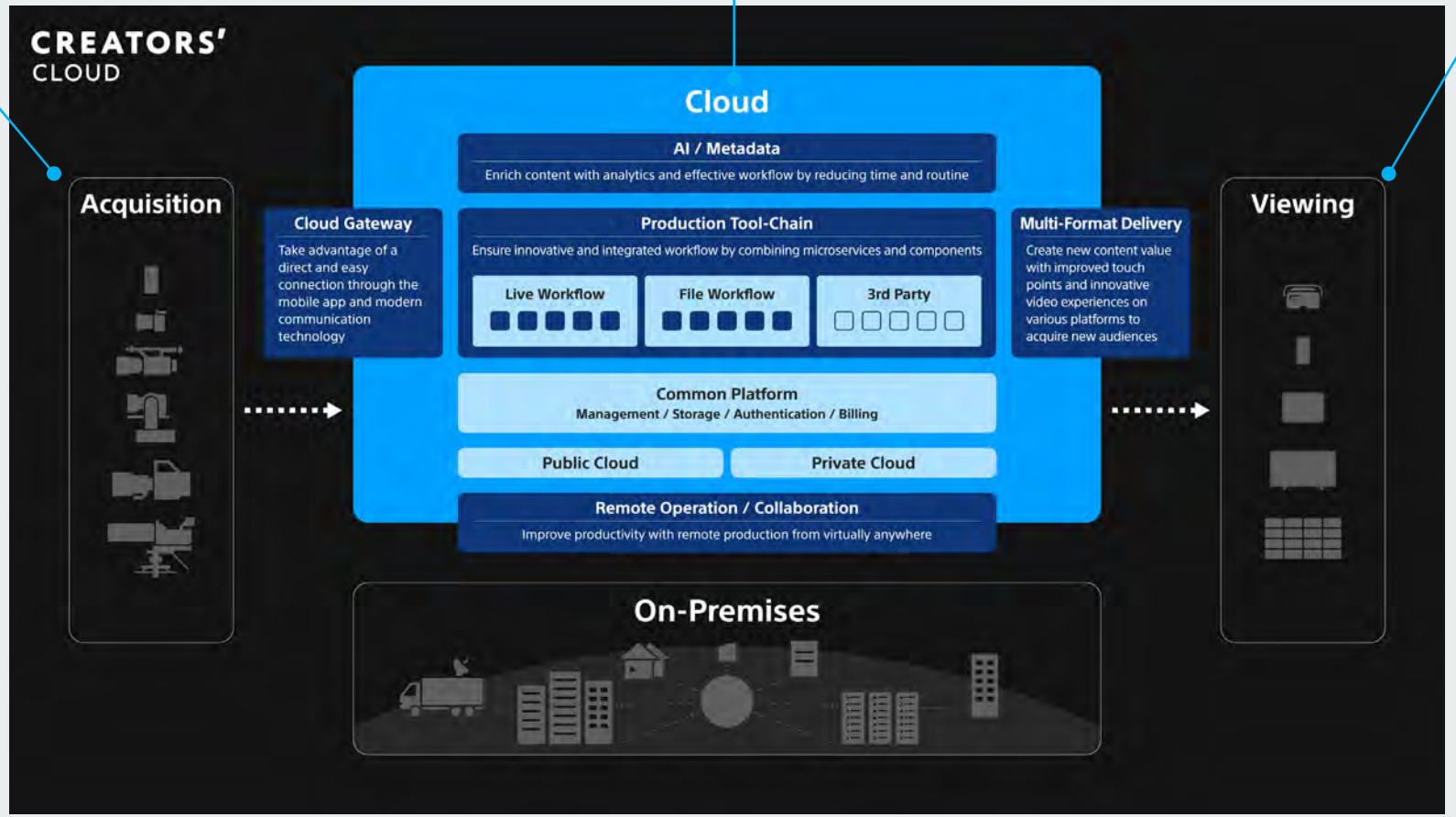
Entertainment & Metaverse Contents Creation Flow

Create and Process Data from anywhere

Capture Data from anywhere

Distribute Created Data to anywhere



Delivering Reality
Cloud based AR/VR

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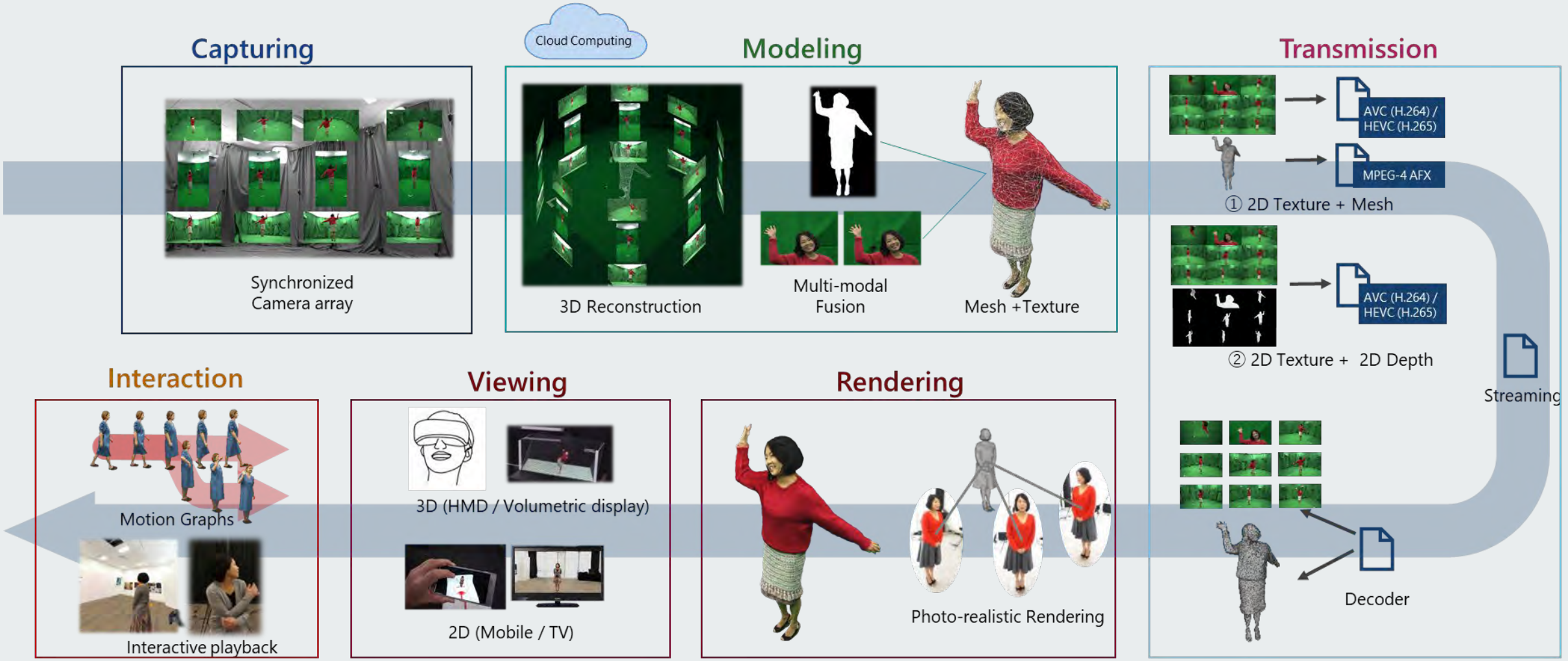
Delivering Reality – Volumetric-3D Contents (6DoF) Delivery Flow of Today



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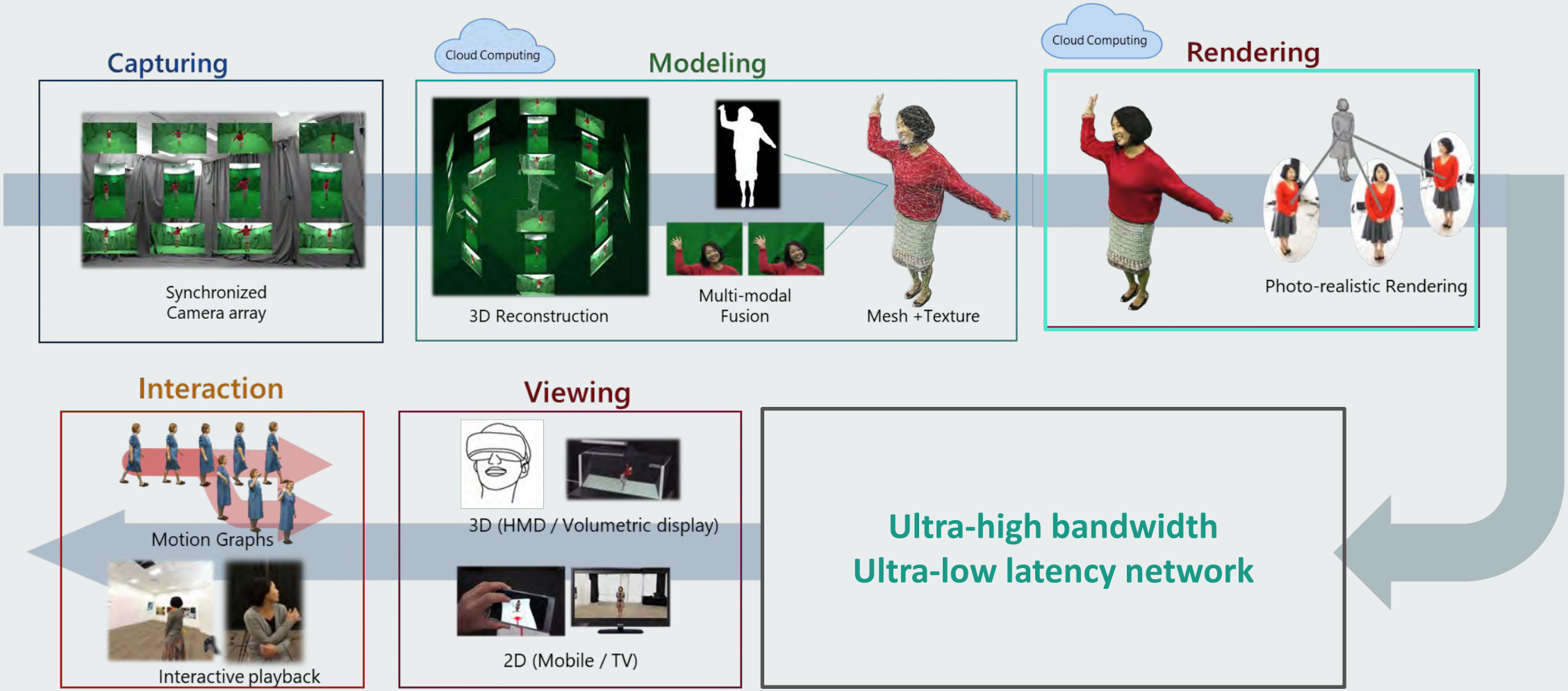
Delivering Reality – Volumetric-3D Contents Delivery Flow – Cloud Side Rendering



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Delivering Reality – Motion to Render to Photon Latency

Input | Network | Cloud | Network | Devices (HMD)

Volumetric Capturing

10-Gbps

② **View Dependent Rendering (Personalized Processing)**

>1-Gbps

①**Posture/Eye-Tracking (Motion Sensing)**

③ **Personalized Content Display (Photon representation)**

Sensing Latency + Network Latency + Rendering Processing Latency + Network Latency + Display Latency << 100msec

Network and Computing integration is a key for End-to-End application implementation

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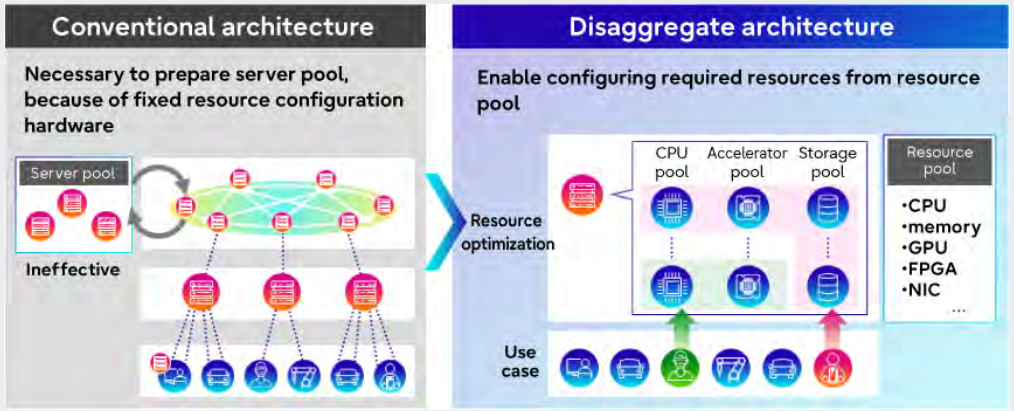
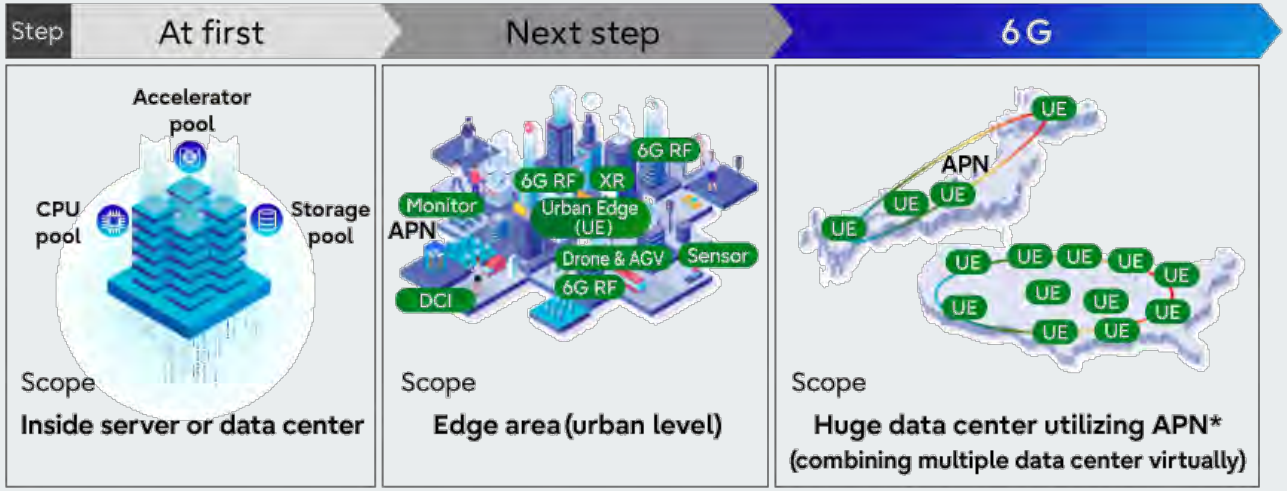
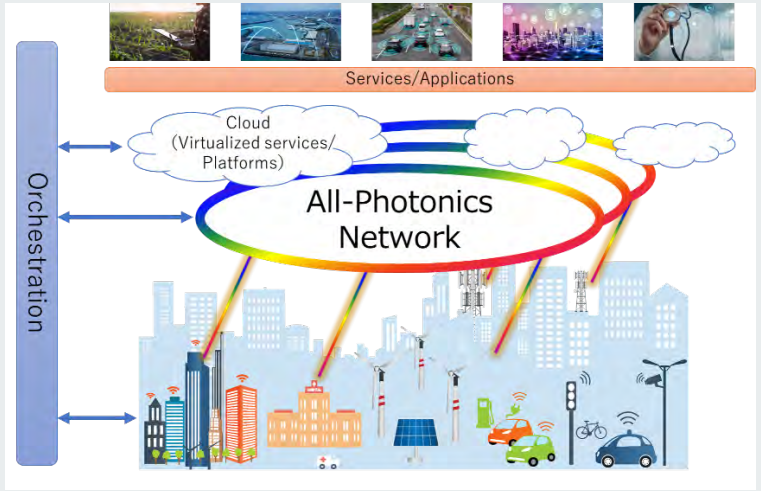
Beyond 5G, 6G, All Photonics Network

Enabler for high bandwidth, low latency, **disaggregated scalable computing power**







出展
https://www.fujitsu.com/global/about/research/technology/6g/disaggregated-architecture/
https://news.kddi.com/kddi/corporate/english/newsrelease/2023/03/17/6629.html

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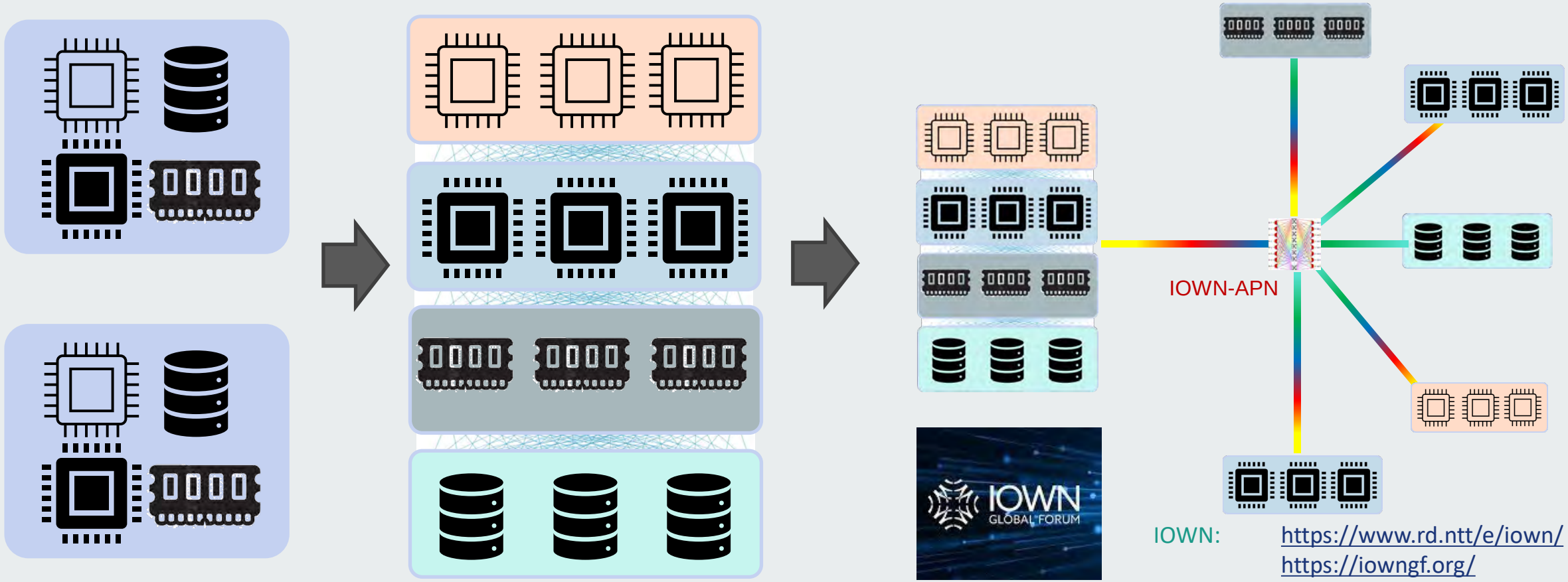
All Photonics Network : Enabler for disaggregation

Integrated

Intra-DC Disaggregation

Inter-DC Disaggregation
-Full Network & Computing Integration-



IOWN: https://www.rd.ntt/e/iown/
https://iowngf.org/

Elastic Processing for Remote and Distributed Application

Unleashing Imaginations and Creativities

- Constraint of being distant
- Constraint of time
- Constraint of expression
- Constraint of money

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Wireless R&D

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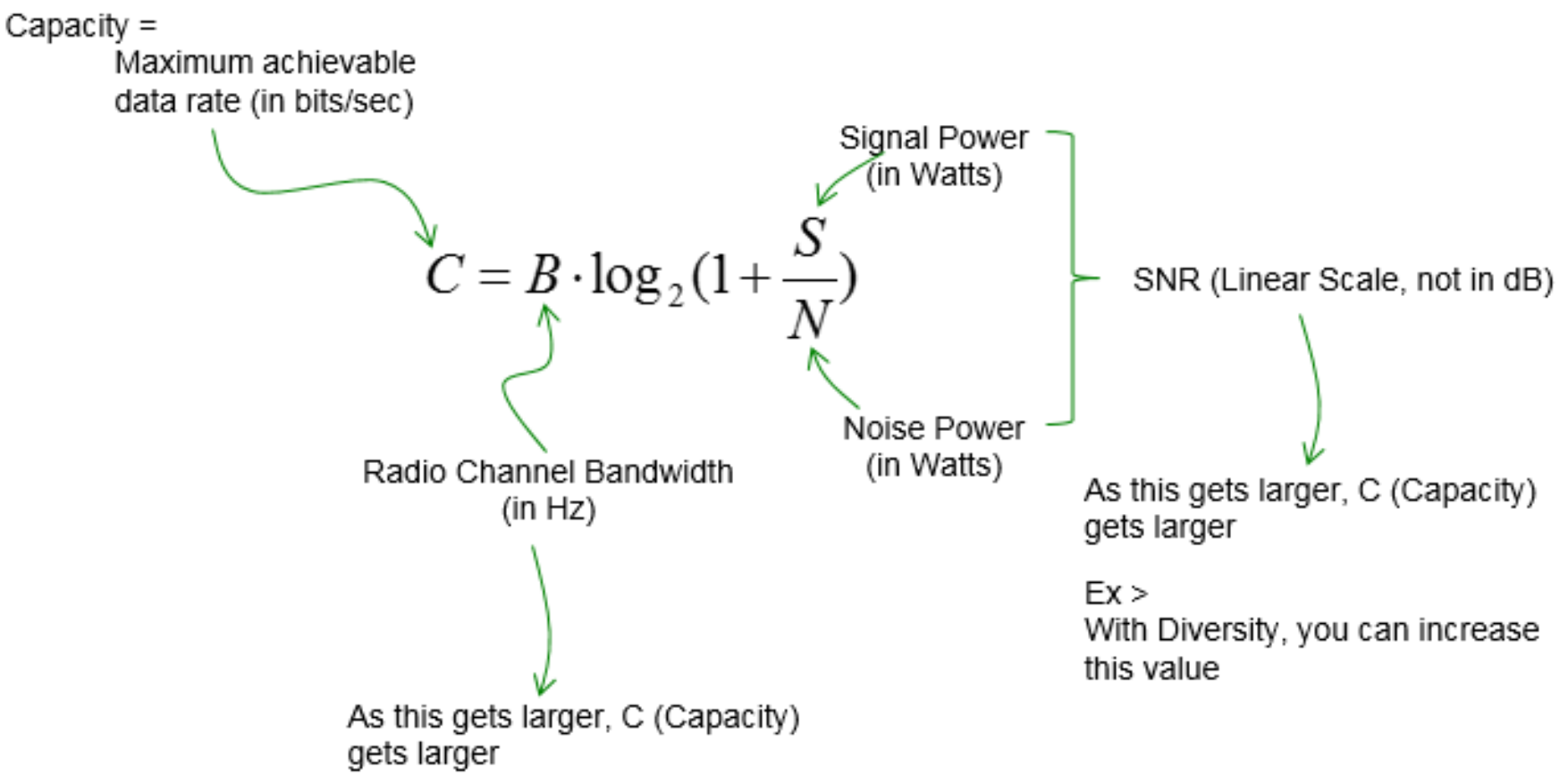
Shannon-Hartley's Channel Capacity Theorem

__Upper limit__ of the information transmission rate under additive noise channel



Source: https://www.sharetechnote.com/html/Handbook_Communication_ChannelCapacity.html

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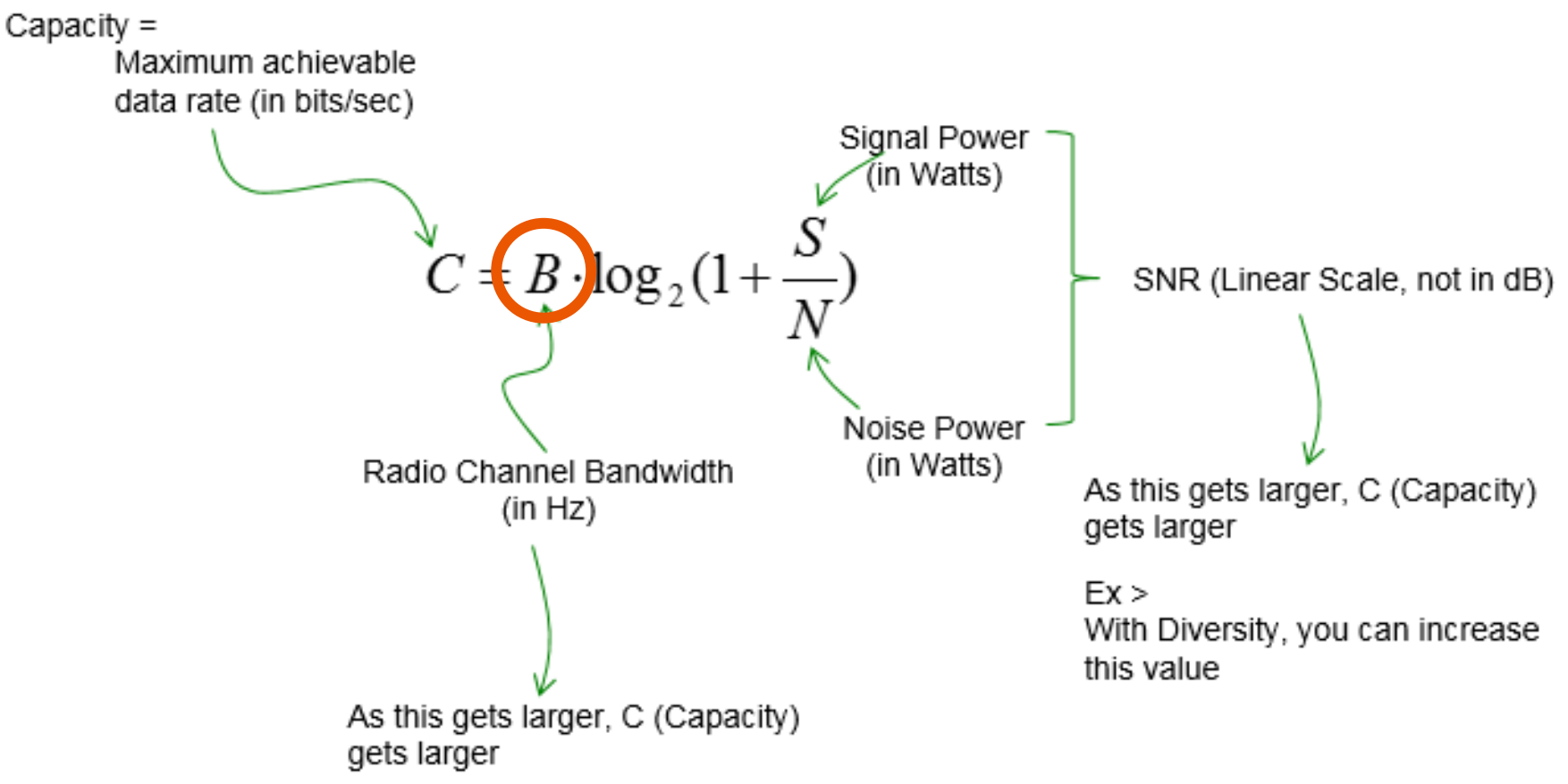
Shannon-Hartley's Channel Capacity Theorem

***Upper limit** of the information transmission rate under additive noise channel*



Source: https://www.sharetechnote.com/html/Handbook_Communication_ChannelCapacity.html

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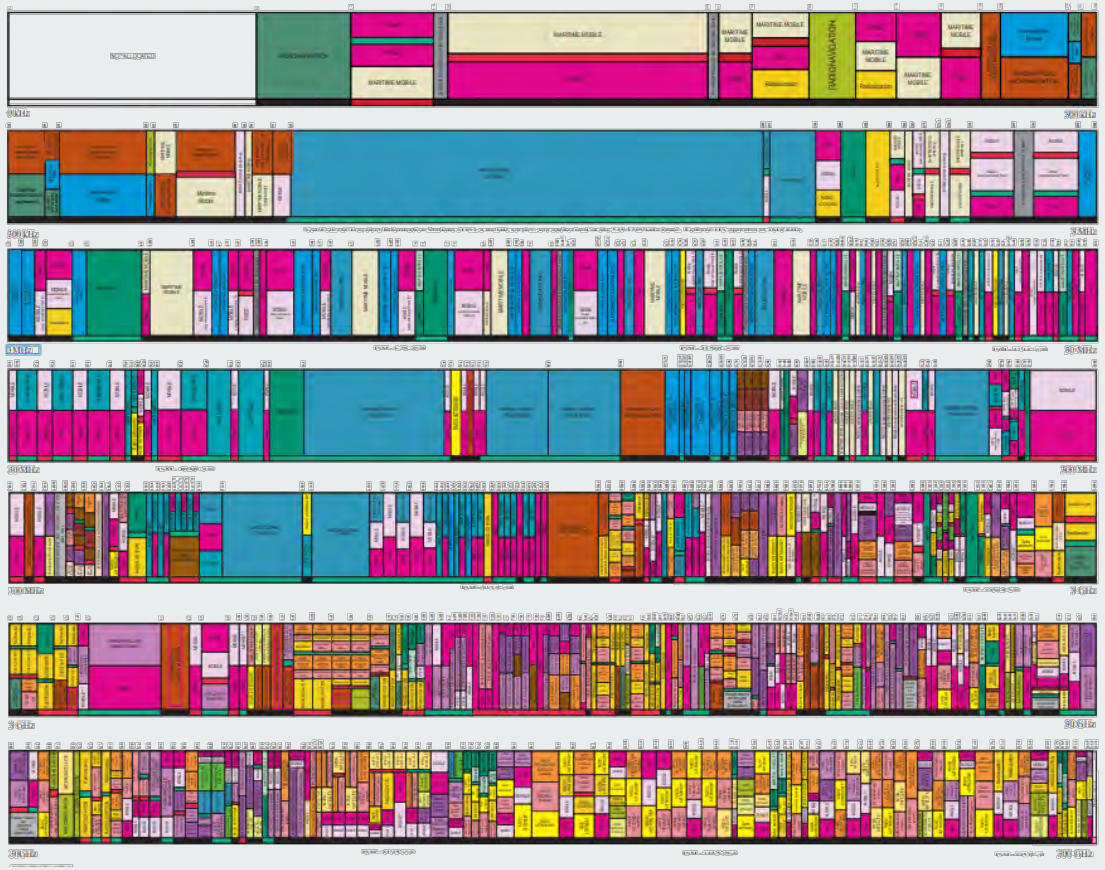
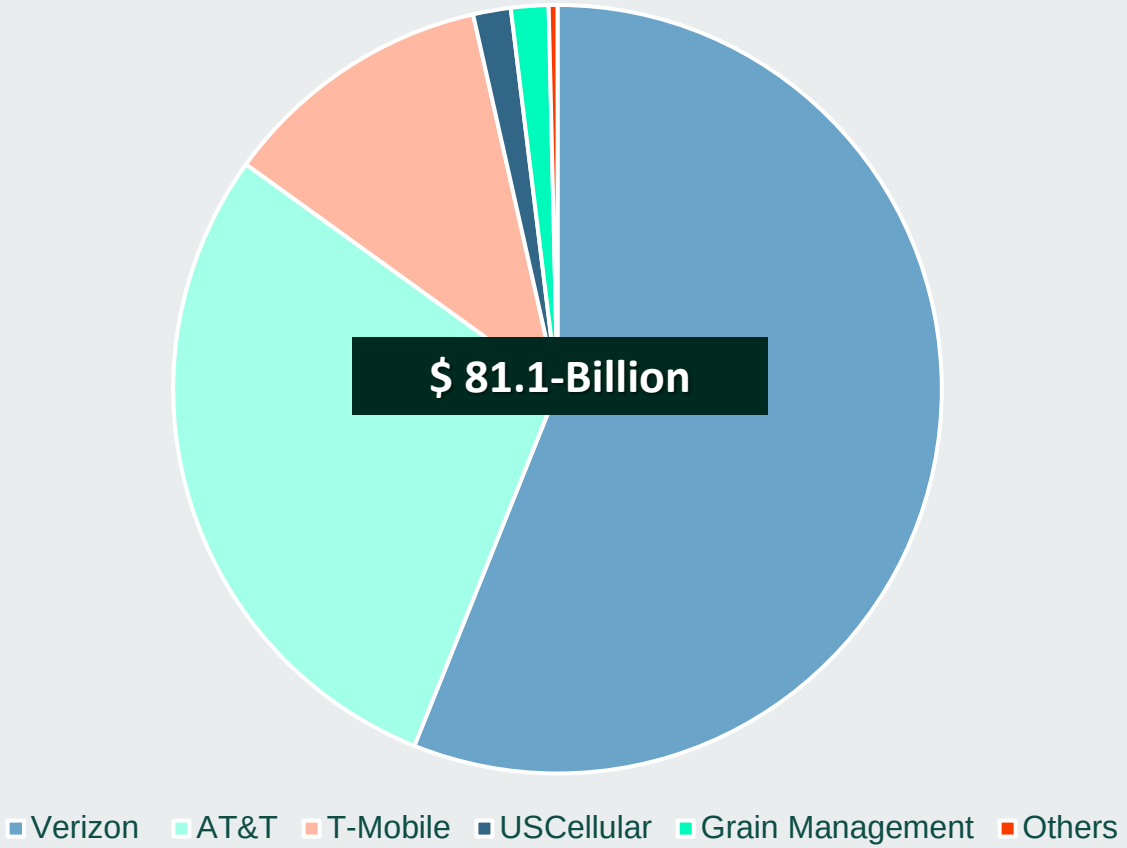
Spectrum is Everything: Scares and Expensive Resource

US Spectrum Allocation Below 300GHz



NTIA, “U.S. Frequency Allocation Chart as of January 2016”,
URL: < https://www.ntia.doc.gov/files/ntia/publications/january_2016_spectrum_wall_chart.pdf >

US C-Band (3.7GHz-280MHz BW) Auction in 2021



https://www.fcc.gov/auction/107

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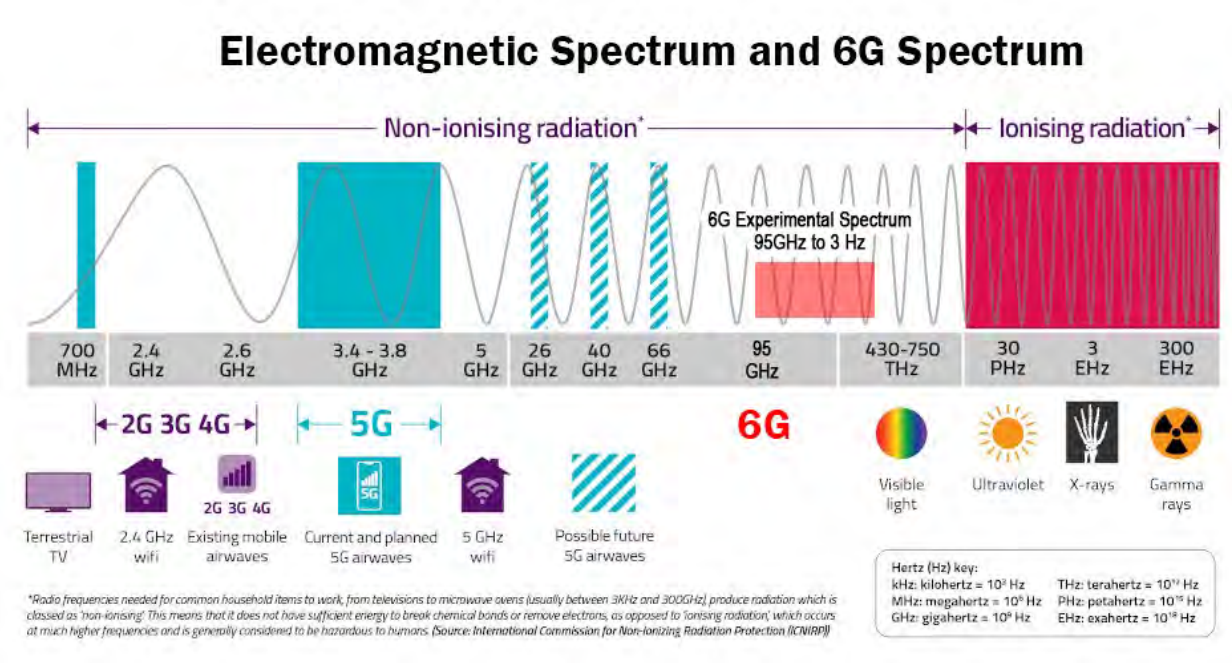
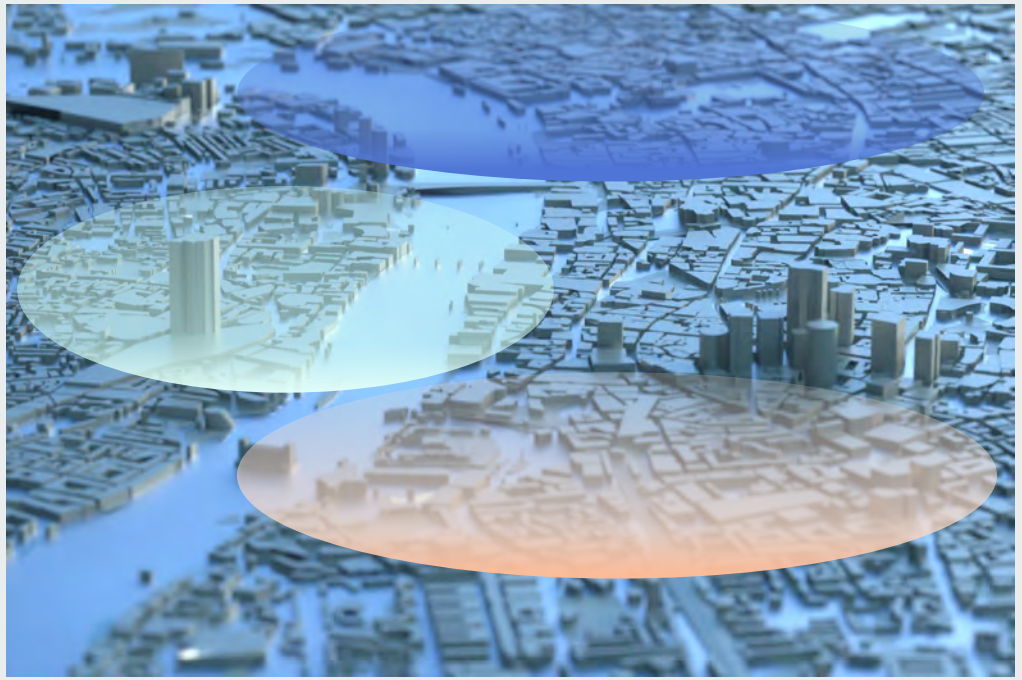
Finding Spectrum: Approaches

Higher Frequency Band



Source: Ofcomm and MI-WAVE (http://www.miwv.com)

Spectrum Sharing



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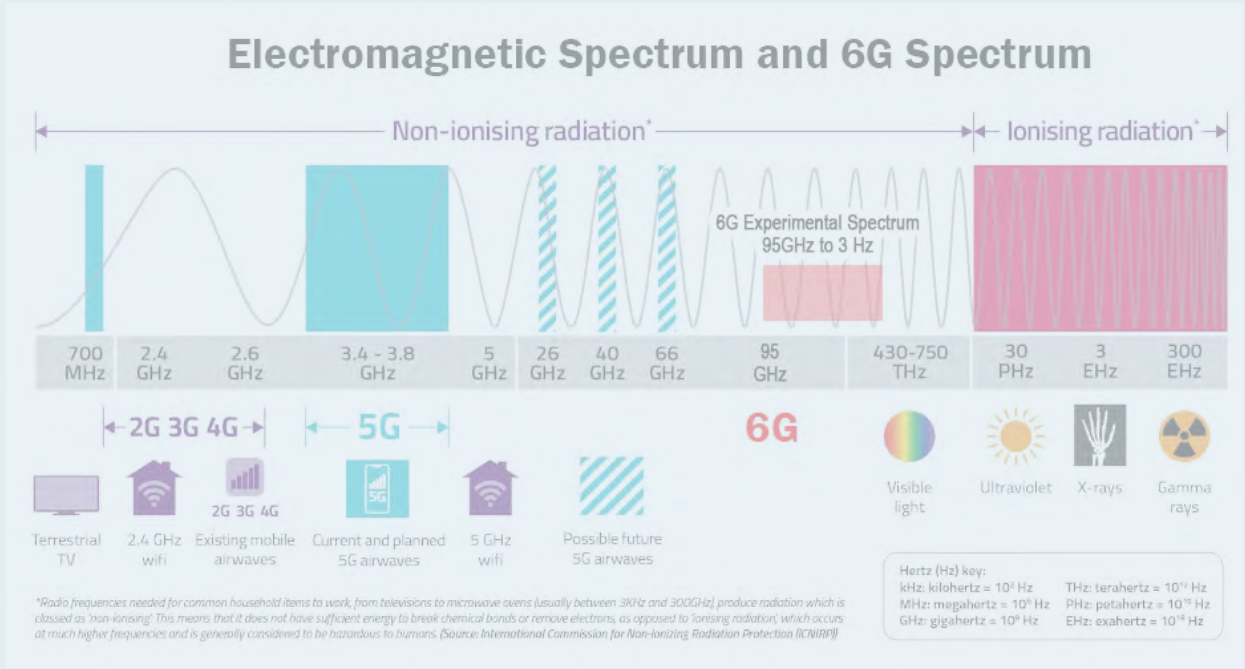
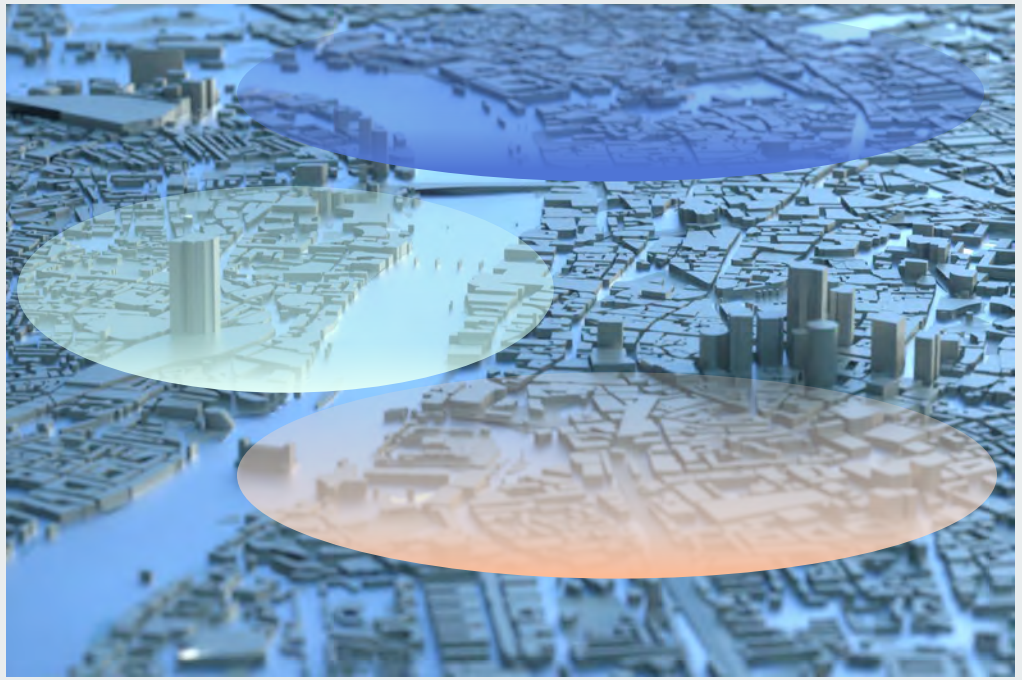
Finding Spectrum: Approaches

Utilize Higher Frequency Band



Source: MI-WAVE (http://www.miwv.com)

Spectrum Sharing
-Dynamic Spectrum Access-



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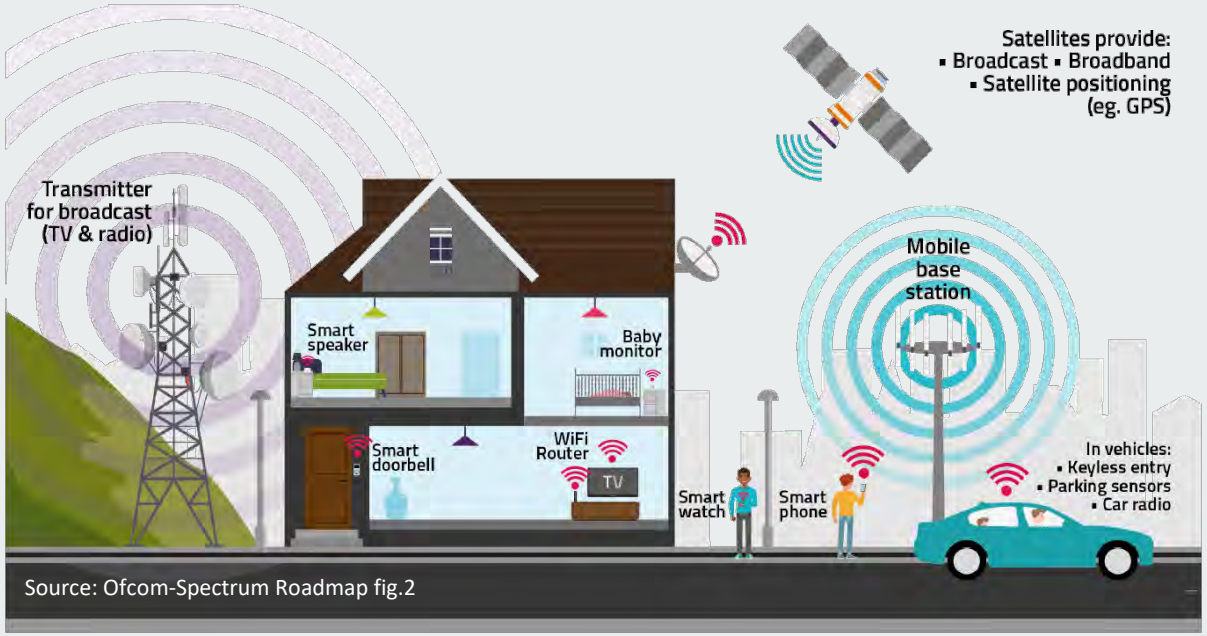
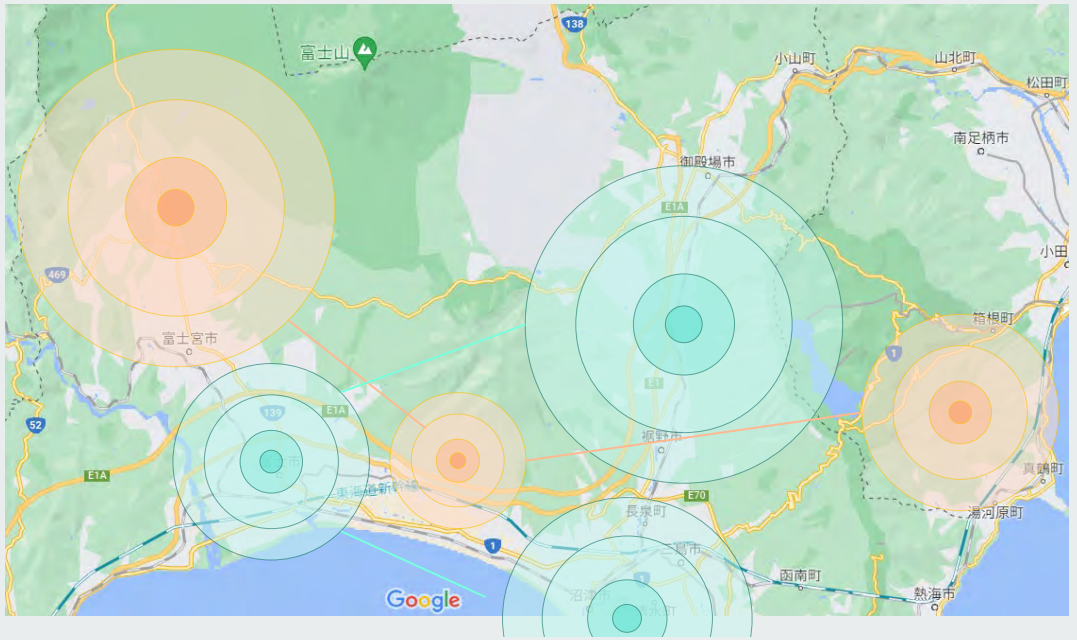
Dynamic Spectrum Access

Use of spectrum is not uniform

- Dependency over time and place
  - usage model, traffic, interference, propagation characteristic
- Current spectrum allocation not exploiting this nature



Source: Ofcom-Spectrum Roadmap fig.2



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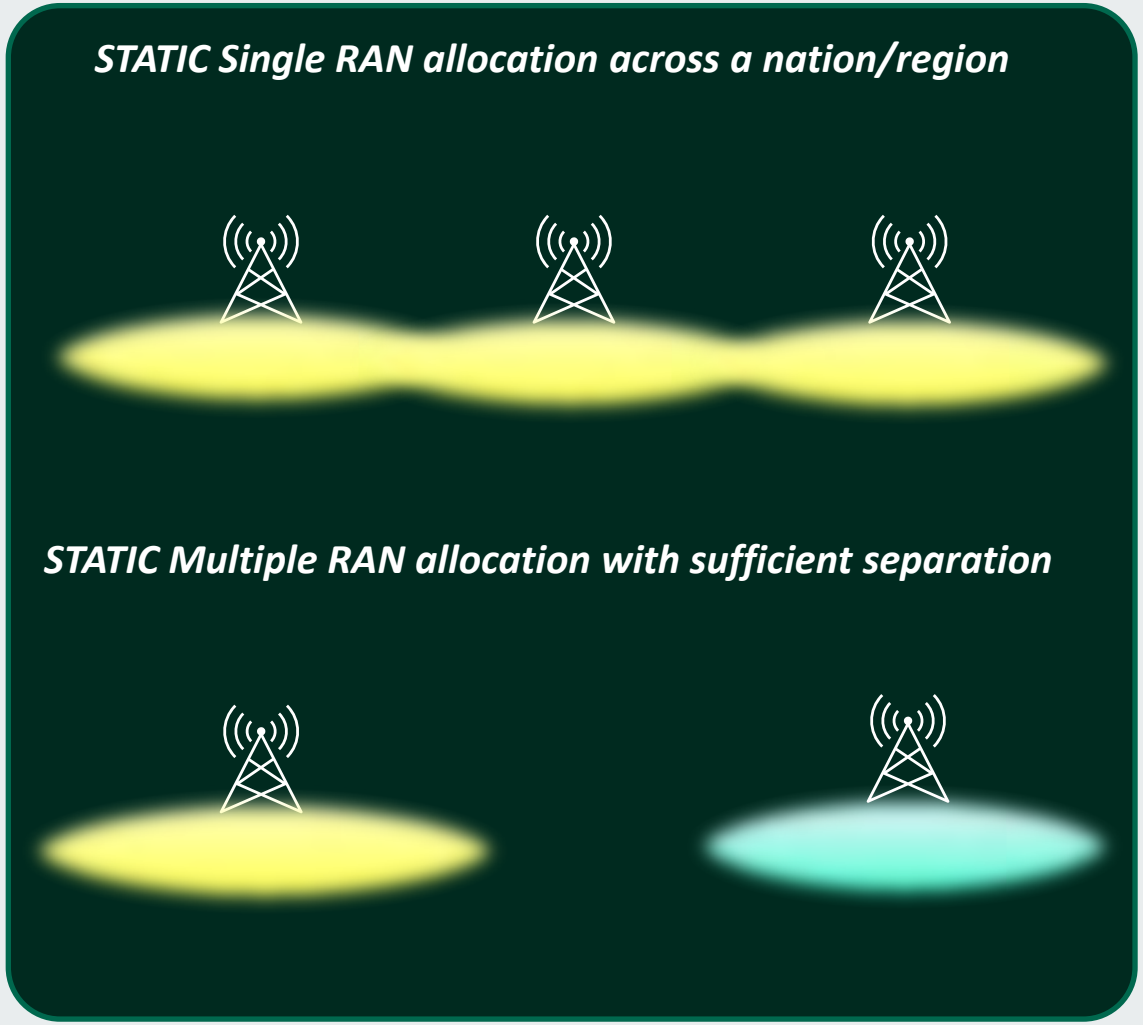
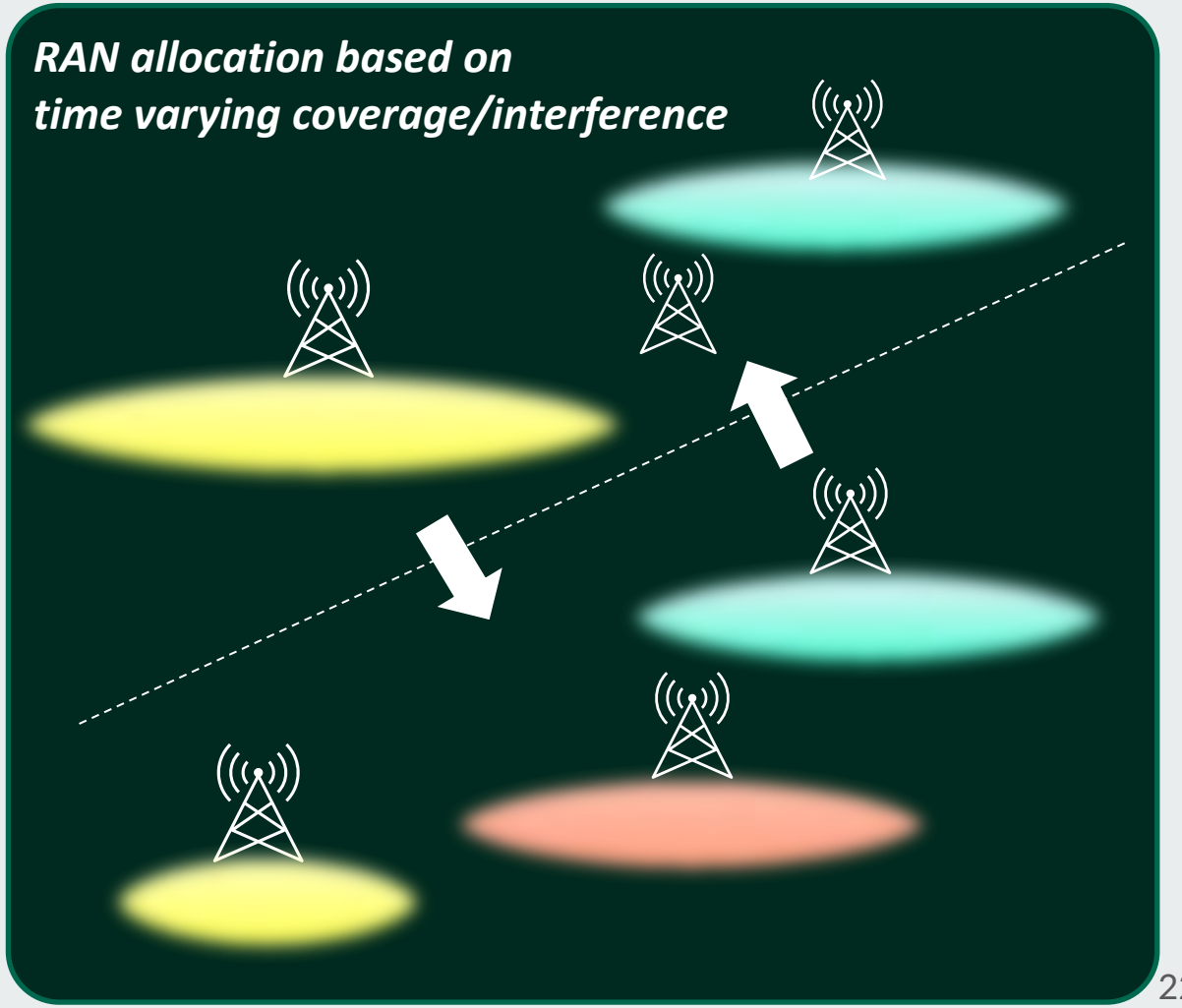
Dynamic Spectrum Access: Concept(1)

-Current Spectrum Allocation-



-Dynamic Spectrum Allocation-



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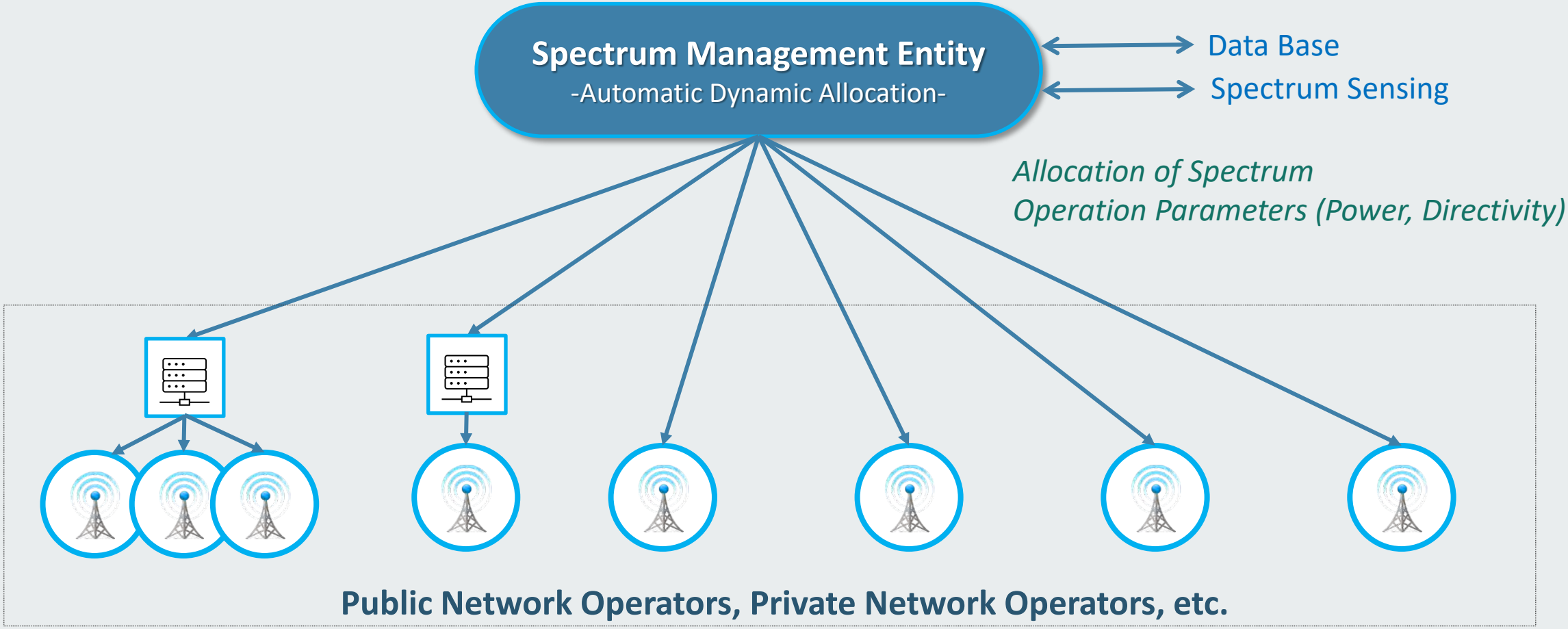
Dynamic Spectrum Access: Concept(2)



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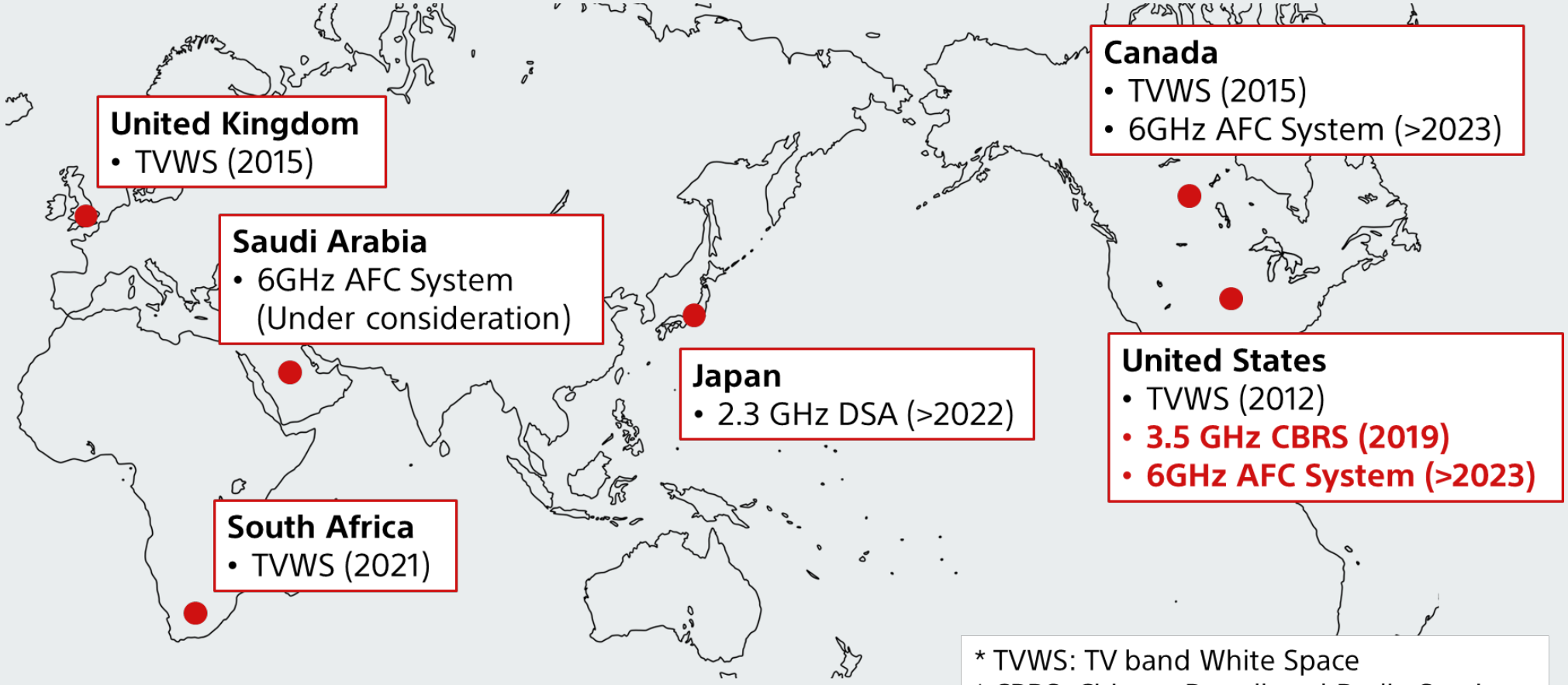
Dynamic Spectrum Access in the World: Rising Technology Trend



* TVWS: TV band White Space
* CBRS: Citizens Broadband Radio Service
* AFC: Automated Frequency Coordination

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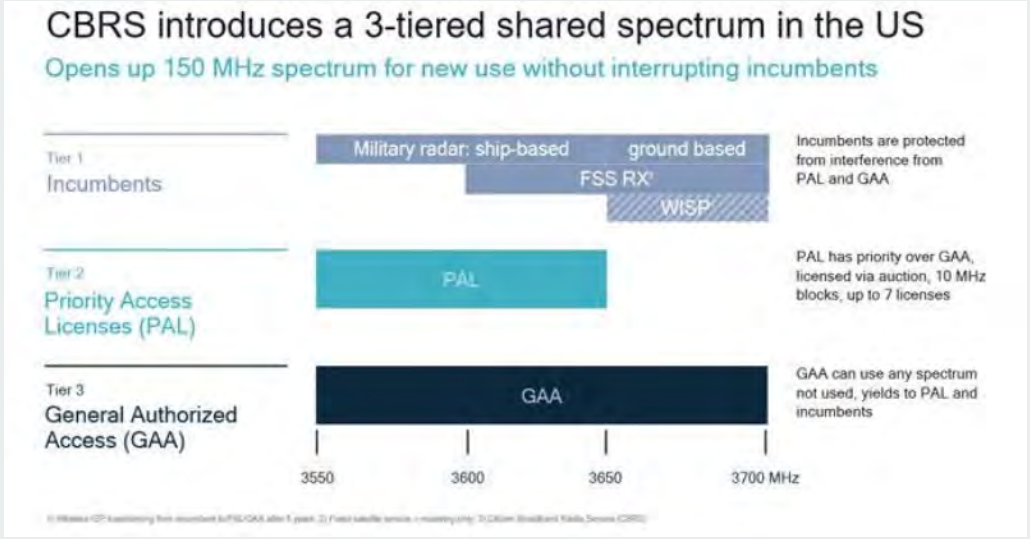
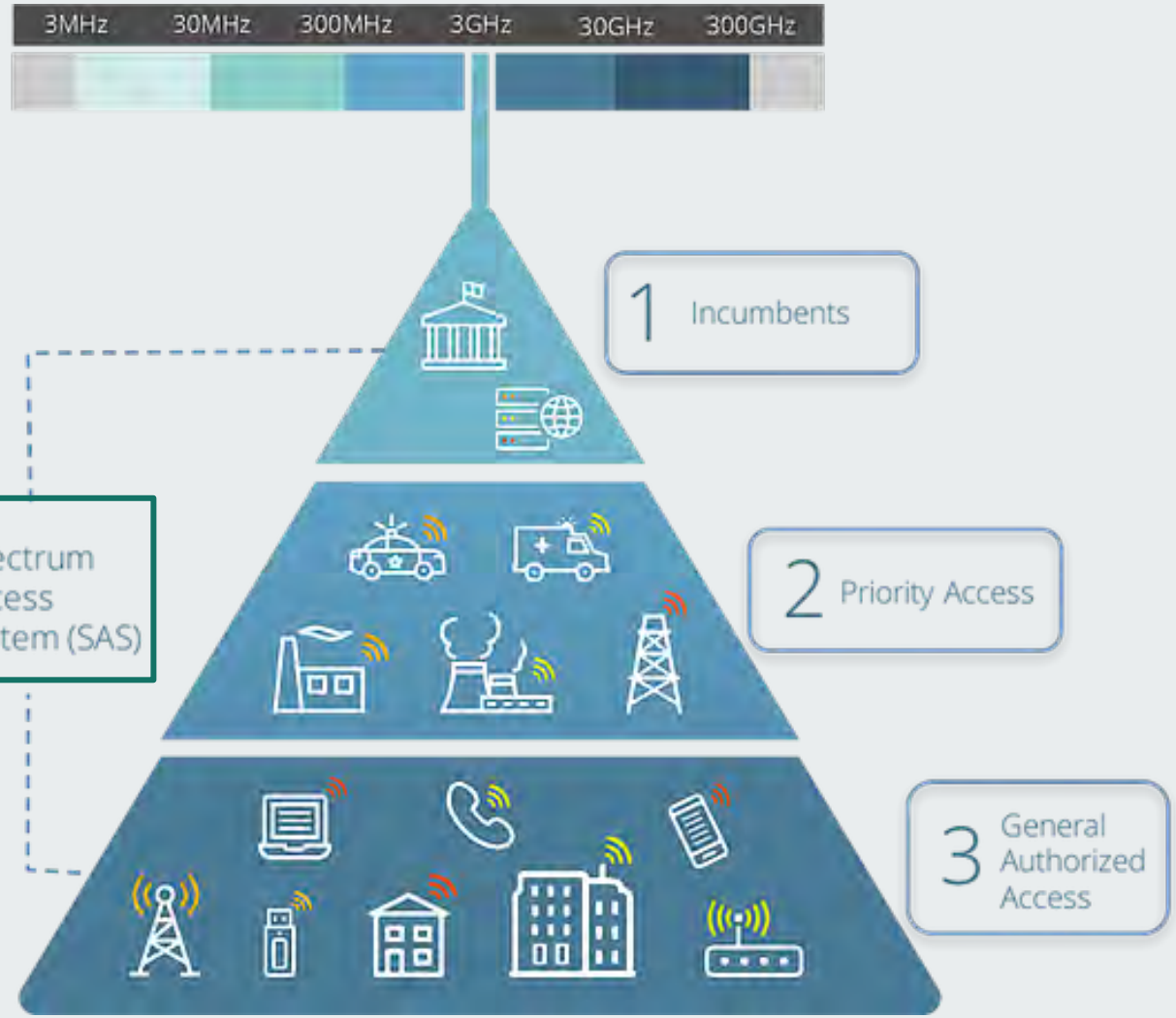
Dynamic Spectrum Access: US 3.5GHz Band in CBRS (Citizen's Broadcast Radio Service)






PUBLIC NOTICE

Sony is one of 5 certified operators* of Spectrum Access System (SAS)

*Google, Federated Wireless, Key Bridge, Comm Scope, Sony

3.5 GHz Band Overview | Federal Communications Commission (fcc.gov)

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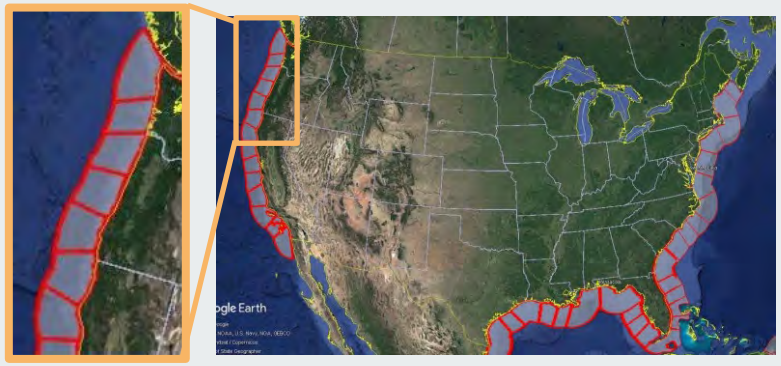
US 3.5GHz Band: Incumbents-Protection Entities

Federal Incumbents

- Shipborne radars (3550-3650 MHz)
- Land-based radars (3550-3700 MHz and <3550 MHz)

Dynamic Protection Areas (DPAs)

- ☐ ESC monitored DPAs (E-DPAs)



- ☐ Portal-controlled DPAs (P-DPAs)
- ☐ Ground-based DPAs (GB-DPAs)

Non-Federal Incumbents

FSS Earth Stations

- In-band FSS (3600-3700 MHz)
- Adjacent band FSS TT&C (3700-4200 MHz)

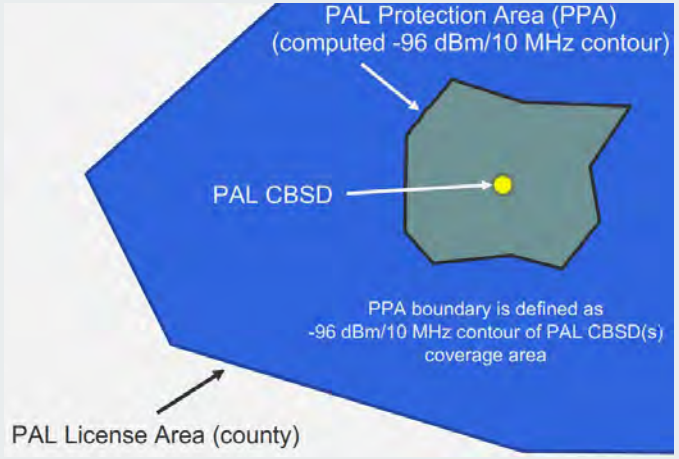
TT&C: Telemetry, Telecommand, and Control

GWPZs

- Operating areas of Part 90 Wireless Broadband Services (3650-3700 MHz)

PPAs

- Coverage areas of PAL CBSDs established by SAS (3550-3650 MHz)



Other Protected Entities

- Radio quiet zones and coordination zones (3550-3700 MHz)
- Cross border coordination with Canada (3615-3620 MHz, 3650-3700 MHz)
- ESC sensors (3550-3650 MHz)

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US 3.5GHz Band: Protection Requirements

Protected entity	Neighborhood area	Point or Area protection	Protection method	Protection criteria
DPA	150 km	Area protection	DPA Move List	-144 dBm/10 MHz
In-band FSS	150 km for co-channel 40 km for blocking	Point protection	Iterative Allocation Process (IAP)	-129 dBm/MHz for co-channel -60 dBm for blocking
Adjacent band FSS TT&C	40 km	Point protection	FSS OOBE Purge List	-129 dBm/MHz for out-of-band emissions -60 dBm for blocking
GWPZ, PPA	40 km	Area protection	IAP	-80 dBm/10 MHz
ESC sensor	40 km for Category A CBSDs 80 km for Category B CBSDs	Point protection	IAP	Depending on each sensor

[Source 1] WINNF-TS-0112 V1.9.1, "Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band", available at: https://cbrs.wirelessinnovation.org/release-1-of-the-baseline-standard-specifications

[Source 2] WINNF-TR-5003 V1.0.0, "CBRS Incumbent Protections and Encumbrances Overview", available at: https://cbrs.wirelessinnovation.org/reports-and-recommendations

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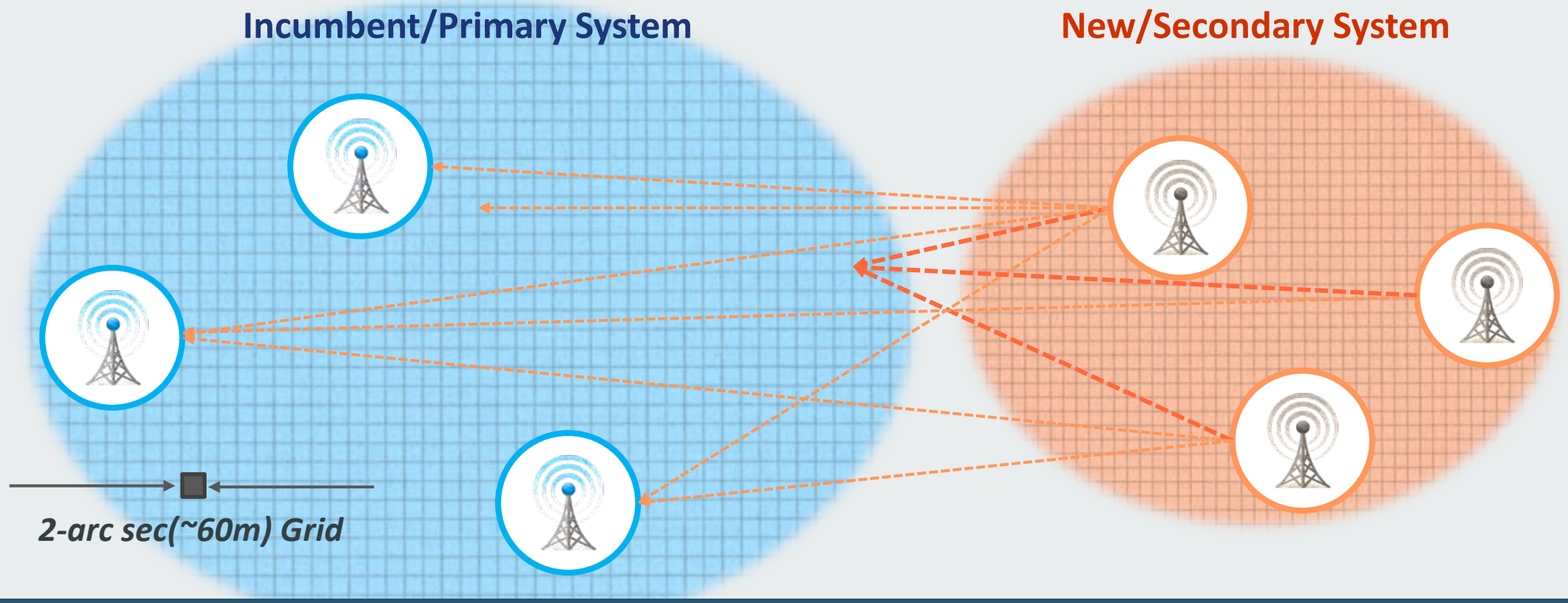
Dynamic Spectrum Access: Key Technology

Aggregate Interference Estimation



Interference induced by secondary system need to be acutely estimated

-to protect primary system

-to fully exploit sharing capability leading to better spectrum efficiency

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Dynamic Spectrum Access: Key Technology

Simple Expression in Equation – Not easy to do this practically….

- Large computation
- Iterative approach need to fully exploit availability

$$I_{Accept(dBm)} \geq \max_{1 \leq i \leq N_{Point}} \sum_{i=1}^{M_{secondary}} P_{Max,Tx(dBm)}(i) + G_{Ant(dB)}(i) - L_{(dB)}(i)$$

Over Coverage Space -2-arc second grid-

Aggregated Interference from multiple source

Power Transmitted from Secondary System

Tx-Rx ANT Gain

Propagation Model

Accurate, Real time, and Cost-Effectiveness are Key

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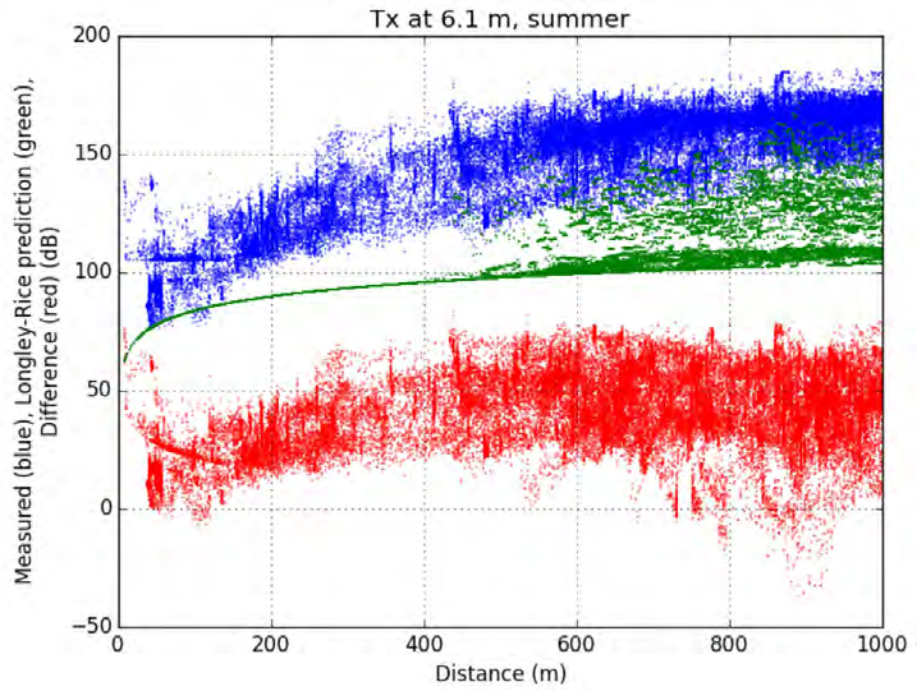
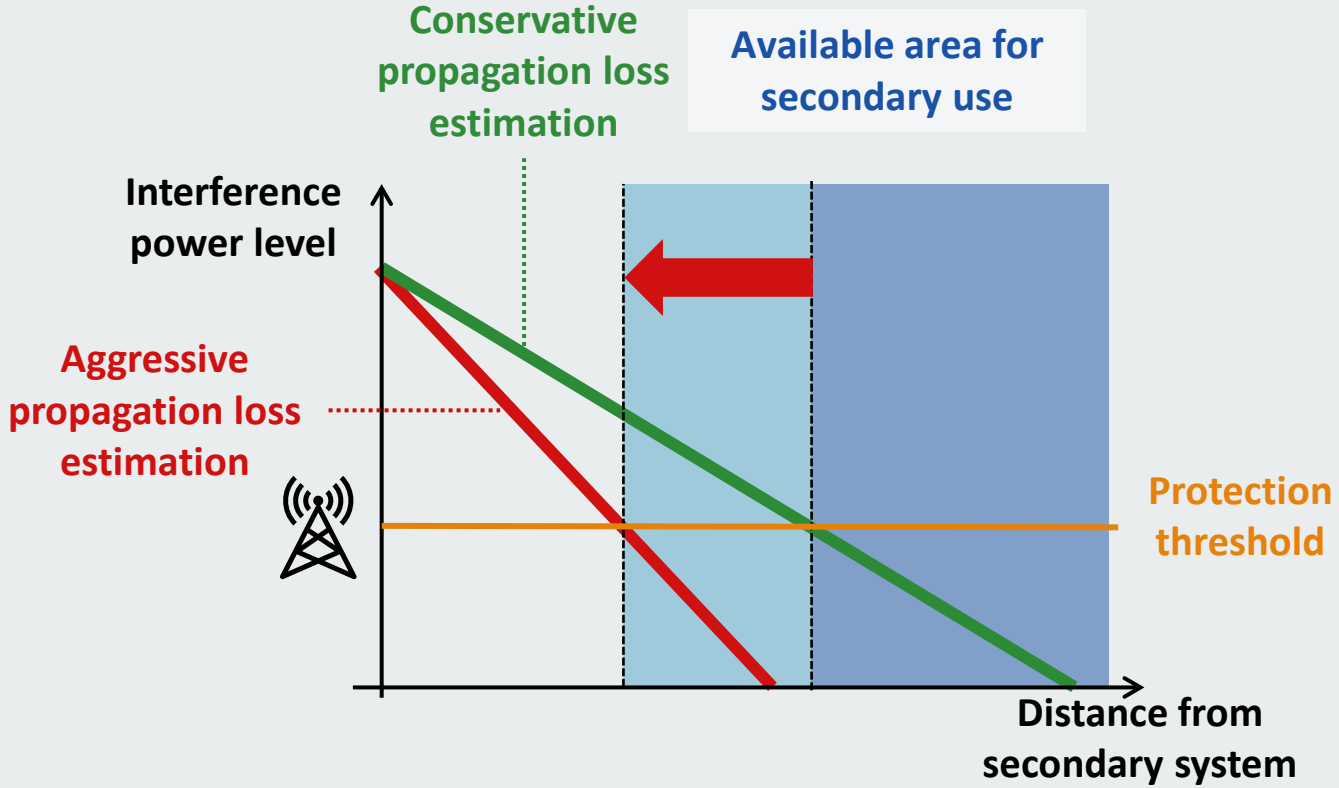
Improving propagation model accuracy for more efficient use of spectrum

Propagation models used in US CBRS

- Irregular Terrain Model (ITM) -Longley-Rice Model
- Hybrid model based on Extended Hata model and ITM



Blue: Measured
Green: Longley-Rice Model
Red: Difference



[Source] Andy Clegg, Google, The Problems with ITM in Four Pictures, ISART2022, available at: https://its.ntia.gov/isart/past-programs/2022-isart/

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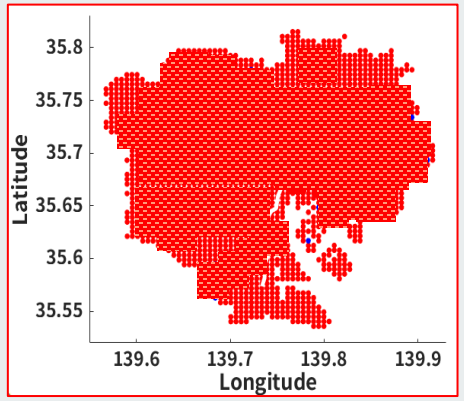
Propagation Modeling: Improving the Model

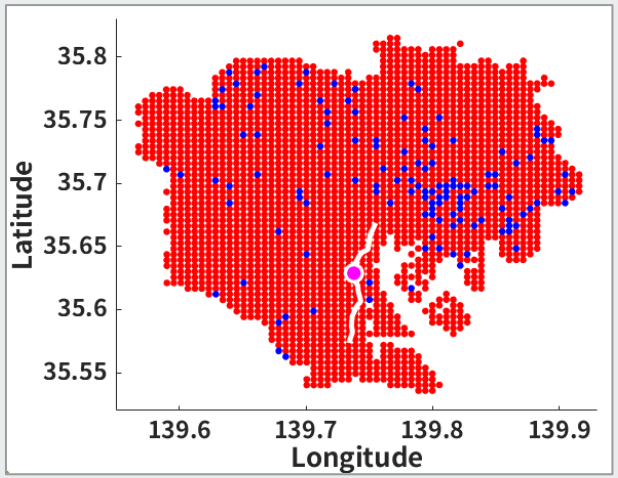
Case Study: Japan 2.3GHz DSA: Incumbents FPU-Mobile Broad Camera Tokyo-Kanagawa Area

FPU operating in ~200km marathon route



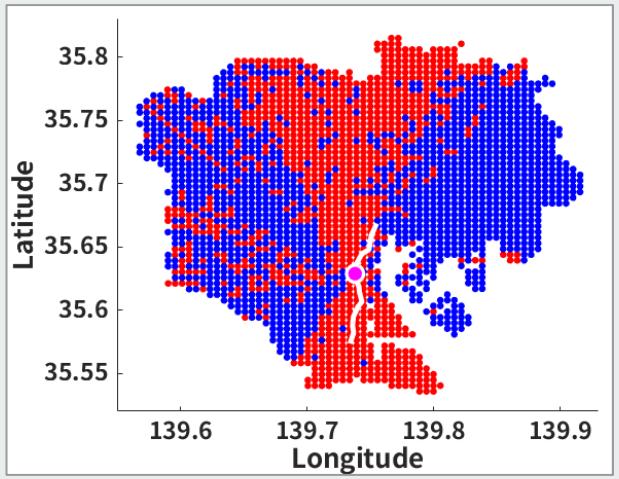
No DSA-No 5G

Conventional ITM based DSA (Conservative Model)



Limited Availability for 5G

Improved Propagation Model based DSA (Aggressive Model)



Over x10 Availability for 5G

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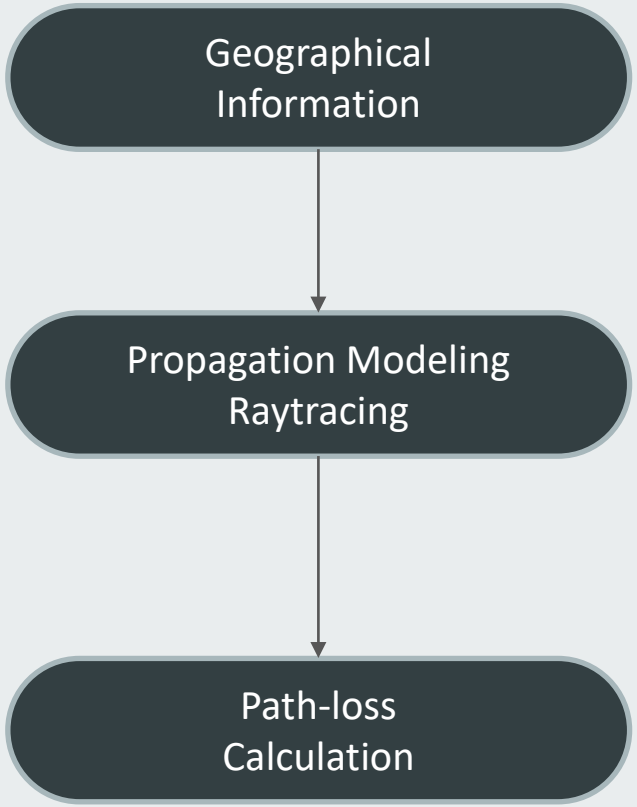
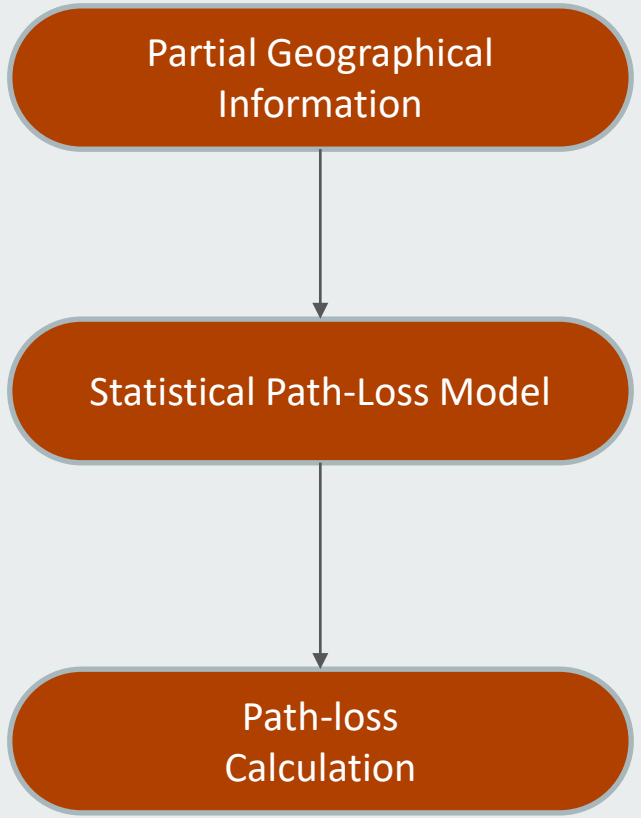
Dynamic Spectrum Access: Propagation Model

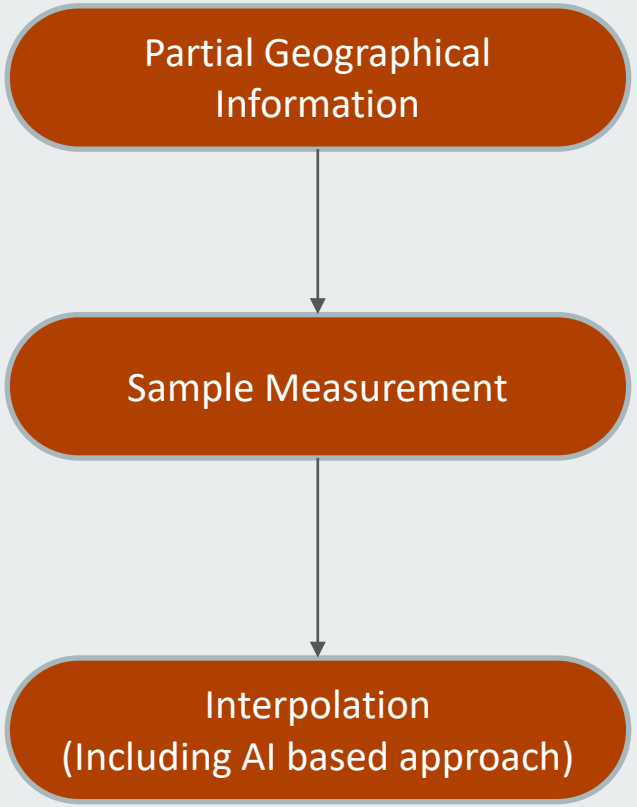
What we really want to do…..



GAP

Current Approach





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Propagation Modeling: Japan-Complex Geography

#1 Tokyo

#2 Yokohama

#3 Osaka

#4 Nagoya

#5 Fukuoka

#10 Hiroshima

#20 Shizuoka

#90 Yamagata

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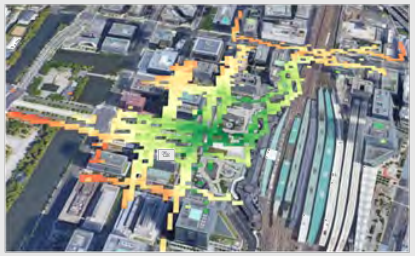
Dynamic Spectrum Access: Key Technology in the future

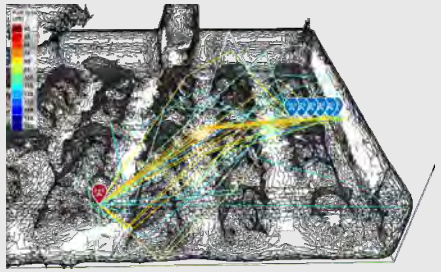
Improving propagation model-going beyond statistical model

Environment modeling

Sensing & 3D Reconstruction x AI
Sensing & Material Recognition x AI

Channel Modeling/Propagation Estimation





Raytracing x AI
-Resolving
location specific, frequency specific nature

Sensing x AI contributing to Propagation Model Improvement

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Key Connectivity Standardization Activities in Sony R&D


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Sony in Lund
An introduction

Sony Lund's heritage and evolution

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ERICSSON

Sony Ericsson

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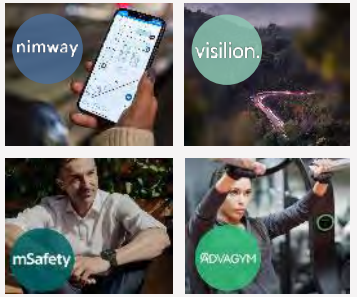
WALKMAN Cyber-shot

XPERIA

THE INTERNET OF THINGS

R&D	Design
Software Dev	New Business



80-90ies 2001 2003 2005 2006 2008 2010 2012 2014 2017 2019 2022

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Our key areas

R&D

Shaping the future
of connectivity

Design

Interdisciplinary
design studio

Software Development

Powering
our purpose

New Business

Our engine for
bold business growth

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Thank You!