ICAO RPG/ITU/WRC-2019 Conference

Development of Wireless Link Applications for Small UAS in Japan

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This study is carried out under a government-commissioned research project of the Ministry of Internal Affairs and Communications.

Contents

Background-1

- Unmanned aircraft systems (UAS) or drones have received a lot of attention in recent years in the world for several applications
  - wind and flood damage and fire, monitoring and observation, deliveries of goods
- Reliability of communication and the safe operation of UAS is becoming urgent need with the expansion of the needs of the UAS.
- The World Radiocommunication Conference (WRC)
  - WRC 2012 (WRC-12) decided the allocation of the frequency band 5 GHz band (5030 MHz ~ 5091 MHz) for the UAS Control and Non-Payload Communications (CNPC) Link.
  - WRC (WRC-15) decided to allocate the Ku/Ka frequency bands to establish a communication link between UA and remote pilot through satellite, and the details of its operations have being discussed in ITU-R

➡ Research and development of applications, reliable link, and interference mitigation techniques has become a pressing issue.

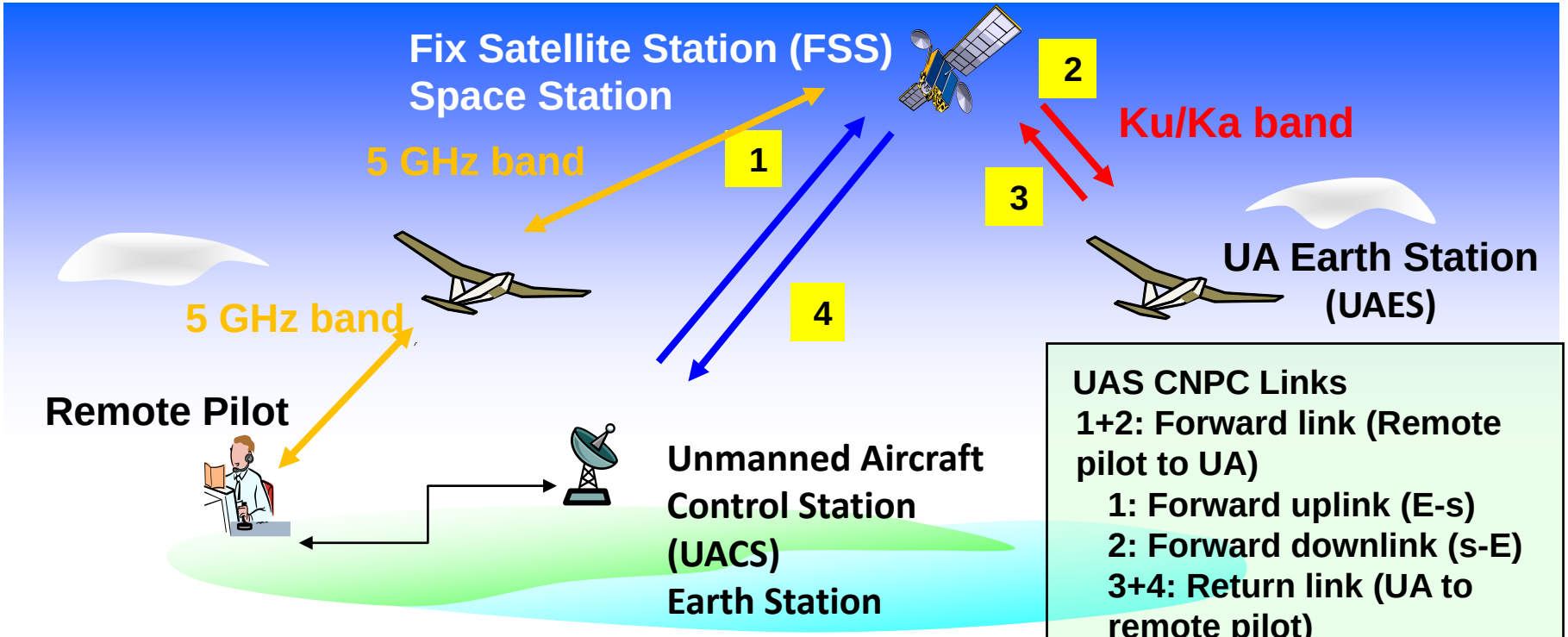
- the antenna beams of an on-board tracking antenna must be controlled properly not to affect the other satellite links.
- UAV-based wireless relay network system
- Etc.

Background-2

- In past disasters such as Great Hansin Earthquake and Great East Japan Earthquake, some isolated areas appeared in disasters area.

- The transportation system and communication system were interrupted by earthquake and tsunami
- The demand of wireless relay network using unmanned aircraft system has grown
- Various applications using UAS are being studied in Japan
- We report the development of a UAV-based wireless relay network system and the current status of frequency regulations for UAS wireless link in Japan

Control and Non-Payload Communications (CNPC) Link for UAS



UAS CNPC Links
1+2: Forward link (Remote pilot to UA)
1: Forward uplink (E-s)
2: Forward downlink (s-E)
3+4: Return link (UA to remote pilot)
3: Return uplink (E-s)
4: Return downlink (s-E)

Line-of-Sight (LOS)

5GHz band (5030-5091MHz) was allocated worldwide (at the WRC-12)

Beyond-Line-of-Sight (BLOS)

5GHz band (5030-5091MHz) was allocated worldwide (at the WRC-12)

Allocations of Ku/Ka bands in the FSS band are being discussed now (toward the WRC-19)

Frequency Regulations on UAS

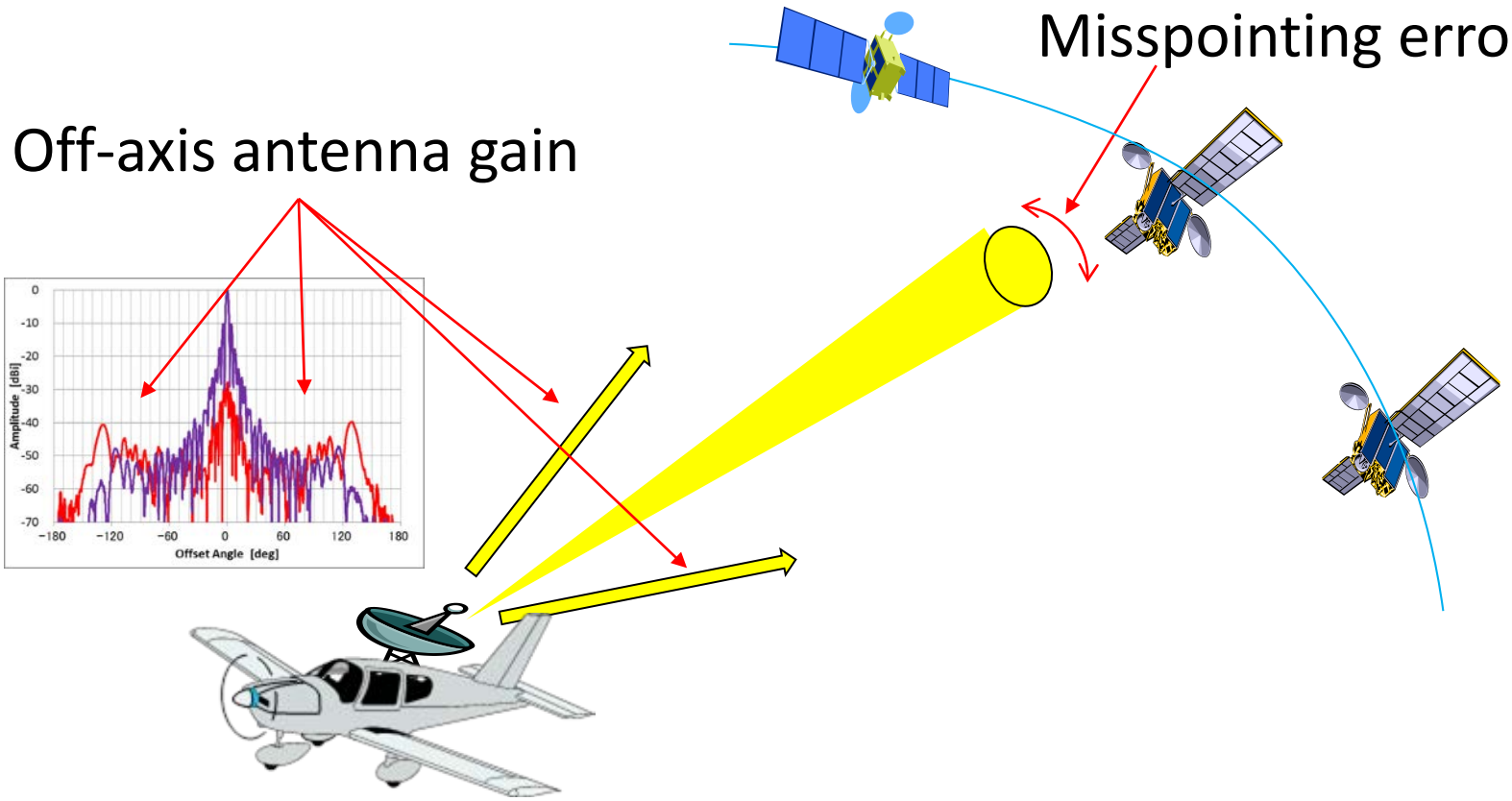
- The frequency bands 5030–5091 MHz and Ku/Ka band were allocated for the CNPC link at WRC-12 and WRC-15
  - The definition of internationally standardized system is required under the footnote 5.443C of ITU-R Radio Regulations
  - NICT is interested in applications operated the frequency bands 5030–5 091 MHz and Ku/Ka for CNPC link.
- Several discussions on UAS frequency usages including channel plan are carried out in ICAO
  - ICAO has a policy that calls for enacting a general framework of flight rules by around 2018
  - The technological and industrial development of the field of unmanned aircraft in Japan has been started
- UAS Traffic Management (UTM) system by NASA

2. DEVELOPMENT OF ON-BOARD ANTENNA FOR UAS

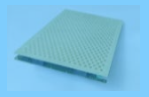
ESOMPs to ESIM at ITU-R WRC-15

- At WRC-15
  - Resolution 156[COM5/2] was approved.
  - ESOMPs(Earth station on mobile platforms) was renamed to ESIM(Earth stations in motion)
  - 29.5-30.0 GHz and 19.7-20.2 GHz bands are allocated for ESIM as primary, which are already allocated
- Control and Non-Payload Communications (CNPC) Link for UAS
  - Ku and Ka-bands: still being discussed in ITU-R
  - Off-axis e.i.r.p. satisfies ITU-R Recommendation S.524-9
  - Misspointing of antenna beam toward satellite must be within 0.2 degrees.
  - Whenever possible, to reduce the size, weight, power saving
  - Propagation characterizes between UAS and satellites

Key Points of Tracking Antenna Design



Recent trend of onboard antenna for mobile satellite

	Ku	Ka
elliptical aperture or flat panel antenna	 height: 24cm  height: 19cm **Astronics** http://www.aerosat.com/products/aerosat%206400%20flyer10_2.pdf  height: 21cm **Panasonic Avionics** http://panasonic.aero/InFlightConnectivity/AntennaTechnology.aspx	 height: 21cm **Viasat** http://www.dailywireless.org/2014/06/09/amtrak-building-broadband-wireless-network/  height: 20cm **Honeywell** **NICT** height: 26cm weight: 29kg 
axisymmetric antenna	 opening size: 30cm **Viasat** http://www.dailywireless.org/2012/04/10/viasat-light-aircraft-broadband/  opening size: 28cm **Astronics** http://aviationweek.com/nbaa-2015/astronics-panasonic-partner-bring-high-speed-connectivity	 opening size: 30cm **Viasat** https://www.viasat.com/sites/default/files/media/documents/vmt-1220he_helicopter_mounted_terminal_datasheet_016_web_0_0.pdf
AESA (Active electronically scanned array)	 高さ: 7cm **(2016年)** **Panasonic Avionics*1** **★under development**  高さ: 3cm **Phasor*3 (2017年)**  height: 12cm **Thinkom*2**  高さ: 5cm **Kymeta*4 (2018年)**	No product

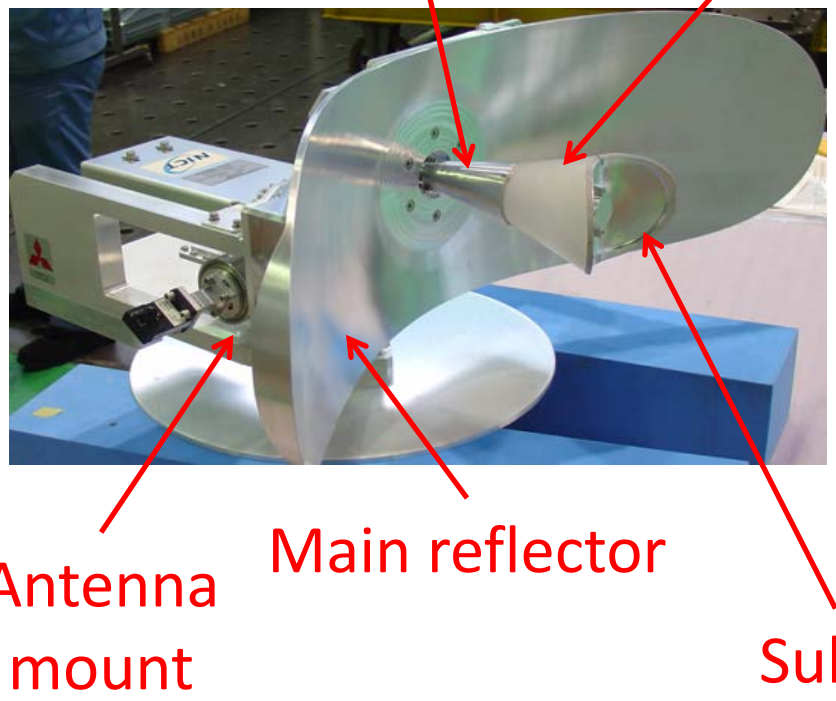
*1) http://www.satellitetoday.com/telecom/2014/10/08/panasonic-boeing-lightweight-antenna-to-offer-ifc-reduced-emissions/

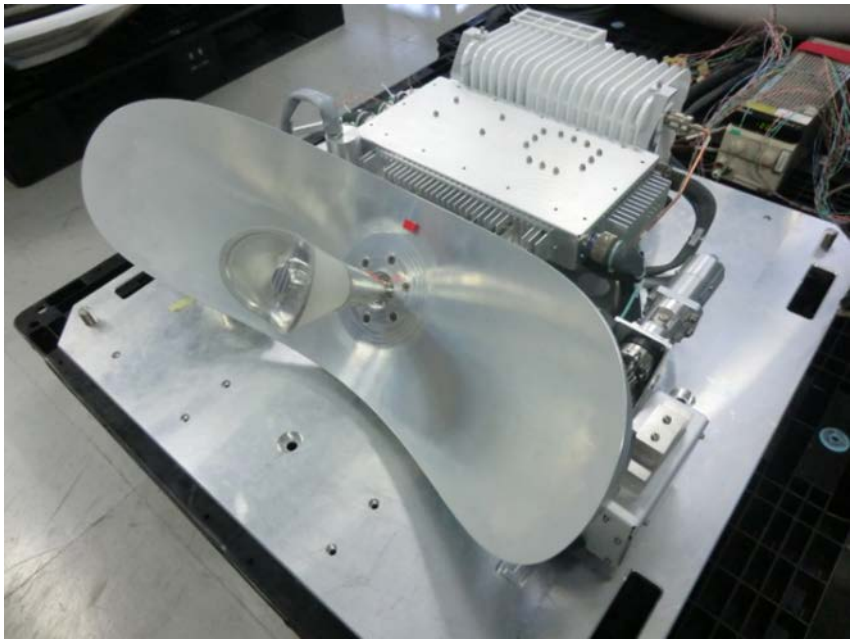
*2)http://concourse.gogoair.com/technology/onboard-technology-makes-inflight-connectivity-possible

*3)http://www.satellitetoday.com/technology/2013/10/18/phasor-solutions-demonstrate-ku-band-flat-satellite-antenna-system/

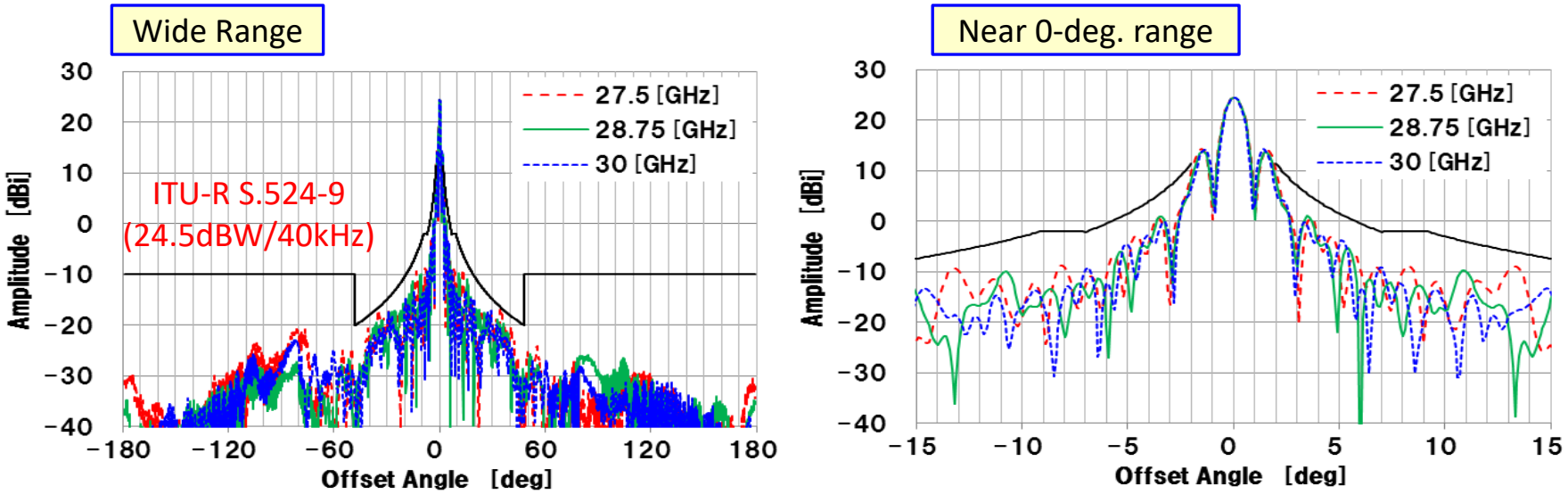
*4) http://www.getconnected.aero/2015/09/just-will-kymetas-meta-material-antenna-work/

Appearance of Radiation and Drive Units of On-board Antenna





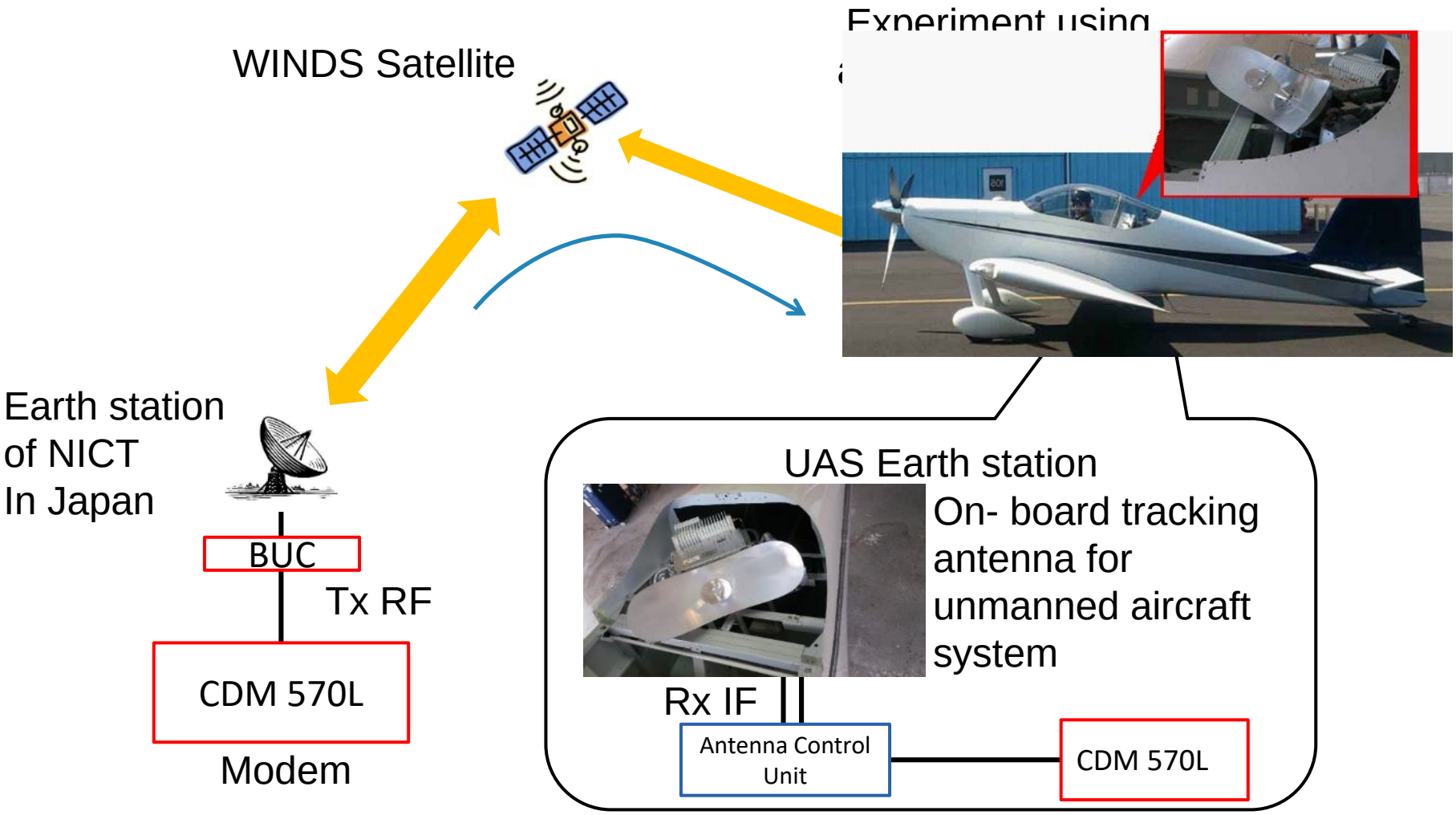
Evaluation Results – Off-Axis Radiation Patterns



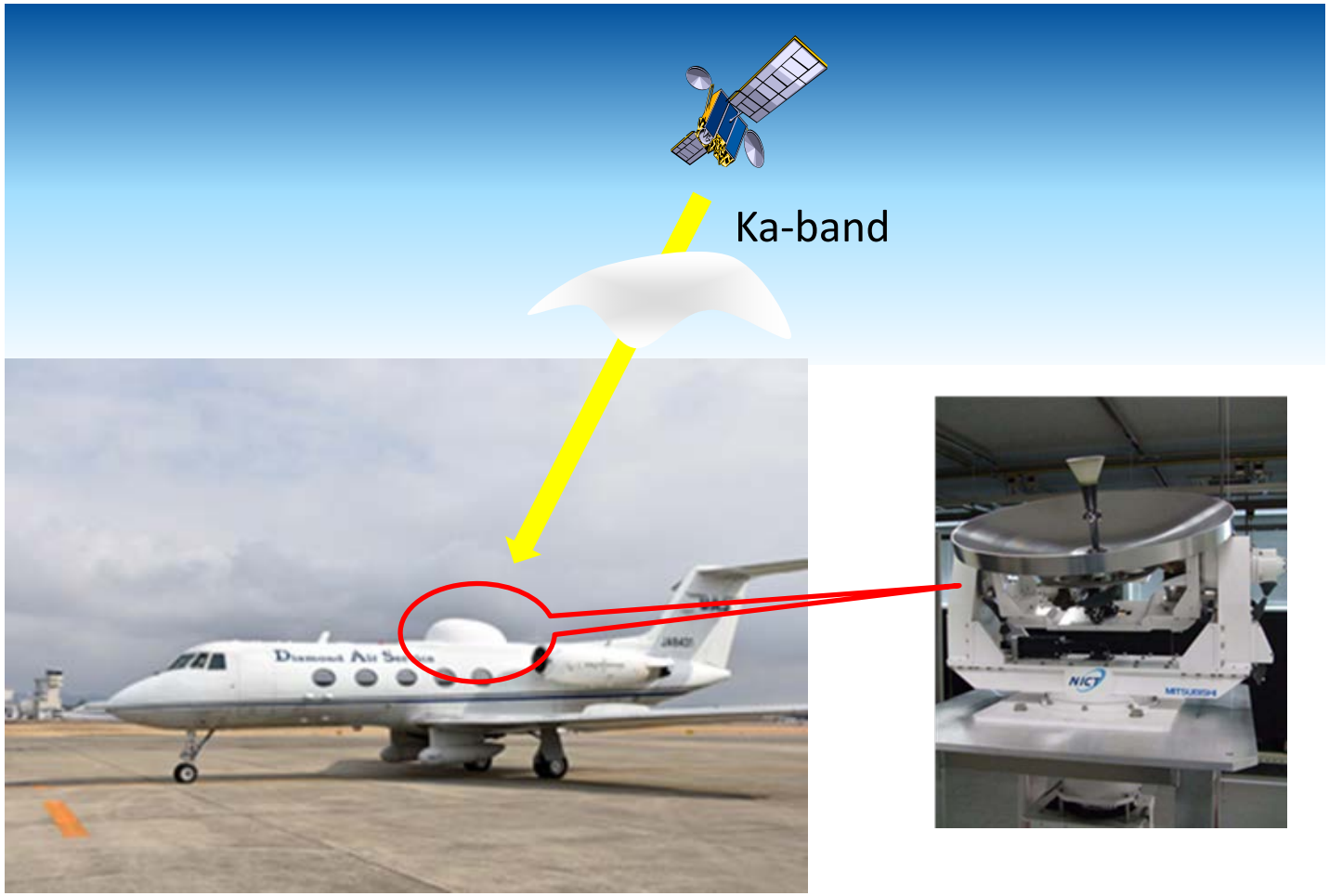
Measured off-axis radiation patterns

We confirmed the developed radiation unit of the on-board antenna satisfied the antenna requirements defined in ITU-R S.524-9

Evaluations of the Antenna using Actual Airplane in 2015



Propagation Measurement of Ka-band for UAS



3. DEVELOPMENT OF WIRELESS SYSTEMS USING SMALL UAS

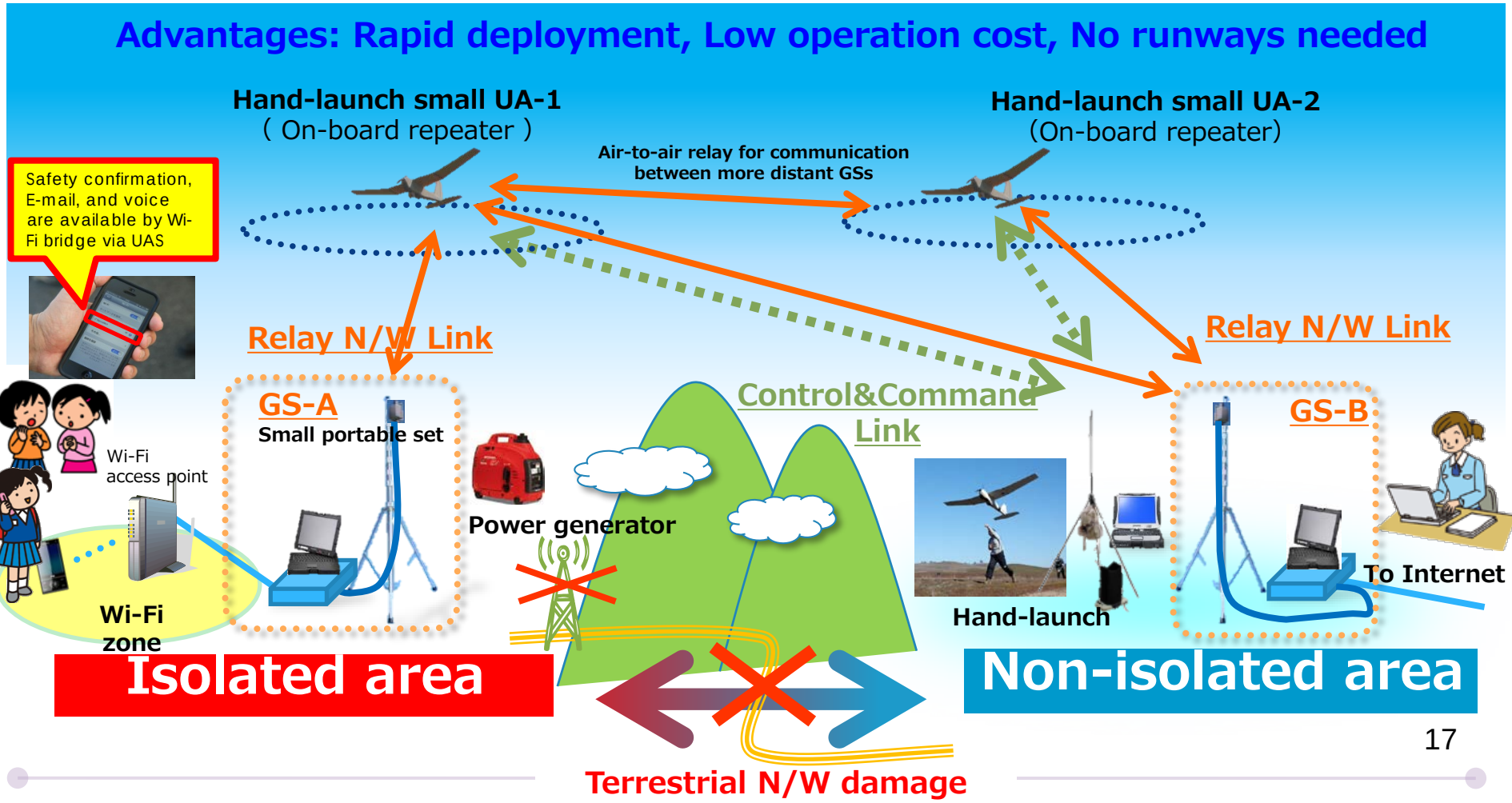
This is the presentation about the spectrum usage and challenges, not on the specific agenda for WRC-19

Examples of wireless system

- Wireless system using small UAS
  - Case 1: UAV-based wireless relay network systems for large-scale natural disasters
  - Case2: Tracking wild boar for measurement of radiation levels
- Wireless system for safety operation
  - Case 3: Location information sharing system of drones beyond-line-of-sight (BLOS)

Case1: Unmanned Aircraft-based Wireless Relay Network

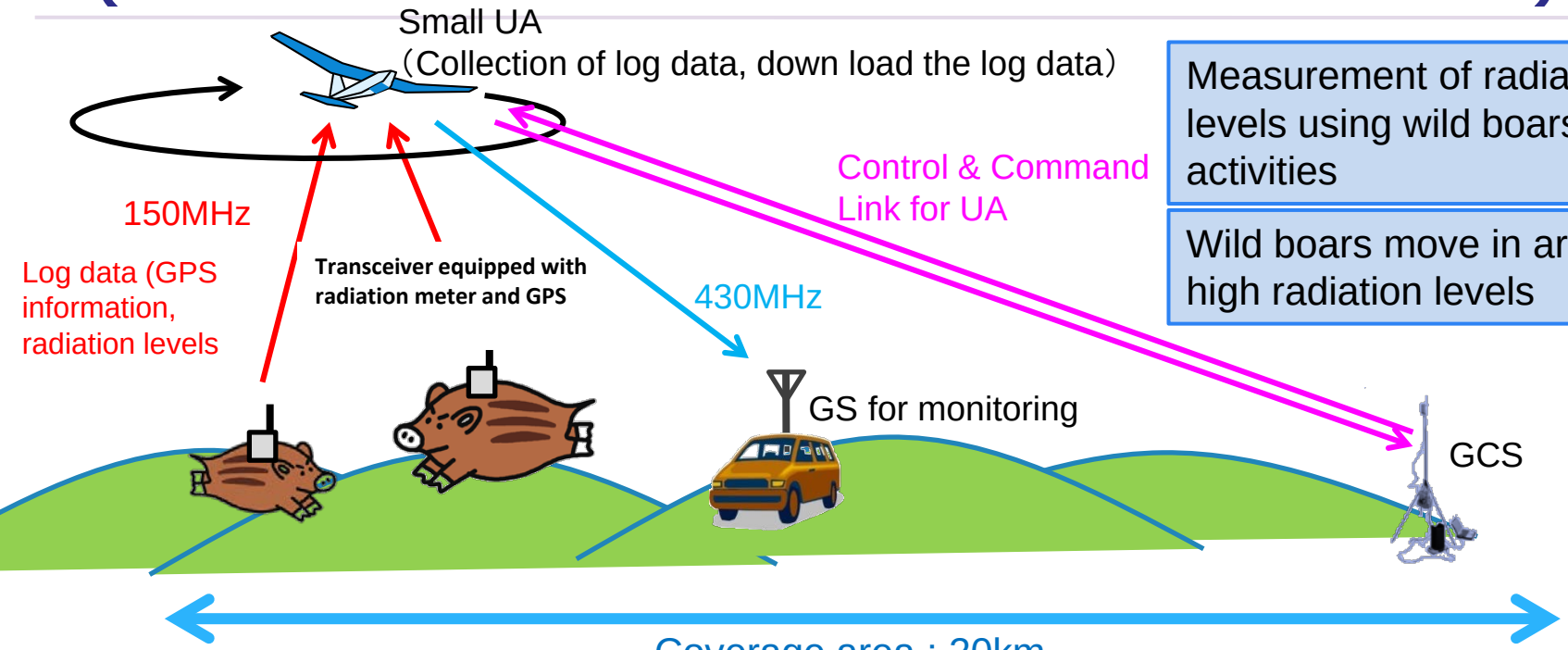
NICT started R&D on disaster-resilient wireless communication system using small unmanned aircraft system (UAS) in order to ensure the communication infrastructure between the isolated and the non-isolated areas at the time of disasters.



Experiment on Mobile Phone Relay System for Isolated Rural Area in Disaster (Feb. 2015)

demonstration video 1

Case2: Demonstration of tracking wild boars (2014.10 Fukushima : difficult-to-return zone)



Measurement of radiation levels using wild boars activities

Wild boars move in area of the high radiation levels

Collar-type transceiver (GPS, 150MHz)

On board receiver

Restricted area
due to the nuclear accident

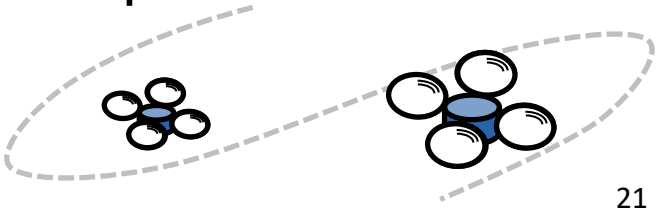
Case3: Location information sharing system for safety operation of Drones beyond-line-of sight (BLOS)

- Background and aim

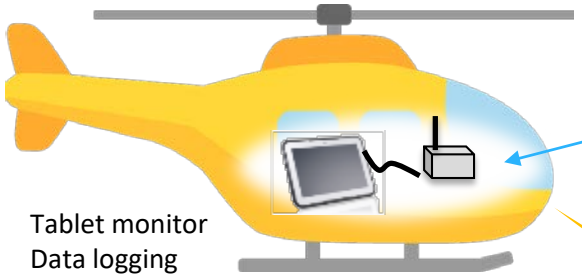
  - There is a growing need for long distance flight BLOS by autonomous flight of small UAs.

  - There is no plan to mandatory to install the ADS-B on drone and VFR manned aircraft.

  - For this reason, an air-to-air communication experiment using low-cost RF devices toward location Information sharing and traffic management for drones and manned helicopters in the same airspace has been conducted.



Air-to-Air Communication Experiment Toward Location Info. Sharing and Traffic Management for Drones and Manned Helicopters in the Same Airspace



Tablet monitor
Data logging

Manned Helicopter
(monitoring the location and ID of nearby drones)

"Drone mapper unit

920MHz band

Drone

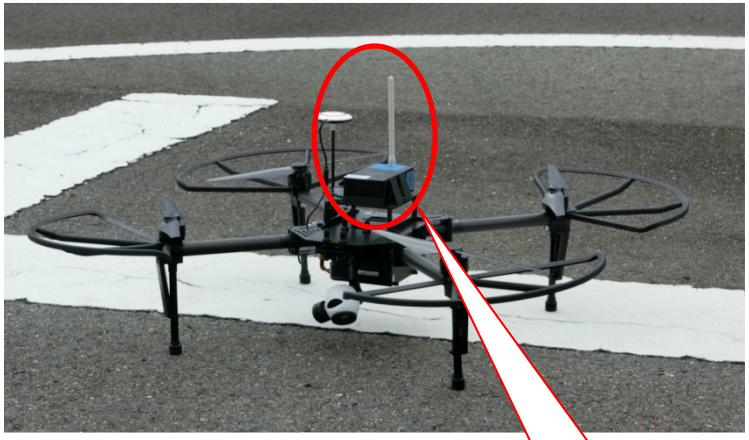
Ground Monitoring Station
(monitoring the location and ID of nearby helicopters and drones)

Tablet monitor
Data logging

Date of Experiment: Mar. 2, 2018
Location : Kiso river area, Aichi Pref., Japan
Organization: NEDO, SKY Perfect JSAT Corporation, Nakanihon Air Service

*This experiment was supported by the DRESS Project of NEDO.

Installation of “Drone Mapper” Units



Installation to Drone

Hand carry into the cabin of helicopter

Drone mapper unit

(920MHz band, 20mW、LoRa moduration)

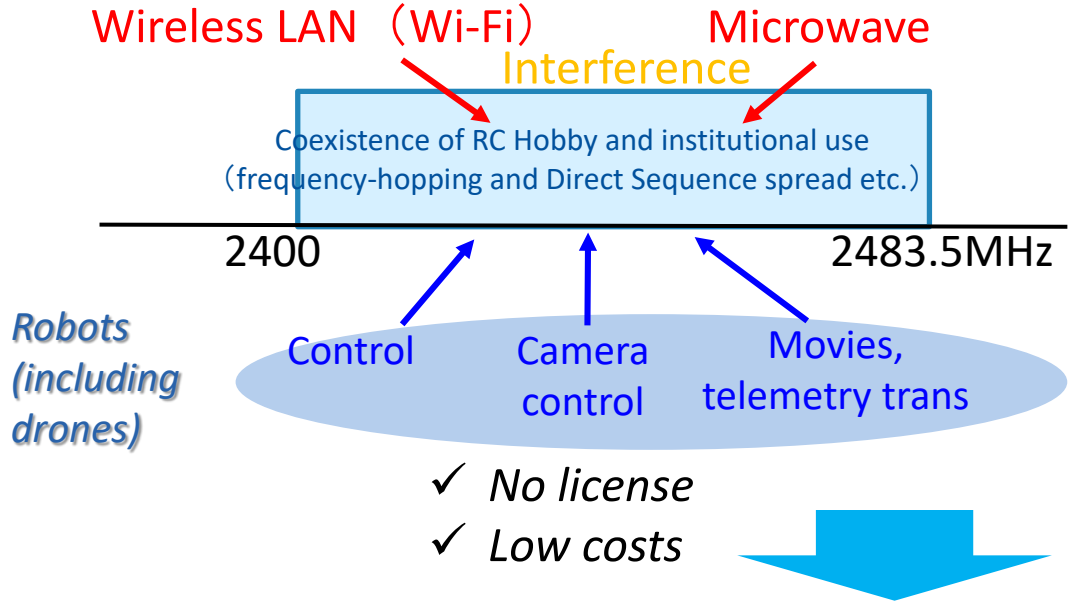
Tablet monitor

demonstration video 2

3 RECENT STATUS OF UAS RADIO REGULATION IN JAPAN

Current Status of Wireless Control Link for Robotics Applications

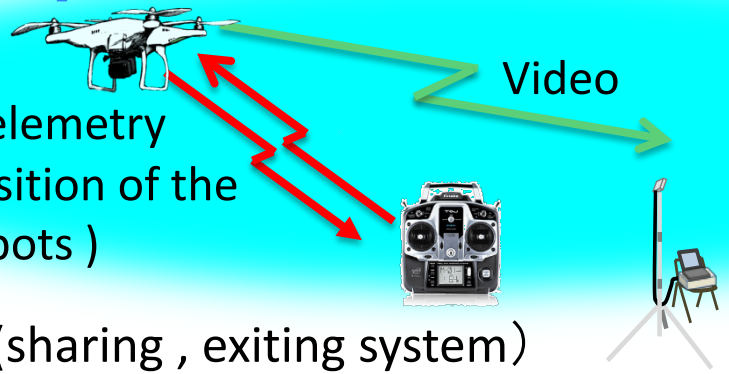
2.4 GHz-band is mainly used （partly 920MHz-band, 73MHz-band）



From website of Wifi Analyzer

- There is no guarantee of connections when congested, therefore the band is not suitable for command and control transmission except video
- The band in not suitable for long distance transmission due to the power limit (within 1km for control, 200-300m for video, telemetry transmission)

New Frequency Allocations for Robot Control



Unlicensed bands (sharing , exiting system）

2.4GHz band （～10mW/MHz, about 84MHz 920MHz band （～20mW, about7MHz）	➢ Short range （～1km） ➢ **No coordination between users**	**As before, hobby and commercial use**

Licensed band (Sharing band, unmanned mobile video tx ; starts in 2016 Sep.)

2.4GHz band （～1W, 10MHz） 5.7GHz band （～1W, 120MHz）	➢ Long range （～5km） ➢ Broadband transmission ➢ **Require coordination between users**	**Mainly video transmission (or command and telemetry)**
169MHz band （～1W, 340+190kHz） （air :10mW ）	➢ Long range （～5km） ➢ Suitable for back-up line ➢ **Require coordination between users**	**Backup line** **5fps video transmission**

Mutual coordination among robot users across different industries in the same area and its surrounding area. And adjustment with business entities other than robots that use the same frequency band for safety radio operations

From the draft report by Ministry of Internal Affairs and Communication Information Council Robot Working Group

http://www.soumu.go.jp/main_content/000395485.pdf

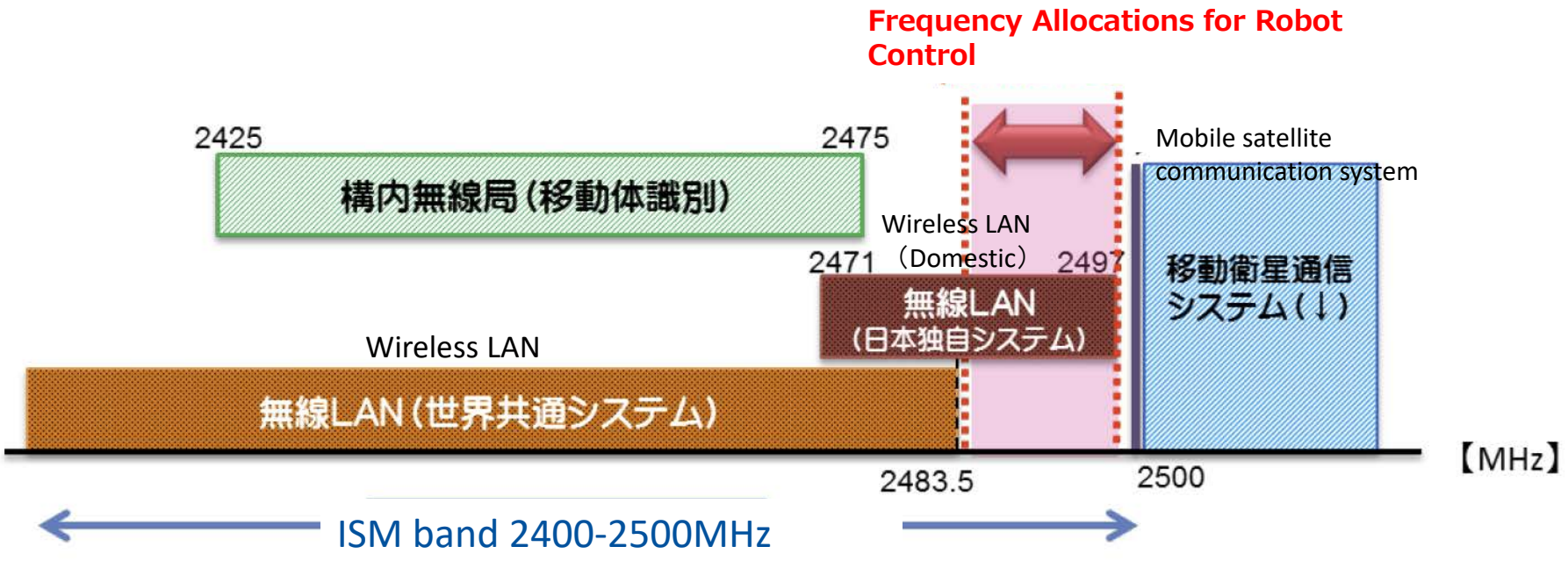


Figure Frequency allocation of 2.4GHz band

New Frequency Allocation in 5.7GHz Band

http://soumu.go.jp/main_content/000395485.pdf

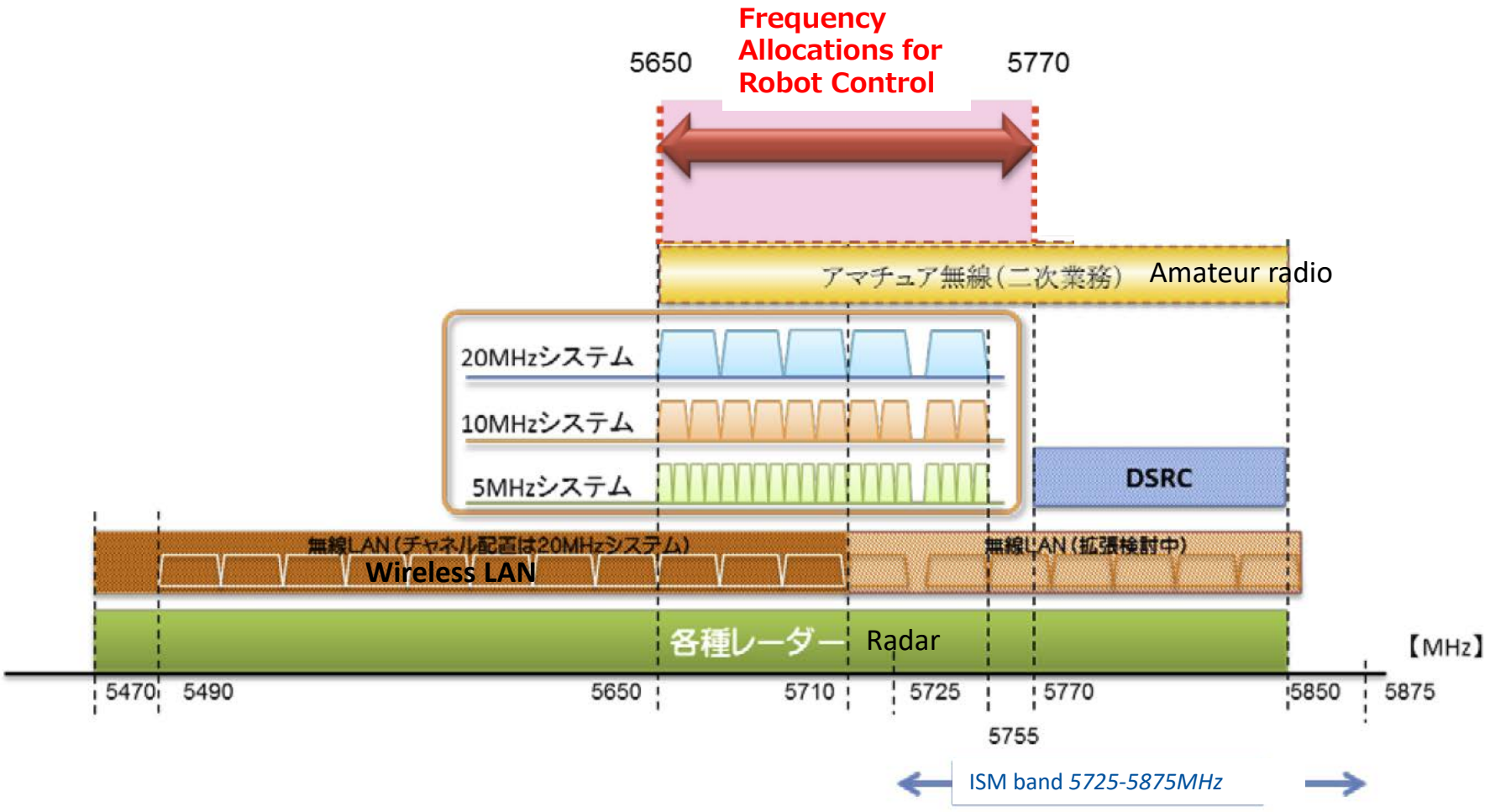


Figure Frequency allocation of 5.7GHz band

New Frequency Allocation in 169MHz Band

http://www.soumu.go.jp/main_content/000395485.pdf

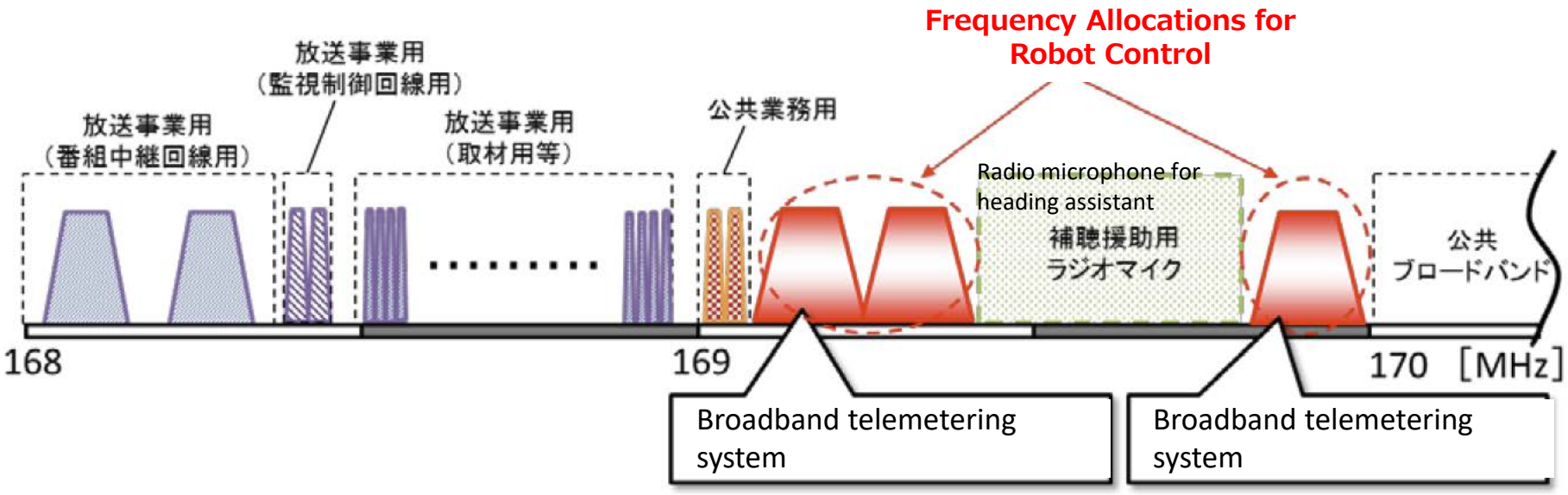


Figure Frequency allocation of 169MHz band

. Conclusions

- On-board Ka band tracking antenna for unmanned aircraft system
  - Status of current standardization
  - We evaluated the antenna system using actual airplane and a satellite
  - We have been evaluating the propagation characteristics between UAS and satellites in Ka-band.
- We developed and tested UAV-based wireless relay network systems in natural disasters
- Location information sharing system for safety operation of drones beyond-line-of-sight
- Recent Status of UAS radio regulations in Japan
  - New frequency bands are allocated for robots and UAS
  - However, more the frequency allocations and high-reliability links are required for safety operations of UAS
  - Research and development of UAS traffic management (UTM) has begun in Japan.

Thank you for your kind attention