

Spectrum issues and challenges, not on the specific agenda for WRC-19

Development of Wireless Link Applications for Small UAS in Japan

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(Revised version)

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

Contents

1. Background of UAV Wireless Communication Systems
2. Development of UAV-based wireless relay network system in natural disasters
3. Recent UAS radio regulation status in Japan
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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.
 - ▶ The definition of **internationally standardized system** is required under the footnote 5.443C of ITU-R Radio Regulations
 - ▶ Several discussions on UAS frequency usages including channel plan are carried out in ICAO
 - ▶ NICT is interested in usage of the frequency band 5030–5 091 MHz for CNPC link which realizes safe operations of small UAs in a short range with small transmission power.

Background-2

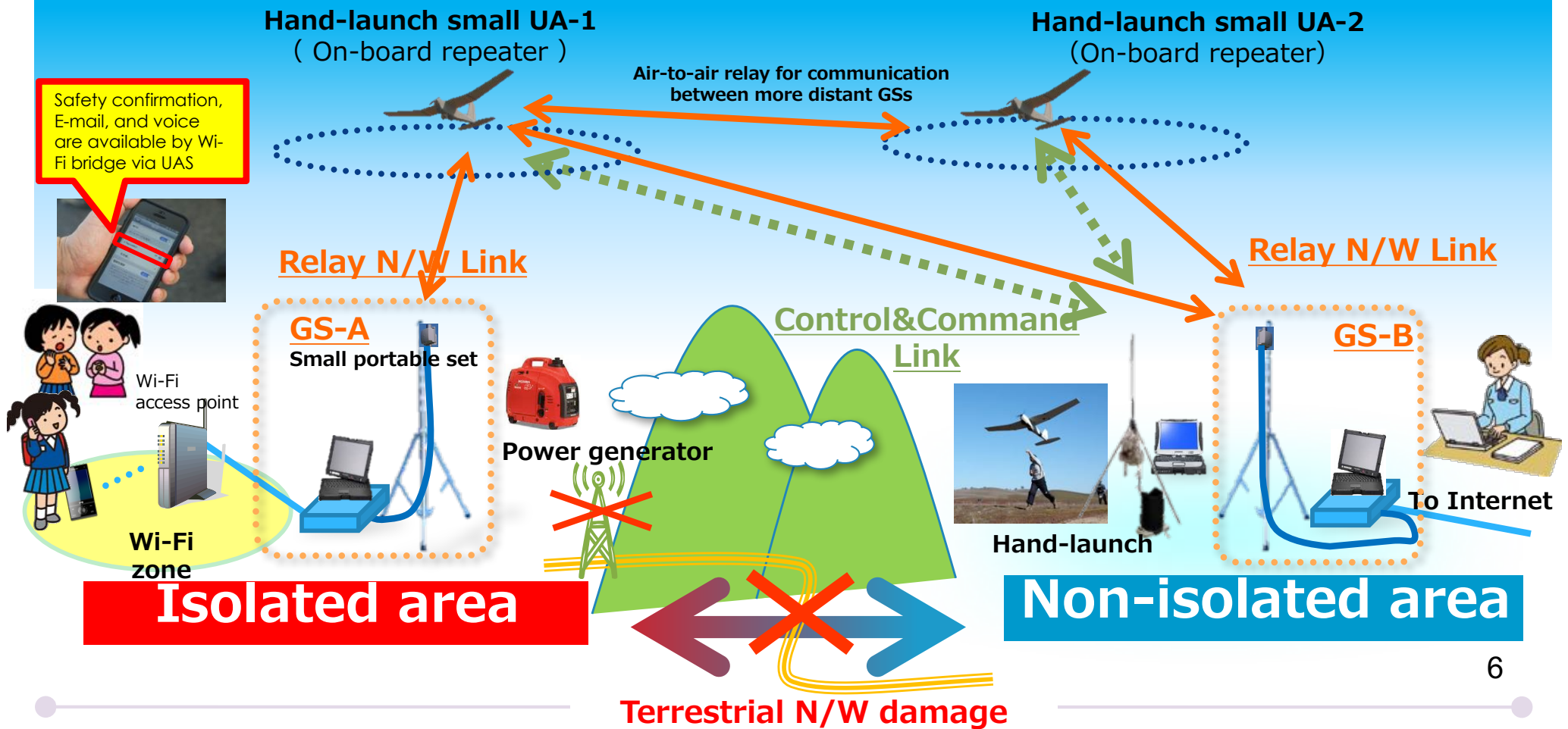
- In past large-scale disasters in Japan, many areas in mountains or islands were isolated due to the total damage of roads, harbors, and communication infrastructures by earthquake and tsunami.
 - Many people left behind on the isolated area have mobile phone and mobile terminal, but they could not work sufficiently due to the broken of backbone network.
- The demand of wireless relay network using unmanned aircraft system has grown
- Now, 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

2. DEVELOPMENT OF UAS WIRELESS RELAY NETWORK

Solution: 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.

Advantages: Rapid deployment, Low operation cost, No runways needed

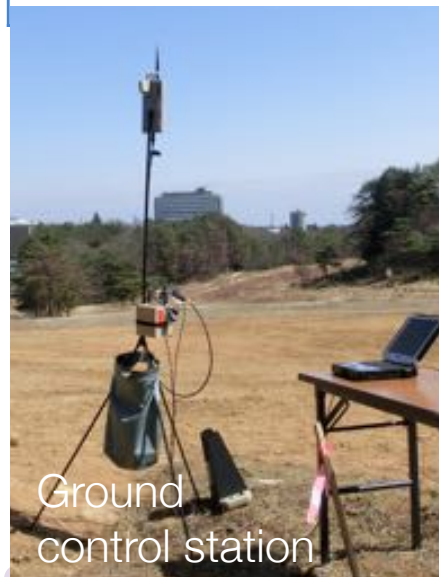


Case-1 Experiment on Mobile Phone Relay System for Isolated Rural Area in Disaster (Feb. 2015)

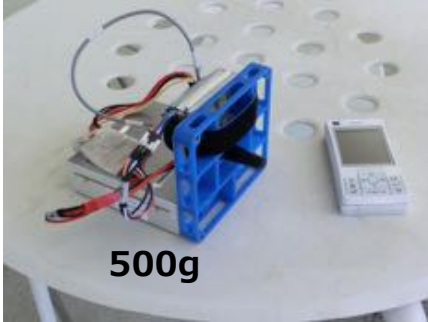




Fixed-wing small UA

Name	Puma AE, Aeroviroment corp. USA
Wingspan, Weight	2.8 m, 5.9 kg
Structure	modular, Kevlar™ composite
Airspeed range	20-40 knots
Payload	Maximum : 0.5 kg
Nominal endurance	about 3 hours
Control range	9 km(2GHz)/ 7 km(5GH)
Wind speed	Maximum: 25 knots
Ceiling altitude	Maximum: 5 km
Control frequency, Signal power	2GHz/5GHz(5035MHz-5085MHz), 1W/0.1 (Experimental test station)



Payload for relaying the data

<p>Pictures</p>	<p>2GHz on-board repeater</p>  <p>500g</p>	<p>Transceiver of GS</p> 	<p>Antenna of 2GHz-band GS</p> 
<p>Frequency</p>	<p>2 GHz (Experimental)</p>		
<p>Bandwidth</p>	<p>8 MHz</p>		
<p>Signal power</p>	<p>2 W</p>		
<p>Modulation</p>	<p>MSK/TDMA/TDD</p>		
<p>MAC</p>	<p>TDMA/TDD, 33 msec/frame</p>		
<p>Antenna for GS</p>	<p>planar patch antenna</p>		
<p>Antenna for On-board</p>	<p>$\lambda/4$ whip antenna</p>		
<p>Data rate/Throughput</p>	<p>6 Mbps/400 kbps</p>		
<p>Frame synchronization</p>	<p>1PPS by GPS</p>		



Please see also [demonstration video](#)





Demonstration Examples of Wireless Relay System using UAS

- Utilization in agriculture, tracking of wild animal, monitoring of environmental level, and disaster medical by using on-board video camera or on-board transponder
- We have conducted on the demonstration and experimental measurement all over JAPAN
- Total number of flights is over 200 times, total flight time is over 100 hours.

NICT has submitted an application form for permission of flight or a report form for flight with domestic aviation act accordingly to the place and flight altitude.


Memuro	Hokkaido
Date	June 2014
UA type	2GHz CNPC UA
Project	Small UA utilization in Agriculture Video image of potato field
	 
	EO camera on UA IR camera on UA

Sakaide	Kagawa
Date	May 2014, May 2015
UA type	2GHz CNPC UA, 5GHz CNPC UA
Project	Small UA utilization of Disaster Medical Assistance Team (DMAT)
	 
	DMAT



Shimanto	Kochi
Date	Feb. 2015
UA type	5GHz CNPC UA
Project	Demonstration experiment of collaboration of UA based wireless relay with the mobile operators network via femto cell

Shirahama	Wakayama
Date	March 2014
UA type	2GHz CNPC UA
Project	Demonstration experiment of UA based wireless relay in disaster

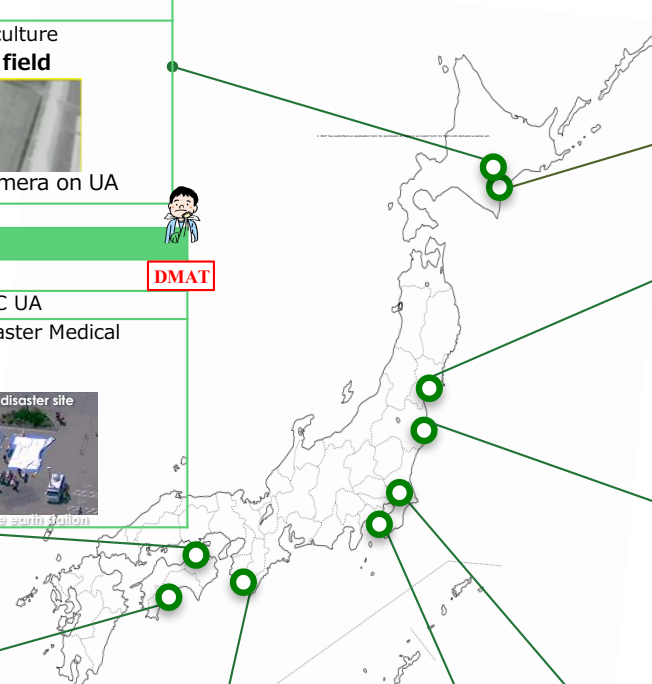
Syonan village	Kanagawa
Date	March 2013
UA type	2GHz CNPC UA
Project	Flight training

Taiki	Hokkaido
Date	June 2013, Nov. 2013
UA type	2GHz CNPC UA
Project	Long-distance relay test (rural area)
	

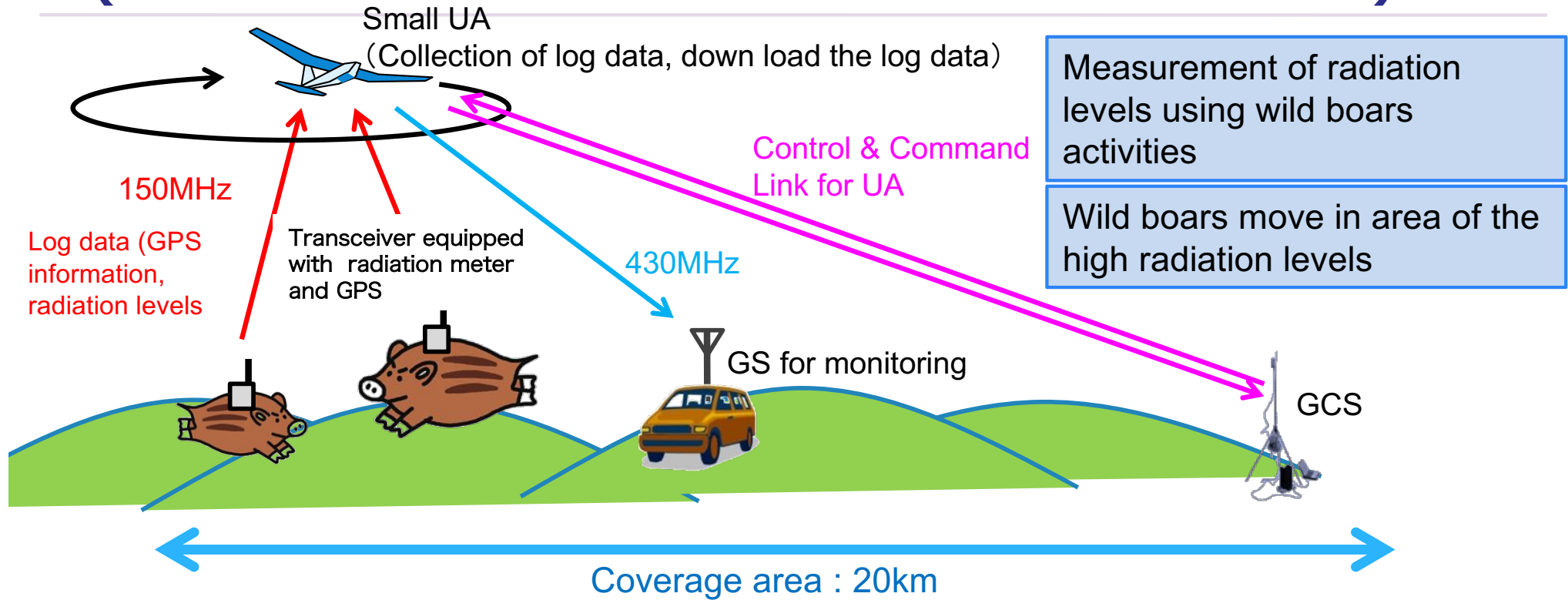
Sendai	Miyagi (Tohoku Univ.)
Date	March 2013, July 2013, July 2014
UA type	2GHz CNPC UA
Project	Demonstration, UA based wireless relay test in disaster, Long-distance relay test (city area)

Tomioka	Fukushima
Date	Oct. 2014
UA type	2GHz CNPC UA
Project	Tracking of wild boars in the restricted residence area by radioactive materials
	 

Ootone airport	Ibaraki
Date	Dec. 2013, Dec. 2014
UA type	2GHz CNPC UA
Project	Interview of TV program "WBS" on TVTOKYO, etc.



Demonstration: Tracking wild boars (2014.10 Fukushima : difficult-to-return zone)



Collar-type transceiver (GPS, 150MHz)



On board receiver



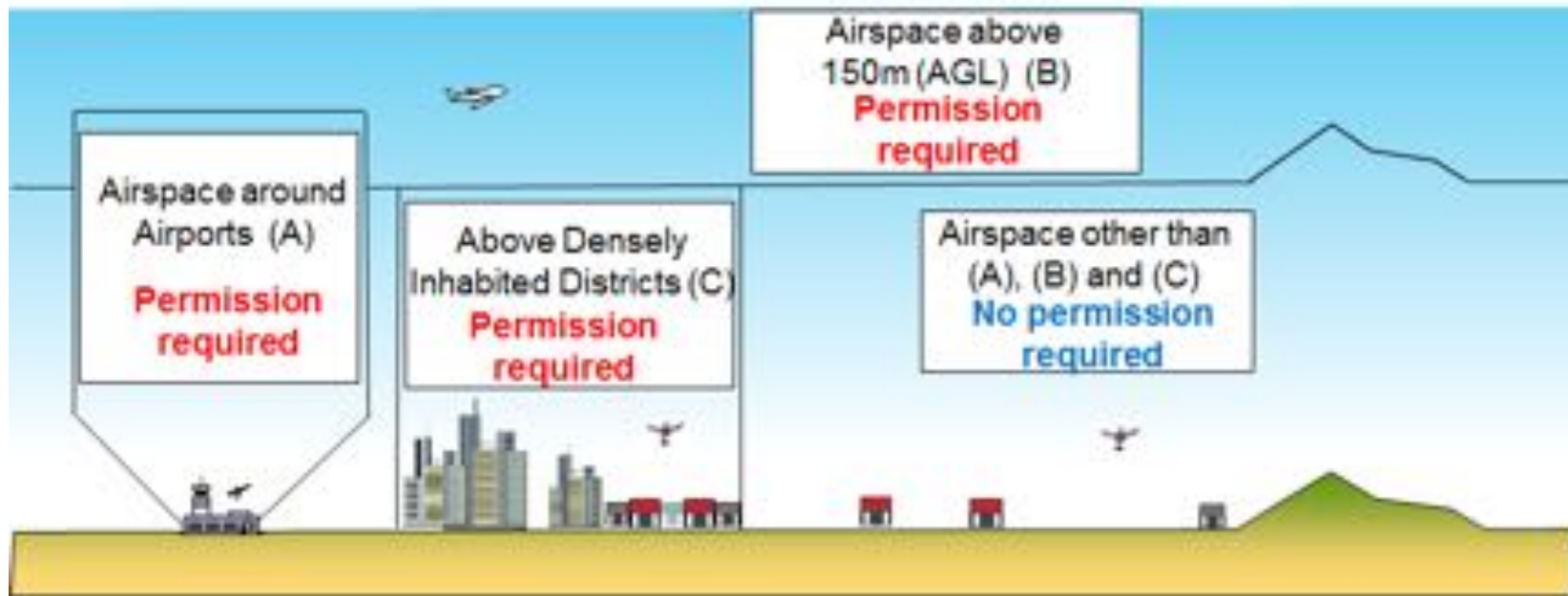
Restricted area due to the nuclear accident

3 RECENT STATUS OF UAS RADIO REGULATION IN JAPAN

Japan's new safety rules on Unmanned Aircraft (UA)/Drone from Dec. 10 2015.

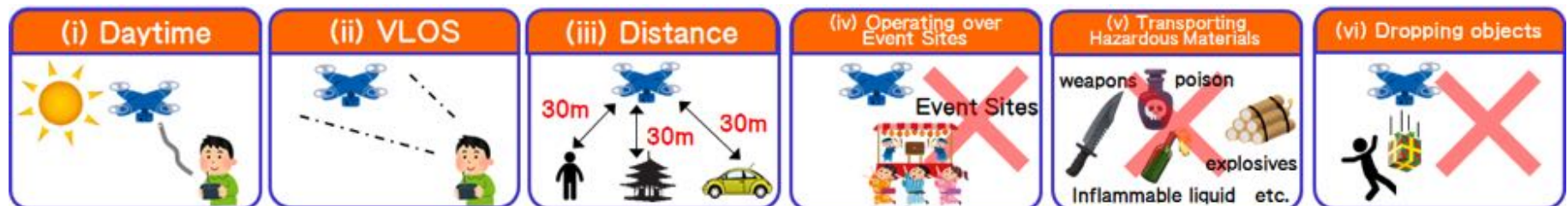
Definition and Prohibited Airspace for Flight

The term "UA/Drone" means any airplane, rotorcraft, glider or airship which cannot accommodate any person on board and can be remotely or automatically piloted (Excluding those lighter than 200g. The weight of a UA/Drone includes that of its battery.).



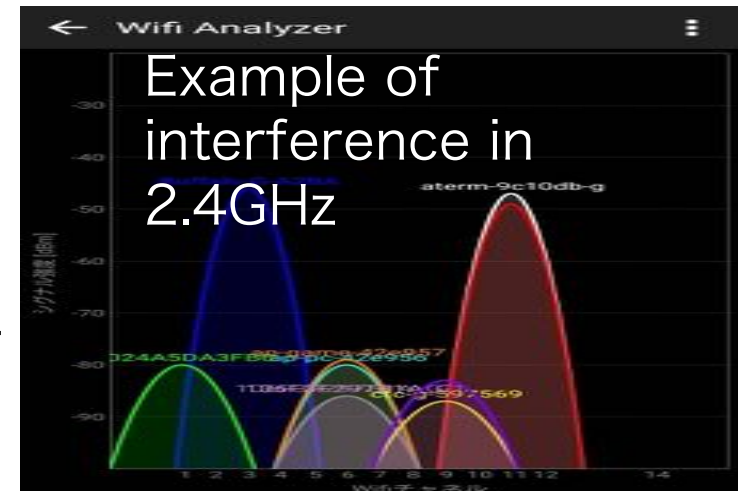
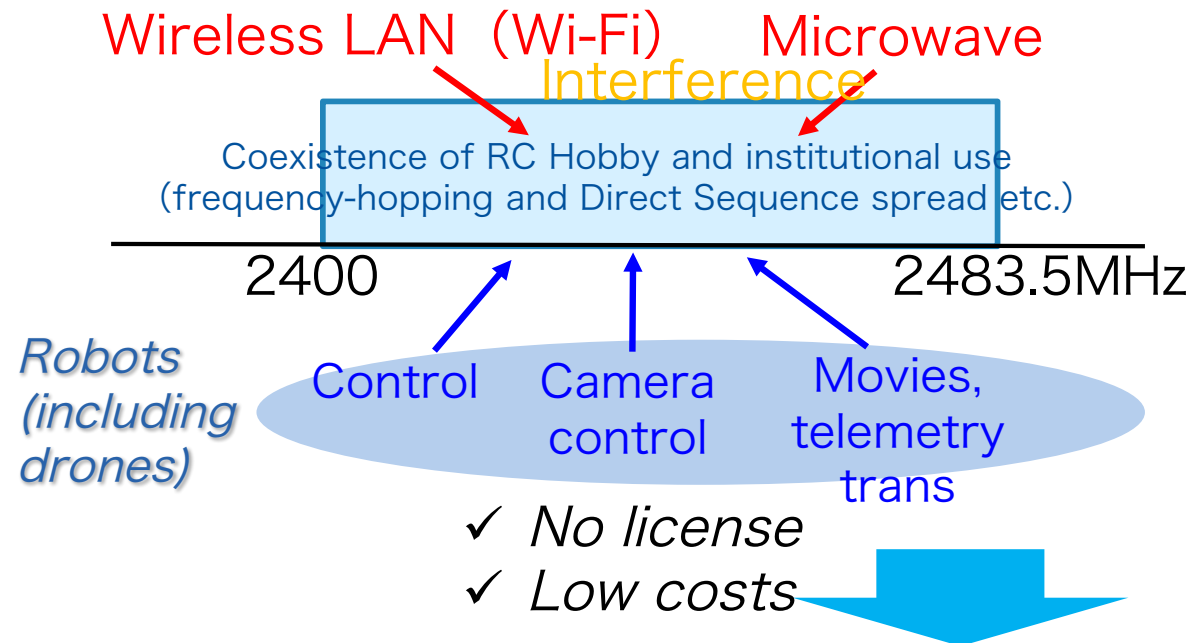
Conceptual Airspace

Operational Limitations



Current Status of Wireless Control Link for Robotics Applications

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

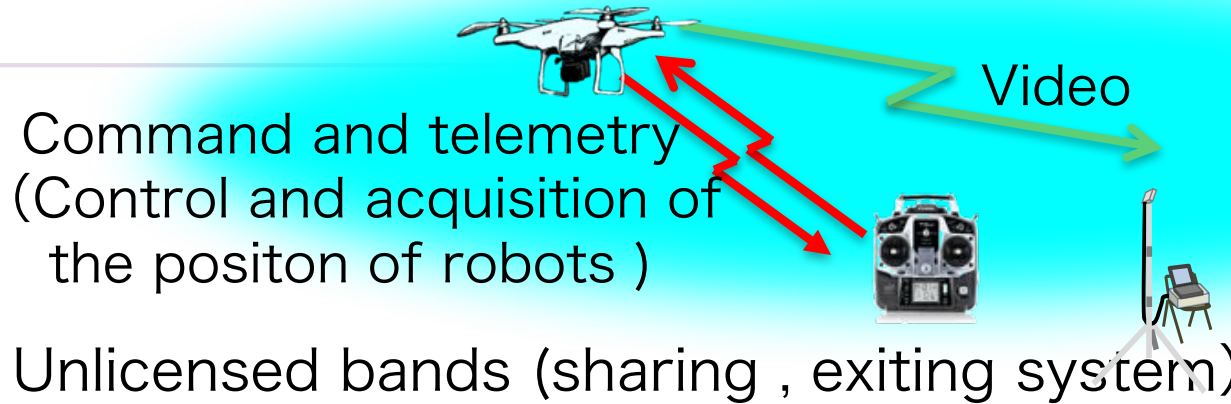


- There is no guarantee of connections when congested, therefore the band is not suitable for command and control transmission except video
- The band is not suitable for long distance transmission due to the power limit (within 1km for control, 200-300m for video, telemetry transmission)

For example



New Frequency Allocations for Robot Control



2.4GHz band (~10mW/MHz, about 84MHz)

920MHz band (~20mW, about 7MHz)

- 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)

169MHz band (~1W, 340+190kHz)

(air :10mW)

- Long range (~5km)
- Broadband transmission
- **Require coordination between users**

Mainly video transmission (or command and telemetry)

- 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

Frequency Allocations for Robot Control

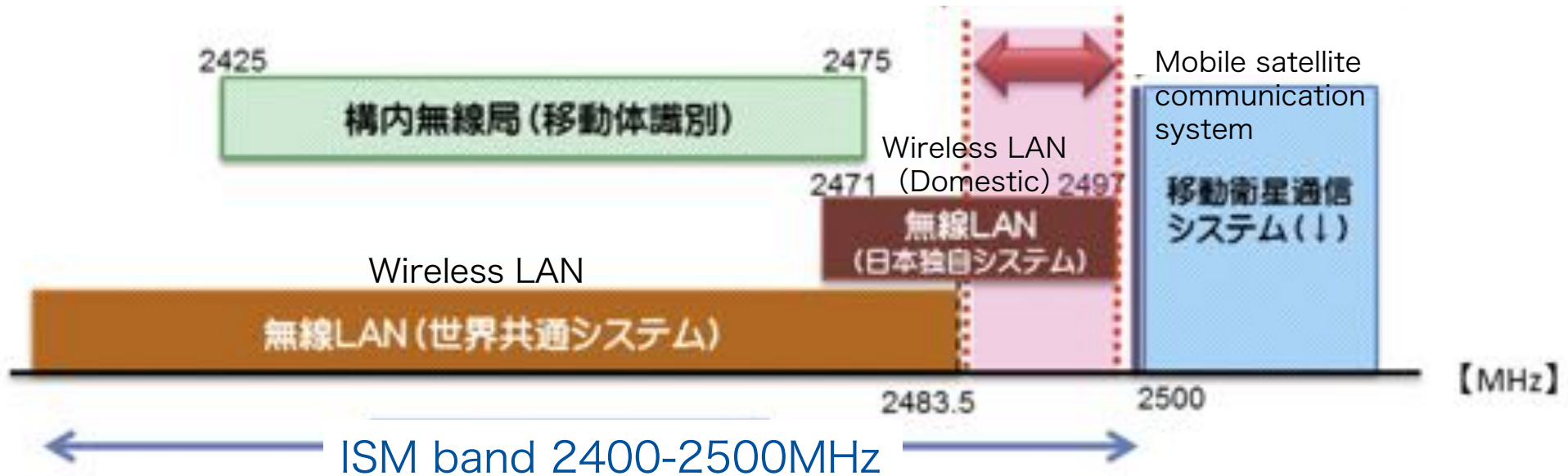
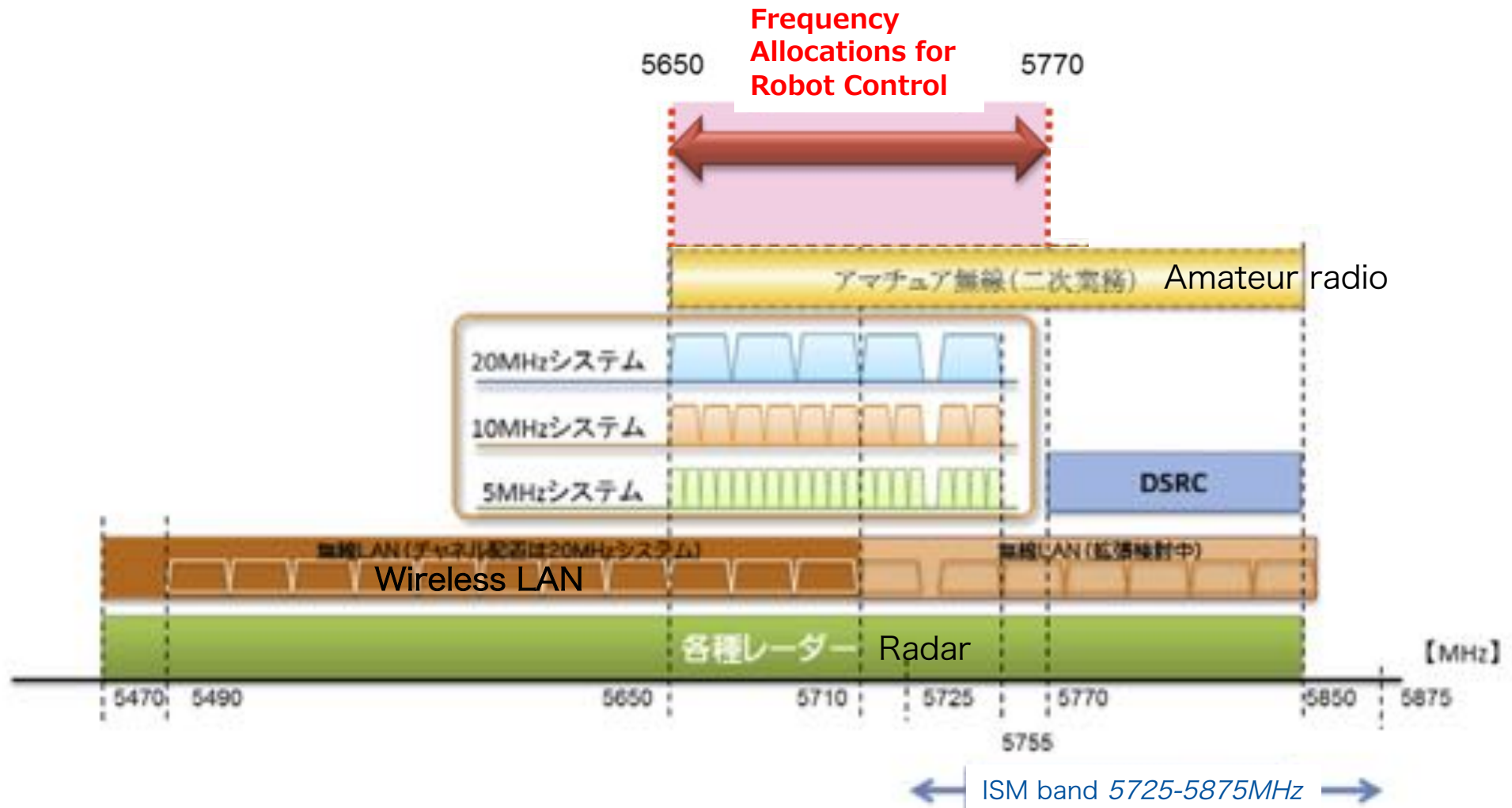


Figure Frequency allocation of 2.4GHz band

New Frequency Allocation in 5.7GHz Band

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



ISM band 5725-5875MHz

Figure Frequency allocation of 5.7GHz band

New Frequency Allocation in 169MHz Band

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

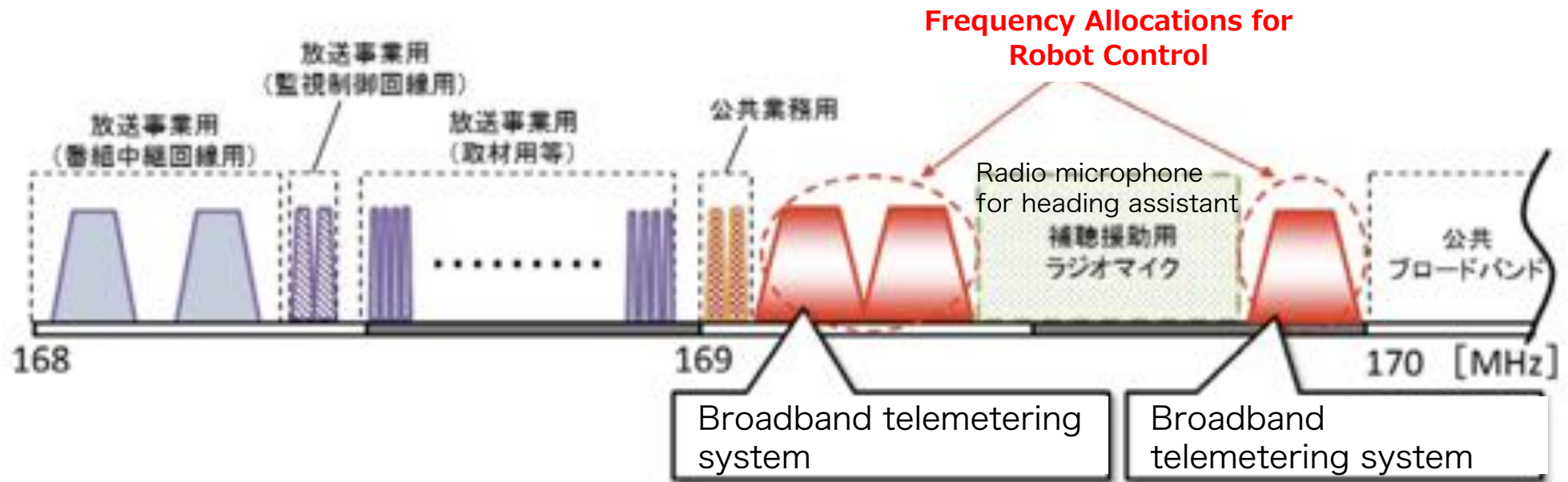


Figure Frequency allocation of 169MHz band

Conclusions

- We developed and tested UAV-based wireless relay network systems in natural disasters
- Recent Status of UAS radio regulations in Japan
 - New frequency bands are allocated for video transmission of robots and UAS, not CNPC
 - However, the frequency allocation of CNPC is required for safety operation of small UAS

Thank you for your kind attention

