Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Harmonization in Ultra Wide Band(UWB) Regulation for both Scientific and Commercial Radio Usages]

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Re: []

Abstract: [This document introduces some activities to harmonize variable applications of UWB radio and other coexisting radio which have been presented in URSI(International Union of Radio Science since 2011.]

Purpose: [information]

Harmonization in Ultra Wide Band(UWB) Regulation for both Scientific and Commercial Radio Usages

Global Regulatory Compliance for UWB Medical Healthcare and ITS Coexisting with Scientific Radio Uses for EES & RAS

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CWC, University of Oulu, Finland

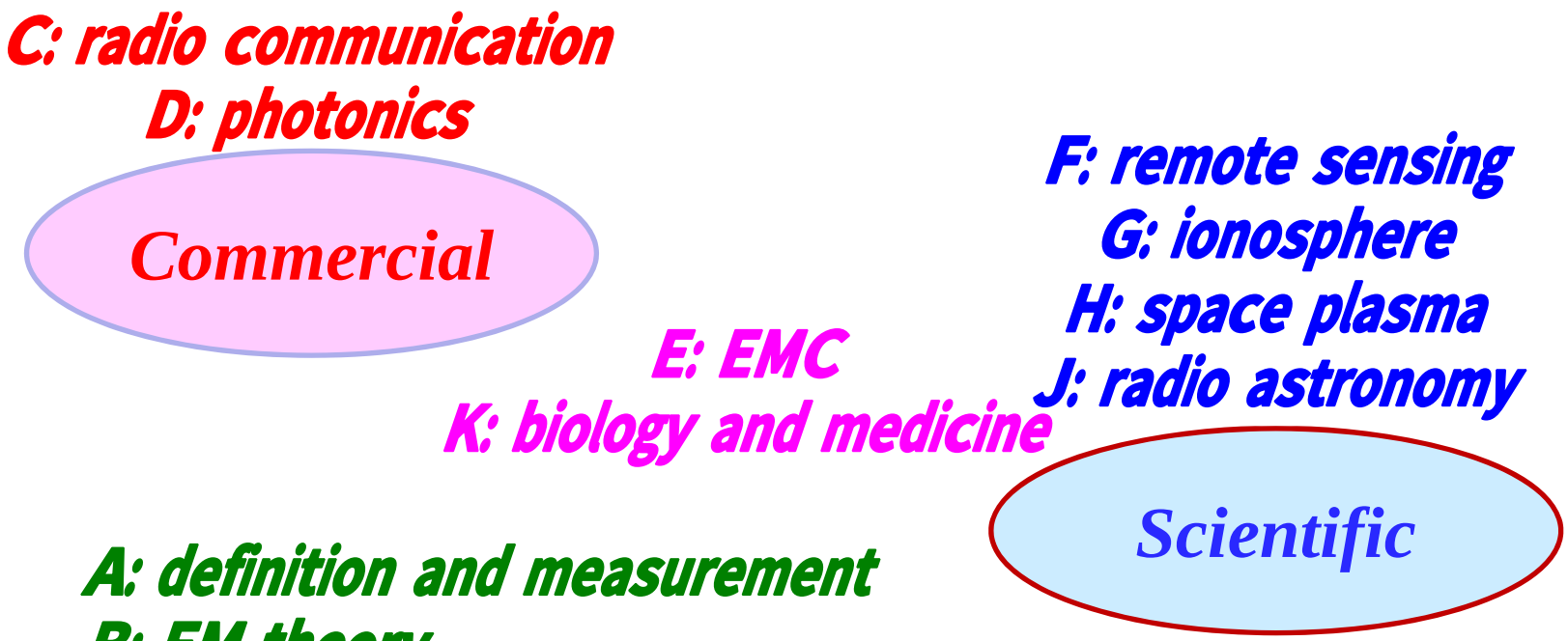
Ref. **URSI (International Union of Radio Science)**
1. Keynote Speech URSI-GASS 2011: Istanbul, Turkey Aug.18, 2011
2. Plenary Keynote Speech, URSI AP-RASC 2013 Taipei, Taiwan, Sept. 4, 2013
3. Keynote Speech, URSI-JRSM 2015, TIT, Tokyo, Sept. 4th, 2015

Necessary Harmonization between Scientific and Commercial Radio Uses

- According to increase of radio uses, relationship between primary and secondary users is not simple unlike last decays.
- Frequency spectrum = common resource
- Regulation should play an important role to harmonize among
  - Commercial radio services
  - Scientific and other non-commercial services

Different Points of View in URSI Commissions A-K for Scientific & Commercial Uses

Wide spectrum of scientists related to this issue



Ref. URSI (International Union of Radio Science)
https://www.ursi.org/homepage.php

Harmonization of Ultra Wide Band(UWB) Regulation for both Scientific and Commercial Radio Usages

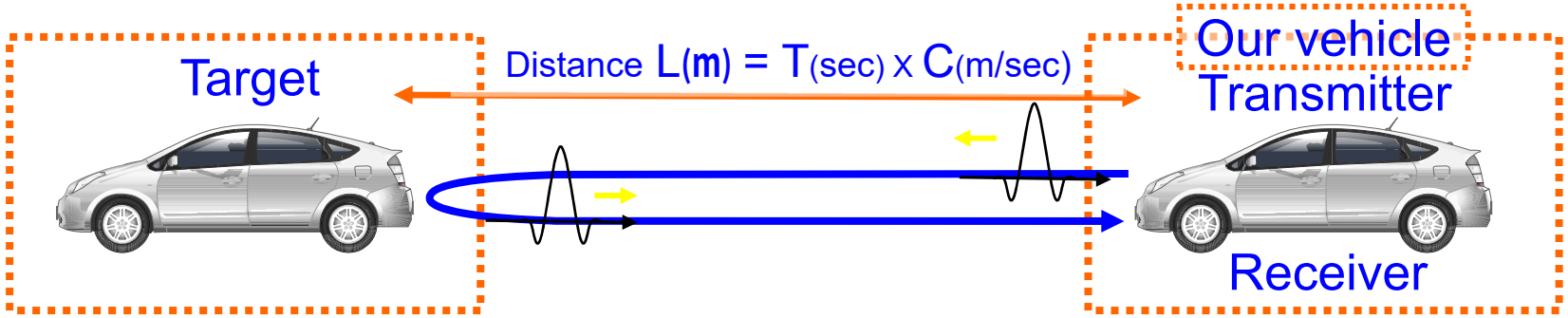
Global Regulatory Compliance for UWB Medical Healthcare and ITS Coexisting with Scientific Radio Uses for EES & RAS

1. R&D & Standard of UWB Systems
1.1 Ultra Wide Band(UWB) Radio
1.2 UWB Applications e.g. PAN, BAN, RFID and ITS
2. Regulation for UWB Systems
2.1 Japanese Regulation for UWB
2.2 Global Regulation for UWB
3. Remained Problems in Global Regulation for UWB
4. Solution by Regulatory Science

Major Applications of UWB

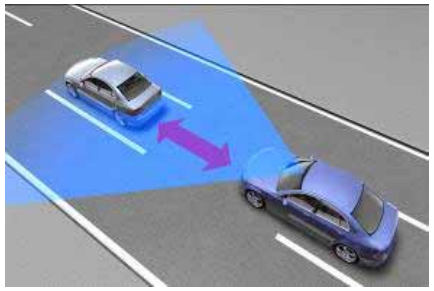
1. **Wireless Peripheral for Personal Computer**: wireless connection between CPU and other I/O, Hard-disk
2. **Wireless Connections for Consumer Electronics**: TV, Audio/Video, non-communication equipment's.
3. **Wireless Gateway between infrastructure and ad-hoc network by Cell-phones**: multi-hop for extension of coverage, ubiquitous connection etc.
4. **Intelligent Transport Systems(ITS):** Collision Avoiding Car Radar, Inter-vehicular networks, Car LAN
5. **Wireless Sensor Network:** 2nd Generation of RFID tag, security system, disaster preventing sensor network etc.
6. **Medical Applications: Medical Body Area Network (BAN)** for medical vital sensing and remote controlling

UWB Impulse Radar for Intelligent Transport Systems (ITS)

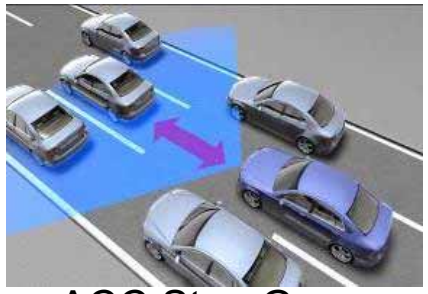


- ITS: Intelligent Transport Systems
  - Colision avoidance radar (in 22-29GHz and 79GHz)
  - Realization of both communication and ranging with a single hardware
  - The shorter time duration of a pulse, the higher resolution of ranging performs.
  - The higher peak a pulse, the longer distance can be ranged.

Possible Safety Applications Based on UWB Short Range Radar (SRR)

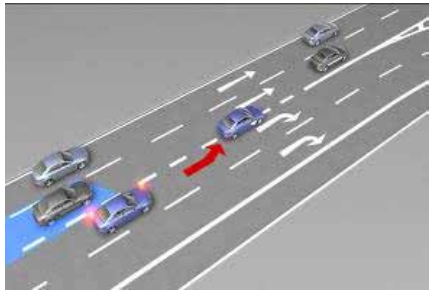


Adaptive Cruise Control (ACC)

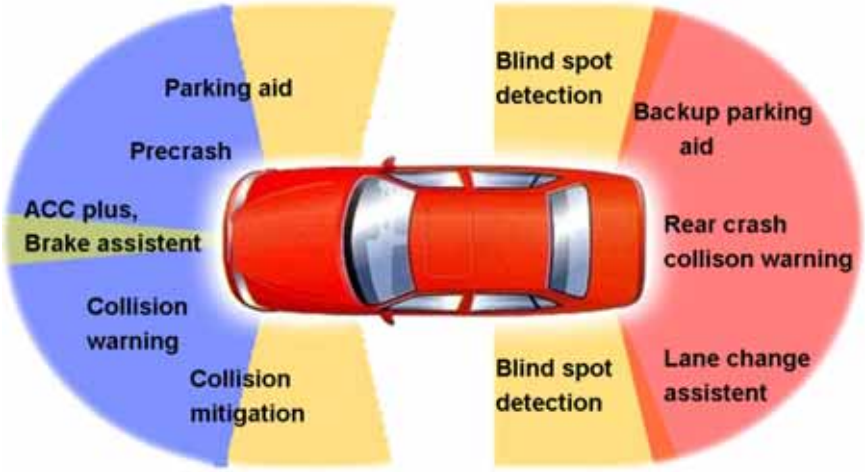


ACC Stop Go Collision Mitigation / Precrash

Park Assist



Blind Spot Detection



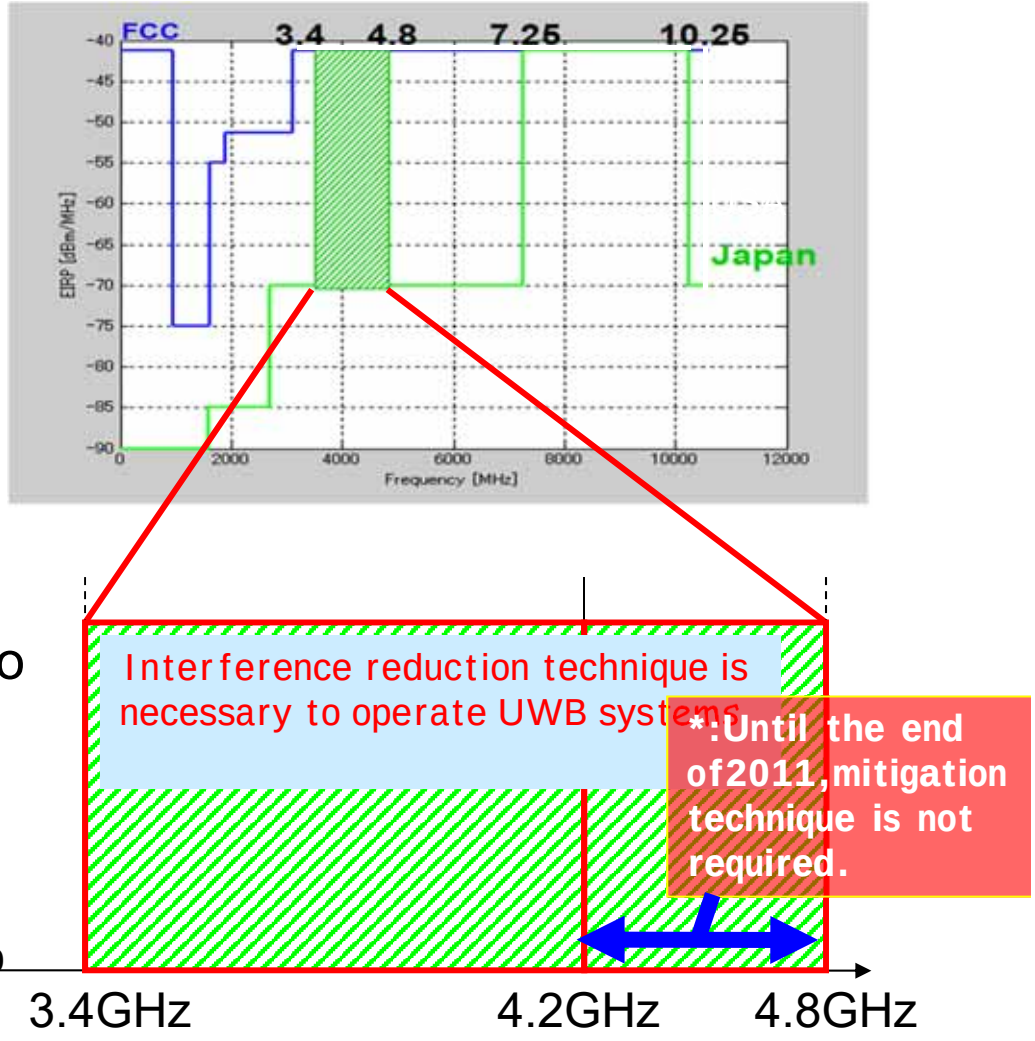
Lane Change Assist

Multiple applications with one kind of sensor or radar possible

Regulation on Microwave-band UWB

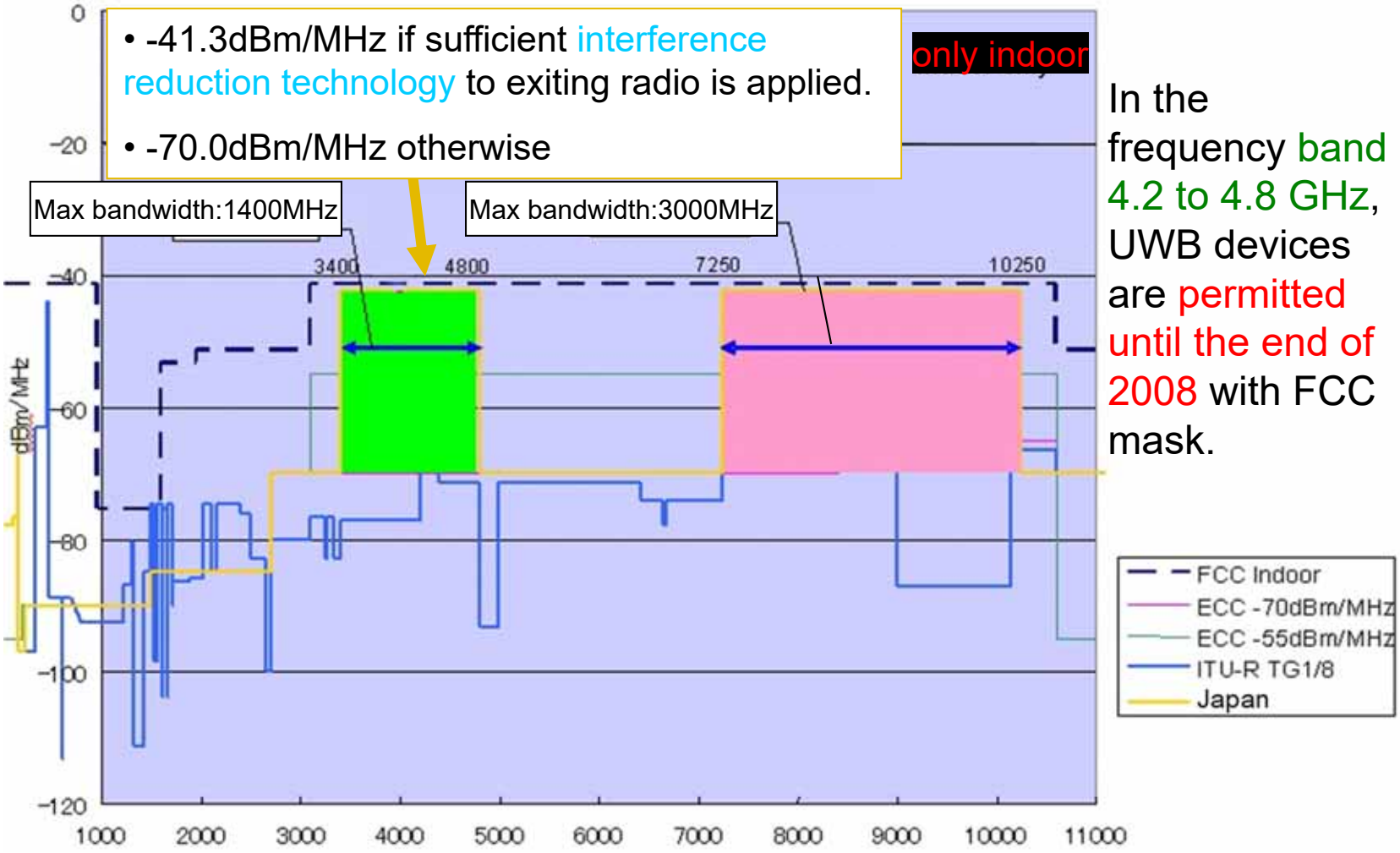
- **USA (FCC spectrum mask)**
  - Level: -41.3dBm/MHz
  - No interference mitigation technology is required.

- **Japanese regulation**
  - Level: -41.3dBm/MHz
  - **Requirement**: a technology to reduce UWB interference to existing radio systems
  - **Note: European regulation** also requires an interference reduction technique to protect existing radio systems.



Japanese Spectrum Mask (MIC)

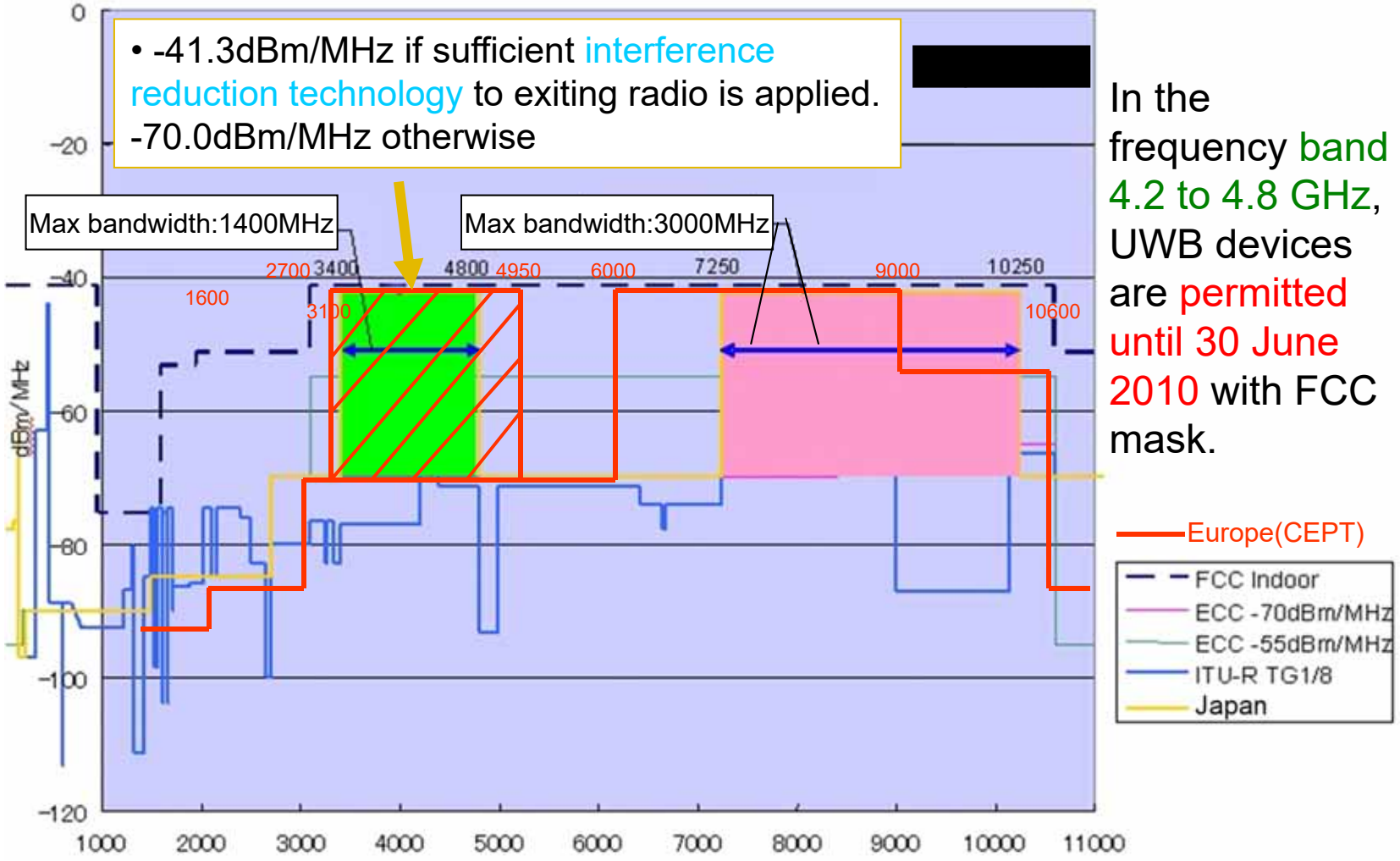
(March 27, 2006) was officially approved.



In the frequency band 4.2 to 4.8 GHz, UWB devices are permitted until the end of 2008 with FCC mask.

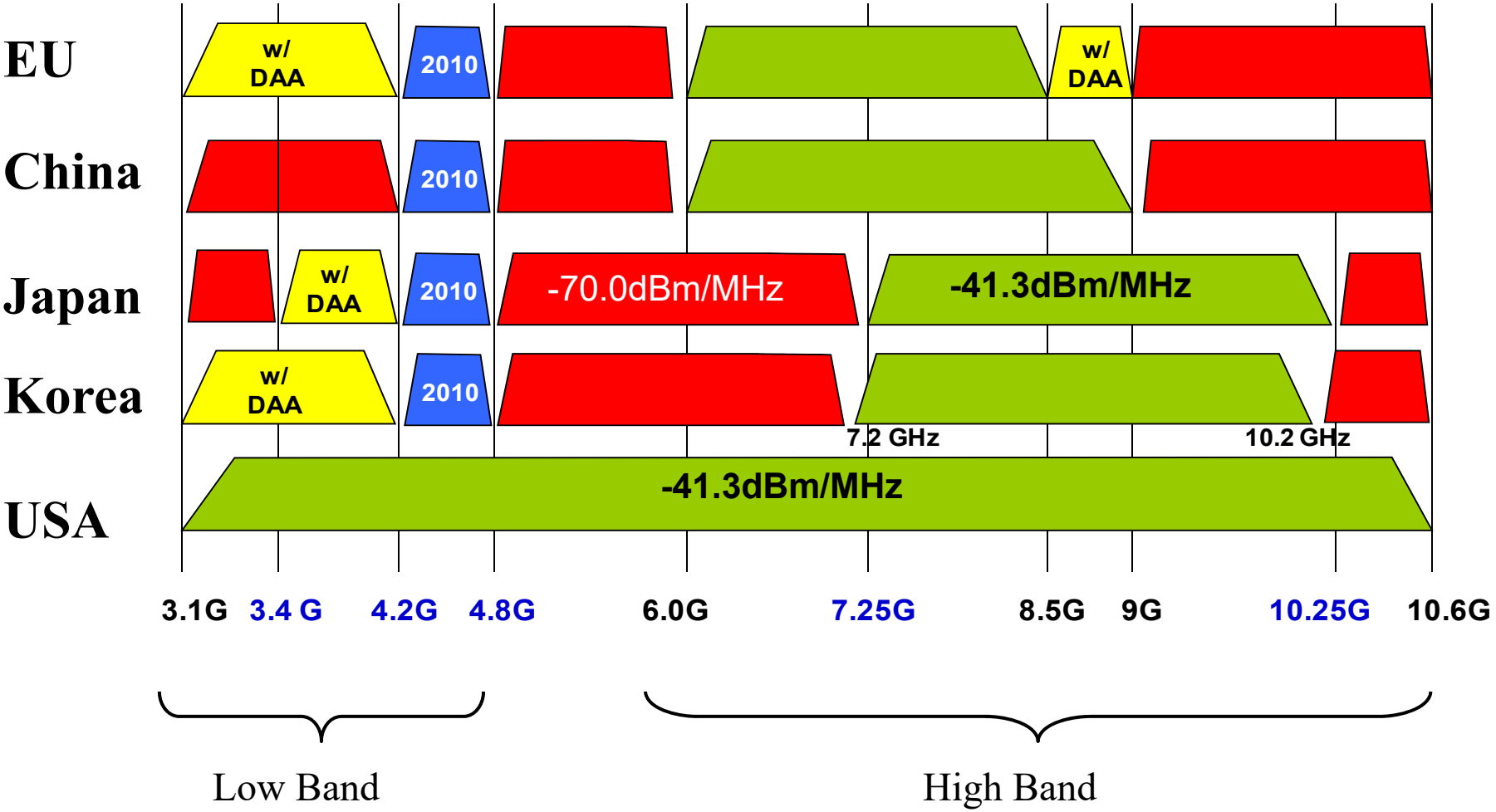
European Spectrum Mask (CEPT)

(June, 2006)



In the frequency band 4.2 to 4.8 GHz, UWB devices are permitted until 30 June 2010 with FCC mask.

World Wide UWB Regulation



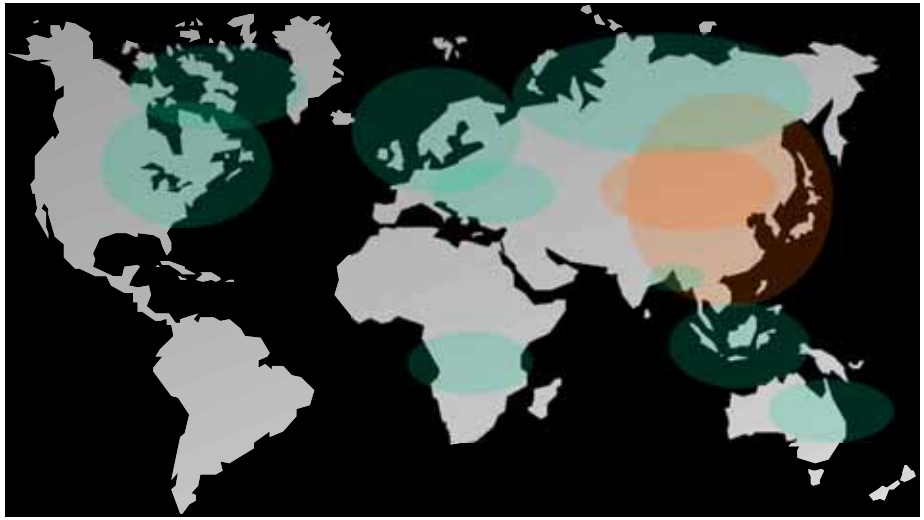
Global Frequency Allocation for 24 GHz UWB Short Range Radar (SRR)

1. UWB SRR already used

- US: February 2002
- EU: January 2005
- Russia: July 2008
- Australia: July 2006
- Singapore: December 2007
  - 22 – 29 GHz and 79 GHz

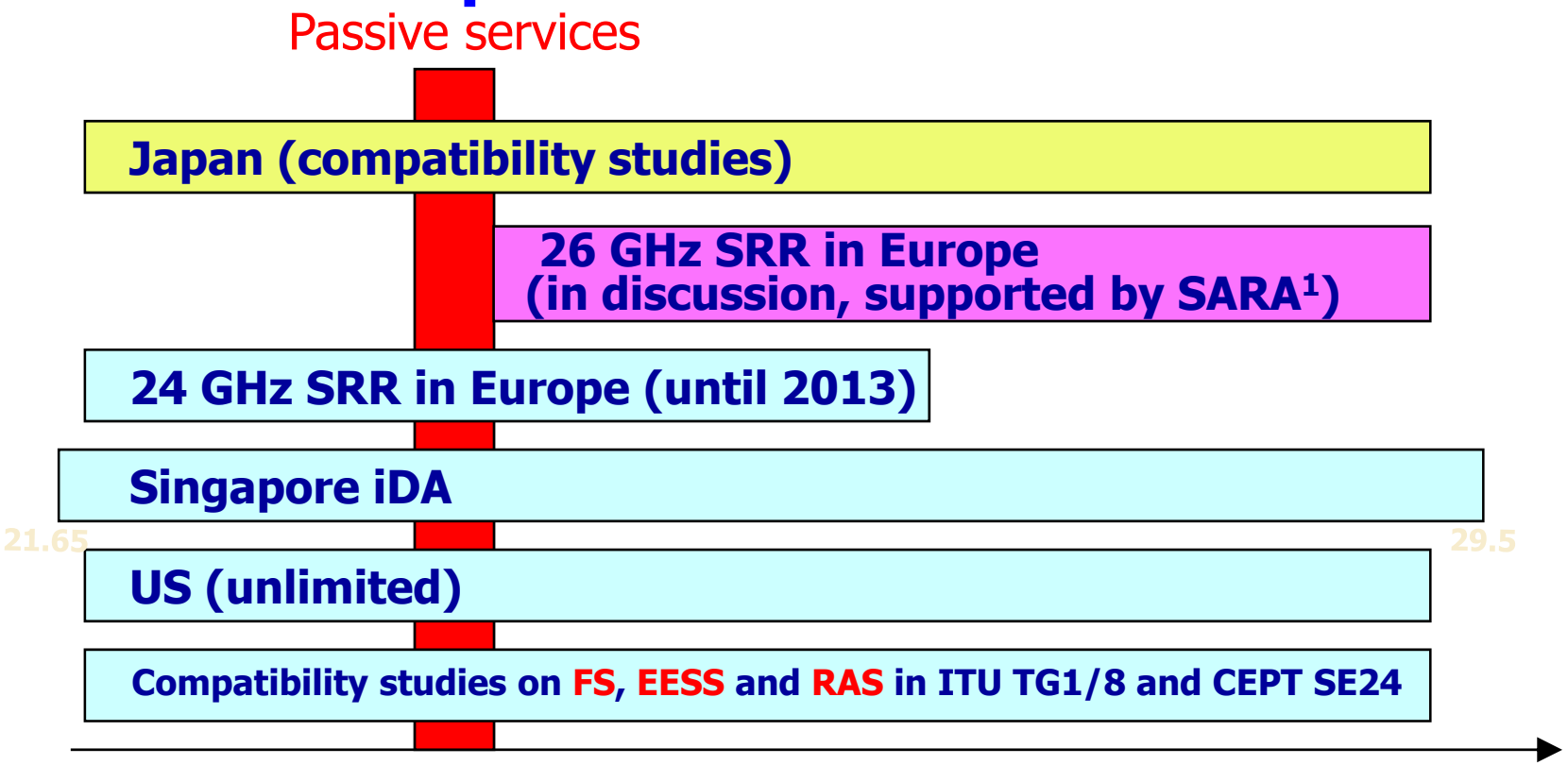
2. UWB SSR under consideration

- Canada
  - Preliminary solution since August 2006
  - Regulation in 2008 expected
- Japan
  - UWB study group in progress
  - Regulation completed: April 20, 2010



Worldwide nearly 60 countries have approved 24 GHz UWB SRR.

Spectrum Overview



FS: **Fixed service**

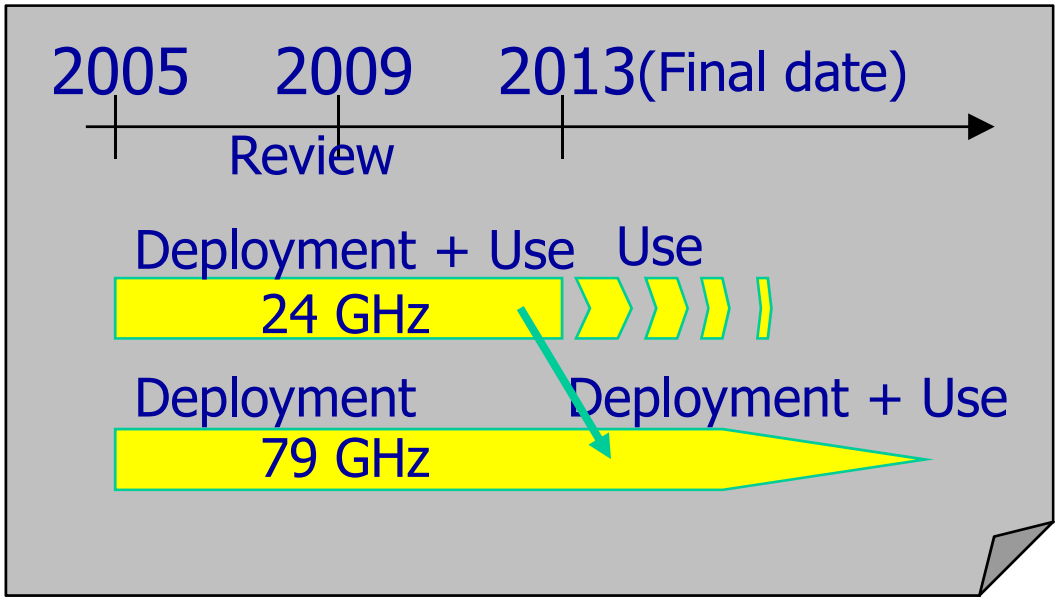
EESS: **Earth exploration satellite service**

RAS: **Radio astronomy service**

SARA[1]: ***S***trategic ***A***utomotive ***R***adar frequency ***A***llocation group

European "Package Solution" for UWB SRR

European 2-Phase Plan 24/79 GHz

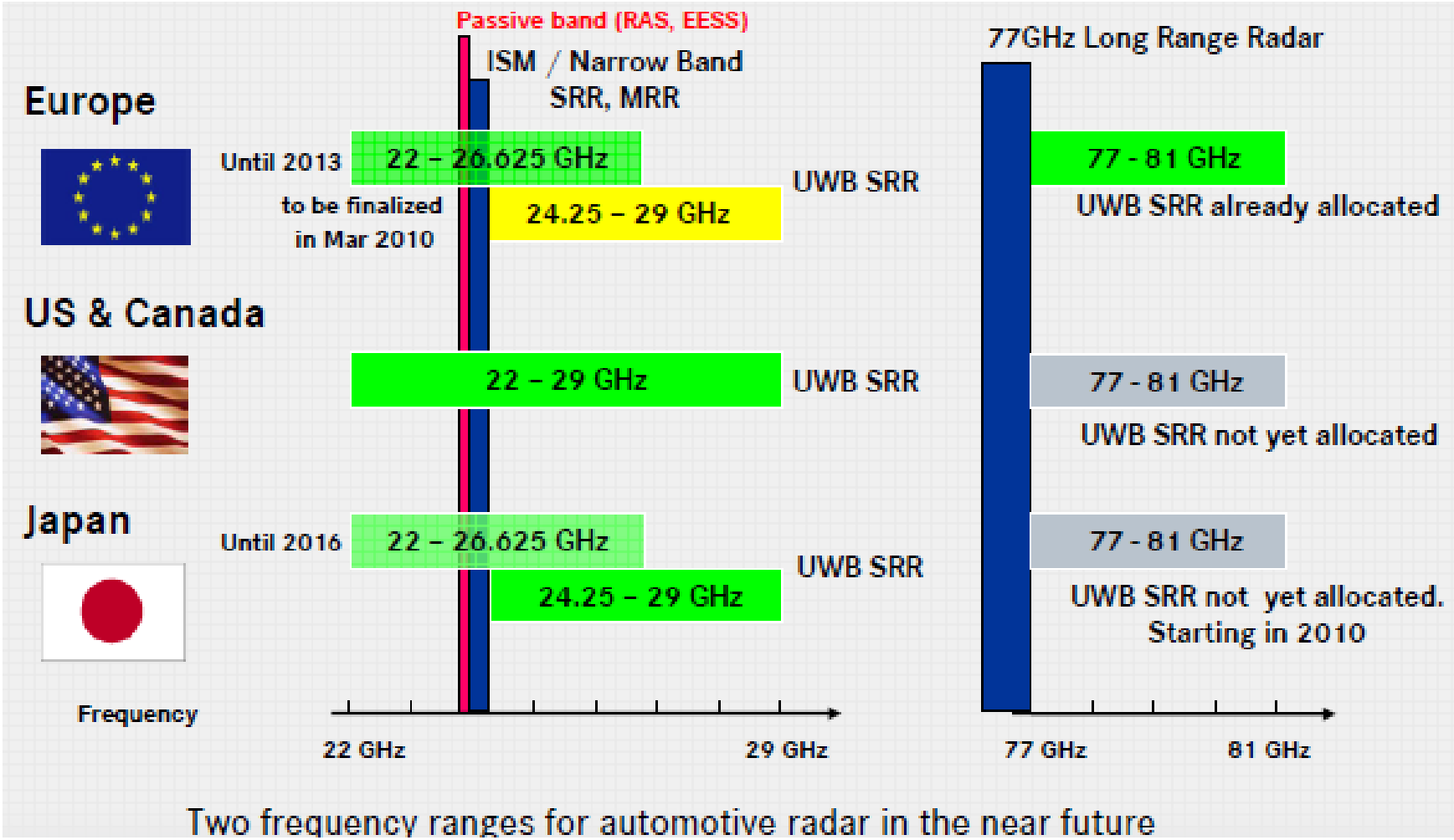


24 GHz Regulation:
- Limited in time and quantity
- Automatic deactivation for RAS sites

79 GHz Regulation:
- No restriction in time and quantity
- Low cost technology not yet available

- "Fundamental Review" of EC Decision started in October 2008

Spectrum for UWB Collision Avoidance Car Radar in a Milli meter Wave Band



Two frequency ranges for automotive radar in the near future

Introduction

Background:

- Japanese radio regulation authority MIC (Ministry of Internal Affairs and Communications) has investigated technical requirement for ultra wide band (UWB) radio use according to UWB research, development, and business after it established regulatory requirement for communication uses for 3.4-4.8GHz, 7.25-10.25GHz in 2006, and collision avoidance radar uses for 22-29GHz in 2013. While UWB communication and sensing systems have been restricted indoor in Japan, the rest of world have been developing them to a lot of outdoor uses.
- Lately in this IoT era, wide variety of UWB radio uses have been expected in Japan as well as in a world and demand for UWB radio outdoor use has been increasing while keeping transparency with other nations.

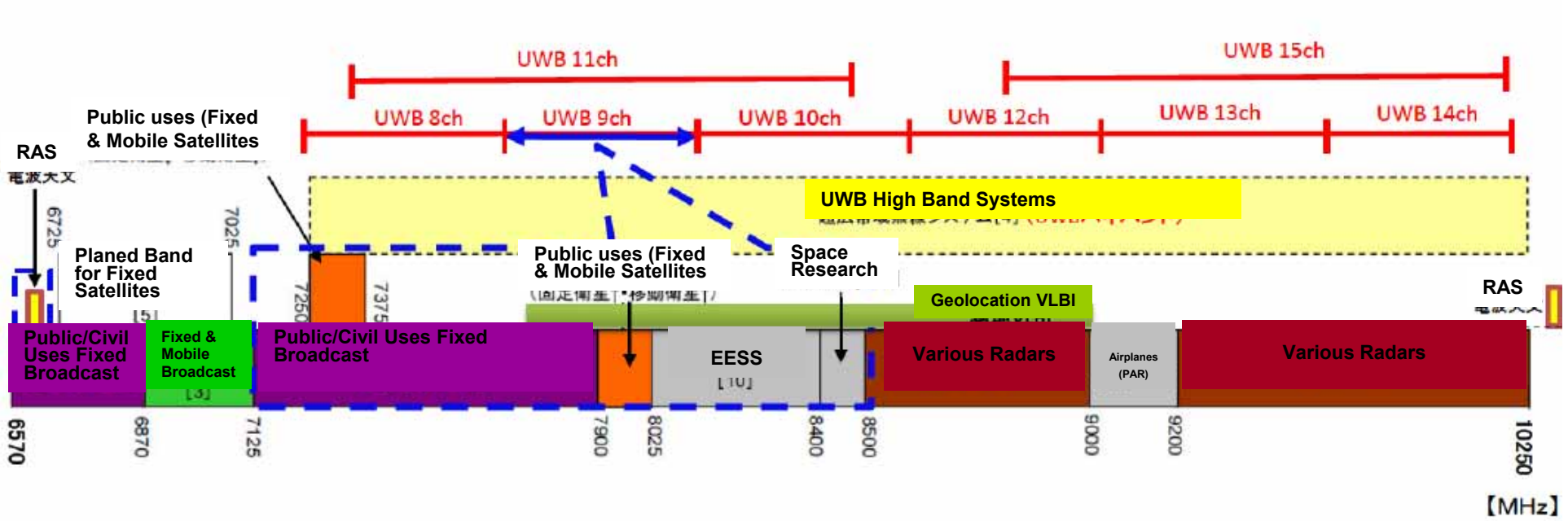
Major Change:

(1) Bandwidth, Occupied, and Impermissible Emission Available Outdoor; Channel 9 of IEEE802.15.4a™ with central frequency 7987.2GHz and bandwidth 499.2MHz out of high band 7.25-10.25GHz has been considered to be available outdoor.

(2) EIRP(Equivalent Isotropically Radiated Power); Japanese regulatory requirement for UWB radio has been regulated by emission power, antenna gain as well as EIRP. For the sake of international compatibility, Japanese regulation for UWB radio uses could be regulated by EIRP.

Radio Uses in the Frequency Band 6.57-10.25GHz

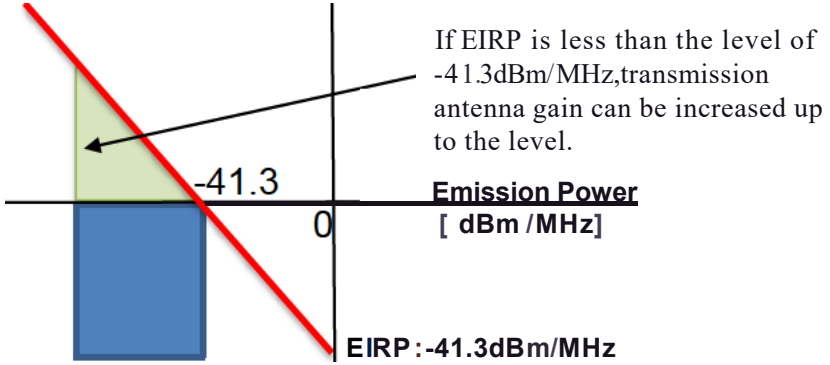
- Red lines indicate channels defined by IEEE802.15.4a.
- Available band is 7.587-8.4GHz. **Blue dotted line** systems should be protected for coexisitence such as fixed micro wave communication, satellite, radio astronomy and VLBI etc.



Update of Emission Power Regulation in case of Low Gain Antenna

- Recently demand of small wireless terminals including UWB terminals drastically. A small terminal cannot perform desired covering range because antenna gain of small terminals is used not to be sufficient.
- Corresponding to the demand, it is permitted that under the range of the regulated Equivalent Isotropically Radiated Power (EIRP), antenna gain can be increased according to attenuation amount of emission power. Increase of emission power can be replaced with attenuation of transmitted antenna gain.

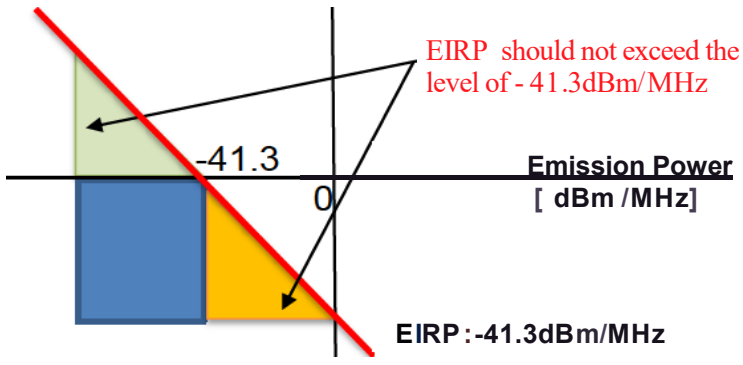
Current Regulation



Average Power -41.3 dBm/MHz
Peak Power 0 dBm/50MHz

Transmission absolute antenna gain should not exceed 0 dBi.
If and only if EIRP is lower than the level of -41.3dBm/MHz, transmission antenna gain can be increased so that EIRP can not be exceed the level.

New Regulation



Average Power -41.3 dBm/MHz(defined by EIRP)
Peak Power 0 dBm/50MHz (defined by EIRP)
EIRP should not exceed the level of -41.3dBm/MHz,.

- In current regulation, it is permitted that under the limit of the regulated EIRP, antenna gain can be increased according to attenuation amount of emission power.
- In new regulation, it is permitted that under the range of the regulated EIRP increase of emission power is allowed in case that antenna gain is small to reach the regulated EIRP

Major Technical Requirement for Outdoor UWB Systems(1/ 2)

Technical Requirement of Outdoor UWB Systems			
Permissible Variance of Band		7.587GHz — 8.4GHz	
Emission Power (by EIRP)		Average Power(EIRP) 7,587 -7,662 MHz: Lower than -51.3 dBm/MHz 7,662 -8,400 MHz : Lower than -41.3 dBm/MHz	
		Peak Power (EIRP) No Change	
Antenna Absolute Gain		No Regulation	
Permissible Occupied Band width		813MHz （Specified Band）	
Permissible Spread Band width		No Change	
Limits of Emission Power subsidiarity (by EIRP)	Not beyond 7.25 GHz	No Change	
	Higher than 7.25 GHz Not Beyond 10.25 GHz	7.25 GHz -- 7.587 GHz	-59.3 dBm/MHz
		7.587 GHz -- 8.4GHz	-54.0dBm/MHz
		8.4 GHz -- 8.5 GHz	-59.3dBm/MHz
		8.5 GHz -- 10.25 GHz	-60.0dBm/MHz
	Higher than 10.25 GHz	No Change	

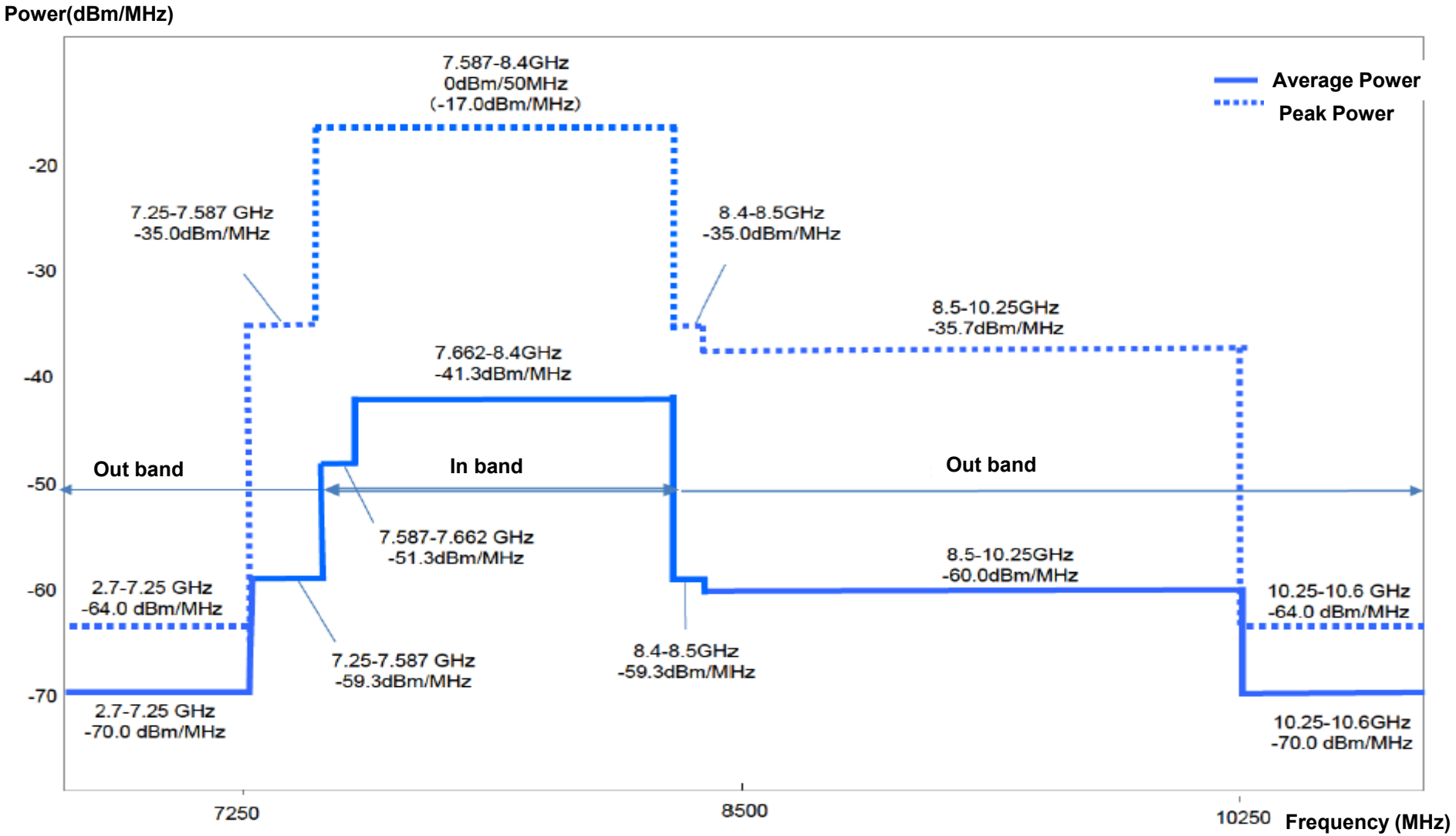
Technical Requirement of Indoor High Band UWB Systems			
Permissible Variance of Band		7.25GHz — 10.25GHz	
Emission Power (by EIRP)		Average Power(EIRP) Lower than -41.3 dBm/MHz	
		Peak Power (EIRP) 0 dBm / 50 MHz	
Antenna Absolute Gain		0 dBm	
Permissible Occupied Band width		3 GHz	
Permissible Spread Band width		More than 450 MHz (10 dB Bandwidth)	
Limits of Emission Power subsidiarity (by EIRP)	Not beyond 7.25 GHz	Less than 1,600MHz	-90.0dBm/MHz
		1,600-2,700 MHz	-85.0dBm/MHz
		2,700MHz -7.25 GHz	-70.0dBm/MHz
	7.25 GHz -- 10.25 GHz	7.25GHz – 10.25GHz	-54.0dBm/MHz
	Higher than 10.25 GHz	10.25-10.6GHz	-70.0dBm/MHz
		10.6-10.7GHz	-85.0dBm/MHz
		10.7-11.7GHz	-70.0dBm/MHz
		11.7-12.56GHz	-85.0dBm/MHz
		Beyond 12.75GHz	-64.0dBM/MHz

Major Technical Requirement for Outdoor UWB Systems(2/ 2)

Technical Requirement of Outdoor UWB Systems			
Limits of Permitted Emission (by Average Power, EIRP)	Not beyond 7.25 GHz	No Change	
	7.25 GHz – 10.25 GHz	7.25 GHz -- 7.587 GHz	- 59.3 dBm/MHz
		7.587 GHz -- 8.4GHz	non
		8.4 GHz -- 8.5 GHz	-59.3dBm/MHz
		8.5 GHz -10.25GHz	-60.0dBm/MHz
	over 10.25GHz	No Change	
Limits of Permitted Emission (by Peak Power, EIRP)	Not beyond 7.25 GHz	No Change	
	7.25 GHz -- 10.25 GHz	7.25 GHz -- 7.587 GHz	-35.0 dBm/MHz
		7.587 GHz -- 8.4GHz	Non
		8.4 GHz -- 8.5 GHz	-35.0dBm/MHz
		8.5 GHz -- 10.25 GHz	-35.7dBm/MHz
	Higher than 10.25 GHz	No Change	
Package is not easily opened.			

Technical Requirement of Indoor UWB Systems			
Limits of Permitted Emission (by Average Power, EIRP)	Not beyond 7.25 GHz	Less than 1,600MHz	-90dBM/MHz
		1,600- 2,700MHz	-85.0dBM/MHz
		2,700MHz-7.25GHz	-70dBM/MHz
	7.25 GHz – 10.25 GHz	Non	
	over 10.25GHz	10.25-10.6GHz	-70.0dBM/MHz
		10.6G-10.7GHz	-85.0dBm/MHz
		10.7-11.7GHz	-70.0dBm/MHz
		11.7-12.75GHz	-85.0dBm/MHz
		Beyond 12.75GHz	-70.0dBM/MHz
Limits of Permitted Emission (by Peak Power, EIRP)	Not beyond 7.25 GHz	Less than 1,600MHz	-84.0dBm/MHz
		1,600-2,700MHz	-79.0dBm/MHz
		2,700MHz-7.25GHz	-64.0dBm/MHz
	7.25 GHz -- 10.25 GHz	Non	
	Higher than 10.25 GHz	10.25-10.6GHz	-64.0.0dBM/MHz
		10.6G-10.7GHz	-79.0dBm/MHz
		10.7-11.7GHz	-64.0dBm/MHz
		11.7-12.75GHz	-79.0dBm/MHz
		Beyond 12.75GHz	-64.0dBM/MHz
Package is not easily opened.			

Updated UWB PSD Mask for Outdoor Uses in Japan



Remark

- MIC said that this change of regulation for UWB radio outdoor use is only for CH9 but will be more reasonable extension to other channels.
- These slides are translated from MICT documents by Ryuji Kohno, so it means these are not official MIC documents.

Possible Victim Systems by UWB Radio

Category 1: Commercial and Hobby Systems

1. Fixed Microwave System
2. Broadcasting System
3. DSRC for ITS
4. Cellular Phone(4th Generation)
5. Wireless Access
6. Amateur Radio Communication System

Category 2: Public Safety

7. Maritime Radar
8. Aeronautical and Meteorological Radar

Category 3: Scientific Systems (Passive Receivers)

9. **Earth exploration Satellite Service (EESS)**
10. **Radio astronomy service (RAS)**

Interference Reduction Techniques

- **Detection and Avoidance (DAA) for Category 1&2 for commercial and public safety**
  - FH-based DAA mechanism for MB-OFDM
  - DAA is applicable to both **low-rate and high-rate UWB systems**.
  - Detection mechanism is required (active approach).

- **Low Duty Cycle (LDC) for Passive Receivers of Category 3 for Scientific Radio**
  - LDC is for **low-rate UWB systems**, including IEEE802.15.4a and 802.15.6.
  - Detection mechanism is not required.

Feasible Mitigation Technologies of UWB

1. Adaptive band eliminating filter

- Analog Implementation
- Digital Implementation or hybrid

2. Adaptative pulse shaping

- Pulse shaping by high-speed DAC
- Pulse shaping by combining an wavelet

Ref. Modified pulse shapes based on SSA for interference mitigation and systems coexistence (update), Doc: IEEE 802.15-03-0457-00-003a

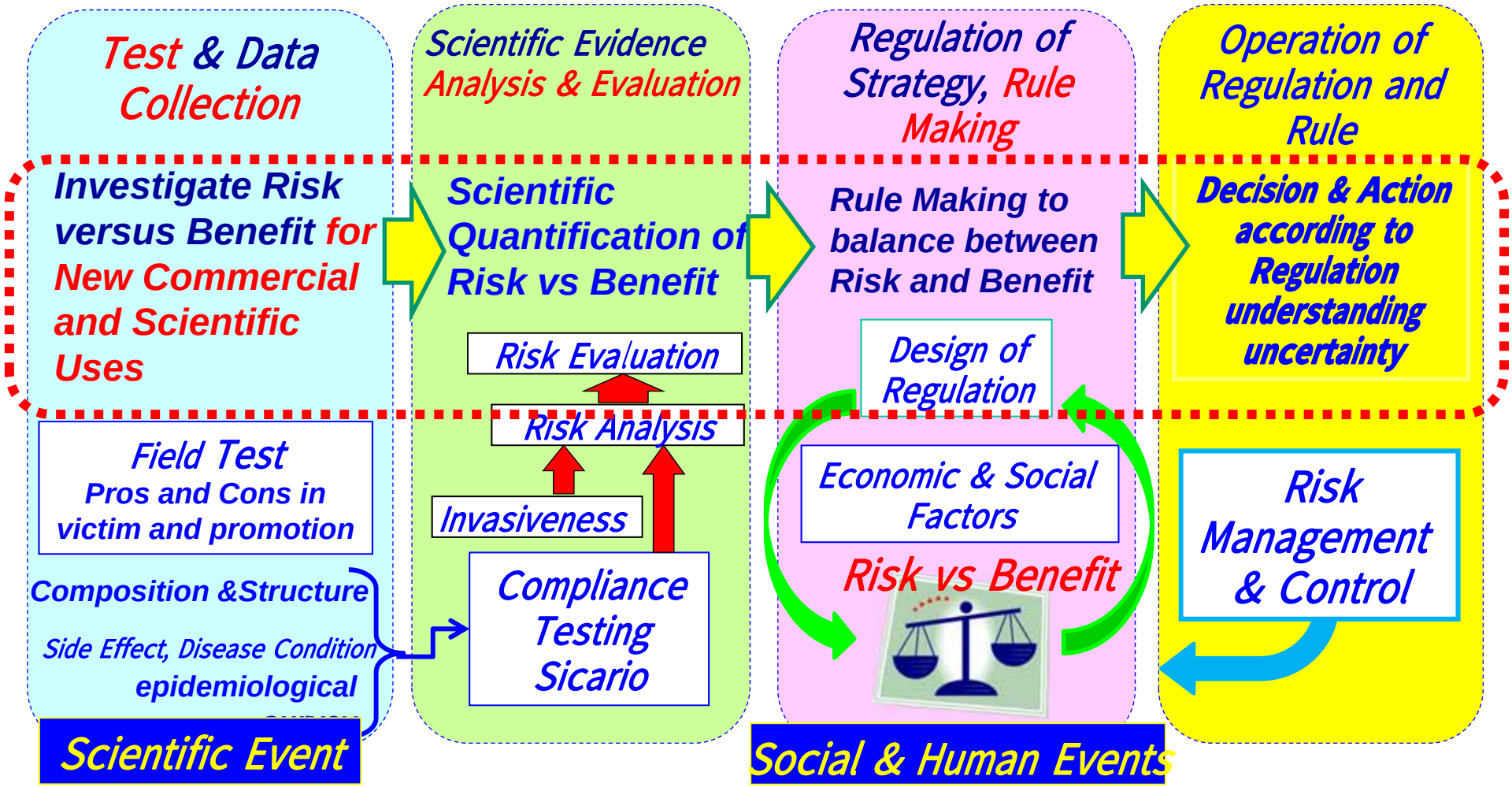
3. Adaptive spreading sequence

- Spectrum null coding

Ref. Alternative Spreading Code and Channel Code for IEEE802.15.4a, Doc: IEEE 802.15-05-0462-01-004a

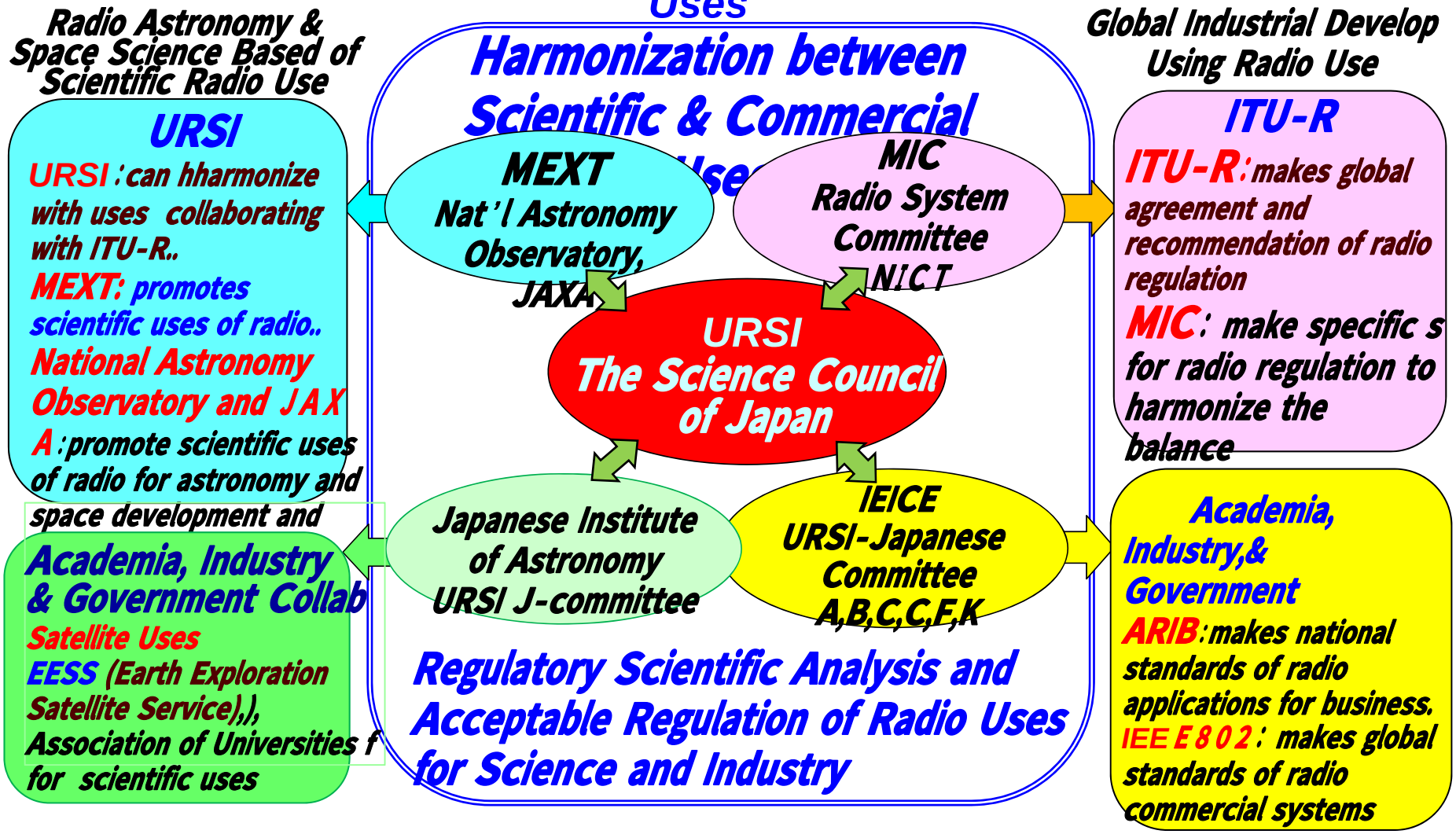
Above-technology can be performed by Cognitive sensing and Adaptive interference avoiding techniques so-called Soft-Spectrum Adaptation (SSA)

Regulatory Science for Harmonization between Scientific and Commercial Radio Uses



Japanese Cabinet Office Master Plan 2020

URSI Regulatory Science Center for Harmonize Scientific & Commercial Uses



Concluding Remark

- **UWB** must be one of promised radio technologies in multiple senses of frequency efficiency, mass business, and public safety including medical healthcare and disaster prevention. No other technology can perform it.
- **Scientific radio services** should be highly protected against UWB and can also use high technology of UWB receiver.
- **ITU** must be a venue to harmonize both scientific and other uses of radio in particular, UWB global regulation.
- **URSI** can contribute to **provide possible solutions** for the harmonization as well as UWB promoters.
- **Regulatory Science Center to harmonize scientific and commercial uses of radio** has been preselected in **Japanese Cabinet Office Master Plan 2020.**