



**Defence Science & Technology Agency; Singapore; 5 Jan. 2016**



**SRTC** 国家无线电监测中心检测中心  
The State Radio\_monitoring\_center Testing Center  
国家无线电产品质量监督检验中心  
The State Radio Product Quality Supervision and Inspection Center

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内部登录

Chinese



**State Radio monitoring center Testing Center (SRTC) Beijing; 8 Jan.2016**  
**Xihua University; Chengdu, Sichuan, China; 11 Jan. 2016**



**GDRTC; Shenzheng, China; 15 January 2015**

# International, Regional & National Regulation of Short Range Devices (SRDs)

You may look at [International, Regional & National Regulation of SRDs](#) at ITU Workshop on SRDs, Geneva 3 June14

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# Definitions

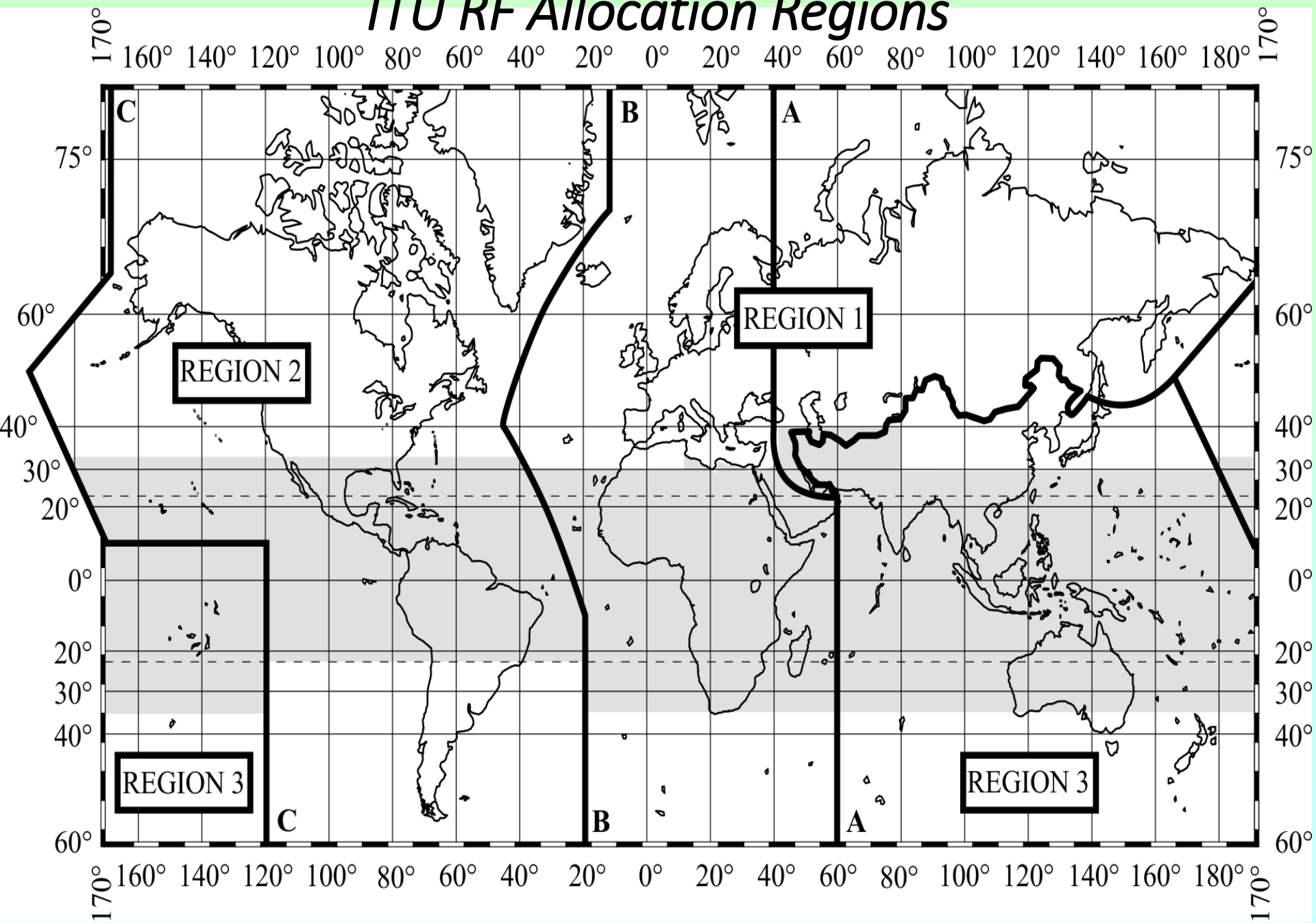
- The regulatory framework for SRDs is a national matter
- SRDs are not a “Radio Service” under [ITU Radio Regulations](#) RR; thus they cannot get primary or secondary allocation
- SRDs are emissions without a corresponding frequency allocation in the [RR](#)
- SRDs are not ISM applications, as defined in No. 1.15 of [RR](#)
- SRD covers radio transmitters, providing either unidirectional or bi-directional communication, with low capability of causing interference to other radio equipment
- For SRDs, individual licenses are normally not required
- SRDs are permitted to operate on a *non-interference* and non-protected basis
- In general SRDs cannot claim protection from radio services, intentional or unintentional radiator, by ISM equipment, or by an incidental radiator
- SRDs are deployed in both bands designated for ISM applications and bands not designated for ISM applications

# ISM Bands: RR

6 765-6 795 kHz	(centre frequency 6 780 kHz)	FN 5.138
13 553-13 567 kHz	(centre frequency 13 560 kHz)	FN 5.150
26 957-27 283 kHz	(centre frequency 27 120 kHz)	FN 5.150
40.66-40.70 MHz	(centre frequency 40.68 MHz)	FN 5.150
433.05-434.79 MHz	(centre frequency 433.92 MHz) in Region 1*	FN 5.138
902-928 MHz	(centre frequency 915 MHz) Region 2	FN 5.150
2 400-2 500 MHz	(centre frequency 2 450 MHz)	FN 5.150
5 725-5 875 MHz	(centre frequency 5 800 MHz)	FN 5.150
24-24.25 GHz	(centre frequency 24.125 GHz)	FN 5.150
61-61.5 GHz	(centre frequency 61.25 GHz)	FN 5.138
122-123 GHz	(centre frequency 122.5 GHz)	FN 5.138
244-246 GHz	(centre frequency 245 GHz)	FN 5.138

SRDs are deployed in both bands designated for **ISM** applications and bands not designated for ISM applications. ISM band is **sufficient** condition **but not obligatory**; SRD band is different than ISM band

# ITU RF Allocation Regions



# Frequency Bands for SRDs

Global

Only in Europe

Only in Americas

9-148.5 kHz; 3,155-3,400 kHz

9 kHz- 47 MHz (specific SRDs)

7,400-8,800 kHz

138.20-138.45 MHz

169.4-216 MHz

312-315MHz (non Europe)

402-405 MHz medical devices

470-489 MHz (normally individually licensed)

823-832 MHz and 1,785-1,805 MHz

862-875 MHz in some Asian counties

862-876MHz Non-Specific SRDs

915-921 MHz (in some countries)

5,150-5,350 & 5,470-5,725 MHz

57-64GHz, 76-77GHz, 77-81GHz

## ISM bands

6,780 kHz; 13,560 kHz

27,120 kHz; 40.68 MHz

433.92 MHz

915 MHz

2,450 MHz; 5,800 MHz

24.125 GHz; 61.25 GHz

122.5 GHz ; 245 GHz

non-ISM candidate bands for SRDs

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**regulation**, descendent of Latin (*rēgula* rule); Regel רגל is leg in Hebrew;  
**legislation's** basis

**standard** from *estaundart* Anglo-Norman  
**flag** displayed on a battlefield, so that  
troops can rally to it

ITU Deputy Secretary-general, Malcolm  
Johnson: 'A common set of **standards** is like a  
universal language: it brings people,  
businesses, functions, economies and  
societies together. In a world constantly  
growing in complexity, common standards  
make things easier'

Emperor Qin Shi Huang unified all of China in  
221 BC. He introduced standardization:  
currency, weights and measures (e.g., length of  
chariot axles). He built new national road  
system, formed one Chinese script and one  
**communication** system for all of China

桃tao 李li 满man 天tian 下xia: Chinese proverb-  
one has many excellent students everywhere

QinShiHuang



# SRDs regulation & standardisation are divided into 3 major camps: Europe, N. America & Asia

- [Part 15](#) *Licence-Exempt Devices vs. Short Range Devices*

FCC [Part 15](#) originated in 1938, inspired the European SRD concept (~1990) and ERC/REC [70-03](#). In US and Canada most of the RF is available to SRD

Europe permits lower emissions: e.g., e.i.r.p. 0.1W versus 4W at 2.4 GHz

Europe constrains Wideband Data Transmission in 5150–5350 MHz, to only indoor use; EU R&TTE (now RED) is more liberal: self-conformity not FCC *ex-ante* certification; *laissez passer*; tests *ex-post*. Different processes to update the 70-03 and part 15

[R&TTE](#) Directive for placing on the market. On 16/4/2014, EU adopted a new set of rules. There is a two-year time period for EU Member States to adapt their National laws to this new Radio Equipment Directive ([RED](#)) ([2014/53/EU](#)), to be applied from 13 June 2016

Placing on the market in the US. Any Part 15 must be tested and authorized before it may be marketed. There are two ways to obtain authorization: Certification & Verification

Possible RF bands to harmonize SRD within Asia-Pacific, based on [APT/AWG/REP-35](#) table 2

<b>Frequency band</b>	<b>Typical Application</b>	<b>Remarks</b>
402-405 MHz	Medical Implant	<a href="#">APT REC-05</a>
433.05-434.79 MHz	RFID	<a href="#">APT REP-07</a>
862-960 MHz	RFID	<a href="#">APT REC-03</a>
5,150-5,350 MHz	WLAN	<a href="#">APT REC-06</a>
5,470-5,725 MHz	WLAN	<a href="#">APT/REP-35</a>
76-77 GHz	Vehicle Radar	<a href="#">APT REP-07</a>



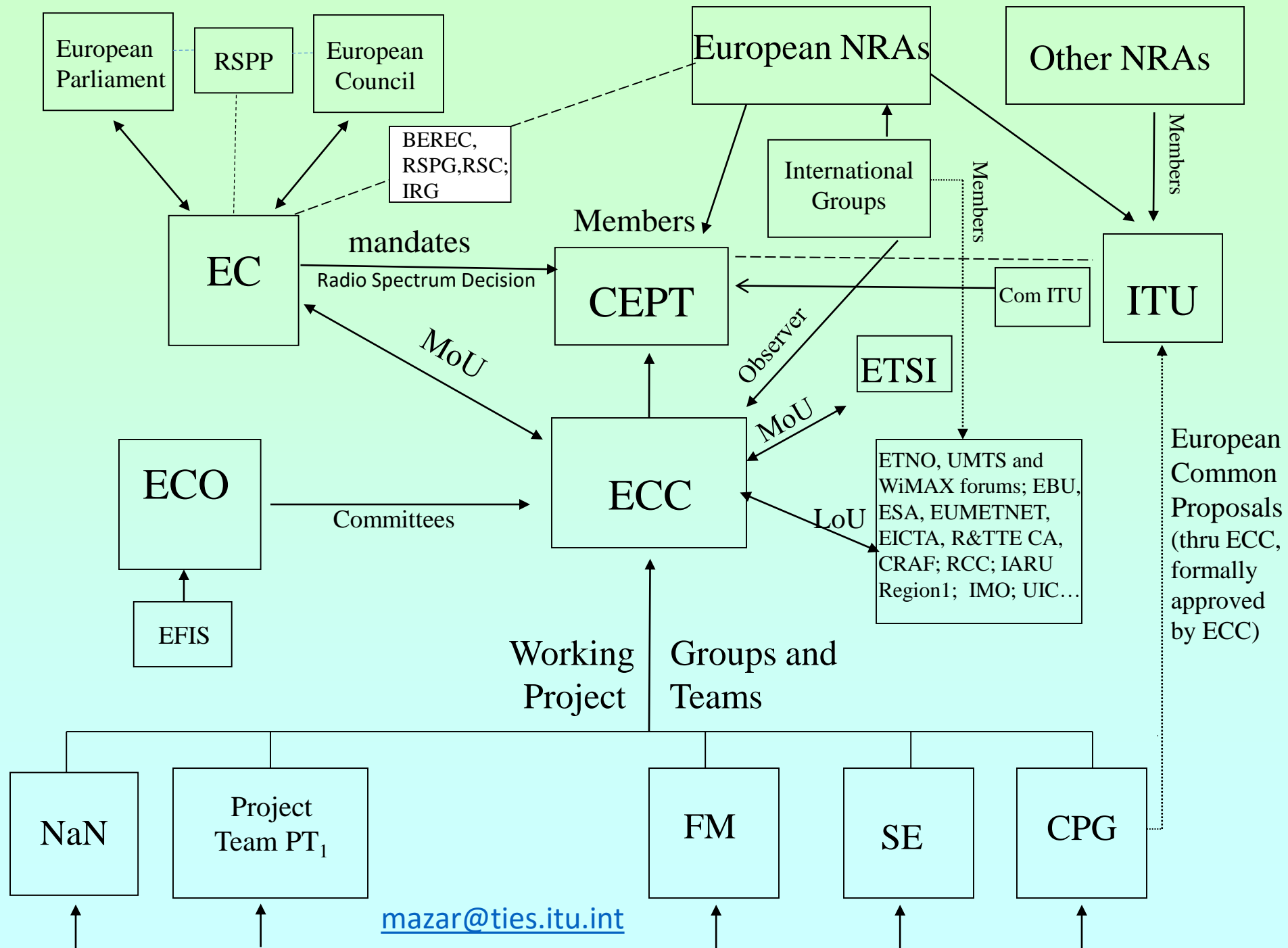
# Japan & Korea, max. field-strength, 3 m from $t_x$

Frequency band	Electric field-strength ( $\mu\text{V}/\text{m}$ )
$f \leq 322 \text{ MHz}$	500
$322 \text{ MHz} < f \leq 10 \text{ GHz}$	35
$10 \text{ GHz} < f \leq 150 \text{ GHz}$	$3.5 \times f(\text{GHz})^*$

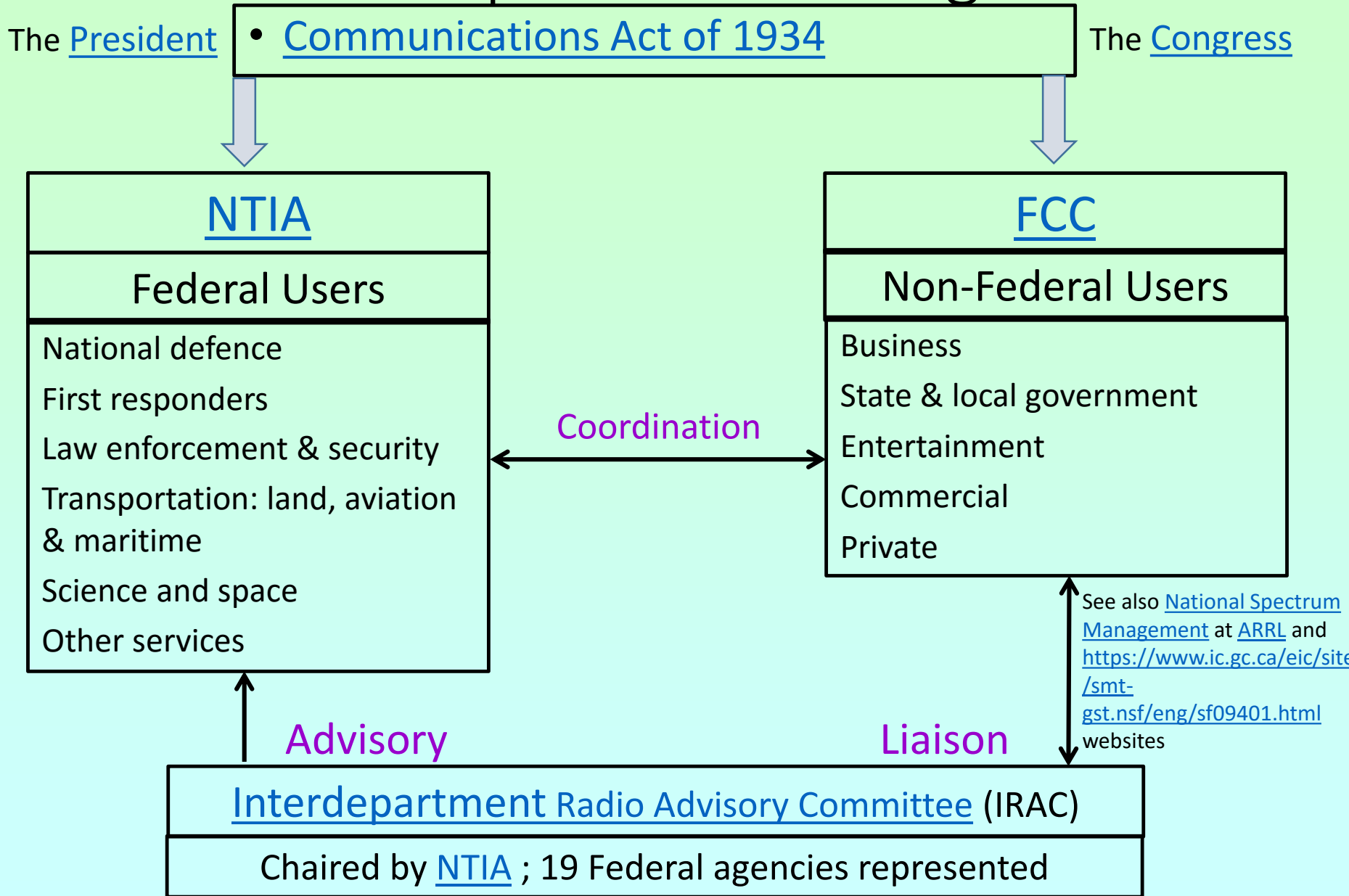
\*the maximal field-strength is  $500 \mu\text{V}/\text{m}$ ; therefore, above 143 GHz the field-strength is steady  $500 \mu\text{V}/\text{m}$

# General technical requirements applicable in certain administrations or regions

General band	Adm. or region	Specific RF band (MHz)	Tx output power (mW) (except as noted)	Antenna gain (dBi)
2.4 GHz band	USA	2,400-2,483.5	1,000	0-6 dBi (Omni)
	Canada		<b>4 W e.i.r.p.</b>	N/A
	Europe		<b>100 mW (e.i.r.p.)</b>	N/A
	Japan	2,471-2,497 2,400-2,483.5	10 mW/MHz 10 mW/MHz	0-6 dBi (Omni) 0-6 dBi (Omni)
5 GHz band	USA	5,150-5,250	50mW; 2.5 mW/MHz	0-6 dBi (Omni)
		5,250-5,350	250mW; 12.5mW/MHz	0-6 dBi (Omni)
		5,470-5,725	250mW; 12.5mW/MHz	0-6 dBi (Omni)
		5,725-5,850	1,000mW; 50.1mW/MHz	0-6 dBi (Omni)
	Canada	5,150-5,250	<b>200 mW e.i.r.p.; 10 dBm/MHz e.i.r.p.</b>	
		5,250-5,350	<b>250 mW; 12.5 mW/MHz; (11 dBm/MHz)</b> <b>1,000 mW e.i.r.p.</b>	
		5,470-5 725	<b>250 mW; 12.5 mW/MHz (11 dBm/MHz)</b> <b>1,000 mW e.i.r.p.</b>	
		5,725-5,850	<b>1,000 mW; 50.1 mW/MHz</b>	
	Europe	5,150-5,250	<b>200 mW (e.i.r.p.); 10 mW/MHz (e.i.r.p.)</b>	
		5,250-5,350	<b>200 mW (e.i.r.p.); 10 mW/MHz (e.i.r.p.)</b>	
5,470-5,725		<b>1,000 mW (e.i.r.p.); 50 mW/MHz (e.i.r.p.)</b>		
Japan	4,900-5,000	250 mW 50 mW/MHz		13
	5,150-5,250	10 mW/MHz (e.i.r.p.)		N/A
	5,250-5,350	10 mW/MHz (e.i.r.p.)		N/A
	5,470-5,725	50 mW/MHz (e.i.r.p.)		N/A
57-66 GHz	Europe	57-66 GHz	40 dBm (e.i.r.p.) <sup>(12)</sup> 13 dBm/MHz (e.i.r.p)	N/A



# US National Spectrum Management



19 federal agencies in IRAC; + FCC as Observer

# Applications of ISM equipment, in and outside ISM bands

Frequency	Applications
Below 1,000 kHz	Induction heating; ultrasonic cleaning and medical diagnostics; Domestic induction cookers; metal melting; billet heating; tube welding; soldering and brazing; component heating; spot welding; selective surface heat; treating of metal parts; semiconductor crystal growing and refining; seam bonding of autobody surfaces; package sealing; heating strip steel for galvanizing, annealing and paint drying; electrical surgical units (ESU); hyperthermia equipment
1-10 MHz	Surgical diathermy (dampened wave oscillator); wood gluing and wood curing (3.2 and 6.5 MHz); valve induction generators production of semi-conductor material; RF arc stabilized welding; ESU
10-100 MHz	Dielectric heating and material preheating. The majority operate in the ISM RF bands at 13.56, 27.12 and 40.68 MHz, but many also operate on frequencies outside the ISM bands): drying (textile, fiberglass, paper and paper coating, veneer and lumber, foundry core, glue, film, solvent, food), ceramics, business products (books, paper, gluing and drying), food (post baking, meat and fish thawing), wood gluing, plastic heating (welding and moulding, die sealing and plastic embossing), adhesive curing. Medical applications: medical diathermy and hyperthermia equipment (27 MHz), MRI (10-100 MHz in large shielded rooms)
100-915 MHz	Medical applications (433 MHz), hyperthermia equipment (433 MHz and 915); food processing (915 MHz); RF plasma generators; Rubber vulcanization (915 MHz); MRI
Above 915 MHz	<b>Microwave ovens</b> domestic and commercial (915 MHz and 2,450 MHz), food tempering, thawing and cooking; RF excited ultra-violet paint and coating curing; pharmaceutical processing; RF plasma generators; rubber vulcanization (magnetrons at 915 and 2450 MHz)

# Typical Applications

1. Wideband data transmission: RLAN/Wi-Fi, UWB, White Space Devices (in the USA, white space devices operate on a non-protected, non-interference basis), Wideband Low Activity Mode (WLAM), short range video
2. RF Identification (RFID), active medical implants, health monitoring, personal identification, inductive systems, proximity sensors
3. Car door openers, Transport and Traffic Telematics (TTT), road tolling, Automatic Meter Reading (AMR), Street Lamp Monitoring and Control, railway applications, car immobilisers
4. Logistics, livestock, Electronic Article Surveillance (EAS)
5. Radiodetermination: Automotive Short Range Radar (SRR), RF level gauges, radar sensor, Level Probing Radar (LPR)
6. Near Field Communication (NFC) & voice like: walkie-talkie, baby monitoring, remote control, radio microphone, cordless loudspeakers and telephones, aids for the hearing impaired, voice enabled data collection
7. Telemetry, tracking, tracing and data acquisition, model control, home automation, automotive industry, sensor monitoring
8. Alarm, social alarms, anti-theft

# RFID technology, as a typical SRD

1. RFID was developed by the British Air Force during World War II to identify enemy aircrafts: identification, friend or foe (IFF)
2. RFIDs consist of transponders or tags, in objects to be identified
3. Many kinds of RFIDs, depending on power source , RF & functionality
4. 3 types: passive, semi active and active
  - 1) Passive: no internal power, inductive coupling or backscattering short range, unlimited life
  - 2) Semi-passive: like passive but uses battery for electronic components
  - 3) Active: battery powered incl. active transmitter; larger size, longer range, shorter life
5. Technological advances in RFID in recent years:
  - 1) RTLS (Real Time Location Systems): addition of location functionality to identification and data transfer, utilizing triangulation and other techniques
  - 2) 5.9GHz DSRC : “Wi-Fi for cars” for high data rate low latency V2V (vehicle to vehicle) and V2I (vehicle to infrastructure) communication

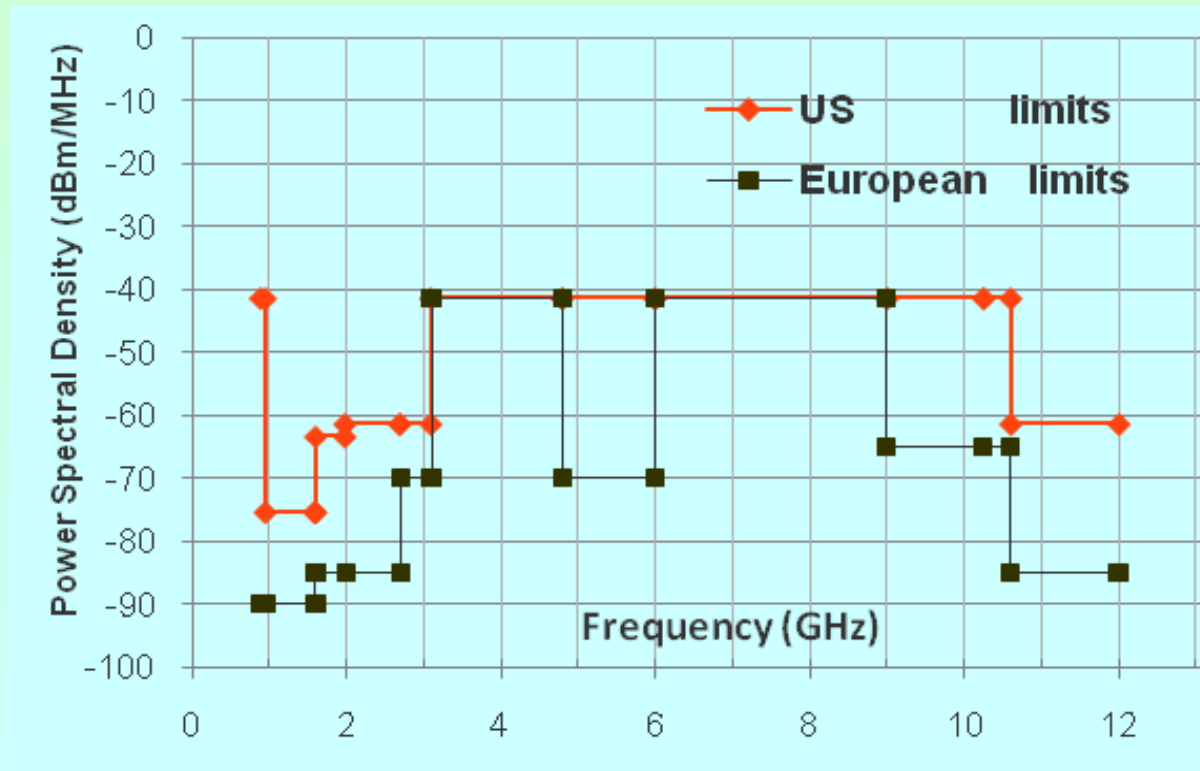
# Wireless Power Transfer (WPT) as SRD (now in China)

- ITU [RR](#) No. 1.15 *ISM applications*: operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, **excluding applications in the field of *telecommunications***
- WPT with no data communication ( e.g. Blue Tooth or ZigBee) is ISM, and may operate in all ISM bands
- ‘equipment with a WPT function may be regarded as another type of SRD’ (CISPR/1302/INF; 2015-03-20)
- WPT is SRD only if there are telecommunications
- USA separates between FCC [Part 15](#) for ‘Radio Frequency Devices’ and FCC [Part 18](#) for ISM



# UHF RFID: Americas versus Europe

	RF band (MHz)	Max e.i.r.p. power (Watts)	Channels (kHz)	Total RF BW(MHz)	Approval process
Europe	865-868	up to 2 (e.i.p.) x 1.64=3.28	15 x 200	3	<a href="#"><i>R&amp;TTE</i></a>
Americas	902-928	4*	52 x 500	26	US tests every RFID



## UWB emission masks in Europe and the US

Differences up to 49 dB@900-960MHz

Europe allowed UWB in 2005, US in 2001

# SRDs & smart sustainable world, cities, houses, cars; Internet of Things

SRDs provide ICT's vital infrastructure & connection for Smart Sustainable Cities



Source: ITU-T Report 2014 [EMF Considerations in Smart Sustainable Cities](#)

# Typical Emerging technology: Z-Wave



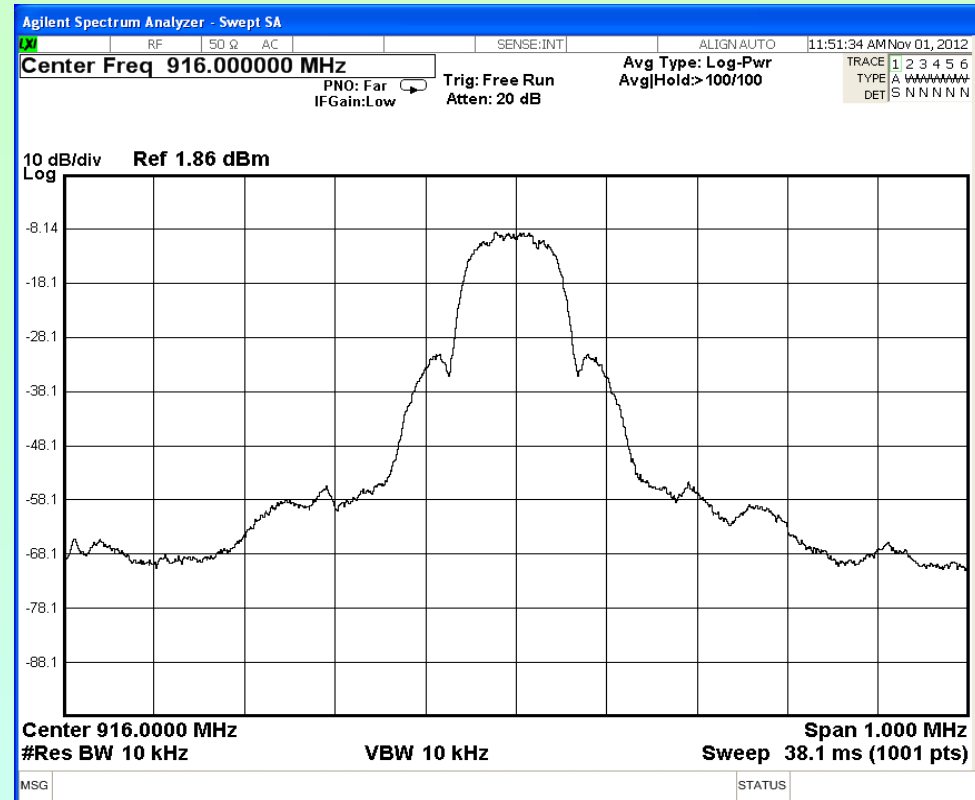
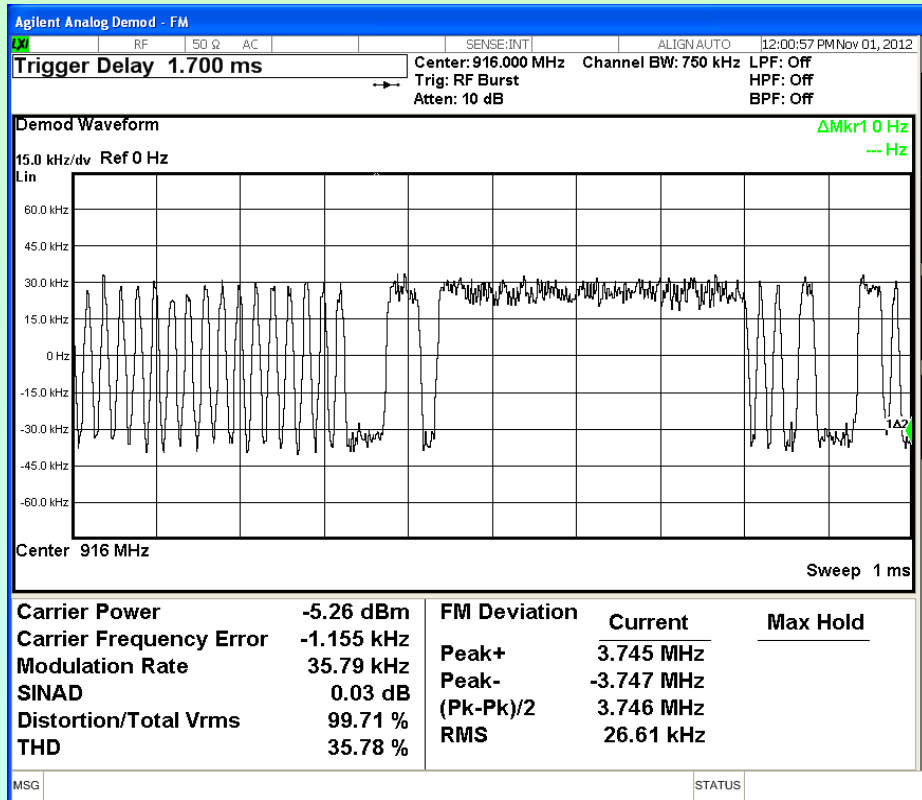
Current sub-1GHz

designed mainly for remote controls, smoke alarms and security sensors

- Z-Wave uses a single frequency FSK
- Data rate up to 100 Kbps; unlike IEEE 802.11, designed primarily for high-bandwidth data flow
- Range between controllers & slave devices up to 100 ft

Country/Region	Standard	Z-Wave RF
Australia	AS/NZS 4268	921.4 MHz
Brazil	ANATEL Resolution 506	921.4 MHz
CEPT	EN 300 220	868.4 MHz
Chile	FCC CFR47 Part 15.249	908.4 MHz
China	CNAS/EN 300 220	868.4 MHz
Hong Kong	HKTA 1035	919.8 MHz
India	CSR 564 (E)	865.2 MHz
Israel	MoC Wireless Act	915-917 MHz
Japan 950 (obsolete by end of 2015)	ARIB T96	951-956 MHz
Japan 920 (since Feb 2012)	ARIB STD-T108	922-926 MHz
Malaysia	SKMM WTS SRD/EN 300 220	868.1 MHz
Mexico	FCC CFR47 Part 15.249	908.4 MHz
New Zealand	AS/NZS 4268	921.4 MHz
Russia	GKRCh/EN 300 220	869.0 MHz
Singapore	TS SRD/EN 300 220	868.4 MHz
South Africa	ICASA/EN 300 220	868.4 MHz
Taiwan	NCC/LP0002	922-926 MHz
UAE	EN 300 220	868.4 MHz
USA/Canada	FCC CFR47 Part 15.249	908.4 MHz

# New Technologies, more immune to interference



SRD to track (& preserve) short-toed snake-eagle (regulated by the author)



© *Guilad Friedemann*

Dr. Haim Mazar; Vice Chair ITU-R Study Group 5

# Preserving Vultures



Rec. [SM.1896](#) annex1: RF for global harmonization of SRDs

RF Range	Remarks
9-148.5 kHz	Inductive SRD applications
3 155-3 400 kHz	Inductive SRD applications RR No. 5.116
6 765-6 795 kHz	Inductive SRD applications ISM band (RR No. 5.138) Centre frequency 6 780 kHz
13.553- 13.567 MHz	Inductive SRD applications; ISM band (RR No. 5.150); Centre frequency 13.560 MHz; Level of side band suppression is dependent on national regulations
26.957- 27.283 MHz	Inductive SRD applications/non-specific SRDs; ISM band (RR No. 5.150); Centre frequency 27 120 kHz
40.66-40.7 MHz	ISM band (RR No. 5.150); Centre frequency 40.68 MHz
2 400-2 500 MHz	ISM band (RR No. 5.150); Centre frequency 2 450 MHz
5 725-5 875 MHz	ISM band (RR No. 5.150); Centre frequency 5 800 MHz
24.00-24.25 GHz	ISM band (RR No. 5.150); Centre frequency 24.125 GHz
61.0-61.5 GHz	ISM band (RR No. 5.138); Centre frequency 61.25 GHz
122-123 GHz	ISM band (RR No. 5.138); Centre frequency 122.5 GHz
244-246 GHz	ISM band (RR No. 5.138); Centre frequency 245 GHz

# Calculating Electric and Magnetic fields

- For RF lower than 30 MHz, power limits are usually converted to magnetic fields at 10 m; see Rec. [70-03](#). The magnetic field strength ( $h$ ) unit is the A/m. The magnetic field strength may be expressed in  $\mu\text{A/m}$  or  $\text{dB}(\mu\text{A/m})$ . Below 1,000 MHz, ERP is used. [70-03](#) uses logarithmic  $\text{dB } \mu\text{A/m}$  magnetic-fields at 10 m. Use of  $\text{dB } \mu\text{A/m}$  unit globally reveals [70-03](#) influence; e.g. first 2 rows at Table 2 APT Report [APT/AWG/REP-07](#)
- Most of [Part 15](#) of the American FCC Regulation 47 CFR emission limits are specified in field strength; numeric units V/m, mV/m and  $\mu\text{V/m}$ ; and not the logarithmic  $\text{dB V/m}$ ,  $\text{dB mV/m}$  or  $\text{dB } \mu\text{V/m}$ ; mainly at 3 m distance; 30 m (at 490 to 30,000 kHz) and 300 m (at 9 to 490 kHz) are also used. Japan, Korea, some Latin Americas and many other countries follow this procedure for SRDs; it reveals the [Part 15](#) influence
- [70-03](#)  $\text{dB}(\mu\text{A/m})$  @ 10 m:

$$|\vec{h}| = \sqrt{\frac{erp \times 1.64}{480\pi^2 d^2}} = \frac{\sqrt{erp}}{53.75 \times d}$$

$$H(\text{dB } \mu\text{A/m}) = ERP(\text{dBm}) - 20 \log d(\text{m}) + 55.38$$

- [Part 15](#) @  $d=3$  m equals

$$ERP(\text{dBm}) = H(\text{dB } \mu\text{A/m}) - 35.38$$

$$e = \frac{\sqrt{30 \times eirp}}{d} = \frac{\sqrt{30 \times eirp}}{3} = \sqrt{\frac{eirp}{0.3}}$$

$$eirp(\text{W}) = 0.3 \times e^2(\text{v/m})$$



# Regulating SRDs

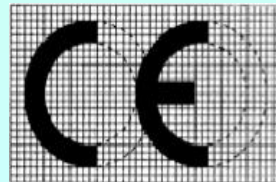
- Adm. define: RF bands, power, channel spacing & mitigation requirements
- Reducing interference: Indoor, Internal antenna, Duty Cycle and Activity Factor, Dynamic Frequency Selection (DFS), Adaptive Frequency Agility (AFA), Listen Before Talk (LBT), Aloha: Carrier Sensing (CS) and Collision Detection (CD), Transmitter Power Control (TPC), One-Time Programmable (OTP), Spread-spectrum technique: Frequency-Hopping Spread Spectrum (FHSS)
- Risk vs. Risk: reducing RF power & BW of SRD or UWB may preclude the entry of new technology. Benefit vs. Benefit: more RF resources available to the citizen & more RF power & BW for SRDs advance rapid growth of new technologies & services. More RF, less congestion and less 'tragedy of commons' in the RF 'public park'
- Will first responders use 'unprotected' RF bands?
- SRDs are unprotected! *Caveat Emptor*: 'let the buyer beware'
- No need to regulate non-active RFID: *de minimis non curat lex*

# Placing on the market, approvals & labeling

- SRDs move thru borders. Administrations should regulate how to place the SRD and label it
- Marking of SRDs indicates its conformance to relevant international, regional & national regulations
- Most administrations require at least that the logo or name of the approval authority is labeled, along with the approval number
- Administrations may establish mutual agreements between countries/regions for the recognition by one country/region of the conformity test results of a recognized/accredited test laboratory in the other country/region
- To use SRDs on board aircraft (like WIFI), regulators may allow usage under conditions; however, for aviation safety aspects, the right bodies to address this matter remains the responsibility of aircraft manufacturers or aircraft owners who should consult with ICAO [International Civil Aviation Organization](#), the relevant regional and national bodies, before installing SRDs on A/C
- Use regulation to ease simple penetration of SRDs to the market

# Labeling SRD in Europe

- [R&TTE](#) (now RED) Directive, Article 12 (CE-marking) states that “any other marking may be affixed to the equipment provided that the visibility and legibility of the CE-marking is not hereby reduced”
- CE-marking has to be placed on the product or affixed to the packaging and the accompanying document. CE marking shall consist of the initials 'CE' taking the following form



## Labeling SRD in Europe (Cont.)

- CE marking indicates compliance with EU legislation and so enables the free movement of products within Europe. By CE marking a manufacturer declares, that the product meets all the legal requirements for the CE marking, & product can be sold throughout the European Economic Area (EEA, 28 Member States of the EU & European Free Trade Association (EFTA) countries Iceland, Norway, Liechtenstein
- The SRD labelling indicates that the equipment operates according to specific requirements

# Placing on the market: Europe

- ETSI has developed harmonized European standards for the majority of SRDs. Other standards or technical specifications are applicable within the framework of the [R&TTE](#) Directive for placing on the market
- [R&TTE](#) Article 4.1 defines the equipment two classes; EC [Commission Decision 2000/299/EC](#) identifies in Article 1 two classes (see next slide)
- On 16 April 14, EU adopted a new set of rules for placing radio equipment and putting them into service. There is a two-year time period for EU Member States to adapt their National laws to this new Radio Equipment Directive ([RED](#)) ([2014/53/EU](#)), published on 22 May 2014), which they will apply from 13 June 2016. The existing Radio & Telecommunications Terminal Equipment Directive (1999/5/EC) will be repealed on that date.

# Placing on the market: USA

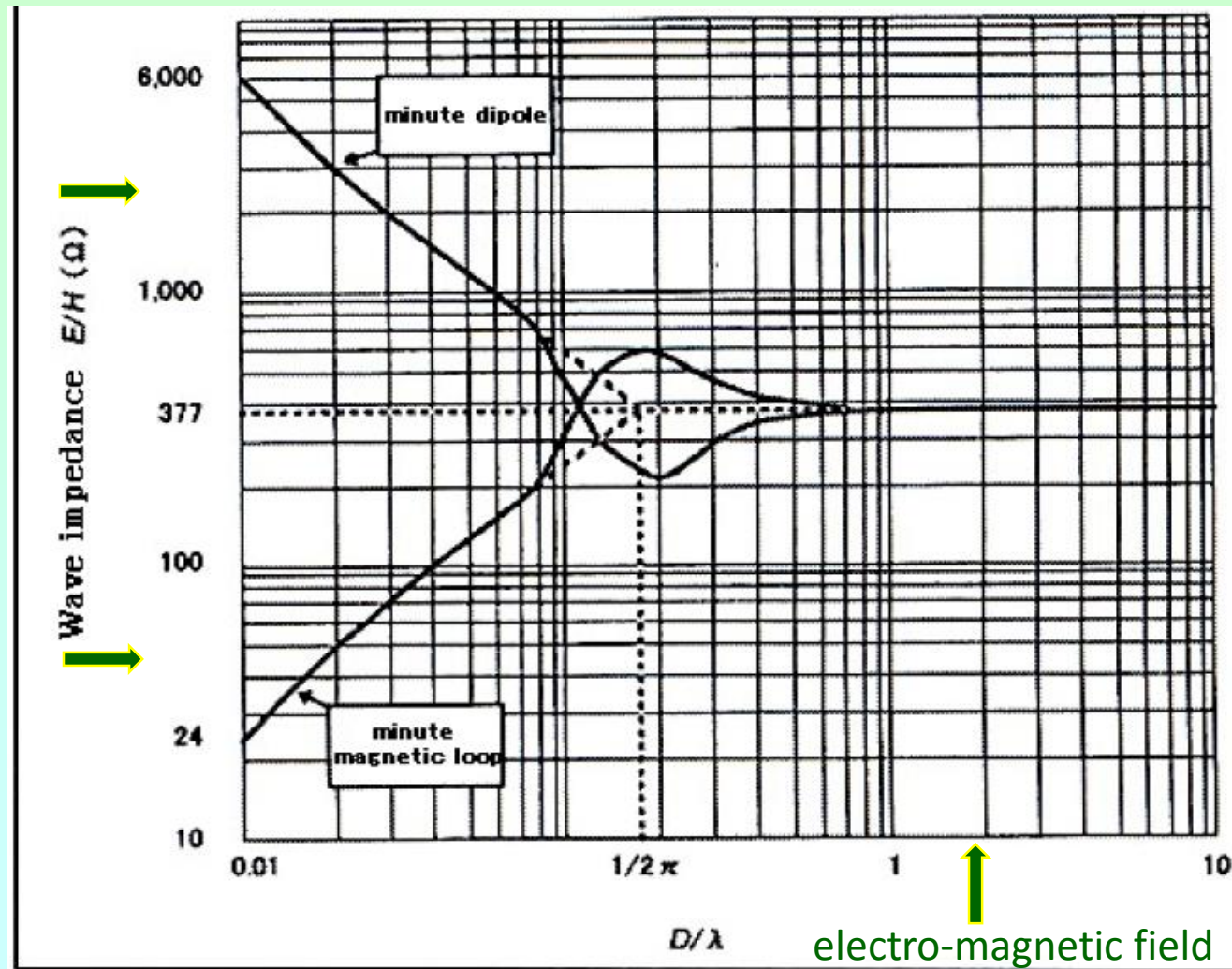
- Any Part 15 'Radio Frequency Devices' 'transmitter must be tested and authorized before it may be marketed
- There are two ways to obtain authorization: Certification & Verification.
- Certification and Verification procedures require that tests be performed to measure the levels of RF radiated. After these tests have been performed, a report must be produced is
- Now **TCBC** Telecommunication Certification Body, Council is accredited by FCC to do it.

Wave Impedance (z) of minute dipole & minute magnetic dipole

$$\text{Poynting Vector} = \frac{P_t g_t}{4\pi d^2} = (\vec{e} \times \vec{h}) = \frac{e_o^2}{z} = h^2 z \quad \text{Most relevant to near field}$$

Wire-  
electric field is  
dominant

Loop-  
magnetic field is  
dominant

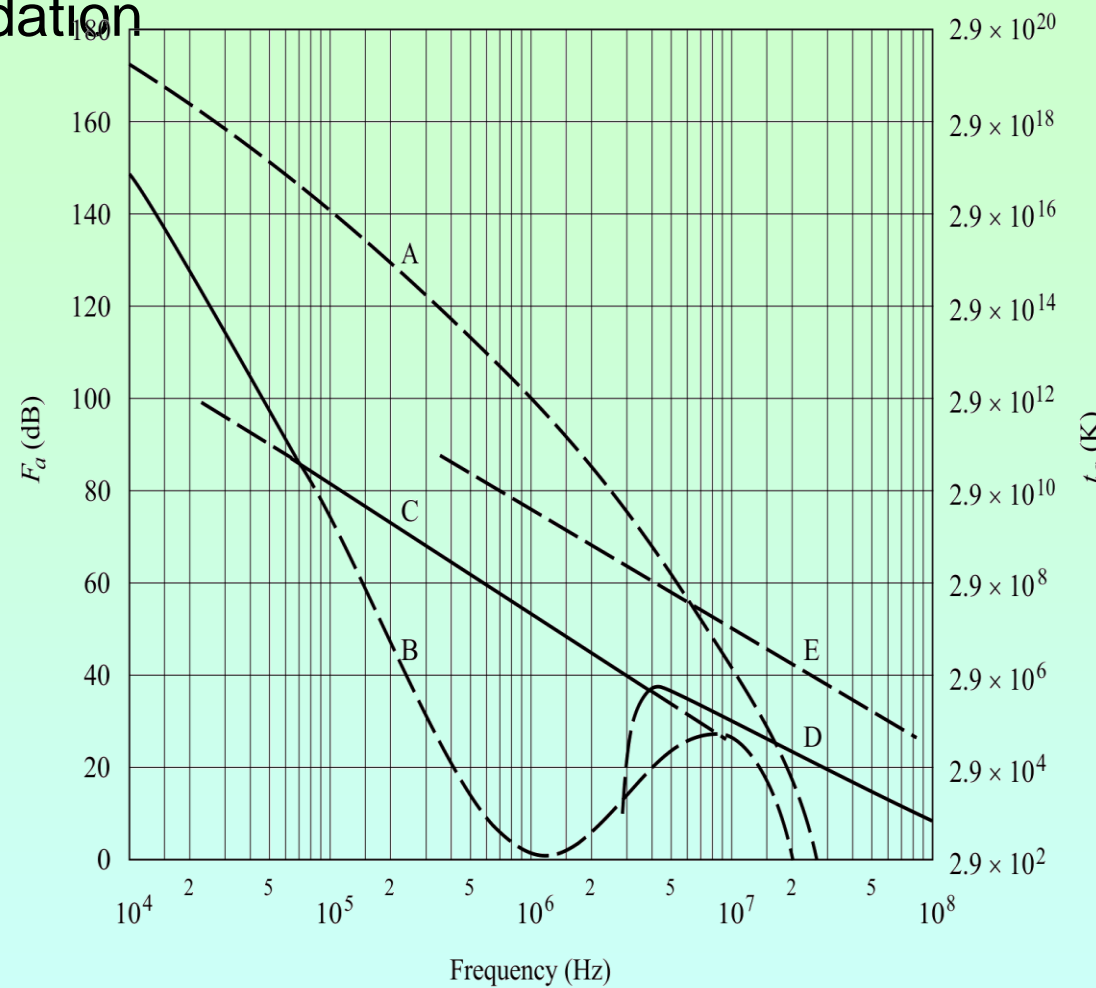


# Interference of SRDs to Radio services

## At low RF no significant degradation

Below 30 MHz, external noise is most influential at victim receiver. Thus, as atmospheric, man-made, galactic noises and emissions from atmospheric gases and hydrometeors are dominant: they are stronger than the KTBF power. Therefore, SRDs operating below 30 MHz, interfere less than SRDs at higher frequencies

FIGURE 2  
 $F_n$  versus frequency ( $10^4$  to  $10^8$  Hz)



- A: atmospheric noise, value exceeded 0.5% of time
- B: atmospheric noise, value exceeded 99.5% of time
- C: man-made noise, quiet receiving site
- D: galactic noise
- E: median city area man-made noise
- minimum noise level expected

0372-02

Atmospheric and man-made noise, 10 kHz to 100 MHz ([P.372](#) Fig. 2)



Case study: Wi-Fi, greatest success after GSM

Wi-Fi, RLAN, WLAN, U-NII  
(Unlicensed-National Information  
Infrastructure) operating in 5.15-  
5.35 GHz and 5.470-5.85 GHz-  
including Recs ITU-R M.1454 and  
RS.1632

The author may assist to study the  
specific W-Fi RF in any country

# Wi-Fi Global: derived from revised Rec [M.1450](#)

Characteristics	IEEE Std 802.11-2012 (Clause 17, commonly known as 802.11b)	IEEE Std 802.11-2012 (Clause 18, commonly known as 802.11a)	IEEE Std 802.11-2012 (Clause 19, commonly known as 802.11g)	IEEE Std 802.11-2012 (Clause 18, Annex D and Annex E, commonly known as 802.11j)	IEEE Std 802.11-2012 (Clause 20, commonly known as 802.11n)	IEEE P802.11ac	IEEE Std 802.11ad-2012	ETSI EN 300 328	ETSI EN 301 893	ARIB HiSWANa,	ETSI EN 302 567
Frequency band	2 400-2 483.5 MHz	5 150-5 250 MHz 5 250-5 350 MHz <sup>(4)</sup> 5 470-5 725 MHz 5 725-5 825 MHz	2 400-2 483.5 MHz	4 940-4 990 MHz 5 030-5 091 MHz 5 150-5 250 MHz 5 250-5 350 MHz 5 470-5 725 MHz 5 725-5 825 MHz	2 400-2 483,5 MHz 5 150-5 250 MHz 5 250-5 350 MHz 5 470-5 725 MHz 5 725-5 825 MHz	5 150-5 250 MHz 5 250-5 350 MHz 5 470-5 725 MHz 5 725-5 825 MHz	57-66 GHz	2 400-2 483.5 MHz	5 150-5 350 and 5 470-5 725 MHz	4 900 to 5 000 MHz 5 150 to 5 250 MHz	57-66 GHz
Interference mitigation	LBT	LBT/DFS/TPC	LBT	LBT	LBT/DFS/TPC	LBT/DFS/TPC	LBT	DAA/LBT, DAA/non-LBT, MU	LBT/DFS/TPC	LBT	
Channel indexing	5 MHz				5 MHz in 2.4 GHz 20 MHz in 5 GHz	20 MHz	2 160 MHz		20 MHz	20 MHz channel spacing 4 channels in 100 MHz	

# Summary of major 802.11 Wi-Fi Standards

## WLAN: IEEE 802.11 Network bearer standards

Source: also Radio-Electronics.com

	802.11a	802.11b	802.11g	802.11n	802.11ad^	802.11ac*	802.11af**
<b>Date of standard approval (release)</b>	Sept. 1999	Sept. 1999	June 2003	Oct. 2009	Dec. 2012	Dec. 2013	February 2014
<b>Maximum data rate (Mbps)</b>	54	11	54	< 600	<7 Gbps		< 600***
<b>Modulation</b>	OFDM	CCK or DSSS	CCK, DSSS, or OFDM		SC and OFDM	OFDM	
<b>RF Band (GHz)</b>	5	2.4		2.4 or 5	60	5	TV bands below 1 GHz
<b>Number of spatial streams</b>	1			1 to 4	5 to 8	1,2,3,4 or 8	up to four streams
<b>Channel width (MHz) nominal</b>	20			20 or 40	80 or 160	20, 40, 80, 160	8 in Europe; 6 in N. America

^ known also as  $\mu$ wave Wi-Fi; brand name WiGig operating in the 2.4, 5 and 60 GHz bands

\* known also as Gigabit Wi-Fi, 5G Wi-Fi and 5G very high throughput (VHT)

\*\* known also as White-Fi and Super Wi-Fi

\*\*\* max data rate is 426.7 Mbit/s in 6 & 7 MHz channels, & 568.9 Mbit/s for 8 MHz channels.

# Wi-Fi offload to improve cellular capacity

(Sources: KDDI May 2013 and Alvarion October 2013)

- In congested areas (outdoors & indoors), the growing need of mobile data exceeds the available cellular capacity
- Main usage: city centers, big malls, airports, train station, stadiums
- WiFi is the most cost effective solution for data offloading
  - RF Spectrum free of charge (at 2.4 GHz and 5 GHz)
  - Embedded in all smartphones and tablets

~150 access points (APs) & more than 1800 stations (STAs) were observed in Ch1 in 2.4GHz band, in Shibuya Metro



Shibuya station of Tokyo Metro; 15 April 2013

In Seoul KTX train station, 351 APs and 1101 STAs were observed in 2.4 GHz band. In underground COEX mall, 277 APs and 917 STAs were observed in 2.4 GHz band

train problems in Shenzheng, due to 2.4 GHz Wi-Fi

# Some author's presentations on SRDs

1. [UHF Global And Regional Ruling and Standardization - The Case Of Different Allocations To Short Range Devices \(SRDs\) & Electronic Devices](#) , [Go Global Compliance Academy™](#) Webinar, 19 Feb. 2013; [the video](#).
2. [International, regional & national regulation of SRDs](#) at ITU Workshop on SRDs, Geneva 3 June 14
3. [Telecommunication Certification Body, Council; 15 April 2015 Holiday Inn, Baltimore MD; US](#)

Presentation is also based on Author's book: [Wiley](#) and Sons "[Radio Spectrum Management: Policies, Regulations, Standards and Techniques](#)" ISBN-13: 978-1118511794; to be printed April 2016

Any Questions?