Spectrum commons; unlicensed spectrum; Short Range Devices (SRDs)

Dr. Haim Mazar; ITU and world-bank Expert
Vice Chair ITU-R Study Group5 (terrestrial Services)
ATDI spectrum management and licensing
h.mazar@atdi-group.com

DOI: 10.13140/RG.2.2.33215.25762

Original presentation in Zanzibar Workshop, on 3 March 2020

Definitions

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

h.mazar@atdi-group.com

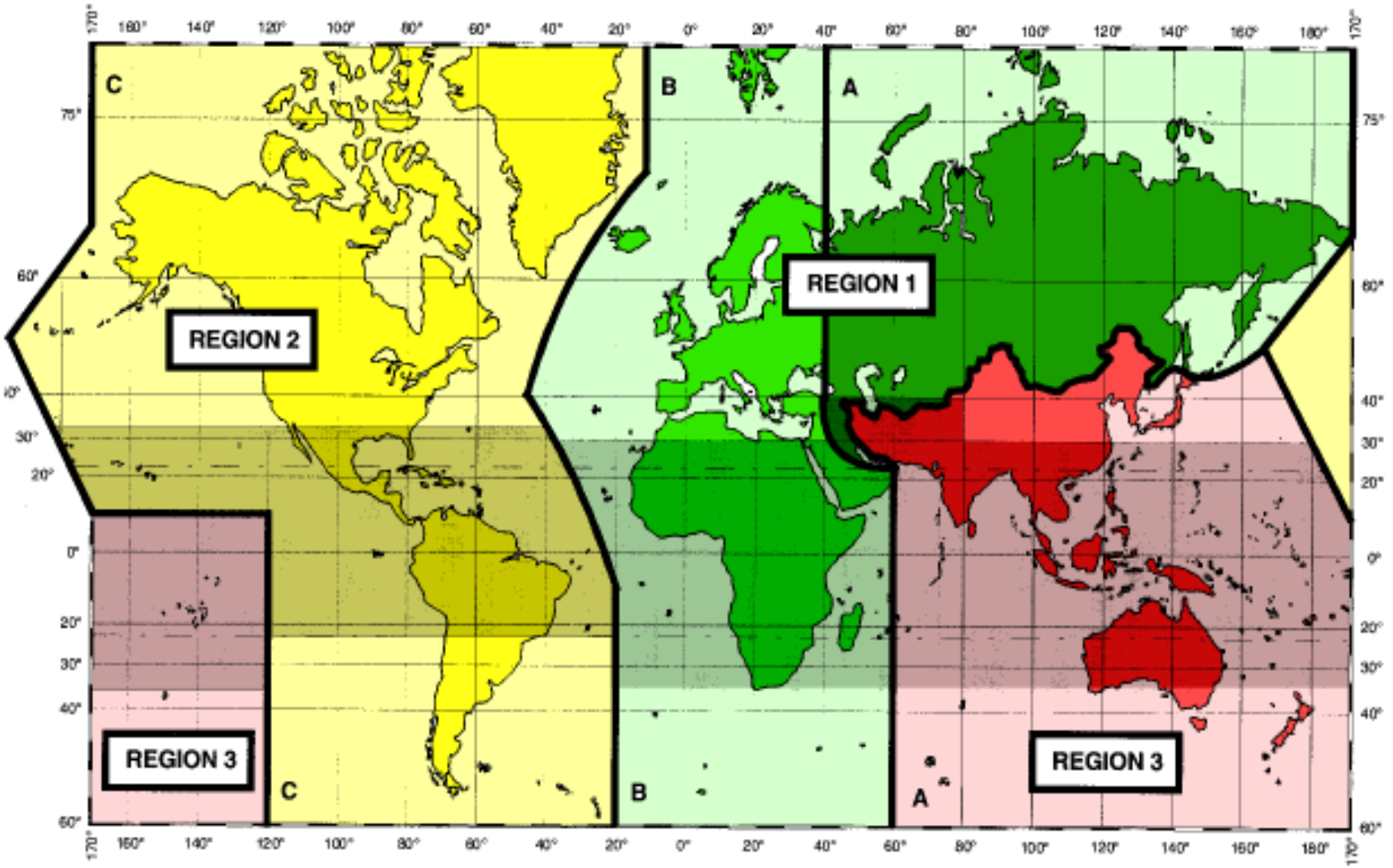
ISM Bands: ITU 2016 Radio Regulations, ITU RR

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

h.mazar@atdi-group.com

ITU RF Allocation; three Regions



h.mazar@atdi-group.com

Frequency Bands for SRDs

Global
Only in Europe
Only in Americas

ISM bands for SRDs

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

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

h.mazar@atdi-group.com

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

Europe constrains wideband data transmission in 5150–5350 MHz, to only indoor use (some changes at WRC-19)

The Radio Equipment Directive 2014/53/EU (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

Part 15 American *Licence-Exempt Devices vs. European Short Range Devices.* Europe permits lower emissions: e.g., e.i.r.p. 0.1W versus 4W at 2.4 GHz

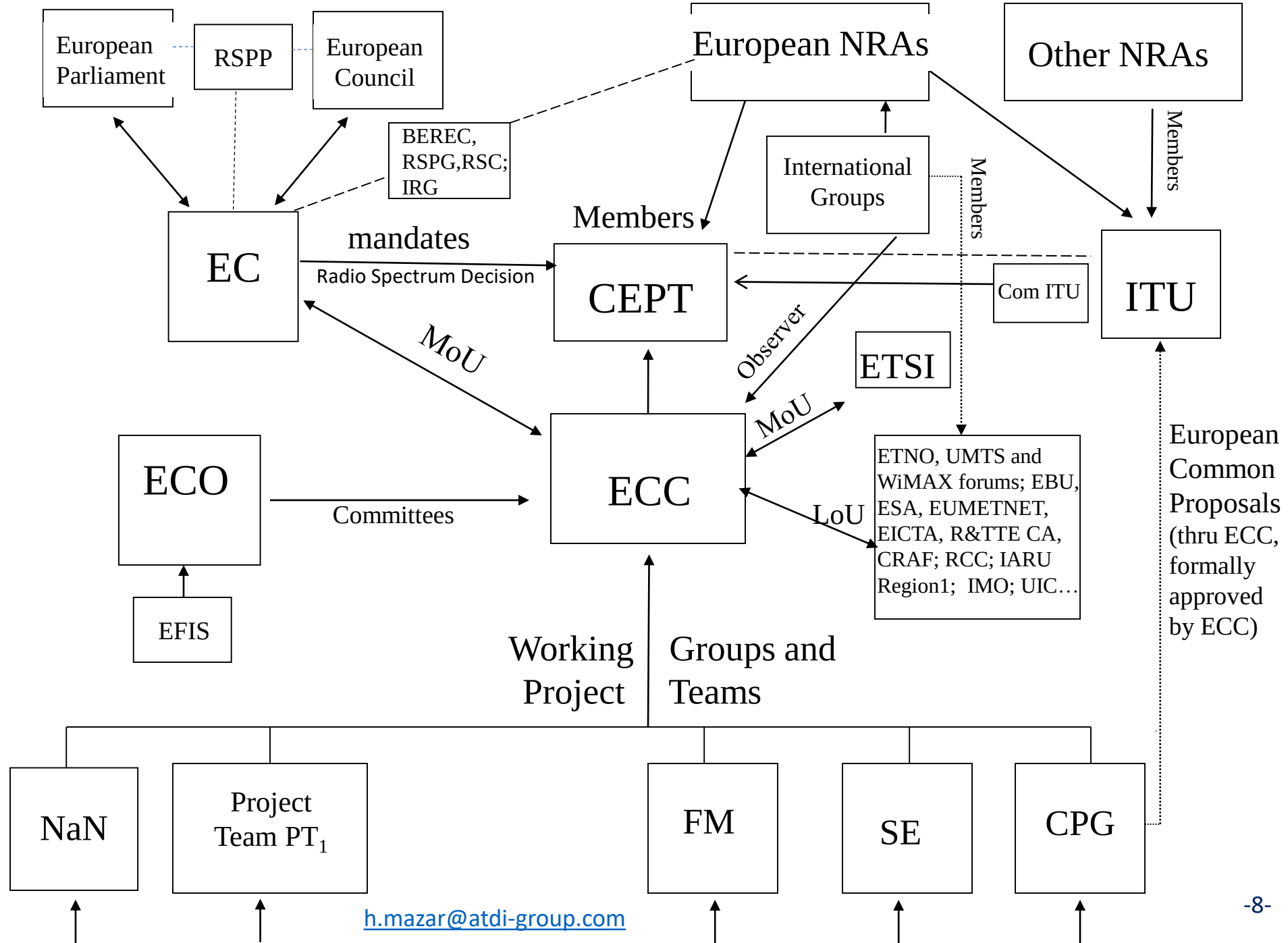
FCC Part 15 originated in 1938, inspired the European SRD concept (~1990) and ERC/REC 70-03. In US and Canada most of the RF is available to SRD

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

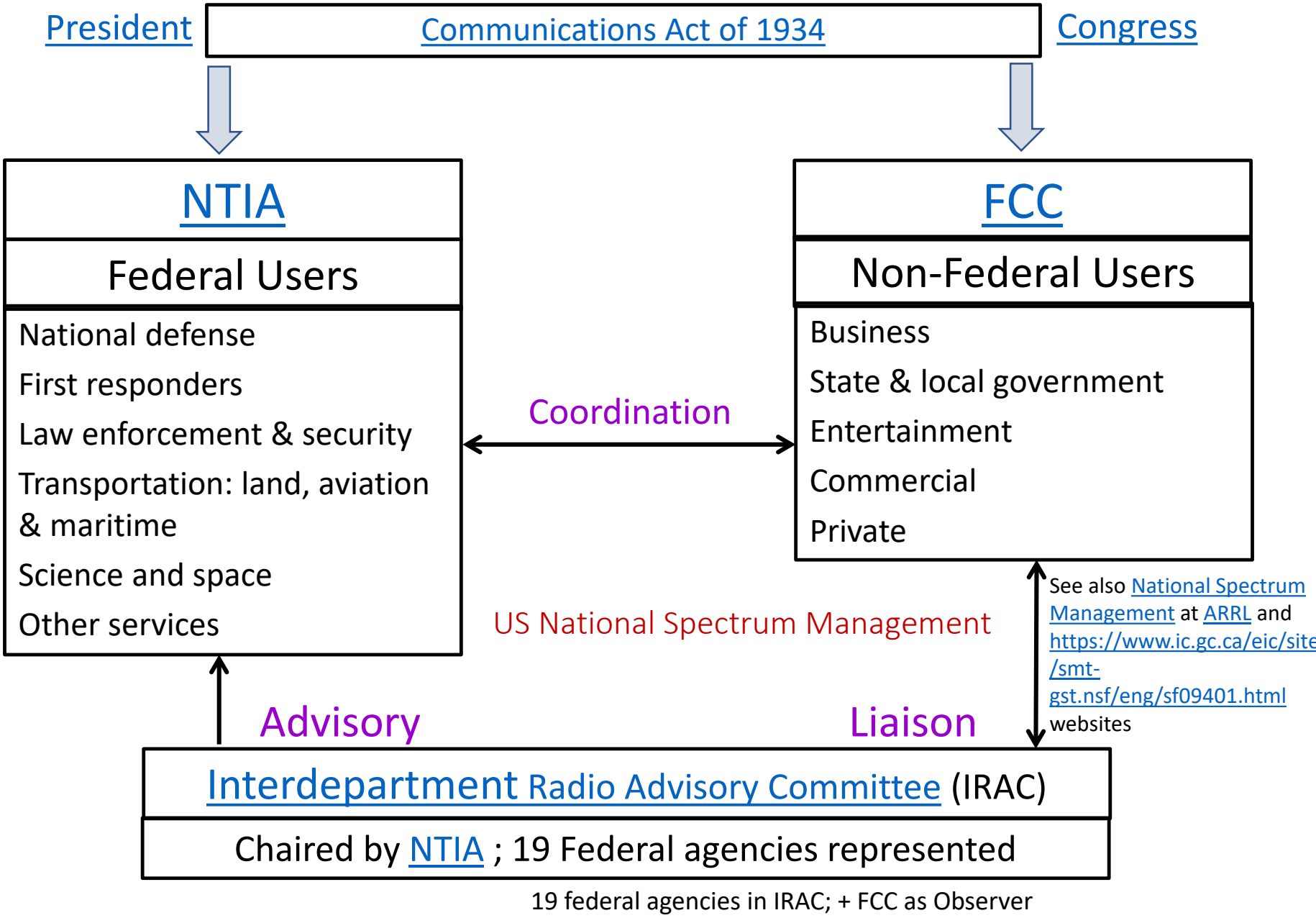
Technical requirements applicable in certain administrations or regions

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		**4 W e.i.r.p.**	N/A
	Europe		**100 mW (e.i.r.p.)**	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 5,250-5,350 5,470-5,725 5,725-5,850	50mW; 2.5 mW/MHz 250mW; 12.5mW/MHz 250mW; 12.5mW/MHz 1,000mW; 50.1mW/MHz	0-6 dBi (Omni) 0-6 dBi (Omni) 0-6 dBi (Omni) 0-6 dBi (Omni)
	Canada	5,150-5,250 5,250-5,350 5,470-5 725 5,725-5,850	**200 mW e.i.r.p.; 10 dBm/MHz e.i.r.p.** **250 mW; 12.5 mW/MHz; (11 dBm/MHz)** **1,000 mW e.i.r.p.** **250 mW; 12.5 mW/MHz (11 dBm/MHz)** **1,000 mW e.i.r.p.** **1,000 mW; 50.1 mW/MHz**	https://www.itu.int/pub/R-REP-SM.2153-7-2019
	Europe	5,150-5,250 5,250-5,350 5,470-5,725	**200 mW (e.i.r.p.); 10 mW/MHz (e.i.r.p.)** **200 mW (e.i.r.p.); 10 mW/MHz (e.i.r.p.)** **1,000 mW (e.i.r.p.); 50 mW/MHz (e.i.r.p.)**	
	Japan	4,900-5,000 5,150-5,250 5,250-5,350 5,470-5,725	250 mW 50 mW/MHz 10 mW/MHz (e.i.r.p.) 10 mW/MHz (e.i.r.p.) 50 mW/MHz (e.i.r.p.)	13 N/A N/A N/A N/A
57-66 GHz	Europe	57-66 GHz	40 dBm (e.i.r.p.)	N/A

h.mazar@atdi-group.com



h.mazar@atdi-group.com



h.mazar@atdi-group.com

ISM applications in & 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	**Microwave ovens** 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)

h.mazar@atdi-group.com

Typical SRDs 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
9. Internet of Things (IoT); IoT may also operate as a cellular application

h.mazar@atdi-group.com

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

h.mazar@atdi-group.com

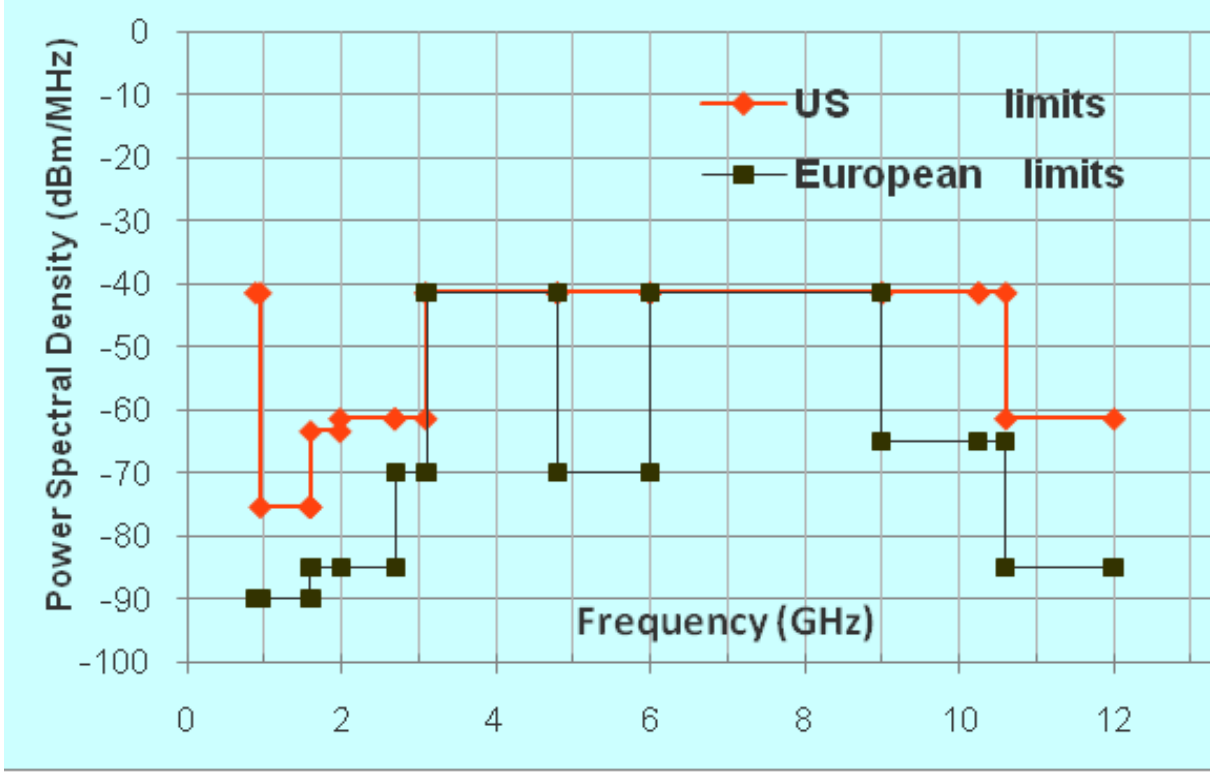
Wireless Power Transfer (WPT) as SRD (in China)

1. 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***
2. WPT with no data communication (e.g. Blue Tooth or ZigBee) is ISM, and may operate in all ISM bands
3. 'equipment with a WPT function may be regarded as another type of SRD' (CISPR/1302/INF; 2015-03-20)
4. WPT is SRD only if there are telecommunications
5. USA separates between FCC Part 15 for 'Radio Frequency Devices' and FCC Part 18 for ISM

h.mazar@atdi-group.com

UHF RFID: Americas versus Europe, UWB emission

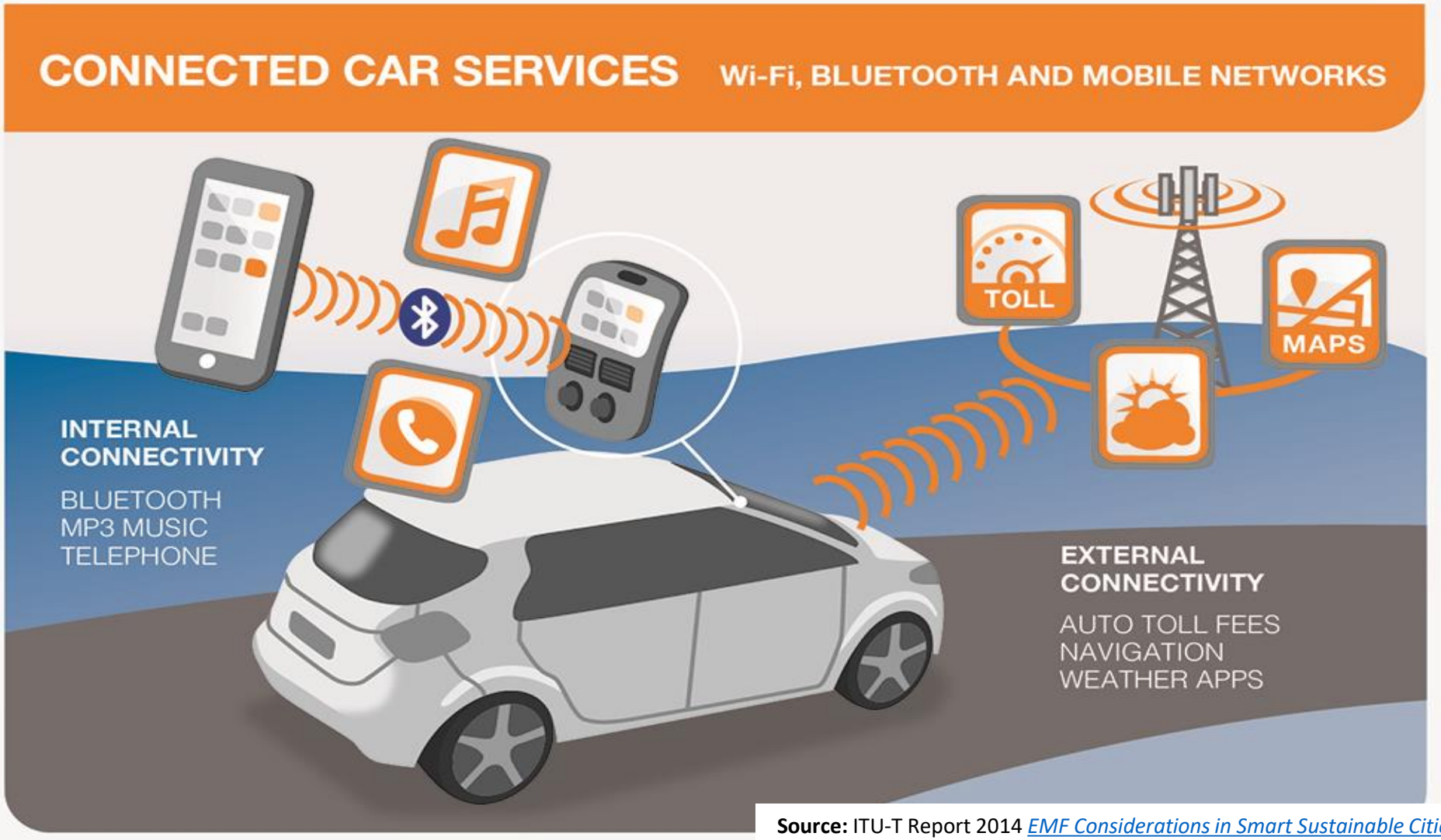
	RF band (MHz)	Max e.i.r.p. power (Watts)	Channels (kHz)	Total RF BW(MHz)	Approval process
Europe	865-868	up to 2 (e.r.p.) x 1.64=3.28	15 x 200	3	*R&TTE*
Americas	902-928	4*	52 x 500	26	US tests every RFID



Differences up to 49 dB@900-960MHz; Europe allowed UWB in 2005, US in 2001

SRDs & smart sustainable world, cities, houses, cars

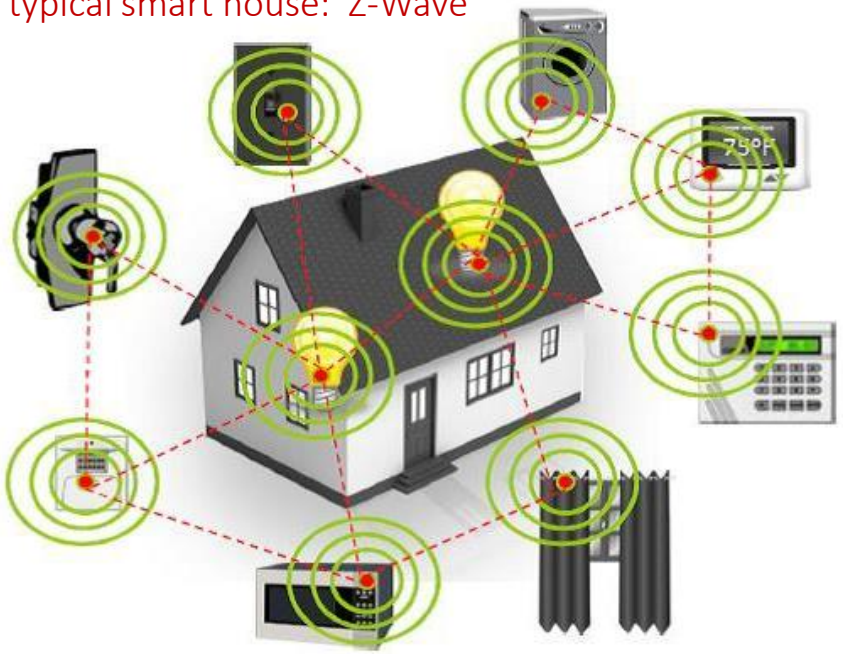
SRDs provide ICT's vital infrastructure & connection for Smart Sustainable Cities



Source: ITU-T Report 2014 *EMF Considerations in Smart Sustainable Cities*

Current
sub-1GHz

typical smart house: Z-Wave



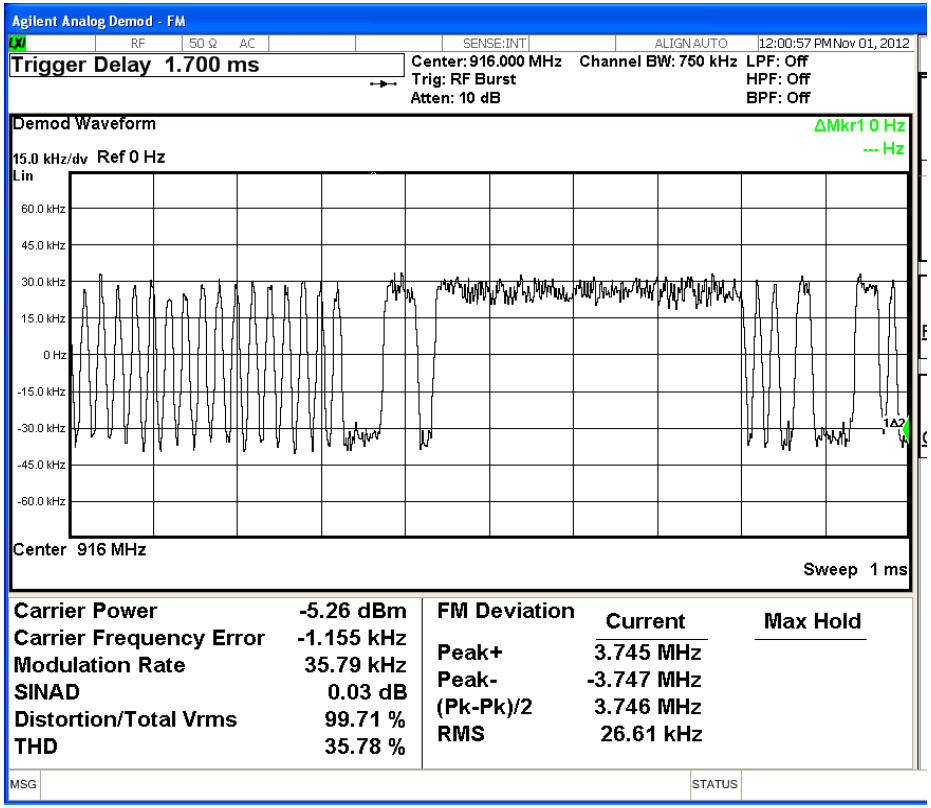
designed mainly for remote controls, smoke alarms and security sensors

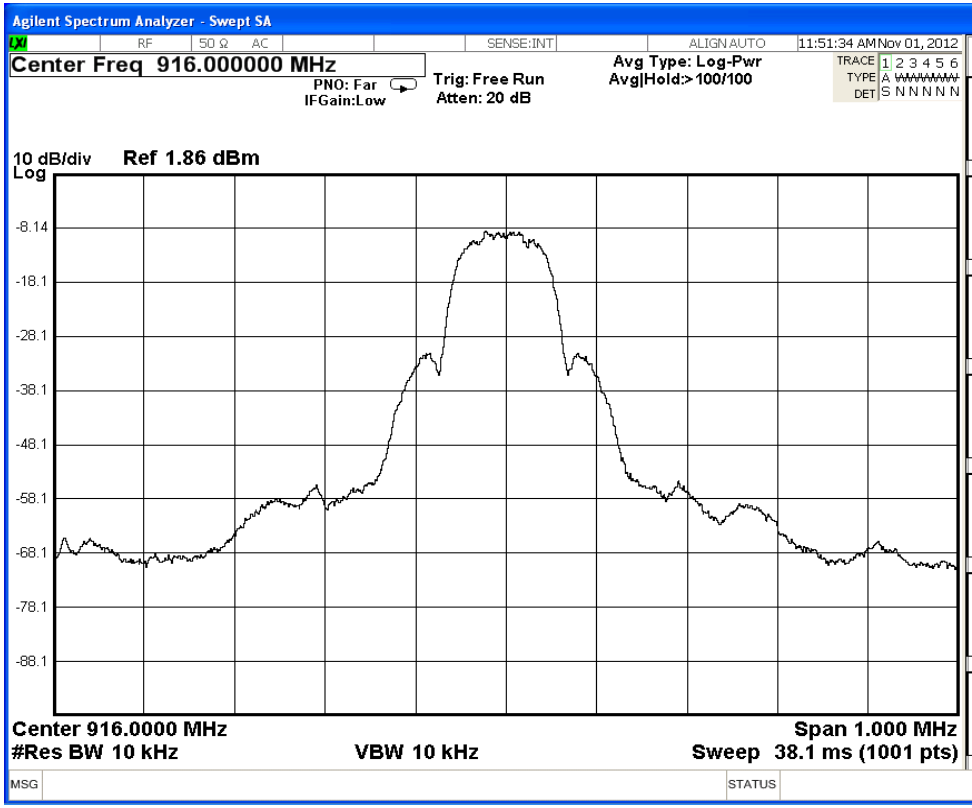
1. Z-Wave uses a single frequency FSK
2. Data rate up to 100 Kbps; unlike IEEE 802.11, designed primarily for high-bandwidth data flow
3. Range between controllers & slave devices up to 100 ft

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

h.mazar@atdi-group.com

New Technologies, Time and Frequency Domains





h.mazar@atdi-group.com

Preserving Vultures

h.mazar@atdi-group.com

SRD to track (& preserve) short-toed snake-eagle

Rec. SM.1896 ann.1: SRDs global harmonization

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

h.mazar@atdi-group.com

Calculating Electric and Magnetic fields

1. 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 µA/m or dB(µA/m). Below 1,000 MHz, ERP is used. 70-03 uses logarithmic dB µA/m magnetic-fields at 10 m. Use of dB µA/m unit globally reveals 70-03 influence; e.g. first 2 rows at Table 2 APT Report APT/AWG/REP-07

2. 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 µV/m; and not the logarithmic dB V/m, dB mV/m or dB µV/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

3. 70-03 dB(µA/m) @ 10 m:

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

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

1. Part 15 @ *d*= 3 m equals

$$ERP\left(\text{dBm}\right) = H\left(\text{dB µA/m}\right) - 35.38$$

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

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

h.mazar@atdi-group.com

Regulating SRDs

1. Administrations define: RF bands, power, channel spacing & mitigation requirements
2. 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)
3. 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 & less 'tragedy of commons' in the RF 'public park'
4. Will first responders use 'unprotected' RF bands?
5. SRDs are unprotected! *Caveat Emptor*: 'let the buyer beware'
6. No need to regulate non-active RFID: *de minimis non curat lex*

h.mazar@atdi-group.com

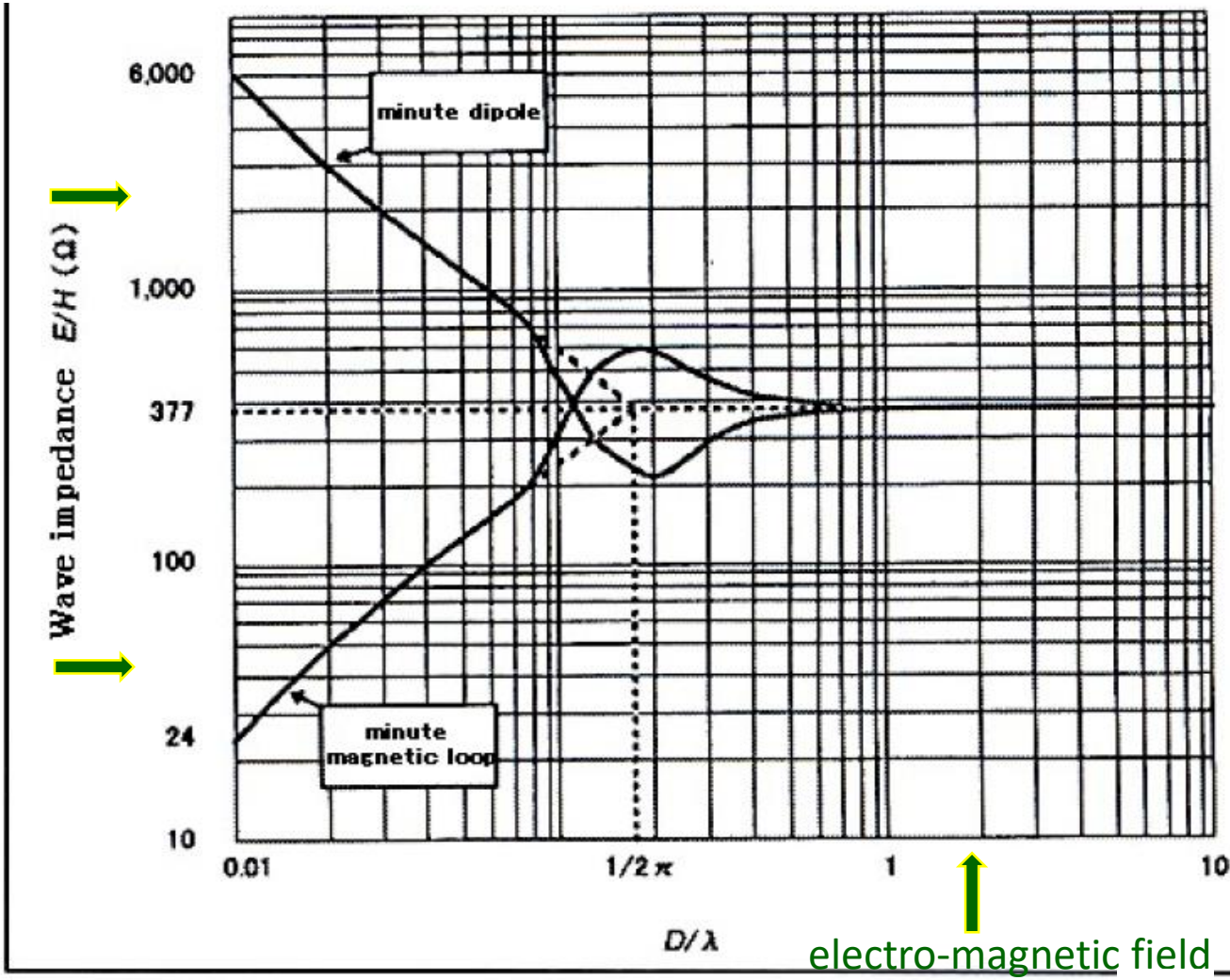
Wave Impedance (z) of minute dipole & minute magnetic dipole

$$PoyntingVector = \frac{p_t g_t}{4\pi d^2} = (\vec{e} \times \vec{h}) = \frac{e_o^2}{z} = h^2 z$$

Most relevant to near field

Wire-
electric field is
dominant

Loop-
magnetic field is
dominant



h.mazar@atdi-group.com

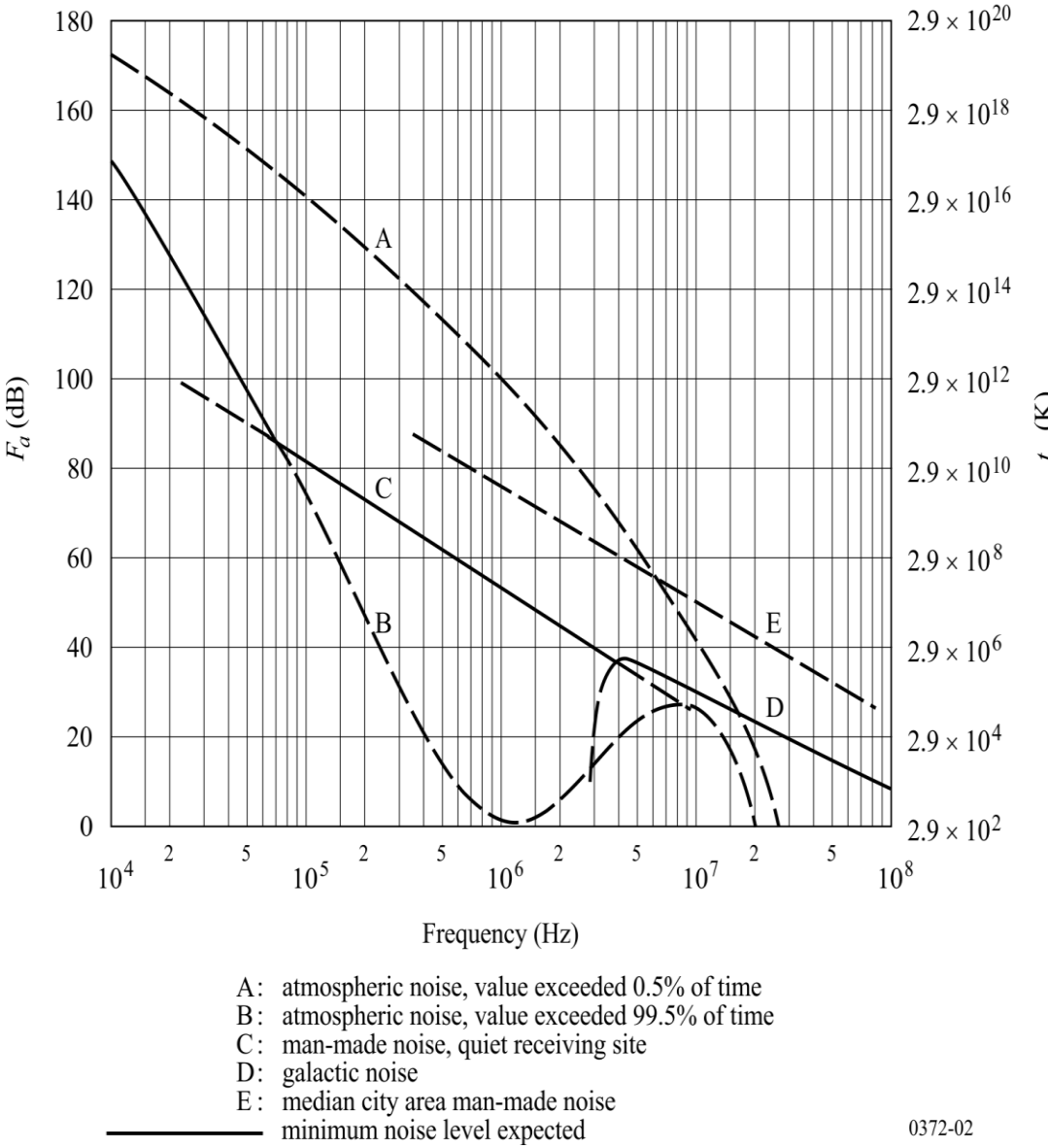
Interference of SRDs to Radio services.
At low RF no significant degradation

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

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

FIGURE 2

F_a 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

h.mazar@atdi-group.com

Wi-Fi: greatest triumph after GSM

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

For me personally, **when abroad**, connected to RLAN is **more important** than cellular connection, to offer **free** internet connection and audio/ **video** calls

h.mazar@atdi-group.com

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[(4)] 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	

h.mazar@atdi-group.com

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

^ known also as µwave 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.

h.mazar@atdi-group.com

Wi-Fi offload to improve cellular capacity

(Sources: KDDI May 2013 and Alvarion October 2013)

1. In congested areas (outdoors & indoors), the growing need of mobile data exceeds the available cellular capacity
2. Main usage: city centers, big malls, airports, train station, stadiums
3. WiFi is the most cost effective solution for data offloading
   1) RF Spectrum free of charge (at 2.4 GHz and 5 GHz)
   2) 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

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

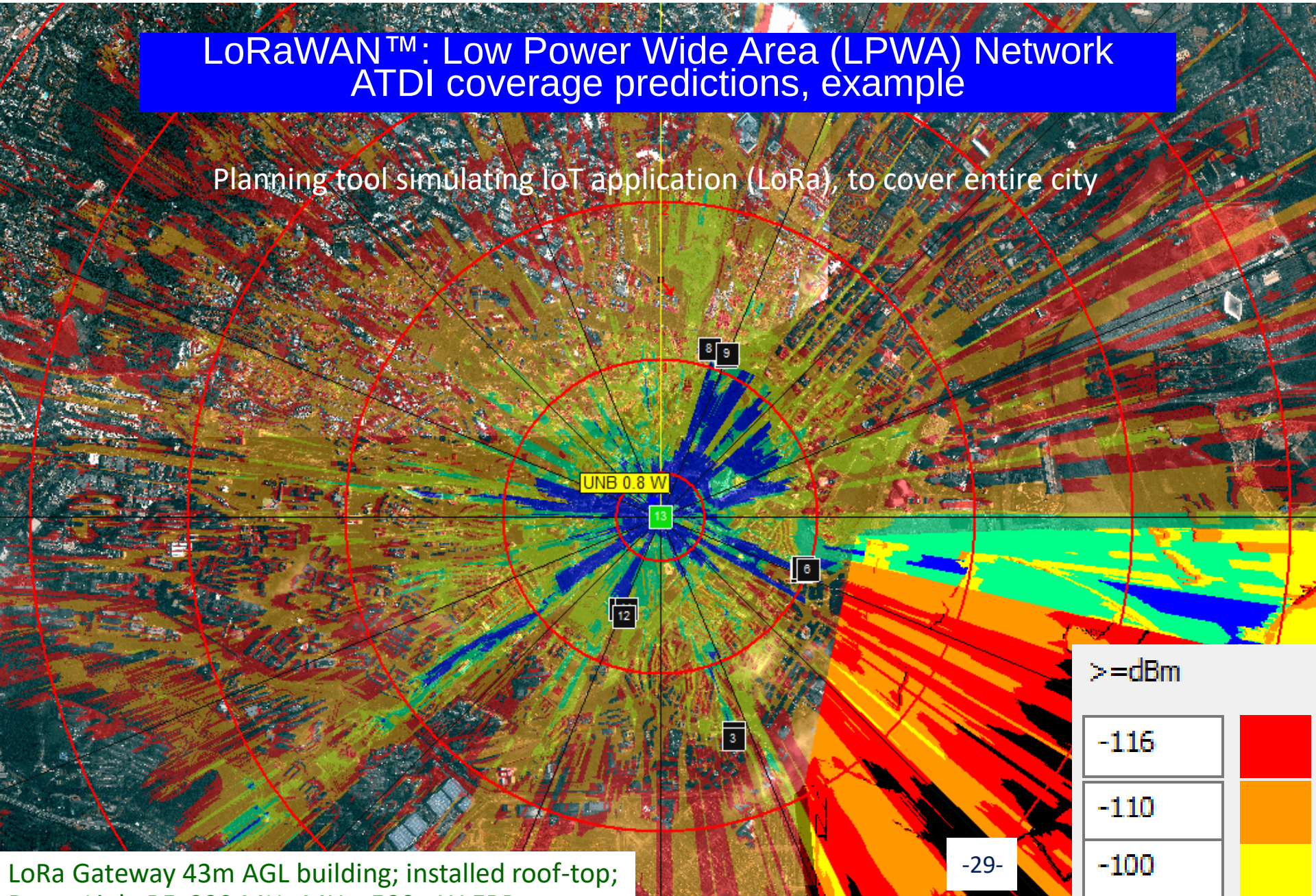
Shibuya station of Tokyo Metro; 15 April 2013

Shenzheng: RFI to 2.4 GHz train comms, due to 2.4 GHz Wi-Fi

h.mazar@atdi-group.com

LoRaWAN™: Low Power Wide Area (LPWA) Network
ATDI coverage predictions, example

Planning tool simulating IoT application (LoRa), to cover entire city



LoRa Gateway 43m AGL building; installed roof-top;

SRDs and Internet of Things (IoT)

SRDs may connect IoT to wireless networking

M2M via cellular or WiFi infrastructure, & other SRDs means

smart grids, homes, and cities; intelligent transportation & smart energy management

Examples for M2M/IoT applications include: RFID; Home automation and Smart meters

h.mazar@atdi-group.com

Relevant Material from Dr. Haim Mazar presentations (1); see http://mazar.atwebpages.com/Downloads

1. Academic_Course_Advanced_Wireless_Communications_Mazar1_Engineering_2020.pdf
2. Academic_Course_Advanced_wireless_communications_Mazar2_Services_2020.pdf
3. Academic_Course_Advanced_Wireless_Communications_Mazar3_Regulation_EMC_HumanHazards_2020.pdf
4. Cameroon_EconomicModels_African_RF_Spectrum23Aug19French.pdf
5. Cameroon_Yaounde_Commonwealth_SM Forum_Mazar_Nov16_Spectrum re-farming.pdf
6. CamerounCellulaires_affectation_bande_470 694_21Dec18_French.pdf
7. CamerounSolutions_techniquesDTTV_MPT_UHF_21Dec2018_French.pdf
8. China_Beijing_SRMC 9July15_National Spectrum Control.pdf
9. China_Beijing_SRMC 9July15_SRD.pdf
10. China_Chengdu_National Spectrum Control Xihua University.pdf
11. Delft_Univ_Cultural_Factors_Shaping_RF_Spectrum_Governance_24Sept2010_Mazar.pdf
12. European vs North American Wireless Regulations_Mazar_ITU world telecom 2011_2633.pdf
13. Geneva_ITU-RSG1SG5-IoT-Workshop_Mazar_22Nov16.pdf; the video includes Author's my 16 minutes presentation 2:36:13 till 2:53:10
14. Heron5G_RF_regulations_6June19_Mazar.pdf
15. How_Geography_and_Culture_influence_RF_regulation_NZL_case_Wellington_4Feb2010_Mazar.pdf
16. IMT_5G_frequencies_HERON_ATDI_Mazar.pdf
17. ITUD_Gambia_Optimised_Ways_to_Transmit_the_Video_Signals_16July2010_Mazar.pdf
18. ITUD_Gambia_Policies_and_Strategies_to_Optimise_RF_Spectrum_Use_14July2010_Mazar.pdf
19. ITU_regional_SM_conference_connecting_Yerevan13Dec2017.pdf

h.mazar@atdi-group.com

Relevant Material from Dr. Haim Mazar presentations (2); see http://mazar.atwebpages.com/Downloads

20. ITU_regional_SM_workshop_parameters_Yerevan14Dec2017.pdf
21. ITU_workshop_international_regional_and_national_regulation_of_SRDs_Mazar.pdf
22. International_Regional_National_RF_Regulation_Standardisation_Ruppin_Mazar.pdf
23. International_Regional_National_RF_Spectrum_Management_13Dec2011_Afeka_Tel_Aviv_Academic_College_of_Engineering_Mazar.pdf
24. January 2016_National Spectrum Control_China@SRTC&XHU.pdf
25. January 2016_SRD_Mazar_SNG&SRTC&XHY&GDRTC.pdf
26. Lusaka_ZICTA_Auctioning_Training_30Sept-4Oct19_Mazar.pdf
27. Paper WT11 Technical Symposium TS11 Haim Mazar_A Comparison between European and North American Wireless Regulations.pdf
28. Presentation WT11 Technical Symposium TS11 Haim Mazar_A Comparison between European and North American Wireless Regulations.pdf
29. Regulating_SRD_Israel_MoC_28Jan2019_Mazar.pdf
30. Regulation of SRDs_Mazar_TCBC_Baltimore_15April2015.pdf
31. Regulation_and_Standardization_of_Wireless_Communications_Israel_Europe_America_22Dec09_Ort_Braude_College_Mazar.pdf
32. WarsawEMF2019_Mazar_WRC19_5G_IMT2020_ITU4Dec19.pdf
33. Webinar_International_GoGlobal_Haim_Mazar_UHF_RFID_global_and_regional_ruling_19Feb13.pdf
34. Wireless_Communications_Coexistence_between_Israel_and_Neighbors_Ashdod_17May2010_Mazar.pdf
35. Wireless_Telecommunications_training_program_Nepal_Kathmandu_24_28Nov08_Mazar.pdf
36. ZICTA_CEPT&UK_9Jan17_Mazar.pdf
37. ZambiaZICTA_PricingModel19April2017Mazar.pdf
38. ZambiaZICTA_RF_Audit19Apr2017Mazar.pdf

h.mazar@atdi-group.com