Spectrum Supporting IoT

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ITU Asia-Pacific CoE Face to Face Training Programme
IoT Technologies and Applications for Smart Cities
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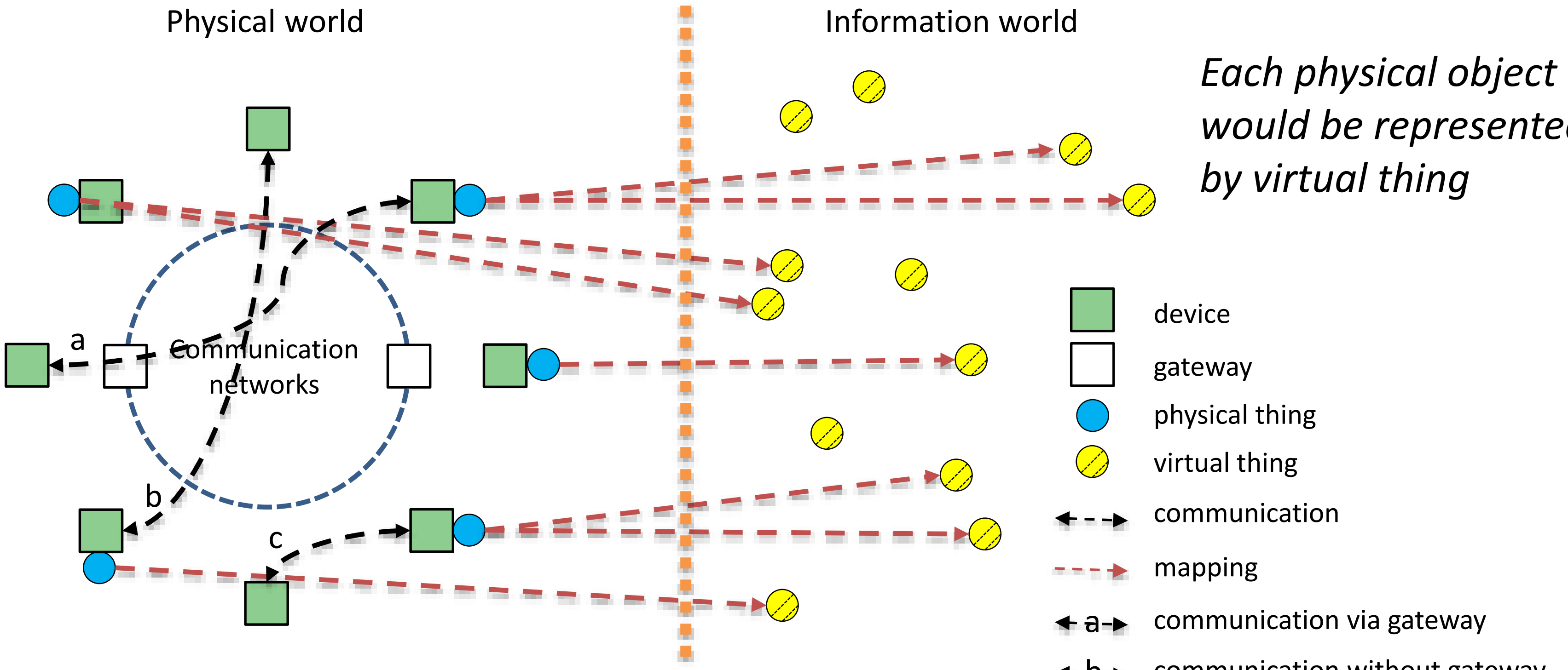
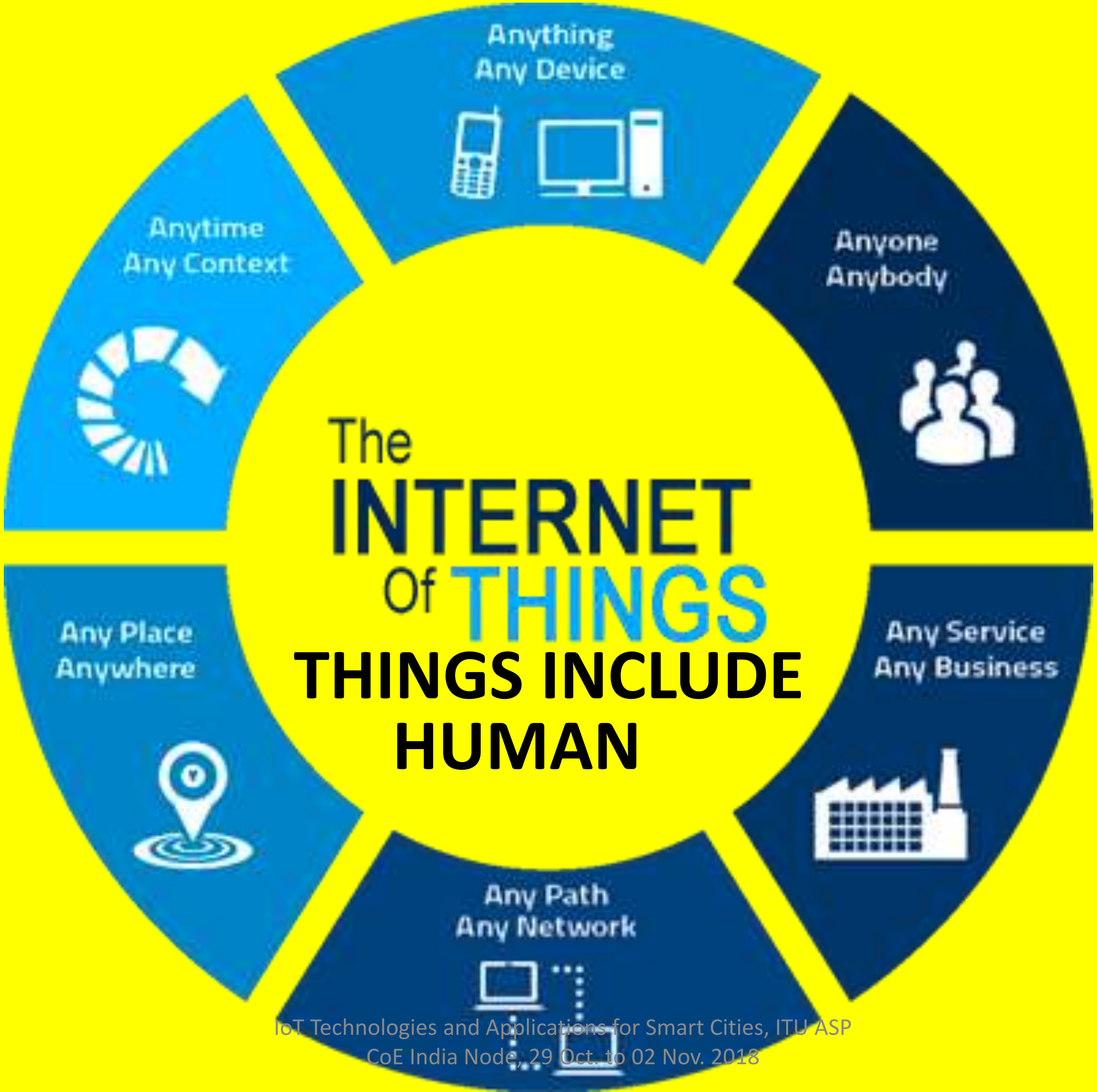
Technical overview of the IoT, as defined by ITU-T Y.2060



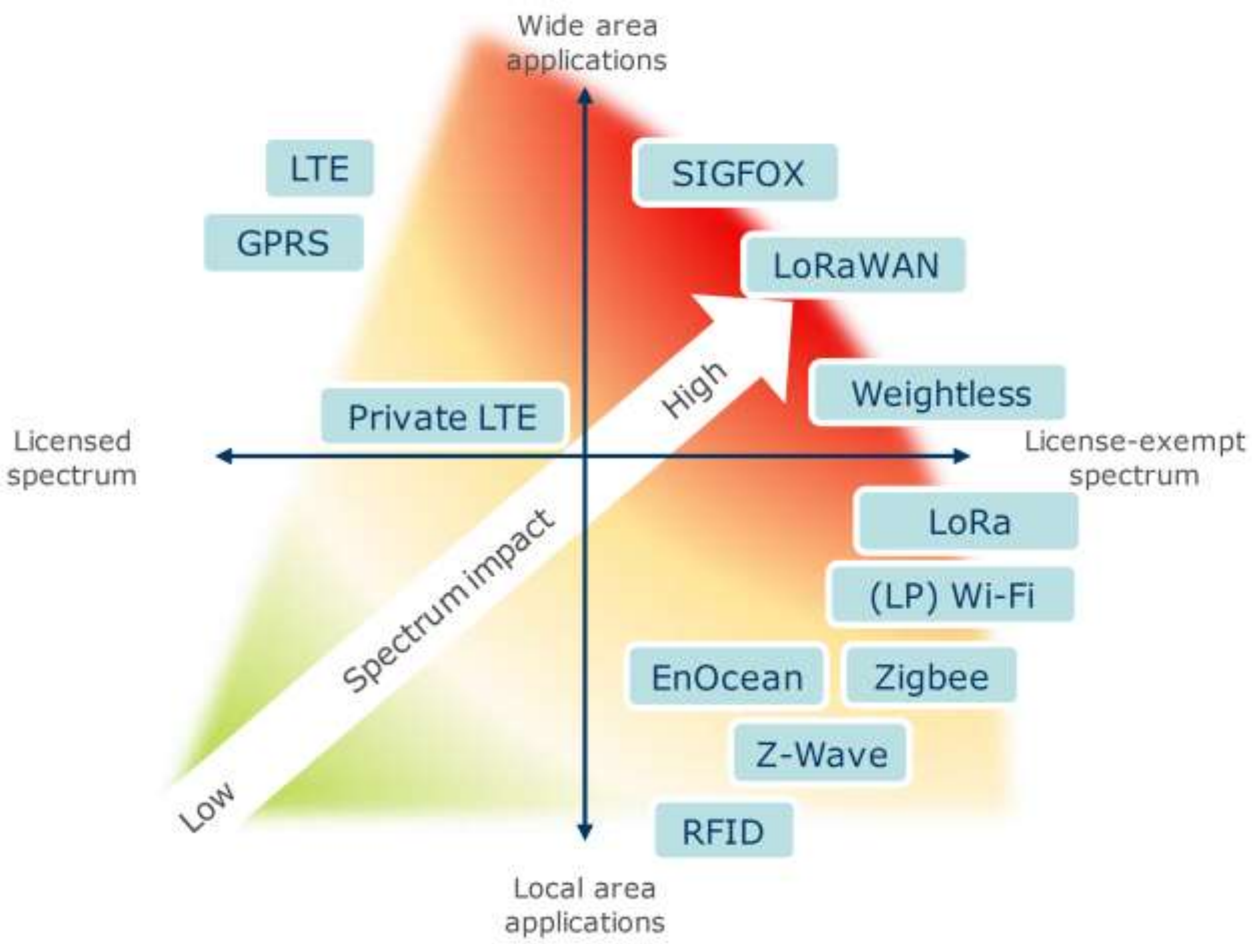
Each physical object would be represented by virtual thing

It is expected that a significant portion of the connections that make up the IoT will be wireless



THINGS INCLUDE HUMAN

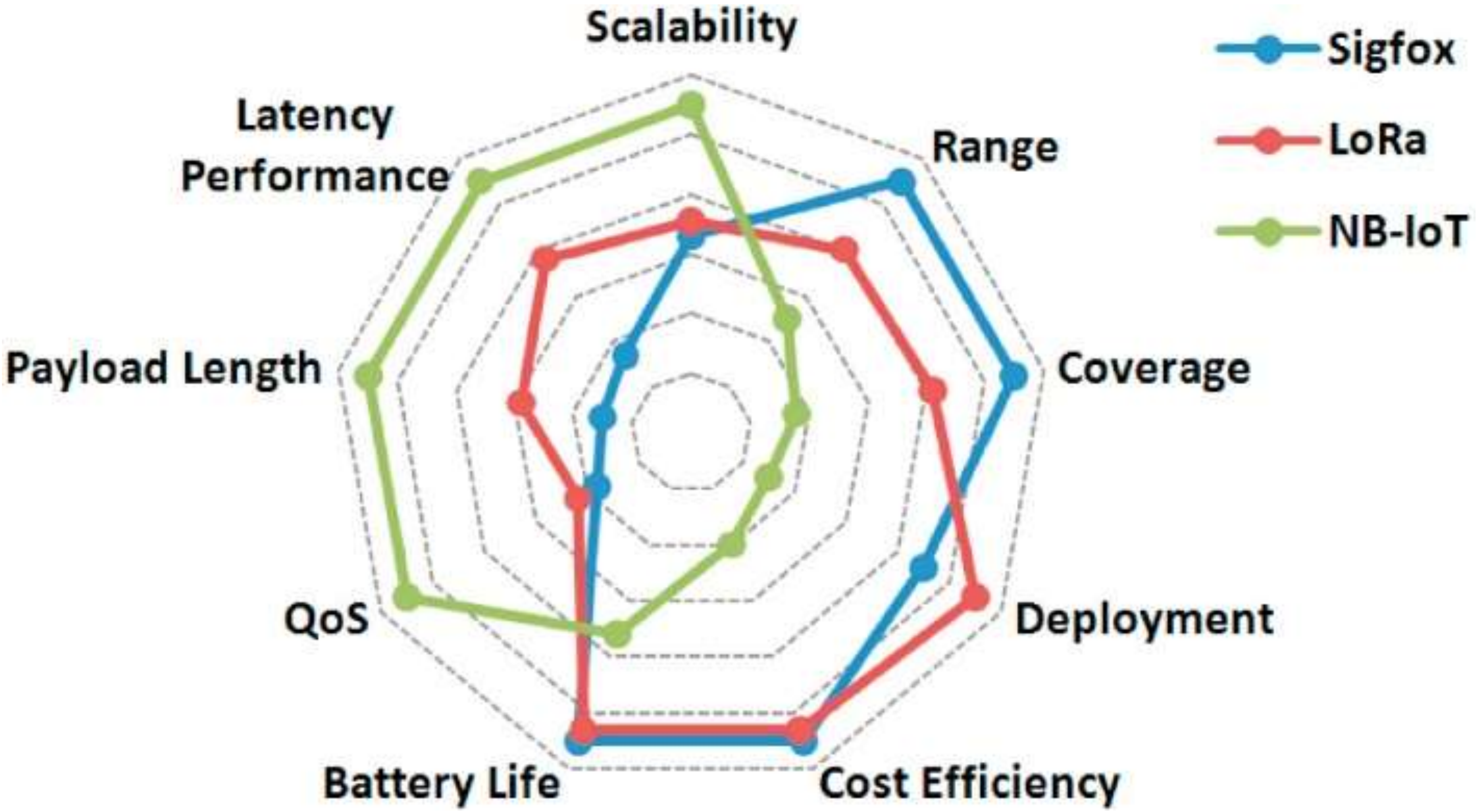
Technologies for Wireless IoT Connectivity, by Spectrum Type and Scope



Some of the Wireless Sensor Network Technologies in IoT

Features	LORAWAN	SIGFOX	INGENU	NB-IoT
Modulation	CSS (Chirp Spread Spectrum)	UNB DBPSK(UL), GFSK(DL) (UNB: Ultra Narrow Band)	RPMA-DSSS(UL), CDMA(DL)	QPSK
Band	SUB-GHz ISM:EU (433MHz, 868MHz), US (915MHz), Asia (430MHz)	SUB-GHz ISM:EU (868MHz), US(902MHz)	ISM 2.4GHz	Licensed LTE bandwidth
Data rate	0.3-37.5 kbps (LORa), 50 kbps (FSK) 50 kbps (LORa),	100 bps(UL), 600 bps(DL)	78kbps (UL), 19.5 kbps(DL)	DL:234.7 kbps; UL:204.8 kbps
Bandwidth	500 to 125 kHz	100 Hz	1000 kHz	200 kHz
Range	5 – 20 km	10 – 40 km	2 - 8 km	1 – 10 km
FEC	YES	NO	YES	YES
MAC	unslotted ALOHA	unslotted ALOHA	CDMA-like	slotted aloha
Topology	star of stars	star	star	Star
Adaptive Data Rate	YES	NO	YES	NO
Authentication & encryption	AES 128b	encryption not supported	16B hash, AES 256b	EEA EPS Encryption Algorithm
SLA support	NO	NO	NO	**YES**
Localization	YES-TDOA	NO	NO	NO
Capex	Low	high	medium	**High**
Opex	Low	Low	medium	**High**

Comparing SigFOX, LoRa and NB-IoT



Source: K. Mekki et all, A comparative study of LPWAN technologies for large-scale IoT deployment, Science Direct, Dec. 2017

Common Spectrum for Non-IMT IoT So-called ISM Band

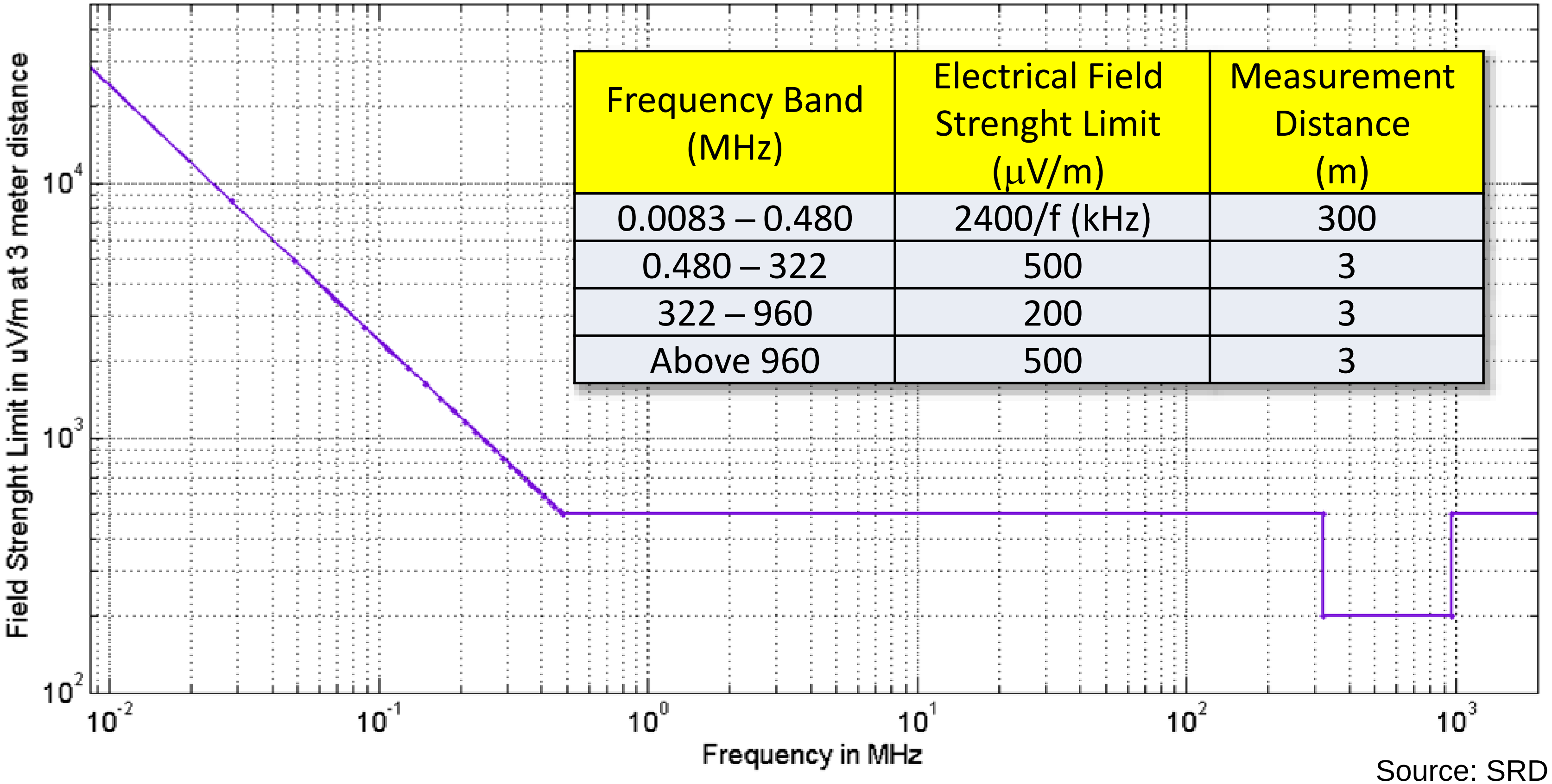
ISM Bands: Just in regulatory point of view

	ITU RR No. 5.138	ITU RR No. 5.150
Below 1 GHz	6 765-6 795 kHz, 433.05-434.79 MHz in Region 1 except in the countries mentioned in No. **5.280**,	13 553-13 567 kHz, 26 957-27 283 kHz, 40.66-40.70 MHz, 902-928 MHz in Region 2,
1-6 GHz	-	2 400-2 500 MHz, 5 725-5 875 MHz
Above 6 GHz	61-61.5 GHz, 122-123 GHz 244-246 GHz	24-24.25 GHz

- Basic requirements: shared among all, no right to claim for protection
- Popularly utilized ranges by IoT: 433.05-434.79 MHz, 902-928 MHz, 2400 – 2483.5 MHz

Common Spectrum for Non-IMT IoT Non-ISM Band

- In regulatory point of view: All frequencies non-specifically if they radiate below threshold level



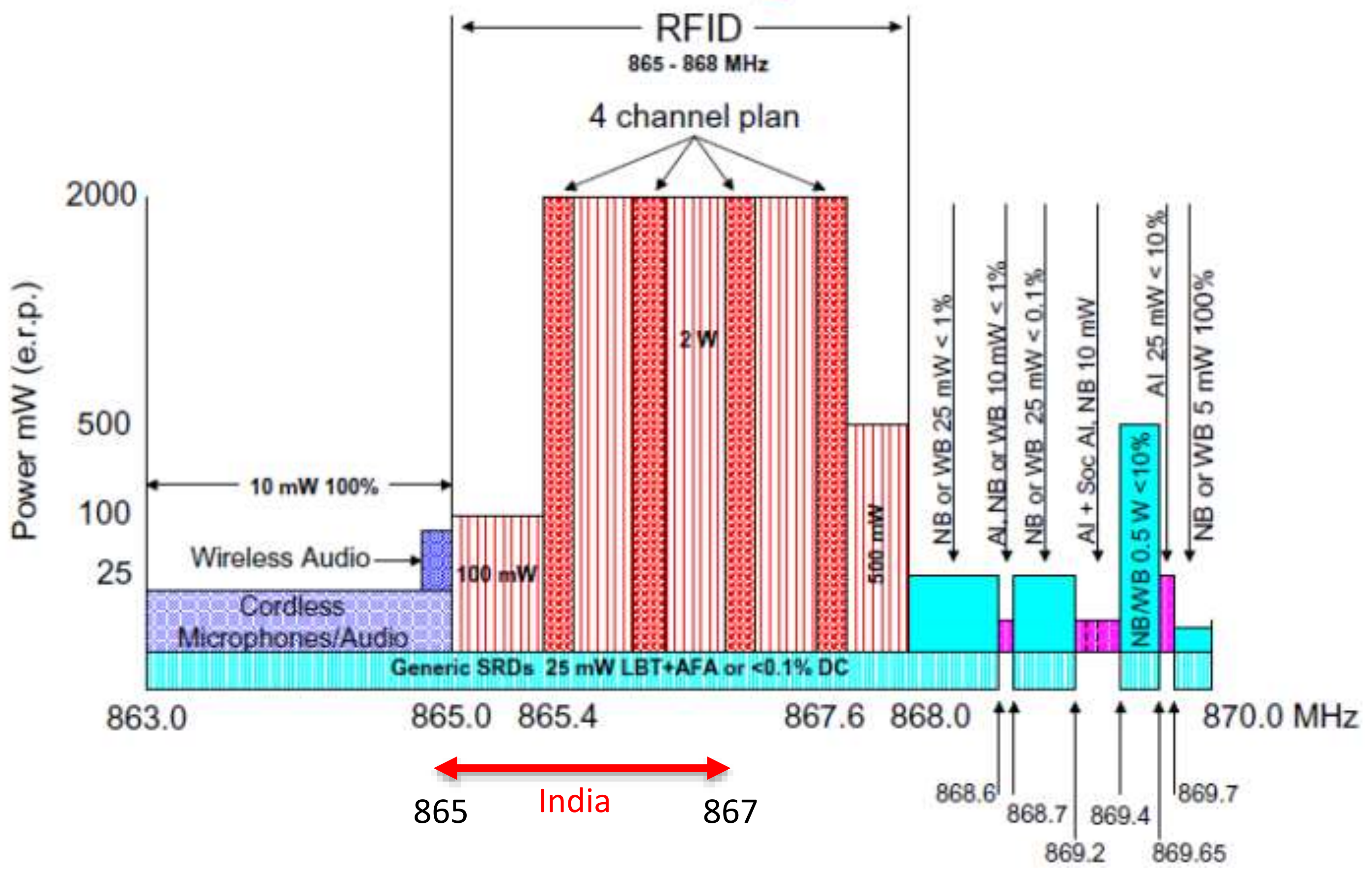
Frequency Band (MHz)	Electrical Field Strenght Limit (μV/m)	Measurement Distance (m)
0.0083 – 0.480	2400/f (kHz)	300
0.480 – 322	500	3
322 – 960	200	3
Above 960	500	3

Source: SRD Regulation, Iran)

Common Spectrum
for Non-IMT IoT Non-ISM Band

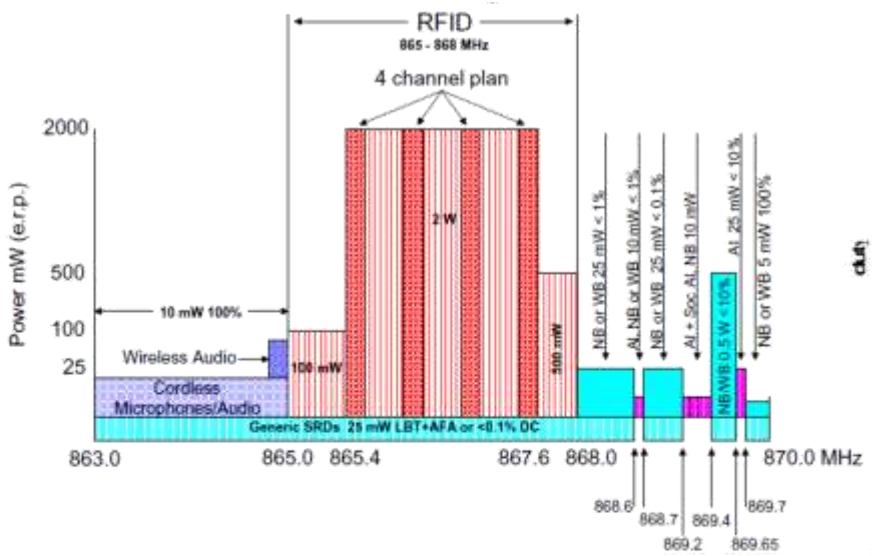
- Frequency bands may be identified by the Regulators:

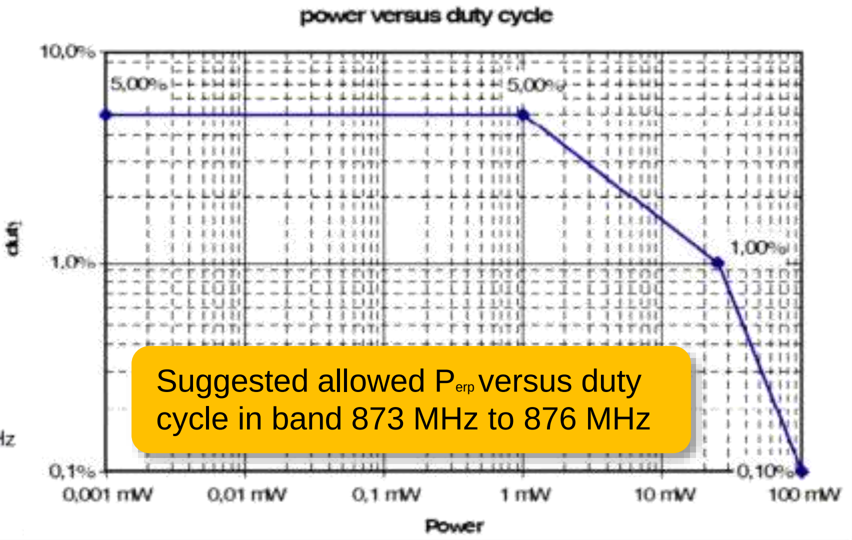
Source: ETSI TR 103 055 V1.1.1 (2011-09)



Duty Cycle – Radiated Power Equilibrium Criteria in the 865 MHz Band

Source: ETSI TR 103 055 V1.1.1 (2011-09)



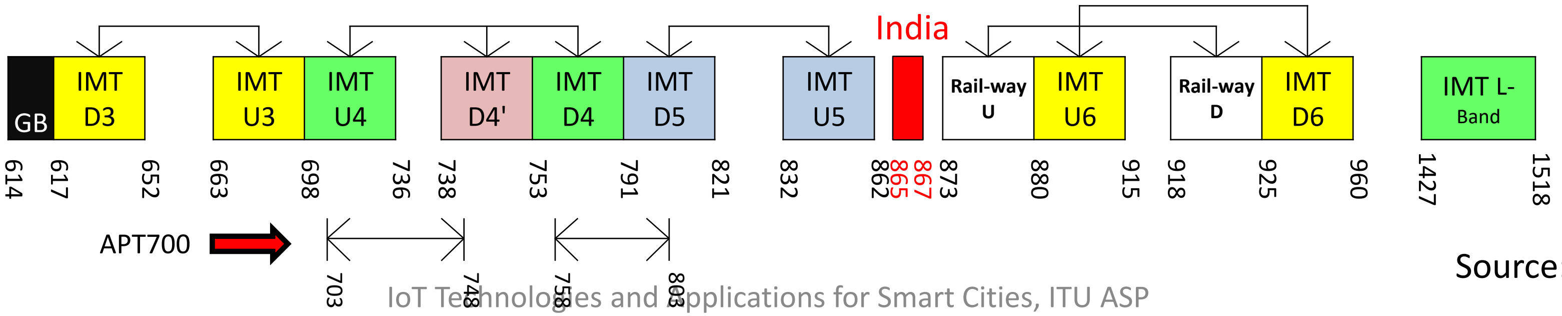


Frequency Band	Applications	Maximum radiated power (e.r.p.)/power spectral density	Channel Spacing	Transmitted duty cycle
870 MHz to 873 MHz	All	25 mW	None	1 % duty cycle or LBT +AFA
873 + 0,2n MHz; 1 ≤ n ≤ 14	All	100 mW	200 kHz	See table 5

Frequency Band (G6)	Power	Duty Cycle	Channel bandwidth	Remarks
873 MHz to 876 MHz specific SRDs. Short Burst Telegrams	≤ 1 mW e.r.p. (to be studied) ≤ 25 mW e.r.p. ≤ 100 mW e.r.p.	Up to 5 % D.C. Up to 1 % D.C. Up to 0,1 % D.C.	No channel spacing	Narrow/wideband, DSSS with 0,1 % duty cycle permitted. FHSS duty cycle and T_{on} time of hops to be studied

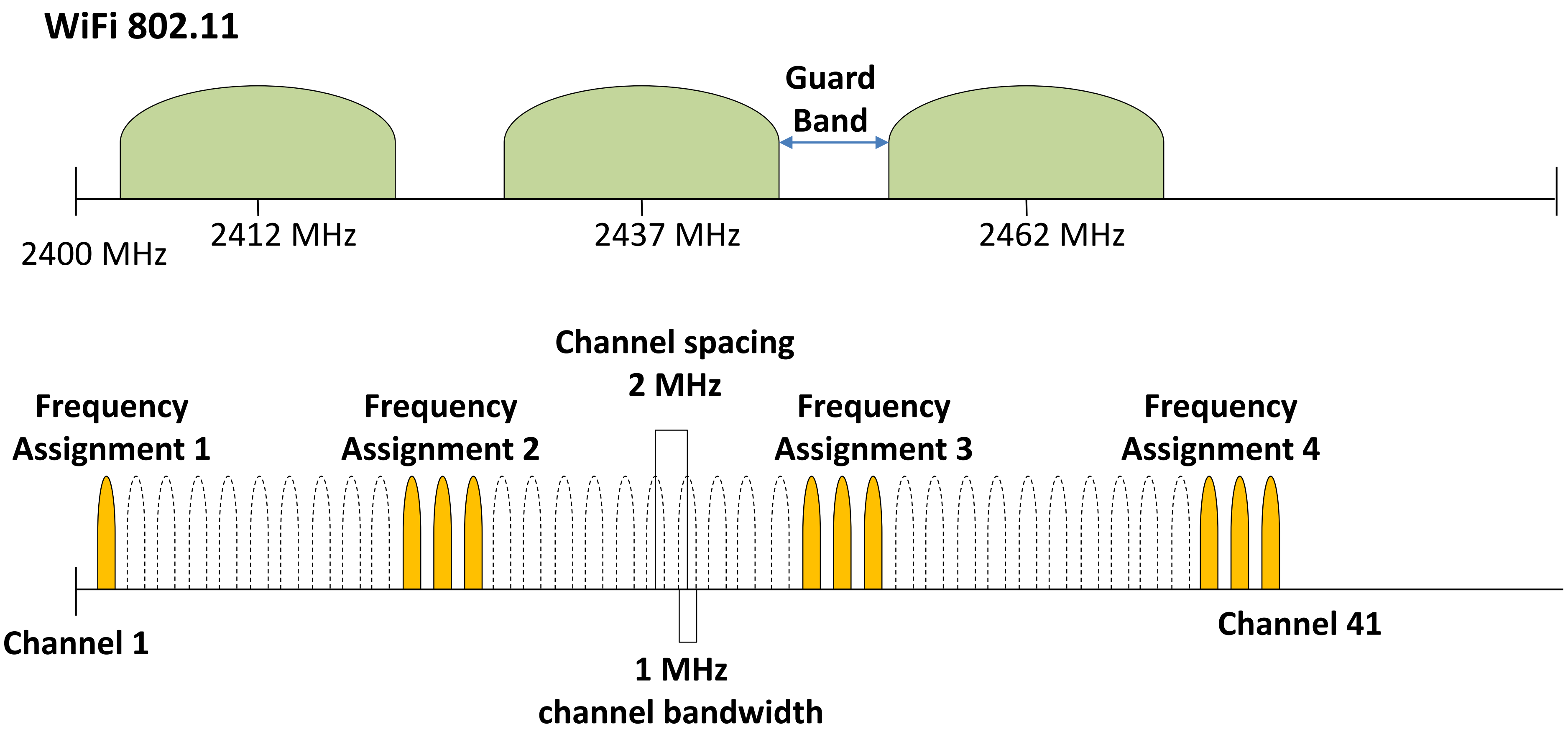
Spectrum Issue in 865 MHz band

Frequency arrangements	Paired arrangements				Un-paired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
A1	824-849	20	869-894	45	None
A2	880-915	10	925-960	45	None
A3	832-862	11	791-821	41	None
A4	698-716 776-793	12 13	728-746 746-763	30 30	716-728
A5	703-748	10	758-803	55	None
A6	None	None	None		698-806
A7	703-733	25	758-788	55	None
A8	698-703	50	753-758	55	None
A9	733-736	52	788-791	55	None
A10	External	–	738-758	–	None
A11 (harmonized with A7 and A10)	703-733 External	25 –	758-788 738-758	55 –	None



Source: ITU-R Rec. M.1036-5

IoT Spectrum in 2.4 GHz



Source: RPMA Technology for the Internet of Things, Connecting Like Never Before, Genu

NB-IoT and Designated Bands

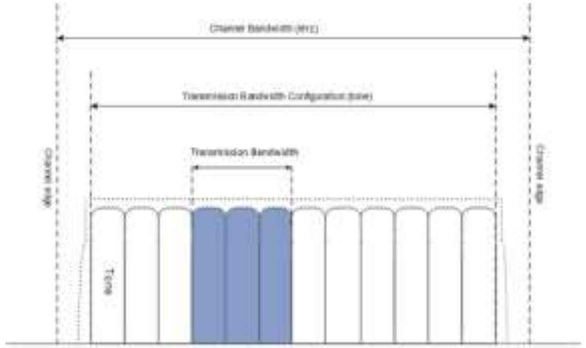
Bands that are Currently Designated by 3GPP for Use by NB-IoT

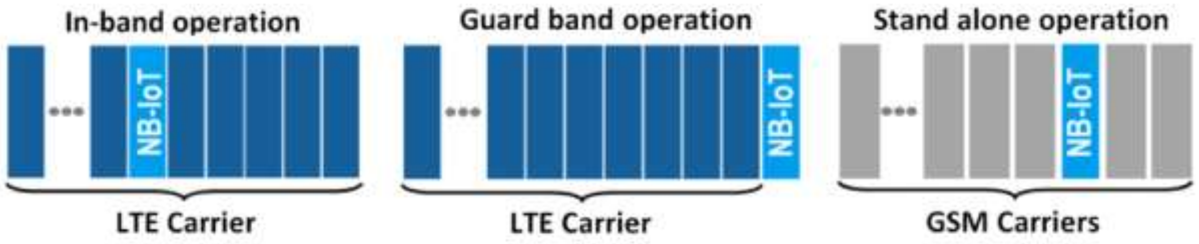
NB-IOT Operating Band	Uplink BS RX, UE TX	Downlink BS TX, UE RX
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}
1	1920 – 1980	2110 – 2170
3	1710 – 1785	1805 – 1880
5	824 – 849	869 – 894
8	880 – 915	925 – 960
12	699 – 716	729 – 746
13	777 – 787	746 – 756
17	704 – 716	734 – 746
19	830 – 845	875 – 890
20	832 – 862	791 – 821
26	814 – 849	859 – 894
28	703 – 748	758 – 803

Different Types of NB-IoT

NB-IoT	Stand alone	In band	Guard Band
UE Channel bandwidth $BW_{Channel}$ [kHz]	200	200	200
BS Channel bandwidth $BW_{Channel}$ [kHz]	200	LTE channel BW	LTE channel BW, FFS for 1.4 and 3 MHz
Transmission bandwidth configuration N_{RB}	1	1	1
Transmission bandwidth configuration $N_{tone\ 15kHz}$	12	12	12
Transmission bandwidth configuration $N_{tone\ 3.75kHz}$	48	48	48

Definition of Channel Bandwidth and Transmission Bandwidth Configuration for one NB-IoT carrier





Downlink: OFDMA
- sub-carriers: 15 kHz

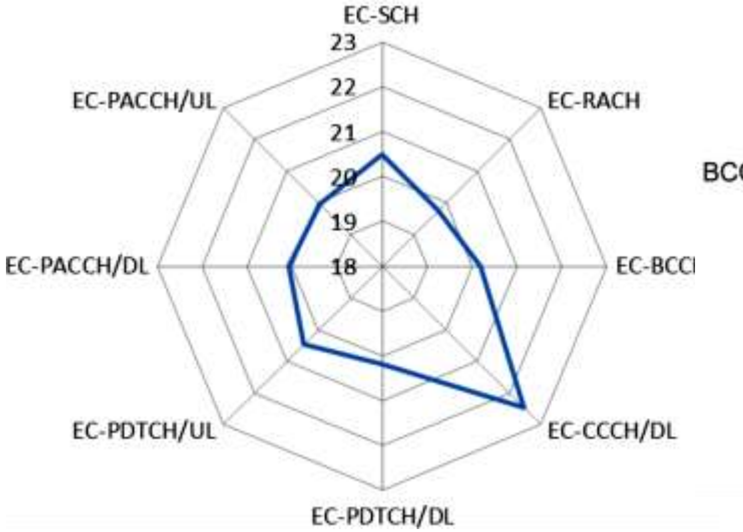
Uplink: QPSK

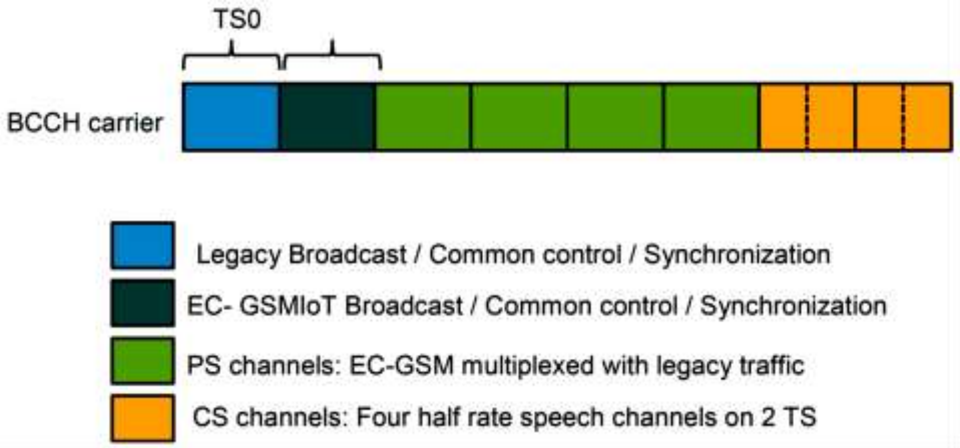
Source: 3GPP TR 36.802 V13.0.0 (2016-06)
and
K. Mekki et all, A comparative study of LPWAN technologies for large-scale IoT deployment, Science Direct, Dec. 2017

EC-GSM IoT

(Extended coverage GSM IoT)

- EC-GSM is a standard-based Low Power Wide Area (LPWA) technology
- This technology can be activated by a simple software update on existing GSM networks (repetition and encoding enhancement)
- The signal quality could be increased 20 dB which is about 7 times more communication range





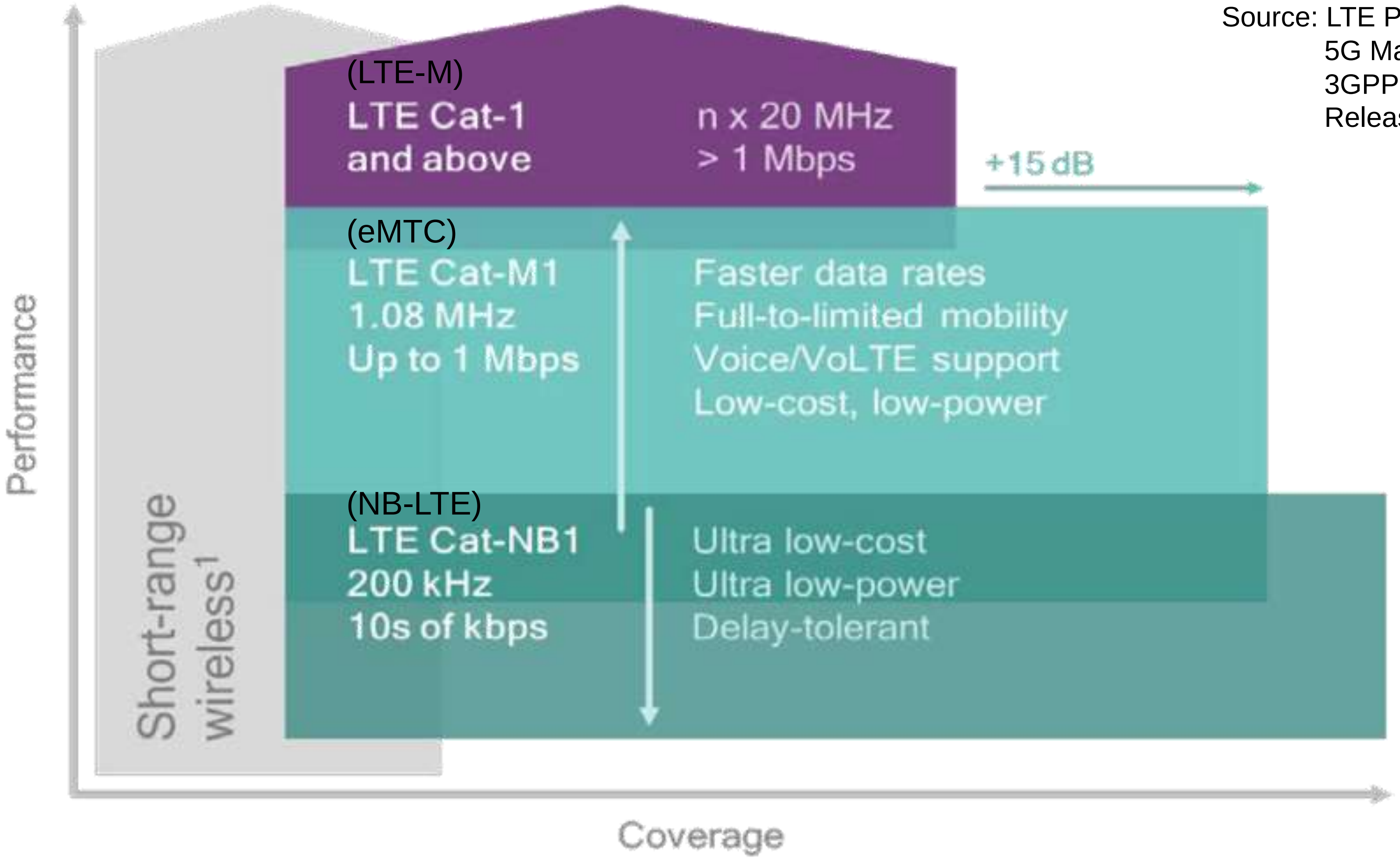
Comparing Non-IMT and IMT IoT

Cat-M1 =
= enhanced MTC =

	Cat-1	Cat-0	eMTC	NB-IoT	EC-GSM	LoRa	Sigfox
Specification	3GPP	3GPP	3GPP	3GPP	3GPP	Open	Private
Spectrum	Licensed	Licensed	Licensed	Licensed	Licensed	Unlicensed	Unlicensed
Channel BW	1.4MHz to 20MHz	1.4MHz to 20MHz	1.4MHz	180KHz	200KHz	7.8 to 500KHz	100Hz
System BW	1.4MHz to 20MHz	1.4MHz to 20MHz	1.4MHz	180KHz	1.4MHz	125KHz	200KHz
Peak Data Rate	UL: 5Mbps DL: 10Mbps	UL: 1Mbps DL: 2Mbps	UL: 1Mbps DL: 800kbps	UL: 204.8kbps DL: 234.7kbps	UL: 74kbps DL: 74kbps	180bps~37.5kbps	UL: 100bps DL: 600bps
Max. number of Messages per day	unlimited	unlimited	unlimited	unlimited	unlimited	50000(BTS)	140(Device) 50000(BTS)
Device Peak Tx Power	23dBm	23dBm	23dBm	23dBm	26dBm	14dBm	14dBm
MCL (Maximum Coupling Loss)	144dB	144dB	156dB	164dB	164dB	UL: 156dB DL: 168(SF12, BW7.8) 132(SF6, BW125)	UL: 156dB DL: 147dB
Device Power Consumption	Medium	Medium	Low-Medium	Low	Low	Low-Medium	Low

Advanced Techniques to Extend LTE IoT Coverage

Source: LTE Progress Leading to the 5G Massive Internet of Things, 3GPP Enhancement Up To Release 14, Dec. 2017

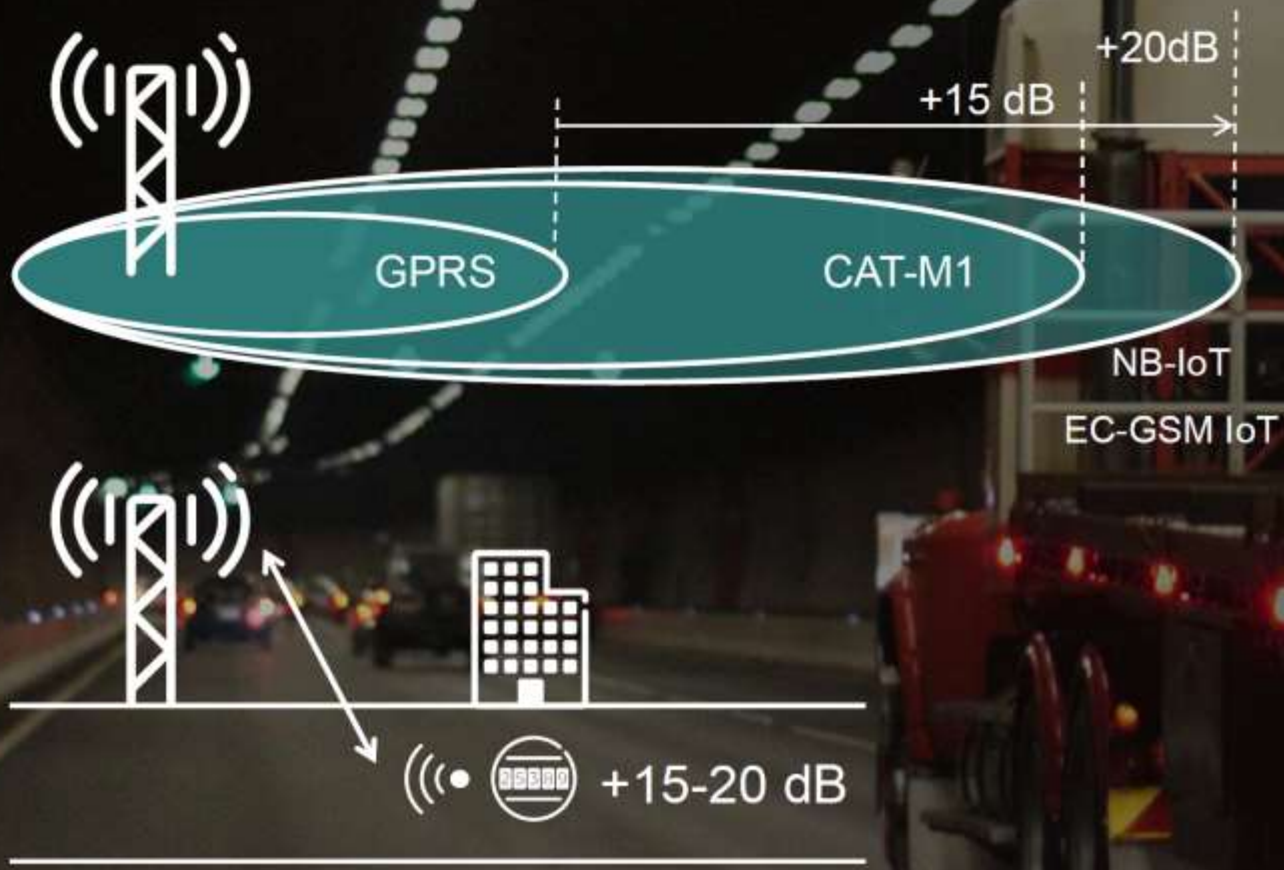


IMPROVED COVERAGE
(UP TO 20 DB)

EXTENDED COVERAGE MODE

EXTENDS COVERAGE BY UP TO +20 dB ACHIEVED BY:

- Repetition of transmissions
- New control channels



Other Improvement of 3GPP

- Increasing device-sleeping time (reducing signaling load): Extended Discontinuous Reception (eDRx)

Source: LTE Progress Leading to the 5G Massive Internet of Things, 3GPP Enhancement Up To Release 14, Dec. 2017

- Network and protocol improvements:
  - Dedicated Core Networks (DECOR)
  - Architecture Enhancements for Services capability exposure (AESE)
  - Optimization to support High Latency Communication (HLCom)
  - Group Based Enhancements (GROUPE)
  - Monitoring Enhancements (MONTE)
  - Architecture Enhancements for Cellular Internet of Things (CIoT)

CELLULAR FOR MASSIVE IOT

Meeting diversity of use case requirements

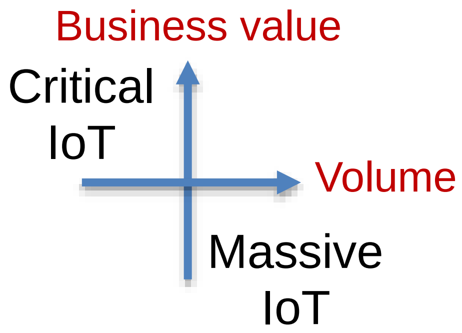
	Bandwidth	Coverage	Battery life	Capacity	Peak Throughput	Mobility
EC-GSM-IoT	200 kHz/ 600 kHz	164dB (+20dB)	10+ Year	190,000 per cell	473/473 kbps (97/97 kbps)	Idle mode mobility
NB-IoT	200 kHz	164dB (+20dB)	10+ Year	200,000 per cell	227/250 kbps (21/63 kbps)	Idle mode mobility
Cat-M1	1.4 MHz	160dB (+15dB)	10+ Year	1M+ per cell	0.8/1 Mbps (300/375 kbps)	Connected & idle mode mobility

Massive IoT (MIoT)

Refined scenarios and requirements of Massive MIMO

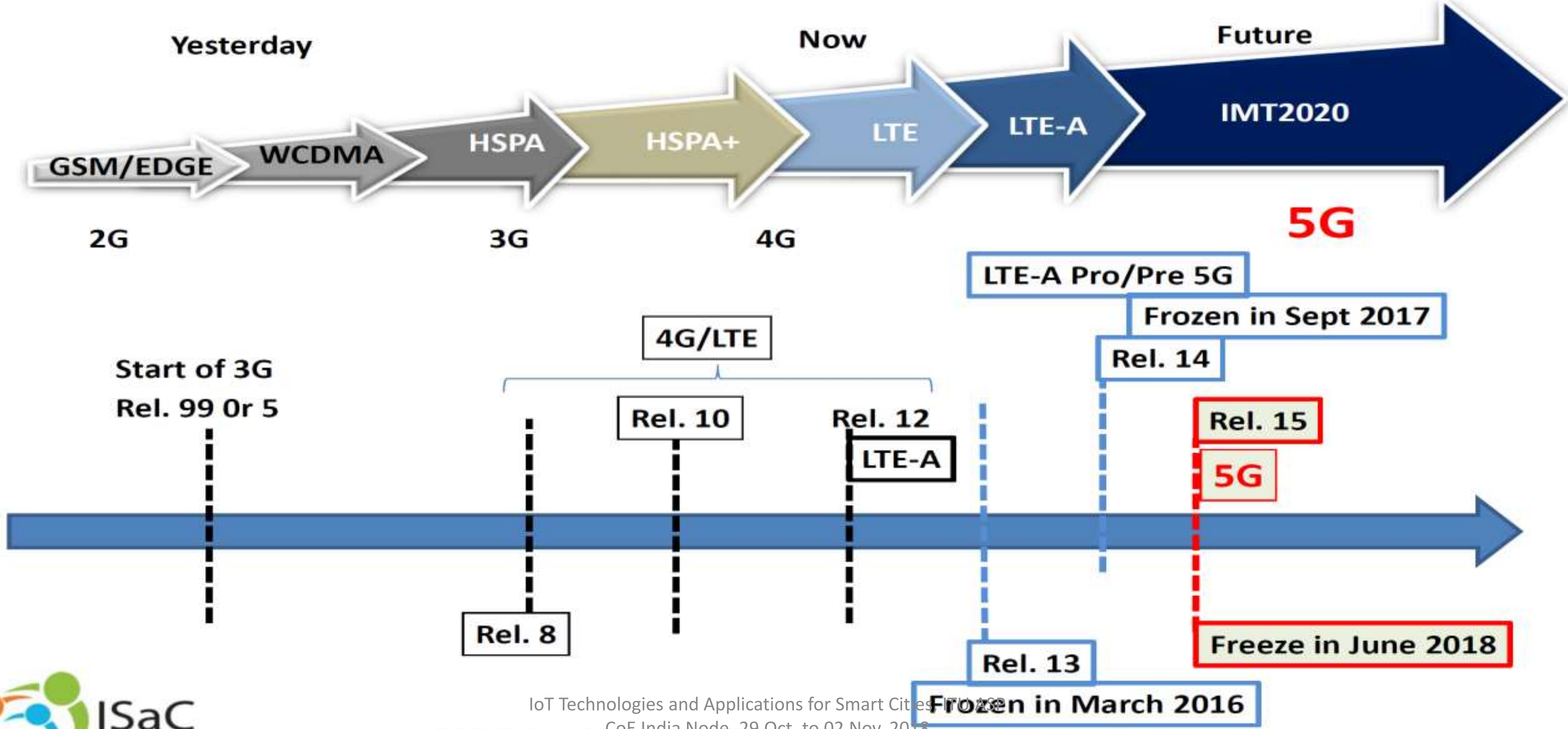
Availability	99.9%
Device density Traffic volume per device	1 000 000 devices/km^2 125 bytes message per second
Battery life	10 years (assuming 5 Watts-hour battery and restricted traffic model)

Architecture and protocol enhancements for MIoT and Critical IoT to be realized in Release 16 in 2020.

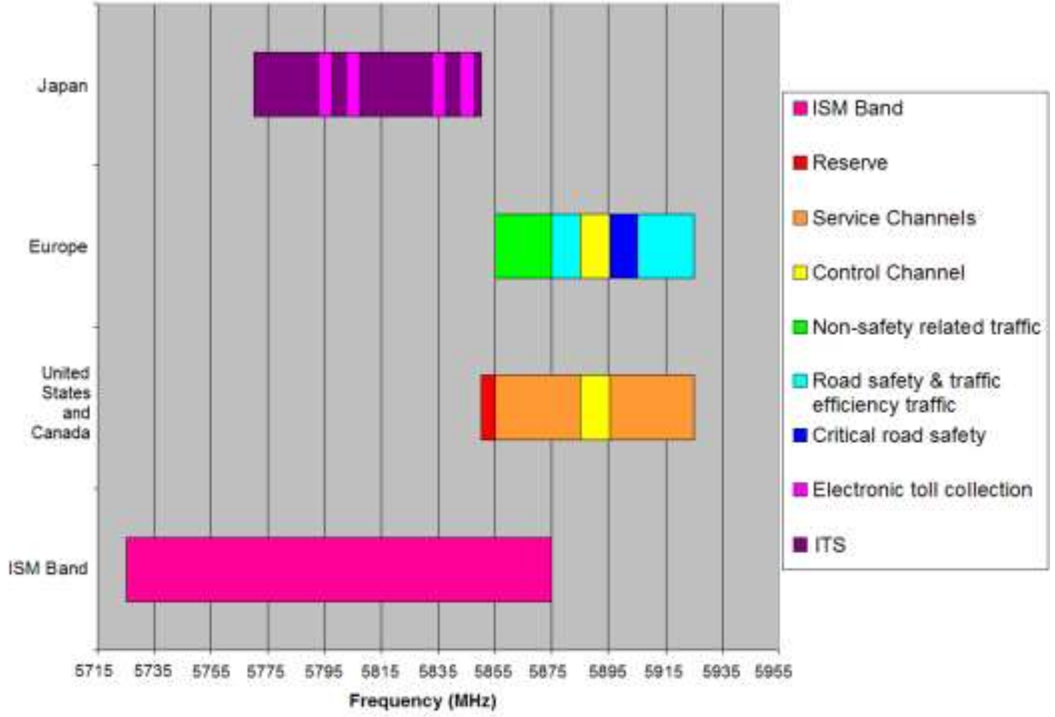


Source: LTE Progress Leading to the 5G Massive Internet of Things, 3GPP Enhancement Up To Release 14, Dec. 2017

Evolution of Mobile Communications - up to 5G



ITS 5.9 GHz Spectrum



Separation distance is necessary with earth stations (more than 33 km)

Reference: Planning for intelligent transport systems, ACMA, Oct. 2009

Region 1	Region 2	Region 3
5 725-5 830 FIXED-SATELLITE (Earth-to-space) RADIOLOCATION Amateur 5.150 5.451 5.453 5.455	**5 725-5 830** RADIOLOCATION Amateur 5.150 5.453 5.455	
5 830-5 850 FIXED-SATELLITE (Earth-to-space) RADIOLOCATION Amateur Amateur-satellite (space-to-Earth) 5.150 5.451 5.453 5.455	**5 830-5 850** RADIOLOCATION Amateur Amateur-satellite (space-to-Earth) 5.150 5.453 5.455	
5 850-5 925 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 5.150	**5 850-5 925** FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Amateur Radiolocation 5.150	**5 850-5 925** FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Radiolocation 5.150
5 925-6 700	FIXED 5.457 FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B MOBILE 5.457C 5.149 5.440 5.458	

Pre-WRC-19 Estimation for IMT-2020
WRC-15 CPM Text for A.I. 1.1 (below 6 GHz)

RATG: Radio access technique Group

- ITU-R Recommendation M.1768-1 was used

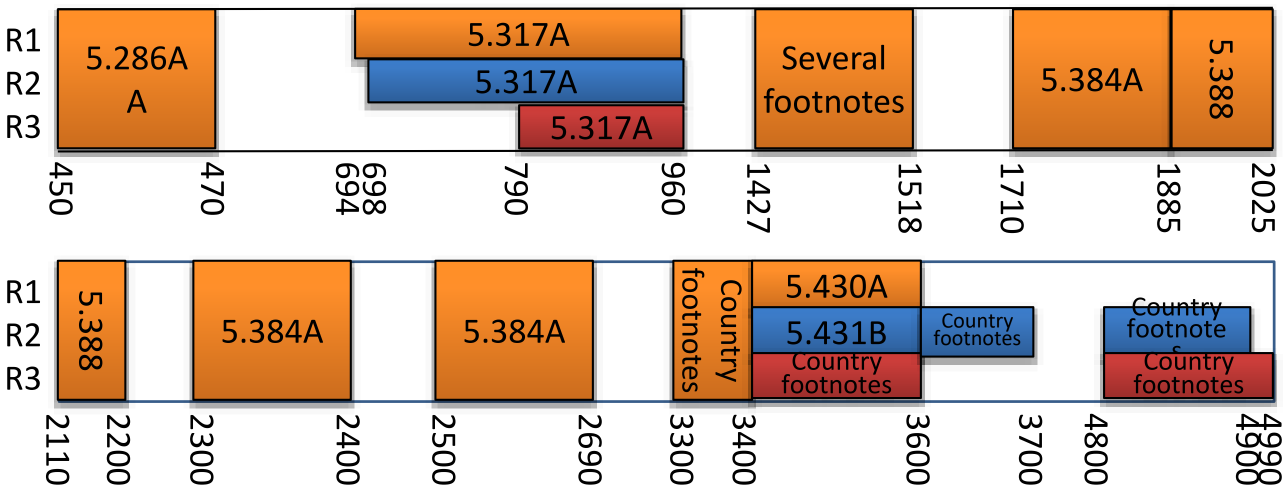
	Total spectrum requirements for RATG 1	Total spectrum requirements for RATG 2	Total spectrum requirements RATGs 1 and 2
Lower user density settings	440 MHz	900 MHz	1 340 MHz
Higher user density settings	540 MHz	1 420 MHz	1 960 MHz

RATG 1 (i.e. pre-IMT, IMT-2000, and its enhancements)
RATG 2 (i.e. IMT-Advanced)

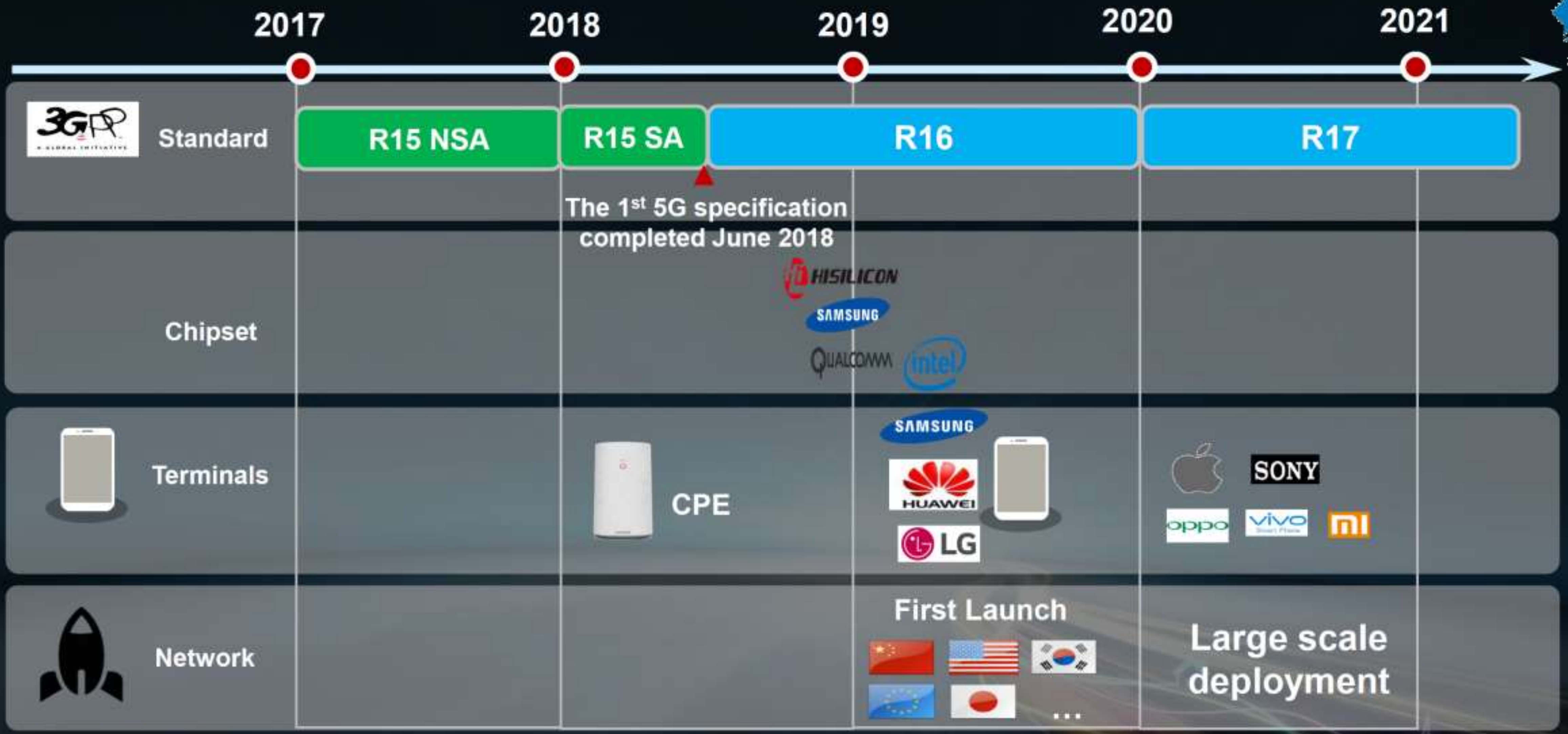
- Above forecast assumed that are relevant to spectrum requirement of Advanced-IMT **below 6 GHz**

Frequency Band Available for 5G below 6 GHz

- Frequency bands that are currently in ecosystem of wideband/broadband networks, according to ITU RR Article 5 (reach to 1662 MHz)



5G will launch commercially from 2019



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3GPP 5G New Radio (NR) Bands (by 2018 June)

NR operating band	Uplink (UL) operating band	Downlink (DL) operating band	Duplex Mode
n1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
n2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
n3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
n5	824 MHz – 849 MHz	869 MHz – 894 MHz	FDD
n7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
n8	880 MHz – 915 MHz	925 MHz – 960 MHz	FDD
n20	832 MHz – 862 MHz	791 MHz – 821 MHz	FDD
n28	703 MHz – 748 MHz	758 MHz – 803 MHz	FDD
n38	2570 MHz – 2620 MHz	2570 MHz – 2620 MHz	TDD
n40	2300 MHz – 2400 MHz	2300 MHz – 2400 MHz	TDD
n41	2496 MHz – 2690 MHz	2496 MHz – 2690 MHz	TDD
n51	1427 MHz – 1432 MHz	1427 MHz – 1432 MHz	TDD
n66	1710 MHz – 1780 MHz	2110 MHz – 2200 MHz	FDD
n70	1695 MHz – 1710 MHz	1995 MHz – 2020 MHz	FDD
n71	663 MHz – 698 MHz	617 MHz – 652 MHz	FDD
n75	N/A	1432 MHz – 1517 MHz	SDL
n76	N/A	1427 MHz – 1432 MHz	SDL
n77	3300 MHz – 4200 MHz	3300 MHz – 4200 MHz	TDD
n78	3300 MHz – 3800 MHz	3300 MHz – 3800 MHz	TDD
n79	4400 MHz – 5000 MHz	4400 MHz – 5000 MHz	TDD
n80	1710 MHz – 1785 MHz	N/A	SUL
n81	880 MHz – 915 MHz	N/A	SUL
n82	832 MHz – 862 MHz	N/A	SUL
n83	703 MHz – 748 MHz	N/A	SUL
n84	1920 MHz – 1980 MHz	N/A	SUL
n86	1710 MHz – 1780 MHz	N/A	SUL

5G NR bands in FR1

Frequency range designation	Corresponding frequency rang
FR1	450 – 6000 MHz
FR2	24250 – 52600 MHz

The frequency ranges in 3GPP Release 15 for 5G NR designed for the frequency ranges FR1 and FR2

NR operating band	Uplink (UL) and Downlink (DL)	Duplex Mode
n257	26500 MHz – 29500 MHz	TDD
n258	24250 MHz – 27500 MHz	TDD
n260	37000 MHz – 40000 MHz	TDD
n261	27500 MHz – 28350 MHz	TDD

5G NR bands in FR2

The most harmonized bands are specified as 5G NR bands by 3GPP

Some UE RF and RRM requirements for NR CA and mmWave bands are not finished yet, to be completed by 2018.12

All spectrum will support 5G
C-band and mmWave are the leading 5G bands

C-band: primary band for the introduction of 5G globally, countries planning 300M - 500M bandwidth

n77: 3.3-4.2 GHz
n78: 3.3-3.8 GHz
n79: 4.4-5.0 GHz

mmWave: The 24.25-29.5 & 37.0-43.5 GHz are the most promising high frequency ranges for 5G early commercialization globally, at least 800 – 1000 MHz channel bandwidth per 5G network for initial deployment

n257: 26.5-29.5 GHz
n258: 24.25-27.5 GHz
n260: 37-40 GHz
n261: 27.5-28.35 GHz

- Already available for IMT / offical plans
- Considered for IMT by regulators
- Potential for future IMT use
- WRC-19 candidate, global primary Mobile Service band
- WRC-19 candidate, not global primary Mobile Service band
- Not in scope of WRC-19 AI1.13

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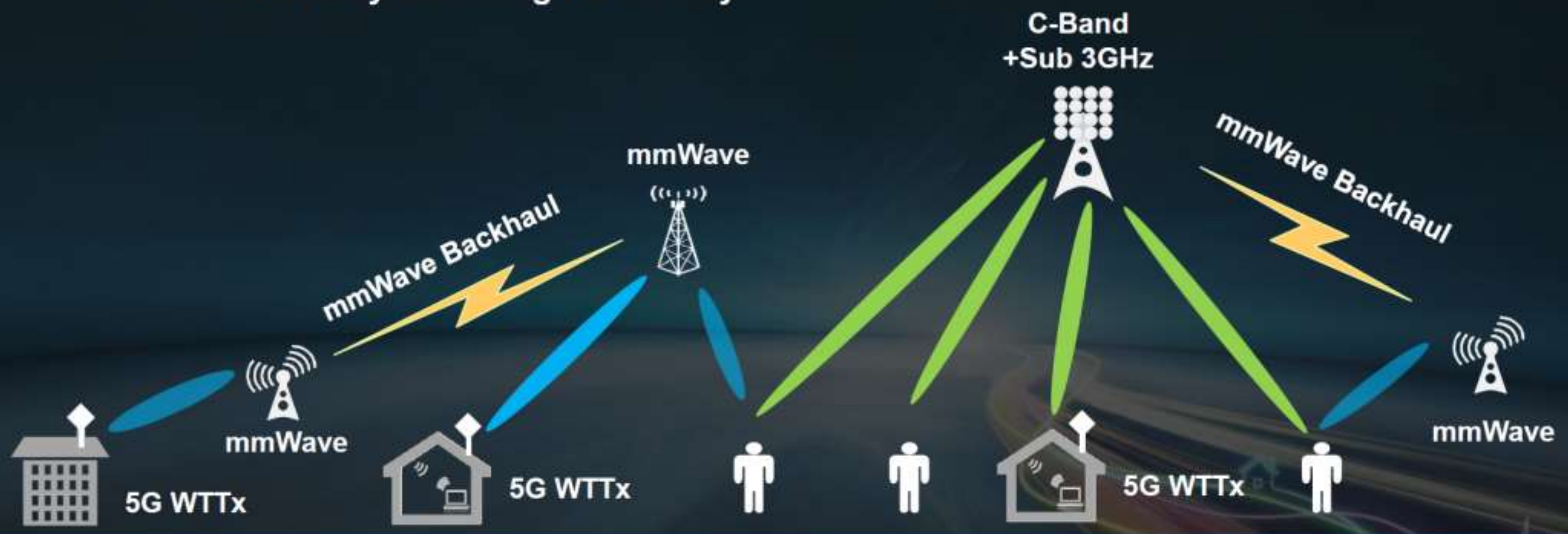
Sub 6 GHz bands for basic capacity & Coverage mmWave for Ultra High Capacity

- **C-Band:**
  - Massive MIMO for capacity & coverage
- **Sub 3GHz:**
  - Connectivity & coverage & mobility
- **mmWave:**
  - Capacity boosting for hotspot
  - Home broadband access
  - Self-Backhaul for easy site acquisition



C-band: continuous 100 MHz per operator becoming the trend

C-band potential 100 MHz/operator in China, Japan, Korea, Europe

China	3.3-3.6 4.8-5.0	To be released in 2018	100~200M/MNO
Europe	3.4-3.8	Whole or portion of the range released (e.g. UK) or to be released in 2018/2019	100/MNO
Japan	4.4-4.9 3.6-3.8	To be released in 2020	150~200M/MNO
Korea	3.4-3.7	Already released to 5G	80~100M/MNO
USA	3.7-4.2	Issued consultation for mobile usage	

4G bands of 2.6GHz and 2.3GHz TDD mode facilitate migration to 5G

Continuous 100 MHz/operator for higher investment efficiency

Band40: unpaired(TDD)

2.3GHz — 100MHz (2300 – 2400)

Band41: unpaired(TDD)

2.6GHz — 190MHz (2500 – 2690)

LTE/NR UL sharing facilities 3.5 GHG & 1.8 GHz Co-Site provides similar coverage using MIMO technology

WRC-19 Agenda Item 1.13

(summary of) *Resolves* of Resolution 238(WRC-15)

1 To determine the spectrum needs for the terrestrial component of IMT in the frequency range between 24.25 GHz and 86 GHz, taking into account:

- technical and operational characteristics of terrestrial IMT, including the evolution of IMT through advances in technology and spectrally efficient techniques;
- deployment scenarios envisaged for IMT-2020 systems and related requirements of high data traffic;
- the time-frame in which spectrum would be needed;

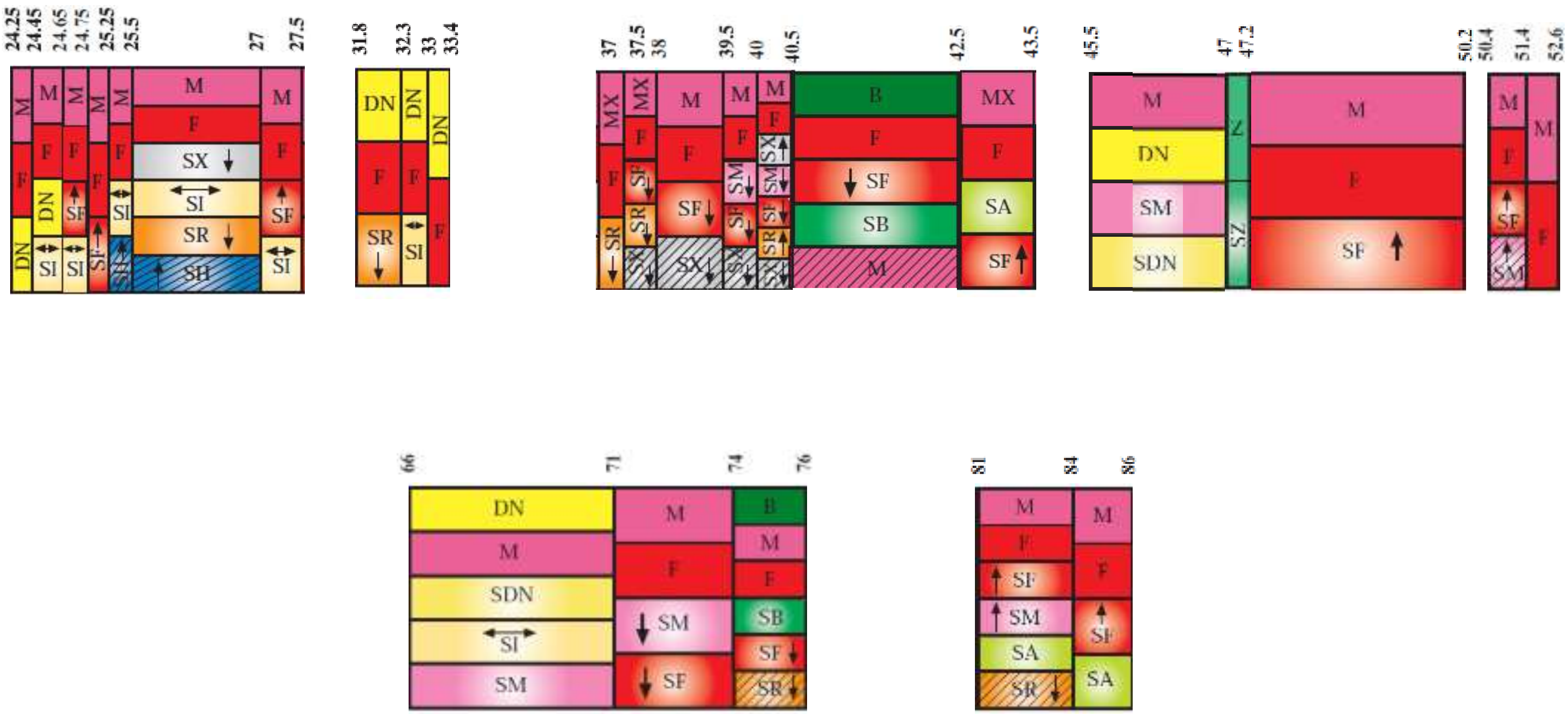
2 to conduct sharing and compatibility studies[1], taking into account the protection of services to which the band is allocated on a primary basis, for the bands:

- **24.25-27.5 GHz[2], 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz,** which have allocations to the mobile service on a **primary basis**; and
- **31.8-33.4 GHz, 40.5-42.5 GHz and 47-47.2 GHz**, which **may require additional allocations** to the mobile service on a primary basis,

1 Including studies with respect to services in adjacent bands, as appropriate.

2 When conducting studies in the band 24.5-27.5 GHz, to take into account the need to ensure the protection of existing earth stations and the deployment of future receiving earth stations under the EESS (space-to-Earth) and SRS (space-to-Earth) allocation in the frequency band 25.5-27 GHz.

Resolve 2
Spectrums of Resolution 238(WRC-15)



Partitioning WRC-19 AI. 1.13 Frequency Bands

Res. 238	Frequency ranges, GHz	Country Comment
Resolves 2, first bullet	**24.25-27.5**	Lower parts, early implementation
	37-40.5	Lower parts, early implementation
	42.5-43.5	Lower parts, early implementation
	45.5-47	Upper parts, less interest for sharing study
	47.2-50.2	Upper parts, less interest for sharing study
	50.4-52.6	Upper parts, less interest for sharing study
	66-76	Upper parts, less interest for sharing study
	81-86	Upper parts, less interest for sharing study
Resolves 2, second bullet	**31.8-33.4**	Lower parts, early implementation
	40.5-42.5	Lower parts, early implementation
	47-47.2	Upper parts, less interest for sharing study

Calculated Spectrum Needs for frequency ranges 24.25 to 86 GHz

	Examples	Associated conditions for different examples	Spectrum needs in total (GHz)	Spectrum needs (GHz) per frequency range
Application-based approach	1	Overcrowded, dense urban and urban areas	18.7	3.3 (24.25-33.4GHz range) 6.1 (37-52.6GHz range) 9.3 (66-86 GHz range)
		Dense urban and urban areas	11.4	2.0 (24.25-33.4GHz range) 3.7 (37-52.6GHz range) 5.7 (66-86 GHz range)
	2	Highly crowded area	3.7	0.67 (24.25-33.4GHz range) 1.2 (37-52.6GHz range) 1.9 (66-86 GHz range)
		Crowded area	1.8	0.33 (24.25-33.4GHz range) 0.61 (37-52.6GHz range) 0.93 (66-86 GHz range)

Calculated Spectrum Needs for frequency ranges 24.25 to 86 GHz

	Examples	Associated conditions for different examples	Spectrum needs in total (GHz)	Spectrum needs (GHz) per frequency range
Technical performance-based approach (Type 1)	1	User experienced data rate of 1 Gbit/s with N simultaneously served users/devices at the cell-edge, e.g., Indoor	3.33 (N=1), 6.67 (N=2), 13.33 (N=4)	Not available
		User experienced data rate of 100 Mbits/s with N simultaneously served users/devices at the cell-edge, for wide area coverage	0.67 (N=1), 1.32 (N=2), 2.64 (N=4)	Not available
	2	eMBB dense urban	0.83-4.17	Not available
		eMBB indoor hotspot	3-15	Not available
	3	With a file transfer of 10 Mbits by a single user at cell-edge in 1 msec	33.33 GHz (one direction)	Not available
		With a file transfer of 1 Mbit by a single user at cell-edge in 1 msec	3.33 GHz (one direction)	
		With a file transfer of 0.1 Mbits by a single user at cell-edge in 1 msec	333 MHz (one direction)	

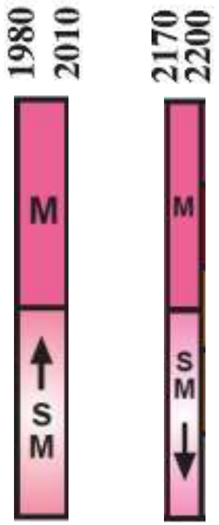
Calculated/Reported Spectrum Needs for frequency ranges 24.25 to 86 GHz

	Examples	Associated conditions for different examples	Spectrum needs in total (GHz)	Spectrum needs (GHz) per frequency range
Technical performance-based approach (Type 2)	–	Dense urban micro	14.8-19.7	5.8-7.7 (24.25-43.5GHz range)
		Indoor hotspot		9-12 (24.25-43.5 GHz and 45.5-86 GHz range)
Information from some countries based on their national considerations	–	–	7-16	2-6 (24.25-43.5 GHz range) 5-10 (43.5-86 GHz range)

WRC-19 Agenda Item 9.1, Issue 9.1.1

Agenda Title: **9** *to consider and approve the Report of the Director of the Radiocommunication Bureau, in accordance with **Article 7** of the Convention:* **9.1** *on the activities of the Radiocommunication Sector since WRC-15;*
ISSUE 9.1.1: Resolution 212 **(Rev.WRC-15)** *Implementation of International Mobile Telecommunications in the frequency bands 1885-2025 MHz and 2110 -2200 MHz*
Responsible Group(s): (**WP 4C**[1] **and WP 5D**[2,3] / -) 1 WP 4C is responsible for the studies requested in Res. **212 (Rev.WRC-15)** *invites ITU-R* with respect to the satellite component of IMT, taking into account the technical and operational characteristics provided by WP 5D. 2 WP 5D is responsible for the studies requested in Res. **212 (Rev.WRC-15)** *invites ITU-R* with respect to the terrestrial component of IMT, taking into account the technical and operational characteristics provided by WP 4C. 3 The conclusion of the draft CPM text shall be agreed by both WP 4C and WP 5D. For this purpose, the Chairmen of both WPs shall coordinate the schedule of the meetings, as appropriate.

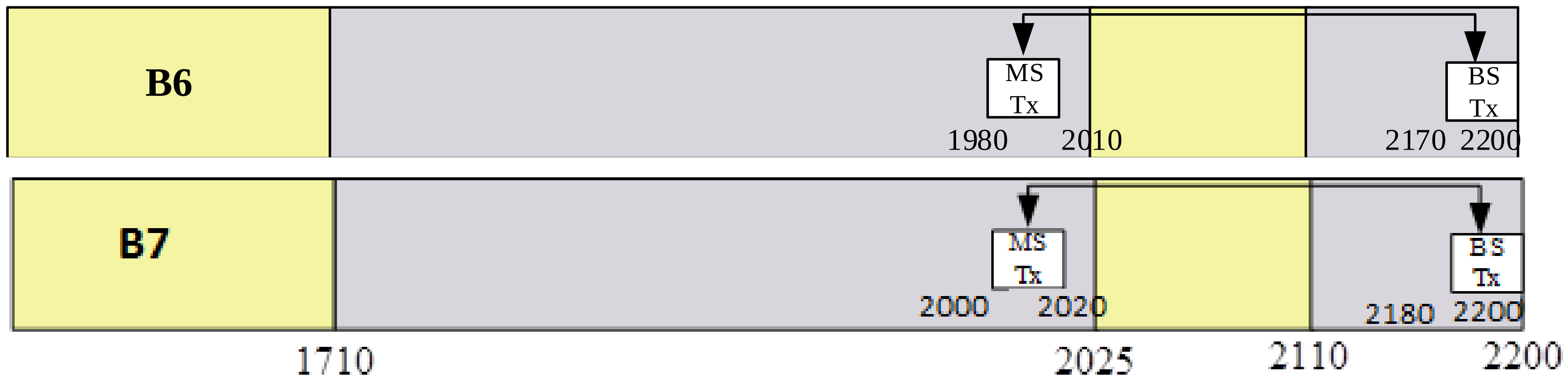
Spectrum of Agenda 9.1 issue 9.1.1



Allocation to services		
Region 1	Region 2	Region 3
1 980-2 010	FIXED MOBILE MOBILE-SATELLITE (Earth-to-space) 5.351A 5.388 5.389A 5.389B 5.389F	

2 170-2 200	FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A 5.388 5.389A 5.389F

Arrangement from ITU-R Rec. M.1036-5



Source: ITU-R Rec. M.1036-5

WRC-19 Agenda for MTC IoT

Agenda Item 9.1, Issue 9.1.8

Agenda Title: **9** *to consider and approve the Report of the Director of the Radiocommunication Bureau, in accordance with **Article 7** of the Convention:* **9.1** *on the activities of the Radiocommunication Sector since WRC-15;*
ISSUE 9.1.8: **Issue 3) in the Annex to Resolution 958 (WRC-15)** *Urgent studies required in preparation for the 2019 World Radiocommunication Conference* *3) Studies on the technical and operational aspects of radio networks and systems, as well as spectrum needed, including possible harmonized use of spectrum to support the implementation of narrowband and broadband machine-type communication infrastructures, in order to develop Recommendations, Reports and/or Handbooks, as appropriate, and to take appropriate actions within the ITU Radiocommunication Sector (ITU-R) scope of work.*
Responsible Group: **WP 5D** **Concerned Groups:** **WP 1B, WP 5A**

Example Frequency Bands Useful for IoT

Chapter 3 to Doc. 5D/758

IMT Arrangement (according to Rec. ITU-R M.1036)	Example frequency bands			Channel size
	Mobile station transmitter	Base station transmitter	Unpaired	
A9	733-736	788-791	None	200 kHz (200 kHz blocks can be aggregated up to 1.4 MHz)
A1	829-849	874-894	None	200 kHz
A2	895-905	940-950	None	180 kHz
B1	1 735-1 755	1 830-1 850	None	200 kHz
G3			1427-1517	
G2	1427-1470	1475-1518		200 kHz

Example Frequency Bands for LTE-M

Chapter 3 to Doc. 5D/758

MHz	690	700	710	720	730	740	750	760	770	780	790	800
A9					MS Tx					BS Tx		
					733	736				788	791	

Policy Regarding to Radio Frequency Spectrum

Spectrum identified for IMT IoT:

- NB/WB-IoT spectrum requirements shall be accommodated **within 5G spectrum**
- Actually **all 5G spectrum could be used for IoT**

Non-IMT IoT spectrum:

- Air interface shall be used on **shared basis and license-free**
- Air interface protocols shall provide enough opportunity to maximum number of sensors to communicate
- Sharing of license-free spectrum with licensed spectrum is impossible
- 433 MHz, 865 MHz, 921 MHz and 2.4 GHz frequency bands are more popular

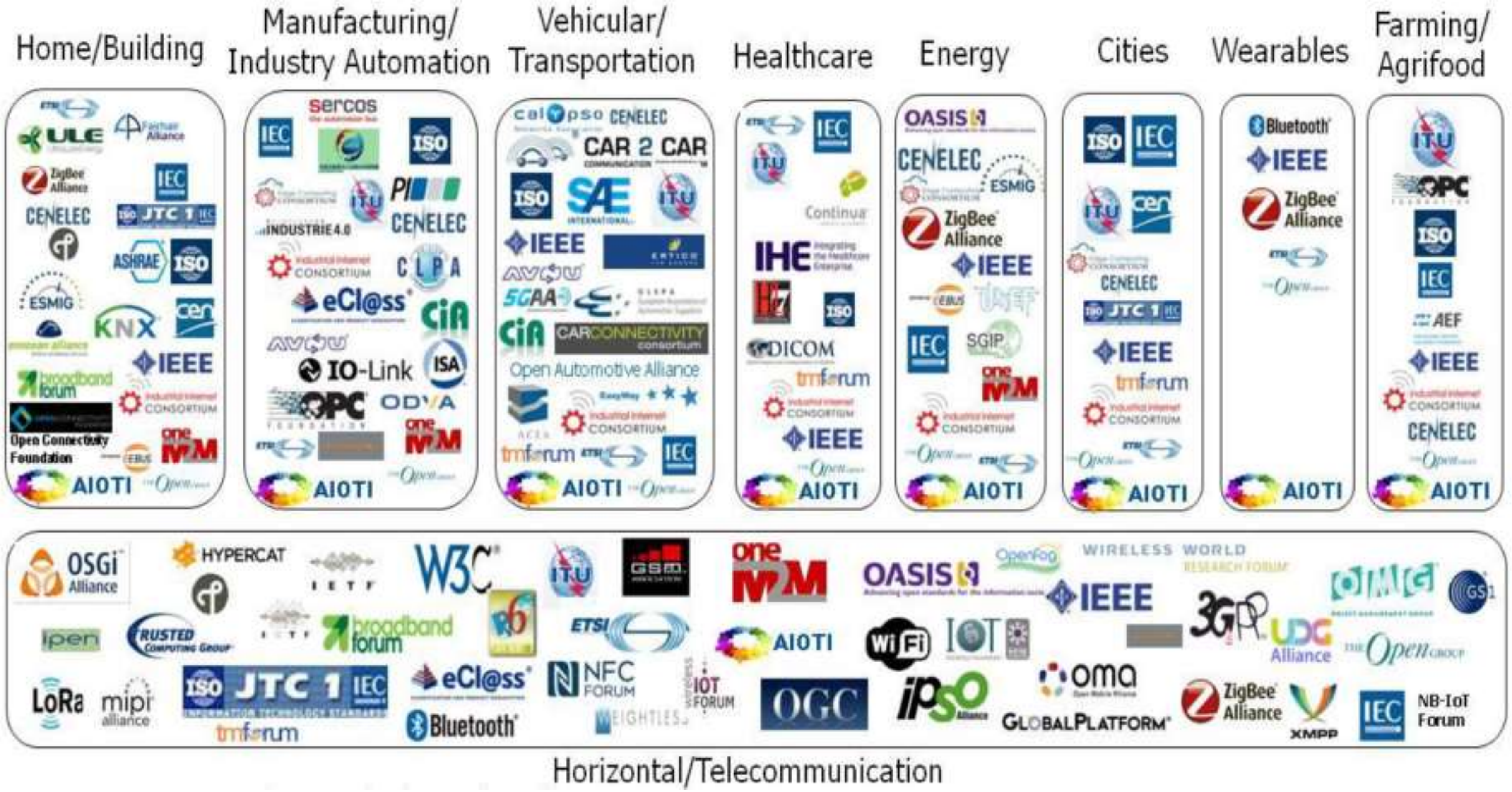
Estimate your own **spectrum requirement for IoT**

IoT Standard Makers

The Landscape of IoT Standard Developing Organizations

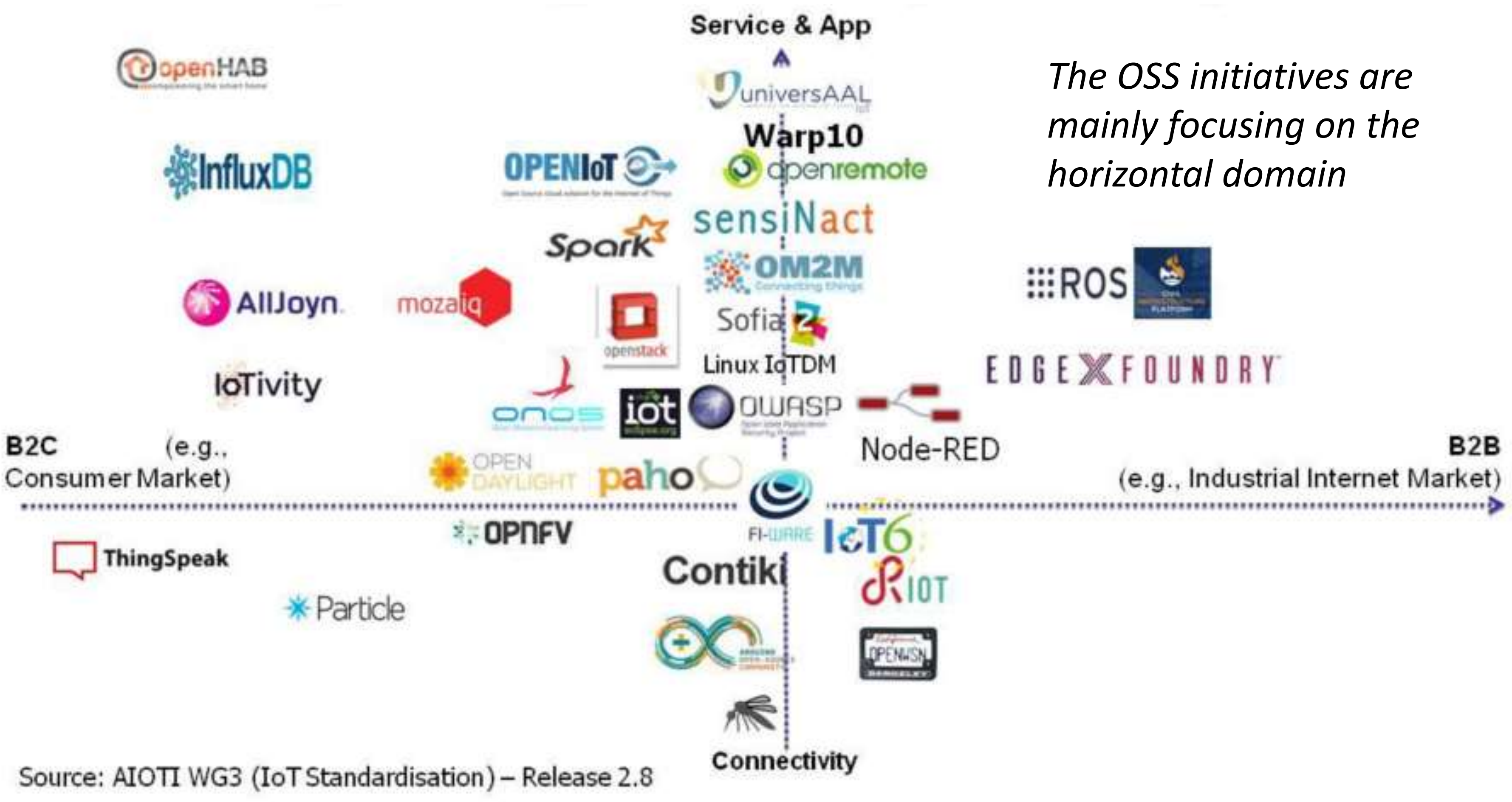
Source: AIOTI WG3 (IoT Standardisation) – Release 2.8

The Landscape of
Vertical and Horizontal Domains of SDOs



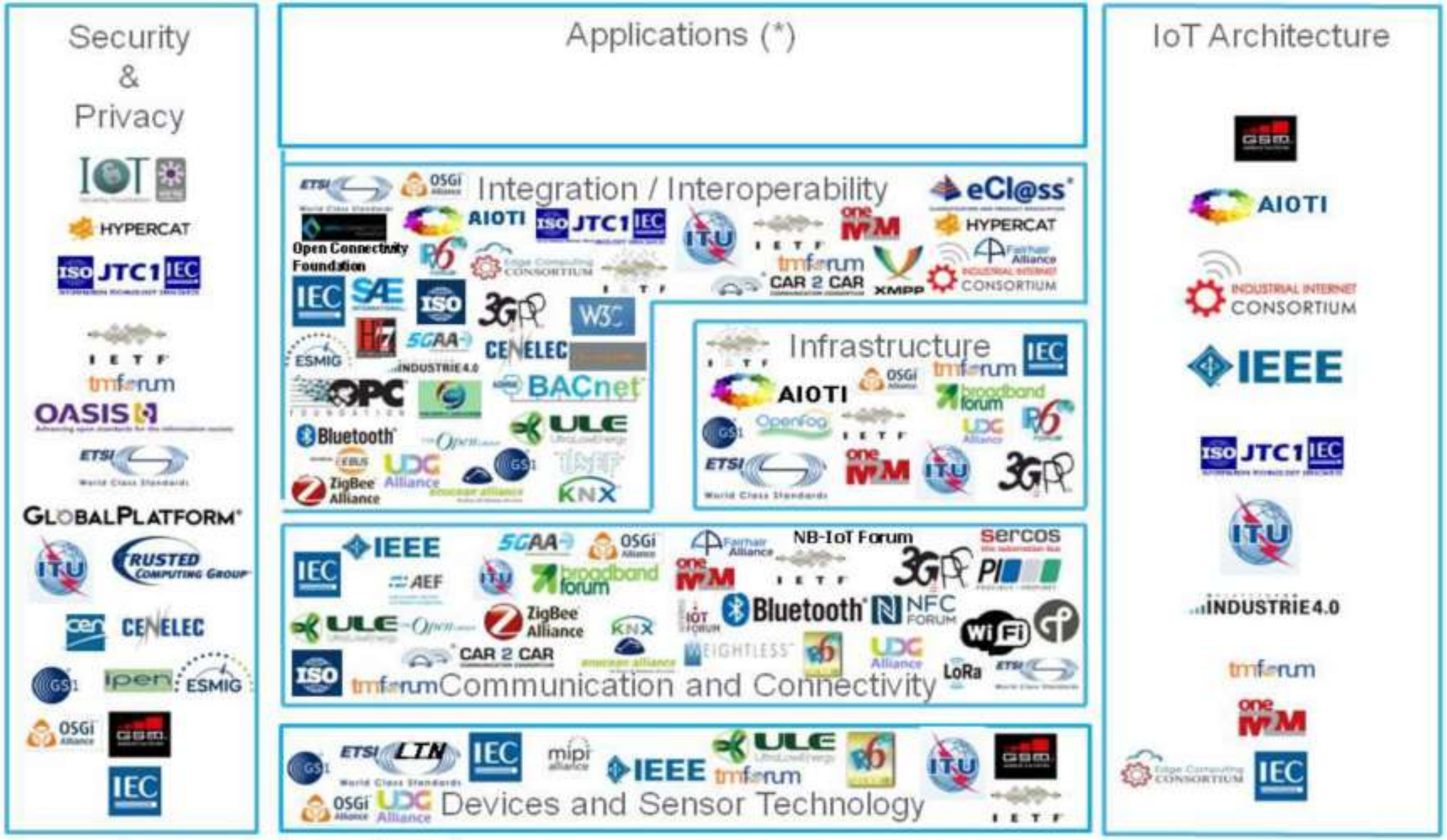
Source: AIOTI WG3 (IoT Standardization) – Release 2.8

IoT Open Source Software (OSS) Initiatives Landscape



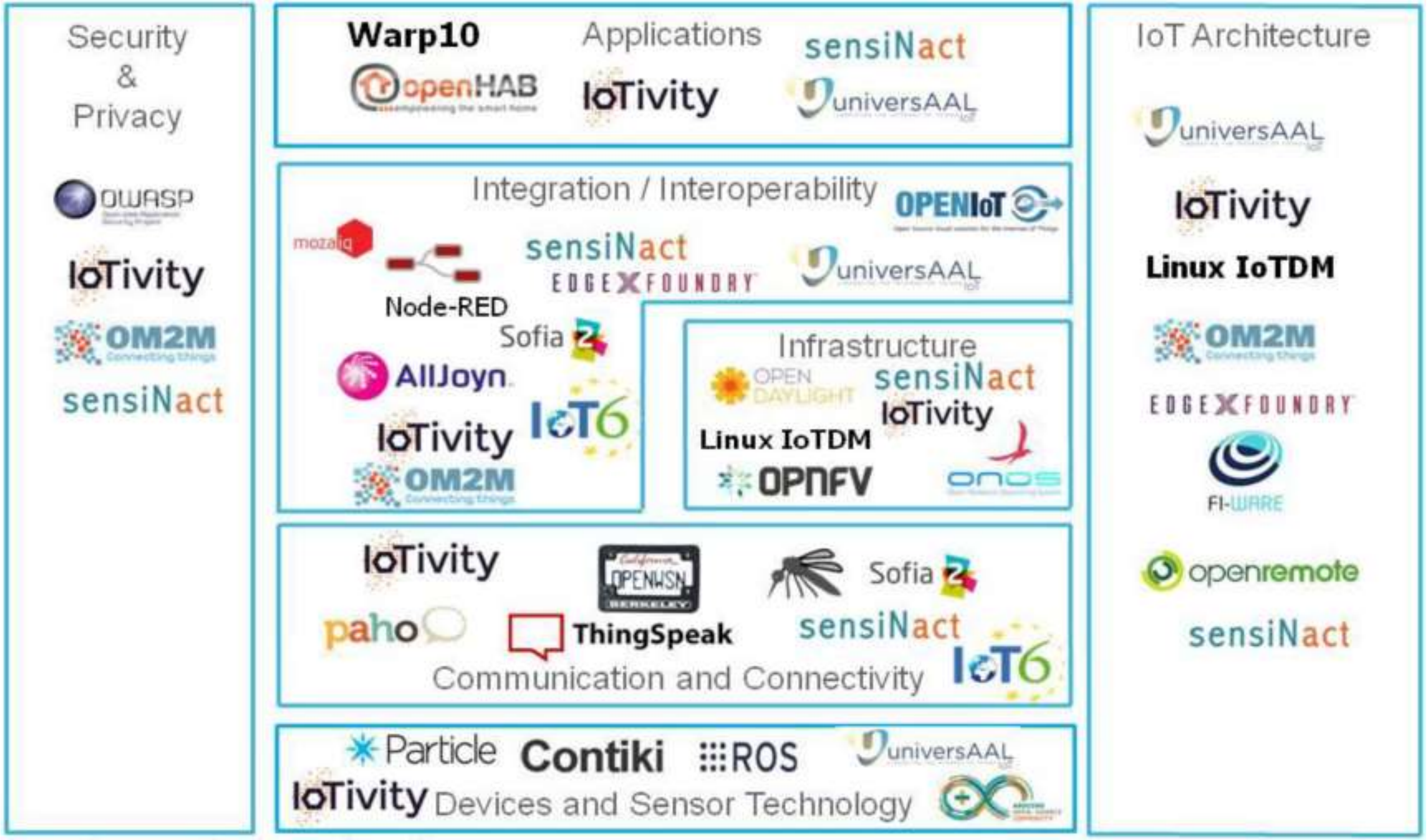
The OSS initiatives are mainly focusing on the horizontal domain

Mapping SDO/Alliance Initiatives into Knowledge Areas



Source: AIOTI WG3 (IoT Standardization) – Release 2.8

Mapping of IoT OSS Initiatives into Knowledge Areas



Source: AIOTI WG3 (IoT Standardization) – Release 2.8

Notes and Conclusion

- IoT is growing in parallel to the mobile communication world under IMT as well as independently
- Accommodating IMT IoT spectrum requirement does not need identification of exclusive frequency bands
- Calculation of IoT spectrum requirement in DENSED areas is necessary and it could reach multiple 10 MHz
- 5G would provide technology-details and network configuration for massive and critical IoT
- IoT through space is available now but it is also an issue to be addressed specifically in future

Thank You