Trends in Spectrum Management

Pacific Radiocommunication Workshop 2018 (PRW-18)

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Honiara, Solomon Islands

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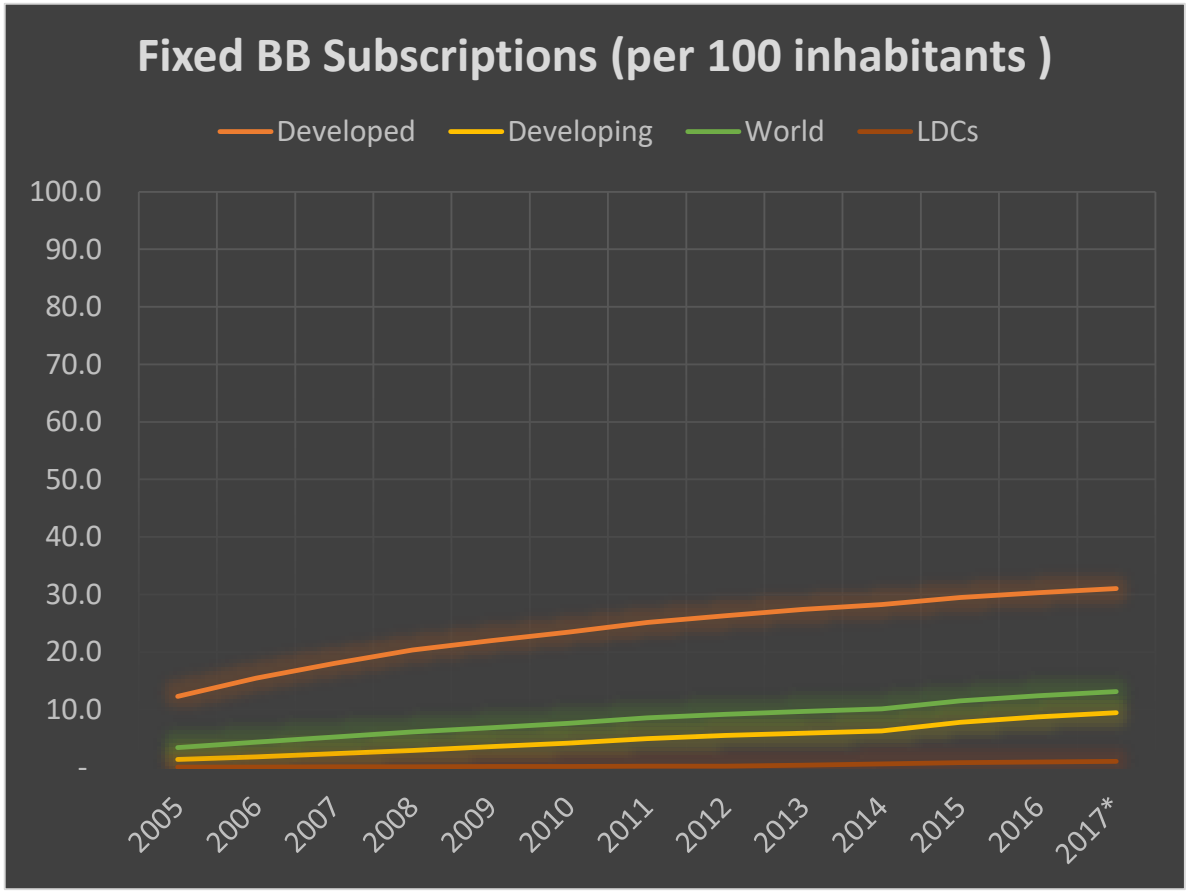
CELEBRATING 25 YEARS OF ACHIEVEMENTS

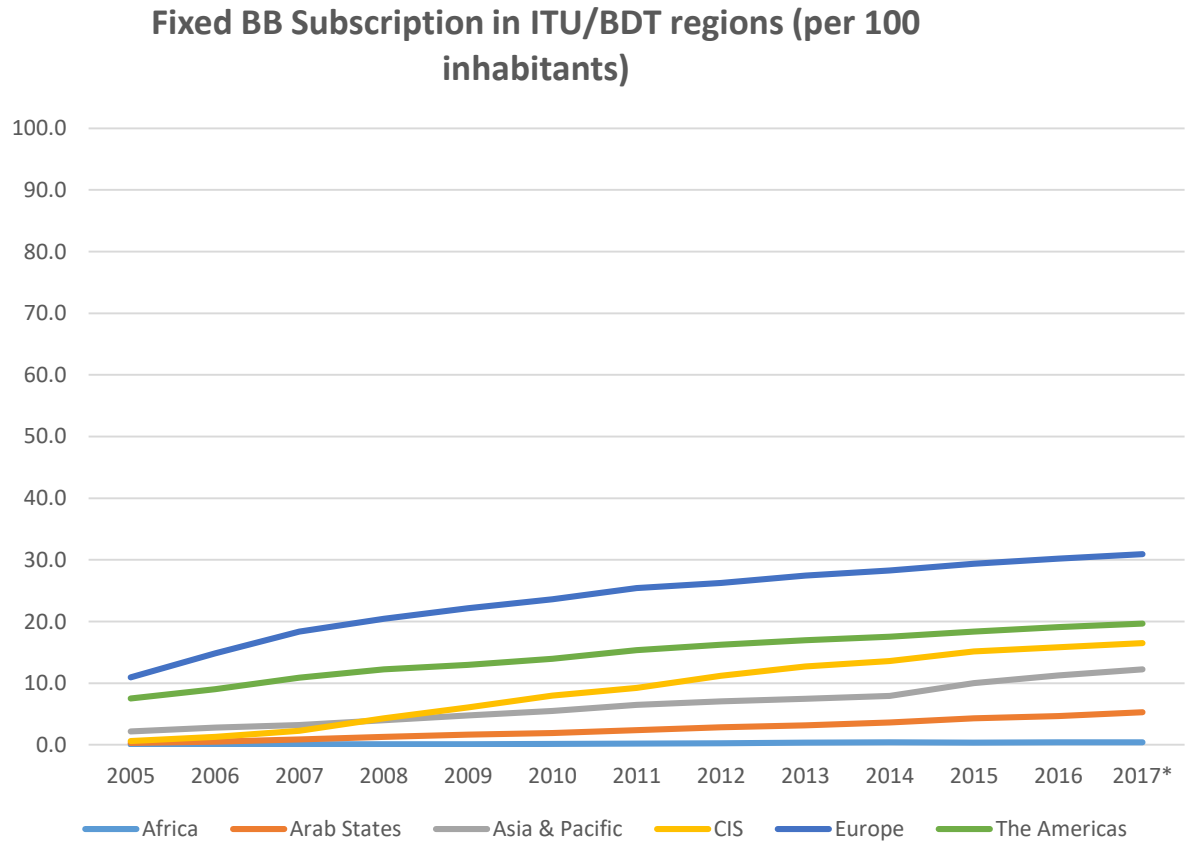
AGENDA

- Technological trends in Spectrum Usage
- Spectrum Regulatory Trends
- Regional Challenges on SM

Why the need for Efficient SM now?

Fixed BB Growth Globally and across regions of the world





Notes:

- The developed/developing country classifications are based on the UN M49, see: http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx.html
- * Estimate
- Source: ITU World Telecommunication /ICT Indicators database

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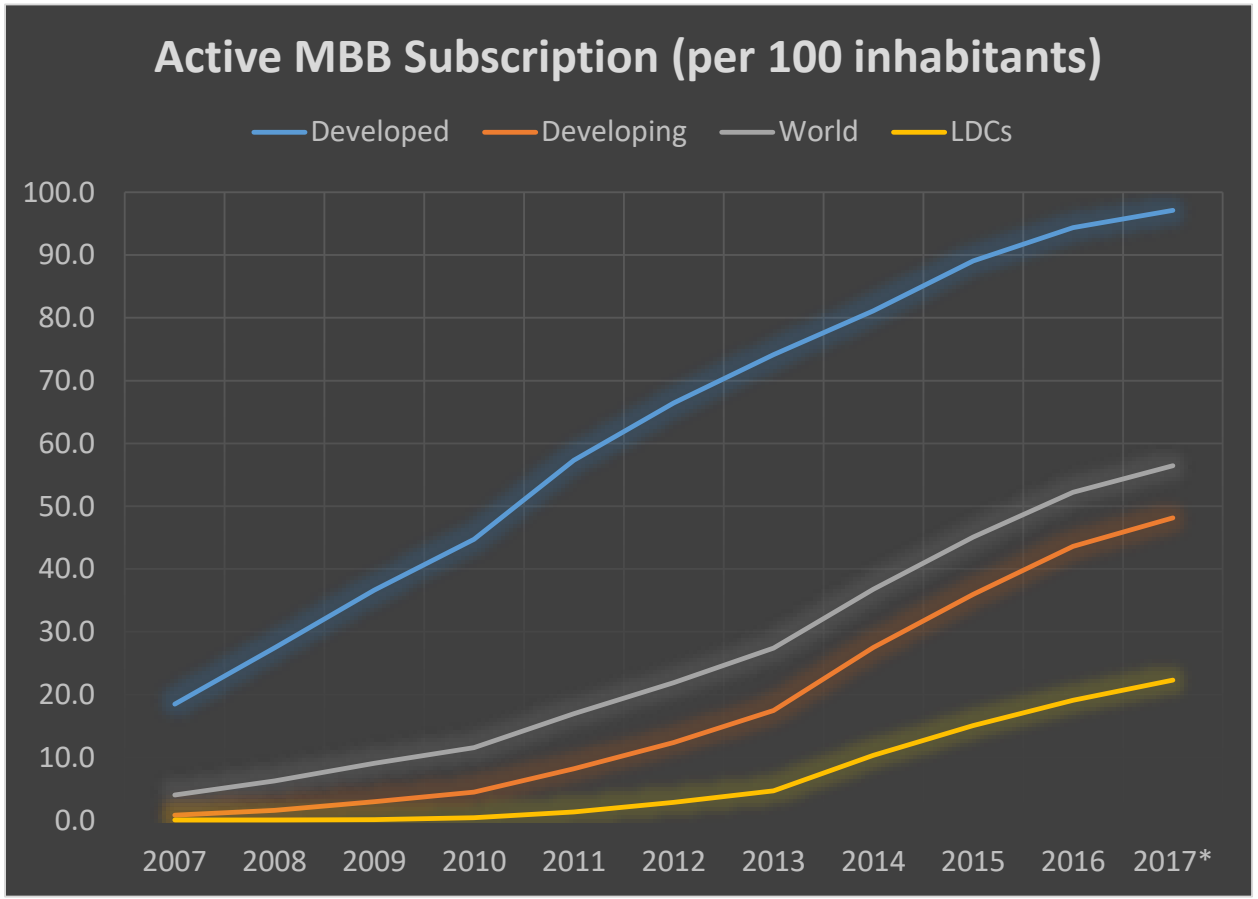
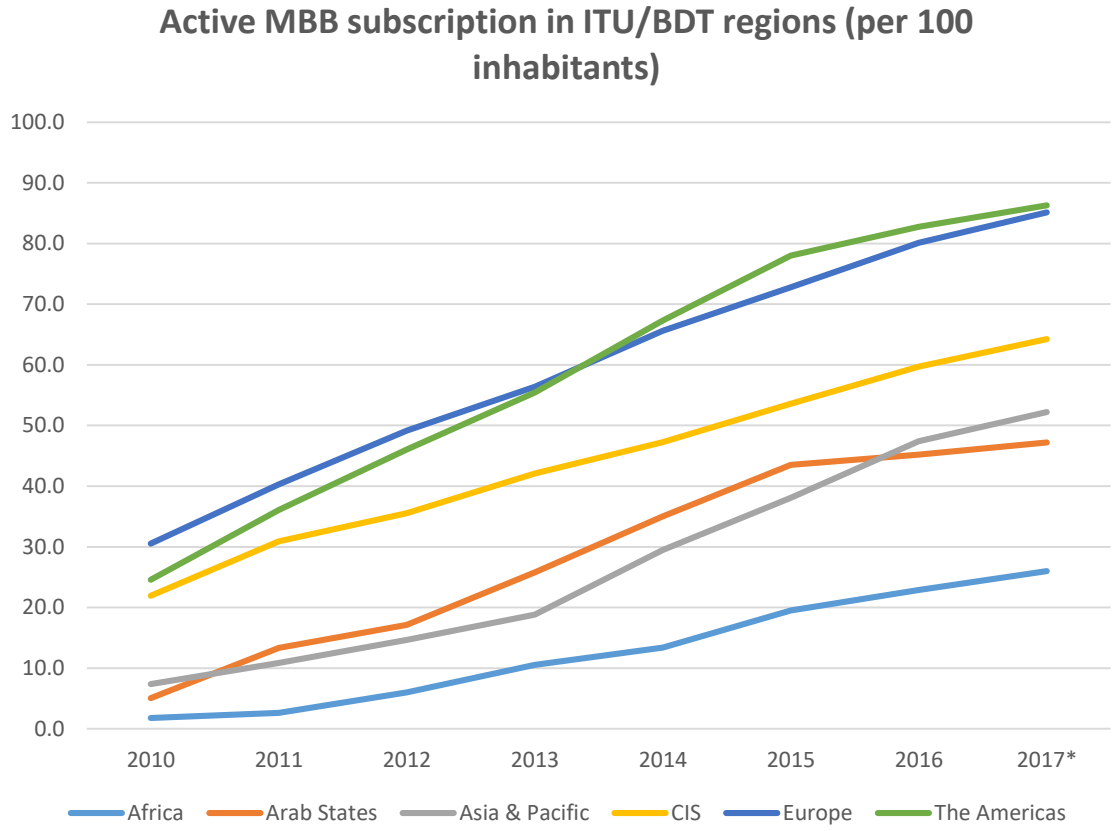
Why the need for Efficient SM now?

Mobile BB Growth Global and across regions of the world





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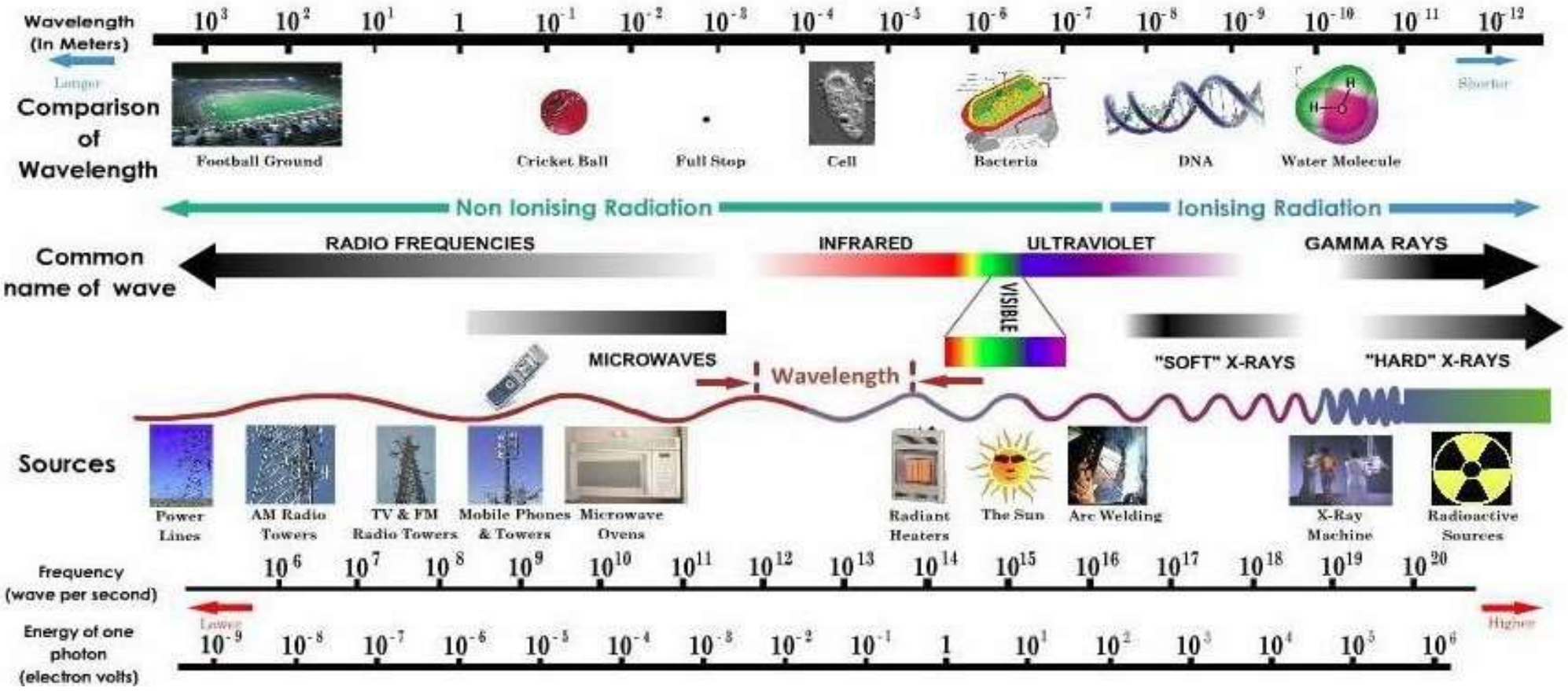
Radio-Electric Spectrum



Portion of Electromagnetic Waves, used for Communications

Artificial boundary, based on technologic development

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ITU-D 1992 2017

Radio-Electric Spectrum: *General Technical Usage*

Band	Frequency range	Range	Common use	Bandwidth
VLF (myriametric waves)	3-30 kHz	1 000 km	Long-range radionavigation	Very narrow
LF (kilometric waves)	30-300 kHz	1 000 km	Long-range radionavigation	Very narrow
MF (hectometric waves)	300-3 000 kHz	2-3 000 km	Long-range radionavigation	Moderate
HF (decametric waves)	3-30 MHz	Up to 1 000 km	Fixed point-to-point, Global broadcasting	Wide
VHF (metric waves)	30-300 MHz	2-300 km	Broadcasting, Mobile, WAN	Very wide
UHF (decimetric waves)	300-3 000 MHz	< 100 km	Broadcasting, Mobile, Satellite	Very wide
SHF (centimetric waves)	3-30 GHz	30-2 000 km	Fixed, Broadcasting, Mobile, WAN, Satellite communications	Very wide up to 1 GHz
EHF (millimetric waves)	30-300 GHz	20-2 000 km	Broadcasting, Fixed point-to- point, Mobile, Satellite communications	Very wide up to 10 GHz

RF Spectrum as a National Resource

Features	Natural Resource			
	Spectrum	Land	Oil	Water
Is the resource varied?	**YES**	YES	Not very	Not very
Is it scarce?	**YES**	YES	YES	YES
Is it renewable?	**YES**	Partially	NO	YES
Can it be stored for later use?	**NO**	NO	YES	YES
Can it be exported?	**NO**	NO	YES	YES
Can it be traded?	**YES**	YES	YES	YES
Can it be made more productive?	**YES**	YES	YES	NO

Spectrum Management (SM)

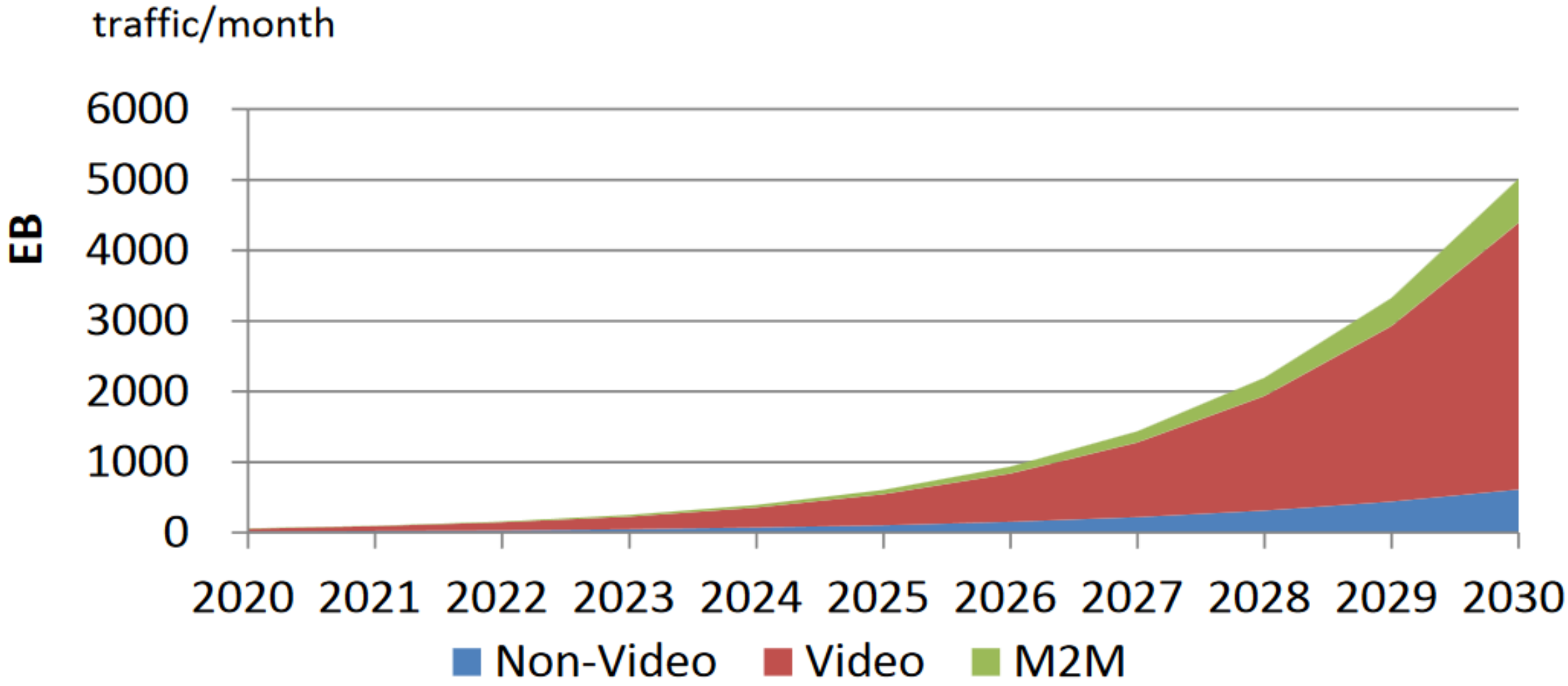
Key Terms

	Allocation	Allotment	Assignment
Definition	Allocation (of a frequency band): Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space radiocommunication services or the radio astronomy service under specified conditions. This term shall also be applied to the frequency band concerned.	Allotment (of a radio frequency or radio frequency channel): Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space radiocommunication service in one or more identified countries or geographical areas and under specified conditions.	Assignment (of a radio frequency or radio frequency channel): Authorization given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions.
Frequency Distribution to	**Services**	**Areas or Countries**	**Stations**

Technological Trends in spectrum usage

Why the need for Efficient SM now?

Traffic Explosion - beyond 2020

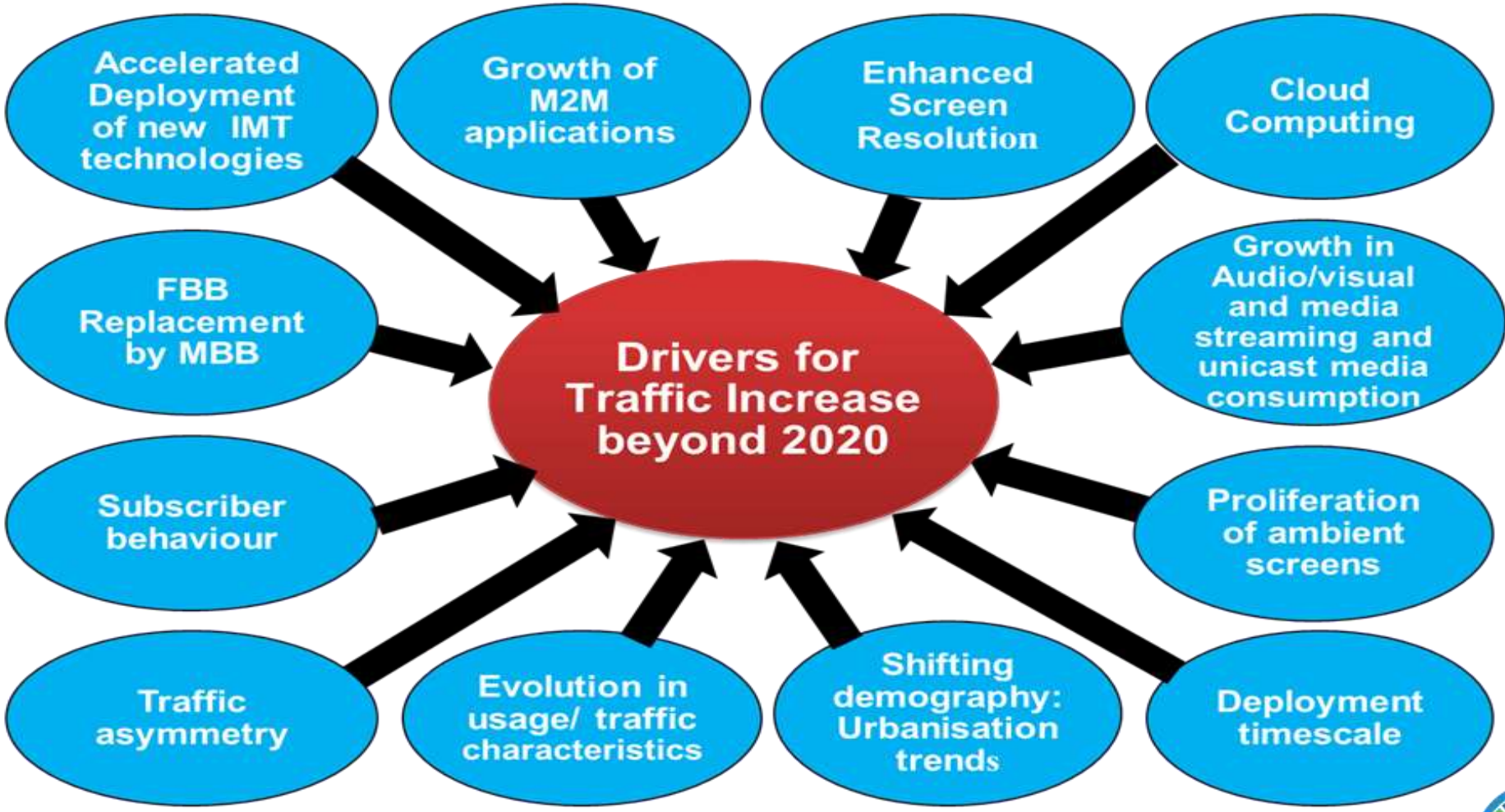


Estimation of Mobile traffic by different service types : Globally

Source: ITU Report M. 2370-0

Why the need for Efficient SM now?

Drivers for traffic increase

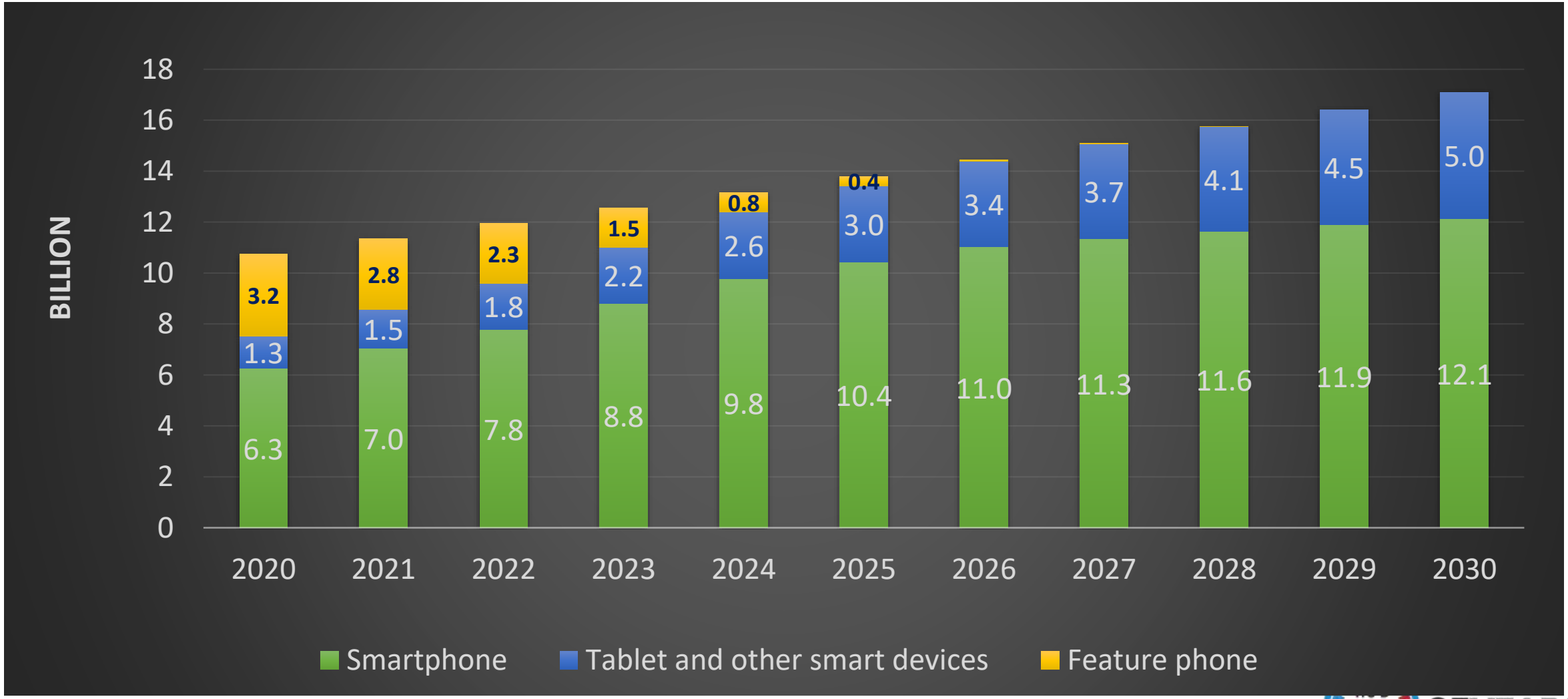


Source: ITU Report M. 2370-0

Why the need for Efficient SM now?

Estimation of global mobile subscriptions with different categories

Beyond 2020



Source: ITU Report M. 2370-0

1992 2017 25YEARS OF ACHIEVEMENTS

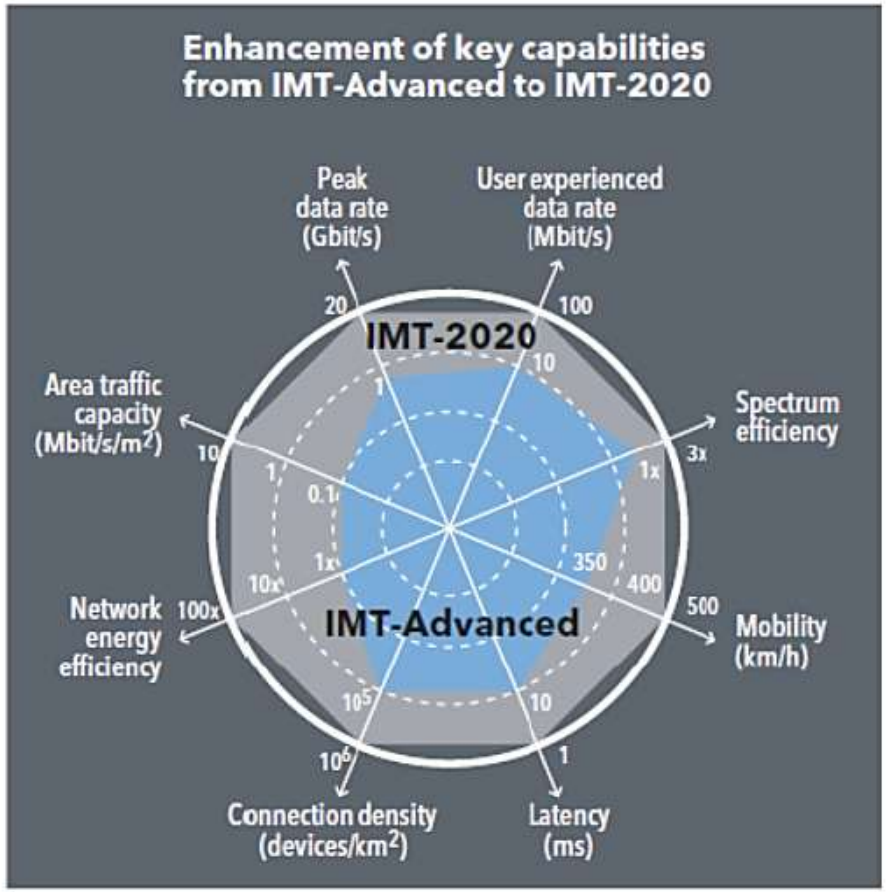
Definition

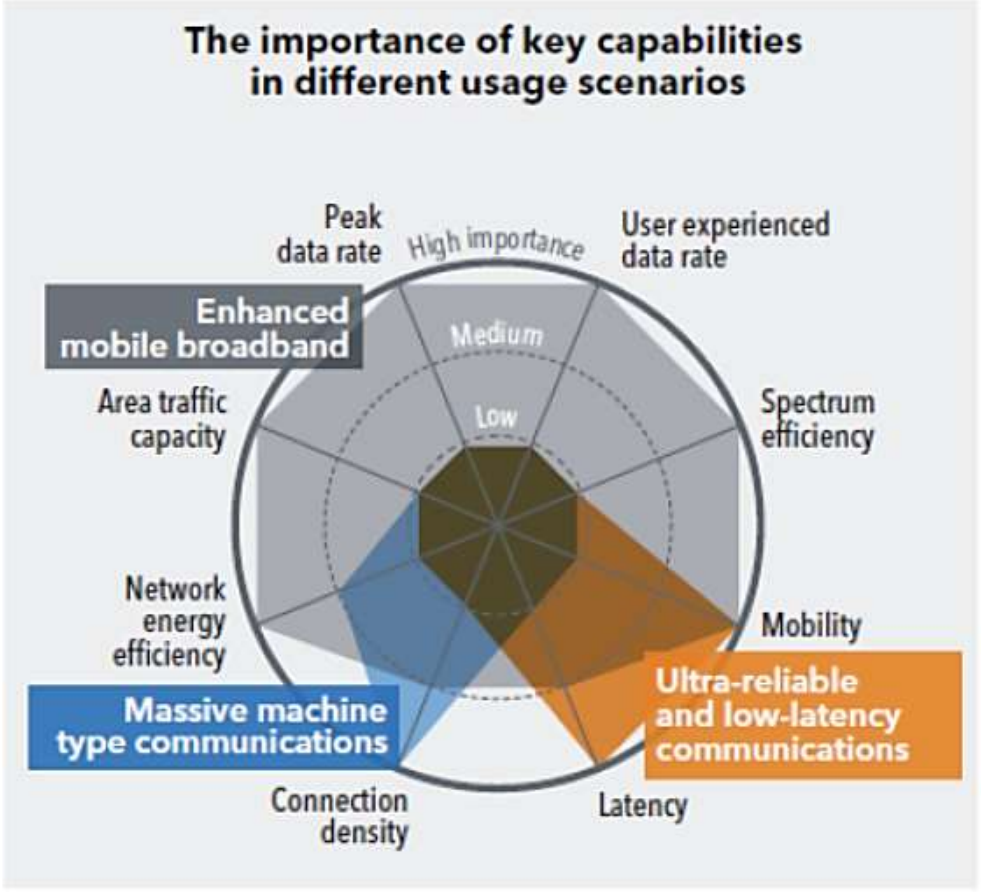
➢ Res. ITU-R 56-1: *Naming for International Mobile Telecommunications*

Since ITU is the internationally recognized entity that has sole responsibility to define and to recommend the standards and frequency arrangements for IMT systems, with the collaboration of other organizations such as standard development organizations, universities, industry organizations and with partnership projects, forums, consortia and research collaborations, therefore the RA-15 debated especially on naming of IMT systems.

- *the existing term* **IMT-2000** *continues to be relevant and should continue to be utilized;*
- *the existing term* **IMT-Advanced** *continues to be relevant and should continue to be utilized;*
- *However for systems, system components, and related aspects that include new radio interface(s) which support the new capabilities of systems beyond IMT-2000 and IMT-Advanced, the term "***IMT-2020***" be applied*
- *In addition it was resolved that the term "IMT" would be considered the root name that encompasses all of IMT-2000, IMT-Advanced and IMT-2020 collectively.*

IMT





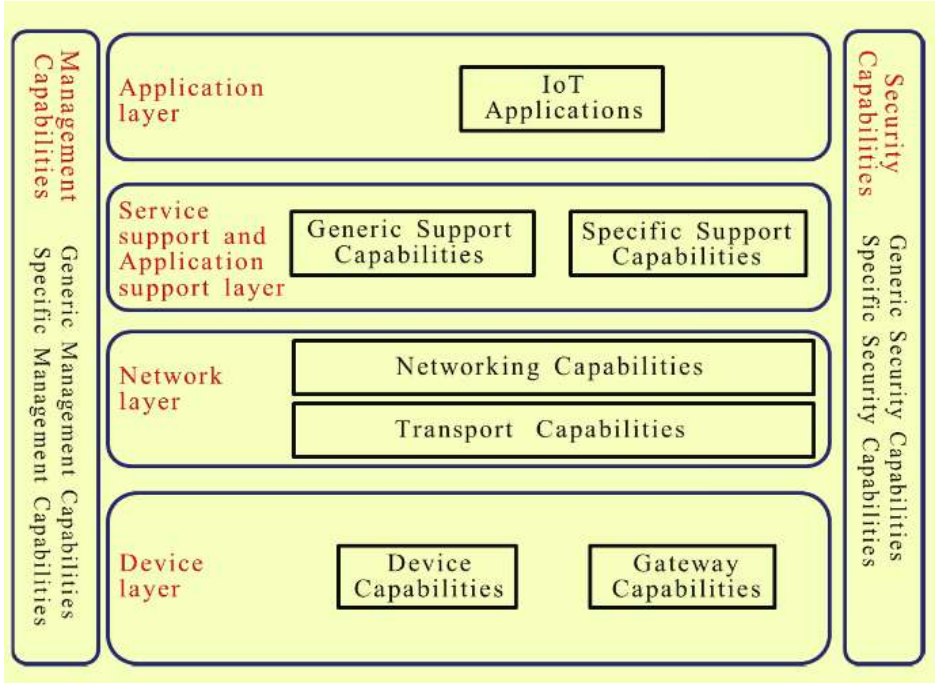
The values in the figures above are targets for research and investigation for IMT-2020 and may be revised in the light of future studies. Further information is available in the IMT-2020 Vision ***(Recommendation ITU-R M.2083)***

Technology Trends

IoTs

	Short-range	Long-range Unlicensed	Long-range licenced
Standards	Bluetooth, Wi Fi, Z-Wave, RFID, NFC	SIGFOX, LoRa	LTE Advanced Pro, GSM EC-GSM, NB-IoT, LTE Cat-M1
Range	Up to 200 m	Up to 50km	Up to 50km
Spectrum Bands	ISM Bands (915MHz, 2.4GHz, 5.8GHz)	900MHz (868MHz in Europe and 902MHz in the US	Mobile operator spectrum
Applications	Wearables, home automation, tolls	Sensing, smart grid, smart city, monitoring	Automotive, logistics transportation

IoT Access



IoT Reference Model

ITU SG20 – Unleashing the potential of the Internet of Things (https://www.itu.int/en/publications/Documents/tsb/2016-InternetOfThings/index.html)

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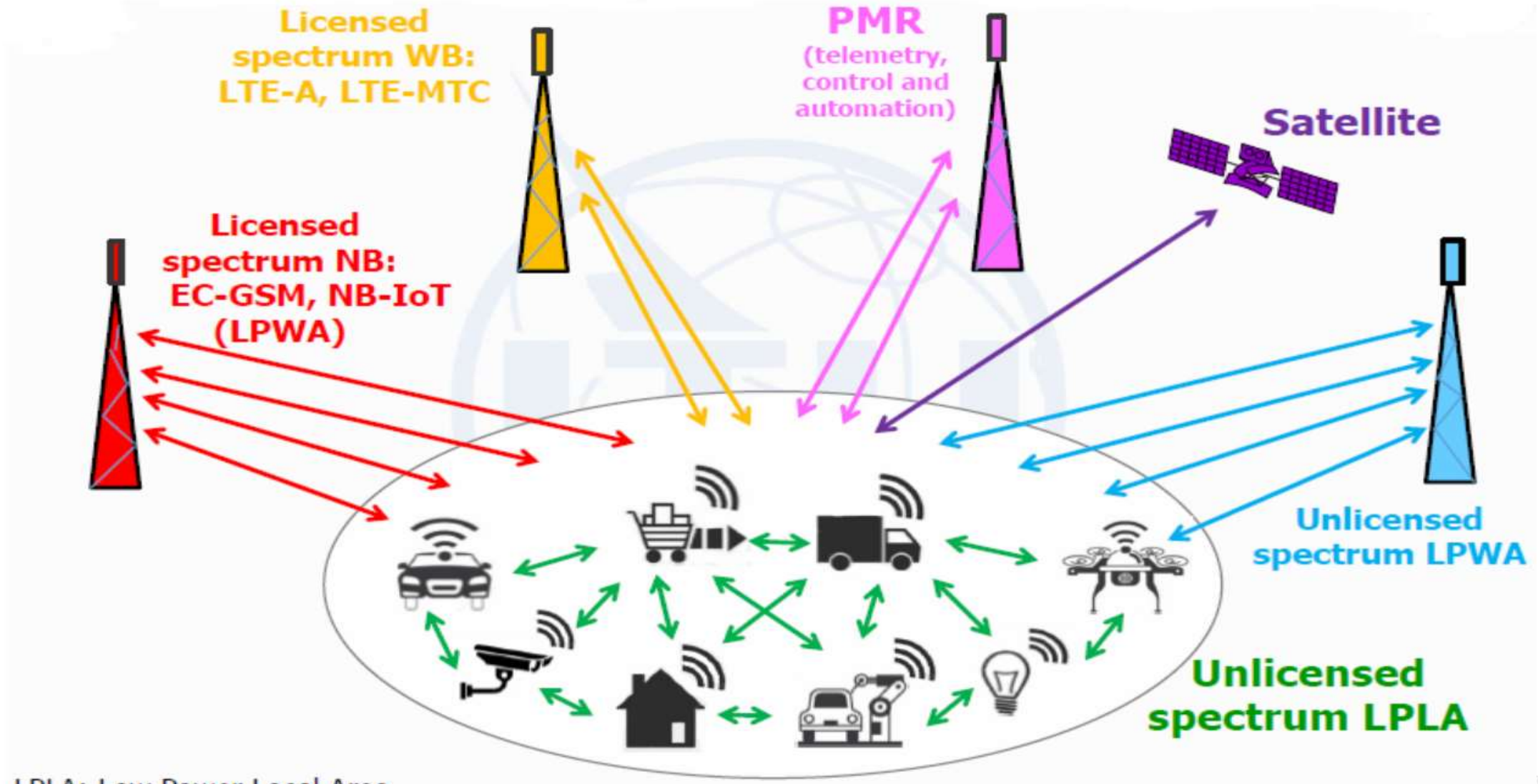
IoT Connectivity Options



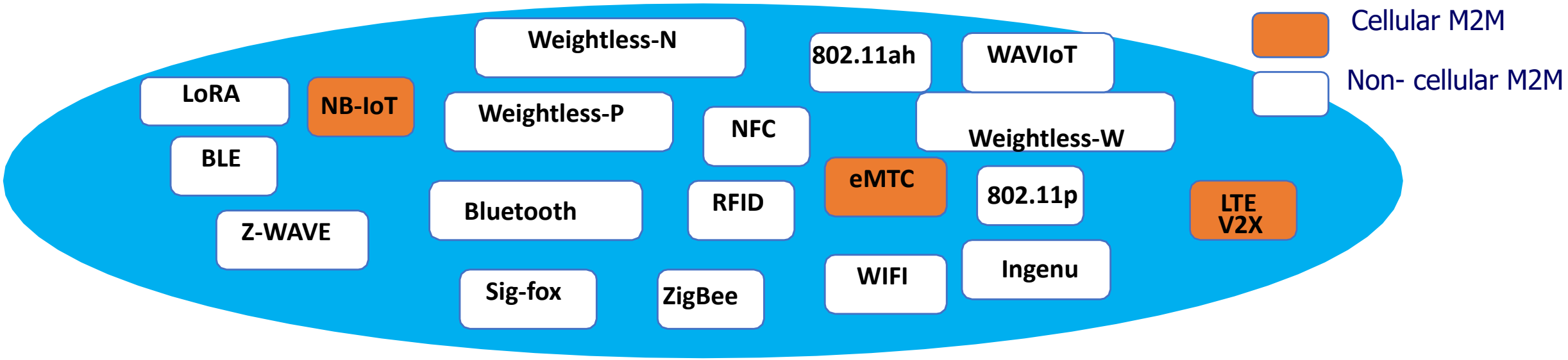
LPLA: Low Power Local Area
LPWA: Low Power Wide Area

Source: ITU Workshop on Spectrum Management for Internet of Things Deployment, 22 November 2016, Geneva

IoT Technical Solutions

Study in ITU under **WRC-19 agenda item 9.1, issue 9.1.8** (Machine Type Communication - MTC)

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



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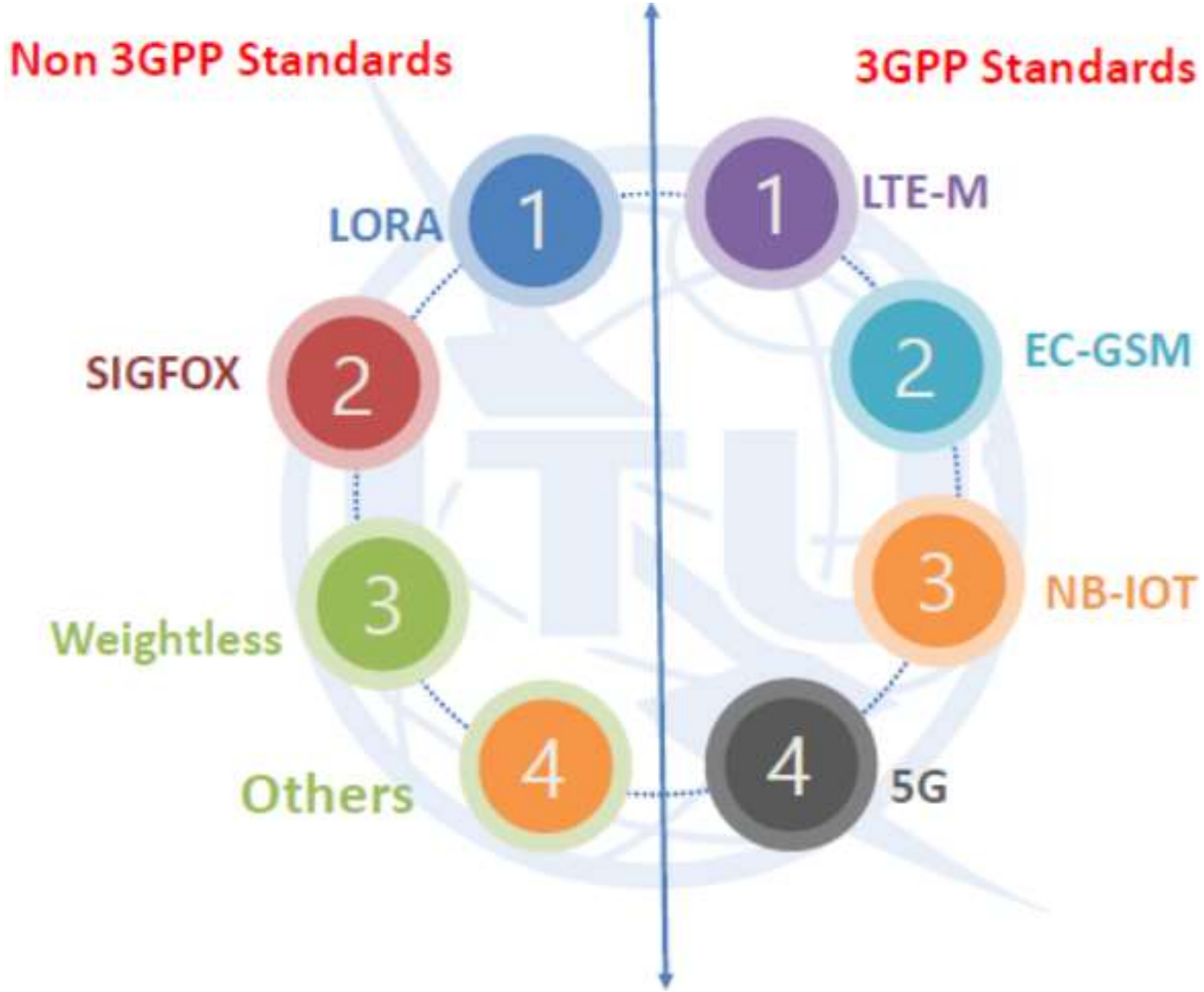
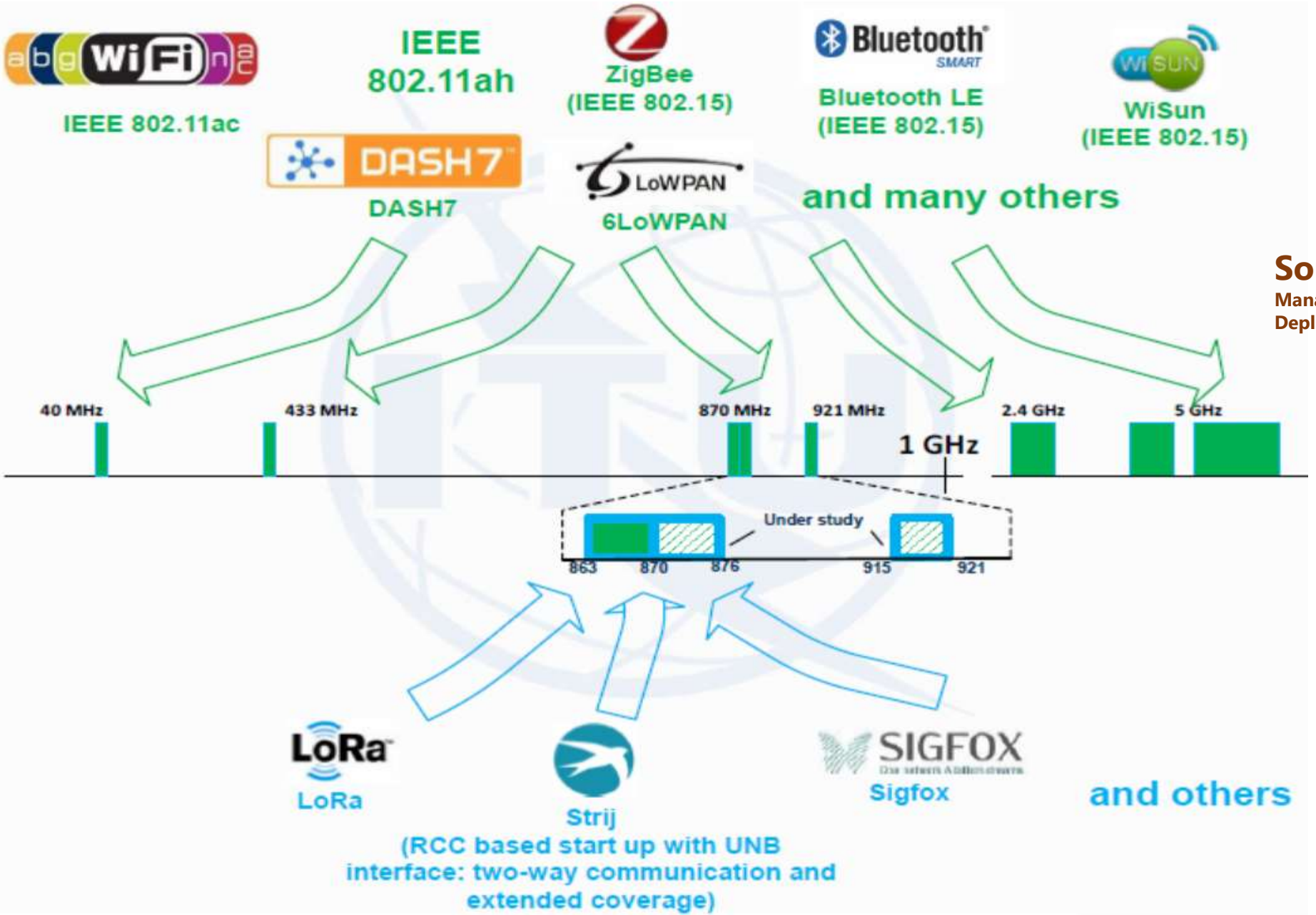
IoT Long Range Technical Solutions



Spectrum usage for IoT - SRDs



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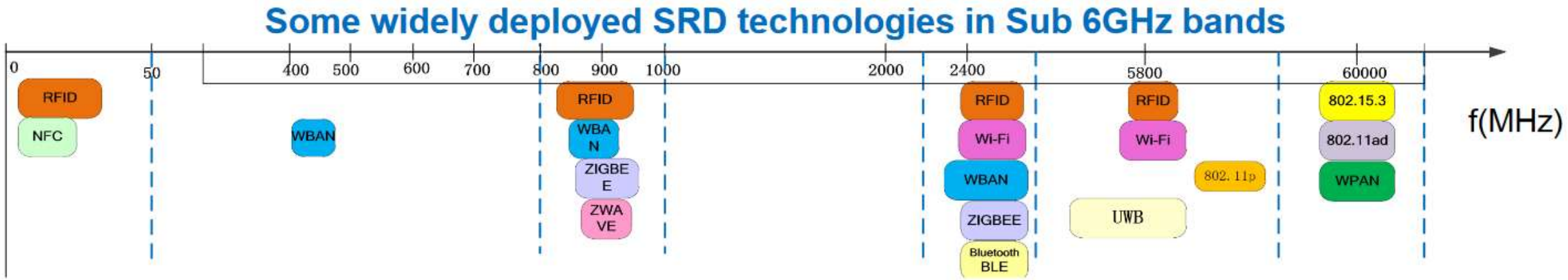
Spectrum usage for IoT - SRDs



Source: ITU Workshop on Spectrum Management for Internet of Things Deployment, 22 November 2016, Geneva

Technology Trend

Short Range Devices

- **SRDs will continue to be in demand as connected home and Internet of things (IoT) becomes a reality.**

- **New Equipment making use of unlicensed spectrum to have applications including**
  - ***WLAN*** *- Three blocks of spectrum in the 5GHz range for radio LAN – 5150 – 5350 MHz, 5470 – 5725 MHz and 5725 – 5875 MHz already identified. Manufacturers are developing wireless access in higher frequency range (57 – 66 GHz) to support multiple Gbps data rate (European standard EN 302 567)*
  - *RFID*
  - *NFC*
  - *UWB based applications*
  - ***Radiolocation*** *- WRC 2015 agenda item 1.18 will consider the allocation to the radiolocation service for automotive applications in the 77.5 – 78.0 GHz frequency band*

- **Manufacturers working through the ITU and other standardisation bodies to harmonise the frequency ranges and the technical standards.**

- **Administration working to have Mutual Recognition Agreement (MRA) in order to ease the Type approval process and generate economies of scale**

Technology Trend

Land Mobile Services

- **Trend of A to D conversion with simple data services like SMS**
- **More spectrum efficient equipment**
  - *Digital land mobile equipment operates with 12.5 kHz (or 6.25 kHz) as compared with 25 kHz for analogue equipment*
- **Spectrum demand from some services fading**
  - *Paging replaced by SMS and Walkie Talkie by Smartphones that can mimic the same service*
- **Spectrum demand from new consumer oriented mobile systems**
  - *Family Radio Systems and General Mobile Radio Systems (GMRS) (462/467 MHz)*
- **Critical role in Emergency and Public safety systems**
  - *Public Protection and Disaster Relief (PPDR) systems require more spectrum to support mobile video (WRC agenda item 1.3 – BB in UHF)*

Technology Trend

Terrestrial Broadcast Services

- Trend of A to D conversion with cut off dates defined
  - DSA and TVWS
- Further planning of SFN
- Adoption of APT 700 MHz band plan (more band for Mobile Services)
- Usage of more spectrally efficient broadcasting technologies
- ITU portal on status of the Status of the transition to Digital Terrestrial Television Broadcasting

http://www.itu.int/en/ITU-D/Spectrum-Broadcasting/Pages/DSO/Default.aspx

Technology Trend

Terrestrial Broadcast Services

DSA and TVWS (SM Issues)

- **Cross Border Interference**
  - *The need to take into account cross-border coordination in accordance with the Radio Regulations;*
- **Detailed Spectrum occupancy Requirements**
  - *The need for mature sensing technology, if applicable, to be able to measure accurately the spectrum occupancy;*
- **Risk Assessment of long term investment in TVWS**
  - *The risk for investments in opportunistic uses, associated with the uncertainties on the medium and long term availability of spectrum, either as a result of changes in the spectrum requirements of higher priority users or as a result of a change in higher priority allocations;*
- **Enforcement of License Conditions**
  - *The challenge of ensuring the compliance of the devices with national and international regulations and the enforcement of these regulations. These compliance and enforcement aspects will need to be addressed in a satisfactory way if such spectrum sharing technologies are to be implemented in the future;*
  - *The database related issues including complexity reliability and management if applicable;*
- **Technical Challenges**
  - *The technical challenge of developing devices that are able to operate in any channel over a wide frequency range while having to avoid adjacent channel interference into higher priority services.*

Source:

Final Report: Resolution 9 (*Participation of countries, particularly developing countries in spectrum management*) "Evolving Spectrum Management Tools to support development needs", ITU-D Study Group 1, 6th Study Period 2014-2017

Technology Trend
Terrestrial Broadcast Services

International Regulations

- ***RR 4.4*** *Administrations shall not assign …any frequency in derogation of either the Table of Frequency Allocations …, except on the condition that using such assignment shall not cause harmful interference to, and shall not claim protection from a station operating in accordance with …these Regulations*. Means usage is not stable (reliable) : if there are no free channels for TVWS device, it has to switch-off, stopping service to customers
- ***RR18.1*** *No transmitting station may be established or operated … without a licence issued in … conformity with the provisions of these Regulations by or on behalf of the government of the country to which the station is subject. All radios shall operate under a license (individual or general) and follow established national rules*

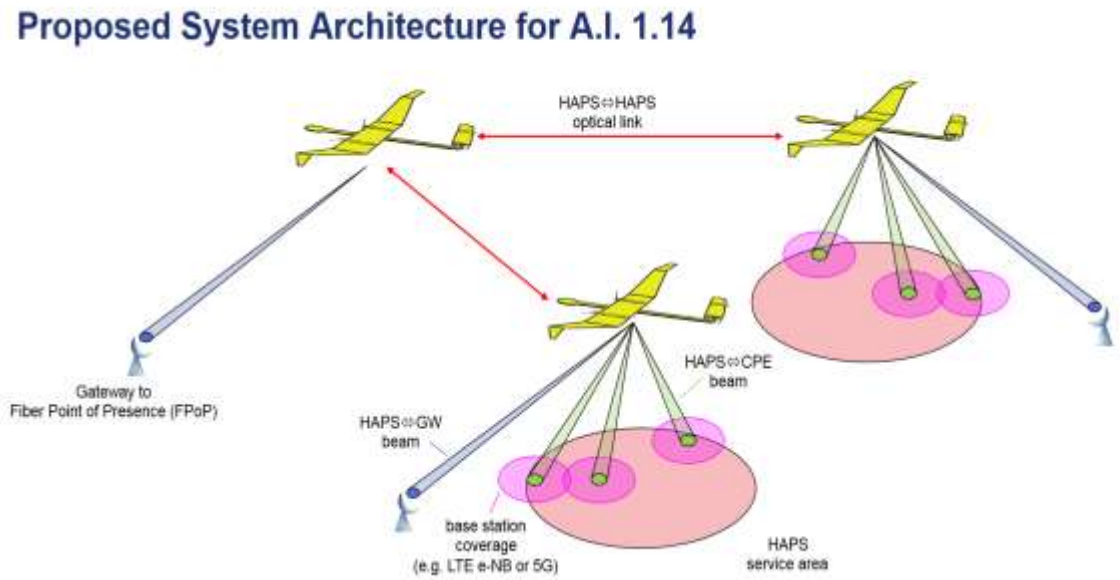
Some references of ITU Work on the TVWS and DSA *(Dynamic Spectrum Access)*:

- *Final Report Resolution 9: Participation of countries, particularly developing countries, in spectrum management "**Evolving spectrum management tools to support development needs**"*
- *Resolution ITU-R 58 "Studies on the implementation and use of cognitive radio systems"*
- *Recommendation 76 (WRC-12) "Deployment and use of cognitive radio systems"*
- *Question ITU-R 230-3/5 "Software defined radios"*
- *Question ITU-R 241-2/5 "Cognitive radio systems in the mobile service"*
- *Question ITU-R 235/1 "Spectrum monitoring evolution"*
- *Report ITU-R SM.2152 "Definitions of Software Defined Radio (SDR) and Cognitive Radio System (CRS)"*
- *Report ITU-R M.2225 "Introduction to CRS in LMS"*
- *Report ITU-R M.2242 "CRS specific for IMT systems"*
- *PDN Report ITU-R [LMS.CRS2]" CRS in land mobile service*
- *ITU-R WP 5A Seminar: Seminar on Cognitive Radio Systems and the use of White Spaces (Geneva, 18 November 2013)*
- *ITU-R WP 1B Workshop: Spectrum Management issues on the use of White Spaces by Cognitive Radio Systems (Geneva, 20 January 2014)*

Technology Trend

High Throughput satellites, HAPS and UAVs

- **HTS in MEO and LEO**
  - Example: Indonesia Palapa Ring project supplemented by HTS satellite
- **Commercial use of UAVs**
  - Terrestrial network based monitoring



Source: Airbus

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Spectrum Regulatory Trends

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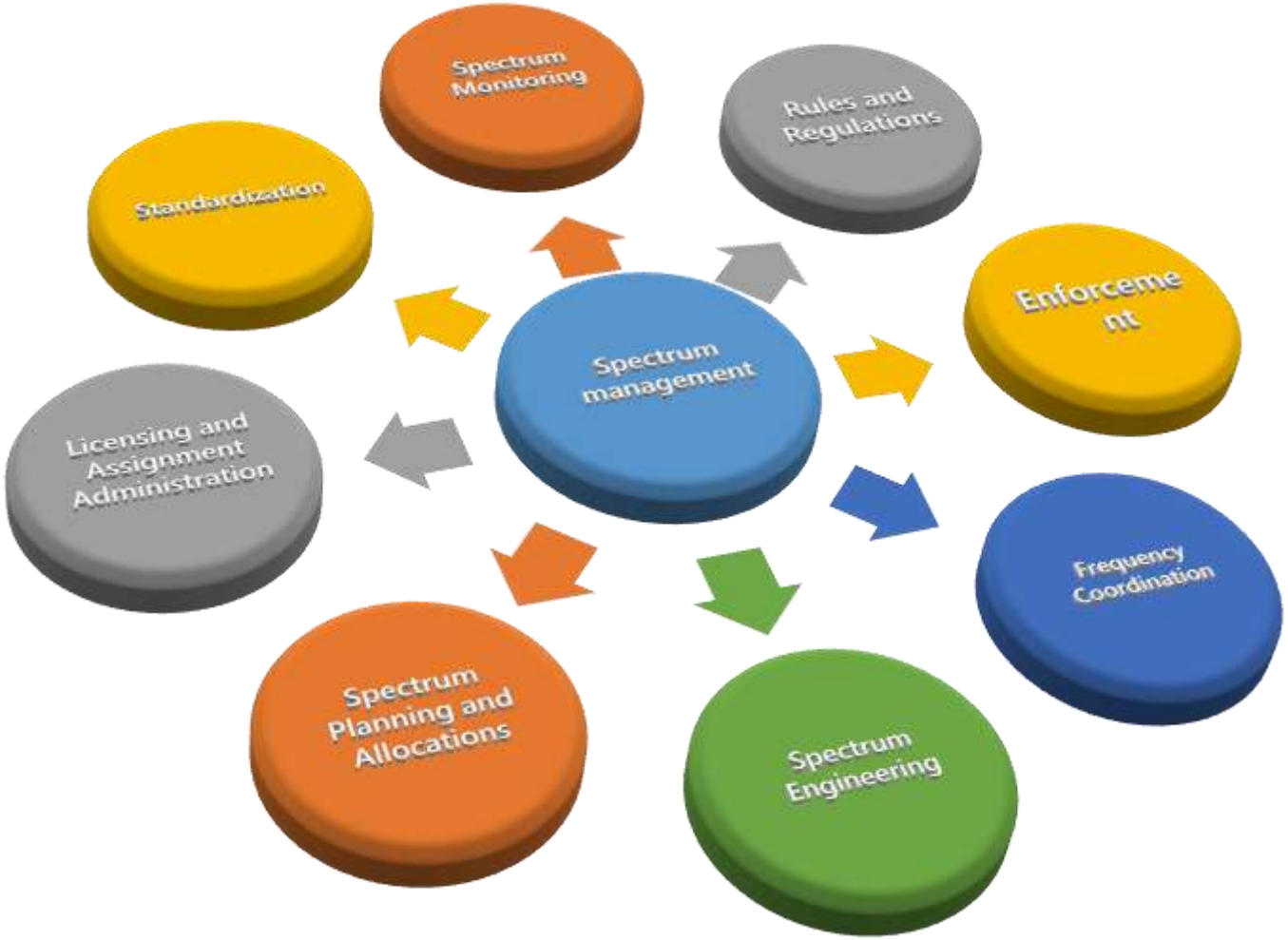
National Spectrum Management

Spectrum management is a combination of administrative and technical activities for efficient utilization of spectrum by users without causing harmful interference in their service area



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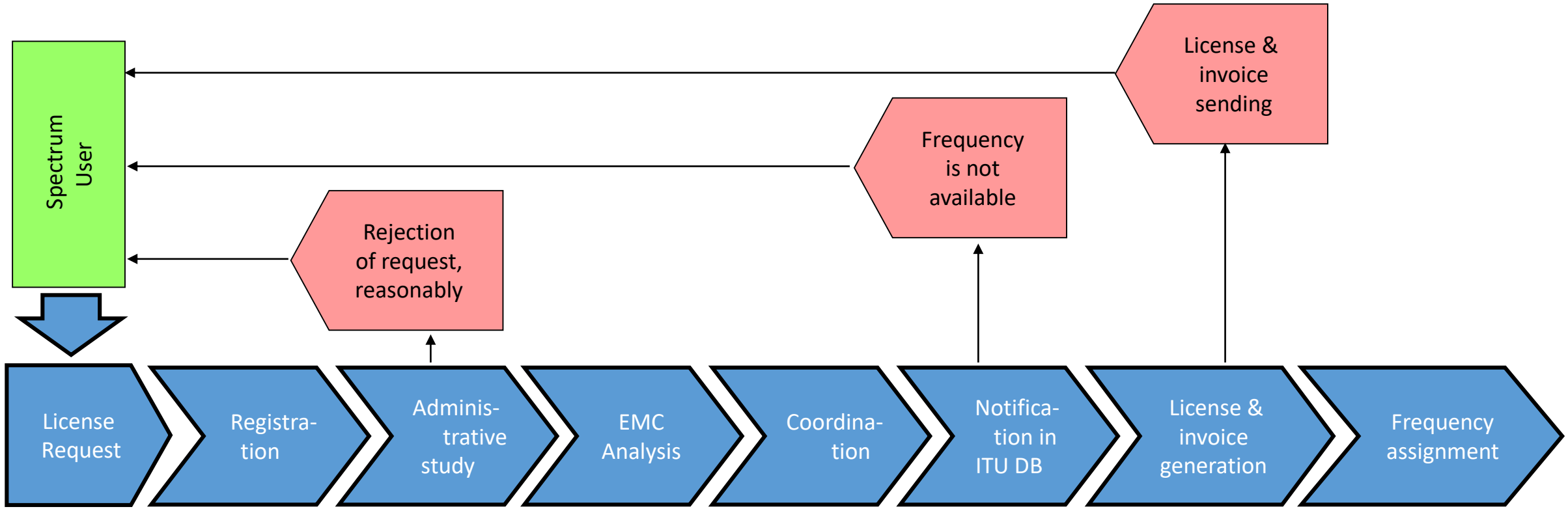
General Procedure for SM

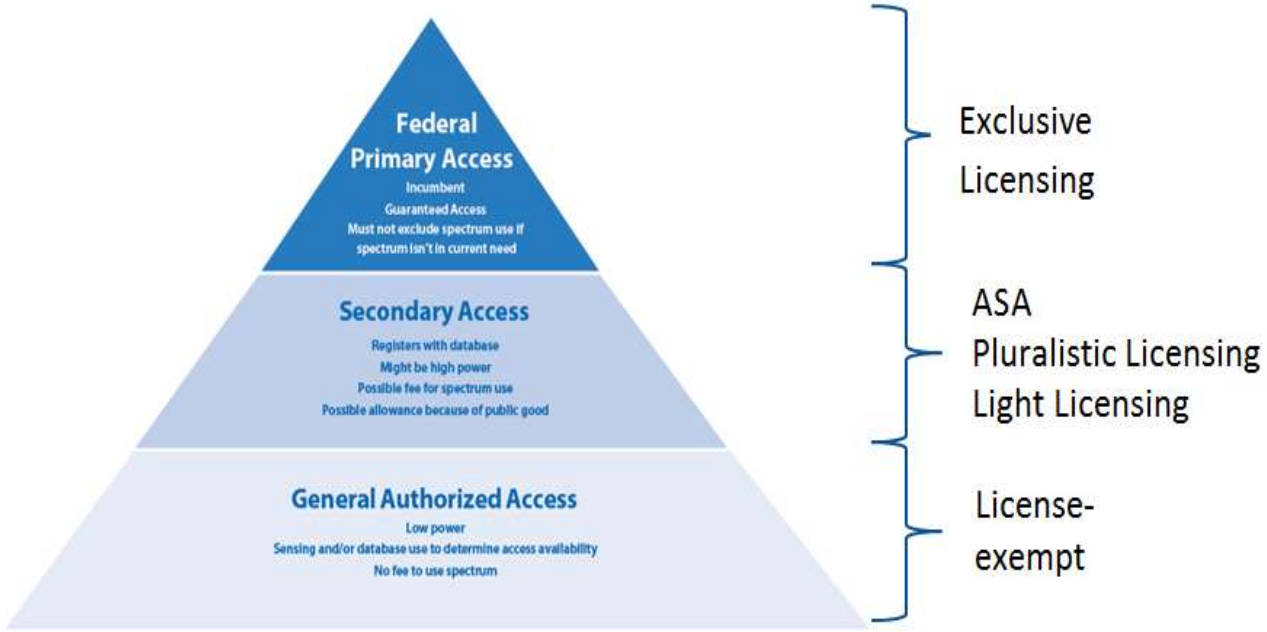


* *ITU notification is not required for each cases, and that a bi/multilateral agreement is stronger than the RR (see Article 6 of the RR)*

Spectrum Licensing

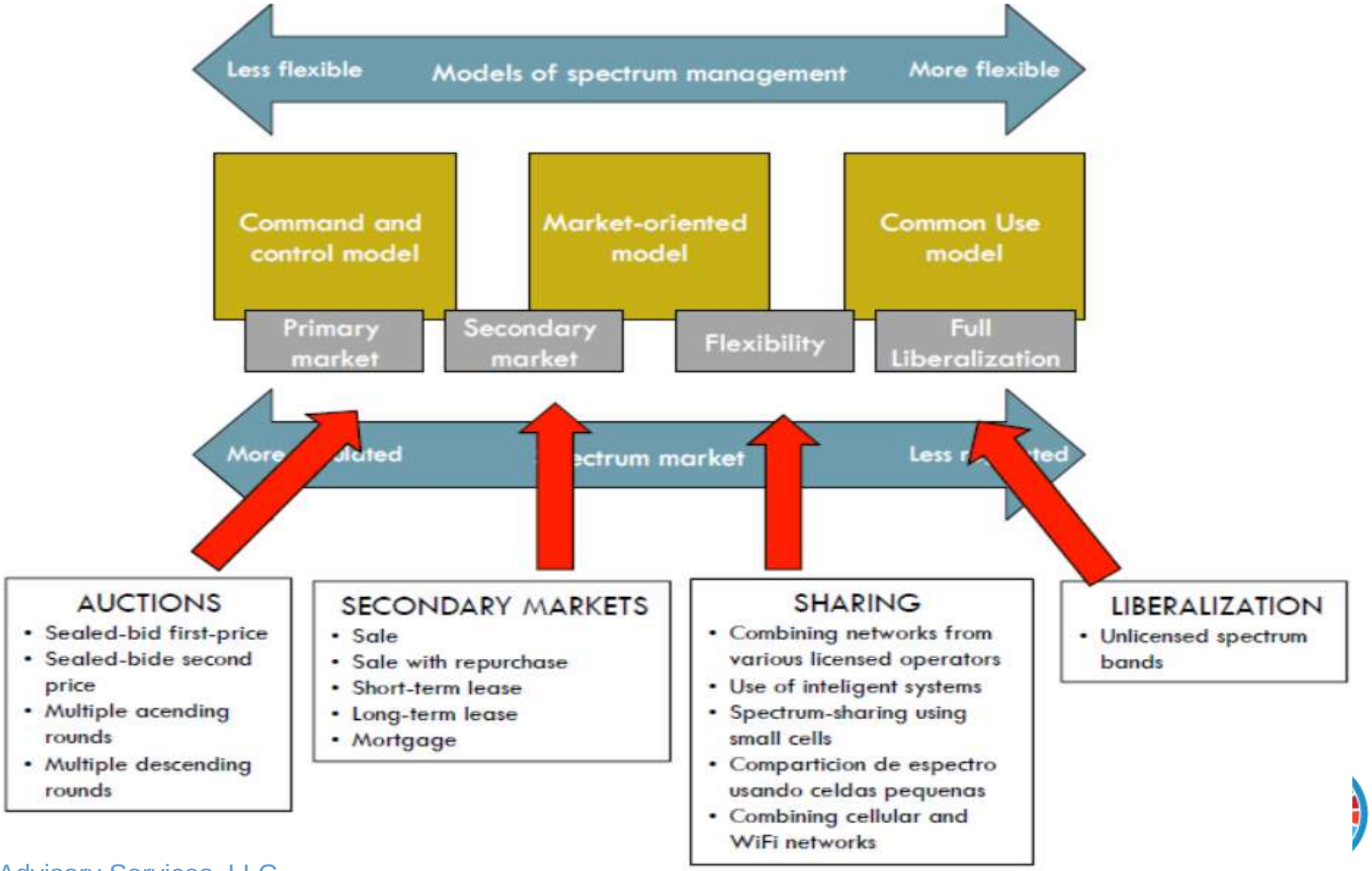
Novel solutions that promote various forms and degrees of organised sharing of spectrum:

- Light-licensing
- Authorised Shared Access/Licensed Shared Access
- Pluralistic Licensing, etc.



Source: Adapted from US PCAST report

Spectrum Licensing: *Trends*



Source: Telecom Advisory Services, LLC

National Spectrum regulation strategies

- Technology neutrality and Spectrum Licensing

Attributes	ALs *(Apparatus Licenses)*	*SLs (Spectrum Licenses)*	*CLs (Class Licenses)*
Regime focus	Device-centric	Space-centric	Tech-centric
Efficiency objective	productive (use)	allocative	dynamic
Exclusivity	medium to high	very high	none
Coordination rules	administratively set	proprietary	self-governed
Flexibility (tech-service)	**none to moderate**	**high**	**variable**
Individually assigned	Yes or No	Yes	No
Assignment by	ad-pricing, auction	auction	not assigned
Price	**admin fee / market pr.**	**market pricing**	**free**
Tenure and Term	up to 5 years/renew.	15 years / renew.	Unlimited
Interference protection	provided	provided	not provided
Tradable	**Moderate**	**High**	**None**
Sub-division	not allowed	allowed	not possible
Coordination needed	low	high	very low
Service – tech neutrality	usually none	high	high or low

Example: Australian Licensing System

Income from Spectrum Management

- **Fees collected :**
  - *License application (not refundable);*
  - *License issuing, renewing and amendment;*
  - *Periodically (on monthly/annual basis) from spectrum users proportional with the occupied bandwidth, service type, used frequency, covered location, service area, time duration and etc.;*
  - *Penalties imposed in effect of breaching of regulation;*
  - *Type approval fee;*
  - *Special technical assistance;*
  - *Auction;*
- **Spectrum management authority could earn much more money than its administrative needs if a suitable spectrum pricing regulation developed**

Deciding: *When to give out spectrum?*

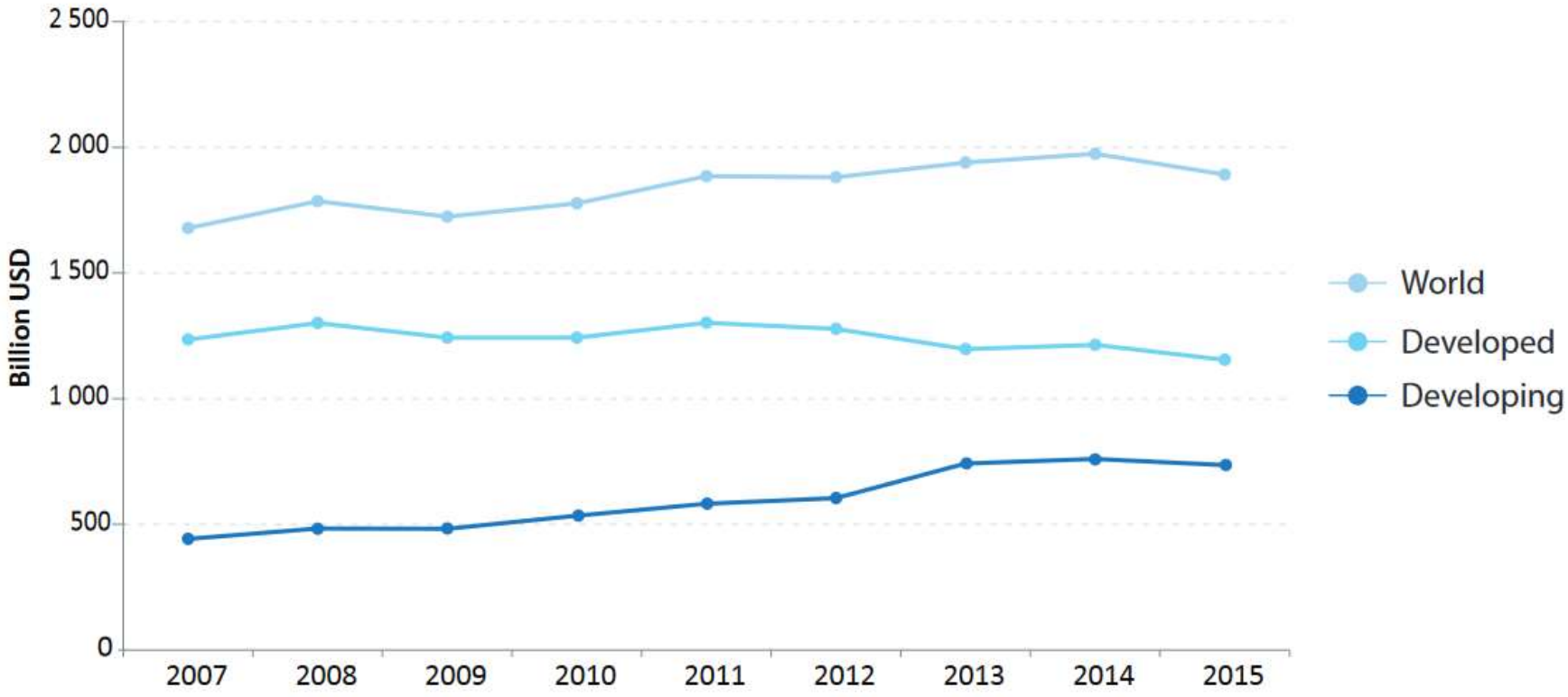
- Low access frequencies: *High demand*
  - Less choice and need a balanced approach
    - Ever increasing demand from commercial mobile sector
  - Decision of when depends on band clearance

- Higher frequencies: *Lower demand*
  - More choice on timing.
  - The choice is essentially whether it is better to hold the band in the regulator's inventory **OR** to make it available to a licensee even if that licensee will not use it immediately

- Importance of Spectrum Trading
  - If the spectrum is tradable, so that a licence bought for one purpose can be sold for use in another purpose,
  - **Early release** may speed up innovation
    - depending on whether the regulator has sufficient resources to conduct non-urgent auctions.

Delaying access is as detrimental to a country as is withholding it permanently

Telecom Revenues



Source: ITU.

Global telecommunication revenues declined by 4% between 2014 and 2015, falling back to USD 1.9 trillion.

Developing countries saw a compound annual growth rate in telecommunication revenue of 6.6% in the period 2007-2015, whereas developed countries experienced a contraction of -0.8% during the same period.

Developing countries are home to 83% of the global population but generate only 39% of the world's telecommunication revenues.

http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2017.pdf

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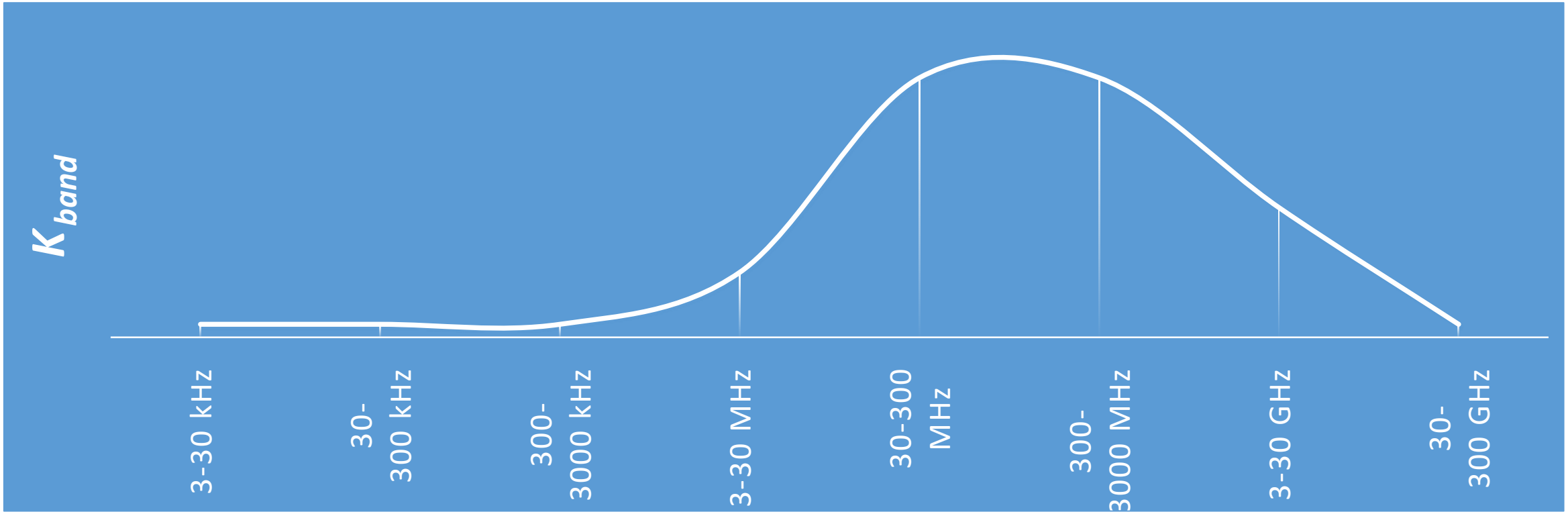
Granting Spectrum Access

	Pros	Cons
01 Cost Recovery	• Most straightforward to administer • For national interest/public service	• Often too low to instil discipline in ensuring spectrum efficiency • Tendency to maintain the same fees for years without review
02 Spectrum Auction	• Transparency & fairness • Outcome determined by market demand • For commercial services, highest economic value	• Potential of overpricing; affecting operators' profitability • Often with a long licence duration
03 Administrative Incentive Pricing	• Encourage users to optimise spectrum; avoid hoarding • Reflect the value of spectrum and generate revenue for the government	• Difficult in establishing the right level of pricing • May result in spectrum being underutilised if the prices are too high

Income from Spectrum Management: *Russian Case study*



Spectrum fees V/s frequency range

Source: *Russian case study submitted to BDT study 1 Resolution 9: The experience of the Russian Federation in the field of spectrum fees*

Summary

- SM remains a vibrant sphere of activities that makes an important constituent part of ICT industry functioning and innovation

- Regulate/Manage Spectrum like natural resource AND for long term benefits

- ITU remains ready to work with you

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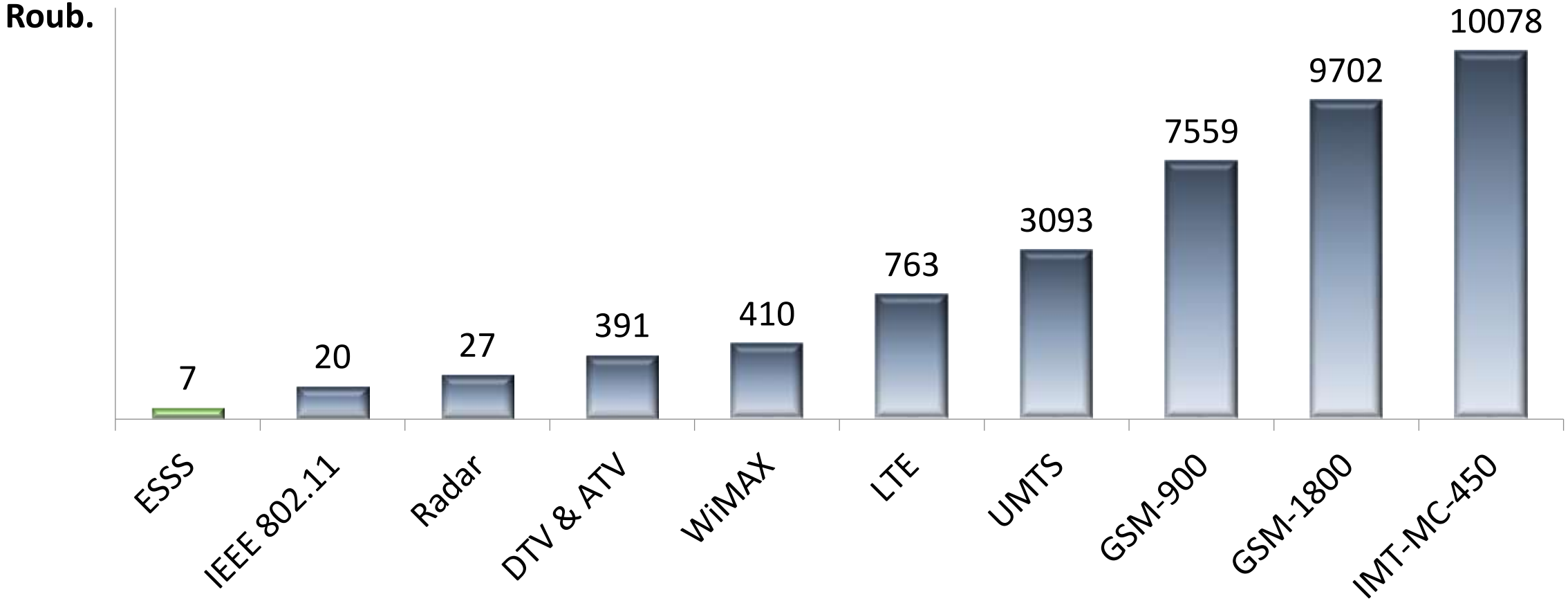
Spectrum Fee per MHz: *Russian Case study*



Average Radio Fee per MHz

Source: *Russian case study submitted to BDT study 1 Resolution 9: The experience of the Russian Federation in the field of spectrum fees*

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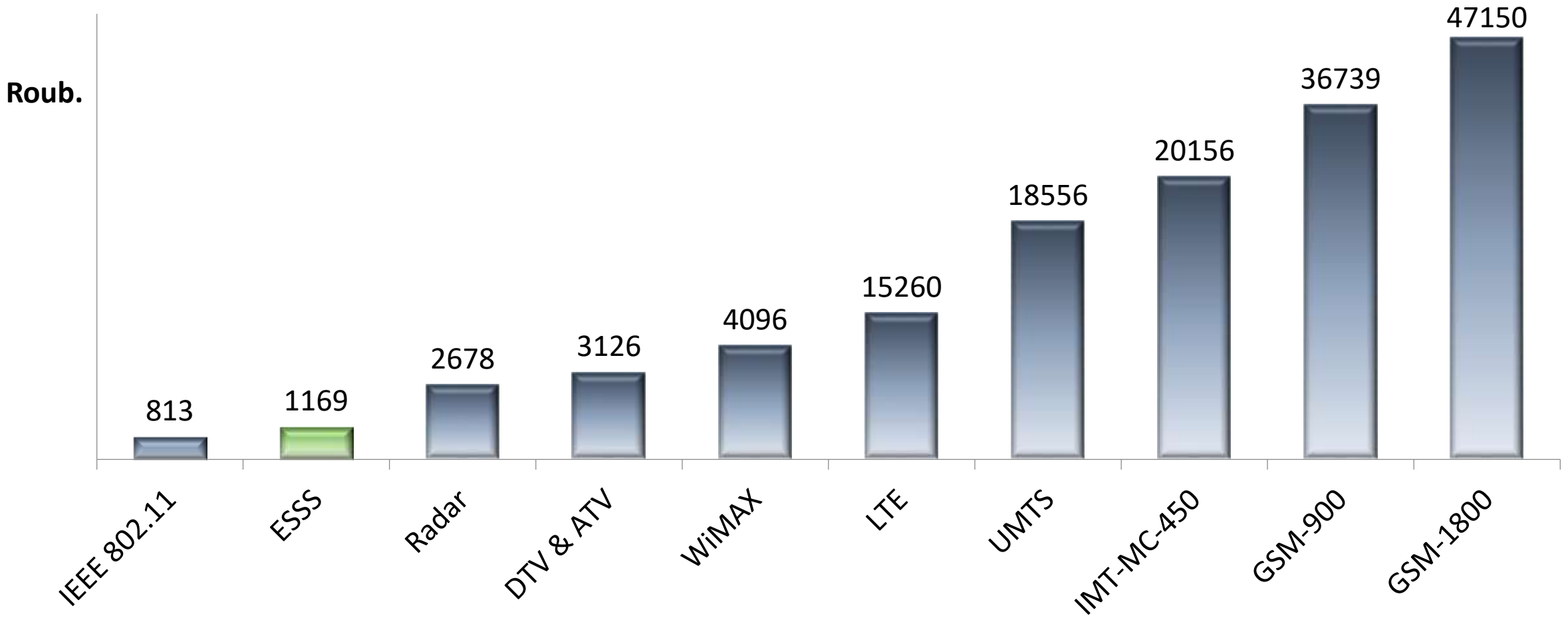
Spectrum Fee per device: *Russian Case study*



Average Radio Fee per device

Source: *Russian case study submitted to BDT study 1 Resolution 9: The experience of the Russian Federation in the field of spectrum fees*

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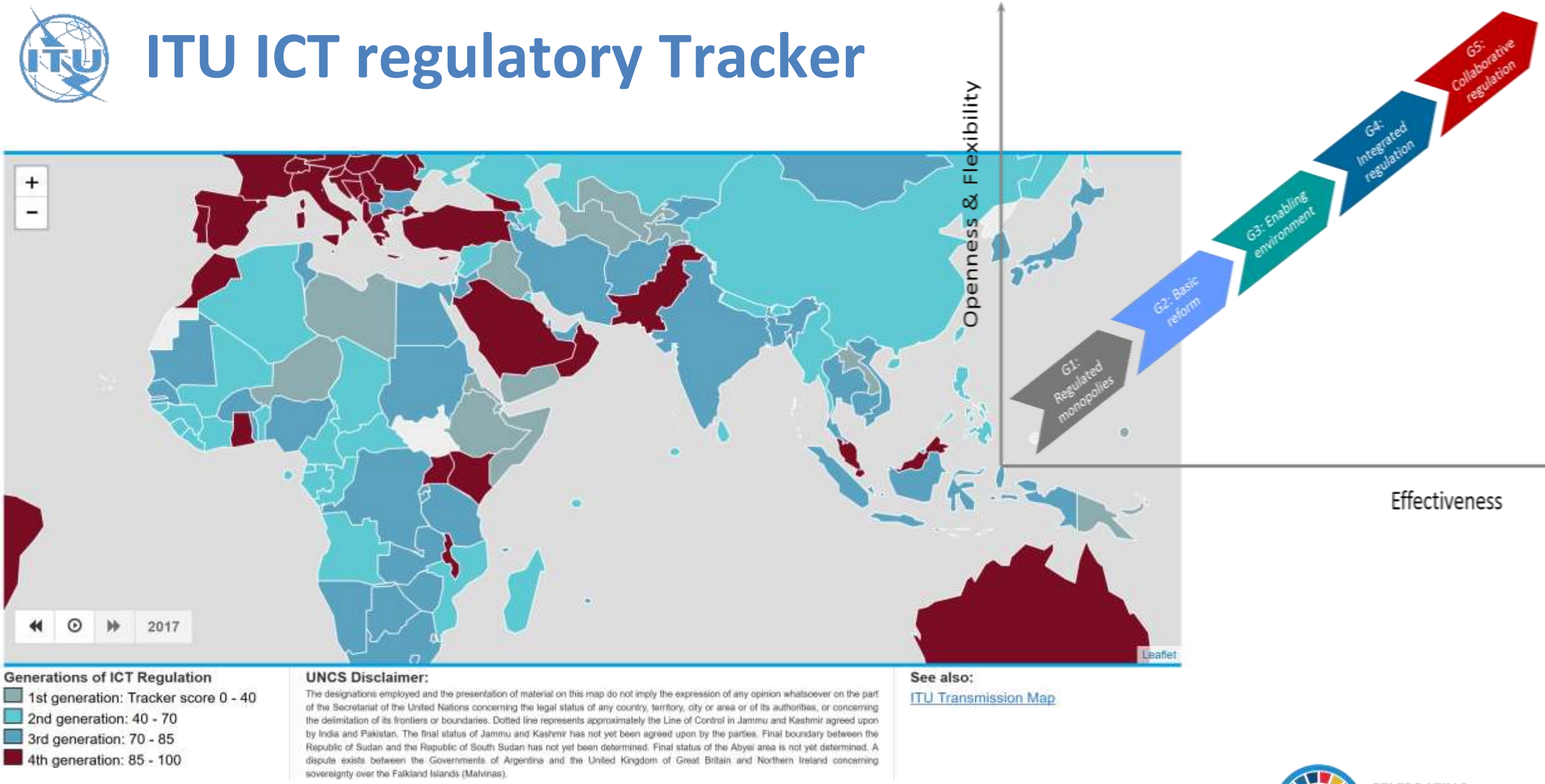
ITU ICT regulatory Tracker



Source: ITU (https://www.itu.int/net4/itu-d/irt/#/map?ind=generation-of-regulations&year=2017)

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Regional Challenges on SM

Other High level Challenges

Automation of Spectrum Invoicing and licensing system

01

Sustainable Expertise development

02

2017: SMS4DC Version 5.1 includes

Results of WRC-15/ RR-16

Spectrum Fee Calculation Example

Import tool for existing database

The SMTP comprises of two levels Basic and Advanced. Each level includes a number of obligatory (OM) and elective (EM) modules which are the following:

- **OM1** "Legal Basis and Regulatory Framework of Spectrum Management";
- **OM2** "Spectrum Engineering Fundamentals";
- **OM3** "Wireless Telecommunications Technologies";
- **EM1-1**: "Spectrum Monitoring";
- **EM1-2**: "Enforcement and Type Approval of Equipment";
- **EM1-3**: "SM for Satellite Systems";
- **EM1-4**: "SM for HF Systems, Science, Maritime and Amateur Services";
- **EM1-5**: "SM for Aeronautical and Radio Determination Services and Military Systems";
- **EM1-6**: "Computer-aided Spectrum Management";
- **OM4** "Economic and Market Tools of Spectrum Management";
- **OM5** "Strategic Planning and Policies for Wireless Innovation";
- **EM2-1** (Legal Specialization): "Advanced Spectrum Authorization Regimes";
- **EM2-2** (Legal Specialization):"Socio-Economic Impact of Spectrum Regulation; Competition and Consumer Protection";
- **EM2-3** (Technical Specialization): "Terrestrial TV Broadcasting Planning and Digital Transition";
- **EM2-4** (Technical Specialization): "Opportunistic Spectrum Access and Cognitive Radio".

SMTP

International Telecommunication Union

ITU Academy
Spectrum Management Training Programme – SMTP

CZECH TECHNICAL UNIVERSITY IN PRAGUE

brought to you by
Czech Technical University in Prague

2 semesters of blended learning
lectures – distance education
practical training and exams – 1 week per semester in Prague

Beginning on January 30, 2017

1st semester

Module OM1: "Legal Basis and Regulatory Framework of Spectrum Management"
Module OM2: "Spectrum Engineering Fundamentals"
Module OM3: "Wireless Telecommunication Technologies"
Module EM1: "Spectrum Monitoring"

2nd semester

Module OM4: "Economic and Market Tools of Spectrum Management"
Module OM5: "Strategic Planning and Policies for Wireless Innovation"
Module EM2: to be elected
Module EM3: to be elected

Graduates will be issued ITU certificate

Tuition fee (for 2 semesters): USD 1000 (regular – to be paid before November 30, 2016)
USD 800 (early – to be paid before October 31, 2016)

FEE CTU is an Academia Member of all ITU sectors and ITU Centre of Excellence for Cybersecurity in Europe

relevant links

ITU Academy
ITU SMTP Programme
ITU-D
ITU Home

SMTP at CTU

contact & registration

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https://comtel.fel.cvut.cz/sites/default/files/public/itu/itu_smtp_leaflet.pdf

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I Thank U

"Committed to connecting the WORLD"

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