Trends in Spectrum Management

Workshop on Spectrum Management and Harmonized use of Spectrum Resource
Nadi, Fiji
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CELEBRATING 25 YEARS OF ACHIEVEMENTS

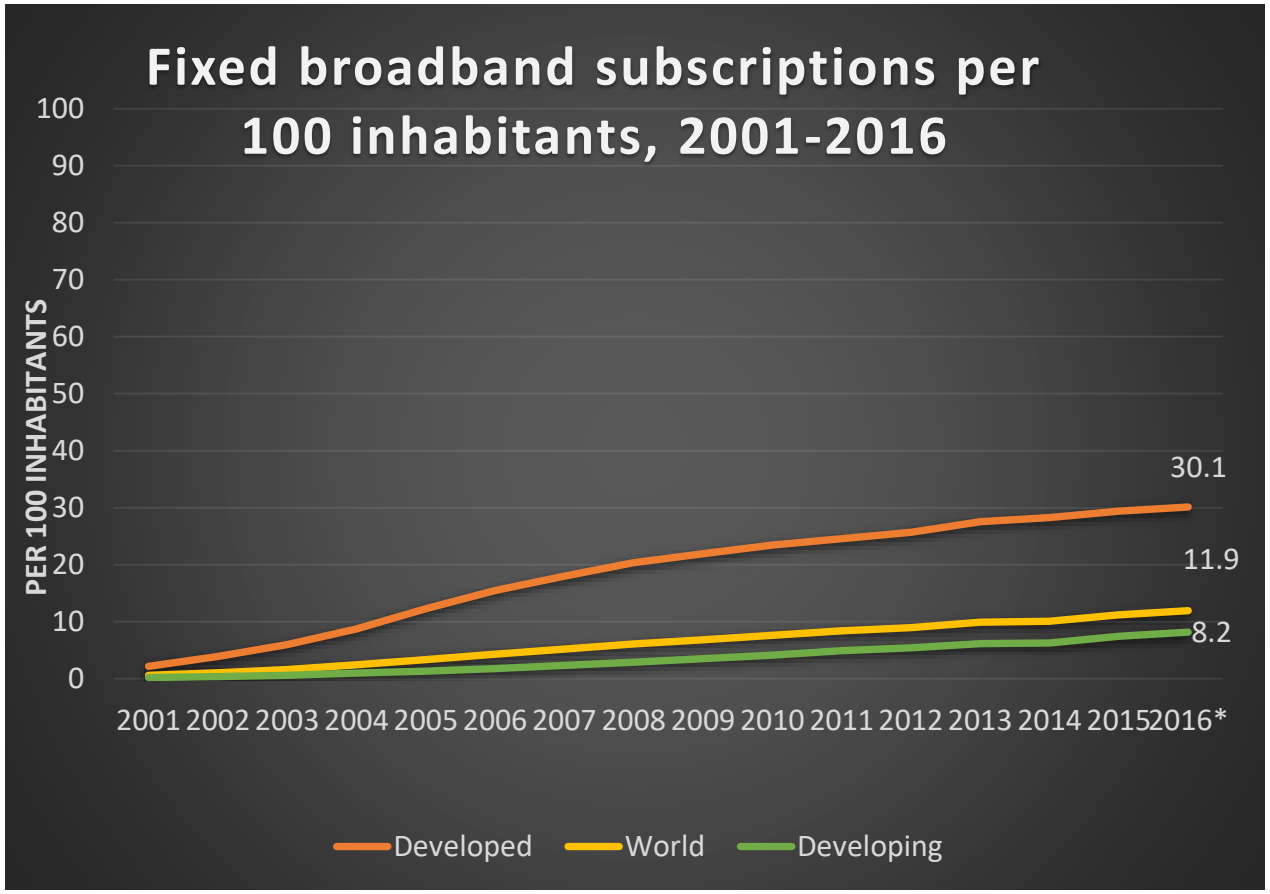
AGENDA

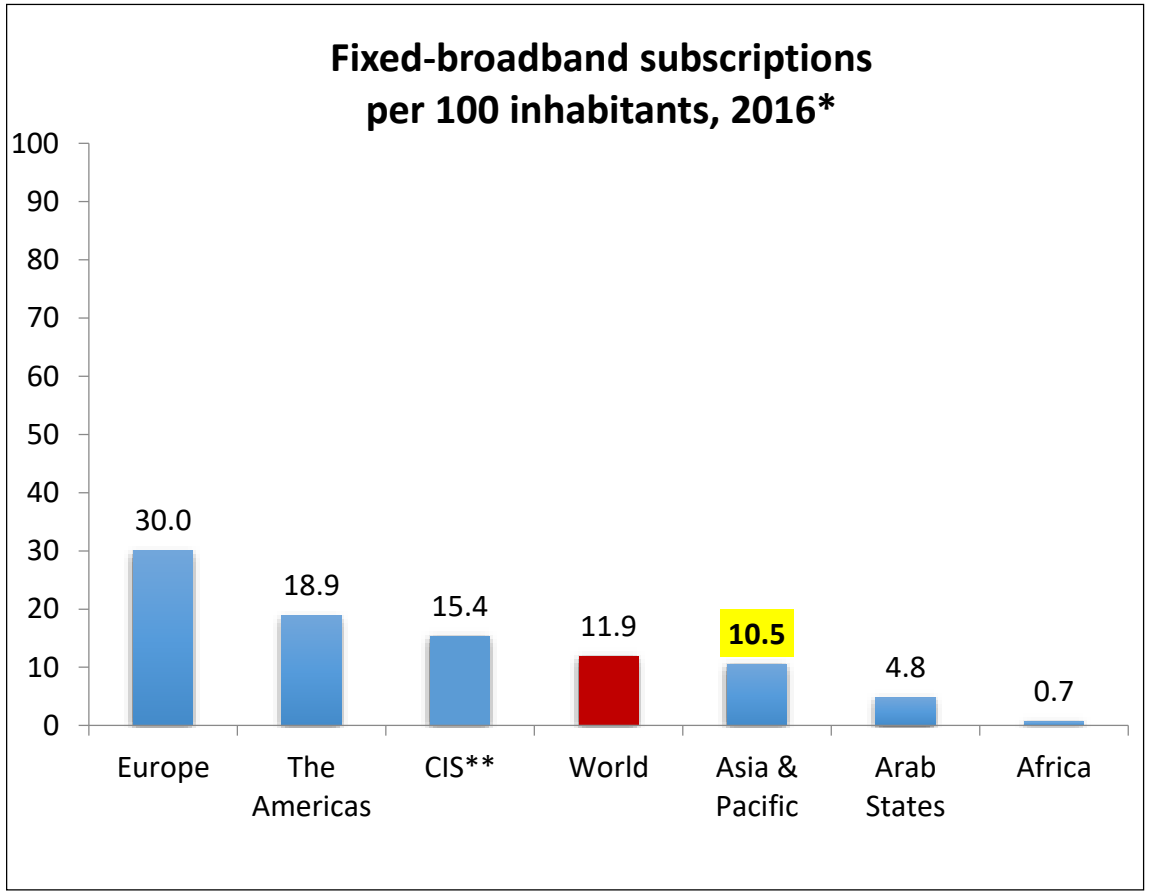
- Radio Spectrum and its Value to Economy
- Economics of Granting access to Spectrum
- Technological trends in Spectrum Usage
- Spectrum Licensing trends
- Institutional Best practices in Spectrum Management
- Regional Challenges on SM

Radio Spectrum and its Value to Economy

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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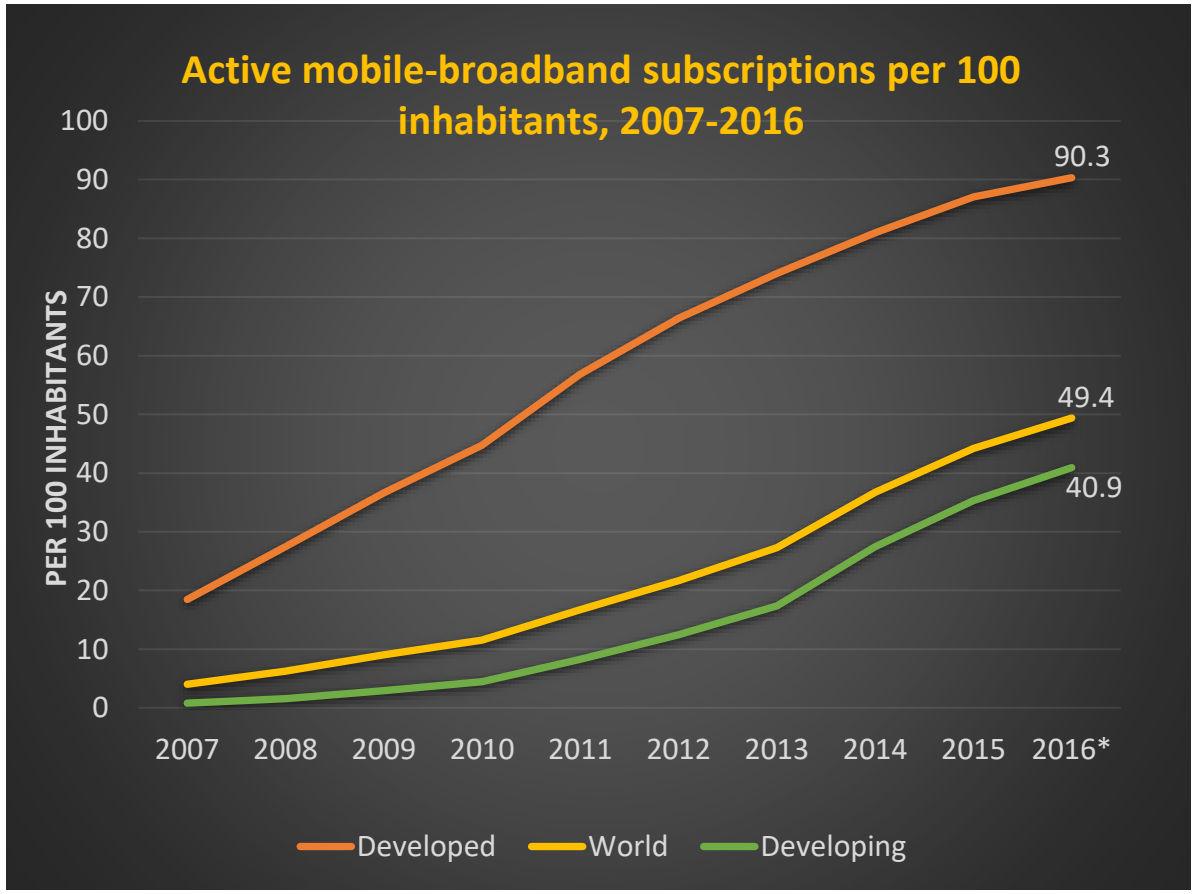
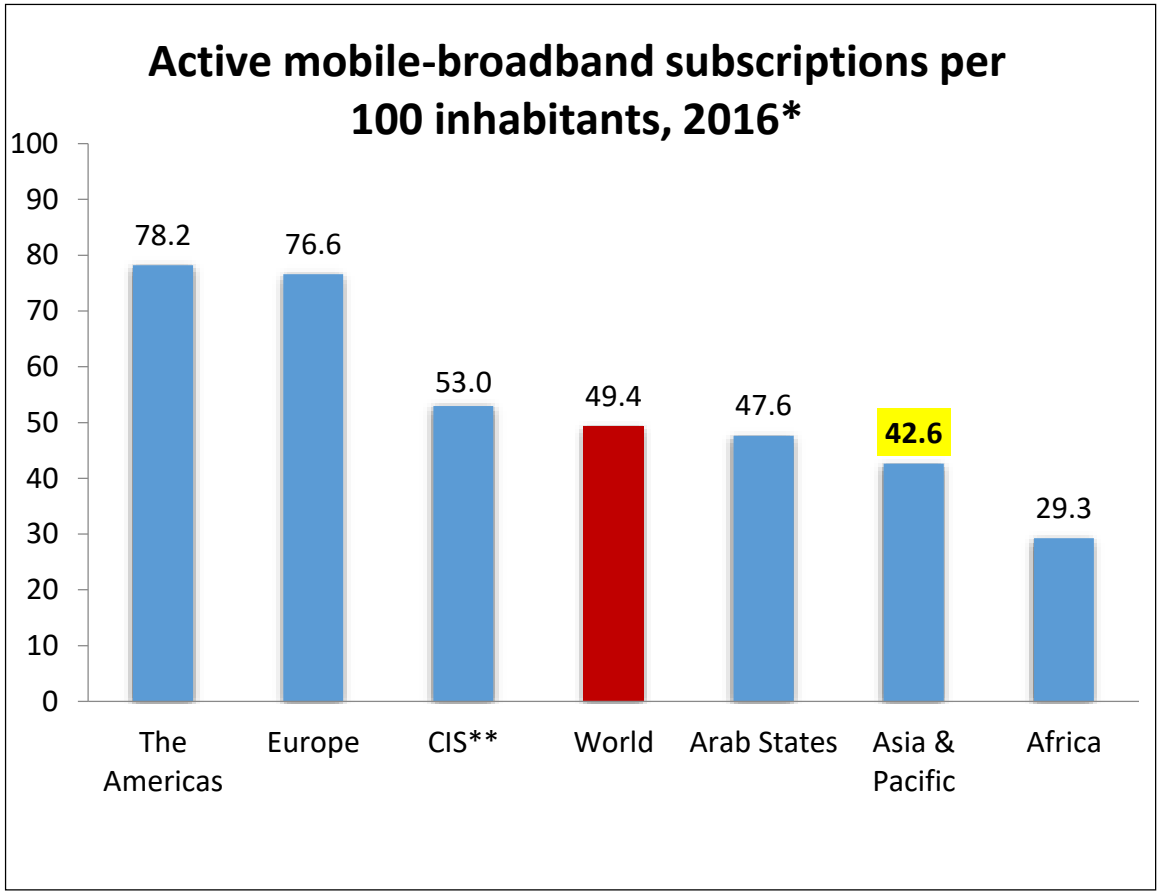
Why the need for Efficient SM now?

Mobile BB Growth Global and across regions of the world





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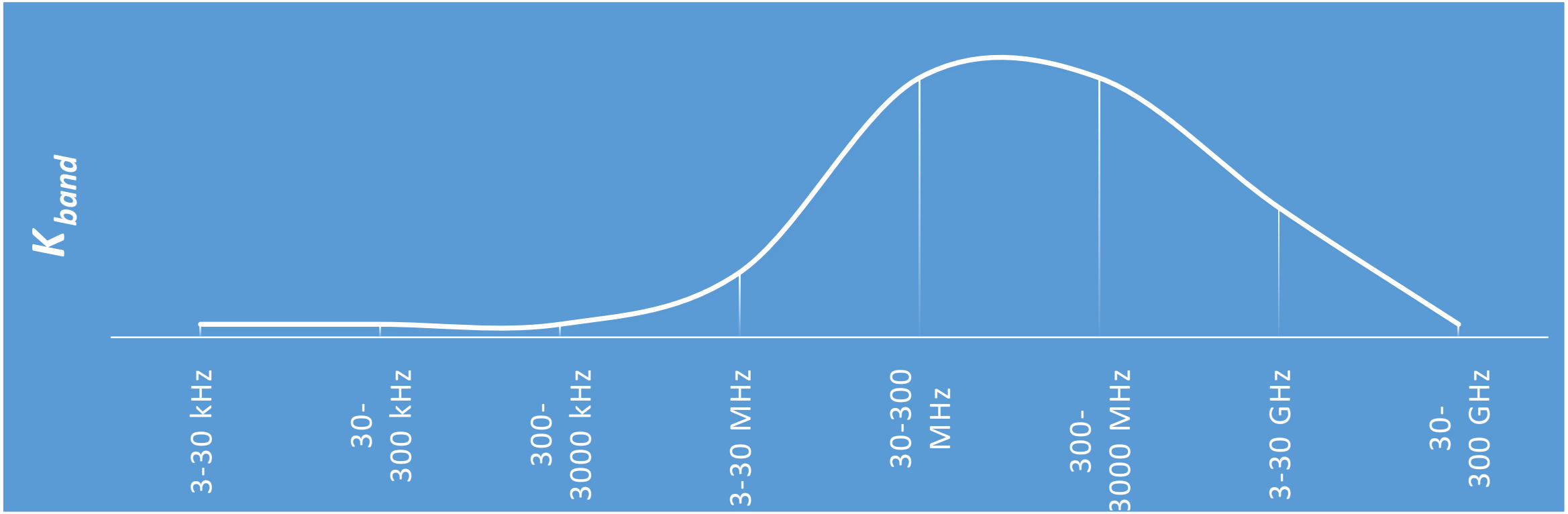
Income from Spectrum Management

- **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**
- **Roughly, spectrum fee should not be more than 3~5% of net revenue of licensee**

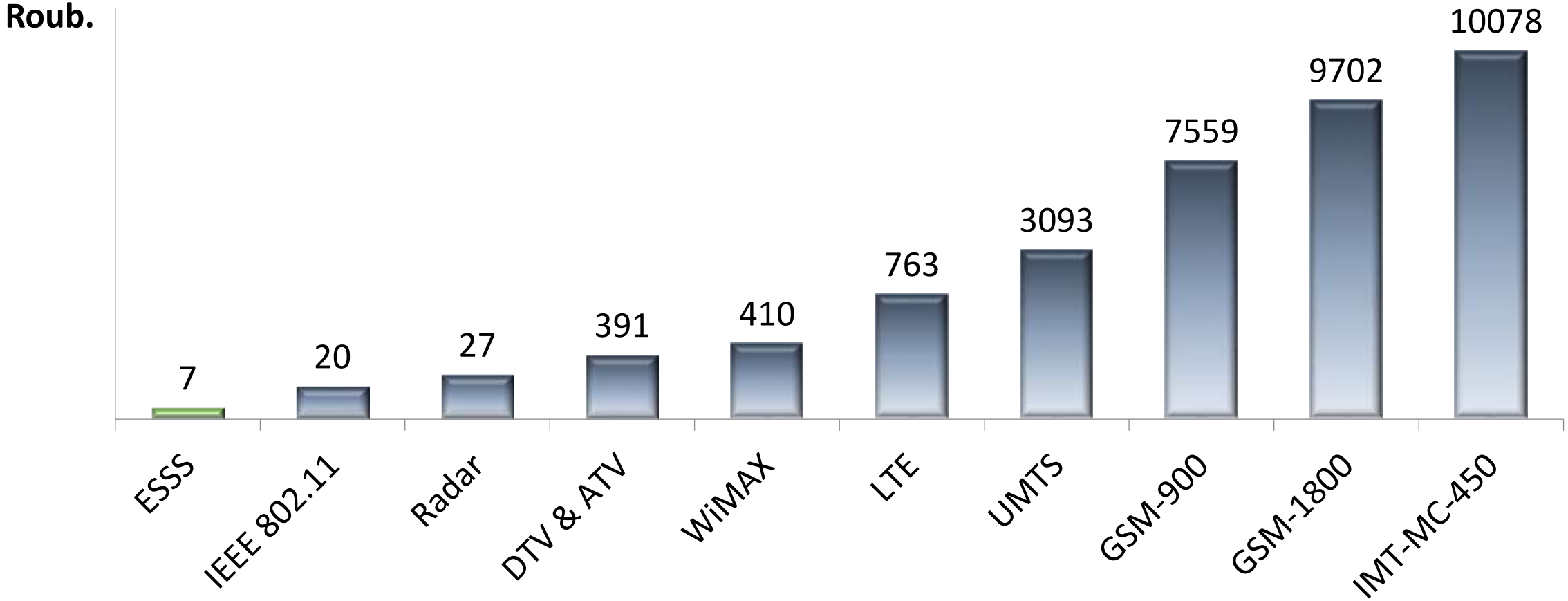
Income from Spectrum Management: *Russian Case study*



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*

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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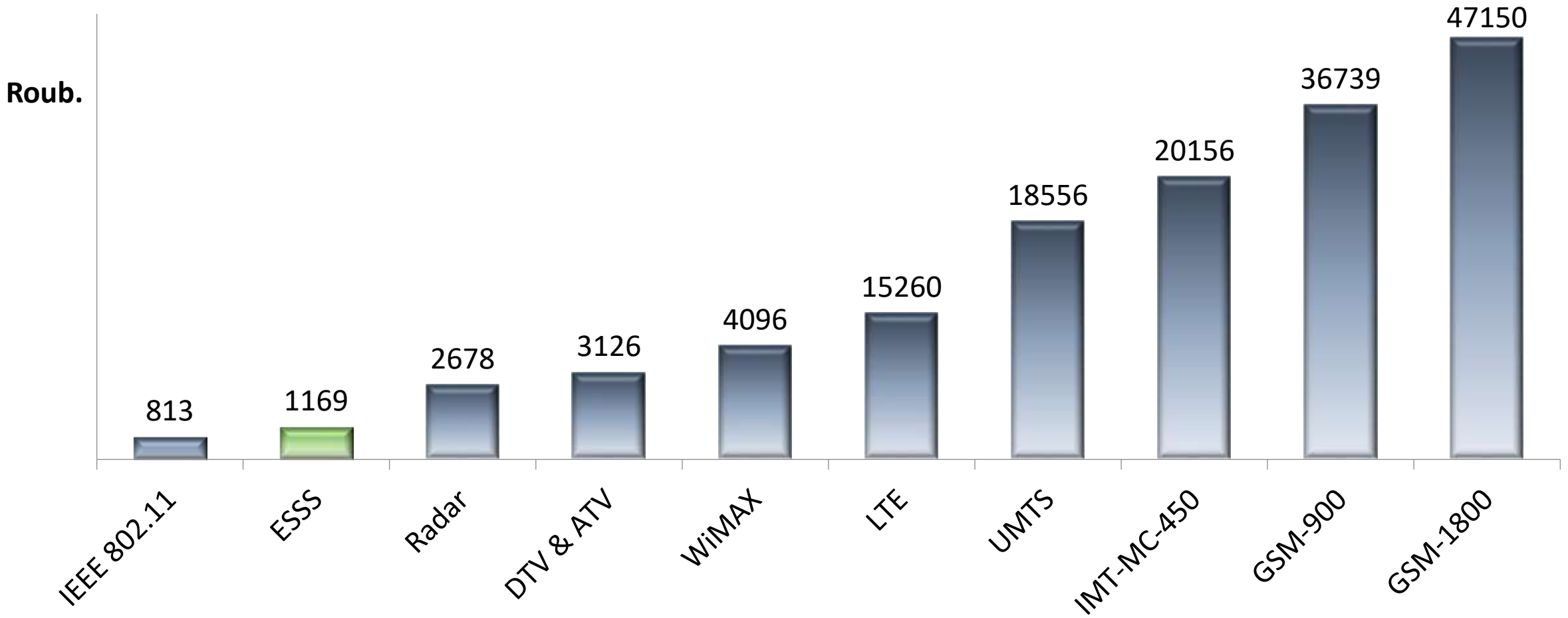
Spectrum Fee per device: *Russian Case study*



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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Traditional methods of granting access to Spectrum

- **Apart from unlicensed (commons) spectrum bands , the spectrum regulator has traditionally assigned frequencies within geographical areas to users, often via granting them a licence, which has normally been for their exclusive use**

- **Three general ways are predominant**

  - **FCFS:** Giving licence to the first applicant for it, if that is the only one (First come, first served)
    - PMR frequencies

  - **Beauty contests:** Asking applicants to make written requests for the licence, and allocating the licences to those making the most convincing case
    - Commercial mobile services in smaller market

  - **Reserving particular entity:** Specially for which there was excess demand at a zero or negligible price
  - Government spectrum use

Spectrum Auctions

- **Practical use of this auctions started about 25 years ago,** ***although the notion predates that considerably***

- **In the early days, a small number of licences were auctioned**
  - in the same band,
  - their use confined to mobile services
  - Technology specific
  - Applicant could only be awarded one licence

- **Over the years there have been 2 major developments:**
  - Identical units of spectrum have been auctioned as individual lots, leaving it up to the firm to decide, within limits, how many to bid for
  - Auctions now often contain lots in several different bands, allowing firms to put together at one time a combination of holdings with different characteristics

Spectrum regulators choosing the auction route now have a wide choice of auction designs.

Spectrum Access through Auction

➢ Recent Criticism and problems

- **Revenue or BB growth**
  - Arguments that state sees spectrum primarily as a resource to be sold to raise revenue, and restricts its availability for that end, rather than seeing spectrum as a means of extending the coverage and take up of mobile voice and broadband, and thus promoting economic growth and development.

Studies have shown that a 10% increase in mobile voice or broadband penetration increases a country's national income by in excess of 1%. This benefit should take priority over increasing revenue form spectrum sales.

Difficulty?

How to incorporate Auction as spectrum assignment method while including objectives, such as extending network coverage and **WITHOUT** adding complexity that adds to the risk of failure?

Grating Spectrum Access

	Pros	Cons
Cost Recovery 01	• 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
Spectrum Auction 02	• 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
Administrative Incentive Pricing 03	• 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

Deciding: *How much Spectrum to Auction?*

➢ International Influence

- To some degree this is determined by international rules established by the ITU at World Radio Conferences;

➢ Availability

- It also depends on whether any spectrum which is being re-assigned has been cleared of its previous licensees

➢ Supply may satisfy demand but priorities may be different

- As noted, there has been a recent tendency to combine spectrum form several bands in a single award, to give bidders more choice over what to buy
- The regulator may be tempted to restrict the size of an award to create an **artificial shortage** and put the price up

- **BUT consequences are that** Spectrum shortage will push up the price of and reduce the take-up of mobile communications services, and this risks slowing down the country's growth rate

Temptation is short-sighted and should be resisted

Deciding: *When to auction 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 auction's 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 an auction is as detrimental to a country as is withholding it permanently

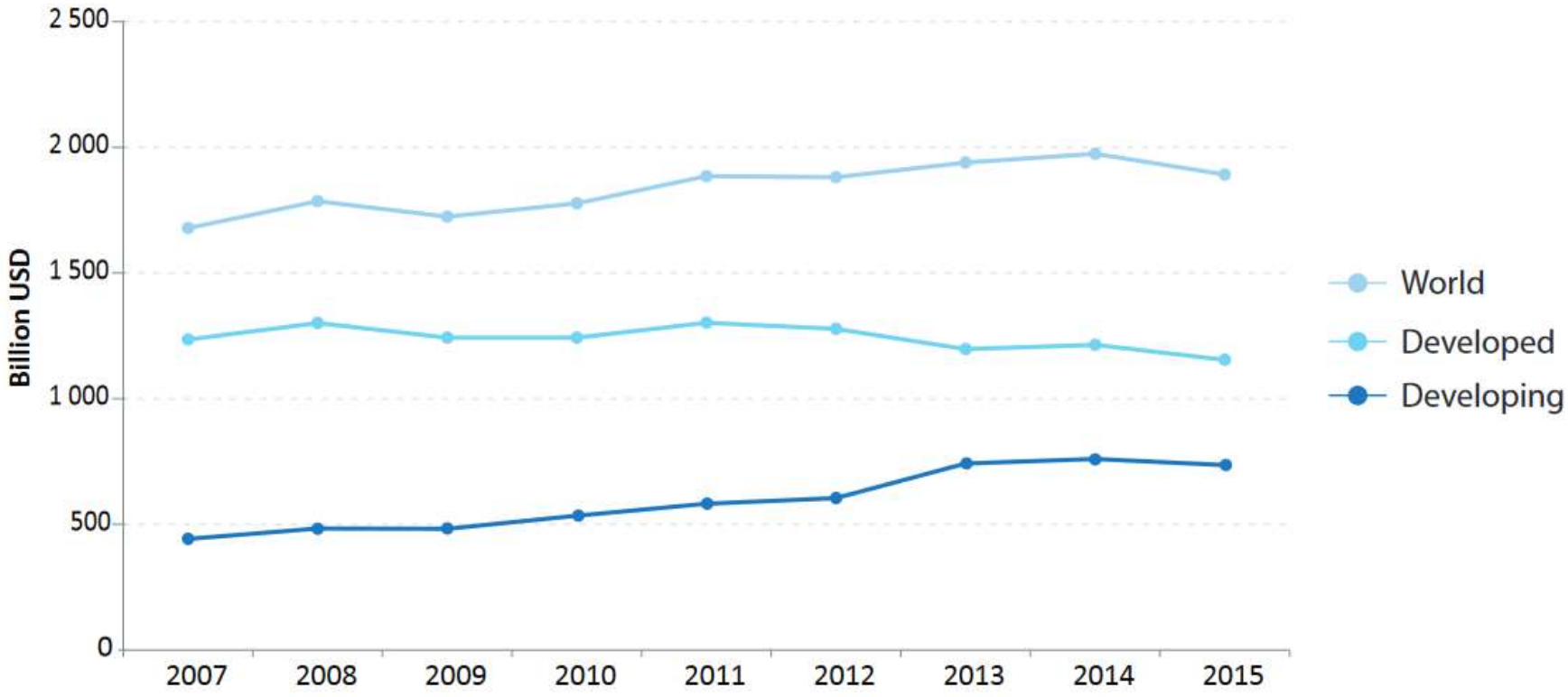
Challenges with Auction

- **Collusion of operators**

- **Too Few Bidders**
  - In recent auctions for mobile spectrum, the number of bidders has been limited
    - *Sometimes Regulator intentionally restricts new operators in market to avoid over heating/over competition.*

- **Regulator's reaction to challenges**
  - A good regulator would never welcome the problems created winner's curse
  - Regulators design Auctions in way to ensure that collusion of bidders does not occur
    - *By taking or publishing strenuous steps to find and punish such actions.*
  - Reserve Price Dilemma
    - *Too low a price, and the operators can retain excess profits; too high a price, and the spectrum will remain unused, probably for a long period*

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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Spectrum Management for future?

Radio spectrum shall continue playing ever more vital role in provisioning of broad variety of radiocommunications services - public, private and governmental alike

Pressure on spectrum managers to find solutions to ensure unrestricted long term growth of services through allocation of new bands and finding innovative ways of more efficient utilisation of spectrum

TIME TO CRANK EFFICIENCY OF SPECTRUM USE, TIME TO SHARE ITS BENEFITS EVEN MORE ..

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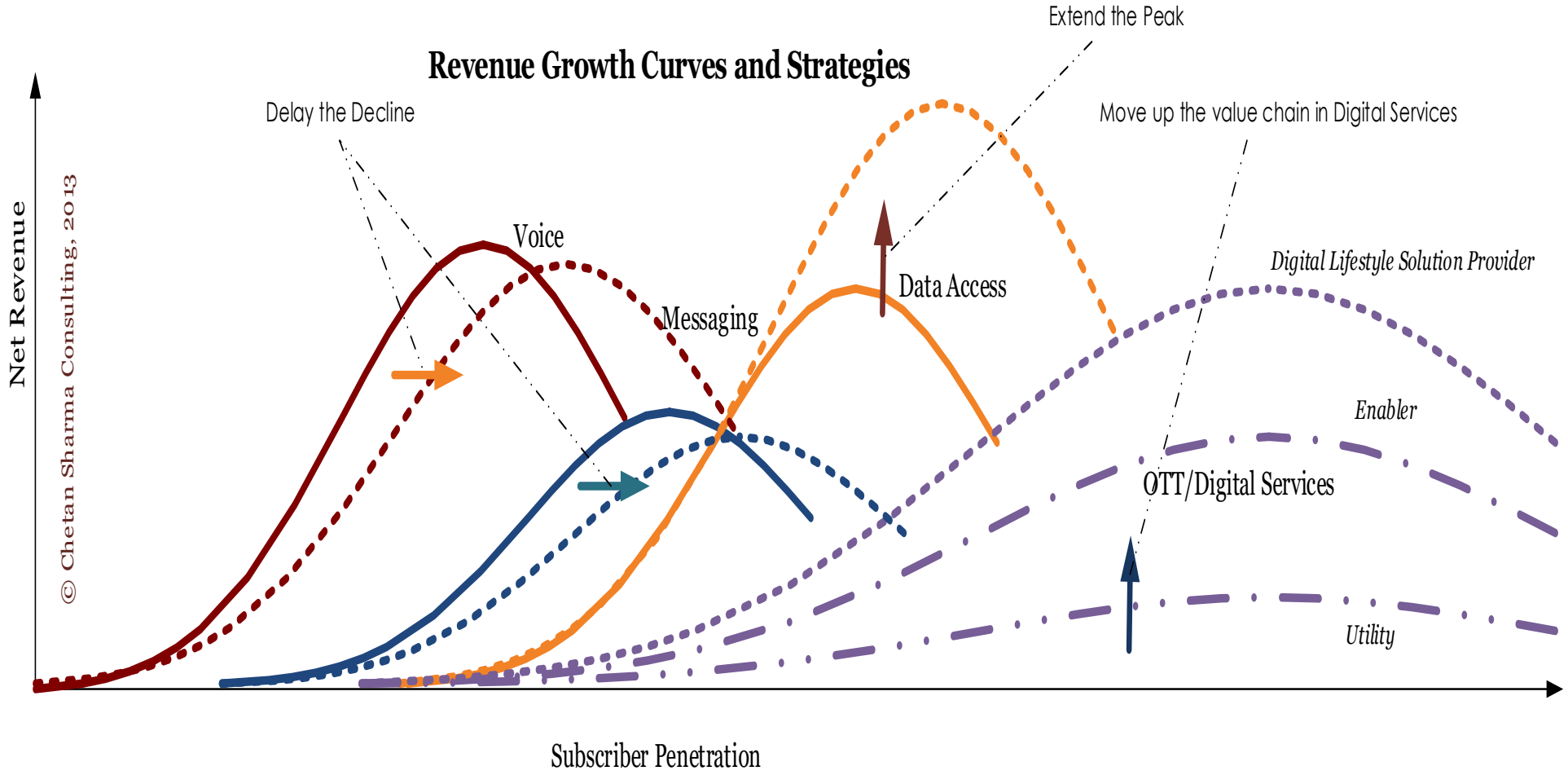
Technological Trends in spectrum usage

Why the need for Efficient SM now?

4th wave of growth in telecom sector



Current wave is defined by its complexity

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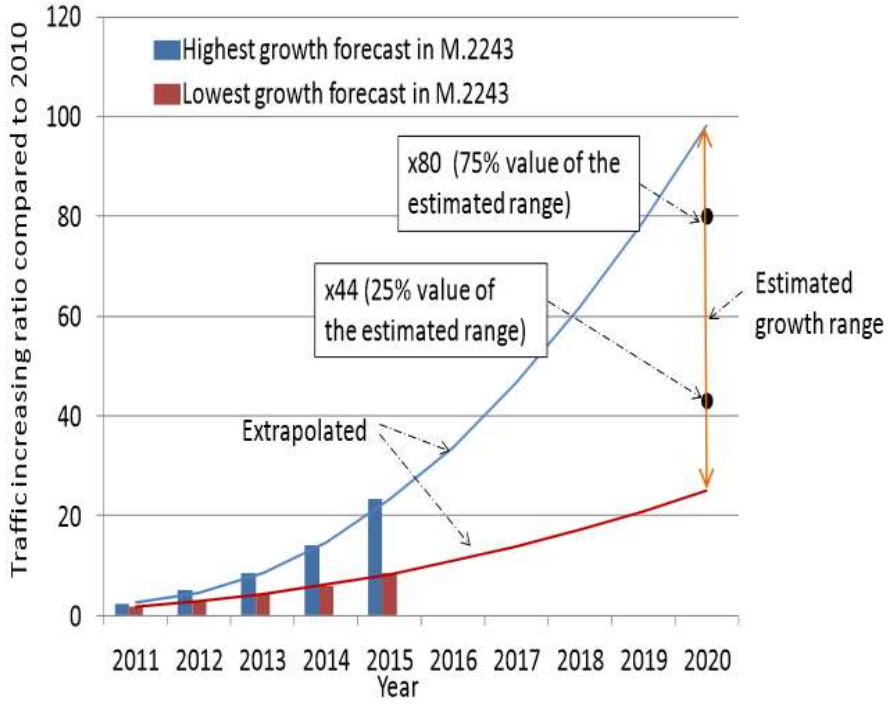
Why the need for Efficient SM now?

Demand of Content – Internet Traffic Explosion



37% of Internet traffic during prime time is online video

Video	Smartphones	Mobile Internet	Machine-to-Machine
~ 70% of internet traffic **by 2014**	**2.5 billion** devices **by 2015** **32x** increase per km^2	**~ 70%** of mobile traffic **by 2014**	**3x** growth in the **next five years**

Mobile broadband networks are at the heart of this trend ...

Source: ITU Report M. 2290-0 and Alcatel Lucent

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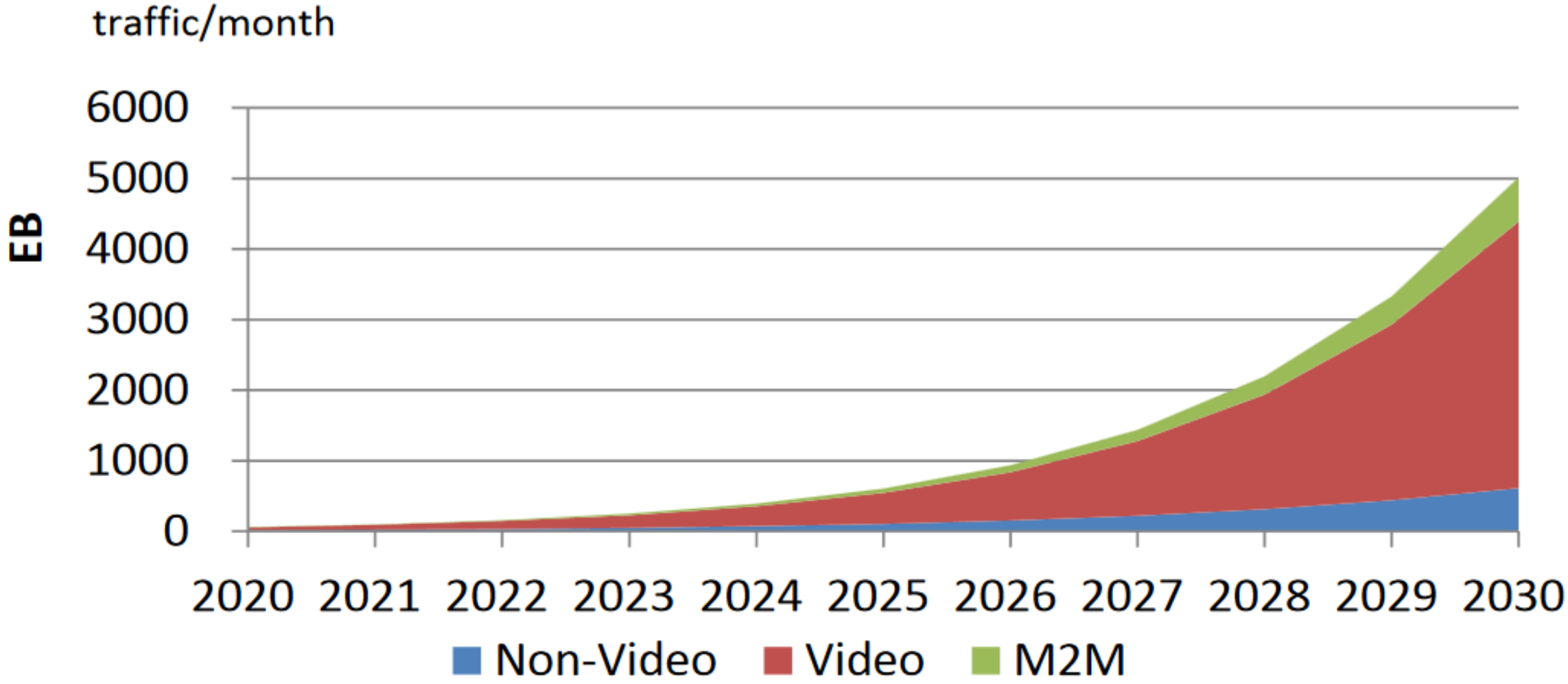
Why the need for Efficient SM now?

Traffic Explosion - beyond 2020

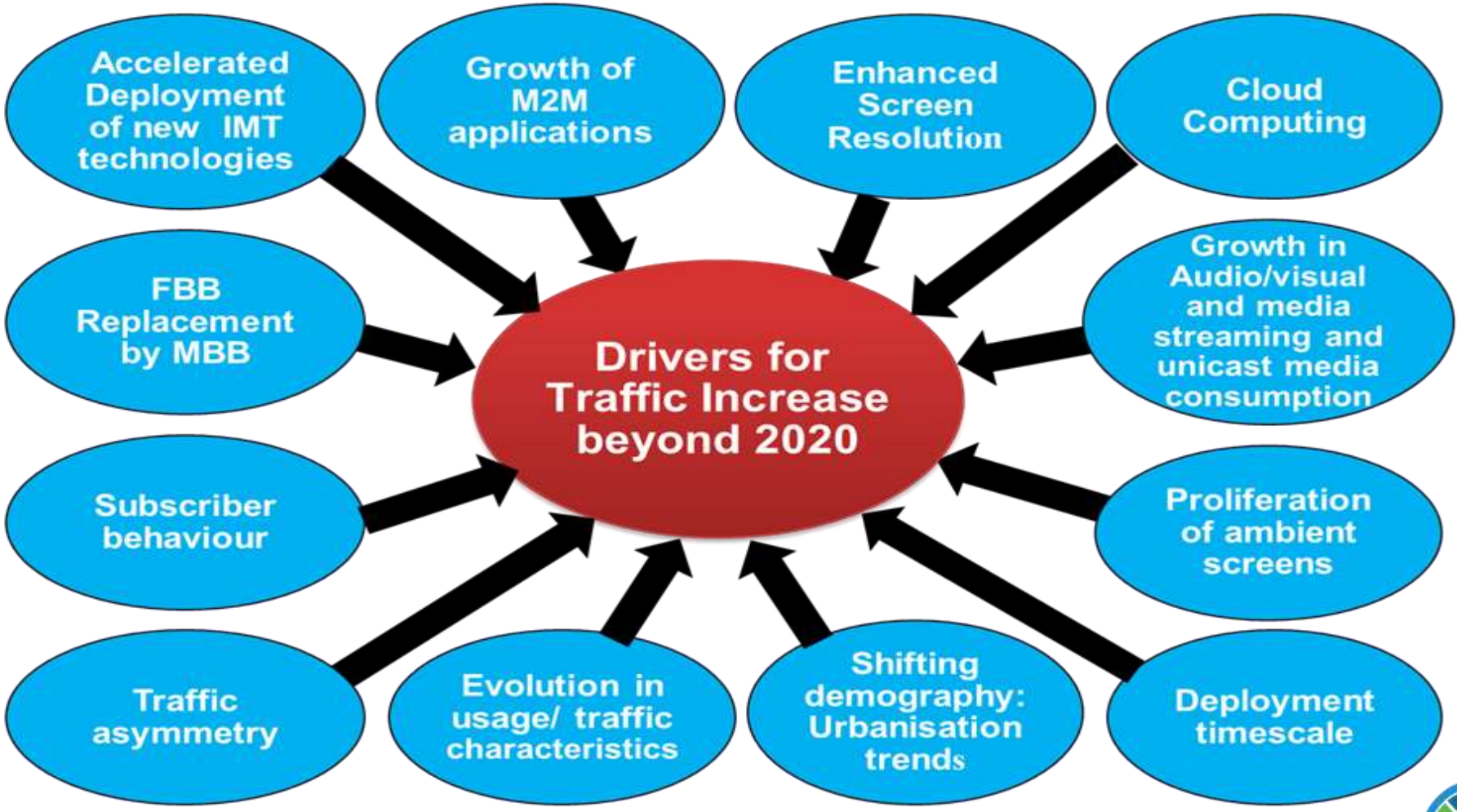


Estimation of Mobile traffic by different service types : Globally

Source: ITU Report M. 2370-0

Why the need for Efficient SM now?

Drivers for traffic increase

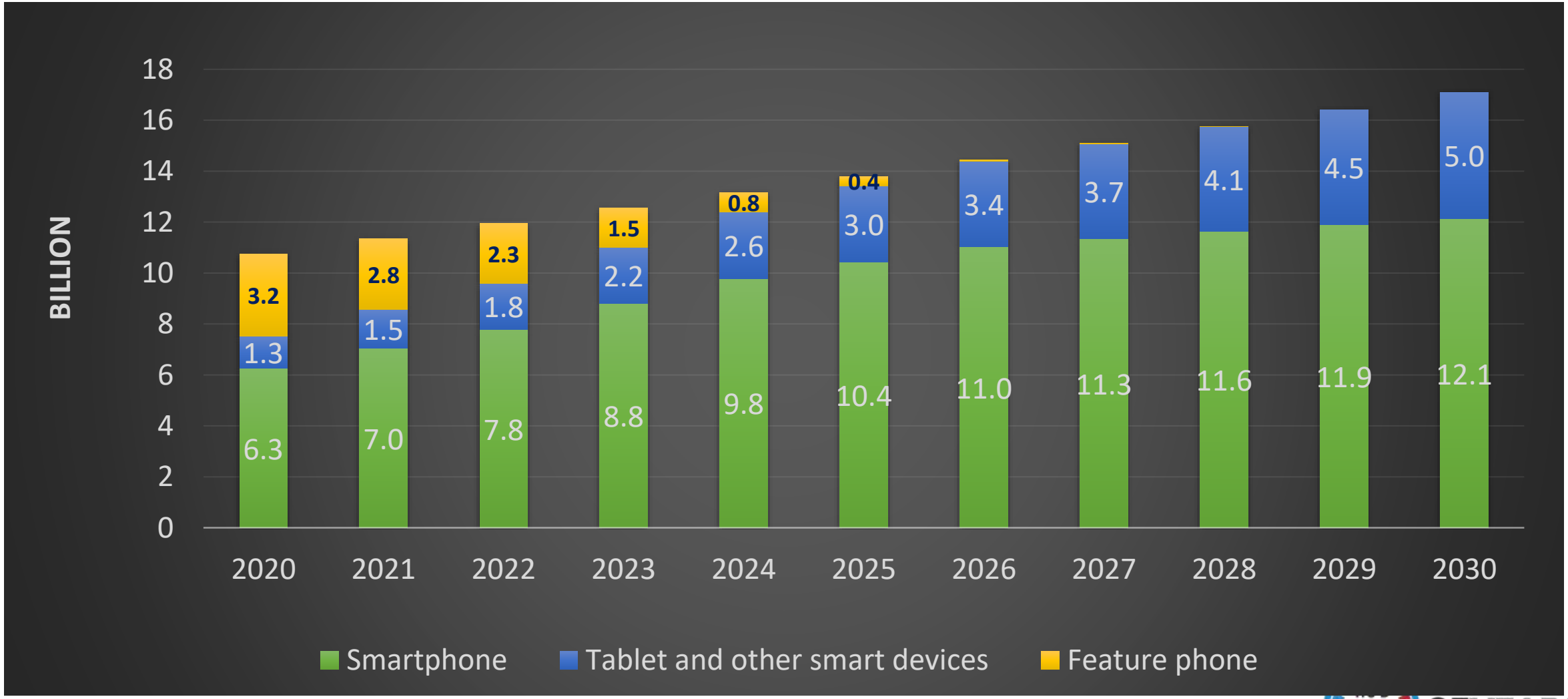


Source: ITU Report M. 2370-0

Why the need for Efficient SM now?

Estimation of global mobile subscriptions with different categories

Beyond 2020



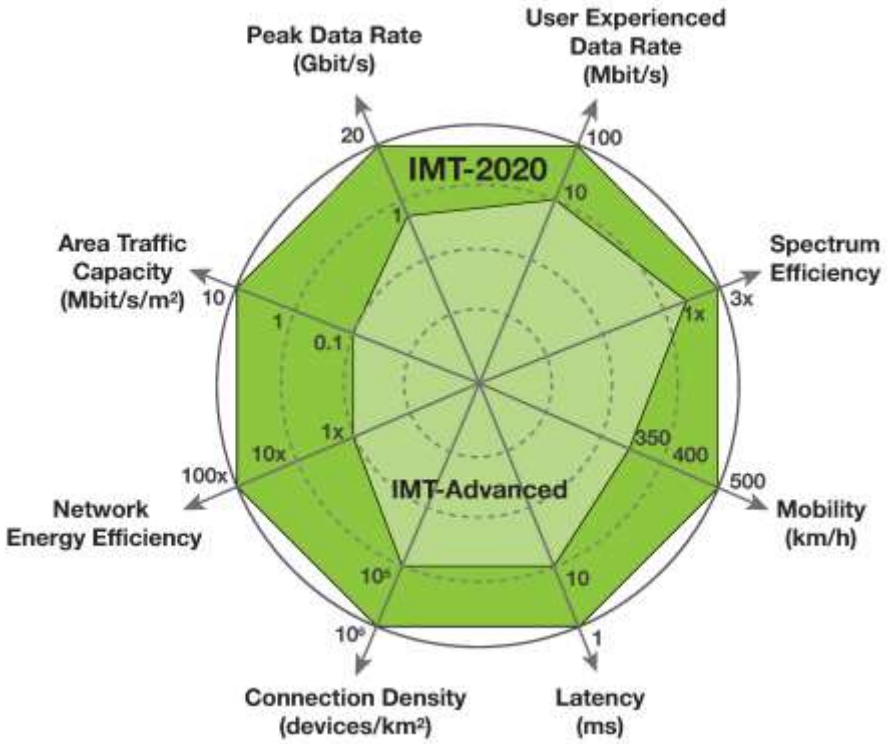
Source: ITU Report M. 2370-0

1992 2017 25YEARS OF ACHIEVEMENTS

Technology Trends

Commercial Mobile Services

- General Trend of Timely availability and efficient use of spectrum
- All upcoming IMT/IMT Advanced technologies based around data
- Increasing requirements of Spectrum for access



Source: ITU-R Recommendation M.2083-0 (09/2015)

Technology Trends

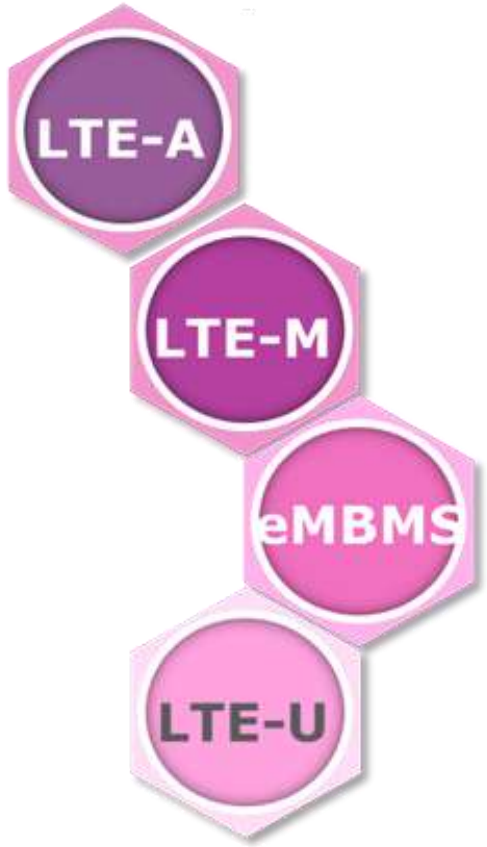
Commercial Mobile Services

Pre-IMT
1990s – 64kbps

IMT2000
2000s – 2Mbps

IMT-Advanced
NOW – 100Mbps – 450Mbps

IMT2020
Beyond 2020 – Above 1Gbps

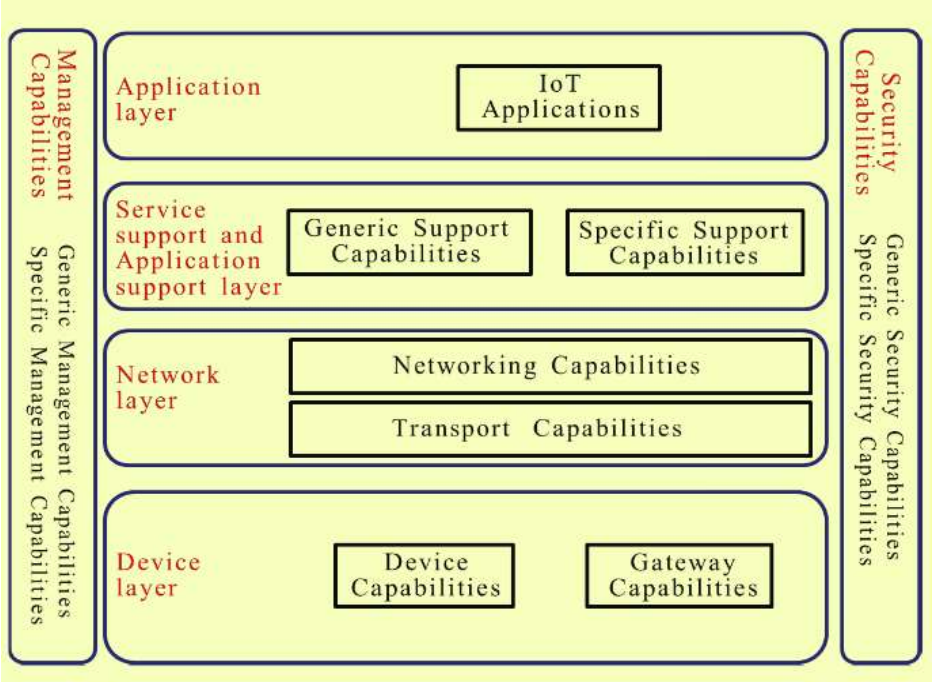


Technology Trends

Commercial Mobile Services - 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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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

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

Short Range Devices

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

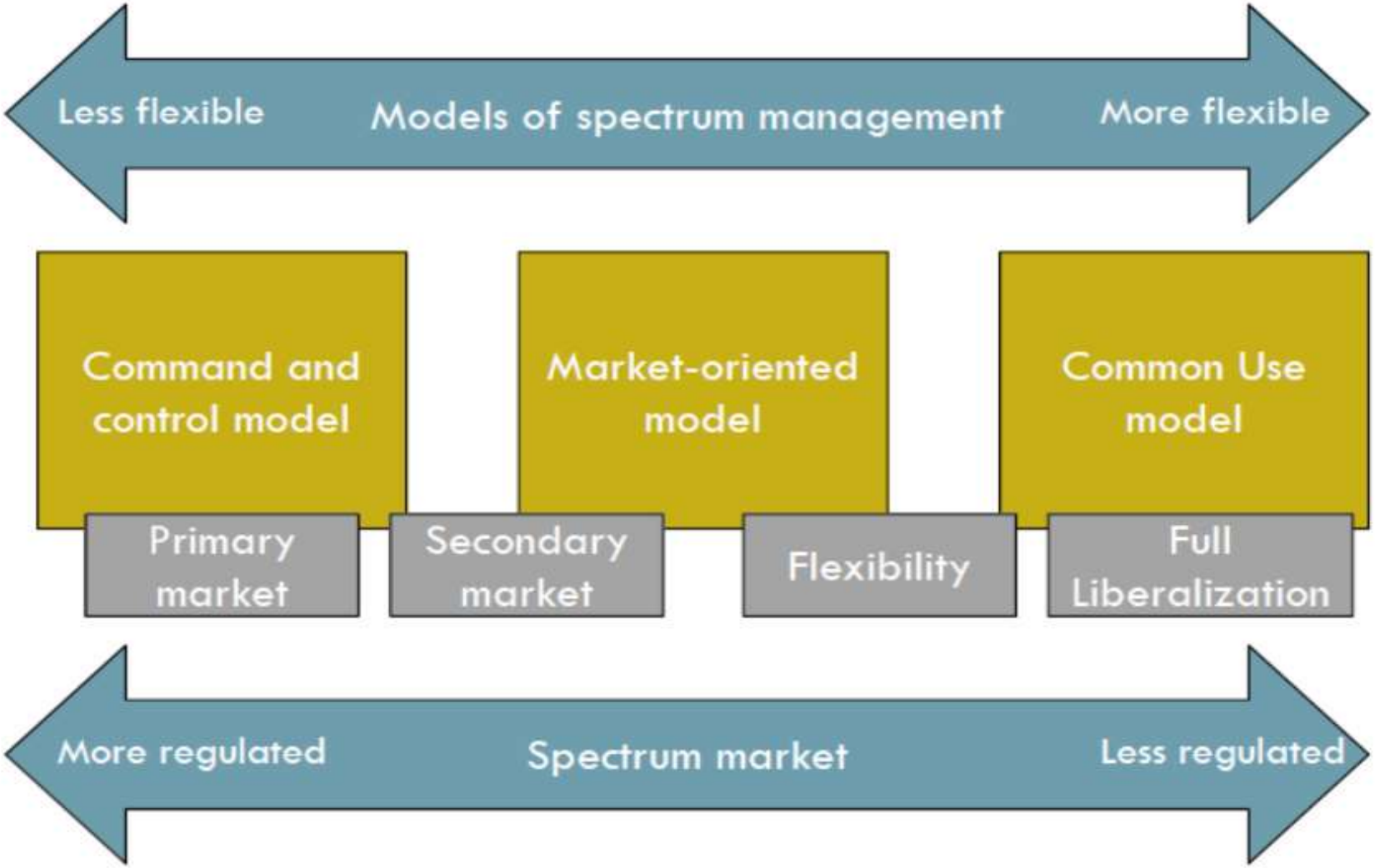
- **New Equipment making use of unlicensed spectrum to have applications including**
  - ***WLAN*** *- Three blocks of spectrum in the 5GHz range for radio LAN – 5150 – 5350 MHz, 5470 – 5725 MHz and 5725 – 5875 MHz already identified. Manufacturers are developing wireless access in higher frequency range (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**

Spectrum Licensing Trends

Spectrum Licensing: *Trends*



Source: Telecom Advisory Services, LLC

Spectrum Licensing

Model	Characteristics
Unlicensed spectrum (common-use bands)	• The use of the bands is free and is regulated solely on the basis of technical restrictions and type-approval of equipment in order to limit interference to other services • Currently, the application of common bands is becoming more widespread in many industrialized countries (United States, United Kingdom, Canada)
Combination of spectrum from various licensed operators	• This sharing model assigns given frequency bands for cooperative use in restricted geographic areas • The concept has been developed by New Zealand in what it calls "licensed spectrum parks"
Use of software defined radio (SDR) and cognitive radio system (CRS)	• Software-defined radio systems allow the operational parameters of radio frequencies, including band selection, type of modulation and output power, to be set or changed by means of software • Cognitive radio systems allow transmitters and receivers to adapt dynamically and independently to operational parameters and protocols based on information taken from the operating and geographic environment
Sharing of spectrum using small cells	• When the primary licensee uses spectrum in remote areas, this spectrum can be reused by small cells in high-demand urban areas that are far away from the remote location • For example, the United States telecommunications regulator allows shared-spectrum use and the deployment of small cells in the 3.5 GHz band, where maritime radar is the primary user
Combinations of wireless networks (e.g. Routing cellular traffic through Wi-Fi sites, off-load)	• Combining Wi-Fi and cellular technologies that operate in different spectrum bands means that a large amount of the increase in wireless traffic can be accommodated • Analysts estimate that 40 per cent of wireless traffic (mainly Internet access) is routed via public and private Wi-Fi locations

Source: Telecom Advisory Services, LLC

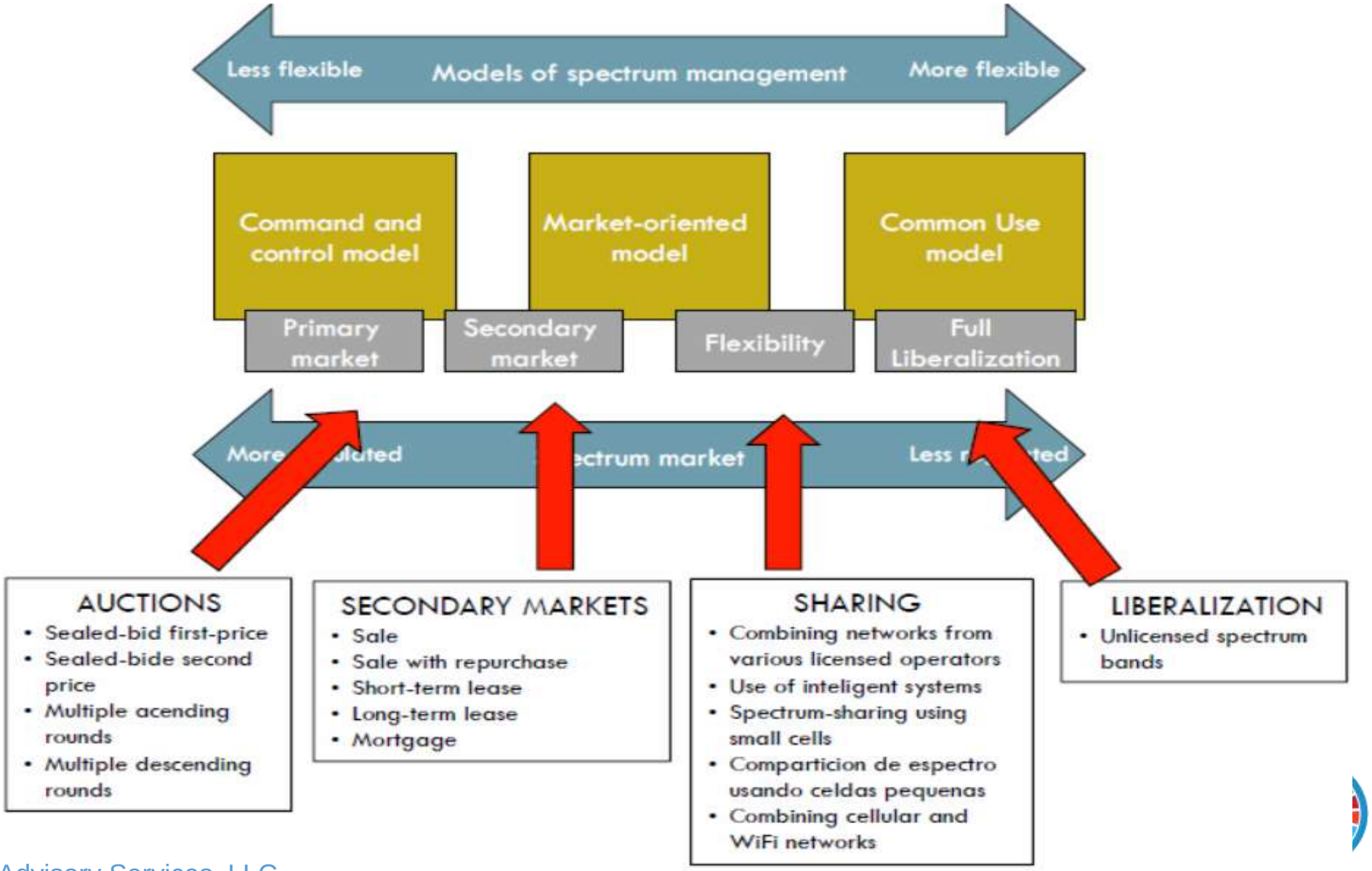
National Spectrum regulation strategies

- 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

Spectrum Licensing: *Trends*

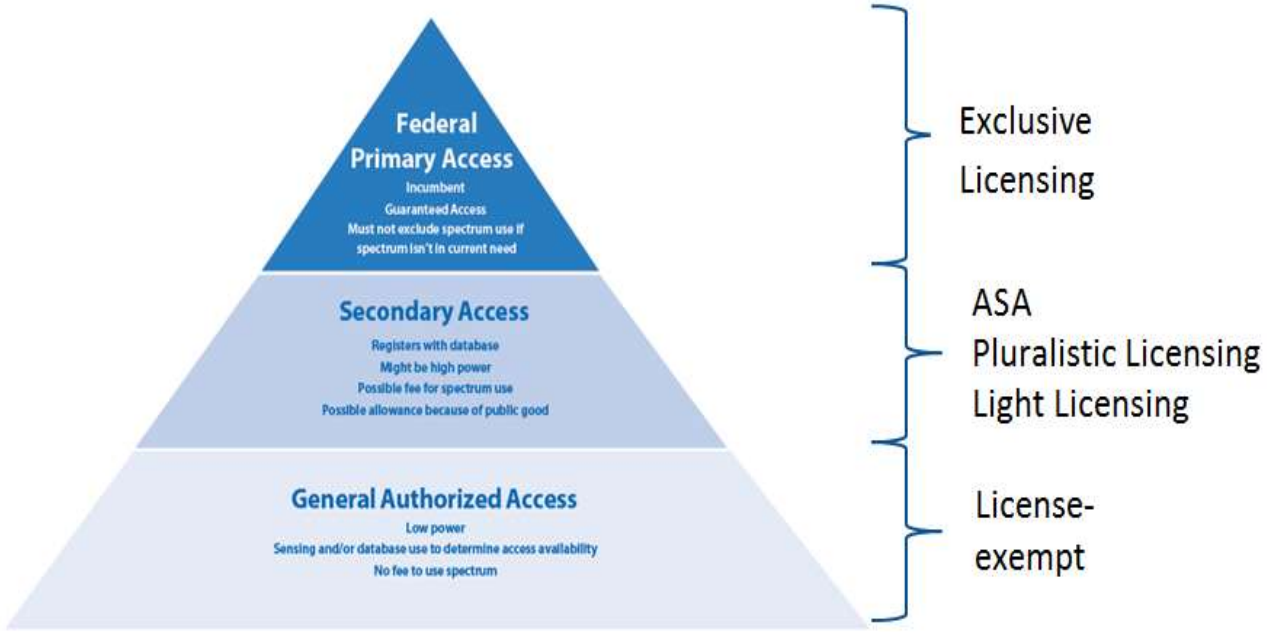


Source: Telecom Advisory Services, LLC

Spectrum Licensing

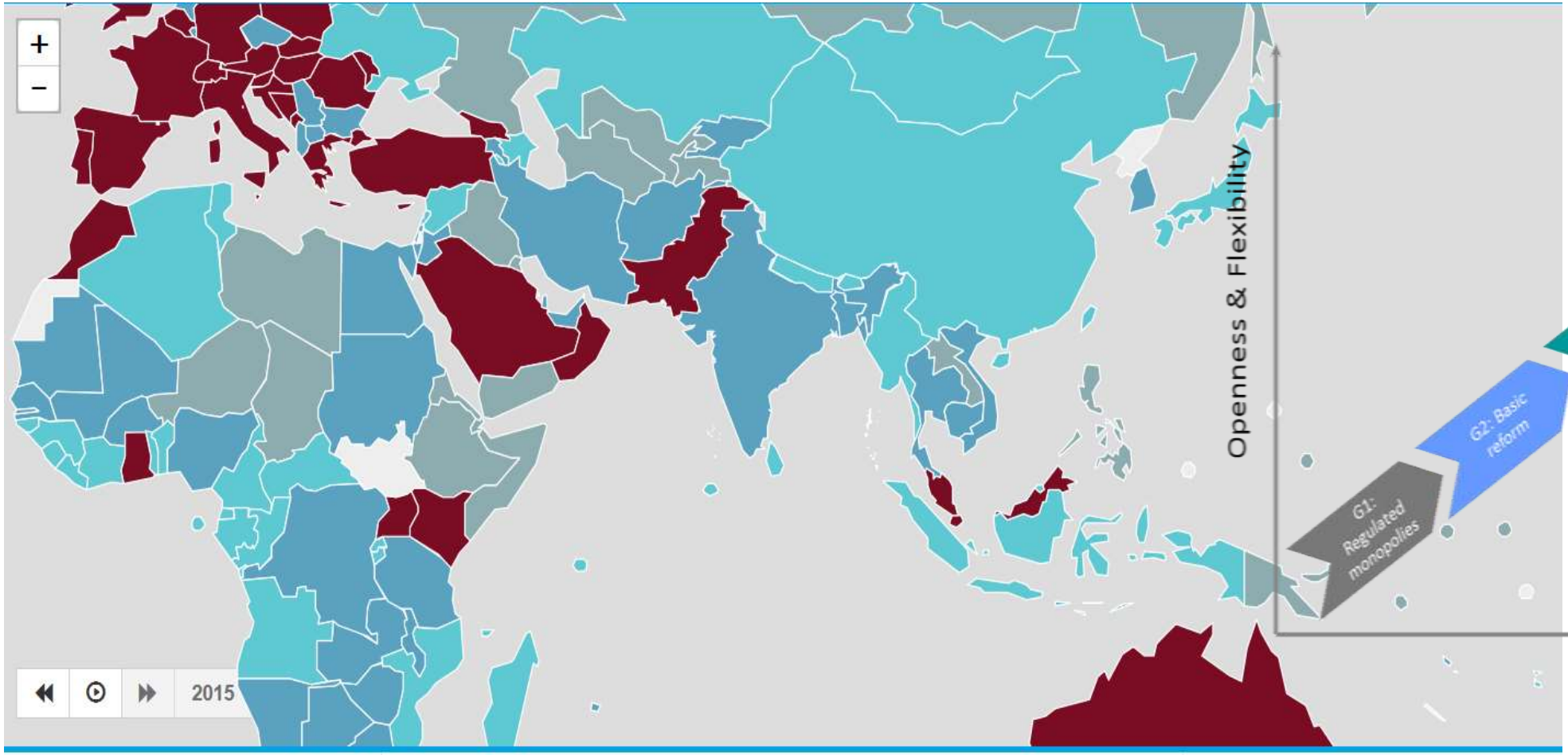
Novel solutions that promote various forms and degrees of organised sharing of spectrum:

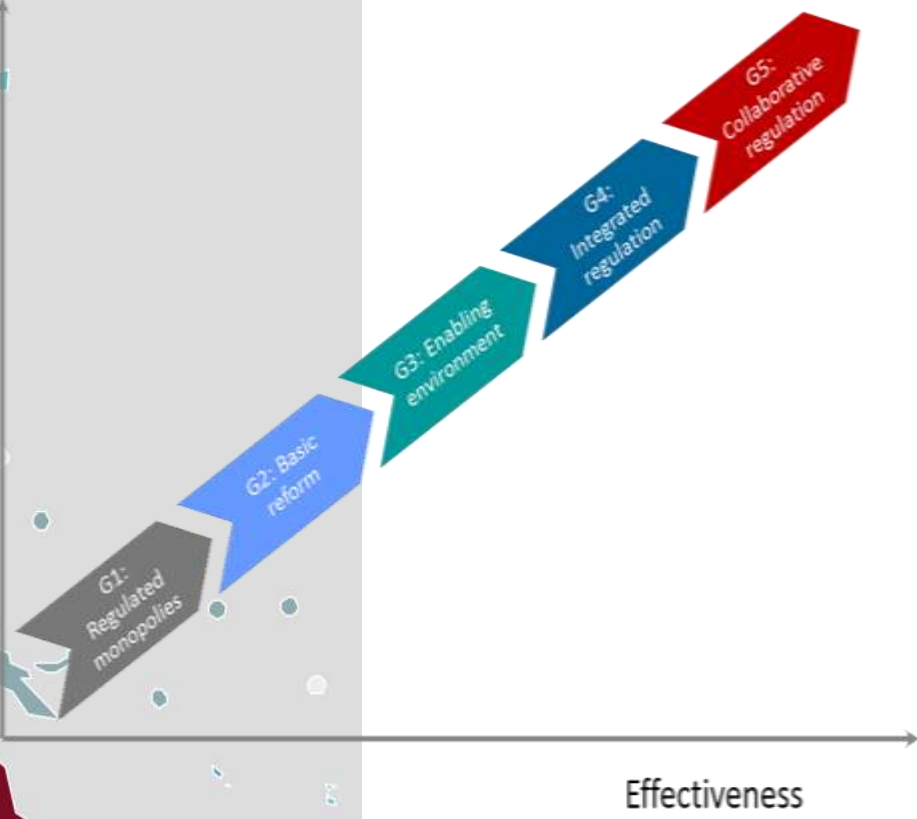
- Light-licensing
- Authorised Shared Access/Licensed Shared Access
- Pluralistic Licensing, etc.



Source: Adapted from US PCAST report

ITU ICT regulatory Tracker





Generations of ICT Regulation

- 1st generation: Tracker score 0 - 40
- 2nd generation: 40 - 70
- 3rd generation: 70 - 85
- 4th generation: 85 - 100

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The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area is not yet determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

See also:

ITU Transmission Map

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Source: ITU (https://www.itu.int/net4/itu-d/irt/#/map?ind=generation-of-regulations&year=2015)

Institutional Best practices in SM

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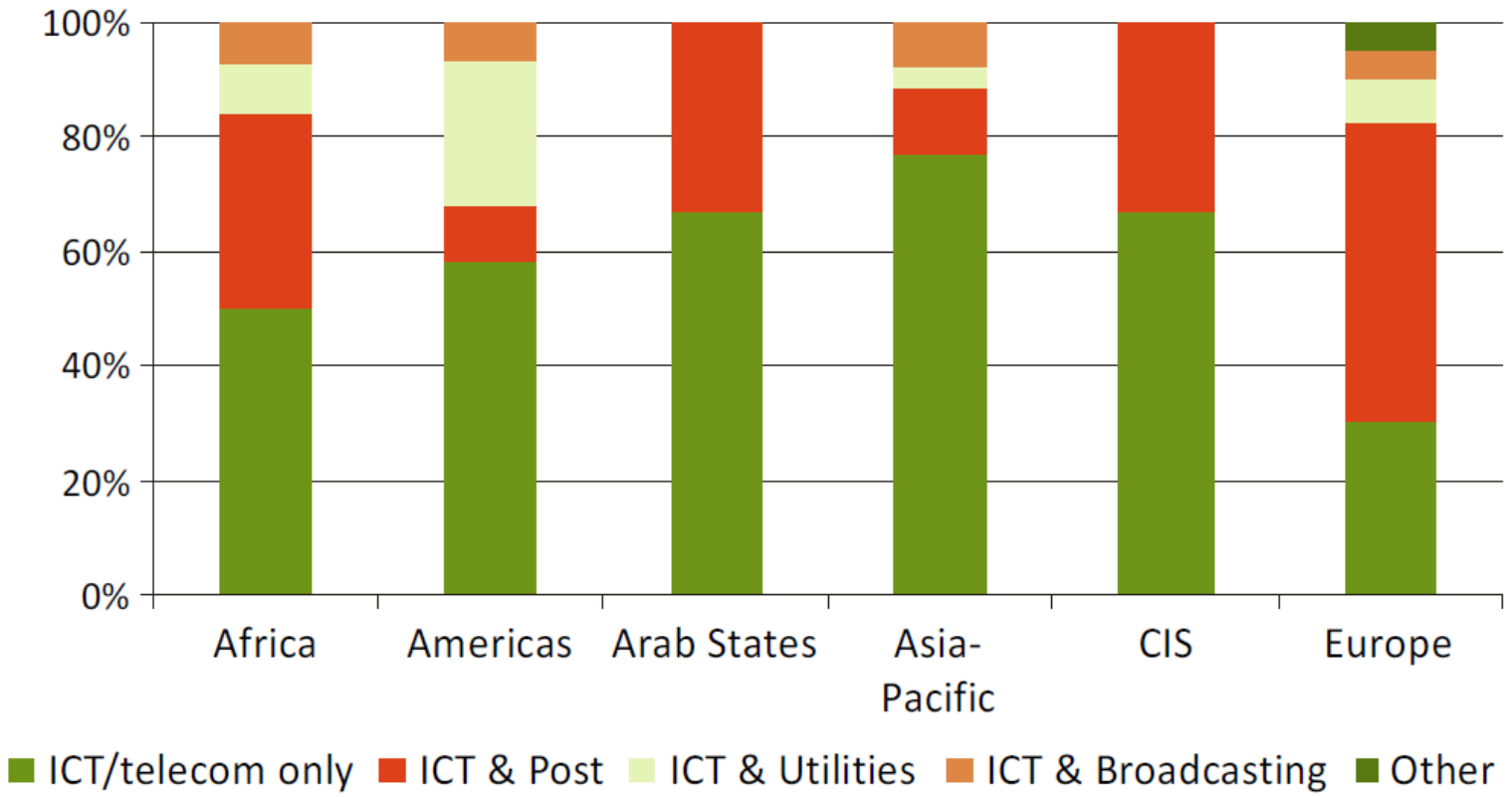
Mandate of Modern NRA



Increasing trend towards seeing ICT policy and regulation as integral part of overall national infrastructure provisioning platform

Source: ITU – Based on data form 158 countries

Institutional Best Practices 1/2

- **Setting up efficient SM organization:**
  - *Achieving streamlined and efficient SM on both short-term and long-term basis*
  - *Allocating spectrum in an economic and efficient manner, and by relying on market forces, economic incentives and technical innovations*
- **Transparency of SM operations:**
  - *Promoting transparent, non-discriminatory, economically efficient and effective SM policies, that provide regulatory certainty*
- **Technological neutrality and flexible spectrum use:**
  - *Promoting wireless innovation, by creating conditions for the development of new services, reducing investment risks and stimulating competition among different technologies, including facilitating entry into market of new competitors*

Institutional Best practices 2/2

- **Timely availability and efficient use of spectrum**
  - *Facilitating timely introduction of new applications and technology, while protecting existing services from harmful interference; ensuring most efficient use of radio spectrum*
- **International harmonization:**
  - *Aligning domestic spectrum policies with international best practices, in order to achieve faster take-up of new bands and economies of scale*
- **Affordable and fair spectrum access:**
  - *Reducing financial barriers for new wireless entrants to the market and promoting development of wireless technologies, especially in less developed areas*
  - *Ensuring that all wireless players have equitable and fair access to spectrum resources*

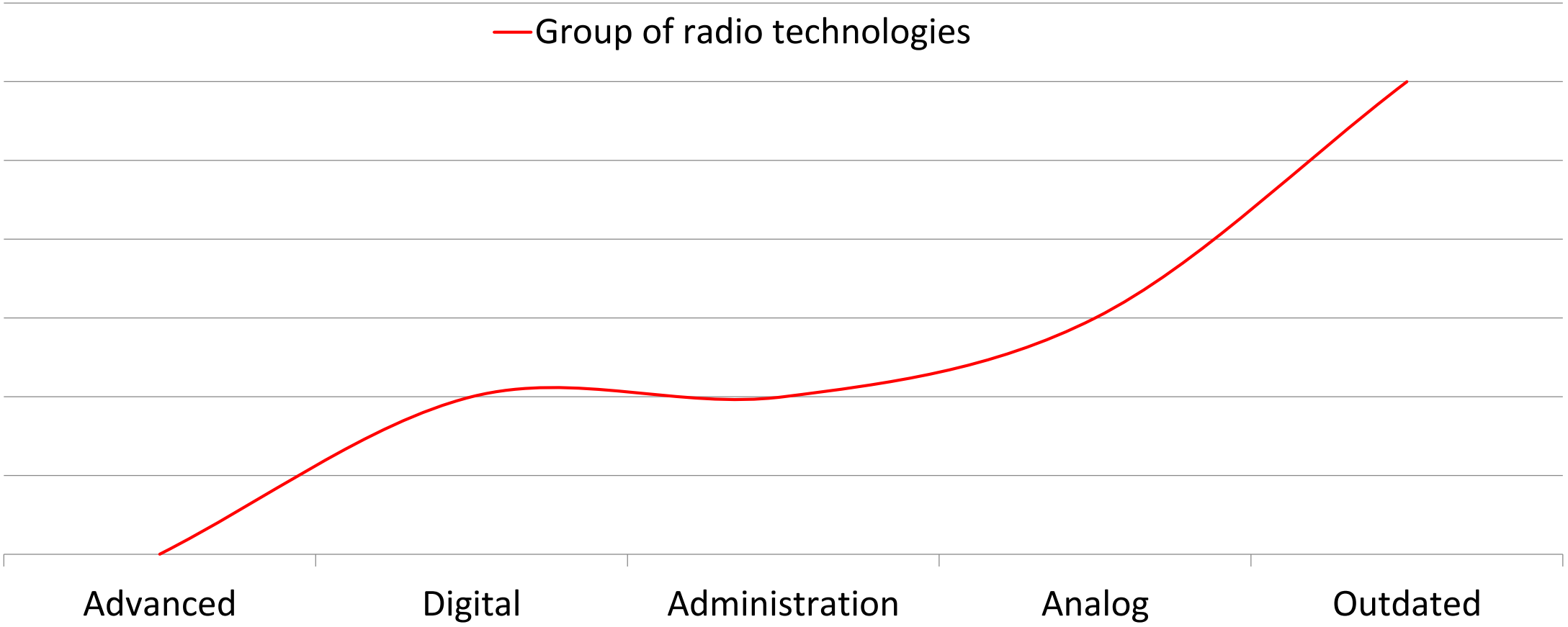
Granting Access to Spectrum

UK : Study Case

SM method	% of spectrum allocated in the UK *(source: Ofcom)*	
	Year 2000	**Year 2010**
Administrative	**96 %**	**22 %**
Market	**0 %**	**71 %**
Commons *(Unlicensed Spectrum)*	**4 %**	**7 %**

Market consultations and self-regulation as means of deciding the most economical way to utilise spectrum are gaining importance

Spectrum Usage Efficiency: *Russian Case study*



size of spectrum fees and group of technology

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

Visibility of Spectrum availability

- **Important for operators to business strategy based on future resource availability**

- **Recommended to develop and publish a Master-plan on Spectrum Management**
  - *Such strategy document needs to be reviewed (which doesn't mean modification) regularly (say annually or biannually)*

Spectrum Monitoring trends 1/2

- **Monitoring, market-supervision and enforcement become increasingly integrated fields of operation**

- **Trend to make all monitoring stations (including the regional stations spread throughout the country) a generic hub for control and enforcement functions, whereas one or more teams of inspectors would carry out regular inspections of:**
  - *Licensed radio stations: prior and at regular intervals during their operation*
  - *Vendors of radio equipment in order to control whether they put on the market suitable (type approved) equipment*
  - *Assessment of interference complaints*

- **Concept and studies on "cloud" monitoring by dispersed nodes**

- **Airborne Radio Monitoring**

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Spectrum Monitoring Trends 2/2

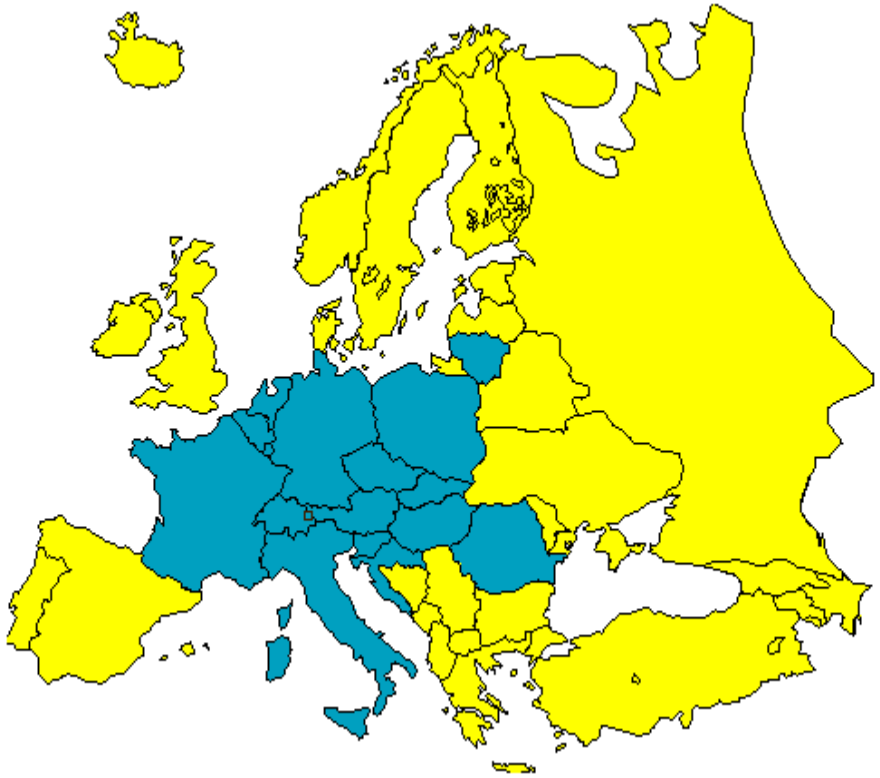
- **Market self-regulation, especially for the highly congested bands used by a limited set of professional operators**

- **Bi or Multi lateral Cross Border Agreements practice is now becoming most optimal approach to mitigate cross border Radio Frequency interference issues in order to:**
  - *Ensure equal distribution, and*
  - *Speed up the day-to-day frequency assignments in border areas*

Coordination Agreements Examples

- **HCM Agreement is the official designation of the Agreement between 17 European Administrations namely:**

Austria, Belgium, the Czech Republic, Germany, France, Hungary, the Netherlands, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Poland, Romania, the Slovak Republic, Slovenia and Switzerland



- **Deals with Coordination of frequencies between 29.7 MHz and 43.5 GHz for fixed service and land mobile service**

Regional Challenges on SM

Other High level Challenges

Automation of Spectrum Invoicing and licensing system

01

Sustainable Expertise development

02

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

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SMTP at CTU

contact & registration

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phone: [redacted]

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

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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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I Thank U

"Committed to connecting the WORLD"

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