ITU White Paper on: Managing TVWS

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1. ITU & ITU-R
2. RADIO REGULATIONS
3. “UNLICENSED” DEVICES
4. WHITE SPACES
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6. QUESTIONS AND CONCLUSIONS

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International Telecommunication Union

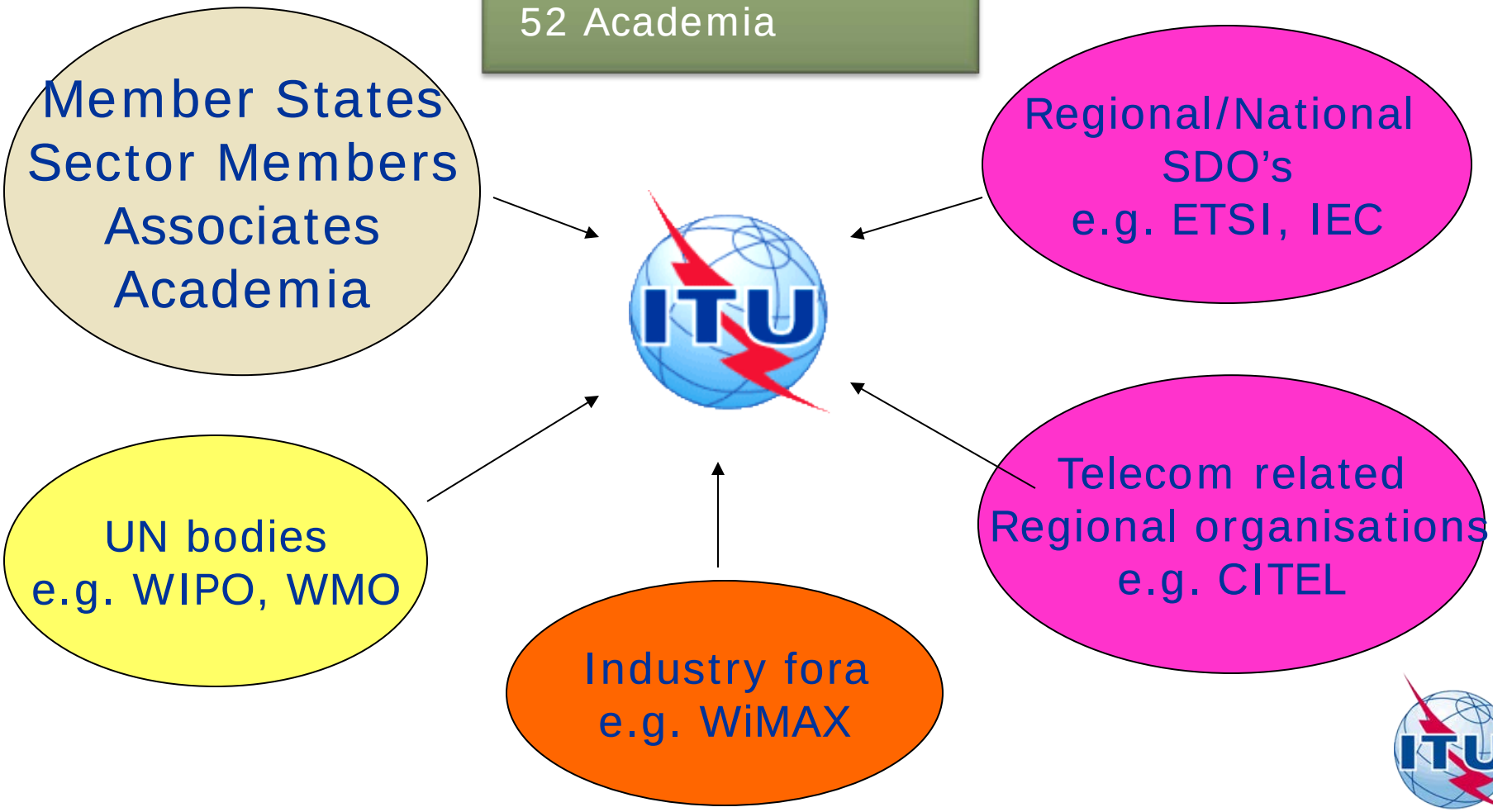
Founded at Paris in 1865 as the International Telegraph Union. Present name in 1932

In 1947 became a specialized agency of the United Nations, responsible for issues concerning Information and Communication Technologies

ITU coordinates the shared global use of the radio spectrum and satellite orbits, works to improve telecommunication infrastructure in the developing world, and assists in the development and coordination of worldwide technical standards.

International Telecommunication Union

193 Member States
579 Sector Members
175 Associates
52 Academia



ITU Basic Texts

ITU is governed by their basic legal instruments, configured as international treaties and therefore binding on all signatory States. These legal instruments are:

1. The Constitution of the International Telecommunication Union
2. The Convention of the International Telecommunication Union
3. The Administrative Regulations governing the use of Telecommunications:
    a. International Telecommunication Regulations, RTI
    b. Radio Regulations, RR (including the Rules of Procedure)

ITU Structure

Sector ITU-T
Telecommunication standardization - network and service aspects
(Bureau: TSB)

Sector ITU-D
Assisting implementation and operation of telecommunications in developing countries
(Bureau: BDT)

Sector ITU-R
Radiocommunication standardization and global spectrum management
(Bureau: BR)

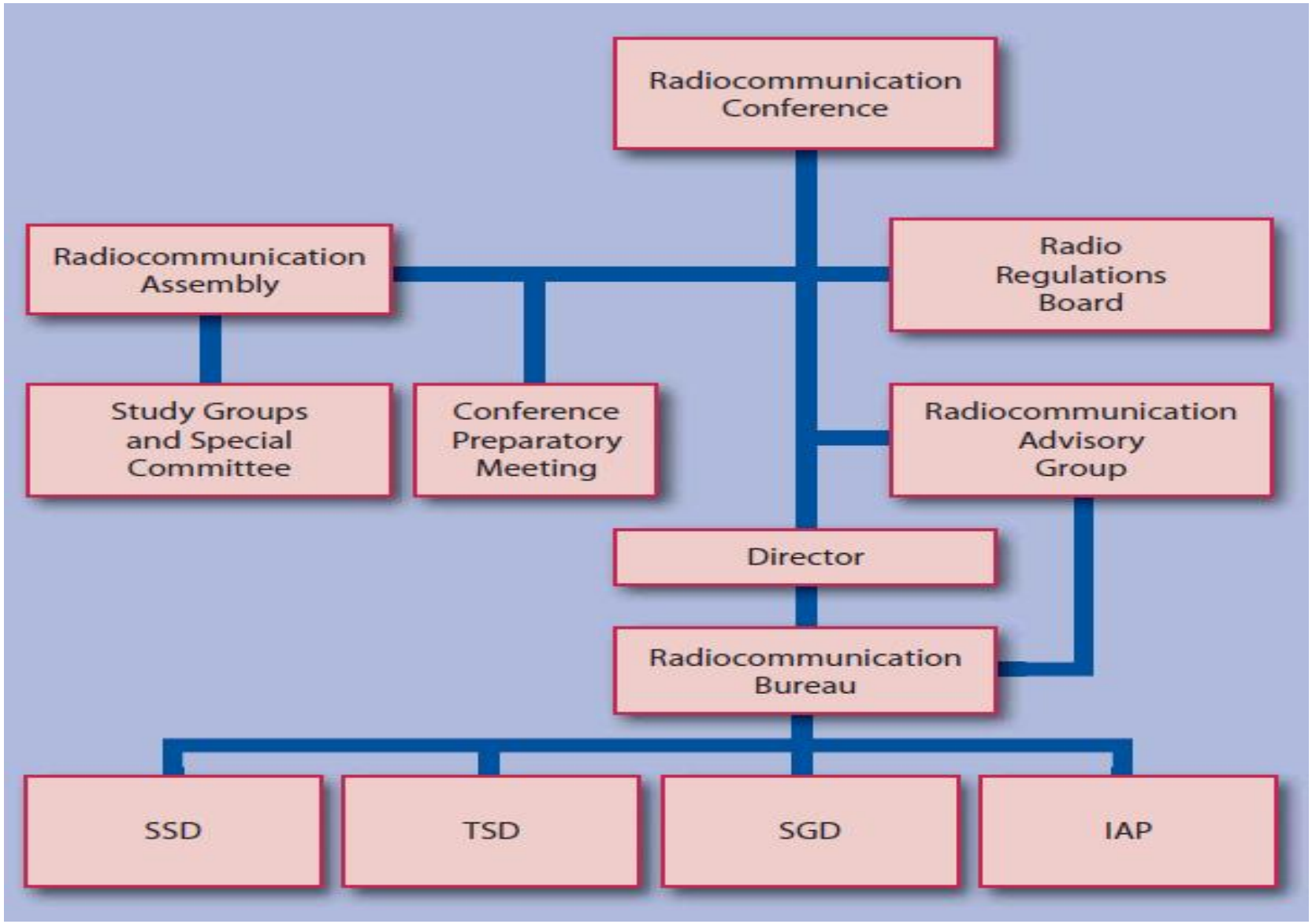
Radiocommunication Sector (ITU-R)

ITU-R primary objective is to ensure interference free operations of radiocommunication systems.

This is ensured through implementation of the Radio Regulations and Regional Agreements, and the efficient and timely update of these instruments through the processes of the World and Regional Radiocommunication Conferences.

Radio standardization also establishes ´*Recommendations*´ intended to assure the necessary performance and quality in operating radiocommunication systems, and seeks ways and means to conserve spectrum and ensure flexibility for future expansion and new technological developments.

ITU-R Structure



ITU-R Study Groups

More than 5000 specialists, from: ITU Member States, Sector and Associate Members, and Academia

ITU-R SG accomplish their work in cooperation with other international radiocommunication organizations. Particular attention is paid to the radiocommunication needs of developing countries.

SG are composed by Working Parties, WP

WP meets twice a years (some WP 1 or 3), normally at Geneva.

SG meets yearly after sessions of their respective WP

http://www.itu.int/en/ITU-R/study-groups

ITU-R Study Groups

CCV: Coordination Committee for Vocabulary
CPM: Conference Preparatory Meeting
SC: Special Committee on regulatory/procedural matters

SG 1: Spectrum management; 3 WP
SG 3: Radiowave propagation; 4 WP
SG 4: Satellite services; 3 WP
SG 5: Terrestrial services; 4 WP
SG 6: Broadcasting service; 3 WP
SG 7: Science services; 4 WP

- >900 Recommendations
- “Standards” in areas of spectrum management and radio technology
- Result of consensus from meetings of world-wide experts
- Some referred to in RR
- Used by spectrum planners and system designers

ITU-R Releases

- *ITU-R Recommendations:* http://www.itu.int/pub/R-REC
- *ITU-R Reports:* http://www.itu.int/pub/R-REP
- *ITU-R Opinions:* http://www.itu.int/pub/R-OP
- *ITU-R Handbooks:* http://www.itu.int/pub/R-HDB

All ITU-R Rec, Rep, Op, and the SM related Handbooks are of public access (download), free of charge

Compliance with ITU-R Recommendations is not mandatory. However, while some are incorporated by reference in the ITU Radio Regulations,

ITU-R Recommendations are developed by radiocommunication world experts, thereby enjoying a high reputation and worldwide implementation, having the status of international standards in their domain of application.

ITU-R Releases

BO: Satellite delivery

BR: Recording for production, archival and play-out; film for television

BS: Broadcasting service (sound)

BT: Broadcasting service (television)

F: Fixed service

M: Mobile, radiodetermination, amateur and related satellite services

P: Radiowave propagation

RA: Radio astronomy

RS: Remote sensing systems

S: Fixed-satellite service

SA: Space applications and meteorology

SF: Frequency sharing and coordination between fixed-satellite and fixed service systems

SM: Spectrum management

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RADIO REGULATIONS

As spectrum cannot be limited to a given territory, international coordination is necessary

RR is an International Treaty, elaborated and revised by administrations and membership, during WRC; has a binding nature for ITU Member states.

ITU acts as depositary of RR

Last version: RR-12 (as revised during WRC-12)

RR is of public access (download), free of charge

http://www.itu.int/pub/R-REG-RR-2012

RADIO REGULATIONS

VOLUME 1: Articles (59)

VOLUME 2: Appendices (22)

VOLUME 3: Resolutions (151) and Recommendations (24)

VOLUME 4: ITU-R Recommendations incorporated by reference (39)

MAPS: Set of Maps for App. 27

All ITU-R deliverables that are of public access (download) free of charge might be found at:
http://www.itu.int/en/ITU-R/Documents/BD_Flyer_A4_E.pdf

RADIO REGULATIONS

Services and Stations:

*1.3 **Telecommunication:** Any transmission, emission or reception of signs, signals, writings, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems*

*1.5 **Radio waves (or hertzian waves)**: Electromagnetic waves of frequencies arbitrarily lower than 3000 GHz, propagated in space without artificial guide*

*1.19 **Radiocommunication service:** A service involving the transmission, emission and/or reception of radio waves for specific telecommunication purposes*

*1.61 **Station:** One or more transmitters or receivers or a combination of transmitters and receivers, including the accessory equipment, necessary at one location for carrying on a radiocommunication service, or the radio astronomy service*

RADIO REGULATIONS

The RR defines 41 **different types of radiocommunications services**, according to some main features as:

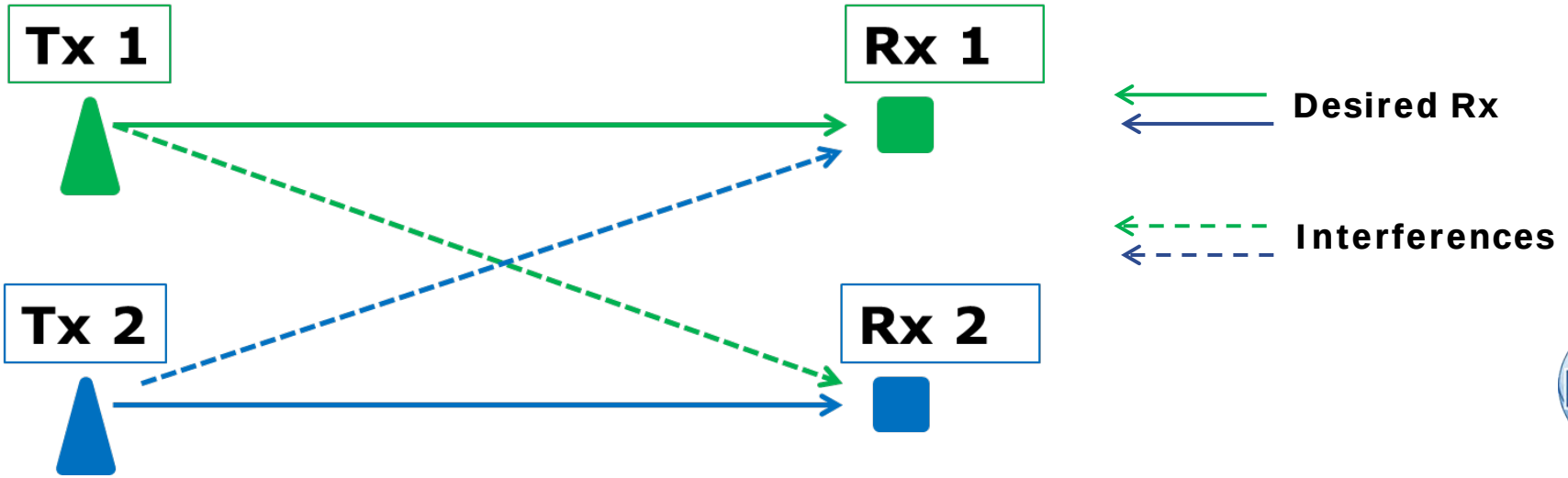
1. **Link:** Terrestrial (stations onto earth) or space (earth-space; space-earth, space-space)
2. **Area of action:** land, maritime, aeronautical
3. **Mobility:** fixed, mobile
4. **Use:** backhaul, broadcasting, meteorological, scientific, navigation and associated, earth observation, time standard, astronomy, amateur, security, special, etc.

The RR also defines *53 types of radio stations*, based on similar main features. In most of cases a given station might be associated to a specific service, while in other cases a station might involve several services.

RADIO REGULATIONS

*1.166 **Interference:** The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy*

*1.169 **Harmful interference:** Interference which endangers the functioning of radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations (*hereafter, by default : "*interference*")



RADIO REGULATIONS

*1.16 **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.*

*1.17 **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.*

*1.18 **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.*

Allocations vs. Assignment:

Allocations are granted to Services; Assignments are granted to Stations

Allocation: reserving a given band for a specific service; *Assignment* (also licensing): authorization (license) a station to transmit in a specific channel (licensing remains consistent with the allocation). e.g.:

- Allocation of the Band 88-108 MHz for Broadcasting (terrestrial), for the use of audio broadcasting in FM

- Licensing a FM Station in 89.0-89.5 MHz to cover a given area (or city) with a given transmitting power

Once Band 88-108 MHz is allocated to broadcasting(Audio Broadcasting in FM), licenses to operate onto that band can be only granted to stations which will use a given channel into it for emissions of Audio Broadcasting in FM (allocated service)

Before Licensing a Station a Band/channel shall be allocated

RADIO REGULATIONS

Other concepts: although not explicitly defined, on the RR when dealing with band allocations (Art. 5), the use into footnotes of expressions: "*identified*" and "*designated*" express the interest/intention of some administrations on a future use of that band for a specific application; that in benefit of a mid and long term harmonization of the use of that band. Examples:

5.138, 5.150: Bands *designated* for industrial, scientific and medical (ISM) applications.

5.552A: Bands *designated* for use by high altitude platform stations

5.516B: bands *identified* for use by high-density applications in the fixed-satellite service

5.286AA, 5.313.A, 5.317A, 5.3: 84A, 5.388, 5.430A. 5432A, 5.432B, 5.433A: Bands *identified* for International Mobile Telecommunications (IMT)

RADIO REGULATIONS

IMT identified Bands:

All footnotes indicates that:

the band X MHz is identified for International Mobile Telecommunications (IMT). This identification does not preclude the use of this band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations

Band (MHz)	Bandwidth (MHz)	RR Footnotes identifying the Band for IMT
450-470	*20*	*5.286AA*
698-960	*262*	*5.313A, 5.317A*
1710-2025	*315*	*5.384A, 5.388*
2110-2200	*90*	*5.388*
2300-2400	*100*	*5.384A*
2500-2690	*190*	*5.384A*
3400-3600	*200*	*5.430A, 5.432A, 5.432B, 5.433A*

RADIO REGULATIONS

RR is technically neutral: when allocating band to services, allocations are not associated to specific applications and/or particular technologies that might provide those services, e.g.:

Allocation to: “MOBILE (*service*), not associated to:

- cellular networks (*application*)

- GMS, LTE, Wimax, etc. (*technology*)

Nonetheless, spectrum needs for the diverse applications and technologies are discussed on ITU-R SG, and its issues are on considerations during WRCs. Those revisions includes technologic, commercial, and regulatory trends, challenges and trade-offs *vis à vis* other involved services

RADIO REGULATIONS

Type of Allocations:

PRIMARY (with capital letters) Secondary (with lower case)

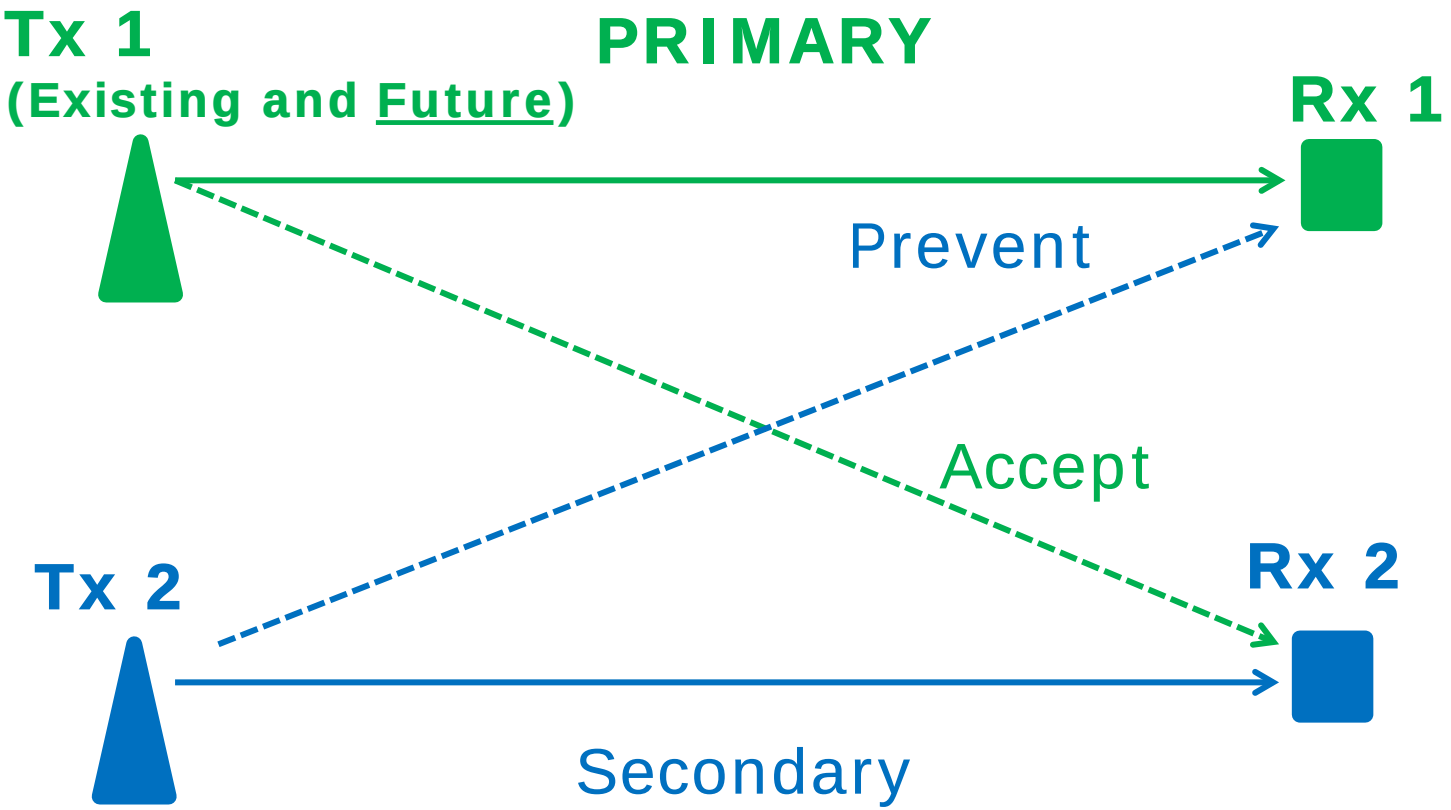
5.28 Stations of a secondary service:

5.29 a) shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date;

5.30 b) cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date;

5.31 c) can claim protection, however, from harmful interference from stations of the same or other secondary service(s) to which frequencies may be assigned at a later date

PRIMARY vs Secondary

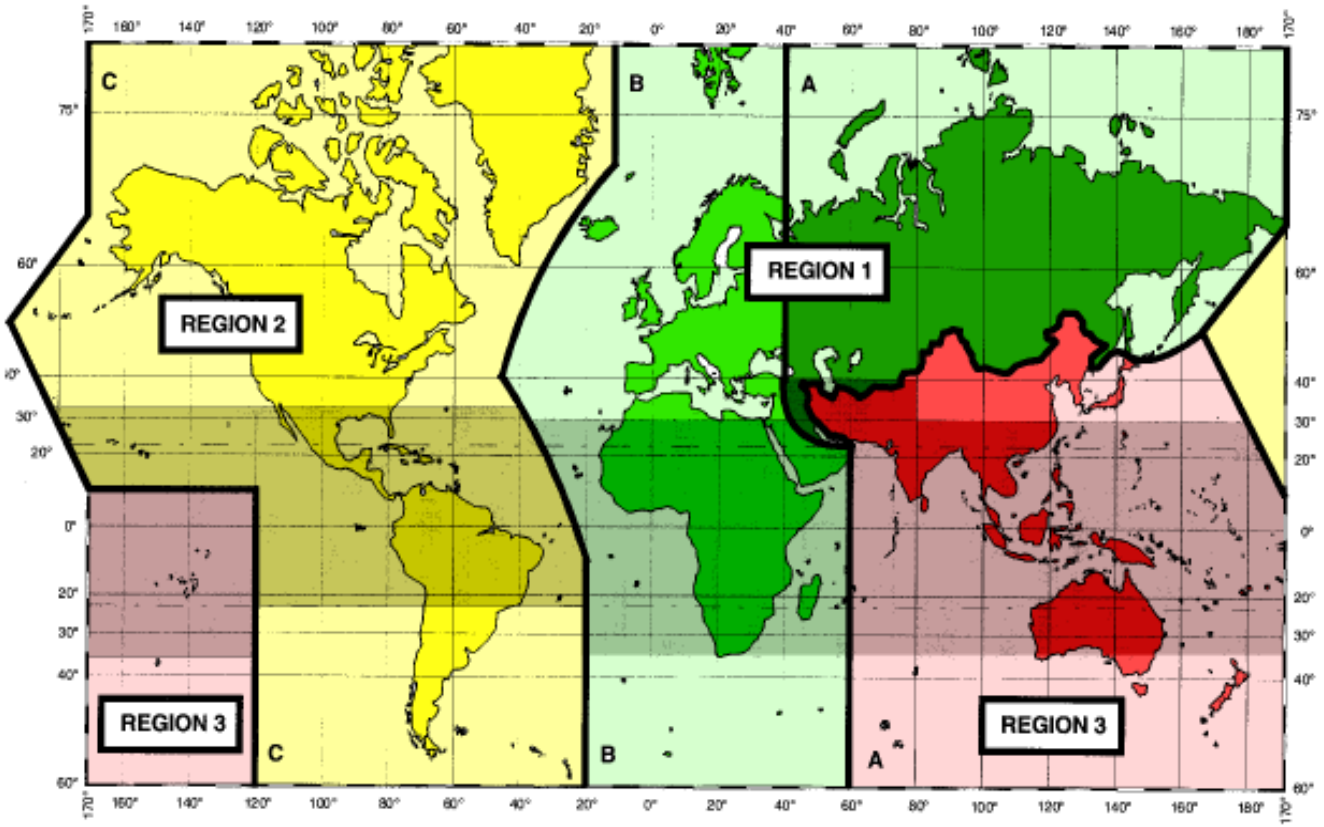


RR ALLOCATIONS

Art. 5 of RR contains the Table of Frequency Allocations (commonly named: International Frequency Table of Allocations, ITFA).

Allocation *footnotes*: specific considerations of some administrations

Allocations are split by Regions:



Global Harmonization

Example: excerpt from Art. 5:

Allocation to services		
Region 1	**Region 2**	**Region 3**
495-505 MARITIME MOBILE		
505-526.5 MARITIME MOBILE 5.79 5.79A 5.84 AERONAUTICAL RADIONAVIGATION	**505-510** MARITIME MOBILE 5.79 **510-525** MARITIME MOBILE 5.79A 5.84 AERONAUTICAL RADIONAVIGATION	**505-526.5** MARITIME MOBILE 5.79 5.79A 5.84 AERONAUTICAL RADIONAVIGATION Aeronautical mobile Land mobile

footnote

Harmonized

PRIMARY

Secondary

Global Harmonization: Ultimate goal (as far as possible); RR Rec 34:
recommends that future world radiocommunication conferences:

2. should, wherever possible, allocate frequency bands on a worldwide basis (aligned services, categories of service and frequency band limits) taking into account safety, technical, operational, economic and other relevant factors;

3. should, wherever possible, keep the number of footnotes in Article 5 to a minimum when allocating frequency bands through footnotes, in line with Resolution 26 (Rev.WRC-07);

LICENSES

RR Art 18: Licenses

18.1:*No transmitting station may be established or operated by a private person or by any enterprise without a licence issued in an appropriate form and in conformity with the provisions of these Regulations by or on behalf of the government of the country to which the station in question is subject*

Central provision of the RR: enables recognition of spectrum uses and their protection against harmful interference, at national and international level.

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NATIONAL SPECTRUM MANAGEMENT

RR is applied on the international context; for national issues, each country should apply its national framework.

National spectrum regulations use to “replicate” RR concepts provisions, adopting them into their legal framework, including:

- Allocations: contained on a National Table of Frequency Allocations (NTFA), and maybe also channeling Plans. They are free to associate allocations to applications and/or technologies

- Licenses(assignments): authorizations to stations, fixing specific conditions, as; RF Power, coverage. Also regulatory and financial conditions, as: timeline terms, spectrum fees, etc. A Spectrum Users Database shall storage and process Licensing information (duly tuned with NTFA)

STATIONS REGISTRATION

Stations protection cannot be “in abstract”

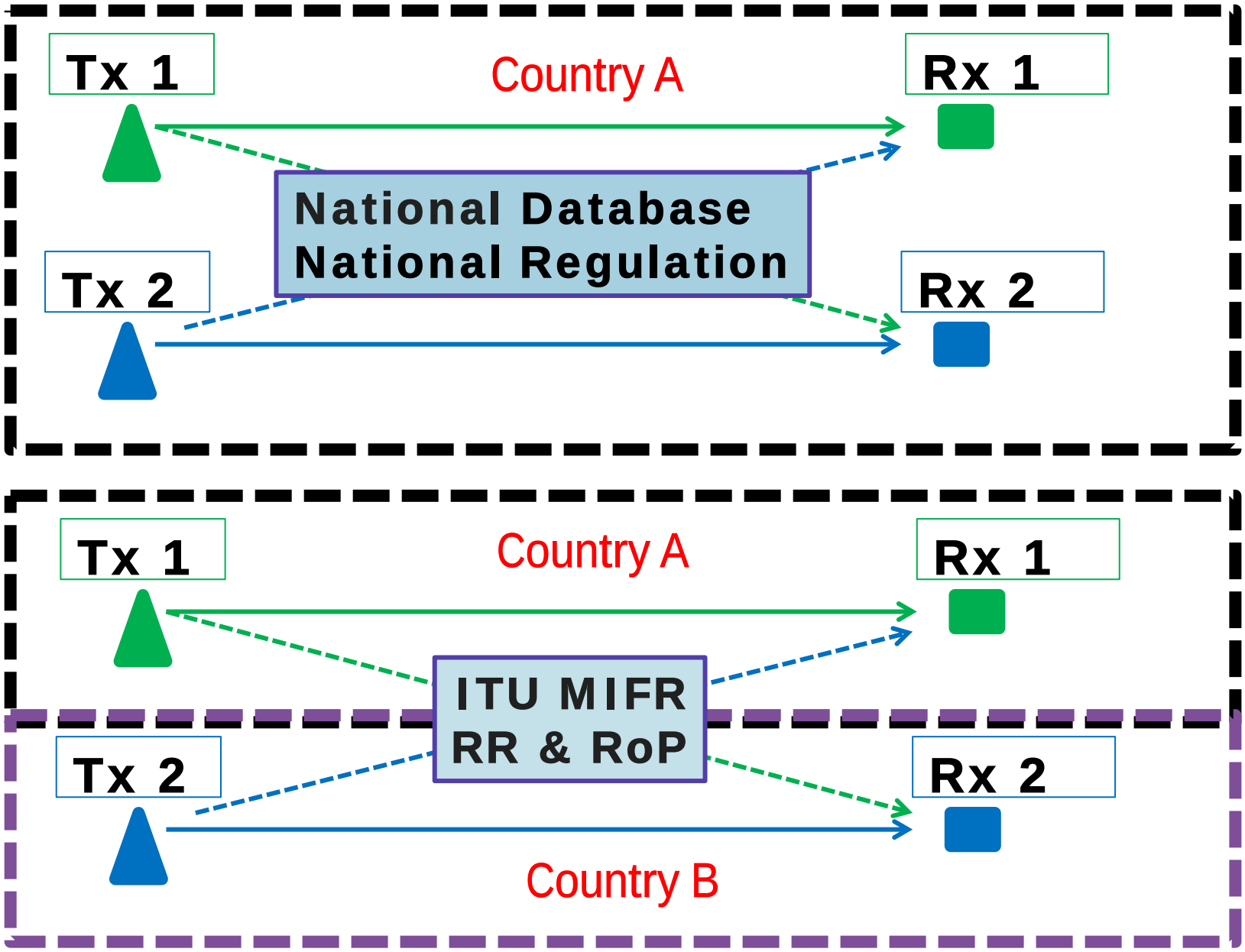
Stations shall be duly registered, with all their technical parameters, and other issues:

- National recognition : Register into National Table
- International recognition: Register into TU MIFR

Interference situations need to be objectively analyzed, and measured, based on register information

- National: Spectrum National Rules
- International: RR and its Rules of Procedure (RoP)

STATIONS REGISTERS



“Unlicensed Devices”

There is no a “unlicensed operation” of any radio device/station. To guarantee use of spectrum without interference, all services shall be previously allocated and all stations shall be assigned (obtaining a license) before enter in operation.

Expression “*unlicensed*” refers to radio devices with transmitting capabilities (emitting radio waves) that can be operated by any person, without previously obtaining a particular authorization for it (particular license).

Particular licensing waiving is only possible because of operation of “unlicensed devices” has been previously authorized to all public through a Generic Use Authorization, GUA (also named General License, or equivalent names). GUA always includes a set of detailed technical and operational specifications that must be strictly obeyed when operating such devices, in order to guarantee their use without interfering to other similar devices or other services.

“Unlicensed Devices”

Every “unlicensed device” shall be pre set-up to obey its GUA specifications, in order to be able to operate without needing particular adjustments performed by its final user before or during its operation.

They are commonly labeled as “*X compliant*” to indicate to buyers alignment with concerned GUA.

The expression “unlicensed” shall not be misinterpreted as permission to operating concerned devices in a free will fashion, as its operation must strictly observe its pertinent GUA. In fact, exceeding any established GUA limits by intentionally altering the pre setup parameters of such devices is an infringement of that Generic License.

Unlicensed devices shall “share” the band authorized on their GUA in equally rights of use. No limit to amount of devices operating simultaneously in a same area, hence average used bandwidth cannot be guaranteed

“Unlicensed Devices”

Regime of Operation for “unlicensed”:

As there is not restriction about quantity of unlicensed devices simultaneously operating in a given area, the actual amount is unknown, then it cannot be possible to grant them any protection. Therefore, unlicensed devices always operate in a regime of: non-interference/non-protection and shared conditions (operation in lower than secondary services basis)

Regarding the coexistence between primary and secondary stations (current and future ones) and “unlicensed devices”, those devices:

- cannot cause interference to those stations
- cannot claim protection against interference coming from those stations

Commonly referred as: “*shared non-interference/non-protection basis*”

Specifications of “Unlicensed Devices”

In order to ease the compliance of the sharing non-interference/non-protection condition, most of “unlicensed devices” used to have :

- Short range (very limited coverage, usually less than 10 m radio)
- Preferably operate “indoor” and/or in very low population-density areas\
- Very low transmitting power (usually up to 100 mW)

This set of specifications mitigates significantly for “unlicensed devices” the risks of interfering/being interfered among them and with primary & secondary services; it also allows to largely increase the number of those devices operating at same time/same area.

Most common examples of these “unlicensed devices” are: remote controls, Bluetooth devices, Wi-Fi (hotspots and built in interfaces), “walkie talkies”, wireless microphones, wireless keys, etc.

Lincensed vs. Unlicensed

LICENSED STATIONS

1. Require a particular license prior to operate, indicating, among other issues, its own particular technical conditions of operation.
2. Operator shall setup emitter parameters to obey particular conditions of his particular license, and constantly verify them
3. are submitted to a competitive impartial process of selection (bidding, auctions, beauty contest, etc.)
4. Shall comply with license terms, including QoS and associated indicators
5. Usually shall pay spectrum fees
6. Is registered on National Spectrum Licenses database.
7. Obtain a recognition and protection accordingly
8. Number of licenses in a same area are known (actual and potential)
9. Has a spectrum tenure guarantee (license timeline terms)

Lincensed vs. Unlicensed

UNLICENSED DEVICES

1. Do not require particular license prior to operate; pre-authorized through a GUA that indicates, technical conditions of operation for open public
2. “plug and play” operation (under the premise that devices are pre setup in conformance to pertinent GUA: GUA Standard compliance)
3. Not submitted to any process of selection
4. No demands on QoS (they cannot guarantee QoS)
5. do not pay spectrum fees
6. They are not registered on National Spectrum Licenses database.
7. They do not have particular recognition neither protection; band shall be shared
8. Number of simultaneous devices in a same area are unknown;
9. Do not have spectrum tenure guarantee

DYNAMIC SPECTRUM ACCESS, DSA

DSA is the real-time adjustment of spectrum utilization in response to changing circumstances and objectives

DSA might be performed through radio stations with some degree of intelligence, and capability to interact with spectrum use environment, and adjust its operation in conformity; e.g., Cognitive Radio, Software Radio, Database Radio, Adaptive Coding and Modulation, etc.

DSA concept does not depend of the service or station; it can be used indistinctly by licensed (primary/secondary) or unlicensed systems. (and it is used by both)

DYNAMIC SPECTRRUM ACCESS, DSA

The principles of DSA might be theoretical applied in any frequency band; therefore, there is no need to allocate specific frequency bands to DSA, neither to radio stations performing it (cognitive radio, software radio, etc).

At WRC-12, it was concluded that: "*the current framework of Radio Regulations provide sufficient flexibility to enable the use of cognitive radio systems, in accordance with its provisions, recognizing in particular the obligations of administrations in preventing interference*" (Recommendation 76, WRC-12)

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“White Space”

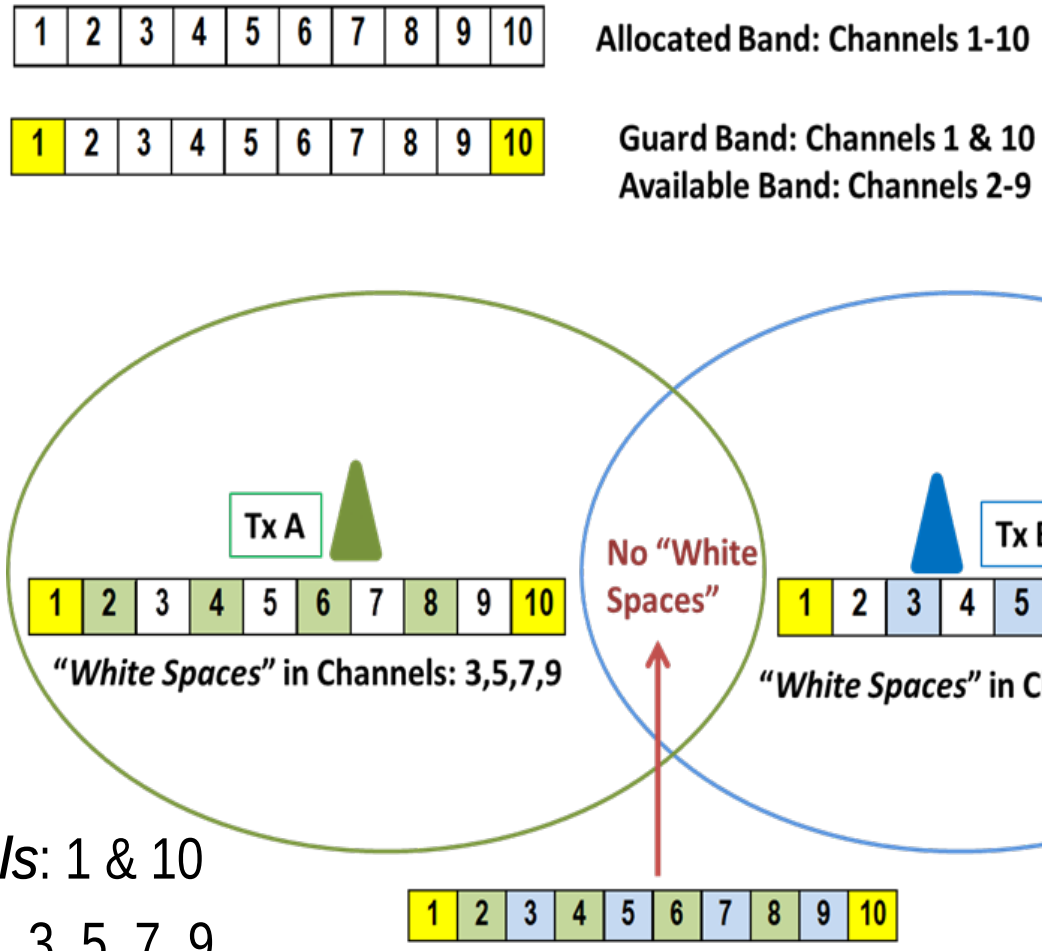
When a Band is allocated to a given service, a channel plan is associated to it (splitting the Band in channels). Due to several reasons, it might occur that in given time and area, some channels are not operating

Those channel allocated to service, but not licensed to any station in a given area (idle) named “white space”.

Main reasons for a “white space

- Guard Band Channels: band boundary channels not licensed, to avoid interfering/being interfered to/by channels from contiguous bands
- Channel Separation: Some technologies require that since a same location emitting stations shall have at least one channel of separation
- Low demand: in a given area low demand of a service leads to amount of emitting channels being lower that band capacity
- Emitting Times: some stations do not emit 24hours/7days

“White Space”



TxA:

Band Guard Channels: 1 & 10

Channel Separation: 3, 5, 7, 9

Low demand: If 8 not yet licensed then available as White Spaces

Emitting Times: If 6 emits from 16h to 24h, then white space available from 0h to 16h

“White Space” Operation

Availability: depends on specific and particular coverage and scheduling conditions of operation of concerned primary/secondary stations (national and international, including passive services): *Opportunistic Radio*

Band: Principles of “white space” might exists in any band; there is not a particular band for applying “white spaces”

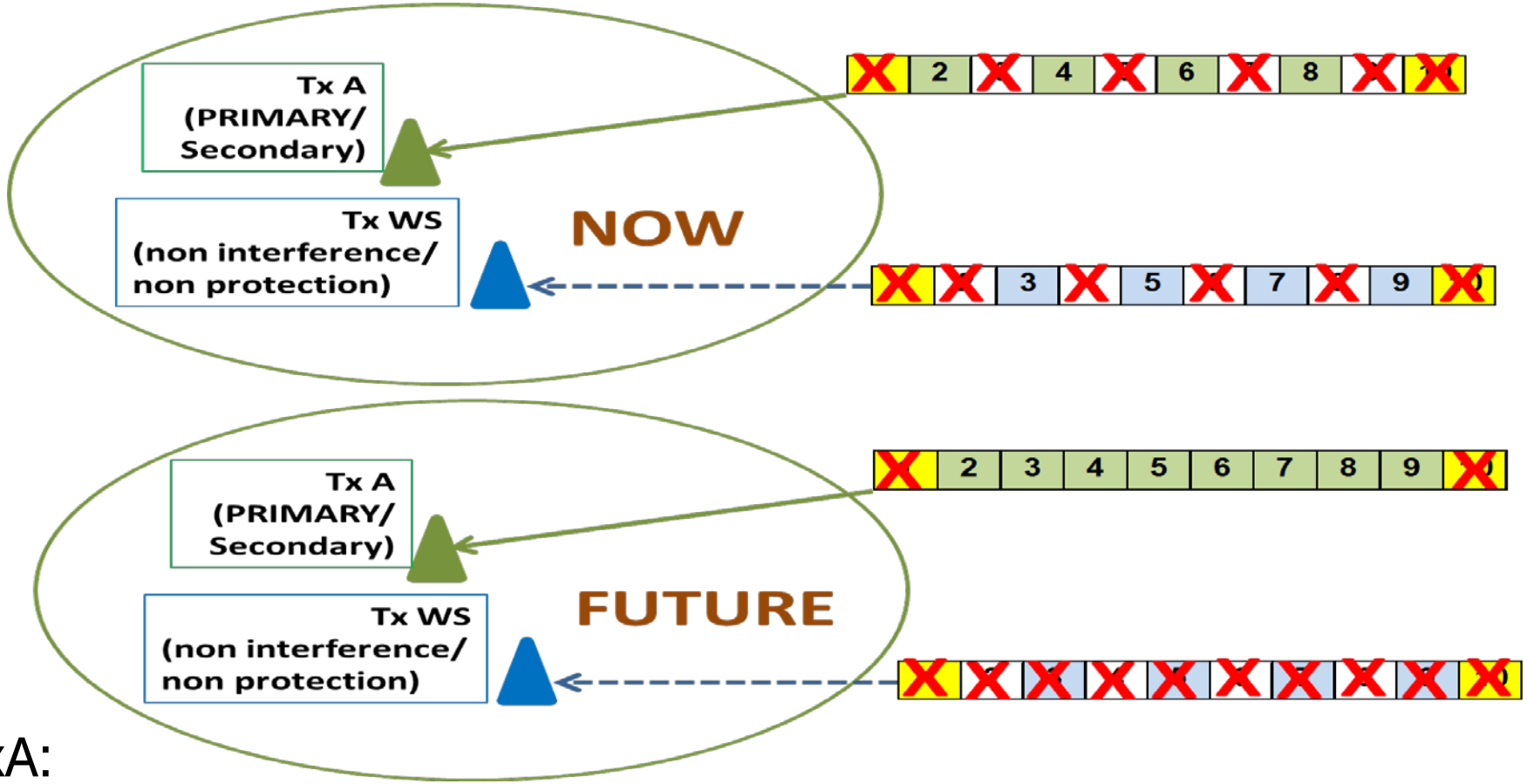
Regime: idle channels are allocated to a service X in a primary/secondary basis; operation of “white space” is feasible only in a regime of: non-interference/non-protection and shared conditions (stated on their pertinent GUA); *an idle channel cannot be used in a free will*

Performing: It performs it by DSA procedures and technologies

Service: White space cannot be exploited for the same primary/secondary services of its Band (bypassing licensing process)

Long time availability: White Space can be used as long actually does exist “idle but allocated channels” on the concerned area. If that channel enter into service, that “white space” disappears.

“White Space”



TxA:

Guard Band Channels: 1 & 10

No Channel Separation: 3, 5, 7, 9 are not longer “white space”

Low demand: If 8 is licensed then not anymore available as White Spaces

Emitting Times: If 6 emits from 24h, then not timeline for white space available

“White Space”

Band Reallocation:

Whether a Band, or a portion of it, is reallocated to a different service, also in a primary or secondary basis, “white space” availability are now subjected to the licensing status of these new service (licensed stations)

As new service very likely will have a different channeling Band Plan, then specific frequencies of “white spaces” channels shall be changed in conformance to this new Band allocation and licensing

New “white spaces” might operate on presence of this new service, again in a non-interference/non-protection and sharing conditions regime

It is also valid whenever a new service (primary or secondary) is added to current band allocation.

Protecting “White Space”?

For a hypothetical protected operation protection of a White Space”

- Channel shall be “reallocated” to a compatible service (in a primary or secondary basis)
- Channel shall be protected by a License (in a primary or secondary basis)
- Station equipment shall be adjusted to License conditions

Implications

- Licensed Channel in primary/secondary basis is not a “white space”
- Licensed Station is not a “unlicensed device”

Paradox:

The only manner to protect a “white space” station is by reallocating the channel and licensing the station (both in primary/secondary basis); hence:

- concerned channel would not be any longer a “white space”

- concerned station is not any longer a “unlicensed device”

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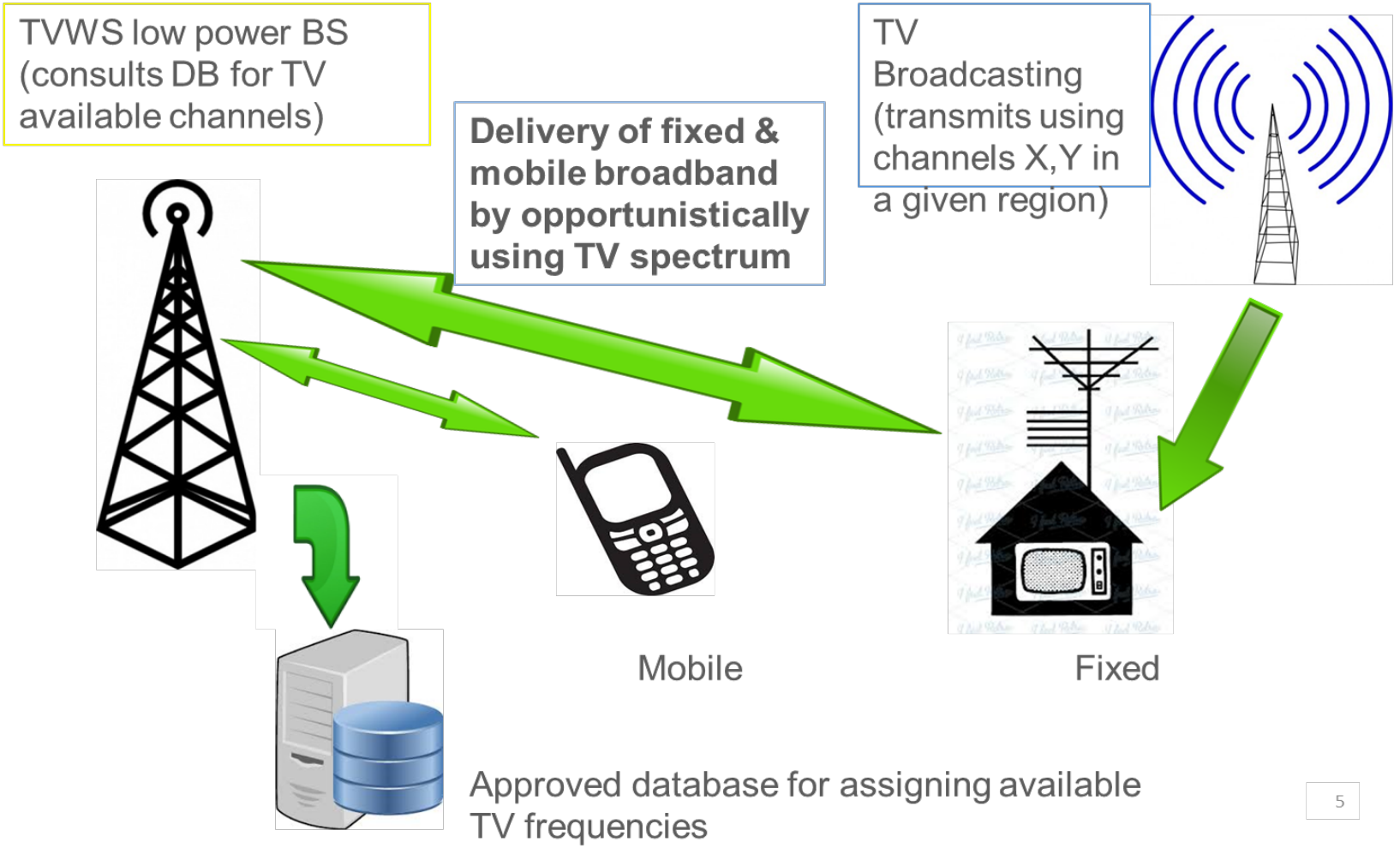
“TV White Space”

The “TV white spaces” (TVWS) refers to white spaces onto bands allocated to TV Terrestrial Broadcasting. Today, discussions are mainly focused on TV UHF Band



“TV White Space”

TVWs Availability

Digital TV (TDT) does not need channel separation, and channels have increase its capacity (several emissions into a same channels).

TV Bands Plans have been redesigned to benefit of this improvement notably:

- Consecutive channels in lower part of UHF
- Reallocation of upper part of UHF to mobile (digital dividend)

Opportunistic operation of TVWS would be shrunk to:

a. Looking for candidate channels only onto the remaining TV UFH Band

b. Possibilities of operation mostly in remote regions with:

- isolated coverage area (no overlapping with other stations coverage ones)

- Those areas having a low terrestrial TV offer (idle channels might exist because of not enough TV stations to fulfill the band)

“TVWS vs WiFi”

Most commons :

- Aimed to provide broadband access to Internet
- Wireless operation (spectrum use)
- “Unlicensed Devices” approach
- Spectrum use on a non-interference/non-protection regime

Main differences :

- TVWS coverage range is highly larger (radio of km instead meters)
- TVWS intends to operate in lower frequencies (~700 MHz Band), while WiFi operates in 2.5 and 5 GHz Band (due to propagation characteristics, with same power, lower frequencies can cover larger areas)
- TVWS targets both outdoor and indoor use; WiFi is mainly for indoor use.
- TWWS Output power are larger than WiFi (Watts instead of mili Watts)

“TVWS vs WiFi”

The “short range” coverage approach is then the key driver for “unlicensed devices” (also technically named as: Short Range Devices, SRD).

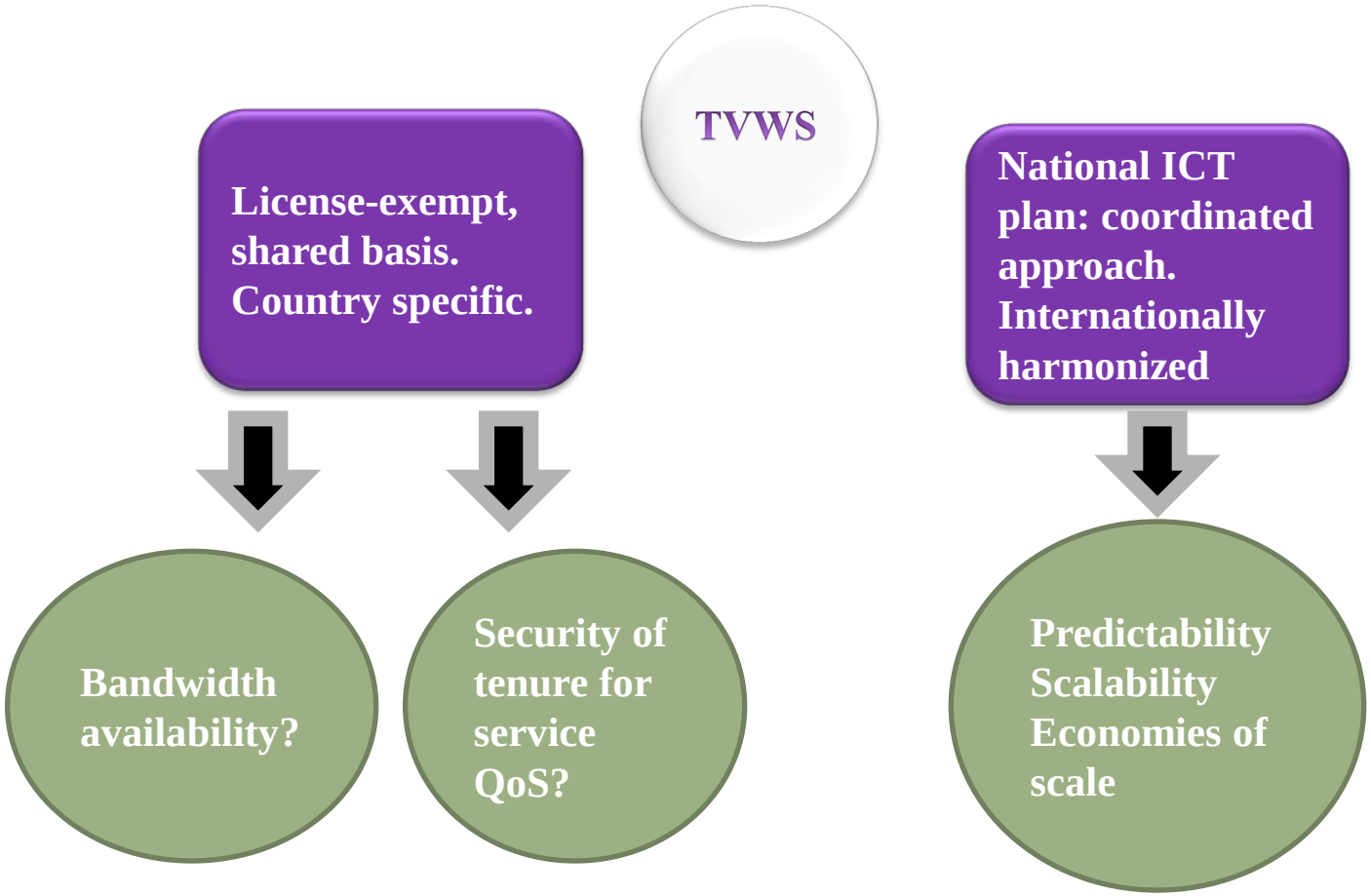
TVWS approach is “long range” coverage (coined expression: “SuperWiFi)

Therefore, this change of paradigm will entail new and more stressing challenges for this kind of stations, as this approach sensitively:

a) increases the risks of interference with primary services
b) reduce the quantity of possible simultaneous

“TVWS”

TVWS: Managing the spaces or better managing inefficiencies: short-term? long-term?



“TVWS”

Considerations for implementing TVWS

- Probability of new digital dividends?
- Costs generated by regulatory changes?
- Service expectations?
- Total costs, who pays?
- Transition to Digital TV: availability of TVWS?
- Increasing demand: bandwidth bottlenecks?
- Border coordination?
- Service continuity and scalability?
- Alternative technologies or mix of technologies?

1. ITU & ITU-R
2. RADIO REGULATIONS
3. “UNLICENSED” DEVICES
4. WHITE SPACES
5. TV WHITE SPACES
6. QUESTIONS AND CONCLUSIONS

Key Questions on the paper

1) What would be the situation for TVWS service providers and users with regard to TVWS deployments in the recently agreed digital dividend extension 694-790 MHz in ITU-R Region 1? What would be the situation in ITU-R Regions 2 and 3 in their digital dividends?
2) Should new digital dividends occur in the remaining UHF TV bands, what would be the impact on TVWS service providers and users in bands that can be identified for primary services other than broadcasting?
3) Would an incoming primary service different from broadcasting be capable of co-existing with widespread TVWS devices?
4) Which party (or parties) would be accountable for funding the costs of TVWS service providers and users in potential scenarios of migration or reallocation of TVWS devices

Key Questions on the paper

5) What studies would be necessary to assess the compatibility between license-exempt TVWS devices and licensed mobile services, should further allocations be made for the mobile service in the UHF TV band?
6) Is it possible to guarantee a continuity of service for TVWS service providers in UHF TV spectrum bands in regions where DTT deployment is still ongoing?
7) What will happen with TVWS networks using analogue TV channel gaps once digital TV is fully deployed?
8) What are the risks and benefits for TVWS service providers and users if early adoption of TVWS takes place in regions where DTT transition has not been finalized?
9) Is there a need to consider some form of spectrum security of tenure for TVWS service providers in order to provide them with a minimum "spectrum pool" for successful service provision?

Key Questions on the paper

10) What studies would be necessary to assess the level of availability of TVWS in a combined deployment scenario including TVWS Wireless Regional Access Networks, wireless microphones and TVWS M2M devices? Would there be an impact on service provision due to bandwidth bottlenecks in cases of low TVWS availability?

11) Will TVWS be deployed for backhaul alternatives? Would there be potential bandwidth bottlenecks for TVWS backhaul service providers?

12) What would be the impact on TVWS service providers and users should numbers of TVWS Wireless RANs and TVWS M2M devices grow rapidly at any given area? Could such situation result in interference for TVWS devices given the greater coverage ranges possible in UHF spectrum?

13) Could the above situation find some alternatives through the implementation of licensing arrangements other than a license-exempt framework?

Key Questions on the paper

14) Could infrastructure monopolies arise in connectivity services provided through TVWS? Are there competition issues that need consideration?

15) Can local mobile operators and small rural ISPs benefit from opportunities through TVWS? What types of services are expected to be offered by TVWS service providers after the pilot projects?

16) In terms of TVWS service provision and TVWS central database management. Would there be a need to review the legal framework and propose new regulatory arrangements or assess the possibility of conflicts of interest between these two service areas?

17) What is the potential level of scalability, resiliency and reliability that TVWS service providers can offer? Will these levels be sustainable in front of increases in demand and increased sharing of TVWS? Is TVWS a short-term solution or a long-term connectivity strategy?

18) How does TVWS broadband connectivity fit into a long-term national ICT strategy?

Conclusions from the paper

1. Spectrum sharing as an alternative to address efficiency.

2. Long-term strategy is needed to benefit from spectrum sharing without incurring in future increased costs.

3. Potential for expansion of Digital TV and future changes in the nature of the current primary service can limit and/or exclude opportunistic TVWS services in UHF TV spectrum bands.

4. There is a need to consider aspects of security of tenure and market harmonization in order to achieve long-term benefits from TVWS in the UHF TV spectrum bands.

5. The paper provides a regulatory checklist as a set of questions for regulators to consider when assessing TVWS.

THANKS

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