

Capítulo 1.- Ingeniería del espectro radioeléctrico

Chapter 1.- Spectrum engineering

1. Kapitulua.- Espekto irrati-elektrikoaren ingeniartza



Bsc Degree on Telecommunication 2023-2024

Dpt. Communication Engineering

Bilbao Faculty of Engineering

V 0.0

Chapter 1.- Spectrum engineering

- ❑ Introduction: Radiocommunication
- ❑ Radio spectrum
 - The electromagnetic spectrum
 - Radio spectrum
 - Frequency bands
 - Characteristics of the radio spectrum
- ❑ Spectrum Management
 - Institutions: ITU and others
 - Definitions: allocation, allotment and assignment. Services
 - ITU Regions. Primary and secondary services. Spectrum management process
 - Table of Frequency Allocations
 - Spectrum management models
 - Licensing. ISM frequency bands

Introduction: Radiocommunication

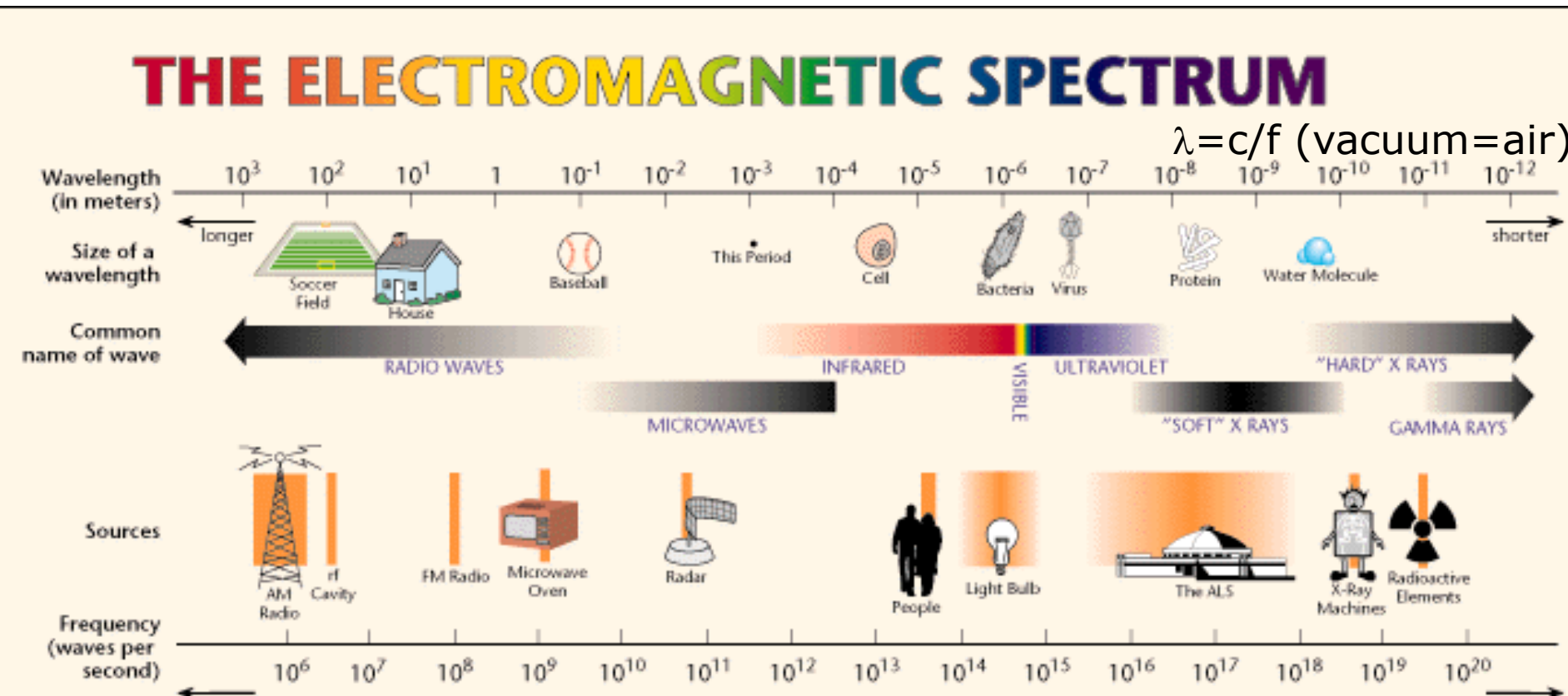
What is Radiocommunication?

- ❑ **Radiocommunication:** Telecommunication by means of radio waves
- ❑ **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
- ❑ **Radio:** A general term applied to the use of radio waves
- ❑ **Radio waves** or **hertzian waves:** Electromagnetic waves of frequencies arbitrarily lower than 3 000 GHz, propagated in space without artificial guide.
- ❑ Terrestrial radiocommunication, Space radiocommunication...
- ❑ Fixed service, Mobile service, Broadcasting service

<http://life.itu.int/radioclub/rr/frr.htm>

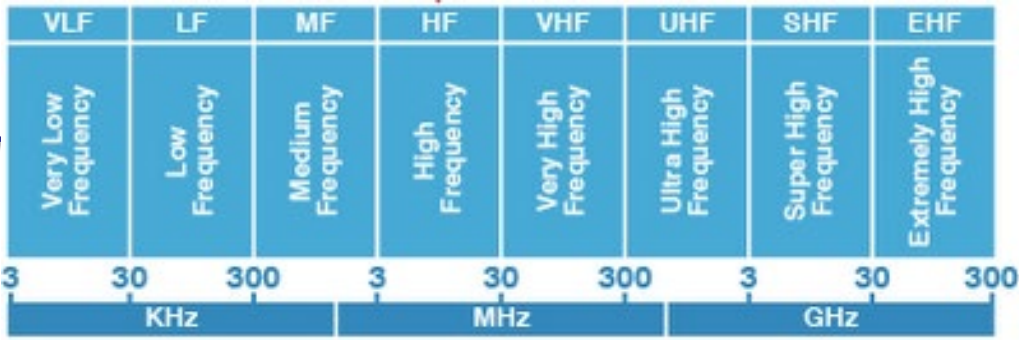
Radio spectrum

The electromagnetic spectrum



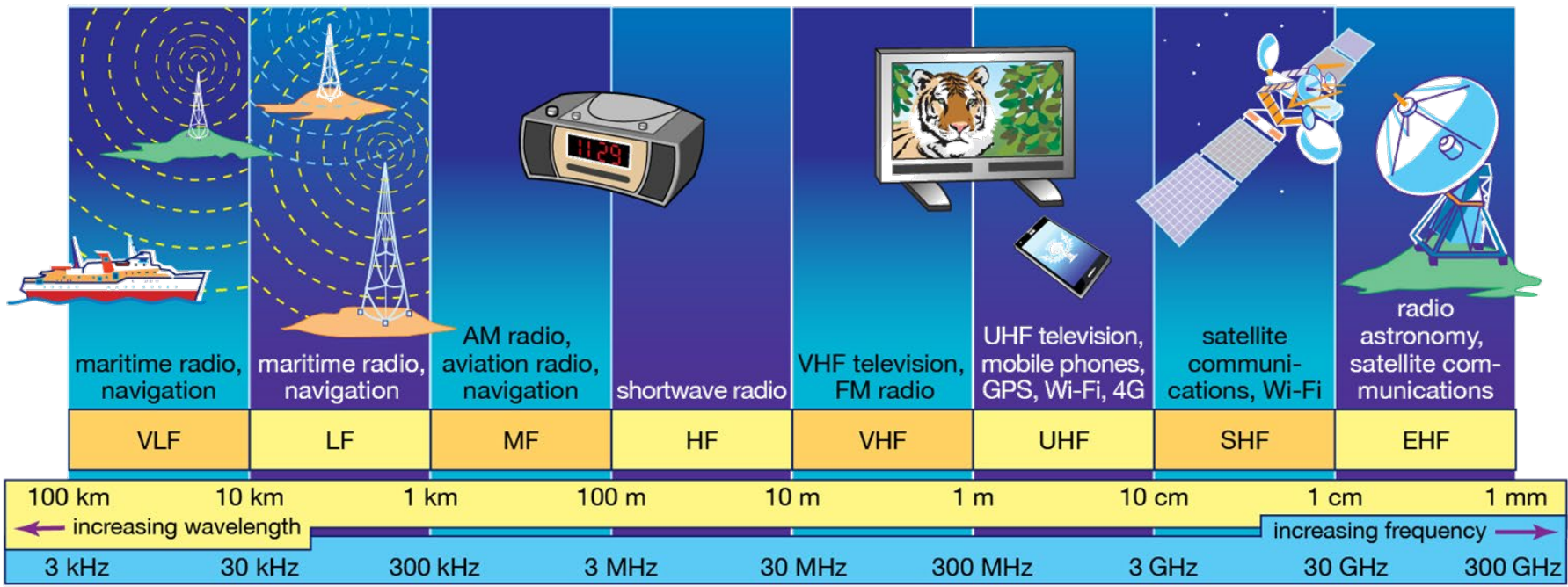
- ❑ The radio-frequency spectrum or radio spectrum is only a comparatively small part of the electromagnetic spectrum

Radio spectrum



- Radio spectrum:
 - from 3 kHz to 300 GHz
 - It includes a range of a certain type of electromagnetic waves, called radio waves, generated by transmitters and received by antennas.

IZENAK IKASI BEHAR DIRA BANDA HAUETARAKO!!



Frequency bands

Different names:

- International Telecommunications Union (ITU) Frequency Band Nomenclature
- European Broadcasting Union, EBU
- ITU Radar Band Nomenclature
- IEEE Standard Radar Band Nomenclature (IEEE Std. 521-2002, IEEE Standard Letter Designations for Radar-Frequency Bands)
- Military Radar Band Designations

Frequency bands

□ ITU Frequency Band Nomenclature

ITU Band: N band from 0.3×10^N Hz to 3×10^N Hz

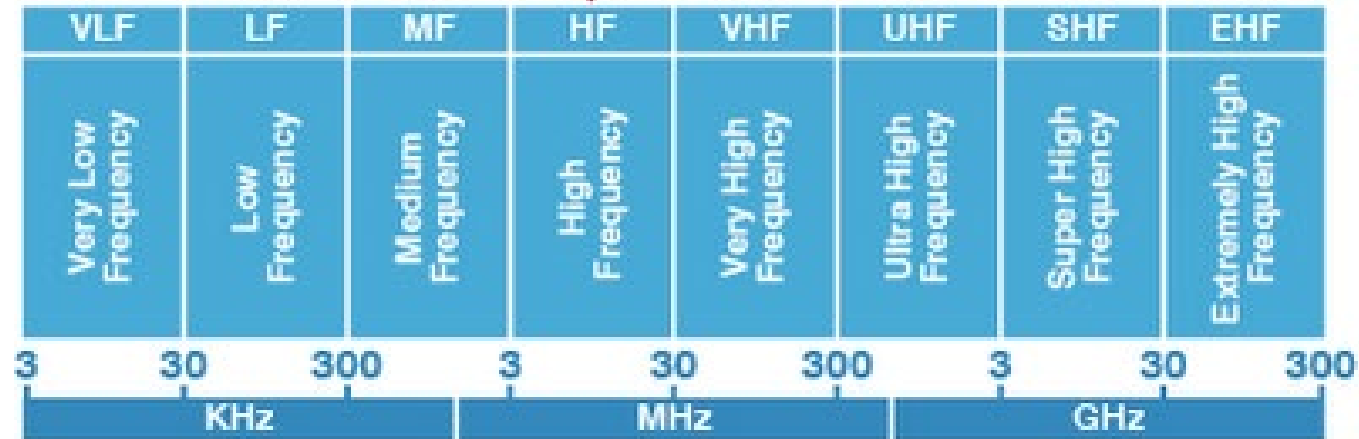
Hz=hertz=cycles per second

k=kilo (10^3)

M=Mega (10^6)

G=giga (10^9)

T=tera (10^{12})



Frequency bands

Band number	Symbols	Frequency range (lower limit exclusive, upper limit inclusive)	Corresponding metric subdivision	Wavelength range
4	VLF	3 to 30 kHz	Myriametric waves	100 km to 10 km
5	LF	30 to 300 kHz	Kilometric waves	10 km to 1 km
6	MF	300 to 3 000 kHz	Hectometric waves	1 km to 100 m
7	HF	3 to 30 MHz	Decametric waves	100 m to 10 m
8	VHF	30 to 300 MHz	Metric waves	10 m to 1 m
9	UHF	300 to 3 000 MHz	Decimetric waves	1 m to 10 cm
10	SHF	3 to 30 GHz	Centimetric waves	10 cm to 1 cm
11	EHF	30 to 300 GHz	Millimetric waves	1 cm to 1 mm
12		300 to 3 000 GHz	Decimillimetric waves	1 mm to 0.1 mm

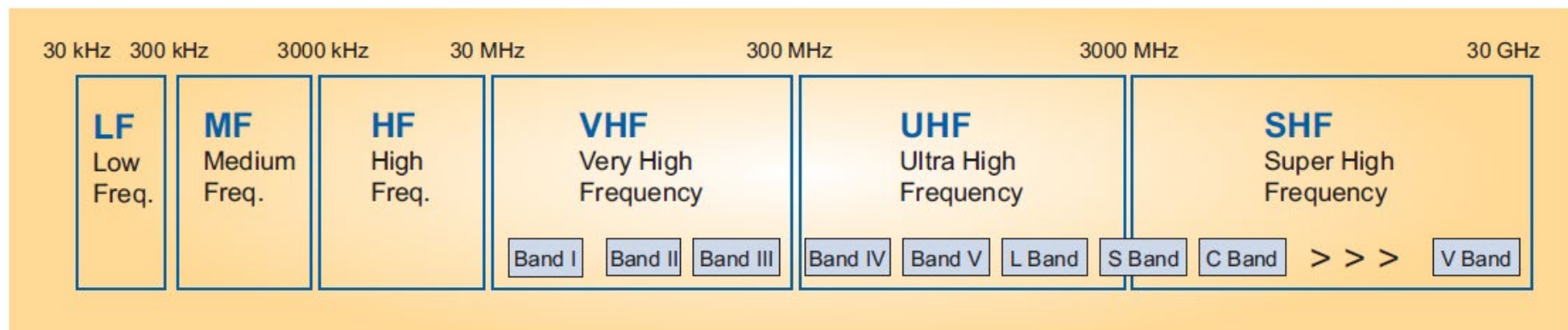
NOTE 1: “Band N” (N = band number) extends from 0.3×10^N Hz to 3×10^N Hz.

NOTE 2: Prefix: k = kilo (10^3), M = mega (10^6), G = giga (10^9).

Frequency bands

❑ Band names - European Broadcasting Union, EBU

- Band I 41 – 68 MHz
- Band II 87,5 – 108 MHz
- Band III 162 – 230 MHz
- Band IV 470 – 582 MHz
- Band V 582 – 960 MHz
- Band VI 12 GHz (broadcasting by satellite)



Frequency bands

❏ Band names – ITU Radar Band Nomenclature

■ L band	1 – 2 GHz
■ S band	2 – 4 GHz
■ C band	4 – 8 GHz
■ X band	8 – 12 GHz
■ Ku band	12 – 18 GHz
■ K band	18 – 27 GHz
■ Ks band	27 – 40 GHz
■ mm band	40 – 300 GHz

Frequency bands

❑ Band names – Standard Radar Frequency Letter-Band Nomenclature (IEEE Standard 521-1984)

■ L band	1 – 2 GHz
■ S band	2 – 4 GHz
■ C band	4 – 8 GHz
■ X band	8 – 12 GHz
■ Ku band	12 – 18 GHz
■ K band	18 – 27 GHz
■ Ka band	27 – 40 GHz
■ V band	40 – 75 GHz
■ W band	75 – 110 GHz

Characteristics of the radio spectrum

- ❑ Radio spectrum is a limited natural resource but reusable.
- ❑ The limitation of radio frequency spectrum is mainly due to the following:
 - Propagation characteristics of radio waves.
 - Availability of technology and equipment for different applications.
 - Suitability of frequency bands for specific applications.
- ❑ Demands on spectrum have always been more than its availability.

Characteristics of the radio spectrum

- ❑ There is only one radio spectrum:
 - Capability only expandable to a limited extent into the mm wave bands or by improving modulation and coding methods.
 - We must use it effectively to get best value, and to have potential for future expansion of services.
- ❑ Radio waves do not respect international borders, buildings or each other. International harmonisation is needed for each spectrum band.

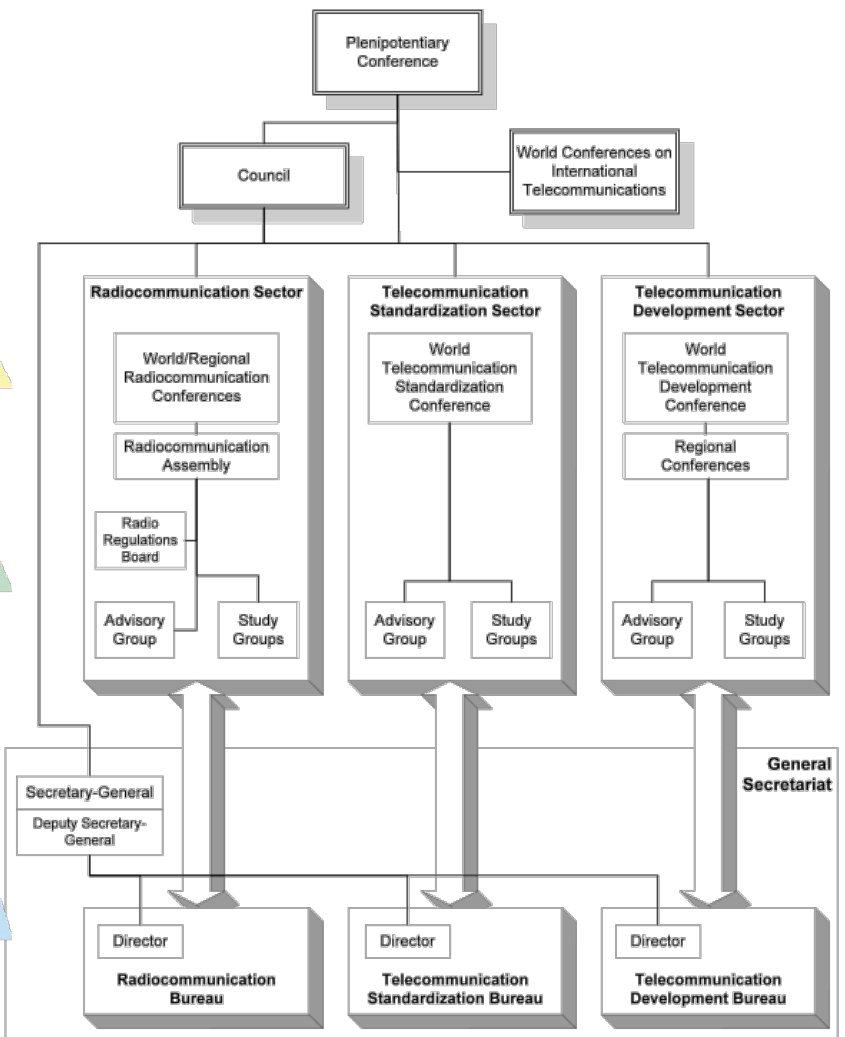
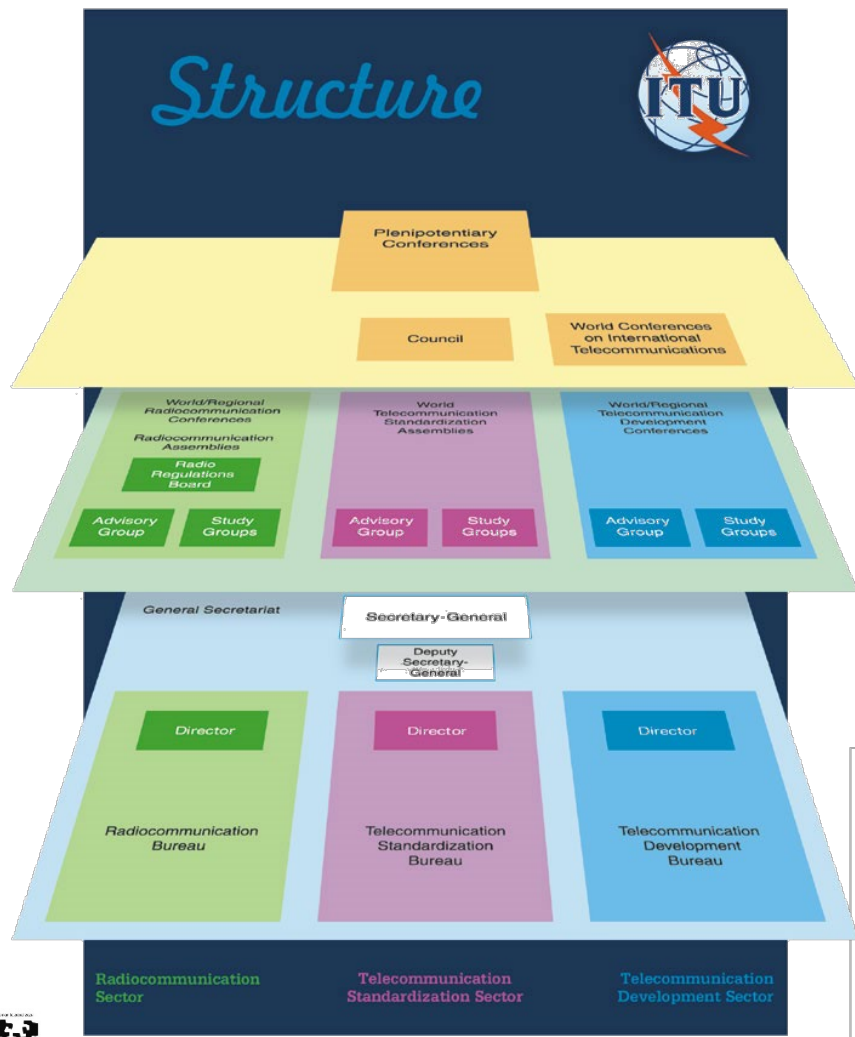
Spectrum Management



- ❑ **ITU, International Telecommunication Union**, is the United Nations' oldest agency. It is the specialized agency for information and communication technologies – ICTs:
 - allocate global radio spectrum and satellite orbits,
 - develop the technical standards that ensure networks and technologies seamlessly interconnect
 - strive to improve access to ICTs to underserved communities worldwide.
- ❑ **ITU Sectors:**
 - Radiocommunication (ITU-R)
 - Standardization (ITU-T)
 - Development (ITU-D)

Spectrum Management: ITU




- Radiocommunication Sector (ITU-R). Standardization (ITU-T). Development (ITU-D)



Spectrum Management: ITU

- ❑ ITU was founded in Paris in 1865 as the International Telegraph Union. It took its present name in 1934.
 - 1924 Creation of International Telephone Consultative Committee (CCIF)
 - 1925 Creation of International Telegraph Consultative Committee (CCIT)
 - 1927 Washington — Radiotelegraph Conference (Plenipotentiary). Creation of the International Radio Consultative Committee (CCIR)
- ❑ In 1947 ITU became a specialized agency of the United Nations.
- ❑ ITU currently has a membership of 193 countries and over 700 private-sector entities and academic institutions.
- ❑ ITU is headquartered in Geneva, Switzerland.

Spectrum Management: ITU

itu.int/en/myitu/Membership/ITU-Members/Member-States/Entities?eID=1000100480									
 MyITU News Publications Events Membership					English ▾ Log in 				
Comisión Nacional de los Mercados y la Competencia (CNMC) , MADRID	-	-	-	ADMIN RELATED					
Axon Partners Group Consulting , Madrid	-	-	SG1	OTHER ENTITY					
Cellnex Telecom, S.A. , BARCELONA	x	-	-	ROA					
Colegio Oficial de Ingenieros de Telecomunicación (COIT) , MADRID	Academia	Academia	Academia	UNIVERS,RSRCH					
HISPASAT, S.A. , Alcobendas, Madrid	x	-	-	ROA					
Iberdrola , Madrid	-	SG15	-	OTHER ENTITY					
Indra Sistemas , Alcobendas	x	-	-	SIO					
INVELCO SA , Tres cantos	SG3	-	-	SIO					
Telefónica S.A. , MADRID	x	x	x	ROA					
Universidad de Cantabria , SANTANDER	Academia	Academia	Academia	UNIVERS,RSRCH					
Universidad Del País Vasco , LEIOA	Academia	Academia	Academia	UNIVERS,RSRCH					
Wavecontrol S.L. , Barcelona	-	SG5	-	SIO					



ITU Global Directory

[TIES Main Page](#) | [FAQ](#) | [Email](#) | [GD Map](#) Mon Jan 7 12:14:16 CET 2013

[Introduction](#)

[How to SEARCH](#)

[SEARCH](#)

[How to ORDER](#)

[How to UPDATE](#)

[Terminology](#)

[TIES](#)

[GD Map](#)

Address details:

Category: UNIVERS,RSRCH

Universidad Del País Vasco
Barrio Sarriena s/n
48940 LEIOA, Bizkaia
España

Tf +34 94 6012142

Fax +34 94 6013550

Email charo.sanchez@ehu.es

URL www.ikerkuntza.ehu.es

☒ Member ITU-R (Academia) ☒ Member ITU-T (Academia) ☐ Member ITU-D

Profesor Miguel Angel Gutiérrez

Mr Charo Sánchez, Vicerrectorado de Investigación

(Email charo.sanchez@ehu.es)

Mrs. Eva Ibarrola Armendariz, (UIT-T)

(Tf ++34 94 6013900)

(Fax ++34 94 6014259)

(URL www.det.ehu.es/s0147-gingacon/es/contenidos/informacion/qi0298_profesorado/es_00298_pr/00298_evaibarrola.html)

(Adr Electronics and Telecommunications ETSI de Bilbao, Alda. Urquijo s/n, 48013 Bilbao, Vizcaya, Spain)

(Email eva.ibarrola@ehu.es)

Sr. David Guerra Pereda, (UIT-R)

(Email david.guerra@ehu.es)

TIES: [TIES FocalPoint](#) + [TIES users](#)

Spectrum Management: ITU

- ❑ **ITU World Radiocommunication Conferences (WRC):**
 - every three or four years in Geneva.
 - to review and revise the Radio Regulations, the international treaty governing the use of radio-frequency spectrum and satellite orbit resources.
 - any other question of a worldwide character within the competence of the conference.
 - the general scope of the agenda of world radiocommunication conferences is established four to six years in advance, with the final agenda set by the ITU Council two years before the conference, with the concurrence of a majority of Member States.
- ❑ WRC-19, WRC-15, WRC-12, WRC-07, WRC-03, WRC-2000, WRC-97, WRC-95
- ❑ WRC-2023, Dubai. Provisional Final Acts:
 - RESOLUTION 223 (REV.WRC-23) – Additional frequency bands identified for International Mobile Telecommunications
 - RESOLUTION 235 (REV.WRC-23) – Review of the spectrum use of the frequency band 470-694 MHz or parts thereof for some countries in Region 1
 - <https://www.itu.int/es/mediacentre/Pages/PR-2023-12-15-WRC23-closing-ceremony.aspx>
 - https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.15-2023-PDF-S.pdf
 - <https://www.itu.int/wrc-23/>

Spectrum Management: Other institutions

□ Other institutions:

- ETSI (European Telecommunications Standards Institute)
- IEC (International Electrotechnical Commission)
- CISPR (Comité International Spécial des Perturbations Radioélectriques- International special committee on radio interference)
- CENELEC (European Committee for Electrotechnical Standardization)
- ISO (International Organization for Standardization)
- AENOR (Asociación Española de Normalización y Certificación)
- CEPT (The European Conference of Postal and Telecommunications Administrations)

Spectrum Management: Other institutions

❑ ETSI (European Telecommunications Standards Institute):

- Produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies.
- Founded initially to serve European needs, ETSI has become highly-respected as a producer of technical standards for worldwide use.
- Standards available to anyone free of charge.
<http://www.etsi.org/standards>
- Not-for-profit organization with more than 700 ETSI member organizations drawn from 62 countries across 5 continents world-wide.

Definitions: allocation, allotment and assignment



	French	English	Spanish	Basque
<i>Frequency distribution to:</i>				
<i>Services</i>	Attribution (attribuer)	Allocation (to allocate)	Atribución (atribuir)	Atribuzioa (Atribuitu)
<i>Areas or Countries</i>	Allotissement (allotir)	Allotment (to allot)	Adjudicación (adjudicar)	Adjudikazioa (Adjudikatu)
<i>Stations</i>	Assignment (assigner)	Assignment (to assign)	Asignación (asignar)	Esleipena (Esleitu)

ASKOTAN TEST-EAN AGERTZEN DA HONELAKO ZEOZER

❑ **Example:**

- ❑ Allocation: Digital TV (TDT) in Spain - UHF band
- ❑ Allotment: EITB in Euskadi - channel 35 (586 MHz) in Bizkaia, channel 50 (706 MHz) in Gipuzkoa and channel 58 (770 MHz) in Alava.
- ❑ Assignment: Ganeta station (Bilbao) - channel 35

Definitions: allocation, allotment and assignment

- ❑ **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. [Radio Regulations]
- ❑ **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. [Radio Regulations; allotment plans]
- ❑ **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. [by States, after international coordination is completed]

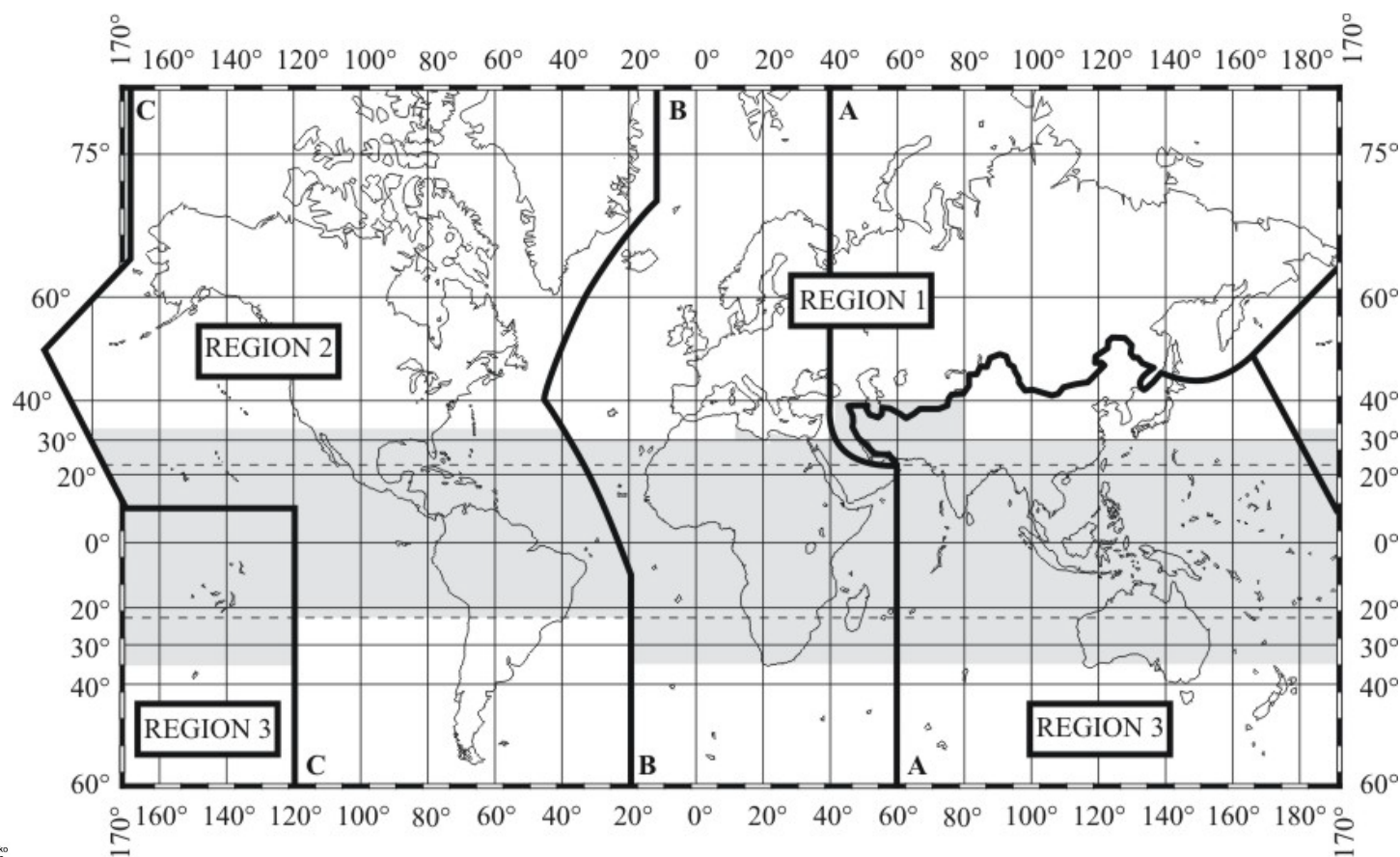
Services

□ Services:

- FIXED
- MOBILE
- MARITIME MOBILE
- BROADCASTING
- RADIONAVIGATION
- AERONAUTICAL RADIONAVIGATION
- AMATEUR
- METEOROLOGICAL-SATELLITE
- RADIO ASTRONOMY
- ...

ITU Regions

- For the allocation of frequencies the world has been divided into three Regions as shown on the following map



Primary and Secondary Services

- ❑ Types of frequency allocations:
 - **Exclusive** – allocation for one radio service
 - **Shared** - allocation for several radio services (compatible radio services, often with similar technical characteristics)
- ❑ Category of services:
 - **Primary** (printed in "capitals"; example: FIXED)
 - **Secondary** (printed in "normal characters"; example: Mobile).
Stations of secondary service:
 - shall not cause harmful interference to stations of primary services
 - 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
 - can claim protection, however, from harmful interference from stations of a same or other secondary service(s) to which frequencies may be assigned at a later date

Spectrum Management Process

Article 5 of Radio Regulations and associated Plans

Table of Frequency Allocations in Article 5 is agreed by the ITU at world radio conferences for all three ITU Regions

Regional Harmonization:

Regional Plans, Directives, Decisions etc.

National Table of Frequency Allocations

National Plans

Bilateral/multilateral agreements

Overview of the spectrum management process:

- Regulatory domain: ITU Radio Regulations
- Technical domain: ITU-R Recommendations
- Licensing domain: Radio station license (issued by States)

Training Workshop, Isfahan, Iran, 20 – 23 May 2012

National Table of Frequency Allocations: Spain

- ❑ **Table of Frequency Allocations** (ITU) in Radio Regulations
 - ❑ Table of Frequency Allocations → National Table of Frequency Allocations.
 - ❑ Spain:
 - **Cuadro Nacional de Atribución de Frecuencias - CNAF** 2021 (Boletín 16 de diciembre de 2021)
<https://www.boe.es/buscar/pdf/2021/BOE-A-2021-21346-consolidado.pdf>
 - Notas de Utilización Nacional (UN)
 - Tablas de atribución de frecuencias
- Consulta del registro público de concesiones:
- https://sedeaplicaciones.minetur.gob.es/RPC_Consulta/FrmConsulta.aspx

National Table of Frequency Allocations: Spain

ATRIBUCIÓN A LOS SERVICIOS según el RR de la UIT		
460 - 890 MHz		
Región 1	Región 2	Región 3
790 - 862 FIJO MOVIL salvo móvil aeronáutico 5.316B 5.317A RADIODIFUSIÓN		
	806 - 890 FIJO MÓVIL 5.317A RADIODIFUSIÓN	
5.312 5.319		
862 - 890 FIJO MÓVIL, salvo móvil aeronáutico 5.317A RADIODIFUSIÓN 5.322		
5.319 5.323	5.317 5.318	

ATRIBUCIÓN NACIONAL	USOS	OBSERVACIONES
460 - 890 MHz		
790 - 862 FIJO MÓVIL, salvo móvil aeronáutico	P P	5.316B 5.317A Sistemas terrenales capaces de prestar servicios de comunicaciones electrónicas (790-823/832-862 MHz) UN-151: Dispositivos PMSE (823-832 MHz) UN-153, UN-154, UN-168
862 - 890 FIJO MÓVIL, salvo móvil aeronáutico	* *	5.317A 5.322 Sistemas terrenales capaces de prestar servicios de comunicaciones electrónicas (880-890 MHz) UN-39, UN-40, UN-41, UN-111 UN-115 UN-118: MICRÓFONOS SIN HILOS UN-135 RFID, UN-154, UN-168 * Usos M y C (según notas UN)

C: Uso común E: Uso especial P: Uso privativo
 R: Uso reservado al Estado M: uso mixto que comprende P y R

National Table of Frequency Allocations: Spain

UN-36	Televisión digital en la banda 470-694 MHz
-------	--

La banda de frecuencias 470 a 694 MHz se reserva para la prestación de los servicios de televisión digital terrestre (TDT).

En virtud de lo establecido en el artículo 12 del Real Decreto-ley 23/2020, de 23 de junio, por el que se aprueban medidas en materia de energía y en otros ámbitos para la reactivación económica, y en el marco de la Decisión (UE) 2017/899 del Parlamento Europeo y del

Consejo, de 17 de mayo de 2017, desde el 31 de octubre de 2020, la banda de frecuencias de 694-790 MHz (banda 700 MHz) está destinada para los sistemas terrestres capaces de prestar servicios de comunicaciones electrónicas de banda ancha inalámbrica, de acuerdo con lo establecido en la nota UN-153.

La banda 470 a 694 MHz se utilizará para la prestación de los servicios de televisión terrestre con tecnología digital conforme al Plan Técnico Nacional de la televisión digital terrestre, aprobado por Real Decreto 391/2019, de 21 de junio.

Por otra parte, los equipos de uso doméstico destinados a favorecer la recepción portátil de la televisión digital terrestre en el interior de recintos cerrados (microreemisores de hogar), se consideran conformes al Plan Técnico Nacional cuando sus canales de emisión coincidan con los canales de recepción, sin efectuar conversión de frecuencia, y la potencia radiada aparente máxima no supere 1 mW. La utilización de estos equipos tiene la consideración de uso común y no deberá causar interferencias a otros sistemas radioeléctricos ni reclamar protección frente a la interferencia perjudicial.

European Table of Frequency Allocations

- ❑ THE EUROPEAN TABLE OF FREQUENCY **ALLOCATIONS** AND APPLICATIONS IN THE FREQUENCY RANGE 9 kHz to 3000 GHz
 - Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT)
 - Approved October 2021

<https://efis.cept.org/sitecontent.jsp?sitecontent=ecatable>

Reference document when developing national frequency allocation tables and national frequency usage plans
- ❑ ECO Frequency Information System <https://efis.cept.org/>

European Table of Frequency Allocations

790 MHz - 862 MHz

<i>RR Region 1 Allocation and RR footnotes applicable to CEPT</i>	<i>European Common Allocation and ECA Footnotes</i>	<i>ECC/ERC harmonisation measure</i>	<i>Applications</i>	<i>Standard</i>	<i>Notes</i>
BROADCASTING FIXED MOBILE EXCEPT AERONAUTICAL MOBILE 5.317A 5.316B 5.312 5.319	BROADCASTING MOBILE EXCEPT AERONAUTICAL MOBILE 5.312 5.316B 5.317A ECA13		-		This band is planned for future mobile applications, based on the RR provisions
			Broadcasting (terrestrial)	EN 302 296 EN 302 297 EN 302 998	Geneva Agreement 2006. TV Broadcasting
		ECC/DEC/(09)03 ECC/REC/(11)04	MFCN	EN 301 908	
		ERC/REC 25-10 ERC/REC 70-03	Radio microphones and ALD	EN 300 422	Within the band 823-832 MHz

862 MHz - 870 MHz

BROADCASTING 5.322 FIXED Mobile except aeronautical mobile 5.317A 5.319 5.323	MOBILE 5.317A 5.323 ECA13 ECA36		-		This band is identified for IMT in the RRs, but within CEPT this band is not planned for the harmonised introduction of IMT
		ERC/REC 70-03	Alarms	EN 300 220	Within the band 868.6-869.700 MHz
			Land military systems		
			Maritime military systems		
		ERC/REC 70-03	Non-specific SRDs	EN 300 220	Within the band 862-876 MHz
		ERC/REC 70-03	RFID	EN 302 208	Within the band 865-868 MHz
		ERC/REC 25-10 ERC/REC 70-03	Radio microphones and ALD	EN 300 422 EN 301 357	Within the band 863-865 MHz
		ERC/REC 70-03	Tracking, tracing and data acquisition		Within the band 865-868 MHz
		ERC/REC 70-03	Wideband data transmission systems		Within the band 863-868 MHz

Spectrum Management

- ❑ Spectrum management reflects many separate activities:
 - planning spectrum use
 - allocating and assigning spectrum licenses
 - interacting with regional and international organizations
 - ...
- ❑ Historically, regulators (mainly governments) have assigned frequencies by issuing licenses to specific users for specific purposes – The Administrative Method
- ❑ More flexible forms of licensing :
 - bands were made available for a range of uses rather than just one
 - auctions were introduced to assign spectrum to users.

Spectrum Management in UK

❑ OFCOM:

- The **Office of Communications (OFCOM)** is the government-approved regulatory and competition authority for the broadcasting, telecommunications and postal industries of the UK.
- Launched in 2003.
- Independent regulator and competition authority for the UK communications industries.
- OFCOM regulates the TV and radio sectors, fixed line telecoms, mobiles, postal services, plus the airwaves over which wireless devices operate.

Spectrum Management in USA

❑ FCC (USA):

- **Federal Communications Commission (FCC)** regulates interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Columbia and U.S. territories.
- It was established by the Communications Act of 1934.
- It operates as an independent U.S. government agency overseen by Congress.

Spectrum Management in Spain

□ Spain:

- Agencia Estatal de Radiocomunicaciones
- 30 de marzo de 2012,... ha suprimido, en su disposición final sexta, la Agencia Estatal de Radiocomunicaciones, pasando sus competencias a la Secretaría de Estado de Telecomunicaciones y para la Sociedad de la Información.

Spectrum as a National Resource

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

Spectrum Management models

❑ The **Administrative approach**:

- It is the one currently employed by most regulators around the globe.
- The regulators be the centralized authorities for spectrum allocation and usage decisions.
- The allocation decisions are often static in temporal and spatial dimensions, meaning that they are valid for extended periods of time (usually decades) and for large geographical regions (country wide).
- It does not result in efficient outcomes.

Spectrum Management models

❑ Market methods:

- The spectrum resources should be treated like land, i.e. private ownership of spectrum portions.
- The allocation implemented by means of market forces.
- The spectrum owners should be able to trade these portions in secondary markets.
- Use their bands in any way they want through any technology they prefer (service and technology neutrality)

❑ Spectrum commons theory:

- Everyone has access
- Probably some rules will be needed

Spectrum Management models

❏ Two alternative spectrum ownership models:

■ Ownership with non-interference

- I own the spectrum and have absolute use priority; others can use it only if they don't interfere with this absolute use priority.

■ Ownership with real-time leasing

- I own the spectrum and you can use it if you pay me.
 - Identifiable emitter
 - Real-time price, long-term lease Price
 - Perfectly competitive market
 - Software to negotiate and bill

Spectrum Management in the future


- ❑ Spectrum management in the future:
 - Greater demand for spectrum expected from all radio services
 - Spectrum planning focuses on increased sharing of spectrum between services
 - Spectrum planning focuses on releasing spectrum not used or not efficiently used
 - In some countries spectrum pricing is being proposed
 - Progressive introduction of more spectrum efficient systems

Licensing

- ❑ Licensing domain:
 - Radio station license (issued by States)
 - Usually licenses to specific users for specific purposes
 - Auctions

- ❑ Unlicensed:
 - Frequencies for ISM applications and SRD (Short Range Devices)
 - Transmitted power is limited

Unlicensed spectrum

- ❑ Anyone can transmit without a license while complying with rules that are designed to limit/avoid interference. 
- ❑ The main unlicensed bands were those designated as **industrial, scientific and medical (ISM): ISM bands**. These were bands where there was non-communications use of spectrum.
- ❑ In the past fifteen year, interest in greater use of unlicensed spectrum has grown sharply.
- ❑ WiFi, Bluetooth....

ISM frequency bands

□ ISM:

- Frequency bands for **industrial, scientific and medical (ISM)** applications.
- Industrial, scientific and medical (ISM) applications (of radio frequency energy): Operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications. [ITU-Radio Regulations]
- The term "unregulated frequencies" is not used within ITU texts.
- The international Table of Frequency Allocations specifies some frequency bands that may be made available for ISM applications.
- Examples of applications in these bands include radio-frequency process heating, microwave ovens, and medical diathermy machines.

Unlicensed spectrum

- ❑ Despite the intent of the original allocations ...
- ❑ The Government also makes spectrum available for “unlicensed use”:
 - WiFi, the broadband wireless access technology
 - walkie-talkies
 - remote controls
 - cordless microphones at pop concerts and theatres.
- ❑ Unlicensed spectrum. It means that you don’t have to apply for a license to plug in your wireless headphones at home or your Bluetooth enabled mobile phone headset while you are on the move.
- ❑ These devices emit a low-power signal that covers a very small area and therefore are not likely to cause interference with other similar devices.
- ❑ Limited power (PIRE)

ISM bands

5.150	Las bandas:
13553-13567 kHz	(frecuencia central 13560 kHz),
26957-27283 kHz	(frecuencia central 27120 kHz),
40,66-40,70 MHz	(frecuencia central 40,68 MHz),
902-928 MHz	en la Región 2 (frecuencia central 915 MHz),

2400-2500 MHz	(frecuencia central 2450 MHz),
5725-5875 MHz	(frecuencia central 5800 MHz) y
24-24,25 GHz	(frecuencia central 24,125 GHz)

están designadas para aplicaciones industriales, científicas y médicas (ICM). Los servicios de Radiocomunicación que funcionan en estas bandas deben aceptar la interferencia perjudicial resultante de estas aplicaciones. Los equipos ICM que funcionen en estas bandas estarán sujetos a las disposiciones del número **15.13**.

Unlicensed spectrum

UN-85	RLANs y datos en 2400 a 2483,5 MHz
-------	------------------------------------

La banda de frecuencias 2400-2483,5 MHz, designada en el Reglamento de Radiocomunicaciones para aplicaciones industriales, científicas y médicas (ICM), podrá ser utilizada también para los siguientes usos de radiocomunicaciones bajo la consideración de uso común:

- a) Sistemas de transmisión de datos de banda ancha y de acceso inalámbrico a redes de comunicaciones electrónicas incluyendo redes de área local.

Estos dispositivos pueden funcionar con una potencia isotrópica radiada equivalente (p.i.r.e.) máxima de 100 mW conforme a la Decisión de Ejecución (UE) 2019/1345 de la Comisión, por la que se modifica la Decisión 2006/771/CE, y se actualizan las condiciones técnicas armonizadas en el ámbito del uso del espectro radioeléctrico para los dispositivos de corto alcance y a la Recomendación CEPT ERC/REC 70-03, anexo 3.

Además, la densidad de potencia (p.i.r.e.) será de 100 mW/100 kHz con modulación por salto de frecuencia y de 10 mW/MHz con otros tipos de modulación. En ambos casos, se deberán utilizar técnicas de acceso y mitigación de interferencias con rendimiento al menos equivalente a las técnicas descritas en las normas armonizadas según la Directiva 2014/53/UE.

En cuanto a las características técnicas de estos equipos, la norma técnica de referencia es el estándar ETSI EN 300 328 en su versión actualizada.

- b) Dispositivos genéricos de baja potencia en recintos cerrados y exteriores de corto alcance, incluyendo aplicaciones de video.

La potencia isotrópica radiada equivalente máxima será 10 mW, de acuerdo con la Decisión de Ejecución (UE) 2019/1345 de la Comisión, por la que se modifica la Decisión 2006/771/CE, y se actualizan las condiciones técnicas armonizadas en el ámbito del uso del espectro radioeléctrico para los dispositivos de corto alcance y a la Recomendación CEPT ERC/REC 70-03, Anexo 1, siendo la norma técnica de referencia el estándar ETSI EN 300 440.