RIT

Spectrum Management and 6G Midband Technology

EEEE.789

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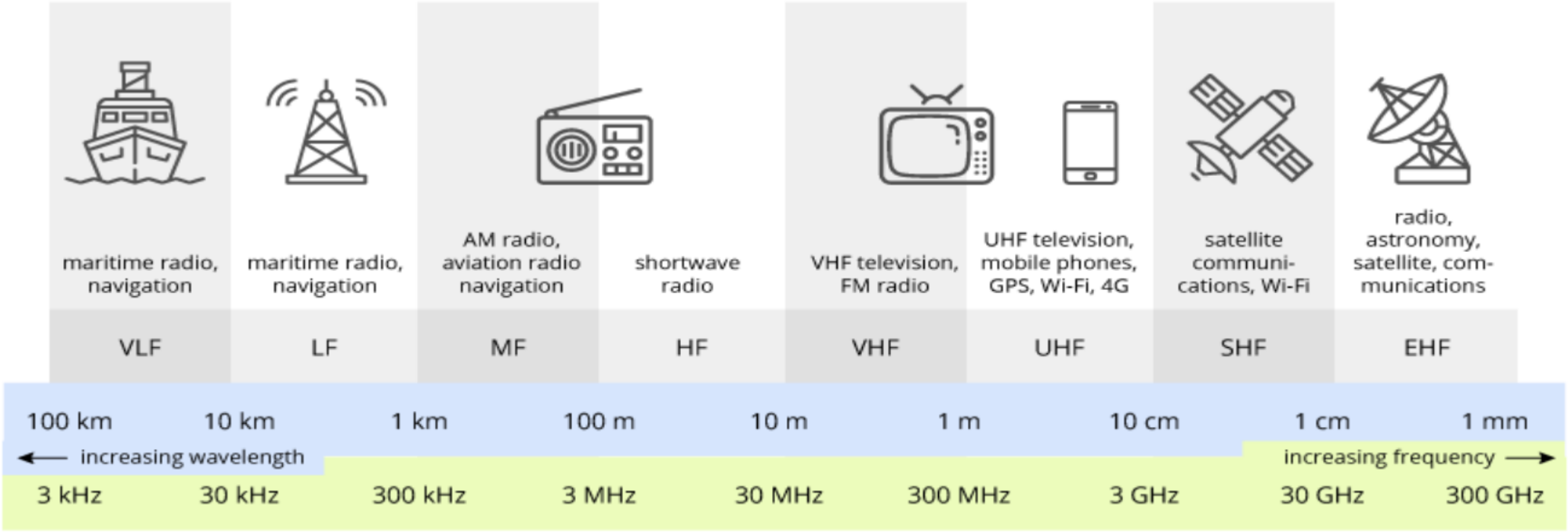
Topics To Covers

- Spectrum Management
- International Telecommunication Union (ITU)
  - ITU-D
  - ITU-T
  - ITU-R
- U.S. Spectrum Management
  - NTFA
  - NFAC
- 6G Technology
  - 6G usage and capabilities
  - 6G spectrum

Spectrum management

- **Spectrum management** is the process of regulating the use of [radio frequencies](#).
- frequency range from **10 kHz to 300 GHz.**

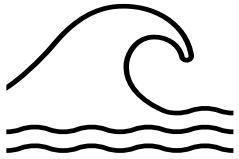


https://www.google.com/url?sa=i&url=https%3A%2F%2Fterasense.com%2Fterahertz-technology%2Fradio-frequency-bands%2F&psig=AOvVaw0uh1QgjwdM0tgRg4UZArmg&ust=1737490876737000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCKj95JaQhYsDFQAAAAAdAAAAABAE

Spectrum management

- Spectrum is **reusable but finite resource**.
- The purpose of spectrum management is to mitigate radio **spectrum pollution**, and maximize the benefit of usable radio spectrum.
- Governments around the world regulate who can use what part of the spectrum in what locations.

Electromagnetic Spectrum



Water

Mineral

Land

Natural Resource

Gas

International Telecommunication Union (ITU)

About ITU

International Telecommunication Union (ITU)

Who They are

- ITU is the United Nations specialized agency for information and communication technologies (ICTs).
- ITU is the oldest agency in the UN family.

What they do

- They allocate global radio spectrum and satellite orbits, develop the technical standards that ensure networks and technologies connect seamlessly.

Why they matter

- Networks and devices everywhere rely on ITU's work.

https://www.itu.int/en/about/Pages/default.aspx

International Telecommunication Union (ITU)

Formation

The ITU was established in **1865** by the name of International Telegraph Union.

In **1934**, it adopted its current name.

Headquarters

The headquarters of the ITU is situated in **Geneva, Switzerland.**

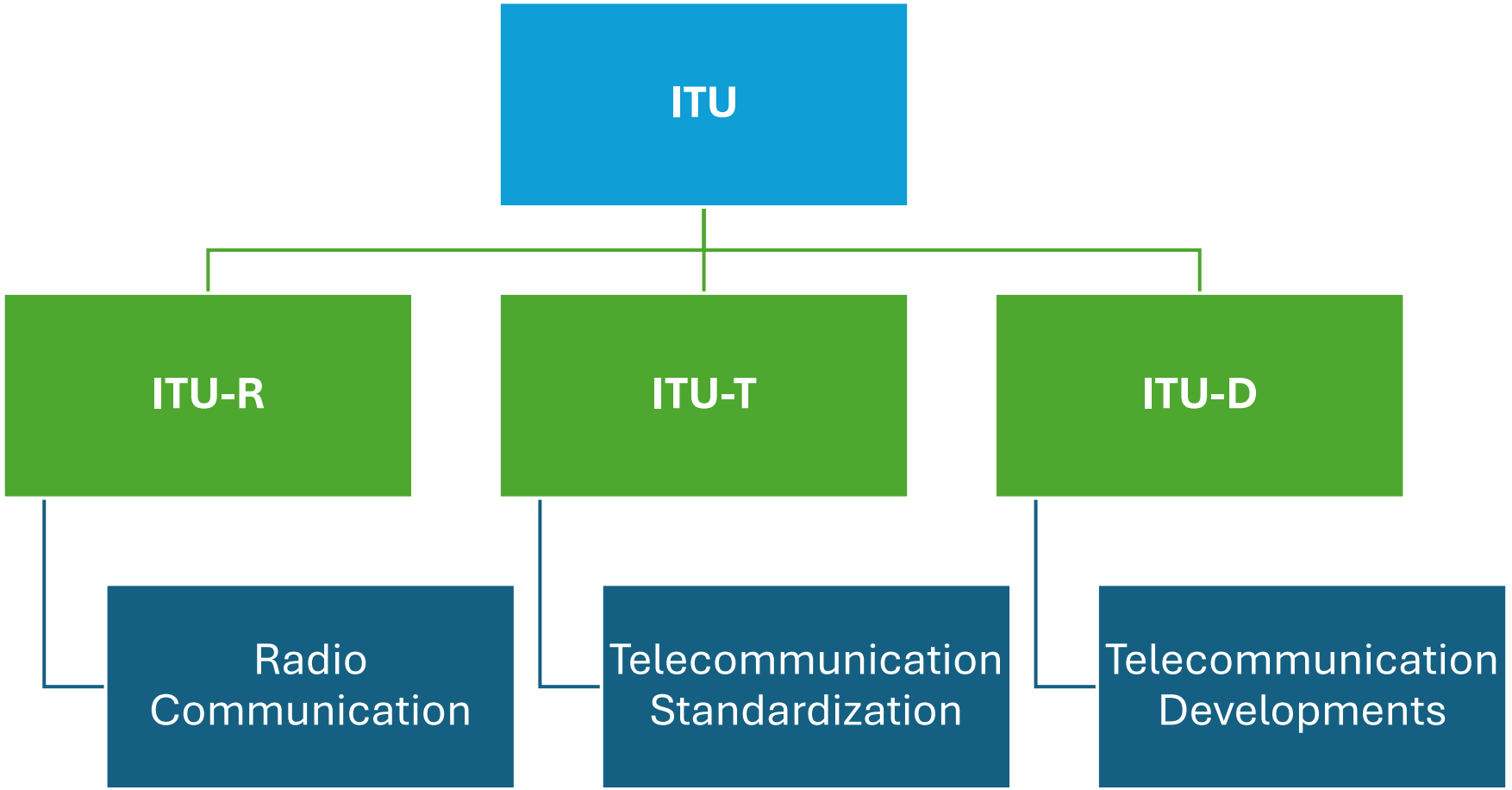
Members

The ITU has 194 member states, including all the member states of the United Nations.

https://commons.wikimedia.org/wiki/Category:International_Telecommun_Union_Headquarters

https://www.itu.int/en/history/Pages/ITUsHistory.aspx

International Telecommunication Union (ITU)



ITU-D Telecommunication Development

- Equitable, sustainable and **affordable** access to information and communication technologies (ICT).
- Creating **policies**, **regulation** and providing **training programs** and **financial strategies** in developing countries.
- The ITU-D hosts the **World Telecommunication Development Conference (WTDC)** every four years.
- Two Study Groups: Enabling Environment for Meaningful connectivity, Digital Transformation.

https://www.itu.int/en/ITU-D/Pages/About.aspx

https://www.itu.int/en/ITU-D/Study-Groups/2022-2025/Pages/default.aspx
https://www.gp-digital.org/the-itu-a-brief-explainer/
https://en.wikipedia.org/wiki/ITU-D

ITU-T Telecommunication Standardization

- It is responsible for coordinating standards for telecommunication and ICT, Known as ITU-Recommendations.
- The ITU-D host the World Telecommunication Standardization Assembly.
- The technical work, the development of Recommendations, of ITU-T is managed by Study Groups (SGs). There are currently **11 SGs.**
  - **SG11 - Protocols, testing & combating counterfeiting**
  - **SG12 - Performance, QoS & QoE**
  - **SG13 - Future networks**
  - **SG17 - Security**

https://en.wikipedia.org/wiki/ITU-T#cite_note-4
https://www.itu.int/en/ITU-T/about/Pages/default.aspx
https://www.itu.int/wtsa/2024/
https://www.itu.int/en/ITU-T/studygroups/2025-2028/Pages/default.aspx

ITU-R Radio Communication

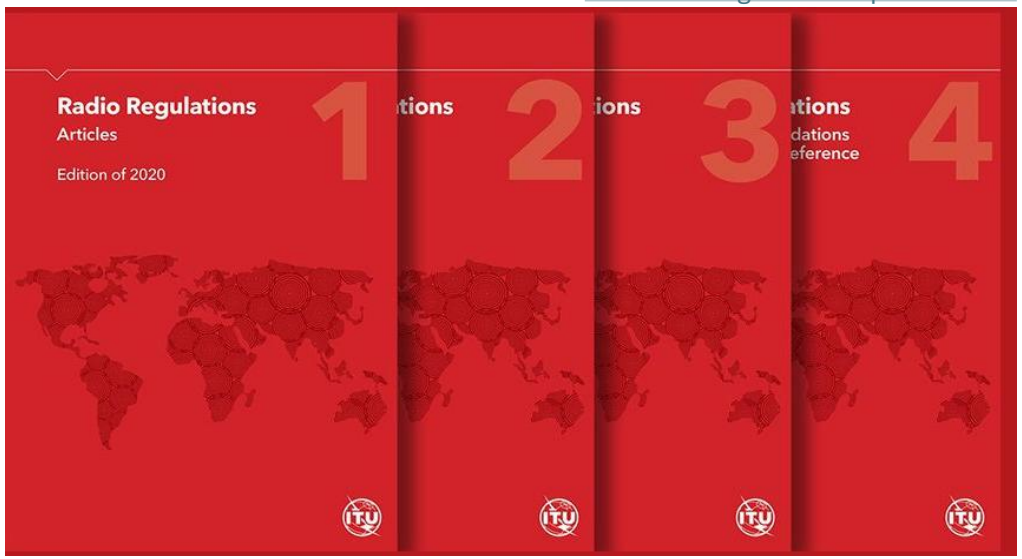
- ITU-R defines and manages the international regulatory framework for the **use of spectrum and satellite orbits.**
- Develop standards for **radiocommunication systems**.(ITU-R recommendations)
- Each member country submits its proposal of spectrum allocation to ITU. After deliberate discussions on the received proposal in the meeting of all country members, decision are taken for opening of bands.
- 6 Study groups:
  - **SG1: Spectrum management**
  - **SG4: Satellite Services**
  - **SG5: Terrestrial Services**

https://www.itu.int/en/ITU-R/Pages/default.aspx
https://en.wikipedia.org/wiki/ITU-R
Radiocommunication Study Groups

World Radiocommunication Conference (WRC)

- The WRC is organized by ITU-R and held typically every 3 to 4 years in Geneva.
- It allocates frequency bands to different applications, including mobile cellular communication (the business of 3GPP), which is called **International Mobile Telecommunication (IMT)** by ITU.
- The **Radio Regulations (RR)** incorporate the decisions of the WRCs.

ITU Radio Regulations updated - ITU



World Radiocommunication Conferences (WRC)
ITU World Radiocommunication Conference 2023 opens in Dubai, UAE – IEEE ComSoc Technology Blog

ITU World Radiocommunication Conference 2023 opens in Dubai, UAE – IEEE ComSoc Technology Blog

Master International Frequency Register (MIFR)

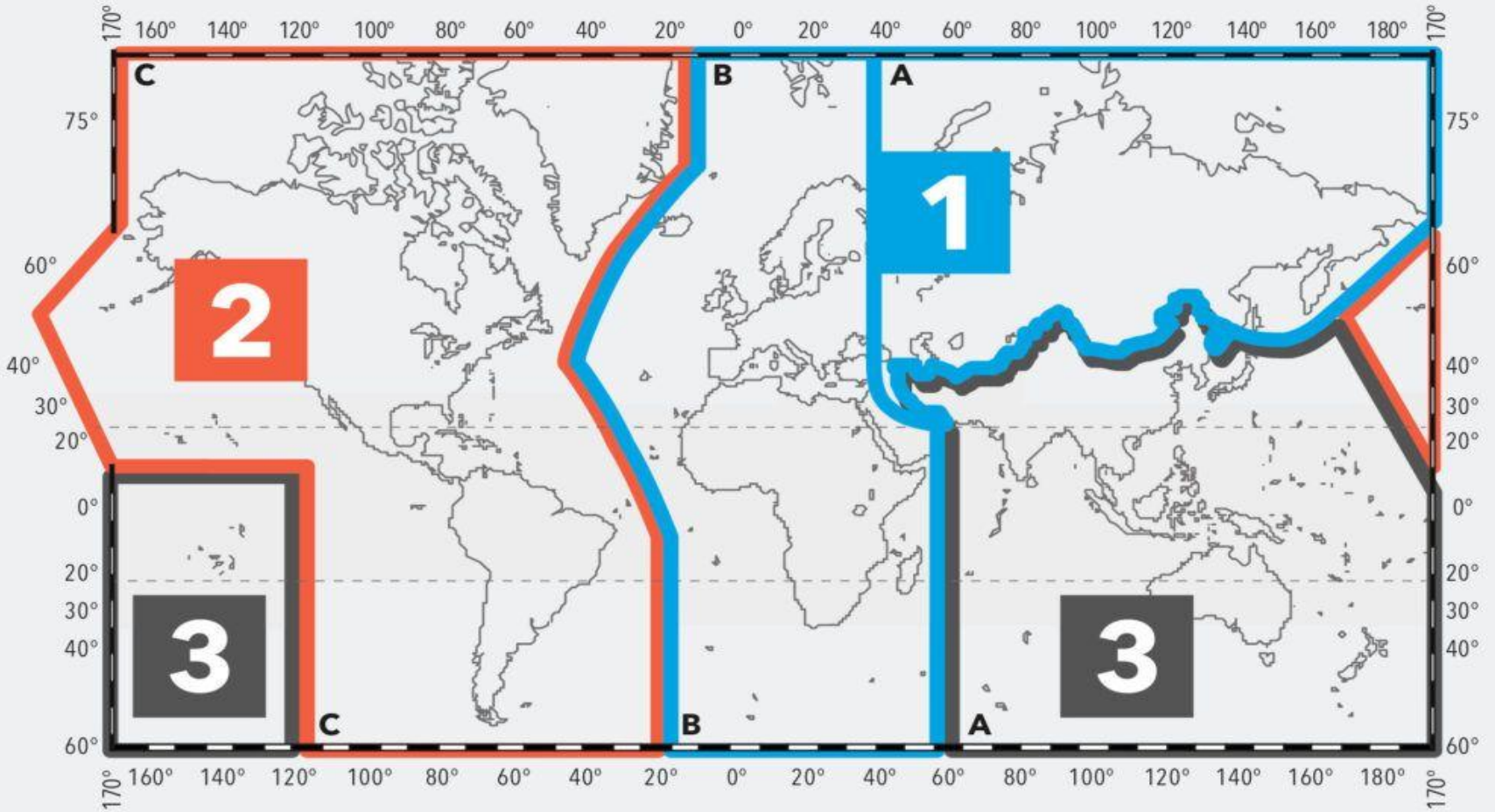
- Containing all **registered frequency assignments.**
- Contains database of **satellite and terrestrial** frequency assignments.
- Recording in the MIFR is the final stage of the frequency coordination process.
- Confers international recognition and **protection from interference.**

https://www.itu.int/hub/2023/07/keeping-interference-in-check-seven-decades-of-itus-radio-frequency-circular/

Master International Frequency Register (MIFR)
https://ustti.org/wp-content/uploads/2019/11/Day-1-4_RR-and-allocations-table_20190903.pdf

ITU-R Regions

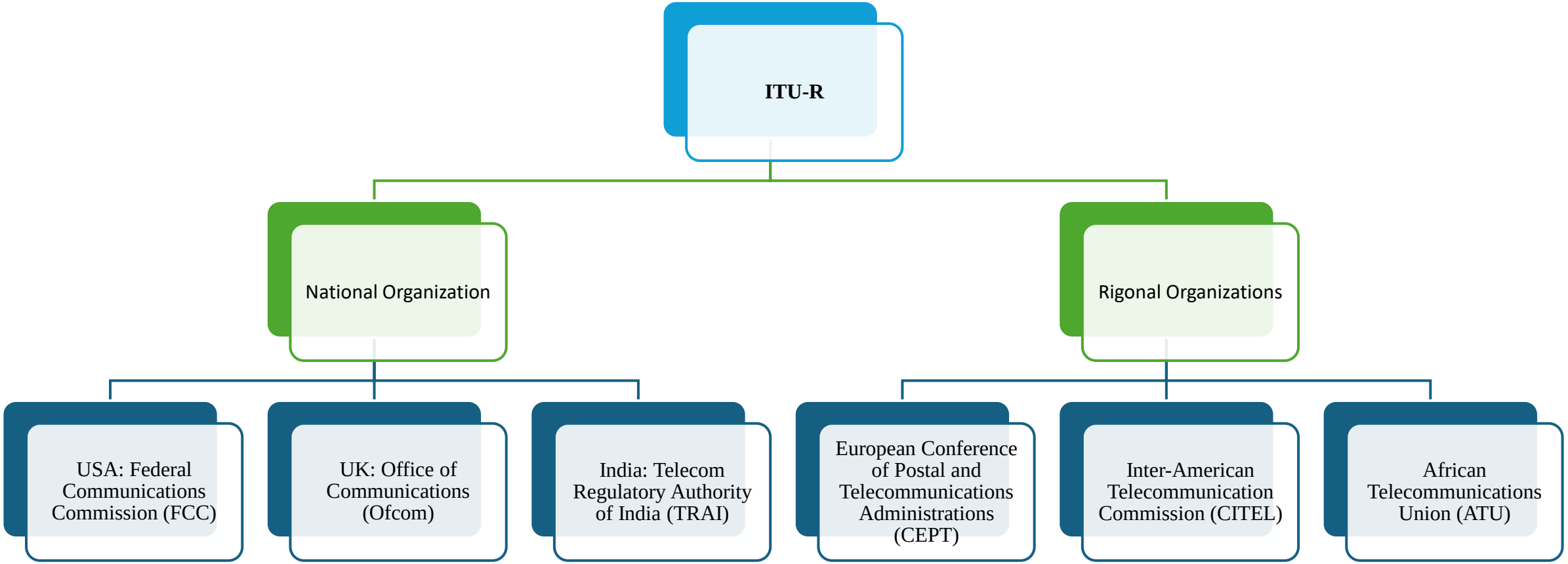
- The Radio Regulations, divides the world into three **ITU regions** for the purposes of managing the global radio spectrum.



https://www.itu.int/en/ITU-R/information/Pages/emergency-bands.aspx

https://www.itu.int/hub/2024/06/itu-helps-countries-achieve-robust-radio-frequency-planning/

ITU-R Radio Communication



U.S. Spectrum Management

- NTIA and FCC Jointly Manage Radio Spectrum in the U.S.
  FCC = Federal Communications Commission
  NTIA = National Telecommunications and Information Administration

National Spectrum Management

Communication ACT OF 1934

The Congress

FCC

Non-Federal Users

Business
State & Local Government
Commercial and Entertainment
Private

Interdepartment Radio Advisory Committee (IRAC)

Chaired by NTIA. Representative from 19 federal Agencies

https://www.ntia.gov/book-page/who-regulates-spectrum
https://www.fcc.gov/engineering-technology/policy-and-rules-division/general/radio-spectrum-allocation?utm_source=chatgpt.com

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NTIA
Federal Users
National Defense Law Enforcement & Security Transportation Resource Mgmt. & Control Emergencies

FCC
Non-Federal Users
Business State & Local Government Commercial Private

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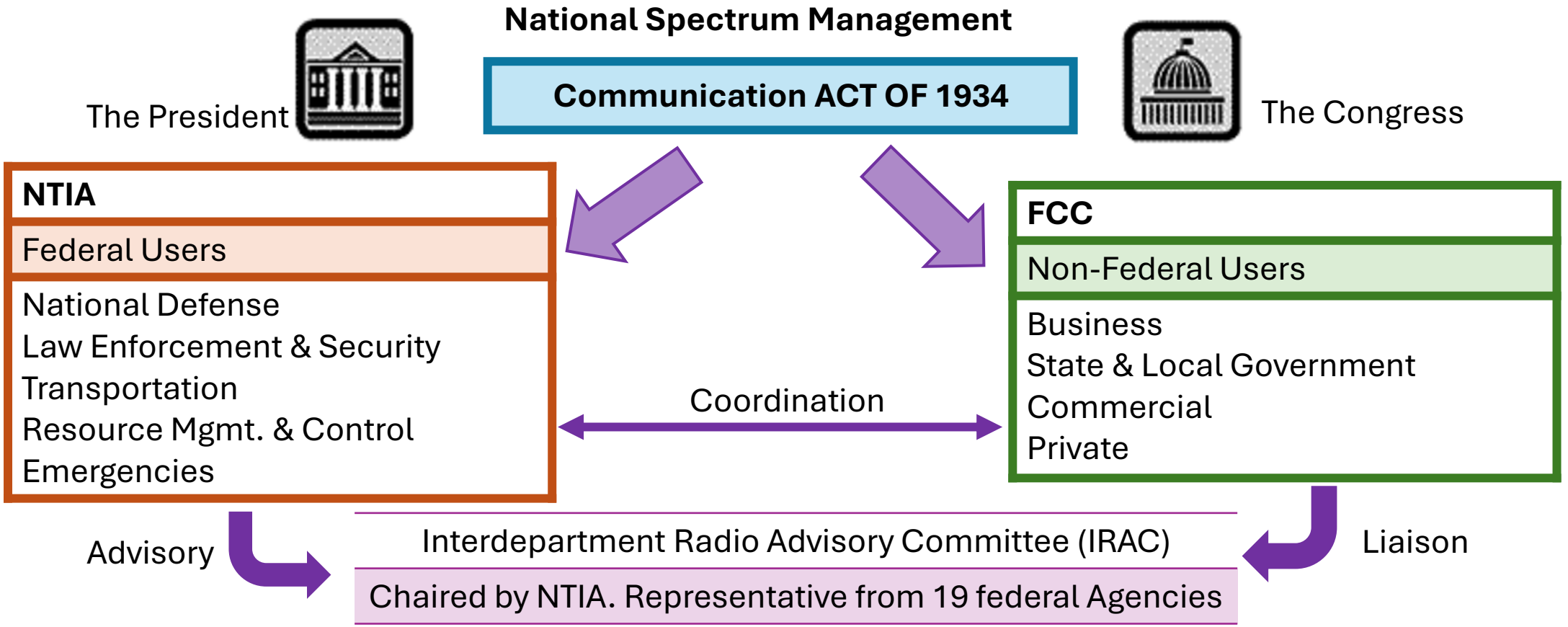

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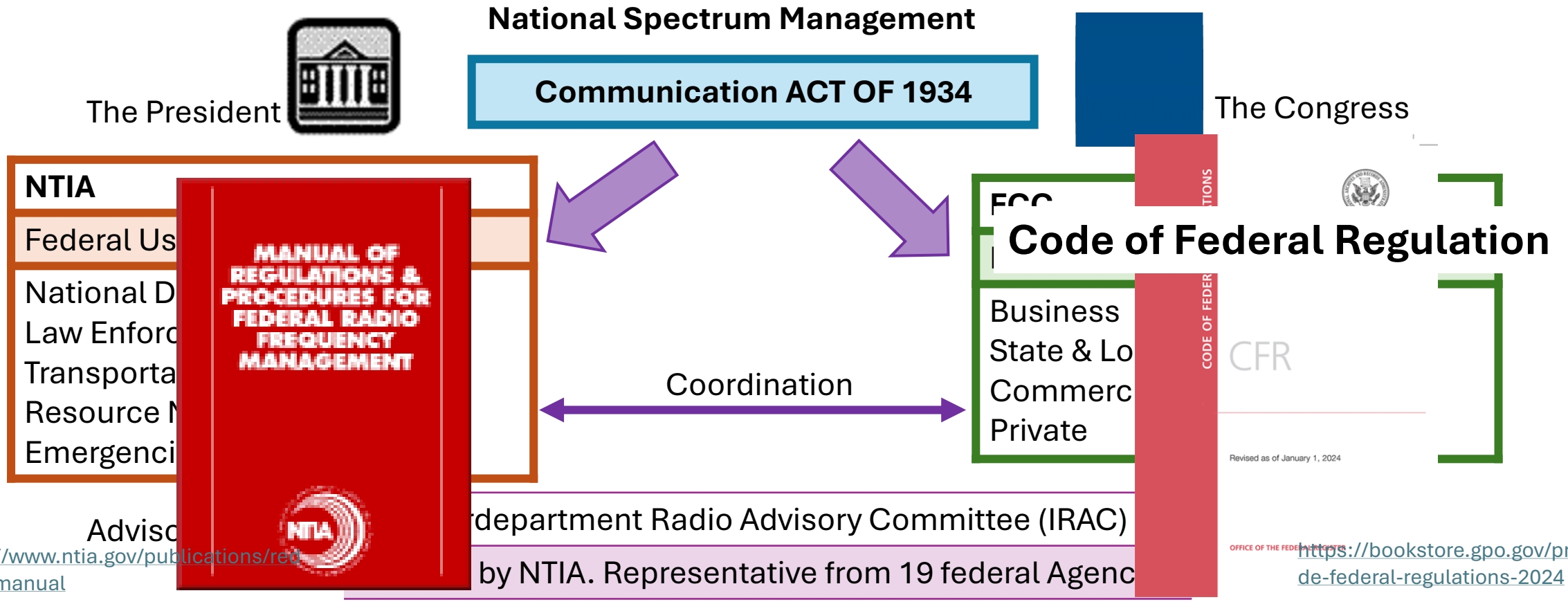

https://www.ntia.gov/publications/red book-manual

https://bookstore.gpo.gov/products/code-federal-regulations-2024

National Table of Frequency Allocations (NTFA)

Table of Frequency Allocations	941-1525 MHz (UHF)				Page 31
International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
(See previous page)	(See previous page)	(See previous page)	941-944	941-944	
942-960 FIXED MOBILE except aeronautical mobile 5.317A BROADCASTING 5.322 5.323	942-960 FIXED MOBILE 5.317A	942-960 FIXED MOBILE 5.317A BROADCASTING 5.320	FIXED US268 US301 G2 944-960	FIXED US268 US301 NG30 NG120 944-960 FIXED NG120	Public Mobile (22) Aural Broadcast Auxiliary (74E) Fixed Microwave (101) Public Mobile (22) Aural Broadcast Auxiliary (74E) Low Power Auxiliary (74H) Fixed Microwave (101)
960-1164 AERONAUTICAL MOBILE (R) 5.327A AERONAUTICAL RADIONAVIGATION 5.328			960-1164 AERONAUTICAL RADIONAVIGATION 5.328 US224 US400		Aviation (87)
1164-1215 AERONAUTICAL RADIONAVIGATION 5.328 RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328B 5.328A			1164-1215 AERONAUTICAL RADIONAVIGATION 5.328 RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328A US224		
1215-1240 EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328B 5.329 5.329A SPACE RESEARCH (active) 5.330 5.331 5.332			1215-1240 EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION G56 RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) G132 SPACE RESEARCH (active) 5.332	1215-1240 Earth exploration-satellite (active) Space research (active)	
1240-1300 EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328B 5.329 5.329A SPACE RESEARCH (active) Amateur 5.282 5.330 5.331 5.332 5.335 5.335A			1240-1300 EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION G56 SPACE RESEARCH (active) AERONAUTICAL RADIONAVIGATION 5.332 5.335	1240-1300 AERONAUTICAL RADIONAVIGATION Amateur Earth exploration-satellite (active) Space research (active) 5.282	Amateur Radio (97)
1300-1350 RADIOLOCATION AERONAUTICAL RADIONAVIGATION 5.337 RADIONAVIGATION-SATELLITE (Earth-to-space) 5.149 5.337A			1300-1350 AERONAUTICAL RADIONAVIGATION 5.337 Radiolocation G2 US342	1300-1350 AERONAUTICAL RADIONAVIGATION 5.337 US342	Aviation (87)
1350-1400 FIXED MOBILE RADIOLOCATION	1350-1400 RADIOLOCATION 5.338A		1350-1390 FIXED MOBILE RADIOLOCATION G2 5.334 5.339 US342 US385 G27 G114	1350-1390 5.334 5.339 US342 US385	

https://transition.fcc.gov/oet/spectrum/table/fcctable.pdf

National Table of Frequency Allocations (NTFA)

- National tables should be updated within the same cycle as WRC.
- They are key for spectrum management at the national level and should be updated regularly to align with the latest version of the Radio Regulations.
- includes frequency allocations at global and regional levels

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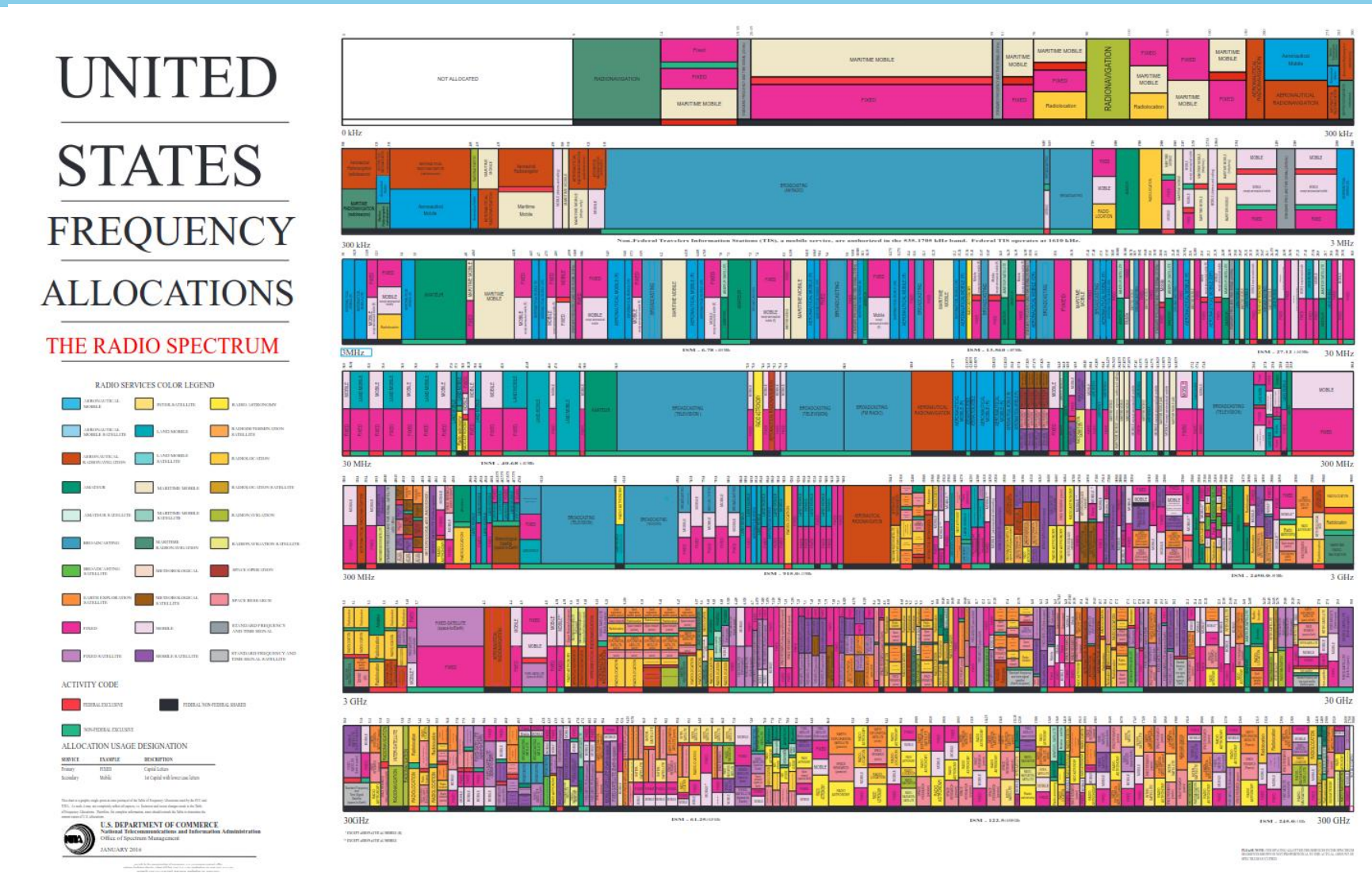
National Frequency Allocation Chart (NFAC)



https://www.ntia.gov/page/united-states-frequency-allocation-chart

National Frequency Allocation Chart (NFAC)

- **Frequency Bands**: The chart divides the radio spectrum into frequency bands, typically ranging from a few kilohertz (kHz) to terahertz (THz).

LF (0-300 kHz)

MF (300 kHz - 3 MHz)

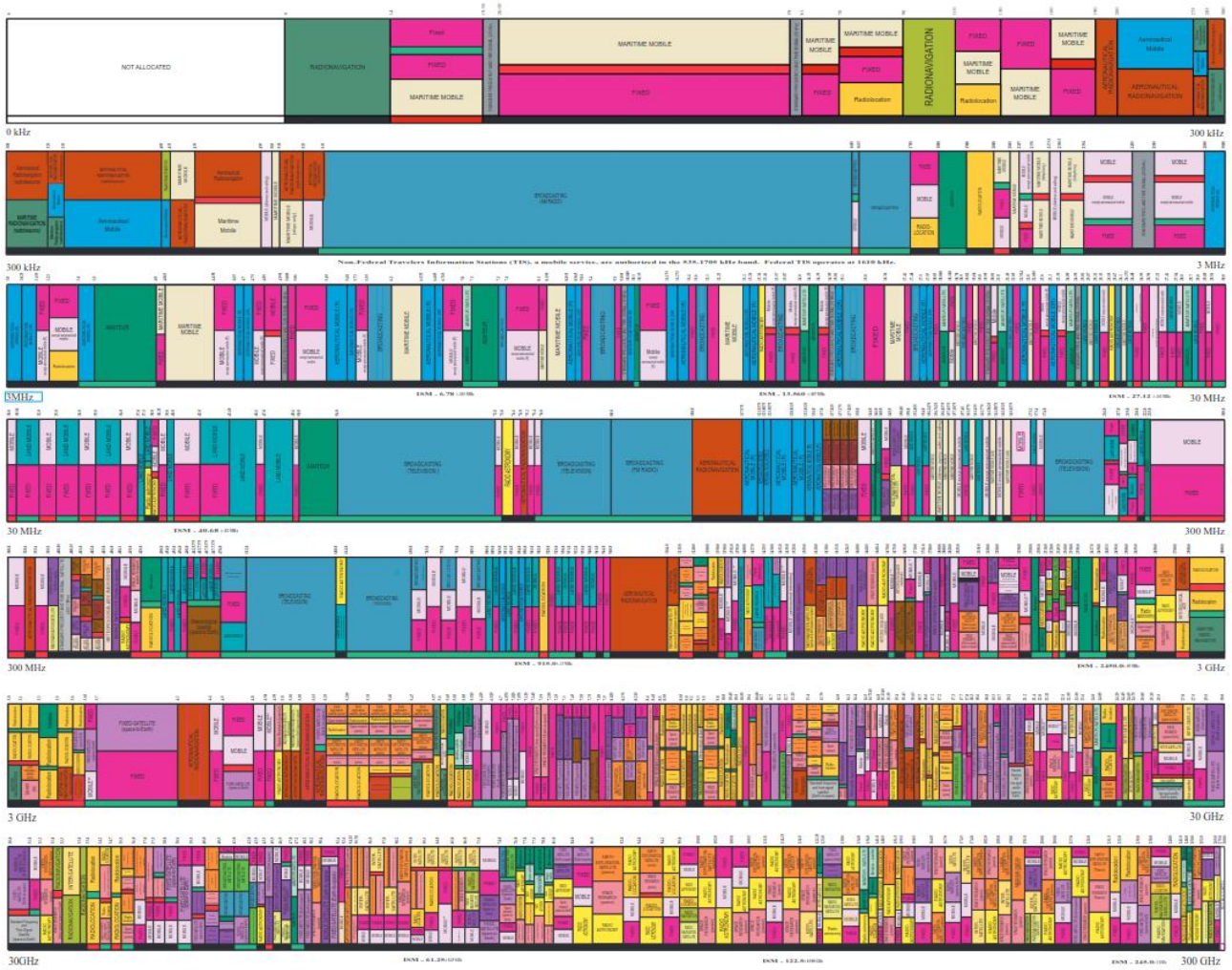
HF (3MHz – 30 MHz)

VHF (30 MHz – 300 MHz)

UHF (300 MHz- 3 GHz)

SHF (3 GHz – 30 GHz)

EHF (30 GHz – 300 GHz)



National Frequency Allocation Chart (NFAC)

- **Allocated Services**: Each frequency band is assigned to specific services or applications.

ACTIVITY CODE

- FEDERAL EXCLUSIVE
- FEDERAL/NON-FEDERAL SHARED
- NON-FEDERAL EXCLUSIVE

ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with lower case letters

RADIO SERVICES COLOR LEGEND

- AERONAUTICAL MOBILE
- AERONAUTICAL MOBILE SATELLITE
- AERONAUTICAL RADIONAVIGATION
- AMATEUR
- AMATEUR SATELLITE
- BROADCASTING
- BROADCASTING SATELLITE
- EARTH EXPLORATION SATELLITE
- FIXED
- FIXED SATELLITE
- INTER-SATELLITE
- LAND MOBILE
- LAND MOBILE SATELLITE
- MARITIME MOBILE
- MARITIME MOBILE SATELLITE
- MARITIME RADIONAVIGATION
- METEOROLOGICAL
- METEOROLOGICAL SATELLITE
- MOBILE
- MOBILE SATELLITE
- RADIO ASTRONOMY
- RADIODETERMINATION SATELLITE
- RADIOLOCATION
- RADIOLOCATION SATELLITE
- RADIONAVIGATION
- RADIONAVIGATION SATELLITE
- SPACE OPERATION
- SPACE RESEARCH
- STANDARD FREQUENCY AND TIME SIGNAL
- STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

National Frequency Allocation Chart (NFAC)

ACTIVITY CODE

FEDERAL EXCLUSIVE

FEDERAL/NON-FEDERAL SHARED

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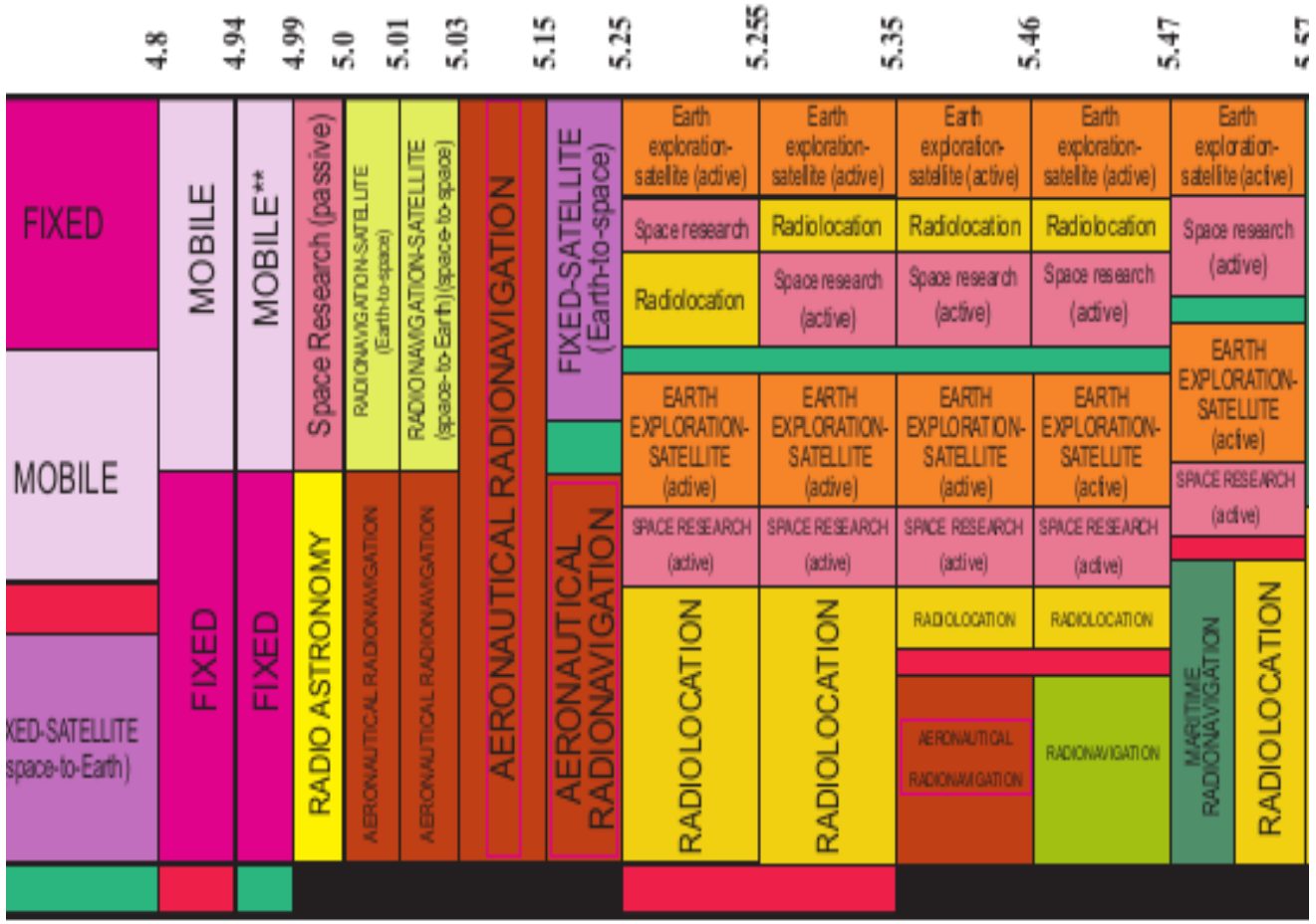


Licensed and unlicensed band

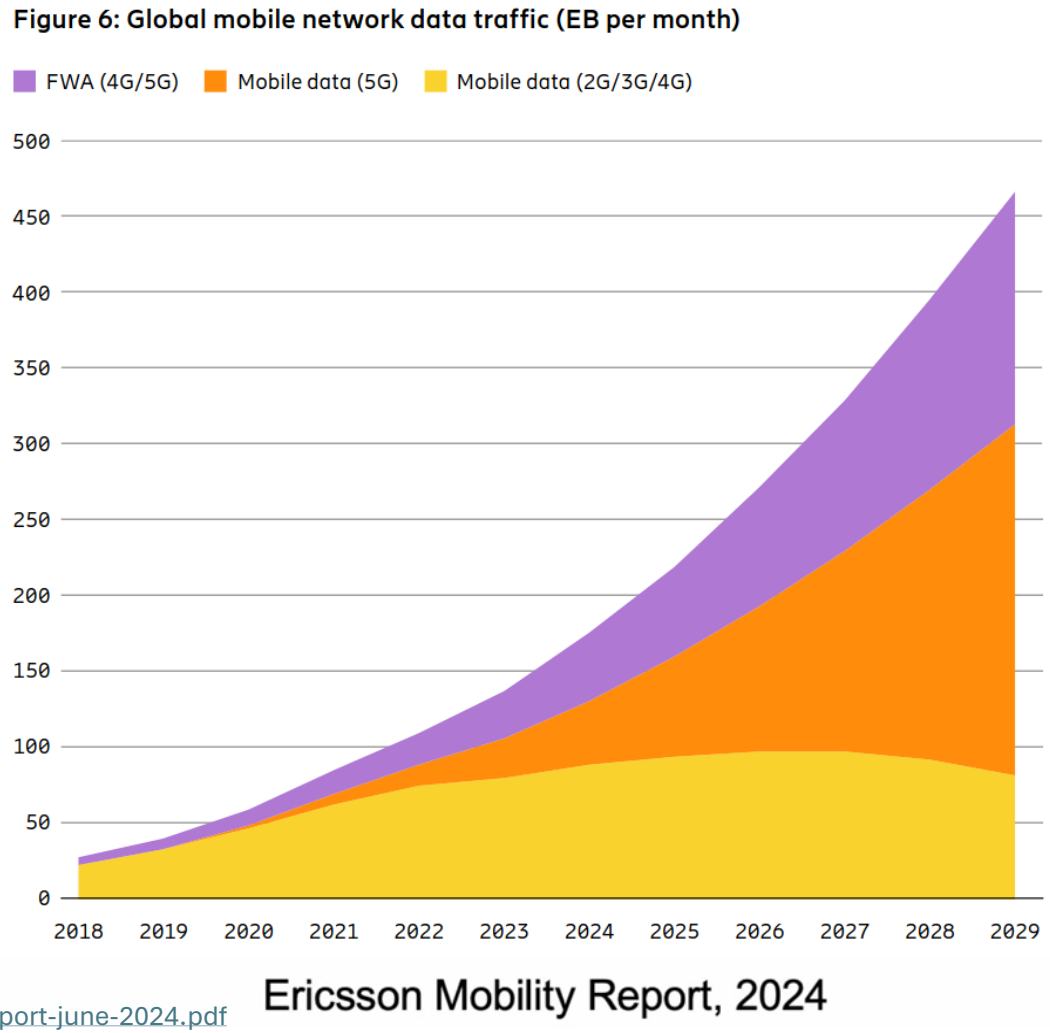
Aspect	Licensed Spectrum	Unlicensed Spectrum
Access	Exclusive access granted to specific users	Open for anyone to use
Cost	Requires a fee for rights	No licensing fee, but usage rules apply
Usage Examples	Cellular networks, TV and radio broadcasting	Wi-Fi, Bluetooth, IoT devices
Interference Management	Well-managed with minimal interference	Shared usage, potential for interference

6 Generation Technology

Generated by ChatGPT

The need for 6G: Network Capacity Growth

- From the latest Ericsson Mobility Report (EMR):
  - Monthly data traffic per smartphone in North America increased: 13Gb to 20Gb (+54%) from 2021 to 2022 and is expected to triple (to 58Gb) by 2028.
  - In those same periods, total monthly mobile traffic (all device types) increased from 4.6 to 6.7 Exabytes (EB) (+46%) and will increase to 21EB (21% CAGR)



https://www.ericsson.com/49ed78/assets/local/reports-papers/mobility-report/documents/2024/ericsson-mobility-report-june-2024.pdf
https://www.fcc.gov/sites/default/files/Consolidated_6G_Paper_FCCTAC23_Final_for_Web.pdf