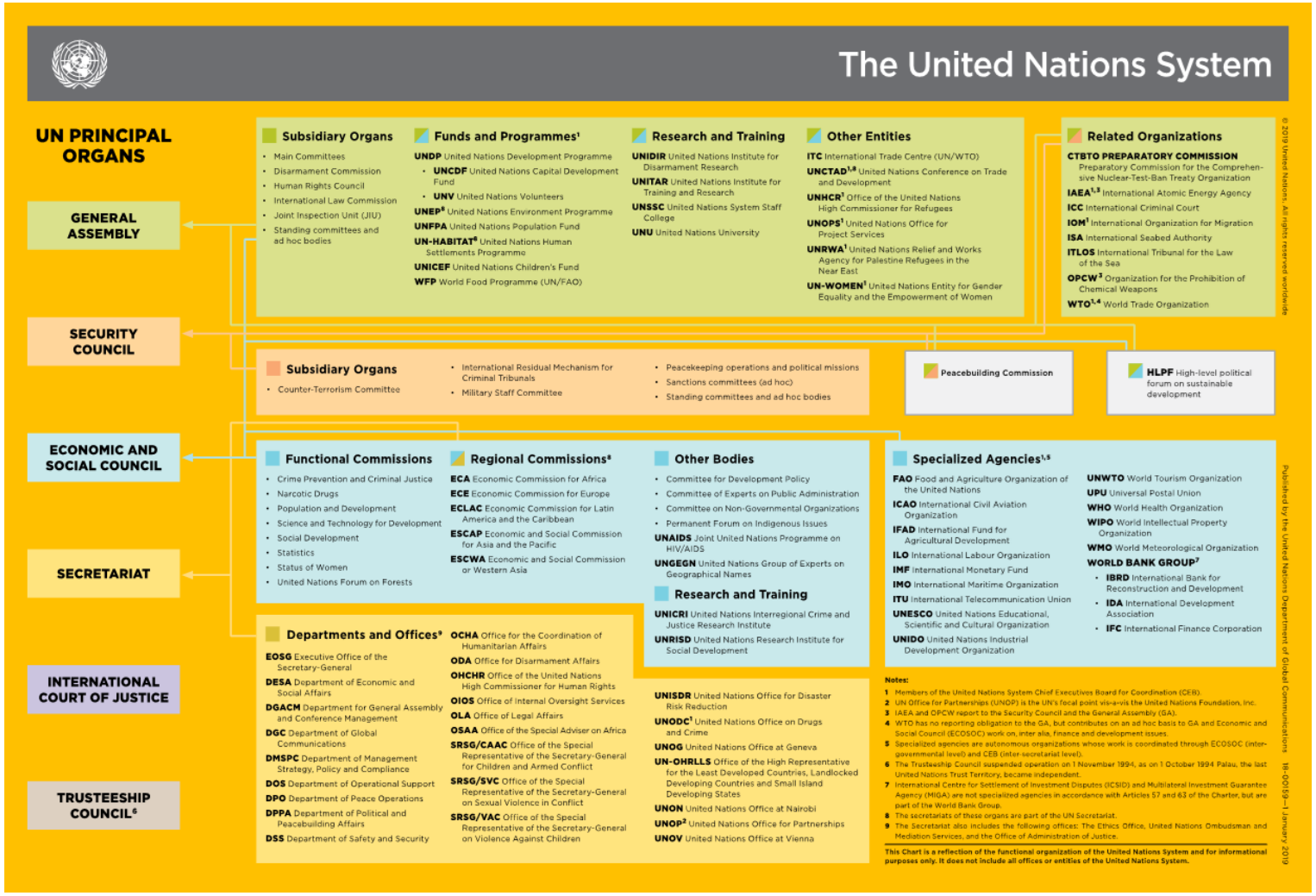
International spectrum management system

ITU seminar on Science Services in relation to ITU Radio Regulations and WRC-27
Cyberjaya, Selangor, Malaysia – 9-10 December 2025

Dr Vadim Nozdrin, Counselor of Study Groups, Radiocommunication Bureau

ITU – UN specialised agency

- Since 1865
- Since 1947 UN agency
- 194 Member States
- 1 000 Sectors Members
- 100 Academies
- 600 employees
- HQ in Geneva
- 12 regional offices

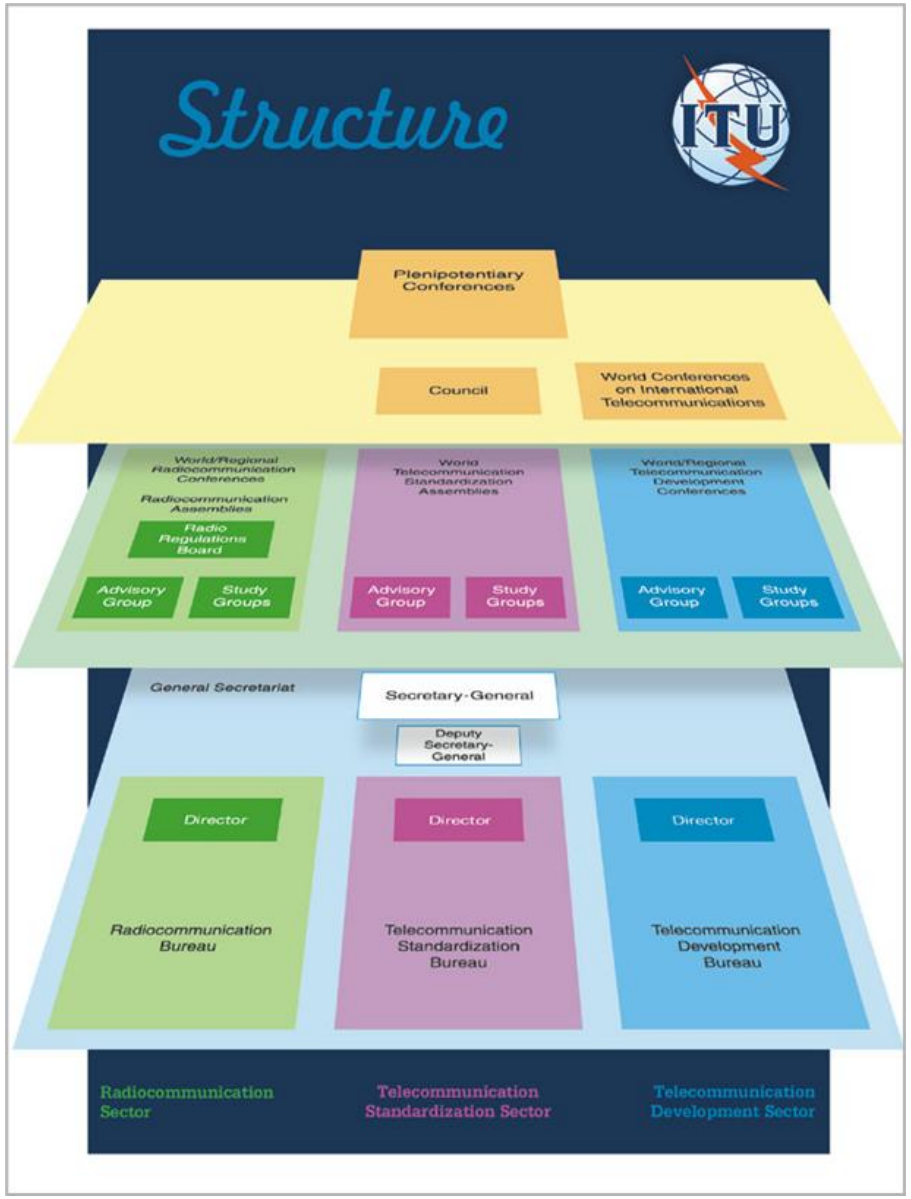


ITU overview

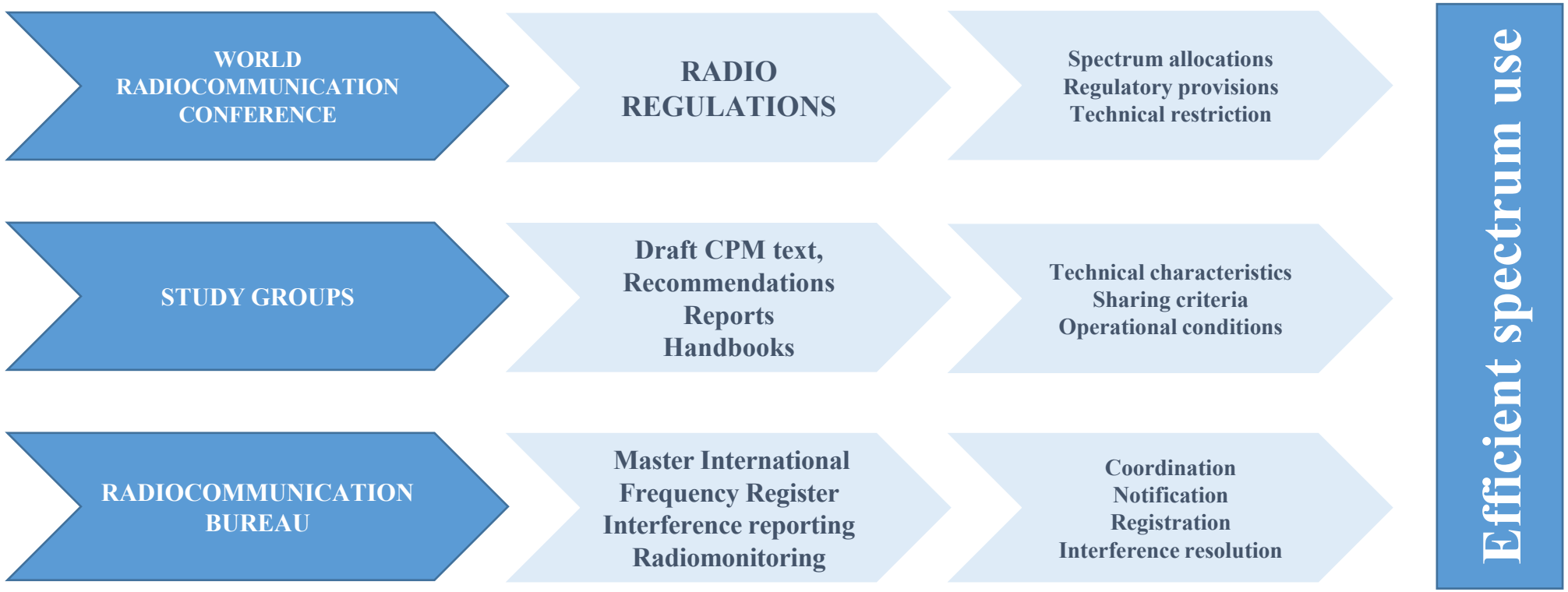
✓***ITU-R*** Radio standards and spectrum management

✓***ITU-T*** Telecom standards, interoperability, network architecture, quality of service, security, numbering, tariffs, EMF, CO, power consumption

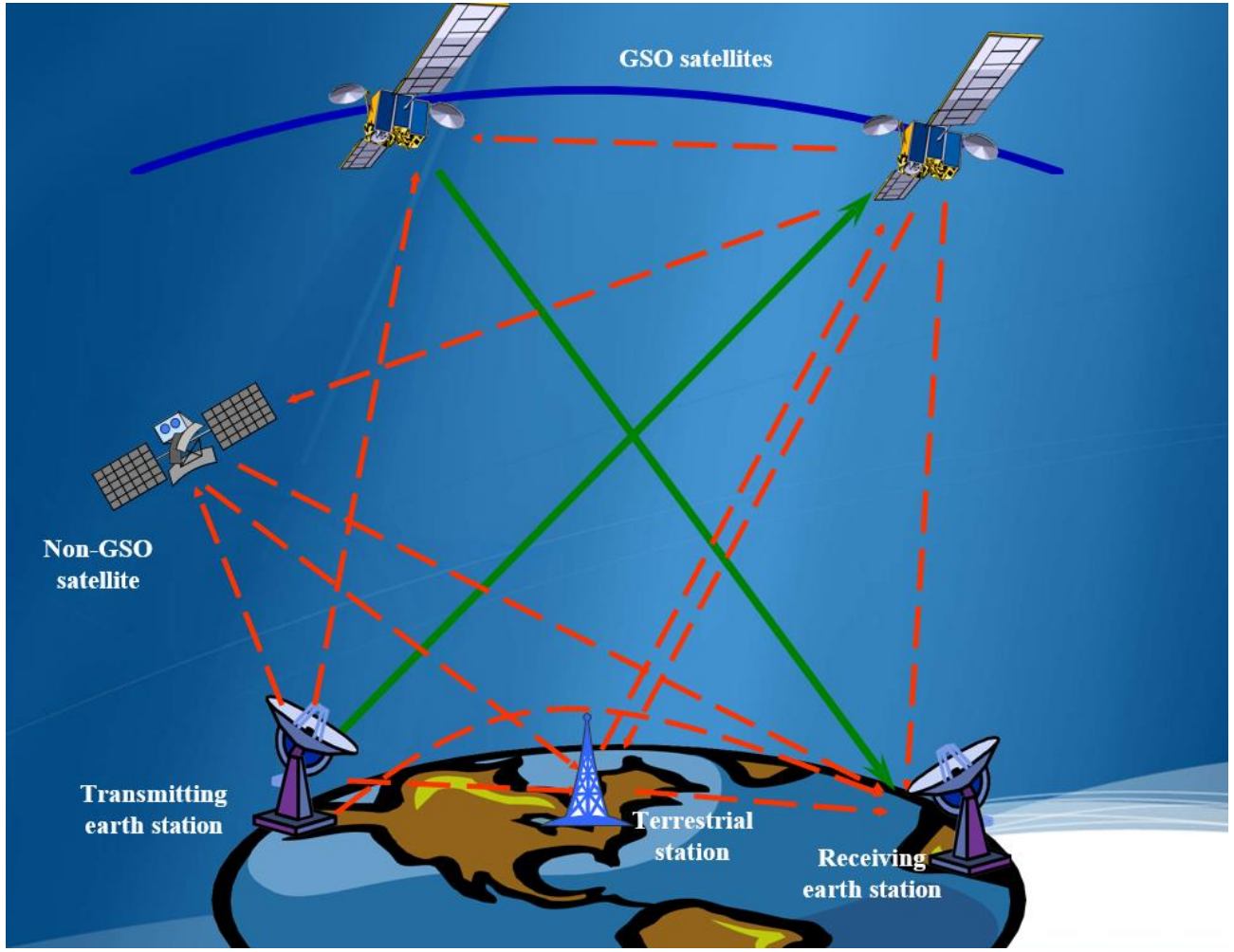
✓***ITU-D*** Assisting telecom projects in developing countries: foster the development of infrastructure and services, digital transformation, resource mobilisation



ITU-R: Radiocommunication Sector



Interference

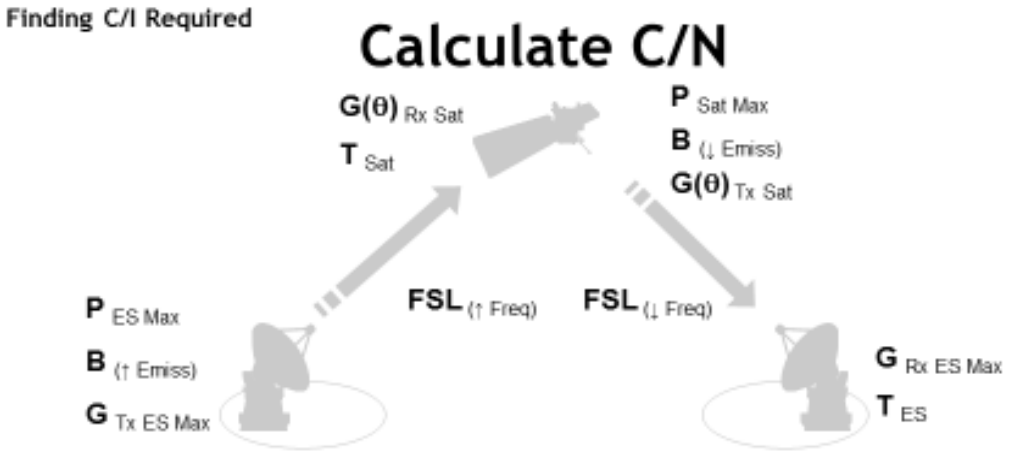


Interference free operation

Harmful interference-effect of unwanted energy due to emission upon reception, manifested in any performance degradation

Spectrum sharing conditions

Radio link budget



P_{max} – average power supplied to the antenna transmission line under normal operating conditions

B- for a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions

G- the ratio of the power required at the input of a loss free reference antenna to the power supplied to the input of the given antenna to produce, in given direction, the same fiel strength at the same distance

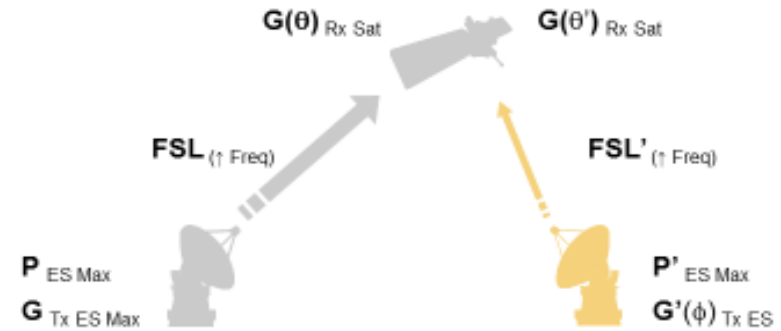
T- temperature of a hypothetical resistor at the input of an ideal noise-free receiver that would generate the same output noise power per unit bandwidth as that at the antenna output at a specified frequency.

Interference

Protection ratio- minimum value of the wanted-unwanted signal ratio, at the receiver input, determined under specified conditions such that specified reception quality of the wanted signal is achieved at the receiver output

Finding C/I

Calculate C/I basic

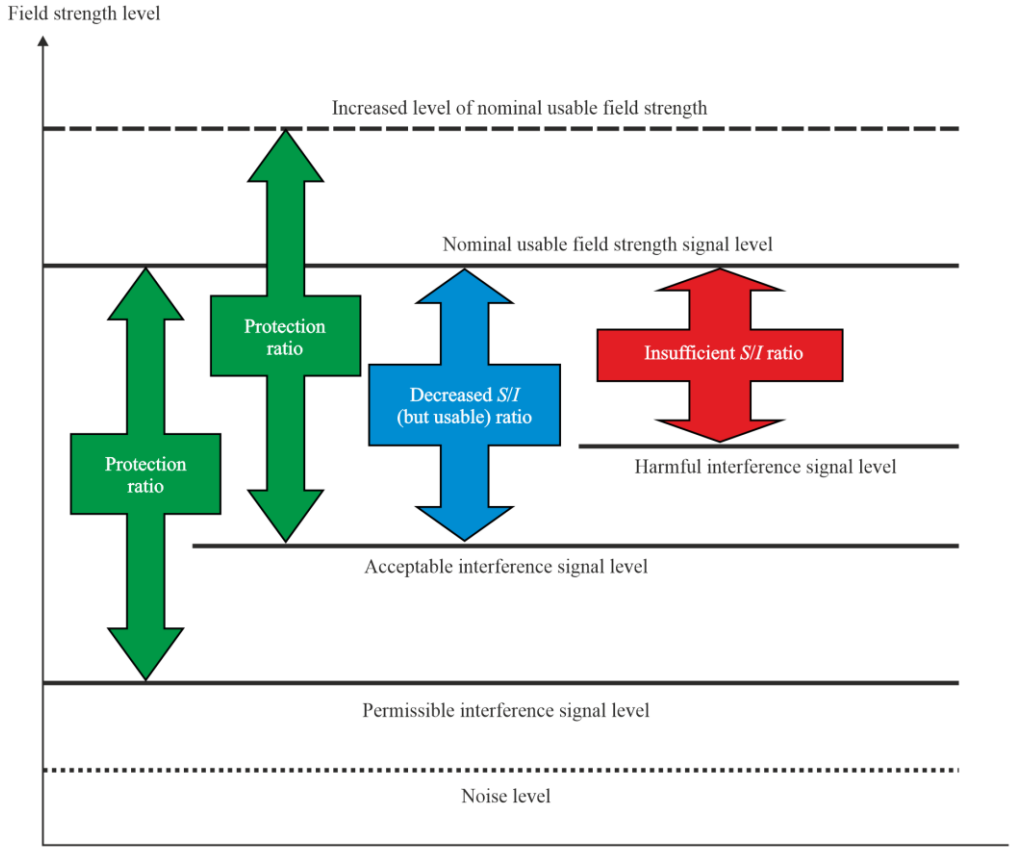


$$C\uparrow = P_{ES\ Max} + G_{Tx\ ES\ Max} + G(\theta)_{Rx\ Sat} - FSL_{(\uparrow Freq)}\ (dBW)$$

$$I\uparrow = P'_{ES\ Max} + G'(\phi)_{Tx\ ES} + G(\theta')_{Rx\ Sat} - FSL'_{(\uparrow Freq)}\ (dBW)$$

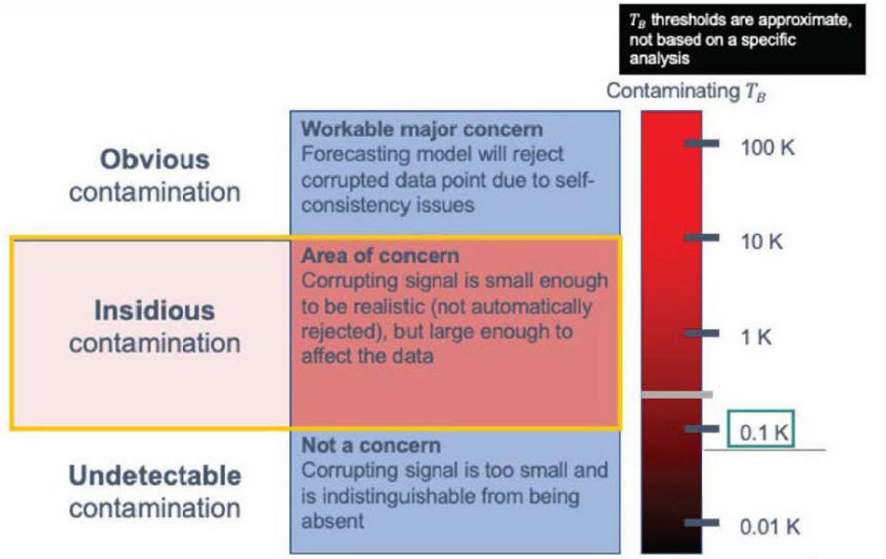
$$C/I\uparrow = C\uparrow - I\uparrow\ (dB)$$

22 Source: ITU-R S.740



Interference

- **Degradation of Quality of Service**
- Some new radio technologies are more sensitive to interference or more interference aggressive than traditional systems —**out of service umbrella**
- **Late comer costs** – increasing CAPEX (bigger antenna size, restricted parameters, more expensive equipment, shielding, specialised software) and OPEX (more qualified staff, advanced signal processing methods, more power, coordination requirements) —**uncertainty of investments**
- Growing trend of ignoring RR requirements, **resulting in RFI**

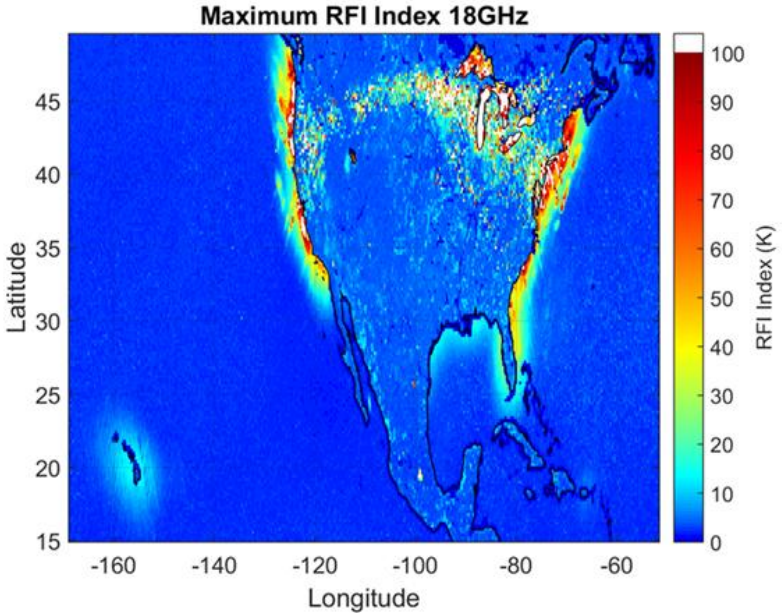


Source: Testimony by David Lubar to U.S. House of Representatives; Hearing of the Science, Space & Technology Committee, July 2021.

The received energy from Voyager, if integrated for 10 trillion years, would be just enough to power a refrigerator light bulb for one second! (F. Manshadi)

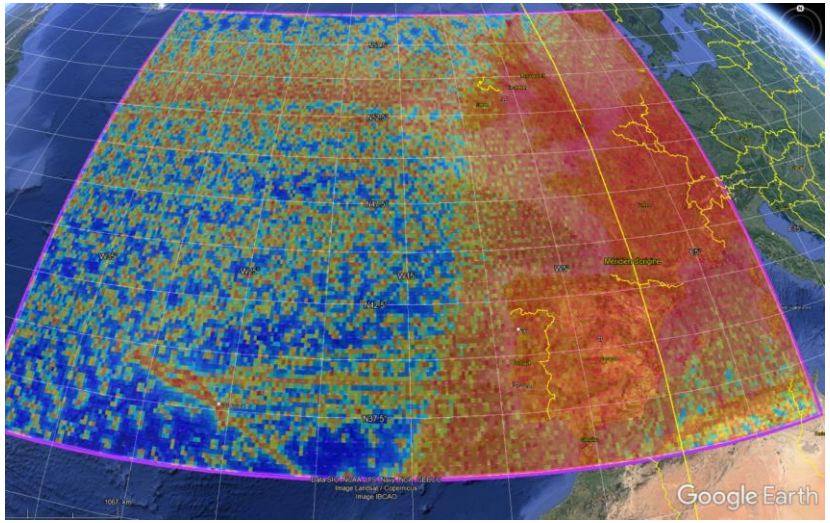
Interference

New interference scenarios



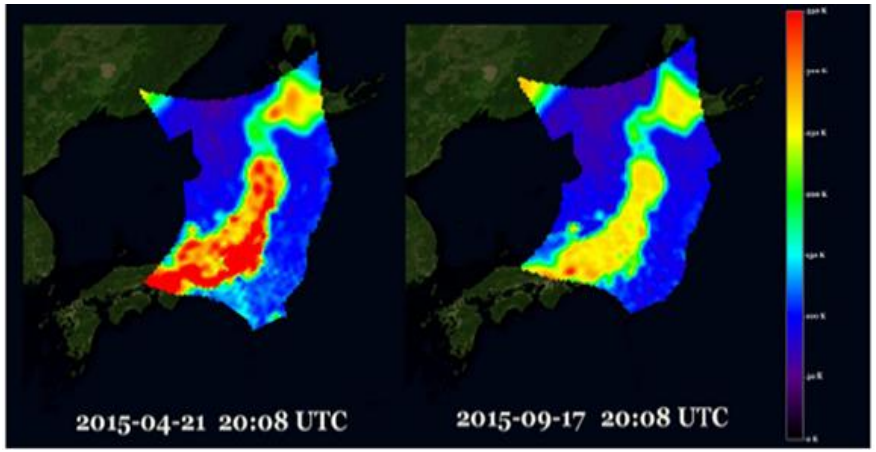
Reflection (18.6-18.8 GHz)
Water vapour profile, precipitation, clouds, snow, ice, sea surface wind

New radio applications



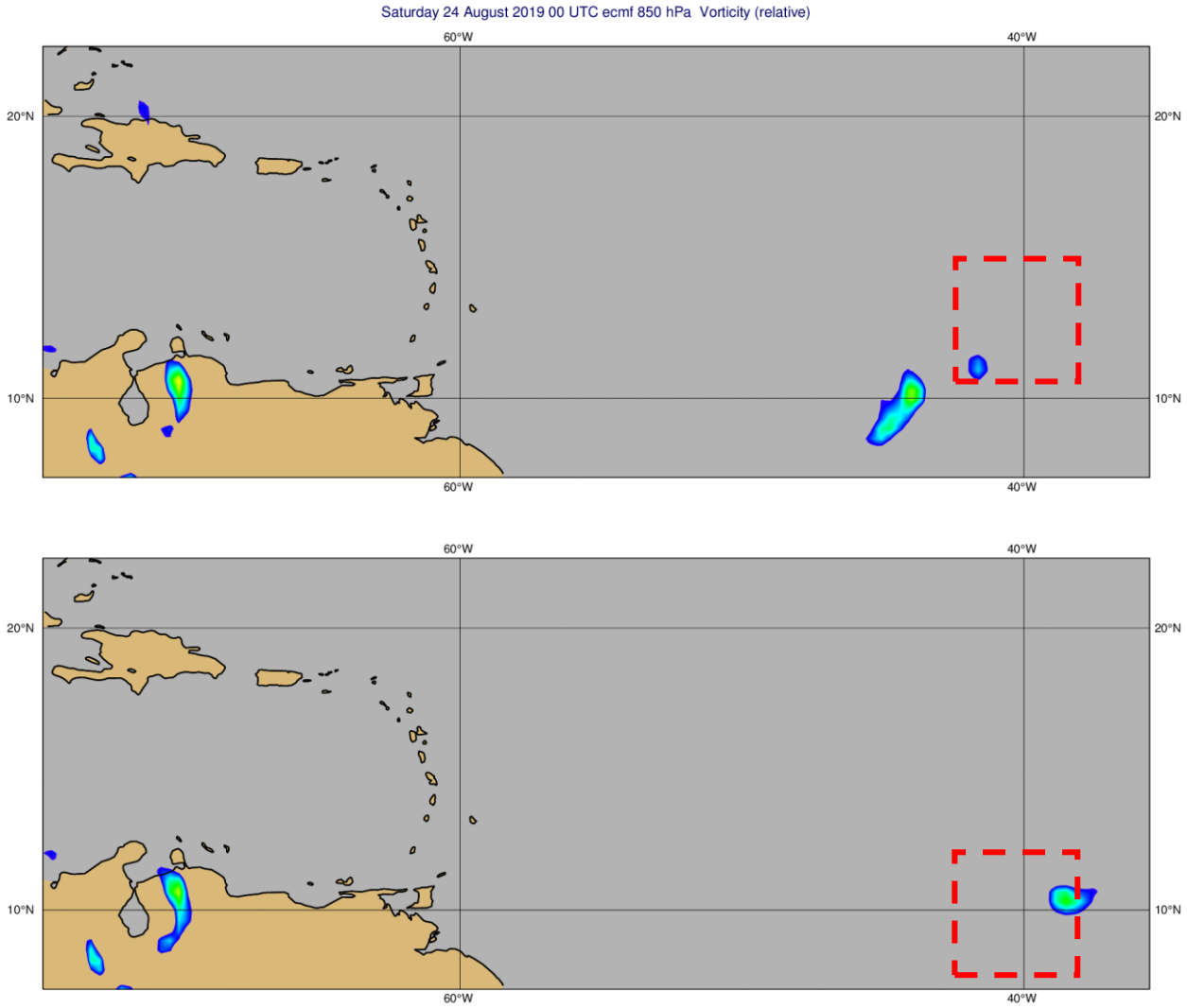
WAIC (4 200-4 400 MHz)
Sea surface temperature

Non-compliance with regulations



TV sat receivers (1 400-1 427 MHz)
Ocean salinity

Interference



Dorian genesis to landfall on Windward Islands

Control system with satellites identifies storm genesis on 24 August and provides 4 days warning of direct strike on Windward Islands

System with satellites denied (for 36 hrs prior to forecast) misses the storm genesis and provides no warning of strike on Windward Islands

Source: European Centre for Medium-Range Weather Forecasts

Radio Regulations

Status

- Mandatory intergovernmental treaty

Concept

- Make spectrum and orbital positions allocations in order to avoid **harmful interference** between radio stations of different countries and to achieve **efficient and rational use**

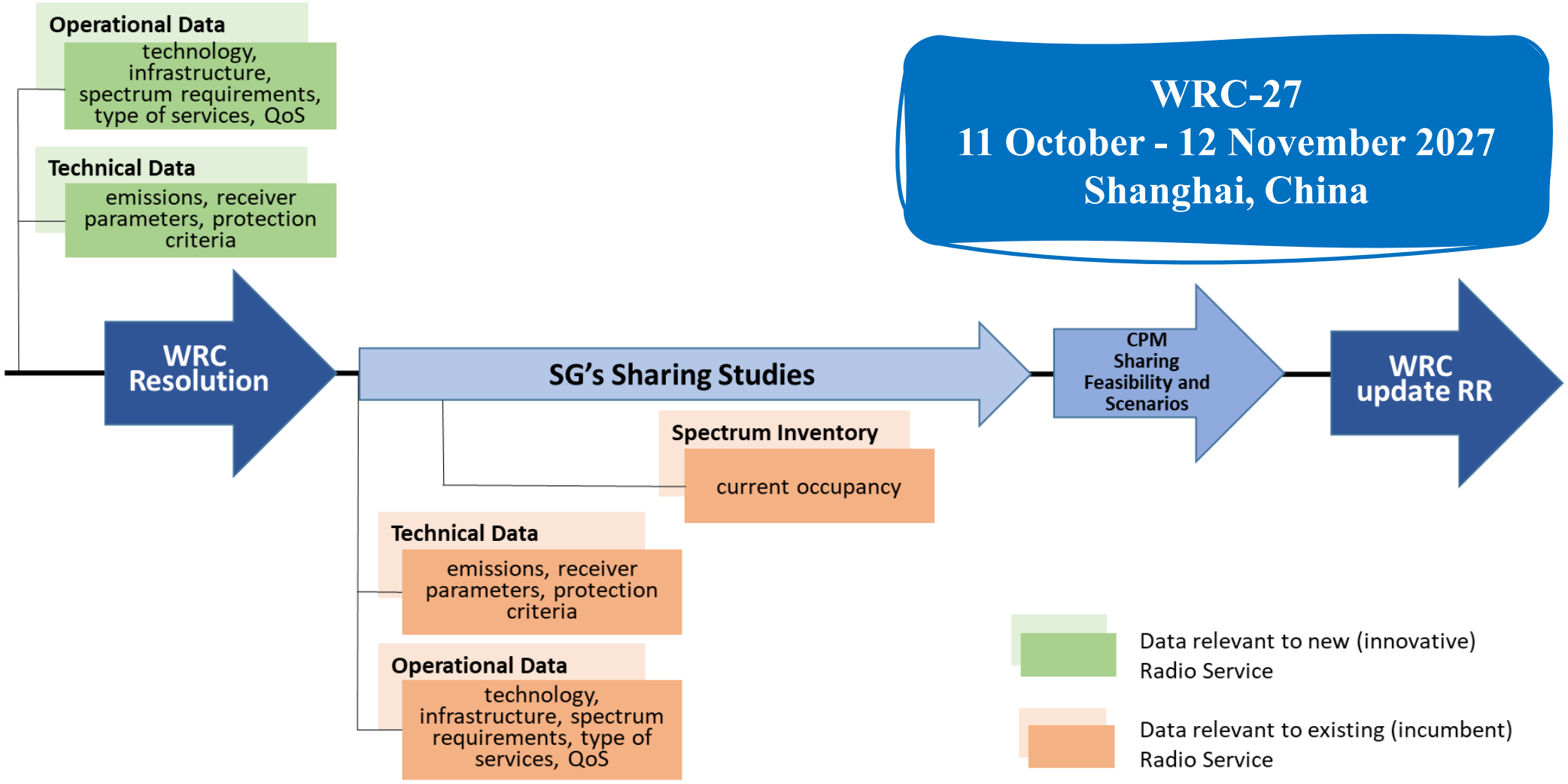
Instruments

- Allocation table, technical limitations, predetermed parametres, operational measures, coordination procedures

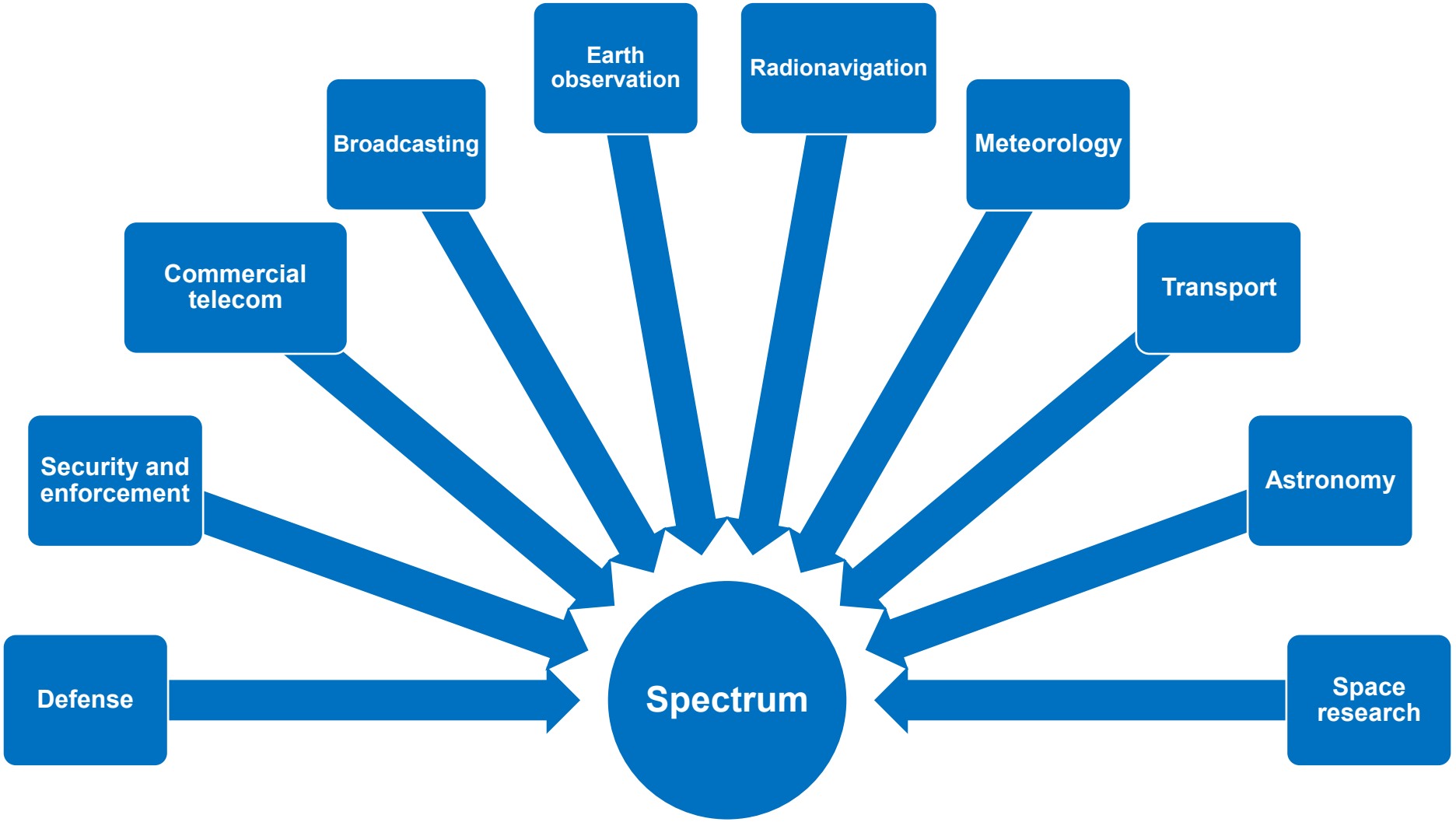
Objectives

- International spectrum sharing
- Interoperability and roaming
- Mass production and roadmap for industry, investors, operators
- Global protection of safety and passive bands

WRC (international spectrum allocations) process



Spectrum users



Radio Regulations

- Allocation – Entry in the Table of Frequency Allocations for the purpose of its use by one or more terrestrial or space radiocommunication services under specified conditions.
- Radiocommunication service – A service as defined in this section involving the transmission, emission and/or reception of radio waves for specific telecommunication purposes
- Radio services related to Earth observations (see Resolution **673 (Rev.WRC-23)**).

SPACE SERVICES	• **Space research service** • **Earth exploration- satellite service** • **Space operation service** • **Standard frequency and time signal-satellite service**
TERRESTRIAL SERVICES	• **Standard frequency and time signal service** • **Meteorological aids**
OTHER SERVICES	• **Radio astronomy** • **Safety service** • **Special service**

Radio Regulations instruments

NO RESTRICTION

Exclusive or shared bands

148-156.8375 MHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
149.9-150.05	MOBILE-SATELLITE (Earth-to-space) 5.209 5.220	

RR No. 5.149 – In making assignments to stations of other services adm are urged to protect radioastronomy

13 360-13 410 kHz	1 660-1 670 MHz	22.21-22.5 GHz	111.8-114.25 GHz
25 550-25 670 kHz	1 718.8-1 722.2 MHz	22.81-22.86 GHz	128.33-128.59 GHz
37.5-38.25 MHz	2 655-2 690 MHz	23.07-23.12 GHz	129.23-129.4 GHz
73-74.6 MHz (in	3 260-3 267 MHz	31.2-31.3 GHz	130-134 GHz
Regions 1 and 3)	3 332-3 339 MHz	31.5-31.8 GHz (in	136-148.5 GHz
150.05-153 MHz (in	3 345.8-3 352.5 MHz	Regions 1 and 3)	151.5-158.5 GHz
Region 1)	4 825-4 835 MHz	36.43-36.5 GHz	168.59-168.93 GHz
322-328.6 MHz	4 950-4 990 MHz	42.5-43.5 GHz	171.11-171.45 GHz
406.1-410 MHz	4 990-5 000 MHz	48.94-49.04 GHz	172.31-172.65 GHz
608-614 MHz (in	6 650-6 675.2 MHz	76-86 GHz	173.52-173.85 GHz
Regions 1 and 3)	10.6-10.68 GHz	92-94 GHz	195.75-196.15 GHz
1 330-1 400 MHz	14.47-14.5 GHz	94.1-100 GHz	209-226 GHz
1 610.6-1 613.8 MHz	22.01-22.21 GHz	102-109.5 GHz	241-250 GHz
			252-275 GHz

RR ARTICLE 5

335.4-410 MHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
402-403	METEOROLOGICAL AIDS EARTH EXPLORATION-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Fixed Mobile except aeronautical mobile 5.264A 5.264B	

RR No. 5.340 – All emissions are prohibited

1 400-1 427 MHz	31.5-31.8 GHz	100-102 GHz	182-185 GHz
2 690-2 700 MHz	48.94-49.04 GHz	109.5-111.8 GHz	190-191.8 GHz
10.68-10.7 GHz	50.2-50.4 GHz	114.25-116 GHz	200-209 GHz
15.35-15.4 GHz	52.6-54.25 GHz	148.5-151.5 GHz	226-231.5 GHz
23.6-24 GHz	86-92 GHz	164-167 GHz	250-252 GHz
31.3-31.5 GHz			

Radio Regulations instruments

CONDITIONS OF SPECTRUM SHARING

Regulatory or technical restrictions: RR Articles (ex. Article 21), WRC Resolutions, footnotes.

No. ***5.482*** – In the band 10.6-10.68 GHz, the power delivered to the antenna of stations of the fixed and mobile, except aeronautical mobile, services shall not exceed −3 dBW.

ALLOCATION TABLE (RR ARTICLE 5)

No. ***5.465*** – In the space research service, the use of the band 8 400-8 450 MHz is limited to deep space.

No. ***5.536A*** – Administrations operating earth stations in the Earth exploration-satellite service or the space research service shall not claim protection from stations in the fixed and mobile services operated by other administrations.

Radio Regulations instruments

PLANNED BANDS

Appendices 17, 18, 25 (Maritime), 26, 27 (Aeronautical), 30 (BSS), 30A (FL BSS), 30B (FSS), Regional plans

Predetermined technical parameters that ensure equitable and interference-free access to the spectrum.

ALLOCATION TABLE (RR ARTICLE 5)

No. ***5.487*** – In the band 11.7-12.5 GHz in Regions 1 and 3,… shall not cause harmful interference to, or claim protection from, broadcasting-satellite stations operating in accordance with the Regions 1 and 3 Plan in Appendix **30**.

Plan BSS: MLA orbital position – 91.50°
Plan FSS: MLA orbital position – 78.5°

Radio Regulations instruments

INTERNATIONAL COORDINATION

Articles 9, 11; Appendices 5 and 7, footnotes

No. ***9.6*** – Before an administration notifies to the Bureau or brings into use a frequency assignment in any of the cases listed below, it shall effect coordination as required, with other administrations identified under No. **9.27**.

ALLOCATION TABLE (RR ARTICLE 5)

No. ***5.220*** – The use of the bands 149.9-150.05 MHz and 399.9-400.05 MHz by the mobile-satellite service is subject to coordination under No. **9.11A**.

No. ***5.230*** – Additional allocation: in China, the band 163-167 MHz is also allocated to the space operation service (space-to-Earth) on a primary basis, subject to agreement obtained under No. **9.21**.

ITU-R Study Groups

SG 1 – General
SG 3 – Propagation
SG 4 – Satellite services
SG 5 – Terrestrial services
SG 6 – Broadcasting
SG 7 – Science services

- 5 000 experts
- 2-3 meetings per year

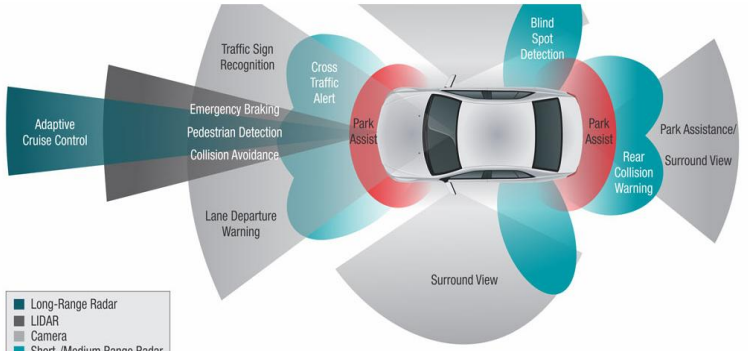
Technical studies for WRC

1 165 Recommendations
536 Reports
42 Handbooks

ITU-R Study Groups

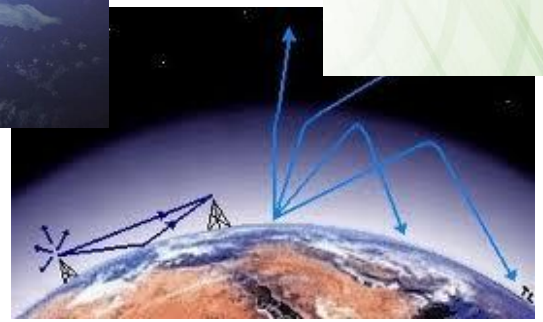
IMT Family History

		IMT-2000 (3G)	IMT-Advanced (4G)	IMT-2020 (5G)	IMT-2030 (6G)
Report (FTT)	Future Tech Trends (FTT)	-	-	Rep. ITU-R M.2320	Rep. ITU-R M.2516
		-	-	Nov 2014	Nov 2022
Recommendation (Vision/Framework)	Vision	Rec. ITU-R M.687 & M.816	Rec. ITU-R M.1645	Rec. ITU-R M.2083	Rec. ITU-R M.2160
		Feb/Mar 1992 → 1997	June 2003	September 2015	November 2023
Reports (Requirements, evaluation methodology and submission template)	Technical Performance Requirements	Rec. ITU-R M.1034	Rep. ITU-R M.2134	Rep. ITU-R M.2410	Future work
		Feb 1997	2008	2017	
	Submission Template	8/LCCE/47 + Add	Rep. ITU-R M.2133	Rep. ITU-R M.2411	
		1998	2008	2017	
	Evaluation Methodology	Rec. ITU-R M.1225	Rep. ITU-R M.2135-1	Rep. ITU-R M.2412	
		Feb 1997	2009	2017	
Recommendation (Radio Interface Tech.)	RIT Specifications (1st release)	Rec. ITU-R M.1457	Rec. ITU-R M.2012	Rec. ITU-R M.2150	
		May 2000	Jan 2012	Feb 2021	



Report ITU-R SM.2505-0
(07/2022)

Impact studies and human hazard issues for wireless power transmission via radio frequency beam



Radiocommunication Bureau

Any frequency assignment recorded in the Master Register shall have the right to international recognition. This right means that other administrations shall take it into account when making their own assignments, in order to avoid harmful interference…

- Processing of electronic filings
- Maintaining MIFR
- International radiomonitoring
- Assistance in interference resolution
- Interference reporting

EO for SDG

Key indicator in hurricane onset prediction strengthen resilience to climate related hazards (*SDG Target 1.5*)

Prediction and assess risks related to disasters (*SDG Target 11.5 and 13.1*)

Passive observation at 6-7 GHz provide unique window for measurements for sea surface temperatures

Assessment of ocean acidification (*SDG Targets 14.3*)

Estimate fish stocks (*SDG Target 14.4*)

Source: European Scientists on Spectrum for Earth Observation/ESA

EO for circular economy

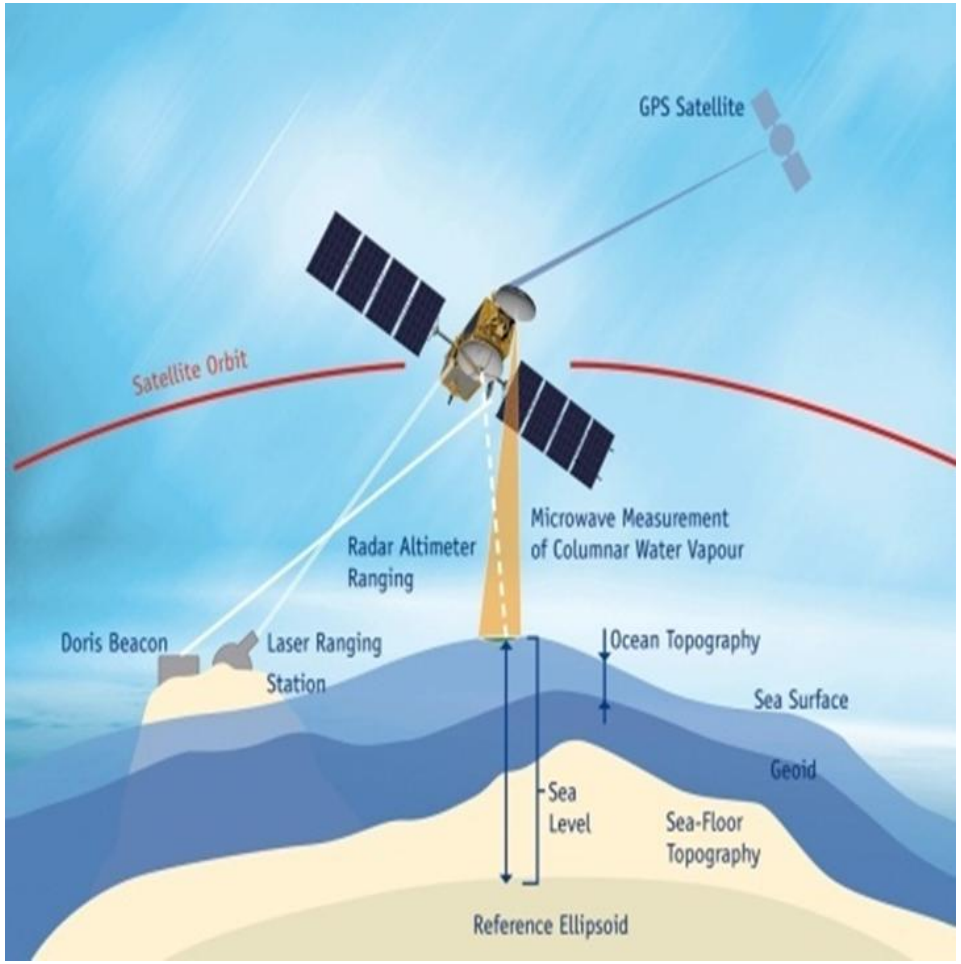
- CEOS Open data cube network initiative
- Copernicus Data Space Ecosystem – **600 000 registered users**, 500 PB data, **€67 and €131 billion** annually between 2017 and 2035, land, atmosphere, ocean, disaster, security, climate change
- Land productivity dynamics in 1999-2014 – 12% declined productivity, 21% stressed productivity, **€1.25 billion potential lost** each year in European agriculture because of soil erosion (Anthesis Group, 2023), transfer to sustainable agriculture **€78 billion** in 2017
- Potential savings in the electricity and gas **US$2.56 billion** in 2017 (*NASA, 2013*)
- Economic benefits to US agriculture (planting decisions) US$265-300 million/year (*NOAA, 2012*)
- Epidemy predictions (*ex. M. C. Wimberly, 2021*)

EO for emergency

- Triple augmentation of extreme weather events by 2100
- $1 invested in disaster prevention, $4 to $7 are saved in disaster response *(UNDP)*
- The economic benefits of data for forecasts obtained from observation satellites can mitigate the economic consequences of natural disasters in EU countries are estimated at **€61 billion annually** *(Ratier, 2014)*
- Volcanos
  - **30 million people** live within 10 km of active or potentially active volcanoes – 45% of volcanoes are not monitored *(Petiteville, ESA, 2019)*
  - Eyjafjalljokull eruption – **100 000** vols cancelled
  - A Four-Legged Early-Warning System *(ICARUS)*

EO for emergency

- Tsunami- 48 tsunamis have caused roughly $300 billion in damage (*NOAA*)
  - 10^5 Data collection platforms, worldwide (ex. Argos), 10^6 messages per day
- Global mean sea level – 4.8 mm/yr, **about 800 000 000 potential emigrants** (*US National Academy of Science, 2018*)
  - Altimeter (Jason)
- Annual losses to the world economy for lightning damage and transport disruption **around US$ 4 to 5 billion** (*NLSI, 1999*)
  - Worldwide lightning detection systems
- SFCG Disaster Management Database



More info

Publications:http://www.itu.int/en/publications/ITU-R/Pages/default.aspx

ITU News Magazine https://www.itu.int/en/itunews/Pages/default.aspx

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