

Burj Khalifa Tower, Dubai

# National Science Foundation

## Electromagnetic Spectrum Management

# WRC-23 Outcomes

Dubai, United Arab Emirates  
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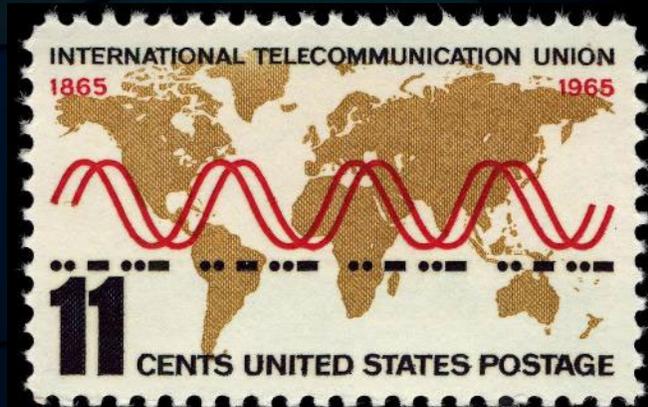


# ITU and WRC Overview



# International Framework

## International Telecommunication Union Facts



- Founded in Paris in 1865 as the International Telegraph Union
- Renamed International Telecommunication Union in 1932
- Became part of the UN system in 1947
- Maintains the International Radio Regulations
- Initially held conferences every 10 years, at which Radio Regulations were rewritten
- Governed by high-level instruments (Constitution and Convention)
- Three sectors (Radiocommunication, Telecommunication, Development)
- 193 Member States, more than 700 private member entities



# International Radio Regulations

- Managed by the Radiocommunication Sector (ITU-R)
- Four volumes
- Updated at each World Radiocommunication Conference
- Encompasses allocations and service/coordination rules
- A product of multilateral diplomacy from the working party to treaty conference



# ITU-R Subgroups

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- SG1: General spectrum management (technical, regulatory, measurement) – 3 Working Parties
- SG3: Radio-wave Propagation – 4 Working Parties
- SG4: Satellite issues – 3 Working Parties
- SG5: Terrestrial issues – 4 Working Parties
- SG6: Broadcast issues – 3 Working Parties
- SG7: Science Services – 4 Working Parties

\* There is no Study Group 2 in ITU-R, for historical reasons



**SG1**  
Spectrum  
management

**SG3**  
Radiowave  
propagation

**SG4:**  
Satellite  
Services

**SG5**  
Terrestrial  
Services

**SG6**  
Broadcasting  
Service

**SG7**  
Science  
Services

**WP1A**  
Spectrum engineering  
techniques

**WP3J**  
Propagation fundamentals

**WP4A**  
Efficient orbit/spectrum  
utilization for FSS and BSS

**WP5A**  
Land mobile service  
above 30 MHz (excluding  
IMT); wireless access in  
the fixed service; amateur  
and amateur-satellite  
services

**WP6A**  
Terrestrial broadcasting  
delivery

**WP7A**  
Time signals and  
frequency standard  
emissions

**WP1B**  
Spectrum management  
methodologies and  
economic strategies

**WP3K**  
Point-to-area propagation

**WP4B**  
Systems, air interfaces,  
performance and  
availability objectives for  
FSS, BSS and MSS,  
including IP-based  
applications and satellite  
news gathering

**WP5B**  
Maritime mobile service  
including Global Maritime  
Distress and Safety  
System (GMDSS);  
aeronautical mobile  
service and  
radiodetermination  
service

**WP6B**  
Broadcast service  
assembly and access

**WP7B**  
Space  
radiocommunication  
applications

**WP1C**  
Spectrum monitoring

**WP3L**  
Ionospheric propagation  
and radio noise

**WP4C**  
Efficient orbit/spectrum  
utilization for MSS and  
RDSS

**WP5C**  
Fixed wireless systems; HF  
and other systems below  
30 MHz in the fixed and  
land mobile services

**WP6C**  
Programme production  
and quality assessment

**WP7C**  
Remote sensing systems

**WP3M**  
Point-to-point and Earth-  
space propagation

**WP5D**  
IMT Systems

**WP7D**  
Radio astronomy



# SG7 Science Services

## WP7A

Time signals and frequency standard emissions  
Systems and applications (terrestrial and satellite) for dissemination of standard time and frequency signals

## WP7B

Space radiocommunication applications  
Systems for transmission/reception of telecommand, tracking and telemetry data for space operation, space research, Earth exploration-satellite, and meteorological satellite services

## WP7C

Remote sensing systems  
Active and passive remote sensing applications in the Earth exploration-satellite service and systems of the MetAids service, as well as space research sensors, including planetary sensors

## WP7D

Radio astronomy  
Radio astronomy and radar astronomy sensors, both Earth-based and space-based, including space very long baseline interferometry (VLBI)



# Other International Tools

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- **ITU-R Documents**

- Resolutions: provide instructions on organization or working methods of the Union and its study groups
- Recommendations: as name implies, puts ITU's name on recommended methods and values to be used in spectrum management
  - May be used by some administrations in formulating their regulations
  - If referenced by International Radio Regulations, have regulatory force
- Reports: technical in nature, may be referenced by other documents
- Handbooks: provide more detailed and comprehensive technical information than Reports

- **Bilateral/Multilateral Agreements**

- Satellite Coordination
- Cross-border
- Regional



# Examples: Work Completed – ITU-R Reports

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- RA.2507: Technical and operational characteristics of the existing and planned Geodetic Very Long Baseline Interferometry (Hilliard, Rajagoplan, VanderLey, Williams)
- RA.2508: Widely-distributed radio astronomy array systems operating above 200 GHz (van Zee, Fish, Schinzel)
- RA.2509: Technical and operational characteristics of radio astronomy systems operating below 350 MHz (85 cm) (Schinzel)
- RA.2510: Technical and operational characteristics of radio astronomy systems in the 67-116 GHz (3-4 mm) range (Schinzel)
- RA.2512: Technical and operational characteristics of broadband, background-limited detectors operating in the millimetre-wave regime (Paine, Barron)
- RA.2259: Characteristics of radio quiet zones (Woody, Williams, Vanderley)



# Bilateral/Multilateral Agreements

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- Case-by-case basis agreements worked out between administrations
- May supersede Radio Regulations
- May cover a large range of issues



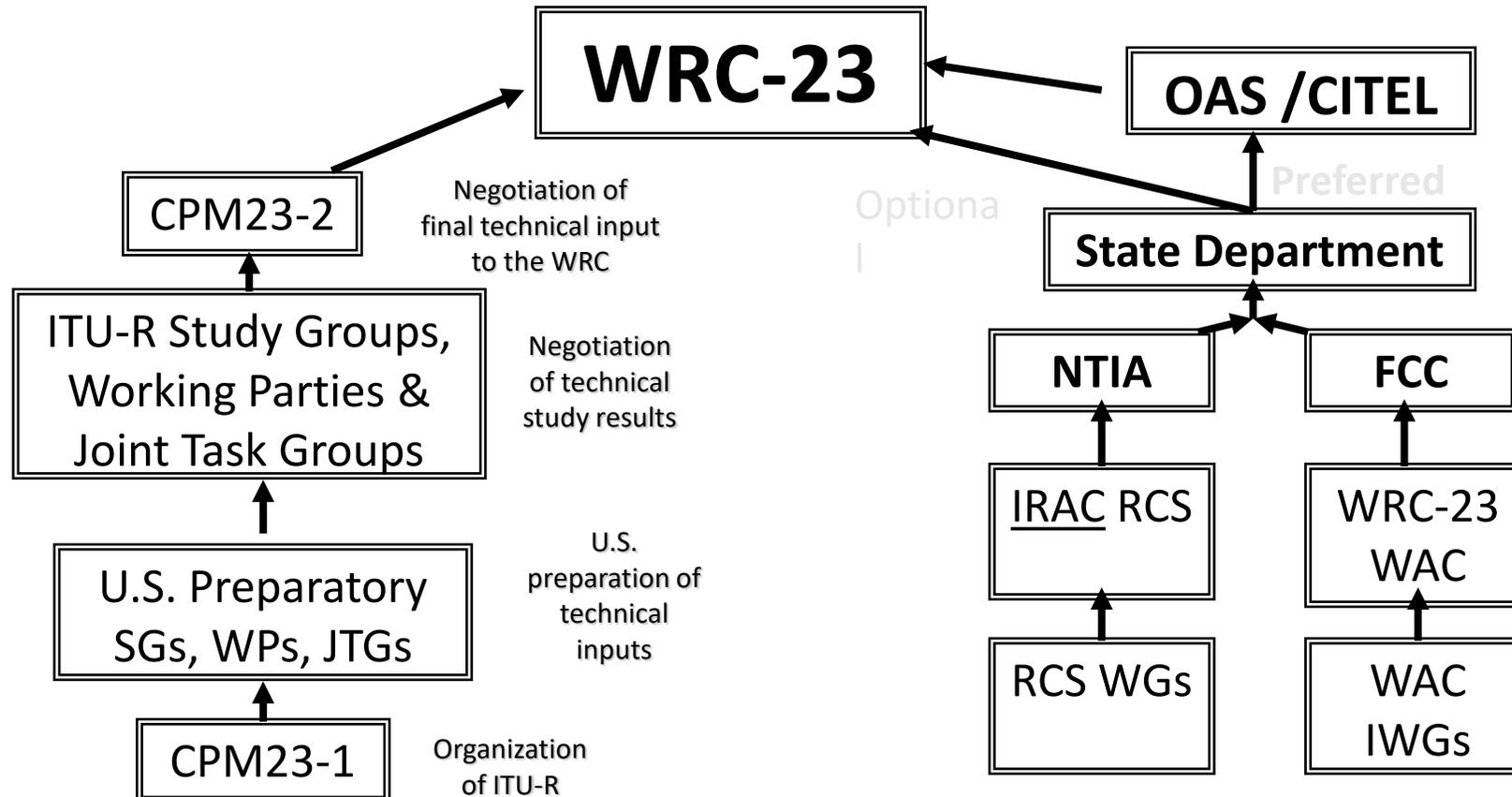
# Regional Groups



**Each Nation has Sovereignty Over the Use of its Spectrum**



# U.S. Preparatory Processes



U.S. View and  
Proposal Preparation



# Domestic and International

International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
2483.5-2500 FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A RADIODETERMINATION-SATELLITE (space-to-Earth) 5.398 Radiolocation 5.398A	2483.5-2500 FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A RADIOLOCATION RADIODETERMINATION-SATELLITE (space-to-Earth) 5.398	2483.5-2500 FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A RADIOLOCATION RADIODETERMINATION-SATELLITE (space-to-Earth) 5.398	2483.5-2500 MOBILE-SATELLITE (space-to-Earth) US319 US380 US391 RADIODETERMINATION-SATELLITE (space-to-Earth) 5.398	2483.5-2495 MOBILE-SATELLITE (space-to-Earth) US380 RADIODETERMINATION-SATELLITE (space-to-Earth) 5.398  5.150 5.402 US41 US319 NG147  2495-2500 FIXED MOBILE except aeronautical mobile MOBILE-SATELLITE (space-to-Earth) US380 RADIODETERMINATION-SATELLITE (space-to-Earth) 5.398  5.150 5.402 US41 US319 US391 NG147	ISM Equipment (18) Satellite Communications (25)
5.150 5.399 5.401 5.402	5.150 5.402	5.150 5.401 5.402	5.150 5.402 US41		
2500-2520 FIXED 5.410 MOBILE except aeronautical mobile 5.384A	2500-2520 FIXED 5.410 FIXED-SATELLITE (space-to-Earth) 5.415 MOBILE except aeronautical mobile 5.384A	2500-2520 FIXED 5.410 FIXED-SATELLITE (space-to-Earth) 5.415 MOBILE except aeronautical mobile 5.384A MOBILE-SATELLITE (space-to-Earth) 5.351A 5.407 5.414 5.414A	2500-2655	2500-2655 FIXED US205 MOBILE except aeronautical mobile	Wireless Communications (27)
5.412	5.404	5.404 5.415A			
2520-2655 FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING-SATELLITE 5.413 5.416	2520-2655 FIXED 5.410 FIXED-SATELLITE (space-to-Earth) 5.415 MOBILE except aeronautical mobile 5.384A BROADCASTING-SATELLITE 5.413 5.416	2520-2535 FIXED 5.410 FIXED-SATELLITE (space-to-Earth) 5.415 MOBILE except aeronautical mobile 5.384A BROADCASTING-SATELLITE 5.413 5.416  5.403 5.414A 5.415A  2535-2655 FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING-SATELLITE 5.413 5.416			
5.339 5.412 5.418B 5.418C	5.339 5.418B 5.418C	5.339 5.418 5.418A 5.418B 5.418C	5.339 US205	5.339	



# WRC Facts

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- World Radiocommunication Conference 2023 (WRC-23)
  - Treaty conference through the UN – lots of things can happen
  - Nearly 6 weeks, including Radiocommunication Assembly and Conference Preparatory Meeting for WRC-27 (CPM 27-1): 11/13-12/19, 2023
  - Breakneck pace, with many meetings overlapping
  - Many delegation members are assigned specific duties; coverage of other issues may be impacted by this
  - 32 issues on the regular agenda, of which 19 were technical study issues
  - Nearly 60 inputs proposing issues for the WRC-27 agenda



# Meetings Adjacent to the WRC

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- Immediately Before: Radiocommunication Assembly
  - 1 Week
  - Highest non-regulatory meeting
  - Addresses unresolved/remaining study output from Study Groups
- Immediately After: CPM 27-1
  - 2-3 Days
  - Develops initial assignment of work from the just-completed WRC-23 to Study Groups/Working Parties



# Satellites

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- In addition to limited spectrum resource, satellites must contend with limited orbital space
- Satellite coordination is a complex international process with many steps, and generally taking from 2-7 years to complete
- Changes to international satellite coordination are handled under Standing Agenda Item 7 at each WRC – nearly a mini-Conference for this specific topic
- For some services, to maintain equity, orbital spots have been set aside for countries to use



# Outcomes



# RA-23

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- November 13-17, 2023
- Proposed database for radio quiet zones: approved as an action for Study Group 7 (after challenging discussions)
- Proposed database for space weather sensors: not agreed (and not crucial)
- Space sustainability Resolution: both radio spectrum use and debris/deorbit considerations—ties in with work done in UN COPUOS
- Changes to the way ITU-R does business



# Protection of Science Spectrum Access

- Protection criteria
  - Transmissions into bands allocated for radio astronomy, Earth sensing, and other applications
  - RAS: Recommendation ITU-R RA.769-2
  - Other services: relevant recommendations
- Guard bands/separation
- Direction of transmission
- Geographic separation

TABLE 1

Threshold levels of interference detrimental to radio astronomy continuum observations

Centre frequency <sup>(1)</sup> $f_c$ (MHz)	Assumed bandwidth $\Delta f$ (MHz)	Minimum antenna noise temperature $T_A$ (K)	Receiver noise temperature $T_R$ (K)	System sensitivity <sup>(2)</sup> (noise fluctuations)		Threshold interference levels <sup>(2) (3)</sup>		
				Temperature $\Delta T$ (mK)	Power spectral density $\Delta P$ (dB(W/Hz))	Input power $\Delta P_H$ (dBW)	pfd $S_H \Delta f$ (dB(W/m <sup>2</sup> ))	Spectral pfd $S_H$ (dB(W/m <sup>2</sup> · Hz))
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
13.385	0.05	50 000	60	5 000	-222	-185	-201	-248
25.610	0.12	15 000	60	972	-229	-188	-199	-249
73.8	1.6	750	60	14.3	-247	-195	-196	-258
151.525	2.95	150	60	2.73	-254	-199	-194	-259
325.3	6.6	40	60	0.87	-259	-201	-189	-258
408.05	3.9	25	60	0.96	-259	-203	-189	-255
611	6.0	20	60	0.73	-260	-202	-185	-253
1 413.5	27	12	10	0.095	-269	-205	-180	-255
1 665	10	12	10	0.16	-267	-207	-181	-251
2 695	10	12	10	0.16	-267	-207	-177	-247
4 995	10	12	10	0.16	-267	-207	-171	-241
10 650	100	12	10	0.049	-272	-202	-160	-240
15 375	50	15	15	0.095	-269	-202	-156	-233
22 355	290	35	30	0.085	-269	-195	-146	-231
23 800	400	15	30	0.050	-271	-195	-147	-233
31 550	500	18	65	0.083	-269	-192	-141	-228
43 000	1 000	25	65	0.064	-271	-191	-137	-227
89 000	8 000	12	30	0.011	-278	-189	-129	-228
150 000	8 000	14	30	0.011	-278	-189	-124	-223
224 000	8 000	20	43	0.016	-277	-188	-119	-218
270 000	8 000	25	50	0.019	-276	-187	-117	-216



# WRC-23 Agenda Items

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- **IMT (Mobile Broadband):**
  - 10 GHz item not authorized for U.S. use; not adjacent to radio astronomy. Strong protections for EESS(passive).
  - New identifications for mobile broadband in 3, 6, and 10 GHz (regional footnotes)
- **HBS (High-altitude IMT Base Stations):**
  - Addition of allocations in the 698-960 MHz in limited number of administrations. 698-728 MHz & 830-835 MHz uplink only. 9.21 coordination required.
  - 2500-2690 MHz emissions limited to Rec ITU-R RA.769-2 levels
  - Strong protections for EESS(passive)
- **New aeronautical mobile applications: Rec ITU-R RA.769-2 level limits for operation in 15.41-15.7 GHz**



## WRC-23 Agenda Items (cont.)

- GMDSS in 1610-1626 MHz: maintained strong protections for radio astronomy systems.
- Space research transmissions in 14.8-15.35 GHz: strong protections for radio astronomy in 15.35-15.40 GHz (new incorporations by reference for Recs ITU-R RA.769-2 and RA.1513-2) while enabling such transmissions.



## WRC-23 Agenda Items (cont.)

- Modification of passive service allocations in 231.5-252 GHz: Reallocation of Earth-sensing bands more appropriately
- Earth Stations in Motion: protections for EESS(passive) in 18.6-18.8 GHz
- Inter-satellite links: new allocations in 18-20 GHz and 27-30 GHz, while protecting EESS(passive)
- Resolution 731: removal of 23-year-old call for studies into the possibility of transmissions in passive-only (no emissions) bands above 71 GHz



## WRC-23 Agenda Items (cont.)

- Time reference: agreed update to Resolution regarding implementation of phasing out the leap second.
- Lunar: addition of requirements to comply with regulatory conditions protecting the far side of the Moon (Shielded Zone of the Moon, SZM) for satellite networks with the Moon as the reference body.
- Space Weather: issue resolved using NSF-proposed solution (addition of new regulatory Article to add definitions and conditions).



# WRC-27 Agenda Items

- Radio Astronomy:
  - AI 1.16: to consider studies on the technical and regulatory provisions necessary to protect radio astronomy operating in specific Radio Quiet Zones and, in frequency bands allocated to the radio astronomy service on a primary basis globally, from aggregate radio-frequency interference caused by non-geostationary-satellite orbit systems, in accordance with Resolution COM6/11 (WRC 23);



Credits: SKAO, ALMA



# WRC-27 Agenda Items (cont.)

## Radio Quiet Zone agenda item

- Consideration of adjacent band studies:

Radio astronomy frequency band	Active space service operating in adjacent or nearby frequency band	Active space service (space-to-Earth)
10.6-10.7 GHz	10.7-10.95 GHz	FSS
42.5-43.5 GHz	42-42.5 GHz	FSS
76-77.5 GHz	74-76 GHz	FSS, MSS
94.1-95 GHz	95-100 GHz	RNSS, MSS
100-102 GHz	95-100 GHz	RNSS, MSS
114.25-116 GHz	116-119.98 GHz	ISS
130-134 GHz	123-130 GHz	FSS, MSS, RNSS

- Also:

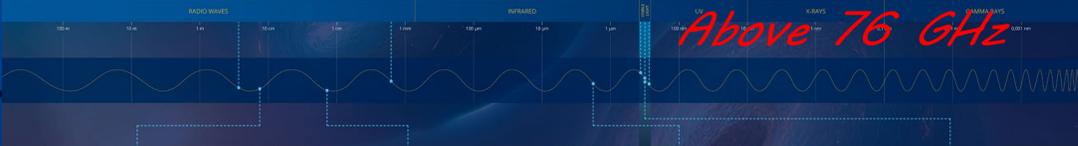
- Addressing aggregate interference
- Consideration of recognition for specified Radio Quiet Zones
- Methodology for gateway separation distance calculations
- Coexistence Methodologies



# WRC-27 Agenda Items (cont.)



WHERE DISCOVERIES BEGIN



- Radio Astronomy:
  - AI 1.18: to consider, based on the results of ITU Radiocommunication Sector studies, possible regulatory measures regarding the protection of the Earth exploration-satellite service (passive) and the radio astronomy service in certain frequency bands above 76 GHz from unwanted emissions of active services, in accordance with Resolution COM6/5 (WRC-23);



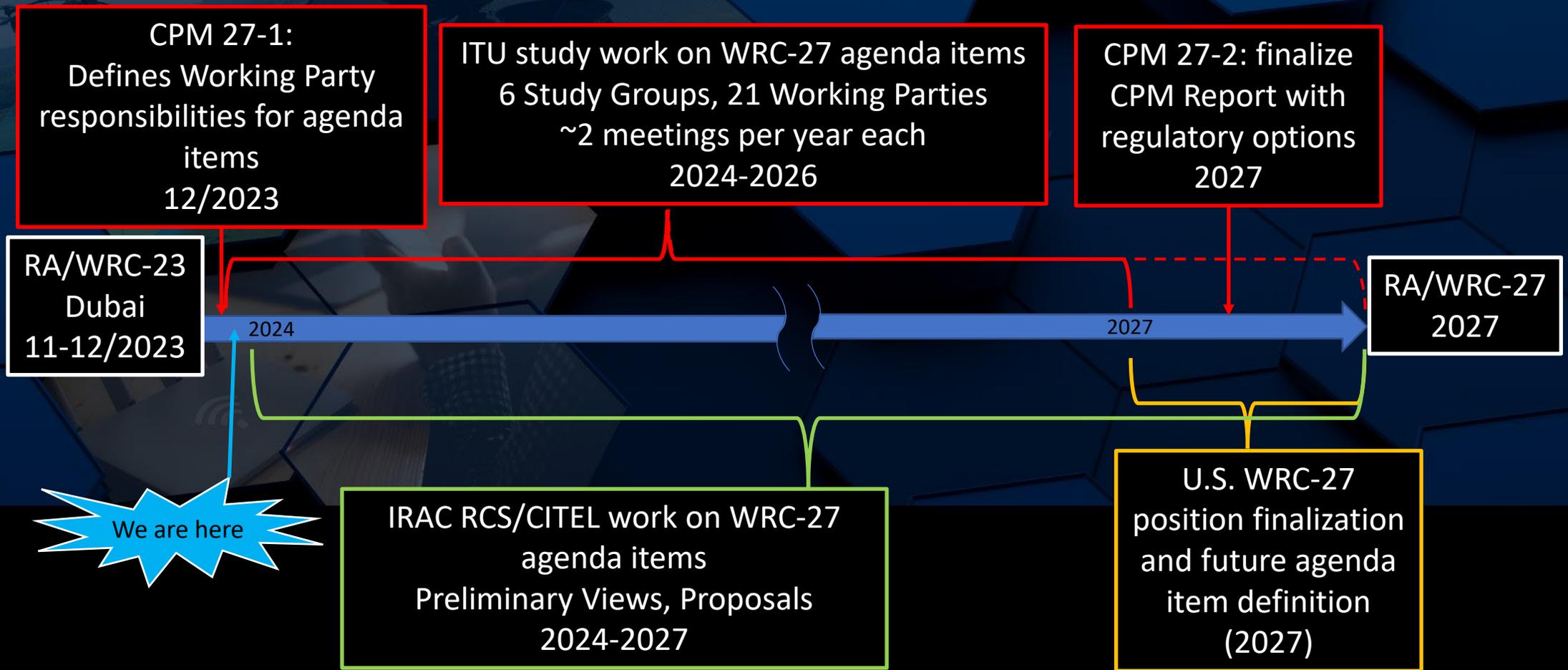
# WRC-27 Agenda Items

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- Other issues (Radio Astronomy and Other Sciences):
  - 1.1: 50 GHz ESIMs
  - 1.3: 50 GHz nGSO gateways
  - 1.5: nGSO Right to Transmit
  - 1.6: FSS in 30-50 GHz
  - 1.7: IMT (4, 8, and 15 GHz)
  - 1.8: 275-700 GHz RLS
  - 1.10: FSS/MSS PFD limits in 71-86 GHz
  - 1.11: MSS Inter-satellite links
  - 1.12: MSS Narrowband
  - 1.13: MSS/IMT
  - 1.15: Lunar
  - 1.17: Space Weather



# WRC-27 Study Cycle Timeline



# Takeaways



# WRC-23 Highlights

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- Worldwide effort to support science
- Representatives from administrations (U.S., Australia, South Africa, several others)
- Representatives from academic institutions and sector members (SKAO, CRAF, IUCAF)
- Many newcomers; U.S. delegation had several
- Most successful WRC for science in more than a decade
- Every issue was hard fought
- Overall, more than 620 pages of modifications to the International Radio Regulations.



## WRC-23 Highlights (cont.)

Many items on the 2027 agenda potentially impact science applications, and in contrast to the 2019-2023 study cycle, there will be greatly increased demands on personnel and agencies in 2023-2027, both for issue coverage and studies/analyses required.





# Questions?

