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Session 4 – Science Issues
WRC-23 agenda items
1.12, 1.14, 9.1 Topic a), 9.1 Topic d)

Markus Dreis
Chairman Working Party 7C

WRC-23 Agenda Items under WP 7C responsibility

1.12 (Res **656 (WRC-19)**) (Possible new secondary allocation to the Earth exploration-satellite (active) service for spaceborne radar sounders within the range of frequencies around 45 MHz)

1.14 (Res **662 (WRC-19)**) (Review and consider possible adjustments of the existing or possible new primary frequency allocations to EESS (passive) in the frequency range 231.5-252 GHz)

9.1 Topic a) (Res **657 (WRC-19)**) (Technical and operational characteristics, spectrum requirements and appropriate radio service designations for space weather sensors with a view to describing appropriate recognition and protection in the Radio Regulations)

9.1 Topic d) (Protection of EESS (passive) in the frequency band 36-37 GHz from non-GSO FSS space stations)

1.12 (Res 656 (WRC-19)) (New secondary EESS (active) allocation for spaceborne radar sounders around 45 MHz)

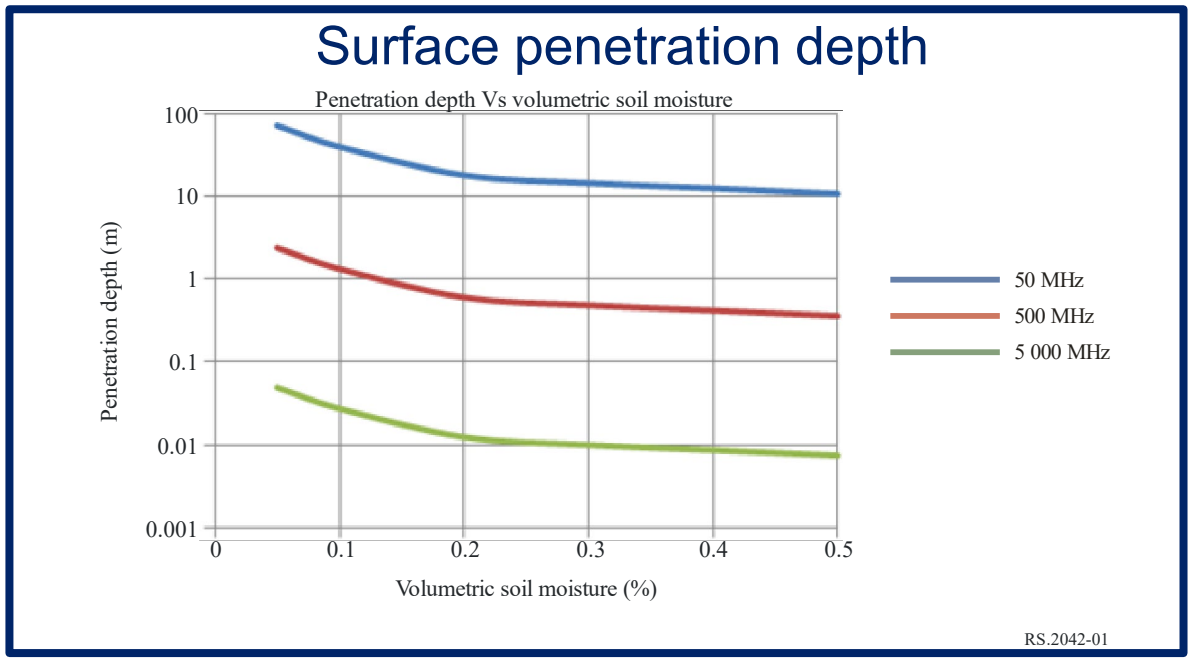
1.12 to conduct, and complete in time for WRC 23, studies for a possible new secondary allocation to the Earth exploration-satellite (active) service for spaceborne radar sounders within the range of frequencies around 45 MHz, taking into account the protection of incumbent services, including in adjacent bands, in accordance with Resolution 656 (Rev.WRC-19).

- In accordance with Resolution 656 (Rev.WRC-19), ITU-R is invited to conduct studies on spectrum needs and sharing studies between the Earth exploration-satellite (active) service and the radiolocation, fixed, mobile, broadcasting, amateur and space research services in the 40-50 MHz frequency range and in adjacent bands.

1.12 (Res 656 (WRC-19)) (New secondary EESS (active) allocation for spaceborne radar sounders around 45 MHz) – Scientific requirement

There is significant interest among climate researchers for measurements of the Earth's sub-surface with the intent of locating water/ice/deposits and examining sub-ice glacial bed surfaces.

Spaceborne active sensor operating in the 40-50 MHz range can provide such sub-surface data with a vertical resolution of 5-7 m.



1.12 (Res 656 (WRC-19)) (New secondary EESS (active) allocation for spaceborne radar sounders around 45 MHz) - Characteristics

Recommendation ITU-R RS.2042-1 (December 2018) provides the technical and operating characteristics of spaceborne radar sounders that would operate in the 40-50 MHz range, to be used for compatibility studies.

These spaceborne radar sounders are to be operated exclusively over un-inhabited or sparsely populated areas of the ice sheets of Greenland and Antarctica and the deserts of northern Africa and the Arabian Peninsula and will only operate for a short period of time over a given geographical area (e.g. for 10 minutes per 92.7 minute orbit).

One (probably the first) system for the Earth orbiting sounding radar is an Earth enhanced duplicate of the Shallow Radar Sounder (SHARAD) which was a Mars orbiting sounding radar.

The mission's scientific objectives are:

1) to understand the global thickness, inner structure, and the thermal stability of the Earth's ice sheets (e.g. in Greenland and Antarctica) as an observable parameter of Earth climate evolution, and

2) to understand the occurrence, distribution and dynamics of the earth fossil aquifers in desertic environments such as northern Africa and the Arabian peninsula as key elements in understanding recent paleoclimatic changes.

Note: There will not be so many of such specific sensors. These will likely only be operated by some of the space agencies, but the data acquired are to the benefit of the global society.

1.12 (Res 656 (WRC-19)) (New secondary EESS (active) allocation for spaceborne radar sounders around 45 MHz) (4) – Sharing studies

- The results of sharing studies between such a spaceborne radar sounder operating in the 40-50 MHz band and incumbent services (fixed, mobile, broadcasting, other secondary services) are provided in Preliminary Draft Revision of Report ITU-R RS.2455-1.
- In the static analysis, a separation angle towards the incumbent service under investigation can be used to define exclusion cone regions over which the spaceborne VHF sounder radar is not allowed to transmit.
- In the dynamic analysis, the interference exceedance level (IEL) of the incumbent services was violated only in the order of 0.05%, except for wall penetration radars (WPR) which is in the order of 0.5%.
- Conclusion so far: Sharing is feasible with the incumbent services!

1.14 (Res 662 (WRC-19)) (Review and consider adjustments, possible new primary EESS (passive) allocations in 231.5-252 GHz)

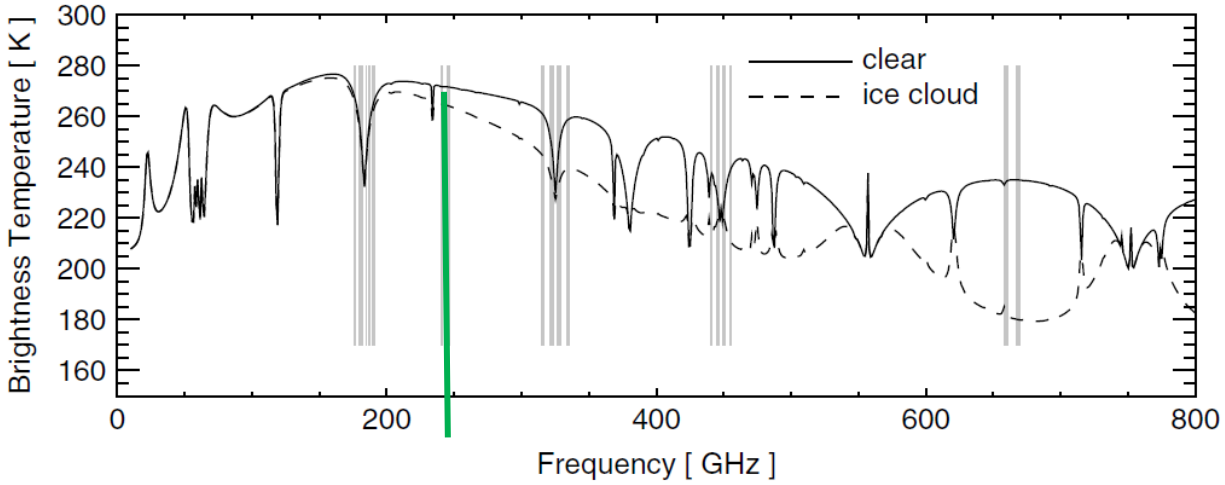
- The objective of WRC-23 agenda item 1.14 is to review and consider possible adjustment of the existing or possible new primary frequency allocations to EESS (passive) in the frequency range 231.5-252 GHz in order to:
  - to ensure that the allocations to EESS (passive) within the considered range correspond to the observation requirements for satellite passive microwave sensing;
  - without unduly constraining the operation of other primary services currently allocated in this frequency range.

1.14 (Res 662 (WRC-19)) (Review and consider adjustments, possible new primary EESS (passive) allocations in 231.5-252 GHz) – Scientific requirement

- In line with the scientific observation requirements the need for ice cloud measurements with passive microwave sensors was identified in the bands 239.2-242.2 GHz and 244.2-247.2 GHz.

Reason:

- Ice clouds, covering more than 33% of Earth's surface, have important effects on Earth's climate and hydrological cycle by affecting precipitation, atmospheric structure, and cloud processes. Thus, global measurements of ice cloud properties including ice water path, ice particle size distribution, are critically needed.
- The ability of passive microwave remote sensing instruments to measure ice clouds depends on specific microwave frequencies where this important atmospheric component for weather forecasting can be best observed, see figure.
- The Figure below compares brightness temperature relative to a clear sky over an ice cloud, with bars (in grey) indicating the positions of optimal Ice Cloud measurement channels.



!!! The set of frequencies for the measurement of ice clouds centers around 183 GHz, 243 GHz, 325 GHz, 448 GHz and 664 GHz !!!

1.14 (Res 662 (WRC-19)) (Review and consider adjustments, possible new primary EESS (passive) allocations in 231.5-252 GHz) – Status of studies

- A compilation of information on passive sensor measurements in the frequency range 231.5-252 GHz is gathered in Working document towards a preliminary draft new Report ITU-R RS.[231.5-252 GHz EESS]. In this document the bands 239.2-242.2 GHz and 244.2-247.2 GHz are identified as most appropriate for future ice cloud measurements.

- In response to resolves to invite ITU-R 1 of Resolution 662, it can be concluded that the existing allocations to EESS (passive) are not aligned with the operational requirements of passive microwave sensors.

- Consequently, necessary sharing and compatibility studies would have to be carried out with the services already allocated in the bands 239.2-242.2 GHz and 244.2-247.2 GHz which are currently not covered by EESS (passive) allocations, see overview table on the following slide.

- To progress the work, a Correspondence Group in ITU-R WP 7C was established !

1.14 (Res 662 (WRC-19)) (Review and consider adjustments, possible new primary EESS (passive) allocations in 231.5-252 GHz) (4) – Sharing studies

Next step: Sharing and compatibility studies with the incumbent services (yellow boxes).

Simplified overview of current frequency allocations in the range 231.5 – 252 GHz

231.5-232 GHz	232-235 GHz	235-238 GHz	238-239.2 GHz	239.2-240 GHz	240-241 GHz	241-242.2 GHz	242.2-244.2 GHz *	244.2-247.2 GHz *	247.2-248 GHz *	248-250 GHz	250-252 GHz (5.340)
				Possible new EESS (passive) 239.2-242.2 GHz				Possible new EESS (passive) 244.2-247.2 GHz			
		EESS (passive)									EESS (passive)
		SR (passive)									SR (passive)
						RAS	RAS	RAS	RAS		RAS
FIXED	FIXED		FIXED	FIXED	FIXED						
MOBILE	MOBILE		MOBILE	MOBILE	MOBILE						
	FSS (s-E)	FSS (s-E)	FSS (s-E)	FSS (s-E)							
			RADIOLOC	RADIOLOC	RADIOLOC	RADIOLOC	RADIOLOC	RADIOLOC	RADIOLOC		
			RADIONAV	RADIONAV							
			RADIONAV-SAT	RADIONAV-SAT							
										AMATEUR	
										AMATEUR-SAT	
Radioloc	Radioloc										
						Amateur	Amateur	Amateur	Amateur		
						Amateur-Sat	Amateur-Sat	Amateur-Sat	Amateur-Sat		
							* RR Footnote 5.138: The band 244-246 GHz is designated for ISM applications.				

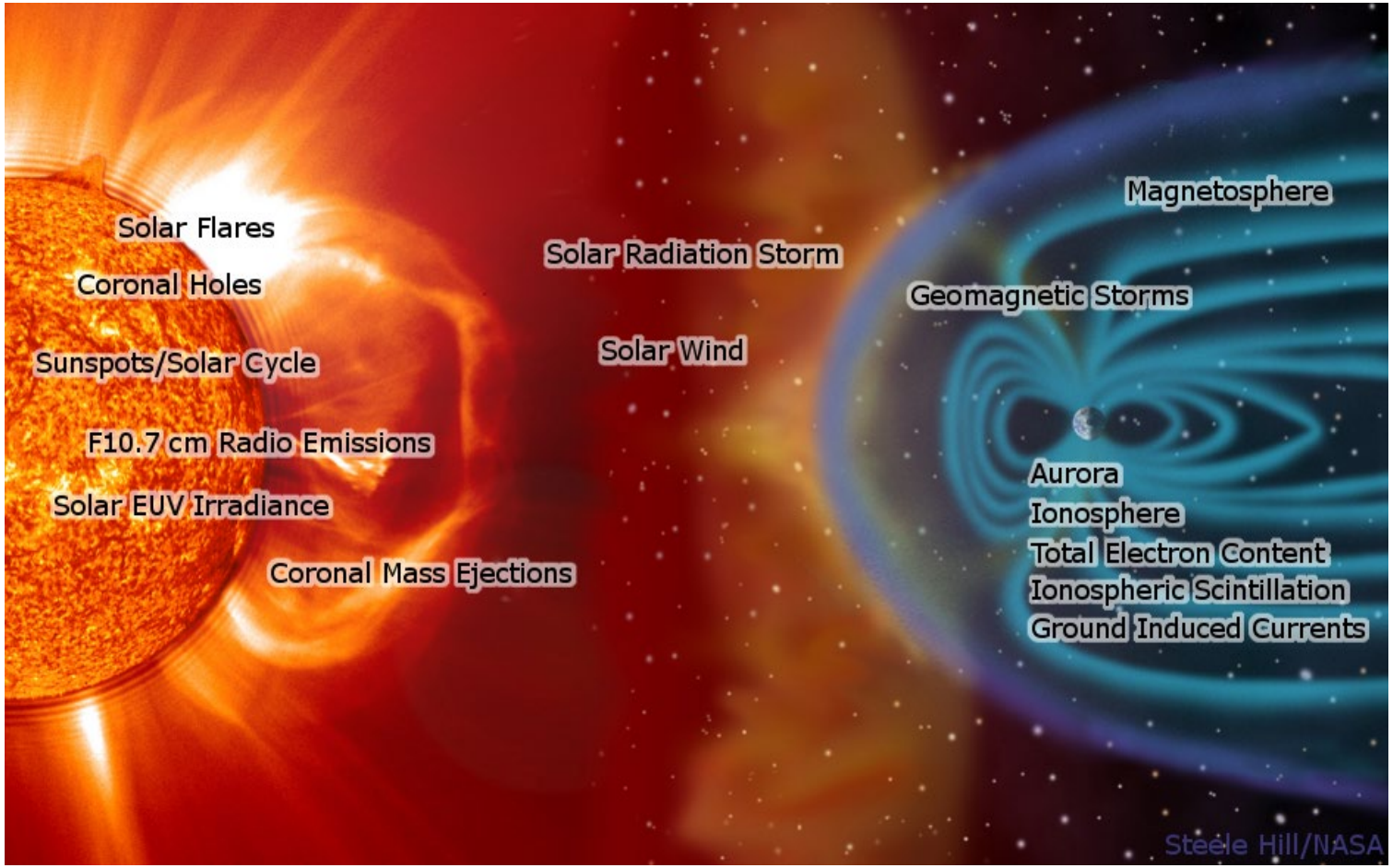
9.1 Topic a) (Res 657 (WRC-19)) (Space weather sensors, characteristics, spectrum requirements, RR service designation) - Background (1)

What is space weather (SW)?

SW refers to the physical processes occurring in the space environment and Earth atmosphere that ultimately **affects human activities on Earth and in space**.

SW is influenced by the solar wind and the interplanetary magnetic field (IMF) carried by the solar wind plasma.

A variety of physical phenomena are associated with space weather are shown in this figure.

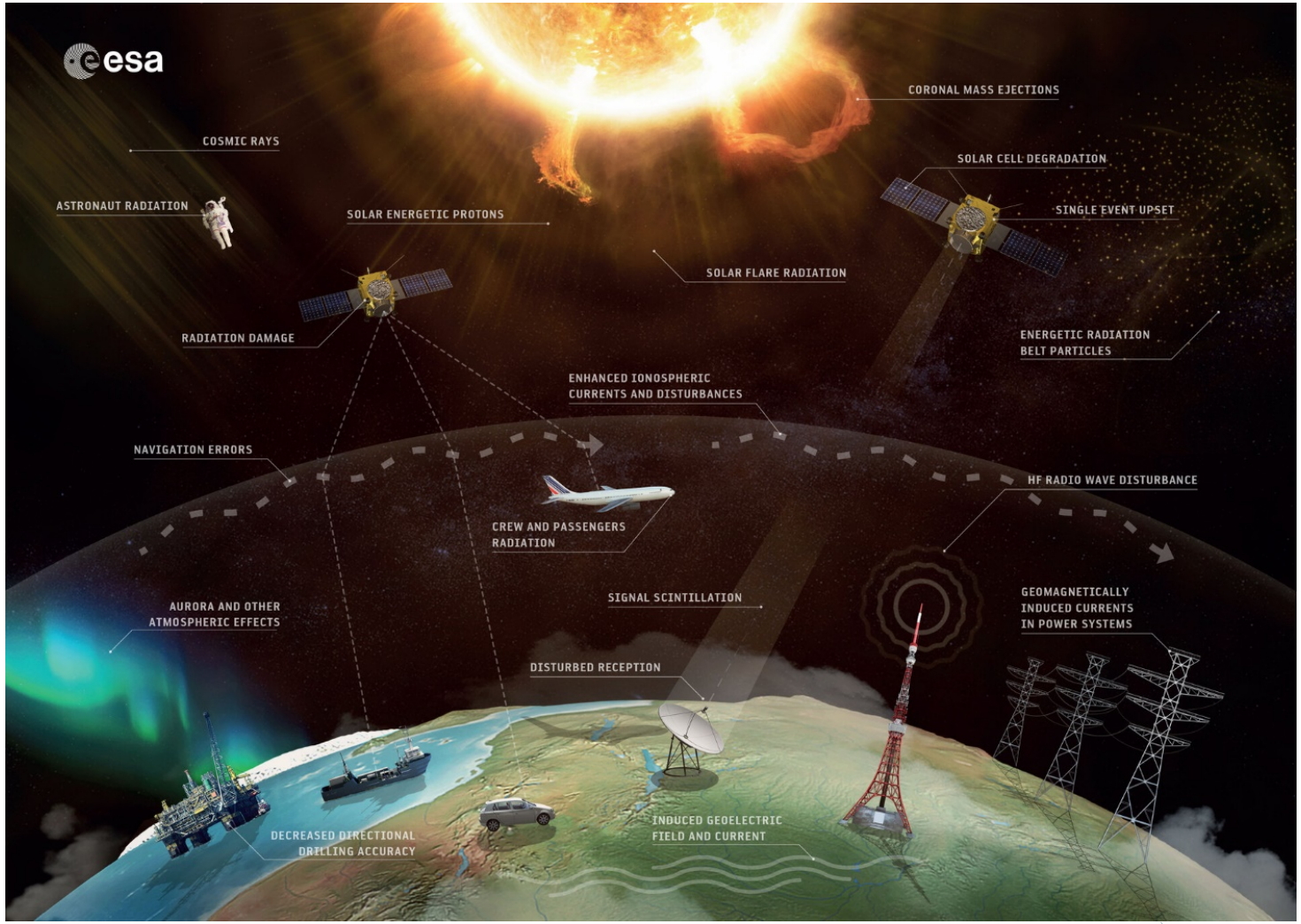


9.1 Topic a) (Res 657 (WRC-19)) (Space weather sensors, characteristics, spectrum requirements, RR service designation) - Background (2)

"…affects human activities on Earth and in space" – What does it mean?

Severe space weather events can results in:

- Power grid outages,
- Disruption to GNSS/GPS,
- Radio communications outages,
- Satellite damage,
- Increased radiation levels at high altitude.



9.1 Topic a) (Res 657 (WRC-19)) (Space weather sensors, characteristics, spectrum requirements, RR service designation) - Background (3)

Industry impacts - summary information:

Industry	Impact	How forecasting can help
Energy	Power blackouts Damage to grid infrastructure	Energy companies can use space weather services to help minimise the impact of geomagnetic storms, improve the design and modelling of future, more resilient, systems and increased monitoring of impacted systems.
Satellite	Damage to satellites Impacts on performance	Satellite operators can use space weather forecasts to advise of potential degradation or failures in the services they provide.
Communications	Loss of long distance radio communication	Advance notice of heightened solar activity can help flag the risk of blackouts.
Aviation	Disruption to HF comms and high latitude routes Additional radiation doses at high altitude	Advance notice of space weather events is critical to rerouting of high latitude flights, and to alert aircraft in flight of possible loss of communications.
Marine	Disruption to critical navigation systems	Mariners can benefit from space weather forecasts to advise of potential degradation or failures in the GNSS service.
Road transport	Disruption of GNSS	Space weather forecasts help road users understand when Sat Navs may be unreliable.
Rail transport	Disruption of GNSS	Space weather forecasts help rail network operators understand when rail systems may be at risk.

Source: UK MetOffice

9.1 Topic a) (Res 657 (WRC-19)) (Space weather sensors, characteristics, spectrum requirements, RR service designation) – Actions

What needs to be done under this WRC-23 Agenda Item?

- Resolution 657 calls for a number of considerations (in essence below):

1) to identify specific space weather sensors and their technical and operational characteristics which need to be protected by appropriate regulation

2) to conduct any necessary sharing studies with the objective of determining potential regulatory provisions that can be provided to receive-only operational space weather sensors for their appropriate recognition in the Radio Regulations

3) to develop potential solutions to describe in the RR, in Articles 1 and 4, and/or as a WRC resolution, if deemed appropriate, for consideration by WRC-23, space weather sensor systems and their corresponding usage, as well as protection requirements for receive-only space weather sensors

4) to conduct studies, in time for WRC-23, on the technical and operational characteristics of active space weather sensors and conduct necessary sharing studies, with the objective of determining the appropriate radiocommunication service for those sensors.

9.1 Topic a) (Res 657 (WRC-19)) (Space weather sensors, characteristics, spectrum requirements, RR service designation) - Status of studies

- Numerous SW sensor systems using radio spectrum are gathered in preliminary draft revision of the Report ITU-R RS.2456, including their categorization in
  1) Operational sensors;
  2) Systems in the transition from research to operational use;
  3) Research systems.
- Spectrum requirements and applicable radio service designations for passive and active SW sensor systems are outlined in two corresponding working documents towards preliminary draft new ITU-R reports;
- Interference criteria of receive-only space weather sensors is under development in a corresponding working document towards a preliminary draft new Report;
- First elements for the Draft CPM-Text.

9.1 Topic a) (Res 657 (WRC-19)) (Space weather sensors, characteristics, spectrum requirements, RR service designation) - Status of studies

- Still the most fundamental questions need to be answered:
  1) The definition of SW (in ITU language);
  2) The identification of the appropriate radio service(s) for passive and active SW sensor systems (MetAids and/or RAS);
  3) What is to be understood by recognition and protection in the RR?
     a) Development of the appropriate protection criteria for passive SW sensors;
     b) What can be done by WRC-23 under Resolution 657 (WRC-19) in particular in response to Resolves to invite?

- To progress the work, a Correspondence Group in ITU-R WP 7C was established !

9.1 Topic d) (Protection of EESS (passive) in the frequency band 36-37 GHz from non-GSO FSS space stations)

- Among the studies considered for WRC-19 agenda item 1.6 was a preliminary study on the protection of EESS (passive) sensors operating in the 36-37 GHz from NGSO constellations in the uplink (47.5-50.2 and 50.4-51.4 GHz) and downlink (37.5-42 GHz) directions.
- However, WRC-19 did neither achieve consensus on the relevant regulatory provision nor where to include it.
- Consequently, WRC 19 invited ITU-R to conduct further studies on this topic and to develop Recommendations and/or Reports, as appropriate, and report back to WRC 23 to take action, if necessary.

9.1 Topic d) (Protection of EESS (passive) in the frequency band 36-37 GHz from non-GSO FSS space stations) – Scientific requirement

- Passive microwave sensors measure in the 36-37 GHz band the atmospheric water vapour and liquid water content.
- These measurements are performed in support of an altimeter instrument on-board of the same satellite.
- It provides correction factors for the amount of water vapour and liquid water in the sub-satellite atmospheric column to be induced into the measurement data of the altimeter.
- Such altimeters perform sea and lake surface topology measurements, i.e. surface height, significant wave height, surface wind speed, and sea ice height and thickness.

9.1 Topic d) (Protection of EESS (passive) in the frequency band 36-37 GHz from non-GSO FSS space stations) - Status of studies

- Two issues are to be considered under this topic:
  1) Interference into the sensing channel of EESS (passive) from FSS non-GSO constellations operating in the 37.5-38 GHz frequency band at a lower altitude than EESS (passive) sensors.
  2) Interference into the cold calibration channel of EESS (passive) from FSS non-GSO constellations operating in the 37.5-38 GHz frequency band at a higher altitude than EESS (passive) sensors.
- First studies on the first issue have been provided to WP 7C and summarized in Working document towards a preliminary draft new Report on studies related to agenda item 9.1, topic d).

Other WRC-23 Agenda Items to which WP 7C contributes

1.2 (Res 245 (WRC-19)) (To consider identification of the frequency bands 3300-3400 MHz, 3600-3800 MHz, 6425-7025 MHz, 7025-7125 MHz and 10.0-10.5 GHz for IMT)

1.4 (Res 247 (WRC-19)) (The use of high-altitude platform stations as IMT base stations (HIBS) in the mobile service in certain frequency bands below 2.7 GHz already identified for IMT)

1.10 (Res 430 (WRC-19)) (Possible new allocations for the aeronautical mobile service for the use of non-safety aeronautical mobile applications in the bands 15.4-15.7 GHz and 22-22.21 GHz)

1.13 (Res 661 (WRC-19)) (Possible upgrade of the allocation of the band 14.8-15.35 GHz to the space research service)

1.15 (Res 172 (WRC-19)) (Operation of earth stations on aircraft and vessels communicating with geostationary space stations in the FSS in the frequency band 12.75-13.25 GHz (Earth-to-space))

1.16 (Res 173 (WRC-19)) (NGSO FSS ESIMs in the bands 17.7-18.6 GHz, 18.8-19.3 GHz and 19.7-20.2 GHz (space-to-Earth) and 27.5-29.1 GHz and 29.5-30 GHz (Earth-to-space))

1.17 (Res 773 (WRC-19)) (Inter-satellite links in the bands 11.7-12.7 GHz, 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz)

1.18 (Res 248 (WRC-19)) (Concerning spectrum needs and potential new allocations to the MSS)

1.19 (Res 174 (WRC-19)) (Primary allocation to the fixed-satellite service in the space-to-Earth direction in the frequency band 17.3-17.7 GHz in Region 2)

9.1 Topic c) (IMT for fixed wireless broadband in the frequency bands allocated to the fixed services on primary basis)