Radio Frequency Interference (RFI) Updates of Interest to Passive Earth Sensing Users

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Summary

- Multiple threats to passive bands at WRC-19; passive mw community was not well prepared; outcome was not great but also not worst-case
- Passive bands are facing potential 5G RFI; 5G RFI will be different than RFI experienced by SMAP/SMOS
- NOAA & NASA believe the threat is real and significant; they are carefully considering possible impacts and options
- Mw sounders will be impacted more than mw imagers
- Expect more passive mw sensors to include RFI detection capability; expect some will launch this decade
- Passive mw community is showing greater awareness of RFI and there are efforts to be better prepared for WRC-23
- Avoid using the word “mitigation” when discussing RFI; it has 2 different meanings & can be mis-interpreted as “RFI is not a problem” → passive bands become harder to protect

List of US Auction Bands, PMW bands, & Status

Passive Sensor Bands	Potential Auction Bands
ATMS channel 1 (band 1) is 23.665 to 23.935 GHz	**Sold**-24.25 to 27. 5 GHz (2nd harmonic)
AMSR2, AMSR3 23.6 to 24.0 GHz	
ATMS channel 2 (band 2) is 31.31 to 31.49 GHz	31.8-33.4 GHz
AMSR2, AMSR3 36.0 to 37.0 GHz	37-40.5 GHz
ATMS channel 3 (band 3) is 50.21 to 50.39 GHz	48.9-50.2 GHz and 50.4-51.4 GHz
ATMS channel 4 (band 4) is 51.56 to 51.96 GHz	50.4-51.4 GHz and 50.4-52.6 GHz
ATMS channel 5 (band 5) is 52.6 to 53.0 GHz	50.4-52.6 GHz
ATMS channel 16 (band 16) is 87.2 to 89.2 GHz	84-86 GHz and 92-94 GHz
AMSR2, AMSR3 87.5 to 90.5 GHz	

note: auction band list changes frequently

What's different about 5G RFI?

- Large RFI is easy to detect and most radiometers can detect it in ground processing
- SMAP primarily deals with RFI sources that are narrow in frequency or time, and the total bandwidth is only 24 MHz; digital technology & algorithms are mature
- 5G is expected to create marginal RFI – near the sensitivity threshold and difficult to detect → different algorithms
- Marginal RFI cannot be detected with ground processing options → requires on-board processing
- 5G is also wideband (100s to 1000s of MHz) → requires more sophisticated digital technology
- Net result: Significant additions/changes to future radiometers

Some RFI Activities to Know About

In the US:

- Large new initiative (many $millions USD)
- National Science Foundation (NSF) Spectrum Innovation Initiative for a National Center for Wireless Spectrum Research
- Proposal teams already formed
- Basic focus: spectrum sharing techniques between passive-only services like Earth Observations and spectrum-hungry services like wireless communications

International:

- Through IEEE/Geoscience and Remote Sensing Society (GRSS) Frequency Allocations In Remote Sensing Technical Committee (FARS-TC) http://www.grss-ieee.org/community/technical-committees/frequency-allocations-in-remote-sensing/
- Development of standards to assess the "quality" of remote sensing frequency bands in terms of amount of man-made Radio Frequency Interference (RFI), with the goal of collecting feedback from our members and form a working group
- Contact: Dr. Paolo de Matthaeis, pdematth@ieee.org

Future Thoughts

- Competition for spectrum by other users will only increase
- The passive microwave Earth sensing community should consider a more proactive approach for the future
- Actions might include:
  - Better documentation of spectrum usage by Earth sensing
  - Ensuring our own equipment is properly filtered
  - Documenting the actual RFI environment
  - RFI measurement guidelines (IEEE GRSS FARS working group)
  - Better RFI impact assessments---direct impact difficult to show
- Agenda items for the WRC-23 include
- more spectrum for 5G in the frequency range 3-15 GHz, esp 10.0-10.5 GHz
- new requests near 18.6-18.8, 22.21-22.5 GHz and 15.35-15.4 GHz passive bands

HANGE OBSERVATION MISSION

The Spectrum Outlook for Earth Remote Sensing Post WRC-19

WRC-19 Results and Looking Ahead to WRC-23

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Introduction/Background

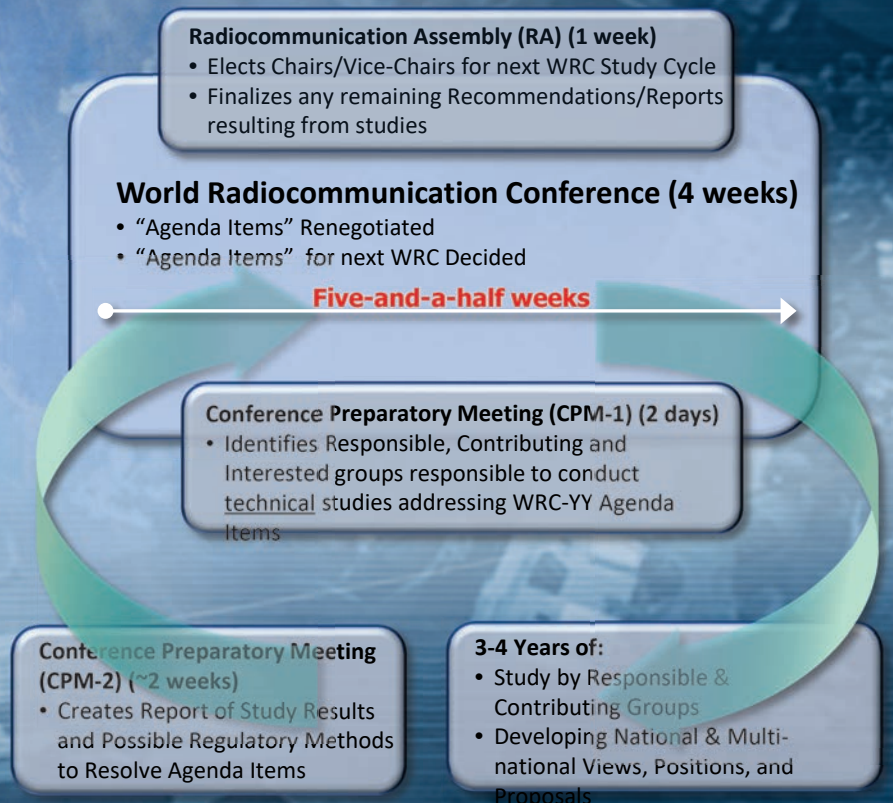
Every three to four years the International Telecommunication Union (ITU), a specialized agency of the United Nations, holds a treaty level meeting known as the World Radiocommunication Conference (WRC) to set international regulations on the use of the radio frequency spectrum. These regulations include protections for critical remote sensing bands.

This presentation will cover:

- **An introduction of the WRC process**
- **Presents outcomes of WRC-19**
- **Provide an examination of the potential regulatory actions that could impact the remote sensing community at the next WRC slated to be held in 2023.**

WRC 2019 **Overview**

- **2019 World Radiocommunication Conference (WRC-19)**
  - Sharm El-Sheikh, Egypt, 28 October-22 November 2019
  - Over 160 members participate in treaty-based modifications to the ITU Radio Regulations (WRC-2015: 3253 delegates)
- Technical preparatory work done in the ITU Radiocommunication Sector Study Groups
- Conference Preparatory Meeting (CPM) report will contain approaches (Methods) for satisfying each agenda item (technical basis upon which Administration proposals are made)



Summary of WRC-19 Agenda Item 1.6

Studies of technical, operational issues and regulatory provisions for nongeostationary fixed-satellite services satellite systems in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space)

New out of band limits for GSO FSS uplinks.

Earth Station Antenna Gain	Earth Station Elevation Angle	Maximum Unwanted Emission Power into the 50.2-50.4 GHz Passive Band
< 57 dBi (UTs)	< 80°	-30 dBW
< 57 dBi (UTs)	≥ 80°	-45 dBW
≥ 57 dBi (Gateways)	< 80°	-25 dBW
≥ 57 dBi (Gateways)	≥ 80°	-45 dBW

NASA's technical studies estimated that -30 dBW (< 80°) and -50 dBW (≥ 80°) was needed to fully protect EESS (passive) operations from GSO ES uplinks.

New out of band limits for non-GSO FSS uplinks.

Earth Station Using Uplink Power Control?	Maximum Unwanted Emission Power into the 50.2-50.4 GHz Passive Band
Yes	-42 dBW at 90° with allowable increase to -35 dBW to compensate for differences in FSPL
No	-42 dBW

NASA's technical studies estimated that -45 dBW for gateways and -50 dBW for UTs was needed to fully protect EESS (passive) operations from NGSO ES uplinks.

Summary of WRC-19 Agenda Item 1.13

Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunications for 2020 and beyond

Protection of 23.6-24 GHz EESS (passive) from 24.25-27.5 GHz IMT:

Technical studies preformed by the science community show that non-trival data loss will occur from 5G systems operating at these TRP limits.

Bring Into Use Date	IMT Station Type	Maximum Total Radiated Power (TRP) in ANY 200MHz of the 23.6-24 GHz Passive Band
Present - 9/1/2027*	Base Station	-33 dBW
After 9/1/2027	Base Station	-39 dBW
Present - 9/1/2027*	User Equipment	-29 dBW
After 9/1/2027	User Equipment	-35 dBW

*Equipment brought into use during this time will be grandfathered at these levels

- Operations of IMT shall protect the existing and future EESS (passive) systems in the frequency bands 23.6-24 GHz

Protection of 36-37 GHz EESS (passive) from 37-40.5 GHz IMT:

- −43 dB(W/1 MHz) or −23 dB(W/1 GHz) maximum TRP for IMT stations into the 36-37 GHz passive band. The recommended TRP limit is -30dB(W/GHz).

NOC (No Change) to the Radio Regulations for the following bands:

- 47.2-50.2 GHz, 50.4-52.6 GHz, and 81-86 GHz – protecting adjacent passive bands

Spectrum Outlook for the Future

- **Demand for spectrum by other services will only increase**
- **Retaining access to remote sensing bands will require a more proactive paradigm by the remote sensing community**
  - **Better documentation of existing bands (is your sensor ITU-registered?)**
  - **Ensure sensing equipment is properly filtered**
  - **Conducting data denial and other impact assessments to determine proper protection levels**
  - **Being more engaged in the spectrum management process (e.g., GRSS FARS)**
  - **Document the RFI environment**
    - > Documenting the RFI environment should include
      - Real-world measurements of RFI
        - RFI measurements must be well-calibrated & consistent
        - GRSS FARS developing “Recommended RFI Measurement Practices”

Overview of WRC-23 Agenda Items

WRC-23 Agenda Item	Brief Description	Affected Passive Bands	Challenges	Responsible ITU-R Group
1.2	Considers a number of frequency bands for IMT (5G) identification between 3300-10500 MHz; also known as IMT "Mid-band".	6425-7025, 7075-7250, 10600-10700 MHz	Currently being argued that 100 MHz separation from passive band is enough and precludes studies from being done. 5.458 is not an allocation, so protection of those bands is not achievable.	WP 5D
1.4	Considers the use of high-altitude platform stations as IMT base stations (HIBS) in bands already with an IMT identification below 2.7 GHz.	2655-2690 MHz (sec), 2690-2700	Combines two concepts (IMT and HAPS) that have individually have a large potential for interference.	WP 5D
1.10	Considers a possible new allocation for non-safety aeronautical mobile applications.	15.35-15.4, 22.21-22.5 GHz	Footnote 5.532 says the use of 22.21-22.5GHz by EESS (passive) shall not impose constraints upon the fixed and mobile services.	WP 5B
1.13	Considers a possible upgrade of the 14.8-15.35 GHz SRS allocation to primary.	15.35-15.4 GHz	Initiated by Russian Federation, and this is already a primary allocation in the US Table of Allocations.	WP 7B
1.14	Considers adjustments to EESS (passive) allocations in 231.5-252 GHz to align with current remote sensing mission requirements.	235-238, 250-252 GHz	Initiated by ESA, and NASA is still in the process of determining future requirements and potential impacts.	WP 7C

Overview of WRC-23 Agenda Items, cont.

WRC-23 Agenda Item	Brief Description	Affected Passive Bands	Challenges	Responsible ITU-R Group
1.15	Studies the use of GSO Earth Stations in Motion (ESIM) near X-band using existing FSS allocations.	10.6-10.7 GHz	WP 7C was not added as a contributing group by CPM23-1, and there's some debate as to whether this frequency band is within scope of the AI. See AI 1.16 Challenges.	WP 4A
1.16	Studies the use of NGSO Earth Stations in Motion (ESIM) in Ku-/Ka-bands using existing FSS allocations.	18.6-18.8 GHz	Since the interference to EESS (passive) comes from the FSS satellite downlink and not the ESIM uplink, opponents generally argue that there is zero change to the interference environment.	WP 4A
1.17	Studies the use of satellite-to-satellite links in Ku-/Ka-bands using existing FSS allocations.	18.6-18.8 GHz	Split interests for NASA: trade-off between the concept of moving more toward commercial services to replace TDRSS and ensuring that passing sensing in 18.6-18.8 GHz does not receive any further degradation.	WP 4A
9.1 c)	Study the use of IMT for fixed wireless broadband in fixed service allocations on a primary basis.	Too many to list!	The scope and intention of this topic is very unclear, but has the potential to be very concerning.	WP 5A, WP 5C
9.1 d)	Protection of EESS (passive) in the frequency band 36-37 GHz from non-GSO FSS space stations; WRC-19 AI 1.6 follow-on.	36-37 GHz	US has a number of low-altitude constellations that sparked some of the impetus for this item. Additionally, studying interference into the cold-calibration channel of EESS (passive) has may prove challenging.	WP 5C

Questions?

Feel free to contact us after today's presentation at jacquelynne.houts@nasa.gov and edward.j.kim@nasa.gov if there are additional questions.