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Assessing Radio Frequency Interference Impact on Microwave Remote Sensing: Recent Progress in the Development of a Standard

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Abstract

The IEEE Geoscience and Remote Sensing Society (GRSS) Frequency Allocations in Remote Sensing (FARS) Technical Committee has been developing a standard to assess the impact of radio frequency interference (RFI) on spaceborne remote sensing that uses either active or passive microwave instruments. In its fifth year of work, we present the most recent progress in the standard development done by the working group P4006 of the IEEE Standards Association, named “Standard for Remote Sensing Frequency Band Radio Frequency Interference (RFI) Impact Assessment”.

1. Introduction

The International Telecommunication Union (ITU) oversees the global allocation of frequency bands to radio services such as telecommunications, broadcasting and remote sensing. All national governments take responsibility for enforcing these regulations so that the radio spectrum can be used efficiently. Growing demand for additional frequency bands by emerging telecommunication services may affect instruments operating under the Earth exploration satellite service (EESS), in other words, Earth remote sensing. The EESS includes both passive and active instruments such as radiometers and radars. The negative impact consists in radio frequency interference (RFI) and has to be treated properly prior to any further analysis and geophysical parameter estimation. Some articles have reported the impact of RFI on both passive [1-3] and active [4] sensors.

At every World Radiocommunication Conference (WRC), many new frequency allocations are assigned to commercial services, especially for telecommunications. Some of these applications have the potential to negatively impact passive and active spaceborne remote sensing. For example, new allocations may be in bands adjacent to frequency ranges protected for passive sensors, which may result in a spectrum environment more polluted by out-of-band interference for microwave remote sensing.

Measuring RFI impacting that band is crucial and geolocating its source is also important. However, no clear standards exist for measuring and evaluating RFI for spaceborne Earth observation satellites.

The IEEE Geoscience and Remote Sensing Society (GRSS) Frequency Allocations in Remote Sensing (FARS) Technical Committee (TC) has been working on these problems. In 2021, the FARS-TC established a working group to develop a standard for the assessment of the RFI impact in bands allocated to EESS by the ITU Radio Regulations [5]. This initiative is undertaken by an IEEE Standards Association (IEEE-SA) Working Group named “P4006 Standard for Remote Sensing Frequency Band Radio Frequency Interference (RFI) Impact Assessment”. This standard will define a process to conduct RFI impact evaluation, including a description of the required methods and techniques to conduct detection, mapping, and reporting of RFI. Since its establishment, the P4006 working group has reported the development of this standard. In this paper, we report the latest progress of the working group [6-9].

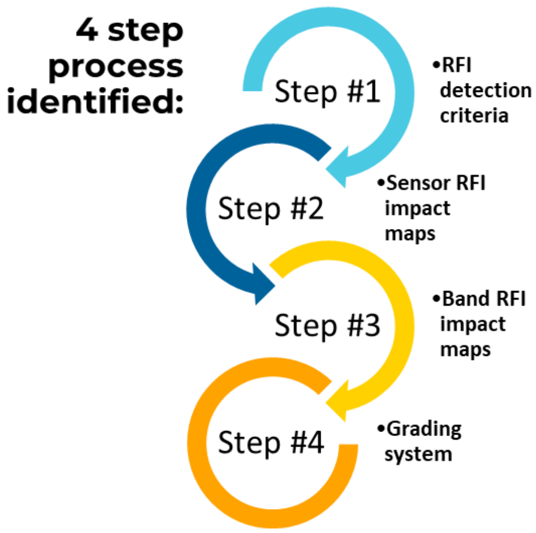

Figure 1. Illustration of the four-step process for RFI assessment in the planned standard.

2. Recent Developments of the RFI Assessment Standard

The developing standard consists of four steps which define the criteria for RFI detection and impact assessment for each specific sensor and for multiple sensors. The accumulated information from multiple sensors will help to characterize the RFI so that not only current users but future users can develop sensors overcoming the RFI.

2.1 RFI detection criteria

The first step of the standard will define the detection process to quantify the RFI detection. For each data acquisition, a binary detection method should be implemented to judge the RFI existence. If there is RFI, it should be quantitatively measured. There might be various methods to detect RFI. For example, in synthetic aperture radar (SAR), some sensors have a passive mode during which there is no transmission so that the radar receiver can directly record RFI more efficiently. However, such sniffing mode is not always implemented in radar systems. Therefore, the standard should not restrict the detection methods to use, but only provide some examples of them.

2.2 Sensor-based RFI impact assessment

The second step defines the assessment and mapping of RFI contamination sensor by sensor. That is, P4006 considers the differences between sensors such as in repetition, sensitivity, bandwidth and coverage of observation width. Sensors may be designed with different technical characteristics in order to fulfill requirements driven by their specific purposes. Therefore, the impact of RFI may be different depending on the particular instrument. In this step, sensor-based RFI maps are produced to provide more general properties of the RFI, for example, its position, bandwidth, temporal duration and power. As P4006 does not aim to geolocate and report RFI sources, the standard regards the spatial resolution of this map is enough to be a scale of a quarter degree.

2.3 Frequency band-based RFI impact assessment

The third step is to merge the sensor-based maps into frequency band-based RFI map. Some weak RFI may only be detected by sensitive sensors. Some narrowband RFI may not be detected by an instrument if its receiver does not cover that part of the band. Therefore, collating reports from multiple sensors may become essential in order to cover the entire band. In addition to the information provided from sensor-based maps in step 2, the band-based maps should provide the RFI distribution in all the EESS-allocated bands. From these maps, the users would be able to estimate the maximum probability of RFI detection observed in each sensor. Some users may also find the existence of weak RFI hidden in the noise of their data.

2.4 Characterization of RFI

Finally, the RFI impact is summarized in any geographical regions. With this information, users can infer how severely the band is degraded by RFI in any region of the world. These data will benefit for not only the current users but also future users who plan to design a new sensor.

3 Conclusion

This paper reports the progress in the activities of the IEEE-SA P4006 Working Group. A standard is being developed for RFI impact assessment for both active and passive microwave spaceborne sensors. This process is open to anyone interested in the topic through the IEEE Standards Association. A standard needs to reflect the latest technical advances, therefore broad participation and collaboration in the development of this standard is greatly encouraged. Anyone can get involved in this activity by signing up at [6].

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