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Radio Frequency Interference Detection in Synthetic Aperture Radar Systems with Multiple Azimuth Channels

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A major concern in Synthetic Aperture Radar (SAR) systems is the increasing occurrence of Radio Frequency Interference (RFI), which introduces artifacts in SAR images and biases the measured radar return. Operational methods for mitigating interference are therefore critical for the successful operation of a SAR mission and the generation of high-quality SAR image products. However, these methods rely on first detecting the RFI in the image, which is especially difficult in the case of RFI with weak to moderate strength relative to the SAR signal.

Future SAR systems with multiple digital channels, such as ESA's Sentinel-1 Next Generation and ROSE-L missions, enable new RFI detection methods utilizing their Digital Beamforming (DBF) capability. With DBF it becomes possible to distinguish and analyze the signals that arrive from different angular directions. This is especially advantageous as the angular arrival direction of the expected SAR ground return follows a predicable and fast-changing behavior within each receive window, which depends on the imaging geometry and is modulated by the ground topography. The angular direction of an interference source, on the other hand, can be assumed stationary within each receive window (below 1 microsecond duration). Therefore, the angular direction of the SAR and RFI signal will only overlap intermittently in the angular domain (cf., Figure 1).

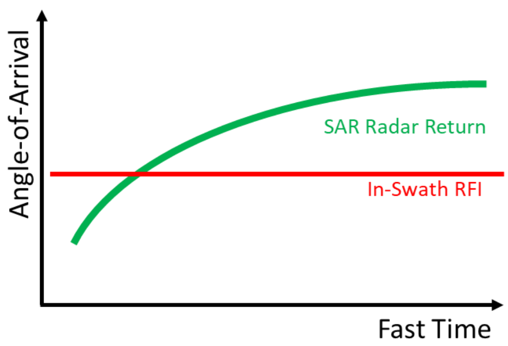

Figure 1. Typical angle-of-arrival direction vs fast time of SAR and RFI signal within a receive window.

Utilizing this property for RFI detection has been proposed in the past for systems with multiple channels in elevation [1,2]. However, the implementation for elevation channels requires sufficient on-board processing capabilities as only the weighted combination of these channels (Scan-on-Receive technique [3,4]) is downlinked to the ground due to data volume constraints.

Another option is the RFI detection using multiple channels in azimuth, which is explored in this presentation. For systems employing the MAPS technique (multiple azimuth phase centers) the data downlink of all azimuth channels is already necessary for accommodating the resource-heavy MAPS processing. Thus, the proposed RFI detection method has the advantage of not requiring any additional increase of the data volume and has no need for on-board processing. The performance of such an approach is investigated with a theoretical assessment supported with first simulations. Specifically, the expected RFI detection performance limitations when using an antenna configuration that is optimized for a typical MAPS system (large phase channel separation, low number of channels, and an undersampling of the SAR raw data) are discussed.

1. T. Bollian and M. Younis, "On-Board RFI Detection in Digital Beamforming SAR Systems using a Series of Digital Square-Law Detectors," EUSAR 2022; 14th European Conference on Synthetic Aperture Radar, Leipzig, Germany, 2022, pp. 1-4.

2. T. Bollian, M. Younis, G. Krieger and A. Moreira, "On-Board RFI Detection Performance of a Multichannel SAR System with Digital Square-Law Detectors," IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium, Kuala Lumpur, Malaysia, 2022, pp. 5141-5144, doi: 10.1109/IGARSS46834.2022.9883878.

3. M. Suess, B. Grafmueller and R. Zahn, "A Novel High Resolution, Wide Swath SAR System," IGARSS 2001. Scanning the Present and Resolving the Future. Proceedings. IEEE 2001 International Geoscience and Remote Sensing Symposium (Cat. No.01CH37217), Sydney, NSW, Australia, 2001, pp. 1013-1015 vol.3, doi: 10.1109/IGARSS.2001.976731.

4. Suess, Martin, and Werner Wiesbeck. "Side-Looking Synthetic Aperture Radar System." European Patent EP 1.241 (2002): 487.