8A.6: The “Horus” Radar—An All-Digital Polarimetric Phased Array Radar for Multi-Mission Surveillance

Wednesday, January 9, 2019
11:45 AM - 12:00 PM
West 211B

Current operational radars for weather observation and aircraft surveillance are specifically designed for their missions and, therefore, have distinct architectures. Modern weather radars, for example, are almost always dual-polarization, use mechanically scanned dish antennas with narrow pencils beams, and provide volumetric coverage with update times on the order of a few minutes. Aircraft surveillance radars are typically not dual-polarization and use one or possibly two fan beams with a rapidly spinning positioner. Although high-fidelity height information is normally not provided, aircraft azimuth positions are updated every few seconds. If these two distinct mission requirements could be met with a single radar, it is possible that overall maintenance and operations costs could be reduced over the lifetime of the radar. The challenge is to design such a multi-mission radar at reasonable cost while continuing to provide high-quality weather observations and air traffic management capabilities. The Advanced Radar Research Center (ARRC) at the University of Oklahoma (OU) is working with NOAA’s National Severe Storms Laboratory (NSSL) on this concept, which will almost certainly leverage phased array radar technology. This goal has presented many challenges, especially regarding meeting mission requirements within the desired update time and the necessity of combining high-quality polarimetry with phased arrays. Many of these challenges can be addressed with a fully digital polarimetric phased array radar. The “Horus” project is currently being undertaken by the ARRC and NSSL and will result in an all-digital, S-band, polarimetric phased array radar testbed. With an aperture of approximately 1.63 m, the Horus radar will have 1024 (32x32) dual-pol channels and will be capable of extreme flexibility in terms array segmentation, channel-independent waveforms, adaptive beamforming, etc. Each channel will produce more than 10 W of peak power with a duty cycle of 5%, providing a sensitivity of approximately 12 dBZ at 50 km. Though its limited size means that the S-band Horus radar does not provide the angular resolution typically expected from a weather radar, it is extremely scalable and will serve as an engineering testbed for next-generation multi-mission radars. Given the importance of radar polarimetry to the weather community, its most-important feature will be the capability of performing real-time and frequent array and polarimetric adaptive calibration as a routine part of the Horus scanning strategy. By exploiting mutual coupling between individual radiating elements that make up the array and the waveform independence of an all-digital array, the ARRC is currently developing automatic algorithms for array/polarimetric calibration. Finally, the all-digital design of the Horus radar will serve as an ideal testbed for evaluation of the level of digitization (e.g., subarrays versus all-digital) needed to meet multi-mission requirements. The system will be based on a slat/brick design for the majority of the electronics, including the RF front-ends, commercial-off-the-shelf (COTS) transceivers, and on-board FPGA processing. This functionality will be combined into a single so-called “Octoblade” composed of 16 highly compact and functional channels. The Octoblade will also include liquid cooling and will be line replaceable for simplification of routine maintenance. The dual-polarization patch antenna has extremely high polarimetric isolation (better than -40 dB), which is enhanced further by the design of the RF channels. Although the system is extremely flexible, if desired to reduce data size, partial systolic beamforming will be possible with the on-board FPGAs. Data transfer will be handled with a high-speed RapidIO network. The overall system concept and rationale for various design decisions will be presented along with the current status of the project.

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