

X-band Synthetic Aperture Radar in SmallSats: Developing a Deployable Phased Array at SmallSat Timescales

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A synthetic aperture radar (SAR) system can offer advanced imaging capabilities complementary to optical imaging systems. SAR systems have been widely used in the past including applications such as pollution detection, maritime safety monitoring, and soil moisture sensing. Currently, there are very few SmallSats that have demonstrated apertures sized appropriately for SAR applications at X-band. Furthermore, active electronic flat panel antenna technology could be a game-changer for future SAR missions on SmallSats, offering multifunctional capabilities that enhance the SAR functionality along with on-orbit calibration capabilities to compensate for potential mechanical deformations. Integrating a SAR system onto a CubeSat or SmallSat—especially a phased array system—presents a combination of many serious challenges.

In the work described here, a deployable, fixed-beam, active phased array antenna was developed for operation at X-band. When deployed, the aperture unfolds to a 5m x 1m span, using a series of flat panels and spring-loaded hinges. The architecture employed a hybrid digital and analog beam steering architecture. Digital beamforming occurs at the 0.65m x 1m panel level, and analog beamforming down to the subarray (4x4 elements). Each subarray contains a 1-to-16 fixed-beam power divider connected to the final aperture layer. The aperture layer uses a fragmented aperture approach, where pixels are turned ON/OFF to create a wide variety of shapes. The best shape is ultimately chosen by a genetic algorithm, where we optimize for antenna gain over the band of interest.

The antenna array design has been developed to an integrated panel level, and GTRI has completed testing of a prototype panel. This includes both the subarrays and the T/R analog electronics behind the subarrays. Near-field measurements were used to characterize the antenna, and very good performance was achieved with this architecture. These measured results will be presented in the special session.