NISAR Radar Antenna Pointing and Antenna Pattern Verifications

Yuhsyen Shen[1], Scott Shaffer, Stephen Durden, Joseph Vacchione, Hirad Ghaemi, Noppasin Niamsuwan

1) yuhsyen@jpl.nasa.gov, NASA/JPL

Abstract

The NASA-ISRO SAR (NISAR) Mission, planned to launch in January 2022, is equipped with a dual-frequency (L/S-band) SAR system, designed with SweepSAR architecture for wide-swath 12-day repeat-pass observations. The SAR system employs a large reflector/feed antenna, rendering pre-launch ground range measurements of antenna patterns and inclusion of metrology for inflight monitoring the antenna impractical. Given that antenna patterns are germane to radar performance and calibration and that the ability to repeat pointing the antenna is important for repeat-pass interferometry, the approaches to verify antenna performance and pointing demand due attention.

The NISAR radar antenna consists of a large offset parabolic reflector (12m diameter circular), a dual polarization array feed (12 elevation elements at 2.2m in length) with 24 transmit/receive modules (TRMs), 12 per polarization, each connected to one pol of the dual-pol element, and a boom supporting the reflector, forming 9m focal length from the feed. The TRMs transmit pulses simultaneously and the target area is illuminated with 12 overlapped elevation beams over the 242km swath, resulting in long echo returns. Each long echo return "sweeps" in time over the feed and gets digitized for the digital electronics to rectify beam overlaps (digital beam forming, DBF) and reconstruct the long echo rangeline. The radar antenna without the TRMs is reciprocal but non-reciprocal if including TRMs. Efficacy of the DBF also affects the effective receive antenna pattern.

The ISRO-provided S-band SAR system share-uses the radar antenna but with its own S-band feed design. The L-Feed and the S-Feed are placed side-by-side in azimuth, consequently the electrical boresights are squinted in azimuth to opposite sides of the antenna mechanical boresight, which is the common boresight that the antenna is to be pointed for observations.

Recognizing that antenna pattern and pointing are not testable, the Project established (1) an antenna pattern simulator (APS) based on the physical antenna system optic (mechanical geometric) prescription; (2) a structural temperature electromagnetic performance (STEP) model in which the physical mechanical layout with its constituent assemblies' thermal-elastic properties and alignment/tolerances are included; (3) a radar (software) emulator/point target simulator (called SALSA), which emulate flight electronics and simulate pointing target echoes under simulated flight geometries. The APS generates antenna gain patterns to feed into the SALSA to generate flight like data for ground

processing for end-to-end system performance evaluation. The STEP model provides "distorted" optical prescriptions for the APS to generate "distorted" patterns, which are fed into SALSA for evaluation of system sensitivity. Once the I&T program is completed, the models will be updated with as-tested parameters to certify system flight readiness.

On orbit, antenna pointing could be disturbed by launch, zero-G unloading, and thermal environments; the pointing of the antenna will be calibrated first and then antenna patterns be evaluated. The radar will be specially configured to create nulls in elevation pattern and make observations over homogenous target areas. The data acquired is used to determine radar electrical boresight, elevation from the peaks-nulls and azimuth from Doppler centroids. Spacecraft attitude control can be commanded to offset the antenna off-pointing and the DBF related onboard tables may be updated for to optimize performance radar observations.

Keywords - Calibration of future missions