Starburst: A Revolutionary Under-Constrained Adaptable Deployable Structure Architecture

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A solution for a high frequency, wide bandwidth, deployable reflector is needed to enable low-cost millimeter wave radar and radiometer missions. Recent developments in W-band radars and radiometers have enabled instrument miniaturization, but these advantages cannot be realized without a deployable antenna. Starburst is an innovative architecture for deployable structures, which is being explored to enable high frequency deployable reflectors up to 240 GHz. The concept would apply to a number of planetary missions with mm wave instruments and enable high frequency (and thus high rate) direct to Earth telecommunications.

Unlike traditional deployables which are constrained throughout deployment, Starburst uses an under-constrained approach to achieve high stowing efficiencies for rigid surfaces. Starburst can achieve highly accurate deployments (~20 micron) using kinematic mounts. It deploys to an over-expanded state via high strain composite rods, and then is pulled into position by cables, guided by the high strain rods. As the approach is under-constrained, the architecture is modular and adaptable. As a first instantiation, the Starburst technology is being developed into the Solid Underconstrained Multi-Frequency (SUM) deployable antenna, a multi-segment, offset-fed parabolic solid deployable antenna, which would enable large, high-frequency apertures to deploy from a compact volume of stacked segments. The antenna technology in development is 2 meters in diameter, operating at frequencies between 2 GHz and 240 GHz, and can stow in a volume of 0.5 x 0.56 x 0.7 m^3. The core elements of the SUM deployable antenna consist of the aperture segments (semi-hexagons), rough deployment guides (high strain composite (HSC) rods), and systems for retrieval, preloading (cable), and kinematic location. When stowed, the segments stack neatly on top of each other into a compact volume. After launch, launch locks are activated, releasing the segments, and the HSC rods deploy the system into an initial configuration. Two HSC rods arrange each element in its proper orientation, so the system can be pulled together. After the deployable antenna opens, the cables are then retracted, slowly reeling in each of the segments into the final deployed shape. Kinematic joints precisely locate each segment relative to each other within 20 microns, preloaded in place by the cable, for an overall surface root mean squared (RMS) error of ~60 microns. The final system has only rigid segments in the design, meaning it is not subject to errors from creep. Because of its under-constrained deployment configuration, unlike hinged antennas, the segments can be stored anywhere on the spacecraft where there is spare volume, maximizing stowed efficiency. The under constrained approach also means that qualifying one system will qualify the architecture for a number of deployables.

Starburst provides a game changing solution for rigid, high accuracy deployables. Beyond the antenna application we are exploring how the architecture can be used to deploy structure from any stowed configuration into nearly any desired shape, and can be used for apertures, booms, telescopes and solar arrays. Potential mission concept use cases for SUM deployable antenna would be a Titan Radar Altimeter and Cloud/precipitation Explorer (TRACE) which could apply to the Titan Orbiter concepts, the interferometric synthetic aperture radar (InSAR) discussed for Prometheus, and the Incoherent Scatter Radar Mission to Mars (ISRMM) Deployable Array Radar Aperture. Also, direct-to-Earth communications, which this deployable antenna would enhance, is mentioned as a need in the “Key

Technology Needs Identified from KISS Report”. The Starburst technology could be used to expand any of the rigid antennas on a number of the orbiter mission concepts, to provide greater gain, and thus increased data rates, for direct-to-Earth communications.