Deployable and Light-weight Array Antennas For Space Application

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The deployable array antenna using inflatable or thin-membrane structure has been identified as one of the enabling technologies to achieve low-mass, high packaging efficiency, low cost, and reliable deployment for future NASA/JPL spaceborne high-gain and large aperture antennas. Array antennas, when compared to parabolic reflectors, although suffering from limited bandwidth performance, offer wide-angle beam scanning capability and a more reliable flat "natural" aperture. To demonstrate the feasibility and capability of this low-mass array technology, three antenna concepts using inflatable and thin-membrane structures were initiated in 1997 at JPL and three sets of breadboard units were successfully developed. These three concepts are (1) the inflatable phased array, (2) the inflatable reflectarray, and (3) the foldable frame-supported thin-membrane array. All three concepts utilize the printed microstrip antenna technology. The inflatable phased array is a 3.3m x 1.0m L-band dual-polarized synthetic aperture radar (SAR) array for Earth remote sensing application. It consists of a rectangular inflatable tube that supports and tensions a three-layer thin-membrane radiating aperture with microstrip patches and microstrip power divider lines. It has a mass density of 3.5 kg/m^2, is 1/3 size of the eventual 10m x 3m full-size SAR array, and was intended as a technology demonstration model. For the second concept, two inflatable reflectarrays were developed for future deep-space telecom applications. One is a 1m X-band inflatable reflectarray (1.2 kg/m^2) and the other is a 3m Ka-band inflatable reflectarray (1.8 kg/m^2). Both reflectarrays use inflated torus tubes to support and tension a flat-membrane reflectarray surface. Each antenna has inflated tripod tubes attached to the torus tube for support of the feed horn. The reflectarray surface emulates a curved parabolic reflecting surface. However, because of its flat surface being a "natural surface", it is much easier to achieve and more reliable to maintain the required surface tolerance than that of a curved parabola during long space flight. For the third concept, an L-band dual-polarized SAR array with a 5m x 3m aperture and 2.5 kg/m^2 of mass has recently been demonstrated. It consists of seven foldable panels each having a rectangular frame that supports a two-layer thin-membrane microstrip subarray aperture. Each frame is made of light-weight graphite composite material. The chief advantage of this deployable "frame" concept is that each frame is able to rigidly support an appropriate number of T/R modules and phase shifters to achieve the desired power distribution and beam scanning.

Several technology challenges, such as development of rigidizable inflatable tubes, a controlled deployment mechanism, thin-membrane thermal effects, a low-mass inflation system, membrane mounted T/R modules, etc. are being investigated and will be discussed in the presentation. With foreseeable success in the development of these challenging areas, the inflatable/thin-membrane array antennas could be mature enough in a few years for actual space flight.

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