The Development of Inflatable Array Antennas

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The deployable array antenna using an 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 several breadboard units have been successfully developed. These three concepts are (1) the inflatable phased array, (2) the inflatable reflectarray, and (3) frame-supported thin-membrane array antenna. All three concepts utilize the printed microstrip antenna technology. Although all three concepts will be briefly presented, this paper will discuss in more detail of the recent development of the second concept. The first concept of inflatable phased arrays that have been constructed are 3 to 5-meter size L-band dual-polarized synthetic aperture radar (SAR) arrays for Earth remote sensing application. They all consist of a rectangular configuration with inflatable cylindrical tubes that support and tension a multi-layer thin-membrane radiating aperture with microstrip patches and microstrip power divider lines. For the second concept, an inflatable reflectarray was developed for future deep-space telecom applications. It is a 3m Ka-band inflatable reflectarray (1.8 kg/m^2). This reflectarray uses inflated torus tubes to support and tension a flat-membrane reflectarray surface. 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 the development of rigidizable inflatable tubes, a controlled deployment mechanism, thin-membrane thermal effects, a low-mass inflation system, membrane mounted T/R modules, means to counter surface tolerance issues, 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.

* The research described in this article was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space administration.