Satellite Communication and I

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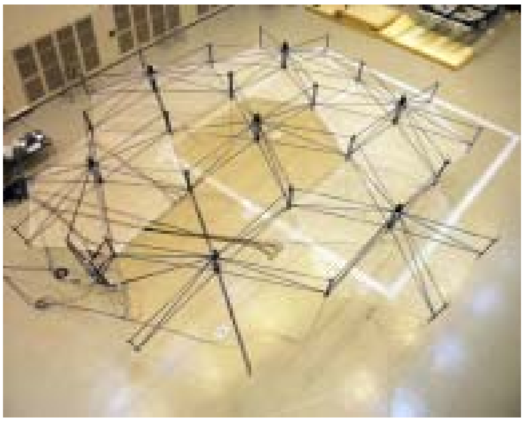
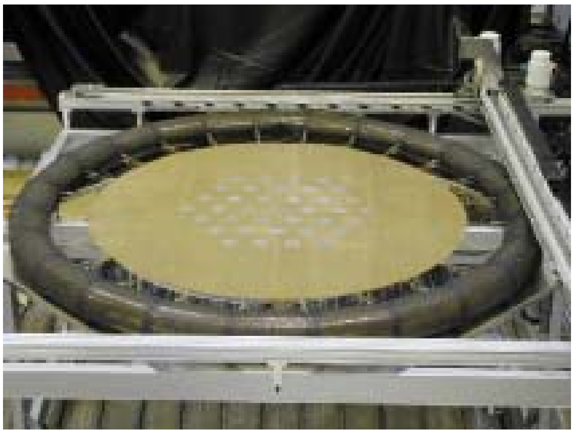
Since joining NTT I have been researching the construction of large space-deployable antennas. Earlier satellite communication systems were designed for quite narrow tasks such as establishing communication links among islands, easing congested ground links or as back-ups against outright failure, or providing private lines. Recently, however, satellite communication systems are expected to be used to achieve communications via cellular phones and broadband communications. The goals are to increase the convenience of cellular phones (make them smaller) and to increase the data transfer rates. Increasing satellite antenna gain is the best solution to these problems. Enlarging the antenna's size increases its antenna gain because the beam is better focused which strengthens the received antenna gain. There is a significant problem in that it is virtually impossible to stow a regular satellite antenna which aperture above than 10 m into the rocket fairing. The antenna's shape must be changed to allow it to be launched. In another words, large antennas must be deployable. Moreover, they must be light to meet the weight limit of the existing rockets, which suggests that adequate stiffness will be difficult to achieve. My research aims at developing large deployable antennas that are light but that offer sufficient stiffness in-orbit.

I have been engaged to the research of two types of deployable antennas. One of them is called the deployable modular mesh antenna. This antenna uses a truss-type structure to construct a number of near-identical modules. Our most recent antenna consists of 14 modules. The reflective mesh stretched over the modules acts as the radiating part of the antenna. The modules are deployed simultaneously, each has its own deployment mechanism, to form the entire antenna. The other type of deployable antenna is the inflatable antenna. The antenna, which I have been researching, consists of a circular inflatable tube that supports a flexible membrane. It is unfurled by pressurizing the tube with a gas. Using



Deployable Modular Mesh Antenna

inflatable structures offers the advantages of low cost, low weight, and long shelf-life. The truss type antenna becomes rather unwieldy as antenna size increases since the increased number of modules means a commensurate increase in the number of trusses and hinges. As a result, antenna weight becomes excessive once the module number exceeds a certain number. The inflatable antenna, however, is simplicity itself and its weight increases more slowly than the truss type as antenna diameter increases. Inflatable antennas are expected to be used not only for communication satellites, but also for space solar power satellites and portable antennas for ground use. In our inflatable antenna, the radiating elements, which are circular patch antennas, are attached to the flexible membrane. This combination of flexible membrane and radiating elements forms a planar array antenna. The inflatable ring is rigidized after inflation to ensure that the required stiffness is maintained since the pressurizing gas may eventually leak out.



Inflatable Antenna Model

Since the use of inflatable structures has only just begun, there are many problems to overcome. We are now working on two key problems. One is how to rigidize of the inflatable ring. We are examining the thermal curing method and the thermal fusing rigidization method to determine their good and bad points. The thermal curing method heats a composite impregnated with a heat-setting resin while the thermal fusing method heats a composite composed of reinforcing fibers and plastic above the plastic's melting point. Both methods exhibit good performance, and we were able to find the rigidizing conditions for both methods. We are also working on the flexible patch antennas that will be attached to the flexible antenna membrane. The flexible patches must be folded to stow the antenna in the rocket, but they must be able to achieve rated performance after being folded and then unfolded in-orbit. The conventional type of patch antenna is made by printing copper foils onto a polyimide film. However, both the polyimide film and copper foils are weak against creasing, so antenna performance is problematic. We searched for a new approach. As the antenna membrane, we have developed a triaxial composite material, a type of cloth consisting of aramid fibers woven in three directions, oriented 60 degrees from each other and impregnated with matrix resin. This material has the advantage of an isotropic deformation response. Since it is impregnated with matrix resin, it has enough stiffness to resist micro-creasing and still remain flexible enough to permit folding. The patch antennas are made of a non-woven mat of conductive fibers. Unlike the regular orientation of fibers of cloth, the conductive fibers are randomly placed and so creasing damages fewer fibers. These patch antennas have adequate levels of antenna performance.

If our inflatable structure technologies are further refined, this type of structure will be used more widely. I would like to continue this research not only for the development of space structure but also for the chance of discovering new approaches to satellite antenna construction.