Needs Assessment and Project Scope

EML 4551C – Senior Design – Fall 2011 Deliverable #2

Team # 5

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Needs Assessment

There are two primary types of reflectors commonly used for the purpose of focusing electromagnetic energy at a particular point or in a particular direction. These two types are solid reflectors and mesh reflectors. The solid reflectors generally perform better than a similarly sized mesh reflector, but the mesh reflectors are easily folded for efficient transportation. If an application demands that the reflector be folded or stored, the only option is to use a lower performance mesh reflector. There is a need for a reflector with the performance and low maintenance of a solid reflector but the portability of a mesh reflector. The solution lies in a deployable solid reflector that will be the best of both worlds.

Project Scope

Problem Statement

The challenge of this project is to develop a two-step hub mechanism that allows for the deployment of a segmented solid reflector panels. This involves creating a CAD model, dynamic simulation, and ultimately a working prototype to show its ability to facilitate the folding process.

Objective

The Goal of the project is to design the two-step hub mechanism. This includes a complete CAD model, full kinematic and dynamic analysis, and working scale prototype. The final prototype should demonstrate that the mechanism capable of deploying the solid reflector could be operated in an effective and efficient manner.

Justification and Background

Since the beginning of telecommunications, it has been a priority to develop better, more transportable reflectors. Reflectors that focus electromagnetic energy are used in applications such as radio-frequency (RF) antennae, solar collectors, cameras, and other optical devices. The reflectors used in these applications are typically shaped to focus electromagnetic energy at a particular point or area. In the case of an antenna feed mounted on or proximate to the reflector, the reflector is shaped to have a parabolic surface to focus the electromagnetic energy in a particular direction.

Reflectors have been configured in two types: solid or mesh configurations. Solid reflectors usually provide higher performance than mesh reflectors. This is because the mesh reflectors generally have a loss in the electromagnetic energy being focused upon it. A solid reflector does not tend to have a very big loss in the focused electromagnetic energy. Also, the mesh of a mesh reflector sometimes requires individual positional or cord adjustments at hundreds or thousands of locations during its assembly and after deployment to achieve its required performance level. A mesh reflector requires a surface roughness deviation from an ideal surface profile of less than 0.010-inch. Even though these required adjustments than could be done to a mesh reflector, it is sometimes very difficult to achieve with the needed precision. In addition, the mesh reflector cannot be used to focus high-frequency RF signals such as Ka and Ku-band transmissions. This is why a solid reflector is more commonly used.

The reason mesh reflectors are used, however, is because they are very dynamic in their ability to be stored. Mesh reflectors can be folded into a compact configuration, allowing them to be stowed in relatively small volumes. A solid reflector cannot typically be stowed in a folded configuration, resulting in a larger ratio of stowed-to-deployed volume than a mesh reflector of comparable size. In applications that are space-based, the sizes of the fairings in which the reflectors are stowed prior to deployment are limited in size. As a result, the reflectors used in space-based applications or any airborne or mobile applications are normally mesh reflectors.

Methodology

The first task is to read and understand all preliminary information received from Harris Corporation and to research existing and previous hub deployment designs. This not only allows for additional understanding of previous designs, but also ensures that the new design is unique and will withstand testing that caused previous designs to fail. This research will reveal to us important parameters that need to be considered while in the construction stage. Harris Corporation has provided detailed drawings, videos, and explanations of past designs; therefore, it is our duty to take them, refine them, and turn them into a tangible, working Hub Deployment Mechanism.

After extensive research, our next task will be to brainstorm methods to (1) deploy all reflective panels with respect to one another and (2) to pull the panels axially to interlock them to one another in order to form a solid parabolic surface. Since these two tasks can be achieved using many different procedures, it is important to choose a design that can be easily implemented and is not too bulky since size and geometry are important. The chosen design will include all desired measurements and implement all limiting factors and all important parameters in order to ensure avoidance of possible modes of failure. After the design is optimized and refined, materials will be chosen for each component of the hub. Parameters that need to be considered include but are not limited to robustness, mechanical strength and durability, thermal stability, and cost of materials used.

Following selection of optimal design and materials, CAD drawings of all parts will be produced in Pro/ENGINEER. Existing drawings will be edited as needed. A 3-D model of the hub mechanism will also be produced within Pro/ENGINEER so that a working, moving hub can be virtually seen. This will allow us to get an idea of how each component of the hub deployment mechanism will move. Since the interface between the hub deployment mechanism and the interlocking panels is important, it is hoped that a 3-D model of the whole system can be produced to ensure that there are no problems between the two.

After the CAD drawings are complete, construction on the components of the hub deployment mechanism will begin. Since a full-sized deployable solid reflector can span up to 30 feet in diameter, a much smaller replica will be built for the purposes of this project. The parts will either be machined in local shops or bought from online sources. A thorough and complete cost analysis will be kept to ensure that all expenses are kept within budget. During this stage, it is important to keep in touch with Team 6 (the interlocking panel team) in order to ensure that the two systems are working together properly.

The last stage in this project will be to test our hub deployment mechanism. This will be done by first attaching the interlocking panels Team 6 will construct then analyzing the deployment and retracting process. Since it is necessary for this action to be carried out multiple times while in space, it is important to carry it out multiple times while NOT in space. If the system is in working order and is problem free, then the project is complete. Time will be accounted for and allotted at the end of this stage just in case there is a problem.

Constraints

There are several constraints to consider while constructing the hub deployment mechanism. In no particular order, below is a summary of such constraints:

a) There is a $2,500 budget
b) Since a full-size, working solid reflector will be modeled after the replica built for this project, there are numerous material constraints that need to be considered
    a. Some materials cannot take the extreme temperatures imposed in outer space
    b. Some materials degrade over time and after repetitious movements
    c. Some materials are not strong enough to uphold the heavy panels
c) There is a surface roughness constraint of 0.010” RMS

d) This hub deployment mechanism should be designed so that it can be used in space and on the ground for the purposes of communication
e) Size and weight constraints have been set in place
    a. The hub can be no heavier than 21 lbs
    b. The whole solid reflector and the hub can be no heavier than 120 lbs with a stowed volume of 50,900 in^3
f) The hub should be constructed mainly of concentric rings each having a mounted panel
g) A minimum torque requirement has been set forth by Harris, but specific numerical values are unknown as of yet

Expected Results

Our overall goal in this project is to create a working prototype of the hub assembly system for solid reflector deployment. Our prototype will prove the functionality of the hub assembly and will interface with the panel prototype of the other Harris senior design team. The prototype will rotate all the panels with respect to one another and then pull the panels axially to interlock them to one another and form the solid parabolic surface. The working prototype will first be created as a CAD model and will be simulated to make sure it performs as described by the patent documents. The minimum torque requirements will be met in both the simulated prototype and the built prototype. Working together with the other Harris senior design group, we expect a fully functional working prototype of a high surface accuracy tangential deployable solid reflector for space and ground applications to be built.