Two-Step Hub Mechanism for Solid Reflector Deployment

Concept Generation and Selection

EML 4551C – Senior Design – Fall 2011 Deliverable #4

Team # 5

Chris Rudolf

Noah Nichols

Audrey Wright

Department of Mechanical Engineering, Florida State University, Tallahassee, FL

Project Sponsor

Harris Corporation

Project Advisor

Prof. Chiang Shih, PhD

Department of Mechanical Engineering

Reviewed by Advisor:

Introduction:

Our team is to develop a two-step hub mechanism that allows for the deployment of segmented solid reflector panels. We have come up with a variety of concepts to achieve this goal. In this report we will be analyzing the concepts and come up with pros and cons for each design. This will allow us to better weigh our options based on functionality, reliability, and monetary cost.

The main requirements of our concept are that the hub mechanism must rotate the solid reflector panels into position and retract them into the same surface plane. Our concepts all rotate the solid reflector panels using a centralized motor, however, we have come up with a few different concepts to guide the motion of the rings to which the panels are attached. There are two main ways of retracting the panels into position. The first way is to retract them all at the same time after they have all been rotated into position. This concept will work best if a second motor were to control this motion. The second method we used to retract the panels implements a step-down motion. This can be done a few different ways, which we will outline in different concepts.

This project is a new idea that has never been accomplished before and therefore will require testing of various ideas to come up with a final concept.

Concept Generation:

While brainstorming conceptual ideas for our project, we considered different methods of deploying the solid panel reflectors. Deployment of the panels can be achieved through the use of multiple motors to perform different tasks, through the use of a spring in tension or compression, and through the use of variously shaped and angled slots that would allow the concentric rings to slide into place as one motor turns a main driving ring. Our sponsor has come up with a preliminary idea consisting of deep vertical slots that lock the rings into place as they rotate; this design will also be considered since it is the most simplistic while still remaining within the design specifications. In all of the designs, we have determined that it is necessary to implement some kind of bearing, bushing, or lubricant in between the concentric rings in order to prevent eroding of the material and binding of the rings as they rotate with respect to one another.

Concept 1: Multiple motors

This is the concept that our sponsor proposed for the project. Multiple motors can be used to perform different tasks within the system. One motor attached to a main driving ring (seen in red in the figures below) can be used to deploy the solid panels. A series of slots and pins would be needed to restrict the motion of the rings so that the panels connected to the rings are in the ideal position and are in place to be interlocked. A second motor would be used to then collapse the rings together, locking the panels into place. Figures 1 through 6 show the process of deploying and collapsing the panels. Figure 1 shows the system in its starting position, while the remaining 5 figures depict the panel deployment and retracting interlocking process.

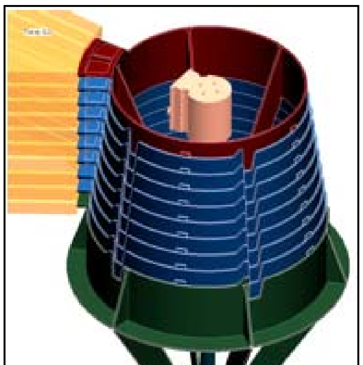

Fig. 1: Starting Position

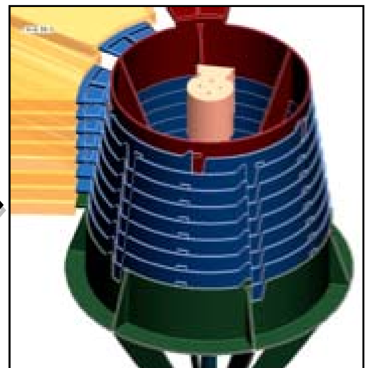

Fig. 2: Start of Rotation

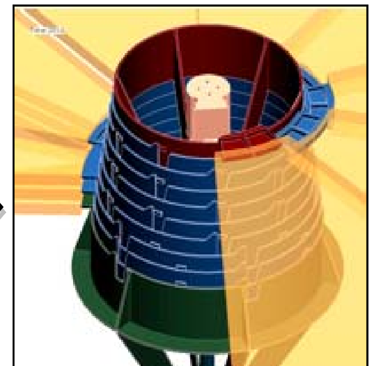

Fig. 3: ¾ Rotated

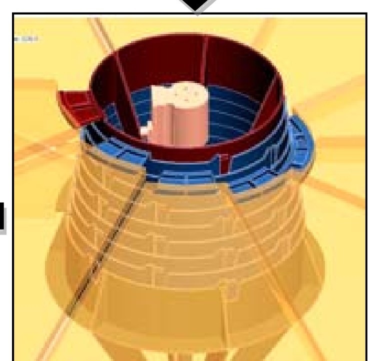

Fig. 4: Fully Rotated

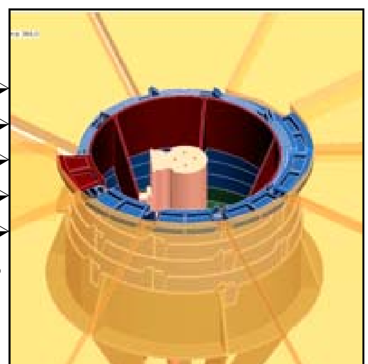

Fig. 5: Halfway Retracted

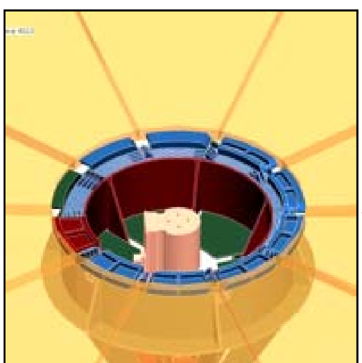

Fig. 6: Fully Retracted

- Pros
  - All panels are deployed then collapsed
  - Ensures precise panel alignment
- Cons
  - Greater weight
  - Increased complexity

Concept 2: Implement Springs

The first idea that our group came up with utilizes springs, either in tension or in compression, to accomplish the retracting interlocking motion of the panels without using a second motor. In this design, a single motor would be used for the sole purpose of deploying or fanning out the panels while a spring centered within the hub would bring the panels together. We have come up with two different ways to implement springs into the system. As seen in Figure 7, the first method uses a single, interior spring in tension that would keep a constant pulling force on the rings such that, as they are being deployed, they are pulled down into some type of machined slot in the ring below. The second way is to uses a spring in compression so that they rings are being pushed down. Compression springs may be the way to go, since objects in compression fail in a more predictable and less destructive way. Either way, the motion of this design would be a step-down rotation process. Spring constants and spring material durability are important factors to consider for this design.

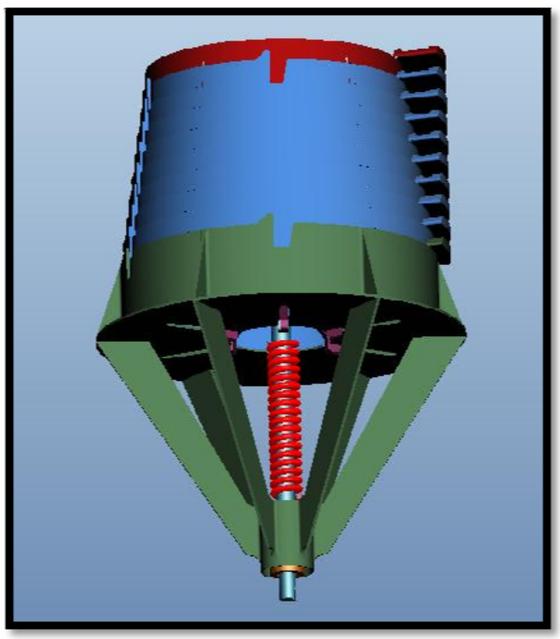

Figure 7: Side view of spring concept

- Pros
  - Single Motor
  - Easy to implement
- Cons
  - Springs could fracture/fail
  - Adequate spacing between panels needs to be maintained

Concept 3: Guide Slots

This concept uses guided slots to step down the panels to their retracted position. Figure 8 illustrates the slot profile used in the original two motor design. This guided slot design uses a single motor to rotate the rings. As the rings rotate, they follow a ramp down that interlocks them in the retracted position one by one as seen in Figure 9. This concept is fairly straightforward and would be easy to implement. The only problem we may run into with this design would be the spacing of the panels based on how much room we need between the rings. This problem could be negated by ramping the panels out to make space and then ramping them back in when retracting.

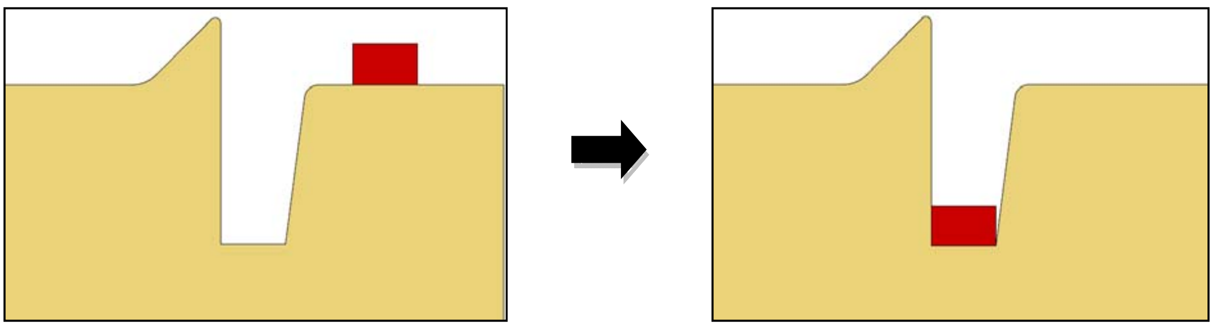

Figure 8: Original ring profile with deep slot

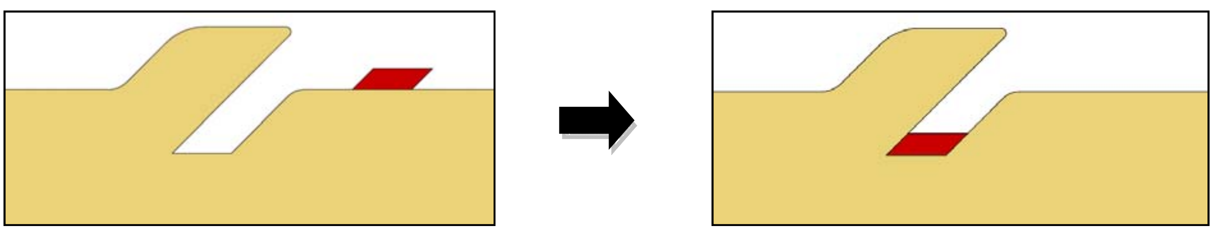

Figure 9: Ramp slot profile with angled slot

- Pros
  - Single Motor
  - Ease of construction
  - Reliable design
- Cons
  - Panels may need to be guided
  - Spacing between panels could be an issue

Selection Criteria:

Each concept we came up with satisfies the costumer's requirement that the hub mechanism must rotate the solid reflector panels into position and retract them into the same surface plane. We had come up with additional concepts as well but were told by our project sponsor that they would not achieve the desired motions. Based on our current views of our concepts, we have come up with a decision matrix that rates each concept based on theoretical workability. We weighted our specifications based on our views of their importance.

The reliability of our hub mechanism is most important because the mechanism will be deployed in space. If the hub mechanism does not deploy correctly, then there is no way to recover it to fix it. Our concept using guide slots should be most reliable because the deployment relies only on a single motor whereas the multiple motor concepts relies on two motors working and the spring implementation relies on the spring staying in tact after a turbulent ride up to space.

The durability is less important since the hub mechanism only needs to work and deploy once. The concept implementing a spring to retract the rotated panel rings was rated below the concepts of multiple motors and guide slots because it involves a spring that can be jarred loose.

The weight of our hub mechanism is not as important because each of the concepts should weigh about the same and since it will be deployed in space it will not have an effect on the rotating movement.

Efficiency of the hub mechanism is important for the reliability of the system. A more efficient mechanism would reduce the strain on the motor and reduce friction imposed by the rotation of the rings.

We thought that ease of construction would be important because of our time constraints in building our prototype. The concept using multiple motors would be the easiest because it requires less machining as compared to the other concepts.

The cost of the hub mechanism is important since we have been given a budget. The concept using a spring to retract the hub will be the most cost effective because it will not require extra machining and bearings. The multiple motor concept would be most expensive because the motors that would be used are very expensive since they must be designed for use in space.

The total weighted ratings for each concept were given based on how we have initially perceived each concept. For our next deliverable we will be conducting more in-depth research to better compare our concepts.

Concept Selection (Decision Matrix):

Decision Matrix		**Concepts**					
		Multiple Motors		Spring Implementation		Guide Slots	
Specification	**Weight**	*Rating*	*Weighted Score*	*Rating*	*Weighted Score*	*Rating*	*Weighted Score*
Reliability	0.4	3	1.2	4	1.6	4.5	1.8
Durability	0.05	4	0.2	3	0.15	4	0.2
Weight	0.1	2	0.2	3	0.3	4	0.4
Efficiency	0.2	5	1	4	0.8	3	0.6
Ease of Construction	0.15	4	0.6	3	0.45	2	0.3
Cost	0.1	1	0.1	5	0.5	3	0.3
Total	1	3.3		3.8		3.6	

Ratings: 1 (worst) to 5 (best)