ISS Longeron Challenge

Total Award Available: $30,000

The Challenge: Position the solar collectors on the International Space Station to generate as much power as possible during the most difficult orbital positions.

The Results: NASA received a huge response to the challenge and took the solar array angle input from the top 20 finishers. While the detailed power analysis was not better than current implementation the solutions gives NASA ideas for the future if issues arise with some of our solar arrays.

How the Challenge Advanced NASA's Mission: The winning solutions are being kept on file for future use in the event of the degradation of solar array joints on the ISS.

At completion, there were 4056 registered solvers, 459 competitors, and 2185 submissions. (https://www.nasa.gov)

Click below to see a video about the Contest.

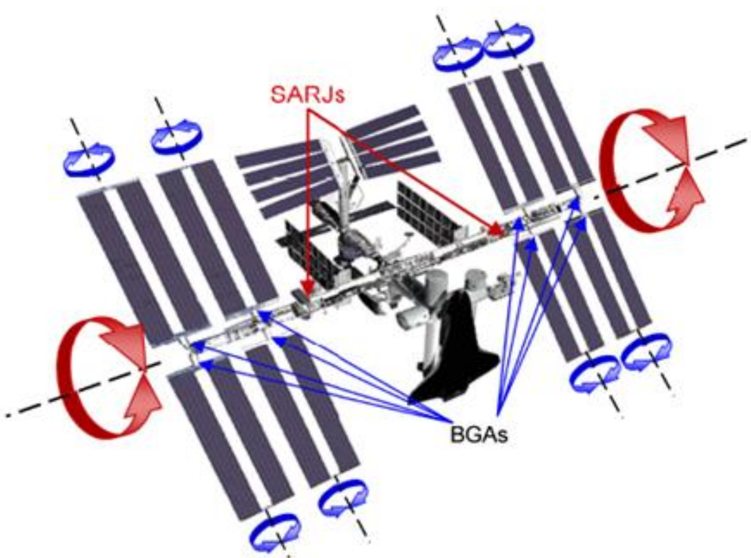
https://www.youtube.com/watch?v=qiFDrwnUgUc

Challenge Details

Welcome to the ISS Longeron Challenge! This is an exciting new challenge that will really test your problem-solving skills. Not only will you be participating in solving a problem for NASA and the International Space Station, you also will be competing for a total prize purse of $30,000 and NASA stickers that actually flew in space! Alon with cash prizes and NASA stickers, we are also offering these limited-edition ISS Longeron Challenge t-shirts.

We wanted to give you a sneak preview of the goals and requirements, so please read below for more details. If you're ready to compete, visit: http://community.topcoder.com/tc?module=MatchDetails&rd=15520.

The goal of the challenge is to position the solar collectors on the International Space Station to generate as much power as possible during the most difficult orbital positions. The solar collectors are arranged in two groups of four Solar Array Wings (SAW). Each group is rotated by a joint called a Solar Alpha Rotary Joint (SARJ). Within each group, each of the four SAWs is rotated by a joint called a Beta Gimbal Assembly (BGA). It is your job to specify the angular position and velocity of these ten joints at each minute of the 92 minute orbit. In addition, you are allowed to adjust the orientation of the entire station by a small amount (which stays constant for th entire orbit).



For each test case you will be given the orbital parameter called the Beta Angle. You can calculate the apparent position and motion of the sun (with respect to the ISS using the Beta Angle. The Beta Angle for each test case will be known throughout the contest, so off-line pre-calculation of answers is possible.

The amount of power generated by each SAW depends on its orientation with respect to the sun and on any shadows on the solar collectors. Code to calculate the power generated at a specific orientation will be provided for the use by contestants in the off-line tester/visualizer.

In addition to maximizing the total power output there are some constraints on the possible movements:

- Each SARJ and BGA is limited to a maximum angular velocity and to a maximum angular acceleration.
- Each SAW must produce at least some minimum average power over the orbit (which is different for each SAW).
- The sequence of positions must be cyclic, so it can be repeated on the next orbit.
- The maximum amount of BGA rotation is not limited, but exceeding a threshold will result in a score penalty.
- Some structural members of the SAW mast (called Longerons) have restrictions on how they can be shadowed.

Longerons are the four long components of the SAW's mast. If a longeron is shadowed for a period of time it will cool and shrink. If some longerons shrink while others do not, this may stress the longerons and weaken them. This weakening would eventually lead to the failure of the mast so this must be avoided at all cost.

You will be provided with a CAD model which specifies the simplified geometrical model of the ISS which is used the scoring calculations. It is not necessary to use this CAD model directly, as it is built into the tester/visualizer calculations, but it is available should you decide to examine or use it. In addition to the CAD model, you will b provided with the detailed dimensions of how the solar collectors are arranged on each SAW. While a solid background in 3D geometry may be useful in this contest, it not necessary. All the 3d calculations can be performed by the tester/visualizer which can return a lot of information to you about your current orientation (SAW shadov angles relative to the sun, longeron shadows and power outputs) which you can use to tune your solutions. To further help you understand what happening at specific orientations, the visualizer will produce images showing the entire ISS in your orientation with shadows from various viewpoints. In addition an animation of the motions and shadows over the entire orbit can be produced.

COMPETE NOW

NTL

The NASA Tournament Lab enables the TopCoder community to compete amongst each other to create the most innovative and optimized solutions for specific, real-world challenges being faced by NASA researchers.

CoECI

The CoECI provides guidance to other federal agencies and NASA centers on implementing open innovation initiatives from problem definition, to incentive design, to post submission evaluation of solutions.

NASA's Center of Excellence for Collaborative Innovation (CoECI) and the Harvard-NASA Tournament Lab - **The Future Is Now: Challenge-Driven Open Innovation in the Federal Government**

Lessons Learned

The NASA Longeron Challenge; William Spetch, NASA

Interview Q&As

1. Please describe your challenge
   a. What was the challenge?
      The ISS Longeron Challenge trying to optimize power generation at high solar beta angles.
   b. Why did you select a challenge to solve your problem?
      We were approached by NASA Headquarters looking for problems that could be used as a challenge potentially. In this case, we had a solution already that was working but took the opportunity to see if it could be improved upon.
   c. What problem solving mechanisms had you already tried and for how long?
      We had iterated on the problem and developed a solution prior to the challenge.
   d. Were there other mechanisms you used to try to solve the problem first? - See Above
   e. What would have been the traditional method you would have used to achieve your goal? – See Above

2. Describe the internal approval process for running the challenge
   a. What did it take to gain approval?
      In this case, only a quick conversation with my management.
   b. How did you obtain funding?
      It was provided by Headquarters as a proof of concept type challenge.
   c. Were there any obstacles to running the challenge and how did you overcome them? - None programmatically.

3. What processes/operational procedures did you put in place to run the challenge?
   a. What resources did you use to execute? If possible, could you break it down into the following phases:
      i. Pre-Competition (e.g., problem definition and challenge design)
         Significant effort had to be placed into developing this challenge. Since we were looking to optimize an engineering problem using individuals with no experience in power generation or structural load,s the first step was developing simplified modeling methodology and parameters. Significant thought had to be put into how aspects of the problem would be scored because there were other considerations needed other than just the final power generation values. The majority of the pre-contest development work was handled by TopCoder, but I drew on my engineering support teams to develop the algorithm's needed for power generation, structural loads, and joint rotations. Overall, it took almost a year to get the challenge off the ground.
      ii. Competition (Launch & marketing, contest/challenge support)
         The launch and marketing of the contest was fairly simple from my end. I participated in an online interview and reviewed the contest forums to help answer some of the questions asked by contestants. We also ran a t-shirt design competition which created some great buzz for the competition.

iii. Evaluation (judging and selection of winners)
We developed a scoring algorithm to evaluate the winners that was fairly simple based on power generation and joint rotations.

iv. Post-Competition (Solver verification and implementation)
This required some effort beyond what we expected once the results came back. We ran the solutions from the contest through our detailed power generation models and noticed some significant differences. There were a lot of questions regarding the final values and what they represented. Looking back, we should have ironed this part out more before the contest began.

4. Describe the outcomes of the challenge:
   a. What product did you receive?
   We received a huge response to the challenge. We looked at the top 20 finishers and received the solar array angles that they provided into the contest. While the detailed power analysis was not better than our current implementation, the solutions gve us ideas for the future if issues arise with some of our solar arrays.
   b. What are you doing, or do you plan to do, with the result of the challenge?
   We are keeping it for the future in case of degradation of solar array joints on the ISS.
   c. If the result was not what you expected, what factors contributed to the result?
   The results were not exactly what we expected, but looking back on the parameters we gave the contestants, they made sense. We provided penalties if certain inputs were used (mainly total joint rotation) that we did not have when we originally solved the problem. This lead to interesting results that were still close to our current capabilities.
   d. Is there anything you learned, that you wish you had known before running the challenge?
   Having a proper set of goals and requirements prior to engaging in a challenge is important. The challenge was not initially defined well by me, so it took more time upfront to explain what was required and therefore delayed the final result.
   e. Would you run a challenge again?
   I Hope to run another challenge in the near future.

5. What value did you receive from the challenge(s)?
We received insight into other options to approach a problem should certain contingencies occur on the ISS,

6. What surprised you about the process?
The difficulty in developing a modeling and scoring architecture.

7. Now that you've done this, what is the level of buy-in within your organization?
   a. How does this not become a one-off effort?
   We are approaching the ISS Program with the idea of performing a second challenge in the next two months.
   b. Can this become a routinized procurement strategy?
   Hard to say at this point.

8. Any final comments?