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## **JWST Six Sigma Team Delivers Millions in Risk Avoidance**

In industry, a finely tuned manufacturing process can be the key to success. When a customer and three subcontractors join with Space Technology employees to hone the process for delivering 18 beryllium mirrors that comprise the optical telescope element on the James Webb Space Telescope (JWST), success translates into \$17 million in risk avoidance over two years.

This was the case when the Six Sigma project brought together Charlie Atkinson, Beth Barinek and Scott Texter of Space Technology with Mark Bergeland and Bob Brown of Ball Aerospace, John Kincade of SSG/Tinsley Laboratories and Lee Feinberg of NASA's Goddard Space Flight Center to tackle improving the process of manufacturing and delivering these optics on time.

Leonard Hoey, Space Technology Lead Black Belt for this project, reports, "This was a very unusual project as it brought together a lot of non-Northrop Grumman people. It integrated participation from the customer, Goddard Space Flight Center, on down through several layers of subcontractors. The fact that we encourage such participation is a differentiator in itself for our Six Sigma program. Most companies don't involve customers and suppliers in their process improvement efforts."

In fact, having such a high degree of collaborative participation may have been the defining reason for the project's success. To appreciate the intricacies of this process, one must understand that the manufacture of the JWST mirrors begins with fine beryllium powder that is pressed into "blanks." These rough blanks then move through nine hand-offs among six different companies before finally arriving at Space Technology, the JWST integrator.

"Recognizing the interdependencies through all of those layers and being able to identify, as a group, what the best procedures are for the overall process enabled this team to optimize for the big picture," relates Hoey. "That's important because if you're just looking at parts of the process and making adjustments in a vacuum, you may be 'optimizing' your steps to the detriment of somebody down the line."

## **JWST Six Sigma/page 2**

The benefit of improving the quality of the mirrors prior to delivery to the next phase of manufacture was, in fact, one of the key findings of the project. Specifically, the team found that by developing an improved manufacturing and machining technique called High Precision Contour Control (HPCC) at Axsys Technologies, they were able to speed the mirrors through the next step in production at the next facility, SSG/Tinsley.

“We were able to do some experiments,” states Scott Texter, Space Technology telescope manager for JWST, “whereby we actually acid etch an accurate profile into the surface of the mirror at Axsys before even moving the mirrors to the grinding and polishing phase at SSG/Tinsley. We expect machining to about 100 microns tolerance with surface figure improvement to be 50 or even 25 microns as a result of acid etching. That will greatly shorten the time required for initial processing operations at SSG/Tinsley and produce significant time savings.”

Improving the process flow between subcontractors wasn't the only aspect of this Six Sigma initiative that produced impressive results. A second optimization came as the team identified and moved to correct bottlenecks that occurred within a single facility.

The team started their project expecting to encounter some specific slowdowns in their process. One such bottleneck they anticipated involved having too few milling machines at Axsys, where they thought mirrors would back up waiting for their turn. What they found was not what they expected.

“One of the biggest surprises we got,” says Beth Barinek, Space Technology acquisition manager for the JWST Ball Aerospace subcontract, “was when we were analyzing the work at Axsys. We were worried that we might not be able to maintain schedule with the milling machines we had on hand and were prepared to buy another. In fact, the number of milling machines proved sufficient, but when we went through the Six Sigma process we found that our biggest constraint was with a coordinate measuring machine. This machine was less expensive to procure than the milling machines so provided an added savings.

### **JWST Six Sigma/page 3**

“Six Sigma forced us to look at things a little differently; especially to delve into areas where we might not have looked otherwise,” Barinek adds. “I think it was a surprise to all of us. If we hadn’t done this project we might just have said, ‘add a milling machine’ and that’s it — never really questioning the benefits of other options.”

Above all, the team recognizes that perfecting the mirror manufacturing process will progress until the final optic is delivered, and that Six Sigma has given them the tools to continue process improvement beyond the Control phase of this project.

“One nice thing about Six Sigma at Space Technology is that we can approach a complex project like this with a cross-company team representing multiple process layers and know that our data-driven methodology can help them reach their goal,” says Hoey.

He provides this conclusion: “One might ask, could the team have gotten to the end results of this project without using Six Sigma? Maybe, eventually, but because of our process framework they got there more quickly and with greater confidence that they identified the real, not just potential, improvements.”

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