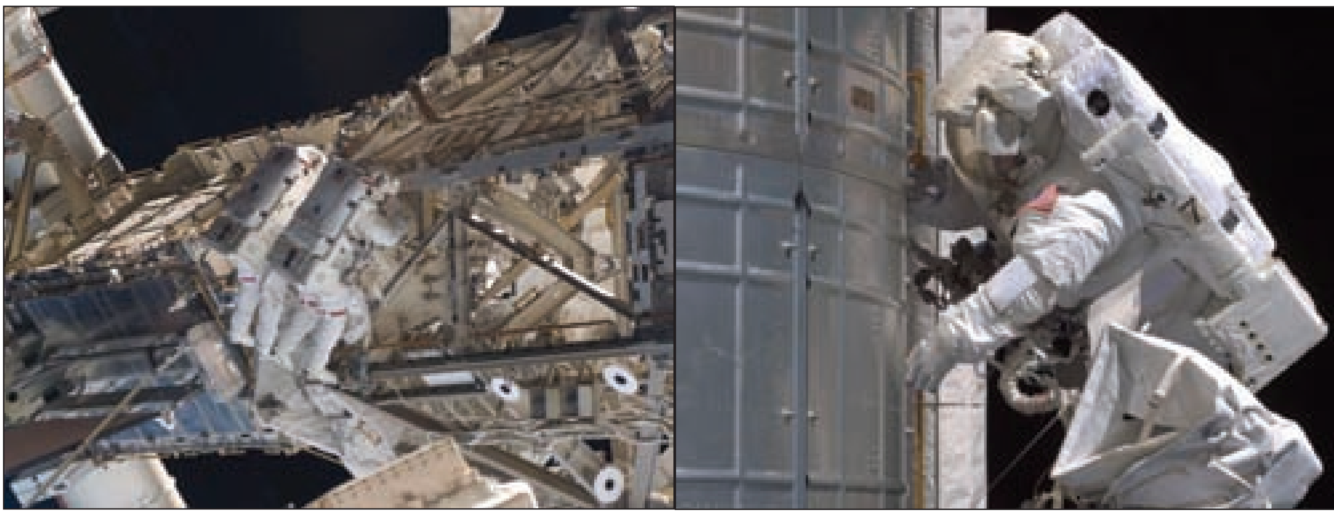
SARJ

REPAIRS SHOW PROMISE FOR SPACE STATION SOLAR POWER

Jack McGuinn, Senior Editor



Several spacewalks were required to make repairs to the SARJ. Photo/NASA.

Much has happened since we last reported on the malfunctioning solar array rotary joint (SARJ) attached to the International Space Station. Space shuttle Endeavour dropped in for a two-week visit in November during which repairs were made and invaluable data collected.

"We were able to clean, lubricate or replace 11 of the 12 trundle bearings assemblies (TBAs) on the starboard side (where the problem first arose)," says Kevin Window, NASA SARJ recovery team leader. "It took the better part of three EVAs (spacewalks); a pretty extensive job."

And, comically—in hindsight—a job not without incident. You may recall that during the initial EVA a tool bag containing a grease gun, a putty tool-like scraper and some other items slipped from the grasp of astronaut Heidemarie Stefanyshyn-Piper—lost in space, never to be seen again. Luckily, there was another set of tools onboard and the scheduled repairs were made without further incident.

From the beginning, the areas of greatest concern for flight engineers on the ground were the build-up of grit-like particles on the raceway of the TBAs, vibration in the SARJ truss and a spike upward in the motor current powering the system. As reported previously, these problems resulted in the SARJ being in disabled mode since its installation.

Window lays out the bearings issue.

"The trundle bearing is made up of three separate bearings—they have a bearing that rolls on each of the three surfaces of the race ring," he explains. "The inner- and outer-canted surfaces are at a 45 degree angle, the other is a flat surface. The bearings themselves have lubricant internal to the bearings and that's Braycote 601. But the lubricant that was utilized to lube the inner face between the trundle bearings roller and the race ring itself was gold—a solid lubricant. What we have determined in tests is that the lack of lubrication on that inner face causes excessive friction, which we have proven in a vacuum test that that excessive friction causes the bearings to tip on-edge, which increases our surface stress, and the surface stress was high enough to crack the nitride layer. That is what we have determined was the root cause."

Window adds that a few unresolved issues remain on his fault tree, but their resolution will come only when the hardware returns to earth for a hands-on inspection.

As for the repairs done in space, things went reasonably well.

"We went out there with a scraping tool, some wipes and Braycote 602, and we cleaned away as much debris (grit) as we possibly could," says Window. "We reapplied a one-eighth bead of lubricant all the way around on all three surfaces. We replaced the trundle bearings, and since then we have rotated (the SARJ) two complete revolutions. And what we have found is that the motor current that we had seen prior to lubrication has gone down tremendously. We had seen motor currents of .9 amps, and we're down to an average of .17 amps. We're

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back down close to where we first started the solar SARJ. The average current when we first started was .15."

Keep in mind, the vibrations caused by the amped-up motor are what set the alarm bells off at mission control. Looking into that problem is what led to the discovery of the debris build-up on the TBAs.

"The vibration is what concerned us tremendously, and it's why we stopped rotating the SARJ," says Window. "Vibrations like that can cause damage to a lot of other things. This is promising data that shows that most of those vibrations have gone away."

As for the debris, Window explains that its origin was the solid—or gold—lubed bearings. The recovery team determined that these bearings were compromised before the shuttle ever launched. Poor application of the gold at the factory was the root cause for that issue. That is what led to the team decision to re-lubricate the bearings with the Braycote. And just to be safe, they also added it to the bearings on the port side solar array.

"We did not replace any hardware on the port side. The port side at this point has no known damage to the race rings. We've inspected several different areas of it, and we haven't seen any damage to the race ring surface."

Once the repairs were made, the SARJ was put through two revolutions and data was collected. It is that data that will help in going forward.

"We're going to conduct another set of rotations and gather that data as well," says Window. "We're putting it in auto track, where the software moves it according to the rotation of the space station," as it was designed to do in the first place.

"We're then going to take that collected data and develop a new spectrum that the structures and dynamics folks can use in their model to determine what impact any vibrations that we see have on the structure itself. Previously, the damage that we were seeing after the vibrations—before we cleaned and lubed—was going to cause us problems. What we hope is that this new spectrum will show that those vibrations are basically in the noise and will not cause any structural damage to the truss. That's the hope. We'll see."

At this writing, the plan is to fly two additional solar arrays to the station in February. Both of them will be added to the existing arrays on the starboard side. Once that is done, more testing will be done and data collected.

"That will drive us to a decision that we need to make on what to do as far as any type of repair, or if we need to do a repair on the truss. We do have plans in place."

As for lessons learned, "We have learned that the lack of gold causes problems," says Window. "In addition to that—and I'm sure that there will be papers written on this and published—we had trundle bearings that flew on the starboard side that we have documented evidence that the gold was flaked off of the rolling surface prior to its use. There was an issue associated with how that gold plating was done. We also found that the gold wears off quicker than expected.

"One of the things that we found on the port side is some of the Braycote 601 that was internal to the bearing housing. It leaked out and that lubricant fell onto the race ring (thus re-lubricating the deficient gold-plated bearings). And that could have been enough to keep the port side from having a failure."

Irving Laskin

RECEIVES AGMA LIFETIME ACHIEVEMENT AWARD

Irving Laskin, a consultant in gear technology specializing in fine-pitch gearing and *Gear Technology* technical editor, received the AGMA Lifetime Achievement Award for his dedicated career in the gear industry. He accepted the award at the annual awards luncheon at the Fall Technical Meeting. Laskin has been involved in AGMA's technical committees for more than 25 years, serving as chairman of the Fine Pitch Gearing, Plastics Gearing and Powder Metallurgy Gearing Committees. Laskin was also a member of AGMA's Technical Division Executive Committee.

Laskin played a pivotal role in establishing the plastics and powder metallurgy segments of the industry within AGMA, and has been instrumental in recruiting many companies to become members. The award is given to a member of the industry who demonstrates vision and leadership, sharing knowledge and experience for the advancement of the gear community.

"Irving Laskin has been a mentor to many in the plastic gearing industry. He exhibits an unequaled thirst for knowledge of gearing issues and is always willing to disseminate that knowledge freely and passionately with many," says Richard Wheeler, president of plastic gear manufacturer ABA-PGT. "His devotion to the industry in preparing industry standards continues to this day and his contribution to the development of AGMA standards is unmatched based upon our experience. We applaud AGMA for their recognition of Irving Laskin."