NASA
GETS DOWN AND DIRTY FOR SARJ SOLUTION

Jack McGuinn, Senior Editor

This recent spacewalk from the ISS included collection of grit from the faulty SARJ rotary joint for further analysis on the ground upon the latest mission's return to earth.

For more than 10 months, NASA ground engineers and International Space Station (ISS) astronauts have been struggling with a perplexing malfunction of one of the station's two solar array rotary joints (SARJ). The SARJ in question, on the starboard side, has since last October been inoperative to the extent that it can only be rotated manually towards the sun, from which it derives power in support of the ISS. The problem exists in the solar array's truss segment—or rotary joint—which was designed to rotate the array's panels sunward.

There has been progress, however, in that NASA has identified the problem to be a roller surface failure in one of the trundle bearing assembly (TBA) raceways and rings. More specifically, the "culprit," as Johnson Space Center's Kevin Window—SARJ Recovery Team Leader—calls it, is a concentration of metallic grit, or debris, in the raceway that is causing undue vibration and is impinging upon the joint, preventing its free movement. As for the root cause of that, it remains a mystery, although Window's team believes it is on track to solve it. To do so, they have been relying on very high-resolution photos and grit samples from ISS team members in order to conduct their testing. One testing drawback, however, is the inability to replicate on the ground what is going on in space. But progress is being made, nevertheless.

"The vast majority of debris we found (in the samples) was nitrided 15-5 (steel)," says Window. "What that tells us at this point in time is that something caused us to crack (or spall) that top layer (outer-canted surface) of the raceway."

There was some confusion at one point in which one of the ISS astronauts, after an in-space inspection, referred to the grit-affected area as a "raised surface," as opposed to a "depression," which it was originally thought to be by personnel on the ground.

"That gave us concern, because a depression is a whole lot different than a raised surface," says Window. "We had a large contingent of folks that expected it to be a depression, but it is a raised surface on the raceway surface. It is concerning because what we discovered during our (pre-mission) testing is that nitride 15-5 is very hard, but it is also very brittle once you start cracking it."

In order to try and minimize the grit issue short term, an ISS astronaut applied a lubricant to the affected surface. The result was less unwanted friction in the raceway surface, but that led to discovery of another problem—misalignment in the trundle bearing.

"We believe there may be a bit of mistracking in our trundle bearing that is causing an edge load," Window says. "Our tests have shown that when the coefficient of friction gets to a certain level, the bearing itself will tip on-edge. In ambient (environments) it doesn't, but when you put it in a vacuum—or space—the roller will tip on-edge. We're still

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doing some analysis and testing to determine what that means and how it fits into our root cause."

But, much like unraveling a string that never seems to end, another issue was identified—the bearings, which are not lubricated but, rather, gold plated. Further inspection discovered some delamination occurring with the bearings.

"There is a potential—and it is still a leg of our fault tree that is still open—that the gold plating was potentially not applied properly on some of the trundle bearings and that could be the cause or contribute to the cause of the failure," Window explains. "We do have paperwork that shows that we did have some issues with delamination of the gold plating. (Prior to the mission) there wasn't much thought that it might cause a problem or could contribute to such a failure that we have today."

So where does that leave things?

Summing up, the "fault tree" Window refers to has 10 remaining "legs" left open in the yellow category, yellow being a "maybe" in determining root cause. Of those 10 there's some overlap, as might be expected.

"Three of (the yellows) are FOD—foreign object debris—that's gotten into the race ring. It all boils down to where the FOD came from. One is magnetic attraction of FOD from the SARJ—something broke off within the SARJ and came onto the surface. Another is magnetic attraction of FOD from outside the SARJ, and a third is that FOD was left during processing on the ground; somebody dropped a piece of debris, and it was left on that area.

"Then we have another set of yellows that we'll call materials and processing. One is that the materials in the surface treatment were incorrectly chosen, so on the design side we shouldn't have been using nitrided 15-5 or gold plated 440C. Two is that the nitride was incorrectly applied to the race ring surface. Then we have a set of yellows called roller traction kinematics. And that is that the gold was inadequately applied and thus the increase in friction. That leads to excessive friction between the drive lock assembly and the race ring, as well as between the trundle bearing assembly and the race ring. And, finally, we have misalignment of the drive lock assembly rollers and the trundle bearing assembly rollers."

That may seem—and in fact it is—a lot to deal with in determining a root cause and corrective action. But "pruning" of the fault tree continues.

"We believe that we will work this out," says Window. "We don't know that we'll actually be able to nail down the root cause until we get some more of our hardware down. We won't know until we get it down and look at it. So far, we've been able to supply the power to perform our mission, based on the analysis we've performed.

"We're putting all the plans in place to try and understand the root cause and fix whatever we need to fix to prevent it from ever happening again."