

Bo Naasz (00:17):

Hello. My name is Bo Naasz. I'm the Rendezvous and Capture System Capability Lead for NASA. I'm presenting today on work that we've been doing for On-orbit servicing, Assembly and Manufacturing and Rendezvous Proximity, Operations and Capture Strategic Technology Planning. I'll start with a little scope of what those areas mean. Rendezvous, Proximity, Operations and Capture obviously are activities to bring spacecraft together and to operate in close proximity and perform mating activities. You can see in the graphic on the right, that scope applies to both spacecraft relative activities and small body relative activities, where small bodies are things like asteroids and comets. On-orbit Servicing Assembly and Manufacturing is an emerging set of capabilities that includes servicing or, on-orbit in space alteration of an asset, to repair it or to upgrade it or relocate it or service it in some other way.

Assembly, of course, is the on-orbit aggregation of components, complex assembly-type activities, or simple element to element mating activities. Of course, manufacture is the on-orbit manufacturer, turning raw materials or feed stock of some kind into usable components and infrastructure. The architectures that these capabilities enable or enhance can be, kind of, divided into four main areas. In the civil space area, obviously we have Human Exploration across the top and some recent examples of that include the in-space manufacturing activities within NSTMD. We're showing here graphic of the Additive Manufacturing Facility, a maintenance space facility on space station that can produce parts, manufacture, additive manufacturer parts. Of course, the Human Landing System, NASA's human landing system, and the gateway, Artemis program, takes advantage of in space assembly and further out in the future, the Mars Ascent Vehicle for human exploration of Mars, which will, at a minimum, will have to perform a Rendezvous and Capture maneuver, but may also take advantage of some other servicing functionality, perhaps on the surface of Mars.

In the science area, science includes NASA science, but it also includes, of course, applied science in other civil space agencies like USGS land monitoring, [inaudible 00:02:44] weather and other climate type science things. We're showing here, the Roman Space Telescope, which is a science mission directorate at NASA, the next big telescope, which currently has requirement to be refuelable.

That's the service that will be provided there and that's at sun earth L2. Of course, OSAM-1 and SPIDER are current ongoing tech demo missions within NSTMD. Then, on the far right, the 2020 Astrophysics Decadal included several very large telescopes that would take advantage of, at a minimum of servicing, but potentially also of assembly-type functionality. The commercial area, there's been some great activities in commercial space lately, especially with the MEV that's shown in the bottom middle there. Of course, OSAM-2 is another NSTMD also known as Archinaut. It's another STMD tech demo mission led by Made in Space. Some other science applications, well, the persistent platform idea or instrument 'hoteling' ideas, one where instruments could be upgraded on a platform in orbit, perhaps low earth orbit or geosynchronous orbit.

We're showing a LEO concept here, where instead of replacing entire spacecraft, we could replace instruments, upgrade instruments on a periodic basis. Then of course, national security also has interest in these areas.

Chart four, just kind of re-summarizes those architecture areas, human exploration, science in the planetary earth, astrophysics, and heliophysics. Commercial, I listed some examples there. Of course, very interested in hearing feedback from commercial folks at this conference on what other areas they're interested in or working on, that OSAM could be applied to. Then of course, national security, again, also Space Domain Awareness and Logistics and other servicing functionality.

So, let's talk for a minute about how OSAM can change the ConOps of a space mission from what we normally do in space. If you consider the black boxes on this chart to be traditional sequence of

events, we develop a mission, we launch it, we commissioned it on orbit. We operate and then we decommission, either when things stop working or we run out of fuel or the mission is complete. Considering how OSAM changes that, without very much thought upfront, we can add some servicing functionality so we can relocate or refuel spacecraft. We can perform remote inspection if things are aren't going well, either during operations or after the fact, and we can perform removal and disposal operations.

Go one step further, we add early design for OSAM for Servicing Assembly and Manufacturing and plan on multiple launches. From the start we can do things like fuel in the beginning of a mission. For example, if a spacecraft weighs too much to launch it with its tanks full, we could just make one of the first steps of commissioning be, fueling. We could also add assembly activities, aggregate elements, like we talked about with the human exploration activities we could assemble or install. Bus modules, we could assemble large structures. We could assemble precision apertures, or we could assemble and install instruments, for example. Of course, we can upgrade, maintain, replace, and repaired during the operation life cycle, including if we go to the next step and we enable manufacturing on-orbit. Now, we can actually take materials potentially from previous missions and recycle and repurpose them, or perhaps just launch materials and use those materials to manufacture large things in space that we can't launch.

We can manufacture parts in the beginning of a mission. If you look out further towards the operational phase, we could also manufacture replacement parts and have those be part of our upgrade and maintenance cycle. So, certainly one of the biggest benefits of this is that we could reduce the need for resupply logistics by manufacturing parts on need, as opposed to launching a lot of spares that may not get used. One more little advancement, if we have a in-space resource utilization capability, we could use those materials as part of this whole life cycle. I think you can see how OSAM really changes the way we look at space missions.

So, we're looking at, in this strategic plan, the gaps that support the outcomes that are shown here and enable these increased flexibility.

I won't dwell on this chart, OSAM capability areas, this kind of taxonomize, if you will, the capabilities that are necessary for these capabilities. The next chart is the Strategic Development Plan, Context and Flow. This is showing how we're going from the architectures we talked about, through the outcomes and the outcomes are kind of the verbs in that ConOps chart I was showing you. We identify the capabilities that we need to support those outcomes. We identify current activities that are building those outcomes and then we are left with the red boxes, which are the capability gaps. And so, this plan has identified those gaps and will be working to understand and plan a process for closing those gaps.

Of course, that plan will go into our strategic thinking. We'll fund gap closing activities, we'll develop new technologies and infuse them into future missions. A chart here kind of focused on SBIR activities. This is the On-orbit Servicing Assembly Manufacturing Activities related to SBIR on the left. On the left, you see the FY20 solicitation topics and the awardees on the right, some other activities that are going on. I already mentioned Archinaut. We have ARMADAS going on, which is a digital assembly system. We have Assemblers, which is a modular system for in-space assembly. The CIRAS work has come to an end, but that was a Tech Demonstration Mission on Robotic Assembly. Of course, there's... I won't list them all, but OSAM in-space manufacturing, we talked about OSAM-1, which was formally Restore-L but now includes SPIDER and MakerSat.

So, you have servicing assembly and manufacturing all in that tech demo mission. Just a couple of little plugs, the OSAM National Initiative, you may have heard of, is an activity that's been ramping up a continuation of the strategic technology partnership that was happening across US government

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agencies. They just held a OSAM technology transfer workshop and so you can go look at the link on the bottom of the screen, if you want to see those details.

I'll leave it there for you. I think, that you'll see when the OSAM Strategic Plan comes out, there's a lot of great opportunity to develop new technologies that are going to make space operations into a completely new concept. We're excited about all the work that's happening and glad to have you all involved.

Thanks.