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FRICITION STIR WELD APPLICATION AND TOOLING DESIGN FOR THE MULTI-PURPOSE  
CREW VEHICLE STAGE ADAPTER

**Abstract**

The Multi-Purpose Crew Vehicle (MPCV), commonly known as the Orion capsule, is planned to be the United States' next manned spacecraft for missions beyond low earth orbit. Following the cancellation of the Constellation program and creation of SLS (Space Launch System), the need arose for the MPCV to utilize the Delta IV Heavy rocket for a test launch scheduled for 2014 instead of the previously planned Ares I rocket. As a result, an adapter (MSA) must be used in conjunction with the MPCV to account for the variation in diameter of the launch vehicles; 5.5 meters down to 5.0 meters. Prior to flight article fabrication, a pathfinder (test article) will be fabricated to fine tune the associated manufacturing processes. The adapter will be comprised of an aluminum frustum (partial cone) that employs isogrid technology and circumferential rings on each end. The frustum will be fabricated by friction stir welding (FSW) three individual panels together on a Vertical Weld Tool (VWT) at NASA Marshall Space Flight Center. Subsequently, each circumferential ring will be friction stir welded to the frustum using a Robotic Weld Tool (RWT). The irregular geometry and large mass of the MSA require that extensive tooling preparation be put into support structures for the friction stir weld. The tooling on the VWT will be comprised of a set of conveyors mounted on pre-existing stanchions so that the MSA will have the ability to be rotated after each of the three friction stir welds. The tooling requirements to friction stir weld the rings with the RWT are somewhat more demanding. To support the mass of the MSA and resist the load of the weld tool, a system of mandrels will be mounted to stanchions and assembled in a circle. The goal of the paper will be to explain the design, fabrication, and assembly of the tooling, to explain the use of friction stir welding on the MSA pathfinder, and also to discuss the lessons learned and modifications made in preparation for flight article fabrication in support of the 2014 launch of the Orion MPCV.