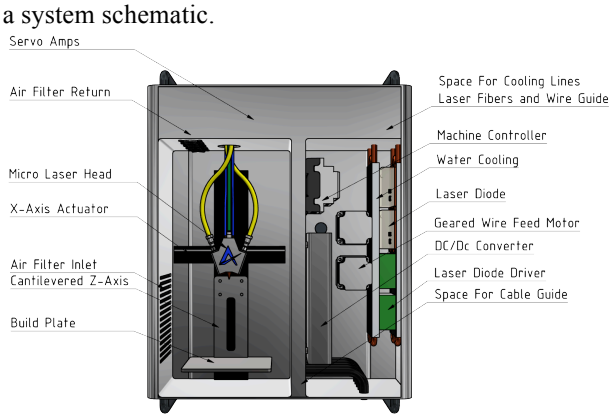
LASER-ASSISTED WIRE ADDITIVE MANUFACTURING SYSTEM FOR THE DEEP SPACE GATEWAY. B. D. Foster[1] and B. Matthews[2], AddiTec, LLC, 4185 W. Post Road, Ste A-B, Las Vegas, NV 89118; [1]bruce.foster@additec.net; [2]brian.matthews@additec.net.

Introduction: Scientific investigation on the Deep Space Gateway will involve experiments and operations inside pressurized modules. Cross-discipline support for those experiments and operations may necessitate a means to fabricate and repair required articles and configurations. This capability can be provided through an additive manufacturing (AM) system. This system provides for experiment continuity and adds flexibility for in situ changes and variations across the science area disciplines accessing the Deep Space Gateway.

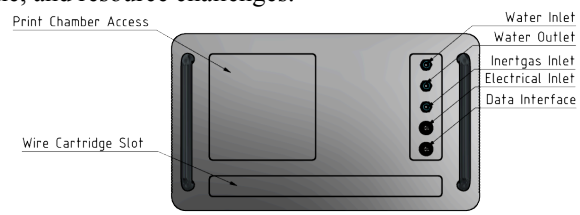
AddiTec proposes to utilize its commercially available TriAx 3D laser-assisted metal wire deposition technology to re-engineer a complete prototype system optimized for operation in a microgravity, confined environment. This system will provide operators with a means to fabricate and repair metal and polycarbonate parts in real-time. The complete system will fit within a user-specified envelope down to minimum dimensions of 440 mm (w) x 515 mm (d) x 250 mm (h). The system will be powered by diode laser technology with a user-specified build volume comparable to system dimensions (e.g., the build volume would be 150 mm x 150 mm x 150 mm for a system with the minimum dimensions identified above). See below for a system schematic.



Base System Configuration

Machine Access: All system interface functions will be addressed via the front panel to ensure ease of access in a rack mounted spacecraft environment. See below for access description. Gateway resources required for operation include water, power, and inert gas along with a data interface.

The metal wire feed will be provided by a cartridge consisting of a custom spool with a large diameter and shallow depth. The spool size is selected such that the wire has the lowest amount of curvature as it is fed into the system. This approach is preferred since wiree straightening cannot be easily automated within the volume constraints of the design, and manual straightening is undesirable since it introduces accessibility, time, and resource challenges.



Access Ports

For Earth-based testing, the system can be oriented with the front panel facing downwards. The top panel includes a large laser-safe window so that the operator has full view of the process. The laser-safe window will be replaced by a windowless panel for use in space.

When operating in a micro-gravity environment such as in space, the operator removes the printed part via the access port positioned within the front panel at the base of the Z-axis. Part removal utilizes the extended travel range of the Z-axis (more than twice the print envelope) to completely retract the printed part from the system.

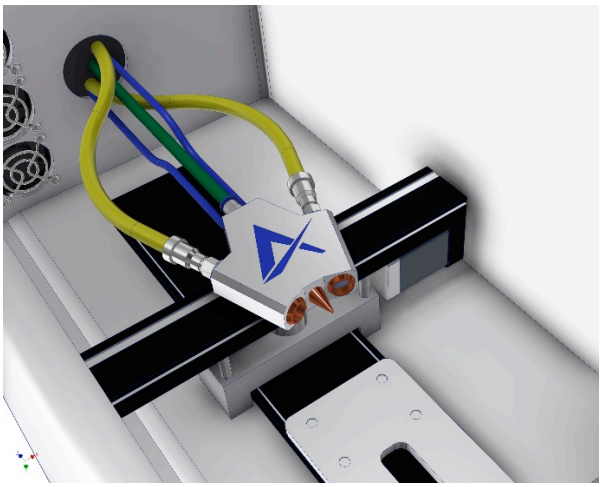
Motion System: The motion system will utilize clean-room certified slide bearings and leadscrews driven by small servo motors. The deposition head will be actuated in the X and Y axes, with the build substrate manoeuvred along the Z-axis.

Filtration System: The system will include a custom filter to collect welding fumes and protect the optics of the deposition head from contamination.

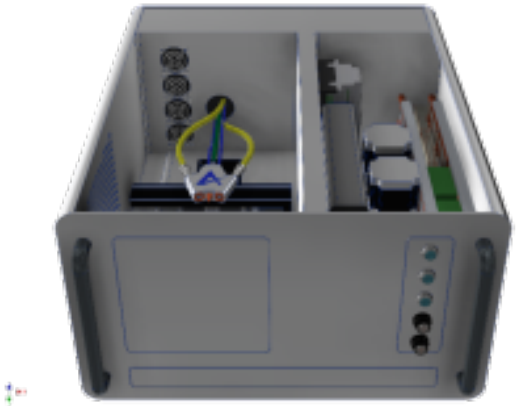
Deposition Head: The dimensional constraints imposed on the system design necessitates a low-profile deposition head that is highly compact in one-axis, as illustrated in below. This constraint favors an approach of using two lasers as opposed to the four lasers usually employed in the AddiTec TRIAX 3D system. Testing previously conducted by AddiTec has shown that using two lasers is sufficient to achieve a direction independent welding process of sufficient power for most applications.

Adjustment of the deposition head will be automated by integrating a photodiode as a sensor target and two piezo actuators for lens angle adjustments. The

deposition head will use the proven spring-loaded wire nozzles employed in the AddiTec TRIAX 3D product line, ensuring firm wire guidance even under varying feedstock diameters. Allowing for integrated water-cooling components, the deposition head will have dimensions less than 95 x 70 x 20 mm.



Diode Laser



Low Profile Configuration

Process Control: The proposed prototype system will incorporate standard AddiTec inline process control technologies for wire feed, including feed-pressure sensing and deposition layer height detection and regulation via laser power and material feed modulation. These controls will enhance system stability.

Pre-Programed Parts Configuration: Experiments and operations to be conducted within the pressurized modules will be screened to identify material and parts requirements. The AM system will be preloaded with programs and prequalified print settings that can be used to reproduce the identified parts. These pre-loaded programs will significantly reduce time and material requirements for part reproduction.

Commercially Technology Basis: System development will be based on AddiTec's TriAx 3D proven direct energy deposition technology shown below.

TriAx 3D Deposition Head

The TriAx 3D dual mode deposition head which allows the use of both metal powders and metal wire as infeed material, will be modified for wire feed only. Metal powder deposition in an microgravity environment introduces significant challenges and is therefore, unsuitable for this applcation. This technology allows the production of parts with functional material gradients and has the potential for very broad applicability.