NASA Plum Brook Station
6100 Columbus Avenue
Sandusky, Ohio

Statement of Work
For
Completion of the Mechanical Vibration Facility Table Fabrication

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June 28, 2013

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1. Introduction

This Statement of Work (SOW) provides requirements for completing the fabrication of the Vibration Table Assembly that will be used at the Mechanical Vibration Facility (MVF). The MVF is located inside the Space Power Facility (SPF) at the NASA Plum Brook Station in Sandusky, Ohio.

The MVF is used for vibration testing of spacecraft. It induces harmonic vibrations into spacecraft in the 5 to 150 Hz frequency range at various G-loads. It accommodates spacecraft up to 18 feet diameter, 75,000 lb mass, and 75 feet tall.

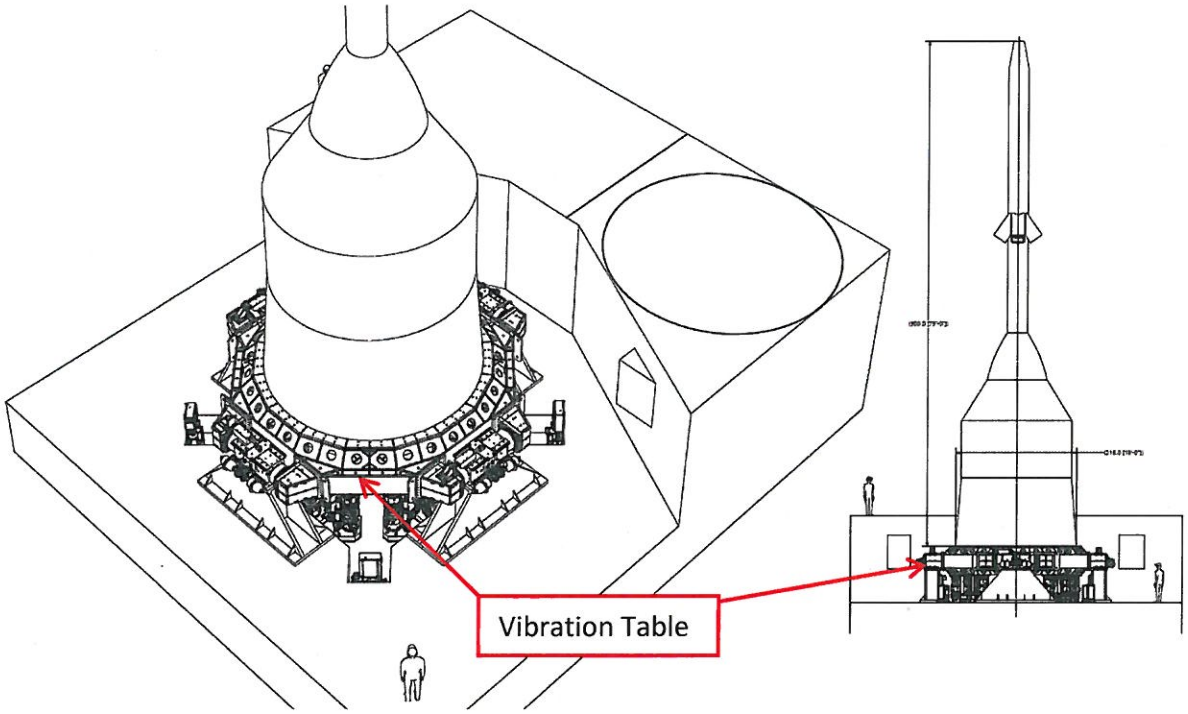

Figure 1: NASA Mechanical Vibration Facility with Orion Spacecraft

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The MVF Table Assembly is primarily an aluminum weldment that, when in its final assembled configuration, weighs approximately 55,000 lb. The main components of the MVF Table are listed in Table 1.

Part	Drawing No.	Quantity	Approximate Overall Size (each)	Total Est. Weight (lb)
Table Assembly	D19663	1	53" x 324" x 324"	55,000
Table Weldment	D19953	1	53" x 262" x 262"	42,500
Table Brackets	D19955	8	31" x 32" x 38"	7,840
Bracket Key	D19980	8	1" x 2" x 32"	144
Counterweights	D20176	8	4" x 15" x 36"	4,520
Counterweight Dampers	D20177	8	1/8" x 12" x 26"	16
Threaded Inserts	N/A	1,032	Varies	210
Misc. Fasteners (Bolts, Washers)	N/A	936	Varies	272

Table 1: Main components of the MVF Table

The NASA / Team drawings are provided with this SOW.

The fabrication of the MVF Table is partially completed. In its current state, the approximate percent completion for each component is listed in Table 2.

Part	Materials Procured	Welding	Stress Relieving	Machining	Finish Coating	Assembled & Installed
Table Assembly	N/A	N/A	N/A	N/A	N/A	0%
Table Weldment	100%	75%	0%	0%	N/A	0%
Table Brackets	100%	100%	100%	10%	N/A	0%
Bracket Key	100%	N/A	N/A	100%	N/A	0%
Counterweights	100%	N/A	N/A	100%	0%	0%
Counterweight Dampers	100%	N/A	N/A	0%	N/A	0%
Threaded Inserts	100%	N/A	N/A	N/A	N/A	0%
Misc. Fasteners	100%	N/A	N/A	N/A	N/A	0%

Table 2: Approximate percent completion of MVF Table components

2. Scope

The Contractor shall transport the MVF Table parts and materials from NASA to the Contractor's facility, complete the fabrication and assembly, and deliver the finished

MVF Table and related documentation to NASA Plum Brook Station in accordance with the all requirements specified in this SOW.

2.1. *Implementation Schedule*

All work defined within this SOW shall be completed within 9 months after the date of contract award.

2.2. *Material and Services Provided by the Contractor*

The Contractor shall provide all material, labor, services, facility infrastructure, tools, permits, equipment, and shipping required to complete the requirements in this SOW, unless otherwise specified in Section 2.3 of this SOW.

2.3. *Government Furnished Equipment, Property, Facilities, Information, or Services*

The contractor is responsible for transporting all Government Furnished Equipment (GFE) from their current locations. The items listed in Sections 2.3.3 and 2.3.4 of this SOW are located in the Building 50 high bay at the NASA Glenn Research Center, 21000 Brookpark Rd, Cleveland, Ohio 44135. The item listed in Section 2.3.5 is located outside at the NASA Plum Brook Station, 6100 Columbus Avenue, Sandusky, Ohio 44870.

2.3.1. The Government will supply the use of existing 30-ton overhead bridge crane at Building 50 of the NASA Glenn Research Center for loading the partially finished MVF Table and all of the associated hardware onto trucks for transport to the Contractor's facility(s).

2.3.2. When the completed MVF Table and associated hardware is delivered to NASA Plum Brook in Sandusky, Ohio, the Government will supply the use of the existing 25-ton overhead bridge crane in the SPF Assembly Bay for unloading the trucks.

2.3.3. The Government will supply the following partially finished components for the MVF Table Weldment in their "as-is" condition:

2.3.3.1. One MVF Table Weldment (Figure 2)

2.3.3.2. Four "Sub-Assembly A" weldments (Figure 3)

2.3.3.3. Sixteen aluminum close-out plates, detail 30 (Figure 4)

2.3.3.4. Forty-eight aluminum close-out plates, detail 34 (Figure 4)

2.3.3.5. Sixteen aluminum close-out plates, detail 48

2.3.4. The Government will supply the following partially finished components for the

MVF Table Assembly in their "as-is" condition

2.3.4.1. Eight Table Brackets (Figure 5) – welded, but not machined

2.3.4.2. Eight Counterweights (Figure 6) – machined, but unpainted

2.3.4.3. Eight Bracket Keys – completely finished

2.3.4.4. Eight pieces of Teflon sheets for protection of datum B surfaces

2.3.5. The Government will supply the following raw materials and supplies for use in completing the fabrication of the MVF Table Assembly:

2.3.5.1. ER5183 welding wire, 1/16" diameter, 263 spools, 16 lbs each (Figure 7)

2.3.5.2. ER5183 welding wire, 3/64" diameter, 33 spools, 16 lbs each (Figure 7)

2.3.5.3. ER5183 welding rod, 5/32" diameter, 3 boxes, 60 lbs each (Figure 7)

2.3.5.4. ER5183 welding rod, 1/8" diameter, 2 boxes, 60 lbs each (Figure 7)

2.3.5.5. 1G82-R ceramic backing, 1/4" x 1" x 1-1/4" flat, 7 boxes, 30 ft / box

2.3.5.6. 1G66-B ceramic Backing, 11/32" x 3/4" x 1" beveled, 9 boxes, 40 ft / box

2.3.5.7. Refrac-T-Back ceramic backing, 1/4" x 1" x 1" flat, 5 boxes, 16 ft / box

2.3.5.8. Miscellaneous ceramic backing materials, 2 boxes

2.3.5.9. 3/4" x 8 ft x 24 ft aluminum plate, 5083-0, 1 piece

2.3.5.10. 2-1/2" x 6 ft x 12 ft aluminum plate, 5083-0, 1 piece

2.3.6. The Government will supply the following fastener materials for assembling of the MVF Table:

2.3.6.1. 3/4-10 x 9" long socket head cap screws, 68 pieces

2.3.6.2. 3/4-10 x 4-1/2" long socket head cap screws, 293 pieces

2.3.6.3. 3/4-10 x 3-1/2" long socket head cap screws, 382 pieces

2.3.6.4. 5/16-18 x 1" long socket head cap screws, 69 pieces

2.3.6.5. 3/4" washers, extra heavy, grade 8, cadmium plated, 684 pieces

2.3.6.6. 5/16-18J x 9/16-12 Threaded Inserts, 462 pieces

2.3.6.7. 5/8-11 x 1"-12 Threaded Inserts, 227 pieces

2.3.6.8. 3/4-10 x 1-1/4" long Threaded Inserts, 1358 pieces

2.3.7. The Government will supply the Steel Mounting & Handling Fixture that was used by the previous fabricators for weld positioning and transportation of the MVF Table weldment (see figure 8).

2.3.8. The Government will supply the Contractor with the drawings listed in Table 1. The Contractor may request any additional drawings that may be required to perform the work stated in this SOW.

2.3.9. The Government will supply the Contractor with the Weld Sequence Plan from the previous fabricator that outlines the welding tasks that need to be completed. NOTE: This document is to be used as a reference only. The Contractor should create a separate work plan for the tasks in this SOW.

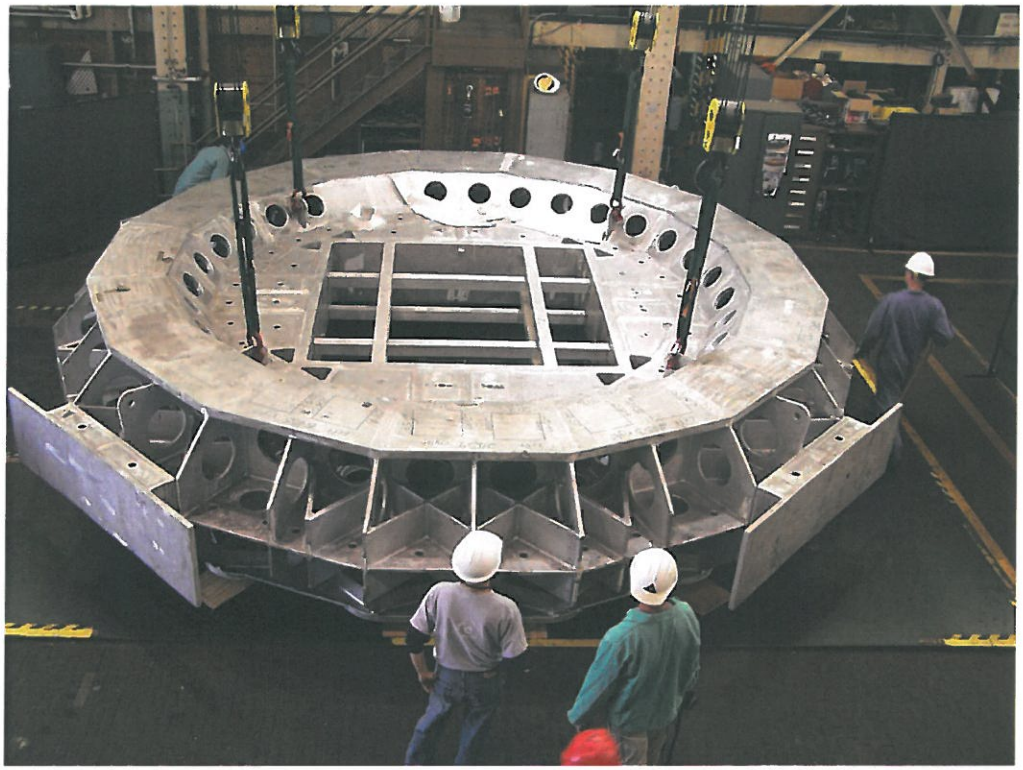

Figure 2: Partially finished MVF Table weldment

Figure 3: Partially finished Sub-Assembly A weldments (3 of 4 shown)

Figure 4: Partially finished close-out plates for MVF Table weldment

Figure 5: Partially finished Table Brackets

Figure 6: Partially finished Counterweights

Figure 7: Welding Wire and Rod

Figure 8: Steel Mounting & Handling Fixture

3. Applicable Standards, Documents and Definitions

3.1. Industry Codes and Standards

This project shall comply with the following pertinent codes and standards (latest edition) as applicable:

3.1.1. 29 CFR 1926, Occupational Safety and Health Administration (OSHA). (Copies of OSHA standards are available at: http://www.osha.gov/comp-links.html).

3.1.2. 40 CFR, Environmental Protection Agency (EPA). Use, collection and disposal of supplies and materials shall be in accordance with the latest revisions of the EPA codes.

3.1.3. *National Electrical Code* (NEC). Work shall be accomplished in accordance with the latest revisions of the NEC.

3.1.4. American Welding Society. All aluminum welding work described in this SOW shall comply with AWS D1.2/D1.2M:2008, *Structural Welding Code - Aluminum*.

3.1.5. American Welding Society. All aluminum welding rod materials used for work described in this SOW shall comply with AWS A5.10/A5.10M:1999 (R2007), *Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.*

3.2. Government Documents and Standards

The Contractor shall comply with the latest revision of the following documents, standards, materials and information (as applicable) that will be provided by the Government:

3.2.1. *NASA GRC Safety Manual*. (Document available at http://smad-ext.grc.nasa.gov/gso/manual/chapter_index.shtml). Safety Manual Chapter 20, *Cranes and Lifting Devices;* are applicable to this procurement.

3.2.2. NASA-STD-8719.9, *Standard for Lifting Devices and Equipment*. (Document available at http://standards.nasa.gov)

3.2.3. NASA-SPEC-5004A, *Welding of Aerospace Ground Support Equipment and Related Nonconventional Facilities.* (Document available at https://standards.**nasa**.gov/documents/viewdoc/3314880/3314880)

3.3. Definition of Terms

"NASA" means the National Aeronautics and Space Administration, Glenn Research Center, Lewis Field and Plum Brook Station, part of the Government of the United States.

"Contractor" means the contractor, its employees, agents, or contractors performing the work detailed in this Statement of Work (SOW).

"COR" means the NASA Contracting Officer's Representative.

4. Technical Tasks

4.1. Contractor Performance Requirements

The Contractor shall provide an uncontrolled copy of their quality assurance manual to the NASA Quality Assurance manager prior to execution of the contract.

4.1.1. The Contractor shall transport the partially finished MVF Table and all related hardware from the NASA Glenn Research Center, Lewis Field, building 50, and the Plum Brook Station, to the Contractor's facility. The transportation task shall be according to the shipping requirements defined in Sections 4.2.1 of this SOW.

4.1.2. The Contractor shall provide all materials beyond those provided by NASA (see Section 2.5) that are necessary to complete the tasks specified in Sections 4 and 5 of this SOW. This task shall be according to the technical specifications defined in Section 4.2.2 of this SOW.

4.1.3. The Contractor shall remove the weld blow-through material on the back side of the groove welds that attach 64 inclined plates to the inside perimeter of the MVF Table according to the technical specifications defined in Sections 4.2.3 of this SOW.

4.1.4. The Contractor shall complete the fabrication of the MVF Table according to the technical specifications defined in Sections 4.2.4, 4.2.5, 4.2.6, and 4.2.7 of this SOW.

4.1.5. The Contractor shall perform final inspections and assemble all finished parts of the MVF Table at their facility to verify proper mating between parts and to verify that the final geometry of the assembled MVF Table satisfies the dimensional tolerances shown on NASA / Team drawing D19663. This task shall be performed according to the technical specifications defined in Section 4.2.8 of this SOW.

4.1.6. The Contractor shall disassemble the completed MVF Table and transport it and all associated hardware to the SPF high bay at the NASA Plum Brook Station in Sandusky, Ohio. This transportation task shall be according to the delivery requirements defined in Section 4.2.9 of this SOW.

4.1.7. The Contractor shall provide all of the deliverables defined in Section 5 of this SOW.

4.1.8. The Contractor shall perform all work in accordance with the codes and standards referenced herein.

4.1.9. The Contractor shall allow NASA and NASA designated representatives access to the work throughout the Contractor's effort.

4.2. Technical Specification Requirements

The edition of documents referred to in this specification is the latest revision in effect on the initial issue date of this SOW. In the event of a conflict between this specification and documents referred to in this specification, this specification shall govern.

4.2.1. NASA-to-Contractor Shipping Requirements

During transportation to the Contractor's facility, the unfinished MVF Table weldment shall be supported from underneath on all sixteen pad areas to minimize flexing stress in the table structure caused by road vibration and shocks. The Steel Mounting and Handling Fixture (Figure 8) is available for use to assist in meeting this requirement.

4.2.2. Procurement Requirements

4.2.2.1. All materials procured by the Contractor that become an integral part of the finished MVF Table Assembly, including aluminum plates, welding rod, and fasteners, shall include material certification documentation that states the results of any chemical analysis or mechanical testing, and the manufacturer's or heat treater's records. The material certification records shall become part of the final deliverables package.

4.2.2.2. Materials procured by the Contractor that become an integral part of the finished MVF Table Assembly shall comply with the following specifications:

4.2.2.2.1. Aluminum Plate: 5083-0 Aluminum Alloy with acceptable substitutions for tempers being 5083-H32, 5083-H112, 5083-H116, 5083-H321. Aluminum Plate shall comply with ASTM B209, *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.* Plate identification shall comply with ASTM B666, *Practice for Identification Marking of Aluminum and Magnesium Products.* The Contractor shall provide material certificates from the supplier(s) stating that each lot has been sampled, tested, and inspected in accordance with ASTM B209 and has met the requirements.

4.2.2.2.2. Stainless Steel: Shall comply with ASTM A276, *Stainless Steel Bars and Shapes,* Type 304 condition A. The Contractor shall provide material certificates from the supplier(s) stating that each lot has been sampled, tested, and inspected in accordance with ASTM A276 and has met the requirements.

4.2.2.2.3. Carbon Steel: Shall comply with ASTM A36, *Carbon Structural Steel,* and painted in accordance with the NASA / Team drawing requirements.

4.2.2.2.4. Weld Filler Metal: ER-5183 filler alloy. Aluminum filler shall comply with the American Welding Society AWS A5.10, *Specifications for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods.* The Contractor shall provide material certificates from the supplier(s) stating that each lot meets the requirements of AWS A5.10. The filler wire procurement shall conform to AWS A5.01, *Filler Metal Procurement Guidelines,* and shall have Lloyd's Register of Shipping certification.

4.2.2.2.5. Bolts and Cap Screws: ASTM A574 alloy steel. Threads shall be rolled. The Contractor shall provide the screw manufacturer's certified test report for the last complete set of mechanical tests for each stock size in each shipment.

4.2.2.2.6. Threaded Inserts: Material shall be type 4140 steel per MIL S-5626 or Type 8740 per AMS 6322. Inserts shall be extra heavy duty and comply with MS 51832, *Locked In Key-Locked Screw-Thread Insert,* Internal thread locks shall not be provided.

4.2.2.2.7. Plating: Bolts, screws, flat washers, and inserts shall be cadmium plated per AMS QQ-P-416 Type 1, Class 2.

4.2.3. Removal of Weld Blow-through Material

The Contractor shall remove the existing weld blow-through material on the back side of the groove welds that attach 64 inclined plates to the inside perimeter of the MVF Table Weldment. The plates are designated as Item 33 on the Table Weldment drawing D19953 (32 of the plates are on the top side of the Table and 32 plates are on the bottom side). Figures 9 and 10 show the backside of the subject welds where the weld blow-through material is to be removed.

The purpose of removing the weld blow-through material is to determine the extent of possible weld defects that currently exist in these welds. The primary defects of interest are cracks, gas inclusions, lack of fusion to adjacent base materials, and incomplete penetration.

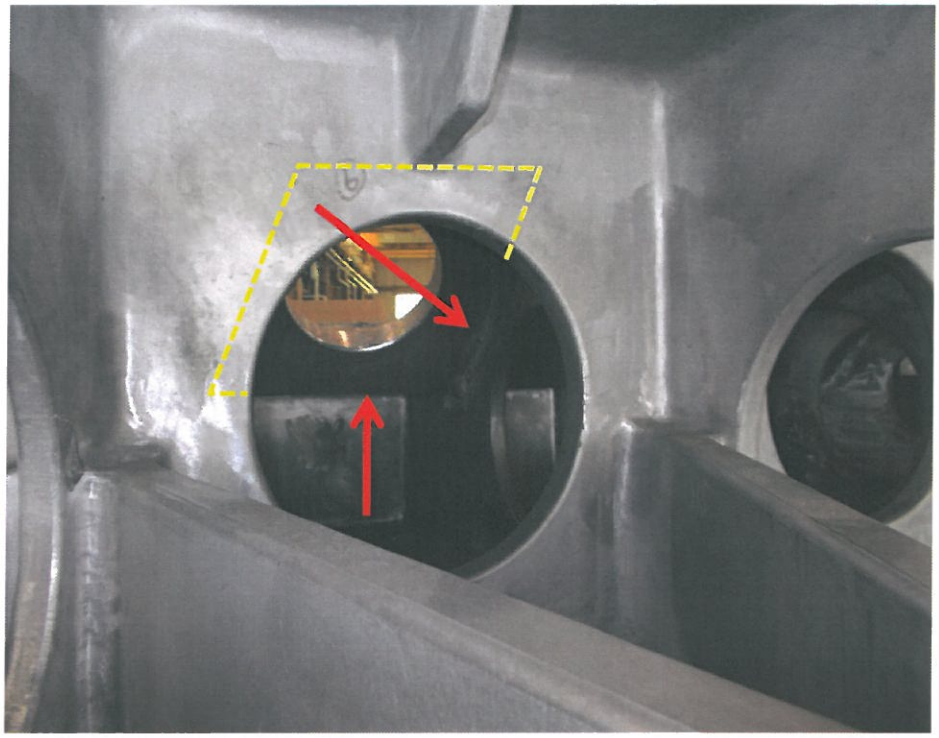

Figure 9: Back Side of Welds around the Perimeter of a Detail 33 Plate as Seen Through Openings in the Outer Perimeter of the MVF Table

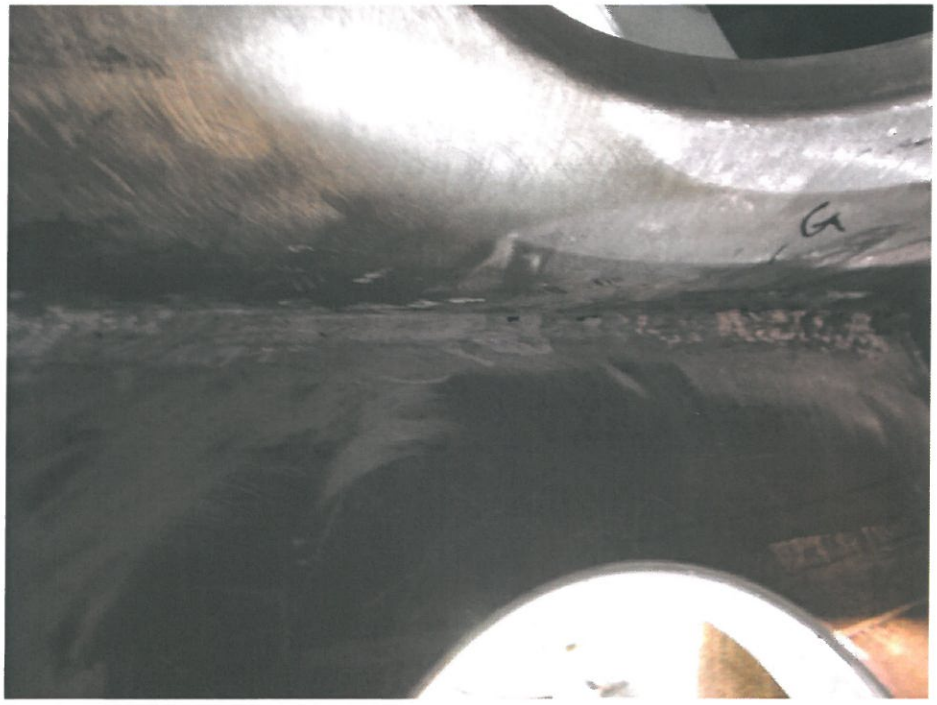

Figure 10: An Area on the Back Side of the Detail 33 Welds where the Blow-Through Material has been removed with a Handheld Tool Bit.

NOTE: Subsequent repairs to any weld defects found after removing the weld blow-through material are not within the scope of this SOW.

The specification requirements for the removal of the weld blow-through are as follows:

4.2.3.1. The weld blow-through material shall be removed on all four sides around the perimeter of each Item 33 plate.

4.2.3.2. The weld blow-through material shall be removed to a sufficient depth to allow visual inspection of the back side of the root pass welds, except that the depth of the weld material that is removed shall not exceed 1/8" below the outer surface of the adjacent base plate materials.

4.2.3.3. A minimum radius of 1/8" is to be maintained at all corner surface profiles after the weld blow-through materials are removed. (This is to reduce corner stress concentrations).

4.2.3.4. Acceptable means for removing the weld blow-through material is by cutting, machining, or chipping. Grinding is not recommended except when using a grinding wheel material made specifically for the weld prepping of 5083 aluminum and 5183 aluminum filler rod materials.

4.2.4. Dimensional Requirements

4.2.4.1. Tolerances: Variations in dimensions shall be limited to those shown on the NASA / Team drawings unless NASA provides written approval for deviations. Dimensions and tolerances shown on the NASA / Team drawings are the dimensions of the assembly when it is supported from a plane surface under the 16 actuator mounting locations on the bottom of the table.

4.2.4.2. Part Thicknesses: Part thicknesses shown on the NASA / Team drawings are the minimum thicknesses in the finished assembly. Parts may be made from thicker material in order to meet final dimensional tolerances after stress relieving and machining.

4.2.4.3. Temperature Correction: All measurements of dimensions shall be normalized to $68^{o}F$. Measurements of dimensions made when the temperature of the part is different from $68^{o}F$ shall be adjusted to determine the equivalent measurement at $68^{o}F$. The temperature of the part at the time the measurement is taken shall be recorded and the adjustment shall be made using a coefficient of thermal expansion for the aluminum of $13 \times 10^{-6} / {}^{o}F$.

4.2.4.4. Records: Before machining, the Contractor shall record actual measurements for those dimensions shown on the NASA / Team drawings that will be modified by machining, and provide these to NASA.

4.2.5. Welding Requirements

The Contractor shall allow NASA's representatives access to the welding work throughout the duration of the effort.

4.2.5.1. Codes: All welds shall comply with AWS D1.2, *Structural Weld Code – Aluminum.* The MVF Table shall be considered to be a cyclically loaded non-tubular structure for applying the requirements of D1.2.

4.2.5.2. Weld Processes: Welds shall be made using either gas metal arc welding (GMAW) or gas tungsten arc welding (AC-GTAW) or a combination of AC-GTAW root weld with GMAW fill.

4.2.5.2.1. Parts to be welded shall be wire brushed and cleaned of all foreign matter before fit up. Foreign matter includes, but is not limited to, chips, dirt, moisture, aluminum oxide, oils, grease, and organic matter.

4.2.5.2.2. Interpass cleaning shall remove all weld smut and debris. At a minimum, interpass cleaning shall be accomplished using mechanical means such as a router or by a power wire brush. Vigorous hand cleaning followed by solvent cleaning shall be permitted where needed.

4.2.5.2.3. Aluminum parts may be preheated for welding up to 150°F indefinitely. Preheating for welding up to 250°F is allowed, but hold times shall not exceed 15 minutes.

4.2.5.2.4. Weld interpass temperatures shall at no time exceed 250°F. Weld interpass temperature shall be measured from the opposite side of the weld joint that the weld pass was made.

4.2.5.2.5. All tack welds and weld stops and starts remaining in weld joints shall be machined to provide a gradual transition to the unwelded joint (feathered out). All evidence of weld craters in the tack welds shall be removed prior to welding over the tack weld. Tack welds shall be made with the same filler alloy as the final weld.

4.2.5.2.6. The welding sequence shall minimize distortion due to welding. Welds shall be made by alternating welding on opposite sides of the weld evenly to completion. Welds shall be back-stepped in such a way that permanent movement of assembled parts remains within the prescribed tolerances.

4.2.5.2.7. Welding tabs used for weld starts and stops shall be of sufficient size and shape to accommodate the joint geometry and weld craters of all weld passes for the entire weld joint on a given side of the weld. When used, run-on and run-off tabs shall be removed by sawing or machining, and the end of the weld shall be made smooth to blend with the adjacent material. Weld craters remaining in cap passes shall

be filled to the full cross-section of the finished weld. Weld craters on intermediate layers not located on a run-off tab shall be gouged or machined out before the next weld pass is made or the arc is re-struck. Weld craters not located on run-off tabs shall be staggered in adjacent passes. Weld starts and stops in interior corners are not allowed.

4.2.5.2.8. Shielding gas shall comply with AWS A5.32, *Specification for Welding Shielding Gases.* The Contractor shall furnish the gas manufacturer's certification that the gas meets AWS A5.32 dew point requirements. Only premixed shielding gases shall be used.

4.2.5.3. Joint Configurations: All welds shall be complete joint penetration (CJP) groove welds and shall conform to one of the recommended CJP groove welded joints shown in AWS D1.2, Annex B, Figure B1, unless an exception is approved by NASA.

4.2.5.3.1. All groove welds shall be back-gouged to sound metal before welding from the other side, unless back side access does not allow, in which case a joint configuration using permanent metal backing or temporary backing may be selected from the options shown in AWS D1.2, Annex B, Figure B1.

4.2.5.3.2. Back gouging of aluminum is to be done by cutting, machining, or chipping. Grinding is not recommended except for contouring final weld surface or when using a grinding made specifically for aluminum.

4.2.5.3.3. Permanent metal backing shall be continuous and of the same metal alloy as the base material.

4.2.5.3.4. Permanent metal backing that cannot be removed shall have a continuous weld to at least one of the base members to insure that it does not vibrate loose after the MVF Table goes into vibration service.

4.2.5.3.5. All temporary backing used shall be removed from the completed MVF Table Assembly.

4.2.5.3.6. Fillet welds used as permanent backing in any joint shall have the root gouged to sound metal from the other side of the joint before welding the remainder of the joint.

4.2.5.3.7. Back-gouged surfaces of all root weld passes shall be visual inspected (VT) prior to welding in the groove.

4.2.5.3.8. Autogenous AC-GTAW may be performed to improve the surface condition of a joint.

4.2.5.3.9. Reinforcing fillets shall be provided at tee and corner joints. The size of the fillet shall equal or exceed one quarter of the nominal thickness of the thinnest member of the joint, but shall not be less than 3/16" and not more than 3/4".

4.2.5.3.10. J-grooves and U-grooves shall be used where practical to minimize distortion. All welded joints shall be filled to the full cross-section of the attached members except that welds on surfaces subject to a final machining need only be filled to bring the cross-section to the final finished dimension.

4.2.5.4. Welding Procedure Qualifications: The Contractor shall conduct a procedure qualification test and generate a Procedure Qualification Record (PQR) for each Weld Procedure Specification (WPS) used in construction of the MVF Table. Test specimens used in generating the PQR and WPS shall pass the tests required in AWS D1.2. The PQR and WPS documents are acceptable for use only after review and approval by NASA.

4.2.5.5. Welder Qualifications: Each welder shall be qualified by testing. Certification of welders shall be in accordance with AWS D1.2. The Weld Qualification Test (WQT) document and the Welder's Certificate for each welder shall be submitted to NASA.

4.2.5.6. Weld Identification: All weld joints shall be identified, numbered and tracked.

4.2.5.6.1. The numbering system shall be consistent with that used by the previous fabricator(s) as specified in the Weld Sequence Plan referred to in Section 2.5.9 of this SOW.

4.2.5.6.2. A weld map shall be generated showing the location of each numbered weld on a drawing.

4.2.5.6.3. Welders shall be assigned a unique symbol allowing the welder's work to be identified. For each weld, the welder's identification symbol shall be recorded on the weld map and the weld log record.

4.2.5.6.4. A weld log shall be used to track the progress and completion of each weld. The weld log shall include the weld number, the WPS Number, the welder's unique symbol, the welder's initials and date of completion, and the inspector's initials and date showing acceptance.

4.2.5.6.5. Stamped or inscribed identifications on the MVF Table are prohibited.

4.2.5.7. Welding Sequence: The Contractor shall submit a written welding sequence plan to NASA for review and comment prior to start of welding. The plan shall be designed to minimize distortion and provide welders access to the weld joints. The plan shall include the position of the table during each weld process.

4.2.5.8. Weld Inspections: Visual (VT) and Dye Penetrant (PT) inspections shall be performed by an AWS Certified Weld Inspector (CWI) in conformance with the provisions of AWS QCI, *Standard for AWS Certification of Welding Inspectors*. The VT and PT inspections shall be recorded in the weld log. A copy of the inspector's weld inspection report and the weld log will become part of the deliverables package given to NASA.

4.2.5.8.1. VT shall be performed on the full length of all welds. VT shall comply with the requirements of AWS D1.2.

4.2.5.8.2. PT shall be performed on all final weld cover passes, including cover passes on the side of a back gouged joint and reinforcing fillets. PT methods shall comply with ASTM E165, *Standard Test Method for Liquid Penetrant Examination.* Acceptance criteria shall be per D1.2. All residues from dye and developer shall be completely removed prior to any weld repair operations and once final welds have passed the PT examination.

4.2.5.8.3. No weld inspections are to be performed on any of the existing welds made by the previous fabricator(s) of the MVF Table. They are to be assumed acceptable. However, if in the course of work a defect is found in an existing weld, it shall be brought to the attention of NASA.

4.2.5.9. Weld Repairs: Repair of welds shall be performed using an approved WPS. Metal removal of aluminum may be done by plasma arc cutting, machining or chipping. Grinding on aluminum is not recommended, except for contouring the final weld surface or when using a grinding wheel material made specifically for the weld prepping of 5083 aluminum and 5183 aluminum filler rod materials. All repairs shall have the gouged area VT inspected and approved by the CWI before welding commences. Surfaces shall be cleaned prior to repair welding. Weld repairs shall be recorded in the weld log. Defective areas may be repaired or the entire weld may be removed and rewelded. Welds shall be repaired in the following ways:

4.2.5.9.1. Overlap or excessive convexity shall be removed by machining, chipping, etc.

4.2.5.9.2. Excessive concavity, undersize weld, or undercutting shall be cleaned of oxides and impurities and additional metal shall be deposited.

4.2.5.9.3. Excessive porosity, incomplete fusion, or slag inclusions shall be removed and rewelded.

4.2.5.9.4. Cracks in weld or base metal shall be evaluated by PT and removed to sound metal as verified by VT, then rewelded.

4.2.5.9.5. Members distorted by welding shall be straightened by mechanical means or by localized heat not exceeding temperatures and hold

times as shown in AWS D1.1 and D.1.2. When heating, part shall be free of stress and from external forces other than stresses resulting from the straightening process.

4.2.5.9.6. The repaired weld shall be reinspected using the same method and acceptance criteria as used to detect the initial defect.

4.2.6. Stress Relief Requirements

After all welding is completed, but before parts are machined to final dimensions, the entire MVF Table weldment shall be stress relieved in an air furnace by uniformly heating to a temperature of 645°F ± 15°F for a minimum of one hour after furnace temperature has stabilized.

The Contractor shall demonstrate by temperature data that their furnace and fixtures used to support the MVF Table in the furnace during stress relieving have heated the entire MVF Table to the required temperatures and durations. All temperature data is deliverable to NASA.

Heating and cooling between 150°F and 450°F shall be performed continuously and as quickly as possible using air as the heating / cooling medium.

After the MVF Table has cooled to room temperature, the Contractor shall perform a cursory visual inspection of all welds and report the findings to NASA.

4.2.7. Machining Requirements

Surfaces to be machined on the Table include: payload mounting surface (1 place); vertical actuator mounting pads (16 places); horizontal actuator mounting pads (8 places); counterweight mounting surface (4 places); and the air spring mounting surface (4 places).

Surfaces to be machined on the eight Table Brackets include: mounting face (1 place per bracket); actuator drive face (1 place per bracket); and the travel stop surface (2 places per bracket).

All machined surfaces shall meet the dimensional tolerances specified on the NASA / Team drawings. Dimensional variations from the NASA / Team drawings are not acceptable unless NASA provides written approval for deviations. An example of a dimensional variance that may be acceptable is the requirement for the surfaces of the 16 vertical actuator mounting pads to be co-planer. In the event that thermal distortions in the table do not leave enough material for final machining some of the vertical actuator mounting pads to a co-planer profile, it is possible that one or more of the pads could be machined lower, but parallel, in a manner such that shim plates could be used to bring the pad surface back into a co-planer tolerance with the other pad surfaces.

Finished machined surfaces shall be protected from surface damage. Scribe marks or metal stamping shall not be used on finished components of the table.

Corners (free edges) of all openings in the fabrication and on the free edges of all parts shall be uniformly rounded to a radius of no less than 1/8 inch.

4.2.8. Final Inspection Requirements

After final machining, the Contractor shall perform a visual and dimensional inspection of all parts. Each part shall be weighed. The final dimensions and weights shall be recorded on an as-built drawing for each part.

Threaded holes in the aluminum shall be fitted with a threaded insert after the final machining operation is performed.

After the final inspections for each part are completed, the finished MVF Table shall be assembled. A final visual and dimensional inspection of the assembled MVF Table shall be performed and final dimensions shall be recorded on an as-built copy of NASA / Team drawing D19663. The assembled MVF Table shall include all fasteners shown on the NASA / Team drawings to demonstrate fit. The fasteners shall be installed at 50% of the final installation torque.

Finished surfaces shall be free of scratches, dents, stains, foreign substances, markings, or gouges visible to the unaided eye as determined by the Contractor and NASA.

The Contractor shall notify NASA two weeks in advance of the final inspection to allow NASA personnel and/or their representatives to witness the final inspection.

4.2.9. Contractor-to-NASA Delivery Requirements

After final inspections are completed, the eight Table Brackets shall be removed from the MVF Table assembly for shipping to NASA. Prior to shipment, all chips, debris, and weld smut shall be removed. The MVF Table minus the Table Brackets shall be shipped as a single piece to the NASA site. The eight Table Brackets shall be shipped separately. Machined surfaces shall be protected from surface damage during shipping.

The Contractor shall provide a written lift procedure to NASA before lifting or shipping the finished components. The Contractor shall furnish the transportation rigging and/or cribbing necessary to transport the MVF Table from the Contractor's facility to the NASA site. The Contractor shall provide drawings of the rigging and/or cribbing to NASA for review and approval prior to procurement of the rigging and/or cribbing.

The MVF Table shall be delivered to NASA in the right-side-up orientation. The Table shall be supported from underneath on the 16 vertical actuator mounting surfaces in such a manner as to protect the structure from induced stresses during transport. Assemblies shall be lifted only from lift points shown on the NASA / Team drawings and in such a manner as to distribute the load evenly. Aluminum parts shall only be lifted using nylon slings or clevises attached to the structure's lifting lugs.

4.3. Meetings and Communications Requirements

4.3.1. Site Visit and Meeting

The Contractor shall meet with the NASA COR and POC's within 10 days of Award of Contract to review scope of work, and review the implementation plan/schedule for accomplishment of the work.

4.3.2. Communications

The Contractor shall provide reports of all fabrication and procurement activities to the NASA COR and POC's via email every two weeks.

The Contractor shall inform the NASA COR and POC's of any delay in schedule within one business day of knowing of the delay. This may be done via e-mail with a confirmation receipt.

4.3.3. Work Acceptance

All tasks are subject to in-process and/or final inspection by NASA personnel or a NASA-designated representative. Work Acceptance shall be completion of all requirements described within this SOW, a final inspection of the work upon Contractor completion by NASA or a NASA-designated representative, and a receiving inspection upon delivery to NASA Plum Brook Station by NASA or a NASA-designated representative.

5. Deliverables

5.1. Performance Deliverables

The Contractor shall complete all work as specified in Section 4 of this document.

5.2. Documentation

The Contractor shall deliver one paper copy and one electronic copy on CD of the following information:

5.2.1. All process drawings or solid models generated by the Contractor.

5.2.2. Material Certification Documentation per Section 4.2.2.

5.2.3. Pre-machined dimensions per Section 4.2.4.4

5.2.4. Procedure Qualification Records (PQR) and Weld Procedure Specifications (WPS) per Section 4.2.5.4.

5.2.5. Weld Qualification Test (WQT) documents and the Welder's Certificates, one for each welder per Section 4.2.5.5.

5.2.6. Weld Map and Weld Log documentation per Section 4.2.5.6.

5.2.7. Weld Sequence Plan per Section 4.2.5.7.

5.2.8. Weld Inspector's Certification documentation per Section 4.2.5.8.

5.2.9. Weld Inspection Reports for all welds per Section 4.2.5.8.

5.2.10. Thermal Stress Report including temperature profiles and times per Section 4.2.6.

5.2.11. Final Inspection Reports with As-Built Drawings per Section 4.2.8.

5.2.12. Lift Procedures and Drawings of Transportation rigging and cribbing per Section 4.2.9.

Appendix A - Government-Provided Information

- The following NASA / Team drawings of the MVF Table are provided:

D19663	Table Assembly
D19953	Table
D19955	Table Brackets
D19980	Bracket Key
D20176	Counterweights

- For Reference, Weld Sequence Plan from previous fabricator:
  Precision Custom Components, Procedure MP-113-003, Rev 3