Statement of Work (SOW) for InRoDES Thrust Chamber Hardware

The National Aeronautics and Space Administration (NASA), specifically Marshall Space Flight Center (MSFC), has a need for the fabrication and post-processing of additively manufactured hardware. This effort requires the production of hardware that explicitly meets NASA's production requirements for powder bed fusion components. The vendor shall be responsible for all fabrication, post-processing, quality, and delivery requirements outlined in the tasks and requirements below to provide finished, high-quality hardware for the InRoDES project.

Task 1, Production of Additively Manufactured Hardware

The vendor shall produce the hardware listed in their quote. All hardware will be designed by NASA engineers at Marshall Space Flight Center and their respective models supplied to the vendor before production. During production, the vendor must meet all technical and quality requirements as detailed in the "Requirements" section of this document.

Task 2, Post Processing of Additively Manufactured Components

The vendor shall conduct and/or manage all required post-processing steps for the additively manufactured components. These steps must be performed in a specific sequence and with exacting criteria to ensure the final integrity of the hardware. The required steps include, but are not limited to, complete de-powdering of all passages, removal of the part from the build plate using electrical discharge machining (EDM), vacuum nucleation to ensure internal cleanliness, and Hot Isostatic Pressing (HIP) at a qualified facility.

Requirements for Additively Manufactured GRCop-alloy hardware:

1. **Fabrication Process:** Vendor shall fabricate all chamber and injector hardware using Laser Powder Bed Fusion (PBF) additive manufacturing in a machine with a standard build volume of 400x400x400 mm. No other build volume will be acceptable.
2. **Material Sourcing and Traceability:** Vendor shall provide all GRCop-42 material required to complete all builds. The powder must be sourced from Linde Advanced Materials Technologies Inc. and the Powder Alloy Corporation, as GRCop-42 from these sources has been validated for these specific NASA hardware. Full traceability for the powder is required.
3. **As-Built Density:** The density of the material in the as-built condition shall be a minimum of 99.2% prior to any post-processing heat treatments or Hot Isostatic Pressing (HIP) operations. This density shall be demonstrated on process-validation coupons supplied on the same build plate.
4. **Build Integrity:** All hardware shall be fabricated in a single, continuous build to produce a monolithic part. The final hardware must be delivered with no evidence of build artifacts such as witness lines, restarts, or coater arm tears. Any anomalies or deviations during the build process must be reported and the hardware shall be rejected immediately and the build restarted at cost to the vendor.
5. **Powder Removal and Channel Clearance:** Vendor shall completely remove all powder from all internal channels and external surfaces. This process must be completed within two (2) weeks of build completion to prevent moisture contamination. The part shall not be exposed to moisture until confirmation of complete powder removal. All passages must be 100% free of powder upon delivery, or the vendor will be required to reprint the hardware at no additional cost to NASA.
6. **Post-Processing Sequence:** All parts must be post-processed in the following specific order: Powder Removal, Wire EDM, Vacuum Nucleation, and Hot Isostatic Pressing (HIP).
7. **Part Removal from Build Plate:** Vendor shall remove parts from the build plate using a wire Electrical Discharge Machining (EDM) process. During this operation, the vendor shall guarantee that no electrolytic fluids or other contaminants infiltrate the internal passages of the part. Should any contaminants enter the part, the build will be restarted at no cost to NASA.
8. **Hot Isostatic Pressing (HIP):** The part shall undergo Hot Isostatic Pressing (HIP) according to NASA-specified processing parameters. Parts will be sent to a mutually agreed-upon and NASA-approved vendor for HIP operations.
9. **Surface Finish:** Hardware shall be delivered with an as-built surface finish. No media blasting or other surface treatments are permitted unless explicitly approved in writing by NASA. Hardware surface finish shall be within the range of 200 to 600 micro-inches and shall be validated before delivery to NASA.

10. **Quality and Documentation:** Vendor shall provide a comprehensive build package for each component upon request. This package must include any build anomaly reports and all data relative to process validation under a quality system compliant with AS9100, ISO9001, or a similar standard.
11. **ITAR Compliance:** Vendor shall be registered with the Directorate of Defense Trade Controls (DDTC) and demonstrate the ability to properly handle International Traffic in Arms Regulations (ITAR) controlled technical data and hardware.
12. **Delivery and Schedule:** All hardware must be delivered to Marshall Space Flight Center within eight (8) weeks of the official start of the build.
13. **NASA Inspection:** The vendor must comply with NASA should any component be selected for Computer Tomography (CT) scanning or other inspection at any point in the process. The time during which NASA takes possession of the hardware for such inspection does not count towards the 8-week processing and delivery period.

Shipping

1. Contractor shall ship any applicable hardware deliverables to:
   Central Receiving, Bldg 4631
   4203:4312
   NASA Marshall Space Flight
   Center Huntsville, AL 35812

Acronyms:

CT = Computer Tomography
EDM = Electrodischarge Machining
GRCop = Glenn Research Center Copper-Alloy (Cu-Cr-Nb)
HIP = Hot Isostatic Pressing
ITAR = International Traffic in Arms Regulations
MSFC = Marshall Space Flight Center
NLT = No Later Than
PBF = Powder Bed Fusion