

Low Cost, Upper Stage-Class Propulsion

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Sponsoring Program(s)

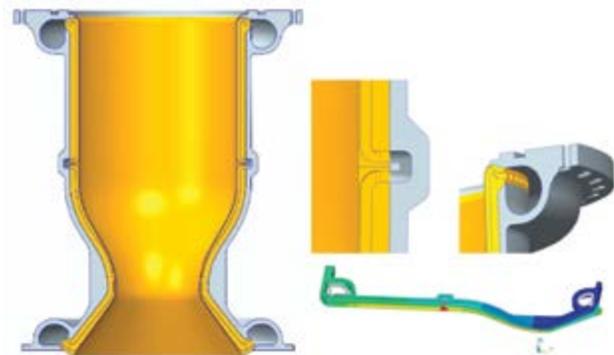
Space Technology Mission Directorate
Game Changing Development

Project Description

The low cost, upper stage-class propulsion (LCUSP) element will develop a high strength copper alloy additive manufacturing (AM) process as well as critical components for an upper stage-class propulsion system that will be demonstrated with testing.

As manufacturing technologies have matured, it now appears possible to build all the major components and subsystems of an upper stage-class rocket engine for substantially less money and much faster than traditionally done. However, several enabling technologies must be developed before that can happen. This activity will address these technologies and demonstrate the concept by designing, manufacturing, and testing the critical components of a rocket engine. The processes developed and materials' property data will be transitioned to industry upon completion of the activity.

Technologies to enable the concept are AM copper alloy process development, AM post-processing finishing to minimize surface roughness, AM material deposition on existing copper alloy substrate, and materials characterization.



Chamber cross sections illustrating the copper alloy liner with built-in coolant passages and the deposited nickel alloy jacket and manifolds.



Small chamber process demonstration article printed by MSFC ER42 from copper alloy C18150.



LaRC EBF3.



Example of a previous engine component testing at MSFC's Test Stand 116. Our hardware will be tested at similar liquid hydrogen and liquid oxygen flow rates and thrust levels.

Specifically, the LCUSP project element will (1) develop materials properties and characterization for selective laser melting (SLM) manufactured GRCop, (2) develop and optimize SLM manufacturing process for a full component GRCop chamber and nozzle, (3) develop and optimize the electron beam freeform fabrication (EBF3) manufacturing process to direct deposit a nickel alloy structural jacket and manifolds onto an SLM manufactured GRCop chamber and SLM manufactured nozzle, and (4) demonstrate the process for integrating the engine system by performing a hot-fire, resistance test.

Anticipated Benefits

Existing AM equipment combined with new, enabling processes and manufacturing 'best practices' will make it possible for more companies to build high-quality rocket propulsion hardware at a lower cost and faster delivery than previously possible. These cost and schedule savings will be passed along to NASA when a new rocket engine is competed. Additive manufacturing can potentially offer an order of magnitude savings of cost and schedule for complex rocket propulsion hardware. The AM process development for copper alloy, materials characterization, and technology transfer to industry will open new competitive markets that may reach beyond the space flight industry.

Another benefit will be to provide the space industry with a new material property database and proven techniques for implementing AM in their manufacturing processes.

Potential Applications

The LCUSP element is complimentary and directly relevant to the continued development of the Space Launch System capability by pursuing affordability improvements for engines and stages.

Notable Accomplishments

NASA Marshall Space Flight Center (MSFC) is partnering with Langley Research Center (LaRC) (for the EBF3 jacket/manifold deposition,) and Glenn Research Center (for materials properties determination). A solid monolithic part with relevant feature sizes has been demonstrated. MSFC EM42 has printed a small chamber demonstration article utilizing an available nickel-silicon-bronze powder and one using copper alloy C18150, which is used in some commercial conventionally manufactured chamber applications. LaRC has completed initial successful trial depositions of Inco625 onto copper alloy.