CASE STUDY

Accelerating Hypersonic Technology with Velo3D's Metal Additive Manufacturing

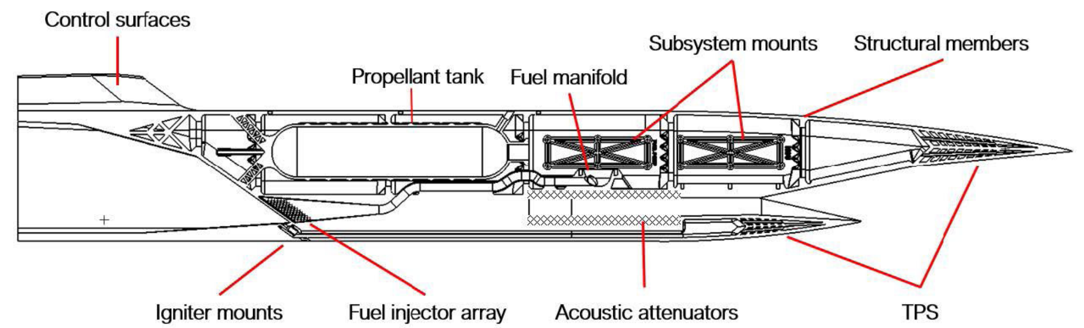
Challenge

Scaling hypersonic technology to high-volume production presents significant challenges for the United States Department of Defense (DoD). Hypersonic systems are complex, composed of state-of-the-art materials, and rely on intricate supply chains. To maintain and expand the U.S.'s technological edge over foreign adversaries, a breakthrough manufacturing solution is necessary to mitigate these issues. Metal additive manufacturing (AM), specifically laser powder bed fusion (LPBF), offers a transformative approach to address these challenges by minimizing cost and lead time, reducing complexity, utilizing advanced materials, and simplifying supply chains.

Technical Summary

Metal additive manufacturing, particularly laser powder bed fusion, is a process where layers of metal powder are welded together by infrared lasers to create monolithic metal components with 99.99% density. Velo3D's LPBF systems can print components up to 24 inches in diameter and 39.3 inches in height with layers deposited in increments of .002 inches, allowing for extremely complex feature resolution. This technology is capable of utilizing nickel-based alloys, historically chosen for manufacturing hypersonic airframes due to their superior material properties.

The proposed solution involves manufacturing the Additively Manufactured Uniform Scramjet Enemy Response Vehicle (AMUSER) primarily using LPBF technology. This concept aims to reduce part count, minimize potential failure points, and ensure more uniform thermal expansion compared to traditional manufacturing methods.



A diagram cross-section of the AMUSER vehicle

The Solution

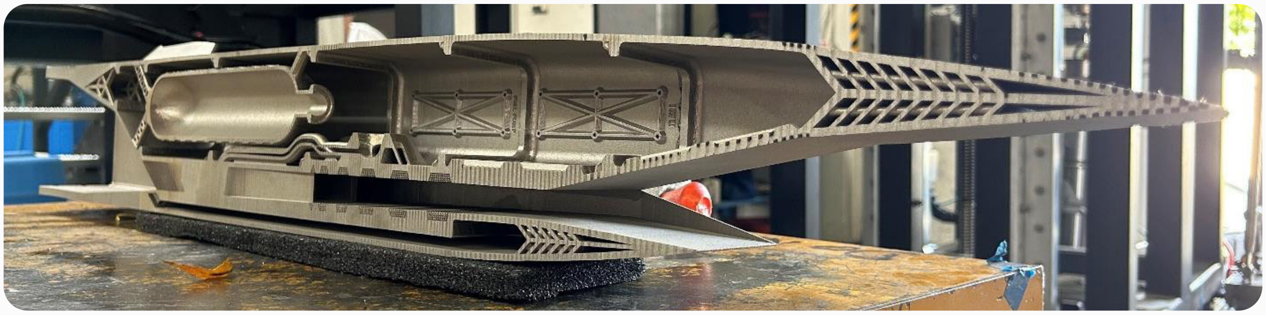
The AMUSER vehicle is an air-breathing scramjet manufactured using LPBF in Inconel® 625, a material suitable for hypersonic primary structures, control surfaces, thermal protection systems (TPS), and propulsion systems due to its strength, thermal characteristics, and extreme corrosion resistance.

KEY BENEFITS:

- **Complex Geometry:** Printed geometries that are very difficult or impossible to achieve with traditional methods.
- **Part Consolidation:** Reduced from a multi-piece assembly to a single part, enhancing reliability.
- **Cost Efficiency:** Drastically reduced manufacturing costs and lead times.

Manufacturing Costs

COST BREAKDOWN: SAPPHIRE SYSTEM	COST BREAKDOWN: SAPPHIRE XC SYSTEM
External Production: $51,845 per unit	External Production: $18,696 per unit (10 units per run)
Internal Production: $31,824 per unit	**Internal Production:** $11,774 per unit (10 units per run)



Printed cross-section of the AMUSER vehicle on a Velo3D Sapphire XC 1MZ

Value to Combatant Commanders

The reduced cost and procurement time translate to a critical value: surplus. Combatant Commanders can confidently approach conflicts with a surplus of hypersonic munitions, capable of neutralizing potential threats. Incorporating U.S.-based additive manufacturing in the hypersonics supply chain enables rapid build-up and maintenance of these advanced systems, ensuring technological superiority.

System Deployment and Operations

The ideal deployment of the AMUSER resembles the X-51 Waverider: an air-to-air or air-to-surface vehicle equipped underwing, brought to altitude, and accelerated to hypersonic conditions by a solid rocket booster before stage separation for final target acquisition. This gradual introduction reduces thermomechanical load, allowing extended flight time.

Further Development

Further development of the AMUSER involves design/simulation, material validation, subsystem design/integration, and ground testing. The design phase will use computational fluid dynamics (CFD) and finite element analysis (FEA) to substantiate the vehicle's function. Representative test specimens will ensure material specifications, and subsystems like flight controllers and APU's will be sourced from OEMs. The ground test campaign will include wind-tunnel testing, subsystem verification, and hot-firing of the fully integrated system.

Conclusion

Velo3D's metal additive manufacturing technology offers a transformative solution for hypersonic technology production. By reducing part count, ensuring material integrity, and significantly lowering costs and lead times, Velo3D provides the DoD with a viable path to maintaining technological superiority. The AMUSER prototype showcases the potential of advanced AM in revolutionizing hypersonic vehicle manufacturing, emphasizing the importance of U.S.-based additive manufacturing in defense applications.

Headquarters
2710 Lakeview Court
Fremont, CA 94538

To learn more visit:
velo3d.com
info@velo3d.com