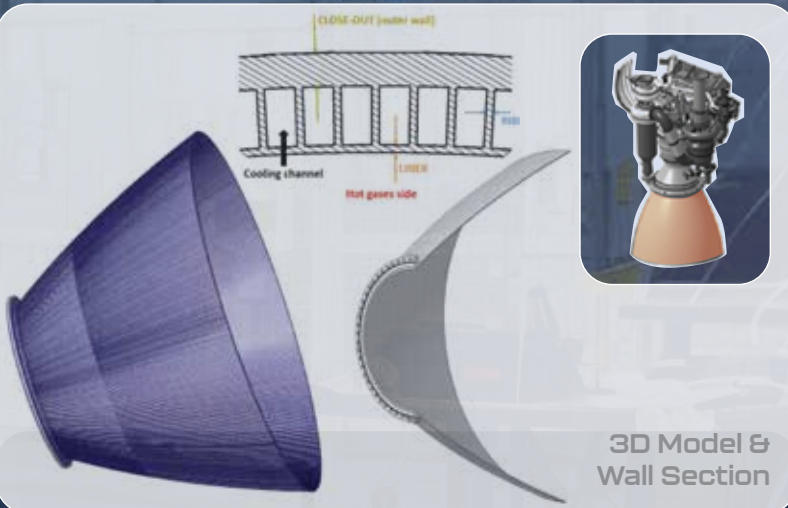


A more efficient and competitive way to space,
leading to new possibilities in the sky and on earth



Factsheet #3

Single-Element Nozzle Extension



3D Model &
Wall Section

A Nozzle Extension is a key component for rocket engines since it allows for the correct combustion gases expansion, by high area ratio, for thrust maximization. The structure is a cone-shaped nozzle with an embedded cooling jacket to allow for hot-gas side wall cooling ensuring structural resistance to severe operational loads. Heat extraction is ensured by supercritical hydrogen flowing from the MCC cooling jacket to the Nozzle Extension cooling jacket.

Within the Enlighten project, AVIO is developing a large 3D-printed nozzle extension to boost engine competitiveness through cost and mass reduction.

For large structures like nozzle extensions, Direct Energy Deposition (DED) has proven the most promising Additive Manufacturing (AM) technique, offering stable processes, improved surface finish, and the ability to print thin-walled geometries. DED scales more easily to large parts, supports repairs, and operates without pressurization.

Pros and Cons

- ⊕ Cost-effective solution thanks to AM technology
- ⊕ Design flexibility and material versatility thanks to AM
- ⊕ Building volume limited only by the robot arm length
- ⊕ Significant advantage in terms of powder consumption
- ⊕ DED is less sensitive to environment & can be stopped
- ⊖ Lower resolution and surface finish than PBF
- ⊖ Higher minimum thickness than PBF
- ⊖ DED can be less stable, leading to potential defects
- ⊖ DED for engine components has lower initial TRL

Companies involved



Key parameters

↑ Height	⊙ Diameter	⚖ Mass
> 900mm	> 1470mm	< 99 Kg

Material

Plays a crucial role in the manufacturing process and the effective required performance at firing operative conditions. **Inconel 625 (nickel-based superalloy)** was selected for its properties, achieved through process parameters optimization.

Printing Quality

Influenced by laser power, travel speed, powder feed rate, shielding gas flow, layer thickness and scan pattern. By carefully controlling these parameters, an enhancement of the quality and performance of the printing was achieved.

from

TRL 3

maturity level limited to
concept and analytical
justification

to

TRL 5

after hardware production
and test in a representative
environment

Expectations for testing phase

The maturity of the Additive Manufacturing (AM) process is evaluated through samples and mid-to large-scale mock-ups. The final Nozzle Extension prototype incorporates designs refined by specialized analyses. Cold-testing aims to demonstrate feasibility and advance the technology to TRL5. This includes a proof test—pressurizing the cooling jacket with water and nitrogen to confirm FEM-defined pressure limits—followed by a cold-flow test to verify CFD-defined hydraulic characteristics.

The results will assess the reliability of DED technology for complex structures under severe conditions and indicate any design or manufacturing updates needed before full-scale hot-fire testing.