# **Environmental Testing and Non-Destructive Inspection of the STAR Additively Manufactured Resistojet**

## Introduction:

The potential of an all-electric spacecraft is enhanced by the possibility of a single integrated propellant supply. A common propellant choice is xenon. This places new performance demands on a high-temperature xenon resistojet, elevating the hot gas temperature requirement to a minimum of 2400 K to achieve 80 s ISP, or 3300 K for 95 s, compared to the current state of the art at 48 s [1]. This represents significant materials and design challenge. Beyond the flow kinetics, a major practical challenge facing the high-temperature resistojet technology is retaining structural integrity at the very high operating temperatures, whilst minimizing viscous and radiative heat losses. The University of Southampton has identified a technical solution to this problem and advanced thermofluid multiphysics simulations are currently ongoing as part of a current collaboration with Surrey Satellite Technology Limited (SSTL), alongside an iterative design process and experimental campaign to reach the performance possible from a high-temperature resistojet.

## Discussion:

This paper presents the design, manufacturing and postproduction analysis of a novel high-temperature resistojet heat exchanger manufactured through selective laser melting (SLM) of 316L stainless steel, to validate the manufacturing approach. The heat exchanger is produced as a single-piece component integrating a convergent-divergent nozzle, significantly reducing the time and cost of manufacture.

Environmental testing will be performed on the component, including: characterisation of thrust and ISP performance in hot and cold gas modes; determination of an effective start-up and shut-down procedure to optimise lifetime and performance; thermal cycle life testing; vibration testing; and cleanliness testing.

These tests will be combined with a novel process of high-resolution micro-Computed Tomography (μ-CT), applied as a tool for volumetric non-destructive inspection, since the complex geometry of the thruster does not allow internal inspection. The results in this paper will be used in an iterative process to further improve the design of the STAR (Super-high Temperature Additive-manufactured Resistojet). The paper will also include the testing of Inconel and refractory alloys via the same methods.

## Conclusion:

A high-temperature xenon resistojet is an enabling technology for an all-electric spacecraft. This paper presents an experimental campaign on additive-manufactured prototypes as a precursor to the development of the refractory metal high-temperature thruster. The data presented will be used to validate the University of Southampton’s thermofluid resistojet model, and inform the next stage of development of the STAR.

## References:

[1] Romei, F., Grubišić, A. and Gibbon, D. (2017). Manufacturing of a high-temperature resistojet heat exchanger by selective laser melting. *Acta Astronautica*, 138, pp.356-368.

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