Development of an Advanced High Temperature Xenon Resistojet Thruster for Telecommunication Spacecraft Propulsion

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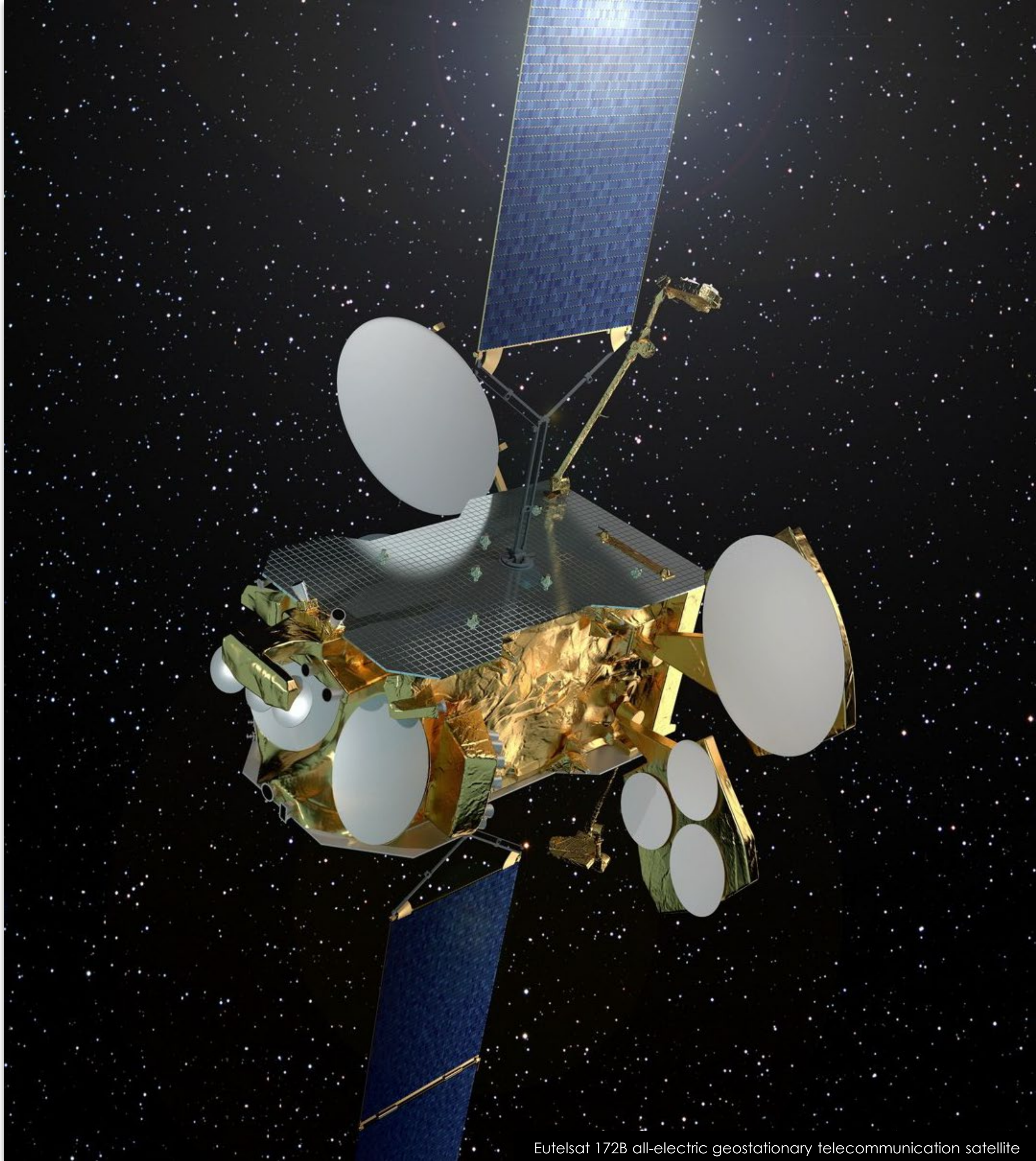
Introduction

Propulsion systems allow spacecraft to control their motion, enabling them to lengthen their mission life, position themselves for observations, and safely deorbit.

Conventional chemical propulsion (CP) systems are being replaced by electric propulsion (EP) with numerous benefits.

CP is still necessary in certain scenarios, e.g. where existing EP systems produce insufficient thrust. In addition, there is a lack of low-cost, high-performance EP systems.



Eutelsat 172B all-electric geostationary telecommunication satellite

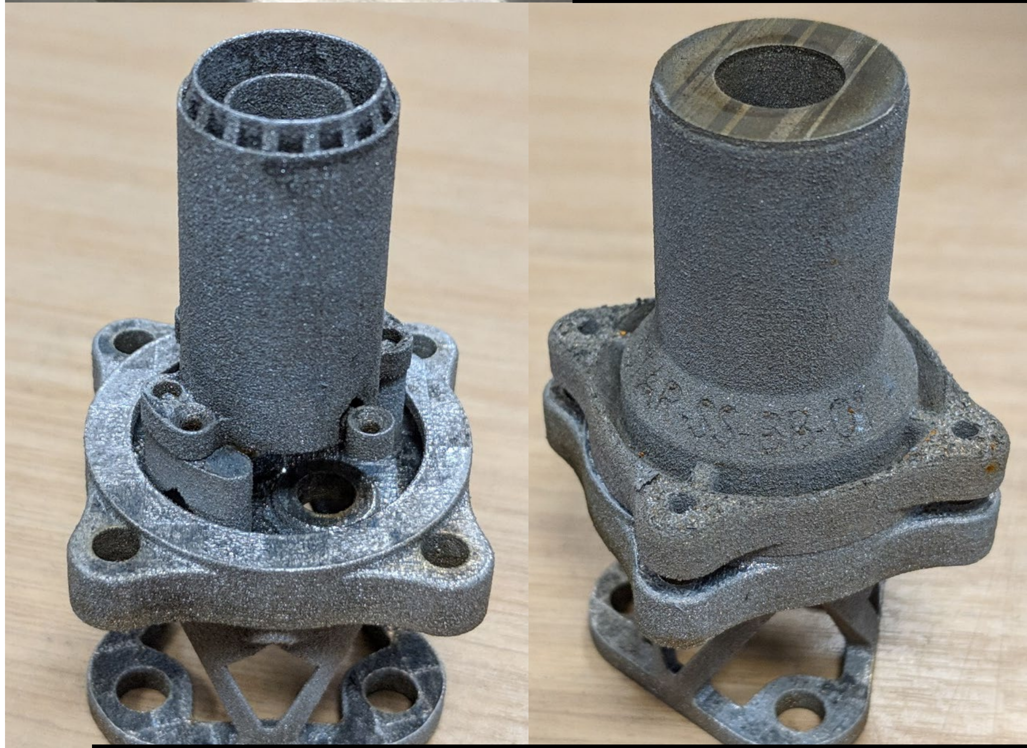
Resistojets and STAR

Resistojets are an "electrothermal" propulsion technology, where propellant gas is heated by a resistive heating element.

Resistojet propellant utilisation efficiency is determined by the operating temperature. Commercial resistojets operate at ~800 K. Using additive manufacturing (AM), a resistojet can be manufactured from high-temperature refractory metals such as tantalum and tungsten.

The STAR (Super-high Temperature Additive-manufactured Resistojet) project aims to develop a resistojet operating at 2400-3000 K, improving propellant utilisation by up to 75 %.


AM build plate with 18 STAR heating elements

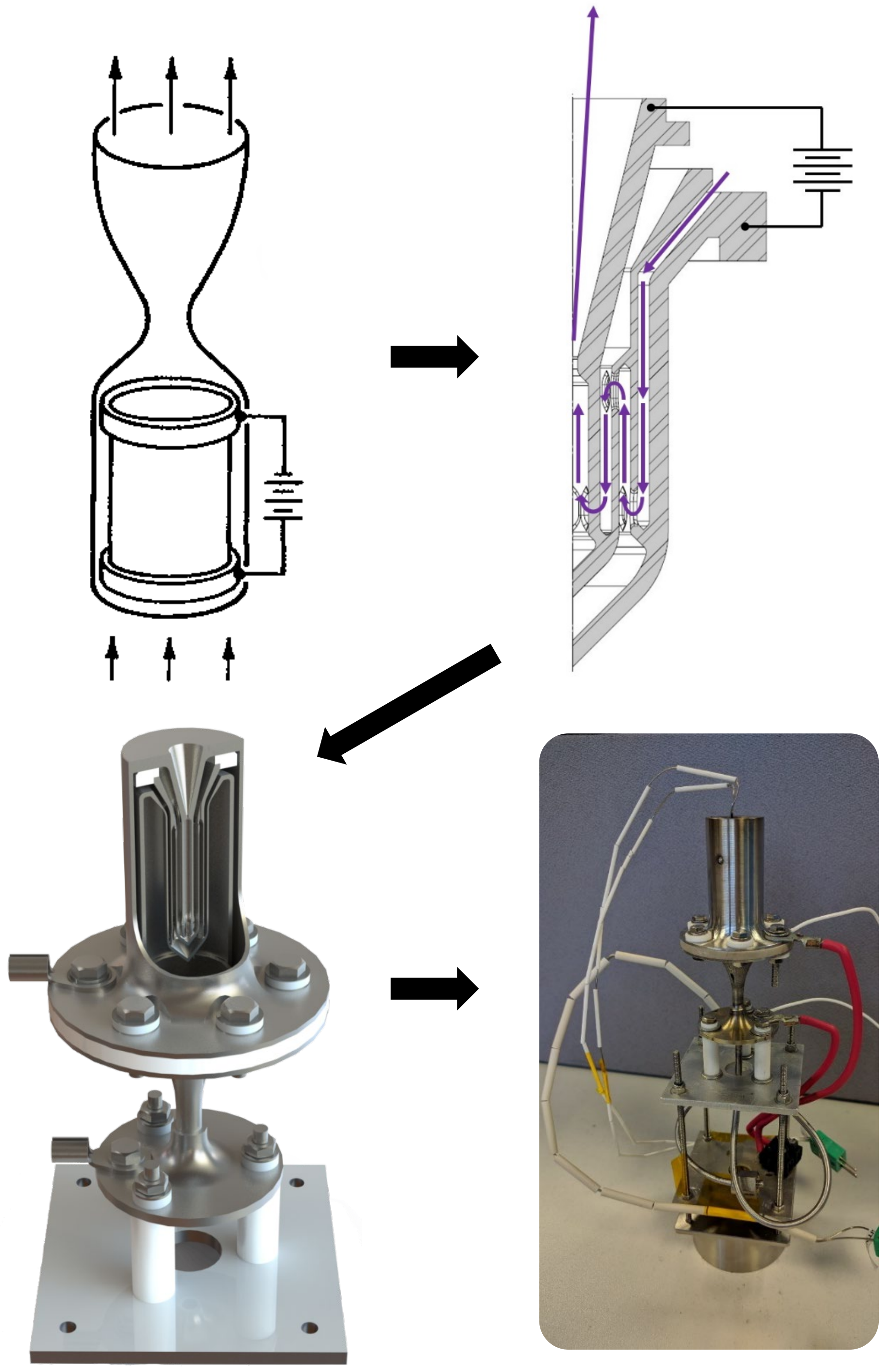

Prototype STAR thrusters showing (left) internal heating element and (right) exterior case and nozzle

STAR design

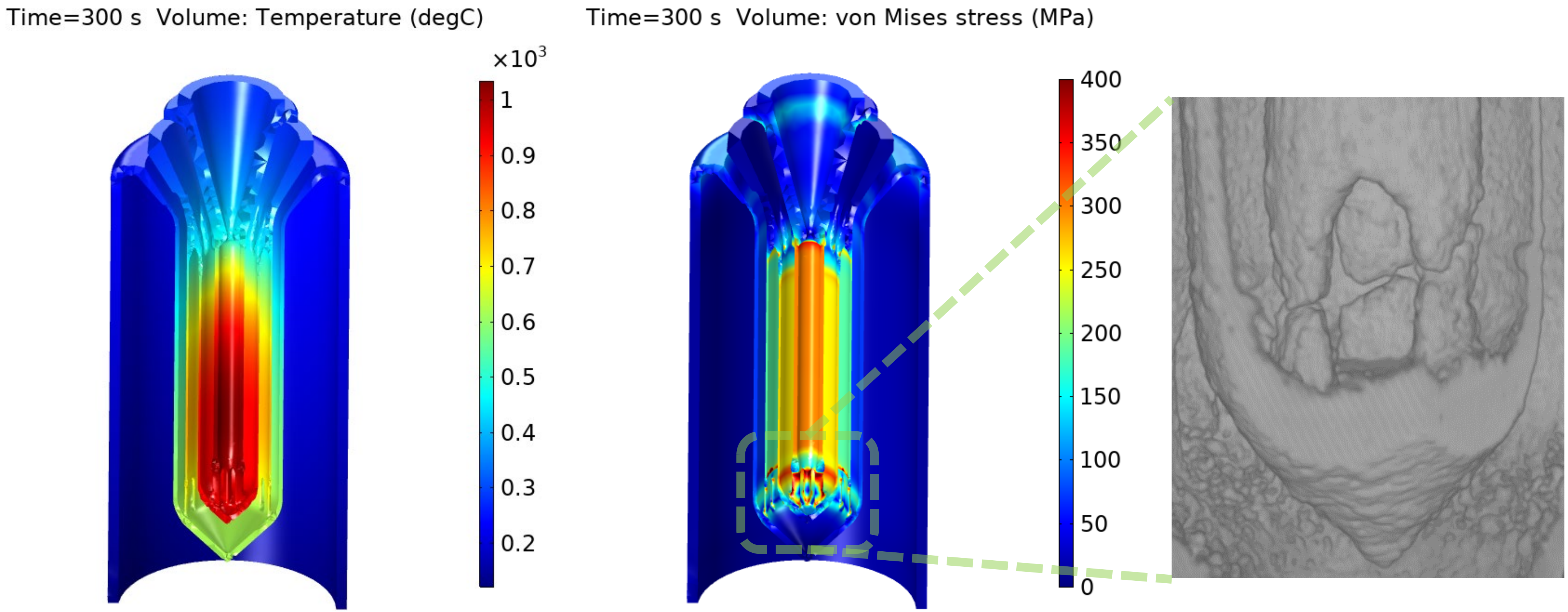
The main component of STAR is an AM heating element. This uses a concentric cylinder design to create a winding flow path of propellant gas, ensuring high efficiency.

AM allows this design to be manufactured in a cost-effective way. Previous attempts to develop concentric cylinder resistojets were not economical, requiring many components and complex manufacturing processes.

However, operation at very high temperatures brings many challenges…



Thermal stress



Thermal stress

Materials and endurance progress

Two design iterations have been tested based on information from the initial prototype testing. By careful design of the heating element's structure, it can thermally expand and contract without generating large stresses.

	STAR-0	STAR-BB-01	STAR-BB-02
Stainless steel	1-300	-	-
Nickel alloys	-	3500	**6000**
Refractory alloys	-	1000	2000
	(initial design)	(reduction of thermal stresses)	(improvement of BB-01 concept)

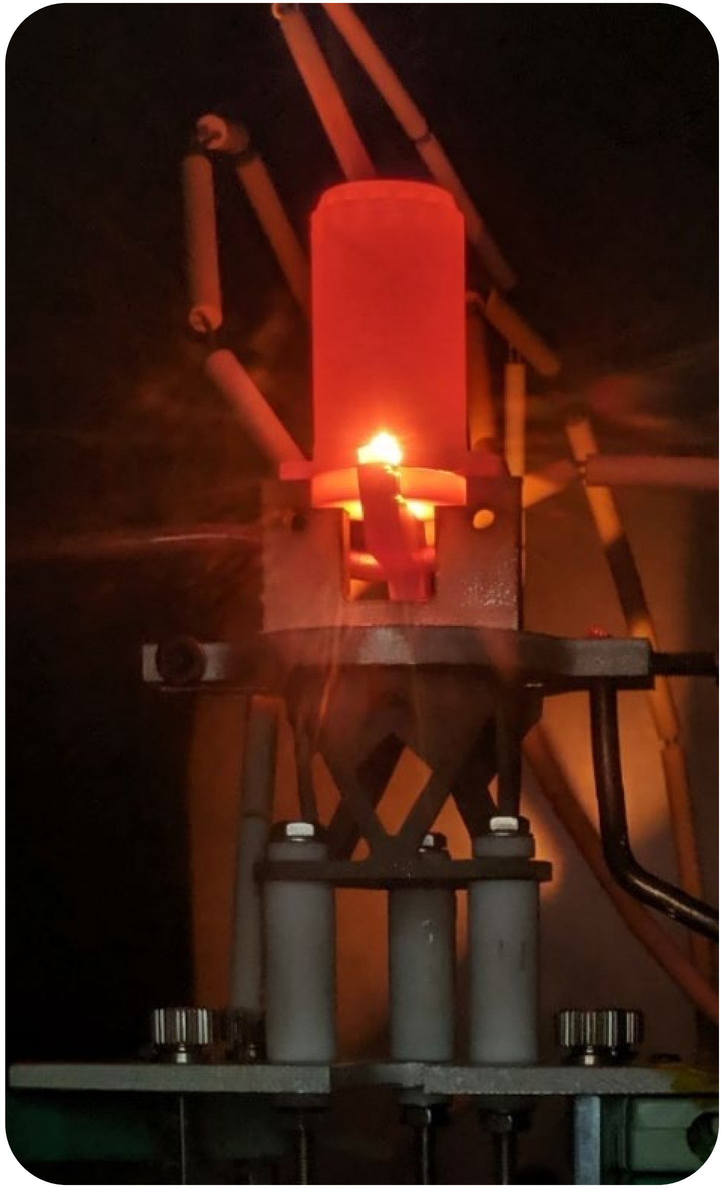
Conclusions

STAR aims to provide a propulsion system which matches the beneficial characteristics of CP, while eliminating chemical hazards, and to do so at low cost.

The major novel component, an AM heating element, has demonstrated sufficient endurance for anticipated mission requirements while operating at much higher temperatures than existing resistojets.

If STAR is successful, it will:

- Reduce the need for hazardous chemicals in spaceflight.
- Enable more organisations to launch small satellites, many of which are vital for observation of the Earth's ecosystems and climate.



Thank you for attending.

Questions ?

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Additional publications:

M. Robinson, A. N. Grubišić et al, "Endurance testing of the additively manufactured STAR resistojet," J. Materials & Design, vol. 180, 2019.

F. Romei, A. N. Grubišić, and D. Gibbon, "High performance resistojet thruster: STAR Status Update," in Space Propulsion 2018, 2018.

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