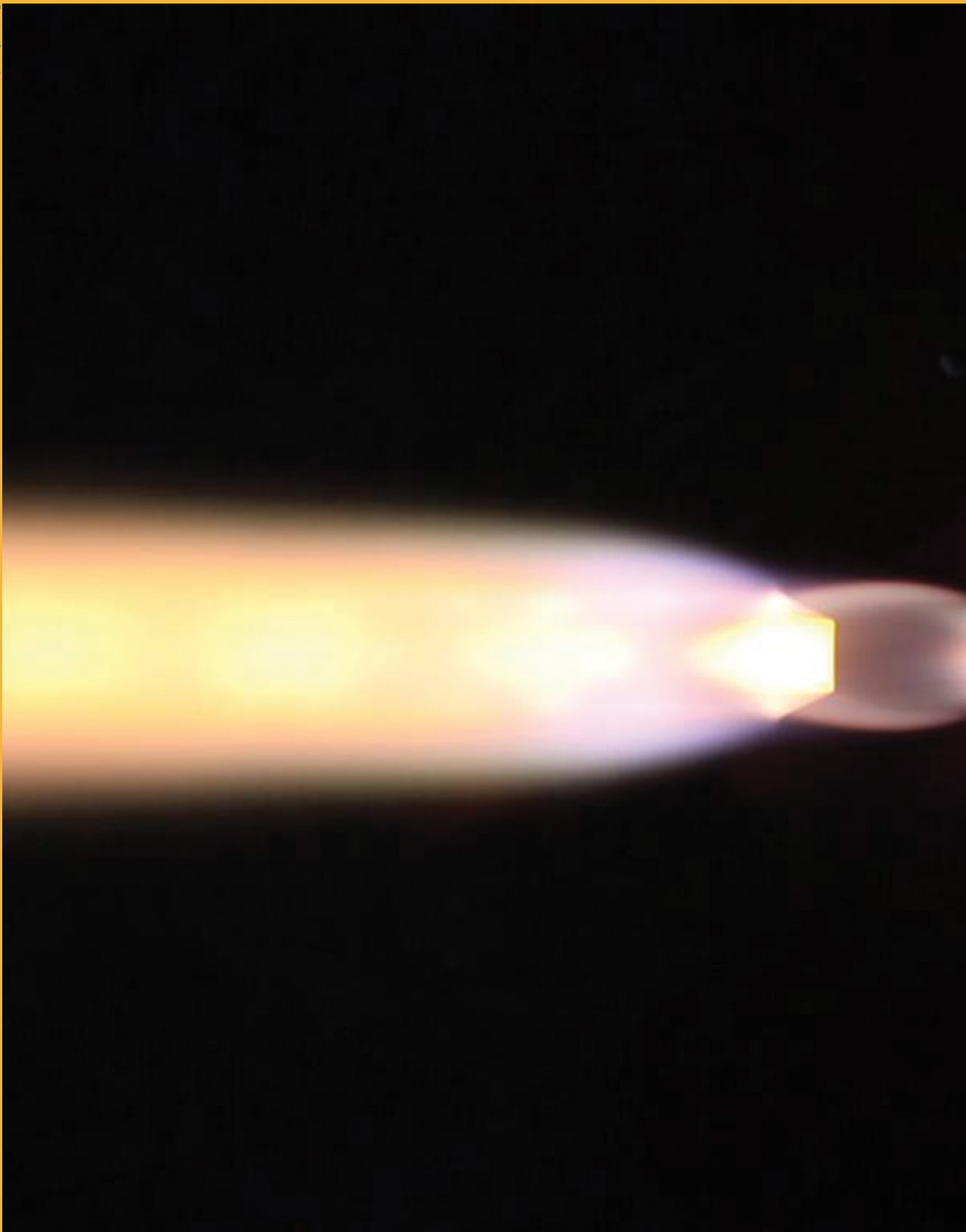
European Space Agency



Having a blast

CHEMICAL engineers working for the European Space Agency (ESA) have helped develop a new engine that may one day propel a spacecraft into orbit around the moons of Mars.

The High Thrust Apogee Engine (HTAE) is a 1,100 N engine currently under development in the UK. Essentially, it's designed to allow ESA to get more scientific hardware to Mars by helping it enter orbit around the planet – and its moon Phobos – more efficiently.

This engine is typically referred to as a 'liquid bi-propellant' and it uses monomethylhydrazine (MMH) and dinitrogen tetroxide as fuel and oxidiser respectively. These are fed from tanks mounted within the spacecraft, through a network of process piping, to two solenoid actuated valves mounted on the engine. The propellants are hypergolic, meaning once the valves are actuated, the chemcials are injected into the combustion chamber where they ignite on contact. This makes for a highly reliable ignition. No one wants to have a mission that has taken about a decade to implement, failing in orbit. It's not as easy to access as a problematic process plant outside your office.

One of the challenges in rocket engine design is containing the hot combustion gas, which in this case can reach temperatures in excess of 3,000K. The development model of the engine shown here uses a high temperature capable niobium alloy with a silicide oxidation resistant coating.

Through a combination of radiative cooling to the vacuum of space, and a fuel rich boundary layer which inhibits combustion near the inner wall, the engine is maintained at an operating temperature that allows it sufficient life – in the order of a few hours – to do the velocity changes needed to get into orbit.

The full engine is approximately 1 m long and 0.5 m in diameter at its exit. This is a photo of a truncated development model, approximately 0.25 m long, firing into ambient pressure. The gasses are flowing at transonic speeds near the throat where they heat the wall to approximately 1600 K. The shock pattern of the plume does not actually manifest in space. The plume instead flows full through an expansion nozzle – not attached during the development testing shown – exiting into the vacuum of space at about Mach 6 (or a little over 2 km/s).

Lolan Naicker, chemical engineer and technical lead for the HTAE design effort