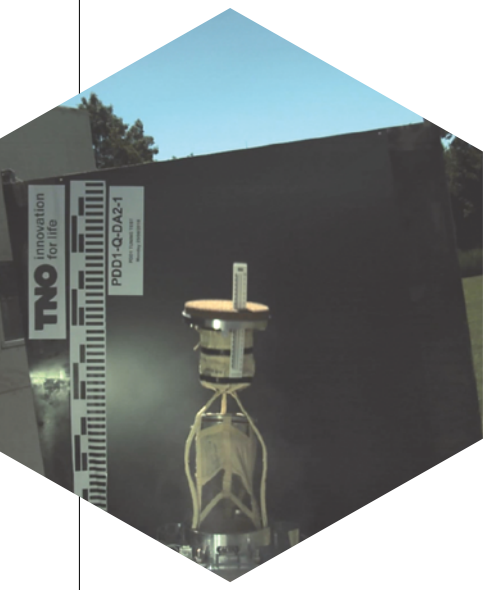
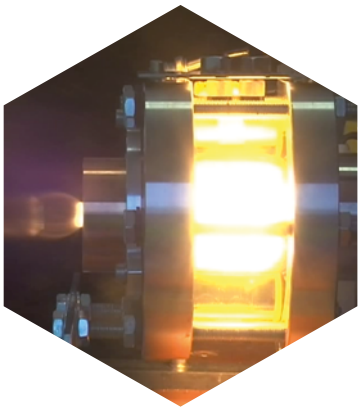
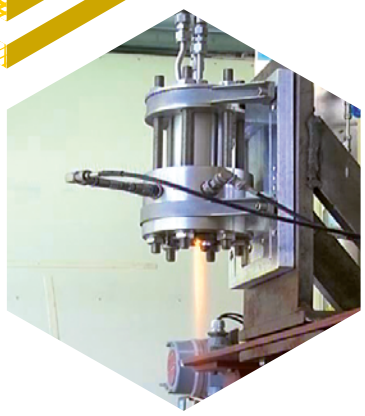
SPACE PROPULSION AND CUSTOMIZED ENERGETICS







TNO innovation for life

Space Propulsion and Custom Energetics (SPaCE) is a product team within TNO's Energetic Materials department. The multidisciplinary SPaCE team is specialized in innovative space propulsion and pyrotechnic product development and testing. It has all the necessary resources and qualifications to assist governments and companies in the aerospace industry. Their high-quality work will enable your organization to adhere to changing regulations by applying affordable and sustainable technology in your products, while maintaining their full functionality and always keeping costs and the environment in mind.

The facilities of the Energetic Materials (EM) department—which include laboratories, test benches and bunkers for rocket engine firings and (gas) explosions—are designed for the synthesis, analysis and handling of energetic materials. In the decades of experience in working with combustible, explosive and toxic materials such as pyrotechnics, (organic) peroxides, rocket propellants, self-reactive, self-heating substances and flammable gases, solids and liquids, the EM-department built a unique expertise while maintaining a perfect track record with respect to safety. Its global customer base, ranging from SMEs to multinationals and governments, values the rapid response, independence and effort to go that extra mile. After every project, you will receive the results and findings, including a thorough interpretation and analysis. While working with you, the EM team will never lose track of that one question: what does this actually mean for your business?

ENGINEERING PROPELLANTS

The SPaCE team distinguishes itself by its extensive knowledge of energetic materials and testing. Their approach brings together the entire process from literature research to prototyping, proof-of-principle and product development. This means that when they receive a set of requirements for a certain product, the experts at SPaCE can turn that into a set of solutions that they are then also able to verify by means of modelling and testing.

Case study: TNO was invited to join the team responsible for realising the parachute mortar on the upcoming ESA mission to Mars, EXOMARS. Based on the customer's specifications for firing profile and speed, as well as aging

characteristics, shock and vibration loads, the SPaCE team was able to select and verify a propellant that is compliant to the complete set of challenging requirements and proposed important design changes to the mortar gas generator. When the mission leaves for Mars in 2020, it will be the first time in decades that a parachute system like that has been developed in Europe–TNO is bringing innovation back home.

INNOVATING IGNITERS

TNO develops innovative igniters for various applications. One major direction of innovation is hybrid igniter technology. Hybrid igniters utilize the optimal compromise between solid fuels and liquid oxidizers by avoiding the unstoppable nature of solid propellant burning, while also getting around the complexity of incorporating two propellant feed systems and the need for an initiator. A hybrid igniter works with a catalyst as initiator to decompose the liquid oxidizer and uses a solid fuel core, making it inherently safe and insensitive to cracks in the fuel.

Case study: The SPaCE team developed a new catalysis bed for a monopropellant rocket igniter. To maximize the decomposition of the propellant, the experts utilized in-house modelling and 3D printing capabilities to design and print an optimized bed. Because of this approach, the bed was not only more predictable and reproducible, but also more efficient: it used counter flow to increase the heat distribution in the propellant as it passed through.

PERFECTING A PATENT

The showpiece of the SPaCE product team is their expertise in cool gas generators. TNO obtained the patent for this technology from Russia, and developed it further into the micro propulsion technique of the future. Cool gas generators contain a solid grain which, when decomposed, releases a pure gas at ambient temperature. Therefore, the need for high-pressure gas storage is avoided during the product's entire life; the gas can just be produced when it is needed. The SPaCE team is now able to make them for nitrogen and oxygen, and are developing generators for hydrogen, carbon dioxide, and methane. They are a very interesting gas storage option for inflatables, emergency oxygen applications and propulsion systems.

Case study: Due to their high gas storage density, cool gas generators prove to be excellent for use in space propulsion systems, especially in the small satellite segment. These nanosatellites, like CubeSats, are often launched together with bigger satellites, and regulations demand that the hitchhiking satellites do not carry pressurized systems on board. In the cool gas generator the gas is chemically bonded in a solid so they are the perfect solution: they adhere to regulations while still providing a way to generate gas in space. The SPaCE team works together with other TNO departments to develop a complete cool gas generator-based propulsion system, from the solid gas producing material in the gas generators to the micro-thrusters that expel the gas.

BEYOND REACH

The European Union developed the REACH legislation with the aim to reduce the use of hazardous chemicals. This coincides with an ever-increasing amount of rocket launches, and the commercialization of space flight. The combination of these dynamics make it due time to develop propellants that are more considerate of the environment and the health of the people working with them. This means that certain propellants –including hydrazine, the monopropellant of choice for in-space propulsion – cannot be used anymore. The SPaCE team is using its knowledge of energetic materials to develop the propellants of the future, which will keep Europe competitive while reducing the environmental and health burden of today's space propellants.

Case study: The SPaCE specialists set out to find an alternative for hydrazine (derivatives). Hydrazine is labelled to become prohibited by REACH but remains, for now, the most widely used propellant for in-space propulsion. The challenge was that while there are many liquid, storable and "green" fuels, none of them is readily hypergolic with one of the liquid, storable and green oxidizers. Using their broad knowledge of energetic materials, the team was able to design an ethanol-based fuel that includes additives that make the mixture hypergolic with hydrogen peroxide at atmospheric conditions. The mixture was then tested and perfected in TNO's test facility.

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DEFENCE, SAFETY AND SECURITY

The independent Netherlands Organisation for applied scientific research (TNO) supports the Dutch comprehensive protection model. Our work in Defence, Safety & Security focuses on technological and behavioural innovations.

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