Defence-related Research Action - DEFRA

ACRONYM: HITS

Title: the effect of High-velocity ballistic Impact on the Thermo-mechanical behaviour of Space material

Duration of the project: 01/12/2024 - 01/03/2028

Key words: Thermal Protection material – Balistic impact – Hypersonics

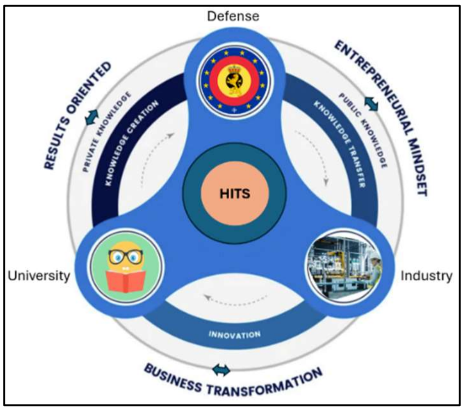
Budget: 1.610.997 €

of which RHID contribution: 1.553.197 €

PROJECT DESCRIPTION

As the demand for faster aerospace vehicles continues to rise, so do the engineering challenges associated with meeting these demands. One area of interest is the material used as thermal protection system for the structure of vehicles and there is an ongoing race to find suitable solutions to address these material challenges. The scope of the HITS project focuses on investigating the thermal and mechanical performance of an additively manufactured ceramic material and its ability to withstand foreign object damage at high velocities (2500 m/s). Our multidisciplinary team combines relevant expertise in the hypersonic, ballistic impact, and material fields involving the Aero-Thermo-Mechanical Department at ULB, the Aeronautics and Aerospace Department at the von Karman Institute for Fluid Dynamics (VKI), the Weapon Systems and Ballistics Department at the Royal Military Academy (RMA), the Mechanical and Materials Engineering Departments at KU Leuven, and the aerospace industry with Telespazio Belgium and in-kind participation of Sonaca.

Our team follows the triple helix composition where academia and industry work together on the HITS project to foster the research and technology of Belgian Defense as shown in the figure. The proposed work is distributed between the consortium as follows: material development, supply and strength characterization will be conducted at KU Leuven and ULB, ballistic impact will be done at RMA, high-temperature ground testing will be carried out in the VKI Plasmatron facility, numerical tools will be developed at ULB and RMA, and Telespazio will conduct the project management, interfaces and risk management, contracting activities, and valorization.



HITS: investigate thermal and mechanical performance of an additively manufactured ceramic material and its ability to withstand foreign object damage at high velocities

1. High-temperature material
2. Foreign Object Damage
3. Plasma testing
4. Computational modeling

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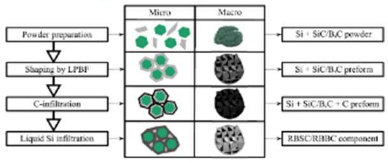
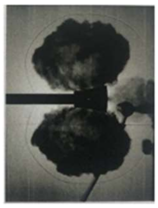
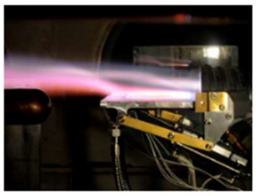
Valorization







The goal of this work addresses the following questions: can we characterize additive manufactured ceramic composites experimentally and analytically for hypersonic defense missions coupling both mechanical and heat loads? What if the vehicle is subjected to foreign object damage during flight (e.g. loose mechanical part, meteoroid, or intentional attack), would that have any effect on the material response and vehicle performance as result of material response, mechanical performance or thermal performance? Or all the above? If so, how much and to what extent? Furthermore, subjected to harsh environment conditions after impact, would that "expand" the damage region around the impact sight and does that degrade the overall material performance (thermally and mechanically)?

Hypersonic Gliding Vehicles can cover additional large distances by flying at Mach 8-20 within the upper atmosphere (30-60 km) glide or phugoid trajectories, overcoming long distances in short time. Hypersonic Cruise Vehicles are based on air breathing technology. They can sustain hypersonic flights at Mach 4 - 7+ for most of their trajectory at 20-35 km altitude. NATO needs to adapt its defensive architecture against new hypersonic threats, Belgium can play a crucial role in hypersonic defense within Europe by involving actors from the research and technology sectors. The von Karman Institute for Fluid Dynamics (VKI) has a recognized expertise on hypersonics and ground testing. It hosts, among other unique facilities, the world's most powerful inductively-coupled Plasmatron facility. This project will pave the way for developing an experimental bench to study thermo-mechanical coupling in thermal protection system materials, focusing on an additive manufactured ceramic composite that is designed and developed in Belgium.

The HITS project aims to enhance the performance of hypersonic vehicles, by investigating 3D printed silicon carbide-based composite materials subjected to flight conditions in ground testing facilities. Additionally, the project examines the material's response to foreign object damage. HITS will improve the current models in a material response code (PATO) to implement mechanical failure.

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