

Technologies in support to Future space transportation systems

Overview on activities of the European Space Agency

Giorgio Saccoccia, Josè Longo
European Space Agency, ESTEC

CESMA 2nd International Symposium: Hypersonic Flight from 100.000 to 400.000ft
Rome, Italy, 30 June – 1 July 2016



Overview

Introduction

Technologies for integrated systems

High speed transportation activities (EC Projects)
Air-breathing engine technology (SABRE)
Airborne launch systems

Technologies for subsystems & components

In-flight demonstration activities
Low TRL activities

Technology Support

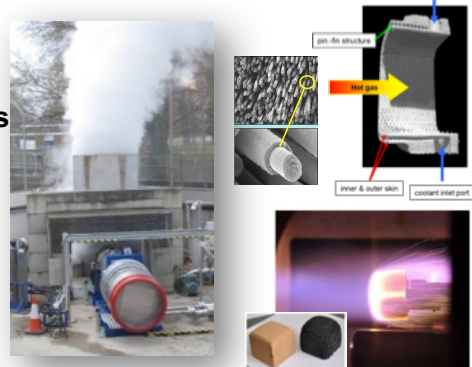
IXV/SPACE RIDER
ExoMars-16
FLPP



Introduction

In addition to the classical support to on-going programmes the area of space transportation, ESA has been involved over the past years in several technology activities related to future space transportation systems and hypersonic vehicles, acting as:

- **Coordinator of multinational EC co-funded activities**
- **Advisor on national and/or commercial initiatives**
- **Technical authority on proposed studies**



European Space Agency

High speed transportation activities (EC FP6/7 Projects)



Synergetic Activities overlapping Aerospace and Aviation

EC Funded in the Aeronautics theme activities granted (coordinated by ESA)

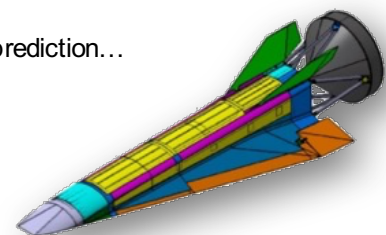
ATLLAS I/II, LAPCAT I/II, FLACON, FAST20XX, HIKARI, HEXAFLY-INT

Participants MS: BE, CH, DE, FR, IT, NL, RO, SE, UK; Int. partners: Japan, Russia, Australia, (Brazil)

Experimental flight testing at high (M=2 to 7) and low speed (take-off & landing) **planned for 2018**

R&D Topics:

- **Vehicle concepts** for high L/D concepts, winged, HTOL, TPS, integration, aerodynamics optimization...
- **Advanced propulsion** air-breathing and rocket-cycles incl. re-usability
- **High-temperature materials and hot structures** re-usability, life-time prediction...
- **Advanced flight control, GNC and HMS...**
- **Environmental Impact** on emissions, sonic boom...



European Space Agency

Air-breathing engine technology (SABRE)



The **Synergistic Air-Breathing Rocket Engine (SABRE)** is an air-breathing engine designed to accelerate a vehicle to Mach 5 by burning on-board fuel with atmospheric air, before transferring to rocket mode which uses on-board oxygen and hydrogen.

SABRE is the KEY technology for the UK SKYLON vehicle concept, a fully reusable Single-Stage-to-Orbit (SSTO) launch vehicle, with approx. 15 metric tons of payload, aircraft like operations and hydrogen fuelled.

Since 2009 TEC has been involved to help develop the SABRE engine technology through a number of activities. In 2015 Phase 3 kicked off (currently investment split between private investors –REL & BAE– and GSTP UK, DE, BE, ES). A **SABRE ground demonstrator engine will be tested in 2020**.



European Space Agency

Airborne launch systems



EC funded FLACON & FAST20XX Alpha (coordinator ESA)

Fully reusable suborbital system. Participants MS: BE, CH, DE, ES, FR, IT, SE

Support to Swiss Space Systems (S3) commercial initiative (on-hold)

Up to 300 kg P/L to SSO using a conventional airliner carrier as 1st stage, a Reusable shuttle as 2nd stage and a (non-reusable) liquid booster as 3rd stage. Participants MS: BE, CH, ES, FR, IT.

Support to XCOR commercial initiative (on-hold)

Participation of the upgrade of the XCOR Mark II into the Mark III space-plane (LoI between XCOR, The Royal Netherlands Air Force, TU Delft and ESA). Participants MS: NL.

Launch system by means of an European fighter (ESA internal GSP)

35 kg P/L to SSO using a fighter aircraft and a combination of solid booster as 2nd and 3rd stage.



European Space Agency

Examples of In-flight demonstration activities



QubeSat for Aerothermodynamic Research and Measurements on AblationN

(QARMAN): a CubeSat platform used as “Atmospheric Entry Demonstrator” for the assessment of ablative Thermal Protection System (TPS) and gather data for rarefied flow aerothermodynamics. Also, an “Aerodynamic Stability and De-Orbiting System (AeroSDS)” to demonstrate the feasibility of a passive system providing aerodynamic stability below 350 km of altitude and during re-entry.

QARMAN will be injected from the ISS into LEO by end 2016.



Mini-IRENE (Italian Re-Entry Nacelle):

a sub-scaled demonstrator of a low-cost deployable re-entry system, to enable payloads return on Earth from the ISS and/or recoverable scientific experiments in Low Earth Orbit (LEO). It could be also applied as aero-brake system on robotic exploration missions and offers also an interesting potential for aero-capture and for de-orbiting without the need of a dedicated propulsive subsystem. **Mini-IRENE will be tested in sub-orbital flight in 2018.**



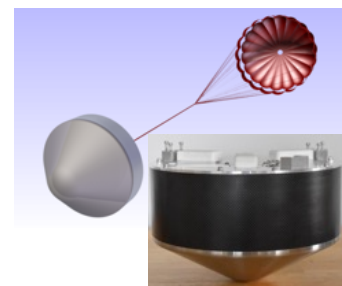
European Space Agency

Examples of In-flight demonstration activities



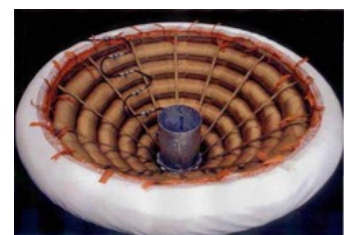
Supersonic Parachute test on a MAXUS flight (SUPERMAX):

a flight experiment to demonstrate the capability of testing new supersonic parachute designs in representative conditions for space missions and reduce the reliance on existing non-European parachute systems. **The flight test will be carried out as a piggyback of the MAXUS-9 suborbital mission in 2016/2017.**



Inflatable Re-entry Demonstrator Technology (IRDT):

was an ESA low-cost flight demonstration program on inflatable technologies which performed 3 flights in the past. Today this technology is being re-assessed for planetary exploration on highlands and for heavy payloads deployment on lowlands, and also as guidance system for planetary exploration using penetrators. The flight experiment definition is still open.



European Space Agency

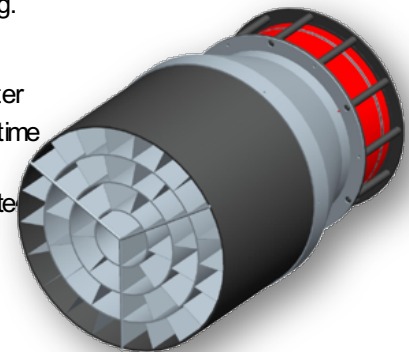
Examples of Low TRL activities



Air-Breathing Electric Propulsion (RAM-EP):

An electrical propulsion system which does not require the storage of the fuel since it generates thrust by accelerating ions obtained by ingesting and ionizing the atmosphere surrounding the spacecraft. Very low operation orbits, in e.g. Mars, and very long operation times are feasible with this technology.

Previous ESA studies have characterized the performance of electric thruster with atmospheric propellants. Currently it is under development for the first time an air-breather electric thruster devoted to demonstrate experimentally the feasibility of the complete concept in a ground facility (vacuum chamber doted with a flow generator).

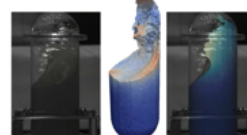


European Space Agency

Examples of Low TRL activities



- Development and testing a generic high thrust apogee engine
- Preliminary studies on 3D printing manufacturing
- Combustion chamber and injection technology developments
- Manufacturing and testing of a laser ignition system for liquid propulsion
- Experimental investigation of cryogenic two phase flows
- Zero boil off propulsion system feasibility demonstration
- Landing system development
- Robotically-Enhanced surface touchdown
- Multispectral sensing for relative navigation
- Camera-aided landing and rendezvous navigation system
- Sensor data fusion for hazard mapping and piloting
-



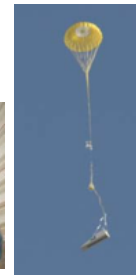
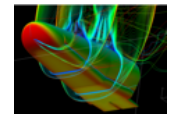
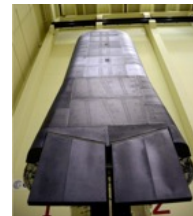
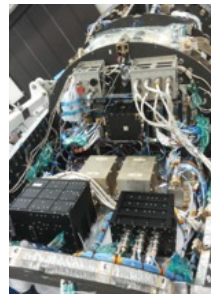
European Space Agency

Technology Support to IXV/ Space Rider



For IXV

- System analysis activities
- Thermal protection, structures and mechanisms
- Descent and recovery
- Thermal control
- Avionic and GNC
- Reaction control
- Flap control
- In-flight experimentation
- System qualification and testing



For SPACE RIDER

- Configuration selection
-

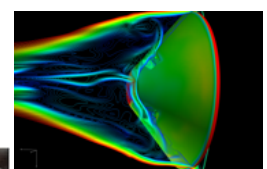
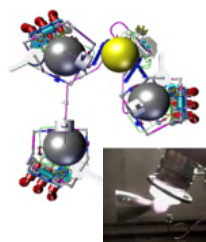
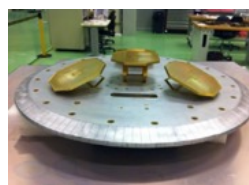


European Space Agency

Technology Support to ExoMars 16



- System analysis activities
- Thermal protection, structures and mechanisms
- Descent and landing (impact attenuation system)
- Thermal control
- Avionic and GNC (doppler radar system)
- Retro rocket decelerators (liquid propulsion)
- In-flight experimentation
- System qualification and testing



European Space Agency

Technology Support to FLPP



Expander Technology Integrated Demonstrator (ETID/Vinci 2)

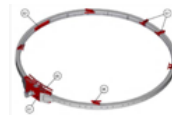
Vinci engine derivatives, including a methanized version for mid-term applications

Storable bi-propellant propulsion

Hot-fire testing of 5kN class engine demonstrator

Solid rocket motor composite casing demonstrator

Automatic manufacturing of a scaled SRM casing, 6 m long

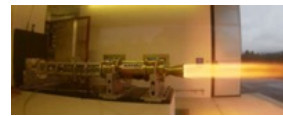


Hybrid propulsion

Manufacturing and hot-fire test of a unitary motor demonstrator

Additive Layer Manufacturing

Selective laser melting for mass reduction by removing joint interfaces



Metallic cryotank structures

Al-Li cryogenic tank structural demonstrator



....



European Space Agency

Conclusion



The path to future space Transportation systems requires significant advancement in technology

ESA is promoting several preparatory activities aiming to the creation of the appropriate know-how and background necessary for Europe to initiate in the future the development of new concepts of transportation systems.

These activities have been funded through different ESA programmes and in the frame of EU initiatives



European Space Agency