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HEXAFLY-INT Project: Design of a High Speed Flight Experiment

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HEXAFLY-INT overview (1/3)

- The HEXAFLY-INT project, funded by the European Commission within the 7th Framework Programme and the European Space Agency, aims at designing, manufacturing, assembling and flight testing an unpowered high speed vehicle in a glider configuration.
- The main target is to gradually increase the readiness level of a number of breakthrough technologies suitable for future high-speed transportation systems.
- The main technical challenges of the project are specifically related to the design of the vehicle gliding configuration and to the complexity of integrating breakthrough technologies with standard aeronautical technologies.

HEXAFLY-INT overview (2/3)

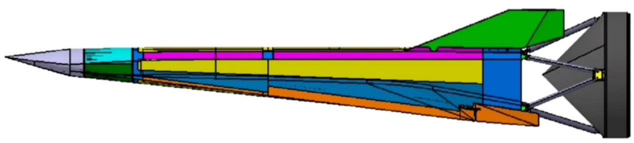
The project is involving partners from Europe, Russia and Australia

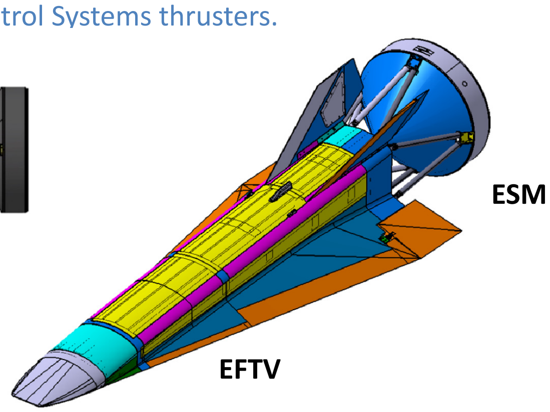
Main responsibilities:

- CIRA Project Engineer and Design Authority
- TET Cold Structure design
- TsAGI (Russia) cold structure manufacturing
- DLR hot structure manufacturing
- DLR and Australian part in-flight experiment

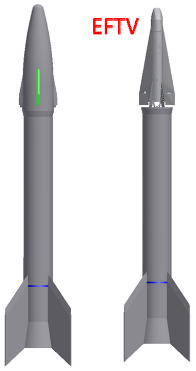
HEXAFLY-INT overview (3/3)

- The experimental payload is composed by the Experimental Flight Test Vehicle EFTV, and the Experimental Support Module ESM.
- The first is designed to glide through the experimental window; it is equipped with an avionic system composed by an inertial measurement unit (IMU), GPS, servo-actuators, a mission specific flight control computer (FCC). The vehicle will also be equipped with an in–flight measurement system.
- The latter has the aim of stabilizing and controlling the vehicle attitude at the higher altitudes by means of cold gas Reaction Control Systems thrusters.





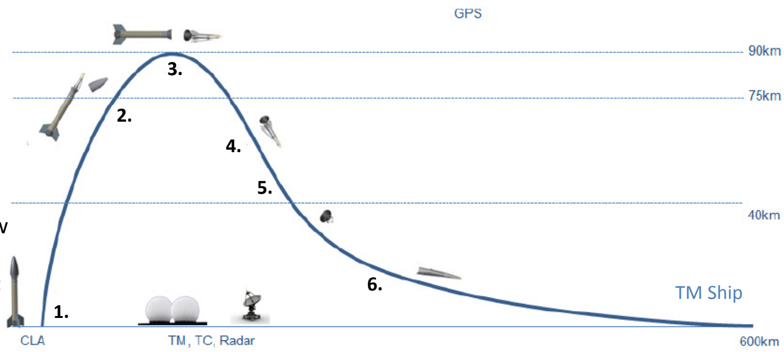
Mission Profile



Objective: to perform a high-speed flight experiment with a target flight Mach number of 7 to 8 altitude range in between 27 and 33 km

Ad-hoc designed sounding rocket provided by DLR in cooperation with Brazil, relying on background experience (SHEFEX)

1. VS-43 Launch Vehicle lifts off;
2. Fairing release (about 80 km);
3. Payload release (90km);
4. Cruise phase to the experiment window (Stabilization by CGS);
5. ESM separation from the EFTV (50 km);
6. Experimental window; gliding phase.



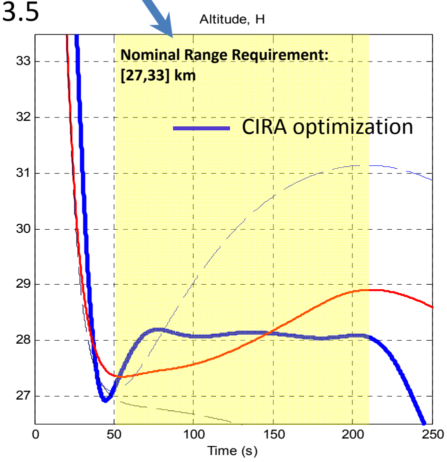
As no recovery of the payload is foreseen, the reception of experimental data is guarantee by telemetry (TM)

Glider Trajectory

		Curved Trajectory traj1 (ONERA)
Trajectory Mission Constraints	Experiment Altitude Range [km]	29,8km at t=300s 29,9km at t=400s 31,1km at t=500s
	Experiment FPA Range [deg]	fpa=-10,9 deg at t=300s fpa=0,99 deg at t=400s fpa=-0,23 deg at t=500s
	Mach number (max.)	7,53
	L/D (max.)	4,096
	L/D > 3.5	183,00 s
	L/D > 3.0	405,20 s
	Angle of Attack range [deg]	[-0,91 ÷ 11,4]
	Angle of Sideslip range [deg]	[-0,29 ÷ 0,26]
	Bank angle range [deg]	[-45,43 ÷ 9,62]
Airframe Constraints	Maximum Dynamic Pressure [kPa]	61,18
	Maximum Heat Flux (nosetip) - cold wall [kW/m^2]	4080,31
	Maximum Heat Flux (nosetip) - hot wall (eps=0.4) [kW/m^2]	709,88
	Maximum Heat Load (nosetip) - hot wall (eps=0.4) [MJ/m^2]	58,93
	Maximum Load Factor [a/g]	6,48
Actuation Lane Constraints	Aileron Deflection range [deg]	[-14,55 ÷ 0,43]
	Aileron Rotation Speed range [deg/s]	[-20 ÷ 20]
	Hinge-moment range [Nm]	[-98,3 ÷ 0,49]
Operations Constraints	Launch Azimuth Angle [deg]	56
	Range [km] from EFTV/ESM separation	674,94
	Telemetry Coverage	complete

After the separation from the ESM, a pull-out manoeuver brings the EFTV at a target altitude;
Banking manoeuvre just after the pull-out;

Experimental window:
min 150 s
L/D > 3.5



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EFTV: Vehicle configuration (1/3)

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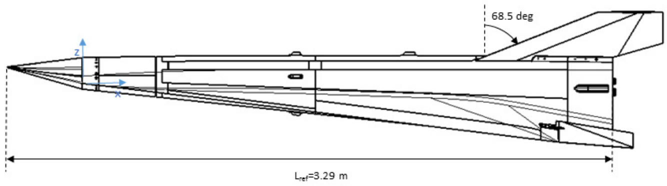
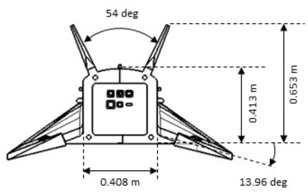
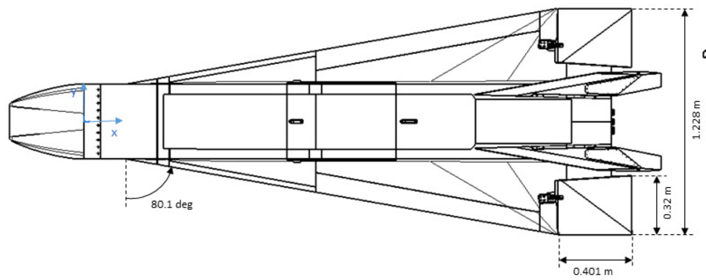
The aeroshape is the result of the analyses driven by key design requirements

- aeroheating
- stability and control
- high aerodynamic efficiency
- necessity to reduce problems in manufacturing and assemblying



Nominal Mass [kg]
461





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EFTV: Vehicle configuration (2/3)

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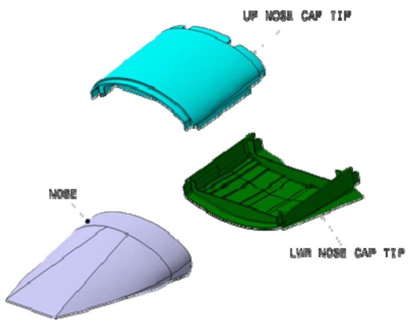
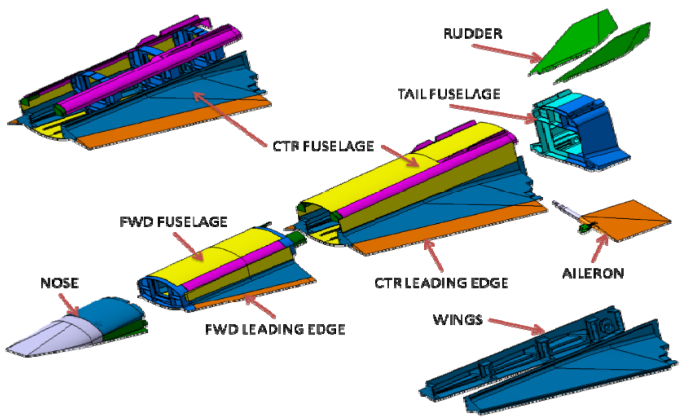
Materials:

The EFTV thermal protection system is composed both of metallic and ceramic parts (hot structures):





CMC (hot structure):

- ➢ Ailerons
- ➢ Wings Leading edge

Copper:

- ➢ Nose cap
- ➢ Vertical tail leading edge

Titanium:

Wings, fuselage, vertical tail

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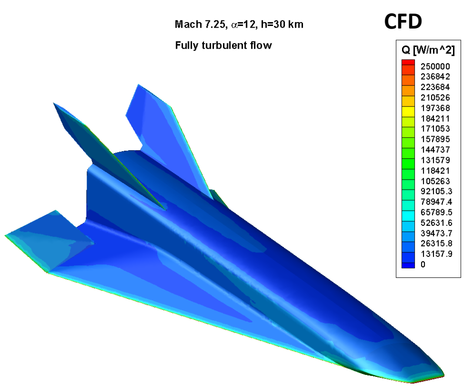
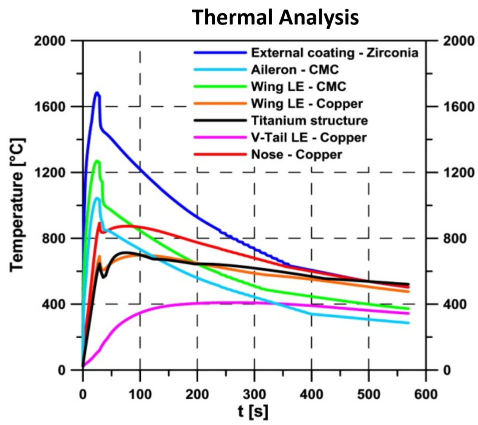
EFTV: Vehicle configuration (2/3)

Materials:

The EFTV thermal protection system is composed both of metallic and ceramic parts (hot structures). Due to the high temperatures involved, the metallic parts of the vehicle are protected by a ZrO_2 coating.

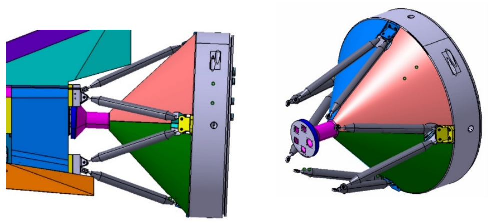


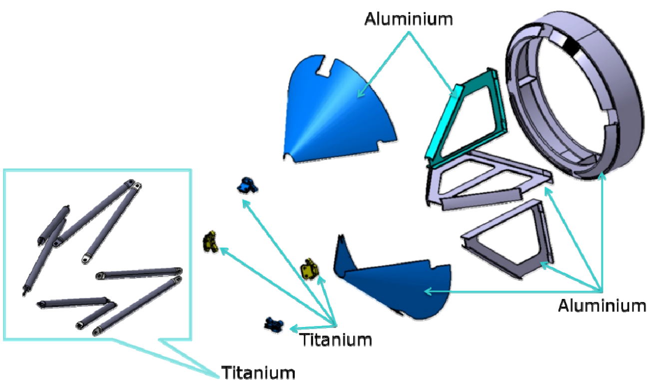


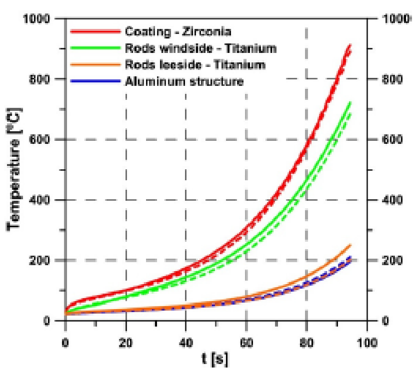
ESM configuration

Materials:

Fittings and Rods: Ti + ZrO_2 coating;
Cone structural parts: Aluminium







On-board Systems

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- Autonomous Guidance, Navigation and Control provided by the Flight Software running on Flight Control Computer and using data from IMU and GPS
- Experimental data collected by the on-board DAQ and sent to ground by a Telemetry System
- The system relies, at the maximum extent, on flight proven or on-ground qualified sub-systems and equipment developed within international projects.
- Use of COTS H/W coming from space and aeronautics heritage

On-board Systems

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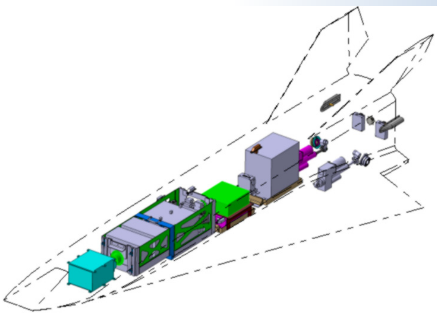
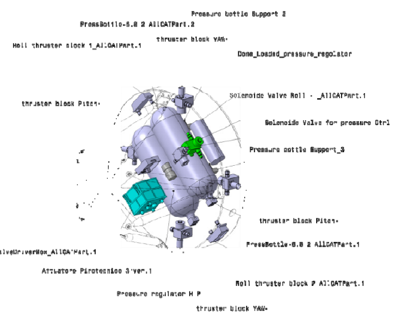
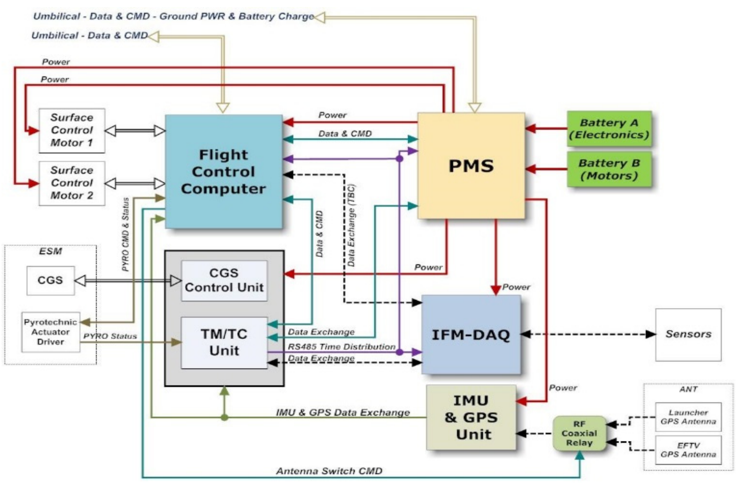


- The PM function ensured by the power supply system.;
- Electrical power supplied to on board systems and actuators by rechargeable Li-ion batteries;
- The control of the vehicle attitude after the Payload release and before the ESM separation by means of the CGS unit;

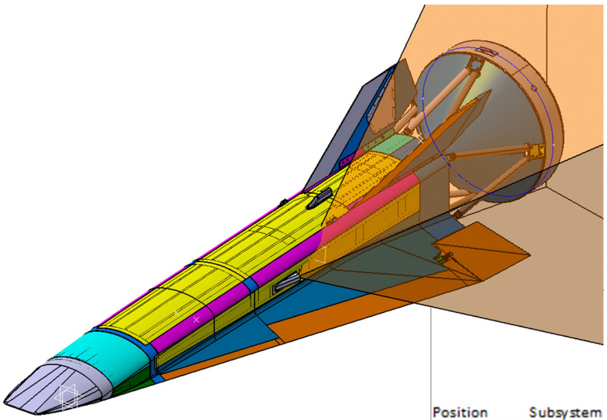
The ESM communicates with the EFTV through Umbilical connections;
The separation of the ESM is realized by means of pyrotechnic devices.





In-Flight Experimentation

Instrumentation layout defined in order to cover different scientific objectives with different sensor types mounted in the interested regions.



- Free stream quantities derivation by means of Flush Air Data System (FADS) integration;
- Aerodynamic heating
- Flap separation and gap-flow;
- Transition;
- Shock wave boundary layer interaction
- Wake and corner flow;
- Internal structure stress determination;
- Internal health monitoring;
- Visual vehicle status.

Five cameras, three external and two internal, used to get visual feedback from the vehicle flight status and get temperature measurements of the Temperature Sensitive Paint.

Position	Subsystem	Comment	Pressure	Structural Temperature	Surface Temperature (HF)	Heatflux	Strain	Acceleration	Sum
Nose	FADS	Orientation/Heating	8	4					12
Top Side	Body	Heating/Aerodynamics	2	2	5	1		2	12
	Wing	Heating/Aerodynamics	2	2				2	6
Bottom Side	Body	Heating/Aerodynamics/Transition	3	2	14	5			24
	Wings	Heating/Aerodynamics/Transition	2	2	6				10
Leading Edges		Heating/Structural		12					12
Vertical Fins		Transition/Heating/SWBL		11			6	2	19
Rudder		Heating/Structural		5			2	2	9
Base		Wake flow	1	3	2				6
Internal Structure		Health Monitoring		8			4		12
Total			18	51	27	6	12	8	122

Schedule

- ❑ **Preliminary Design Review** successfully accomplished in March 2015
- ❑ **Critical Design Review** scheduled by the end of 2016
- ❑ **AIV/AIT** of Launcher and EFTV scheduled by mid 2017
- ❑ **Filght Readiness Review** scheduled by mid 2018

Conclusions

- The key features of the HEXAFLY-INT mission and flight payload have been described.
- The project has the final aim to demonstrate the technical feasibility of concepts and technologies for the hypersonic flight and to increase the Technology Readiness Level (TRL) of the breakthrough technologies on board.
- Project Critical Design review (CDR) is foreseen by the end of 2016.

ACKNOWLEDGMENT

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