



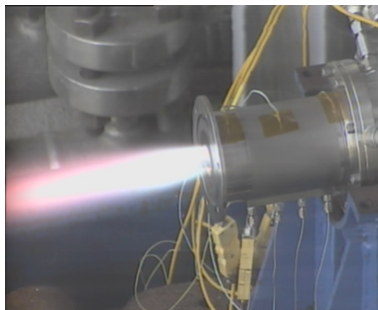
Italian Contribution to Innovative Space Propulsion & Re-entry missions

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CESMA, 2nd International Symposium on
Hypersonic Flight, 30 June 2016, Roma

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INNOVATIVE SPACE PROPULSION

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Innovative Space Propulsion: LOx-CH4

- ❑ Liquid rocket propulsion, in particular in liquid Oxygen-Methane, has become a field of strategic interest in Europe for next decades due to reduced complexities in propellant handling, more efficient ground operation and storage, cheaper turn-around cycle together with overall good propulsive performances (highest Isp among hydrocarbon propellants and excellent cooling capabilities)
- ❑ In this context, the preparation activities of the natural evolution of the Vega-C are focused on the reduction of the launch system recurring costs.
- ❑ Recurring Costs reduction for the LOX-Methane upper stage will be achieved through the implementation of new technologies and innovative manufacturing processes (e.g. 3D printing / additive layer manufacturing etc.).
- ❑ ASI has funded several projects in Liquid Oxygen and Methane propulsion both at national level and also in bilateral cooperation with other national space agencies (e.g. Roscomos and JAXA).

MIRA project and LOx-Methane propulsion

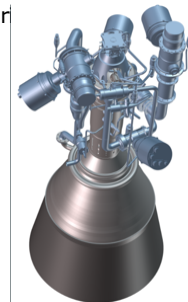
A 10 ton class MIRA Demo engine (derived from existing RD-146) was designed and manufactured by a joint italian-russian design team.

Italian industry is the design authority of critical components as:

- Injectors and Injection Plate
- Methane Turbo-Pump and bearings

Main Characteristics of the engine are:

- thrust level control
- re-ignition capability



MIRA project and LOx-Methane propulsion

Industrial Expertise in the main Engine sub-systems

- Injector head (starting from hydraulic characterization in small and full scale up to hot test at small scale and full scale Demo);
- new methane turbopump (ALM technology applied to complex parts, turbine tests in air, pump tests in water, bearings in LN2 and in LCH4).

Successful tests

- In 2012 a successful test campaign on Thrust Chamber Assembly
- In 2014, a full scale Demonstrator successfully tested validating the multi-re ignition capability



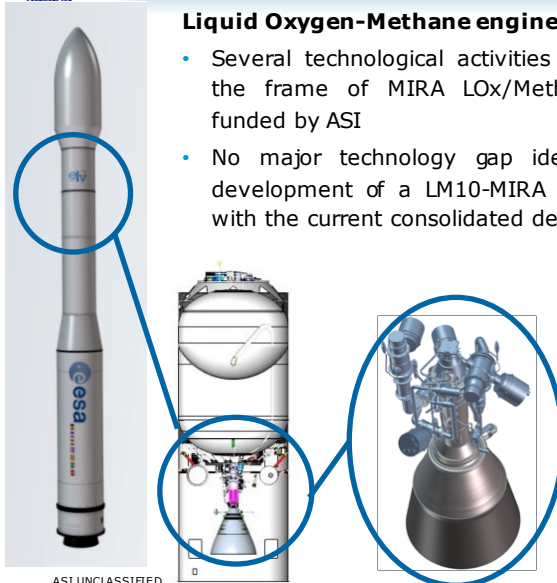
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Breakthrough in the liquid space propulsion

Liquid Oxygen-Methane engine

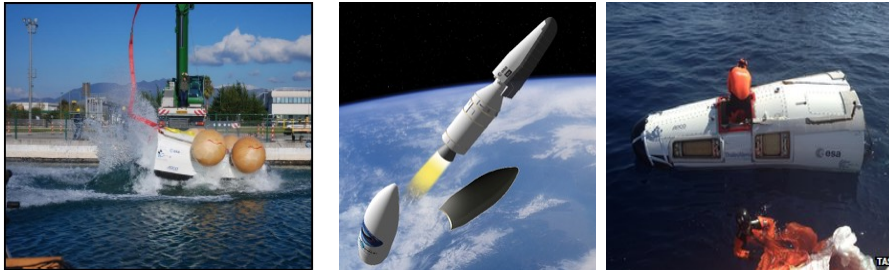
- Several technological activities carried out at national level in the frame of MIRA LOx/Methane demonstrator programme funded by ASI
- No major technology gap identified in Europe to start the development of a LM10-MIRA type LOX-Methane flight engine with the current consolidated design approach and technologies



- LM10-MIRA type LOX-Methane engine represents a **breakthrough** in EU and potentially worldwide.

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RE-ENTRY MISSIONS

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RE-ENTRY MISSIONS

- ❑ The European independent capability to return from space has been recently demonstrated through the successful mission of the Intermediate Experimental Vehicle (IXV).
- ❑ The follow on activities for a **European Reusable Integrated Space Transportation System** to be launched with the **VEGA-C**, are considered a key element in the preparation of the European autonomy for routine “access to” and “return from” space for several fundamental space applications, from IOV/IOD test to in-orbit microgravity experiments.



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IXV-Intermediate eXperimental Vehicle

The ESA IXV project, included in the Future Launcher Preparatory Programme (FLPP), is the first lifting body system flying a fully representative return mission from LEO world-wide.

The IXV mission was successfully accomplished on the 11th February 2015.

Italy has been the leading country with the contribution of about 36%.

The other participating states were Spain, Switzerland, France, Belgium, Portugal and Ireland.



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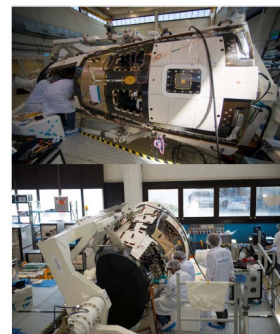
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IXV-Intermediate eXperimental Vehicle

The technologies in flight verification included:

1. to verify and characterize thermal protection technologies in representative operational environment;
2. to understand aerodynamics-aerothermodynamics phenomena, validate models and improve design tools (i.e. CFD and WTT);
3. to verify guidance, navigation and control techniques in representative operational environment (i.e. re-entry from LEO);
4. Flight dynamics to validate the vehicle model during actual flight, focused on stability and control derivatives (VMI experiment).

100% of the IXV mission, system and technologies objectives have been successfully achieved.



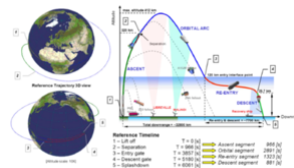
ESA Courtesy

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IXV-Intermediate eXperimental Vehicle

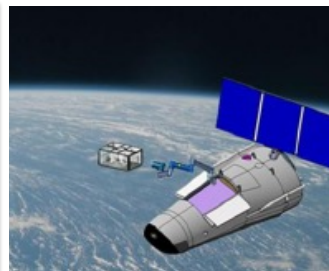
1. The flight hardware and all flight data successfully recovered, through flight segment telemetry transmission and ground segment acquisition, and on-board recording
2. The flight data cope with the overall flight of ~ 25.000 km including 8.000km in hot atmospheric re-entry environment.
1. Automatic guidance starting from an orbital velocity of ~ 7.5 km/sec (Mach=27) and concluding with a splash down in the Indian Ocean in the target area.



SPACE RIDER – Programme Objective

- Space Rider overall objective is to define and develop an affordable reusable European space transportation system to be launched by VEGA (i.e. VEGA-C version)
- able to perform experimentation and demonstration of multiple future application missions in low Earth orbit
- benefit at the maximum extent possible from existing launchers technologies, and addressing where relevant progressive technological challenges with limited risks and minimal financial efforts for Europe.

The combination of the most economic European launcher to access space, with a reusable system requiring limited refurbishment after each return mission from space, is the basis for an integrated space transportation system competitive with respect to any alternative solution.



SPACE RIDER design drivers

1. Launch in 2020 with VEGA C and injection in LEO orbit. Target orbit: ISS and above.
2. In orbit operational phase mission duration > 2 months
3. Payload Mass > 300 kg. Payload Volume > 0,6 m³
4. Precision ground landing allowing fast payload recovery time
5. System reusability with minimum refurbishment costs for a minimum of 4-6 missions.

Strong synergy with the VEGA-C system in terms of technologies development and commonalities (GNC, Avionics, telemetry, etc.) for cost reductions



SPACE RIDER Possible mission applications

1. On the basis of the consultations carried out with several end-users, the following two main fundamental classes of space applications are being retained:
 - ❑ **Free-flyer applications**
 - a. Micro-gravity experimentation;
 - b. Orbital infrastructures inspections/monitoring;
 - c. In-space technologies verification for: - Exploration (e.g. robotics)
 - d. Earth observation (e.g. instrumentation);
 - e. Others (e.g. Earth science, telecommunication).
 - ❑ **Rendezvous and capturing applications:**
 - a. In orbit cargo/experiments return in the short-term;
 - b. Planetary sample return in the long-term.

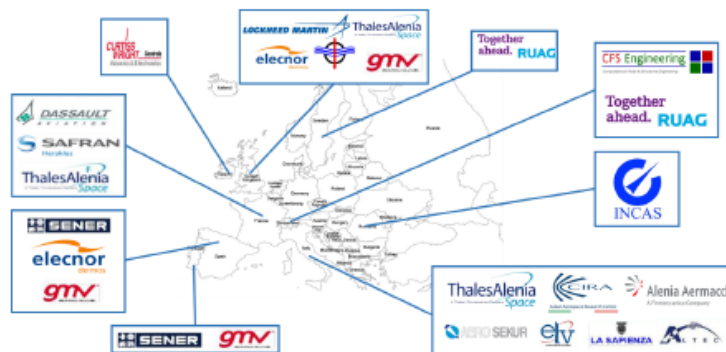
SPACE RIDER Planning

- In November 2015, ESA has designated CIRA as **Prime Contractor** for PRIDE Phase A/B1 in partnership with Thales Alenia Space -Italy

Step	Activities	Milestones	Dates
1	o Elaboration of industrial proposal for mission and system activities	Industrial Contract Negotiation	Q4 2015
	o Definition of mission and system;	Industrial Activities Kick-Off	Q1 2016
	o IXV post-flight activities propaedeutic/beneficial for PRIDE (TBD);	PRR, with preliminary data-package to support CM-16	Q2 2016
	o Maturation of critical and/or enabling technologies;		
o In case of harmonization and cooperation, definition of industrial work-share for development.	SRR	Q4 2016	
2	o Preliminary design	PDR	Q3 2017
	o Detailed critical design	CDR	Q2 2018
	o Qualification and acceptance	QAR	Q1 2020
	o Launch campaign	LRR	Q2 2020
	o Mission operations	MCR	Q4 2020

SPACE RIDER Programme participation

- Nine participating states: Italy, France, Great Britain, Spain, Switzerland, Romania, Portugal, Sweden, Ireland
- 25 Companies including Sub-Contractors+ Affiliates





Thank you