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INTERMEDIATE EXPERIMENTAL VEHICLE TEST FLIGHT

credit: ESA

INTERMEDIATE EXPERIMENTAL VEHICLE MISSION ACCOMPLISHED

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IXV (Intermediate eXperimental Vehicle) successfully completed its first test flight on February 11, 2015, ending with a splashdown in the Pacific Ocean after 100 minutes from launch.

The atmospheric re-entry domain is a cornerstone of a wide array of space applications, ranging from reusable launcher stages developments, robotic planetary exploration and human space flight, to innovative applications such as reusable research platforms for in orbit validation of multiple space applications technologies.

IXV is an advanced demonstrator which has performed in-flight experimentation of atmospheric re-entry, thus enabling systems and technologies aspects, with significant advancements on Europe's previous flight experiences, so consolidating Europe's autonomous position in the strategic field of atmospheric re-entry.

The IXV mission objectives included the design, development, manufacturing, assembling and onground/in-flight verification of an autonomous European lifting and aerodynamically controlled reentry system, integrating critical re-entry technologies at system level. Among such critical technologies of interest, special attention was paid to aerodynamic and aerothermodynamics experimentation, including advanced instrumentation for aerothermodynamics phenomena investigations, thermal protections and hot-structures, guidance, navigation and flight control through combined jets and aerodynamic surfaces (i.e. flaps), in particular focusing on the technologies integration at system level for flight.

Returning from space: the European way.

The number of studies on experimental reentry vehicle concepts and improvements of critical reentry technologies – undertaken in recent years both by ESA with the Atmospheric Reentry Demonstrator (ARD), and by important complementary national efforts in France (Pre-X), Germany (Phoenix) and Italy (USV), among others – underlines Europe's need for flight experience with reentry systems, which are a key to manned flights.

The Advanced Reentry Demonstrator (ARD) was a test-spacecraft designed by Daimler-Benz Aerospace (eventually merged into EADS) which resembled the Apollo capsule. It was designed to test and qualify new technologies and flight control capabilities for atmospheric reentry and landing

A first drop test from a stratospheric balloon balloon was performed at sea in 1996 and launched from the Trapani-Milo base (Sicily, Italy) by Alenia Spazio, a partner in the project, in charge of the subsystem of Descent and Recovery.

The suborbital reentry test was flown on the third Ariane 5 flight, launched on October 21, 1998. The capsule was released shortly after separation of the launcher, at an altitude of about 216 km, 12 minutes after lift-off from the Europe's spaceport in Kourou, French Guiana.

Phoenix-1 was a German-European project for a 1:7 scale model of the Hopper concept vehicle. On Saturday 8 May 2004, the winged vehicle prototype was dropped from 2.4 kilometers (8,000 ft) by a helicopter and landed precisely on a runway at the North European Aerospace Test range in Kiruna, 1,240 km (770 mi) north of Stockholm, Sweden.

IXV: the intermediate step

As its name suggests, IXV was designed as the "intermediate" preliminary step of a wider European Programme to develop future operational systems. Nominally it lies in between a demonstrator of ballistic re-entry (as were EXPERT – previously developed for ESA by Thales Alenia Space in its plants in Turin, Italy [TAS-I] – and the other programmes mentioned above) and a forthcoming new generation operational vehicle.

In fact in the past Europe, with the program "Hermes", has attempted to develop a full operational manned space transportation system. As a matter of fact this has been resulting in a too ambitious project that was dealing at the the same time with all the difficulties of such a development at the same time having to face the non availability of critical technologies. .

"*Objectives of this "flying experiments*" – explains Roberto Provera, TAS-I Director Transportation Systems & Space Exploration Programs -- range from demonstrating a re-entry system and validating the predictive models used in the design for, e.g., fluid dynamics, and aero-thermo-dynamics, to testing peculiar technologies needed for the atmospheric re-entry, like, e.g., materials for thermal protection or guidance/navigation/control algorithms. »

A wide set of space applications – ranging from crew transport to exploration and automatic cargo delivery – makes this project highly challenging and ambitious.

"*As far as possible* – tells Roberto Angelini, IXV Programme Manager for TAS-I – *existing technologies, already developed for space, have been largely used in this project, including the thermal shield (developed in France by Herakles – Safran Group) and the moveable body flaps made of an innovative ceramic matrix composite material (patented and manufactured by MT Aerospace AG, Augsburg , Germany). These devices were developed for the NASA X-38 – the emergency Crew Return Vehicle for the International Space Station's missions whose programme was cancelled in 2002 due to budget cuts. This hardware has been finally space qualified with the IXV flight*"

IXV was the first full lifting body shape ever – in more than sixty years of space exploration – to perform full atmospheric reentry from orbital speed. Lifting body shapes are in fact capable to generate a lift that allows more flexibility in the selection of the landing point and the IXV shape is capable of 700 km of cross-range "*IXV* – Angelini adds – *has no wings of any sort, and used two movable flaps for re-entry flight control. Re-entry was accomplished in a nose-high attitude like the Space Shuttle, with manoeuvring accomplished by rolling out-of-plane and*

then lifting in that direction, like an aircraft. Splashdown was controlled by parachutes ejected through the top of the vehicle: also for hypersonic and subsonic parachutes we used an existing technology: the multistage supersonic parachute was qualified for this purpose, in late 2012, at the Yuma Proving Ground in Arizona, USA, up to the opening of the main subsonic stage."

On 21 June 2013 an IXV drop test vehicle was performed at the Salto di Quirra Inter-force Test Range in Sardinia, Italy. The test was to reproduce the last descent phase of the vehicle validate the water landing system including the subsonic parachute, flotation balloons, and beacon deployment. Transported by a helicopter provided by the Army Light Aviation Unit, the test model was dropped from an altitude of 3,000 meters (1.9 mi) and, splashing down in the Mediterranean Sea, it verified the correct working of the chain of descent and recovery.

IXV after its return from the Drop Test

A small anomaly was encountered in inflating the balloons, but the other systems performed as expected. After the test the vehicle was taken for further analysis at the TAS-I premises in Turin, Italy.

Success for the IXV Mission

Originally planned to make its flight in late 2013, the launch of IXV was eventually scheduled on 18 November 2014, however this launch window was missed due to unresolved range safety concerns completely independent from the IXV project.

Finally the IXV was launched from the European spaceport of Kourou, French Guiana, on 11 February 2015, atop a Vega rocket (the new medium-size ESA rocket, built in Italy) as part of the VV04 mission.

IXV separated from its Vega launcher at an altitude of 340 km and, during the ascent phase, IXV reached the maximum altitude of 412 km. At this altitude, after about one hour of flight, IXV started its decent phase and reached the maximum speed of 27,000 km /h, typical of a re-entry from low orbit. At an altitude of 120 km IXV began re-entry into the atmosphere and started the communications' blackout, "*which* – explains Armando Ciampolini, Operations Director in ALTEC – *is common in every aircraft reentering into the atmosphere and is caused by the ionization of air around the spacecraft due to the heat generated by the compression of air surrounding the vehicle.*" During the re-entry phase, adds Roberto Provera "*due to the friction with air, the thermal shield of the nose of the*

vehicle reached a temperature of about *1600°C and the flaps raised 1700°C, though at the altitude of 120 km atmosphere is very rarefied.*"

After a trip of 35.000 km, of automatic flight IXV dipped into the Pacific Ocean at only 1.5 km away from the planned target, with a precise splashdown, successfully demonstrating its high capacity for precision landing. Once it touched the water surface, a number of floatation balloons were opened to ensure the buoyancy until the arrival of the recovery ship *Nos Aries*.

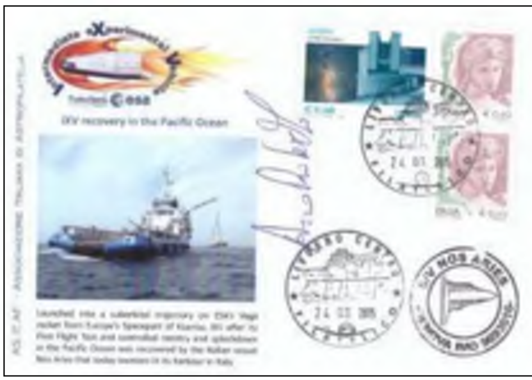
"*This precision landing* – Angelini adds – *was a remarkable validation of the flexibility of our Guidance Navigation and control system that has been able to cope with all the uncertainties and dispersions associated to the models used (a. It is worth to mention that at the time of the IXV designing, the Vega lauchers had not yet flown and no flight data were available and large dispersions have been considered to shape the IXV GNC.*"

It's important to note that before the re-entry in atmosphere, IXV was controlled by means of thrusters while after crossing the Kármán line – which is the conventional boundary between the Earth's atmosphere and outer space, conventionally lying at about 100 km above sea level – it was controlled by means of thrusters and rear-flaps, similar to those used by aircraft.

The mission was supported by the ALTEC Control Centre in Turin, Italy, that developed and managed the IXV's Ground Segment including – besides

IXV after its return from the Drop Test

the IXV MCC (Mission Control Centre) based in its headquarters in Turin – the IXV Ground Stations, encompassing the fixed ground stations in Libreville (Gabon) and Malindi (Kenya), and the station on the Nos Aries recovery ship in the Pacific.



"*The CNES Ground Station located in Libreville, Gabon* – refers Alessandro Bellomo, Head of Scientific & Ground Applications Program Line in ALTEC – *has been used to track the last stage of the IXV launcher, the so-called AVUM (Attitude Vernier Upper Module); a transportable telemetry kit was interfaced with the Libreville antenna to receive IXV spacecraft data. This was possible thanks to INMARSAT, the constellation of geostationary satellites covering the entire globe, with the sole exception of the Poles. The second fixed Ground Station was the ASI station located in Malindi, Kenya that allowed the tracking of the trajectory of IXV until it reached the maximum altitude of 412 km. The data from this station were sent to the MCC through ASInet, the integrated information computer network of the Italian Space Agency.*

The third and final ground station was installed on the recovery ship Nos Aries, owned by the Italian brothers Neri. Such a station was used to follow and acquire the IXV telemetry data during the last phase from about 60 km until the splash-down. This ground station was also equipped with all necessary facilities for the controlled and safe recovery of the spacecraft and for video recording the last phase of the mission and the splashdown. Also in this case the connection with the MCC was ensured through the INMARSAT network.»

After its successful experimental flight, the "little shuttle" aboard the Nos Aries recovery vessel crossed the Panama canal and after a technical stop in Kourou to recover all the equipment used to support the launch campaign went back to her home in Italy, where it arrived in Livorno on

March 23rd and was eventually transferred to Turin, at the premises of Thales Alenia Space, to allow for post-mission evaluations. 200 Gb of data have been registered altogether in memory cards by some 300 sensors, both traditional (temperature, pressure, displacement, strain gauges, deformation detectors) and advanced sensors like the infrared thermo-cameras focused on the flaps. Engineers who analyzed the data report that all of the capsule's systems had performed well and according to expectations; only a higher than predicted consumption of Hydrazine was measured. With the highly successful reentry and recovery of IXV, Europe has moved a step closer to its complete space missions. The parameters collected during the flight, provide the European Space Agency with a reliable data base that is paving the way for the development of new-generation reentry vehicles. An additional test flight is planned for 2019 or 2020. This time the space vehicle will touch down on a conventional runway by either installing a parafoil or landing gear. The IXV's successor will be the Programme for Reusable In-orbit Demonstrator in Europe, or PRIDE.

REFERENCES

Roberto Provera, "IXV, a European experimental re-entry vehicle", in AD*ASTRA n. 18 (September 2013) p. 12-13 Armando CIAMPOLINI and Alessandro BELLOMO, "IXV Mission - Successfully accomplished", in AD*ASTRA n. 24 (March 2015) p. 2-4

PLEASE EXCUSE OUR RUSH TO JUDGEMENT

In our previous issue of the "Astrophile" one of our senior staff writers made a comment in an article, that was read by some readers as being negative concerning collecting early Russian space covers. The comment in question was this one on page 80, that stated, "Covers from the early Russian period are generally suspect."

It was not the intention of our staff member to be derogatory in tone or to slight collecting early Russian space covers. Please accept our sincere apology for this offhanded comment. As is true in all situations in buying or trading all space covers, "Caveat Emptor" or "let the buyer beware" applies, and that was our writer's intention in this article concerning early Russian space covers.

Collectors concerned about suspect space covers are reminded that the Space Unit produced an excellent report in 2001 entitled "Study of Suspect Space Covers" that listed and described known suspect covers from the U.S., Russia, and other countries of the World. This reference is currently out of print. Information concerning how a member may obtain a copy of this booklet will be presented in a later issue of the "Astrophile" in its entirety.

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