Expert Return

The Expert Reentry Testbed

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Introduction

ESA has worked since the early 1990s to gain flight experience of atmospheric reentry in order to design crew vehicles, reusable transportation systems, planetary probes and sample return missions. In 1998, the Atmospheric Reentry Demonstrator (ARD) was successful as ESA's first end-to-end mission: launch, suborbital flight, reentry, splashdown and recovery. The results from its material samples and instrumentation meant that measurements could be compared with computer predictions. National capsules such as Express and Mirka have also flown, with various levels of success. All were characterised by relatively simple or well-tested shapes, and the thermal protection consisted mainly or exclusively of ablative materials. The European Experimental Reentry Testbed (Expert) is taking the work to the next level.

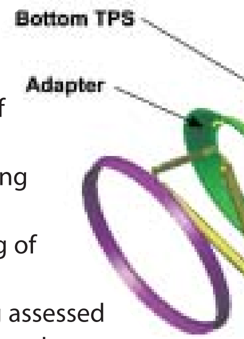
Expert, with a first launch in 2006, will help Europe to design future reentry vehicles ...

The Need for Expert

Previous work in Europe on Hermes, crew capsules and the X-38 lifting body highlighted the need for hypersonic and atmospheric entry flight data in order to benchmark the aerothermodynamic computer predictions and design tools. These consist of computational fluid dynamic analyses, wind tunnel experiments and ground-to-flight extrapolation. We still need to collect more data on a number of aerothermodynamic phenomena:

- flap efficiency and heating;
- shock wave/boundary layer interactions;
- boundary layer transition from laminar to turbulent;
- high-temperature and gas chemistry effects;
- gas-surface interaction effects (catalysis, oxidation).

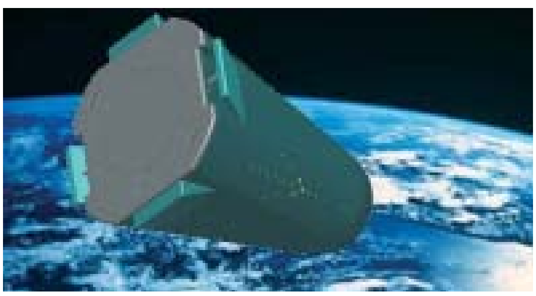
Expert is shaped to address these phenomena via dedicated measurements. A major consequence is the use of non-ablative thermal protection, so that the flow boundary layer is not contaminated by chemical species and solid particles. Of course, this makes these materials candidates for future reusable vehicles, although a single flight will not generate data on extended usability.



Also, special care has to taken with the positioning and number of sensors, the recording of the free stream parameters during entry using by the air data system, and in the storage and telemetry downloading of the data. Innovative and promising measurement techniques are being assessed carefully because they might improve the quality of the flight database.

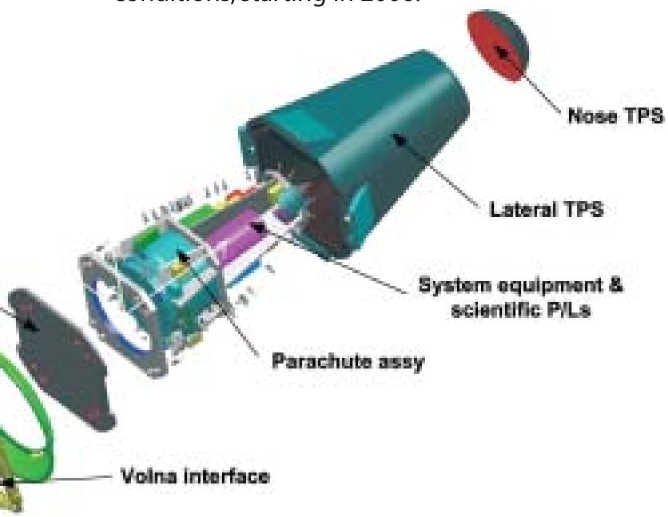
The Expert Project

A feasibility study under ESA's General Study Programme in 2001 analysed and traded-off various candidate shapes. An initial assessment of the mission, layout and subsystems provided confidence about its feasibility. The result was a



low-cost conical capsule with a blunt nose, lofted by the Russian submarine-based Volna launcher. Expert is designed for suborbital flights within a reentry speed range of 5-7 km/s. The recovery site is the Russian military base on the Kamchatka peninsula.

Expert's development was approved at the Ministerial Council in November 2001 as part of of the Interim Technology Phase for Reusable Transportation and Atmospheric Reentry. ESA then refined the vehicle shape and identified a set of experiments. By 2003, subscriptions by Member States allowed development of the first flight unit to begin. The Phase-B contract, with Alenia Spazio as prime and CIRA as the scientific payload coordinator, will take the Expert system up to the Preliminary Design Review, for Phase-C/D to begin in early 2005. At least three flights using dedicated flight units are planned for different reentry conditions, starting in 2006.



The Expert Design

Expert's shape is composed of simple geometrical elements: an ellipsoidal blunt nose, a conical body, a clothoid ellipse/cone junction, and four flat sides with four fixed flaps (two open and two closed). At launch, it is suspended nose-down on the third stage of Volna via an interface adapter. The parachute bay is in the central cylindrical area. The nose, external shield and the four ramps will carry the aerodynamic drag. The external shield consists of four curved corner panels and four triangular panels. Their junctions, and those with the internal structure, will move to cope with the thermal gradients.

The parachute bay cover will jettison to trigger the sequence of mortars for canopy deployment. Expert will impact the ground nose-first so it will probably not be reusable but the structure should allow recovery of the stored data and as much as possible of the avionic equipment.

There are three main areas of thermal protection: the carbon/silicon carbide nose cap; metallic surfaces (PM1000, Gamma-TiAl) on the conical sides and base; and ceramic flaps, which host several experiments.

The avionics architecture is as simple as possible, making major use of commercial off-the-shelf equipment. Modular software for system application and flight control will be developed. The mission application software includes spacecraft separation monitoring, polling of the onboard units and activating experiments, formatting and storing gathered data, managing transmitted telemetry, and controlling the parachute opening process. The flight control software includes attitude control loops (GPS, accelerometers), thruster valve activation and valve monitoring and redundancy management. A guidance system based on cold-gas thrusters will be used typically for nutation damping.

All the data will be stored in a dedicated mass-memory unit. Some will also be transmitted to ground during specific portions of the mission.

A set of experiments is being defined together with the measurement techniques. These include an air data system; pressure, force and heat flux measurement; catalytic gauges; electron beam fluorescence for measuring the concentrations of chemical species; Langmuir probes and reflectometers.

Conclusion

Expert will help to mature our understanding of reentry requirements for future manned missions as the focus shifts from commercial reusable launch vehicles to Space Station cargo transportation and future human exploration missions. ■