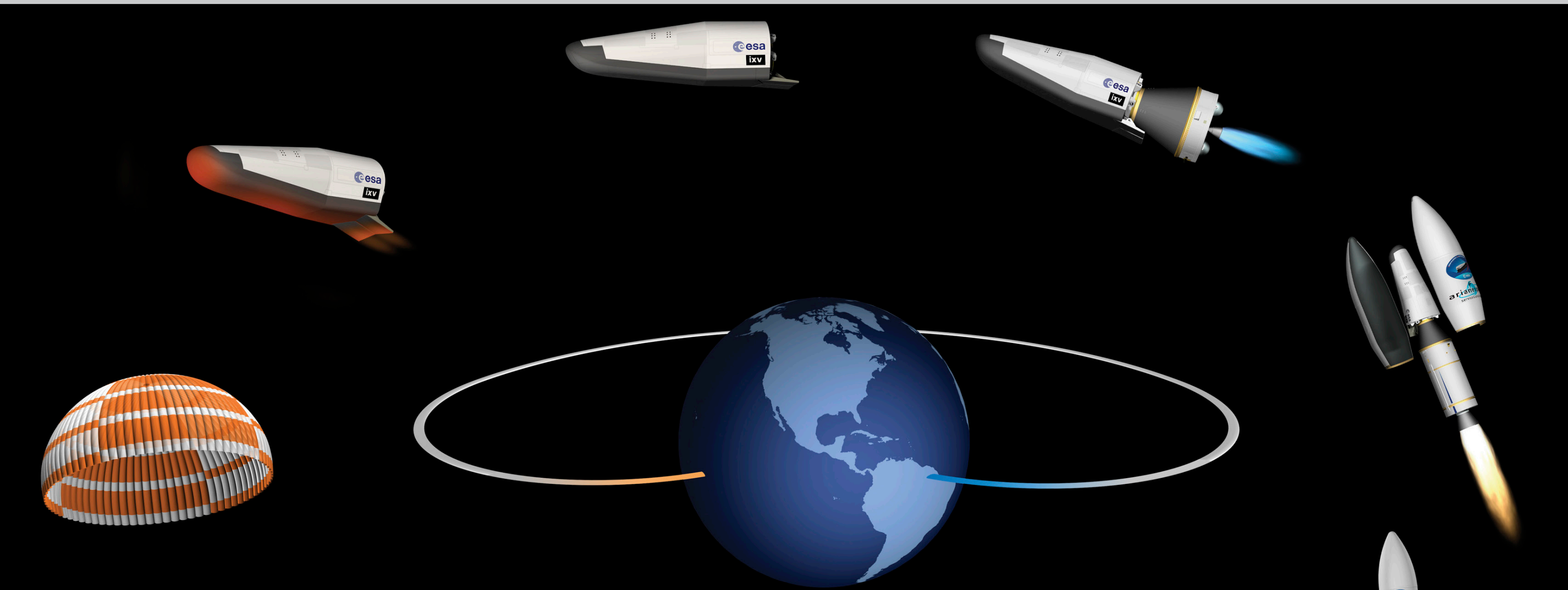
CASE STUDY

Rugged Networked Data Acquisition, Recording & Telemetry for Experimental Re-entry Vehicle

CURTISS-WRIGHT



Challenge

- Design a re-entry vehicle for 'shallow' re-entry and validate its design
- Monitor vehicle performance through test flight in environmentally challenging conditions
- Achieve all of this within the scope of program budget

Solution

- Use a COTS data acquisition system for on-board data gathering and telemetry
- Use a network-based system to easily provision for ground-transmission
- De-risk use of system through ground-based testing

Results

- Successful launch and retrieval of the IXV
- Acquisition of telemetry data throughout the course of the full mission.
- All requisite data recorded for subsequent analysis.

Challenge

The European Space Agency (ESA) has been working since 2005 on a space mission with important implications for the future of space transportation in Europe. The Intermediate eXperimental Vehicle (IXV) is an experimental re-entry vehicle and is an intermediate step on the path to developing autonomous space transportation systems with a reentry capability.

The length of IXV is 5m (16.4ft) with a loaded weight of 1,900 kg (4,188 lb) including the propulsion module. During flight, it would attain a maximum altitude of 450km (280mi). IXV would be deemed a success if flight data can be successfully recovered by ground stations via telemetry and/or by recorders installed onboard the vehicle.

This objective was the driving factor behind the requirement for a data handling and telemetry subsystem and as such, this system was integral to the IXV mission profile. The functional requirements for the IXV on-board data acquisition system were the following:

- Data acquisition of 300+ parameters including temperature, pressure, strain, displacement and serial data streams
- Real-time telemetry with data encapsulated into CCSDS telemetry transfer frames
- On-board recording of real-time telemetry link
- Interface to the On-Board Computer (OBC) via a MIL-STD-1553 bus interface
- Buffering of real-time data during re-entry blackout

There was also the challenge of the space environmental requirements that any system on-board IXV would need to survive

- Extensive mechanical stress during launch
- Extreme temperature changes during flight
- Stringent requirements for EMC and EMI
- The impact of radiation on spacecraft electronics

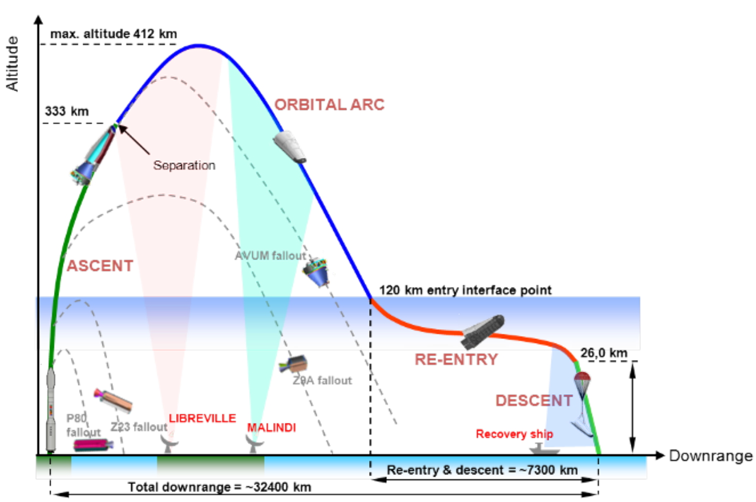
The total estimated cost for the IXV project was €150 million (not including the launch costs) – this all culminated to 100 minutes of flight on the 11th of February 2015. If the data handling and telemetry subsystem didn't function correctly, this investment would have been lost.

In parallel with the IXV program, there has been a growing trend within the space industry towards the wider use of Commercial-Off-The-Shelf (COTS) equipment. This trend has been mainly driven by the restrictions in R&D budgets and a growing demand for shorter product design cycles. The designers of the IXV on-board equipment, in partnership with their supply chain, were encouraged to identify and overcome the obstacles that previously prevented them using COTS equipment.

Solution

Curtiss-Wright was selected to provide on-board data acquisition systems that not only addressed the aforementioned requirements, but also met other common requirements for space equipment such as radiation tolerance, high reliability and a small form factor. Curtiss-Wright provided equipment for the Experimental Layer & Radio frequency, Telemetry, Tracking and Command (RTC) sub-systems and the vital-layer sub-system.

The systems were designed using COTS equipment originally developed for FTI applications. Curtiss-Wright only became involved on the IXV program after the vehicle CDR stage – relatively speaking, there was little time available to provision for a new system designed from scratch. The fact that a COTS-based system could be used was essential in keeping within the program budget and timescales.



The IXV's flight path

The network-based design featured four types of network devices - Data Acquisition Units (DAUs), a network switch, a network gateway and two recorders. Curtiss Wright could meet with all the functional requirements of the Experimental Data Subsystem with the development of a single plug-in module for COTS Acra KAM-500 system. The key system elements were

- Multiple synchronized DAUs to meet with the high parameter count
- An 8-port network switch with spare ports to cater for the requirement to add more measurement parameters if required
- A plug-in MIL-STD-1553 remote terminal module to communicate with the OBC
- The development of a CCSDS output card for data telemetry to the ground which also featured a black-out buffer

The Vital Layer Sub-system involved a stand-alone DAU collecting sensor data and feeding it to the OBC over an on-board MIL-STD-1553 bus – no new modules needed to be developed for this sub-system. Furthermore, the data from this sub-system was used by the OBC to make flight decisions. ESA were initially reluctant to use any Ethernet-based system – they didn't consider it mature for space-based applications. However, by demonstrating to ESA the ease with which Ethernet-native data could be encapsulated for transmission in a CCSDS format, ESA became convinced that a networked KAM-500 system was a viable option.

In order to mitigate against the effects of radiation on a COTS system, Curtiss-Wright undertook a radiation test program. A COTS element of a data acquisition unit (a KAD/BCU/140 DAU Ethernet controller module) was exposed to high energy protons of varying proton flux. A latch-up was eventually detected – however, this was at a level 10,000+ times the SEE limit specified for IXV. This gave ESA the confidence that the system could be used without the need for any redesign.

Results

The IXV was launched on the 11th of February 2015 by a Vega rocket from Kourou in French Guiana and was later recovered by the Nos Aries ship, for analysis of the spacecraft and recorded mission data.

The data handling and telemetry system functioned as expected during flight with telemetry data received during the 'visibility window' all the way up to 10 seconds from splashdown. At the time of writing, the recorded data will be analyzed in more detail when the vehicle is returned to Europe.

Subsequent to this flawless test flight, ESA officials have decided to plan an additional test flight for 2019 or 2020. This time the IXV will land on the ground instead of a splashdown in water by either installing a parafoil or landing gear.

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