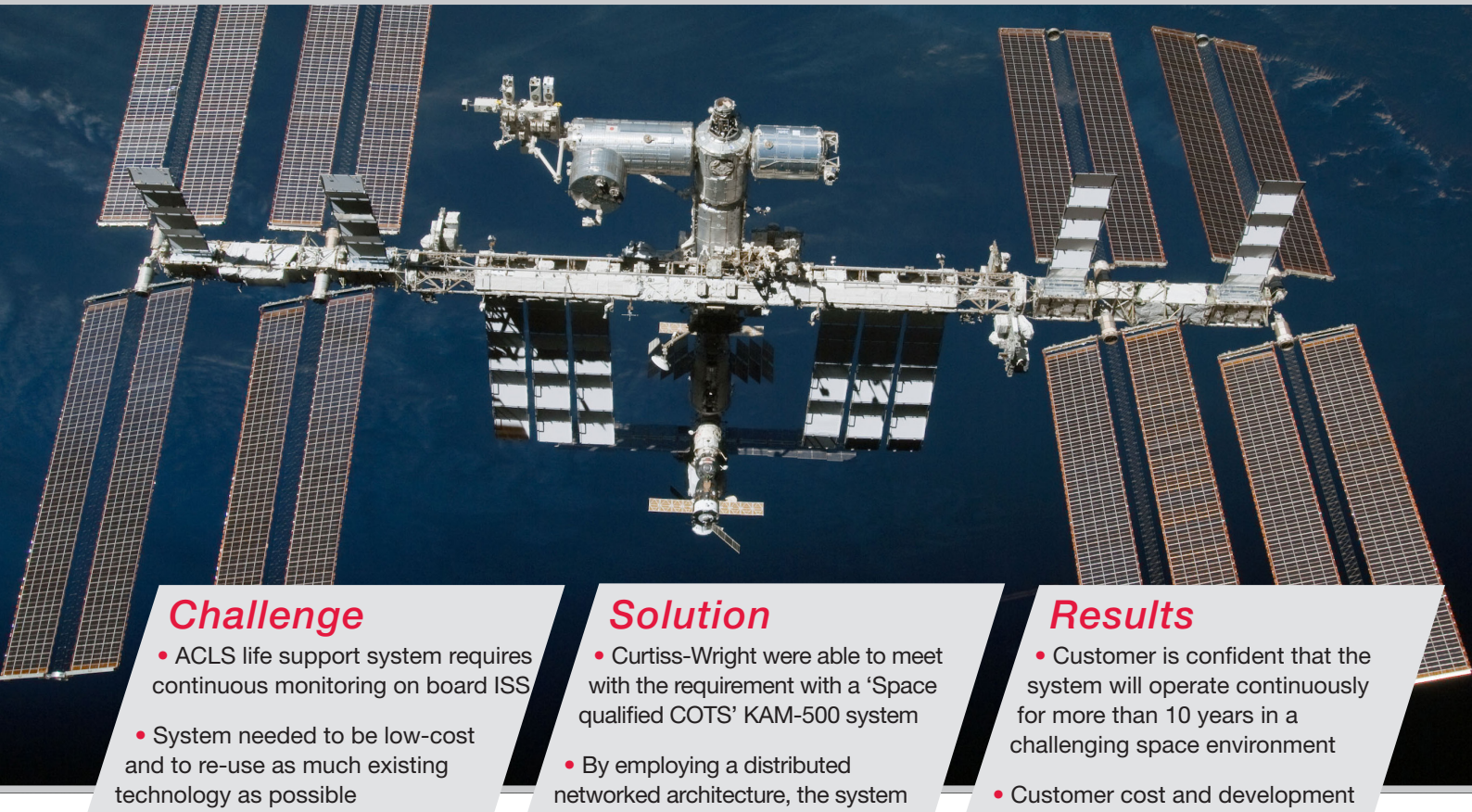
CASE STUDY

Rugged ‘Space COTS’ DAU for use on the International Space Station

CURTISS-WRIGHT



Challenge

- ACLS life support system requires continuous monitoring on board ISS
- System needed to be low-cost and to re-use as much existing technology as possible
- System also needed high reliability – continuous operation on board ISS for 10 years

Solution

- Curtiss-Wright were able to meet with the requirement with a ‘Space qualified COTS’ KAM-500 system
- By employing a distributed networked architecture, the system was optimized for size and weight
- HALT testing proved the reliability of the system to the customer

Results

- Customer is confident that the system will operate continuously for more than 10 years in a challenging space environment
- Customer cost and development time are minimized through the use of a ‘Space qualified COTS’ system
- Program delivered ahead of schedule and on budget

Challenge

The Advanced Closed-Loop System (ACLS) is a regenerative life support system that is planned for installation in the Columbus module of the International Space Station (ISS). It converts waste carbon dioxide (from astronauts breathing) and hydrogen (from the electrolysis of water) into breathable oxygen using the Sabatier process and generates excess water for the crew on board ISS (450kg of water per annum).

The ACLS will be an important element in the life support system on-board ISS and will also have the added benefit of reducing the costs involved in transporting water to the ISS (It costs anything up to $25K to launch one kilogram of mass in to low earth orbit – this is a potential $11M+ saving per annum in transportation costs). ACLS is planned for launch in 2016 on a Japan Aerospace Exploration Agency (JAXA) HTV-II launch vehicle. The ACLS is to be accommodated in a double International Standard Payload Rack (ISPR) and is to contain all main and support functions like power, data handling and process management.

The ACLS consists of the Oxygen Generation Assembly (OGA) and a Carbon Dioxide Concentration Assembly (CCA) – both of these sub-systems required a continuous data monitoring capability, specifically for temperature and pressure sensors installed on the assemblies. ACLS uses similar technology to the life support systems required on-board submarines.

The ACLS monitoring system required a number of distributed Data Acquisition Units (DAU) for both the OGA and CCA. The solution needed to be low-cost and as much as possible, based on existing equipment. Size and weight was also a factor given the limited accommodation for the data acquisition units within ACLS and the need to minimize the weight of the ACLS for transporting to the ISS.

It was a requirement that the system be able to operate for 10 years in the low earth orbit environment on the international space station and by extension, be able to function correctly in the presence of high-energy radiation in a low-earth orbit.

A drawing of the ACLS unit[1]

Curtiss-Wright had been in discussions with the ACLS manufacturer on the scope of this data acquisition requirement since 2010 and it became apparent that there was an off-the-shelf system available that had traditionally been used for flight testing. In response to this data monitoring system requirement, Curtiss-Wright was able to provide a space qualified COTS Acra KAM-500 modular networked data acquisition assembly as part of the ACLS Avionics Subsystems Architecture that could monitor both the OGA and CCA concurrently, and provide this information to the ACLS's onboard computer.

Solution

A distributed system was proposed containing two networked COTS KAM-500 data acquisition units, each acquiring a set of physical sensor measurements from the OGA and CCA subsystems respectively, and outputting this data over Ethernet to the onboard computer. Given the compact nature of the KAM-500, each of the units could be located close to their respective ACLS sub-system. The units were networked together via a 4-port miniature Ethernet switch module integrated in one of the acquisition units. The benefit of such a design was that the units could be synchronized to the same time source over Ethernet (Using an IEEE1588 Precision Time Protocol), there was no need for a dedicated switch unit and that there was only a single Ethernet feed to the onboard ACLS Avionics from the networked system.

This design using distributed DAUs had the additional benefit of reducing the wire-harness mass associated with connecting the monitoring sensors from the OGA and CCA directly to the ACLS Avionics computer. It also served to reduce the power and complexity of the data handling solution for ACLS. The system included the development of a new temperature measurement module for PT1000 temperature sensors, leveraging off an existing COTS KAM-500 PT100 measurement capability, thus enabling a short development cycle for the PT1000 measurement module.

Given the requirement for continuous operation of 10 years on the ISS, Curtiss-Wright undertook a quantitative accelerated life test (ALT) on an identical KAM-500 unit with the objective of demonstrating to the customer that the system would exceed the 10 year operating limit in the ACLS. This involved elevated temperature testing, thermal cycling, power temperature cycling, mechanical shock and temperature humidity testing. The results of this testing demonstrated to the customer that the KAM-500 would be able to withstand a predicted lifetime of 30 years continuous operation in the operational environment within the ACLS on-board ISS.

Furthermore, Curtiss-Wright conducted SEE (Single Event Effect) radiation testing of the KAM-500, where it was subjected to a proton beam with an energy of 200MeV and fluence of 10 billion to simulate 10 years in LEO – the DAU, backplane and power supply were immune to any radiation corruption. No modifications to our COTS product were required to meet with either the operational span or radiation requirements demanded by the ACLS requirement.

Curtiss-Wright's space-qualified COTS (Space COTS) product builds on two decades of flight test COTS equipment experience. Space COTS is designed with the demands of the space-customer in mind:

- The system is typically delivered to detailed program requirements
- It sometimes involves a level of Product Adaptation
- Product is manufactured from batch controlled commercial parts
- It provides for qualification, functional and environmental acceptance testing
- It meets with Space Product Assurance standards

Results

Curtiss-Wright delivered a turnkey customer solution involving Space COTS KAM-500 DAUs, product qualification and program management ahead of program schedule and on budget.

The ACLS data monitoring subsystems are one of the first applications of COTS data acquisition equipment in a mission-critical space system. This successful use of Space COTS is part of a growing trend within the space industry to

- Re-use existing technology on launch vehicles, re-entry vehicles and micro-gravity platforms
- Reduce development time and equipment cost for a particular mission
- As a result of ACLS, Curtiss-Wright has demonstrated the reliability of our Space COTS for long duration, mission-critical applications

1 http://wsn.spaceflight.esa.int/docs/Factsheets/30%20ECLSS%20LR.pdf

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