

# Exercising Control

## 49 months of DMS-R Operations

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### Introduction

The 'Data Management System for the Russian Segment of the ISS' – more succinctly known as 'DMS-R' – was launched in 2000 as a core part of Russia's Zvezda module, the first habitation element of the International Space Station. Provided by ESA, DMS-R manages the Russian portion of the ISS, and handles Guidance, Navigation & Control for the entire Station. In parallel, ESA benefits by using this computer family for its own Columbus and Automated Transfer Vehicles (ATVs).

*The ISS control system provided by ESA has now been operating successfully in orbit for 4 years ...*

Zvezda carries two Fault Tolerant Computers (FTCs) for critical system and mission control tasks, plus two Control Post (CP) Computers for crew interfaces and experiment control. The computer infrastructure connects to the Station's Russian and US segment via an extended system of MIL-1553B data busses.

Each FTC consists of three interconnected identical processing units working in parallel redundancy and providing advanced fault-masking by majority voting. Tasks include interaction with the ATV, both during the approach and docked phases.

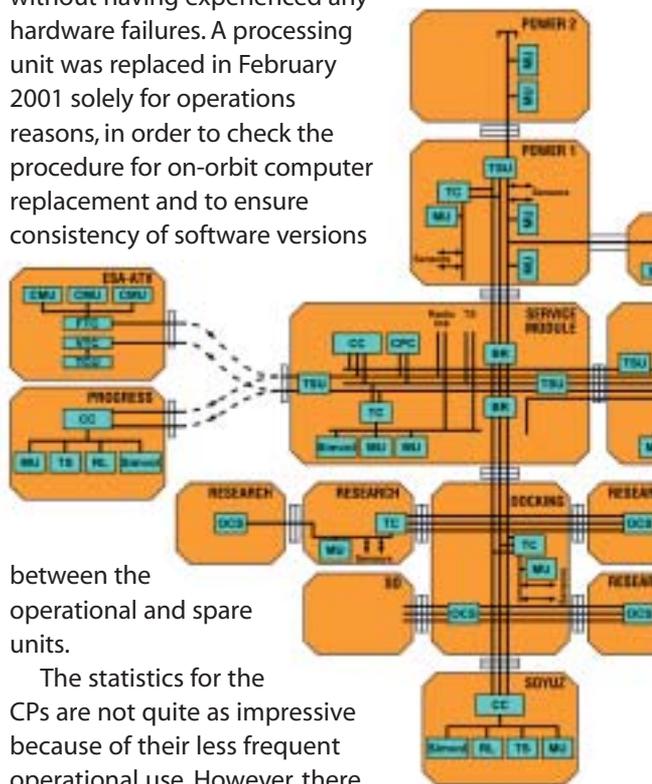
The CP Computers are based on the same basic processing unit but without the advanced fault-tolerance. However, they have a mass memory unit, LAN interfaces and dedicated connections to two standard ISS laptops used for crew interfacing, including control of the European Robotic Arm.

While all the hardware, system software and ground system were developed by ESA and its contractors, the application software was provided by Zvezda prime contractor RSC-Energia.

### Hardware Performance

After the launch of Zvezda on 12 July 2000 carrying two FTCs, a seventh processing unit was delivered by Progress-1P as an onboard spare in August 2000. That ferry also brought the first CP, for installation by the Expedition-1 crew in November 2000. The second CP followed aboard Shuttle 5A and was installed in February 2001.

By early March 2004, the FTC processing units had accumulated more than 36 000 h of operating time (more than 40 000 h with ground testing before launch). The system of these six units is therefore exceeding its calculated theoretical mean-time-between-failure of 45 000 h by almost a factor of six without having experienced any hardware failures. A processing unit was replaced in February 2001 solely for operations reasons, in order to check the procedure for on-orbit computer replacement and to ensure consistency of software versions



between the operational and spare units.

The statistics for the CPs are not quite as impressive because of their less frequent operational use. However, there

Yuri Gidzenko working with the Control Post laptops.

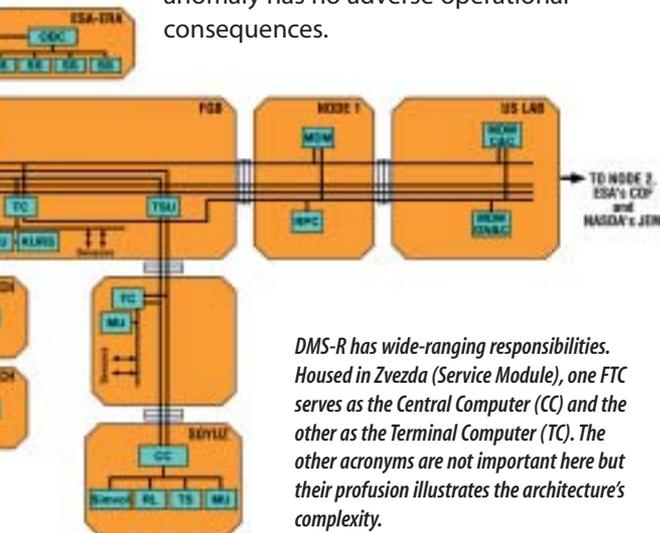
have been no hardware failures so far, although some problems seen recently with the mass memory unit have yet to be evaluated.

Based on this excellent performance, RSC-Energia has decided for the moment not to order additional spares beyond the initial set agreed shortly after the development programme.

### Operational Experience

While the CP Computer has seen one 'warm' restart owing to perturbations on its power supply line, no other problems have been reported. With the FTC, a phenomenon was observed soon after launch that has still not been fully explained and resolved. Although an anomaly, it has never degraded operations thanks to the computer's inherent fault-tolerant design, which masks such faults. The issue is the occasional reset and automatic restart of an FTC processing unit. Evolution to the fourth application software version – required mainly to handle the growing Station, but also offering improved telemetry for software analysis – has reduced the frequency of these events. However, the ultimate origin of this anomaly has not yet been identified and the restarts still happen about every 3 months.

Part of the problem is the difficulty in tracing such a rare event because the diagnostic information in the reset processing unit is lost after the warm restart erases its entire volatile memory. Current software modifications therefore focus on improving the diagnostic possibilities but they are being pursued with modest priority because the anomaly has no adverse operational consequences.



*DMS-R has wide-ranging responsibilities. Housed in Zvezda (Service Module), one FTC serves as the Central Computer (CC) and the other as the Terminal Computer (TC). The other acronyms are not important here but their profusion illustrates the architecture's complexity.*

A more spectacular event alerted the world's press on 4 February 2002 when the Station lost its nominal attitude control for several hours and transitioned into a survival mode. Although the DMS-R is basically responsible for Station GNC, the Russian Segment depends in some situations on extensive data and information from the US Segment. These include desaturation of the US Control Moment Gyros, when Zvezda's thrusters have to take over ISS attitude control. The communication between DMS-R and its NASA counterpart collapsed owing to a number of coincidences and could not be reestablished by a warm restart because of the lack of valid context data. After several unsuccessful attempts, the data exchange was finally reinitiated via a cold start (power off/on) of DMS-R. This brought the Station back into a normal operational mode.

Following an investigation of this event, the Russian application software was modified to provide a more robust context management.



*The two FTCs installed in Zvezda are literally black boxes.*

### Applications Beyond the Russian Segment

From the beginning, DMS-R's development not only targeted the Station's Russian Segment but also ESA's own space elements. Derivatives of the FTC and CP Computers are now being used successfully as Data Management Systems for ATV and Columbus, respectively.

### Summary

RSC Energia and ESA are highly satisfied by the excellent performance of the DMS-R system. Its 49 months of onboard operations feature no hardware failures and minimum effort for solving software and operational problems. DMS-R is clearly a very successful programme both for the Agency and for Industry.

Further information on DMS-R can be found at: [esapub.esrin.esa.it/onstation/onstation5.htm](http://esapub.esrin.esa.it/onstation/onstation5.htm)