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Development of Onboard Computer Complex
for Russian Segment of ISS

Abstract

Report present a description of the Onboard Computer Complex (CC) that was developed during the period of 1994-1998 for the Russian Segment of ISS.

The system was developed in co-operation with NASA and ESA. ESA developed a new computation system under the RSC Energia Technical Assignment, called DMS-R. The CC also includes elements developed by Russian experts and organizations.

A general architecture of the computer system and the characteristics of primary elements of this system are described. The system was integrated at RSC Energia with the participation of American and European specialists. The report contains information on software simulators, verification and de-bugging facilities witch were been developed for both stand-alone and integrated tests and verification. This CC serves as the basis for the Russian Segment Onboard Control Complex on ISS.

Development of Onboard Computer Complex
for Russian Segment of ISS

Development history

Presently, the Onboard Computer Complex providers the resources for solving, attitude control and motion control tasks, plus other tasks. Necessary for control of a large complement of on board systems such as those contained in the International Space Stations. The ISS current design was actually derived from two orbital stations: The US «Freedom» station design and the Russian Mir station. Although about 28 countries are participating in the project, the design is based on actual achievements of the Russian and the American cosmonautics that opened the possibility programs such as OS Skylab and Space Shuttle, the OS Mir and transportation system Soyuz TM – Progress–M.

Russia joined the ISS project already experienced in designing fully digital control systems. The Mir station motion and attitude control system was designed as a basis multi-computer digital system composed of a Host Computer and a number of Terminal Computers inter connected through exchange interface links using a radial (star) network structure.

The American Segment of ISS is based on a multi-computer control system of a tiered network structure. The American DMS or Data Handling System (DHS) is based on a modular type computer system derived from unified modules MDMs (multiplexer-demultiplexer) developed by the Honeywell Company. The network exchange links use the well-known, reliable and mature MIL 1553B (GOST 26765.52-87) bus protocol. The designers of the Russian on Board Control System for the ISS had to solve the difficult task of designing the DMS architecture to be compatible with the American segment architecture. A major consideration in the development of the Russian Segment on Board Computer Complex was the requirement for the RSCC to interact with the AS DHS, Using standard protocols (SPT) for data transmission. This information exchange included important monitoring and control function in accordance with the Russian Segment specification (SSPH1163+). The requirements for interaction between the data management systems of the RS and as were farther defined in the agreed to interface control document (ICD 4121, 50097)

Requirements necessary for the joint development of a large complex, multination project, such as ISS, along with an ambitions development schedule, presented a significant challenge to both management and designers. This success of this effort was achieved due to unpresidented of all partners, RSA, ESA, and NASA.

NASA, with Russian party consent, furnished its BASE computer an MDM-4 to serve as a terminal computer on the first (by the launch terms) module of ISS – the so FGB (Module called «Zarya»).

Since 1993, the European Space Agency together with RSC Energia has been investigating the possibility of developing a new, fault tolerant computer system named DMS-R for the Russian core module (first Mir-2, then the Service Module of ISS). Since 1993, RSC Energia has also been developing a computer control system for the new generation satellite «Yamal» in co-operation with specialists from the Research Institute «Argon», the Research &Technical Center «Module» and TOO «Rubikon». The American

MDM, the DMS-R system developed by ESA and terminal Matching Units developed by Russia was the basis for the ISS RS Onboard Computer Complex.

CC architecture

The DMS general architecture is shown in Fig. 1. The ISS RS CC core is located in the Service Module. The ISS RS CC has its own Host Computer that supervises/controls all Terminal Computers and, consequently, the ISS RS modules. The Host Computer interfaces with the crew via a Central Post Computer and a Laptop Computer accommodated in any modules of ISS, as well as via the Symbol C display system, and other crew panels.

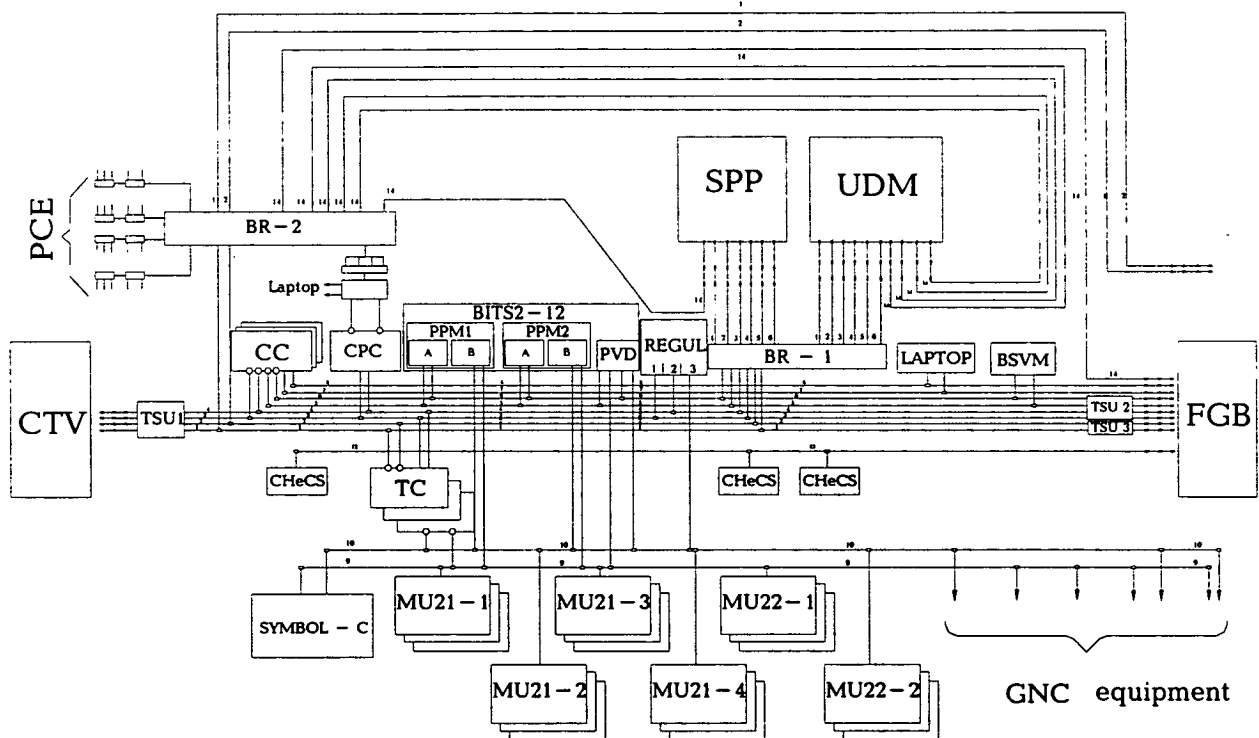## DATA MANAGMENT COMPLEX SERVICE MODULE

Fig. 1. Service Module Onboard Data management System

The Host Computer with the Ground Control Complex via the «Regul» Command Radio Link and Telemetry System ODTS. The Russian Host Computer Interfaces with the American Host Computer (C&C MDM) installed in the Lab module («Destiny») via MIL1553 buses 7, 8.

All tasks associated with the control of onboard systems on SM, as well as the navigation and motion control tasks are executed by the SM Terminal Computer. The Terminal Computer has direct data channels (buses 1, 2) to communicate with the navigation and control computer (GN&C MDM) on the American Segment, to ensures a coordinated interaction between the two navigation systems, RS GN&C and US GN&C during execution or station attitude and motion control.

The CC and DMS-R (Host Computer and Terminal Computer) extends to other modules of ISS and to the American Segment through connectors of the docking units. The System employs several devices such as interface amplifiers, bus repeaters and matching register units, and uses standard distribution of commands and signals, as well as power buses.

MDM serving as a Terminal Computer in FGB has interfaces with the FGB onboard computer system via the Matching Unit 31, as well as the command radio link «Komparus» and onboard automatics (Fig. 2). MDM interfaces with the SM Host Computer via buses 3, 4. Buses 5,6 are used for TM-Information exchange inside CC. The FGB Terminal Computer is operates in a one-channel computer mode with «cold» redundancy. The «cold» redundancy is necessary for the critical tasks executed by the FGB onboard computer system such as the fuel transfer and the «Kurs П» equipment control procedures implemented at docking.

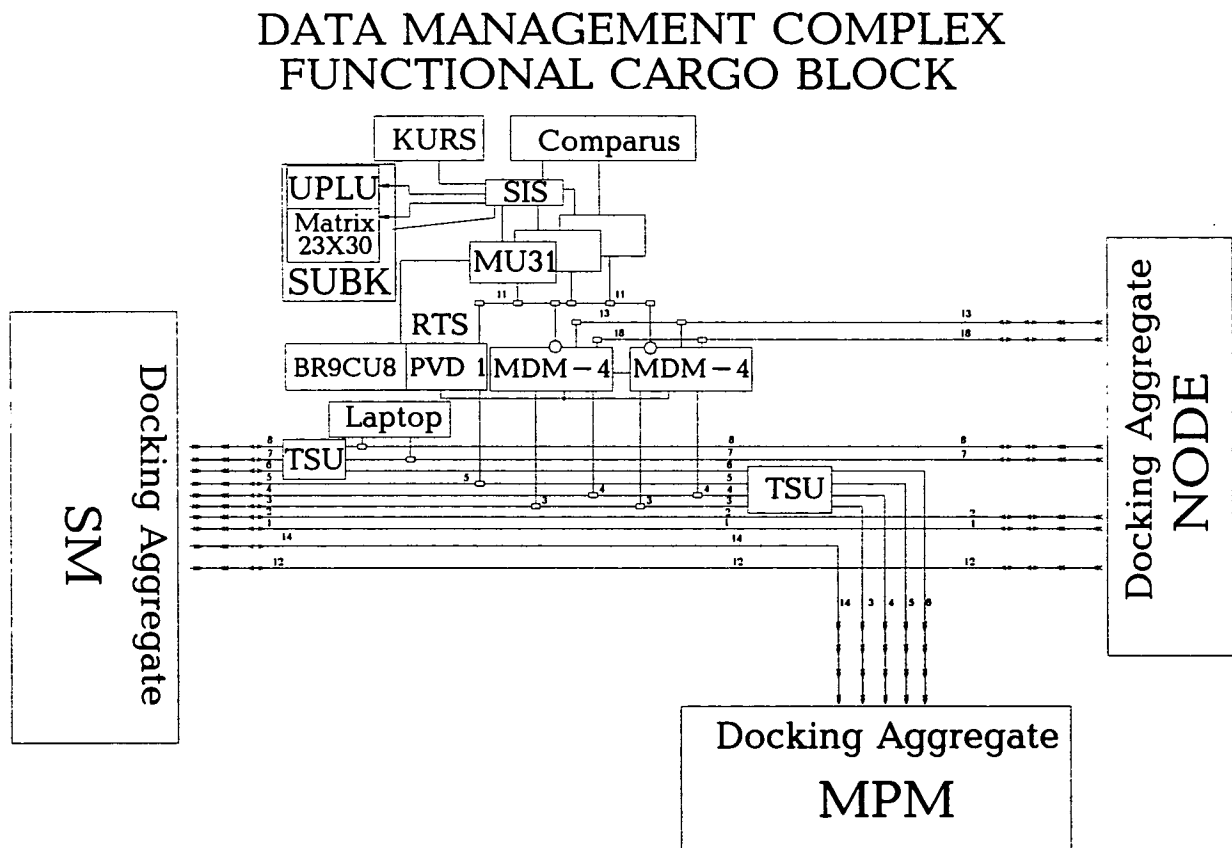## DATA MANAGEMENT COMPLEX
FUNCTIONAL CARGO BLOCK

Fig. 2. FGB onboard Data Management System

The SM CC Matching Units (MU21, MU22) and the FGB CC Matching Unit (MU31) receive and process data from onboard systems and devices and generates required control inputs. All Matching Units are of a three-channel redundant design and operate in a synchronous mode of parallel processing. The primary control functions are generated by the Terminal Computer. However critical tasks, such as corrections for off-nominal situations expected during operations such as fuel transfer and operation of attitude control engines, are executed individually by Matching Units to meet the Required Reliability Level.

Characteristics of CC primary components
Primary computers of Service Module (DMS-R)

The primary component of DMS is DMS-R developed by ESA and made under the RSC Energia Technical Assignment this took place 1994-1997. The DMS-R is composed of two three-channel Computers (Host Computers and a Terminal Computer), two Central Post Computers and Personal Laptop Computers which are common for the entire station. The Laptop computers, common items, are provided and maintained by NASA.
All tasks associated with the Service Module are executed by a fault tolerant process using three-channel synchronous circuit for each HC, TC and Matching Units.

The Host and Terminal Computers are implemented a Fault Tolerant Computer (FTC) designed using three identical channels FCR (Fault Containment Region) connected via a data bus. The FCR structure is shown in Fig. 3. The FCR has a three-level architecture: AVI – for external data exchange and use of interface 1553B buses; FML – for data voting between channels and error correction; AL – a computer solving functional (applied) tasks. The distribution of tasks between levels is schematically shown in Figure 3. The AL level is implemented by a newly developed processor a SPARC of ERC-32 architecture (Matra Marcony Space Company). Levels AVI and FML are implemented via transputer T800. Characteristics of one FCR channel are presented below: