MI2U CONTROL FLIGHT SOFTWARE DESIGN AND DEVELOPMENT IN COMS

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ABSTRACT

In this paper, we describe the MI2U ORB function which is a part of the flight software executed on SCU and controls MI2U/MI which is one of three payloads on COMS. The MI2U ORB function manages MI2U/MI redundancy and reconfiguration, monitors MI2U/MI equipment, performs FDIR, and provides the routing service of commands from Ground/IP (Interpreted Program) through the current used 1553 channel. The MI2U hardware achieves the interface between the SCU and the MI. The MI2U is connected to SCU through MIL-STD-1553B system bus. The MI2U has the internal redundancy but is used in cold redundancy. The MI2U ORB function considers that they are not expected to be simultaneously switched on. The connection combination between MI2U and MI is electrically cross-strapped. However the MI2U ORB function considers only two combinations (MI2U A + MI 1, MI2U B + MI 2). Other combinations can be manually achieved by ground in case of the emergency case.

KEY WORDS: COMS, Flight Software, MI2U, ORB

1. INTRODUCTION

The COMS (Communication Ocean Meteorological Satellite) for the hybrid mission of meteorological observation, ocean monitoring, and telecommunication service is scheduled to be launched in 2008 according to the Korea national space program. The COMS contract to develop the COMS satellite and to provide support for system activities has been awarded by KARI to ASTRIUM France.

The COMS spacecraft bus is based on a generic E3000 Platform catalogue product, so the COMS On-Board Software (OBS) also derives from the E3000 product line. Originally the development of the software has been done according to a strict and rigorous software development methodology (similar to MIL-STD-2167A), as shown on the Figure 1.

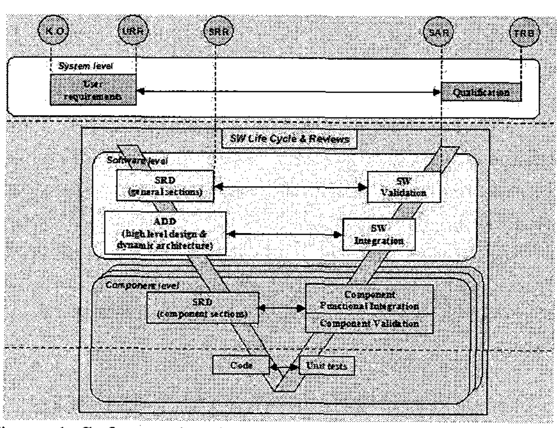

Figure 1. Software development and qualification sequence

It defines the overall approach to perform the engineering, the development, the verification/validation and the delivery of the COMS software, in accordance with the project quality requirements. COMS OBS is not developed according to a standard V software life cycle, due to following two main reasons: First, the software is not developed from scratch, but is derived from the E3000 product line. The development consists mainly in a succession of modifications. Second, for programmatic reasons, the COMS OBS is developed and validated following an incremental approach. So, several versions are successively developed, validated and delivered to validation teams. Each version can be considered as a software sub-project with its own inputs/outputs, internal review points and delivery review board. Flight Software is validated with respect to user requirement documents. The software qualification has been performed through tests at different level of software integration. The Software Validation Bench (SVB) includes a fully representative processor board (VPM). By this way, the first HW/SW integration, the real time aspect and the full SW behaviour consistency can be verified at the software level. The *flight software validation qualification* of the SVB is performed including functional verification, real-time behaviour validation, and compatibility with the SW Data Base and the System Data Base.

The functional validation aims at the qualification of each subsystem with respect to the system requirements in terms of components compatibility, overall behaviour, performances and user requirement document. It also validates globally the compatibility between the different subsystems of the avionics. This functional validation involves different benches. The functional Validation Bench (FVB) is the Attitude Orbit Control Subsystem

(AOCS) functional simulator used by the AOCS study team, running faster than real time. It integrates a SUN compilation of OBS ADA files allowing a reliable functional validation of the AOCS OBS including its parameterisation. The Dynamic Spacecraft Software Simulator (DSSS) includes a complete simulation of spacecraft units and space environment. It is delivered for operation training, it is also a powerful functional validation mean. It integrates the FVB AOCS units and environment modelling. It includes in addition modelling of the other spacecraft units allowing to functionally validating all the SW application. It integrates the compiled RAM, IP and PROM flight software that run on a full simulation of both SCUs (Spacecraft Computer Units). The Avionics Test Bench (ATB) is a real time HW bench including full representative HW and SW the avionics. It is used for HW and SW interface validation, SW architecture qualification and all AOCS, Data Handling Subsystem (DHS) and Electrical Power Subsystem (EPS) qualification.

The COMS mission being largely devoted to meteorological and oceanographic imaging, the spacecraft will carry the dedicated equipments (MI and GOCI) with new electronic interfaces: MI2U (Meteo Image Interface Unit) to interface between the MI (Meteorological Imager) and the MIL-STD-1553B system bus. Those COMS OBS specific components are newly being developed and validated for supporting those missions. In this paper, we describe the MI2U ORB (On-board Reconfiguration Block) OBS function which performs the MI2U equipment management.

2. MI2U ORB GENERAL FUNCTION

The MI is the Meteo Imager embarked on COMS. MI interface module is called MI2U (actually the MI2U unit encompasses 2 channels: 1 nominal + 1 redundant). SCU is connected to the MI2U via the 1553 bus. From OBS point of view, a 1553 command that functionally acts on MI is seen as a MI2U 1553 command). The acquired image data are transmitted by MI to the MODCS equipment that formats the data for ground transmission. The COMS OBS executed on SCU provides the ground with MI2U 1553 acquisition observability via standard 1553 remote terminals acquisition services and telemetry services and with a commanding capability via standard TC and 1553 RT interface services. The OBS function dedicated to MI/MI2U management is called as the MI2U ORB hereafter. The general function of the MI2U ORB is described as follows. The MI2U ORB manages MI2U/MI redundancy and reconfiguration, monitors MI2U/MI equipment status and executes FDIR (Failure Discovery, Isolation and Recovery) in case of detecting failures. For ground image processing, MI2U ORB periodically transmits the epoch and attitude data of the spacecraft to MI through MI2U when the ground requests. This data is included in the image format by MI and then sent to MODCS to transmit to ground.

Regular image programming is simple and may be handled by ground via regular TC and 1553 interface services. However, a 48 autonomy capability is required at the COMS system level. Image programming shall then rely on the Master Schedule service which is provided by OBS general services. However, in the case of non nominal event, the OBS shall initiate some recovery actions at the MI2U ORB level and make sure that no more images will be initiated autonomously anymore before the ground has completely recovered the control. The MI2U ORB function that handles such non nominal event has a means to avoid the execution of on-coming MI2U/MI external TC issued by ground, by the Master schedule or any image planning management function.

The operation principle relies on the assumption that all MI2U/MI related actions posted in the MASTER schedule and image planning management function shall transit via the MI2U ORB function. The MI2U ORB is in charge of routing the command toward the convenient MI2U/MI equipment unit (A or B) or to block the command if necessary.

3. FUNCTIONAL MODES

From a functional point of view, the MI consists of five operational modes as follows.

- OFF : This mode is not expected during orbital life including launch and transfer, except transients when reconfiguring the instrument
- Stand-by : The MI is powered in low-power mode, the instrument is pointed toward Nadir direction.
- Launch : This mode is expected to be used during the 3 first hours of launch in order to protect the instrument from being polluted.
- Early operation : In the early phase of transfer and on-station lifetime, the MI is powered in a dedicated so called decontamination mode.
- Operational : The MI is powered with "operational power". The mirror can be either rotating during image acquisition either toward Nadir.

COMS OBS only manages the switch on of MI channels in stand-by mode (nominal or redundant channel) and doesn't manage the transition from stand-by to operational mode, this transition can be handled by means of 1553 commands sent by ground. The stand-by configuration is the reference state that shall be achieved autonomously by OBS in case of perturbing event detection or function switch on after SCU reset or reconfiguration. In case of anomaly during launch phase, the hardware sequence that acts on mirror pointing is inhibited at OBS level so that the mirror keeps its launch position.

4. REDUNDANCY MANAGEMENT

The MI2U ORB manages the MI2U/MI redundancy and reconfiguration. Figure 2 shows the redundancy management configuration to be considered by MI2U ORB. The 2 MI2U channels are 2 1553 Complex Remote Terminal (A, B). These two RTs used in cold redundancy which means not to expected to be simultaneously switch on.

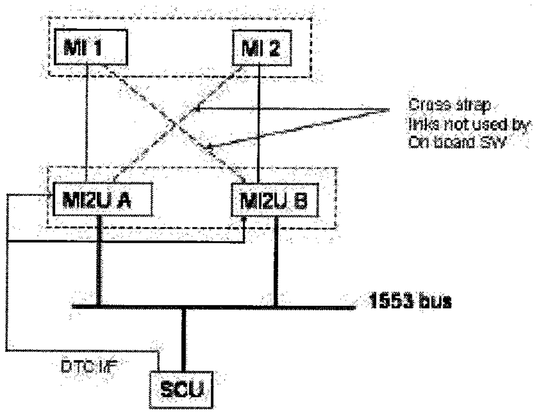

Figure 2. Redundancy Management

The MI has an internal redundancy too: 2 channels MI 1 and MI 2 that shall not be switched on simultaneously. MI channels and MI2U channels are electrically cross-strapped so that any MI2U, MI channel combination is theoretically achievable. However the MI2U ORB considers only two configurations is managed: MI2U A + MI 1 and MI2U B + MI 2, so any further autonomous reconfiguration managed by the MI2U ORB can be only lead as like mentioned.

After a permanent failure of one unit, a cross-strapped combination configuration can be achieved by configuring the equipments manually by ground procedure.

5. EPOCH, ATTITUDE DATA TRANSMISSION

The ground processing of MI imaging requires the knowledge of the on board time and 3 axis attitude. Data and attitude information are therefore periodically sent to the MI2U by the MI2U ORB through MIL-STD-1553B. MI includes these data in the header or trailer of the video format asynchronously with a period depending on the instrument scanning period. The attitude data is computed by AOCS OBS from attitude sensor measurements acquired with a high frequency. The attitude information constitutes 3*32 bit information, the associated measurement data can be presented as an On Board Time (OBT) 32 bits + fine OBT (16 bits). However, only 88 bits are available for additional data in the image format header or trailer. For that reason, the attitude data information in the image format alternatively includes two types of information (packet A and packet B). Packet A includes 1 bit for packet type (A type), 23 bits time stamp, 32 bits X attitude, 32 bits Y attitude. Packet B includes 1 bit for packet type (B type), 23 bits time stamp, 32 bits Z attitude, 32 bits Y attitude. For each type of packet, the MI2U ORB shall thus format the acquired attitude measurements and associated data information into 6 memory load command data words and send those commands to the MI2U using 1553 command service of OBS kernel services.

The MI2U ORB shall send the formatted information to the selected MI2U via synchronous 1553 command service in order to ensure that three commands are sent at the start of HF cycle n+1 (if HF cycle n corresponds to attitude measurement acquisition processing and formatting) and three commands at the start of cycle n+2. This processing service in the MI2U ORB is initially inhibited. To format the epoch and attitude data and send those commands to the MI2U, the ground shall send the command which enable that processing to execute.

6. CONCLUSION

The software requirement document for the MI2U ORB had been written with respect to user requirement document. Coding and verification unit tests have been performed. At the flight software level, the integration and validation test is performed on SVB. The first COMS OBS integration version was delivered to ATB test team to validate and check the COMS specific HW and SW interface and SW architecture qualification.

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