The Development of C&DH subsystem in the D-SAT System

Sitti Zenaida Awalludin
Astronautic Technology (M) Sdn. Bhd.
Suite G-1A, Enterprise 3, Technology Park Malaysia,
Bukit Jalil, 57000 Kuala Lumpur, Malaysia
Tel: +603-89983100 Fax: +603-89983105
sitti@atsb-malaysia.com.my

Norhan Mat Yusoff
Astronautic Technology (M) Sdn. Bhd.
Suite G-1A, Enterprise 3, Technology Park Malaysia,
Bukit Jalil, 57000 Kuala Lumpur, Malaysia
Tel: +603-89983100 Fax: +603-89983105
norhan@atsb-malaysia.com.my

Abstract: This paper demonstrates the in-house development of the subsystem C&DH in a D-SAT satellite project of Astronautic Technology (M) Sdn. Bhd. (ATSB). D-SAT is a non-imaging satellite. It will carry a dosimeter as the payload for scientific objectives. Since one of the D-SAT project establishment intended objectives is to demonstrate the research and development skill of the ATSB engineers on the satellite system building, most of the subsystems of the D-SAT are developed in-house including the C&DH subsystem. C&DH subsystem plays an important role for managing data handling tasks and general operation of the satellite system. The C&DH development includes the research and study on the hardware and software design, the design of both the hardware and software, the development of the software system, the integration between the software and the hardware system and the implementation of the subsystem into the satellite system. This program allows ATSB to accomplish the engineers with expertise not only in the C&DH subsystem but other subsystems too besides developing knowledge in the management of a space project that covers not only on the technical issues but issues relating to the economic, political and legal issues.

Keywords: C&DH, D-SAT.

1. Introduction

D-SAT is a satellite project of Astronautic Technology (M) Sdn. Bhd. (ATSB) to show how the company is moving forward from the learning phase to the improvement phase. The learning phase for the space system had been initiated during the transfer of technology in TiungSAT-1. The improvement phase can be demonstrated through the in-house development on some of the sub-systems of a space system. D-SAT is a non-imaging satellite that will demonstre the technology of a small test satellite for Near Earth Equatorial Orbit (NEqO). It will carry a dosimeter as the payload for scientific objectives. The program objective is to build confidence in building small spacecraft design and integration. ATSB is taking the advantage of state of the art technology of shorter-lived small satellites over traditional large satellites since more rapid technology infusion may provide increases in cost-performance instead of continuing to operate an obsolescent system [1]. The technical objectives will demonstrate the spacecraft design and attitude stabilization using magnetic means and to experience in payload design, manufacture and operation. The scientific objectives will characterize of ionization dose at NEqO and the Earth magnetic field in NEqO Since one of the D-SAT project establishment intended objectives is to demonstrate the research and development skill of the ATSB engineers on the satellite system building, most of the subsystems of the D-SAT are developed in-house including the C&DH subsystem.

2. Space System Architecture

All space missions include these basic elements to some degree: space element (spacecraft bus and payload); orbit and constellation; subject; command, control and communications architecture; mission operations; ground element; and launch element [2]. The space element comprises of spacecraft bus and payload can be divided into various subsystems. C&DH, a subsystem of the D-SAT spacecraft bus is designed to manage all the data handling tasks and general operation of the satellite system. Among the main tasks performed by the C&DH subsystem includes telemetry and telecommand data handling, uploading and downloading data communication management and scheduler and interrupt management.

3. C&DH Development Process

The command and data handling system, C&DH, performs two major functions: (1) receives, validates, decodes, and distributes commands to other spacecraft systems and (2) gathers, processes, and formats spacecraft housekeeping and mission data for down link or use by an onboard computer [3]. There are several stages in the C&DH development process. It includes the research and study on the hardware and software design that can fulfill all the user specification and requirement, the design of both the hardware and software, the development of the software system, the integration between the software and the hardware system and the implementation of the subsystem into the satellite system.

3.1 Research and Study Phase

During the research and study phase there are many factors need to take into account in order to determine the right hardware platform. Normally these factors are based on the user requirements and specification. Among the factors are the ROM/RAM memory size, the availability of the general I/O port, the ADC resolution bit, the availability of the HDLC module on-chip and the price of the whole hardware/software development tool package. Rates for payload commanding and telemetry depend on the payload's design that may require very high data rates (10 kb/s to 500 Mb/s) and storage of payload data [4].

ROM/RAM memory size

The size of the ROM and RAM memory is depending on how large and complex the application software. If the application software requires complex computation and massive scheduling then the commercial real time operating system such as embedded linux and RTEMS is needed and this implementation requires large memory size. Since D-SAT application is intended to manage simple functions the size of FLASHROM and SRAM for the D-SAT platform is decided to be 512KByte each.

I/O Ports

The availability and the size of the general I/O ports is an important factor in designing the interface communication between the hardware components. In the D-SAT design, these I/O lines are used to interface the micro-c with the telemetry, adc, telecommand and watchdog ICs. There are several ways to minimize the usage of I/O lines which one of them is by using an I/O expander IC.

ADC Resolution

The ADC resolution bit determines the accuracy of the digital conversion data from the analog reading data. The principle is the higher the resolution bit the smaller the value of the 1 bit data. Since D-SAT application requires wide range of voltage reading from dosimeter sensors which is from 5V to 15V, the 12 bit resolution ADC is agreed to be suitable.

HDLC (High Level Data Link Control) Module

The HDLC (High Level Data Link Control) module is used to encode and decode AX.25 data communication protocol. Since this module is hardware implemented on the micro controller, the task of encoding and decoding the protocol will be much simpler.

After the hardware platform has been established, the next step is to test all the hardware components functionality. This test software will be the fundamental base for the firmware coding in the future. Among the hardware components that need to be tested are Serial port, HDLC port, Interrupt, Timer, I/O port, ADC, Telemetry circuit and Telecommand circuit.

3.2 Software Design Level

The design of the application software is mainly in accordance to the user requirement and specification derived from the mission analysis. During the software design level, the coding of the software will not be done. Only the flow chart and algorithm of the software structure that includes the detail of the tasks involved will be determined. This approach is important in order to avoid debugging complexity during the finalization process of the user requirement and specification. During this phase the coding of the firmware or the device driver can be performed.

3.3 Software and Hardware Integration

After all the user requirements and specification have been finalized, then the coding of the application software can be done. This process can be performed in parallel with the firmware integration test with the hardware. The coding of the application is recommended to start off from the bottom level upward. This approach is to simplify the debugging and integration process done during many level of software development phase.

3.4 Satellite Integration

Finally after the whole application software have been coded as well as integrated with the hardware platform, then the whole C&DH system is ready to be implemented in the satellite bus system. Normally at this phase most of the problems encountered during the integration with other subsystems require some data calibrations and modification in both hardware and software parts.

4. Summary

The C&DH susbsystem is often one of the last spacecraft to be defined. C&DH equipment cannot be completely defined until the requirements of other systems have been established [5]. As a summary, the success of this project is not only measured on the working final satellite system, but the most important is the knowledge and the experiences gained by the engineers during the phases of the whole processes of the satellite development life cycle. Thus this program allows ATSB to accomplish the engineers with expertise not only in the C&DH subsystem but other subsystems besides developing knowledge in the management of a space project that covers not only on the technical issues but issues relating to the economic, political and legal issues.

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