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1995

NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

MARSHALL SPACE FLIGHT CENTER

THE UNIVERSITY OF ALABAMA

DEVELOPMENT OF THE COMMAND DATA SYSTEM AND GROUND SOFTWARE FOR THE SEDSAT-1 MICROSATELLITE

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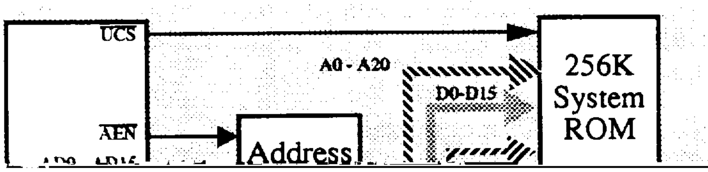
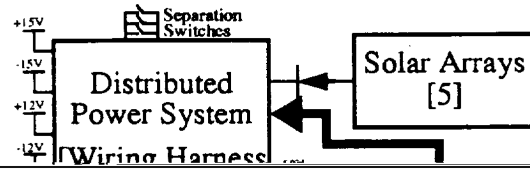
NASA/MSFC:
Small Expendable Deployer Systems

Mission Objectives

SEDSAT-1 is designed to be a low cost scientific satellite which is to be used to perform a minimum of five tasks which include 1) the acquisition of a number of important parameters associated with the tethering processes from the payloads perspective (such as accelerations incurred and imaging data of the tether during deployment), 2) to act as a remote-sensing platform for making measurements of the


UCS
AEN
A0 - A20
D0-D15
256K System ROM
Address


Separation Switches
+15V
-15V
+12V
-12V
Distributed Power System
Solar Arrays [5]

Software Development

Figure 2 is a complete functional description of the software tasks associated with the CDS operation whose function were identified or refined during the fellowship period. These tasks are further subdivided in the detailed schedule which are included in the full report.

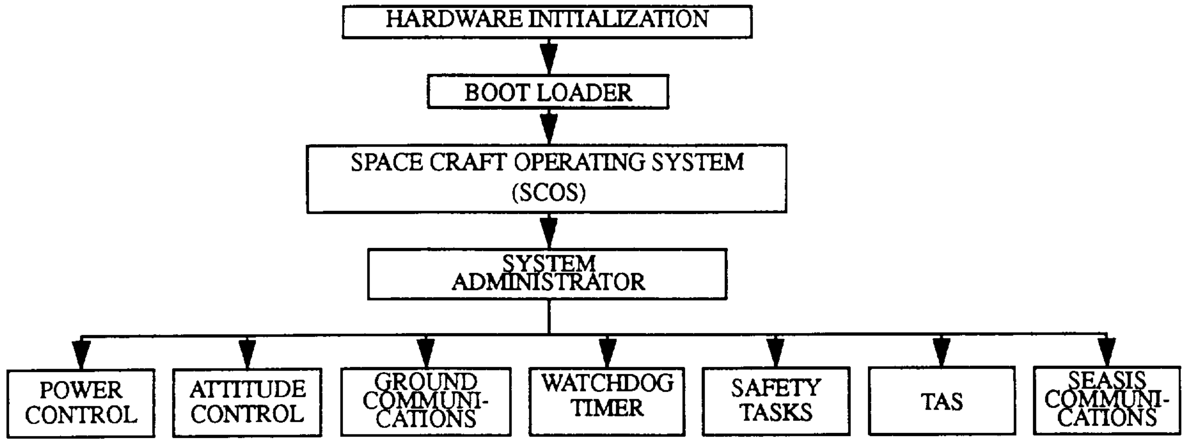


Figure 2: Functional Description of Software Tasks for Command and Control System

Hardware Initialization Routine

This routine is to initialize all the system hardware and includes the following functions: (1) Initialization of all CDS board external (80186) I/O and memory selects, (2) execution of a "memory wash" of the EDAC protected RAM, (3) initialize all external peripherals including 8037A DMA, 825230 Serial Communication Controllers, INMOS C011 Transputer Interface Chip, 80255 Parallel Port and, (4) upon initial start-up, copy ROM to RAM then pass control directly to SCOS for tether mission or upon cold start (i.e. external reset) transfer program control to the Boot Loader Routine.

Boot Loader

The boot loader task is a low-level task written in assembly language that is activated upon system start-up or reset. It is responsible for uploading the basic operating system into system RAM. The boot loader will be invoked each time the SCOS operating system is to be updated. To allow for the tether portion of the mission to occur, the boot load will allow the SCOS operating system and all necessary application tasks to be copied directly from the system ROM into RAM without requiring explicit commands being sent via the RF control links. This code must be very robust and extensively tested since it is mission critical.

Space Craft Operating System

For improved reliability a specialized real-time operating system for the SEDSAT-1 will be deployed that has over 80 operating years on LEO Satellites. This operating system incorporates a real-time multitasker which support the simplified concept of message streams for inter-task communication and has specialized AX.25 libraries to simplify the task of satellite/ground communications. The operating system allows for inexpensive DOS-based PC's to be used for system development and emulation.

System Administrator

A number of actual software tasks (not necessarily a one-to-one correspondence with the functional description in Figure 2) will have to be initialized and placed in the SCOS execution queue. This task is concerned with placing the initial tasks in the instruction queue and other initialization operations.

Power Control Task

To maintain an overall positive power margin, a periodic software task will be invoked that will monitor the current, voltage, and temperature associated with the main power system and the associated subsystems. An algorithm will be developed which will vary the power levels associated with the transponders based upon the calculated charge/discharge rate of the satellite's batteries. In the event of an energy emergency, the power control tasks contain separate software exceptions which will disable all experiments and the Mode A transponder. This is also the default mode which the satellite is placed upon system reset.

Attitude Control

This task uses information such as voltage/current readings from the solar arrays and imaging information from the SEASIS experiments to produce current pulses to the three axis magnotorquers to control in a closed-loop manner the attitude of the satellite.

Ground Communications

This task is concerned with the implementation of a high-level communication protocol to perform store-and-forward operations of data obtained from the on-board experiments. This task utilizes the Bek-TeK AX.25/University of Surey software routines which were provided as part of the SCOS operating system to accomplish this goal.

Safety Tasks

These two tasks control the safety critical operations of the satellite as they reflect on Space Shuttle Operations. The include the enabling of the tether cutter, and the 10 meter antenna deployer. These tasks are not uploaded until after the SEDSAT-1 is fully deployed.

Three-axis Accelerometer (TAS) Software

This task involves recording the accelerations that are undergone by the SEDSAT-1 along each of its three orthogonal axes. This information will be recorded for future downlink to the ground during the tether portion of the mission where it will be evaluated off-line to provide more information on tether dynamics. In the secondary portion of the mission this data will be made available for use as one of the inputs to control the attitude of the spacecraft.

SEASIS Communications

Communications with the SEASIS experiment will occur via the SCC-100 MCM's 20Mbit/sec Transputer link through the IMSC011 interface. The data transferred in this matter will be re-packetized and buffered to be transmitted to the ground station via the Ground Communication task. To improve the transmission speed this operation will in most likelihood require the use of the use of an external DMA.

Mission Milestones

The following represents a list and a short description of the set of milestones determined as part of this research, which will be used to measure the progress of the CDS/Ground Station Software portion of the SEDSAT-1 Mission. Note that the software version numbers have the following format Vx.x, where x.x represents the portion of functionality that the software component is expected to have when compared to its proposed function during flight. It does not necessarily indicate the amount of effort that is required to obtain this functionality. The milestones which are highlighted with an astrict are key MSFC milestones agreed upon on July 6, 1995 as stated in a Memorandum for record from Rein Ise. A complete set of mission subtasks associated with software development are presented in the CDS Software Requirements Documented.

(i) Internal CDR (start date: 8/3/95)

The SEDSAT team will present their work for an internal critical design review. It is desirable that the team employ experts from outside their immediate group to participate in this process. All pertinent design issues will be considered.

(ii) Assembly of CDS PC, Mother Board and Mode L Transponder Flight Hardware (9/1/95)*

At this point the main motherboard, which distributes and routes the power to the daughter boards, and the CDS PC board should be designed, laid out, and fabricated.

(iii) Beginning of the NASA SEDSAT-1 CDR (start date: 9/15/95)*

This milestone is concerned with the initiation of the NASA Critical Design Review. The NASA design review will be centered around Space Shuttle safety concerns.

(iv) CDS V0.5 Software Release (11/30/95)

This software release will contain the tether cutting routines, power system software, bootloader, and functional test routines.

(v) CDS Hardware/Software Interface Verification (12/1/95)*

The CDS board will be tested utilizing the built-in functional test routines associated with CDS Software Release V0.5.

(vi) CDS V0.7 Software Release (1/31/96)

This software release will contain the watchdog software, antenna deployment software, and the CDS/SEASIS communication routines.

(vii) Complete Assembly of CDS Bus (2/1/96)*

The CDS board and portions of the motherboard will be verified using the functional test routines associated with CDS Software Release V0.7. Additionally, the fail-safe reset circuitry should be implemented and tested.

(viii) CDS V1.0 Software Release (4/1/96)

This represents the full flight versions of the CDS software which will be placed in CDS ROM. This will include all CDS V0.7 functionality with the addition of the complete CDS File System and the magnetic stabilization routines.

(ix) Delivery of SEDSAT-1 for Environmental Testing (6/15/96)*

The SEDSAT-1 hardware is to be delivered to MSFC to conduct a number of tests. This should be preceded by a verification of the CDS/SEASIS hardware/software interface and the combined functional test of all SEDSAT systems.

(x) Delivery to KSC (10/1/96)*

The SEDSAT-1 will be delivered to Kennedy Space Center for deployment.

(xi) Ground Acquisition V0.2 Software Release (10/15/95)

This release of the ground software will include the interface specification/demonstration of the icon to high-level language interface definition/demonstration, the basic ground station LABVIEW front