Solar Imager Radio Array (SIRA)

Flight Software

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25-28 August 2003

Agenda

- **Overview**
- **Assumptions**
- **Key FSW Functions**
- **Testbeds & Simulators**
- **Risks Assessment**
- **Issues and Concerns**

Overview

- **Launch 2009, 2 years mission life with 4 years goal**
  - A constellation of 16 microsats
  - Earth-centered, Distant Retrograde Orbit having 500,000 km radius
- **Single String System**
- **C&DH, ACS and PSE FSW reside in a single board computer**
- **Industry standard data bus: cPCI local bus and 1553 external bus**
- **State of the Practice technologies only**
  - CCSDS/AOS command and telemetry formats, X-band COMM using HGA
- **Diagnostic S/W will be developed for low level test of C&DH Cards**
- **Initial assessment: ST-5 C&DH FSW heritage with tailoring for SIRA mission. Leveraging on ST-5 heritage does not represent significant cost saving because of changes in I/F, ACS and processor platform**
  - Add UHF/VHF Transceiver Support for Inter-satellite ranging & timing
  - Add 1553 Bus Support
  - Add articulating solar array control
  - Different RTOS and processor support
  - Different ACS system: Need Three Axis Stabilized System, constellation orbit maintenance
  - Identical Software on S/C other than table of parameters

Assumptions

- **3-axis stabilized**
- **Fixed-mounted high gain antenna always faces earth**
- **Articulating solar array**
- **No reorienting microsat between data-taking and data-dump attitudes**
- **No onboard autonomous formation navigation & control**
- **Safehold mode in C&DH. No independent digital safehold ACE**
- **Instruments provide all electronics and controllers necessary to maintain operational environment of instruments**
  - C&DH/FSW only provide command/time distribution and accept telemetry
- **No active thermal control**
- **No active control of constellation deployment, 2 microsats powered during cruise phase to provide telemetry & command sequences for deployment**
- **Identical hardware, I/Fs, Software on S/C other than table of parameters**
- **No spacecraft collusion avoidance processing onboard**
- **No failure detection & correction of constellation**
- **No controlled re-entry of microsats**

Key FSW Functions

- **A single board computer requiring on-board FSW or Firmware which communicate via MS-1553 Data Bus at 300 kbps**
  - Command & Data Handling (C&DH) Functions
    - Bootstrap Loader and Real-time O/S
    - Spacecraft Uplink/Downlink Processing
    - Precise Time Management onboard to within 1 micro-second
    - Data Recorder Management
    - Stored Command Processor
    - Health & Safety Management
      - Memory Checksum Management
      - EDAC Memory Scrub Management
      - Parameter Table & Memory Management
    - Failure Detection and Correction
  - Attitude Control System (ACS) Functions
    - Sensor and actuator I/F and processing for thrusters, MSS, ST, RW
    - 3 Axis stabilized, ACS attitude determination and control, all modes
    - SA pointing
  - Power System Electronics (PSE) Functions
    - Sensor data & command I/F for Switched Services and Battery Regulation
    - Switched Services Management
    - Battery State of Charge Management

C&DH/PSE FSW Testbed
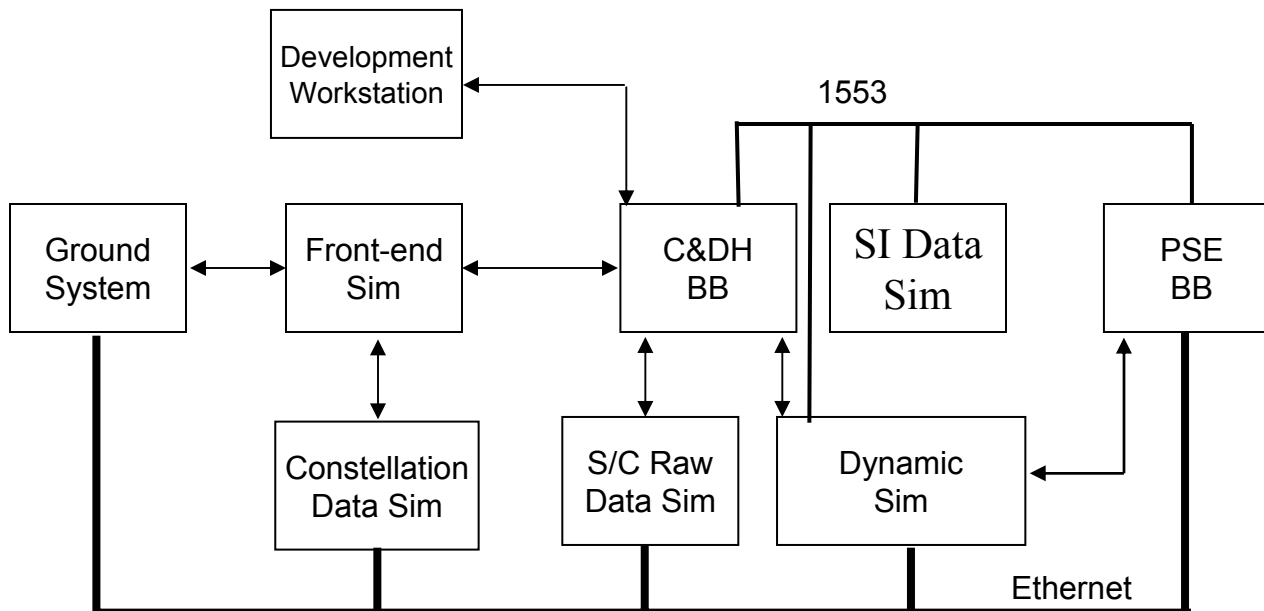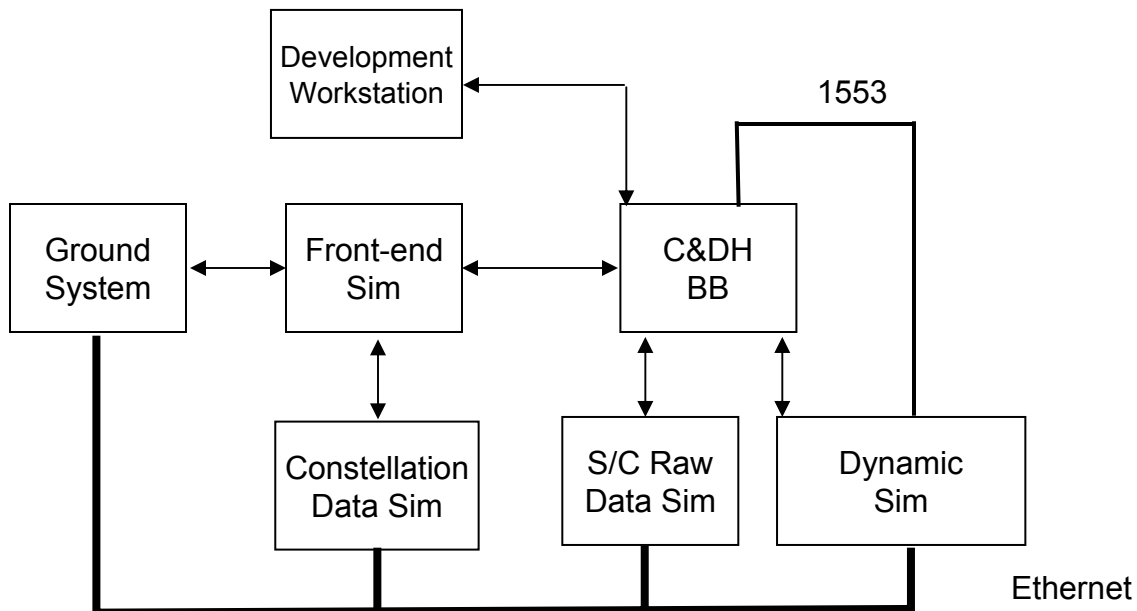
- 6 PCs (simulators & GSE)
- Interface Hardware
- Software Licenses & Tools
- C&DH and PSE Breadboards
- Logic Analyzer

ACS FSW Testbed
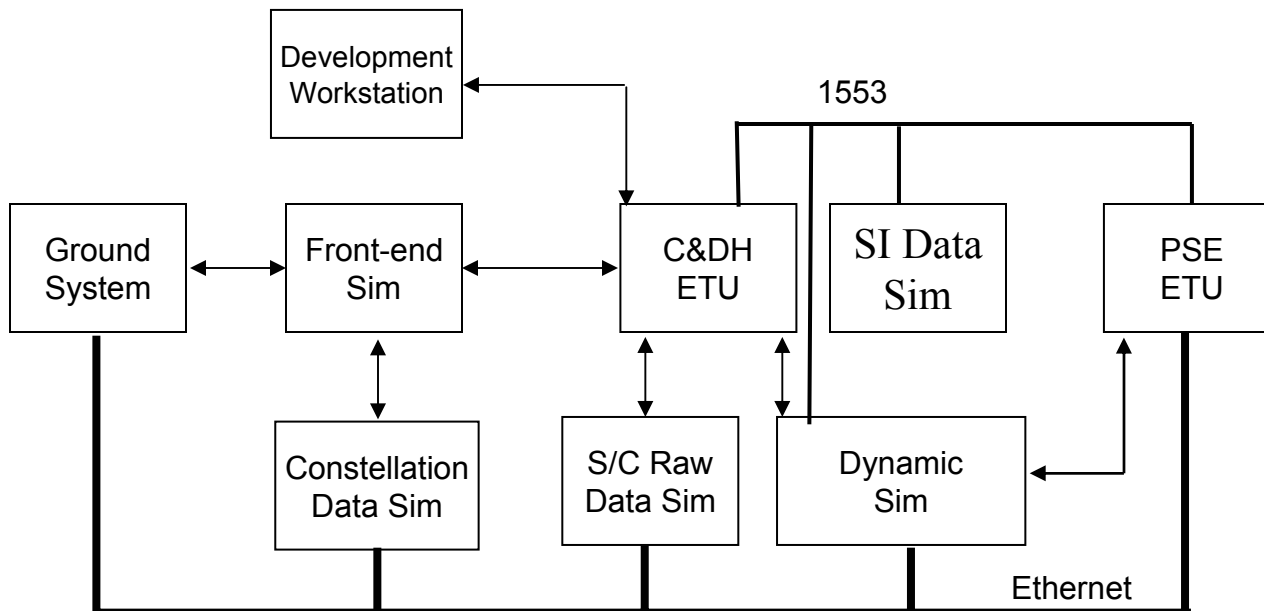
- 6 PCs (simulators & GSE)
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- C&DH Breadboards
- Logic Analyzer

FSW System Testbed

- 6 PCs (simulators & GSE)
- Interface Hardware
- Software Licenses & Tools
- C&DH and PSE Breadboards
- Logic Analyzer

FSW Cost Summary

Item	Man-Years (FTE)	Cost (k)
• Mgt & SW Sys. Eng.	4	800
• FSW Configuration Mgmt	2	240
• Hardware Diagnostics Software	2	400
• C&DH Flight Software	15	3,000
• ACS Flight Software	17	3,400
• PSE Flight Software	1	200
• Software System Testing	4	800
• I&T, H/W Spt. & Maint. Preparation	5	1,000
• Testbed Engineering	2	400
• **Hardware & Software Tools**		**600**
• Total Labor* & Materials	49	10,690
Cost for configure and test of additional 15 s/c, 0.25x15 = 3.75		750
Grand Total	52.75	11,440

Assumed Launch in 2009, 24 mos operation, post-launch FSW maintenance book-kept elsewhere

Assumed $200K/M-Y FSW engineer, $120K/M-Y CM

Breadboards & ETUs for C&DH, all GSE and simulators book-kept elsewhere

WV IV&V book-kept elsewhere, typical 10 – 15% of total software cost

Flight Software Risk Assessment

- **No new concepts identified**

- **Early data system component development required to support FSW development in all areas**

  – Early development and c/o of breadboards/ETUs will be required

- **Typical software risks apply**

  – Good industry practices

  – Adequate test time

  – Adequate test resources

  – Adequate documentation

Flight Software
Issues and Concerns

- **Adequate FSW testbeds must be available to support up to 16 microsats I&T: 3 minimum, 4 ideal**

  – Traditional I&T usually integrates H/W set for 1 S/C

    • Staging of H/W for 16 spacecraft subsystems/components delivery and I&T considerations and FSW testing competing for resources

- **Verification of precise timing and ranging between microsats**

  – Simulation in FSW test environment may be difficult and expensive

  – How do we check this out during spacecraft I&T