Probe Bus Avionics Unit Development and Validation

Bob Kraeuter
THEMIS Mission

- NASA MIDEX program launched in February 2007
- First NASA program to launch five satellites simultaneously

Requirements

- Integrate Bus Computer, Communication interface, and Power Control Electronics functions into a single unit
- Low Mass, Small Footprint, Low Power
- Two-year mission life
- 66 krad TID tolerance

Performance

- Mass: 2.8 kg
- Size: 8.4” L x 5.9” W x 4.7” H
- Consumes less than 6.4 watts
Bus Avionics Requirements

Spacecraft Computer
- Provide command processing and telemetry gathering functionality
- Perform power management functions

Uplink Command Processing
- Perform uplink commanding functions - 1 kbps uplink rate
- Provide hardware-decoded command functionality

Downlink Formatting
- Format real-time telemetry & stored data into telemetry transfer frames
- Route transfer frames to downlink channel according to priority
- Perform Reed-Solomon encoding
- Support 10 downlink rates from 1kbps to 1024 kbps
- Interface to S-Band Transponder

Bulk Memory (64 MB)
- Support Instrument Science data transmission operations
- Provide storage for 1 orbit + 1 day’s worth of housekeeping telemetry

Telemetry Acquisition
- Digital Telemetry
- 14-bit Analog telemetry

Power Control
- Provide Battery charge control function
- Provide high current actuation functionality
- Distribute power to Spacecraft loads
  - 28V Bus power, switched and unswitched
  - Secondary voltages, switched and unswitched
- Hard Short Overcurrent protection available on 28V switched services
Bus Avionics Overview

Digital Processor Module

- RH5208 ColdFire Processor operating at 16 MHz
- 512KB SRAM Main Memory
- 512KB EEPROM Program Memory
- 16KB Startup ROM
- 64MB SDRAM Bulk Memory
  - Triple voting scheme for EDAC protection
- System Timing & Synchronization
- Digital Sun Sensor Interface
- Thruster Command Interface
- Downlink Telemetry Interface
- Instrument Data Processing Unit Interface
Communication Interface Module

- Receives and distributes uplink commands
- Downlinks real-time telemetry, stored housekeeping telemetry, and science data through the transponder
- Implements watchdog timer function to monitor DPM module operation
- Receives, distinguishes, verifies, executes, and distributes up to 16 hardware decoded commands
- Autonomously switches between independent Uplink Transponder and Hardline command interfaces
- Provides High and Low rate downlink interfaces to the S-band transponder and a separate Hardline telemetry interface
Power Electronics Unit

- Processes solar array power
- Controls battery charging
- Distributes primary power to bus components, heaters, and the IDPU
- Collects and processes telemetry data
- Provides interface to Transponder and Inertial Reference Units
- Distributes pulse commands
- Performs propulsion control functions
- Provides hardware ACS Watchdog Timer
Design Verification

EDU Processor module integrated with Communications Interface and PEU emulator to form “Mini-BAU”

• Utilized by flight software to develop flight code and ground software to develop ITOS interface

• Thermal cycled to validate hardware designs

Power Electronics Unit modules developed using custom EGSE to verify interface functionality

• Backpanel interface verified using custom DPM emulator GSE

All three subassemblies integrated together and tested as a unit

• Thermal cycled to minimize risks during environmental testing of first flight unit

• Validated design and implemented changes to flight PC boards

EDU transitioned to flight software development & testing

Second EDU built to support Test Set development
Test Set Development

Test Set implementation comprised of components from the individual module-level EGSE updated to meet Box-level verification requirements

Test Set design supported BAU flight unit testing in five testing environments:

• Module Level Bench Testing
• Box Level Performance Testing
• Vibration Testing
• Thermal Vacuum Testing
• Electromagnetic Compatibility Testing

Three Test Sets built to support parallel testing efforts at different test sites

• Each Test Set interchangeable with custom interface cabling supporting each test environment
Flight Unit Assembly & Test

Flight Unit 1 built & tested to verify the flight design prior to initiating production of the rest of the modules.

Each module was tested as a subassembly and then integrated with other modules for open frame testing.

- The modules were designed to be interchangeable between units to streamline integration and test.

After completing initial box level testing the modules were conformal coated and integrated into the final flight configuration.

Environmental testing proceeded in a serial fashion with completed units moving to Spacecraft I&T.
The Bus Avionics Unit implementation met all of the requirements and goals of the THEMIS mission.

Combining the C&DH and Power subsystem electronics into such a highly efficient package was a major enabler for the mission.

Five identical Bus Avionics Units were built, assembled, tested, and integrated in a timely manner in support of Program requirements.