



TOROID Hardware and Real-Time Software Architecture

Paul Rodriguez-C&DH Lead

paulrodz@gmail.com 435-770-3381

Jared Crace-Software Lead & Systems Engineer

jaredcrace@gmail.com 435-797-6654

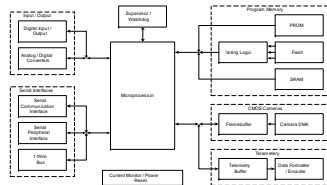
Computer Hardware Requirements

- Low power and processing similar to mobile devices
- Radiation tolerant design to protect system in the event of a single event upset and/or single event latch up
- Good thermal characteristics



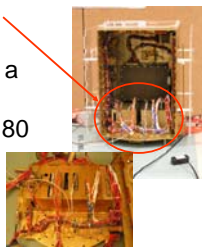
C&DH Design

- Single processor model
- Triple modular redundant flash guards instructions from SEU
- CPU supervisor and current monitors detect invalid operational states
- Task specific devices share processing workload



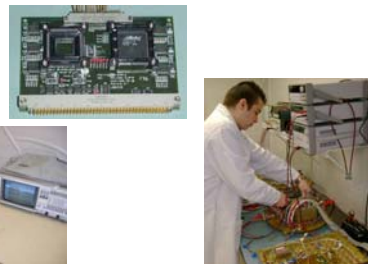
Computer Hardware

- Secured in modular enclosure
- Each board provides a separate function
- Processing power of 80 MIPS

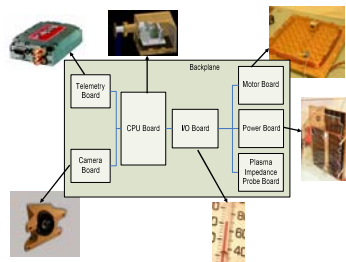


Integration and Testing

- Failure on motor board
- Researched schematics and device drivers
- Discovered method to test electronics
- Verified signals from SPI bus
- Determined FPGA is not responding



Device Interfacing

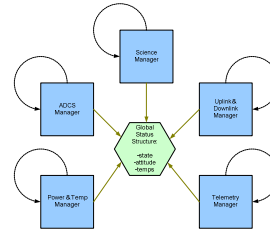


Current Work

- Understand system at schematic and device driver level
- Test and Debug hardware
 - Motor Board
 - New Telemetry Board
- Develop documentation regarding hardware design, functional analysis, and procedures

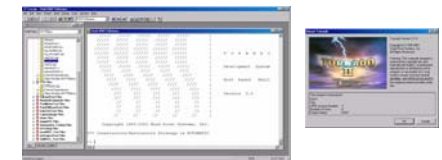
Software Subsystem Design

- Modular separation of software modules based on the C & DH Subsystem
- Basic module, Subsystem manager
 - Shared memory communication scheme
 - Easily Tested
 - Provides modularity in subsystem managers

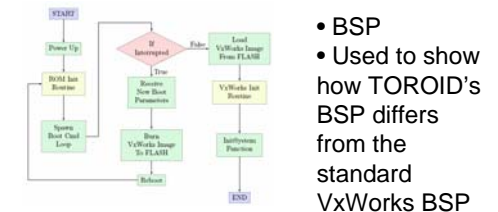


Implementation & Tools

- Implemented in C/C++
- Real-Time Operating System, VxWorks
- Tornado II IDE, provides outstanding debugging facilities



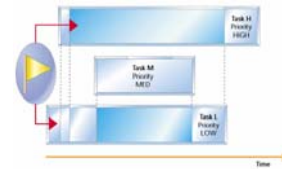
Low-Level / High-Level Time Lines



- BSP
- Used to show how TOROID's BSP differs from the standard VxWorks BSP

Difficulties Of Real-Time System

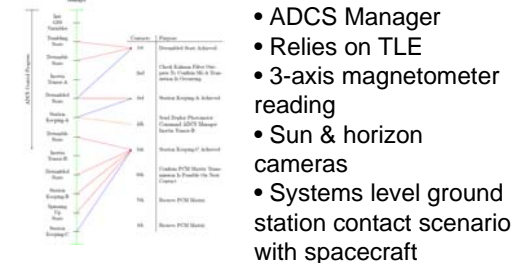
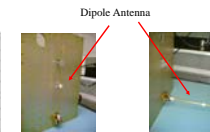
- Will all tasks meet their deadlines?
- Pre-emptive priority based scheduling
- Priority inversion a possibility
- Low-priority process L, blocks High priority process H



Command Set Implementation

- Nominal & Off-Nominal Commands
- Antenna Deploy, Dump Log File, Dump GSS, ... etc

Command	Priority	Timeout	Response
Antenna Deploy	High	10s	Antenna Status
Dump Log File	Medium	5s	Log File Data
Dump GSS	Medium	5s	GSS Data

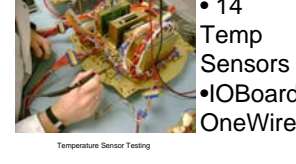
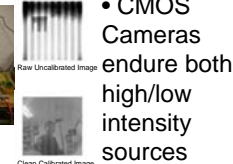
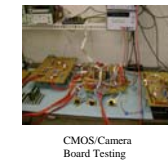


- ADCS Manager
- Relies on TLE
- 3-axis magnetometer reading
- Sun & horizon cameras
- Systems level ground station contact scenario with spacecraft

End-To-End Testing & Debugging

- Camera Board
- Temperature Sensors

Test Case	Pass/Fail	Notes
Camera Board Testing	Pass	CMOS Camera Board Testing
Temperature Sensor Testing	Pass	Temperature Sensor Testing



- 14 Temp Sensors
- IOBoard, OneWire