Structure Design for Modular Platform and Capability on the USUsat 2 Micro-Satellite

Joël Quincieu,
Utah State University
August 11th, 2004

USUsat 2, UNIII program

Extended version with open top
USUsat II: The program and mission

The Program
• University Nanosat III national competition organized by AFRL, NASA, Air Force Office Of Scientific Research, AIAA

The mission
• Science: Measure electron temperature, density and collision frequency in equatorial plasma bubbles
• Technology demonstration: C&DH, Structure, ADCS

The orbit:
• 52 degrees inclination
• Altitude = 380 km
• Period = 92 min

The launch vehicle:
• Space Shuttle/2006
Design-to-capability or platform on USUsat II: Bus

Flexible platform should have:

1. Re-use of sub-systems bus
2. Flexible architecture that can integrate the bus (and payload) for a mission with a minimum amount of modification (engineering, fabrication and documentation) = manufacturing strategy

Reason = reduction in cost and lead time, versatility to carry missions.

Must respond not only on the mission level but also:

Integration, Manufacturing, ease of disassembly, ease of re-use, ease of testing = DFMA (Design For Manufacturing and Assembly)
DFMA on the USUsat II Structure

DFMA on USUsat II = design for:

- Minimum number of parts = machining at once
- Modularity = module pre-assembly and test
- Low part variations = same fasteners
- Multi-functional = structure used as a tool fixture
- Design for multi-use = other possible configuration
- Minimum assembly operations = quick access to components
USUsat II Structure: Highlights

- Mass: 9.0 kg
- Stiffness: >170 Hz
- Rectangular geometry for efficient packaging
- Skin = 0.03 in
USU sat II Structure: Highlights

- Bolt pattern for flexible packaging and ballast balancing (no freezing at the CAD level)
- Harness routing
- Possibility to add payloads when satellite is assembled

Integrated L-shape frame for torquer-coil (on 3 panels)
8-32" standard bolt pattern for components (exterior or interior) and decking
Untouched 0.25" thick structure for load path, non-standards points for attachment (hinges or others)
Possibility to create access holes for optics or sensors
Bolt pattern for a flexible harness routing
USUsat II Structure: Integrated torquer coils

- 3D structure via Rapid Prototyping (Selective Laser Sintering) for fit check
- Wire directly wrapped around the L-shape machined in the structure on the 3 panels (3 axis Attitude Control)
- Bolt pattern used for the spin-tool
- Wire attached with off the shelf zip tie
- Time: 4-5 hours
- Low cost: ~ $500.00 (wire, tool, labor)
- Magnetic torque: ~ 10 Am^2
USUsat II Structure: Decking capability

- Decking extension with one or two decks for extra mounting surface
- Deck designed with same bolt pattern
- Possibility of one side panel large openings for external access from sensors
USUsat II Structure: Module assembly

- Ex: Assembly Module 1
- Module can be assembled separately (no dependant on others)
- Pre-wire harness prior to final system integration
- Open access for tooling, visual inspection
- Only one connector to attach the module to the rest of the satellite
- Module are independently built according to available parts
- Vibration test at module level with one test fixture = duplicate launch configuration
USUsat II Structure: Module assembly

- Modules connected through extension harness for baseline test (functional)
- System integration = connect all modules mechanically and electrically (intro-Module connector)
- Ease of disassembly = access for visual inspection after mechanical test
USUsat II Structure: Internal Configuration

“Light” configuration, direct panel mounted modules

“Heavy I” configuration, one deck as an additional module

“Heavy II” configuration, two decks as additional modules

- Top panel can be removed with a high deck exposed to the outside.
- The structure versatility is not dependent of the bus.
- Solar cells directly attached to the structure, thus avoiding extra panel (part minimization, DFMA)
USUsat II Structure: External Configuration

“Light” with panel mounted cells (USUsat II)

• Same principle applied: Assembly per modules

• Deployable surface extension for solar cells string through off-the-shelf hinge mechanism

“Top deployable” or with fixed angle

“Large deployable” or combined with top

Starsys hinge actuator
Design-to-capability or platform on USUsat II: Case

- Goal: to space certify instruments prior to large mission
- Instruments are for earth sensing, need to be orientated nadir

Must change:

- Elevate internal deck in an open access for instrument, comm. Patch,
- Increase average power with extra panels and keeping surface mounted cells
- Software interface

Lead time shorter:

- Keep same hardware, assembly plan, test plan and Equipment List
- Re-use analytical model in structure, thermal, ADCS