Plug-and-Play Satellite (PnPSSat) Demonstrating The Vision

PnPSSat

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PnPSSat

- Prime directive –
  - Design, assemble, and test a semi-custom satellite in 2-3 days

- PnPSSat is a pure S&T experiment to establish the necessary technologies
  - Giant step in an evolving breed of software defined systems

- Have touched every aspect of satellite design, construction, test, and operation to find those areas that inhibit rapid assembly
Modular Plug and Play Technologies

- What is a Plug and Play Satellite?
  - A modular satellite with open standards and interfaces, self describing components, and an auto-configuring system
  - System integration is simplified and testing tasks can be automated

- Space Plug & Play Avionics
- Modular Spacecraft Structures
- Autonomous Flight Software
- High Performance Computing On Orbit
- Distributed Systems
- Mission and Satellite Design Tools
- Tactical User Interfaces
- Plug and Play Payloads
- Plug and Play LV Interfaces
- Plug and Play Thermal
- Plug and Play Propulsion
- Adaptive Wiring Manifolds

PnP Sat technologies can revolutionize the way spacecraft are designed, assembled, tested, and operated
PnP Sat
A Collection of Modular Systems

- Structure
- Power Grid
- SPA Infrastructure
- Thermal

- Software
- HPCOO
- Power
- GNC

- Communications
- Mission Sensors

- Assembly, Integration, and Test
- Ground Systems
- Launch Systems

Basic Bones Of The Spacecraft
Customization For Bus Performance
Customization For User Needs
Integration and Operations Support
Integrated Structural Panels

- Electronics infrastructure is recessed within the interior of each panel
  - Electronics boards and inter-board harnessing
  - Provides power and data services to each of eight SPA endpoints per panel
  - Networked to all panels through inter-panel harnessing
  - All electrical interfaces exterior to panel are connectorized

- Panel halves are attached with #8 fasteners in the thick sections around perimeter and near the center of the panel

- Hinged joints speed integration while retaining stiff structure
SPA Standard Electrical Interface

- SPA standard electrical interface for components and
  - Electrical endpoint is 25-pin micro-D connector
  - This is the single interface to the PnP electrical infrastructure
- Endpoint can be located on the interior or exterior surface of the panel
- Batteries, solar arrays, and power supplies have access to power grids through 2-lug interfaces
SPA Interface Module (ASIM)

SPA Component Contains Self-Defining Data Sheet (xTEDS)
- Data Products
- Commands Accepted
- Interfaces Supported
- Services Provided

Common Data Dictionary (CDD)
- Standard data meaning
- Distributed to all interested parties
- Extensible
Physics
Measurable Quantities
Measurement Process
Variables & Qualifiers
Names & Formats
SPA Standard Interface

Common Data Dictionary
xTEDS
Interface Control Document

Plug and Play Interface
Data interface based upon common standard (CDD)
Data interface expressed in standard language (XML)
Electrical interface based upon common SPA standard
Autonomous Flight Software Architecture

ActivityAgents
- Deployment
- Charge Batteries
- Safe Mode
- OOCE
- Momentum Dump
- TT&C Contact
- Tactical Contact
- Experiment
  - HTI Imaging
  - iMESA Data
  - ADS Data
  - Laser Detection
  - PCDD & RadFET

ActivityManager
- Planning

Subsystem Controllers
- Comm
- ADCS
- Power
  - Thermal
  - Computing
  - Experiment
- Coordinate Transform
- Celestial Almanac
- Orbit Propagation
- Plant Discovery
- Earth Gravitational Field
- Atmospheric Model
- Magnetic Field
- Vehicle Services
- GPS Helper
- CSS Helper
- Linear Ext Acc

Utility Applications

Components
- RW_X
- RW_Y
- RW_Z
- PST
- IMU
- GPS Radio
- TorqueRod X
- TorqueRod Y
- TorqueRod Z
- Magnetometer
- Battery
- Solar Array
- IMESA
- HTI
- ADS
- PCDD
- MCU-110B
- WSSP
- CSS
- FSS

Schedule
- Red: High Priority
- Green: Medium Priority
- Blue: Low Priority

Protection
- Image Processing

Applications
PnPSat Lessons Learned

- The standard mechanical interface – 5cm grid of threaded holes – is very useful for moving components on the spacecraft. Components can be temporarily moved from panel to panel for testing.

- The standard ASIM design should include an accessible data test port and JTAG programming connector for ASIM code upload. Better design is ability to upload ASIM code through the SPA interface to allow code changes on-orbit.

- The component endpoint connectors should be located around the perimeter of the panel and recessed. The current design is centered on the panel which forces them to be covered by components too often.

- Components connected to endpoints with jumper cables is a good solution. A connector that mates when the adapter plate is installed would be a cleaner solution on paper – but in reality it would restrict the flexibility of placing components on the bus.

- We are using cable tie-downs that are fastened to the 5cm grid. This is a solution that takes only a few minutes to tie-down cables.

- The current PnPSat thermal design uses blanketing that is custom patterned and installed with Velcro. To support moving components they should be blanketed individually so that the blankets move with the component. Exposed structure could be covered with pre-cut shapes (either MLI or radiator tape such as SCT) that are stocked in various sizes.

- All the advantages for ease of assembly and disassembly are still true – removal of components and panels for rework – ability to continue testing by moving components to temporary locations – availability of spare endpoints in case of failures – ability to add test ASIMs to spare endpoints for troubleshooting.

- Flight Software In the Loop (FSWIL) is a very powerful tool for developing and testing flight software but cannot solve processor specific implementation problems.
PnPSat Timed Integration

PnPSat Assembly
August 9, 2008