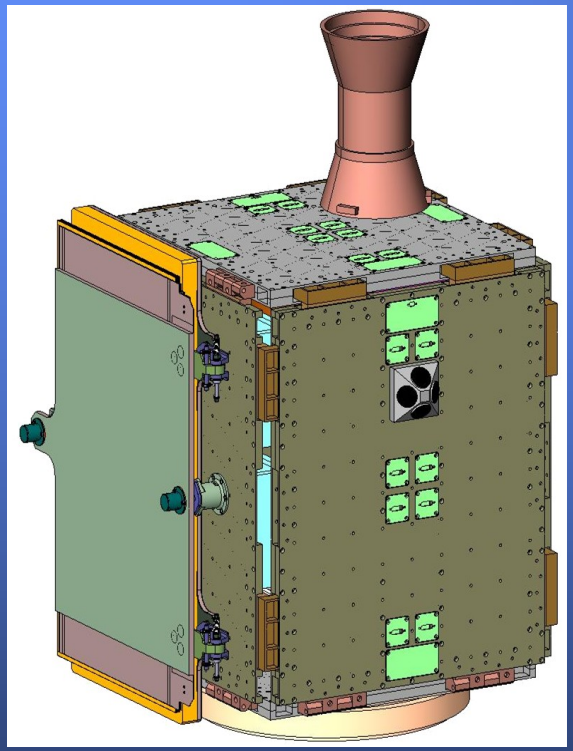
Plug-and-Play Satellite (PnPSat)
Demonstrating The Vision

PnPSat

Don Fronterhouse
James Lyke

PnPSat



Simplify Interfaces

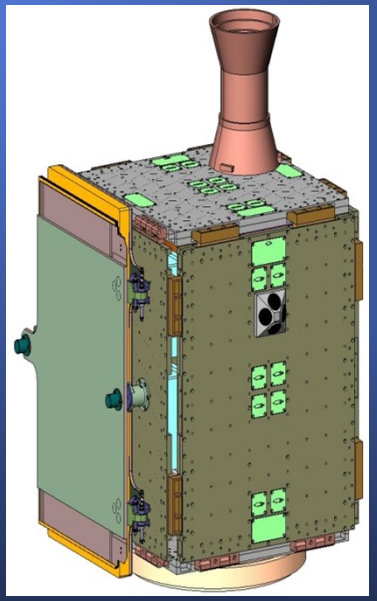
Hide Complexity

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

PnPSat technologies can revolutionize the way spacecraft are designed, assembled, tested, and operated

PnPSat
A Collection of Modular Systems

- Structure
- Power Grid
- SPA Infrastructure
- Thermal

} Basic Bones Of The Spacecraft

- Software
- HPCOO
- Power
- GNC
- Communications

} Customization For Bus Performance

- Mission Sensors

} Customization For User Needs

-

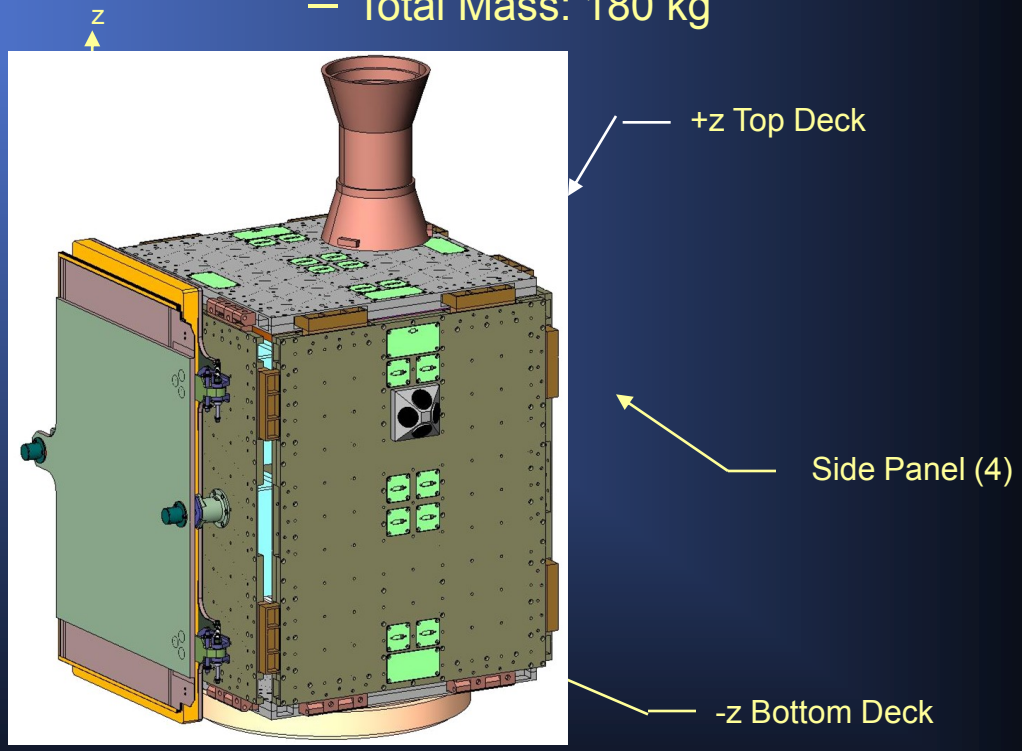
- Assembly, Integration, and Test
- Ground Systems
- Launch Systems

} Integration and Operations Support

Structure Overview

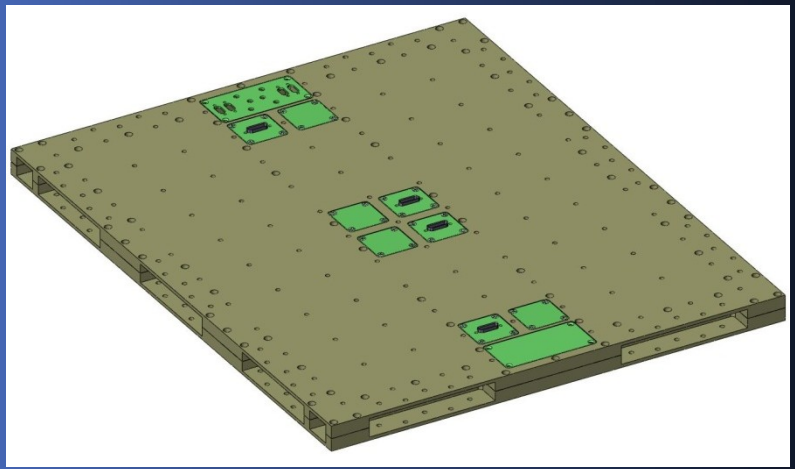
- **Features**
  - Modular panels support quick assembly and flexibility
  - Standard PnP mechanical and electrical interfaces accommodate 48 experiments or components located on the interior or exterior surfaces
  - Electronics infrastructure and harnessing is recessed within each panel to increase footprint and volume for components and experiments
  - Locking hinge joints in five locations allow panels to rotate about hinge line for easy access
  - Inter-panel jumper harnesses across joints allow PnP electrical network to remain intact throughout assembly, integration, and test

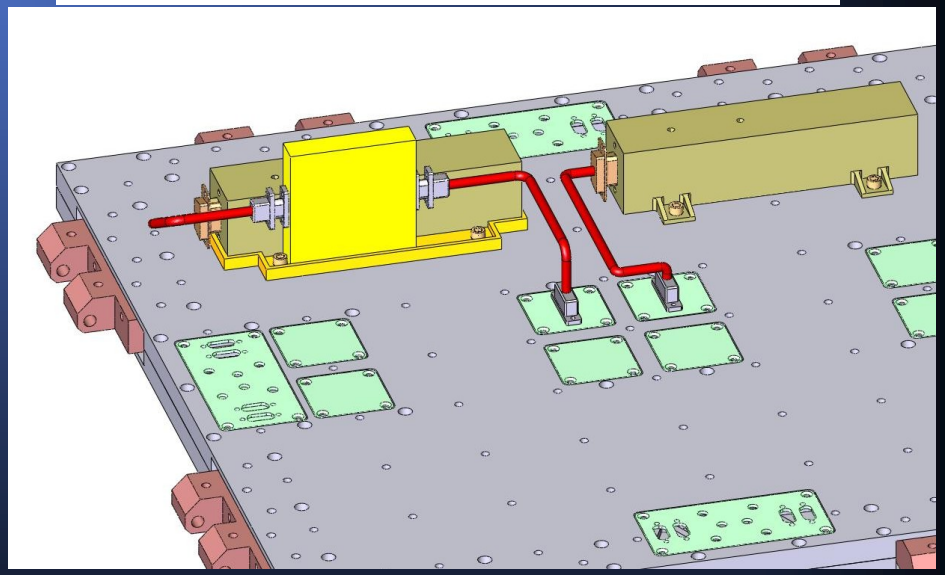
- **Size and Mass**
  - Overall size: 51 x51 x 61.2 cm.
  - CBE Mass: 34.7 kg excluding the LV adapter
  - Total Mass: 180 kg



Standard Mechanical Interface

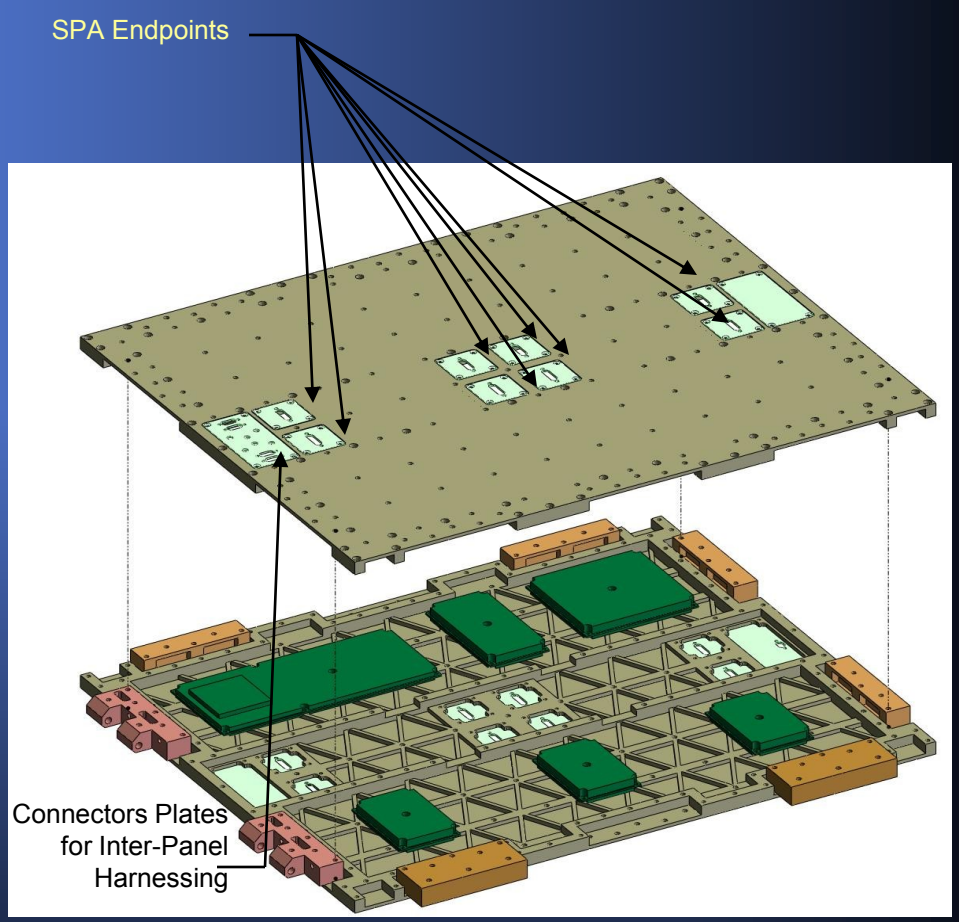
- Simple, standard mechanical interface is established to increase flexibility and quicken integration
  - 5.0 x 5.0 cm grid pattern
  - Across internal and external surfaces of all decks and panels
  - Holes are threaded to support #8-32 fasteners
- New components and experiments should be designed to accommodate this interface
  - Existing components can be integrated with a simple adapter plate





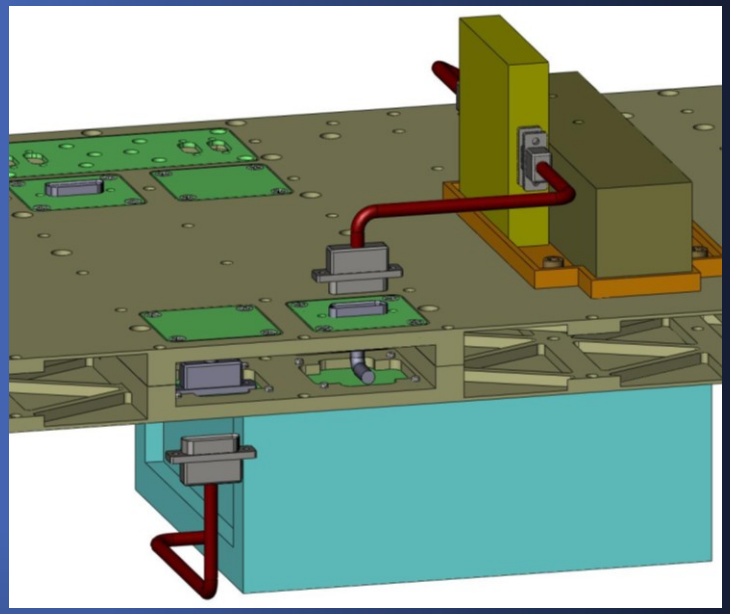
Interior of Panel

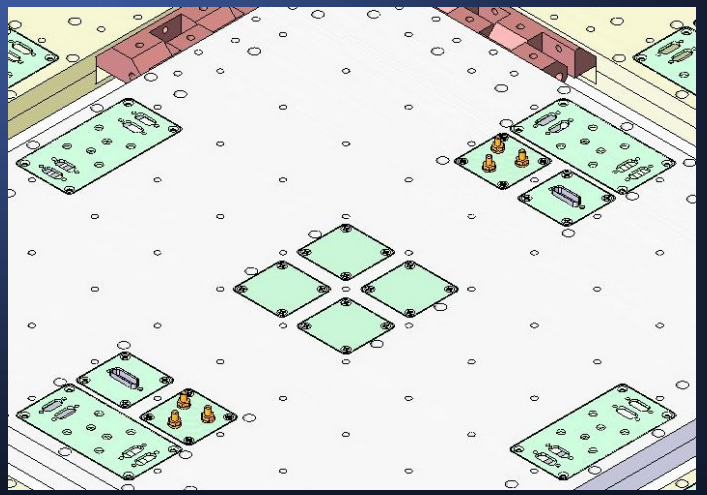
- Electronics infrastructure is recessed within the interior of each panel
  - Electronics boards and inter-board harnessing
  - Provides power and data services to each of eight SPA endpoints per panel
  - Networked to all panels through inter-panel harnessing across specific joints
  - All electrical interfaces exterior to panel will be connectorized
- Panel halves will be attached to one another with #8 fasteners in the thick sections around perimeter and near the center of the panel



Standard Electrical Interface

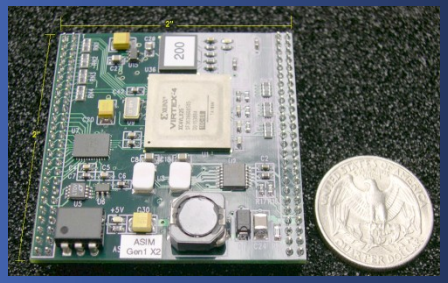
- Standard electrical interface for components and experiments is accommodated by the structure
  - Electrical endpoint is 25-pin micro-D connector
  - This is the single interface to the PnP electrical infrastructure
- Endpoint can be located on the interior or exterior surface of the panel
- Batteries, solar arrays, and power supplies have access to power grids through 3-lug interfaces



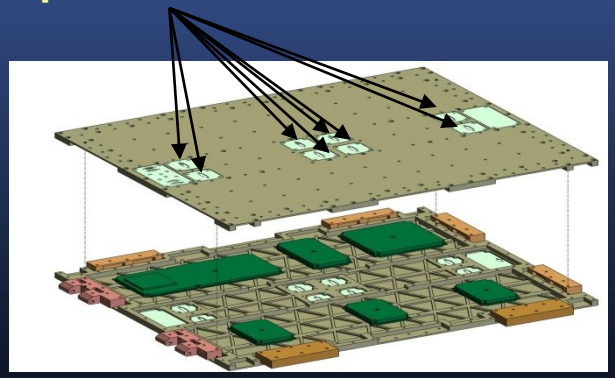


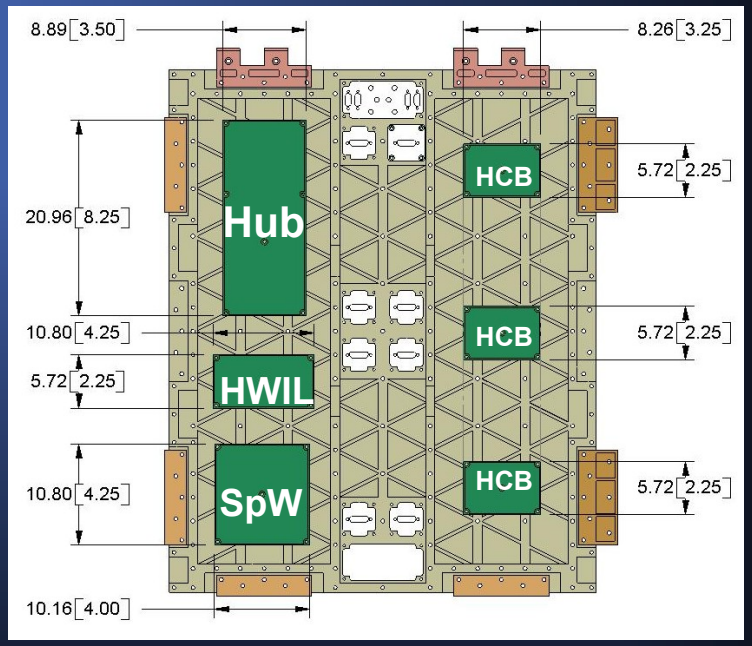
SPA Infrastructure

- ASIM
- Robust Hub
- HWIL Router (ground testing only)
- SpaceWire (SpW) Router
- Hi-power Circuit Breaker (HCB)



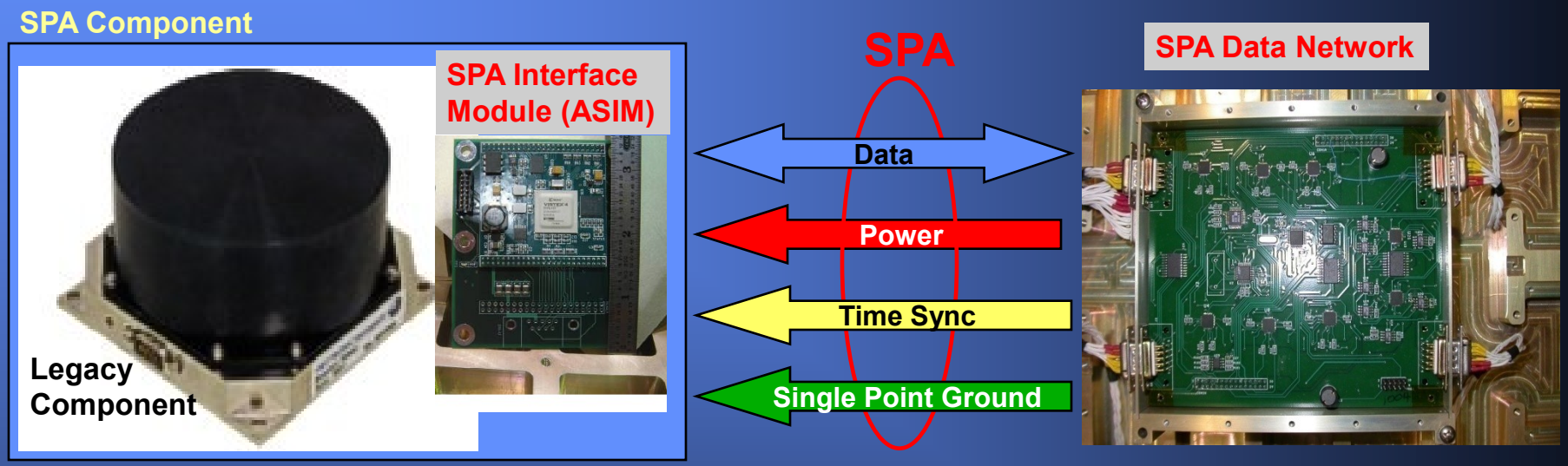
SPA Endpoints





Single Panel

SPA Interface Module (ASIM)

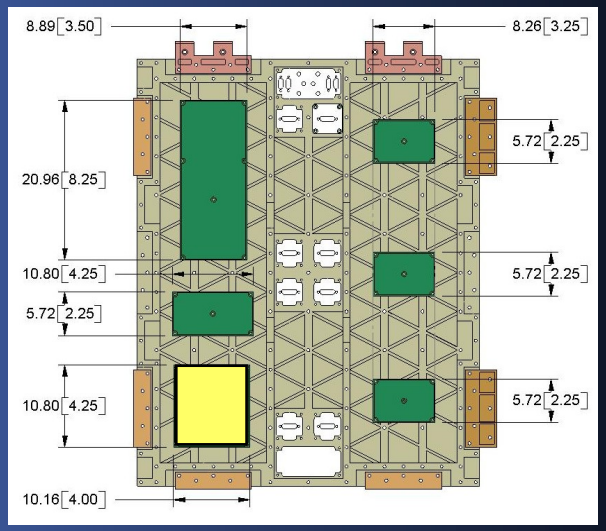


SPA Component Contains Self-Defining Data Sheet (xTEDS)
- Data Products
- Commands Accepted
- Interfaces Supported
- Services Provided

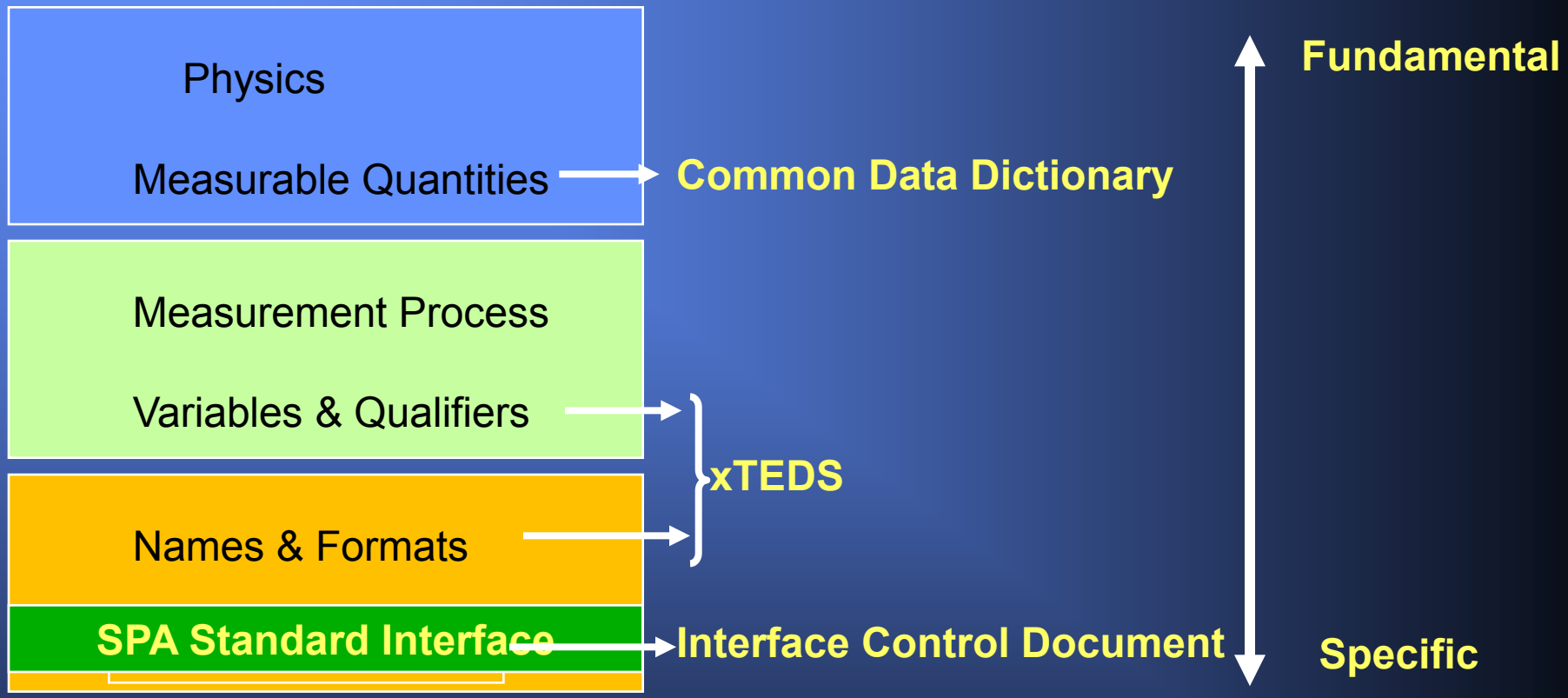
Common Data Dictionary (CDD)
- Standard data meaning
- Distributed to all interested parties
- Extensible

SpaceWire Router

- Provides high speed interconnectivity for all endpoint sites
- Implements SpaceWire protocol to establish switched fabric among 12 ports
- PnPSat link speed of 200 Mbps
  - Demonstrated 625 Mbps in lab
- 12 endpoint ports
  - 8 endpoint ports
  - 2 ports for inter-panel communications
  - 1 port for Robust Hub ASIM
  - 1 diagnostic port



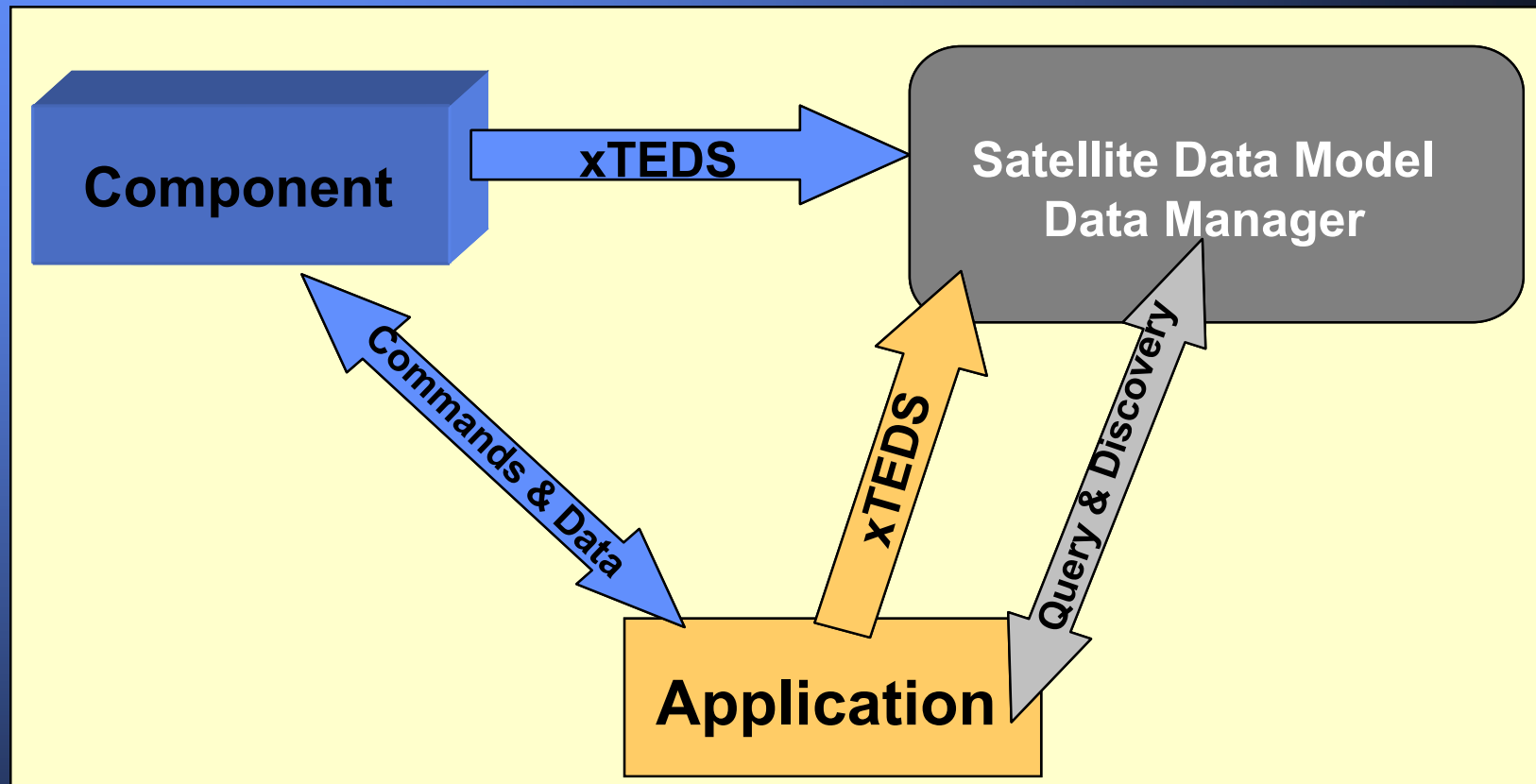
Data Centric Architecture



Plug and Play Interface

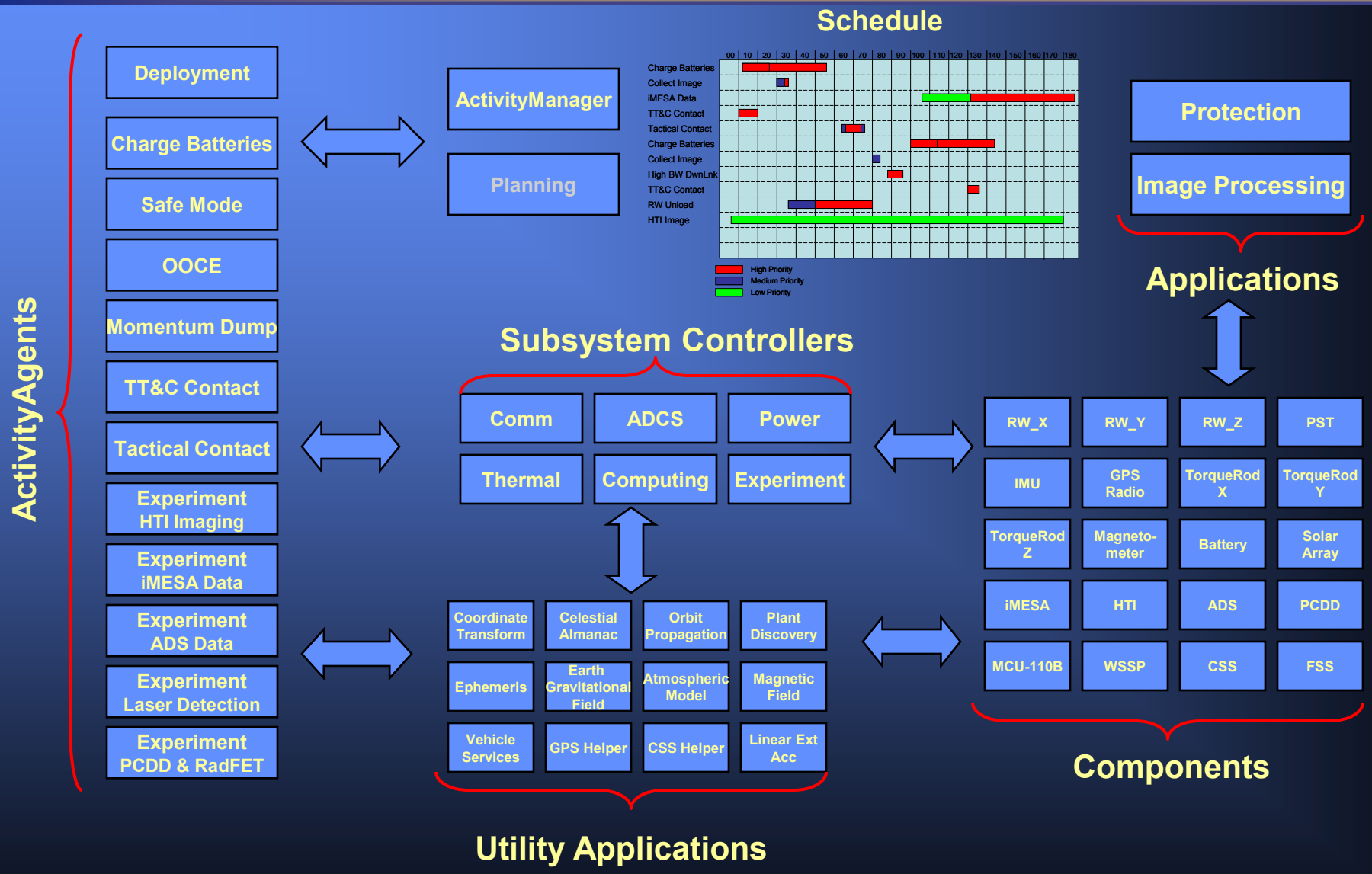
- ***Data interface based upon common standard (CDD)***
- ***Data interface expressed in standard language (XML)***
- ***Electrical interface based upon common SPA standard***

Satellite Data Model



Self -defining – Data, Commands, Services, & Interfaces
Sideware to implement the Play side of SPA
Query and Discovery for software that can adjust to differing configurations
"Help Desk " for flight application software

Flight Software Architecture



PnPSat Separation Timeline

Power(w)	Duration(s)						
20	30	Separation Switch	→	Battery ASIM	→	Bus Power	→ Robust Hubs Boot Power to Endpoints → ASIMs Boot Thermal Control
30	60	WSSP ASIM	→	Boot WSSP Processors	→	Load and Execute SDM	→ Load Initial Task List
30	120	Load and Execute Subsystem Controllers	→	Load and Execute Activity Agents	→	Load and Execute Utility Applications as Needed	
60	600	Activity Agent Deployment	→	Reduce Tip-Off Rates	→	Deploy Solar Arrays	→ Sun Point

Activity Agents Take Over

PnPSat Animation