Spacecraft Loads and Acoustic Measurement (SLAM) Attached ESPA Payload, a Goddard IRAD

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9/14/2022

Agenda:

- SLAM Overview:
  - SLAM Measurement Requirements
  - SLAM History
  - SLAM Development
- Wallops Support:
  - SLAM Development, Test, and Qualification
  - Mission Planning Lab (MPL) Support
  - Access to Space (ATS) Decision Tree (DT) Website:
- SLAM Next Steps

Background on the SLAM ESPA Payload

- SLAM will make direct measurements of the flight environment on ESPA payloads.
- There is measured data on L/V side of the interface, which is used to prescribe the launch environment.
- This data is then used to analytically predict the P/L response as part of the P/L design process.
- However, it is not possible to correlate or evaluate the predicted P/L response w/o a flight measurement.
- The P/L design process is essentially an open loop exercise which many people feel is overly conservative.
- The SLAM measurements will provide information needed to close the loop in the design process and to evaluate the degree of conservatism that currently exist.
- In addition, a L/V's primary P/L is loaded vertically and the flight loads are understood. The secondary ESPA P/L's are cantilevered from the ESPA ports and the flight loads on the ESPA P/Ls are unknown.
- Engineers have estimated the worst flight loads to be 10 g's (TBV) in both the axial and lateral direction, or 14.1 g's vectored (TBV); however, it is believed that this loading is an over-estimate.
- The SLAM P/L will gather data about the flight environment seen by the ESPA ring and secondary ESPA P/Ls.
- More precise data will eliminate the possible over-engineering and over testing of an ESPA P/L, thus decreasing the cost and risk to develop an ESPA P/L.

SLAM Primary / Measurement Requirements

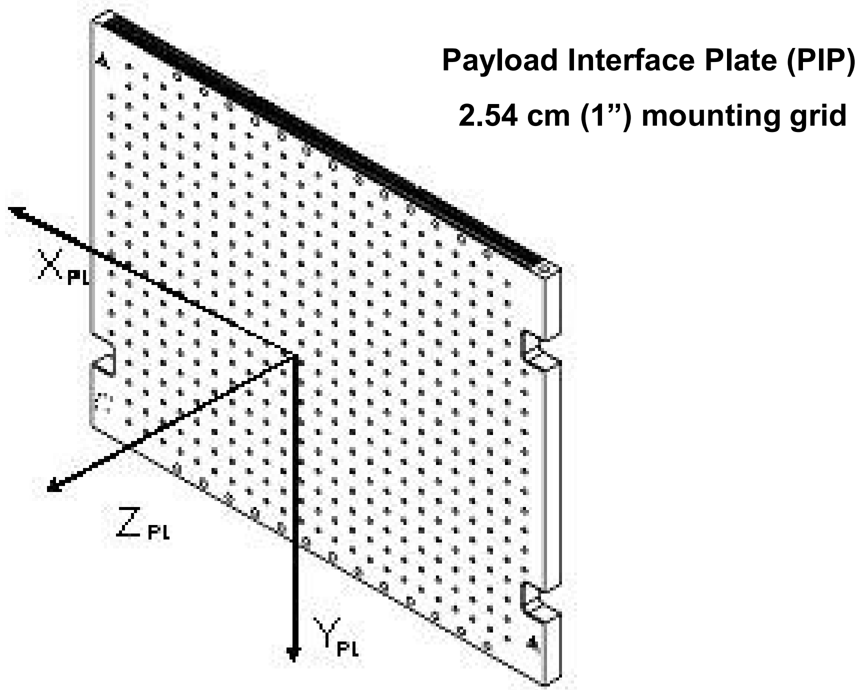
- **Requirement Overview**: Measure the launch environment of rideshare payloads on the ESPA ring from launch through faring separation (~5m) and measure shock, temperature & contamination from launch through rideshare payload separation (where shock measurements are triggered by an event).

- **Requirements**: Measure loads, vibroacoustic levels, temperature, and the contamination environment
  1) Random Vibration – Random levels at an ESPA payload interface are a function of both direct acoustic impingement and mechanically transmitted random. The current guidelines are based on enveloping vibro-acoustic response rather than mechanically transmitted random and are therefore are very conservative.
  2) Shock Environment – Like random vibe, there is a lack of measured shock environments directly at the ESPA port. Current levels are calculated by attenuating the shock source environment, which can be very conservative. Also like random, the shock environment are less sensitive to the P/L configuration on the ESPA ring and will primarily be a function of the specific separation systems and shock producing devices on the LV.
  3) Sine Vibration – This data covers the low-frequency dynamic launch environment. This covers the structural response of the vehicle and the payload stack. As such, the measured data is very sensitive to the actual flight configuration. This data will help to derive better coupled loads simulation for the 50-100 Hz L/V environment.
  4) Quasi-Static Loads – Like sine vib data, this data will help verify the accuracy of the current coupled loads tools.
  5) Acoustic Environment – There is negligible value to making measurements of the acoustic environment
  6) Thermal Environment – This data will use thermal sensors (AD590) to capture the thermal environment at launch.
  7) Contamination Environment – This data will measure the contamination environment at launch (using a QCM).

SLAM Secondary Requirements

– **Requirement**: Explore adding a USAF/STP Payload Interface Panel (PIP), developed by Ball for STP's SIV spacecraft, to the top plate of the SLAM module. The PIP provides a standard mechanical and electrical interface to support cameras and tech demos during for the brief SLAM on-orbit period.

- Accommodates TBD kg of P/L mass
- Mechanical interface provides mechanical support & alignment
- Aluminum PIP provides standard mounting grid
- Payload Area: circular with TBD diameter

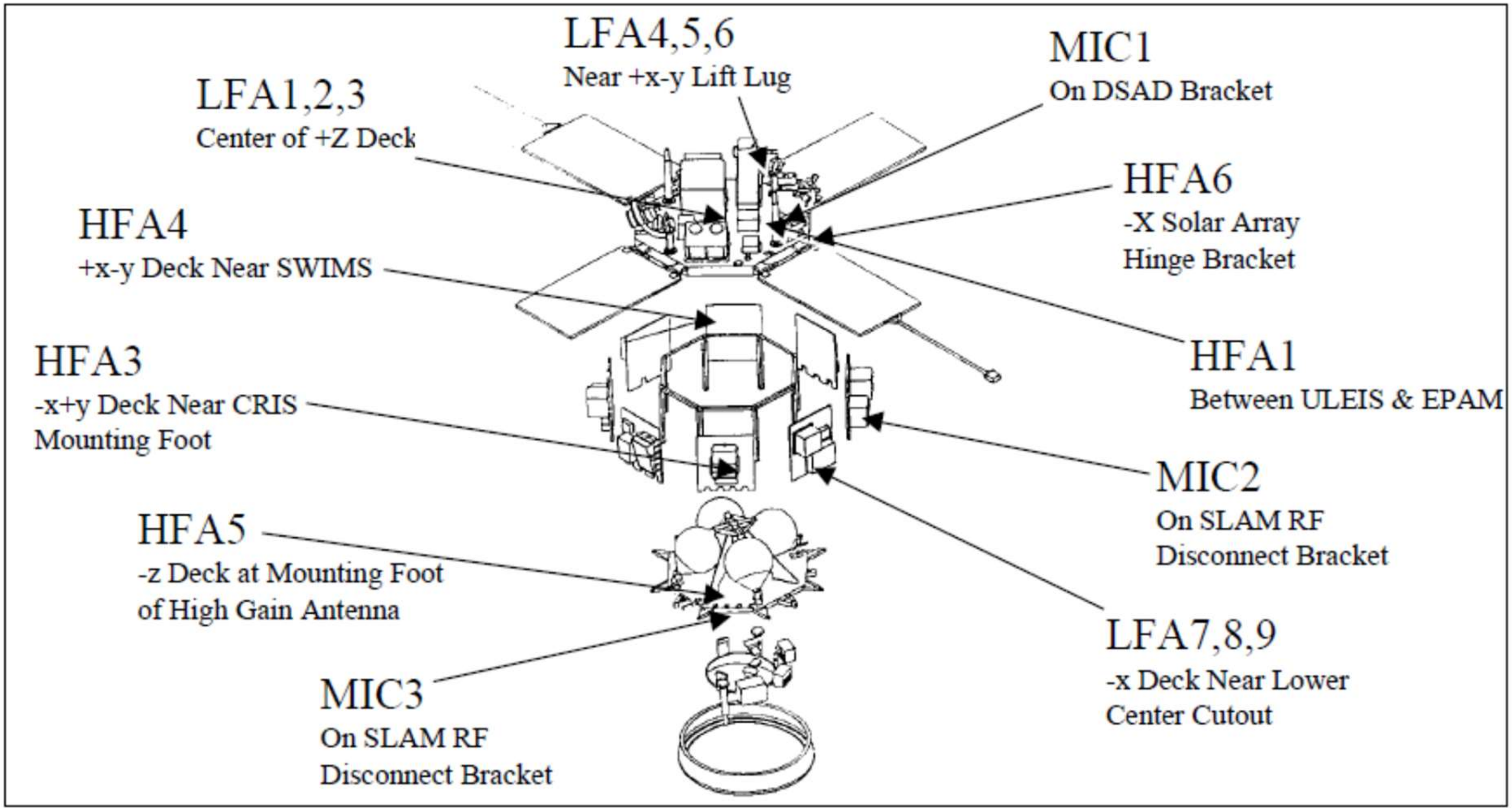


The History of the SLAM Concept

1. SLAM-1: Flew on a Delta II with the Lewis S/C (1996/TBV) and the ACE S/C (1997)
   a) SLAM/Lewis – flew on GSFC's Lewis S/C that launched in 1996 (TBV)
      - SLAM interfaced to the Lewis S/C C&DH and Lewis was going to transmit the data after P/L separation
      - The Lewis S/C failed after fairing separation and the SLAM data was never transmitted to the ground
   b) SLAM/ACE – flew on APL's ACE S/C that launched on 8/25/1997
      - SLAM interfaced to an antenna on the fairing and real-time data was transmitted to the ground
      - SLAM measured the significant P/L events: 1) Lift-off, 2) Airloads (Transonic and Max Q), 3) 1st Pre-main Engine Cutoff (MECO), 4) 2nd Pre-MECO, and 5) MECO

2. ESPA Launch Load Module (ELM): An Eng. Model was developed, but not a Flight Unit
   – ELM was designed by a group of students from Northeastern University (NEU) and Santa Clara University (SCU), under the guidance of engineers from CSA (Moog) and NASA Ames Research Center.
   – NEU did the mechanical design, sensor selection, manufacturing, assembly & vibration testing
   – SCU developed the data acquisition system
   – The ELM planned to attach to an ESPA port, included all measurement devices, recorded and stored the data onboard, and transmitted data to the ground after all ESPA payloads were deployed.

APL's ACE S/C and the SLAM Transducer Locations (1997)



The ACE/SLAM Mission Timeline (1997)

Main Engine Ignition	132.4 sec
Ground Lit Solid Motor Ignition	132.5 sec
Liftoff	132.7 - 139 sec
Transonic - Max Q	155 - 188 sec
Air Lit Solid Motor Ignition	198.2 sec
Ground Lit Solid Motor Separation	198.7 sec
Air Lit Solid Motor Separation	264.2 sec
1st Pre-MECO	300 - 328 sec
2nd Pre-MECO	330 - 346 sec
MECO	392 - 395 sec
Stage 1/2 Separation	405 sec
Stage 2 Ignition	411 sec
Fairing Separation	415 sec

- Launch Date - August 25, 1997
- Liftoff (T0) occurred at 132.67 seconds SLAM time which corresponds to 237 14 39 0.54 GMT

SLAM Configuration Options

– **Baseline Configuration**: ***SLAM-1/Lewis Configuration***

1) Operations: Triggered on launch, collect measurement data, buffer data internally, transfer data to the upper-stage after payloads deployed, and the upper-stage transmits data to the ground..
2) Power: Internal Battery (+28VDC)
3) Data Interface: High-speed serial interface to the upper-stage
4) Hosted Payload Interface: No

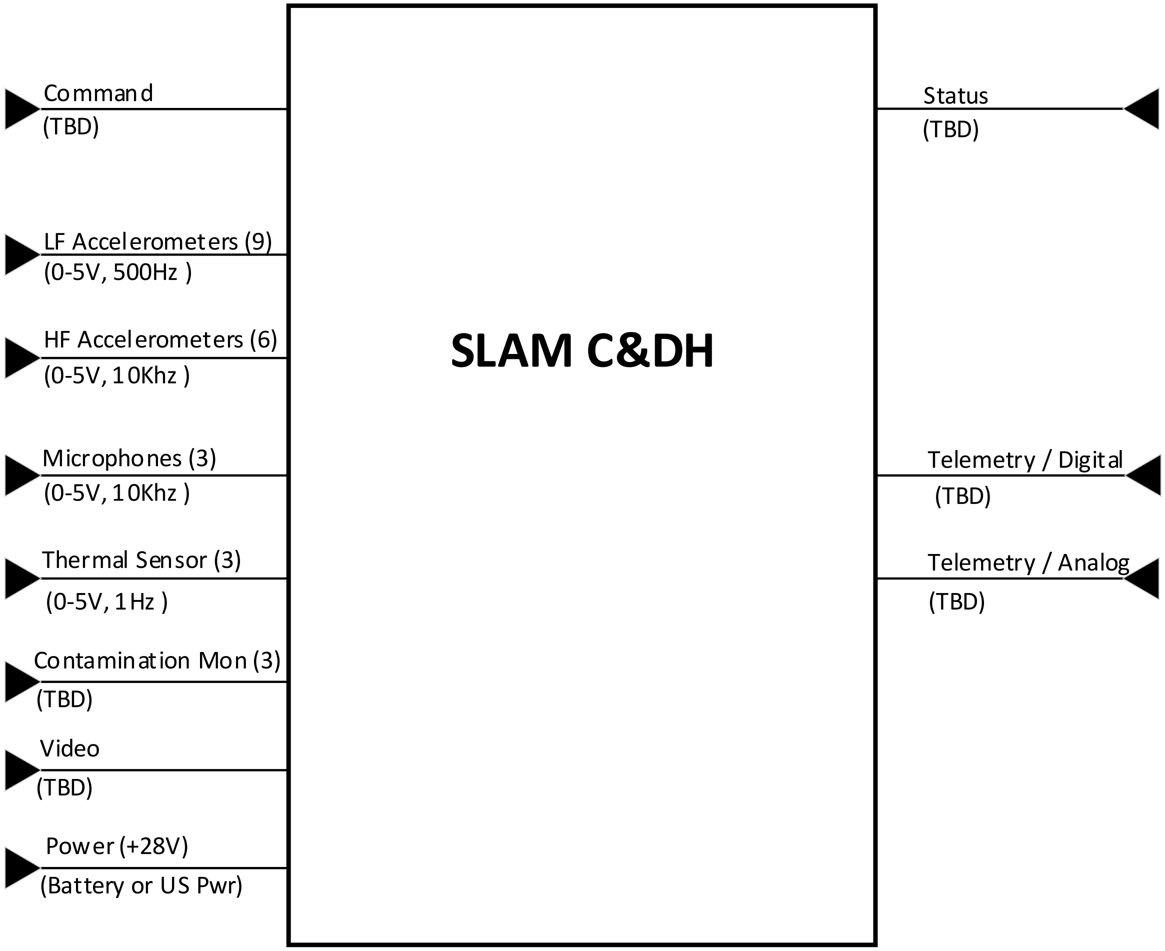
– **Optional Configuration-1**:

1) Operations: Triggered on launch, collect measurement data, transfer real-time data to the upper-stage, and after payloads are deployed, the upper-stage transmits data to the ground.
2) Power: Upper-stage provided power
3) Data Interface: High-speed serial interface to the upper-stage
4) Hosted Payload Interface: Payload Interface Panel (PIP) for tech demo and/or video camera

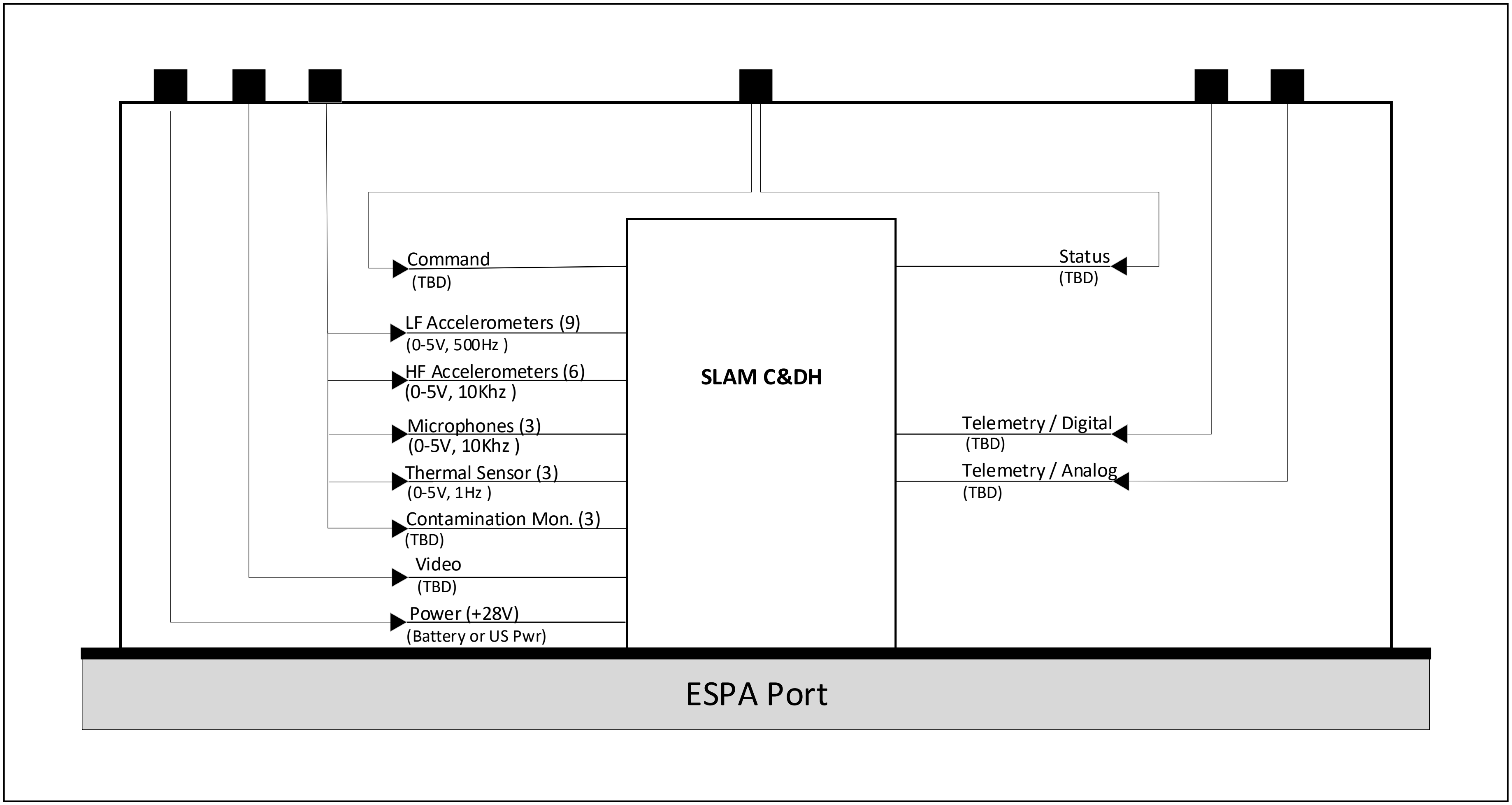
– **Optional Configuration-2**: ***SLAM-1/ACE Configuration***

1) Operations: Triggered on launch, collect measurement data, encode and packetize data, transfer real-time data to a dedicated SLAM transmitter/antenna.
2) Power: Internal Battery (+28VDC)
3) Data Interface: High-speed serial interface to a dedicated transmitter
4) Hosted Payload Interface: Payload Interface Panel (PIP) for tech demo and/or video camera

SLAM Block Diagram (1/2)



SLAM Block Diagram (2/2)



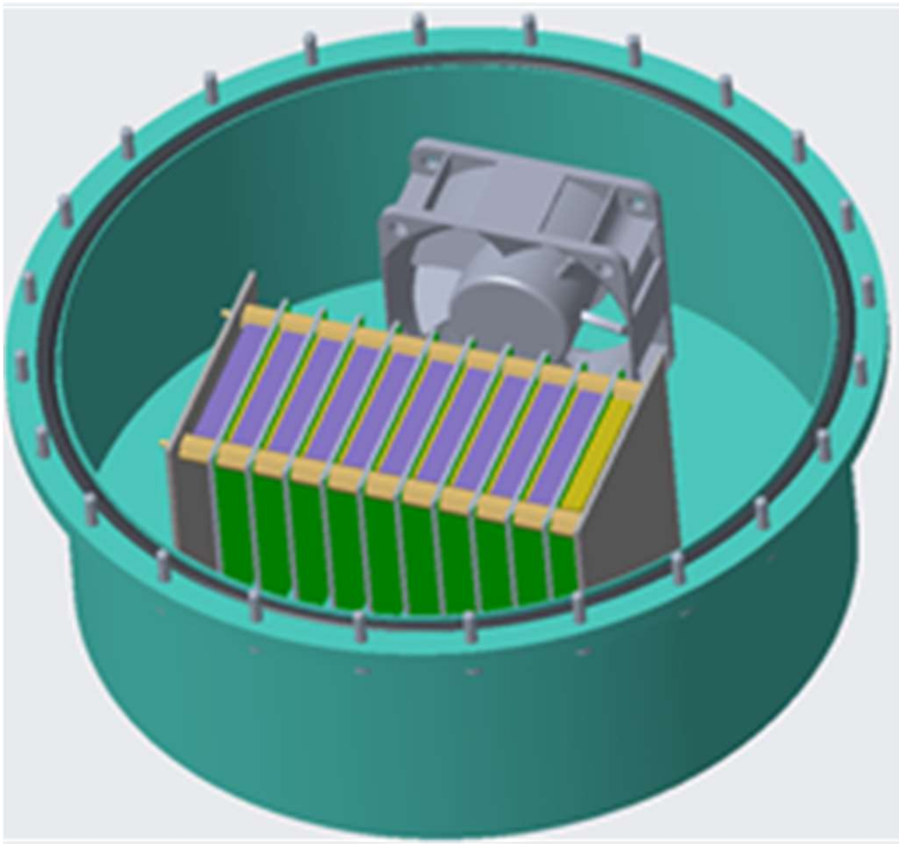
***Back to the Future*:** Revisiting the Shuttle GAS Program

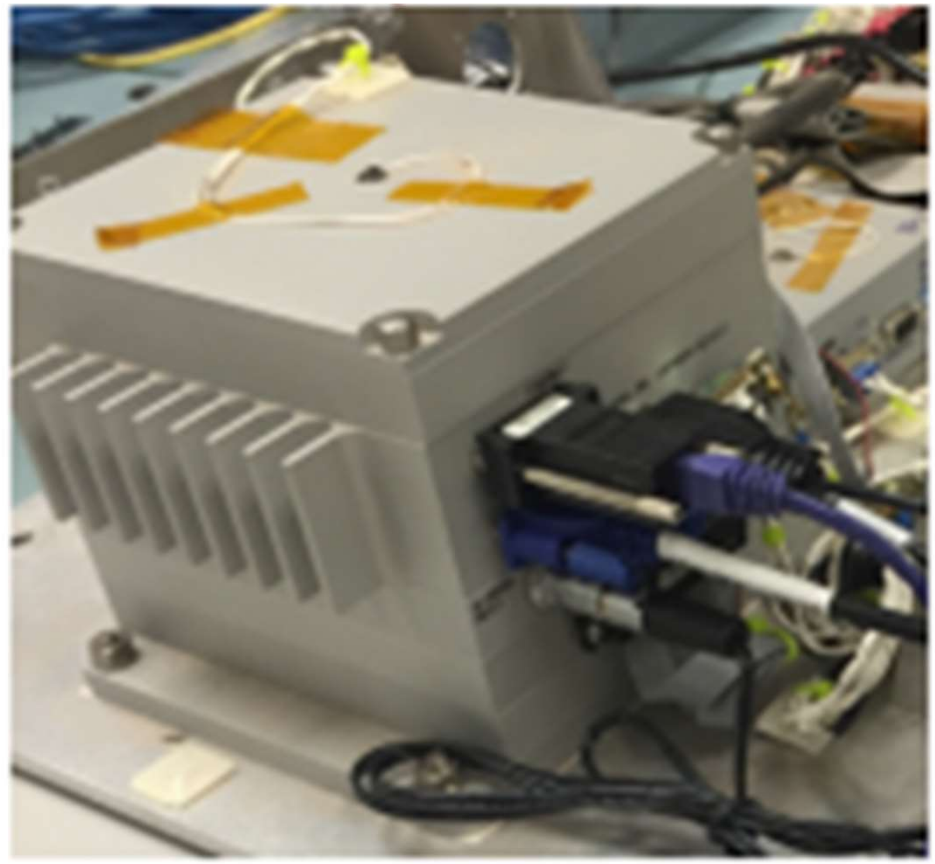
Implementing an Architecture based on Pressurized Canisters

The hardware architecture is called the Capsulation Satellite or CapSat:

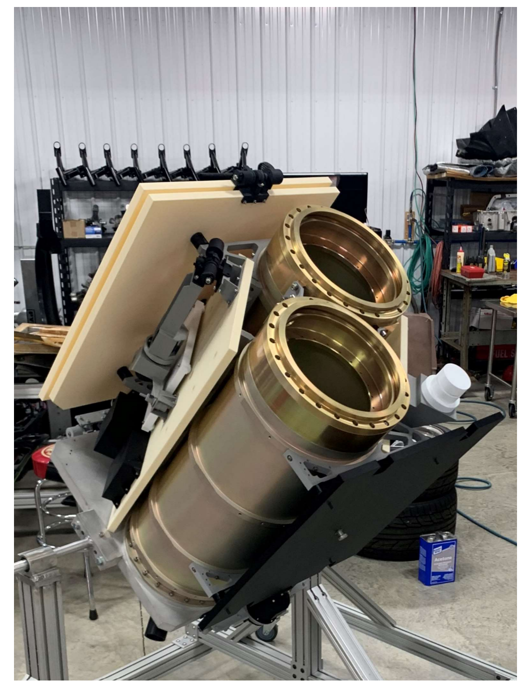
- The concept is based on flying a pressurized Spacecraft (like NASA's GAS and Hitch Hiker programs, pressurized cargo like the Dragon module, Space Station, Space Shuttle, and early unmanned Russian missions as well as the current Russian military communications satellite constellation "Meridian" and GLONASS).
- The CapSat Spacecraft and Payload can be qualified separately (Like a Hitch Hiker or Get Away Special (GAS) can missions), decoupling these tests, helps reduce cost, schedule, and technical risks.
- S/C & P/L components are kept at terrestrial pressures and temperatures for the life of the mission.
- This approach is fully compatible with the test-as-you-fly and fly-as-you-test philosophy.
- It allows a much broader range of commercial and industrial parts to fly in space while maintaining the majority of their design environments
- Thermal design is greatly simplified and considerably more constant adding to the longevity of the mission
- COTS products will undergo a ruggedizing process which will include attention to radiation effects.

The SLAM Top-hat Module & Commercial Avionics

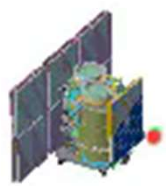




SLAM’s Next Step: Implementing the CapSat Spacecraft



The CapSat Spacecraft



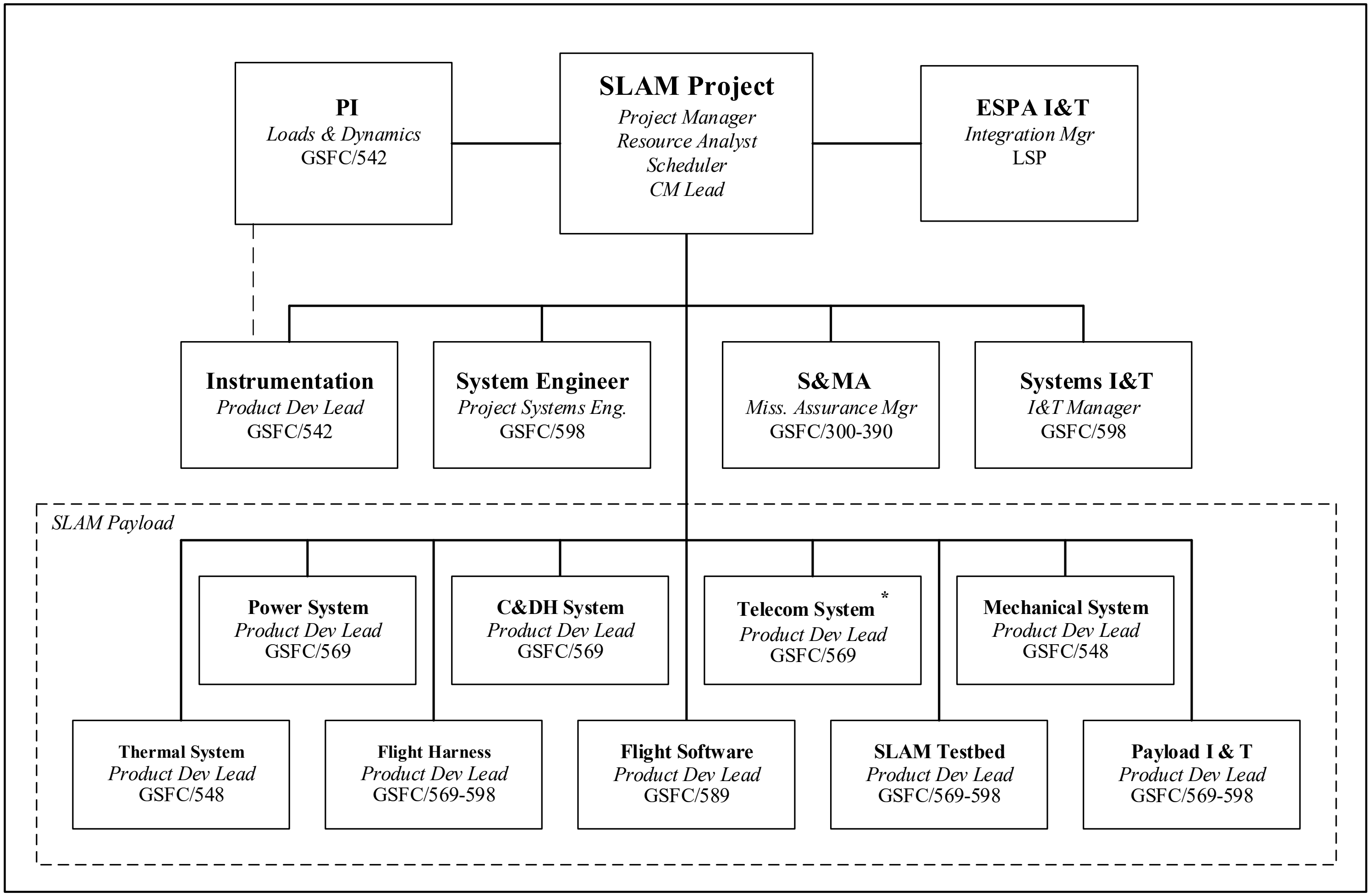
Simp Rep:DEBRIS-SAT_W_JAPANS_INSTRUMENT

Instance GENERIC

Wallops Support:

- SLAM Payload Development, Test, & Qual
- Mission Planning Lab (MPL) Support
- Access to Space (ATS) Decision Tree (DT) Website

Wallops Support: SLAM Implementation NASA 7120.8 vs. 7120.5 (Class D)



Wallops I&T Support: Payload Processing

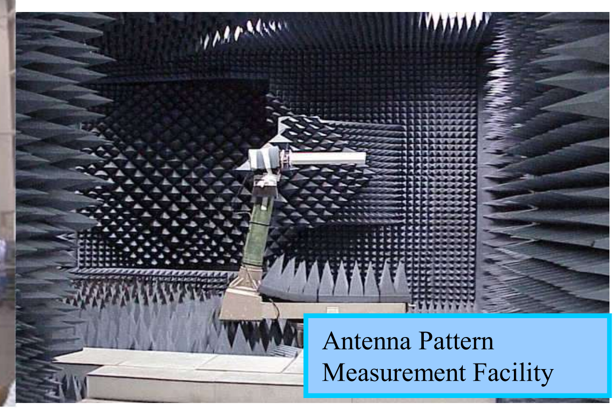

EMI/EMC Facility


Vibration Facility


Thermal Vac Chamber


High Bay East


High Bay West


Antenna Pattern Measurement Facility

Wallops Labs in Engineering Building


Mission Planning Lab


Fabrication Area

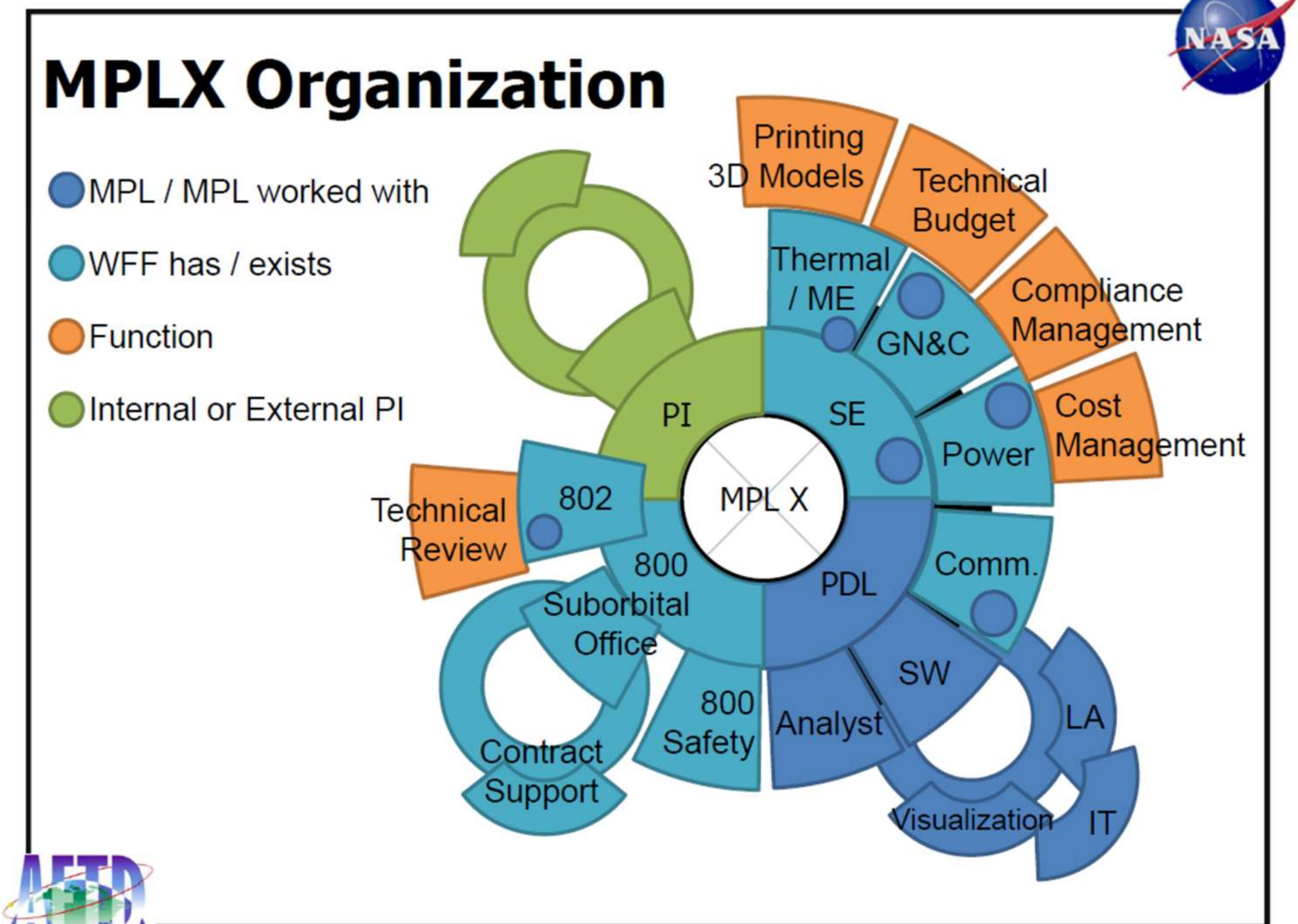

I&T Labs


GPS Simulator Lab

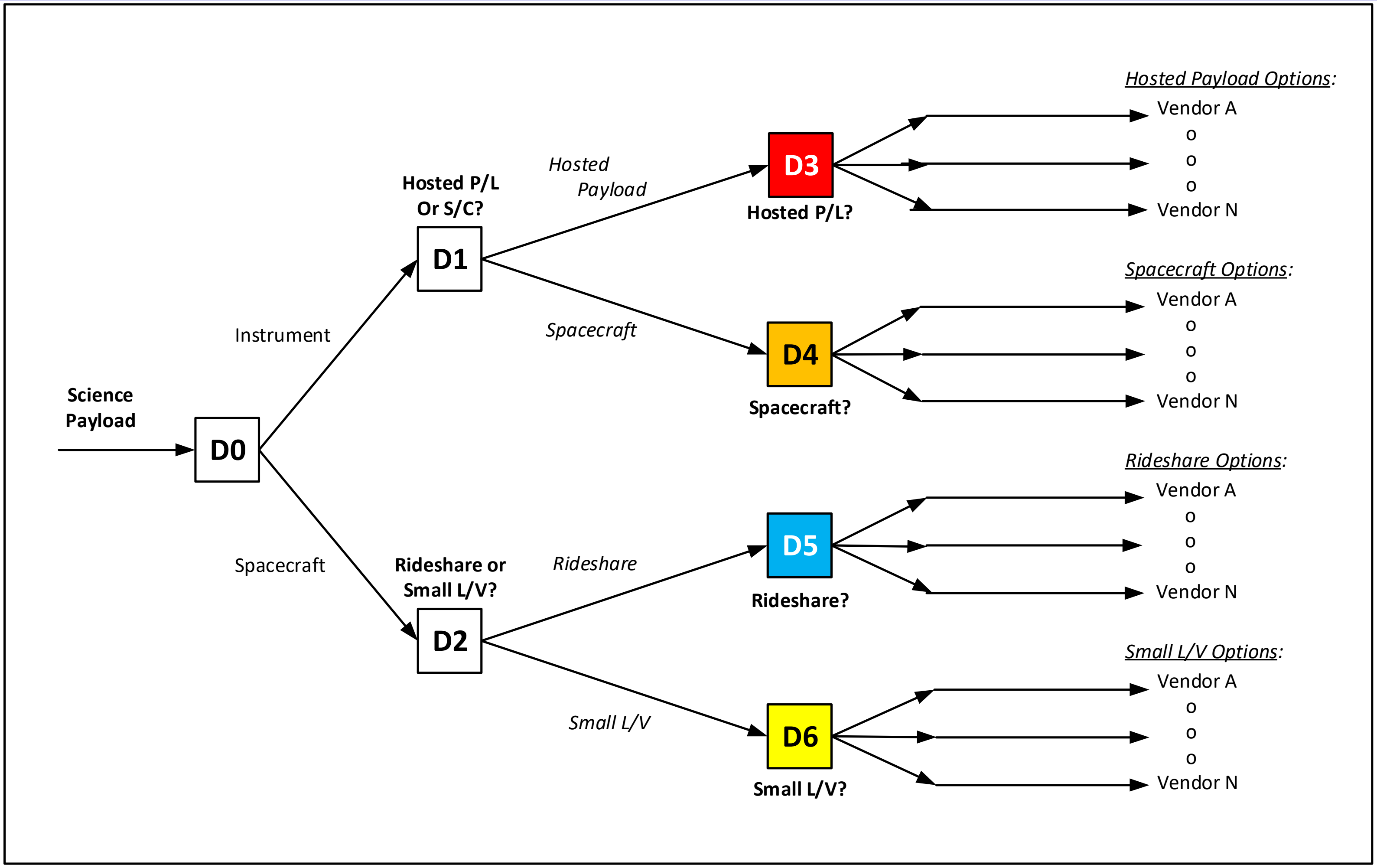

Electrical Labs

Wallops Support: Mission Planning Lab (MPL)

Turning a science concept into a feasible mission for competitive science proposal.



Wallops Support: ATS Decision Tree (DT) Website

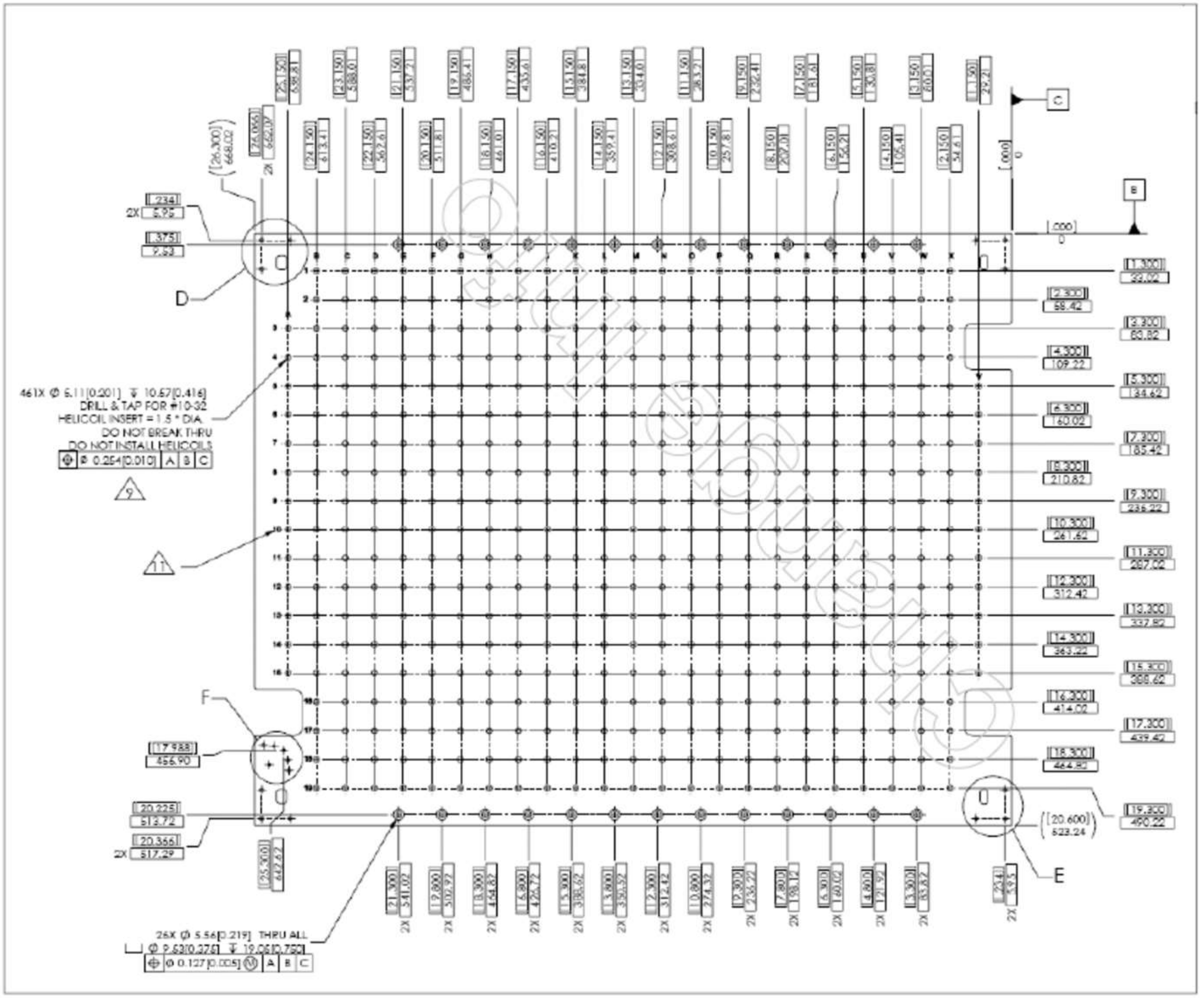


SLAM Next Step

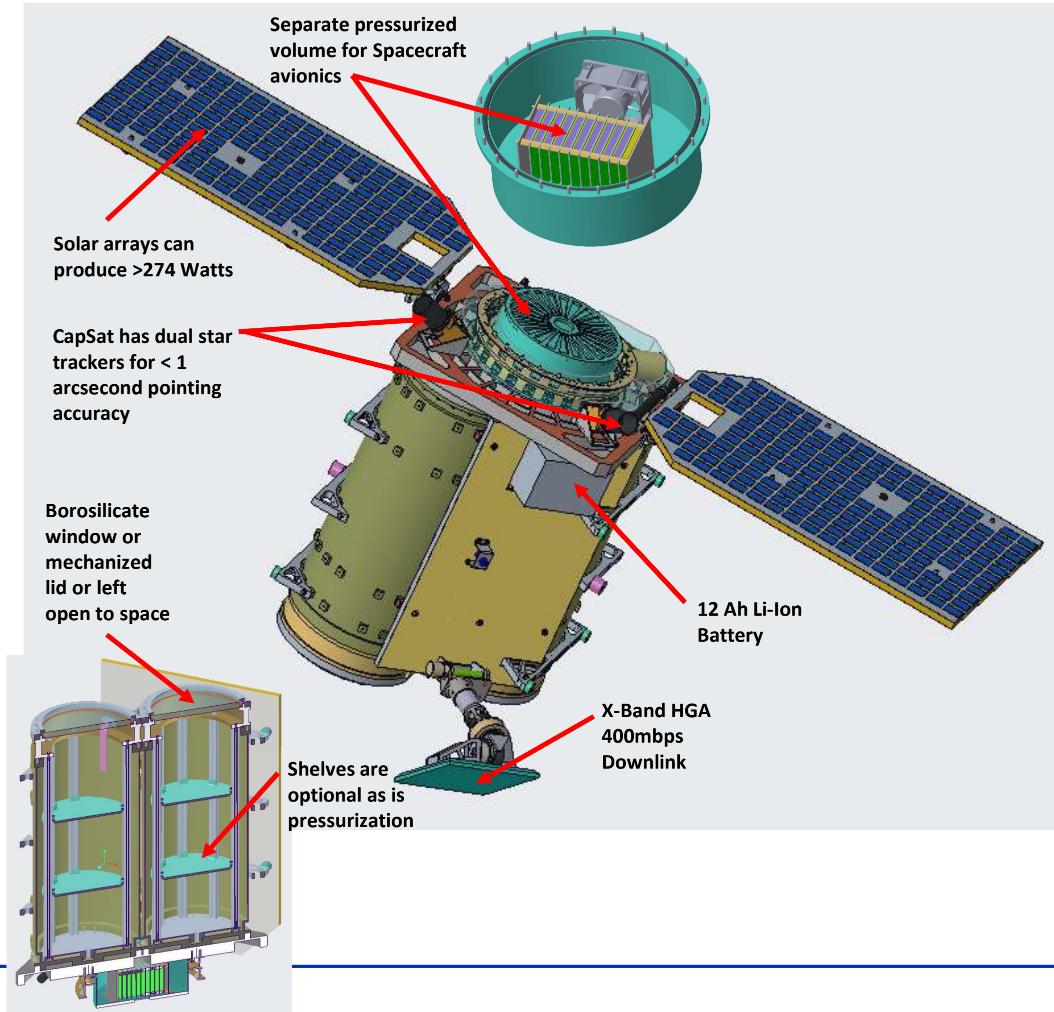
1) Continue weekly and monthly meetings with the SLAM Team & refine the requirements.
2) Review the SLAM WBS elements with the Team and draft their schedule and budget.
3) Draft the SLAM Implementation Plan and review it with partners and stakeholders.
4) Identify funding to transition the SLAM IRAD into a flight project, negotiate potential launch opportunities, and begin project formulation and implementation.
5) Work with partners and stakeholders to agree on how may flights per L/V are required
6) Work with partners and stakeholders to agree on criteria for updating the ESPA payload design guidelines
7) Continue maturing the CapSat spacecraft concept and explore funding options and launch opportunities

Backup charts …

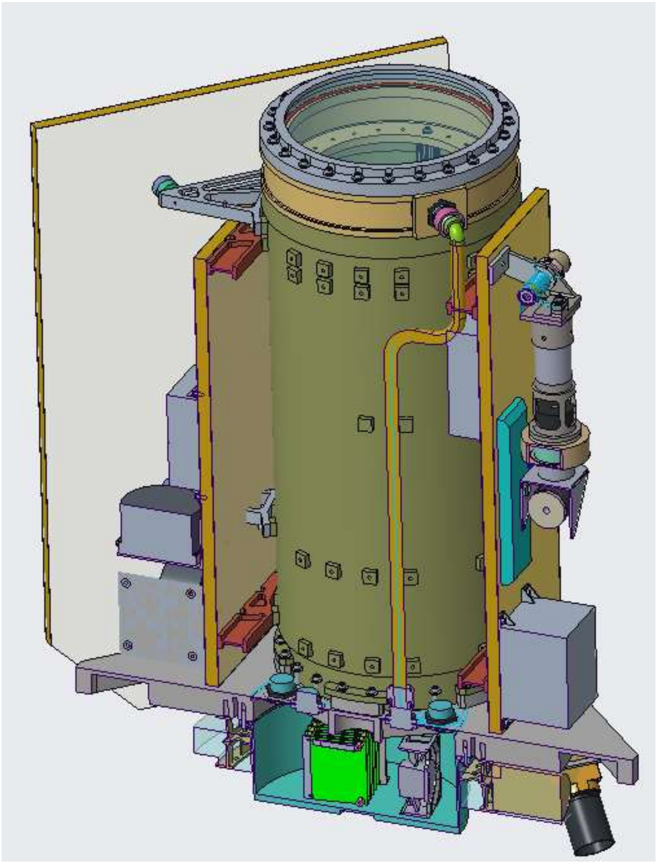
The Original PIP Drawing & Configuration Options

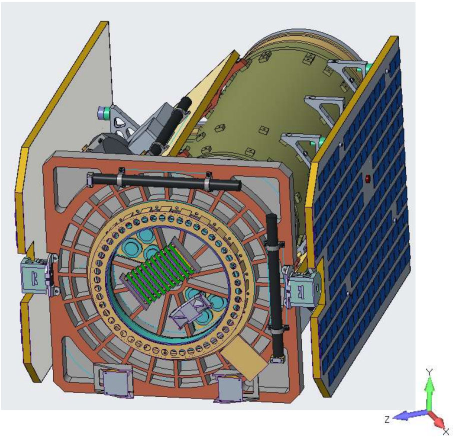


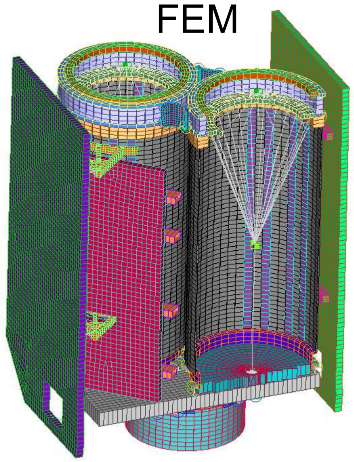
CapSat isometric deployed



CapSIT Tube Interchangeability

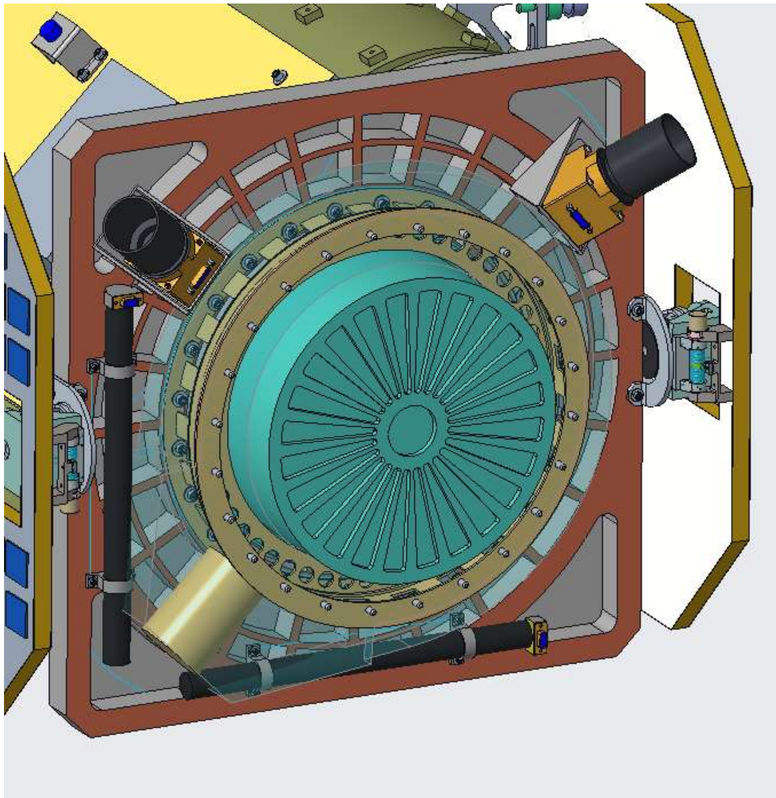




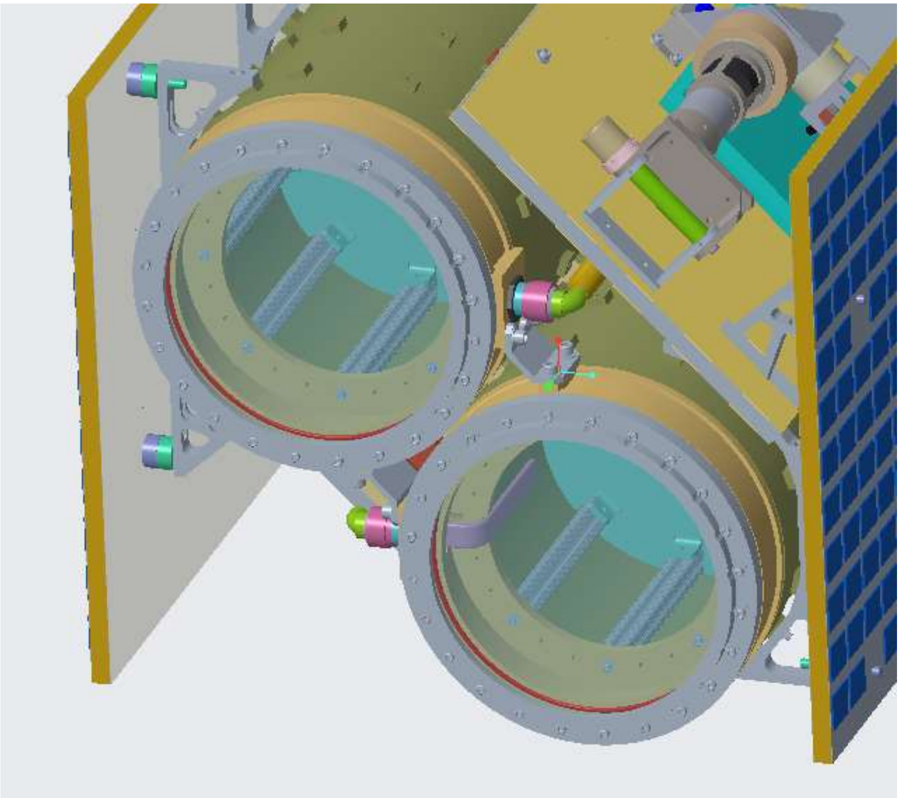


Fully loaded CapSat Spacecraft, including 2 CapSIT tubes with instruments installed, has a 1st fundamental Frequency of 88hz. Coupled loads are being analyzed for 6 CapSats potentially flying with JPSS-2. The CapSIT interchangeability allows for a single coupled loads analysis regardless of which tubes are selected for launch.

Capsat isometric stowed views



Bottom View



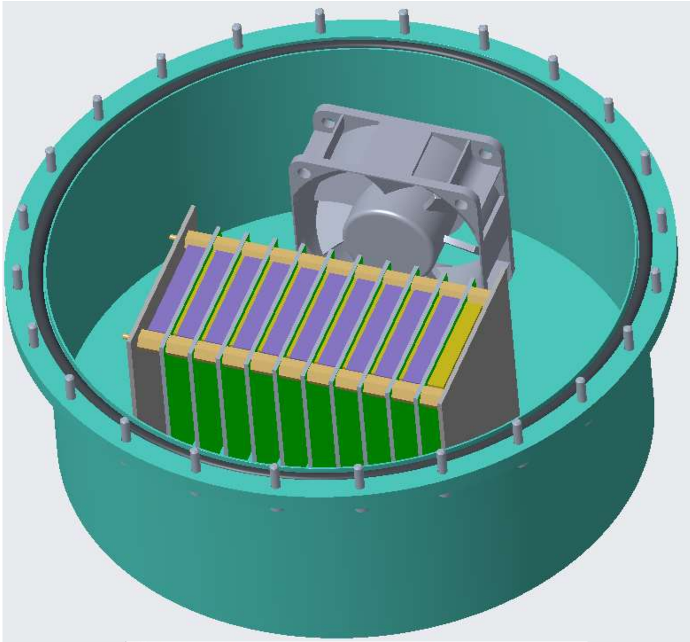
Top View

Pressurized Spacecraft Avionics Compartment

CapSat will take advantage of a pressurized volume for both the spacecraft and the payload.

Highly capable commercial- and military-quality instrumentation systems designed for aviation and other purposes are readily available at low cost. CapSat utilized such a system in its development unit in 2016.

CapSat is upwards compatible. Should an application/customer wish to upgrade; there is always the option to upgrade to a high reliability flight proven avionics system of which Goddard actively builds and fly's. This would allow for a quick and smooth transition to a higher quality system.



VOLUME = 8.6251531e+01 INCH^3
SURFACE AREA = 1.3560890e+03 INCH^2
AVERAGE DENSITY = 9.9576561e-02 POUND / INC
MASS = 8.5886308e+00 POUND