



Bridging the Gap: A Standard Bus For Nonstandard Payload

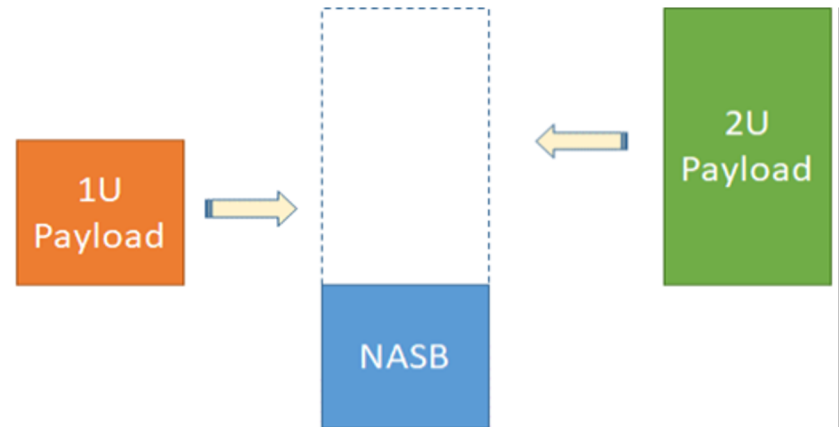
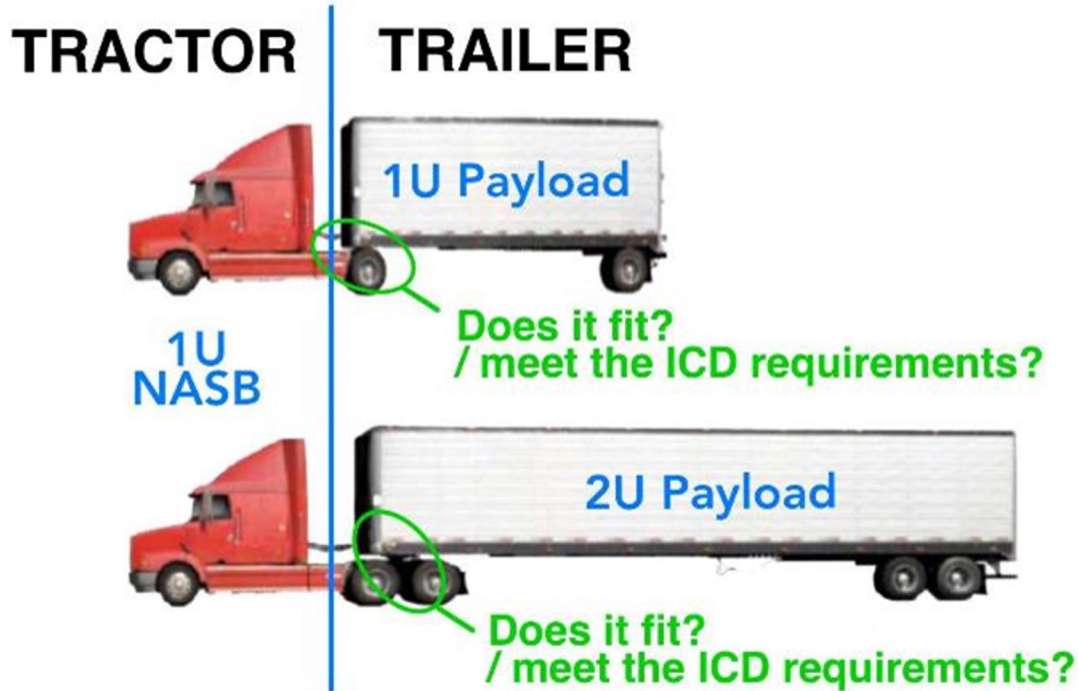
CubeSat Workshop 2024

Anuga Ekanayake, George Hollister, John Moore, Audrey Saroka

April 23, 2024

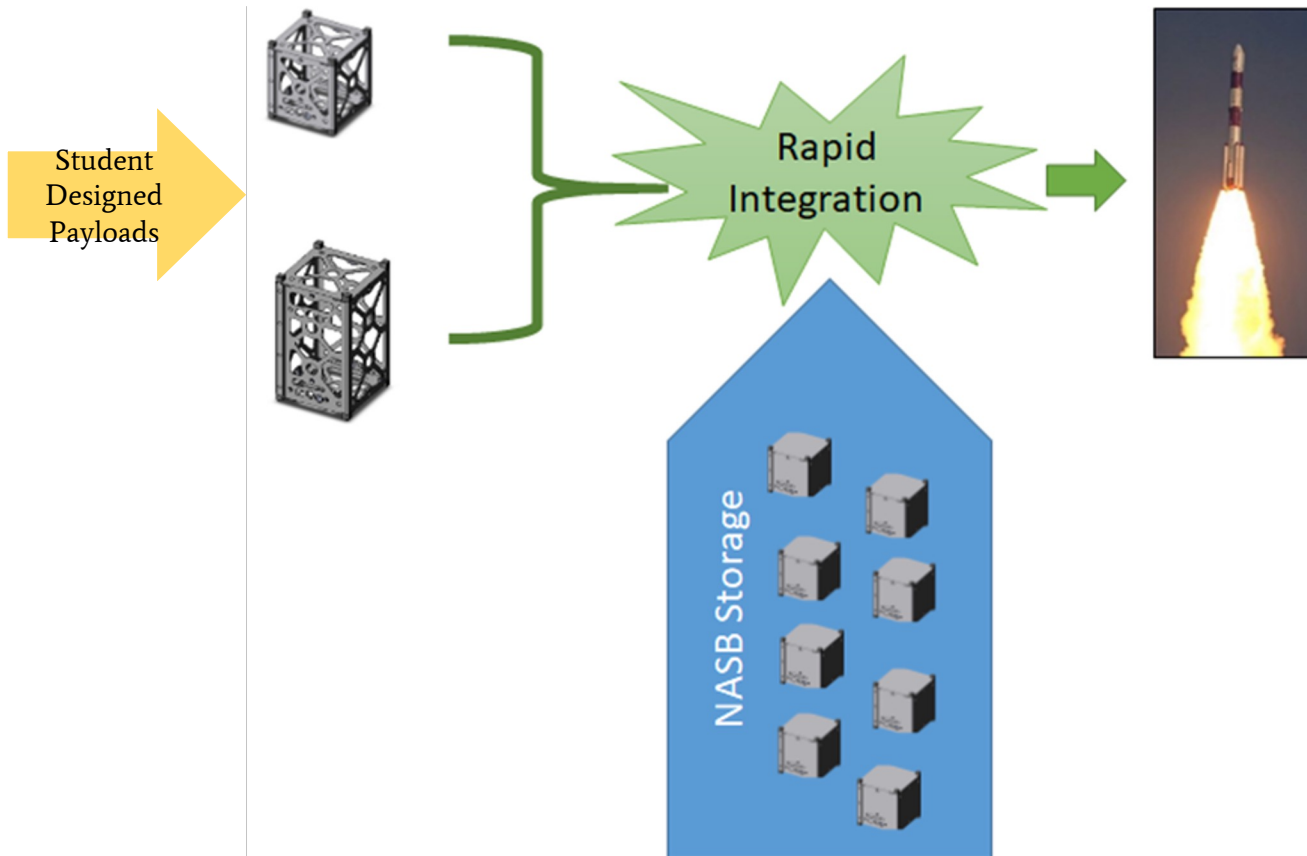


Naval Academy Standard Bus (NASB) Tractor-Trailer Design





Parallel development of NASB and Payload

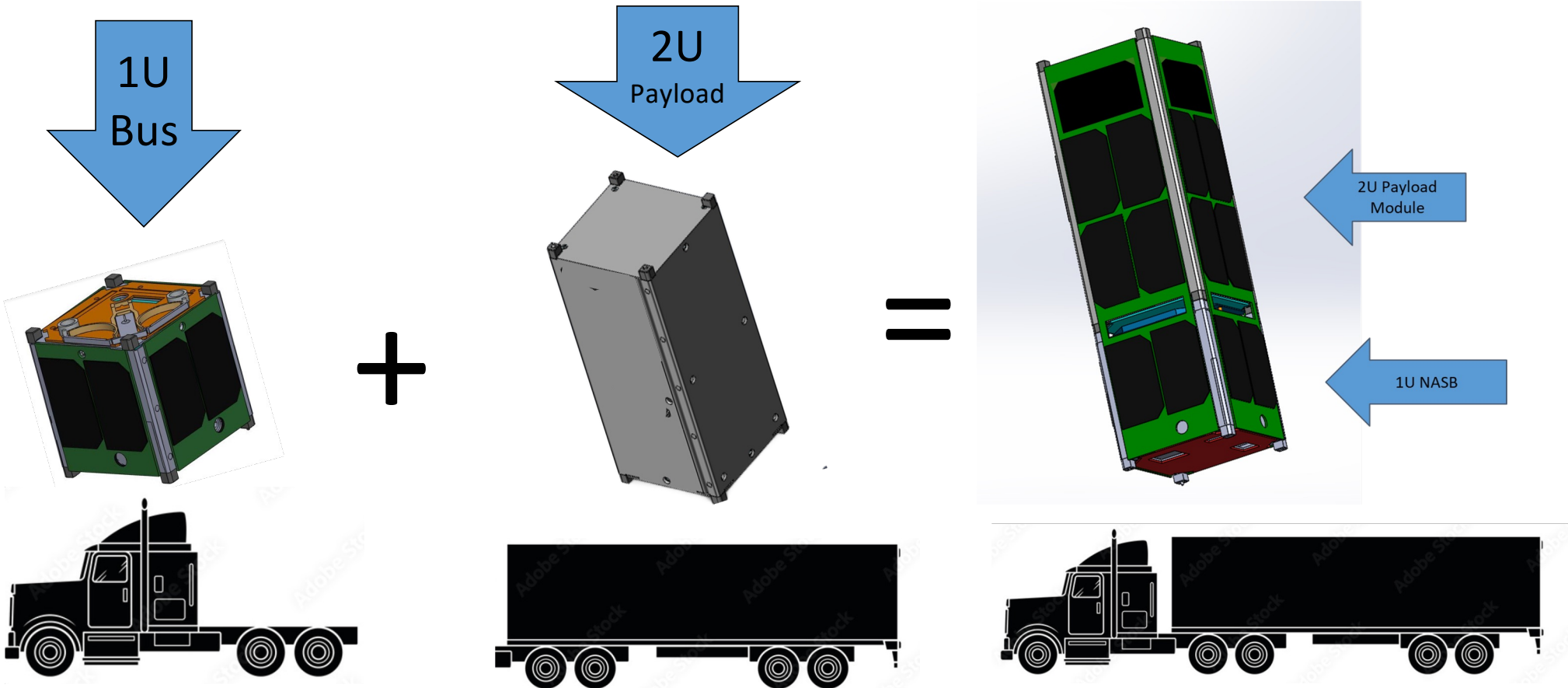


Completed satellites launched whenever opportunity given

- Successful payload developed, OR
- NASB on its own



Combined 3U CubeSat





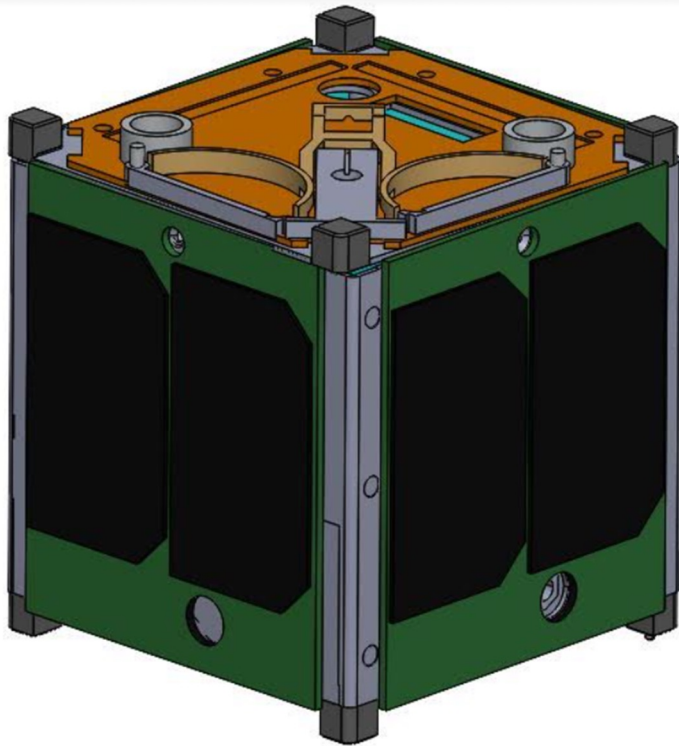
Interface Control Document



- Dimension requirements
- Mass and mass properties requirements
- Integration/adaptor requirements
- Electrical interface requirements



General 1U Standard Bus



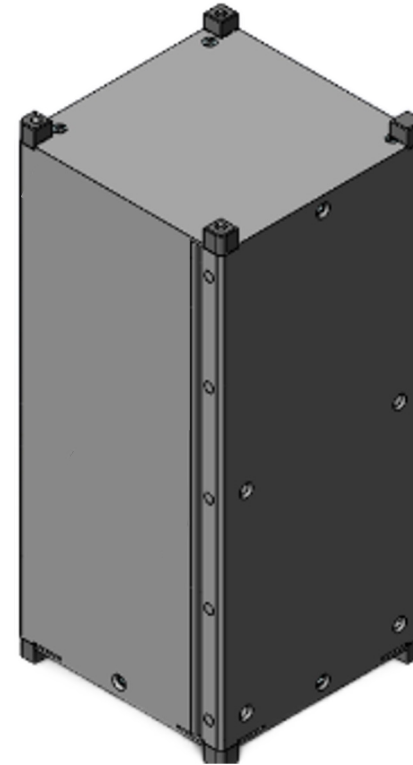
- Modular solution: quick to construct and repeatable
 - Mass: 1.2 kg (1.3kg max)
 - Communications:
 - UHF antennas (up/down): 433 MHz
 - S-Band patch (down): 2.4 GHz
 - Passive attitude control system using hysteresis rods
 - Ability to add other ADCS systems as a “payload”
 - Can accommodate a 1U or 2U payload



Payload Module (PM)



- Passes power and communication for up to 3 payloads
- Provide physical connection of payload module to bus

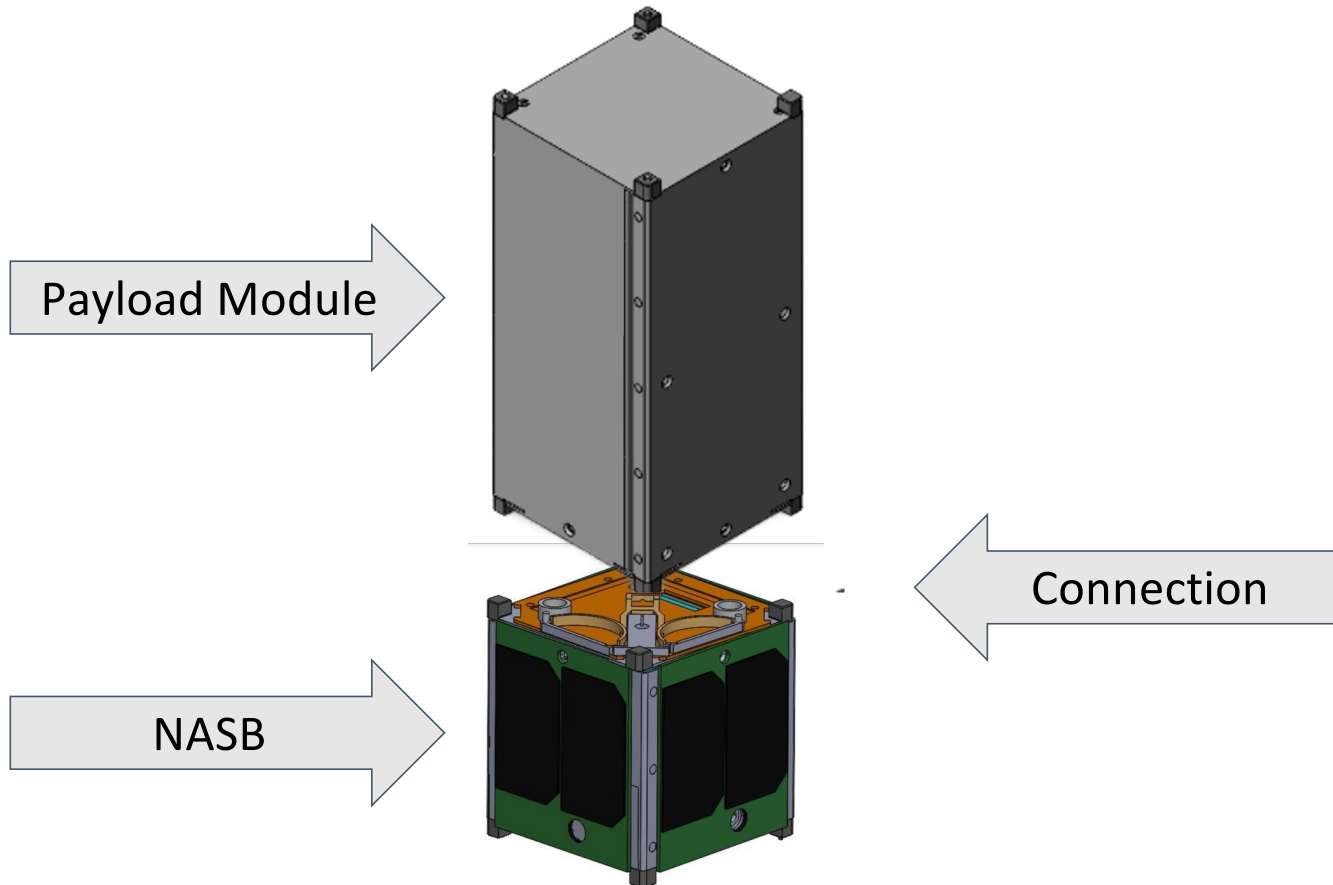




Mechanical Interface



Combined 3U CubeSat

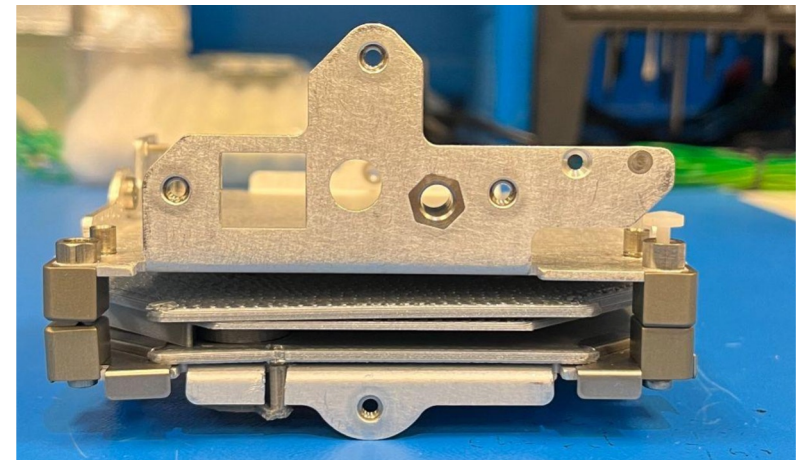
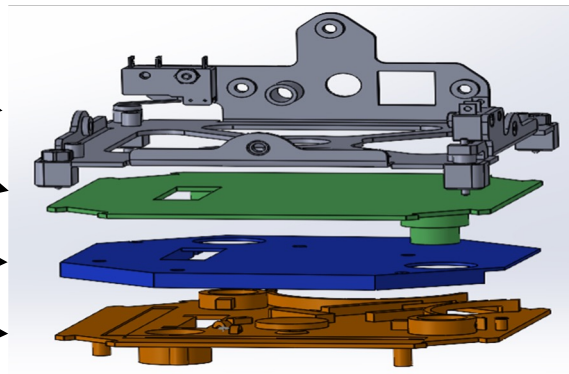




Mechanical Connection from Payload Module to NASB

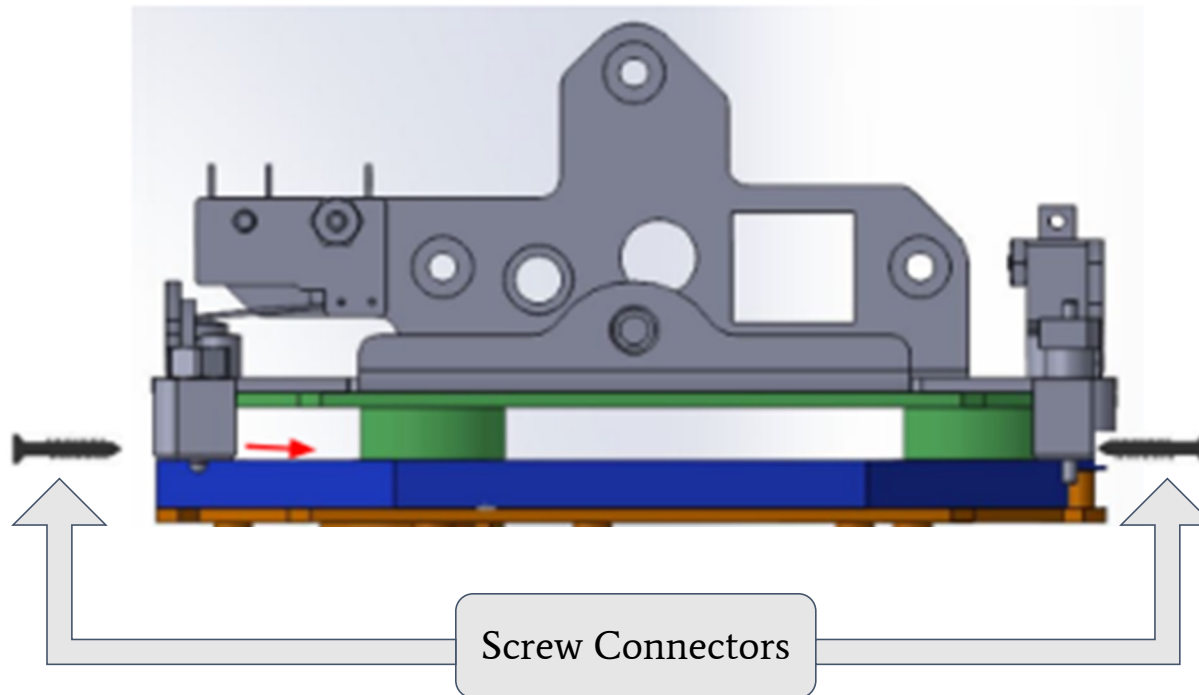


- Payload Module**
- Payload Baseplate
- Payload connection
- NASB**
- Antenna Board
- Cover
- Antenna Board





Structural Attachment of PM to NASB

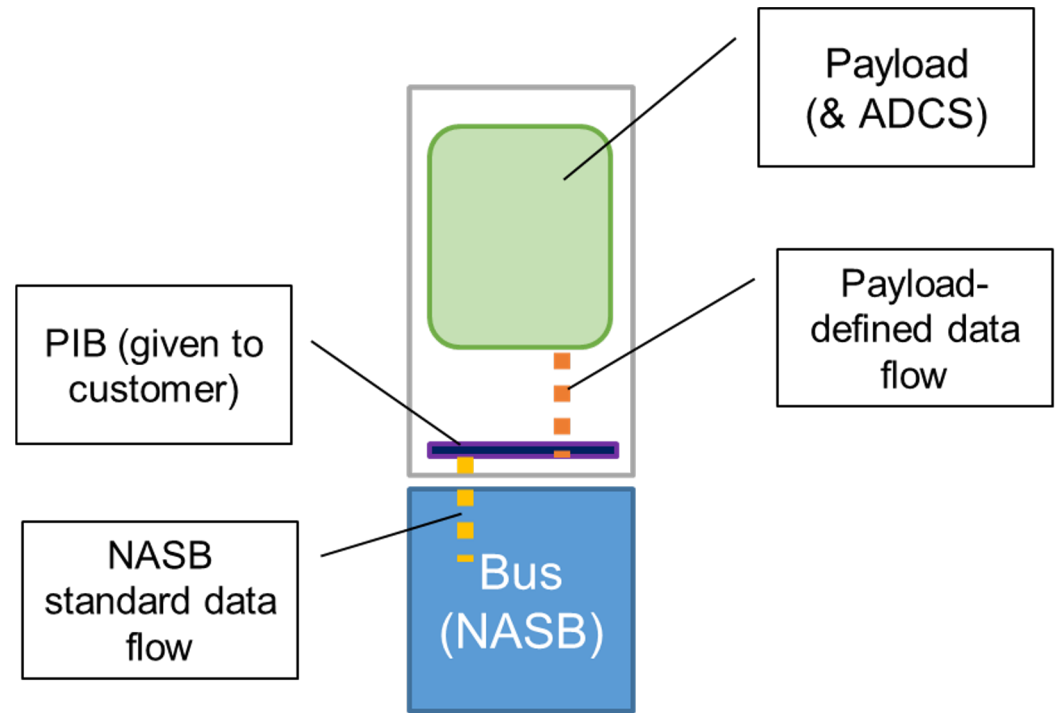




Electrical Interface

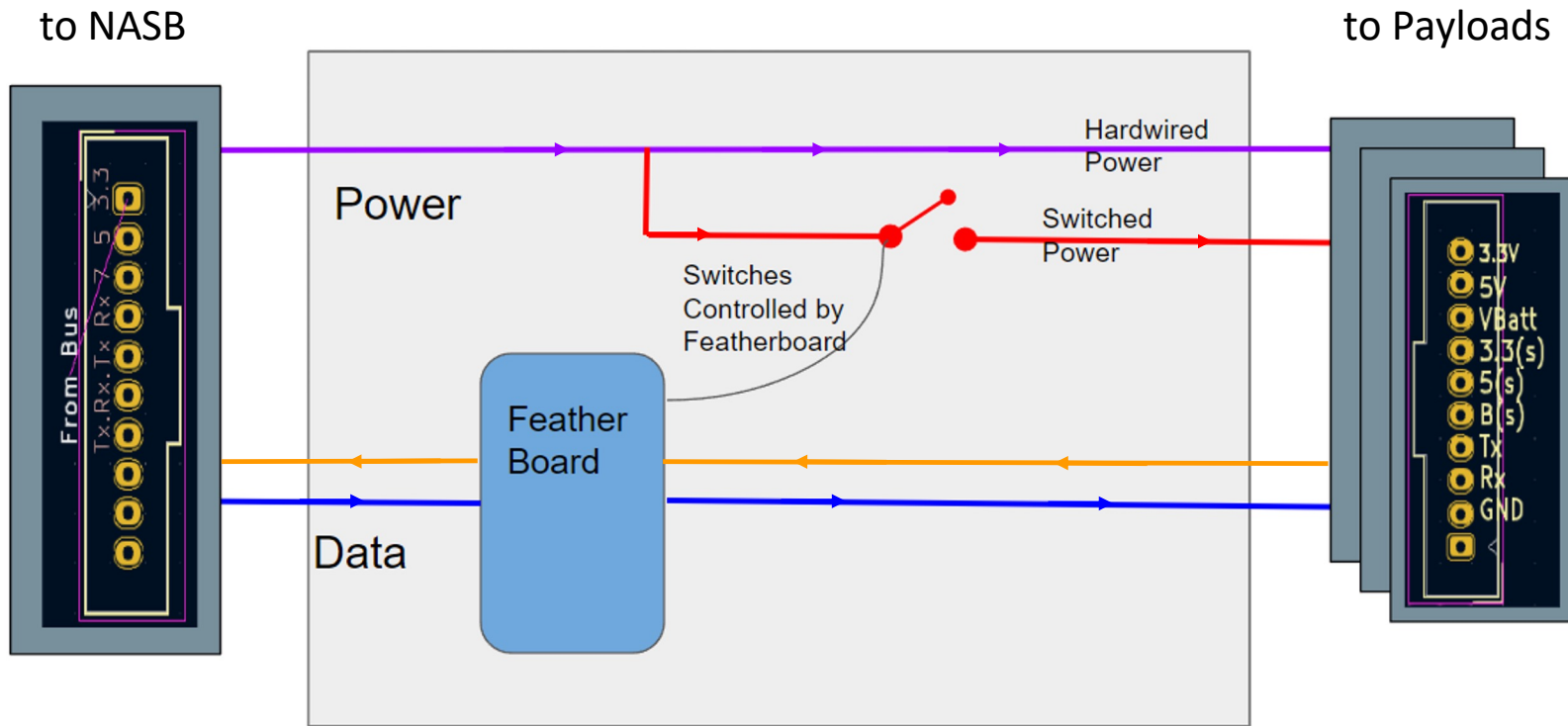


Payload Interface Board (PIB)



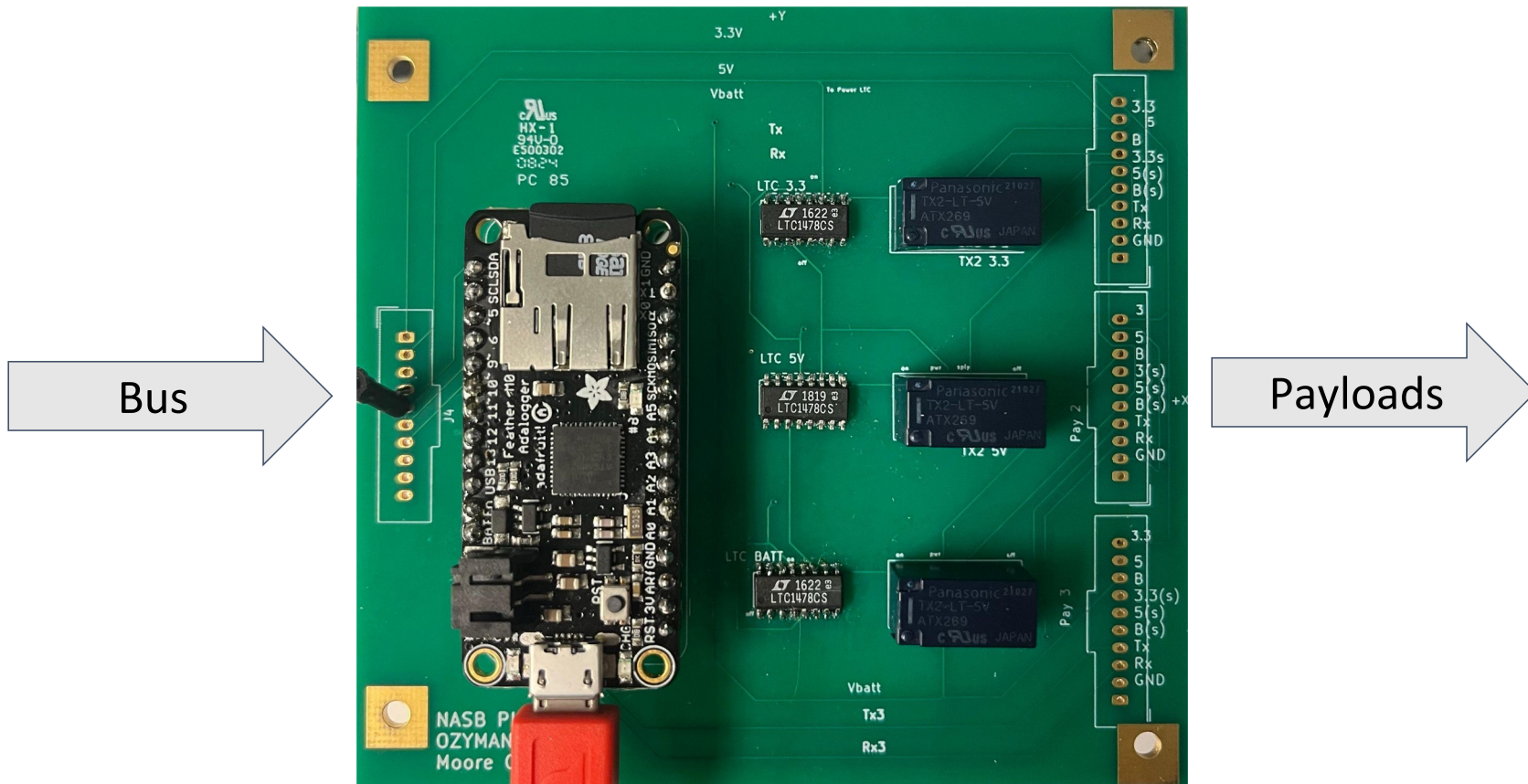


PIB Block Diagram



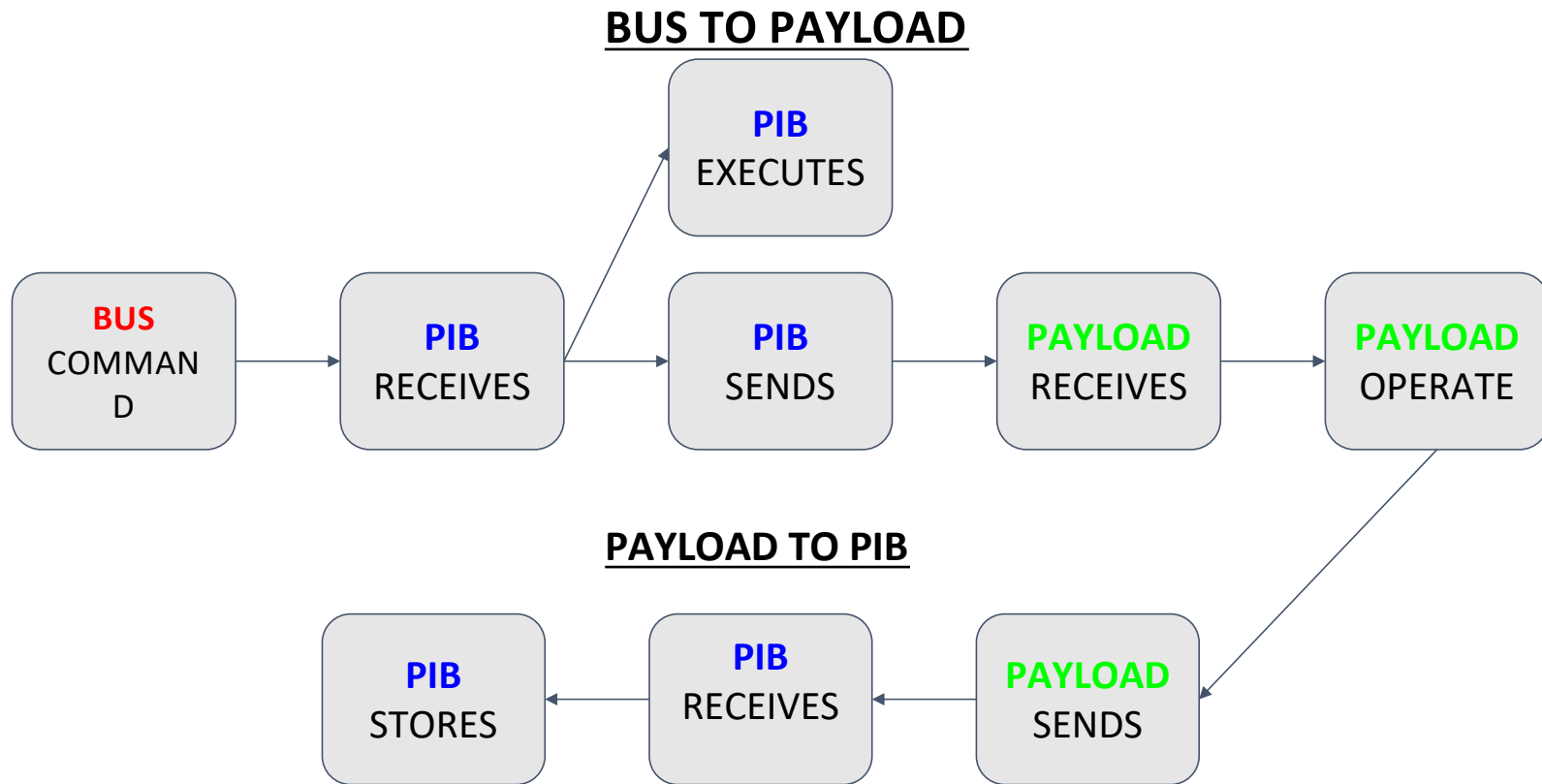


PIB Design





PIB Software





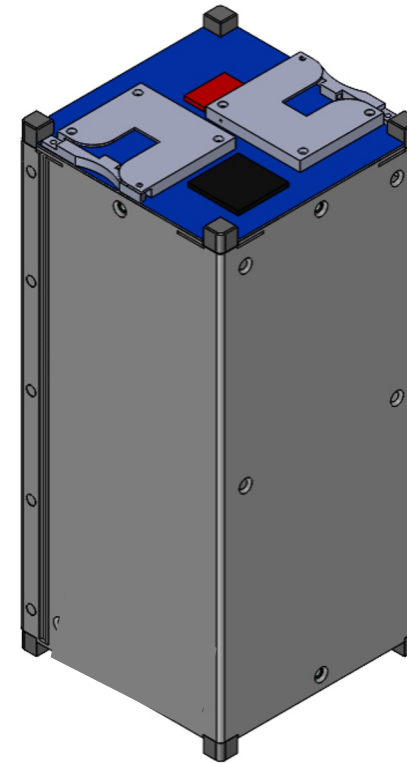
On-orbit Demonstration: USNA-16 Mission



USNA-16 Mission



- Mass CubeSat: 6kg
- Power generation:
 - 5.5 W BOL -> 5.2 W EOL (3U)
- Mission orbit: 500 km
60° inclination
- Mission life: 2 years
- Holds 2 Payloads
 - University of Maryland
 - U.S. Air Force Academy



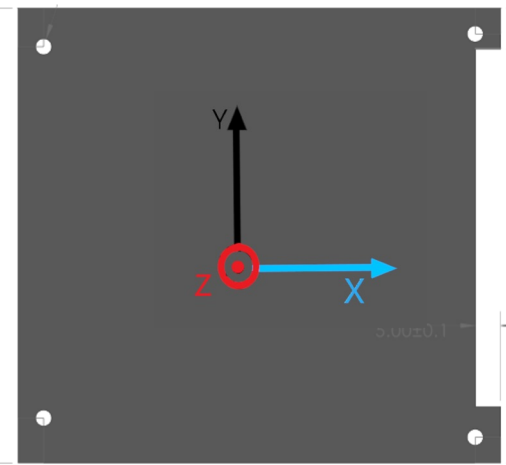
Full 2U Payload Module



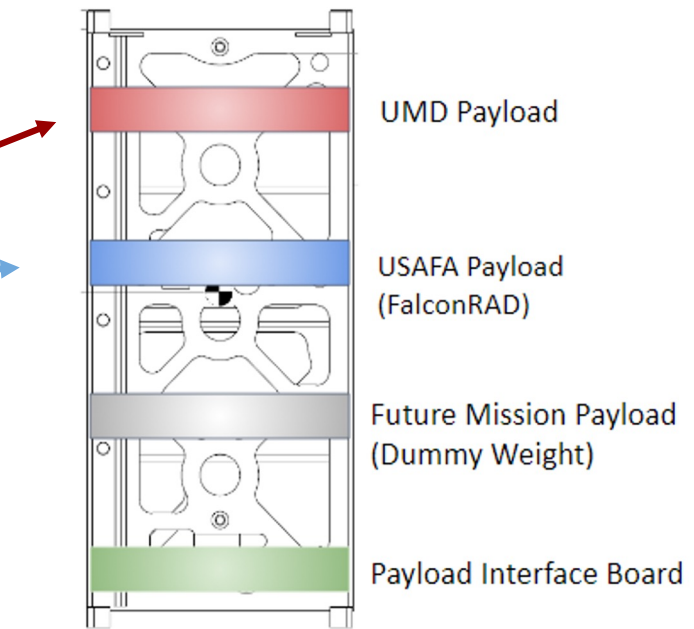
Payload Mechanical Specifications



- 90 x 96 x 40mm
 - PCB hole alignment to meet Pumpkin standard for integration
 - 0.4U allotted to each customer
- Cut out on +X face to allow for frictionless wire connection between PIB and payloads



Top Down View of Customer Payload
Dimensions

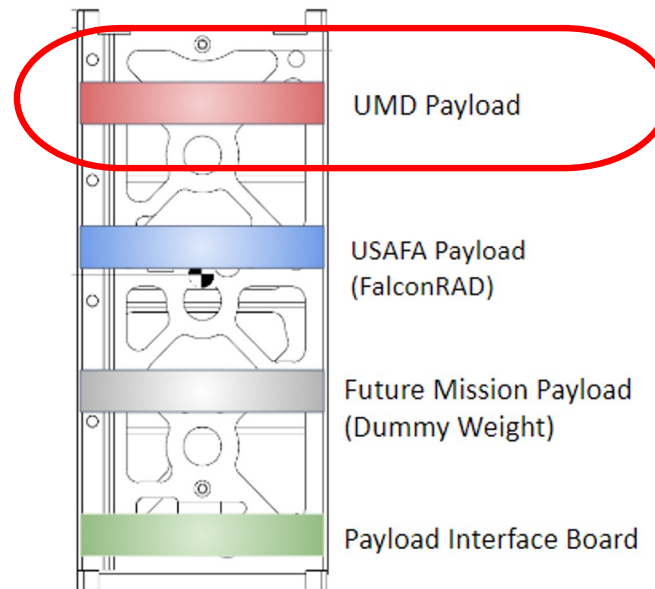




University of Maryland Payload



- An antenna to transmit to their ground station via UHF transmission
- PCB and Antenna Deployment System (ADS)
- Will operate their own antenna
 - USNA Bus will provide power

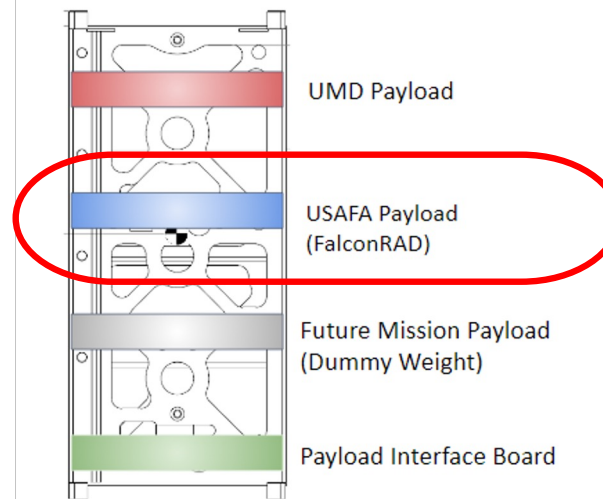




United States Air Force Academy Payload



- Dosimeter to measure radiation
- Data collection in South Atlantic Anomaly
 - Higher radiation
 - Causes spacecraft malfunctions
 - Potentially due to tilt of Earth's magnetic field and currents produced by movement of outer core

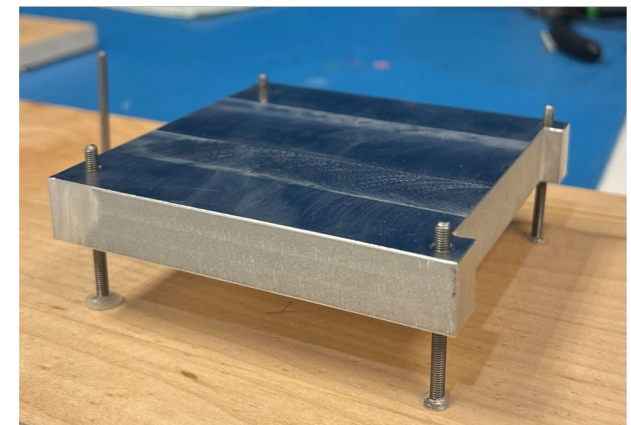
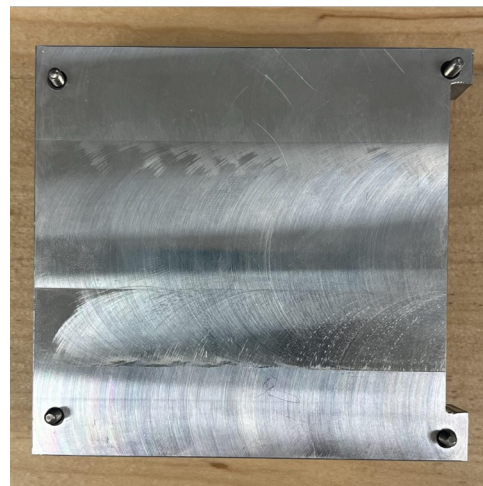
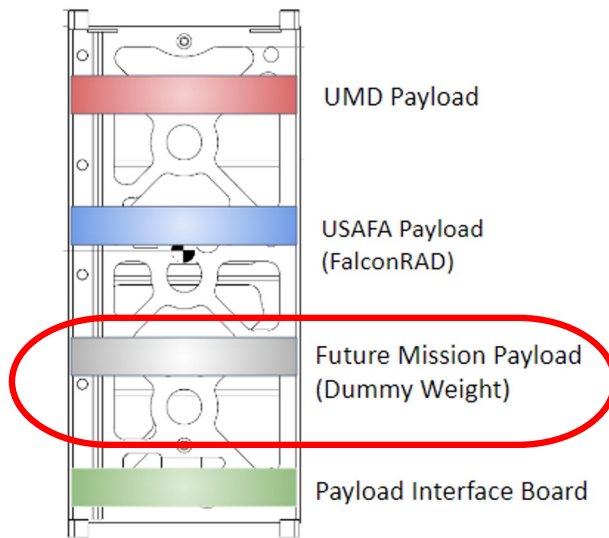




Dummy Weight



- Purpose
 - Demonstrate capability to add a 3rd payload
 - Ensure mass of payload module is sufficient to create an expected center of mass (CM) for the whole satellite
- Variable mass
 - 334g at 50mm from the bottom





Future Benefits



Provides Midshipmen and students opportunity to

- Assemble Fully Functional Satellite
- Go through entire Mission Design Process
- Aids in the learning process for satellite creation and operation





Thank you.
Questions?





CM Calculation



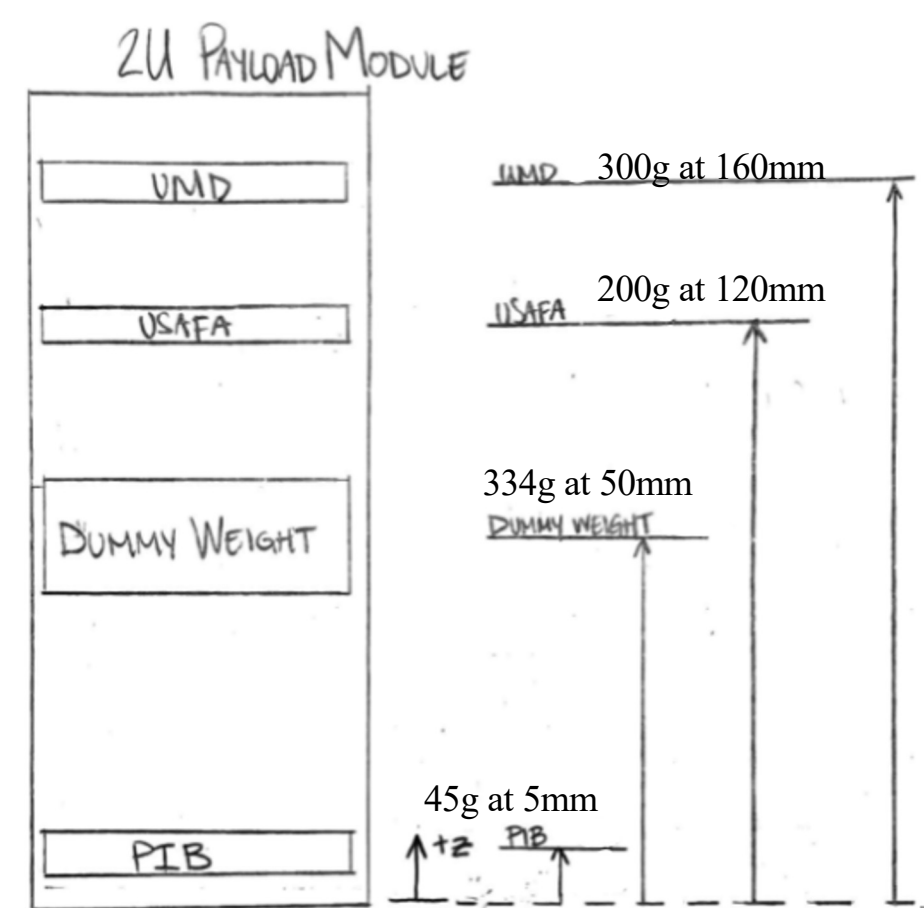
Tolerance: +/- 40mm from geometric center (100mm)

$$CM = \frac{\sum m_i Z_i}{\sum m_i}$$

$$CM = \frac{[43g*5mm] + [334g*50mm] + [200g*120mm] + [300g*160mm]}{[43+334+200+300]g}$$

$$CM = 101.4mm$$

[60 < 101.4 < 140] mm ✓



PIB
0.4U



Payload 3
0.4U



Payload 2
0.4U



Payload 1
0.4U



	MON	TUE	WED	THU	FRI
1 - 0755-0845		FP384		FP384	PE402
2 - 0855-0945	EA461	FP384	EA461	FP384	EA461
3 - 0955-1045	HH216		HH216	EA405	HH216
4 - 1055-1145	EA405		EA405	EA405	
Lunch - 1145-1320					
5 - 1330-1420	EA469	EA467	EA469	EA467	EA469
6 - 1430-1520	EA469	EA467	EA469	EA467	



The Payload Interface Board Software Commands



BUS TO PAYLOAD

“C:” - ID for commands to **PAYLOAD** from **GROUND**

“I:” - ID for commands to **PIB** to control power from **GROUND**

“A:” - ID for commands from **GROUND** to **PIB** requesting message file to be downlinked

“F:” - ID for commands from **GROUND** to **PIB** requesting data file to be downlinked

“\$G” - ID for timecode sent to **PIB** from the **RUIS** GPS

PAYLOAD TO

“D:” - ID for data sent from **PAYLOAD** to **PIB**

“M:” - ID for messages sent from **PAYLOAD** to **PIB**



1/C Schedule



	MON	TUE	WED	THU	FRI
1 - 0755-0845		FP384		FP384	PE402
2 - 0855-0945	EA461	FP384	EA461	FP384	EA461
3 - 0955-1045	HH216		HH216	EA405	HH216
4 - 1055-1145	EA405		EA405	EA405	
Lunch - 1145-1320					
5 - 1330-1420					
6 - 1430-1520					



USNA-16 Payload Module



- 2U (100x100x200mm)
 - Housing external customer payloads
 - United States Air Force Academy (USAFA)
 - University of Maryland (UMD)
 - Enough space for a third customer
- Connection to standardized bus
 - Modular connection
 - Quick and easy to replicate

