SURREY
SATELLITE TECHNOLOGY US

Manufacturing Status Review

FISH & CHIPS

FeatherCraft Integrated Structural Housing &
Computer, Hardware Interface Processing Suite

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Customer: Michael Brown

Advisor: Joe Tanner

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OVERVIEW

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Outline:

- **Project Overview**
- **DAQ Status**
  - On schedule, 200 man-hours left for manufacturing and software development
  - Ordering DAQ and Microcontroller Boards Rev B this week
- **Structure Status**
  - On schedule, 75 man-hours left for manufacturing and preliminary testing
  - Two minor changes since CDR
  - Most structure components are ready for assembly
- **Budget**
  - Margin has increased by 2% since CDR

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Project Motivation:

- Commercialization of International Space Station provides a launch opportunity not only to cubesats but larger **100 kg spacecraft**
- Spacecraft are launched on ISS cargo resupply missions, allowing for soft-stowed configuration and less stress on structure in launch environment
- Surrey Satellite Technology US plans to offer the FeatherCraft system as a cost-effective platform for **payloads of 45 kg** or less.

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Project Statement:

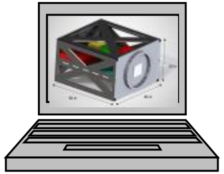
The **5 kg FeatherCraft structure** shall provide support for a **100 kg total mass** commercial spacecraft with reduced structural manufacturing time and materials cost, and enable the spacecraft to **survive launch** to and **deployment from the ISS** for a nadir facing mission.

Levels of Success:

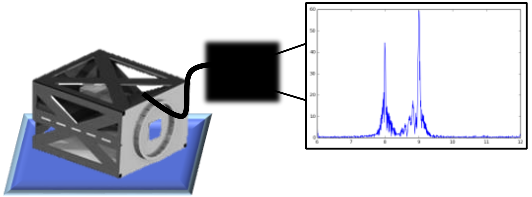
	Structure Design:	Vibration Testing:	Data Acquisition System:	Software:
Level 1	Design meets all physical requirements	Structural Test Model (STM) undergoes vibration test	Data can be collected for up to one hour	Saves CSVs for Excel analysis
Level 2	Design meets 50% reduction requirement	STM shows no failure		Software outputs PSD plots
Level 3		STM exhibits predicted modes within 10%	Real time PSD plotting	GUI allows control of test settings and analysis

CON OPS:

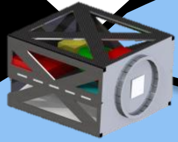
1. Design structure to meet all requirements, manufacture STM, design and create DAQ system



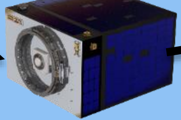
2. Perform vibration test and analyze accelerometer data



3. Final testing and integration with avionics and other bus components

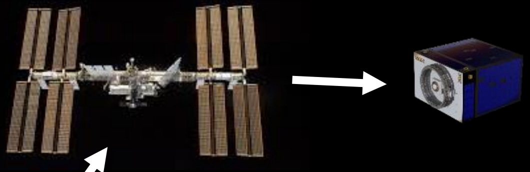


4. Integrate with payload and ISS resupply vessel



5. Launch to ISS

6. Interface with the Kaber Deployment System and deploy from the JEM airlock



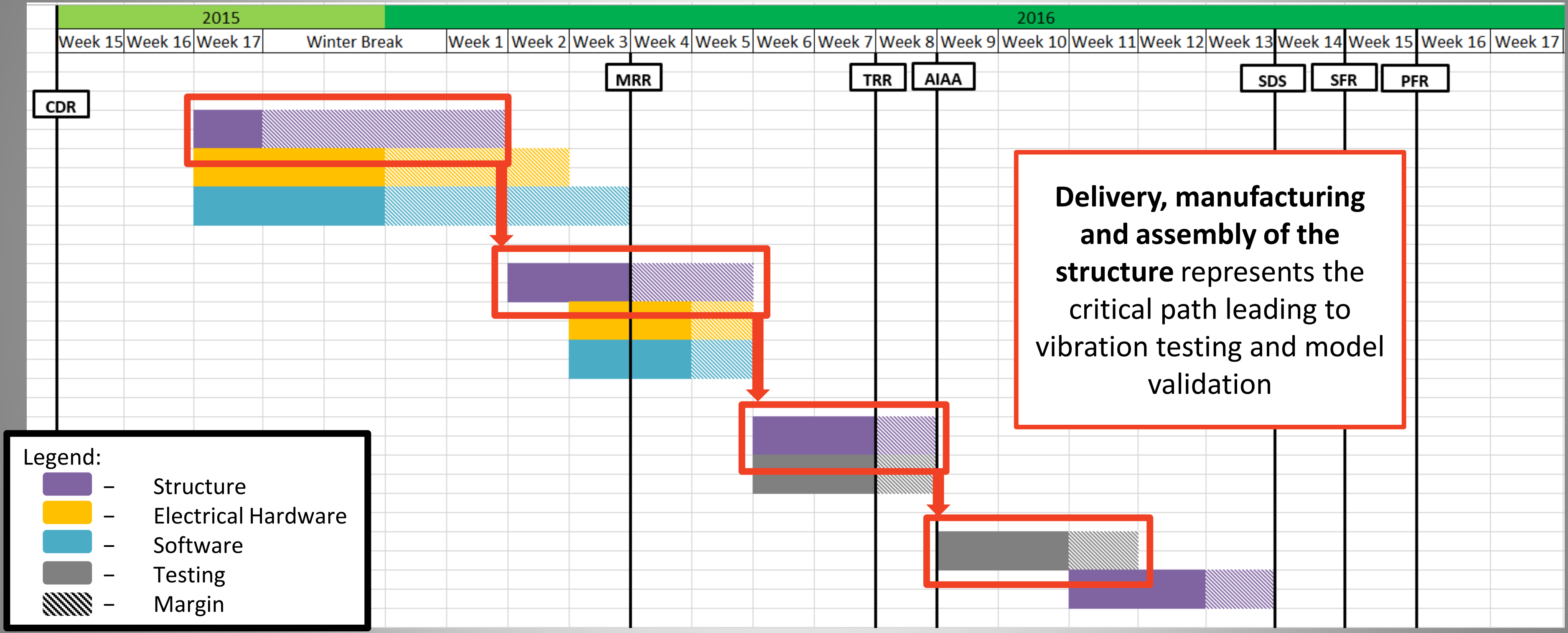
7. Possible Orbit Raising Maneuver and 5 year mission lifetime

CPEs:

Critical Project Element	Manufacturing Challenge
Mass of structure below **5 kg** while **surviving launch** to the ISS (FR 1 and DR 3.1)	- Creating a **composite mid-panel** with little composites experience - Precise manufacturing to fit the entire structure together
Support of up to **60 accelerometer** channels in DAQ system (DR 5.6.1.1)	- Taking time to precisely solder components for 16 channels - Successfully implementing **USB protocol** with the microcontroller

Other CPEs (time and cost of material and vibration test) no longer as critical

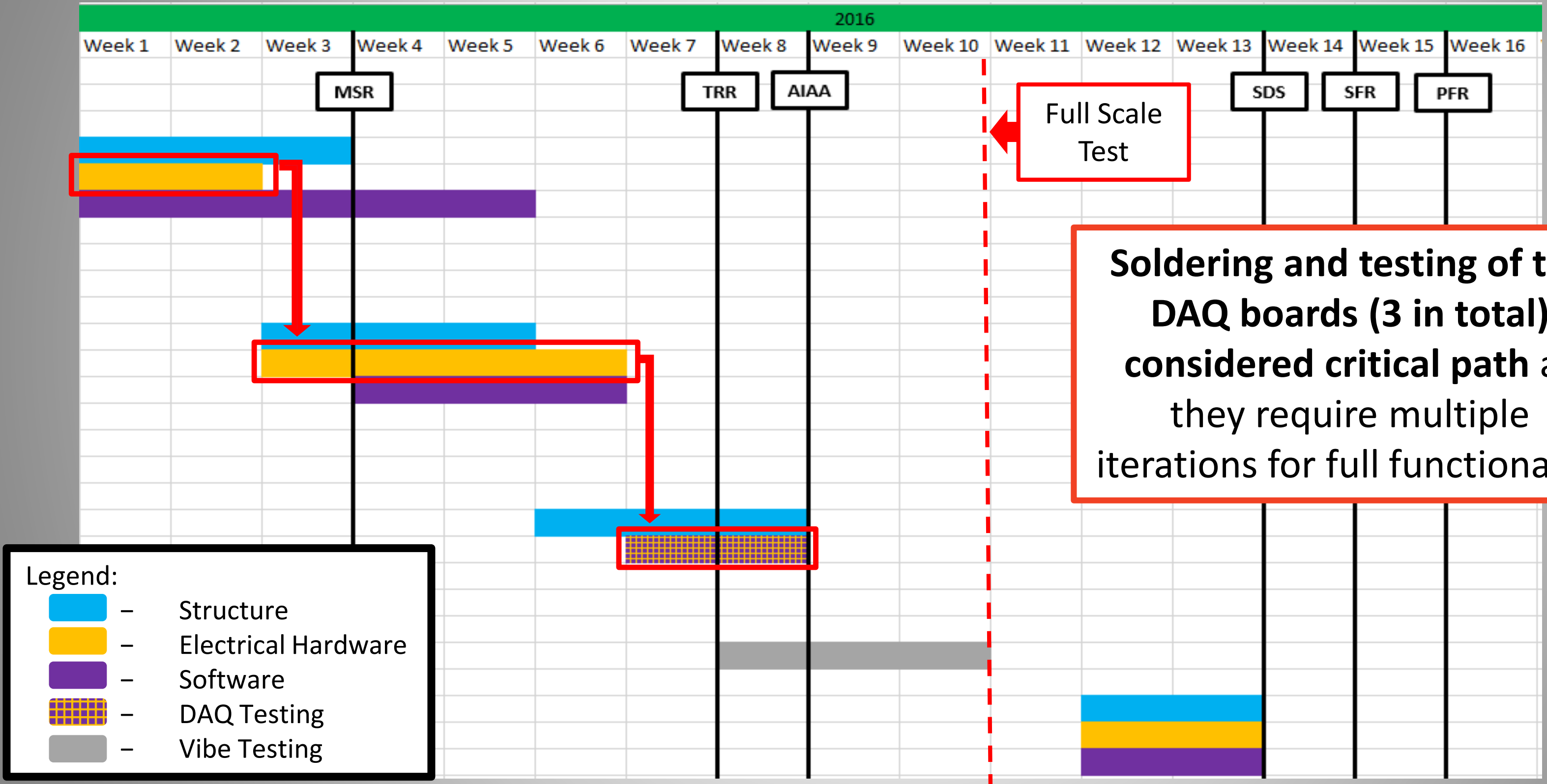
CDR Critical Path:



Delivery, manufacturing and assembly of the structure represents the critical path leading to vibration testing and model validation

Project Overview | DAQ Status | Structure Status | Budget

Current Critical Path:



Soldering and testing of the DAQ boards (3 in total) considered critical path as they require multiple iterations for full functionality

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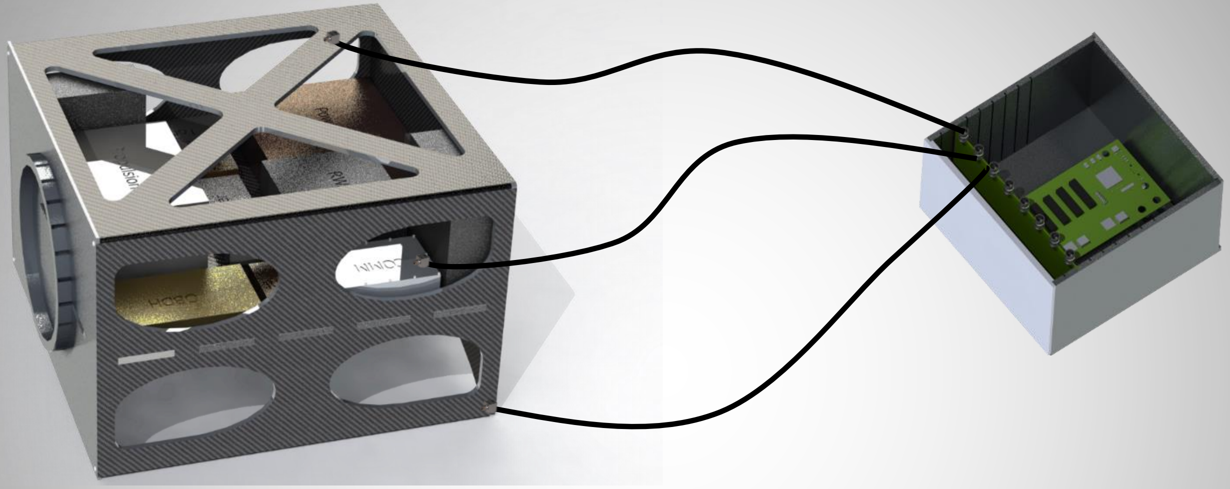
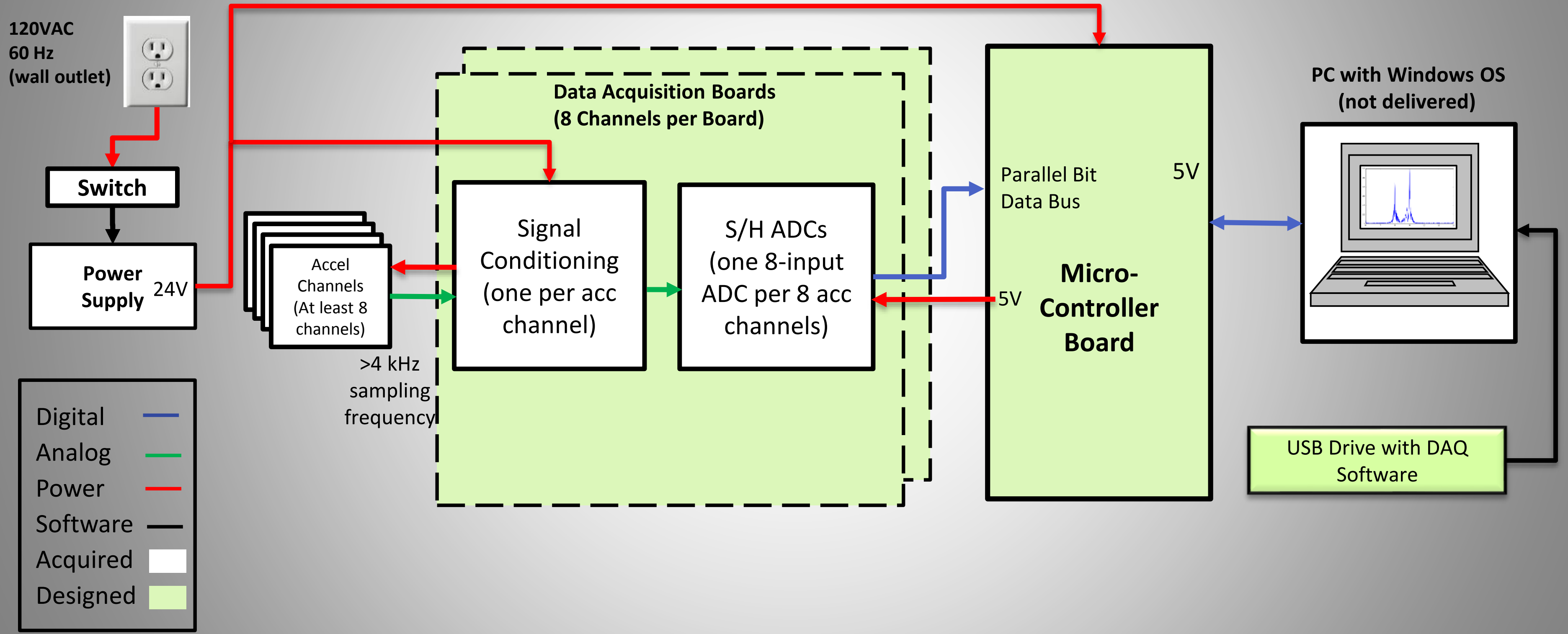


MANUFACTURING STATUS: DAQ

DAQ Hardware FBD:



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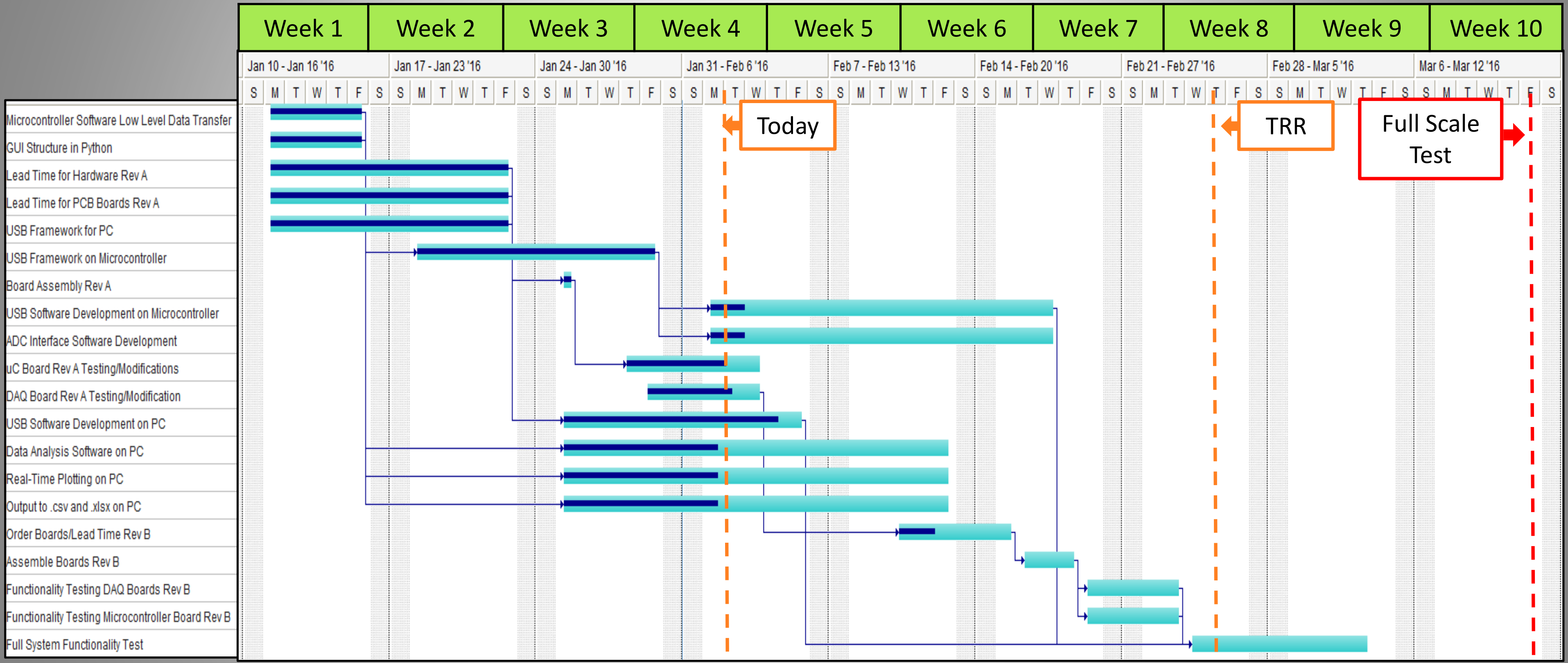
Scope:

Legend:
- Complete
- Future Work

- **Microcontroller Board Hardware**
  - DAQ Board Interface
  - Programming Support
  - Power Regulation: 8 hours
  - USB Comm. Protocol: 8 hours
- **DAQ Board Hardware (x2)**
  - Accelerometer Interface
  - µC Board Interface
  - Low-Pass Filter: 10 hours
  - Charge Amplifier: 2 hours
  - ADC: 15 hours
- **Microcontroller Software**
  - USB capability
  - Application/ Framework: 20 hours
  - ADC Driver: 45 hours
  - Integrate S/W components: 10 hours
- **Data Analysis Software (PC)**
  - GUI
  - Data Analysis: 72 hours
  - USB Comm. Protocol: 1 hour
  - Real Time Data Display: 8 hours

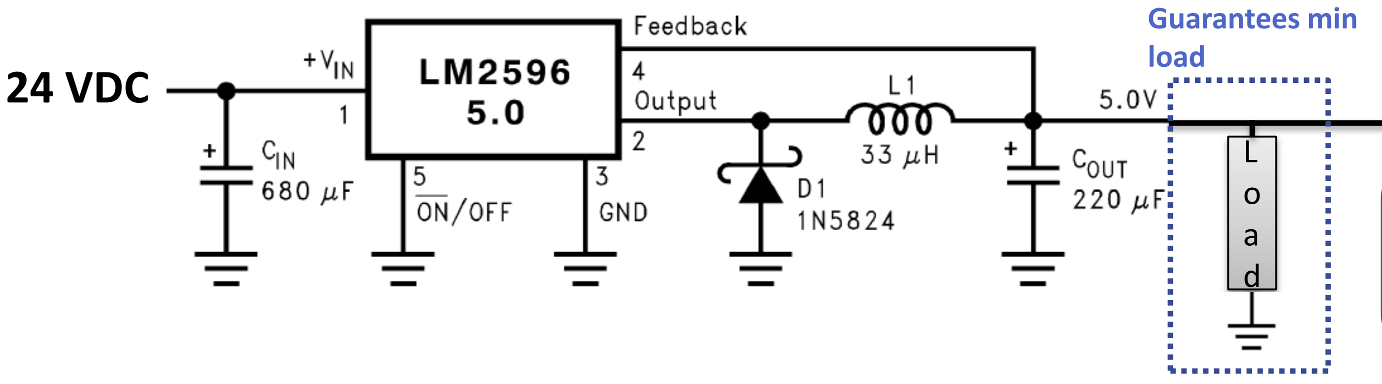
DAQ Schedule:

Legend:
- Percent Complete
- Task



Microcontroller Board: Power Section

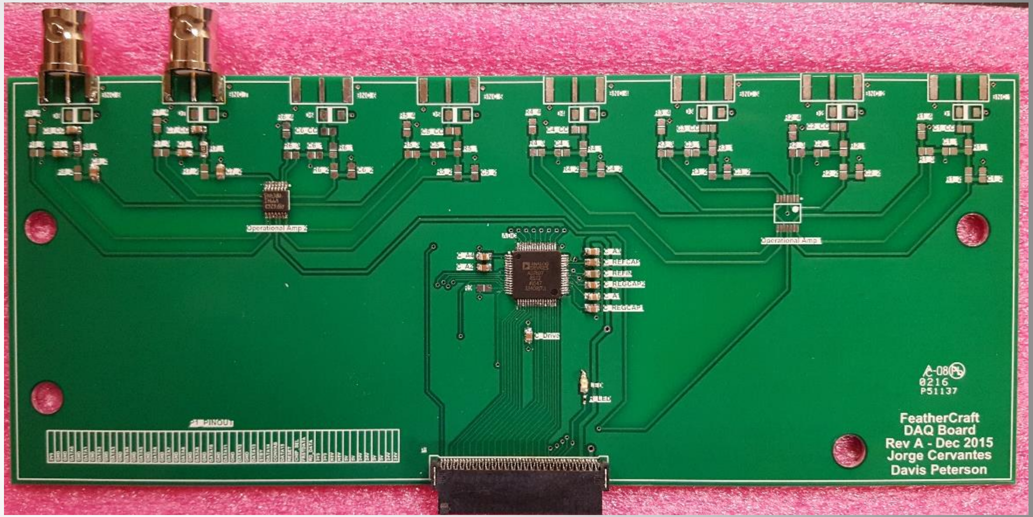
- All components have been populated
- Functionality tests have prompted parts replacement and re-testing
  - Non-constant output voltage that varies with input voltage **due to regulator damage**
    - **Solution: replace switching regulator**
  - Regulator goes into discontinuous mode due to **small load currents**
    - **Solution: larger inductor, add load in parallel to guarantee min load requirements**



Rev A:
57% Complete
16 Hours Remaining

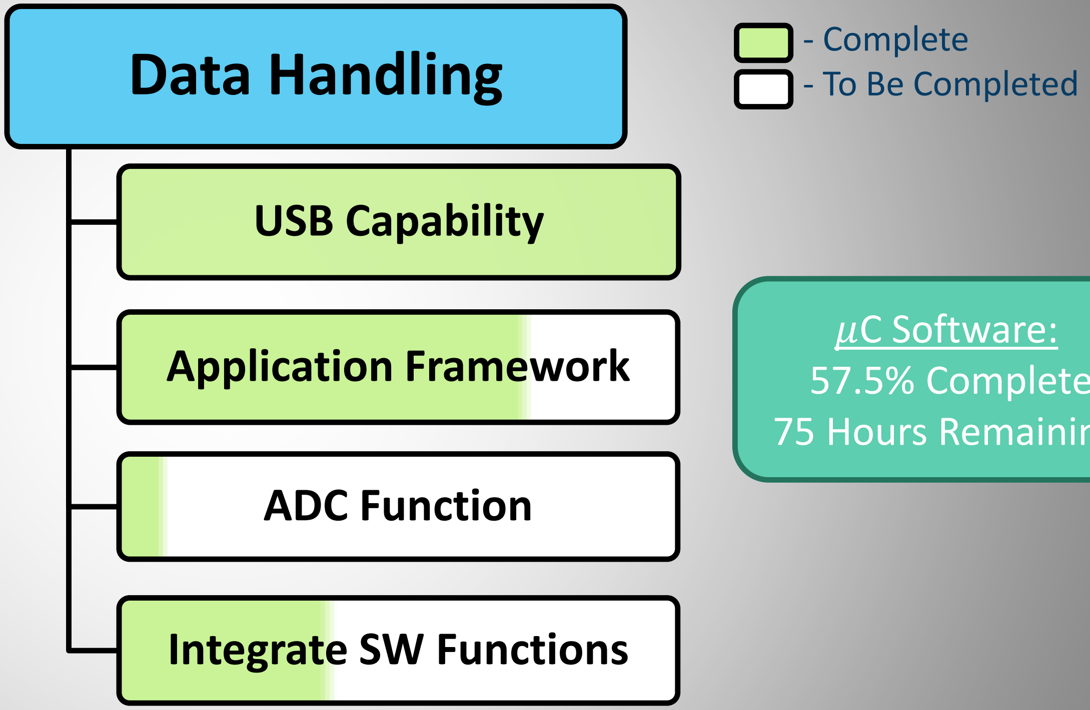
DAQ Boards:

- All testing components have been populated
  (100%, 15 man- hours)
- Functionality testing is under way to verify design (20%, 27 man-hours)
- Tests will tell if re-design is necessary for Rev B



Rev A:
40% Complete
27 Hours Remaining

Microcontroller Software:



- Receives data from 64 accelerometer channels
- Stores and forwards data to the TX buffer (USB)
- TX buffer is polled by computer for quick data transfer

<u>µC Software:</u>
57.5% Complete
75 Hours Remaining

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Data Collection Software:

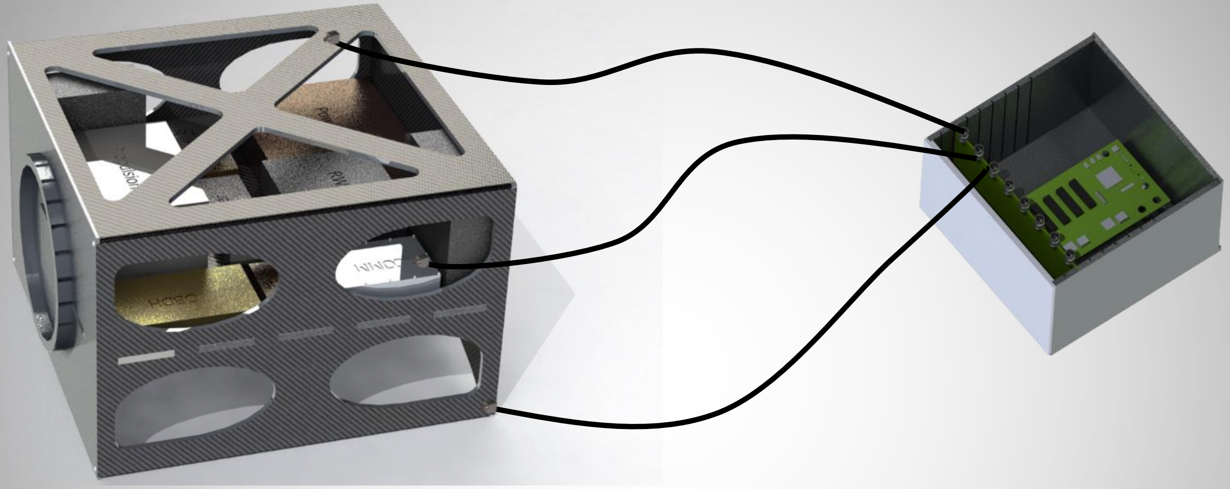
Software Flow:
1) Setup for test
2) Start test
3) Pull data via USB
4) Apply filters
5) Convert to PSD
6) Update plots
7) Repeat 3 - 6
8) Stop test
9) Save test report

Software Setup
- GUI Structure
- Software Configuration
- Debug Log
- .exe Compiling
- LibUSB .dll Compiling

Data Handling
- USB Communications
- PSD Calculation
- Digital Filtering
- Real-Time Plotting
- Output to .csv and .xlsx

- Complete
- To Be Completed

Python Software:
71.5% Complete
81 Hours Remaining



MANUFACTURING STATUS: STRUCTURE

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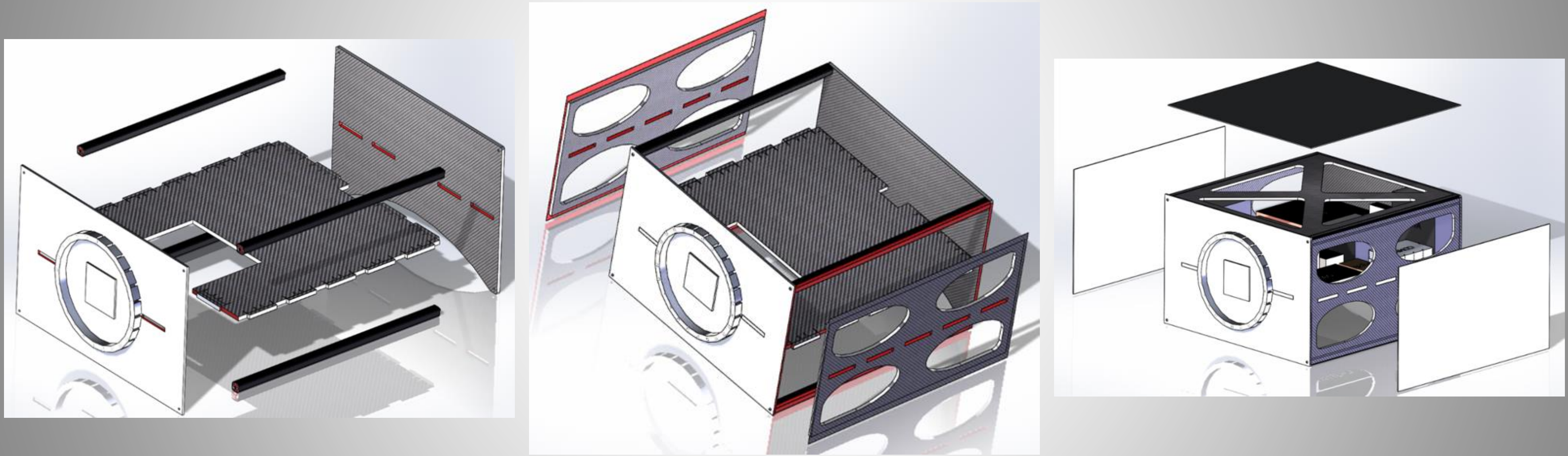
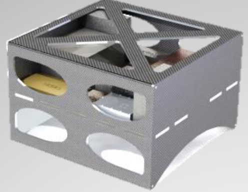
Baseline Design – Structure:

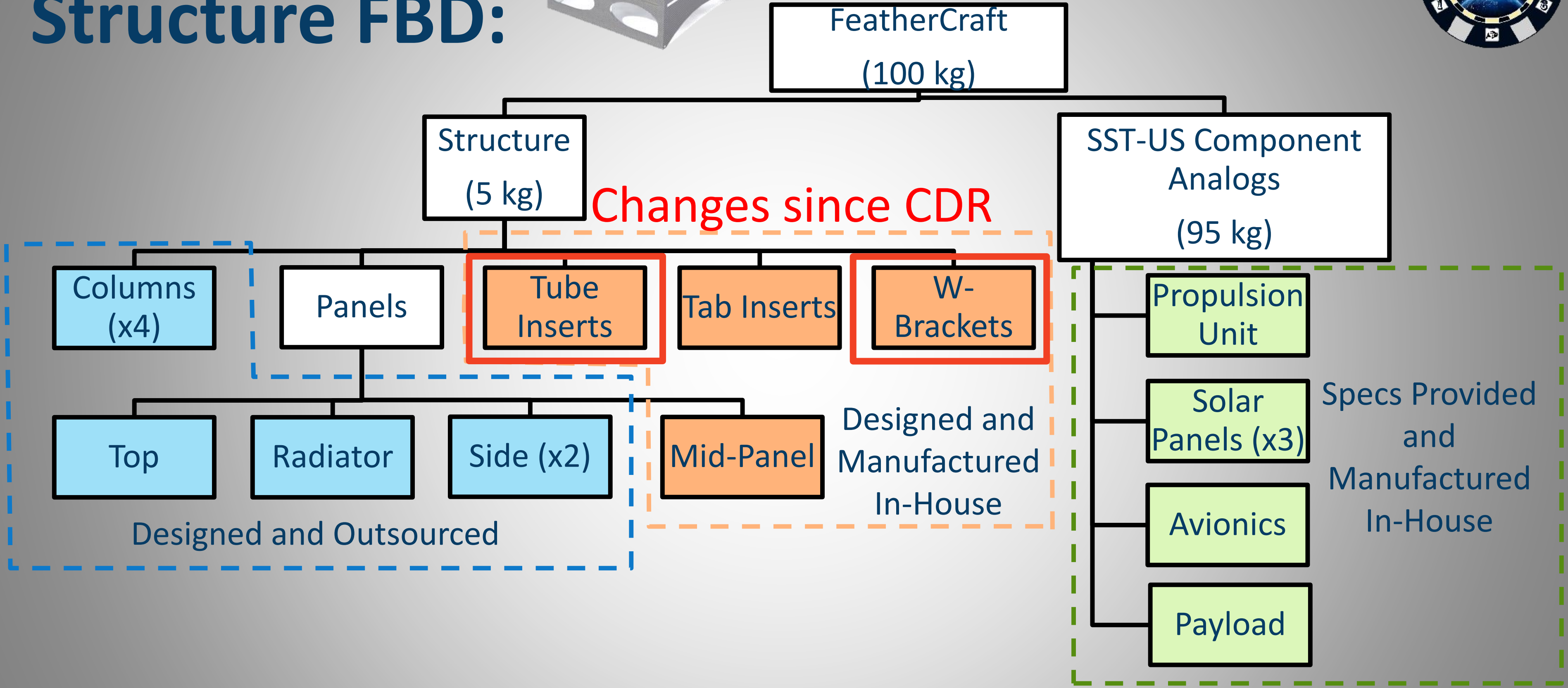
30”x 30”x 19” structure, designed to weigh 4.48 kg



Components are assembled with Scotchweld 2216 epoxy and 8 steel fasteners, with washers and helicoils.

Structure FBD:





Changes Since CDR – Tube Inserts:

Component testing prompted a **material and shape change on tube inserts**

Old Design After Testing

New Design After Testing

	Old:	New:
Material:	ABS	AL 6061-T6
Shear: (required)	4500 N	4500 N
Ultimate Shear: (measured)	1750 N	8800 N
Mass:	10.7 g	9.4 g

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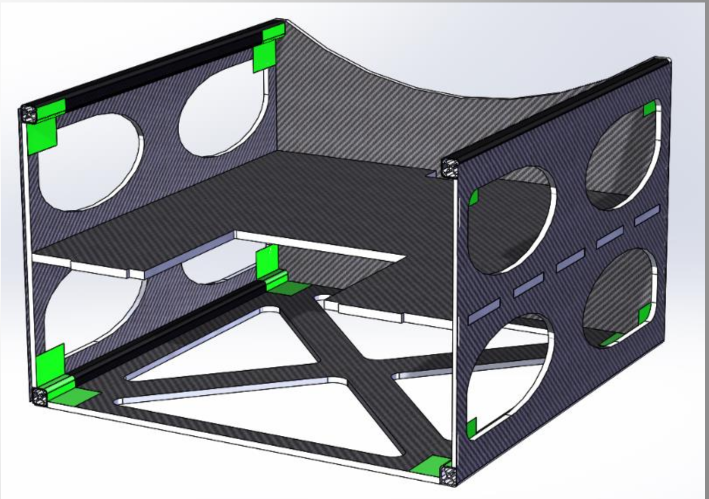
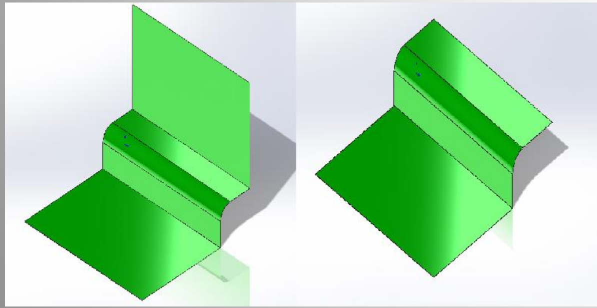
Changes Since CDR - Brackets:

Analysis prompted **the addition of W shaped brackets** around the columns, **increasing adhesive area**

- 4 layers of pre-preg fabric cured on a mold
- Start manufacturing during week 5
- Mass increase due to W-brackets: 20 g
- Does not increase project cost
- Pushes assembly to the end of week 6





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Structure Scope:

- **Structure**
  - Columns
  - Side Panel, Top Panel, Radiator Panel
  - Middle Panel: 13 hours
  - Tube Inserts: 12 hours
  - Tab Inserts: 10 hours
  - W-Brackets: 40 hours
- **Surrey Components**
  - Solar Panels (x3)
  - Avionics
  - Propulsion Plate
  - Payload

- Complete
- To Be Completed

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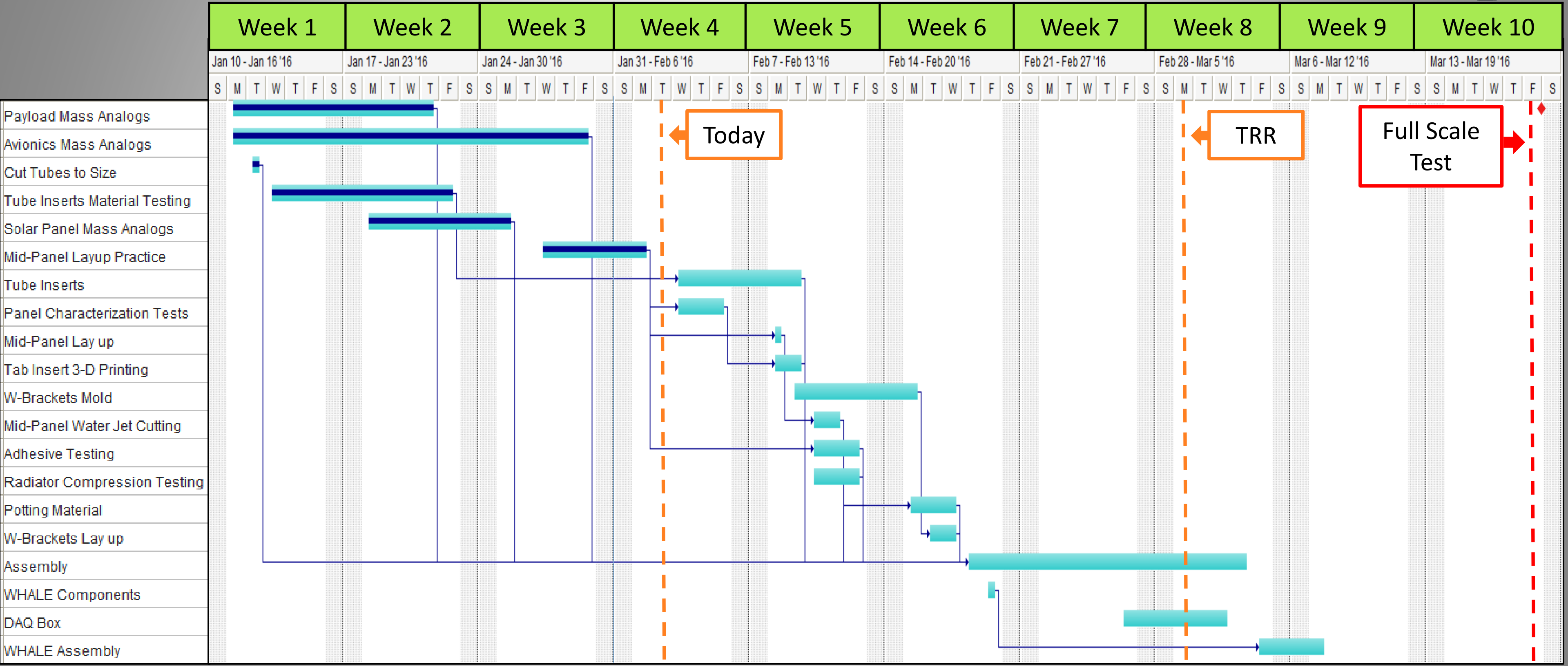
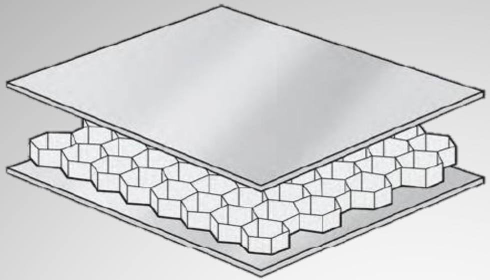
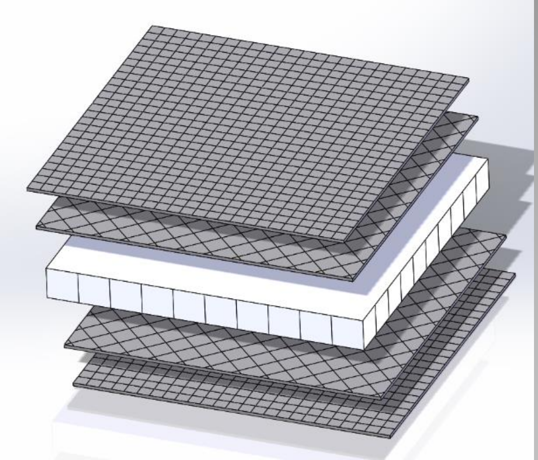
Structure Schedule:

Legend:
- Percent Complete
- Task



Mid-Panel:

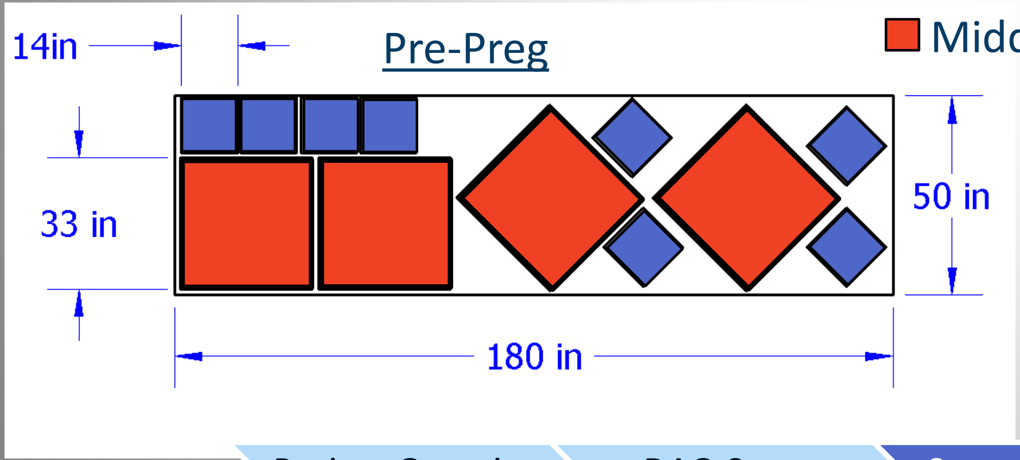




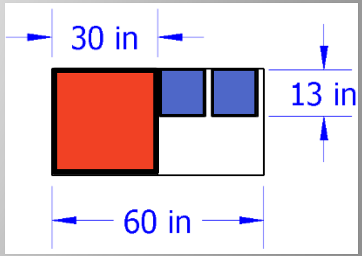
- Materials:
  - 3003 aluminum honeycomb core
  - 3K carbon fiber pre-preg (contains adhesive to bond to honeycomb)

Test Panel

Middle Panel



Core Material



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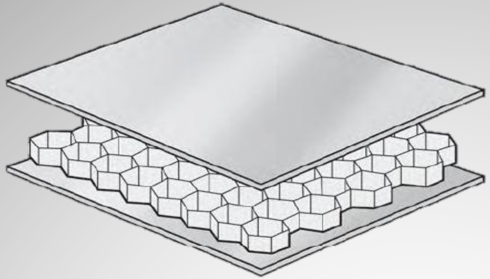
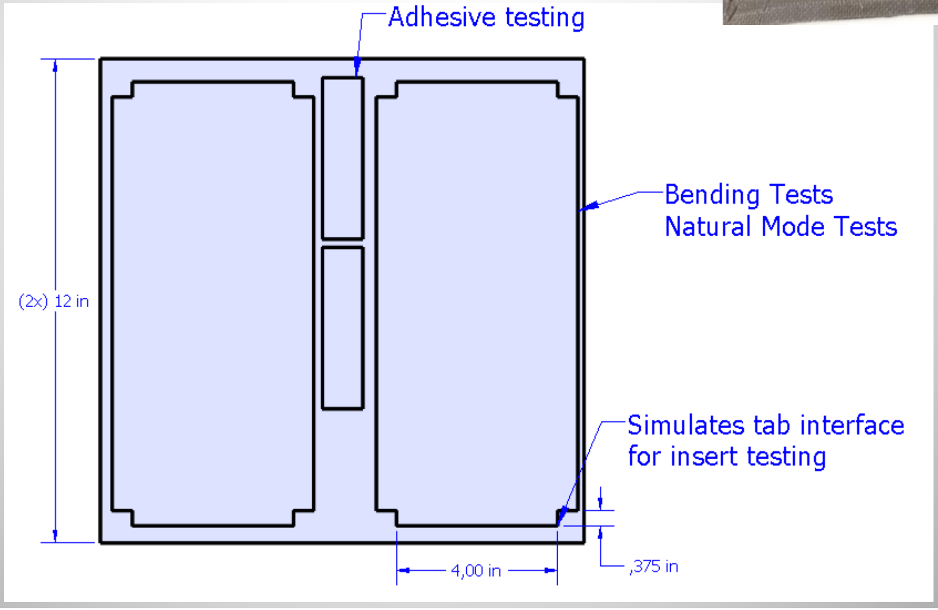
Mid-Panel:

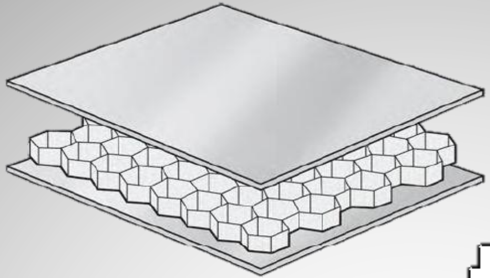
- Test Panels
  - Check flatness, weight, and material properties.



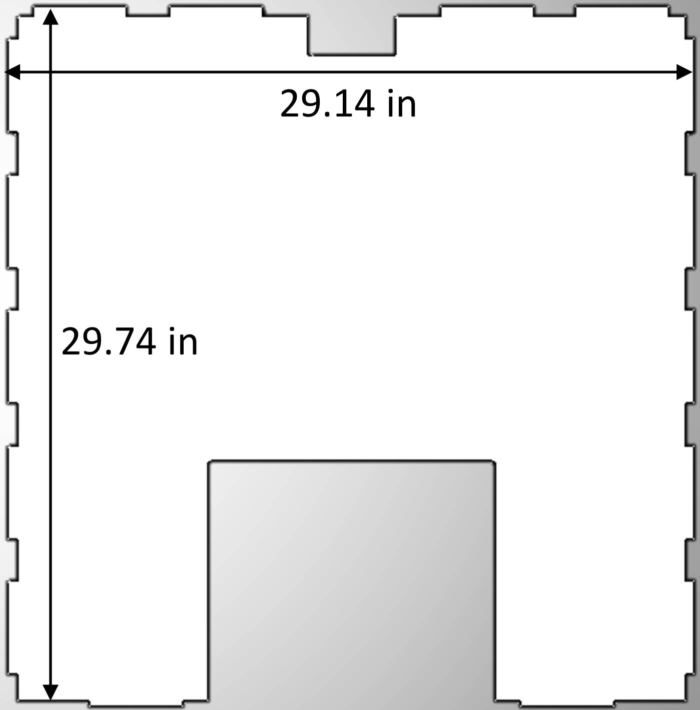
Test Panels:
100% Complete



Mid-Panel:



- Manufacture
  - Waterjet Cutting in Physics department



Mid-Panel:
67% Complete
13 Hours Remaining

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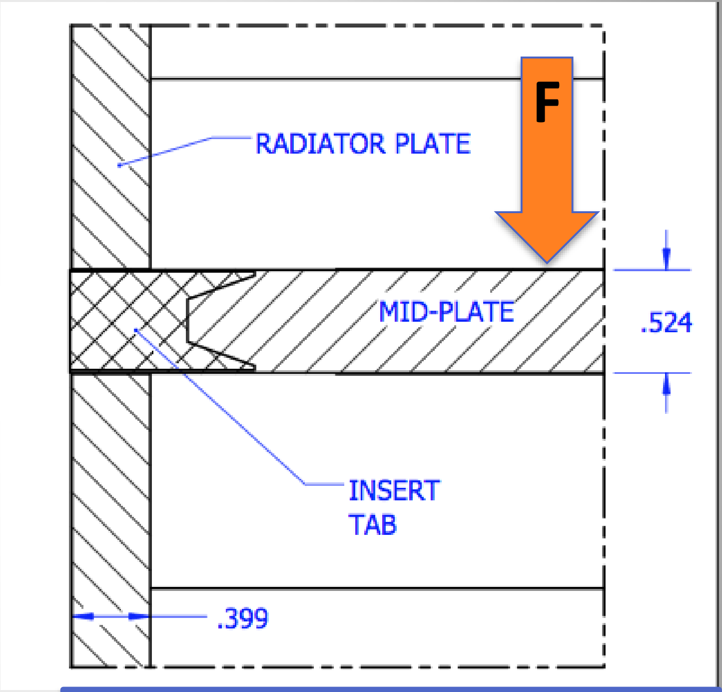
Tab Inserts:

- Transfer loads from the edges of mid-Panel to the middle
- 3D printed and adhered with Scotchweld 2216
- Initial bending test on Friday 2/5

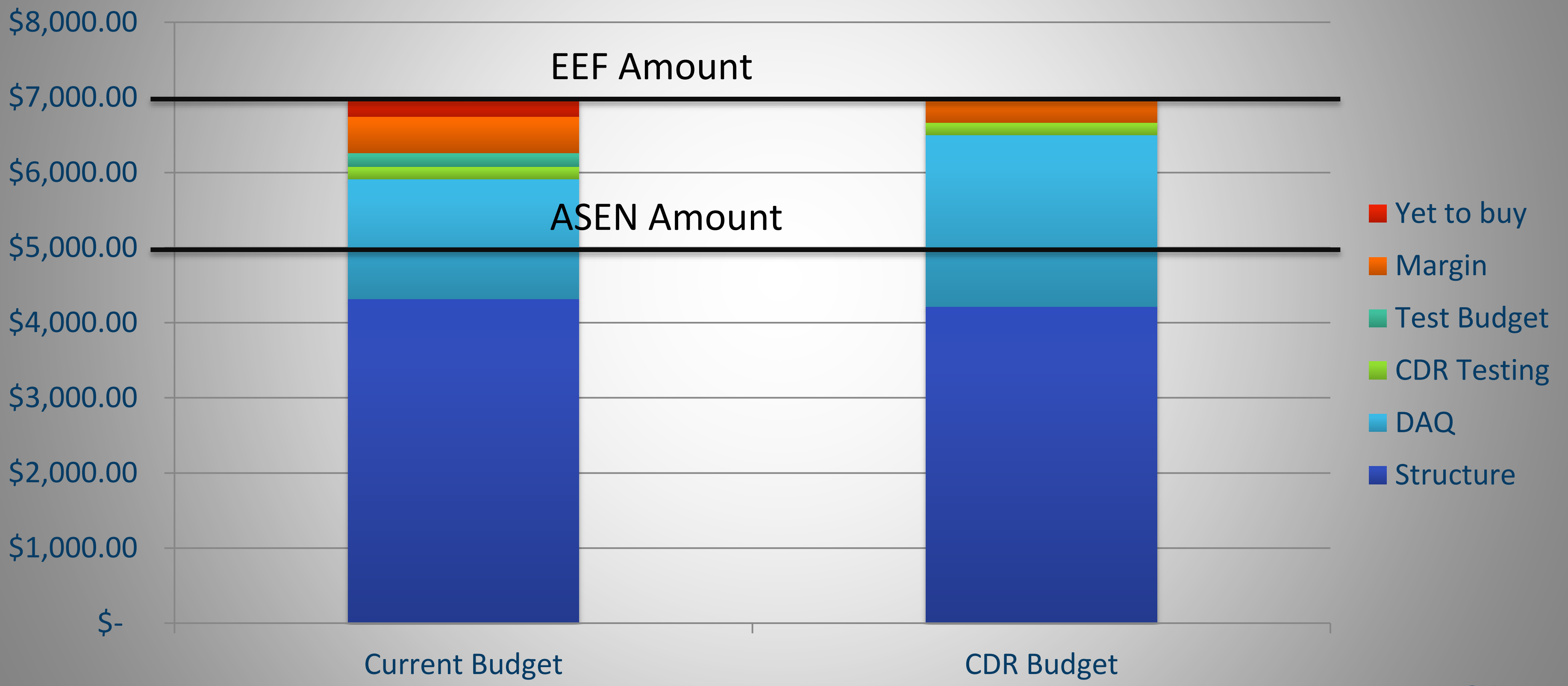
Tab Inserts:
13 Hours Remaining for testing and printing



Panel support

BUDGET

Budget:


$8,000.00
$7,000.00
$6,000.00
$5,000.00
$4,000.00
$3,000.00
$2,000.00
$1,000.00
$-
EEF Amount
ASEN Amount
Current Budget
CDR Budget
Yet to buy
Margin
Test Budget
CDR Testing
DAQ
Structure

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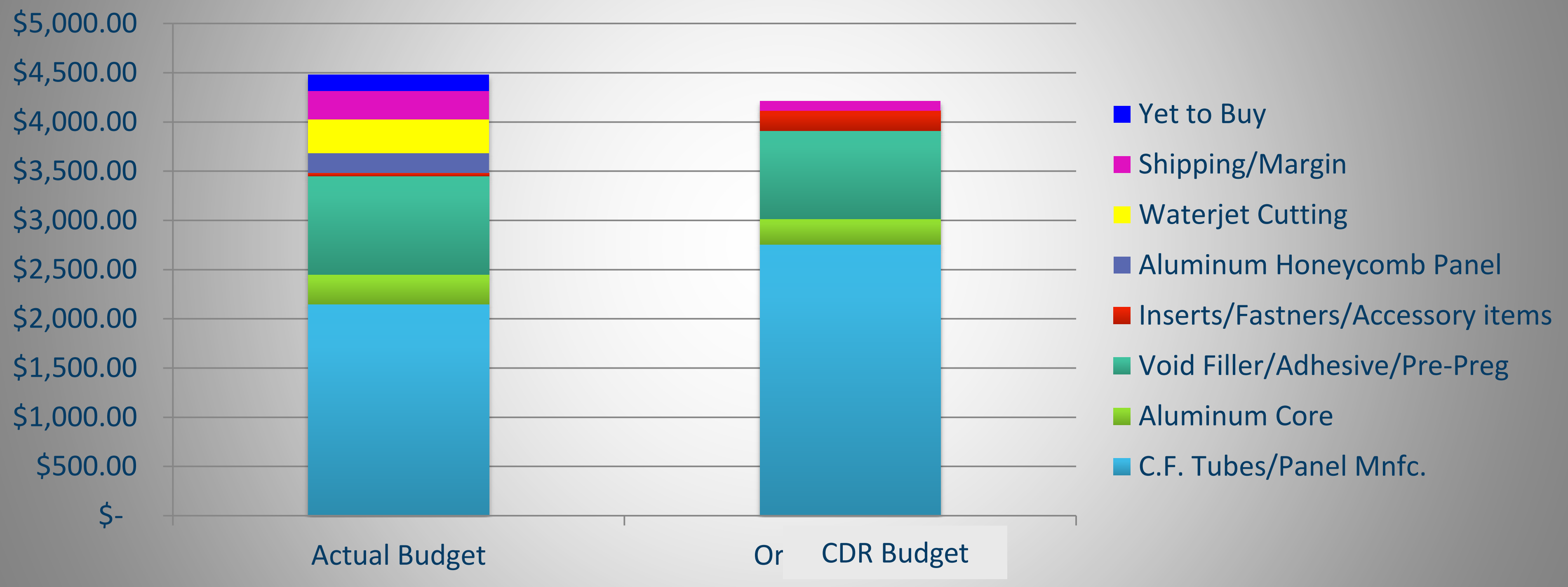
Structure Budget:

Difference: ↑ $267.88



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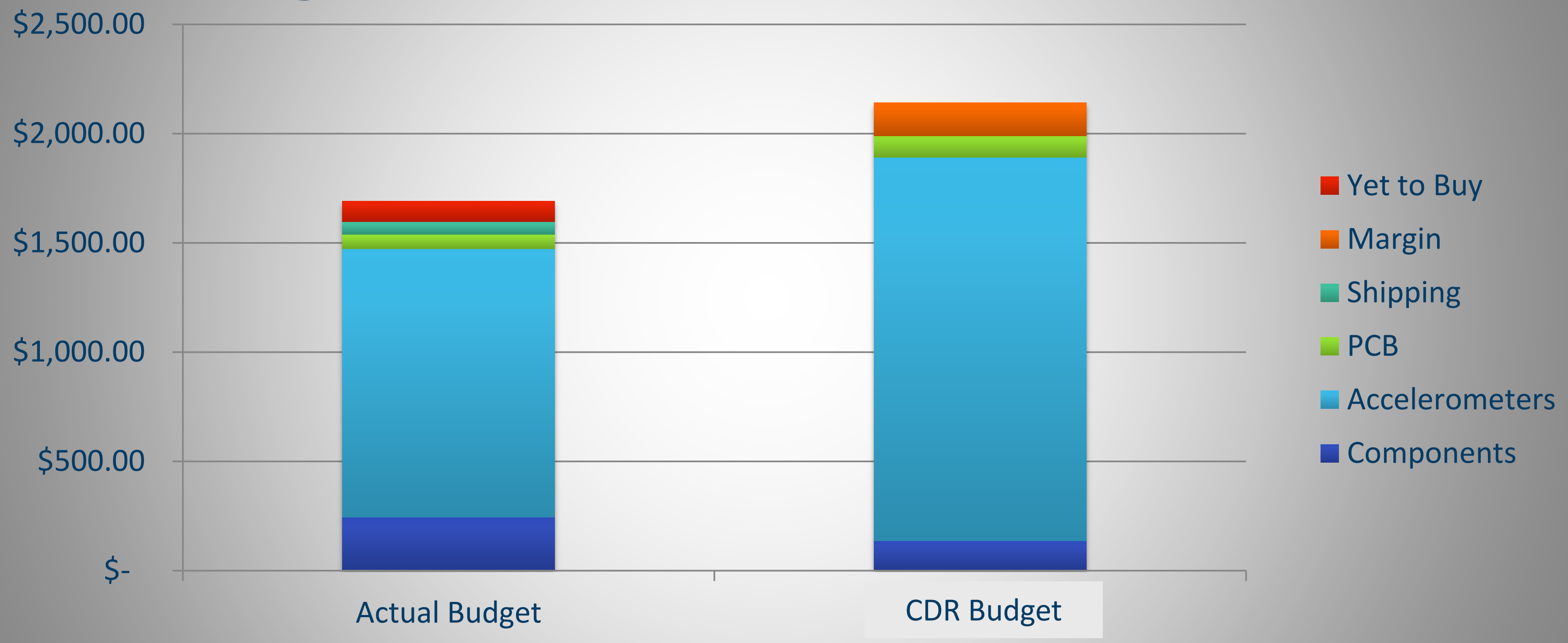
DAQ Budget:

Difference: ↓ $313.78



Project Overview | DAQ Status | Structure Status | Budget

Acknowledgements:

Engineering Excellence Fund

CASCADE TEK FRONT RANGE

Aerospace Engineering

References:

[1] Materion Coroporation. AlBeMet Property Datasheet. Elmore, OH: Beryllium & Composites, n.d. Print.

[2] Sandwich Panel Fabrication Technology. N.p.: Hexcel Composites, 2001. Print.

[3] Honeycomb Sandwich Design Technology. N.p.: Hexcel Composites, 2000. Print.

[4] Roark, Raymond J., and Warren C. Young. Formulas for Stress and Strain. New York: McGraw-Hill, 1975. Print.

[5] Microchip. PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Family. Phoenix AZ: Microchip, n.d. PDF.

[6] PCB Piezotronics. Aerospace Ground Test. Depew, NY: PCB Piezotronics, n.d. PDF.

[7] ST Microelectronics. MEMS digital output motion sensor ultra low-power high performance 3-axes “nano” accelerometer. n.p.: ST Microelectronics, 2010. PDF.

[8] PCB Piezotronics. Quote: SGL11887. Depew, NY: PCB Piezotronics, 2015. PDF.

[9] “ Alloy A286” Delta Fastner Corp. Web. 27 Sept. 2015.. <http://www.deltafastener.com/a286.html>

[10]“The Use of Silicone Adhesives in Space Applications” Adhesives and Sealant Industry. Web. 27 Sept 2015. <http://www.adhesivesag.com/articles/85082-the-use-of-silicone-adhesives-in-space-applications>

[11] “Kaber Small Satellite Deployment System” NanoRacks. Web. 26 Sept 2015. http://nanoracks.com/wp-content/uploads/Kaber-Small-Satellite-Deployment-System-Presentation.pdf

[12] “Sandwich Panels”. ACP Composites. Web. 22 Sept 2015. < http://www.acpsales.com/Carbon-Fiber-Sandwich-Panels.html>

[13] “Spacecraft Thermal Control – Chapter 6” 2011. Print.

[14] “Salary of Aerospace Technicians”. Glass Door. Wed. 15 Nov 2015 https://www.glassdoor.com/Salaries/aerospace-technician-salary-SRCH_KO0,20.htm

QUESTIONS?

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Index:

Overview:	DAQ Status:	Structure Status:	Budget:
Outline Motivation Statement Levels of Success Con Ops CPE CDR Critical Path Critical Path	FBD Scope Schedule uC Board DAQ Boards uC Software Data Collection SW	Baseline Design FBD Tube Inserts Brackets Scope Schedule Mid-Panel Test Panels Final Manufacturing Tab Inserts	Overall Structure DAQ

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Back-Up Slides:

Testing:	Structure:	uC:	Requirements:	Risk:	Assembly:
Overview DAQ	Adhesives DAQ Box Bracket Mfg Mass Budget Mass Analogs Tube Inserts Edge Close Out	Harmony Drivers	FRs Structure Table DAQ Table	Foam Transport Door Late Materials Noisy DAQ No data save Frayed panels Adhesive underperf. Long mfg. Long Vibe test No mass analogs Mode no match Adhesive fails assy USB slow LPF corrupts data CA corrupts data ADC fail Power Fail uC not program	Schedule Assy/Testing Step 1 Step 2 Step 3 Step 4 Step 5

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BACK-UP SLIDES

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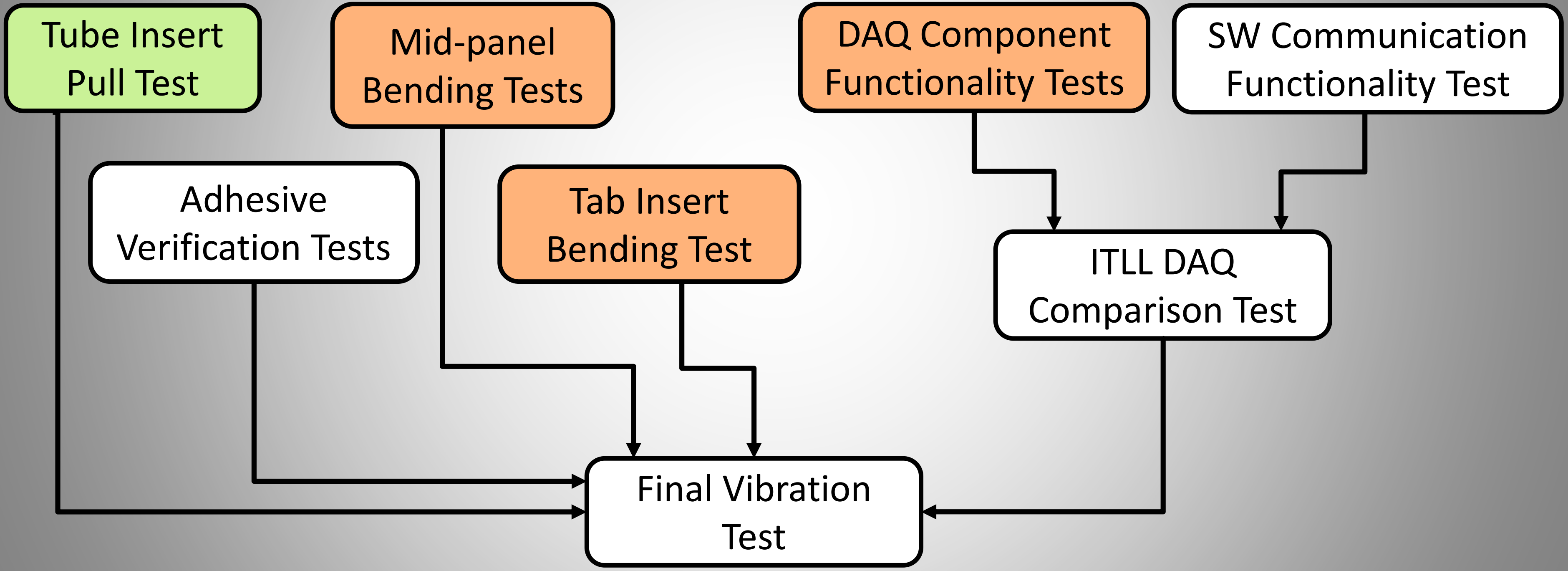
Test Overview:

Testing 20% Complete

Legend:
- Complete
- In-Progress
- Future Milestone



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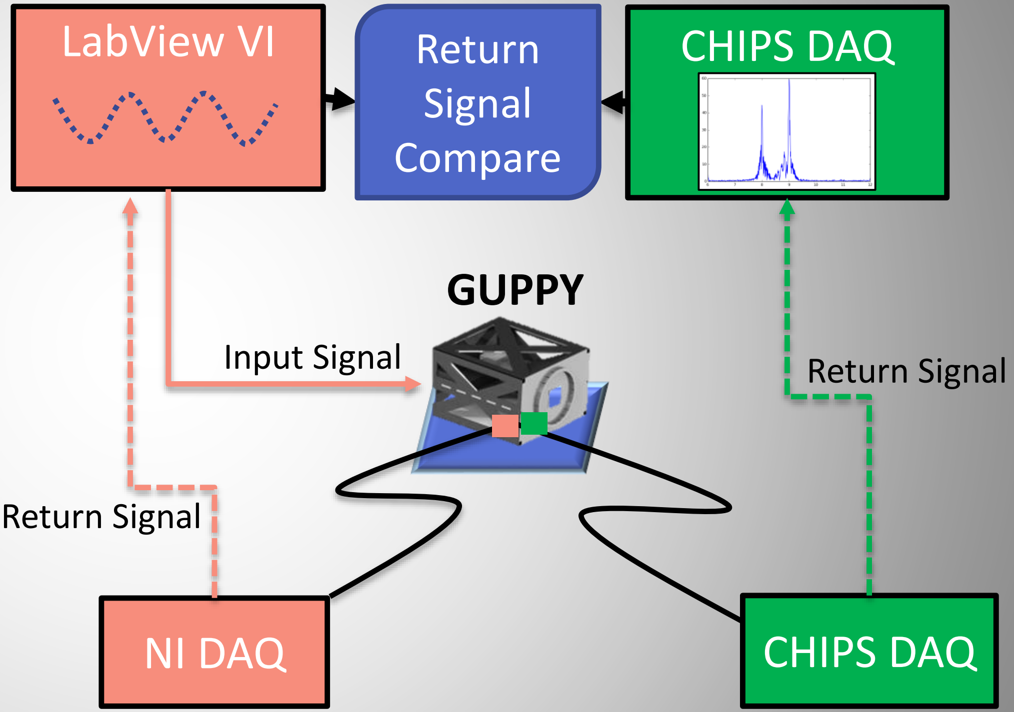
DAQ Test Plan:

- Component functionality tests performed during assembly process
- High-level verification test using NI DAQ and small vibe table in ITLL
- GUPPY will be tested under predetermined vibration profile
- Results from NI will be used as “truth” comparison for DAQ verification



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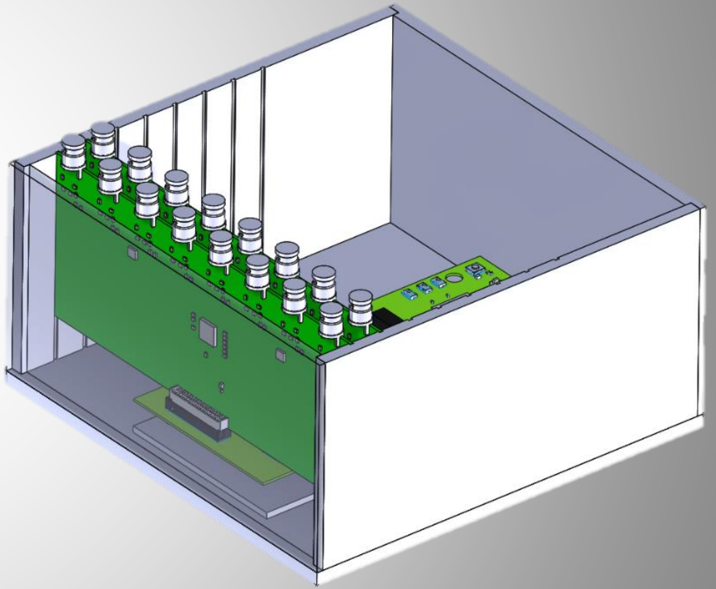
Adhesives

- Epoxy 2216 and 3550 has arrived
- Changes since Fall
  - Glass beads instead of wires for bond line
  - Metal stir sticks instead of wood
  - New oven for curing
- Planned Tests
  - Aluminum block to mid-panel test piece pull test – week of 2/7
  - ACP Panel to ACP Panel – week of 2/7
  - Potting Glue practice and Potting Glue to Epoxy – week of 2/16

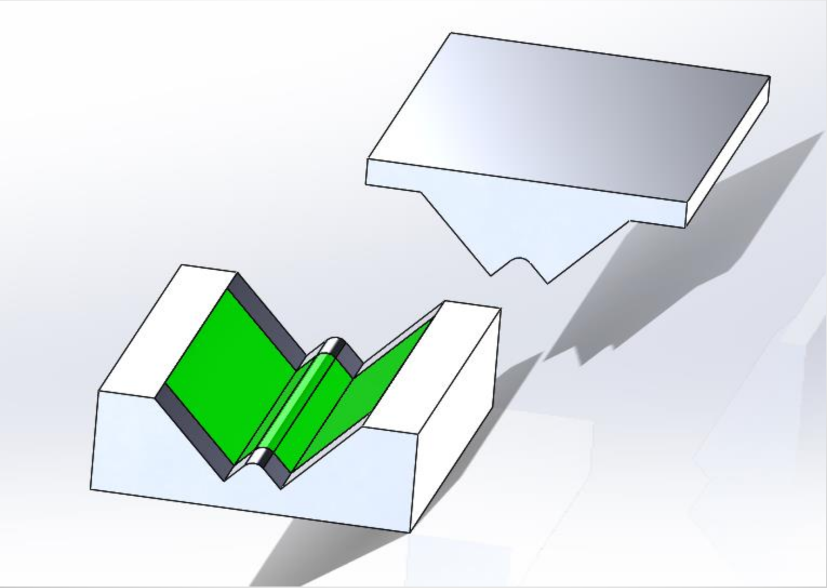
DAQ Box

- Aluminum and acrylic
- Pending final board shapes
- Provides safe housing for sensitive boards



W-bracket Manufacturing:

Mold is machined from extruded aluminum – design completed by 2/3/2016



Mass Budget – STM:

- ACP Composites panels came in just under expected mass
  - 1,28kg vs 1.33kg expected
- Addition of "W"-brackets
  - .22kg expected
- Design still under mass:
  - 4.48kg

Component	Mass (kg)
ACP Panels	**1.28**
Mid Panel	1.18
Adhesive	.77
Tubes	.71
Inserts	.33
Brackets	.22
Total:	**4.48**

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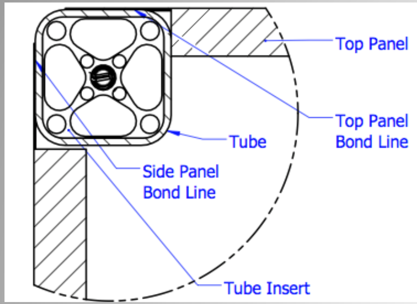
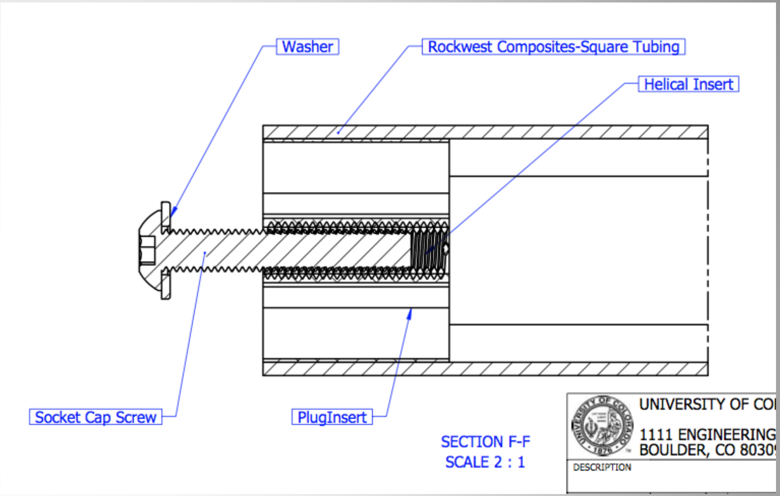
Mass Analogs:

Component:	Quantity:	Mass [kg]:	Dimensions [mm]:	Materials:	Status:
OBDH	1	4	300x150x30	Aluminum, Steel	Complete
AOCS Magnetometer	2	1.25	30x90x130	Aluminum, Steel	Complete
AOCS Torquer	3	1.5	90x250x40	Aluminum	Complete
AOCS Wheel	3	1	R109x100	Aluminum, Foam	Complete
Communications	1	10	190x135x60	Aluminum, Steel	Complete
Power	1	11	335x300x80	Aluminum	Complete
Propulsion	1	12	305x305x255	Aluminum, Aluminum Honeycomb	Complete

85 hours of work

Tube Inserts:

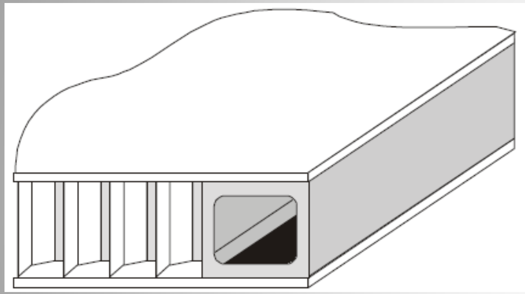




Bond line performed above expectations – the interface is qualified

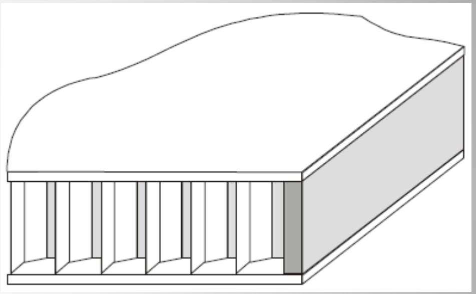
EDGE CLOSE OUT:

Box Extrusion Method - Tabs:



- Use end mill or router table with a fly cutter to clear core
- Used where panels interface with columns

Epoxy Fill In Method– Where Core in Exposed:



- Use block to push core back from edge
- Fill with Scotch Weld 3350

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Functional Requirements:

FR 1	The Feathercraft structure design shall have a **mass of less than 5 kg.**
FR 2	The Feathercraft structure design shall **reduce manufacturing time and material cost** from SST-US's typical spacecraft estimates.
FR 3	FeatherCraft Structure shall be designed to **deploy from Kaber Deployment System on the ISS.**
FR 4	FeatherCraft structure design shall **interface with SST-US-provided spacecraft components and mission design**.
FR 5	An **equivalent manufactured STM** of the FeatherCraft structure design shall be used to **demonstrate the feasibility of the FeatherCraft structure** through a **random vibration test** to the requirements of NASA GEVS documentation.

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Structure Requirements

Completed

1	Structure design shall have a mass < 5 kg	Analysis & Demonstration
2.1	Structure design shall cost < $20,000	Analysis
2.2	Structure design shall take less than 9 months to manufacture	Analysis & Demonstration
2.3	Structure design shall require less than $80,000 labor	Analysis
3.1	Structure design shall exhibit no visual deformation on vibration	Test
3.2	Design shall be less than 30''x30''x19''	Inspection
4.1-4.3	Design shall hold solar panels and prop plate	Test & Demonstration
4.4	Design shall have prop box	Demonstration
4.5	Design shall have mid-plate	Inspection
4.6.1	Designed mid-plate supports 32 kg on top	Demonstration & Test
4.6.2	Designed mid-plate supports 45 kg on bottom	Demonstration & Test
4.7	Radiator panel shall dissipate 100 W heat	Analysis
4.8	Design shall have open aperture on nadir side	Inspection
4.9	Components shall have space heritage	Analysis
5.1	STM shall be made to above specs	Inspection
5.2	Vibration test shall be performed correctly	Inspection
5.3	STM shall support all required weight	Demonstration
5.4	STM shall be foam-wrapped during vibration test	Inspection

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DAQ Requirements

Completed

5.5.1	Shall 4 accelerometers on structure during test	Inspection
5.5.1.1	Accelerometers shall be movable during test	Demonstration
5.5.1.2	Tri-axial accelerometer on mid-panel	Inspection
5.5.1.3	Accelerometer on Velcro-ed panel	Inspection
5.5.2	PSD plots shall be saved	Demonstration
5.6.1	DAQ design shall be capable of 20 accelerometers data transfer	Analysis
5.6.2	DAQ system shall include at least 1 tri-axis and one single axis accel	Inspection
5.6.2.1	DAQ system shall include 2 boards with 8 accel channels each	Inspection
5.6.3.1-5.6.3.4	DAQ system has charge amplifier, low pass filter, and ADC for each channel and 2 kHz accels	Inspection
5.6.3.5	Microcontroller/SW shall transfer data faster than 4 kHz	Demonstration
5.6.4	Software shall display PSD plots realtime	Demonstration
5.6.4.1	Shall be able to run DAQ SW on any Windows computer	Demonstration
5.6.5	SW shall save data as Excel files	Demonstration
5.6.6	Data shall be transferred via USB after test	Demonstration

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Microcontroller Software:

- Completed: Low level USB data transfer

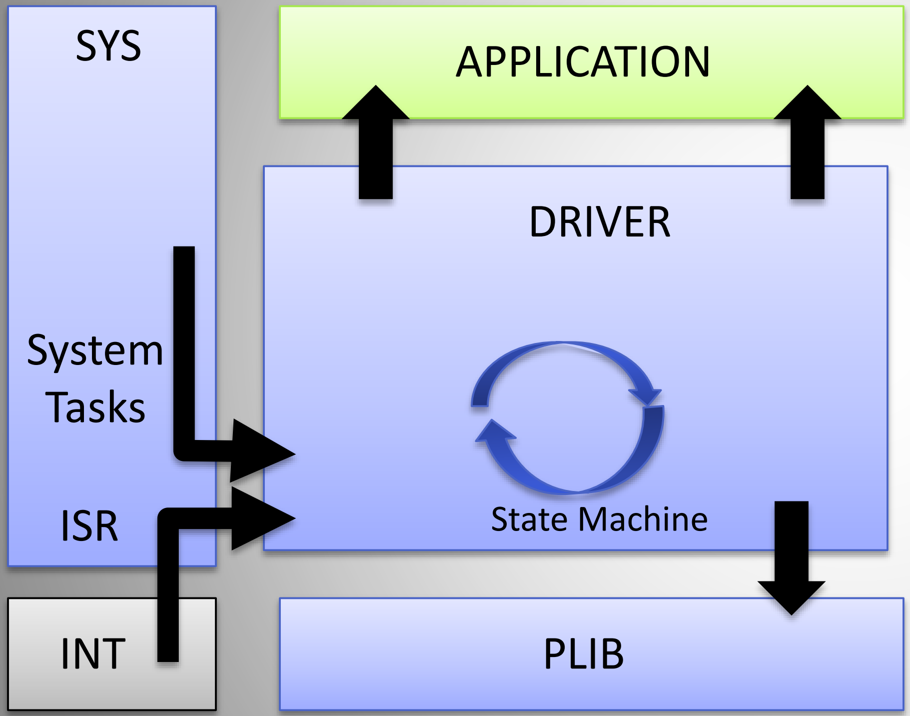
Harmony Framework

```
int main
{
        SYS_Initialize();
        while(1)
        {
                SYS_Tasks();
        }
}
```

- Sets up system configuration, core processes, driver setup(USB, timer)
- USB device layer initialization

- Maintain system:
  - Drivers (USB, timer)
  - Device Layer Tasks
- App Tasks
  - Where the data transfer actually occurs
  - Read data from RX buffer
  - Read data from each 16 bit data bus
  - Write data to TX buffer

Microcontroller Software/Drivers:



- Application Calls Driver – to use functions/services
- Driver calls system services & PLIB to service application call
- System tasks:
  - Those things specific to PIC32MZ2048H144
- State machine:
  - Allows for organization
  - Clear depiction of states
    - ie. On vs off
  - Controls access

1: Foam does not attenuate to 1.29 grms

- Severity: 1 Likelihood: 4 **Total: 4**
- Unexpected foam attenuation is not a failure in the design but a consequence of using an unfamiliar material
- Before Mitigation:
  - Develop fast method of computing modes with a change in attenuated vibration loads
  - Perform small-scale foam tests in ITLL and measure experienced acceleration
- Response After:
  - Stop test and continue at SST's discretion with either a new model or with the structure mounted directly to table and a vibration table setting of 1.29 grms
- Post-Mitigation Severity: 1 Likelihood: 3 **Total: 3**

2 - Structure Fails on the Way to Vibration Test:

- Severity: 5 Likelihood: 2 **Total: 10**
- Structure will need to be fully assembled with adhesive before transferring to vibration test facility, and transfer will likely have more loads than the vibration test itself
- Before Mitigation:
  - Wrap structure at least as much as it will be wrapped during vibration testing
  - Drive slowly and carefully
  - Build box for transport
- Response After:
  - Bring emergency adhesives / tape
- Post Mitigation Severity: 5 Likelihood: 1 **Total: 5**

3: Structure does not fit through door

- Severity: 3 Likelihood: 1 **Total: 3**
- Extreme cautions will be taken so that this challenging inconvenience does not occur
- Before Mitigation:
  - Measure all doors and structures the STM must fit into and develop path to transfer vehicle before assembly
- Response After:
  - Carefully turn structure
  - Find another exit
- Post Mitigation Severity: 3 Likelihood: 0 **Total: 0**

4: Materials are not received on time

- Severity: 4 Likelihood: 2 **Total: 8**
- All materials for structure have been received except potting material, which does not have significant dependencies. Thus this concern has been alleviated.

5: DAQ System data is noisy

- Severity: 2 Likelihood: 3 **Total: 6**
- DAQ system has many complex systems that need to be integrated together and test for noise before going to vibration test where more unexpected noise can be incorporated
- Before Mitigation:
  - Test completed DAQ system on ITLL vibration table and analyze results
  - Communicate with Cascade Tek about what signal effects to expect
- Response After:
  - Apply software filter to data after test day
- Post Mitigation Severity: 2 Likelihood: 1 **Total: 2**

6: DAQ system cannot save data

- Severity: 5 Likelihood: 1 **Total: 5**
- File sizes for test are large and also need to ensure permissions are correct for software to be used on any computer
- Before Mitigation:
  - Test software with fast data transfer on as many Windows computers as possible
- Response After:
  - Attempt to retest or use CascadeTek's data to complete requirements
- Post Mitigation Severity: 2 Likelihood: 1 **Total: 2**

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7: Manufactured Carbon Fiber panels are frayed

- Severity: 2 Likelihood: 3 Total: 6
- If edge-cutting is performed by team, many imperfections could be created
- Before Mitigation:
  - Manufacture test pieces
  - Develop metric to evaluate what imperfections are acceptable
- Response After:
  - Use spare pieces to manufacture again
  - Re-model the structure with these imperfections and test if the imperfections do not cause unexpected failure
- Post Mitigation Severity: 1 Likelihood: 3 Total: 3

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8 - Adhesive Underperforms:

- Severity: 5 Likelihood: 3 **Total: 15**
- Despite high margin, adhesive are least predictable and most critical component
- Mitigation Before:
  - Test adhesive on carbon fiber in small scale (completed)
  - Test adhesive on larger masses similar to payload analog
  - Purchase extra glue, extra VELCRO, and other fast adhesive methods
- Response After:
  - Experiment with different bond lines and attempt to use more glue
  - Use backup fastening methods on test day
- Post-mitigation Severity: 5 Likelihood: 2 **Total: 10**

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9: Manufacturing takes longer than expected

- Severity: 4 Likelihood: 2 **Total: 8**
- Manufacturing in the machine shop is essentially complete, and the composite shop has been very open so far this semester so scheduling is not an issue

10 - Vibration Testing Takes Longer Than 8 Hours:

- Severity: 5 Likelihood: 2 Total: 10
- Budget hinges on paying for an 8 hour testing day and if testing is not completed, measures will need to be taken to pay for another day or use table after hours
- Before Mitigation:
  - Practice entire process of moving accelerometers and unwrapping/rewrapping structure
  - Develop time estimates for each test and off-ramps to complete test more quickly while still meeting requirements
- Response After:
  - Will not be able to reschedule
- Post Mitigation Severity: 4 Likelihood: 1 Total: 4

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11: Mass analogs are not prepared in time for test

- Severity: 5 Likelihood: 1 **Total: 5**
- Mass analogs are complete

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12: Exhibited modes in vibration test do not match predicted model

- Severity: 1   Likelihood: 4   **Total: 4**
- Unexpected modes do not necessarily mean failure, but team model of structure must be validated
- Before Mitigation:
  - Create many possible profiles of structure modes based on calibrations and first tests
  - Consult PAB members and faculty to verify model should be correct
- Response After:
  - Attempt to match modes with prepared model profiles
  - If structure is not experiencing failure, continue with test and analyze results after test day
- Post Mitigation Severity: 1   Likelihood: 3   **Total: 3**

13: Adhesive bonds break during assembly

- Severity: 3 Likelihood: 1 Total: 3
- Adhesive strength is largest variable and may not withstand other elements of assembly
- Before Mitigation:
  - Analyze assembly plan with possible points of failure
  - Prepare schedule and budget for spare gluing time and spare glue
- Response After:
  - Re-glue failed components
- Post Mitigation Severity: 2 Likelihood: 1 Total: 2

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14: USB Communication protocol does not function at necessary speed

- Severity: 5 Likelihood: 3 Total: 15
- USB communication currently has large margin but fast data transfer must be achieved for quality data to be collected
- Before Mitigation:
  - Use development board to demonstrate USB protocol capabilities (In progress)
- Response After:
  - Explore different USB transmission schemes
  - Experiment with other protocols such as Ethernet
- Post Mitigation Severity: 5 Likelihood: 1 Total: 5

15: Low pass filter corrupts accelerometer data

- Severity: 4 Likelihood: 1 Total: 4
- Low pass filter is necessary to signal processing but adds complexity to design
- Before Mitigation:
  - Test low pass filter circuit and model frequency response
- Response After:
  - Perform digital filtering on circuit instead
  - Revise board and reorder
- Post Mitigation Severity: 2 Likelihood: 1 Total: 2

16: Charge Amplifier corrupts signal

- Severity: 4 Likelihood: 2 Total: 8
- Charge amplifier will be created by team and as such includes variability that cannot influence data
- Before Mitigation:
  - Test charge amplifier circuit and demonstrate its capabilities with accelerometer data
- Response After:
  - Rebuild circuit, revise board
- Post Mitigation Severity: 2 Likelihood: 2 Total: 4

17 - ADC Corrupts / Cannot Transfer Signal:

- Severity: 5 Likelihood: 2 **Total: 10**
- ADCs are essential to the transfer of data from sensor to microcontroller
- Before Mitigation:
  - Thoroughly familiarize with ADC specs
  - Review ADC schematic with PAB members
  - Utilize former team’s knowledge and prior experience
- Response After:
  - Debug on board
  - Revise board and remanufacture
- Post Mitigation Severity: 3 Likelihood: 2 **Total: 5**

18: Power distribution fails or destroys components

- Severity: 5 Likelihood: 1 Total: 5
- All electronics are power-sensitive and all failures will be considered before test day
- Before Mitigation:
  - Include fuses, zero-ohm resistors, and voltage regulators for circuit protection
  - Create plan to verify functionality of power section before powering critical components
- Response After:
  - Remove damaged component and replace from available resources
  - Rework board design and remanufacture
- Post Mitigation Severity: 4 Likelihood: 1 Total: 4

19 - Microcontroller Cannot be Programmed:

- Severity: 5 Likelihood: 2 Total: 10
- Microcontroller required for data transfer speed is more complicated than boards previously used by team members
- Before Mitigation:
  - Use development board to program microcontroller (In progress)
  - Read literature and programming manuals
- Response After:
  - Utilize more team resources to debug and revise board
  - Use development board while designed board is in work
- Post Mitigation Severity: 4 Likelihood: 1 Total: 4

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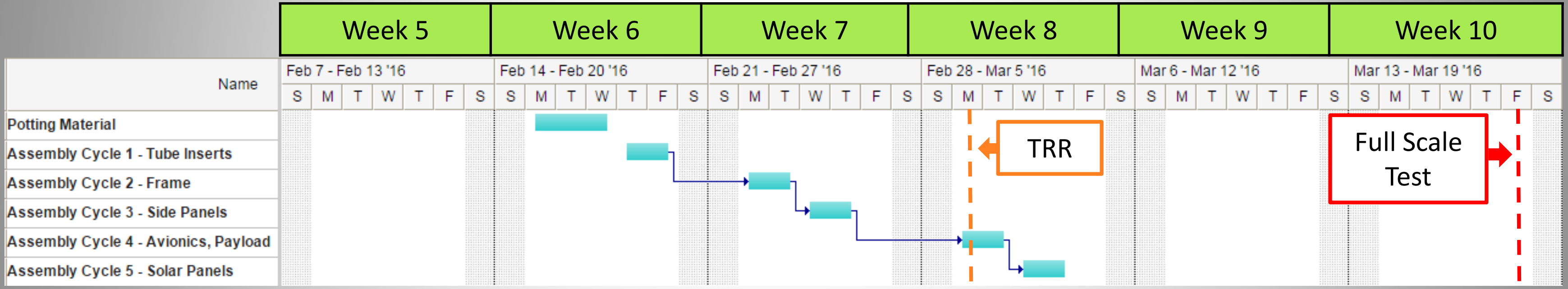
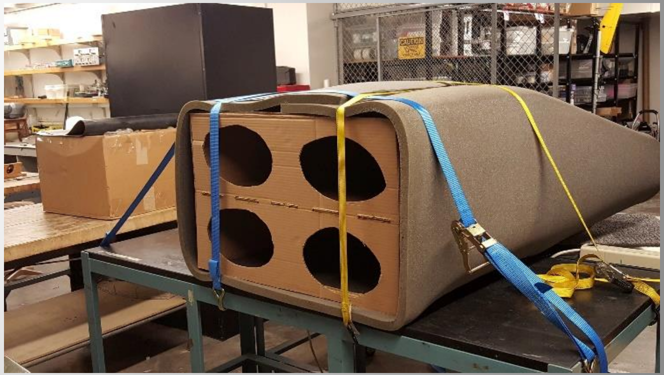
Assembly Detailed Schedule:

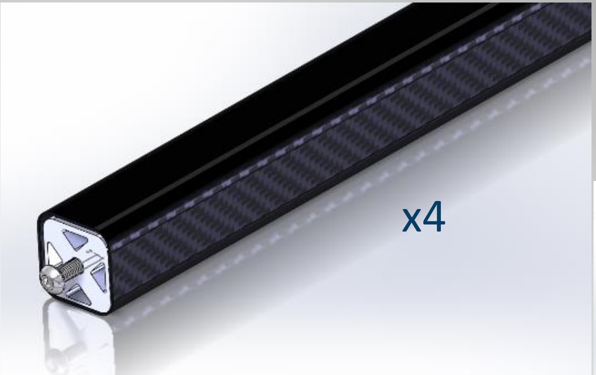


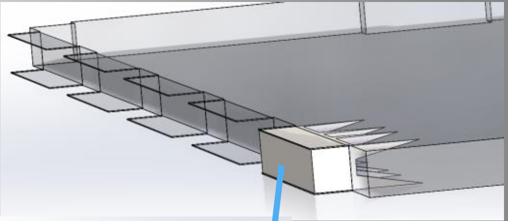
Assembly & Testing:

- On-track to start assembly on 2/16
  - Completed preliminary test with cardboard
  - Assembly Procedure Created
- Pyrell Foam is here and being used for testing
  - Attenuation Testing
  - Wrapping examples & practice
- Vibration Testing date set - 3/18
  - Test Plan developed, being reviewed by Surrey & Cascade Tek

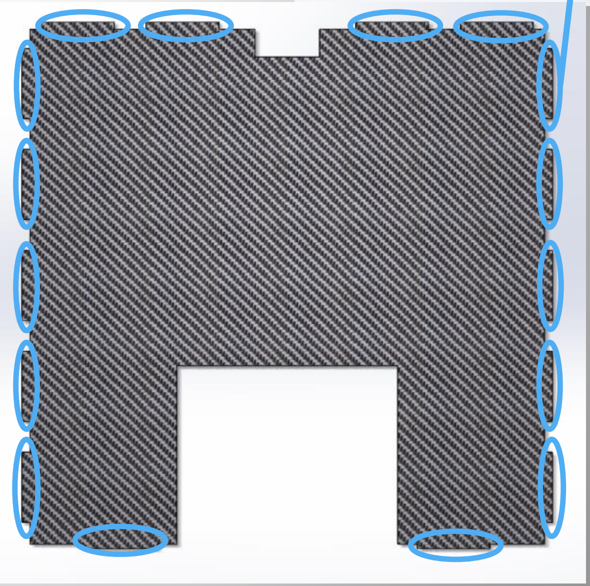


Assembly Step 1:





- Columns
  - Inserts are bonded into columns
- Middle Plate
  - Inserts are bonded into tabs

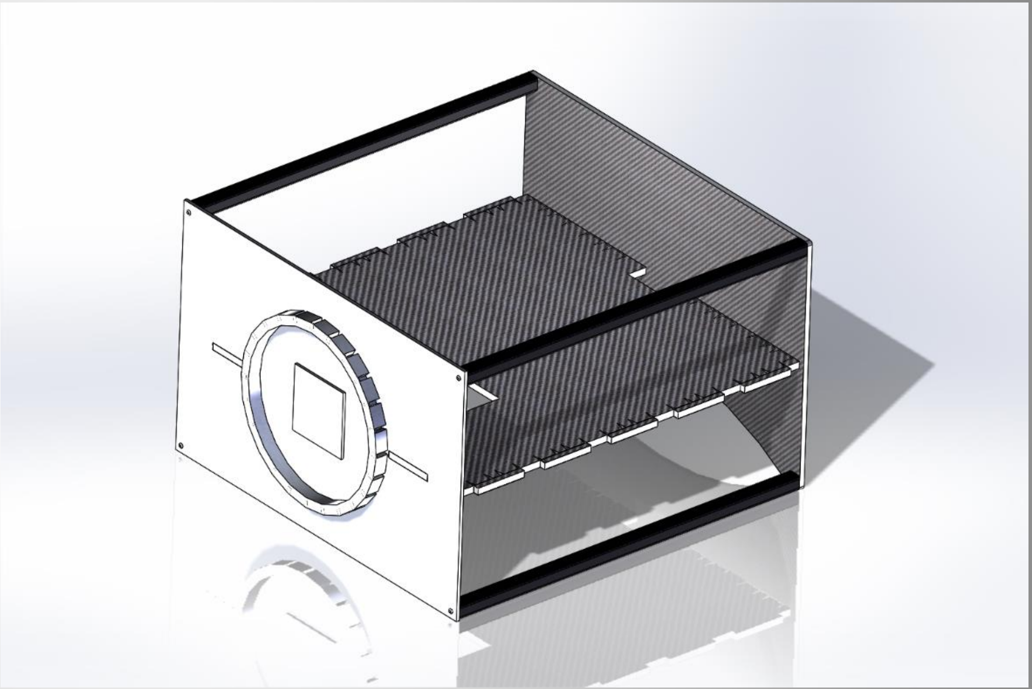


Sub-assemblies are cured in thermal chamber

Assembly Step 2:

Assemble frame

- Install Propulsion Plate and Radiator
- Install Middle Panel

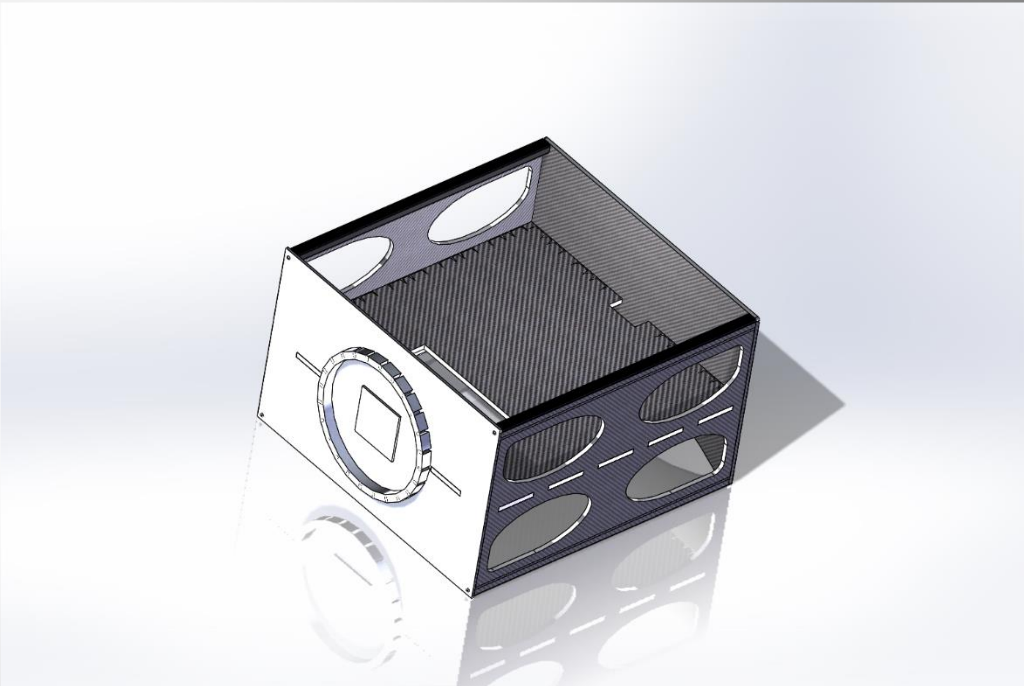


Assembly Step 3:

Install Side Panels

- Ensure proper alignment within structure
- Apply pressure on glued components

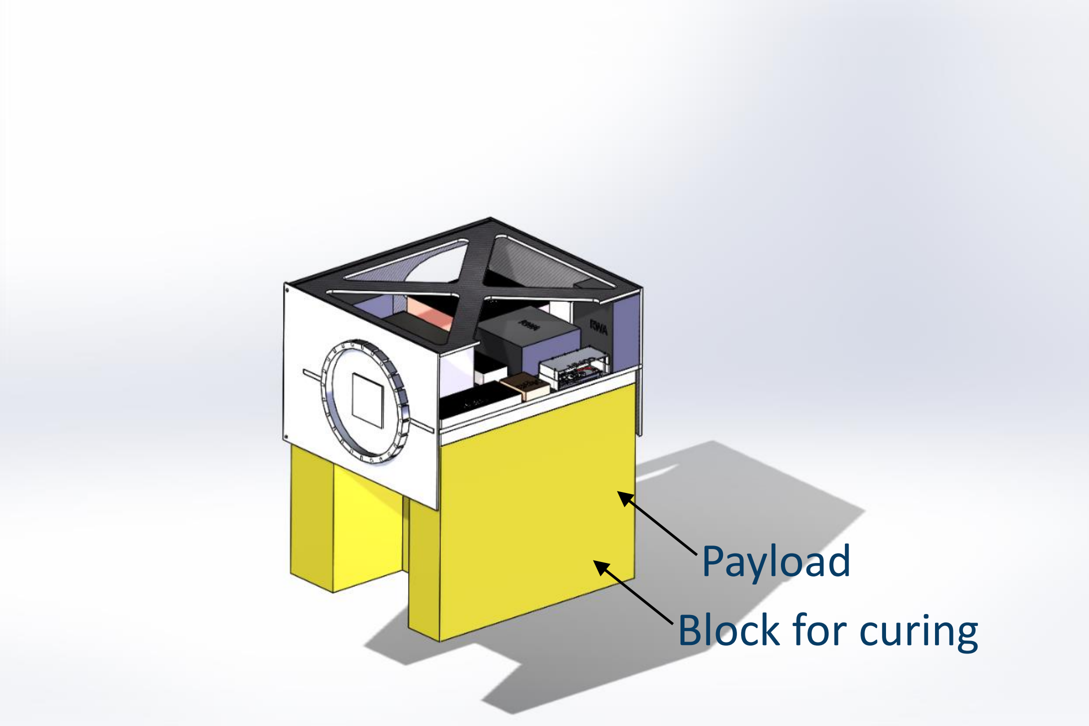
Cure in thermal chamber



Assembly Step 4:

- Integrate Payload
  - Assembly block configuration
  - Cure STM in thermal chamber

- Install avionics mass simulators
  - Gluing of mating surfaces
  - Install Top Panel with glue
  - Cure STM in thermal chamber



Assembly Step 5:

- Install Solar Panels
  - Adhesive (Side)
  - Velcro (Top & Side)