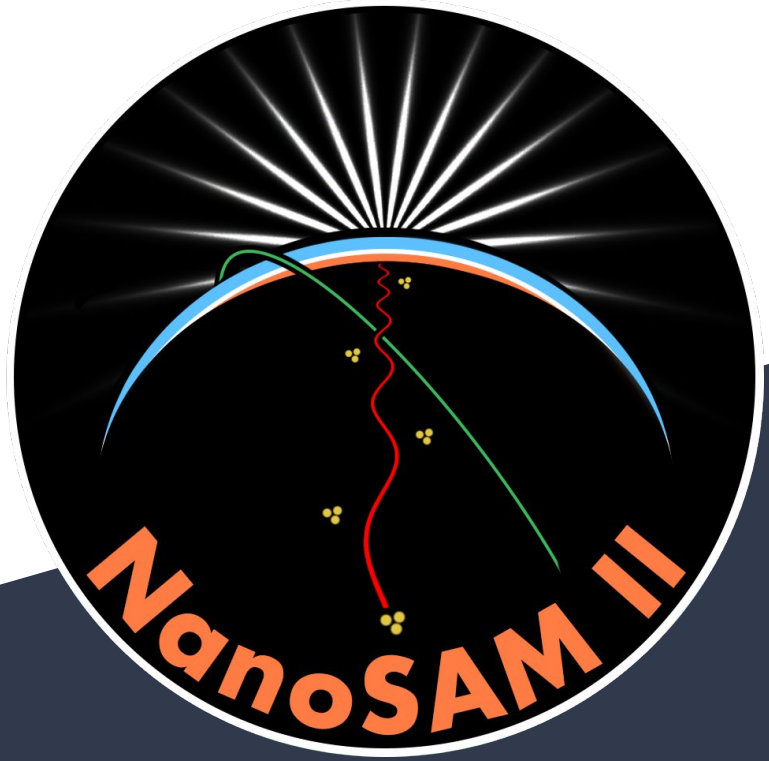
NanoSAM II

Nano-Stratospheric Aerosol Measurement

Manufacturing Status Review

February 1, 2021



Ball Aerospace

University of Colorado Boulder
Department of Aerospace Engineering Sciences

Agenda

NanoSAM II
MSR

- Overview
- Schedule
- Manufacturing
- Budget

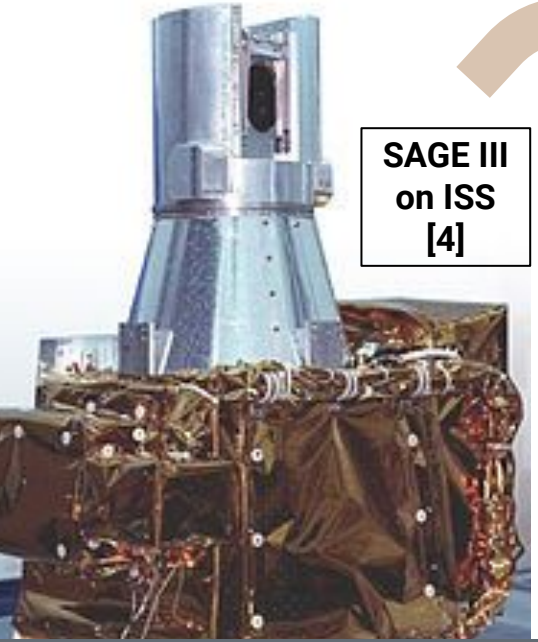
Project Overview

Daniel Barth

Project Background & Purpose

SAM/SAGE Instruments
(1979-1984, 2001-2006, 2011-Current)

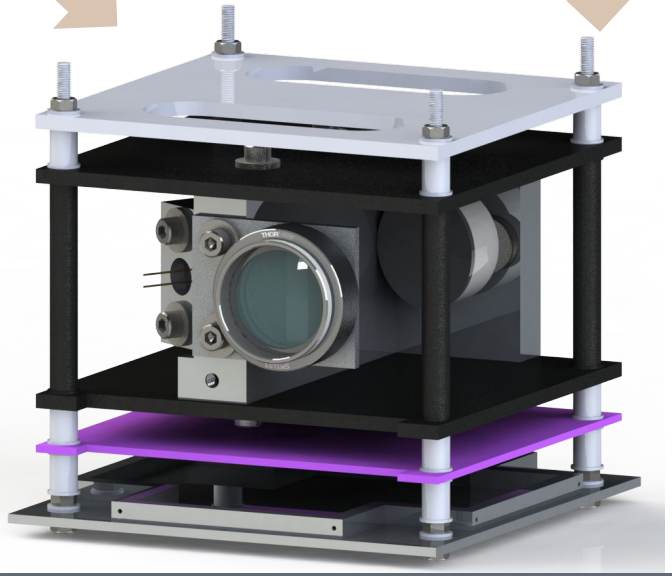
Bulky, High Cost, Low Data Volume



SAGE III on ISS [4]

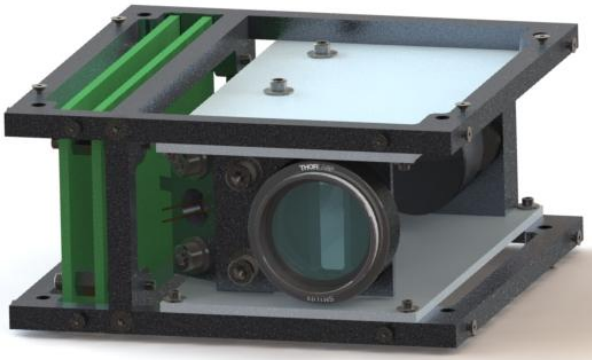
NanoSAM I
(2019-2020)

Optical Instrument for CubeSat Footprint



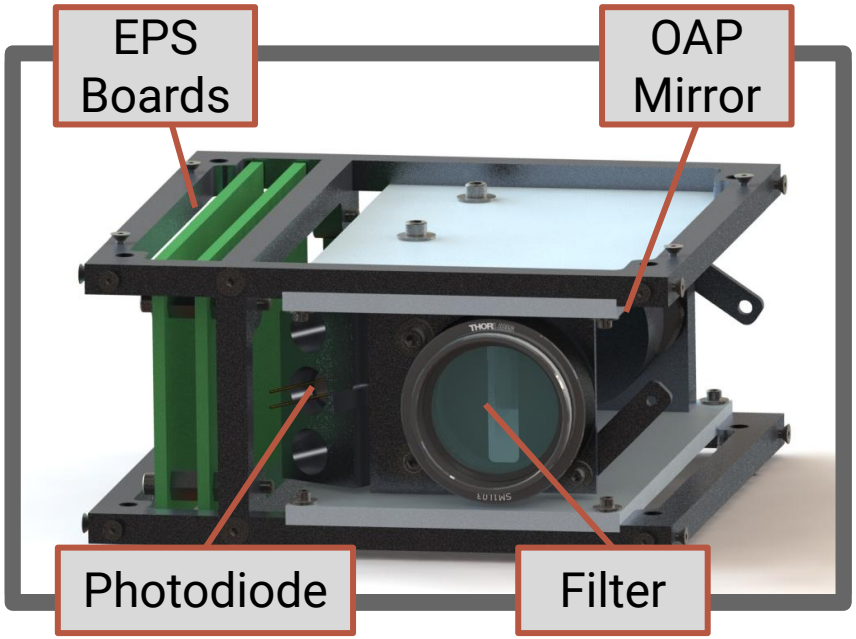
NanoSAM II
(2020-Current)

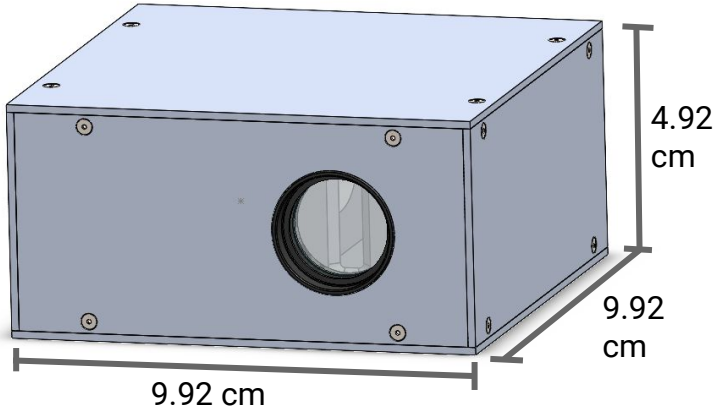
Integrated 0.5U CubeSat Payload



NanoSAM Mission CONOPS

NanoSAM II Payload

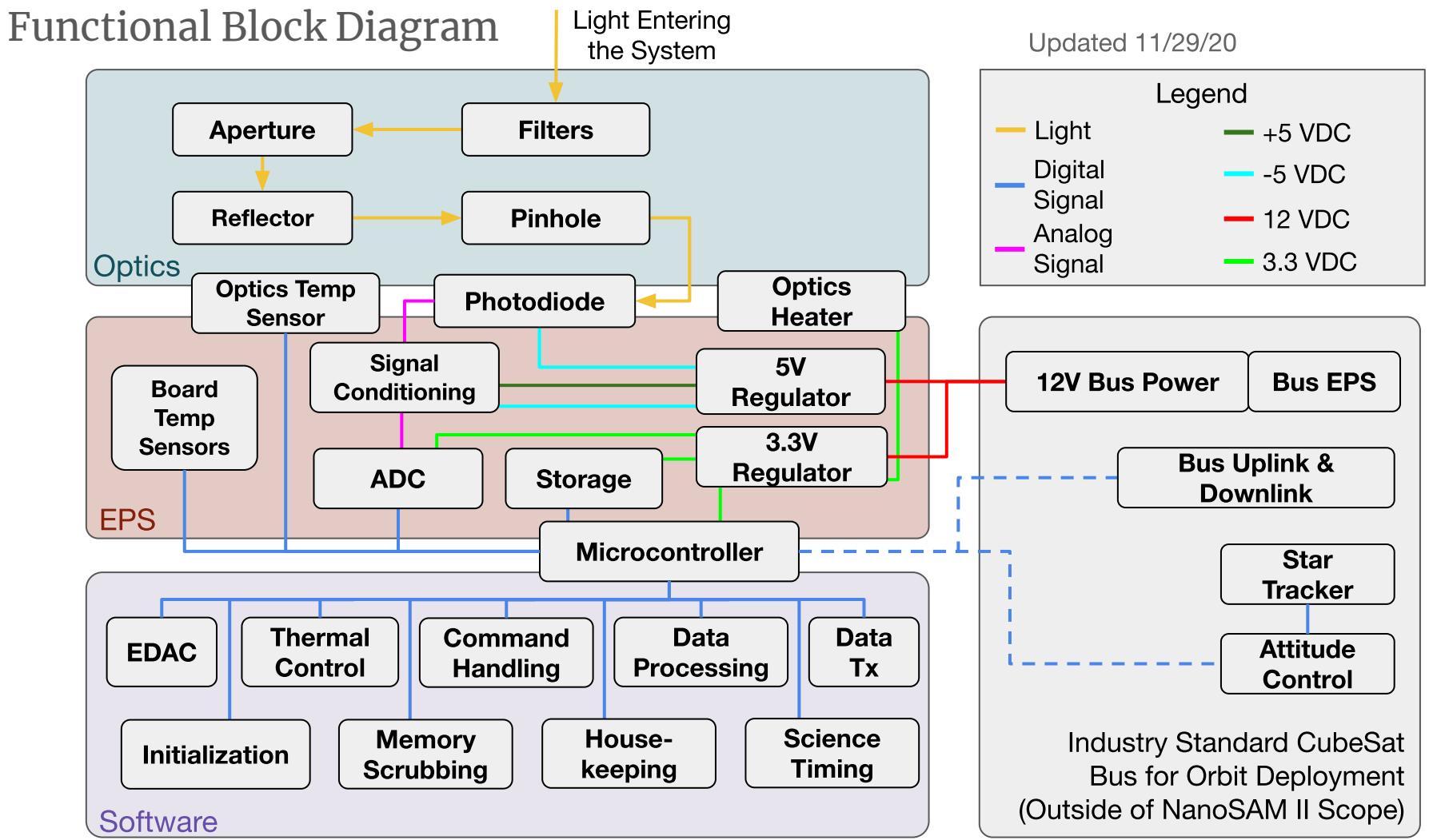




Mass: 0.48 kg
Size: 0.5 U

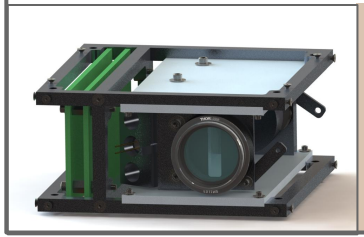
Gathers Irradiance Measurements at 50 Hz

Functional Block Diagram



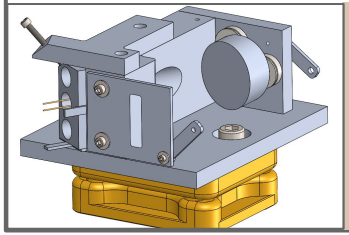
Status on Critical Project Elements

Structure



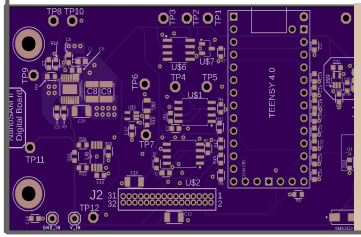
0.5U Payload Form Factor

Optics



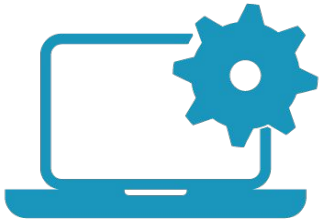
Match SAM-II Instrument Legacy Performance

Electronics



Low-Noise Signal Processing

Software

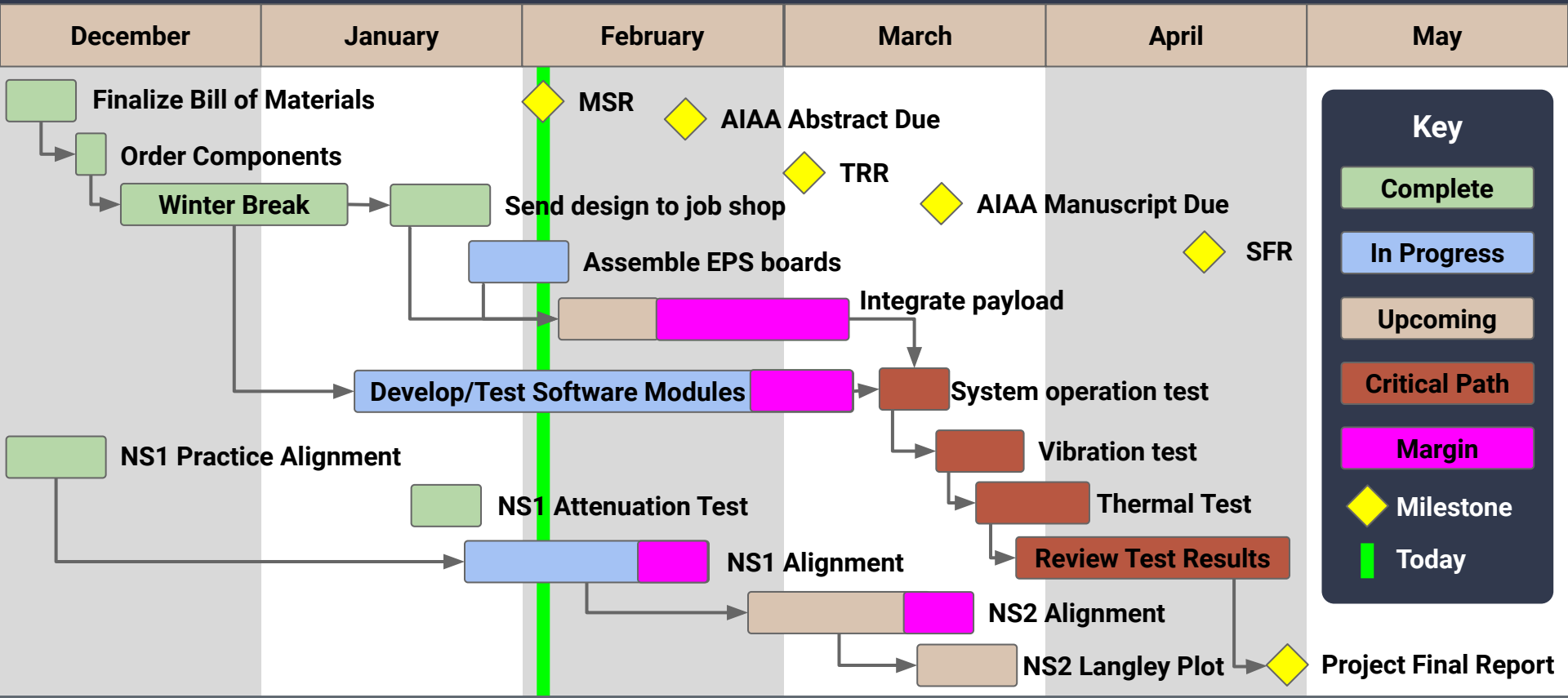


Timely and Reliable Data Collection

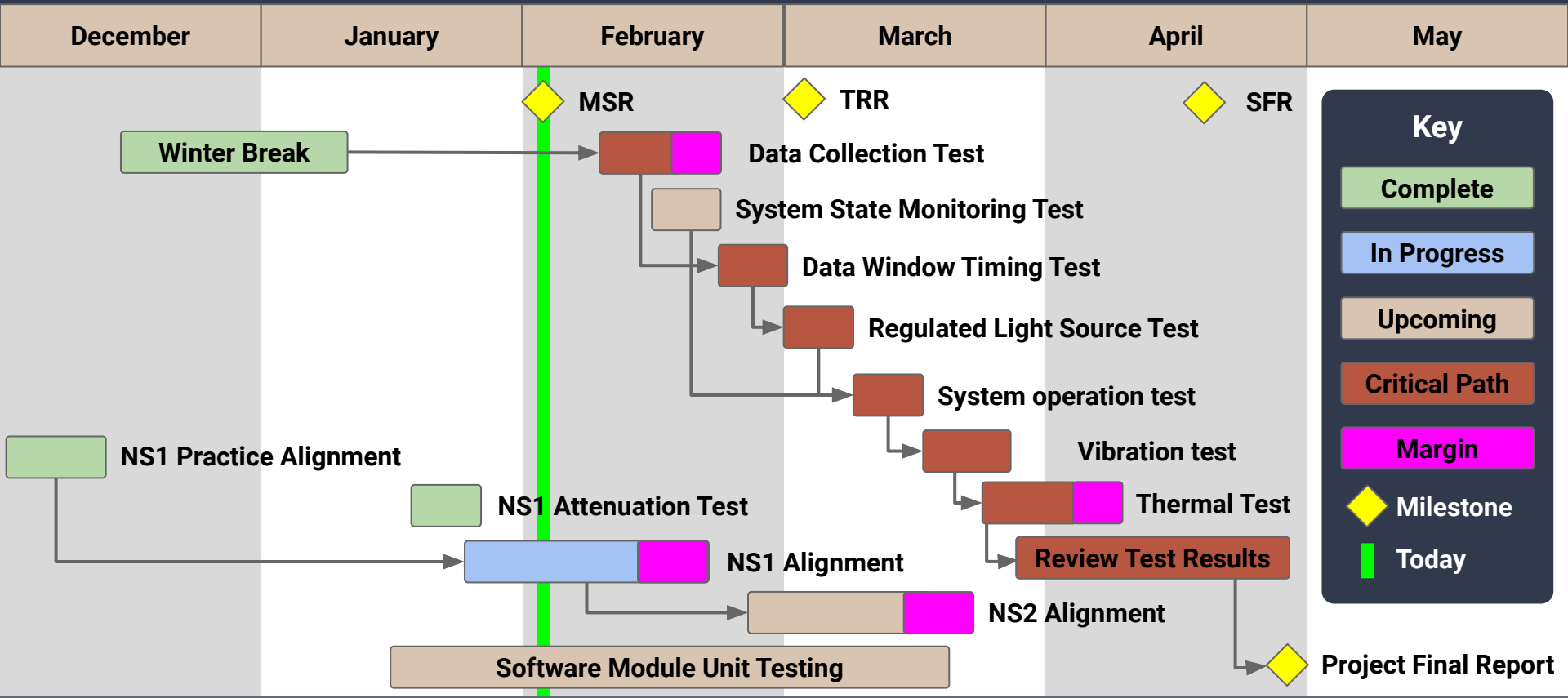
Schedule

Daniel Barth

Schedule


December
January
February
March
April
May
Finalize Bill of Materials
Order Components
Winter Break
MSR
AIAA Abstract Due
TRR
Send design to job shop
AIAA Manuscript Due
SFR
Assemble EPS boards
Integrate payload
Develop/Test Software Modules
System operation test
Vibration test
Thermal Test
Review Test Results
NS1 Practice Alignment
NS1 Attenuation Test
NS1 Alignment
NS2 Alignment
NS2 Langley Plot
Project Final Report
Key
Complete
In Progress
Upcoming
Critical Path
Margin
Milestone
Today

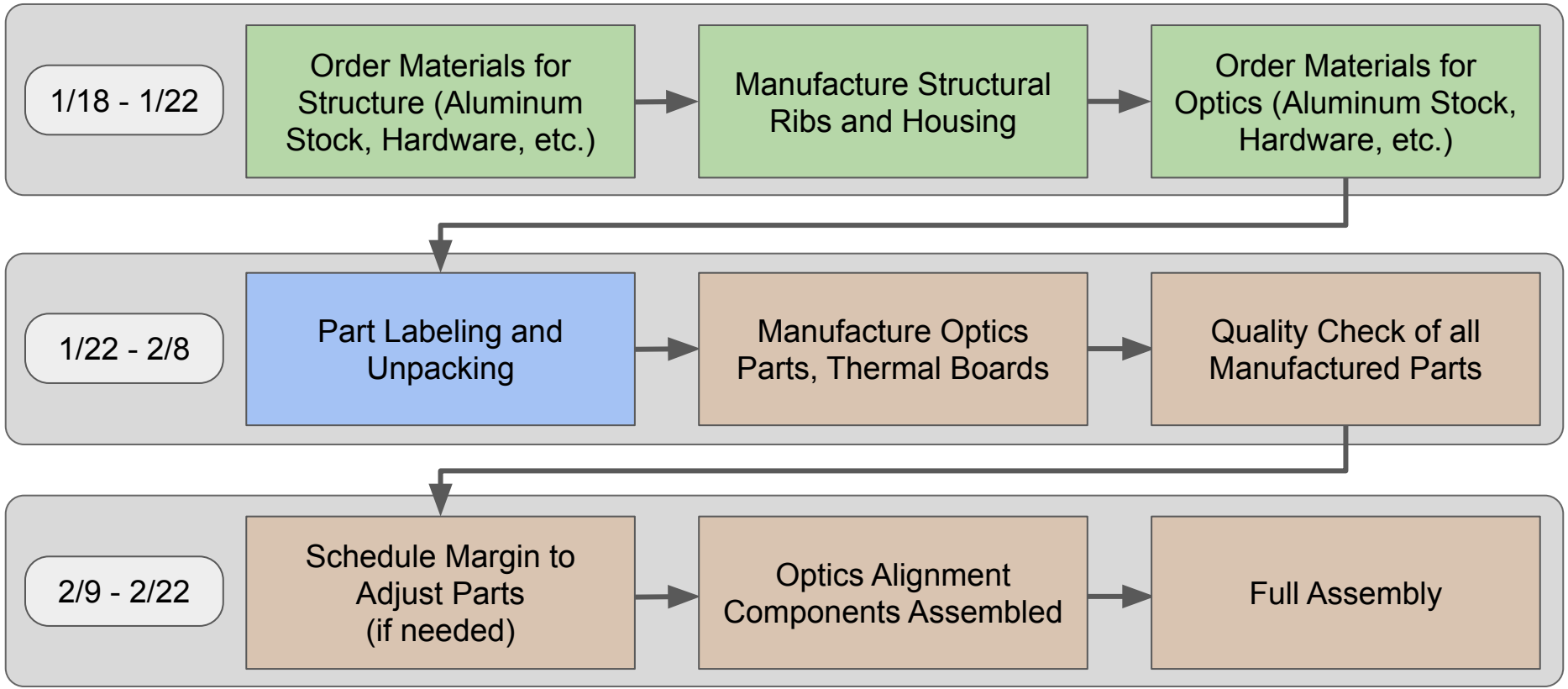
Schedule: Testing



Manufacturing

David Perkins, Emma Tomlinson, & Jackson Kistler

Structures Manufacturing Flow



Structures Manufacturing Scope

Parts Needed

(2) Horizontal Ribs

(1) EPS Mount Rib

(4) Small EPS Spacers

(4) Board-Board Spacers

(2) Thermally Isolating Boards

(6) Housing Panels

Manufacturing Steps*

I. Stock Thickness Refinement

II. Cut Ribs

III. Cut Housing Panels

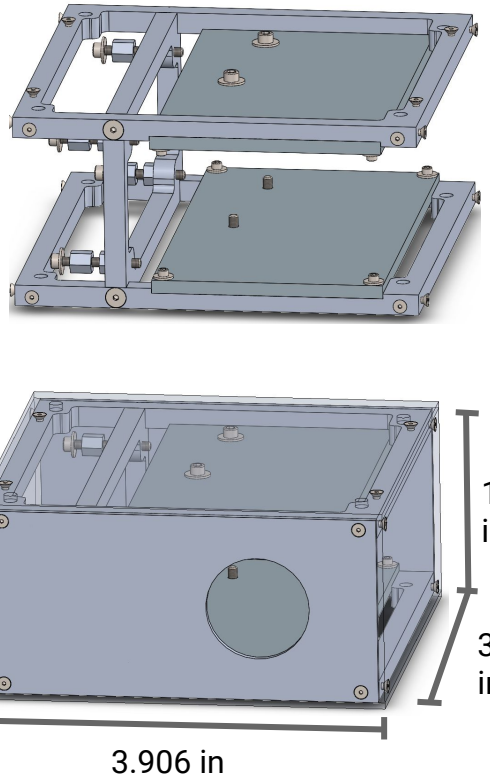
IV. Clearance and Tap Holes

V. Spacer Cutting/Drilling

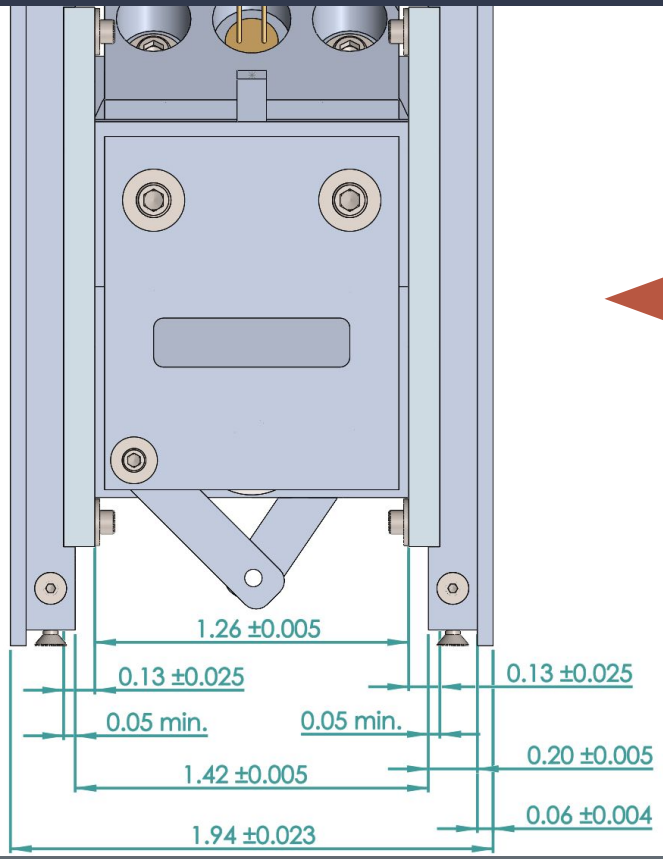
VI. Dry Fit Parts

VII. Special Thread in Front Wall

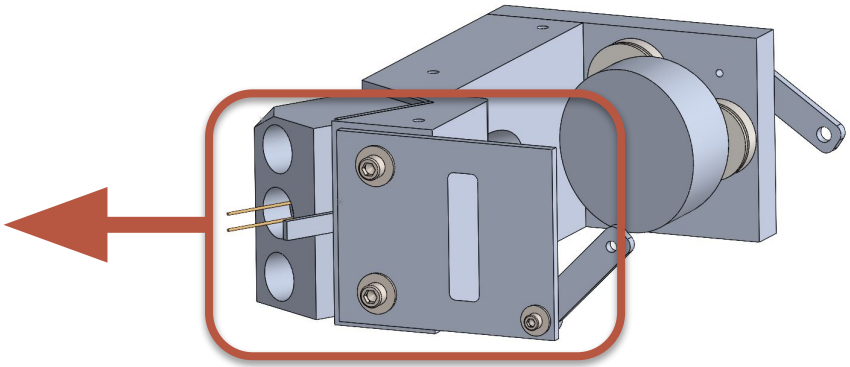
* Manufactured in Aero 155 (Job shop)



Manufacturing Tolerances



dimensions in inches

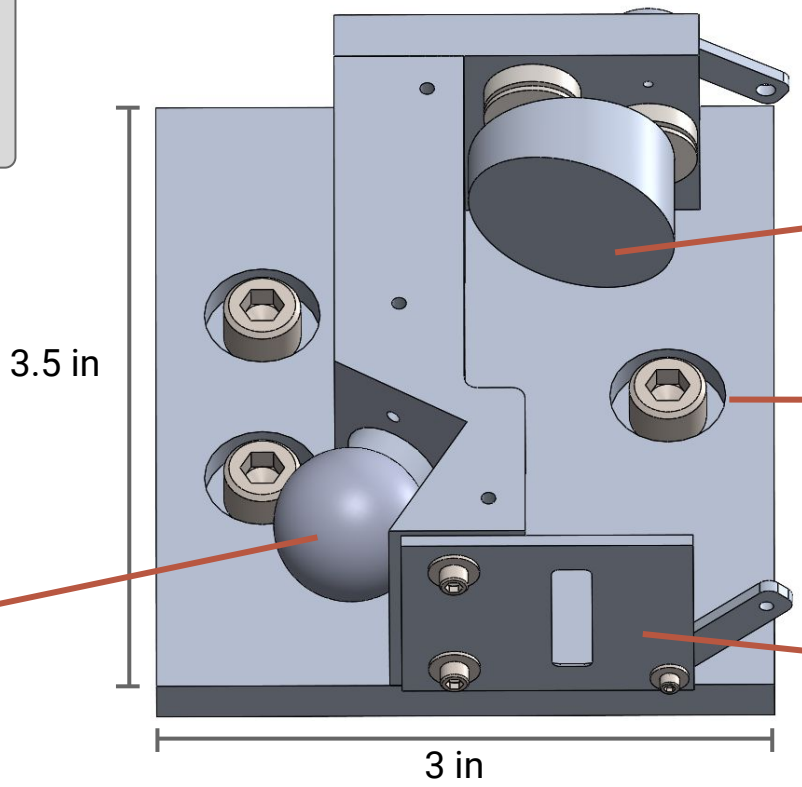


Side view of optics

Optics Finalized CAD - Motivation

Purpose

Determine the quality of the mirror via interferometry



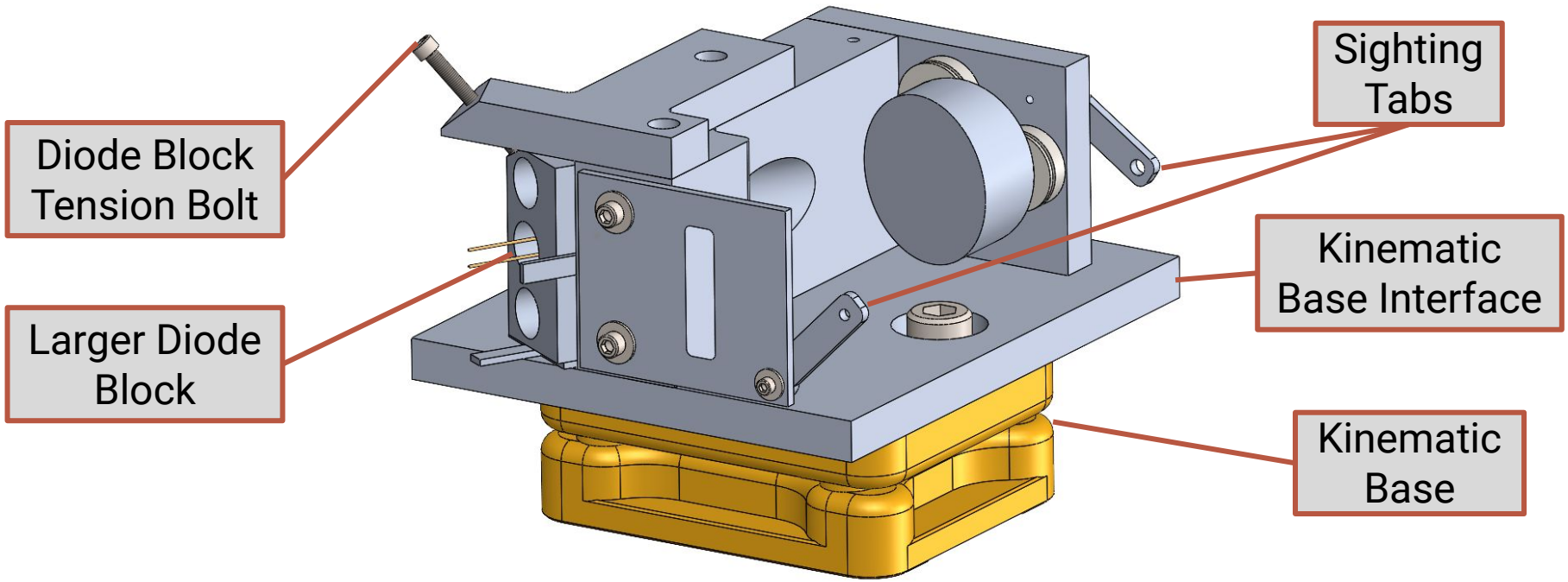
Off-Axis Parabolic Mirror (d = 1 in)

Kinematic Base Interface Hardware (#6-32 0.5in)

Return Sphere (d = 0.75 in)

Aperture Plate

Optics Finalized CAD - Alignment Hardware



Optics Manufacturing Scope

Parts Needed

(1) Optics Base - Diode Mount

(1) Optics Base - Mirror Mount

(1) Kinematic Mount Interface

(1) Tension Screw Holder

(1) Diode Block

(1) Aperture Plate

(1 ea.) Front, Rear Crosshair

(~10 ea.) Diode Shims

Manufacturing Steps*

I. Mill Optics Base Parts

II. Optics Base Main Hole

III. Mill Interface, Aperture Plate, Tension Holder

IV. Mill Diode Block

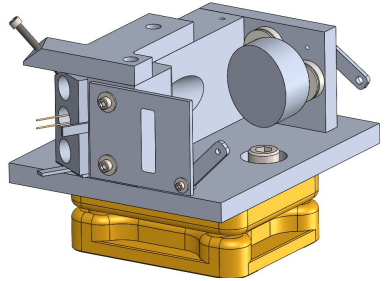
V. Clearance and Tap Holes

VI. Crosshair cutting

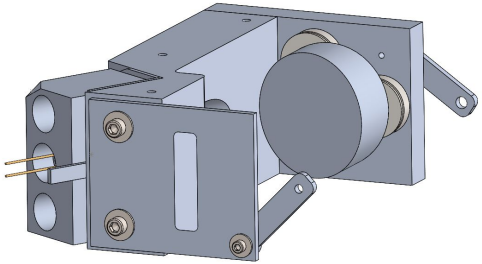
VII. Assembly

* Job shop model

Alignment Hardware



Flight Hardware



Completed Parts

Horizontal Ribs, EPS Mount Rib, and Housing Panels

Material:

- 6061 Aluminum

Tolerance:

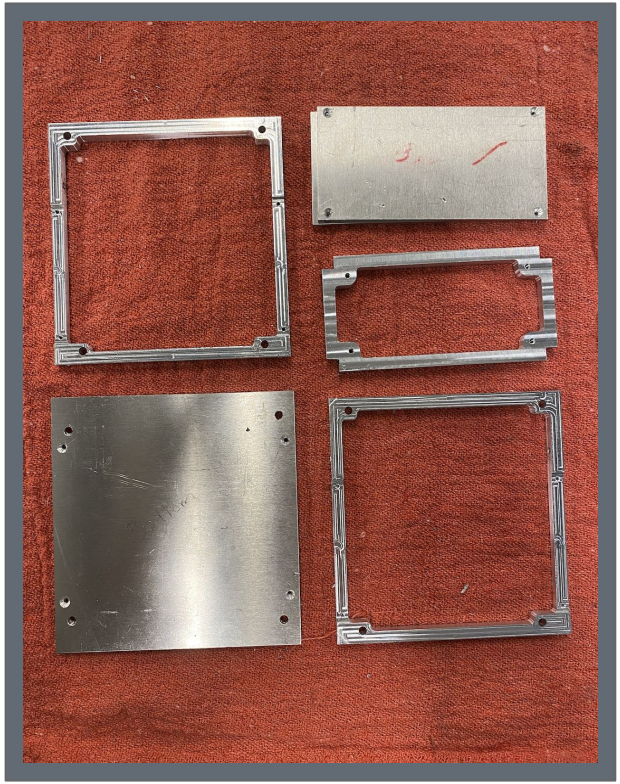
- ± 0.005 in.

Equipment:

- CNC Mill and Mill

Method:

- Cut to size, shape using mill, tap or drill holes to correct dimensions



Uncompleted Parts

Board-Board Spacers and Small EPS Spacers

Material:
- 6061 Aluminum

Dimensions:
- Length = 0.10 and 0.20 in.

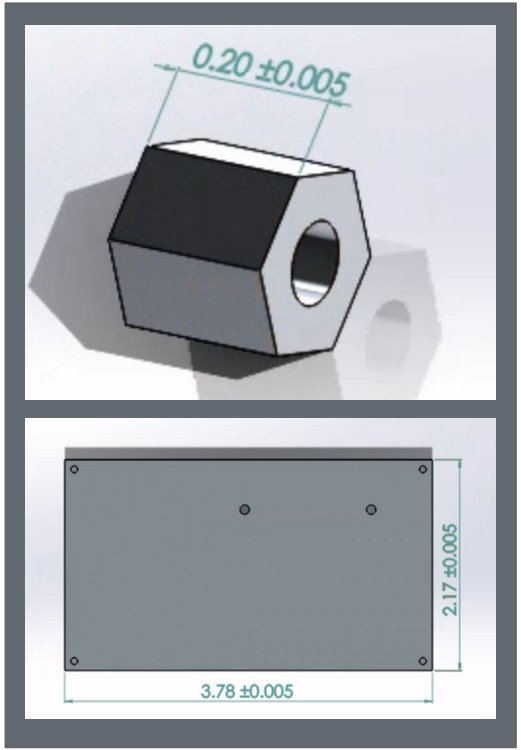
Method:
- Cut hex stock to correct length, drill through-hole in center of cross section

Board-Board Spacers and Small EPS Spacers

Material:
- FRP Fiberglass

Dimensions:
- 3.78 x 2.17 in.

Method:
- Cut to correct dimension with horizontal band saw, use drill press to create through-holes



Uncompleted Parts

Front Housing Panel

Material:

- 6061 Aluminum

Tolerance:

- ± 0.05 in.

Equipment:

- Mill

Method:

- Cut to correct size, use specific ordered thread mill to tap the largest hole

Electronics Manufacturing Scope

Parts Needed

(1) Populated Analog Board

(1) Populated Digital Board

(3) Shielded twisted pair wires

(3) Clip Connectors

Manufacturing Steps*

I. Application of solder paste

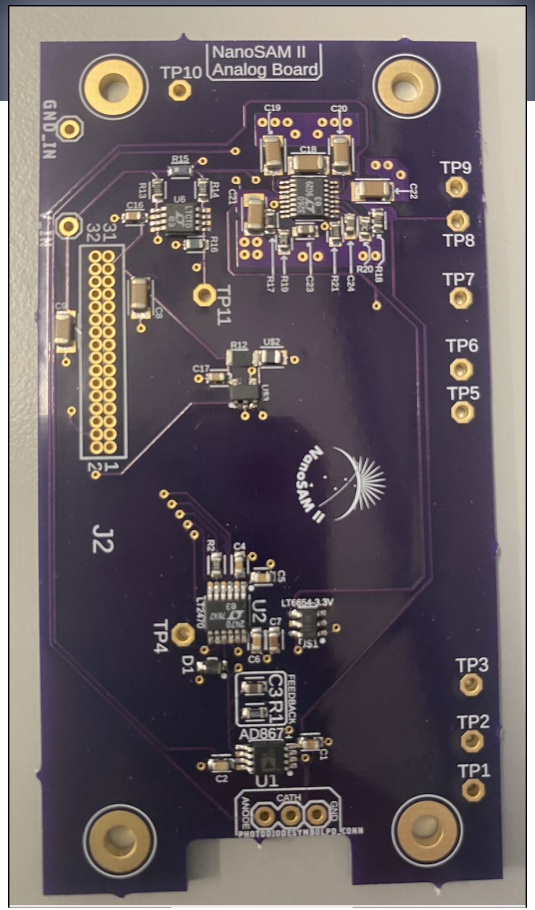
II. Population of board parts via pick and place machine

III. Reflow soldering of boards

IV. Creation of off-board part harnesses

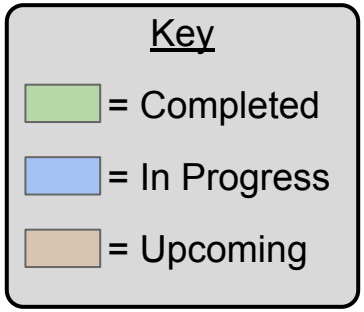
V. Connect boards and integrate in structure

* Manufactured in Aero 150



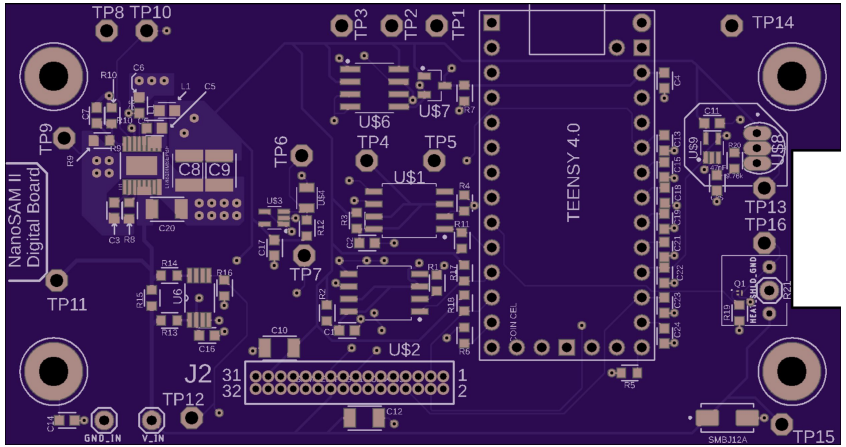
Electronics - Purchases vs Manufactured

Purchases	Manufacturing
Analog Boards Digital Boards All Board Parts (Resistors, capacitors, connectors, IC's) Board-Board Connector	Populated Analog Board Populated Digital Board
Clip Connectors (2/2-2/9) Shielded Twisted Pair Wire (checking lab availability before ordering)	Off-Board Harnesses (2/9-2/22)



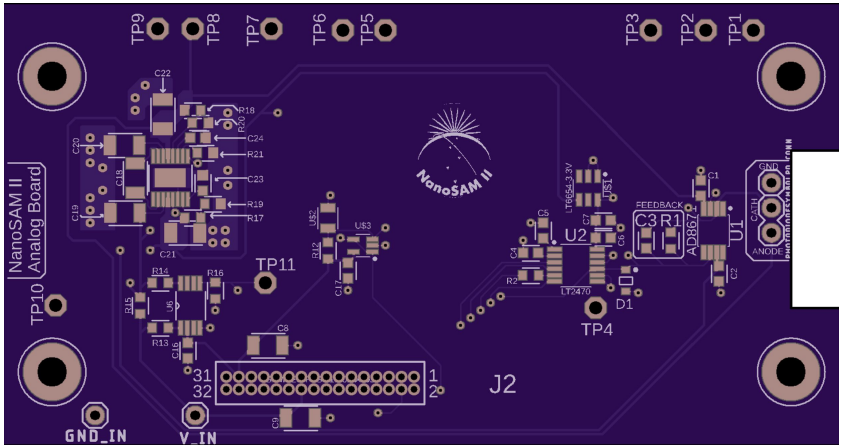
Electronics - Analog and Digital PCBs

Analog Board



3.36 in.

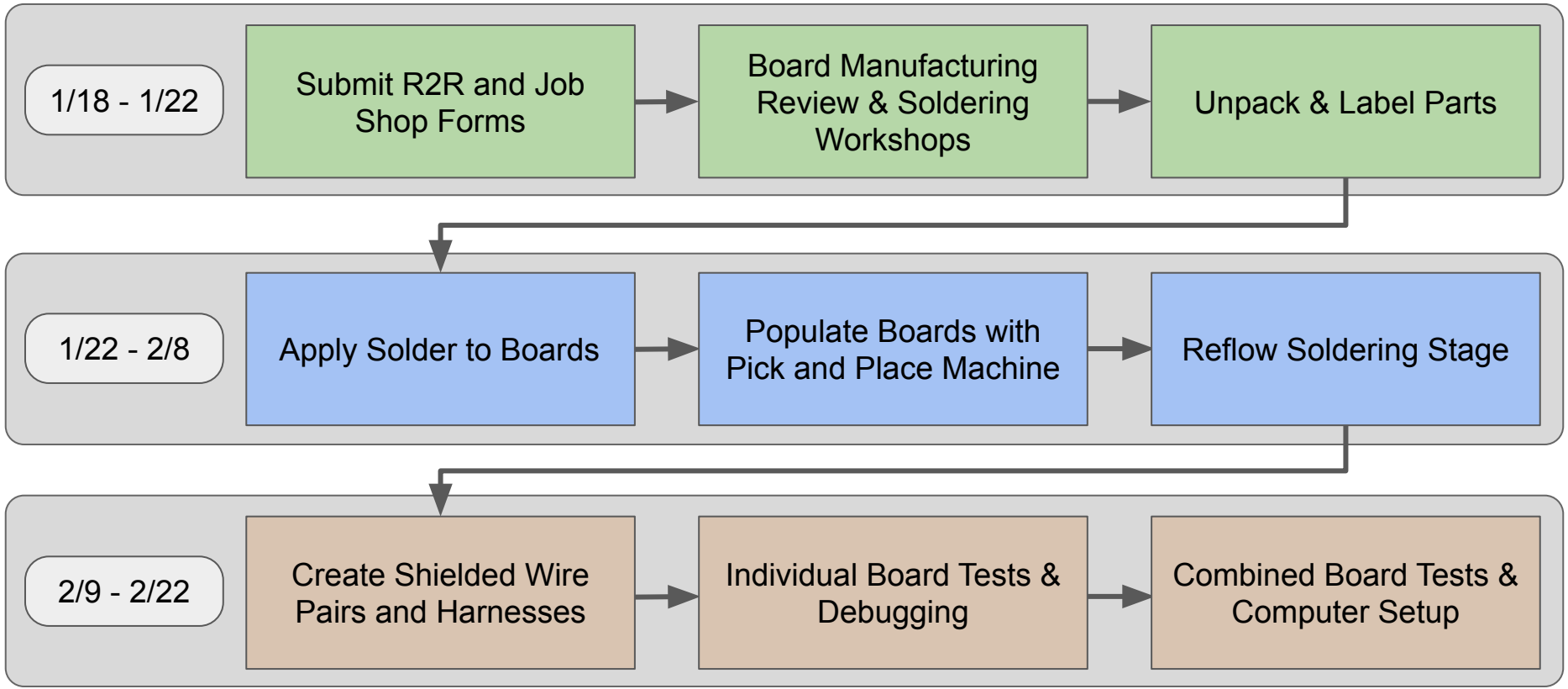
Digital Board



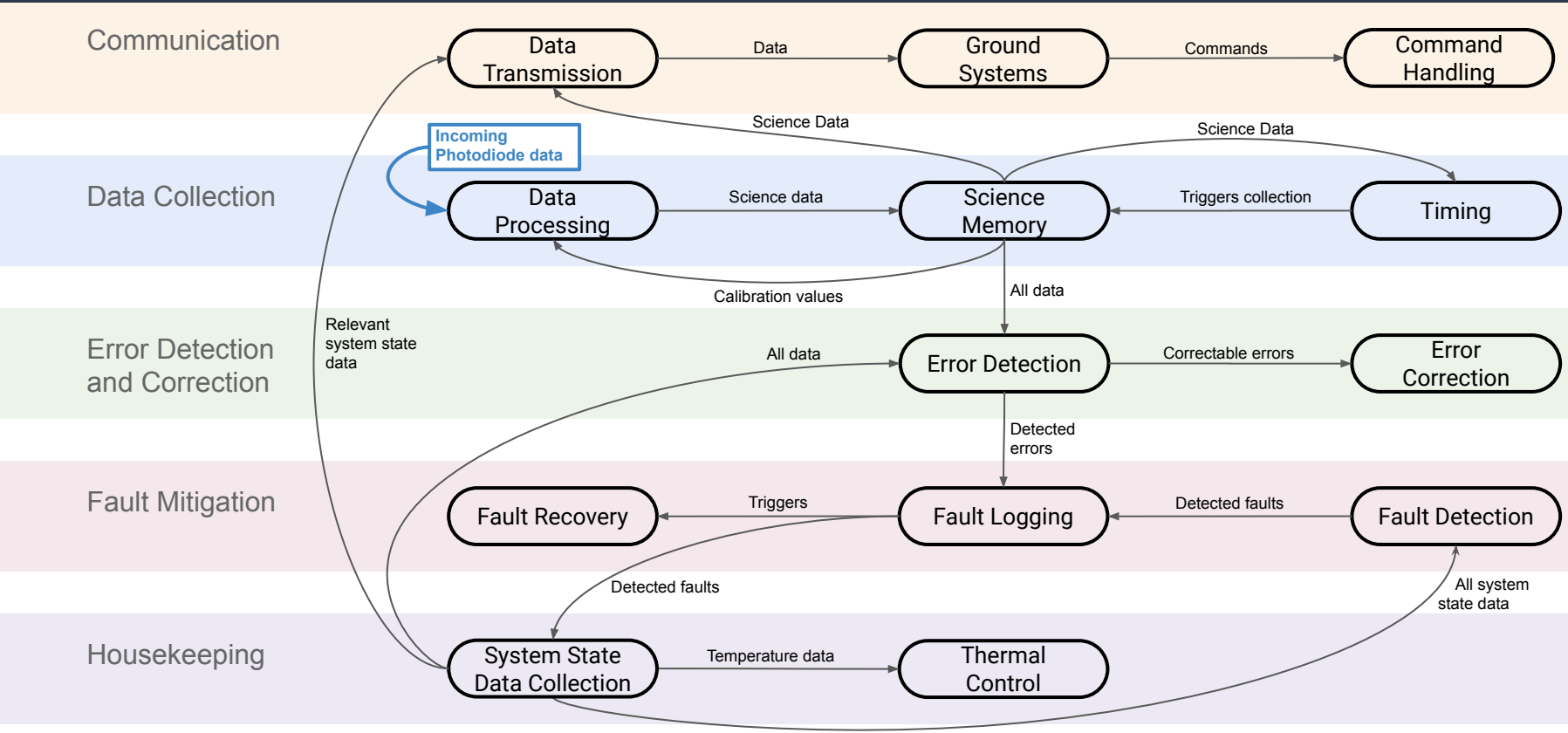
1.78 in.

3.36 in.

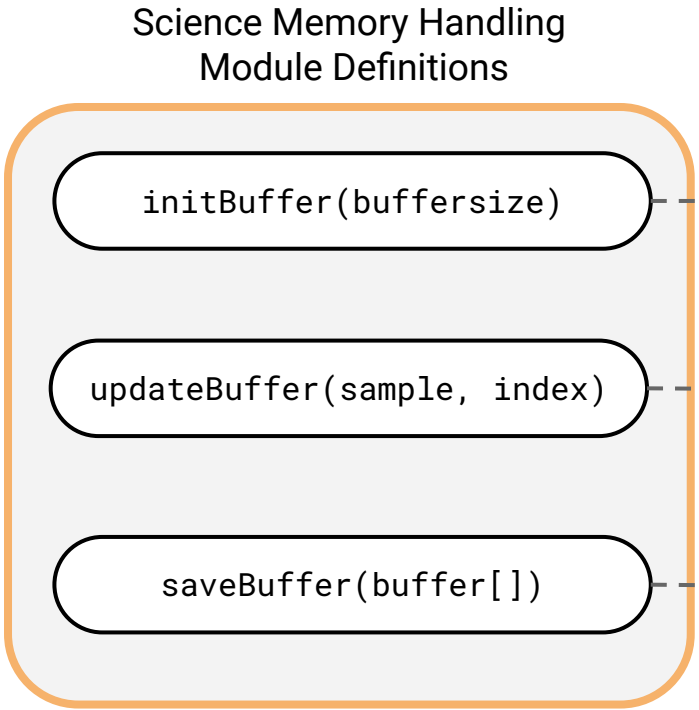
Electronics Manufacturing Flow



Software Scope



Science Memory Handling Module Breakdown

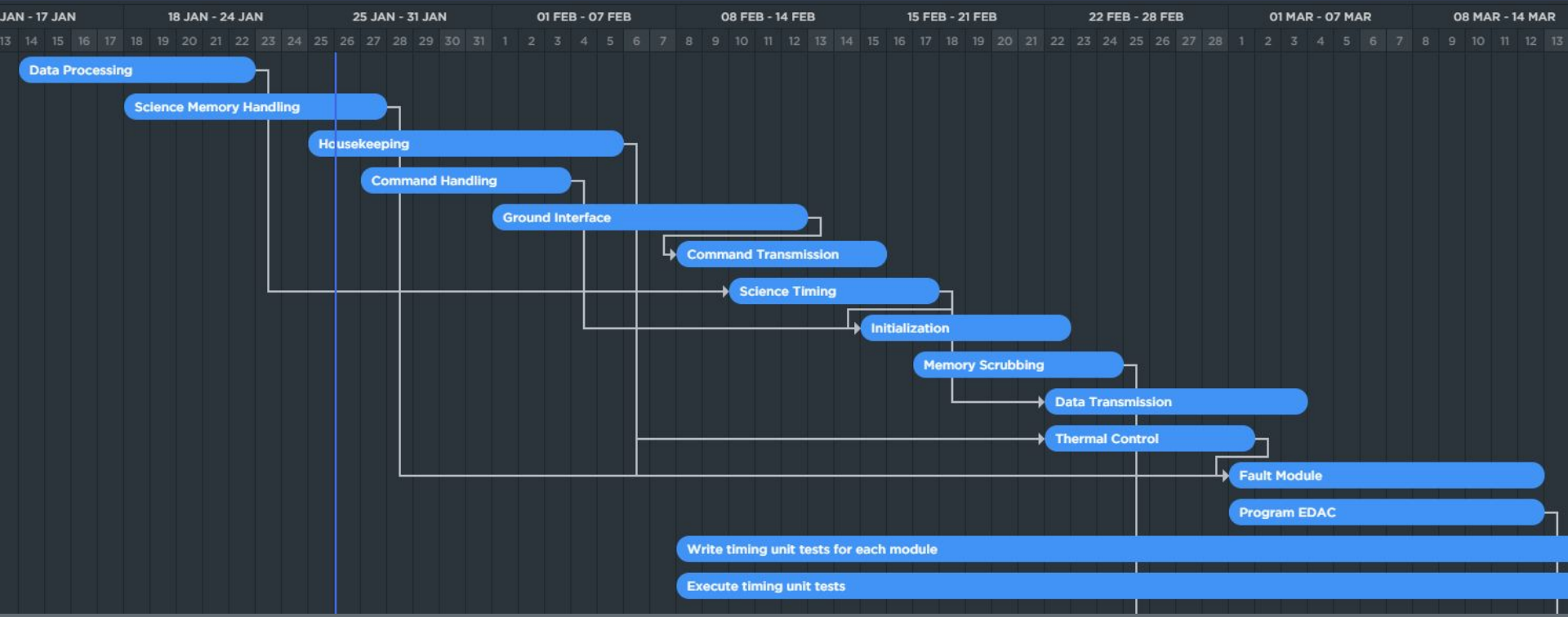


Called to initialize buffer array in memory if it does not exist

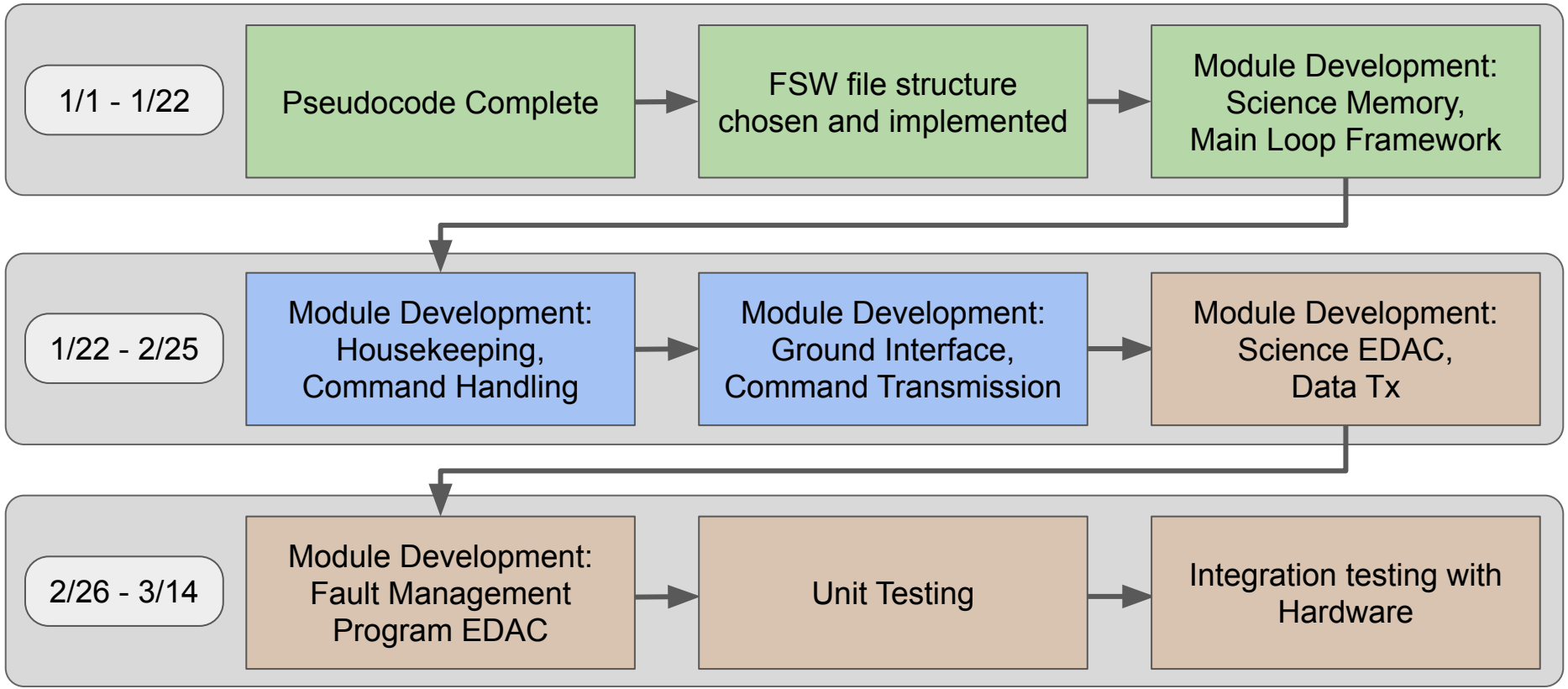
Add the sample gathered by data processing module to the buffer
Overwrite oldest buffer element if the buffer is full

Saves buffer from temporary storage (array) to long-term memory (file)
Calls an EDAC module function to apply a Hamming code to the buffer
Clears buffer once stored to long-term memory

Software Development Status



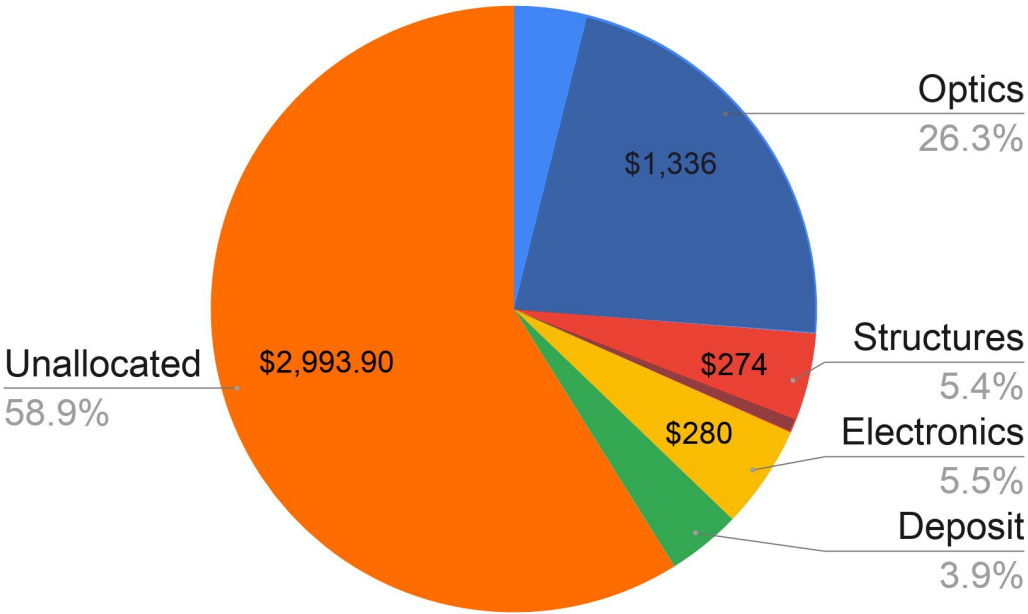
Software Development Status



Budget

Daniel Barth

Budget Update



CDR

Large margin (2x) to account for unknowns in costs related to shipping and additional components needed

Current

- Reduced margin (1.5x) due to larger certainty in allocated funds
- All purchases completed for the structures and electronics systems
- Expensive components still to be purchased for optics
  - Additional mirror and light filtering components

Acknowledgements

Our Customers:

Jim Baer & Jaykob Velasquez
Ball Aerospace

CU Aerospace Department:

Dr. Allison Anderson
The PAB

Our Peer Evaluators:

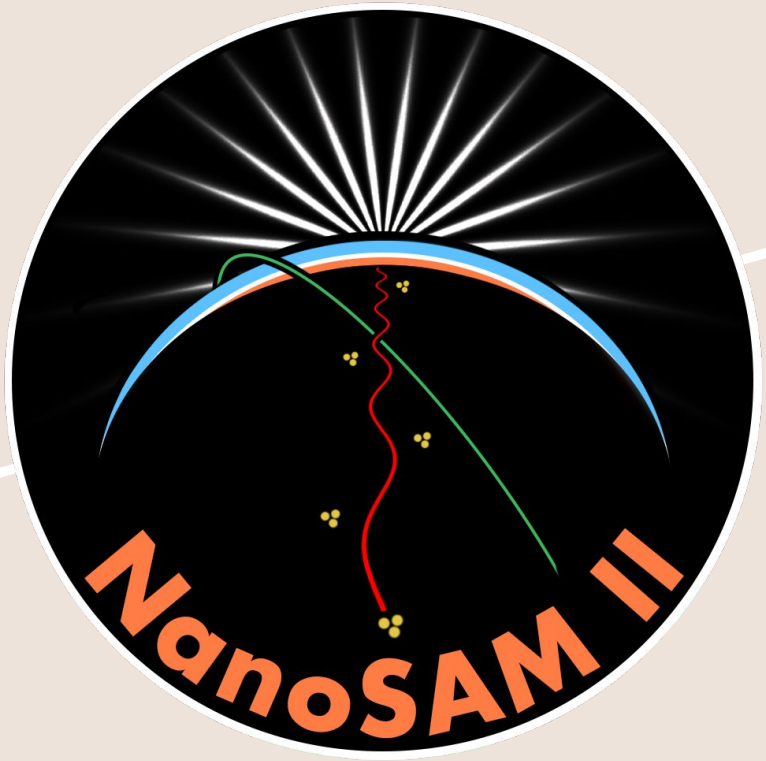
Lara Buri & Colin Claytor

… and all of our personal friends who should send us a bill for their time doing engineering review

Our Local Professionals:

Meadowlark Optics Inc
Blue Canyon Technologies
John Ferguson

Questions



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Backup Slides

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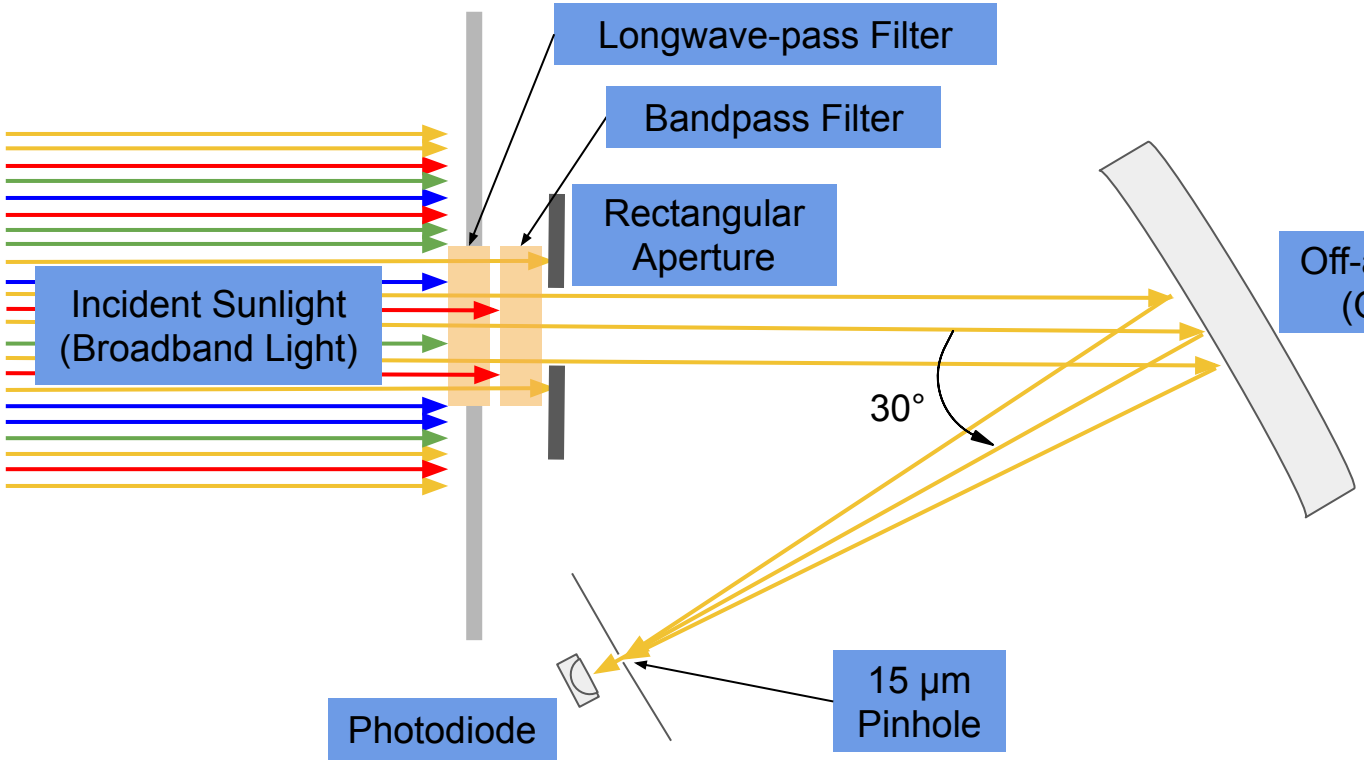
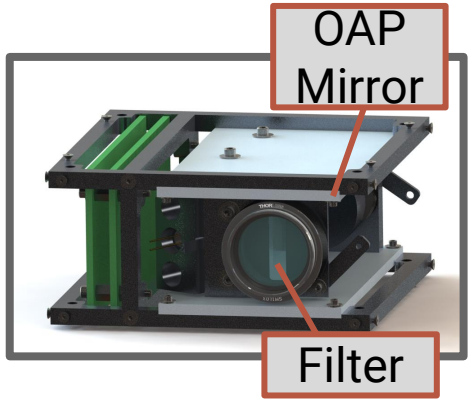
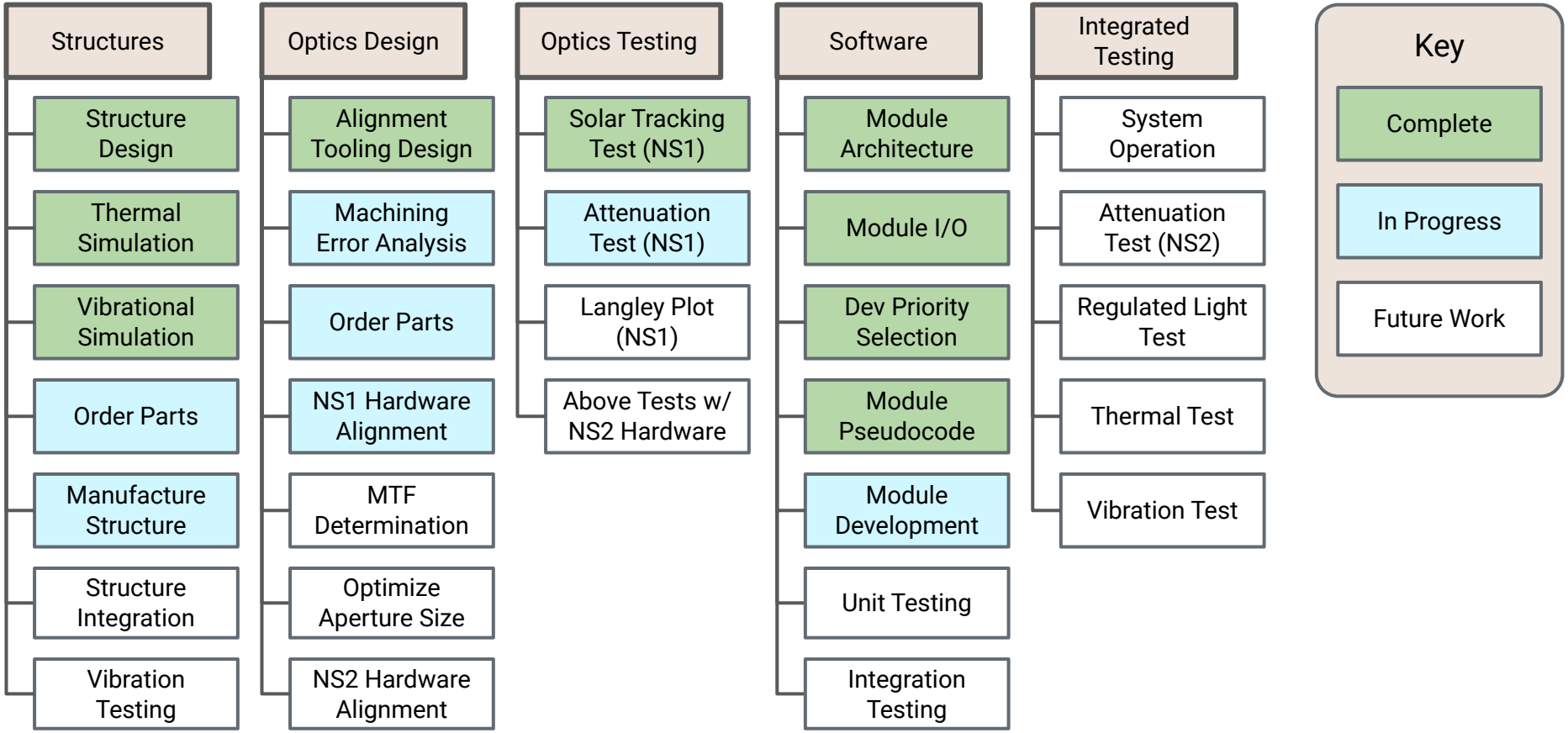
Backup Slides

Optics Instrument Overview





Work Breakdown Structure



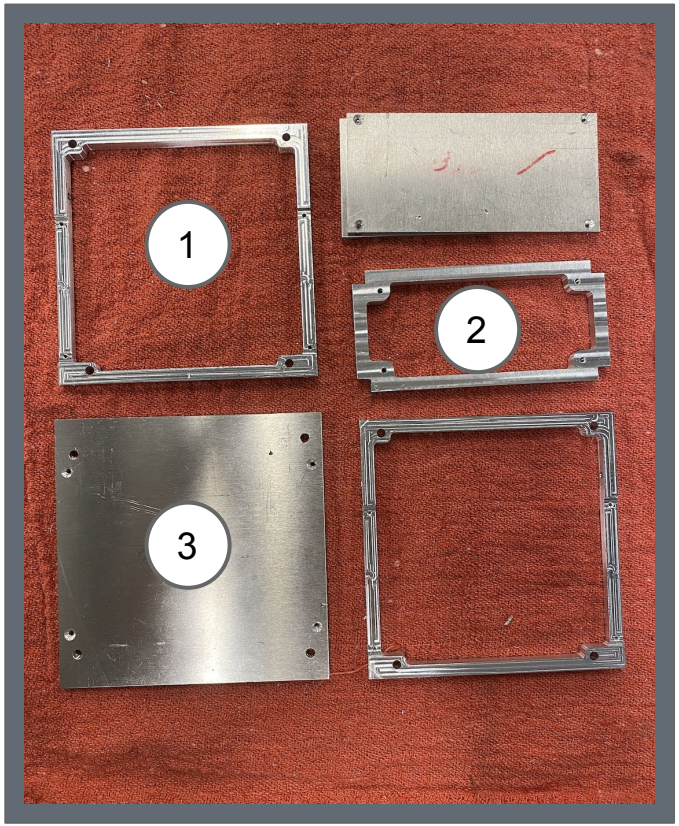
Structure Parts and Quantities

S01: Structural Ribs (2x)
S02: EPS Board Rib (1x)
S03: Top/Bottom Walls (2x)
S04: Left/Right Walls (2x)
S05: Front Wall (1x)
S06: Back Wall (1x)
S07: Structural to Board Rib Screws (4x)
S08: 0.5 cm PCB Spacers (4x)
S09: 0.25 cm PCB Spacers (4x)

S010: PCB Screws (4x)
S011: PCB Washers (4x)
S012: External Wall Screws (24x)
S013: Optics Bench to Thermal Isolator Screws (4x)
S014: Optics Bench to Thermal Isolator Washers (4x)
S015: Thermal Isolator to Structural Rib Screws (8x)
S016: Thermal Isolator to Structural Rib Washers (8x)
S017: Fiberglass Isolators (2x)

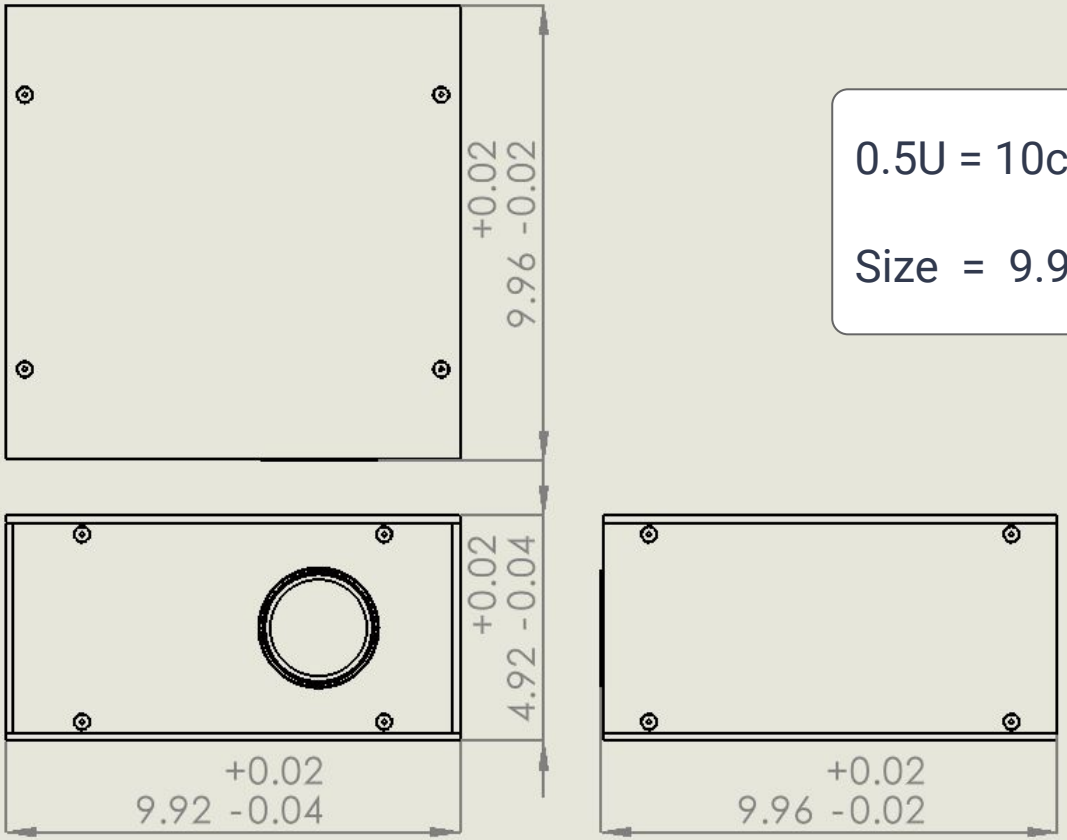
* Parts all Ordered from McMaster Carr

Structures Parts Status



Completed (Job Shop 01)	To be Completed
• Horizontal Ribs (1) • EPS Mount Rib (2) • All Housings/Walls (3)	• Board-Board Spacers • Small EPS Spacers • Thermal Isolators

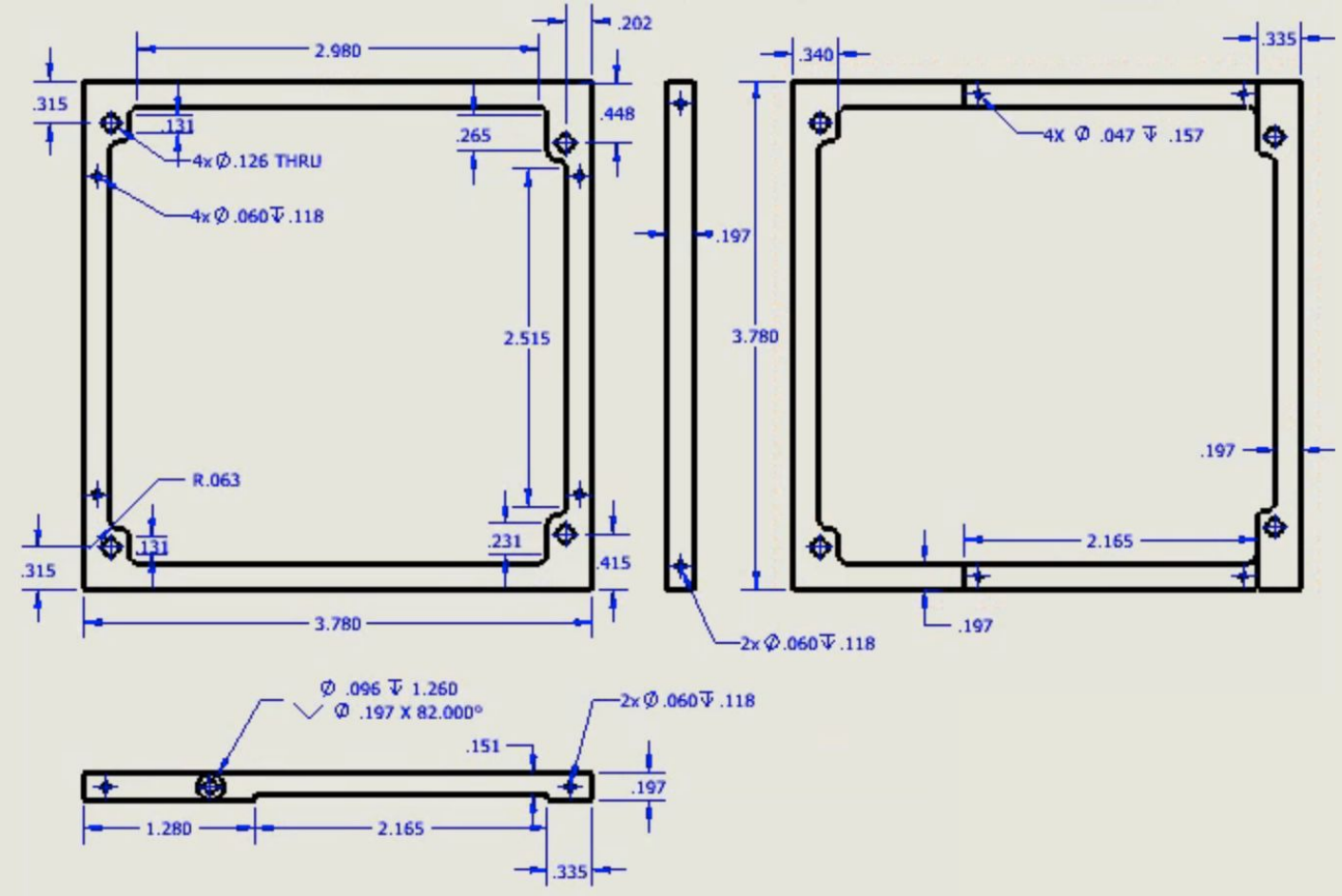
NanoSAM II Dimensioned Drawing



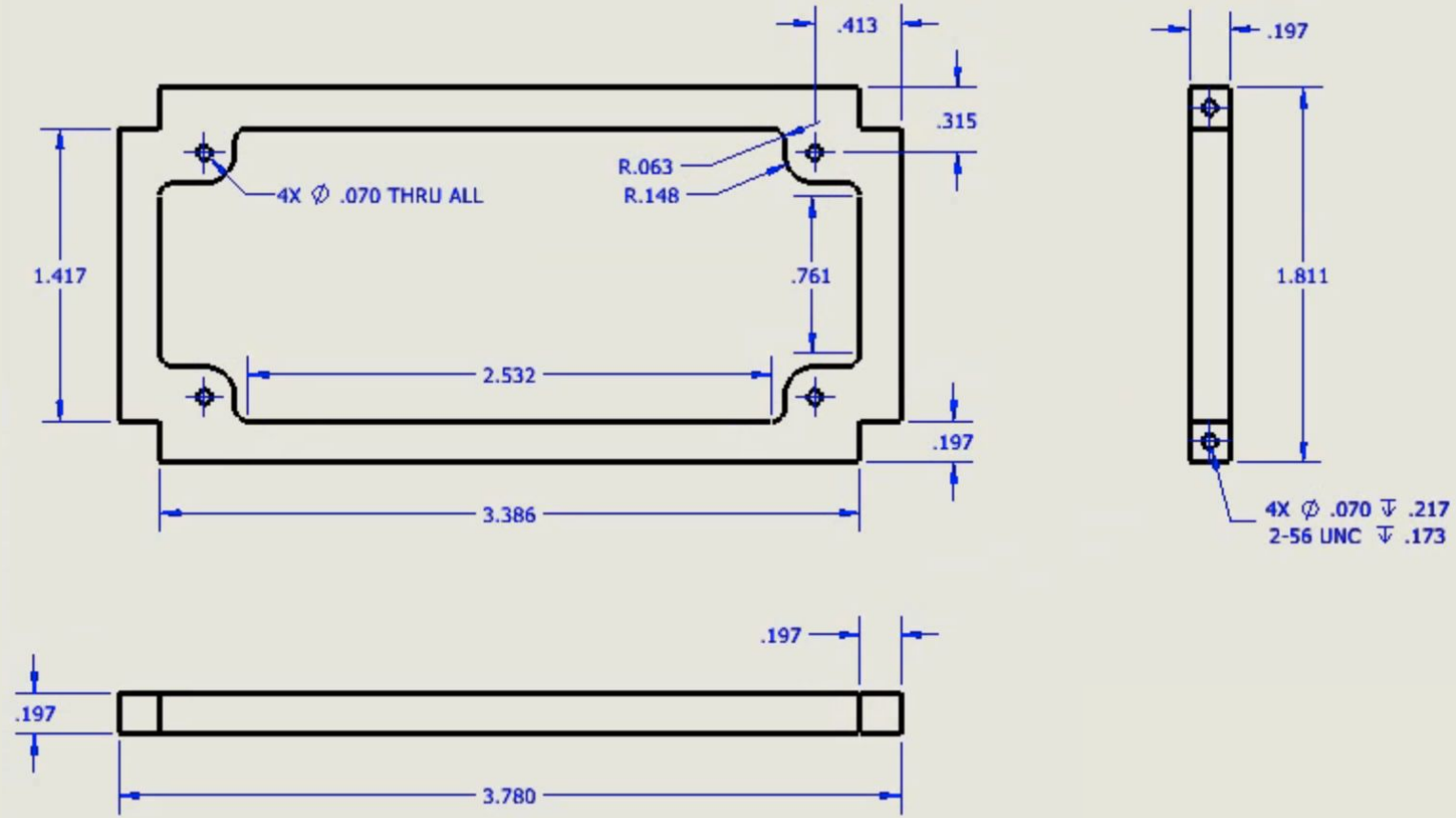
0.5U = 10cm x 10cm x 5cm

Size = 9.96cm x 9.92cm x 4.92cm

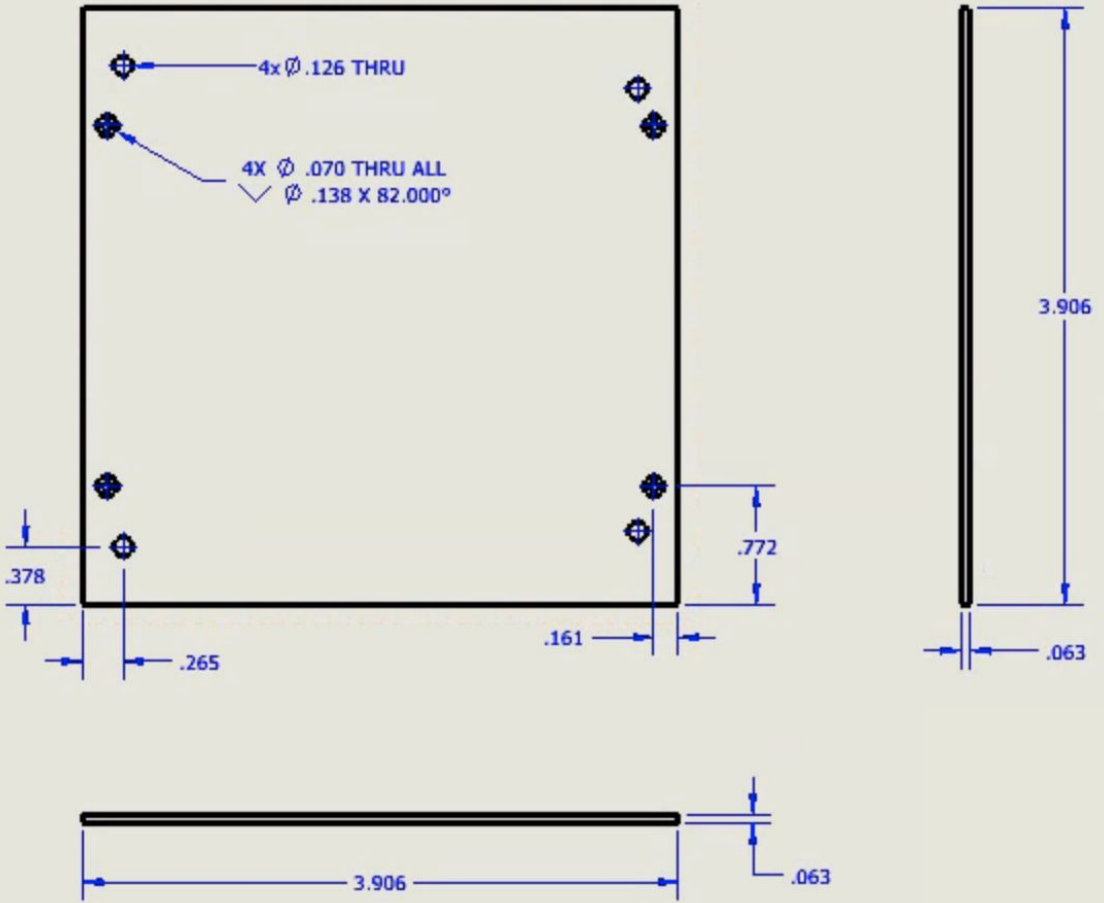
NanoSAM II Horizontal Rib Drawing



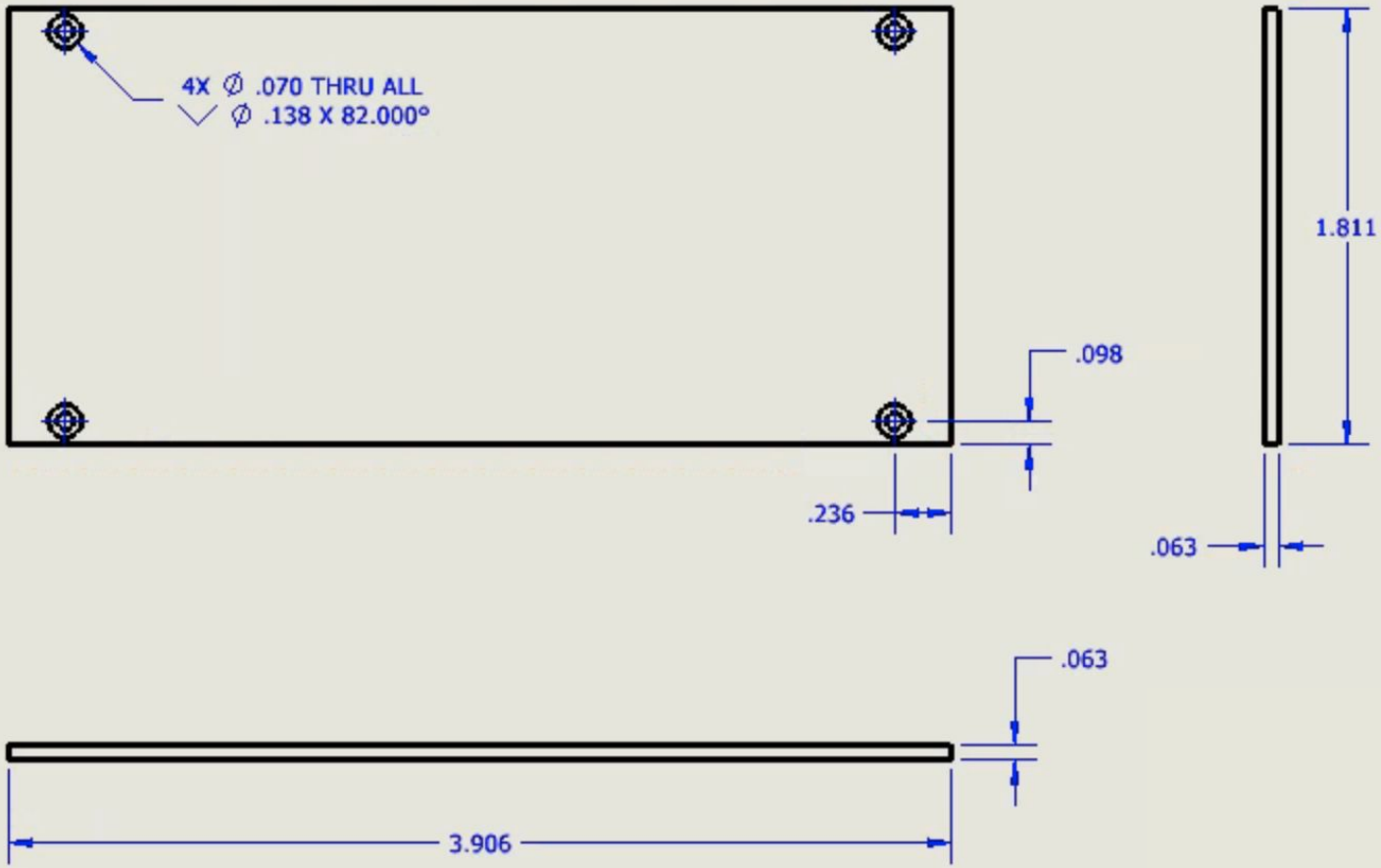
NanoSAM II EPS Board Rib Drawing



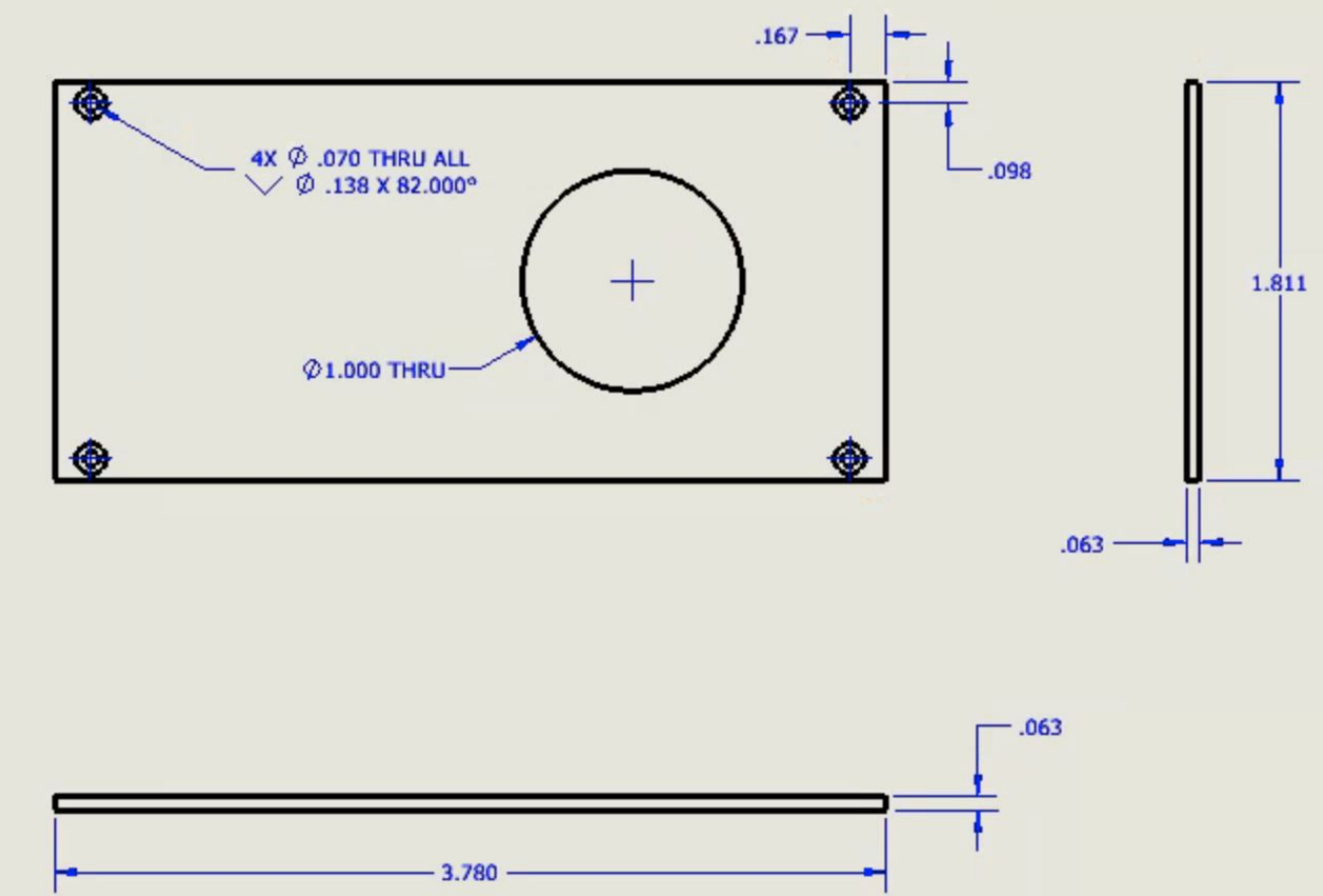
NanoSAM II EPS Top/Bottom Housing Drawing



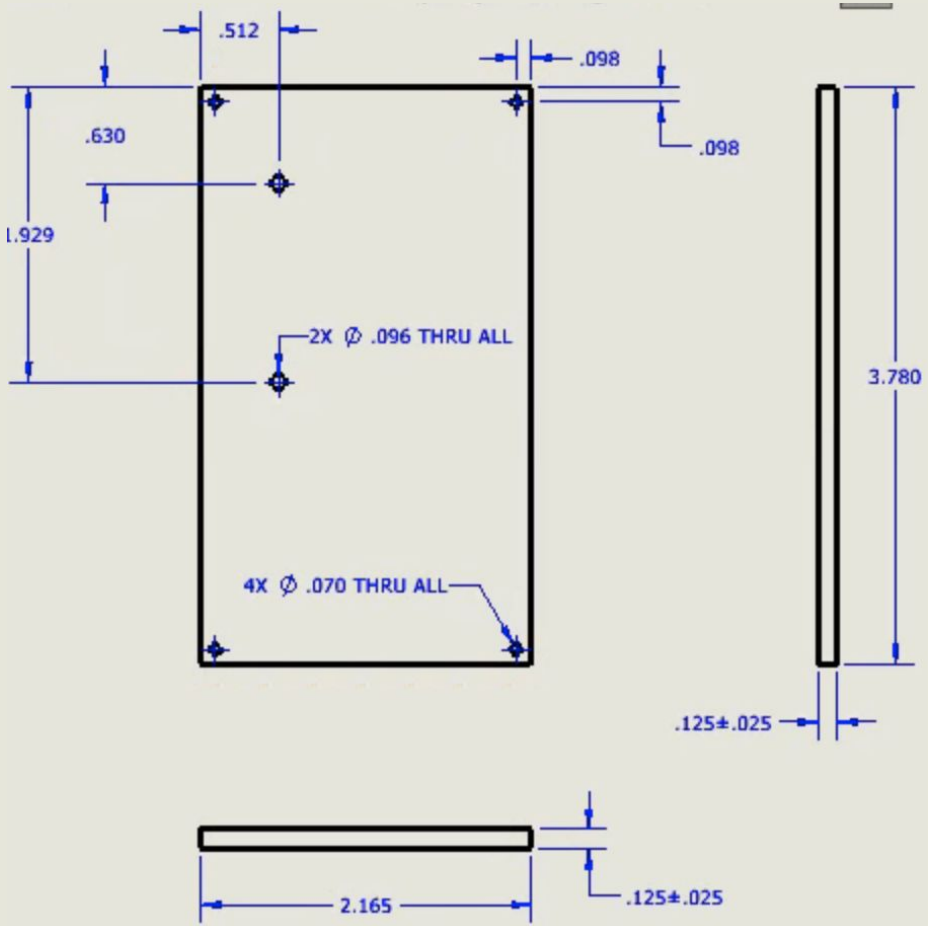
NanoSAM II Left/Right Housing Drawing



NanoSAM II Front Housing Drawing



NanoSAM II Bench Isolator Drawing



Electronics: Test Points

Test Point	Description	Expected Value	Checks?
1	Pre Feedback Resistor	Depends on light source	Photodiode working
2	Post Transimpedance Amplifier	Depends on light source	Transimpedance amp working
3	ADC Vcc	3.3V	Voltage reference working
4	ADC Ref-	GND	ADC reference good
5	Analog Thermistor Voltage Divider Output	Depends on temperature	Thermistor good
6	Analog Thermistor Voltage Buffer Output	Should be the same as T5	Voltage follower good
7	5V Regulator Positive Output	+5V	Bipolar regulator good
8	5V Regulator Negative Output	-5V	Bipolar regulator good
9	5V Regulator EPAD Ground	GND	Bipolar regulator good
10	Voltage Bus Input	System Vin	Voltage source good
11	Current Sense Output	Backsolve for Vin	Current sense monitor good

DIGITAL BOARD TEST POINTS

Test Point	Description	Expected Value	Checks?
1	Microcontroller Vin	3.3V	Microcontroller getting required power, also checks MOSFET not busted
2	Watchdog RST Signal	3.3V	If watchdog triggers, RST goes high
3	Watchdog /ST Signal	3.3V, 50ns width square	Microcontroller outputs watchdog signal
4	Flash 1 Vin (U$1)	3.3V	Flash 1 power
5	Flash 2 Vin (U$2)	3.3V	Flash 2 power
6	Digital Thermistor Voltage Divider Output	Depends on temperature	Thermistor good
7	Digital Thermistor Voltage Buffer Output	Should be the same as T6	Voltage follower good
8	3.3V Regulator Output	3.3V	Linear regulator good
9	3.3V Regulator GND	GND	Linear regulator good
10	3.3V PG Pin	High (~3.3V)	Linear regulator good
11	Voltage Bus Input	System Vin	Voltage source good
12	Current Sense Output	Backsolve for Vin	Current sense monitor good
13	Optical Bench Thermistor	Depends on temperature	Thermistor good
14	Optical Thermistor Voltage Buffer Output	Same as T13	Voltage follower good
15	Resistor Heater Vin	~System Vin (minus TVS diode drop)	Use to check heating resistor voltage drop
16	Resistor Heater GND	~GND (+MOSFET Drop)	Use to check heating resistor voltage drop

Electronics: Test Plan(s)

Analog Board, Individual Tests

Test notes: For this test, the boards will not be connected. Thus the 3v3 line from the digital board will not exist. This means the analog thermistor will not be powered, its outputs should thus be zero volts. This also means the current sense monitor will not be powered, its output will be zero volts. The photodiode may or may not be connected for this test, which will affect the voltage at test point 2.

		I.C
	Test operator must be grounded. **Testing must be done on an ESD safe mat.**	
1	Set power supply to 12 VDC, set current limit to 0.5A.	
2	Orientate the board such that the cutout is on the right side. Insert GND banana plug from power supply to GND_IN through hole in the bottom left corner of the board. Insert 12 VDC banana plug from the power supply to V_IN through hole	

16	Disconnect GND_IN and V_IN banana plugs from the board.	
17	Place the disconnected board in an ESD safe storage location.	

Testing Notes:

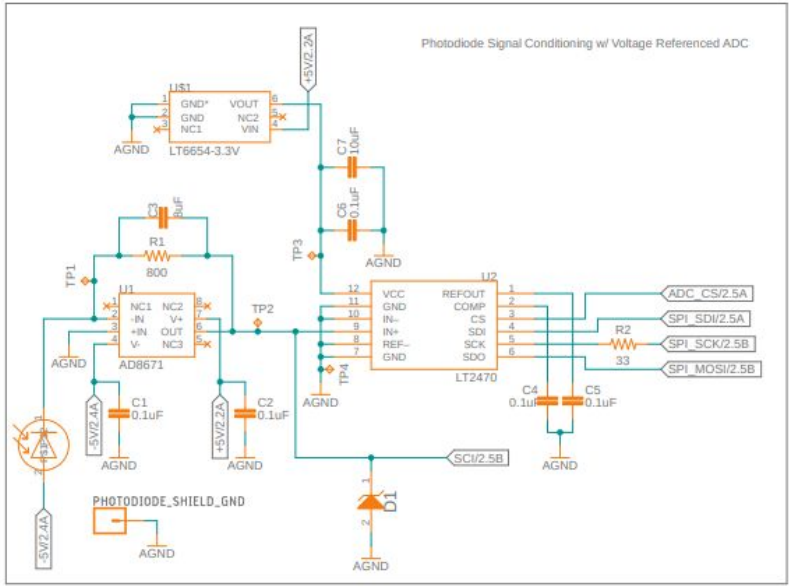
Test Operator signature: _____

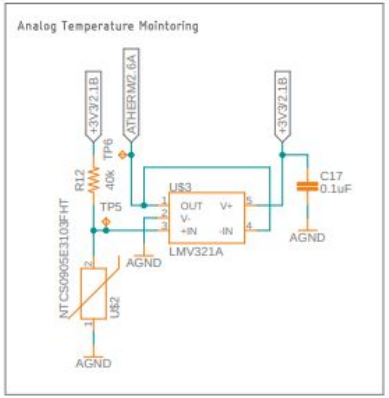
Date of test completion: _____

Detailed step by step instructions such that even another team could carry out the test.

Initials and signature force test accountability & traceability.

Analog Board (1/2)

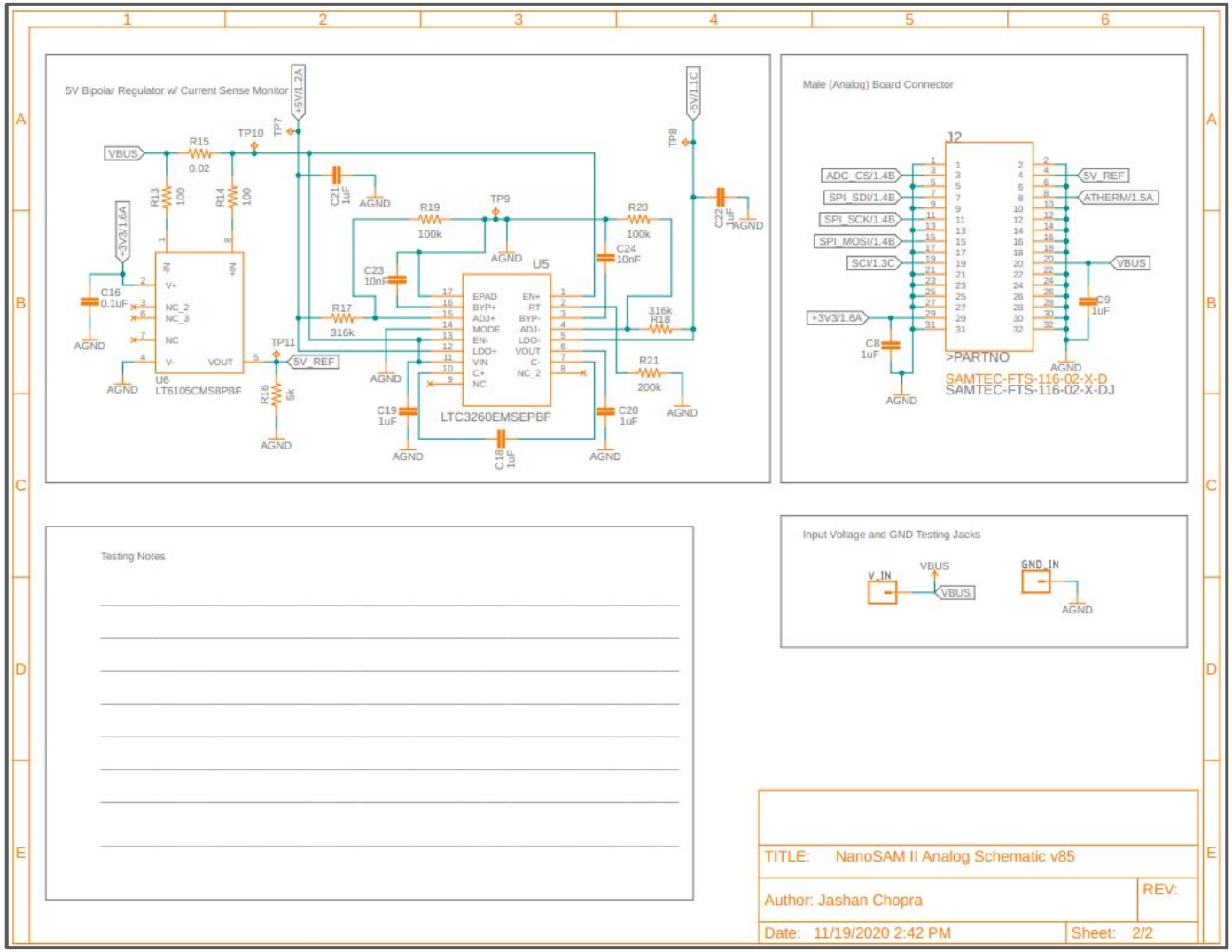




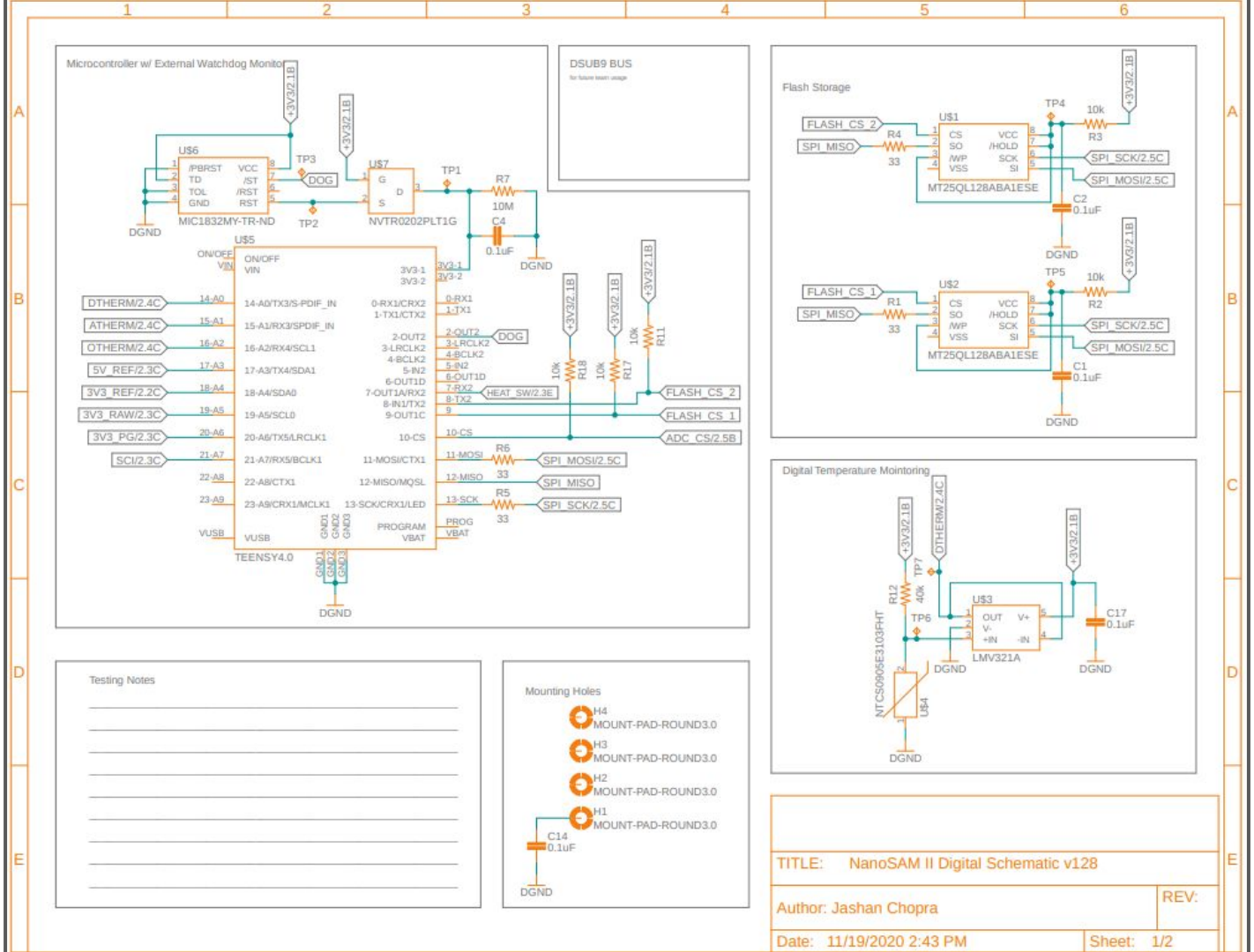
Testing Notes

TITLE: NanoSAM II Analog Schematic	
Author: Jashan Chopra	REV:
Date: 11/17/2020 2:45 PM	Sheet: 1/2

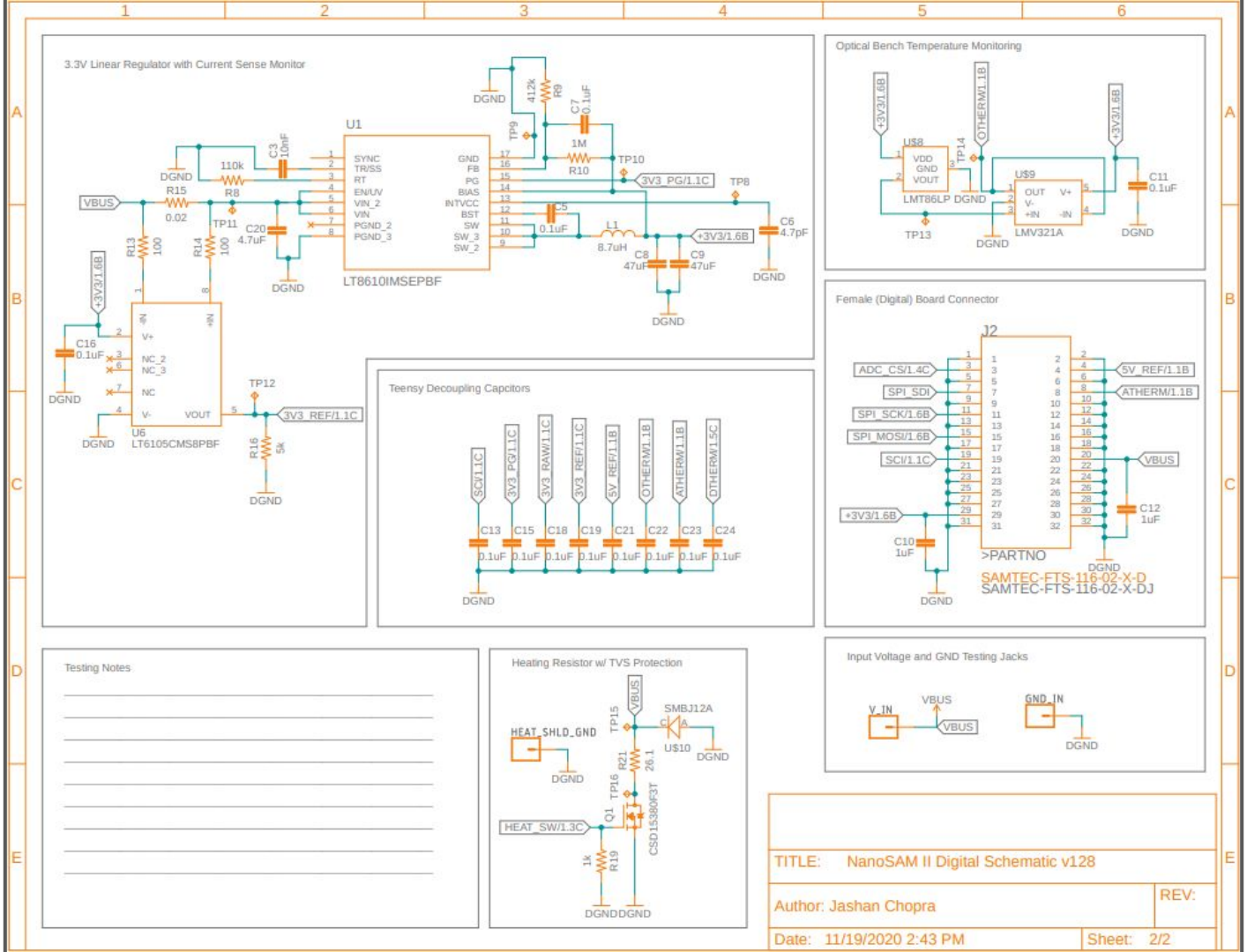
Analog Board (2/2)



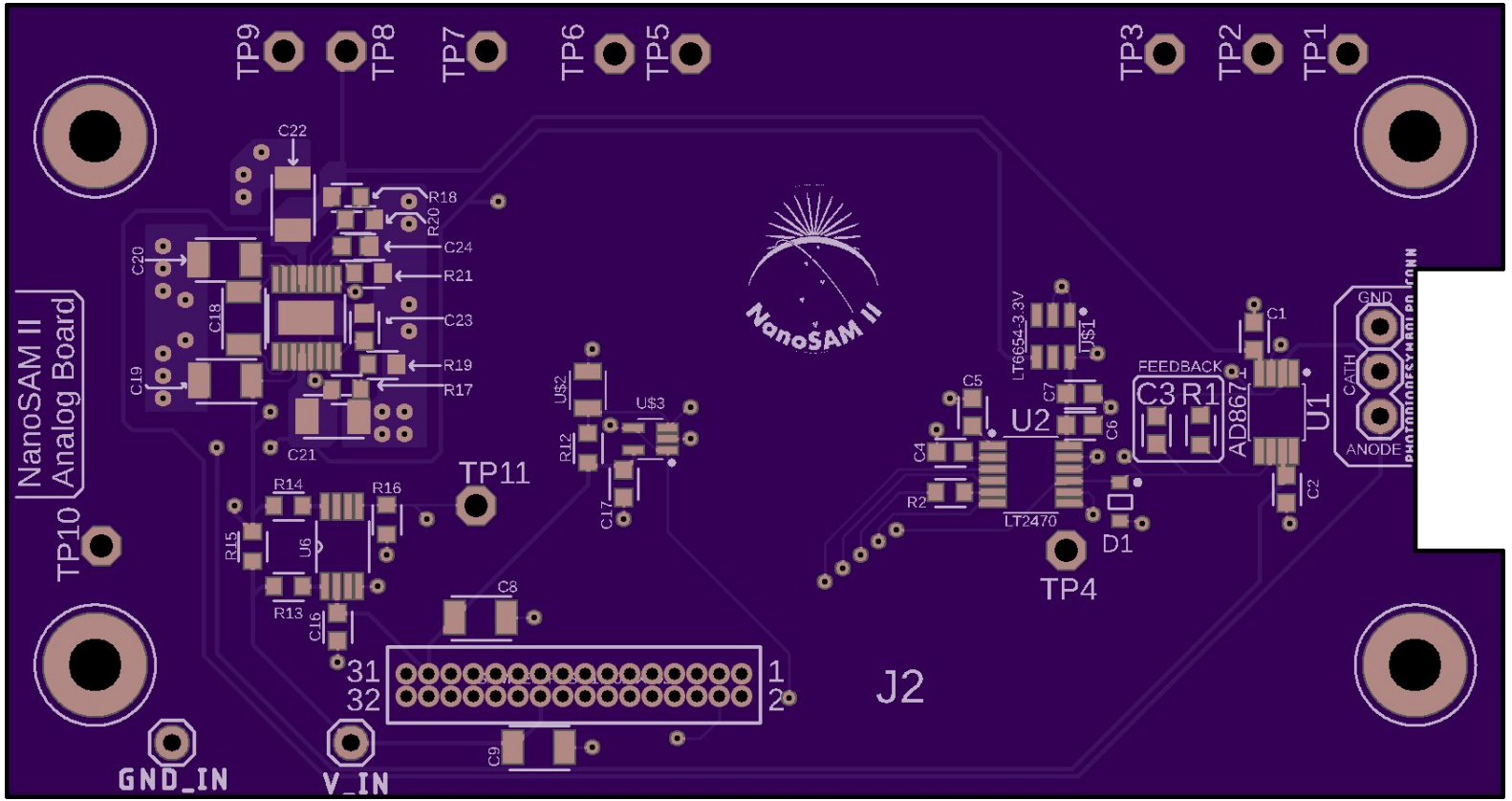
Digital Board (1/2)



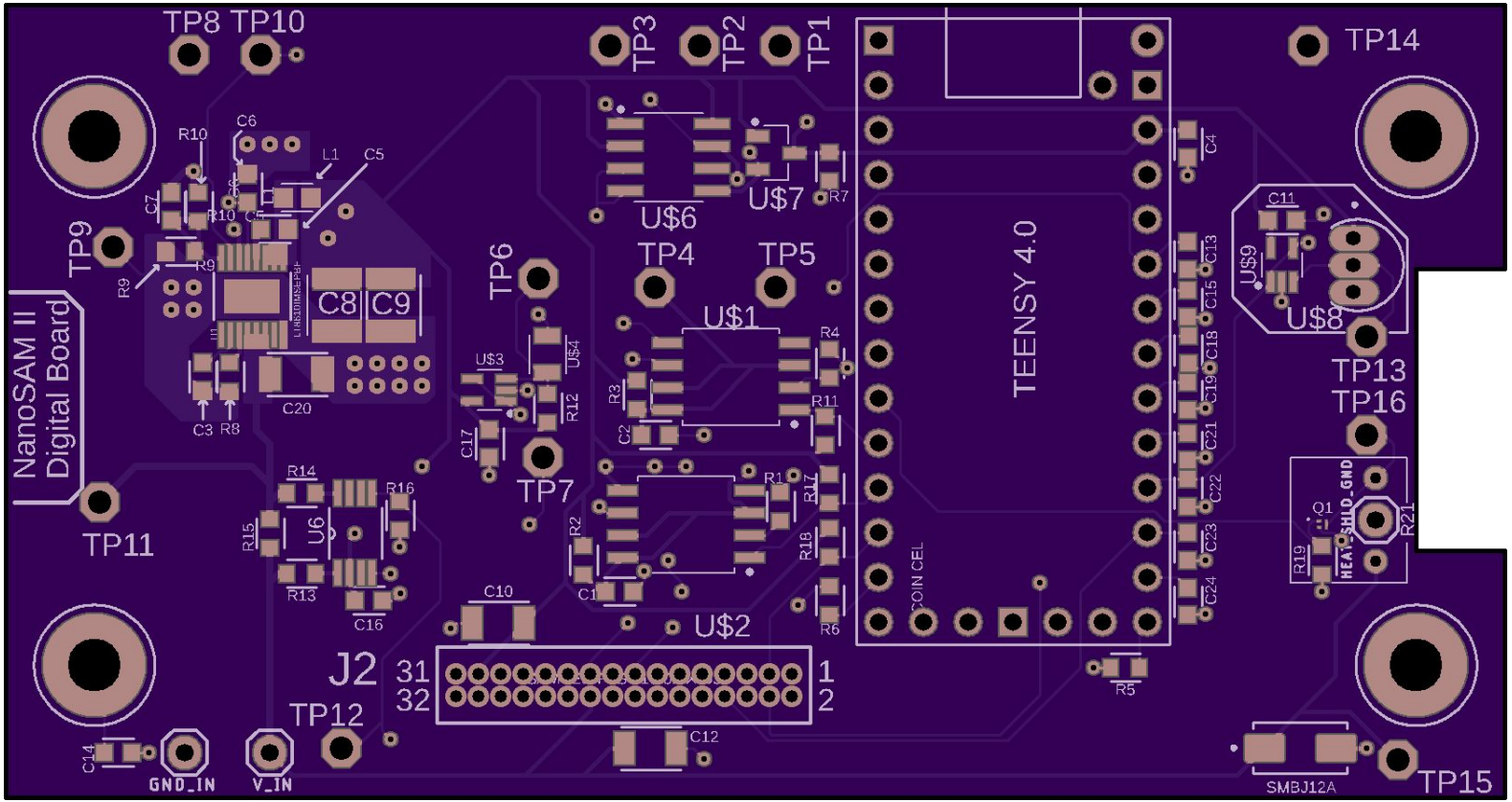
Digital Board (2/2)



OSHPark CAM Job Render [Analog]



OSHPark CAM Job Render [Digital]



Completed Analog Board