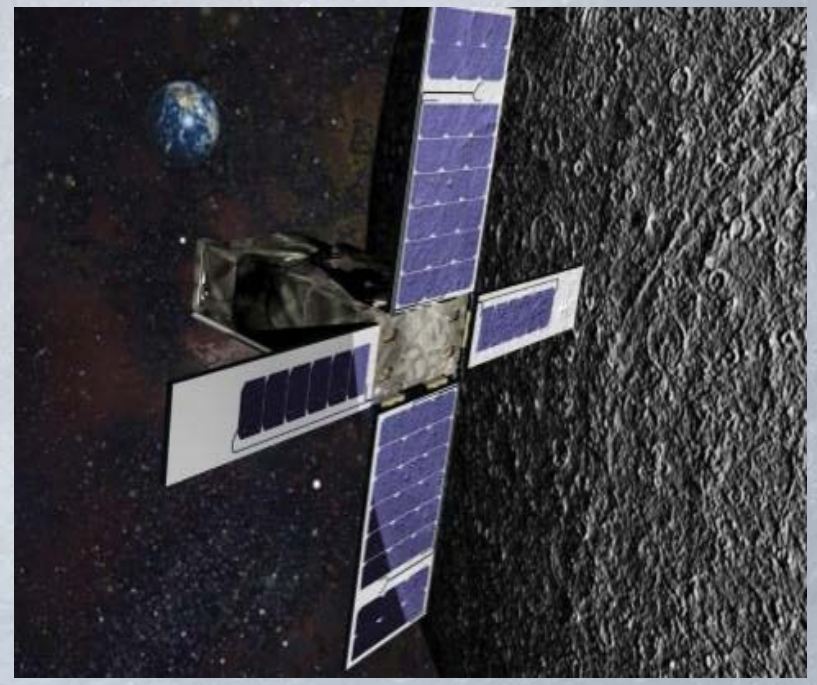
OSPRE
Manufacturing Status Review

OVERVIEW

Project Purpose

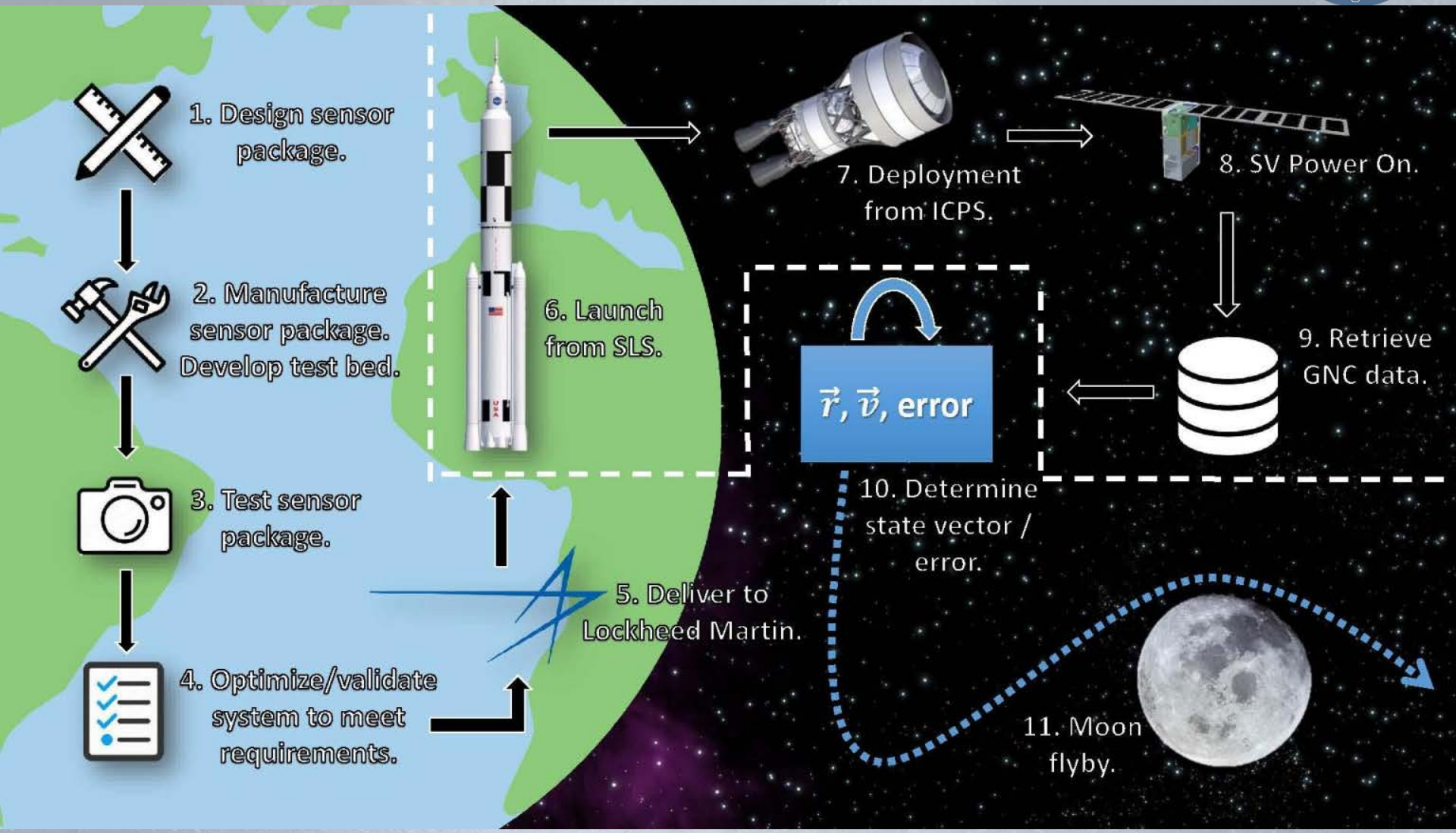
- To use optical relative navigation to determine a spacecraft's state vector and state vector error during a lunar transit
  - CubeSat based on NASA CubeQuest Challenge
    - Lunar mission
    - Launch on SLS EM-1
  - Lockheed Martin



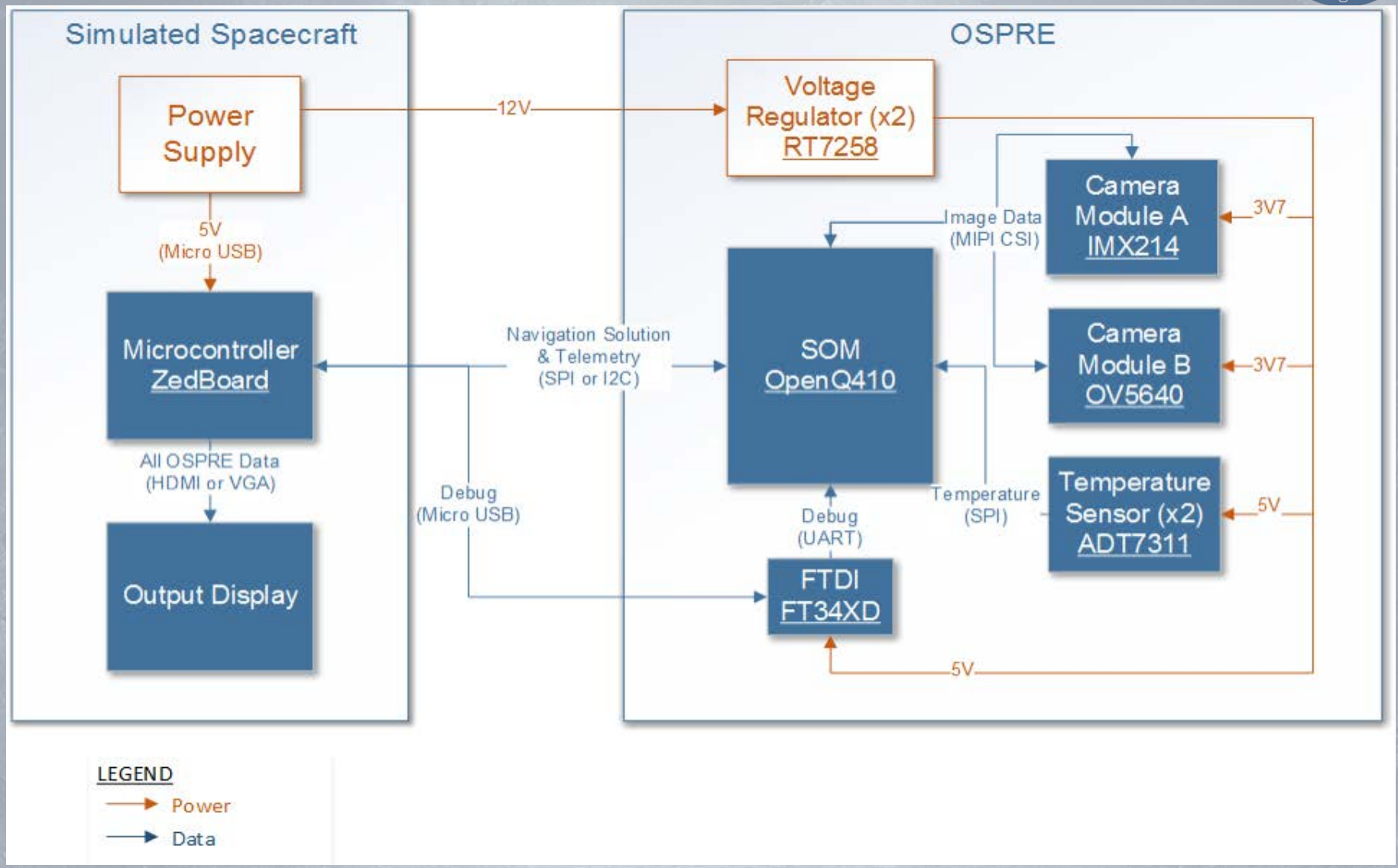
Specific Objectives

	Level 1	Level 2	Level 3
Data Processing	OSPRE shall output a state vector for full Moon and Earth disks and shall gather data for no longer than an hour at a time.	OSPRE shall estimate the error of the state vector.	OSPRE shall provide the state vector error within an accuracy of 1000km and 250m/s and shall function for all Moon and Earth phases.
Electrical	OSPRE shall operate nominally provided 3.3V, 5V, or 12V electrical power, and interface with the ZedBoard and image sensor(s) using SPI, I^2C, or Cameralink.	OSPRE shall have a peak current of no more than 500mA and maximum power draw of no greater than 3W.	The system shall provide voltage sense and current sense telemetry.
Structural	OSPRE's mass shall not exceed 0.8kg.	OSPRE's dimensions shall not exceed 5cm x 5cm x 1cm.	-
Testing	OSPRE's testing shall include testing the accuracy of the algorithm. OSPRE shall create a software test capable of quantifying the navigation software's error.	OSPRE's testing shall include a physical simulation. OSPRE shall create an Earth-Moon testbed that quantifies the error of the navigation hardware.	OSPRE's testing shall incorporate hardware and software testing simultaneously. The system shall compute the state vector autonomously in a test environment.

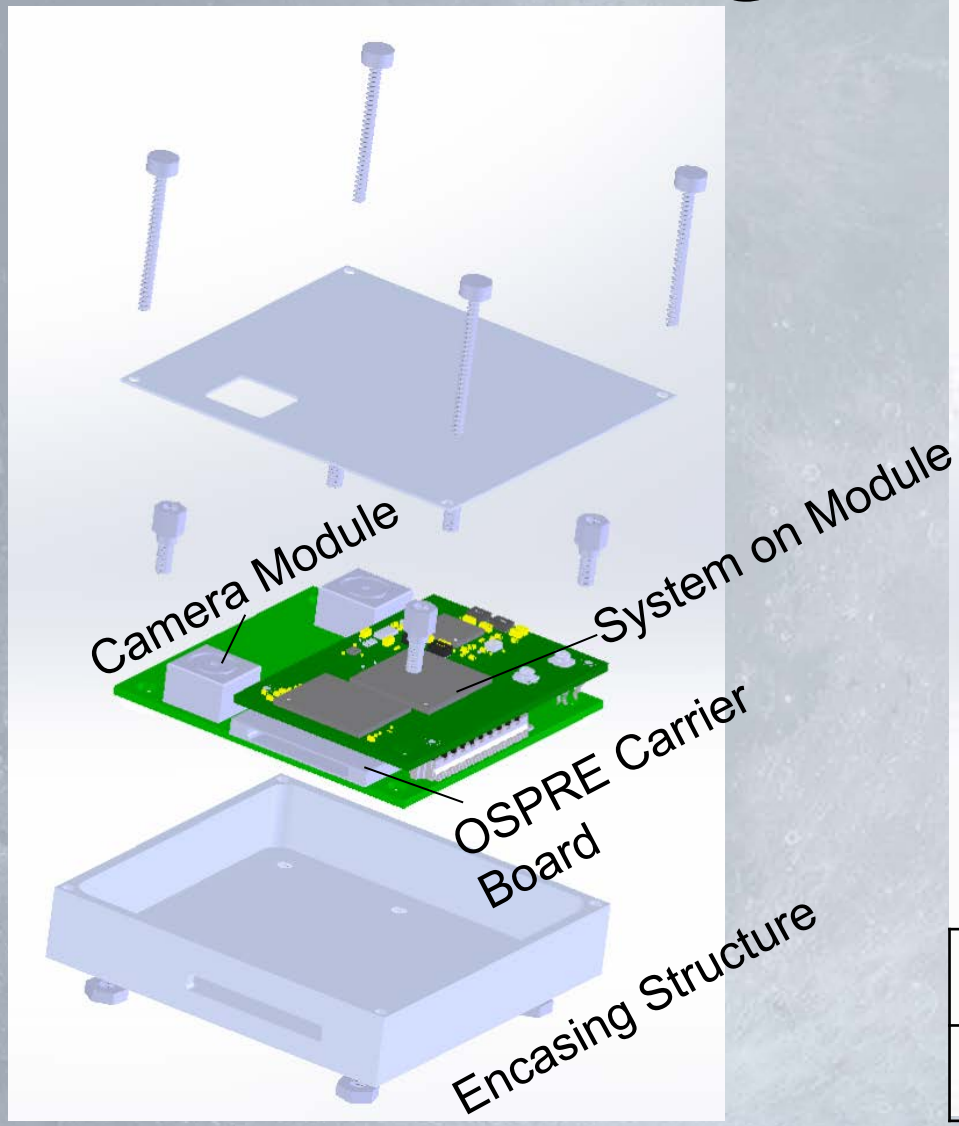
Mission CON-OPS

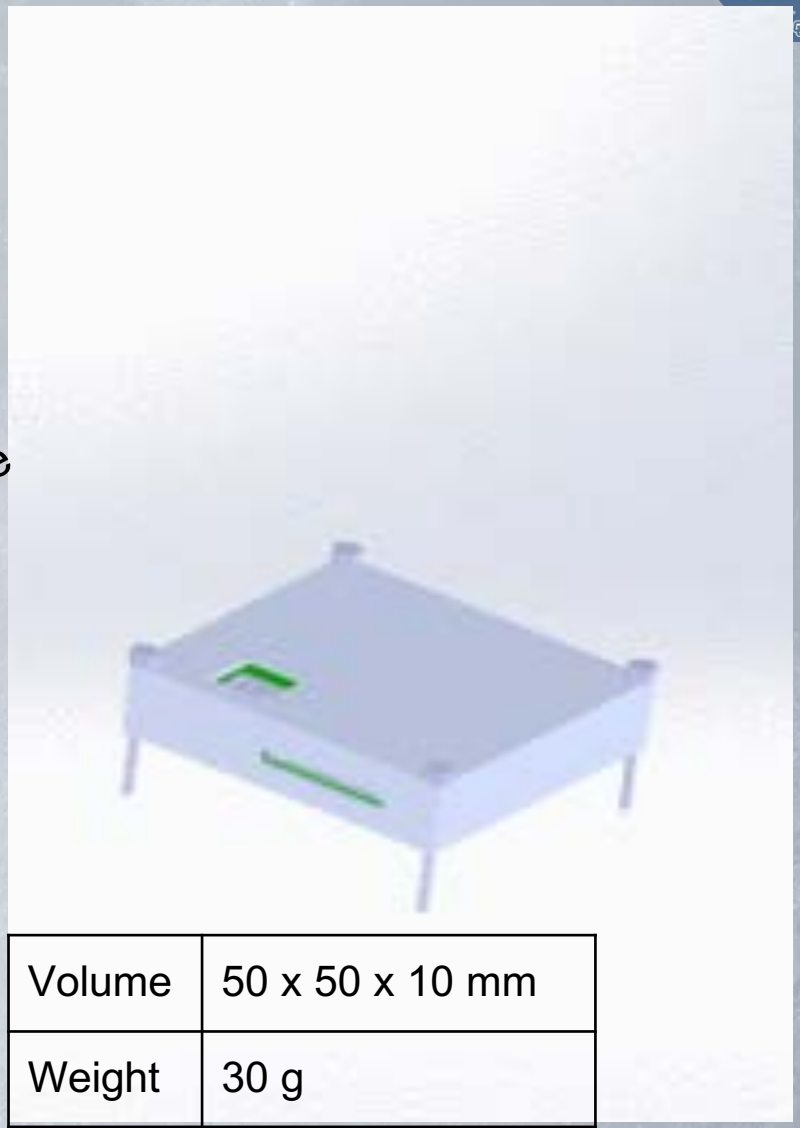


Functional Block Diagram



Baseline Design





Volume	50 x 50 x 10 mm
Weight	30 g

Critical Project Elements

Solution Accuracy

- State vector must be determined to within the required accuracy
  - Camera resolution, Image Processing, Navigation algorithms

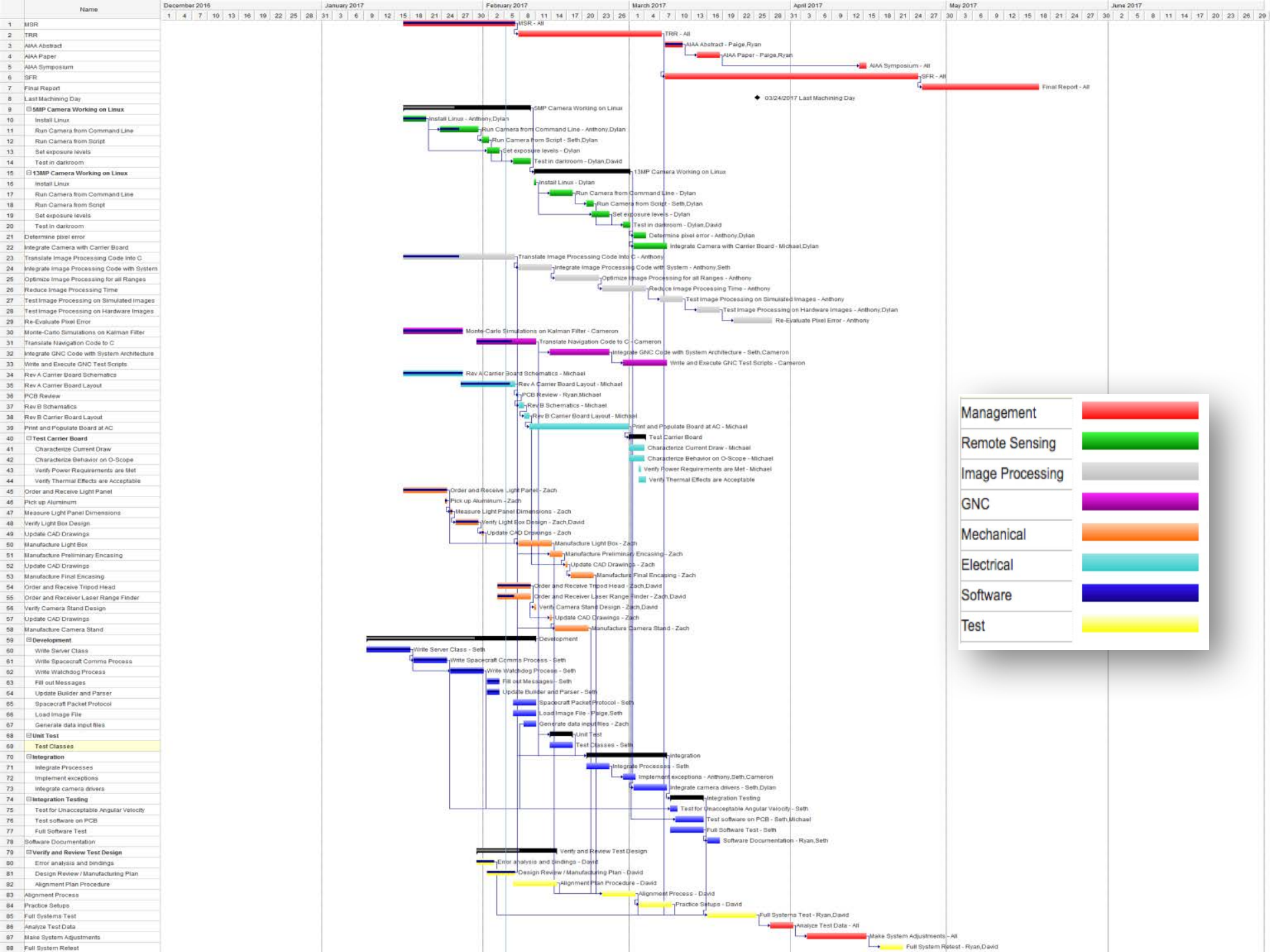
Testing Accuracy

- Solution accuracy must be verified in testing
- Scaling of the Earth-Moon system
  - Measurement of distance between camera and target, measurement of the location of the center of the target

SWAP

- Size, Weight, And Power requirements must be met
  - Component size, component power draw, component weight

SCHEDULE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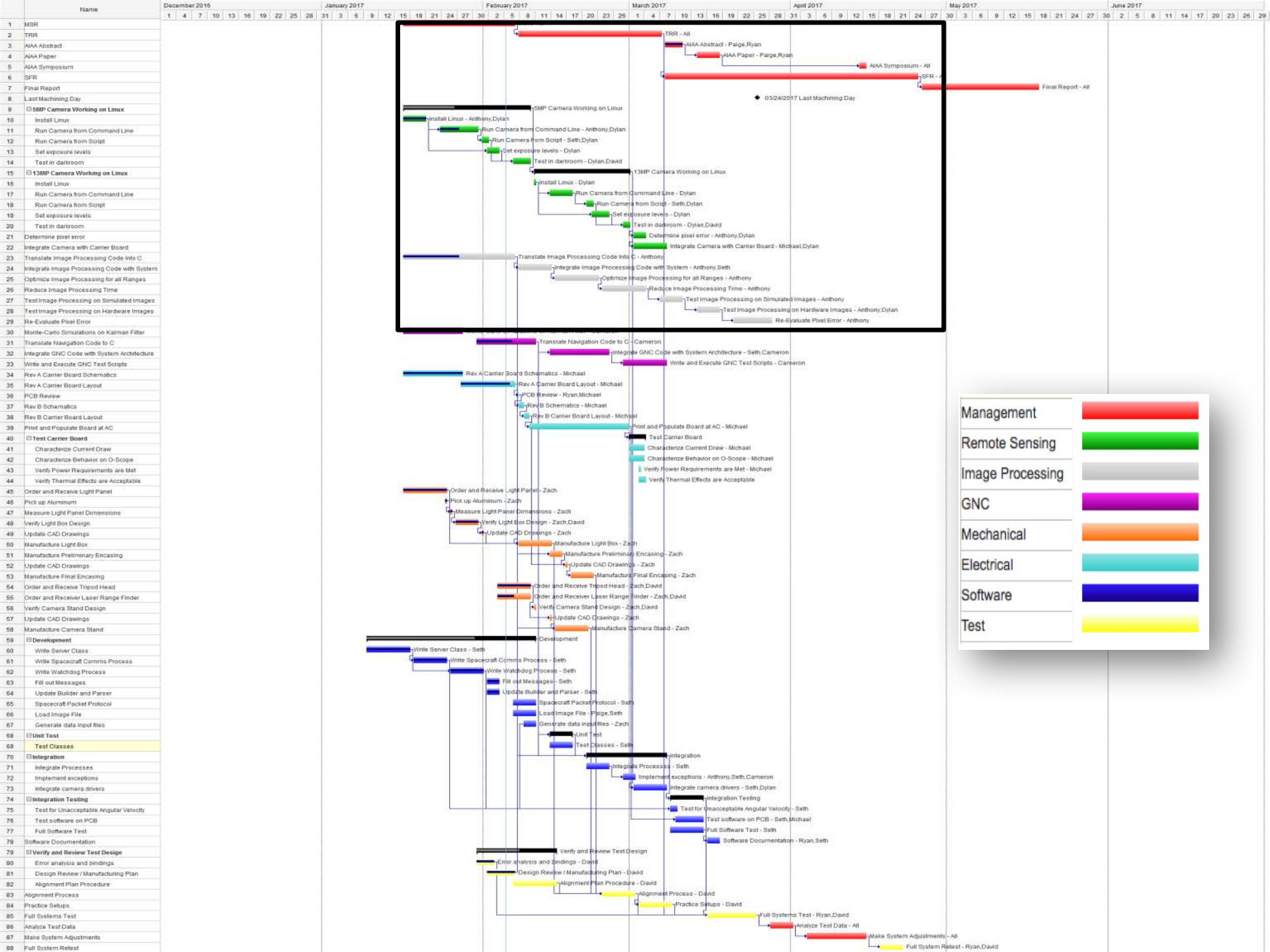
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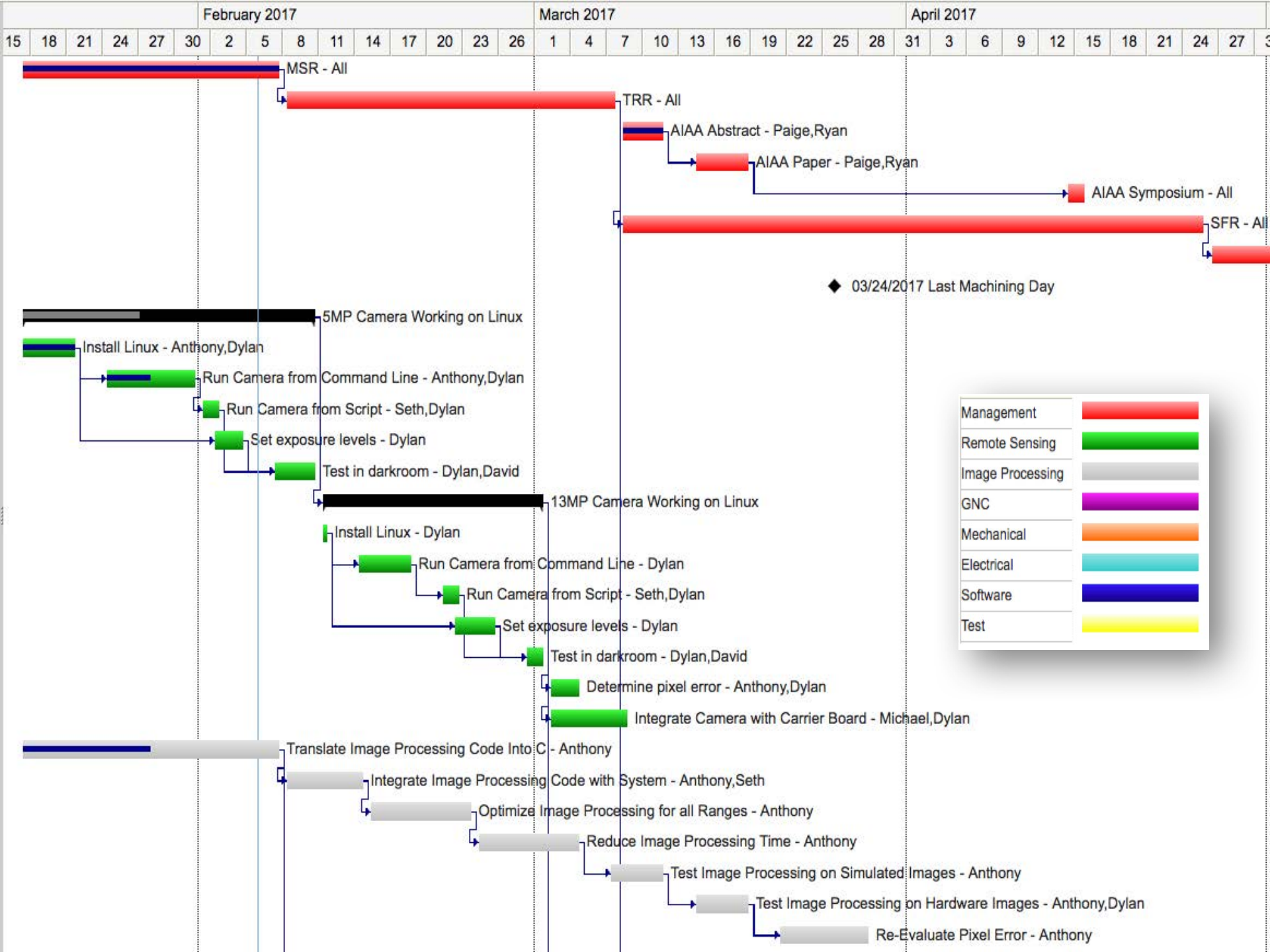
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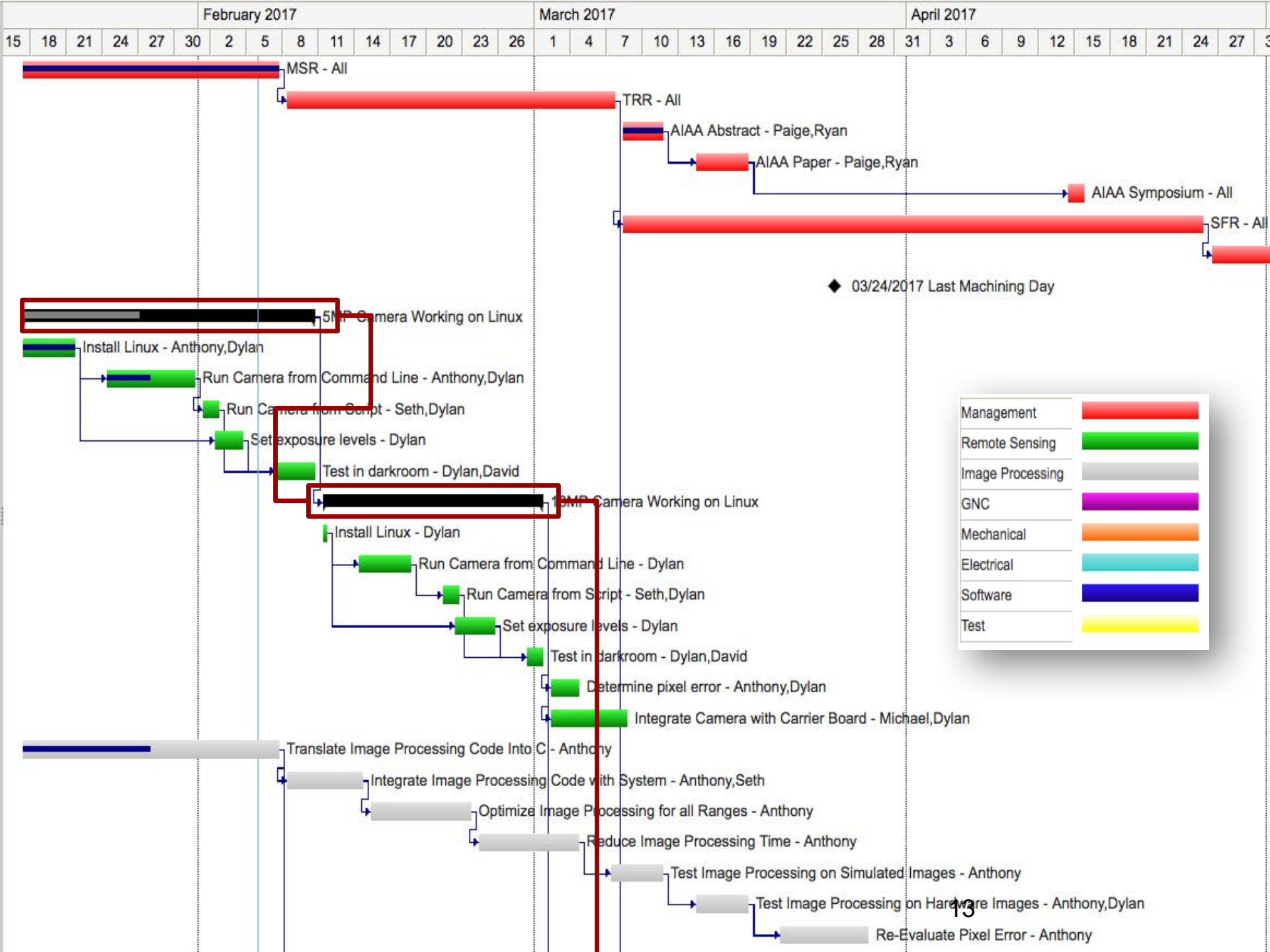
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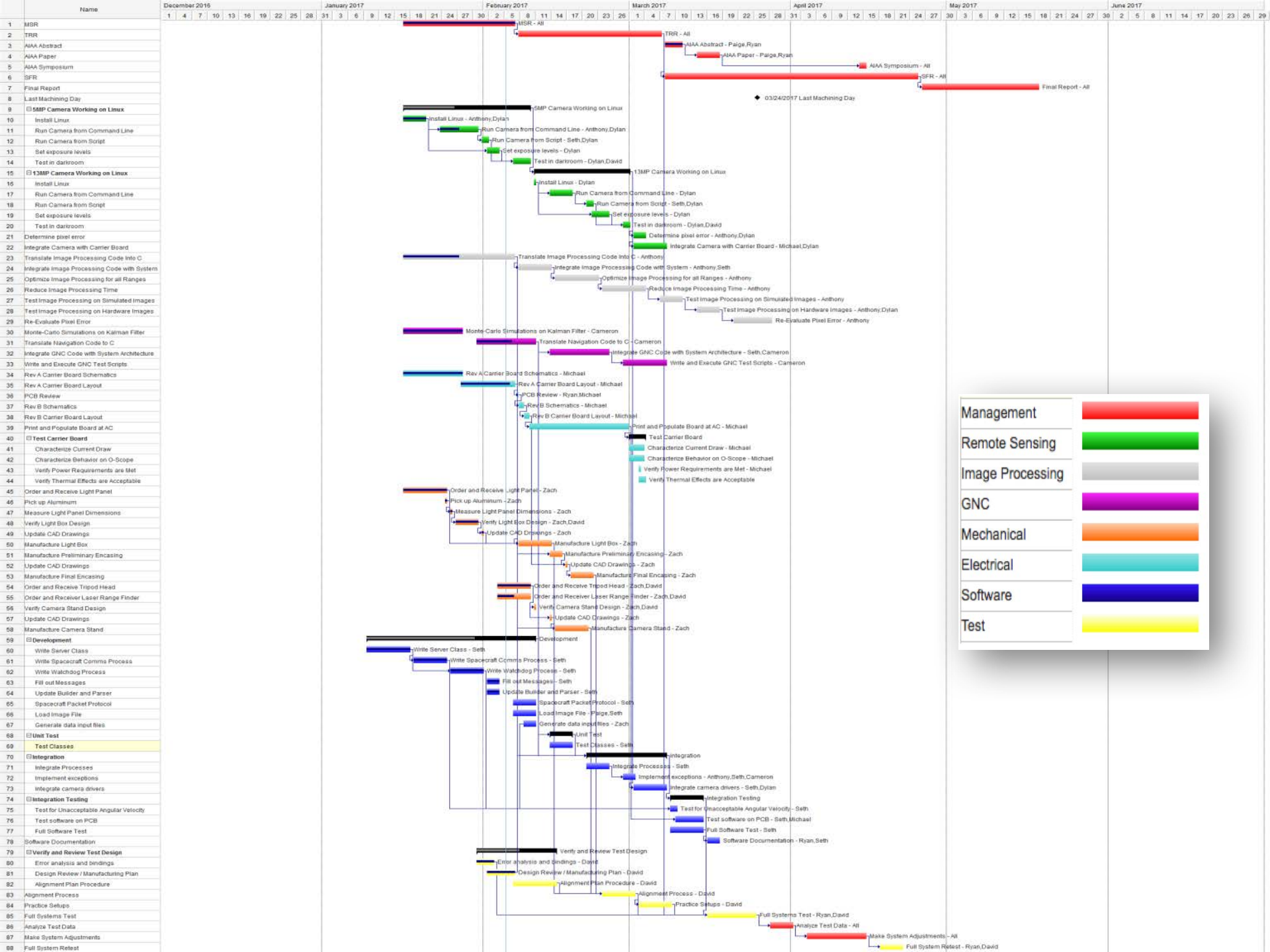
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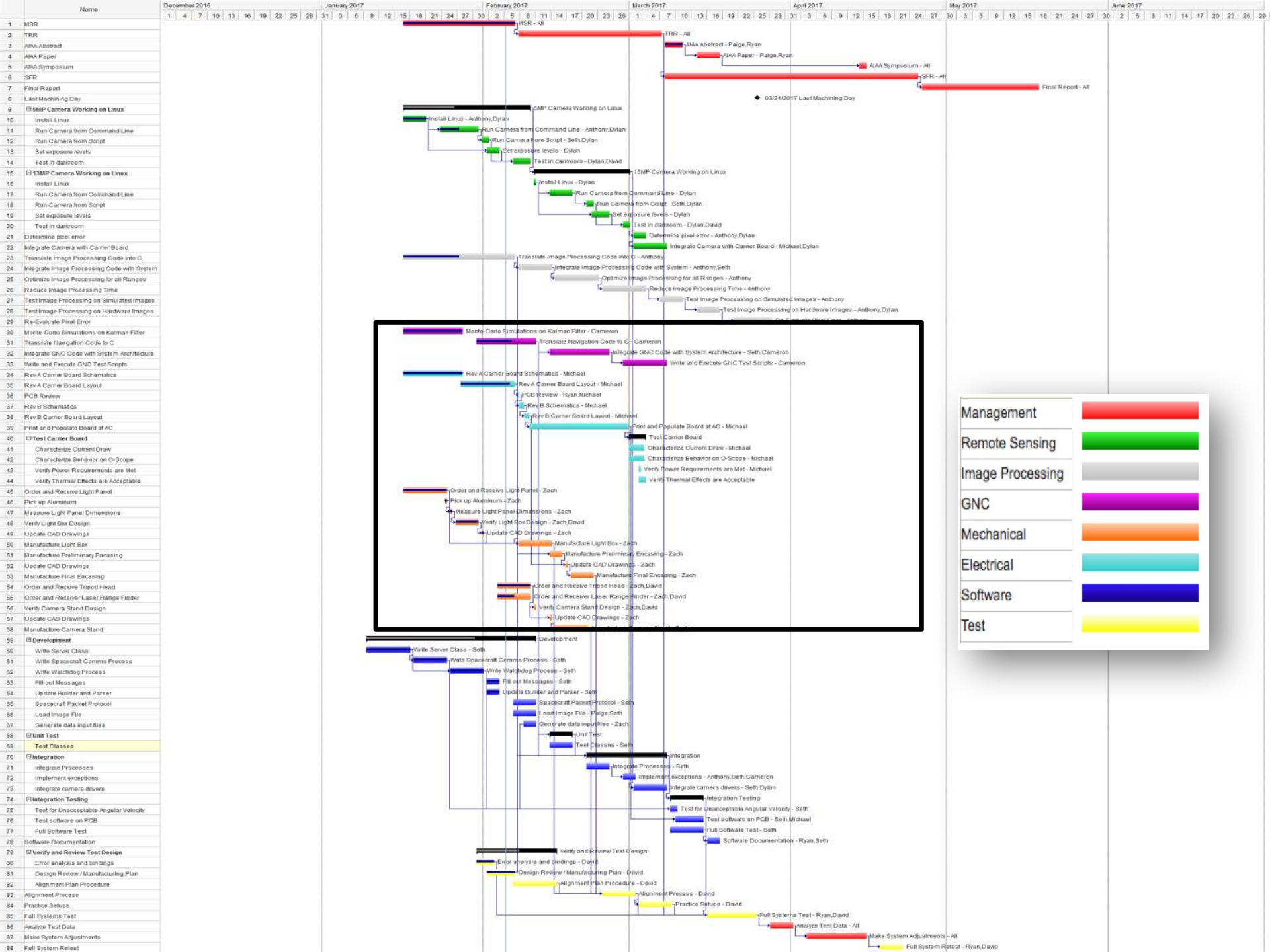
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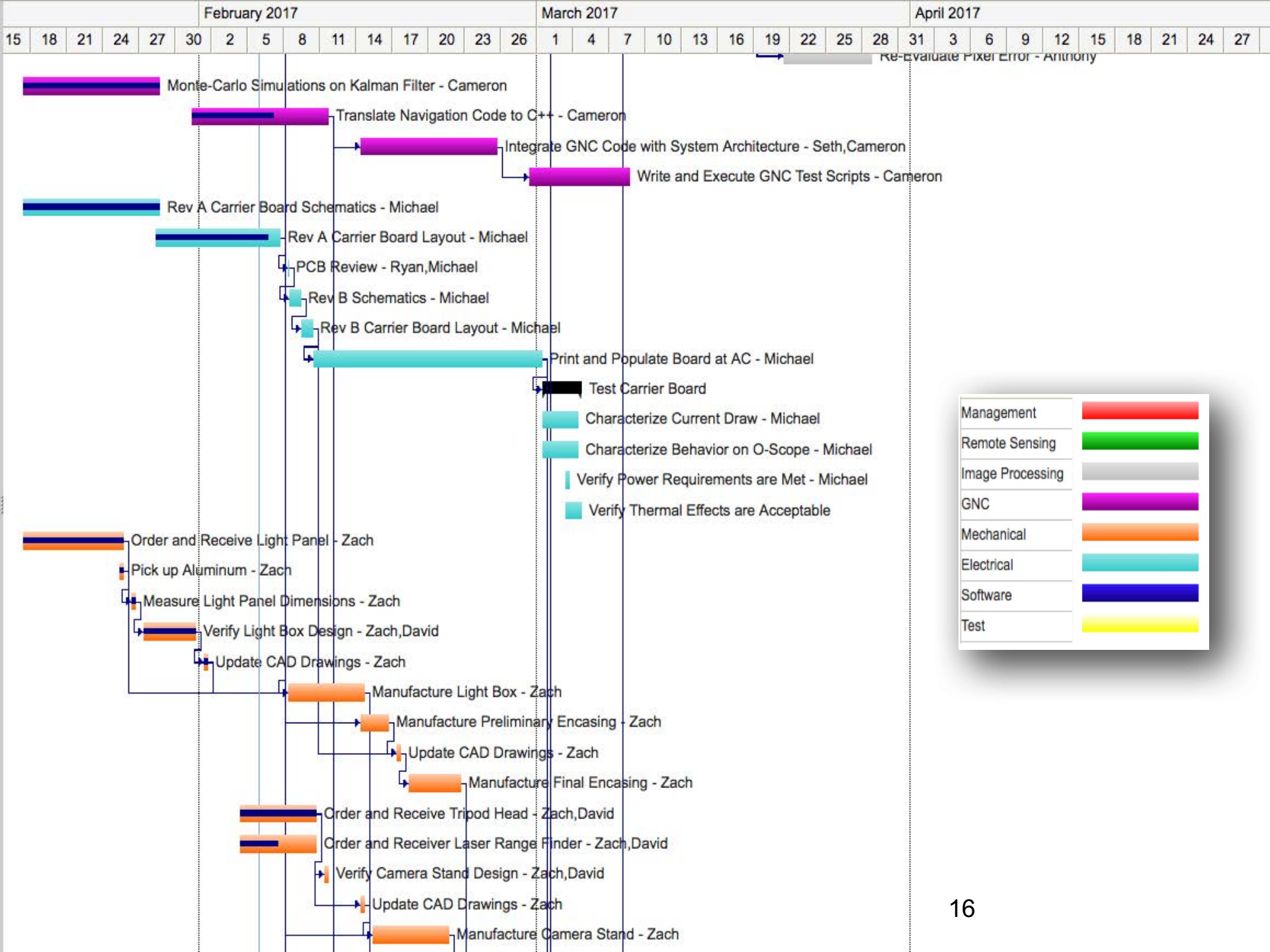
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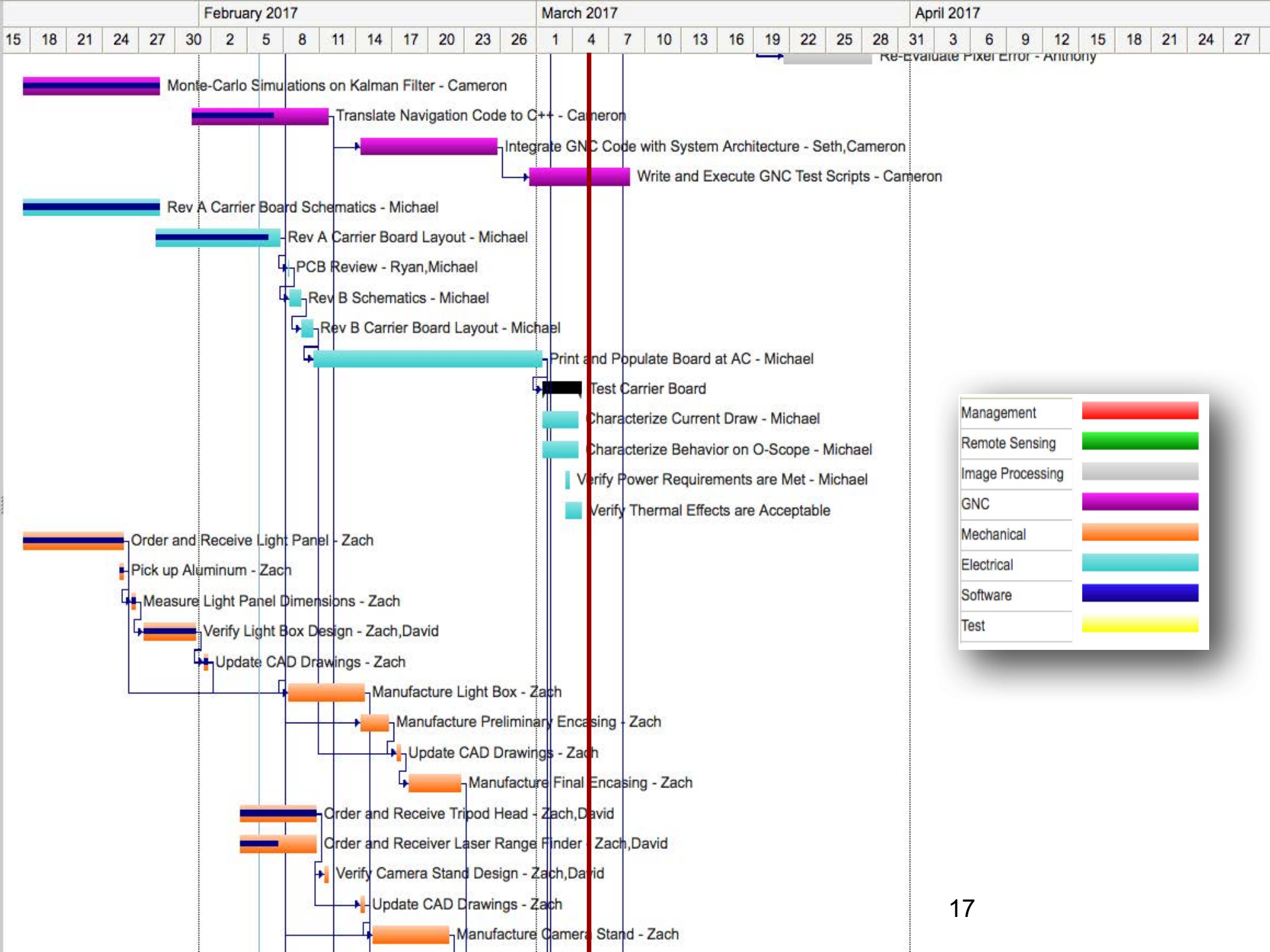
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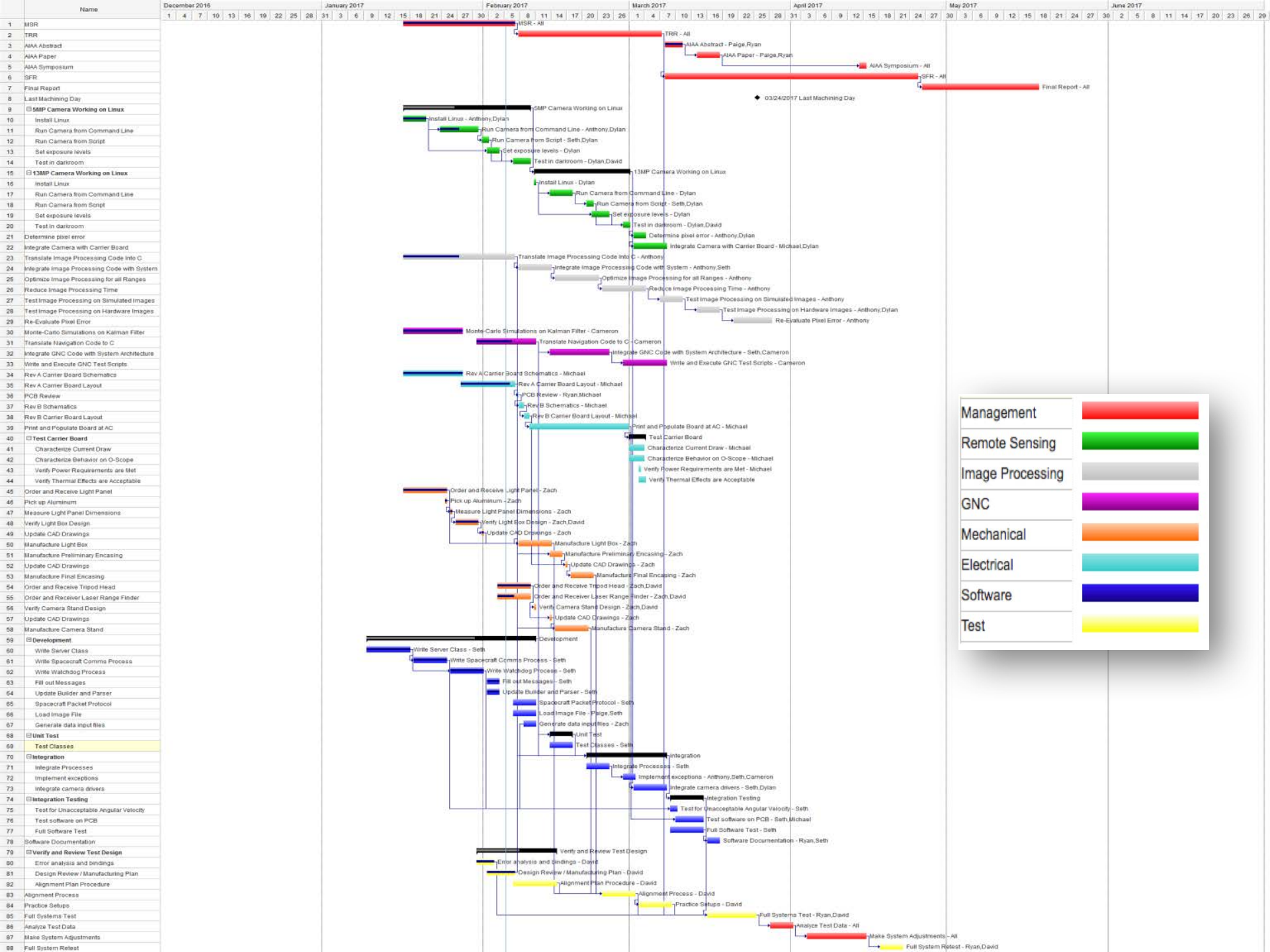
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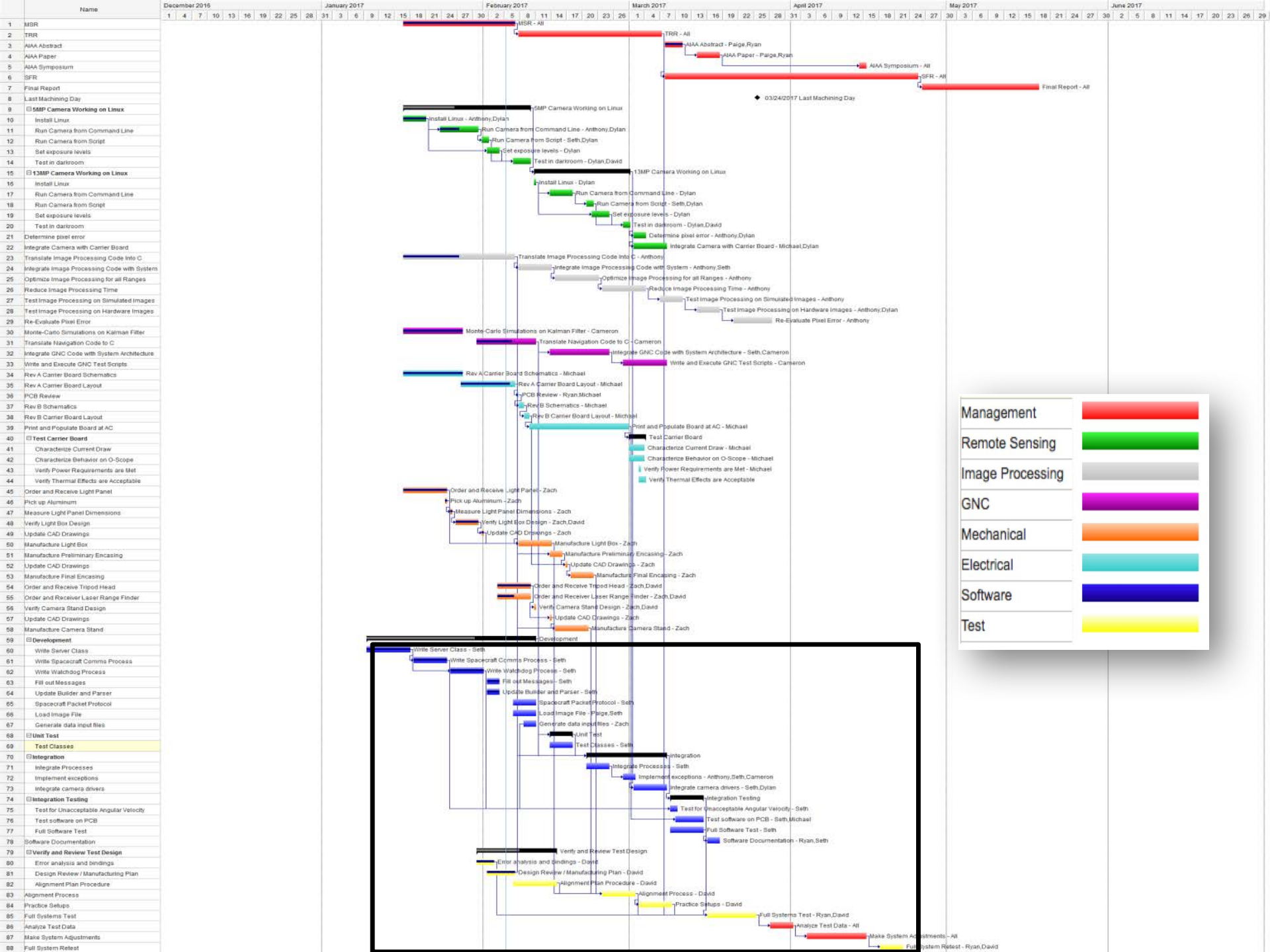
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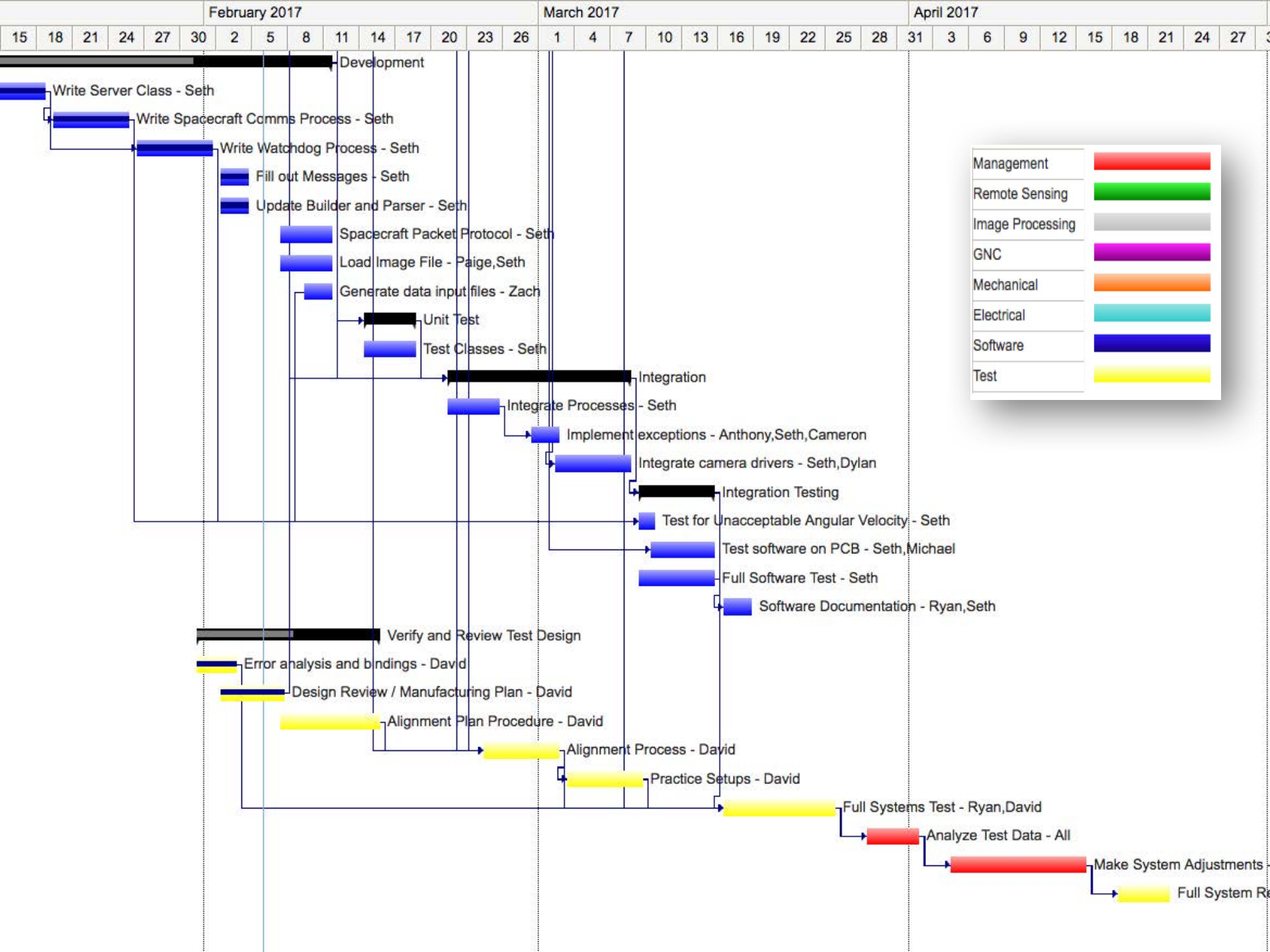
Translate Image Processing Code into C
Integrate Image Processing Code with System
Optimize Image Processing for all Ranges
Reduce Image Processing Time
Test Image Processing on Simulated Images
Test Image Processing on Hardware Images
Re-Evaluate Pixel Error
Monte-Carlo Simulations on Kalman Filter
Translate Navigation Code to C
Integrate GNC Code with System Architecture
Write and Execute GNC Test Scripts
Rev A Carrier Board Schematics
Rev A Carrier Board Layout
PCB Review
Rev B Schematics
Rev B Carrier Board Layout
Print and Populate Board at AC
Test Carrier Board
Characterize Current Draw
Characterize Behavior on O-Scope
Verify Power Requirements are Met
Verify Thermal Effects are Acceptable
Order and Receive Light Panel
Pick up Aluminum
Measure Light Panel Dimensions
Verify Light Box Design
Update CAD Drawings
Manufacture Light Box
Manufacture Preliminary Encasing
Update CAD Drawings
Manufacture Final Encasing
Order and Receive Tripod Head
Order and Receiver Laser Range Finder
Verify Camera Stand Design
Update CAD Drawings
Manufacture Camera Stand
Development
Write Server Class
Write Spacecraft Comms Process
Write Watchdog Process
Fill out Messages
Update Builder and Parser
Spacecraft Packet Protocol
Load Image File
Generate data input files
Unit Test
Test Classes
Integration
Integrate Processes
Implement exceptions
Integrate camera drivers
Integration Testing
Test for Unacceptable Angular Velocity
Test software on PCB
Full Software Test
Software Documentation
Verify and Review Test Design
Error analysis and bindings
Design Review / Manufacturing Plan
Alignment Plan Procedure
Alignment Process
Practice Setups
Full Systems Test
Analyze Test Data
Make System Adjustments
Full System Retest
03/24/2017 Last Machining Day
Management
Remote Sensing
Image Processing
GNC
Mechanical
Electrical
Software
Test


February 2017
March 2017
April 2017
15 18 21 24 27 30 2 5 8 11 14 17 20 23 26 1 4 7 10 13 16 19 22 25 28 31 3 6 9 12 15 18 21 24 27
Development
Write Server Class - Seth
Write Spacecraft Comms Process - Seth
Write Watchdog Process - Seth
Fill out Messages - Seth
Update Builder and Parser - Seth
Spacecraft Packet Protocol - Seth
Load Image File - Paige,Seth
Generate data input files - Zach
Unit Test
Test Classes - Seth
Integration
Integrate Processes - Seth
Implement exceptions - Anthony,Seth,Cameron
Integrate camera drivers - Seth,Dylan
Integration Testing
Test for Unacceptable Angular Velocity - Seth
Test software on PCB - Seth,Michael
Full Software Test - Seth
Software Documentation - Ryan,Seth
Verify and Review Test Design
Error analysis and bindings - David
Design Review / Manufacturing Plan - David
Alignment Plan Procedure - David
Alignment Process - David
Practice Setups - David
Full Systems Test - Ryan,David
Analyze Test Data - All
Make System Adjustments
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Management
Remote Sensing
Image Processing
GNC
Mechanical
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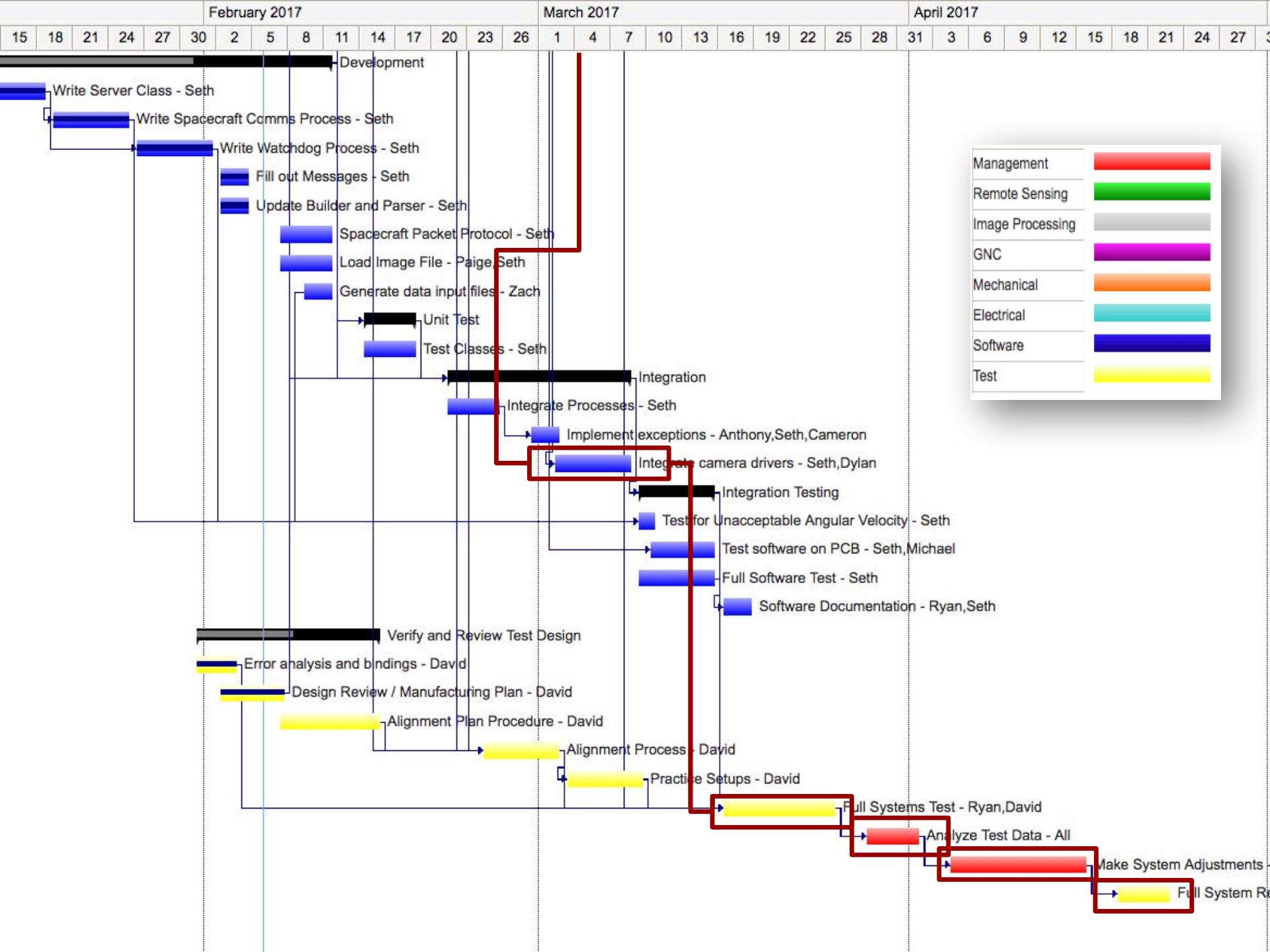
Software
Test


February 2017
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15 18 21 24 27 30 2 5 8 11 14 17 20 23 26 1 4 7 10 13 16 19 22 25 28 31 3 6 9 12 15 18 21 24 27
Development
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Write Watchdog Process - Seth
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Design Review / Manufacturing Plan - David
Alignment Plan Procedure - David
Alignment Process - David
Practice Setups - David
Full Systems Test - Ryan,David
Analyze Test Data - All
Make System Adjustments
Full System Re
Management
Remote Sensing
Image Processing
GNC
Mechanical
Electrical
Software
Test

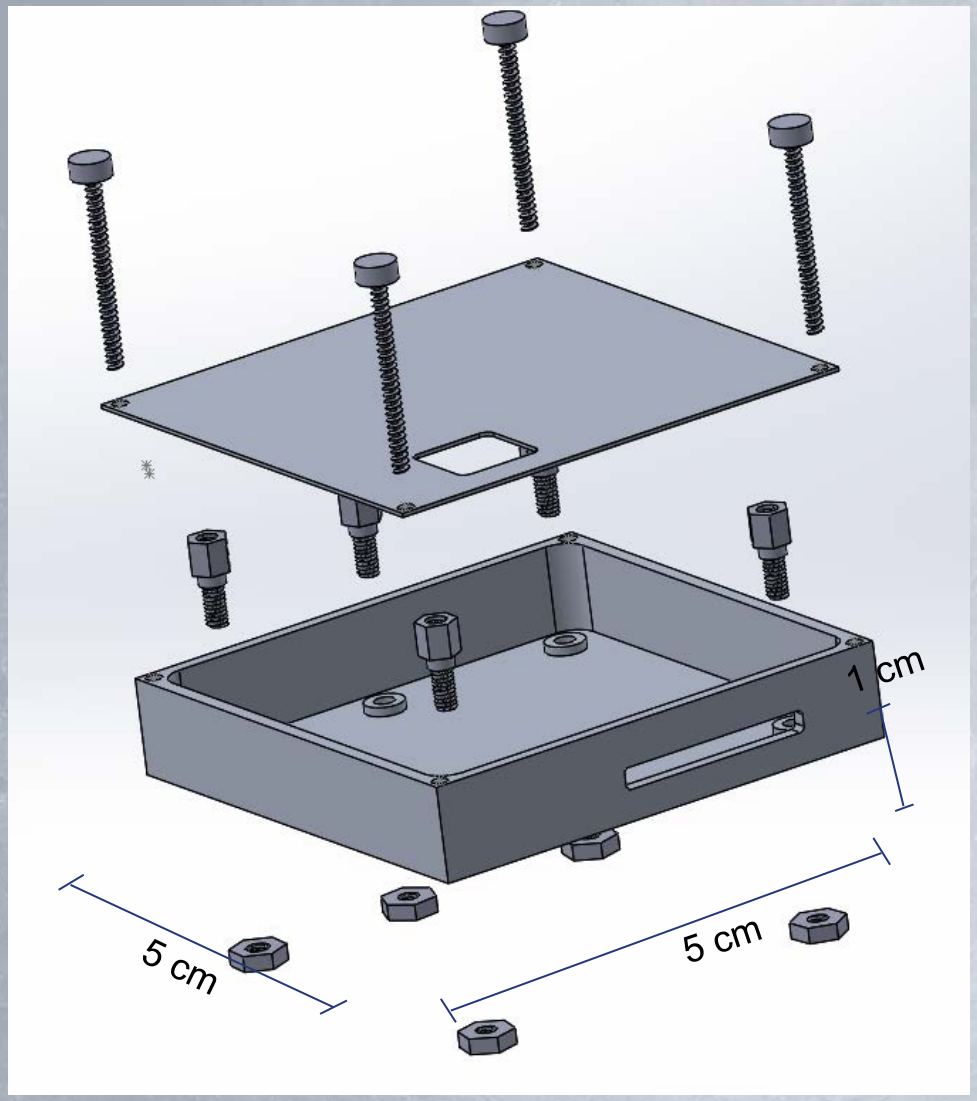
Changes from CDR

- Manufacture light box before OSPRE encasing
  - encasing dependency on finalized PCB layout
- Getting cameras working is now the majority of the critical path
  - team members have least amount of experience in this area
  - dependency for finishing OSPRE's software, determining the pixel error, and running a systems test
  - may need to find external help

MANUFACTURING

MANUFACTURING STATUS: Structure

Structure - Scope

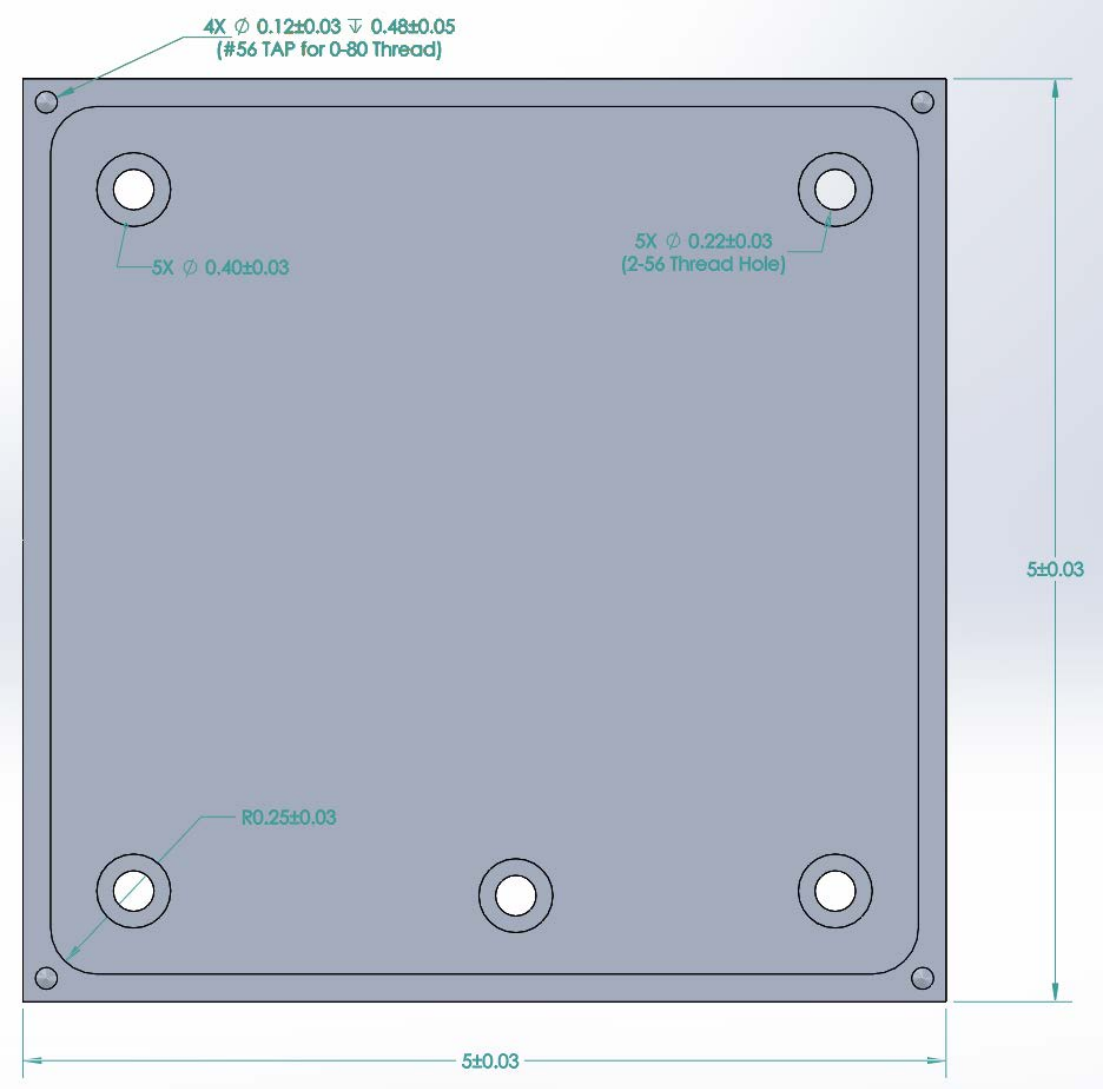


EXPLODED VIEW

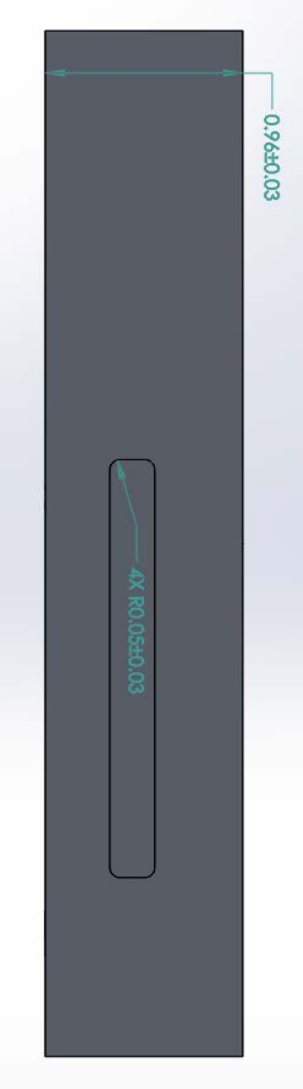
Encasing Components

- **Purchased**
  - 2-56 Jacksocket (x7)
  - 2-56 Nut (x5)
  - 0-80 Bolt [3/16in] (x4)
- **Manufactured**
  - Top Sheet
    - 0.016” Aluminum 6061-T6 [5cm x 5cm]
  - Bottom Plate
    - Aluminum 6061-T6 Bar
- **Alterations**
  - Machined spacers into bottom plate
  - 0.1 cm in height

Structure - Encasing

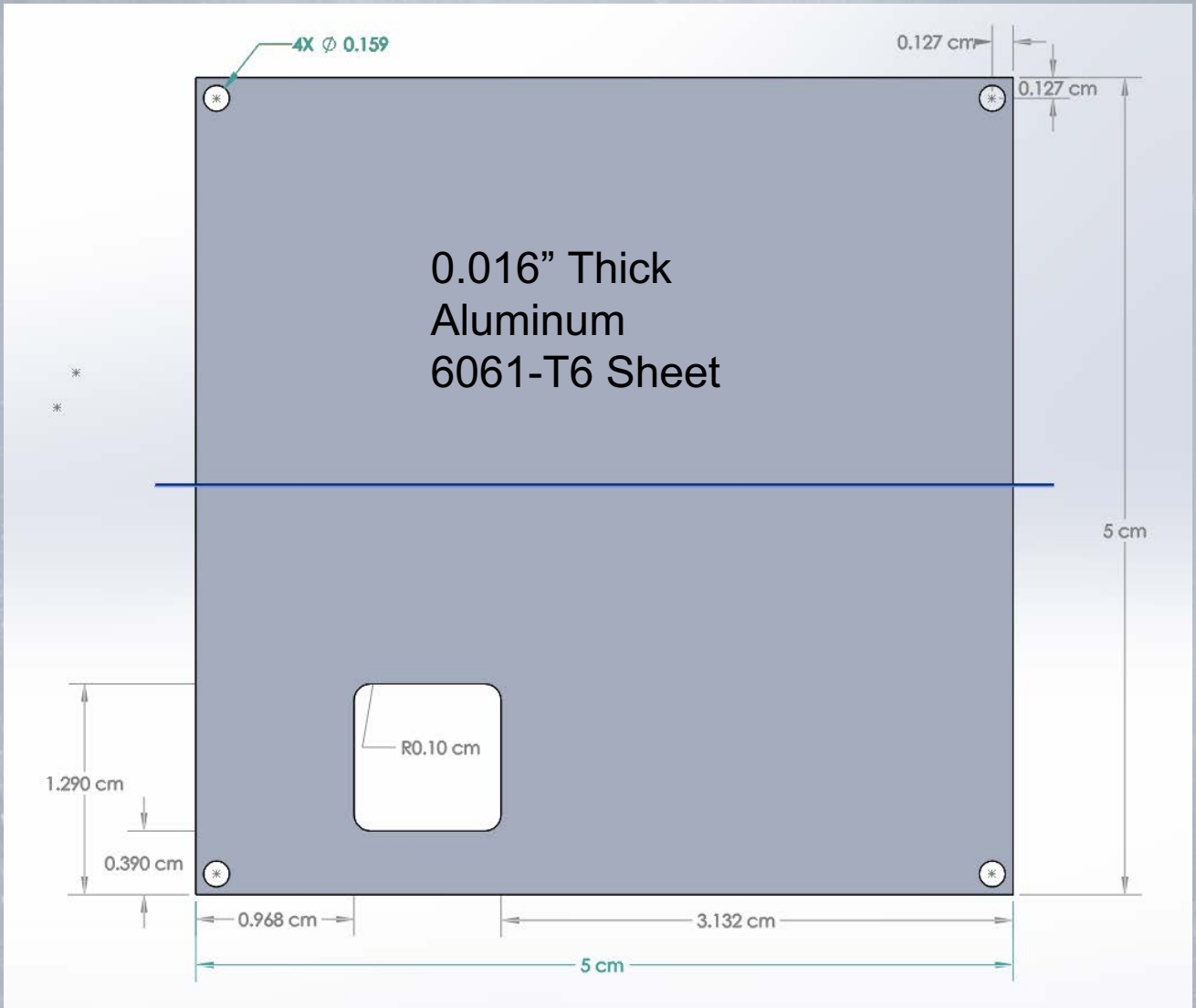


BOTTOM VIEW



SIDE VIEW

Structure - Encasing



TOP VIEW

Structure - Status

Component	Source	Status
Top Cover	Construct	ACQUIRED
Bottom Structure	Construct	ACQUIRED
2-56 Jacksocket (x5)	Purchase	PURCHASED
2-56 Nut (x5)	Purchase	PURCHASED
0-80 Bolt [¾ in] (x4)	Purchase	PURCHASED

Manufacturing Plan:

- Top Cover
  - Manufacturing Process
    - Where -- Aerospace Machine Shop
    - How -- CNC Mill
  - **Due Date** -- **Feb 16th**

- Bottom Structure
  - Manufacturing Process
    - Where -- Aerospace Machine Shop
    - How -- Drill Press
  - **Due Date** -- **Feb 16th**

MANUFACTURING STATUS: Electrical

Electrical - Scope

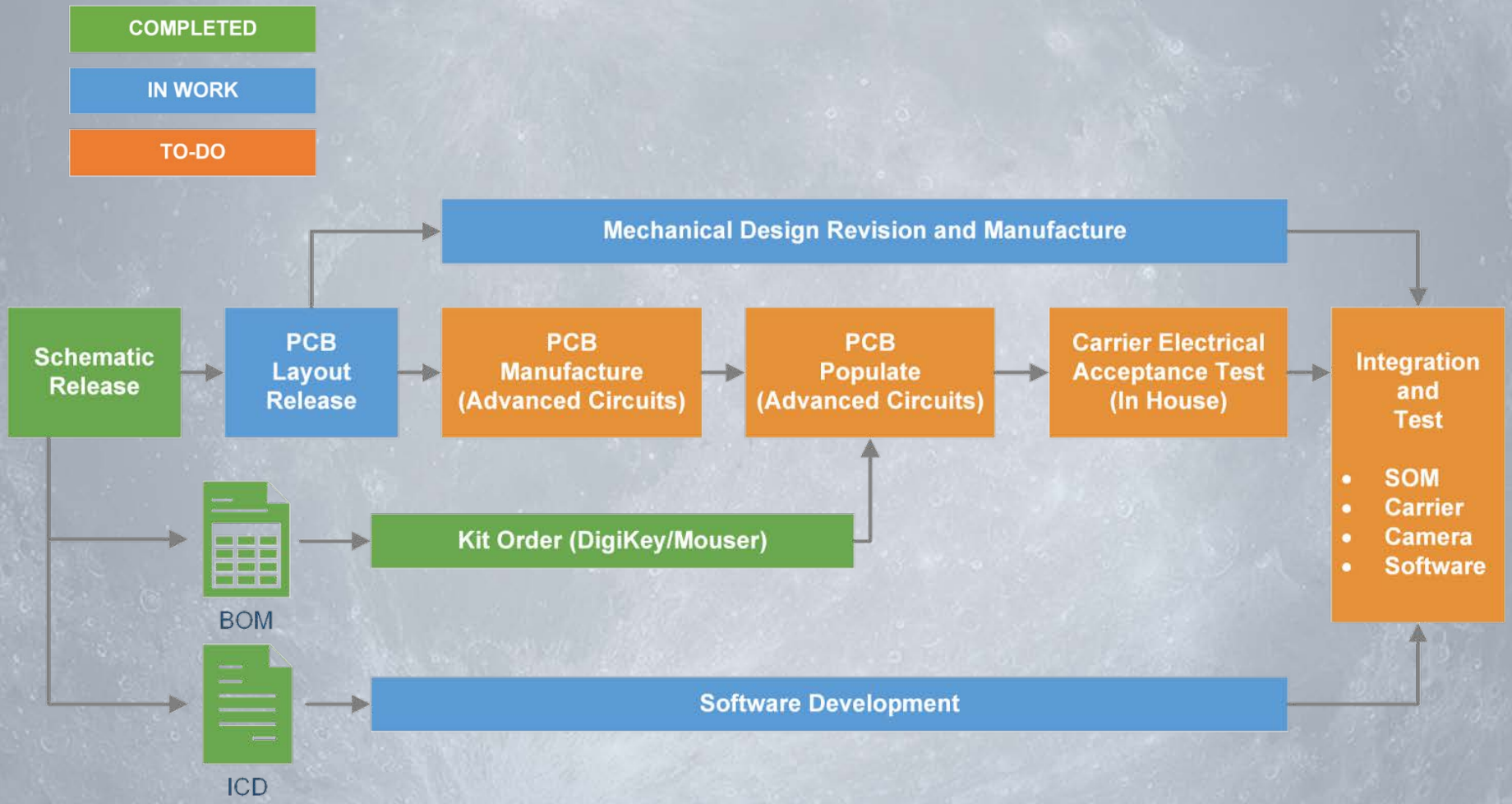
Product Structure

Assembly, Navigation Module

- Assembly, Lower Housing
  - PCB Assembly
    - Assembly, Carrier Board
      - » PCB (IPC-6012 Class 2 from Advanced Circuits)
      - » IC Components (COTS)
    - SOM (COTS)
    - Camera Module (COTS)
  - Housing, Cover

Electrical - Scope

Product Integration

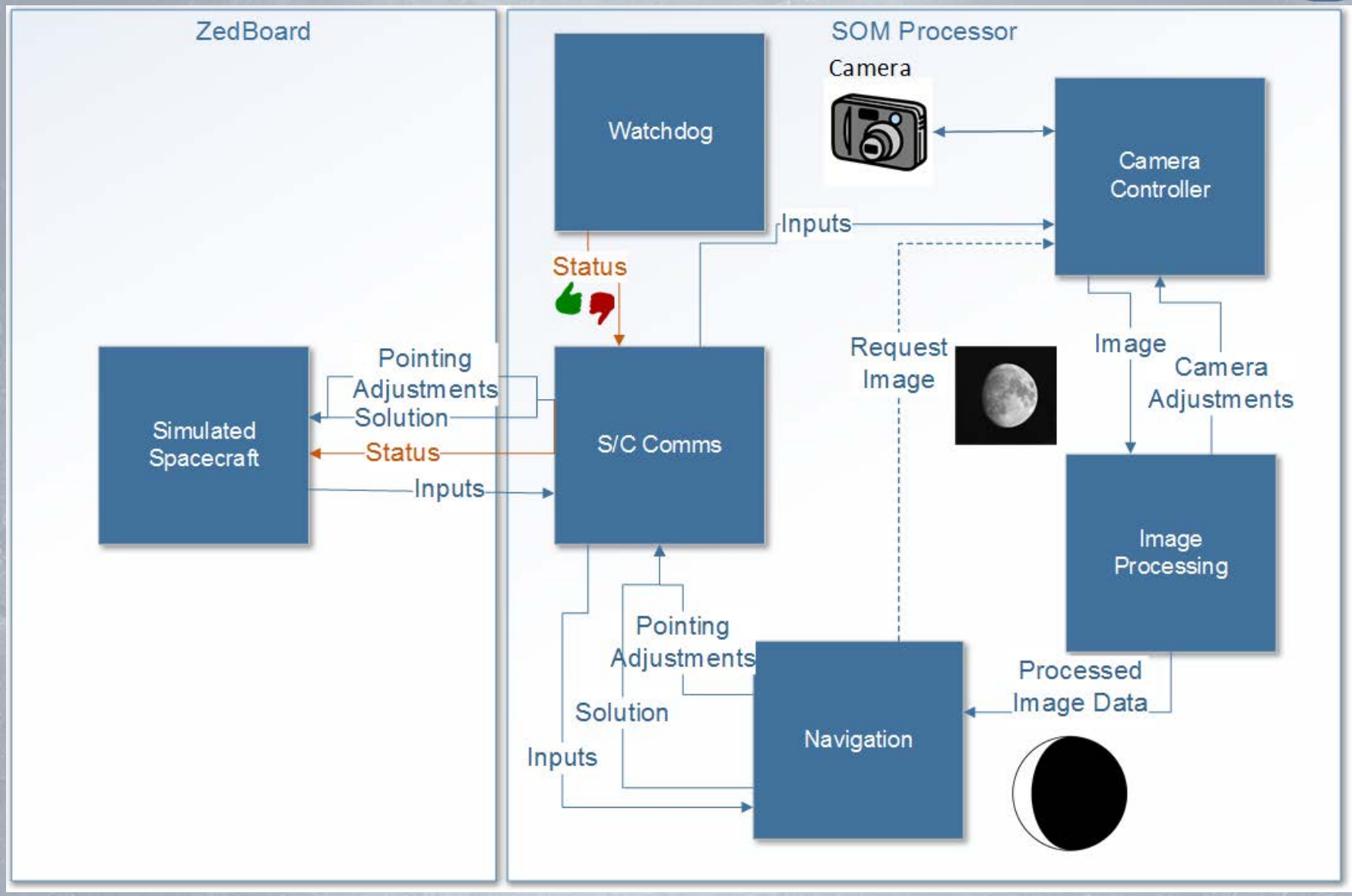


Electrical - Status

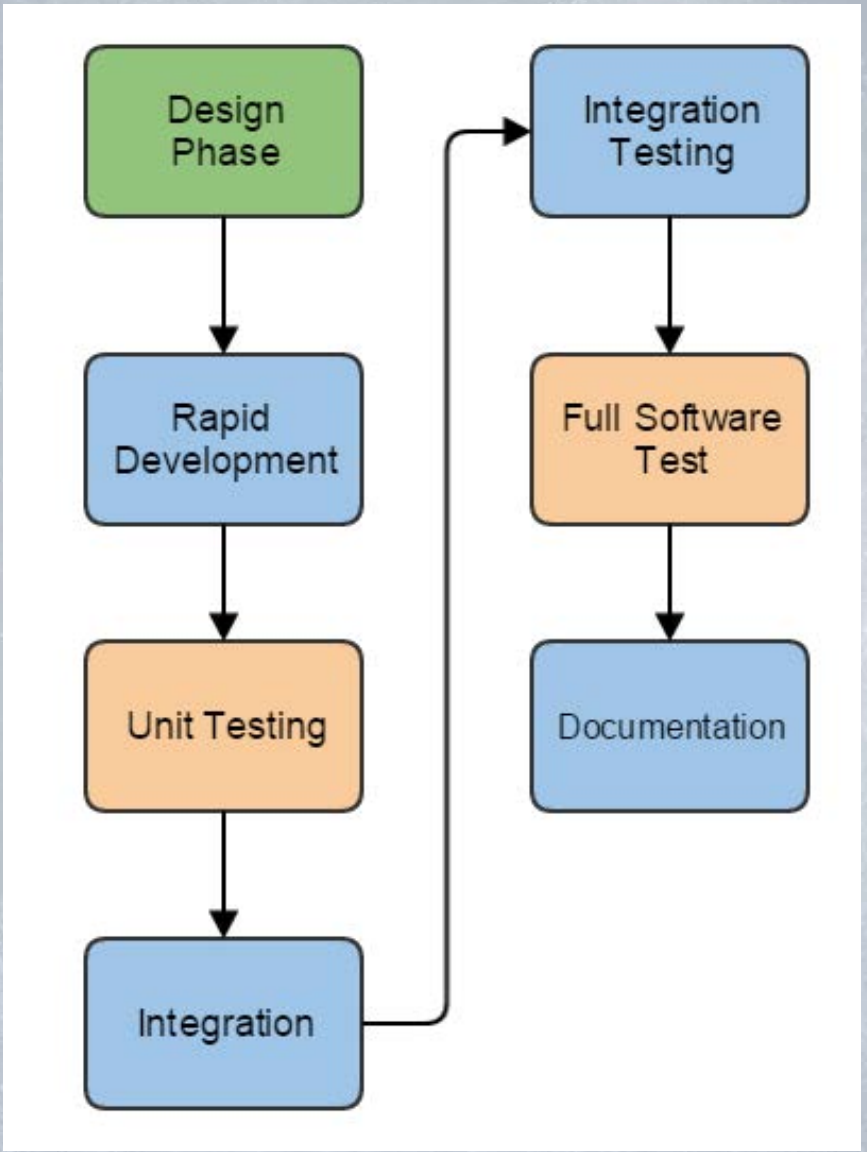
Current Production Tasks	Status
Production Schematic Release (Rev A) • Minor IC component changes based on availability • “Bum-Down” IC design simplifications	**COMPLETE**
BOM (Rev A)	**COMPLETE** Ready to order with layout release
ICD (Rev A)	**COMPLETE**
IC Design support content aggregation • Altium component models and footprints • SolidWorks component models	**COMPLETE**
Production Layout Release (Rev A) • Development hardware study and measurement • Very tight real-estate	**LAYOUT IN PROGRESS** Design Review this week
Manufacture and Populate PCB • Advanced Circuits, Aurora CO • IPC 6012 Class 2	**PENDING** Quote and order waiting on layout
Design & Build Carrier-ZedBoard Test Cable	**TO DO**

MANUFACTURING STATUS: Software

Software - Scope



Software: Process



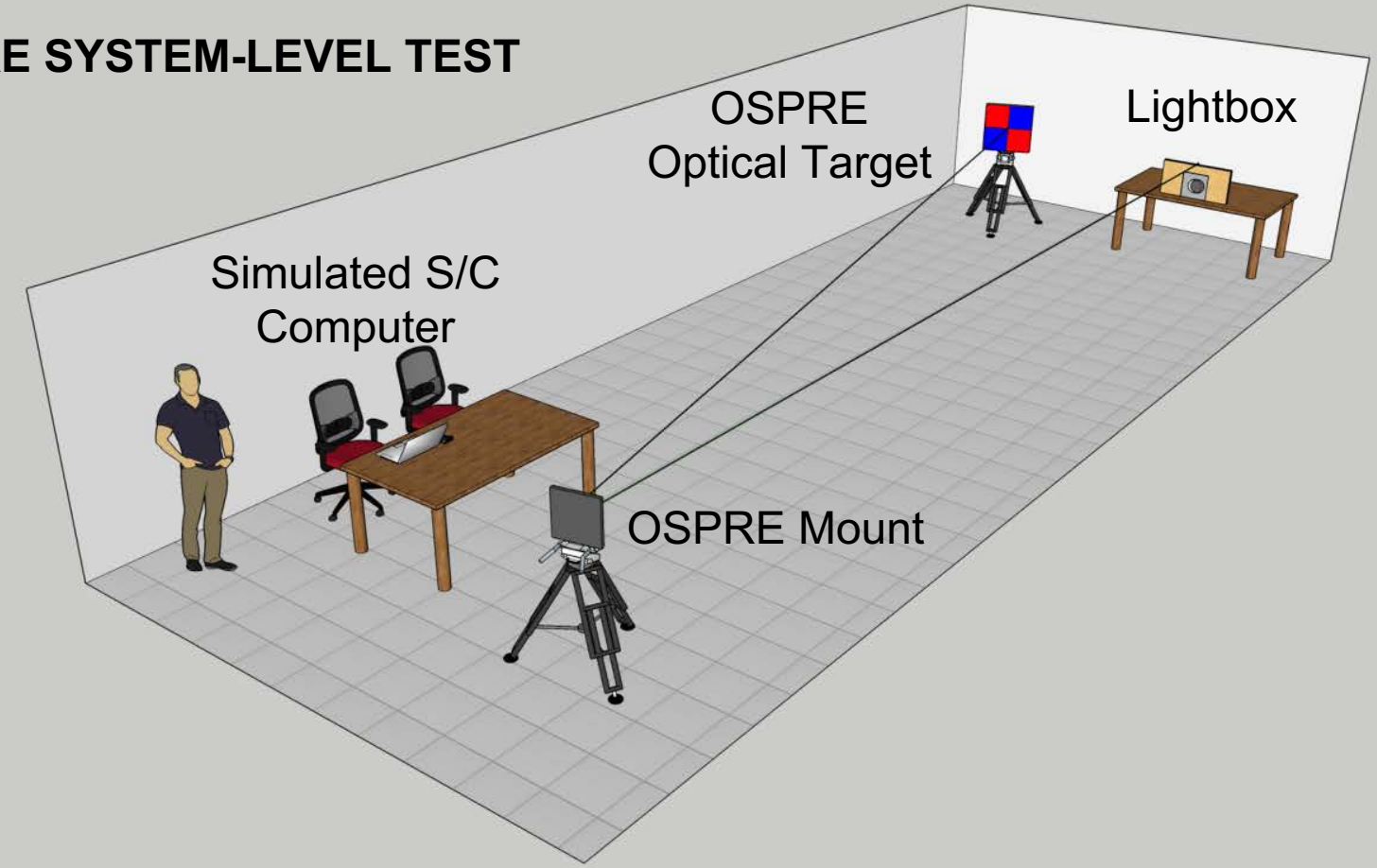
Software - Status

Component	Sub Tasks	Status
OSPRE Server Classes		COMPLETE
Application Communication	- All processes connect and send necessary messages - Develop Space Packet Protocol	IN PROGRESS
OSPRE Camera Control	- Determine Camera API	IN PROGRESS
OSPRE Image Processing	- Translate Code from Matlab to C++ - Add Exception Handling	IN PROGRESS
OSPRE Navigation Algorithm	- Translate Code from Matlab to C++ - Add Exception Handling	IN PROGRESS
Software Integration	- Combine Navigation, Image Processing, Camera Control and Software Architecture Code	IN PROGRESS
Software Integration	- Put software onto hardware - Make sure communication between ZedBoard / OSPRE is working	**PENDING**
OSPRE Software Testing	- Full Mission Simulations with simulated Images and simulated STK data	**PENDING**

MANUFACTURING STATUS:
Test Equipment

Test - Scope

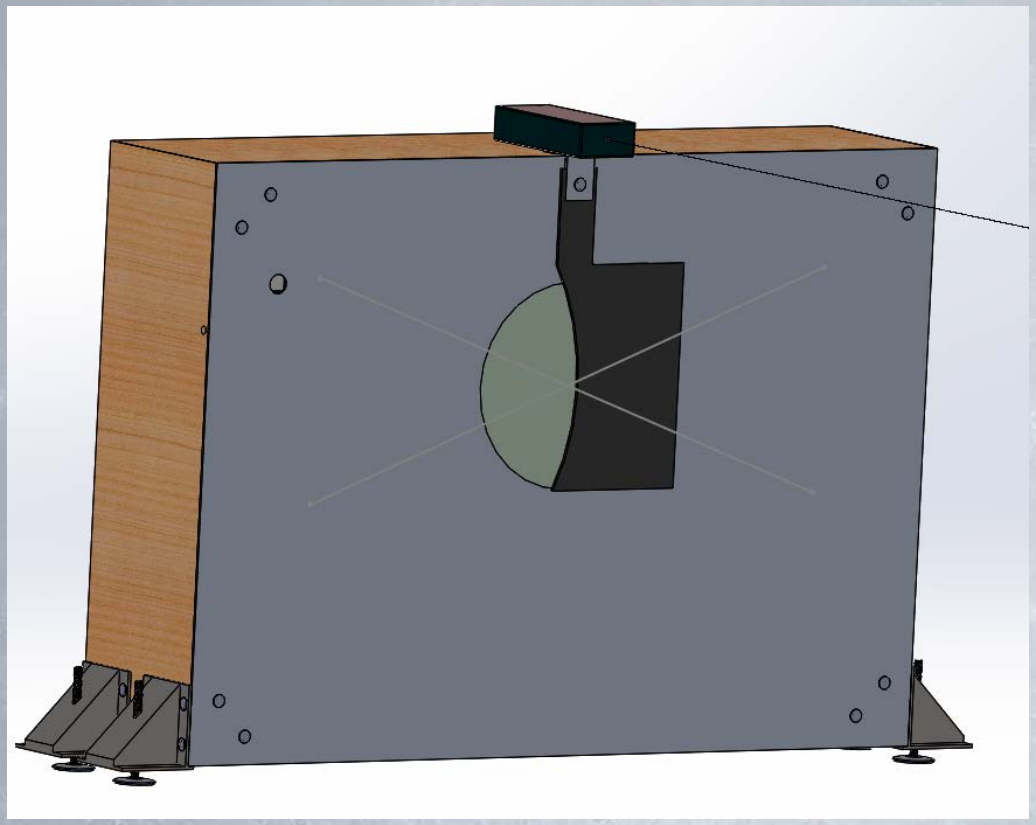
OSPRE SYSTEM-LEVEL TEST



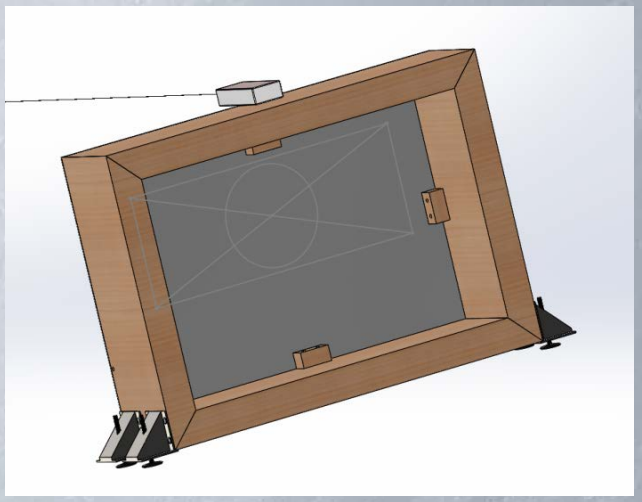
Scaled to ECCE 2B49A

Test Equipment

LIGHTBOX



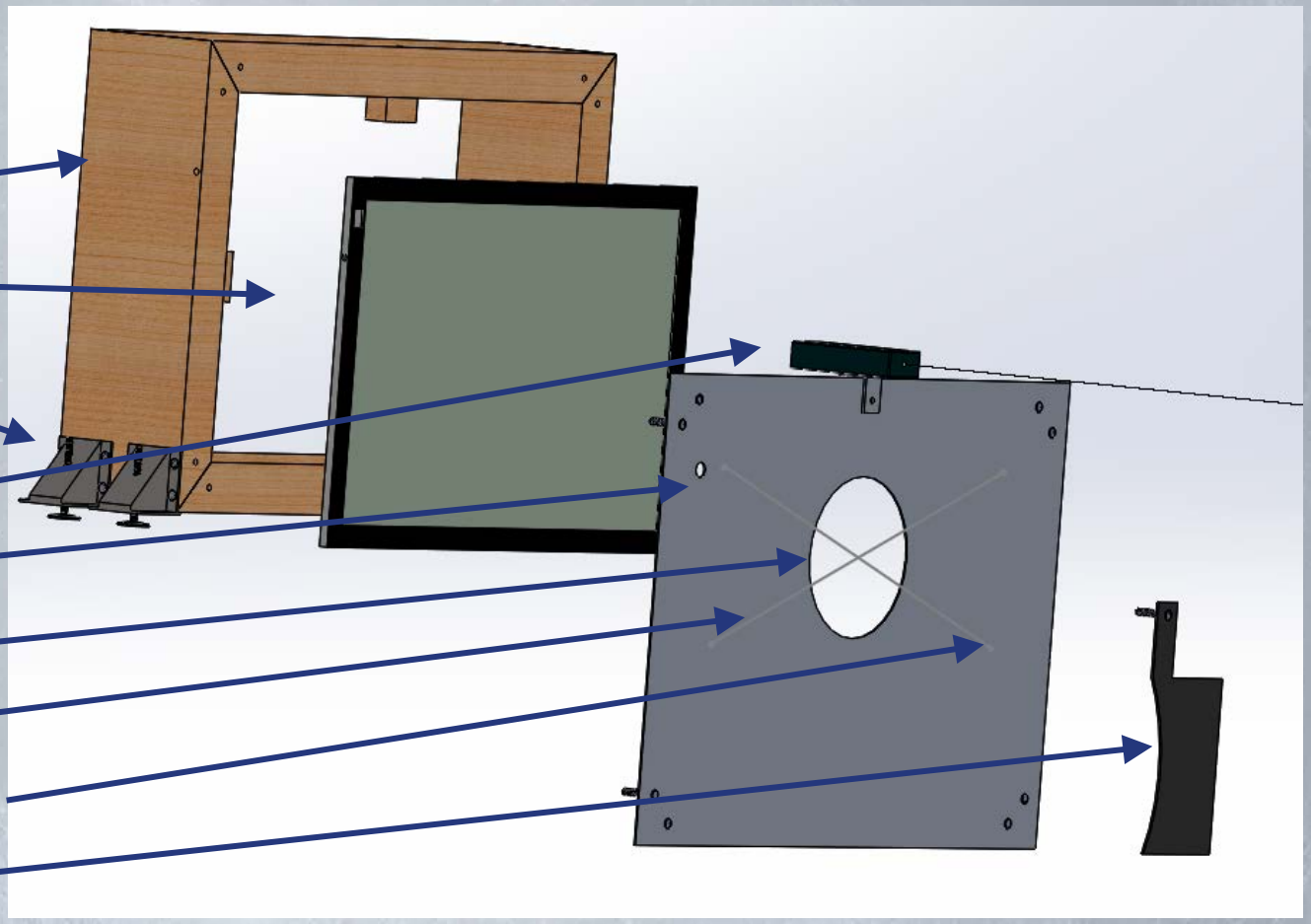
FRONT VIEW



BACK VIEW

Test Equipment

LIGHTBOX
COMPONENTS



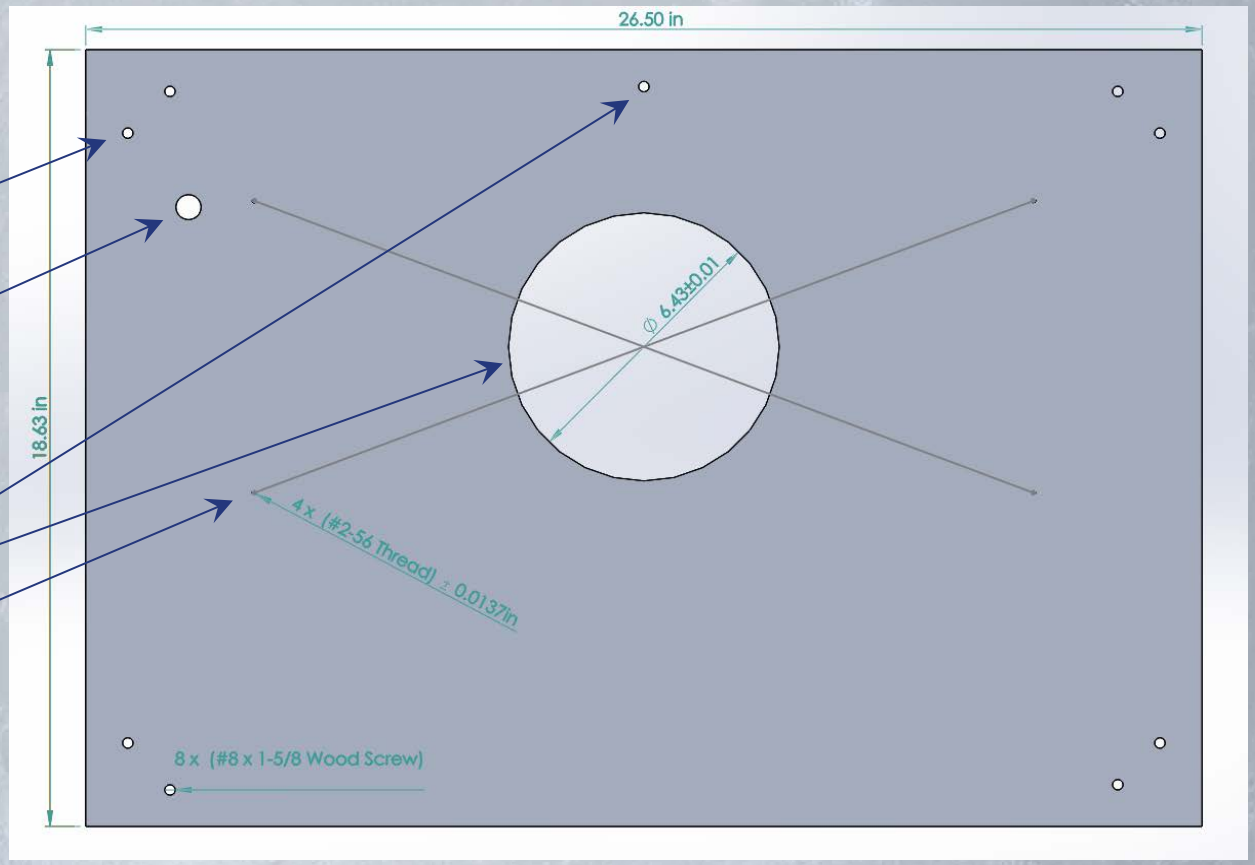
EXPLODED VIEW

Test Equipment

LIGHTBOX FRONT PANEL

Manufacturing Process:

- Drill Press
  - Wood Screw Holes
  - Power Hole
- CNC Mill
  - Centered Hole
  - Moon Cutout
  - Wire Mounts



FRONT PANEL

Test Manufacturing Status

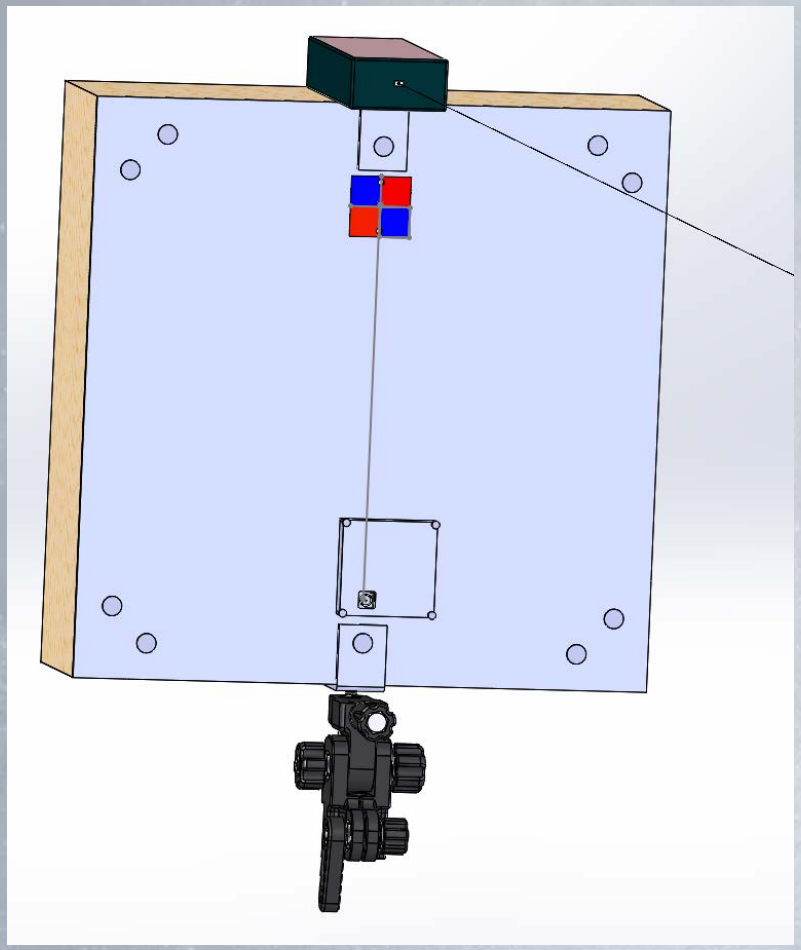
LIGHTBOX

COMPONENT	SOURCE	MATERIAL	STATUS	DATE DUE
Encasing	Construct	Plywood	CONSTRUCTING	**February 13th**
Light Panel	Purchase	-	COMPLETE	NA
Stands	Purchase	Metal	ORDERED	NA
Adjustment Screws	Purchase	-	ORDERED	NA
Front Panel	Construct	Aluminum Plate	CONSTRUCTING	**February 10th**
Laser Range Finder	Purchase	-	ORDERED	NA
Laser Ranger Mount	Purchase	-	ORDERED	NA
Alignment Wires	Construct	Steel Wire	ACQUIRED	**February 11th**
Alignment Wire Mounts	Construct	Metal Screws	ACQUIRED	**February 11th**

Lightbox Completion Due Date: February 13th

Test Manufacturing Status

OSPRE Mount - Materials in Possession
AWAITING CONSTRUCTION



Estimated Weight:
6.8 lbs

Geared Tripod Head - **ACQUIRED**

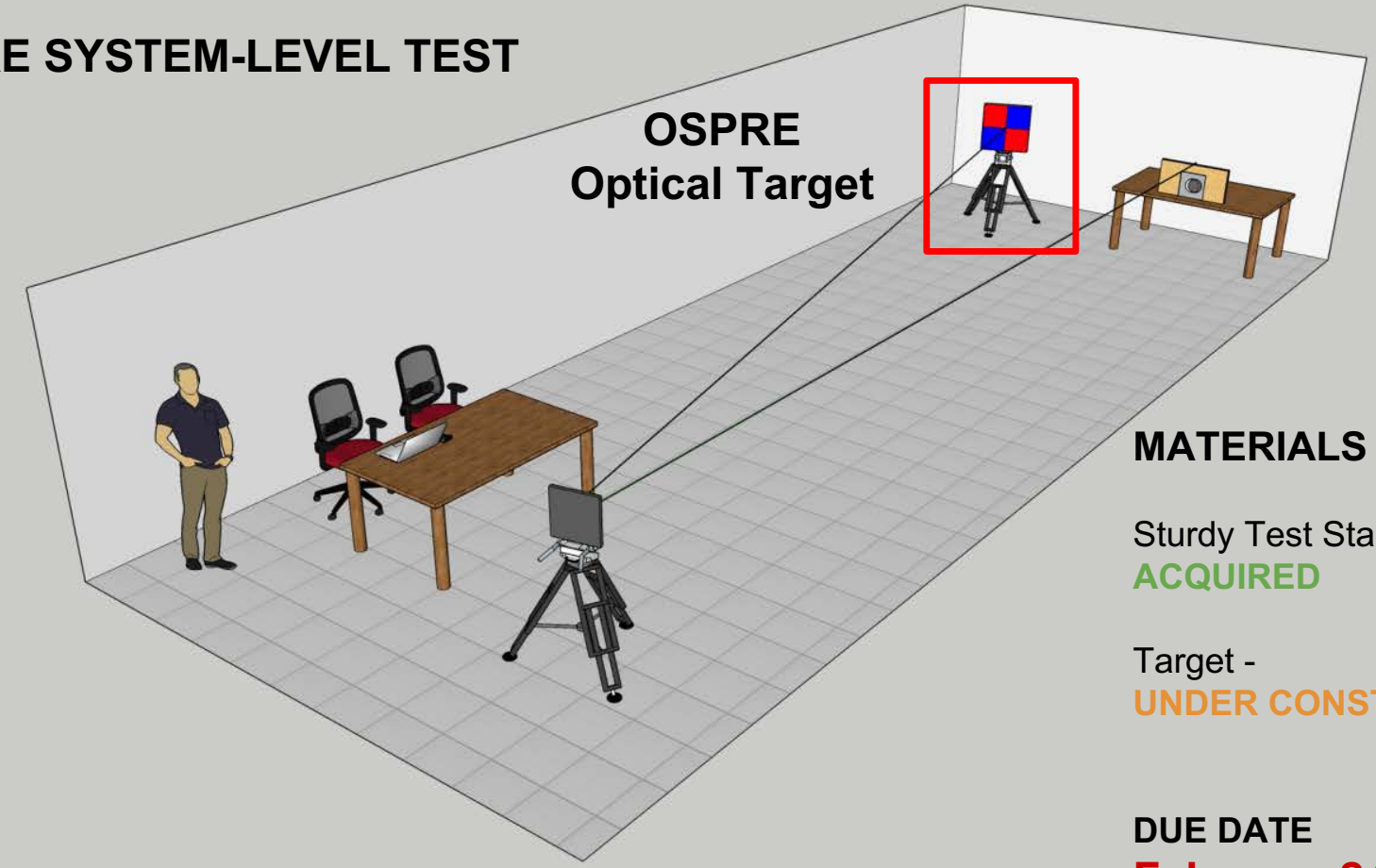
Max Weight:
11 lbs

Tripod Legs - **ACQUIRED**

Due Date: February 17th

Test Manufacturing Status

OSPRE SYSTEM-LEVEL TEST



MATERIALS

Sturdy Test Stand -
ACQUIRED

Target -
UNDER CONSTRUCTION

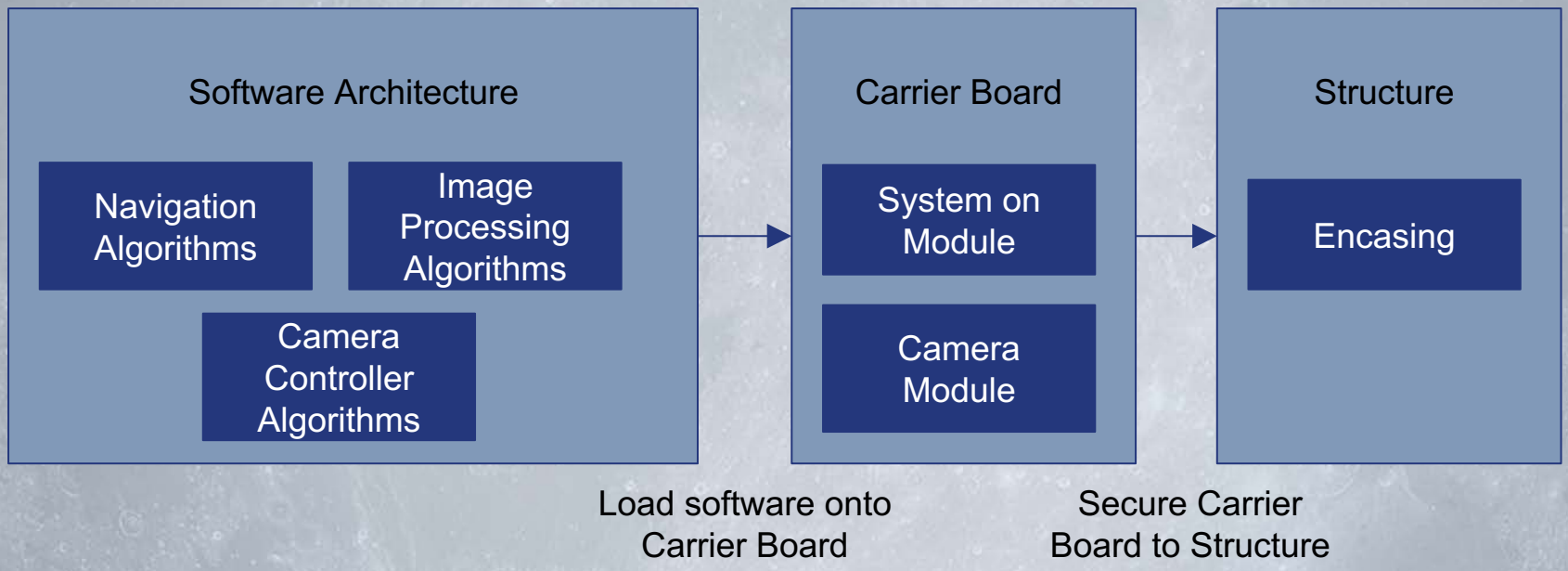
DUE DATE
February 24th

Product Integration

Product Structure

- Assembly, OSPRE Navigation Module
  - Assembly, Lower Housing
    - PCB Assembly
      - Assembly, Carrier Board
        - PCB (IPC-6012 Class 2 from Advanced Circuits)
        - IC Components (COTS)
      - Camera Module (COTS)
      - SOM (COTS)
        - Software, Linux OS
          - OSPRE Software Package
            - Software, Navigation Module
            - Software, Image Processing Module
            - Software, Camera Control Module
      - Fasteners (COTS)
  - Housing, Cover

Product Integration



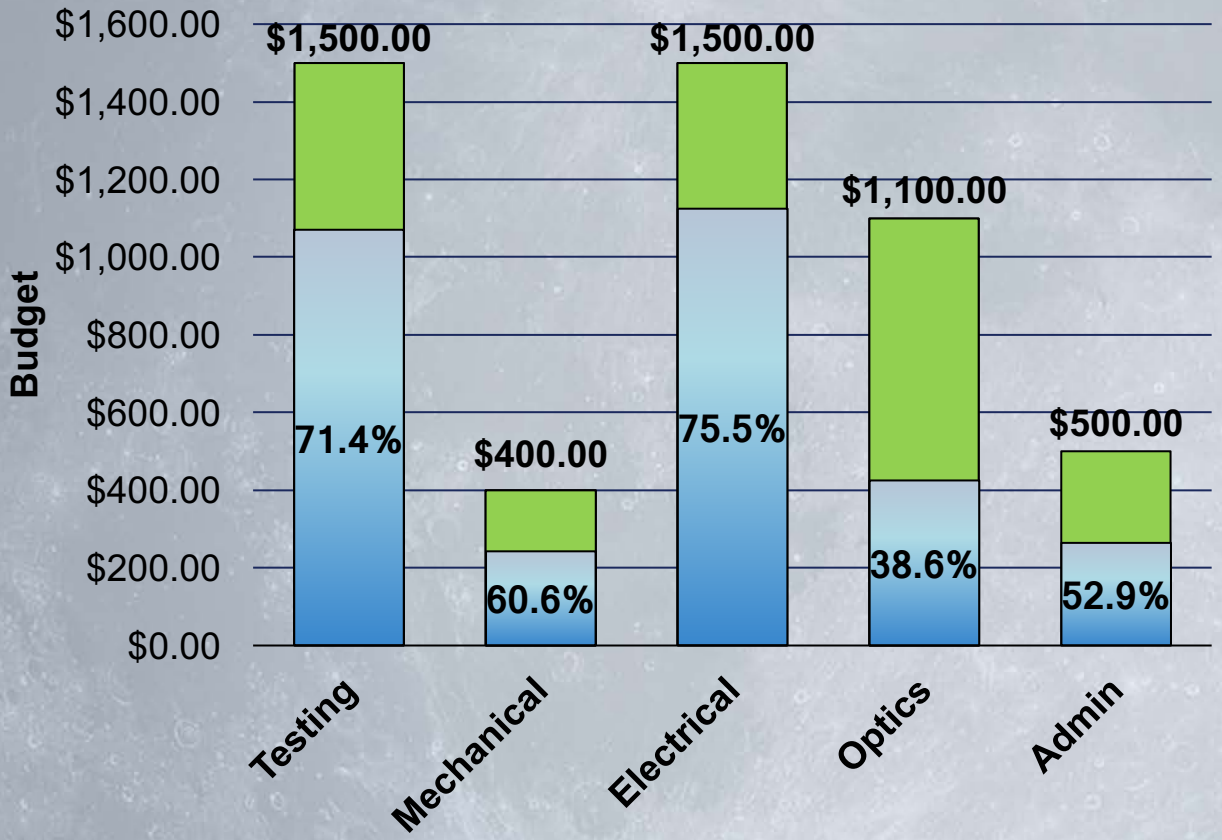
BUDGET

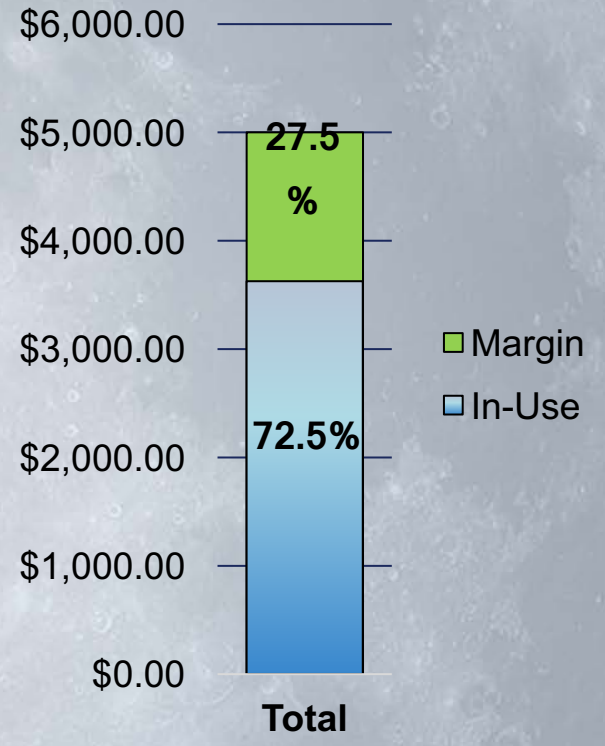
Budget

Significant purchases since CDR:

- Additional Snapdragon 410 Development Board
  - Allow paralleling of development in both Linux and Android
- ZedBoard
  - Spacecraft analog allows primary software implementation
- Lightbox Materials
  - LED Lightpanel
  - Structural materials required for assembly

Budget

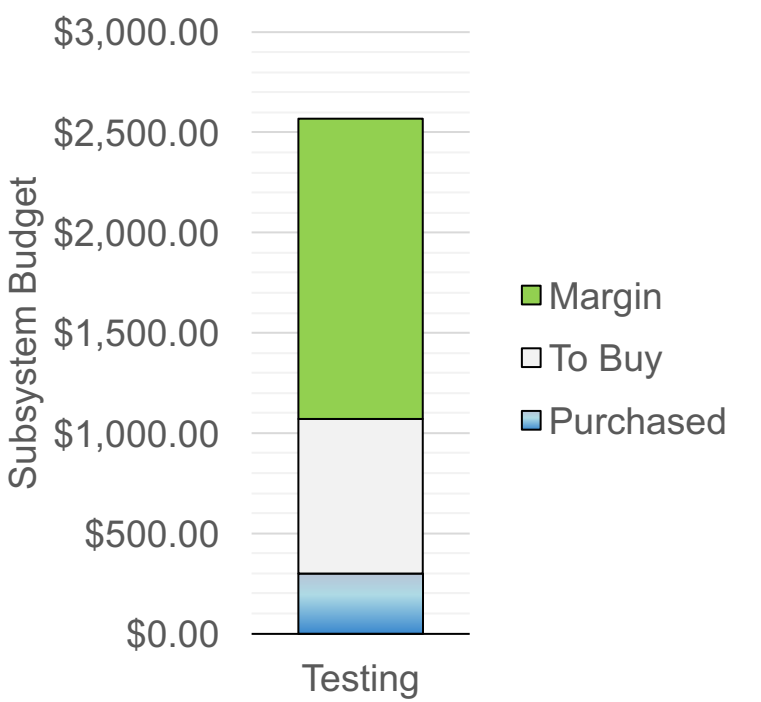




Total In-Use up 10.1% since CDR

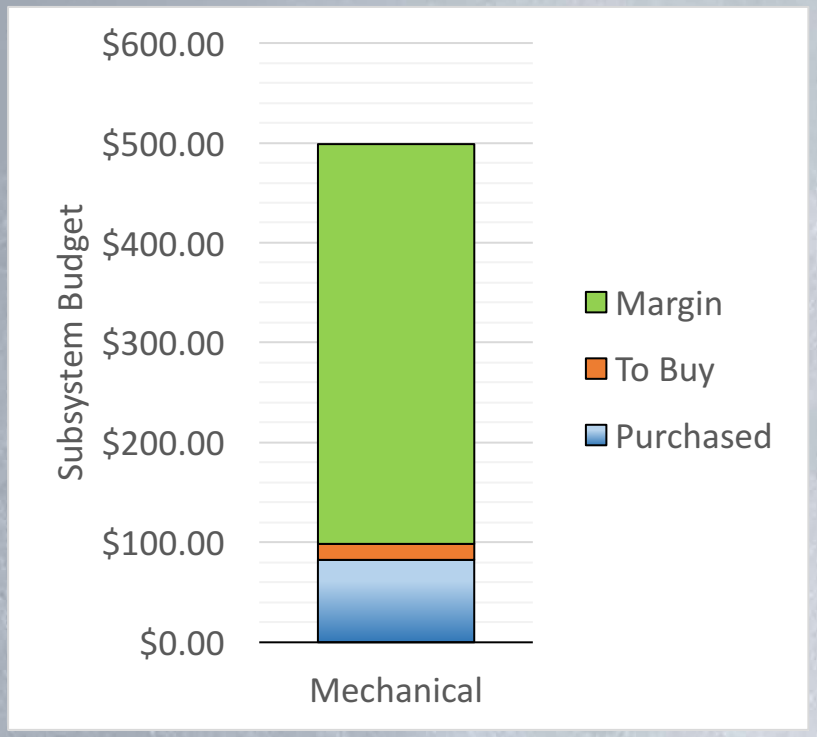
Total margin includes $500 for shipping

Test Budget



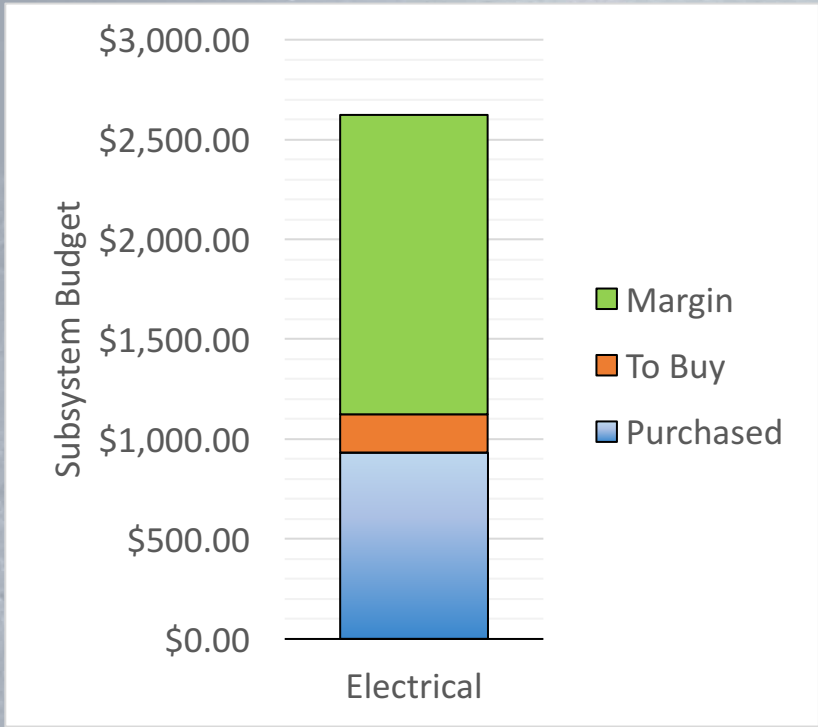
Component	% Subsystem Budget	Status
LED Lightpanel	5.4	Purchased
Precise geared tripod mount	13	Purchased
Laser Range Finder	8.7	To Buy
Measurement Materials	13	To Buy
Structure	28.3	To Buy

Structure Budget



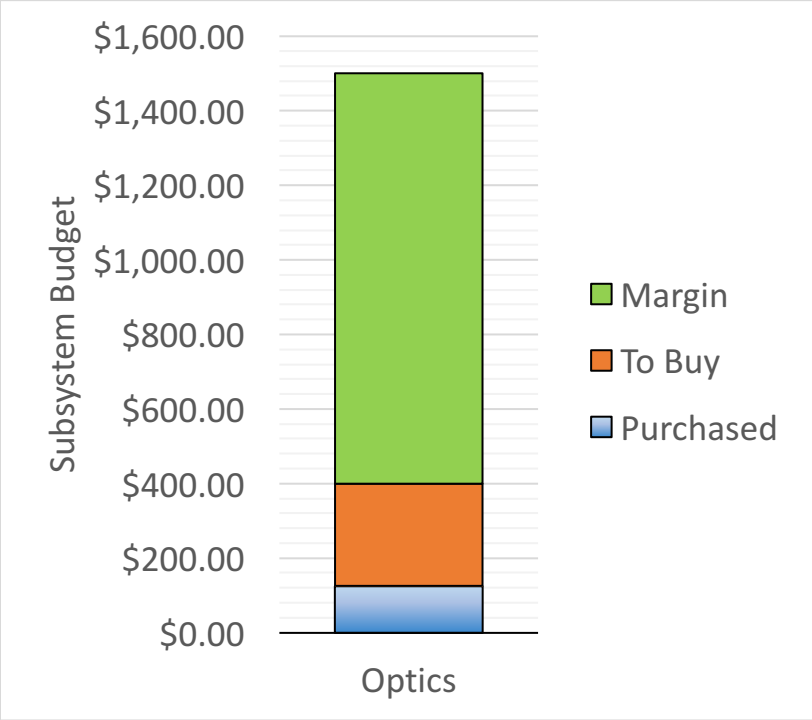
Component	% Subsystem Budget	Status
Aluminum Encasing	9.4	Purchased
Moon Cutout Sheet Metal	11.2	Purchased
Lightbox materials	20	To Buy

Electrical Budget



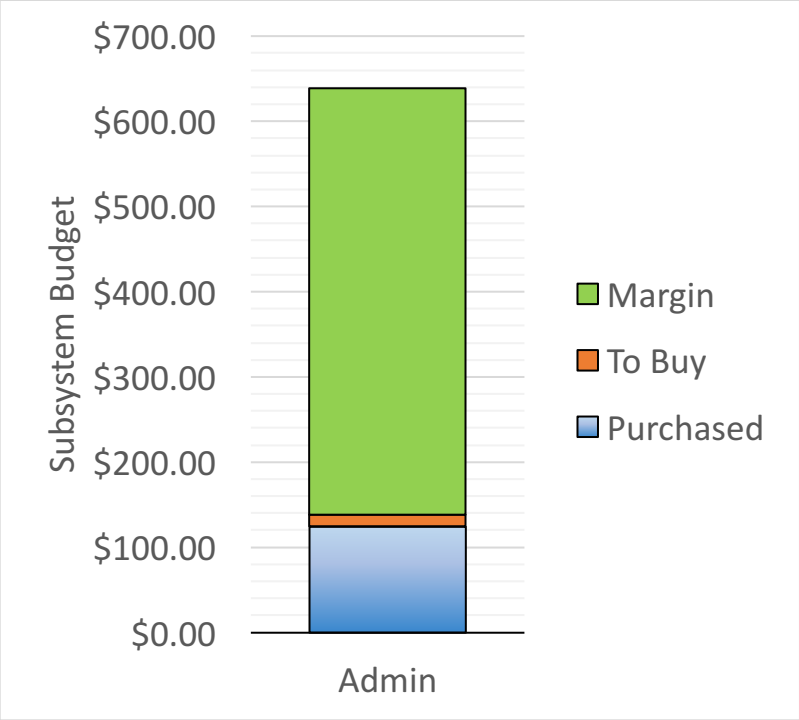
Component	% Subsystem Budget	Status
Snapdragon 410 Development Kit	40	Purchased
ZedBoard	23	Purchased
PCB	10	To Buy
Connectors and Components	2	To Buy

Remote Sensing Budget



Component	% Subsystem Budget	Status
13MP Camera	12	Purchased
Additional Sony Camera	27	To Buy

Management Budget



Component	% Subsystem Budget	Status
CDR, FFR, and PDR Printing	25	Purchased
MSR, TRR, SFR, FDR Printing	28	To Buy

Thank You

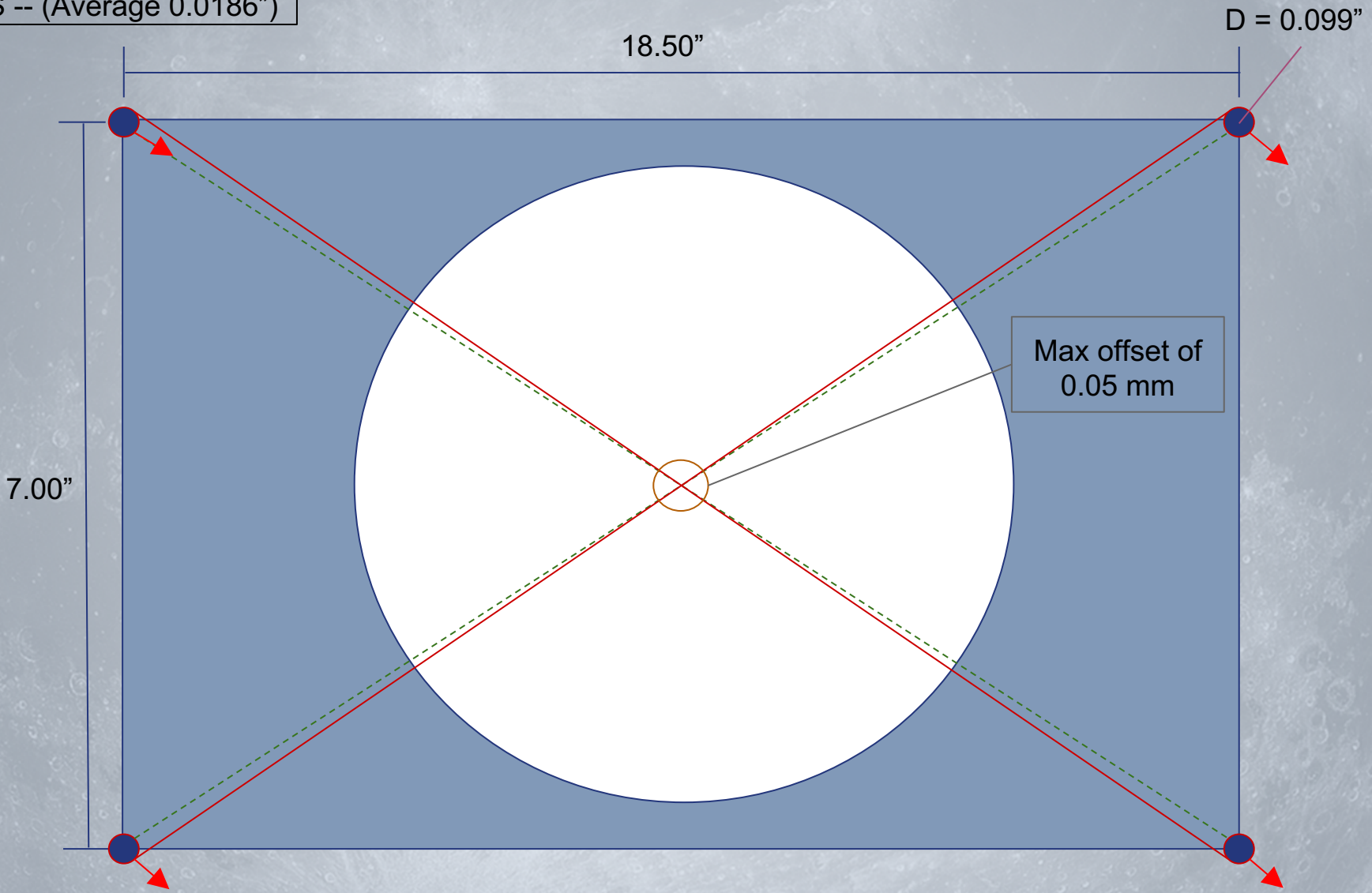
Paige Arthur	PM
Ryan Cutter	Systems
Seth Zegelstein	Software
Michael Ricciardi	Electrical
Anthony Torres	Image Processing
Cameron Maywood	Navigation
Dylan Richards	Remote Sensing
Zach Folger	Mechanical
David Walden	Testing

Backup Slides

Structure - Backup

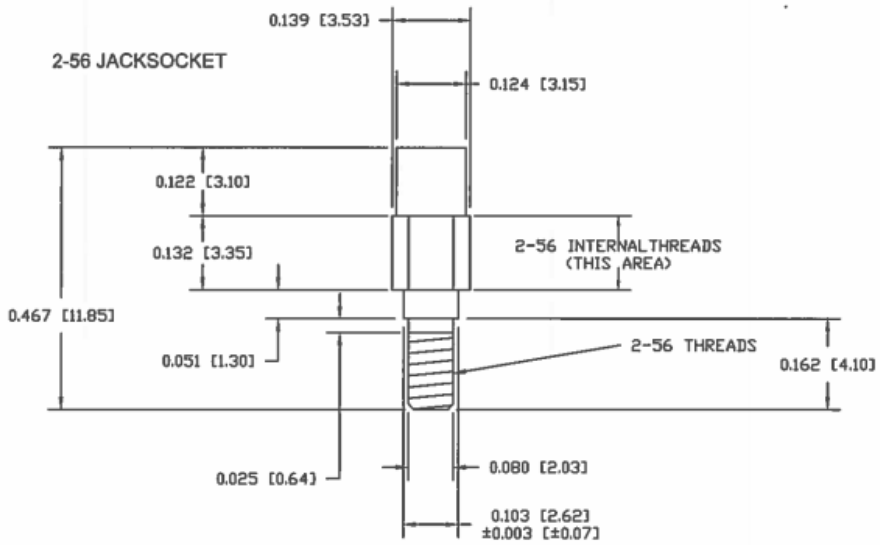
Alignment Wires

Drill Holes required with tolerance of 0.0137” for WCS -- (Average 0.0186”)

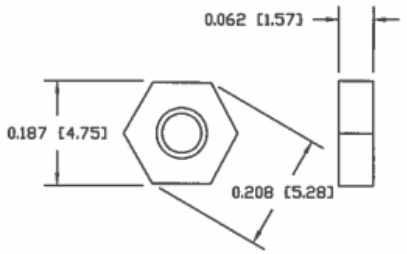


5-36 JACKSOCKET & NUT

DESCRIPTION: MICRO-D HARWARE KIT - 2-56 THREAD

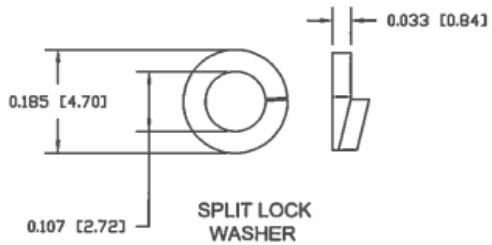


MATERIAL:
JACKSOCKETS: BRASS (3604) NICKEL PLATED
SPLIT LOCK WASHER: STEEL ZINC PLATED
2-56 NUT: STEEL ZINC PLATED



2-56 NUT

KIT INCLUDES:
(2) 2-56 JAKCSOCKETS
(2) SPLIT LOCK WASHERS
(2) 2-56 NUTS



SPLIT LOCK WASHER

ACTUAL SIZE

DO NOT SCALE FROM DRAWING

DRAWN: M. SIGMON	DATE: 08-09-12
CHECKED:	DATE:
SCALE: 4 : 1	SHEET 1 OF 1
REV 1	
DWG NO. 160-380-001R031	

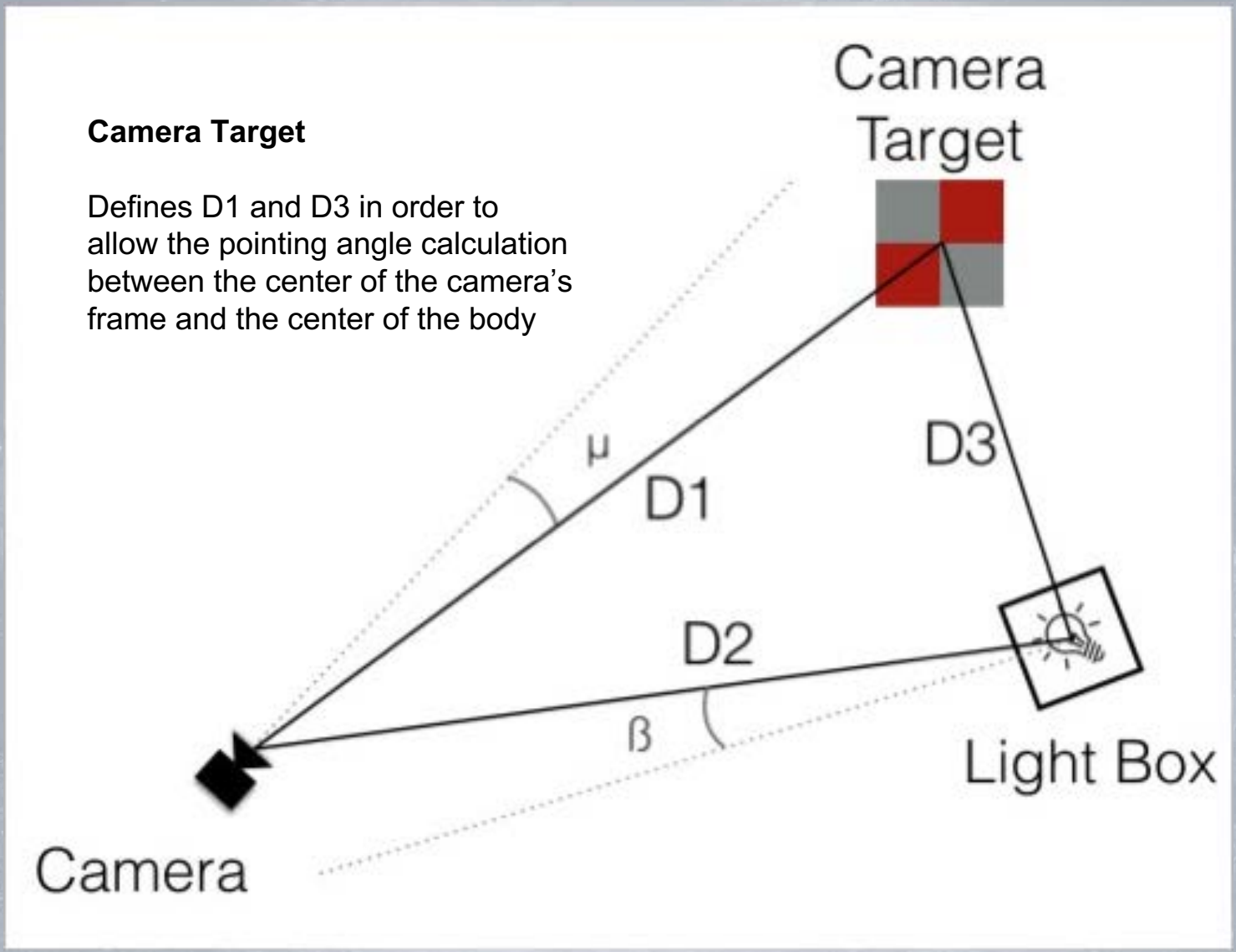
NorComp

RoHS COMPLIANT

Testing - Backup

Camera Target

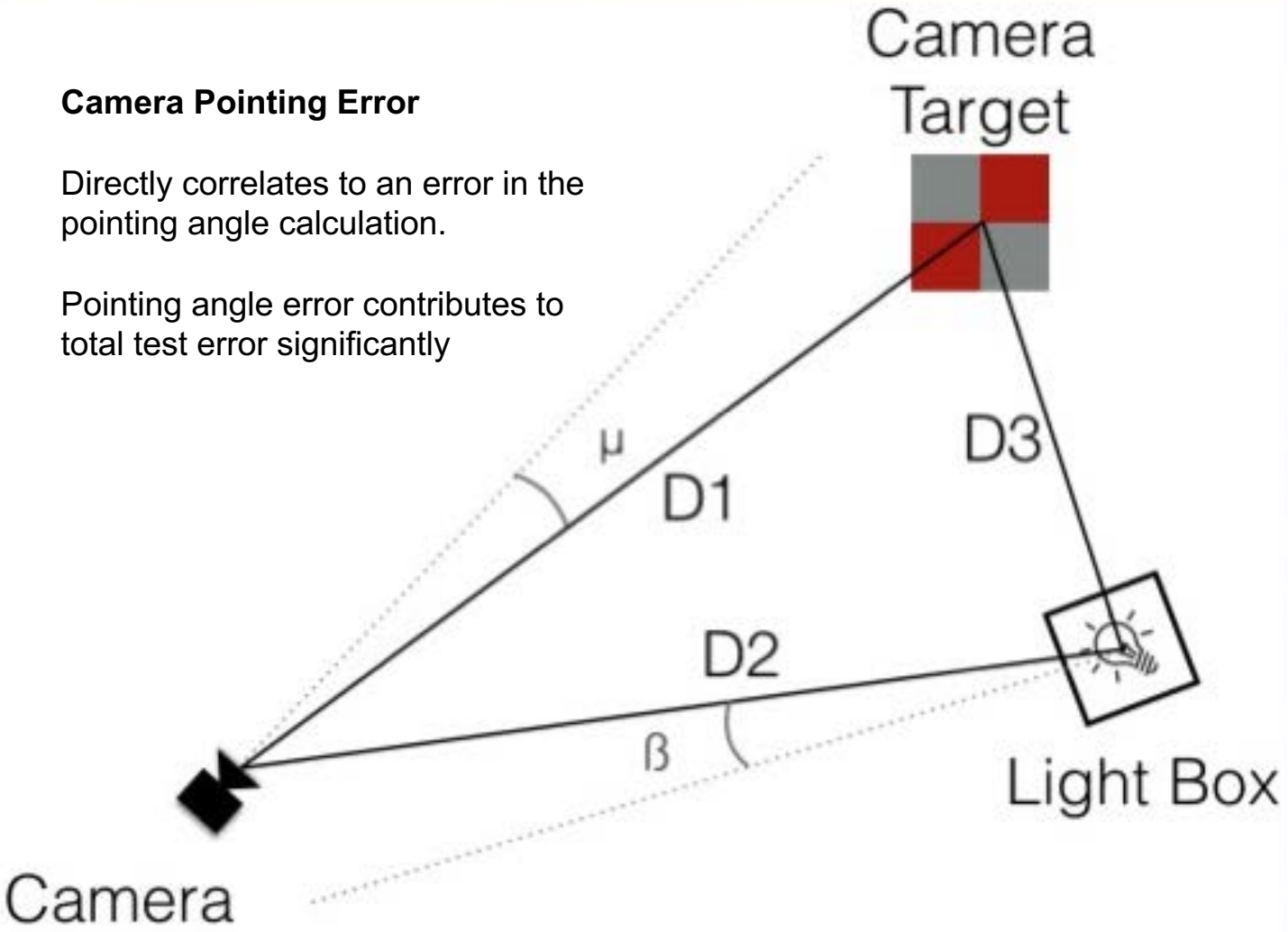
Defines D1 and D3 in order to allow the pointing angle calculation between the center of the camera's frame and the center of the body



Camera Pointing Error

Directly correlates to an error in the pointing angle calculation.

Pointing angle error contributes to total test error significantly



Testing - Pointing Error

Original Pointing Error: Assumed 1 pixel of image processing error

RESULT: Below 50 km error goal **79.9%** of the time
Below 100 km error goal **98.3%** of the time

Revised Studies: Camera image processing achieves 2 pixels of error, in other words double the original error assumed

RESULT: Below 50 km error goal **58.4%** of the time
Below 100 km error goal **85.6%** of the time

TAKEAWAY: The image processing error is highly significant to the total system error and thus must be an area of significant validation and testing prior to conducting system-level tests