Balloon Deployment System

Manufacturing Status Review

Customer: Dr. Dale Lawrence
Advisor: Matt Rhode

Presentation Overview

- Project Purpose and Objectives
- Design Solution
- Critical Project Elements
- Project Planning
- Materials Procurement
- Manufacturing Status
- Budget Status

Project Purpose and Objectives

Project Purpose and Objectives

Mission Statement

The team shall design, build and test a high altitude balloon launcher for use in heavy winds supporting the Hypersonic Flight in the Turbulent Stratosphere (HYFLITS) program. The launcher will stand 3m high when fully extended, pose no risk for balloon puncture, be operable by a single user hands free and be easy to set up and transport.

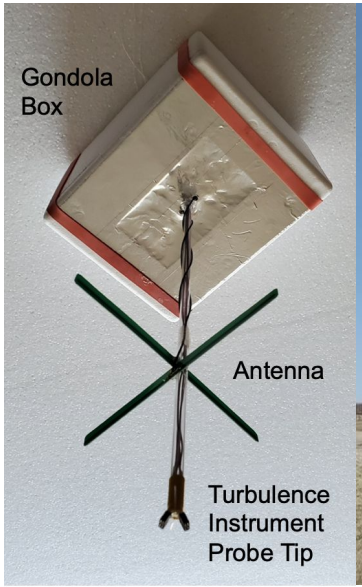
Project Purpose and Objectives

Current Process

Project Purpose and Objectives

- Need: High wind weather balloon launching system
- Program: Hypersonic Flight in the Turbulent Stratosphere (HYFLITS) program
  - Study how future hypersonic vehicles can account for turbulence and particles in stratosphere
  - U of Colorado, Embry-Riddle, U of Minnesota
- Customer: Professor Dale Lawrence at CU-Boulder Smead Aerospace Engineering

Payload:

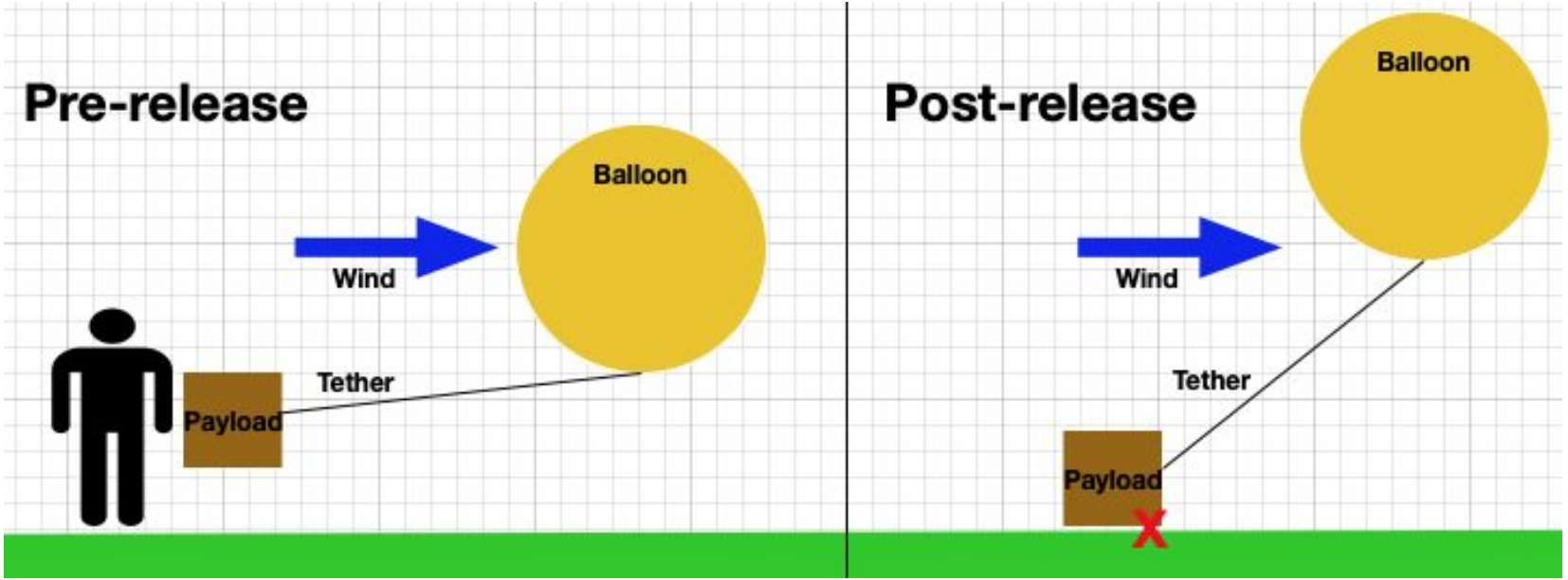


Balloon:

Project Purpose and Objectives

Current Problem

- Instrument payload hits ground



Project Purpose and Objectives

Customer's Requirements

- 3m tall balloon launching structure
  - Allow balloon more time to rise before payload release
- Stable launch in 10-20 m/s winds
- 1 or 2 balloon rigging with single payload
- Does not pose puncture risk to balloon
- User control of release is hands free
- Sub 50 lbs, fits in 1m x .25m case
- Sub $1000 mfg cost

Project Purpose and Objectives

CONOPS

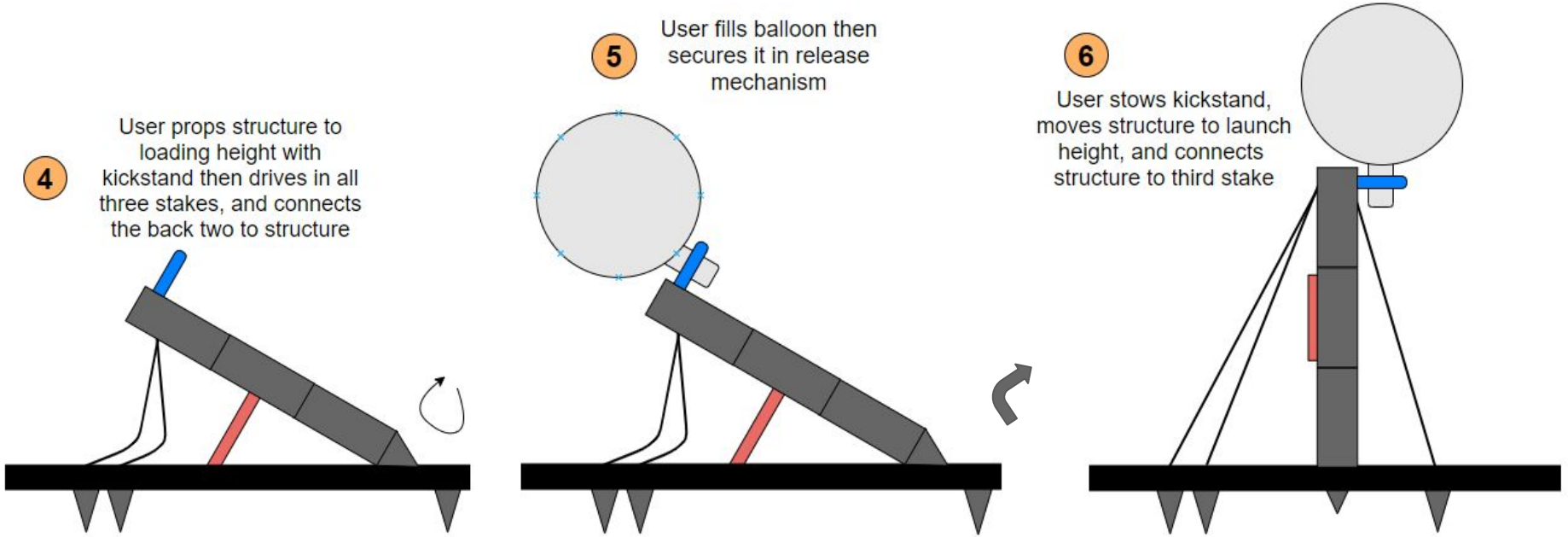
1. User arrives at launch site and begins assembly of BDS

2. User connects the upper, middle, and lower structure pieces

3. User attaches the release mechanism to upper structure piece

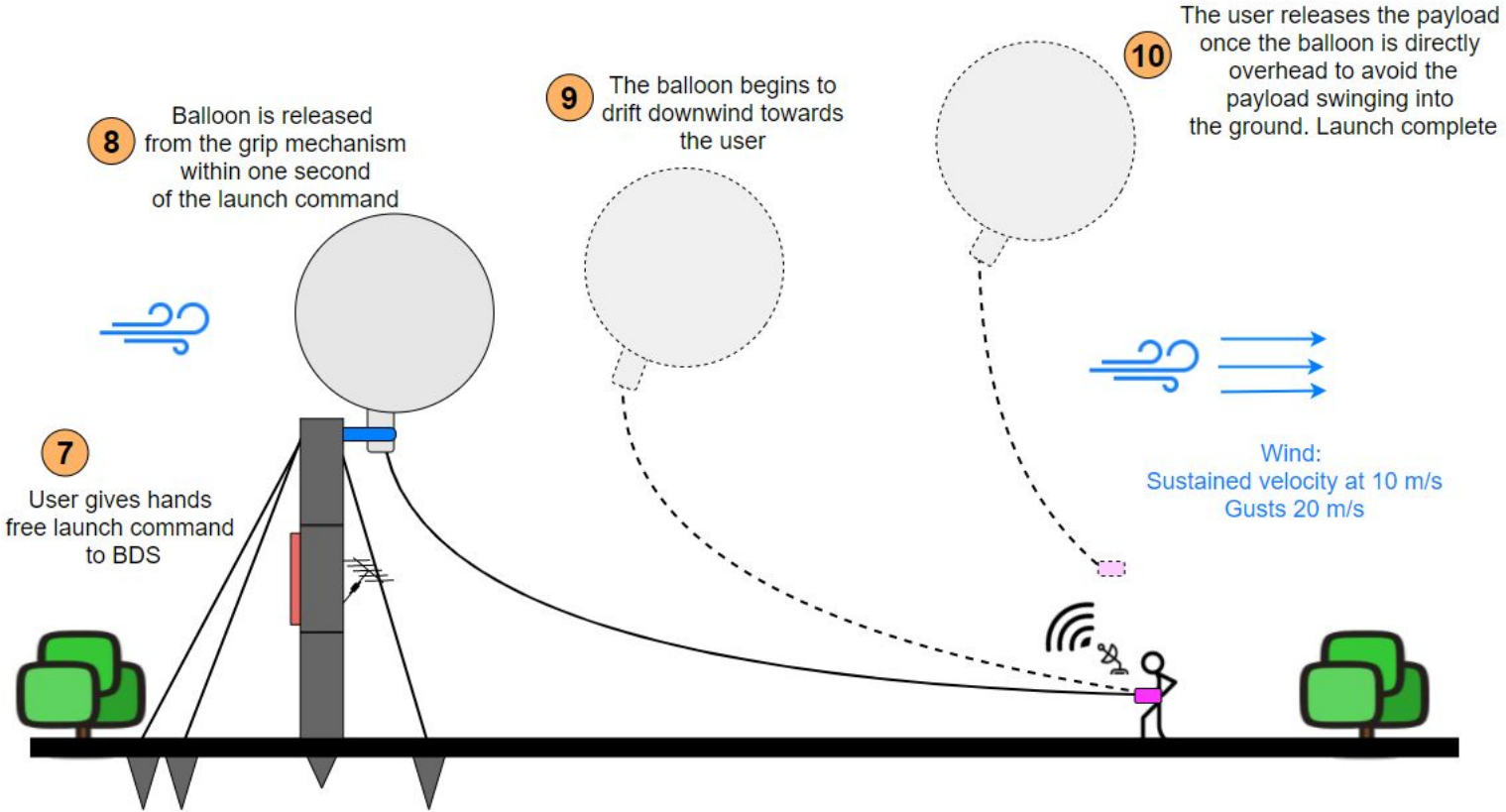
Project Purpose and Objectives

CONOPS



Project Purpose and Objectives

CONOPS



Project Purpose and Objectives

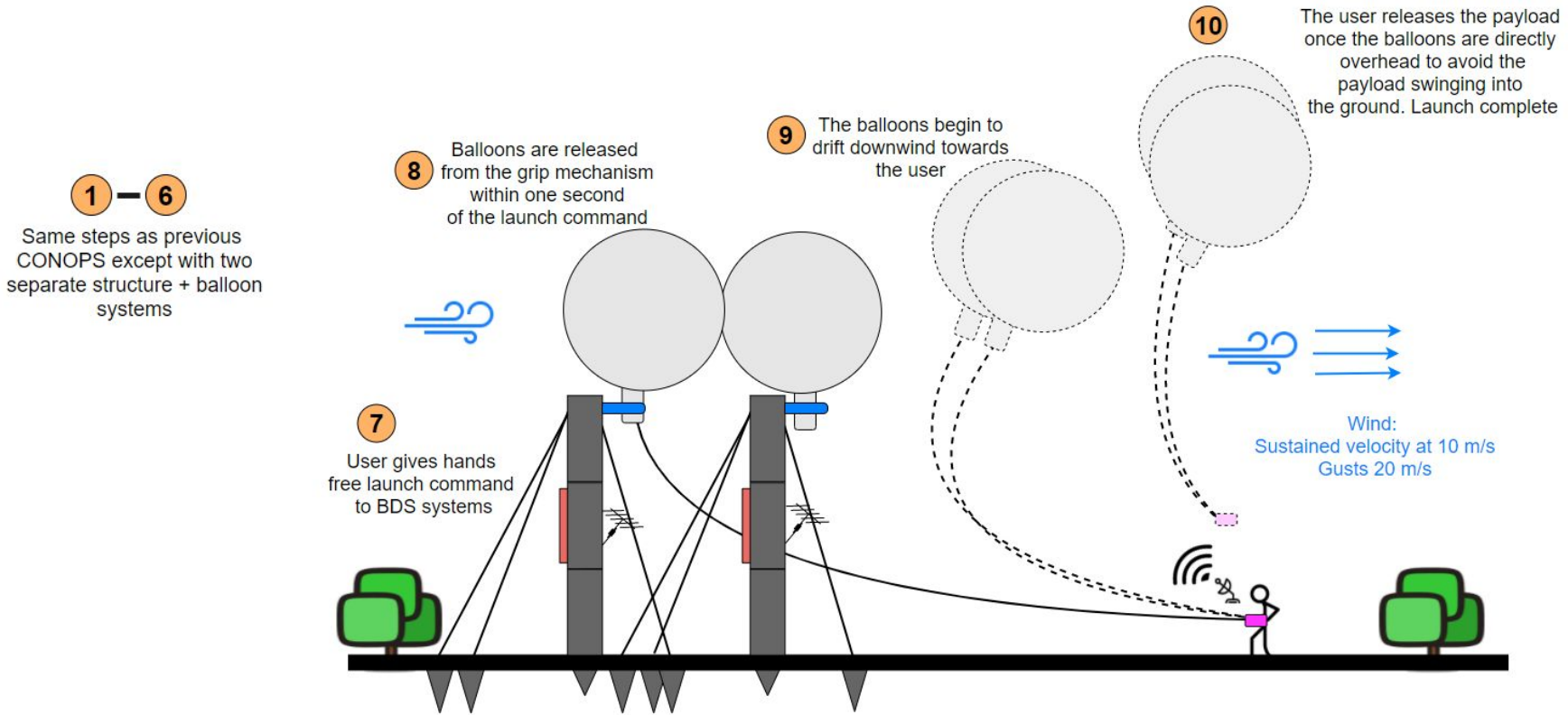
CONOPS

11 After confirmation of a successful launch, the user disassembles BDS and stores the system in the carrying case for departure

12 The user departs the launch site and is able to repeat this process for another launch when needed

Project Purpose and Objectives

CONOPS - Two Balloon Launch

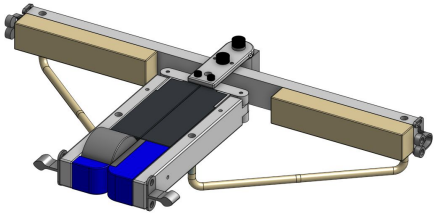


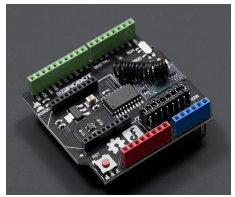
Design Solution

Design Solution

BDS Subsystems

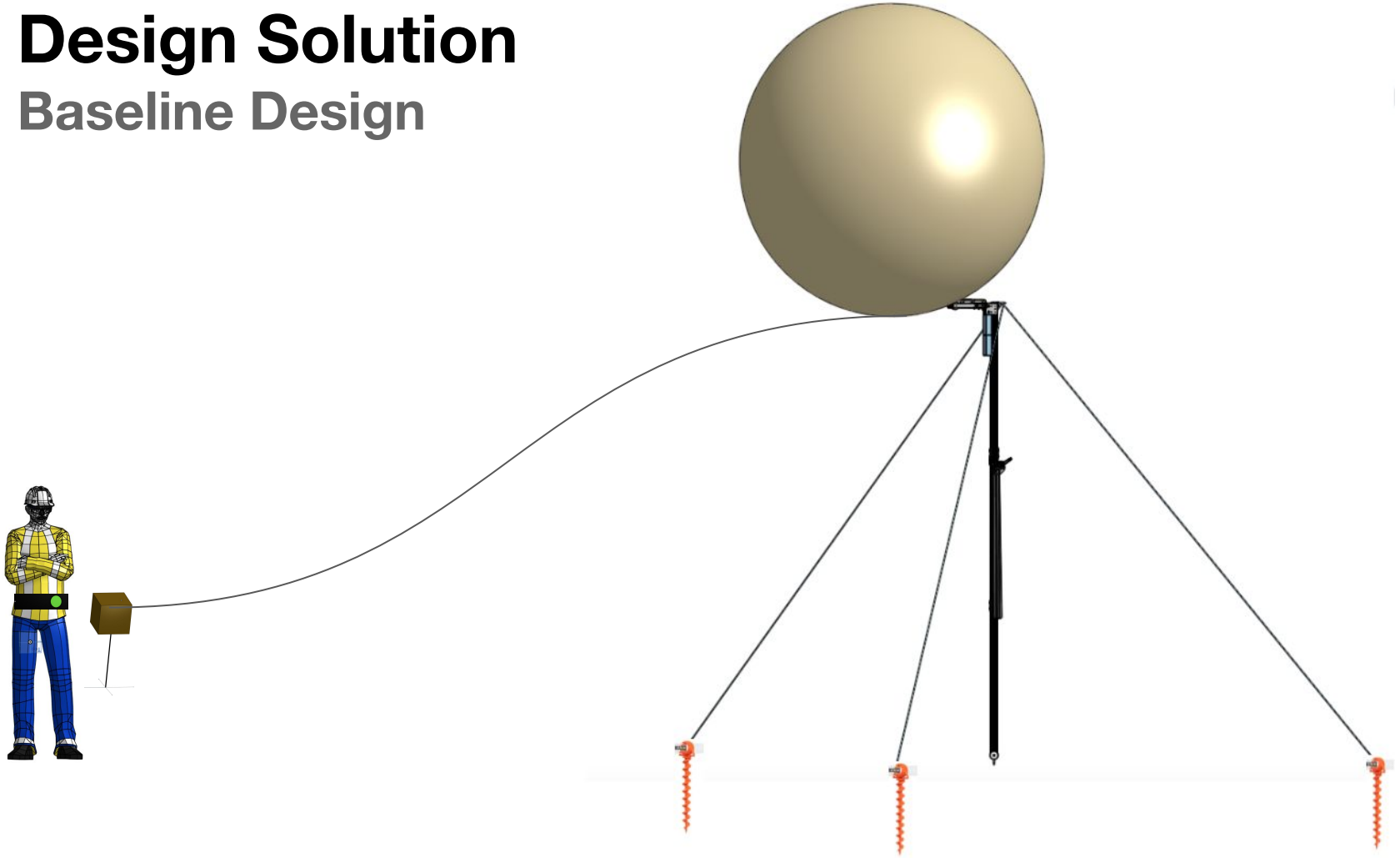
- Balloon Deployment System
  - Support Structure
    - Base
    - Extension
  - Release Mechanism
  - Command & Control
    - Transmitter
    - Receiver





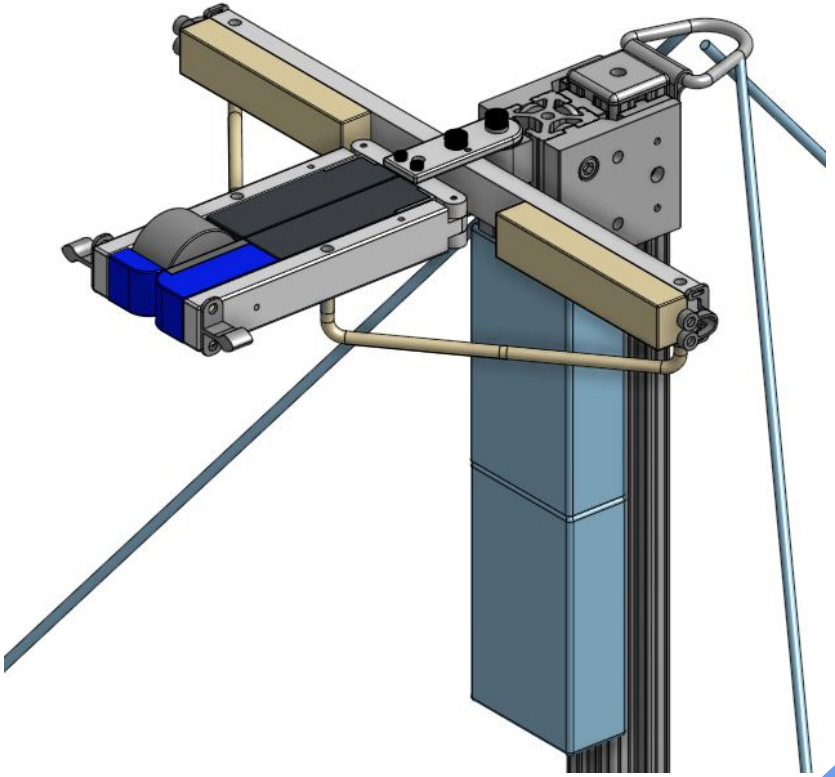
Design Solution

Baseline Design



Design Solution

Release Mechanism



Critical Project Elements

Critical Project Elements

- Ease of set up/transport
  - Launch from multiple sites per HYFLITS need
- Stability in wind
  - Allow for launches in high wind conditions
- Internal structure strength
  - Survive high wind launch forces
- No balloon damage
- No premature release of balloon
- Hands free release command
  - Allow user to focus on payload safety and launch

Project Planning

Project Planning

Collecting Materials & Dry Assembly

Checking on remaining orders and organizing what we have into our assembly. No machining or custom parts are required.

Assembly & Preliminary Tests

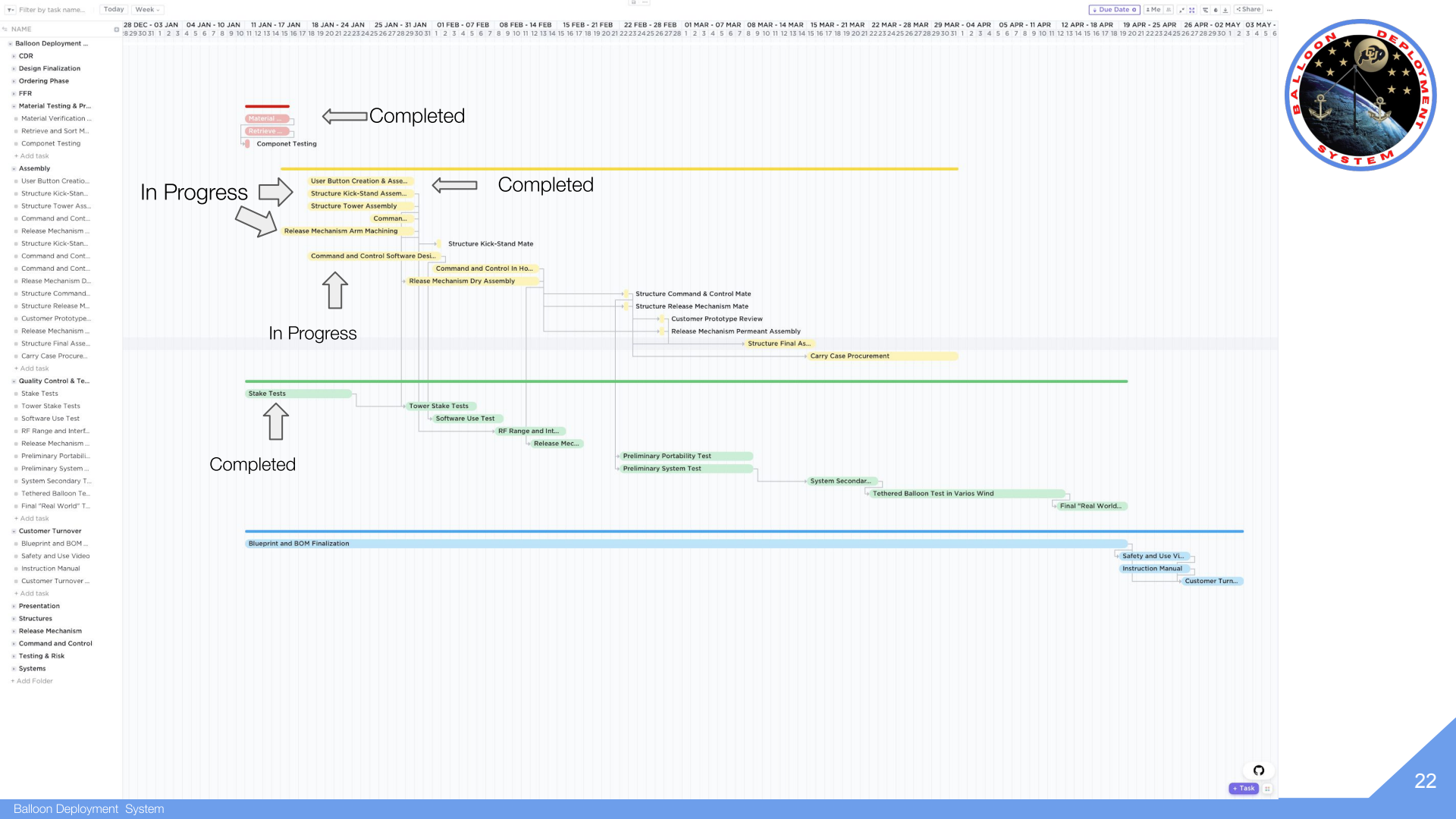
Testing for our requirements will begin and simulated launches will be conducted.

Design Revisions & Final Tests

BDS will be tested against adverse effects to see the operating range of our device.

Final Deliverable & Demonstration

Delivering final product to Dr. Lawrence and demonstration levels of success by end of semester.


Completed
In Progress
Completed
In Progress
Completed
Balloon Deployment ...
CDR
Design Finalization
Ordering Phase
FFR
Material Testing & Pr...
Material Verification ...
Retrieve and Sort M...
Componet Testing
Assembly
User Button Creatio...
Structure Kick-Stan...
Structure Tower Ass...
Command and Cont...
Release Mechanism ...
Structure Kick-Stan...
Command and Cont...
Command and Cont...
Release Mechanism D...
Structure Command...
Structure Release M...
Customer Prototype...
Release Mechanism ...
Structure Final Asse...
Carry Case Procure...
Quality Control & Te...
Stake Tests
Tower Stake Tests
Software Use Test
RF Range and Interf...
Release Mechanism ...
Preliminary Portabili...
Preliminary System ...
System Secondary T...
Tethered Balloon Te...
Final "Real World" T...
Customer Turnover
Blueprint and BOM ...
Safety and Use Video
Instruction Manual
Customer Turnover ...
Presentation
Structures
Release Mechanism
Command and Control
Testing & Risk
Systems
Add Folder
28 DEC - 03 JAN
04 JAN - 10 JAN
11 JAN - 17 JAN
18 JAN - 24 JAN
25 JAN - 31 JAN
01 FEB - 07 FEB
08 FEB - 14 FEB
15 FEB - 21 FEB
22 FEB - 28 FEB
01 MAR - 07 MAR
08 MAR - 14 MAR
15 MAR - 21 MAR
22 MAR - 28 MAR
29 MAR - 04 APR
05 APR - 11 APR
12 APR - 18 APR
19 APR - 25 APR
26 APR - 02 MAY
03 MAY -
Material ...
Retrieve ...
Componet Testing
User Button Creation & Asse...
Structure Kick-Stand Assem...
Structure Tower Assembly
Comman...
Release Mechanism Arm Machining
Structure Kick-Stand Mate
Command and Control Software Desi...
Command and Control In Ho...
Release Mechanism Dry Assembly
Structure Command & Control Mate
Structure Release Mechanism Mate
Customer Prototype Review
Release Mechanism Permeant Assembly
Structure Final As...
Carry Case Procurement
Stake Tests
Tower Stake Tests
Software Use Test
RF Range and Int...
Release Mec...
Preliminary Portability Test
Preliminary System Test
System Secondar...
Tethered Balloon Test in Varios Wind
Final "Real World...
Blueprint and BOM Finalization
Safety and Use Vi...
Instruction Manual
Customer Turn...
Due Date
Me
Share
Today
Week
Task

What We've Done

- Completed the Material Onboarding and Testing Phase
- Completed and Verified our Stake Pull Out Force
- Completed the Button Housing
- Dry Assembled Structure

Present day

Completed	In Progress	Estimated Time of Completion
User Button Creation and Assembly	Structure Kickstand Assembly	Beginning of February
Stake Test	Command & Control Software Design	Beginning of February
	Structure Tower Assembly	Mid February
	Release Mechanism Machining	Beginning of February

The Next Week

- Receive machined parts for release mechanism ~Friday 2/5
- Assemble the structure ~Sunday 2/7
- Assemble the release mechanism ~ Tuesday 2/9
- Full Structure Assembly and Staking ~ Thursday 2/11

The Next Month

- Preliminary Structure Test 2/16
- Solution to Tool Free Assembly 2/16
- Timed Assembly 2/18
- Weighted Tests and Dynamic Loading 2/22 - 2/26
- Customer Meeting and Review 3/1

Materials Procurement

Materials Procurement

- Structure
  - Waiting on: none
- Release Mechanism
  - Waiting on:
    - ¼ - 20, 1.5” machine screw
- Command and Control
  - Waiting on:
    - 12V Battery

Manufacturing

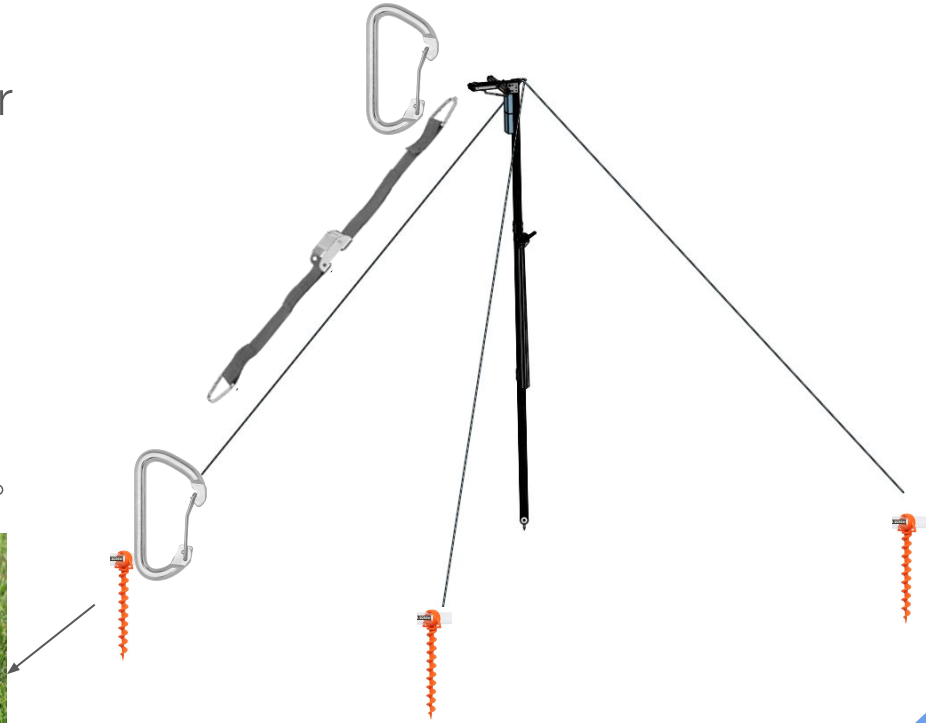
Manufacturing - Subsystem Breakdown

- Structure
  - Cutting Al 8020 structure bars and kickstand
  - Cut threads on structure stake
  - Attach D-ring, bar connections, kickstand mech
- Release Mechanism
  - Brief list of most critical manufacturing
- Command and Control
  - Brief list of most critical manufacturing

Design Solution

Structure

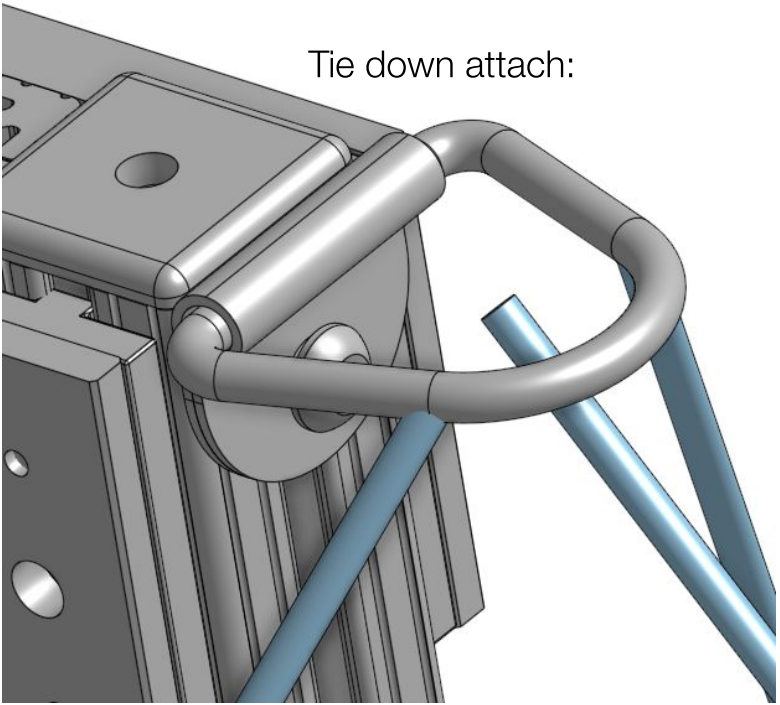
- 3 sections of T-frame Al bars form tower
  - Al brackets bolt together
- Tower staked with 3 ground anchors
  - Screw in anchors
  - Adjustable tie down strap support lines
- Dimension:
  - Tower: 3m x 3.8cm x 3.8cm
  - Footprint: 3 stakes 2.64m from tower @ 120°
- Weight: 29 lbs



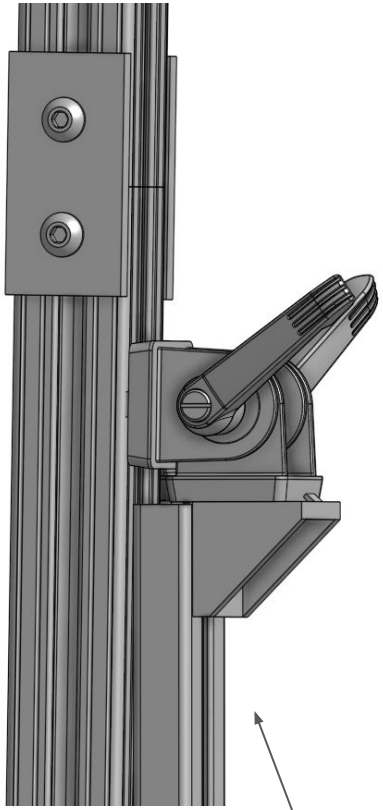
Design Solution

Structure

Tie down attach:

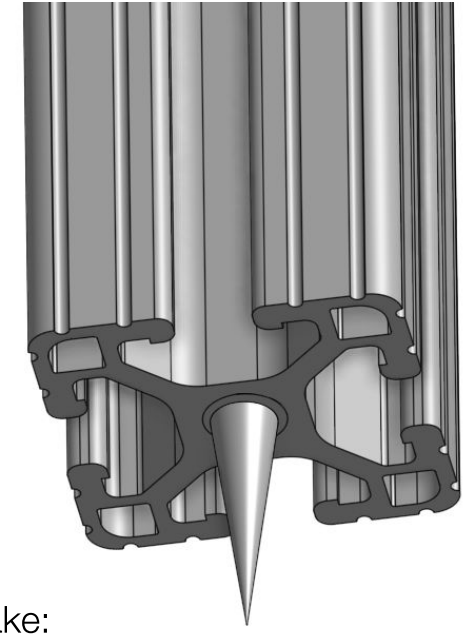


Bar joint:



Folding kick-stand:

Stake:

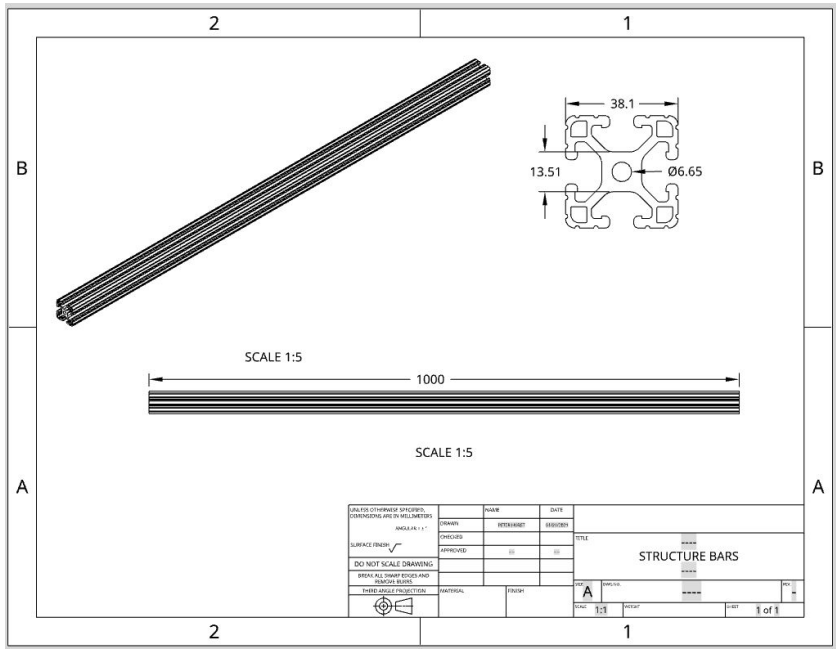


Manufacturing - Structures

- Structure Assembly
  - Machining
    - Cut tower bars/kick-stand bars
    - Cut threads in base tower/Machine base stake
  - Assemble
    - D-ring bolt on for tie downs
    - Kick-stand bolt on
    - Thread in base tower stake

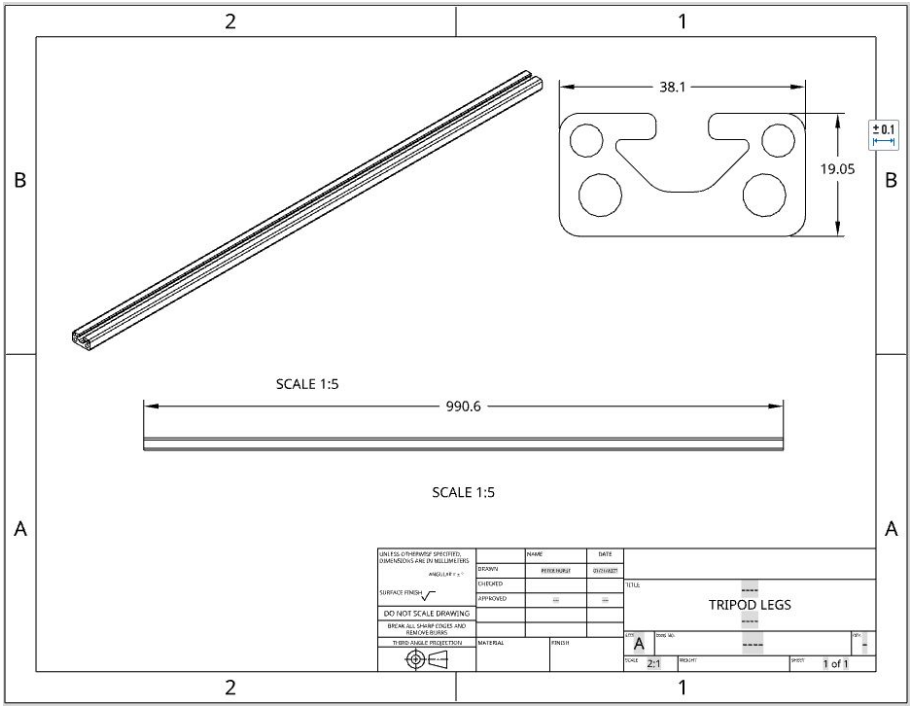
Manufacturing - Structures

- Part: Structure Bars
- Function/integration: Tower holding balloon
  - Tie down support on top
  - Foldable kickstand in mid section
  - Stake at base
- Drawing w/dimensions: (mm)
- Mfg process:
  - Cut to 1m length
  - Cut ⅜-16 coarse thread in base section for stake
- Mfg status: pending cutting



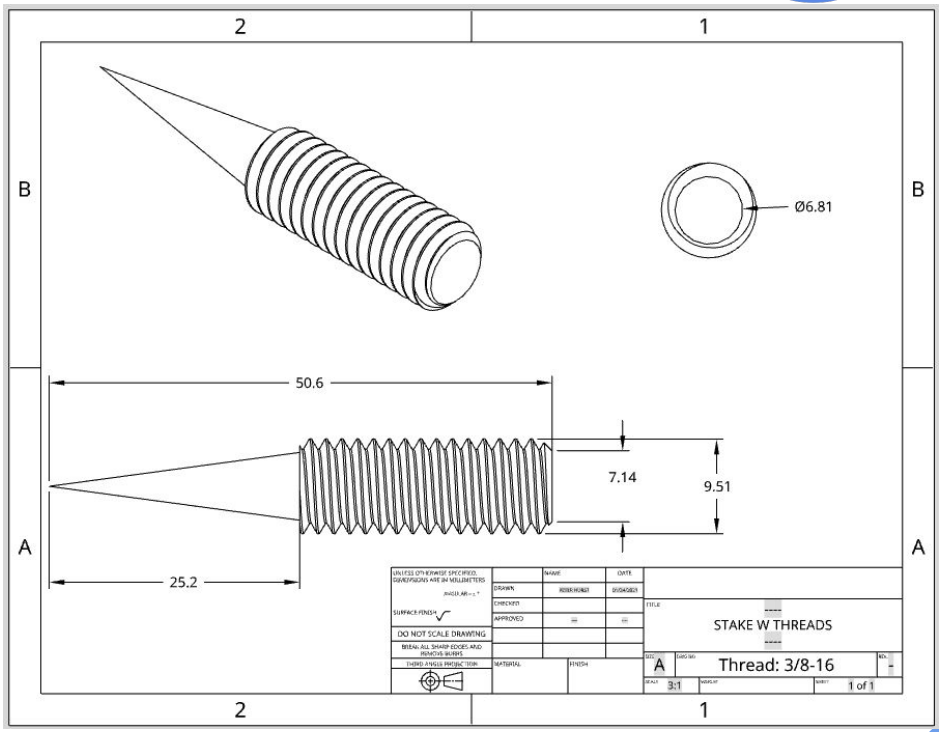
Manufacturing - Structures

- Part: Kickstand legs
- Function/Integration:
  - Decreases height for loading the balloon
  - Stabilize the structure at the loading height
- Drawing w/ dimensions:(mm)
- Mfg process:
  - Cut to length
  - Attach L-brakes
- Mfg status: pending cutting, then bolt together



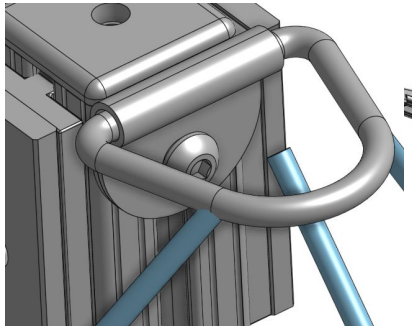
Manufacturing - Structures

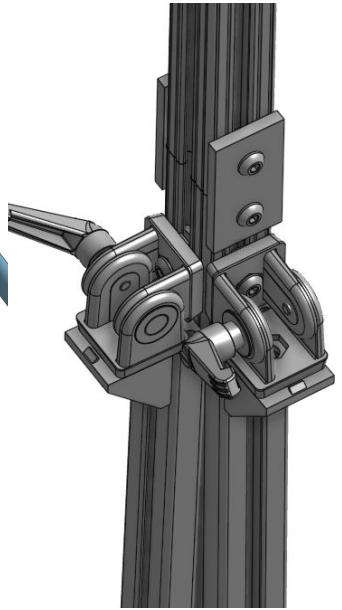
- Part: Base Stake
- Function/Integration:
  - Prevent base of tower from sliding
  - Thread into bottom of tower
- Drawing w/dimensions:(mm)
- Mfg Process: Machine down cone shape from 2” Al threaded rod
- Mfg Status: Pending machining threaded rod

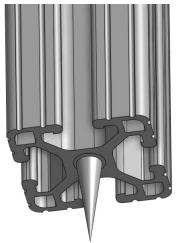


Manufacturing - Structures

- Part: Tower, kick-stand, supports
- Function/Integration:
  - D-ring on top
  - Kick-stand at mid section
  - Base stake
  - Trial assembly for launch
- Drawing w/dimensions:
- Mfg Process:
  - Bolt D-ring to tower via channel in bar
  - Bolt kick-stand to mid-section tower
  - Thread in base stake
  - Clip tie downs to D-ring then to stakes
- Mfg Status: Pending machining







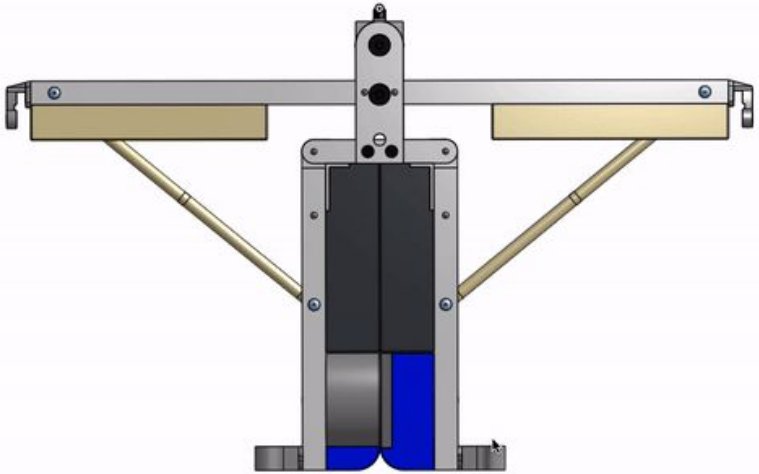
Manufacturing - Release Mech

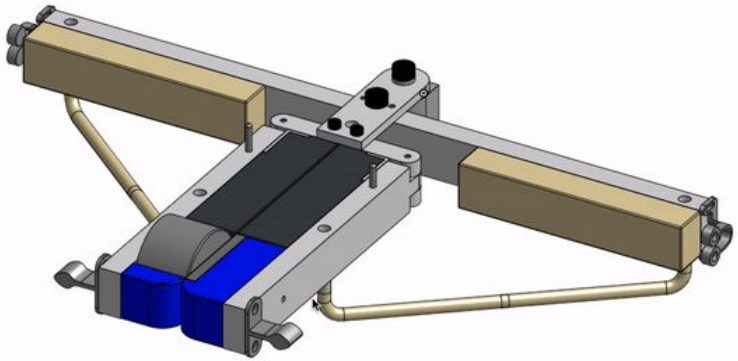
Example slide, include:

- Part name
- Function and integration into the design
- Drawing including dimensions
- Discuss manufacturing process (where and how: i.e. milled at aerospace machine shop)
- Manufacturing status (pending, in progress, completed)

Design Solution

Release Mechanism - DOF



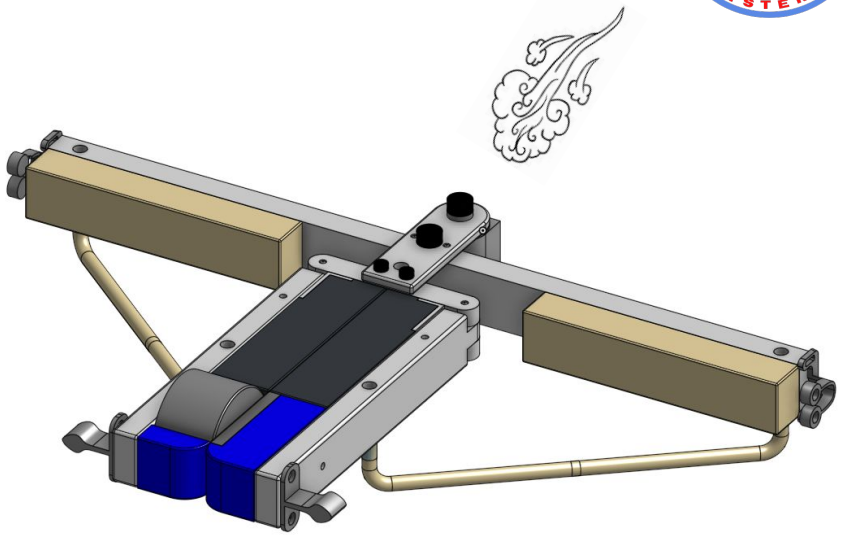


Note: This motion is stopped by locking pin until structure is risen and secure

Design Solution

Release Mechanism - Armed

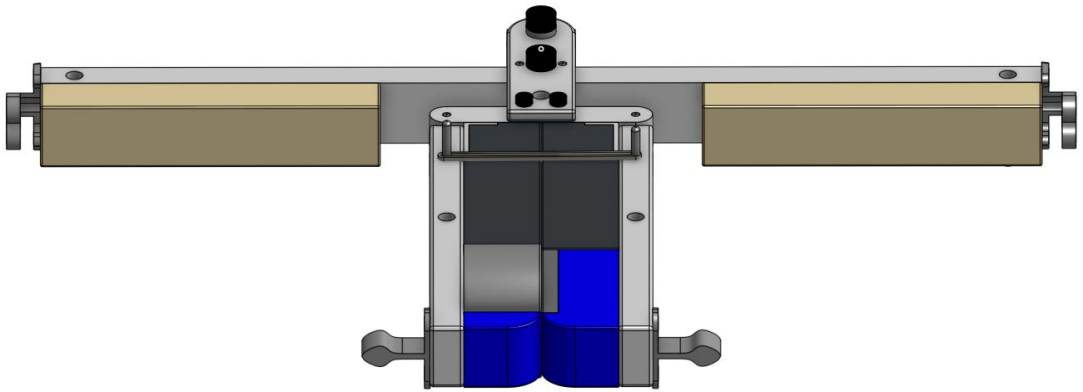
- Permanent Electromagnet latches with ferromagnetic steel
- Surgical tubing mounted to pins
  - Slip fit to swinging arms
  - Friction fit to back-plate
- Polyethylene foam gripping balloon
  - Adhesive spray to secure
- Polyurethane foam backstop coupled with 7lb pull-force cabinet latches



Design Solution

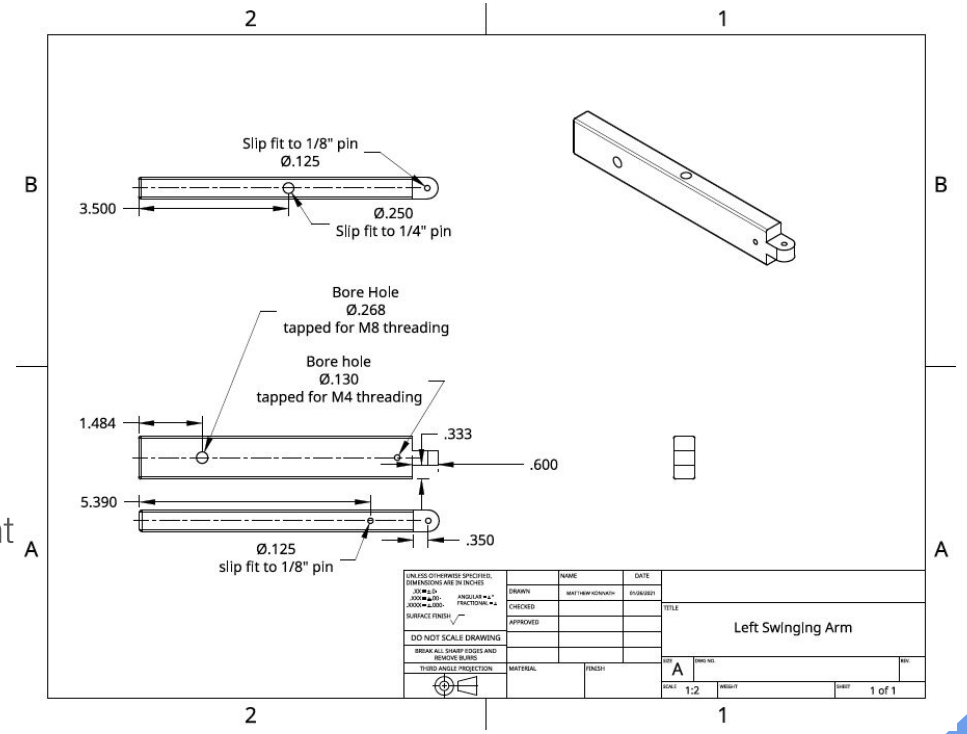
Release Mechanism - Loading

- 5 in. rubber band for loading resistance
  - Removable slip-fit pins
- 108° freedom in mounting swivel
  - Removable locking pin
- Rounded PLA inserts around electromagnet and steel
- Dimensions
  - Swinging Arms: 7 in.
  - Backstop: 14.75 in.
  - Arm-to-arm parallel distance: 3.3 in
- Weight: 7.5 lbm



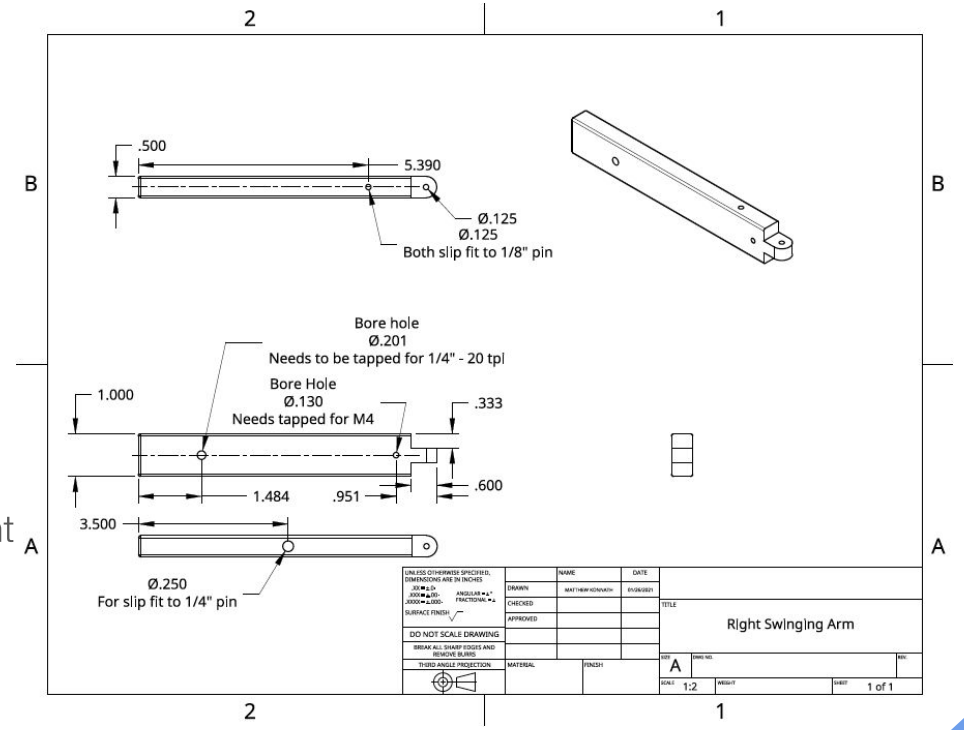
Manufacturing - Release Mech

- Part: Left Swinging Arm
- Function/Integration:
  - First arm of the release mechanism
  - Hinged to small back plate
- Drawing w/ dimensions: Inches
- Machined at the aerospace machine shop
  - Bore holes for slip/friction fit holes
  - Bore and tap through holes for attachment
  - Bore through hole for hinge attachment
  - Mill shape from stock aluminum
- Mfg status: Pending machining



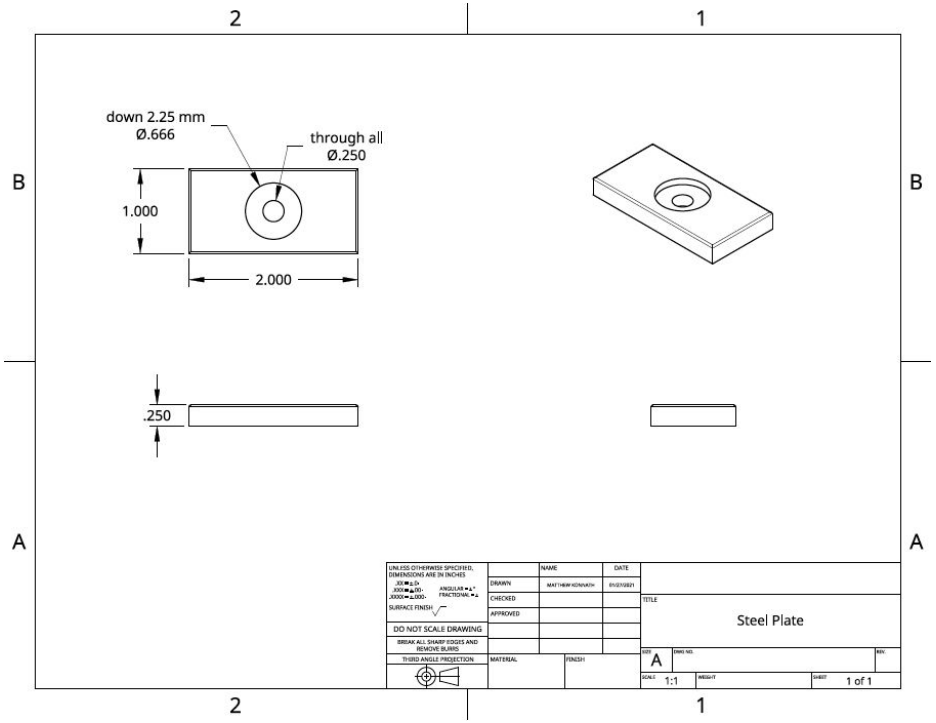
Manufacturing - Release Mech

- Part: Right Swinging Arm
- Function/Integration:
  - Second arm of release mechanism
  - Hinged to small back plate
- Drawing w/ dimensions: Inches
- Machined at the aerospace machine shop
  - Bore holes for slip/friction fit holes
  - Bore and tap through holes for attachment
  - Bore through hole for hinge attachment
  - Mill shape from stock aluminum
- Mfg status: Pending machining



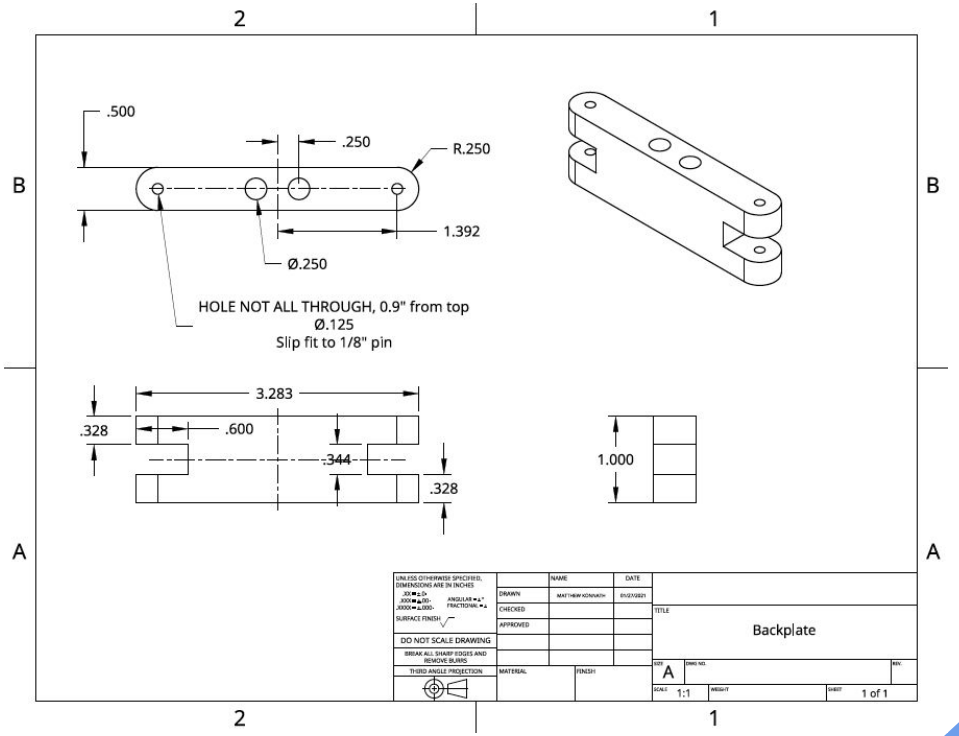
Manufacturing - Release Mech

- Part: Steel Plate
- Function/Integration:
  - Ferromagnetic “latch” for electromagnet
  - Attaches to the right swinging arm
- Drawing w/ dimensions: Inches
- Machined at the aerospace machine shop
  - Bore through hole for securing
  - Mill shape from stock steel
- Mfg status: Pending machining



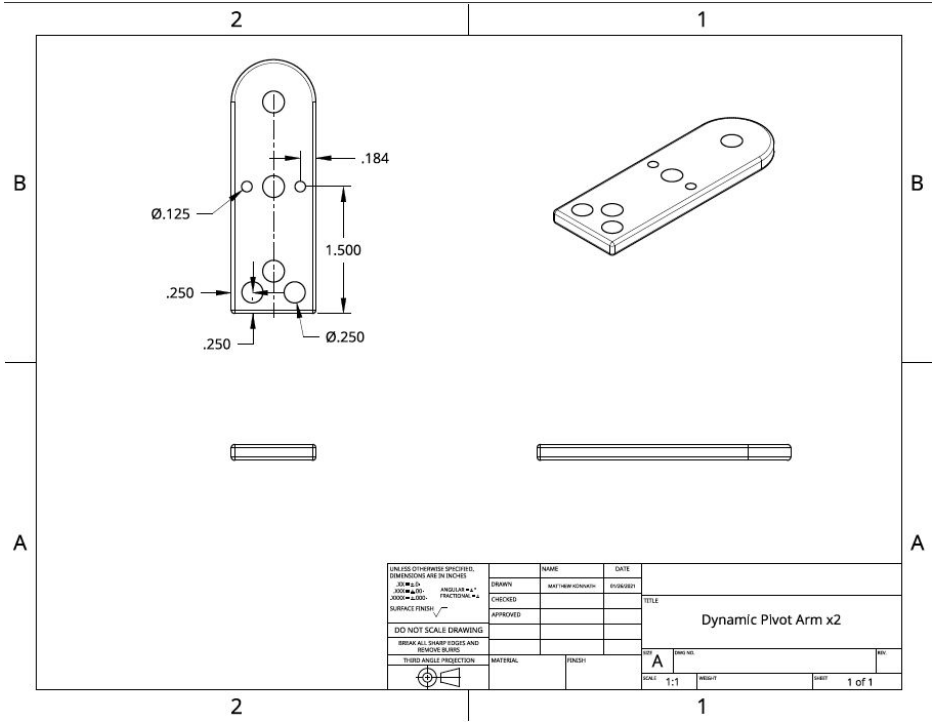
Manufacturing - Release Mech

- Part: Backplate
- Function/Integration:
  - Connects swinging arms
  - Secured to structure via Dynamic Pivot
- Drawing w/ dimensions: Inches
- Machined at the aerospace machine shop
  - Bore holes for attachments at hinge
  - Bore through holes near center line
  - Mill shape from stock aluminum
- Mfg status: Pending machining



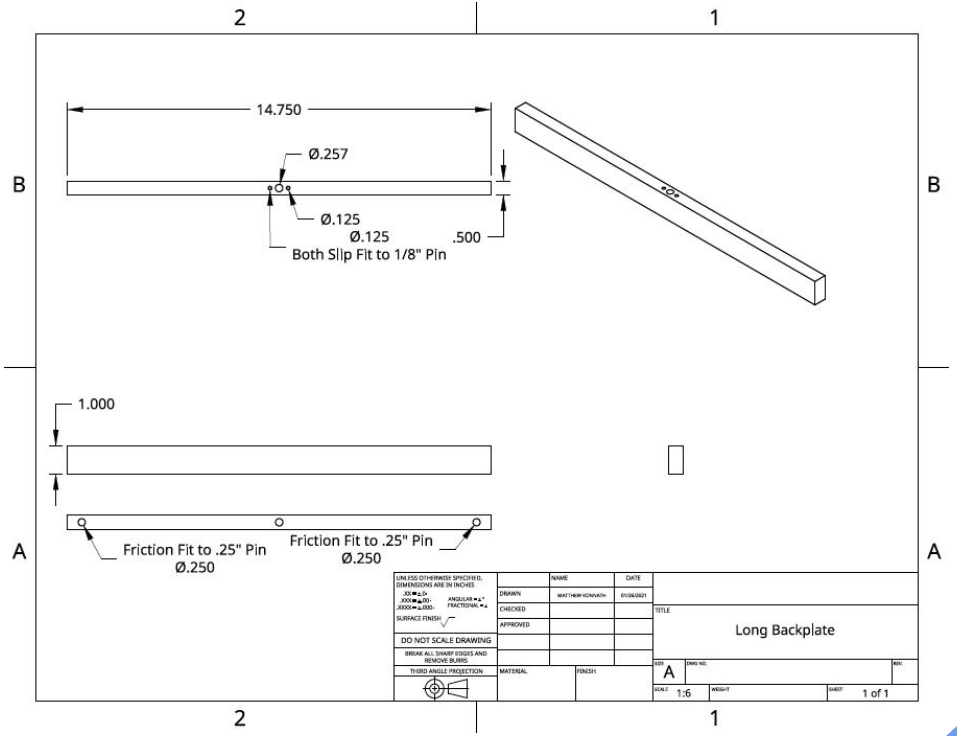
Manufacturing - Release Mech

- Part: Dynamic Pivot
- Function/Integration:
  - Secured release mech to structure
  - Allows rotation to align with wind
- Drawing w/ dimensions: Inches
- Machined at the aerospace machine shop
  - Bore through holes for attachments
- Mfg status: Pending machining



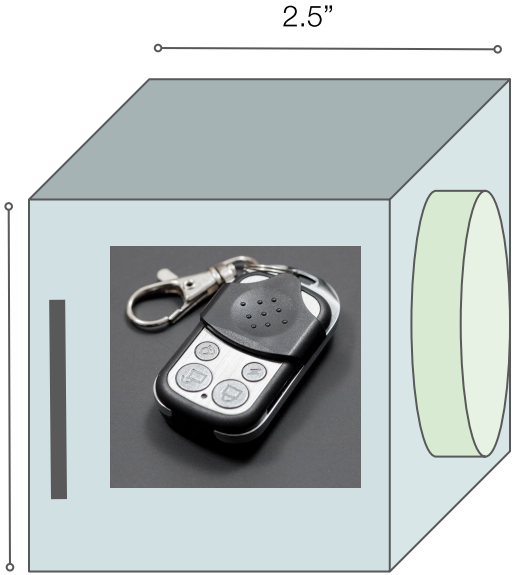
Manufacturing - Release Mech

- Part: Long Backplate
- Function/Integration:
  - Slow and catch arms
  - Secured to Dynamic Pivot
- Drawing w/ dimensions: Inches
- Machined at the aerospace machine shop
  - Bore through holes near the middle
  - Bore friction fit holes
  - Mill shape from stock aluminum
- Mfg status: Pending machining



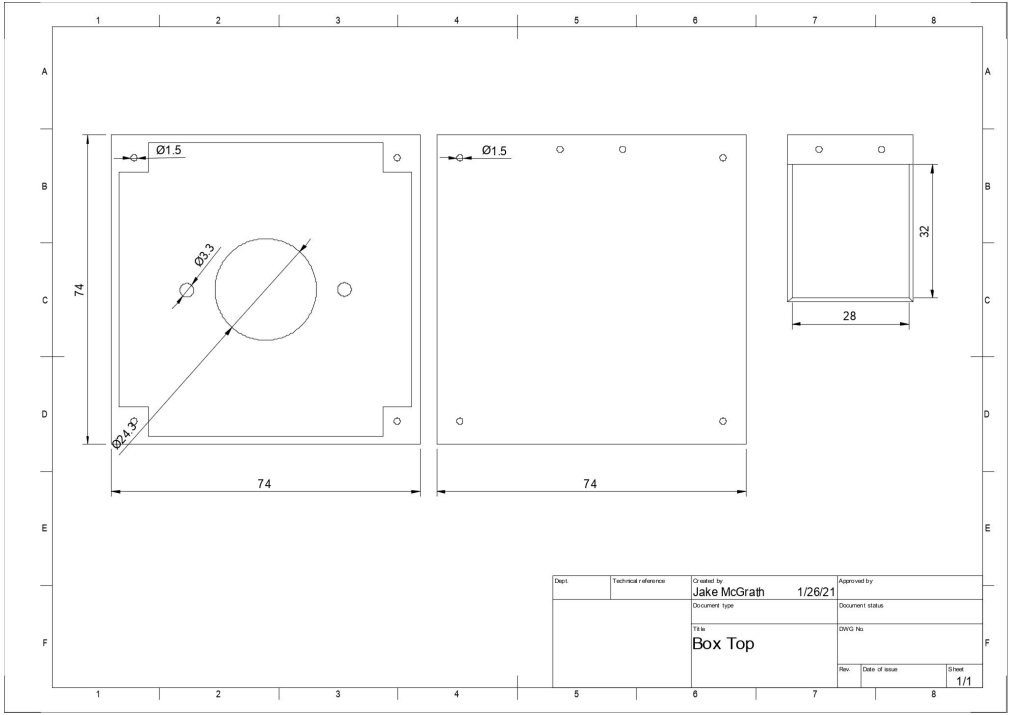
Design Solution

Command and Control



Manufacturing - Command and Control

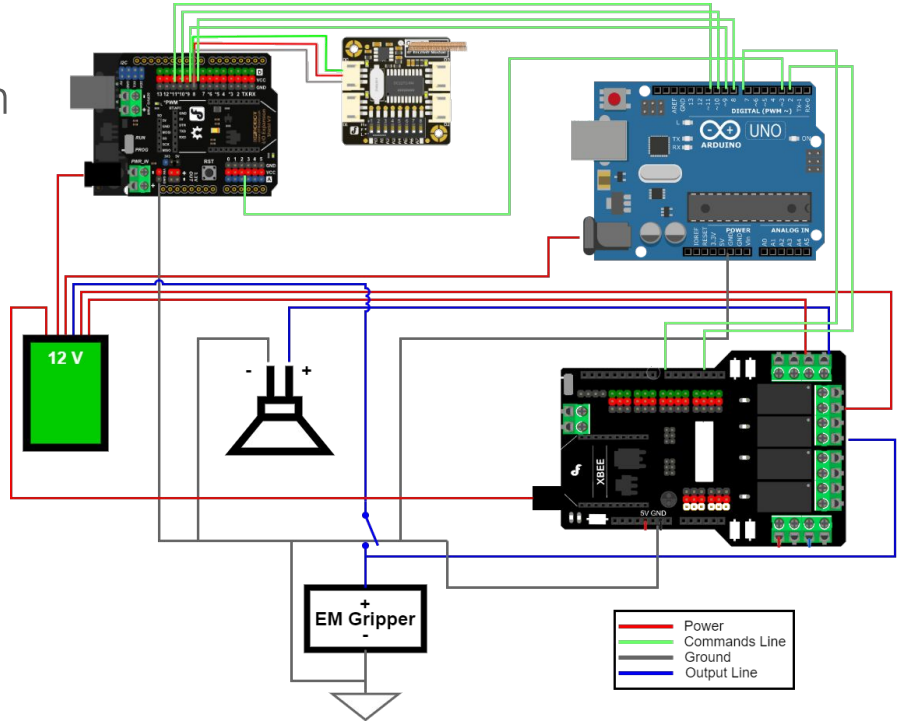
- Part name: Button Housing
- Function and integration into the design
  - Allow the user to more easily press send the release signal through the use of their arm or forearm
- Mfg process:
  - 3D print and assemble housing
- Mfg status:
  - Software development: Complete



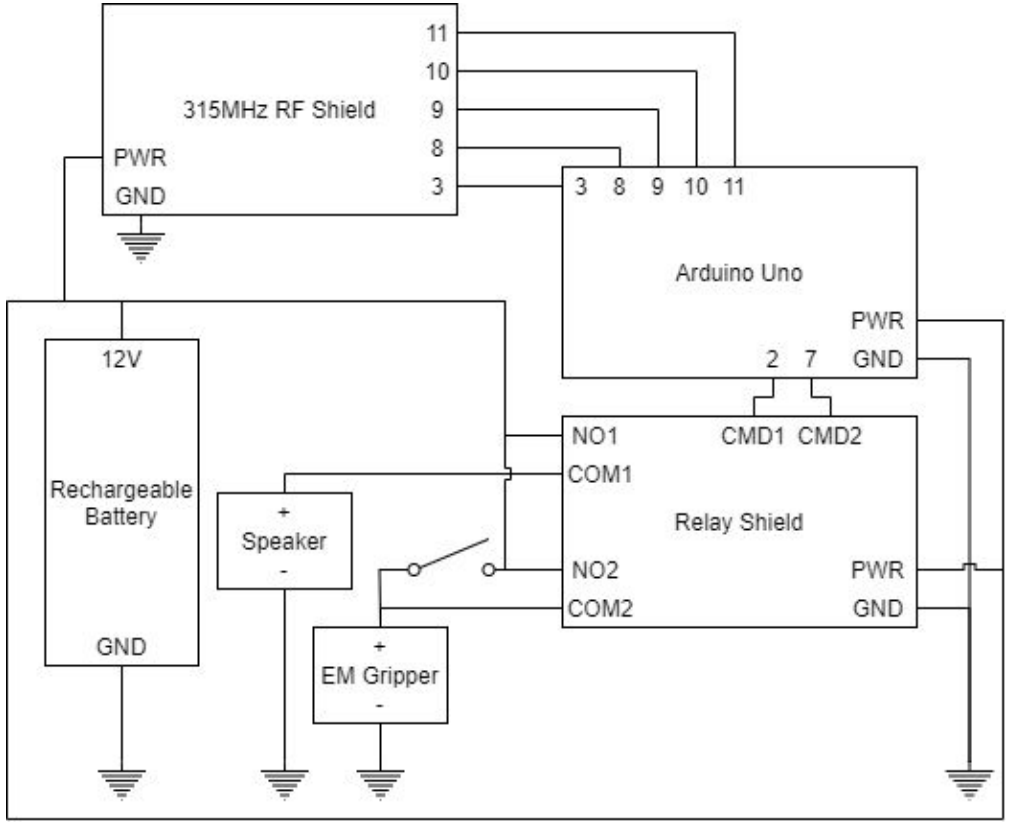
Manufacturing

Manufacturing - Command and Control

- Part name: Electronic box (Hardware)
- Function and integration into the design
  - Receives the RF Signal to release the EM gripper and provides audio feedback to the user
- Dimensions:
  - Size : 7.25 x 5.00 x 2.22 in
  - Weight: 0.47 lbs
- Mfg process:
  - Wiring connections to all hardwares
  - Minor soldering for speaker and EM gripper
- Mfg status: Pending (Waiting for the battery to arrive)



Manufacturing - Command and Control

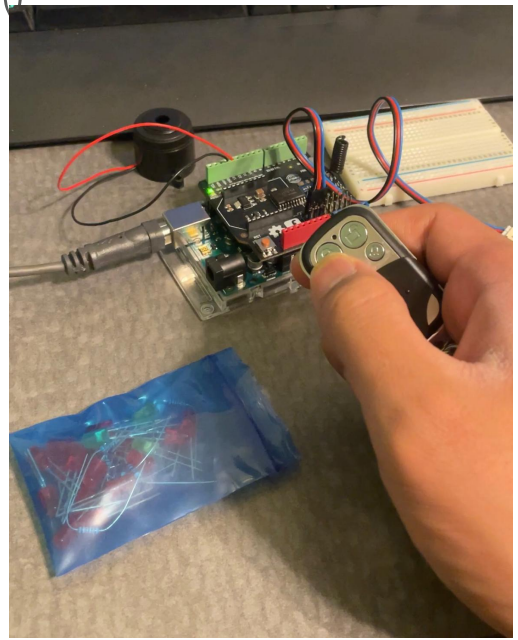


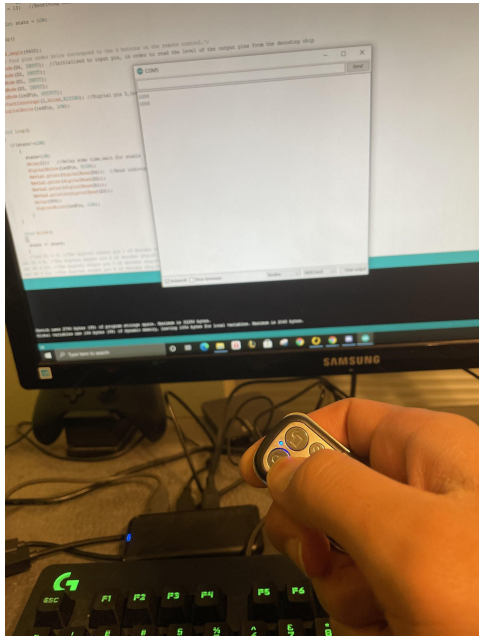
Manufacturing - Command and Control

- Part name: Software
- Function and integration into the design
  - Process the RF signal to output audio feedback when signal has been received by the system
  - Check the battery level and provide audio feedback when battery is low
  - Prevent the accidental launch via override switch
  - Open the electromagnetic gripper automatically using the RF signal
- Mfg process:
  - Software development will be done remotely
- Mfg status:
  - Software development: in progress

Arduino functions, Receiver Side

- **bool signal_rx** = Get_RFcommand()
- **void** speaker(**double time**)
- **void** electro_toggle(**bool state**)
- **bool is_low** = battery_check()
- Main()
  - Setup()
  - Loop()





Budget Status

Budget Status

- Purchased 100% of prototype materials
- $941.59 of $5,000 or 18.8%
- Structures has largest purchasing potential
- Can create 3-4 complete iterations and stay within budget

Budget Breakdown - The Big Spenders

- Structure
  - 80/20 Bars - $120
- Release Mechanism
  - Aluminum - $40
  - Magnet - $100
- Command and Control
  - Arduino - $30
  - Shields - $50

Iterations

- Our iterations are most likely to occur with the structure, NOT the release mechanism or command and control system
- Most Variability
- Biggest Impact on the project
- Many of the parts we have now can be reused

Acknowledgements

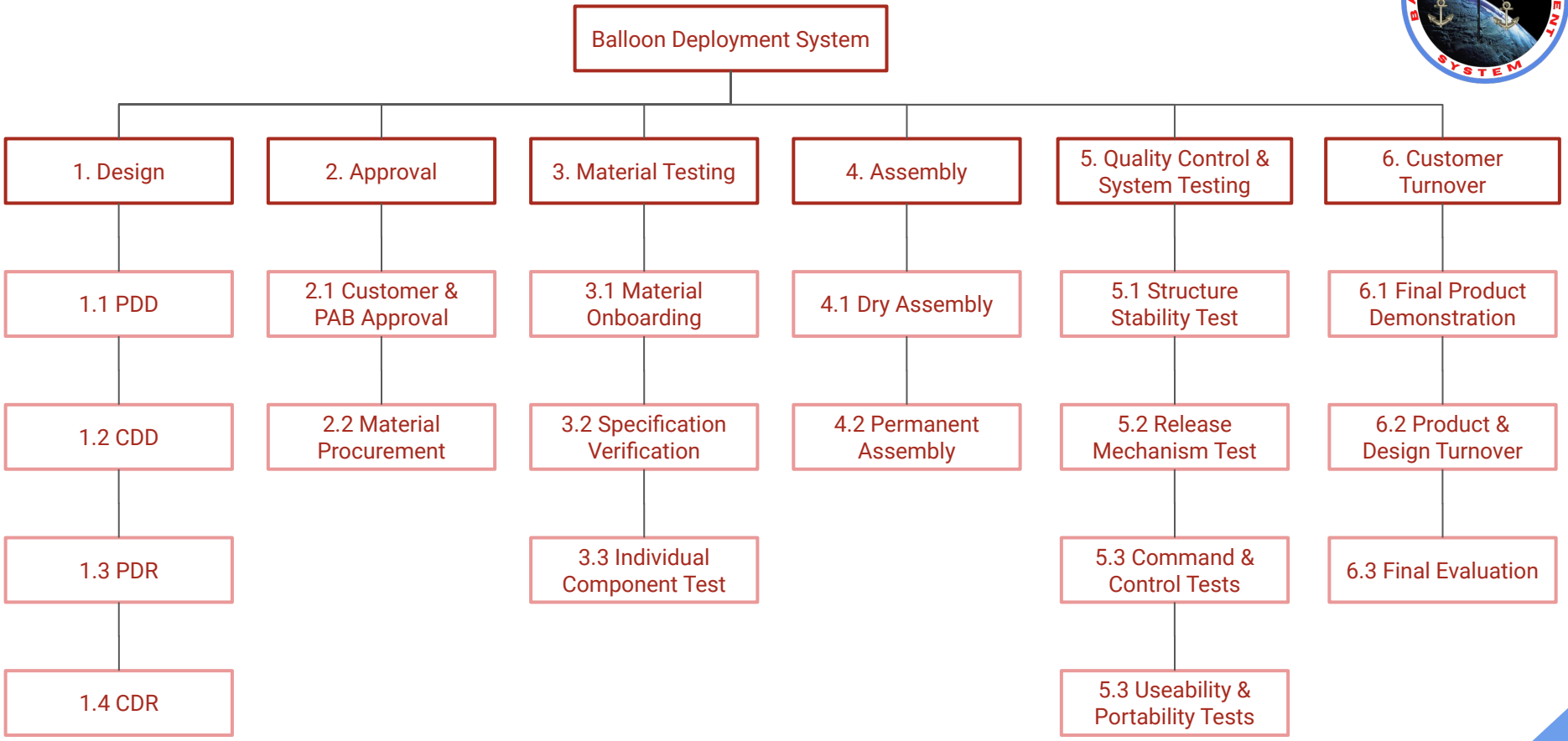
Dr. Dale Lawrence
Customer

Matt Rhode
Advisor

Dr. Jelliffe Jackson
Instructor

Appendix

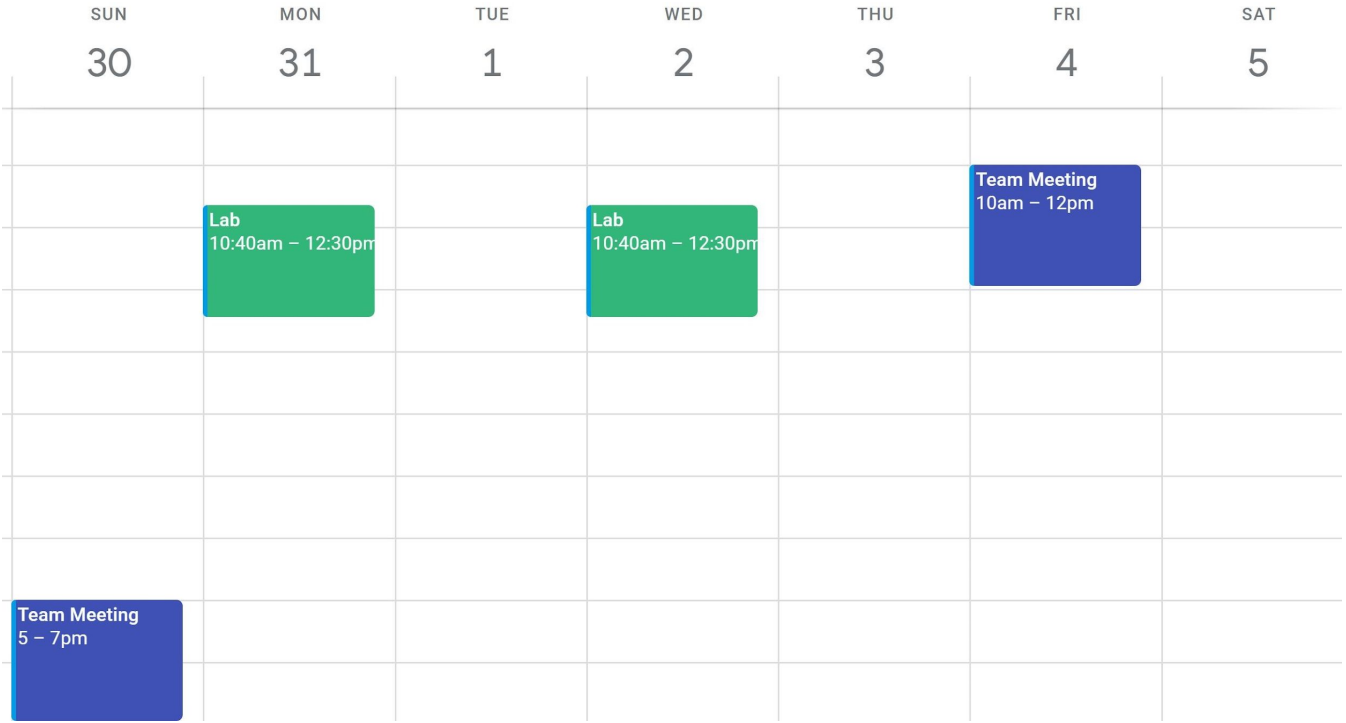
Phase Work Breakdown Structure



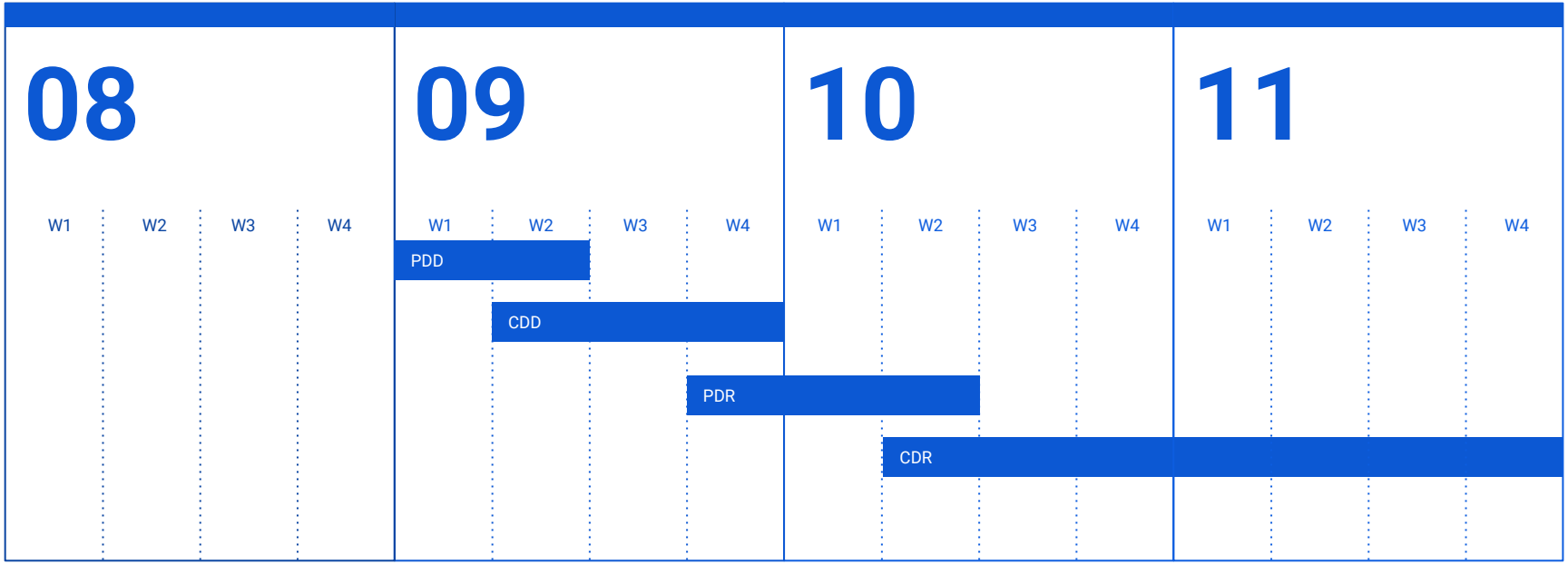
Prices

Item	Quantity	Price per Unit (USD)	Shipping Cost (USD)	Total Cost
Arduino Uno	1	$23.00	$1.63	$24.63
RF Board	2	$23.10	$0.00	$46.20
RF Rx	2	$6.80	$0.00	$13.60
Remote Wireless Key Fob	1	$5.20	$0.00	$5.20
6V Battery (Rx)	4	$15.00	$0.00	$60.00
CR2302 (Tx)	1	$2.85	$0.00	$2.85
Electromagnet	1	$95.00	$0.00	$95.00
F24 Truss	1	$231.00	$0.00	$231.00
1515 80/20	1	$22.82	$0.00	$22.82
1530 80/20	2	$39.06	$0.00	$78.12
L-Brake	4	$12.10	$0.00	$48.40
80/20 Linear Bearings	4	$48.50	$0.00	$194.00
Pulley Wire	1	$2.79	$0.00	$2.79
			Total Cost	$824.61

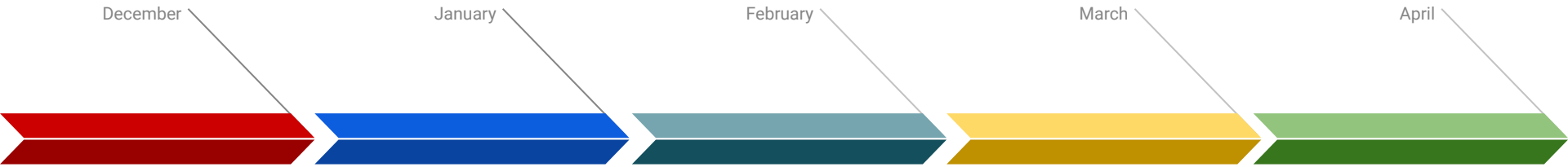
Current Status and Remaining Studies



Current Status and Remaining Studies



Approximate Build & Test Schedule



Complete CDR & Order Materials

Order materials shortly after CDR so we can use winter break as shipping time.

Collecting Materials & Dry Assembly

Checking on remaining orders and organizing what we have into our assembly. No machining or custom parts are required.

Assembly & Preliminary Tests

Testing for our requirements will begin and simulated launches will be conducted.

Design Revisions & Final Tests

BDS will be tested against adverse effects to see the operating range of our device.

Final Deliverable & Demonstration

Delivering final product to Dr. Lawrence and demonstration levels of success by end of semester.

References - PDR

Modulus of Elasticity: https://www.azom.com/properties.aspx?ArticleID=920

Wind direction change: https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1256/wea.176.04
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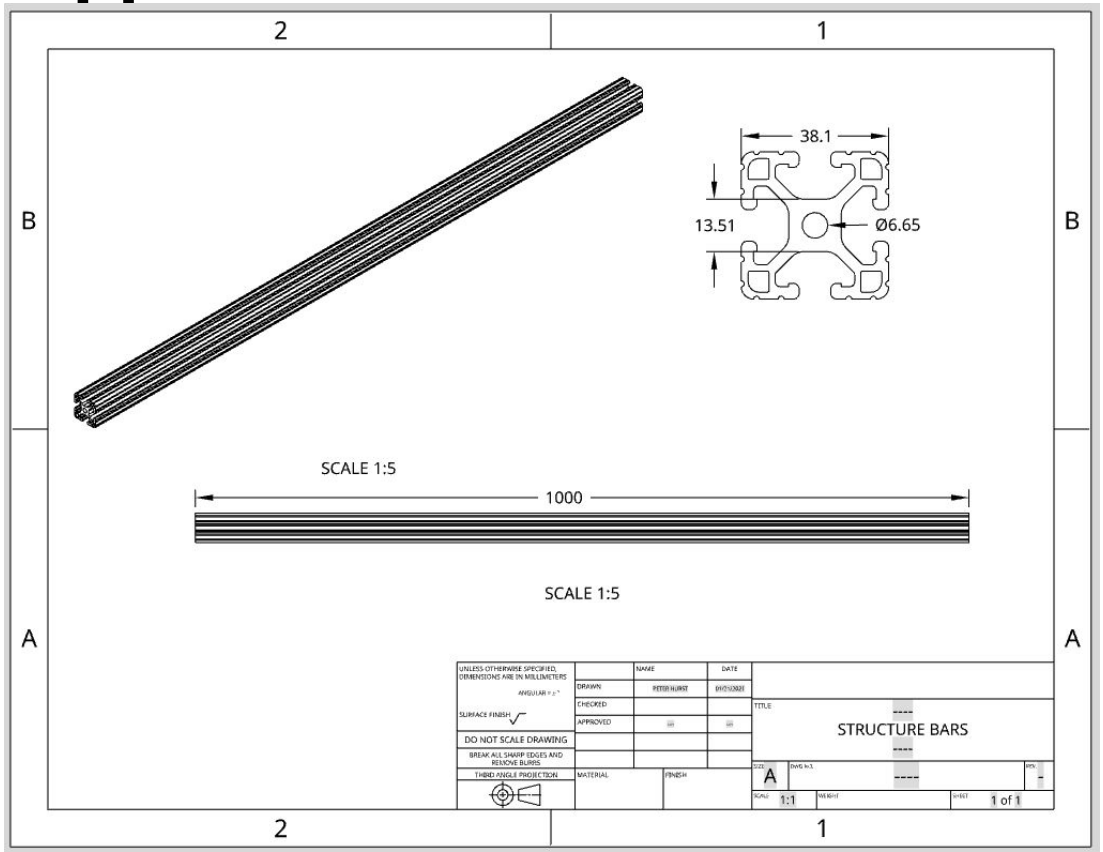
https://cdn-shop.adafruit.com/datasheets/maxell_cr2032_datasheet.pdf

Appendix - Structures full size drawings



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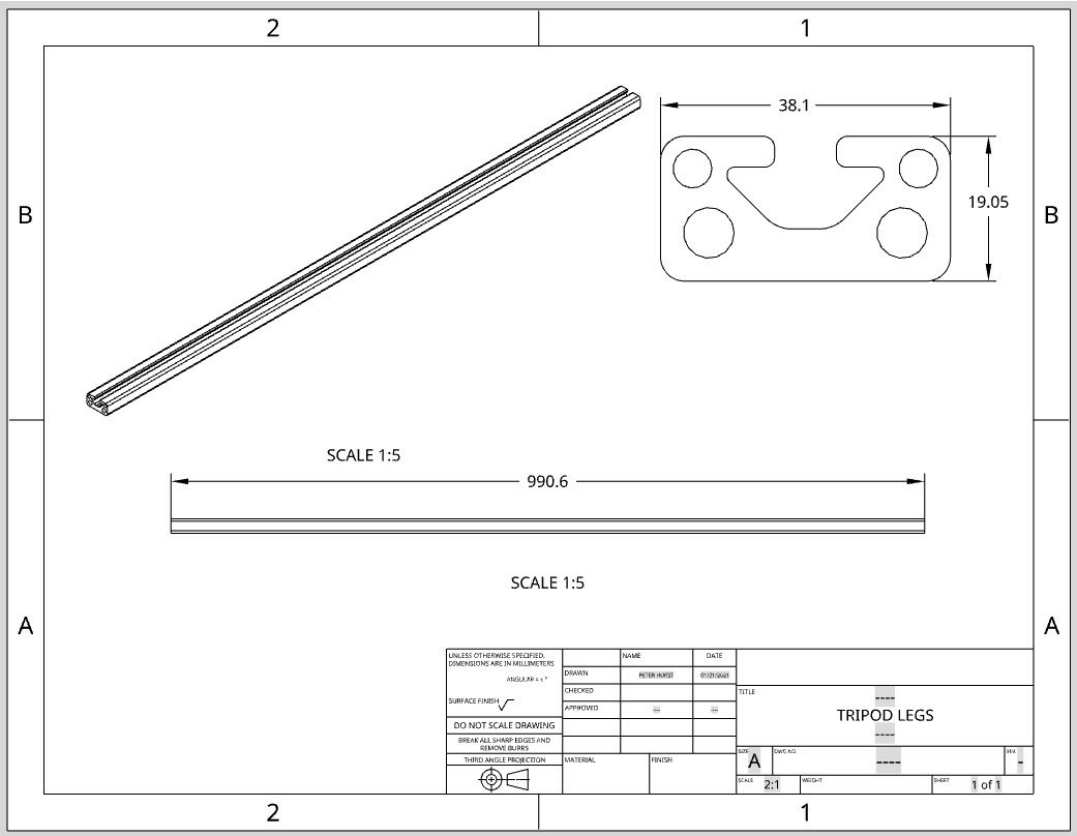

Appendix - Structures full size drawings