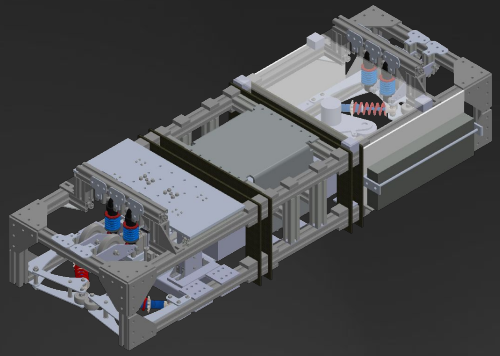


HYPERXITE

# MAE 151A:
# Pod Maintenance & Transport Vehicle

# Introduction

- **HyperXite - Underlying Needs:**
  - To move 250kg Hyperloop pod around
  - A mobile work station
- Old design problems:
  - Difficult to maneuver on uneven terrain
  - Causes minor injury
  - Can’t be used as a workstation
- New design:
  - Shall hold and lift pod for maintenancing
  - Easily negotiate around rough terrain



RK

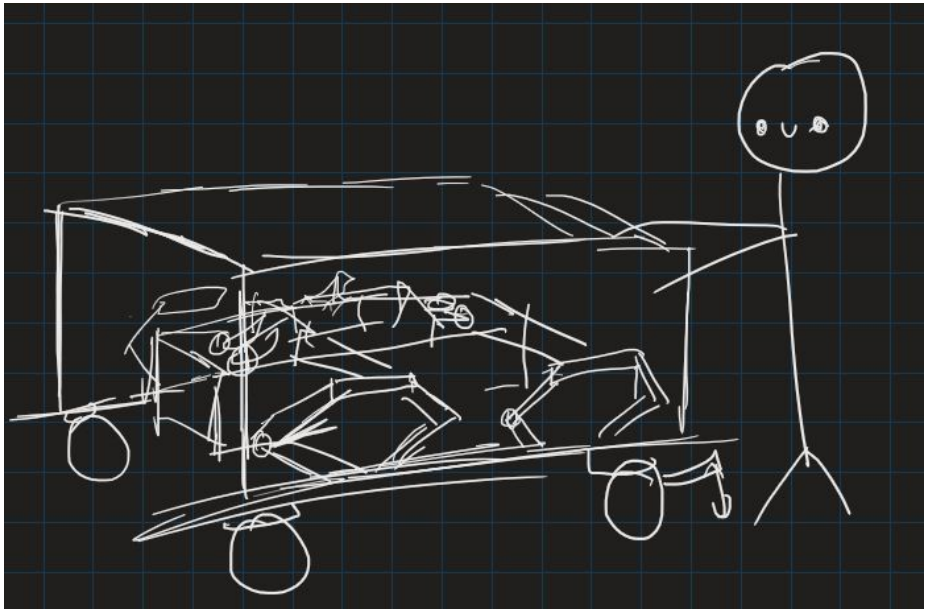
# Introduction

Proposed Solution:

- Cart with high ground clearance
- Locked swivel for back wheels
- Scissor jack for maintenancing pod and mounting/dismounting pod from track

User Interaction:

- Will maneuver dips and hills with ease
- Will have easier control of cart with locked back wheel orientation
- Will conduct maintenance from under the pod anywhere
- Will put cart on track without breaking backs



JN

# Design Attributes

| # | Attribute | O | C | F | M |
|---|---|---|---|---|---|
| 1 | Must be safe | X | X | | |
| 2 | Should be easily assembled and disassembled | | | | X |
| 3 | Must fit in the freight | | X | | |
| 4 | Must raise the pod to a suitable height for maintenance | | X | X | |
| 5 | Could lift pod either pneumatically, electrically, or mechanically | | | | X |
| 6 | Could lift the pod for an individual to operate under | | | X | |
| 7 | Must have a locking mechanism | | | X | |
| 8 | Must be easy to operate | X | | | |
| 9 | Must stay within the project's budget | X | X | | |
| 10 | Must move the pod efficiently | | | X | |
| 11 | Must support at least 300 kg | | X | | |
| 12 | All dimensions should be metric unit | | | | |
| 13 | Could lift the pod for an individual to operate under | | | X | |
| 14 | Must have high-strength, lightweight materials for frames | | | | X |

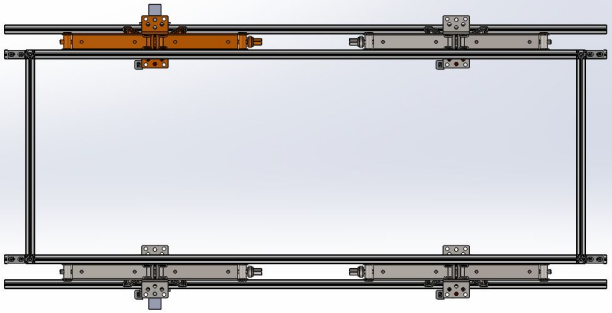
HL

# Requirements

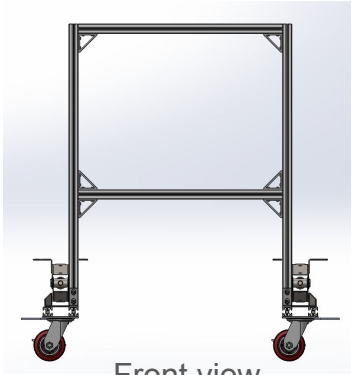
| SYSTEM REQUIREMENTS | | |
|---|---|---|
| **Designation** | **Description** | Origination |
| Operational | | |
| OR-1 | The device shall not become “beached” on slightly curved/elevated ground | StHX6 |
| OR-2 | The device shall lower pod from raised height without falling rapidly | StHX3,StHX10 |
| Functional | | |
| FR-1 | The device shall include an indicator of when it is at a height of 24 cm | StHX7 |
| FR-2 | The device shall spin on the z-axis in 360 degrees | StHX9, StHX6 |
| FR-3 | The device shall include mechanism to lock back wheels in the x- direction | StHX6, StHX9 |
| FR-5 | The device should include a way to steer that is located 0.9m - 1.2m above the ground | StHX4 |
| FR-6 | The device shall stay stationary while pod is being worked on | StHX3, StHX8 |
| FR-8 | The device shall allow dismounting and mounting of the pod is on the ground and maximum height of .375m | StHX11 |
| Performance | | |
| PR-1 | The device shall not deform by more than 5 mm while holding the 300 kg pod | StHX1 |
| PR-2 | The device shall be capable of opening a .375 m gap between the chassis and the bottom of the pod frame | StHX3, StHX5, StHX8 |
| PR-3 | The device shall overcome bumps of 1 cm | StHX6 |
| Constraints | | |
| CR-1 | The device shall have an overall footprint of less than 2m*3m*3.5m. | StHX2, StEHS1 |
| CR-2 | The device design shall stay under $500 or be sponsored | StSpon1 |
| Safety | | |
| SR-1 | Device shall have a way to bring the pod to a complete stop when mechanism is engaged | StHX8 |
| SR-2 | Device shall not injure users through extruded surfaces | StHX10 |
| SR-3 | Device shall have ways to guard against instantaneous lifting failures | StHX10 |
| SR-4 | The device shall secure the pod during any revalent motions | StHX1 |

# Final CAD Design

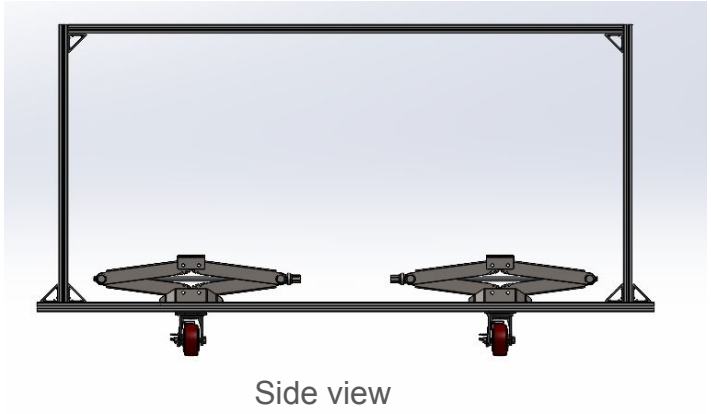
Version 4



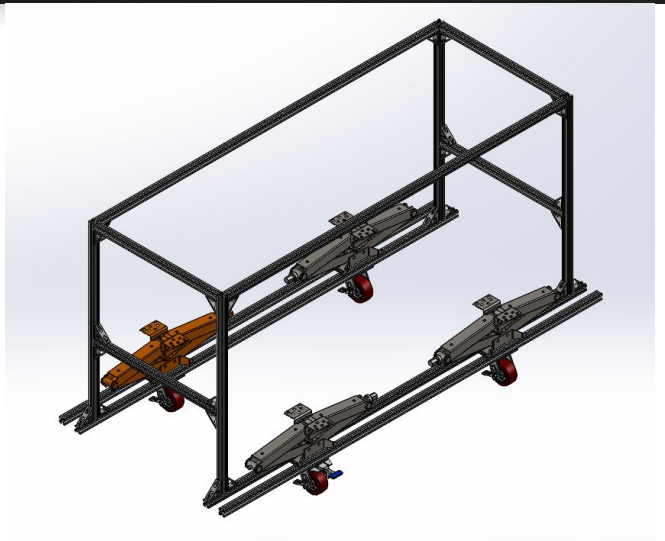
Top view



Front view



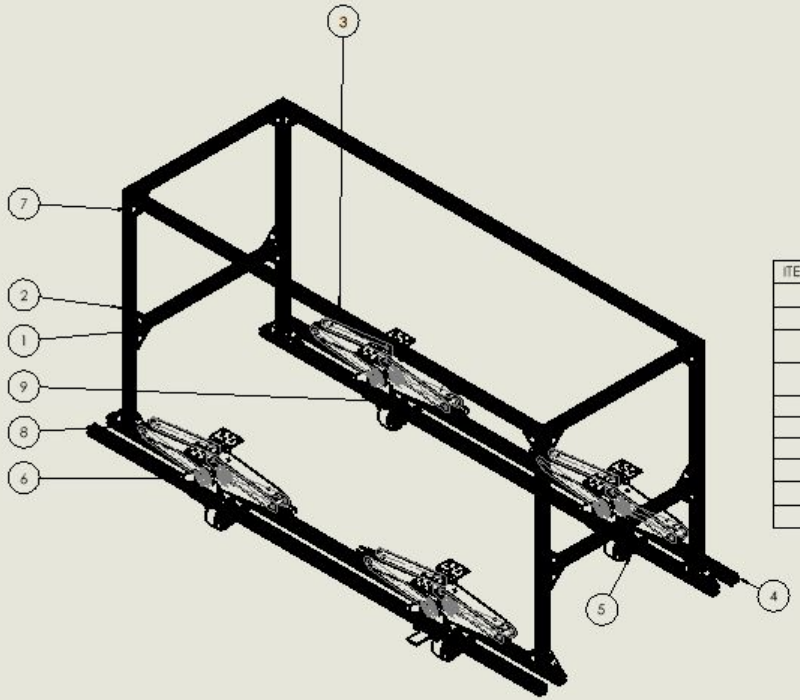
Side view



Isometric view

TT

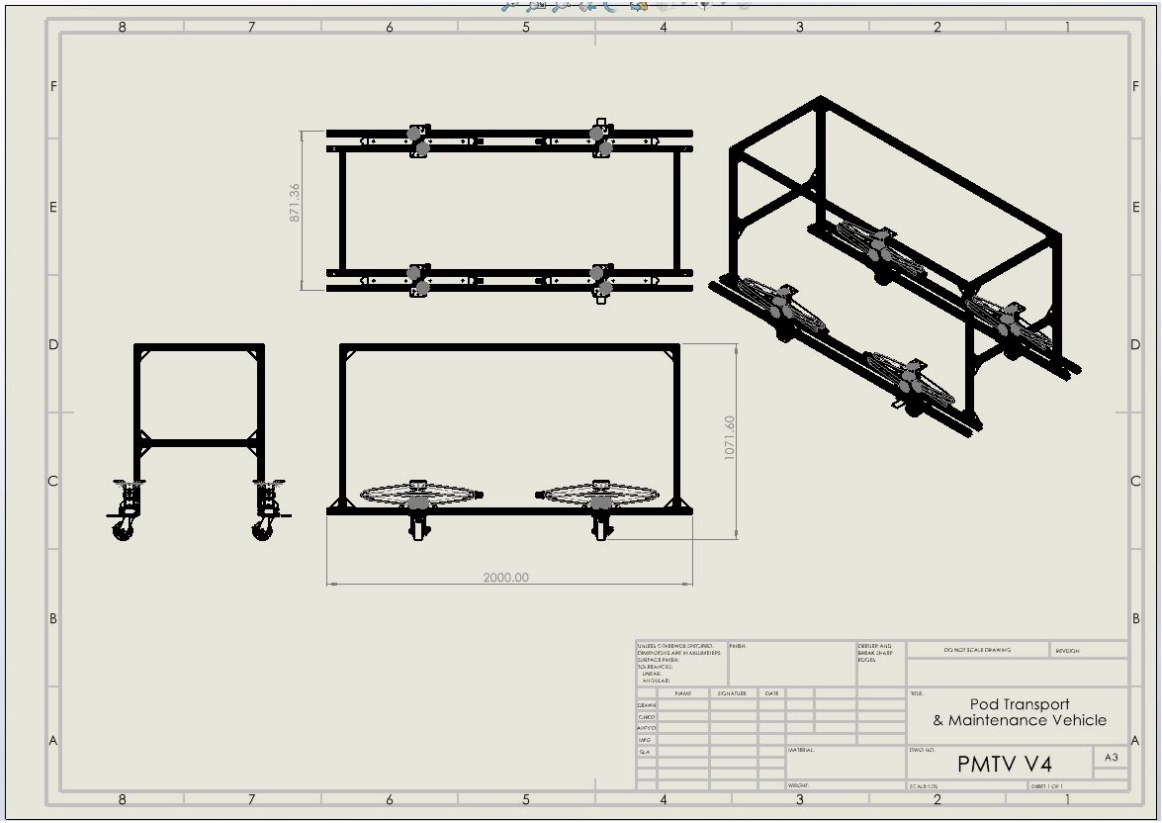
# Final CAD Design




| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | 30-3030 X 650 | 3030 ALUMINUM EXTRUSION 650mm | 4 |
| 2 | 30-3030 X 900 | 3030 ALUMINUM EXTRUSION 900mm | 4 |
| 3 | 30-3030 X 1800 | 3030 ALUMINUM EXTRUSION 1900mm | 2 |
| 4 | 30-3030 X 2000 | 3030 ALUMINUM EXTRUSION 2000mm | 4 |
| 5 | ESRS4X2TUMTBK | CASTER WHEEL | 4 |
| 6 | BJ-S000MSJ30 | SCISSOR JACK HIGH LIFT | 4 |
| 7 | 5537T659 | EXTENDED CORNER GUSSET | 24 |
| 8 | 5537T869 | DOUBLE T-NUT FASTERNER | 48 |
| 9 | 5537T868 | SINGLE NUT FASTENER | 32 |
| 10 | Swivel Locks | Swivel Locks | 2 |

TT

# Final CAD Design




HL

# Final CAD Design

HL

# Compliance Table - Frame

## Subsystem: Frame

| Requirement | Compliant? | Verification |
|---|---|---|
| **VF1:** The frame shall not deform while holding the 300 kg pod | C | CAD Model Representation within SolidWorks<br>FEA Analysis on beams |
| **VF2:** The frame shall accommodate all subsystems of the PMTV | C | CAD Model Representation within SolidWorks |
| **VF3:** The frame must fit through freight elevator door (2.2m x 1.5m x 2.5m) | C | CAD Model Representation within SolidWorks |
| **VF4:** The frame must leave enough room for wheels to swivel 360 degrees at 100 mm radius | C | CAD Model Representation within SolidWorks |



RK

# Compliance Table - Wheel Lock

## Subsystem: Wheel Lock

| Requirement | Compliant? | Verification |
|---|---|---|
| **WR1** - The swivel lock shall apply to 2 of the 4 wheels. | C | Visual Inspection of CAD |
| **WR2** - The swivel lock shall have the option of securely keep the vehicle's back wheels fixed in the x - direction with less thana iggle of 0.1 degrees | C | Hand Calculations |
| **WR3** - The swivel lock shall not break under torque of about 35 Nm at the swivel axis when engaged | C | Hand Calculations |
| **WR4** - The swivel lock shall be made to easily engage and disengage | C | Visual Inspection of CAD & Physical Demonstration |
| **WR5** - The wheel lock shall hold the cart in place at an incline of at least 10 degrees | C | Hand Calculation |
| **WR 6** - The wheel lock shall keep vehicle immobilized under load of 100 N | C | Hand Calculations |



JC

# Compliance Table - Jacks

Subsystem: Jacks

Concept 3: Large Scissor Jacks

| Requirement | Compliant? | Verification | Notes |
|---|---|---|---|
| **JR1:** The device shall be capable of opening a .375 m gap between the chassis and the bottom of the pod frame | C | Physical testing with Hyperxite Pod 10 | A set of smaller jacks are used, the actual jack will be compliant |
| **JR2:** The device shall slowly and gently lift and lower the pod | C | Physical testing with Hyperxite Pod 10 | Controlled & slow lifting & lowering |
| **JR3:**The device shall be simple to use | C | Physical testing with Hyperxite Pod 10 | Socket Wrench Lifting mechanism is intuitive to use |
| **JR4:** The device shall be consistently reliable in lifting and lowering the pod | C | Physical testing with Hyperxite Pod 10 | Lifting is stable and the threads have no inconsistencies allowing for ease of raising/lowering |



TT

# Compliance Table - Jack Mount

Subsystem: Jack Mount

| Requirement | Compliant? | Verification |
|---|---|---|
| **JMR1:** The device shall not deform more than 0.1 mm while holding the 300 kg pod | C | CAD Model Representation within SolidWorks<br>FEA Analysis on beams |
| **JMR2:** The device shall allow jack to mount the pod at a minimum height of 25 cm | C | CAD Model Representation within SolidWorks |

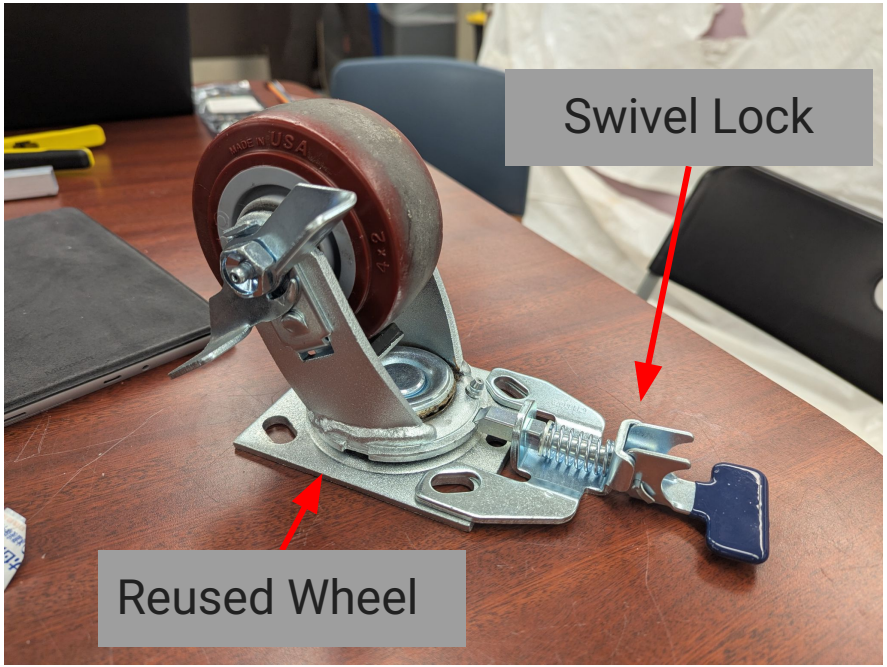


HL

# Design Decisions

Decision Made:

- **Reuse current wheels** from previous PMTV
  - $0 by reusing
  - Proven to work
  - Swivel locks can be retrofitted



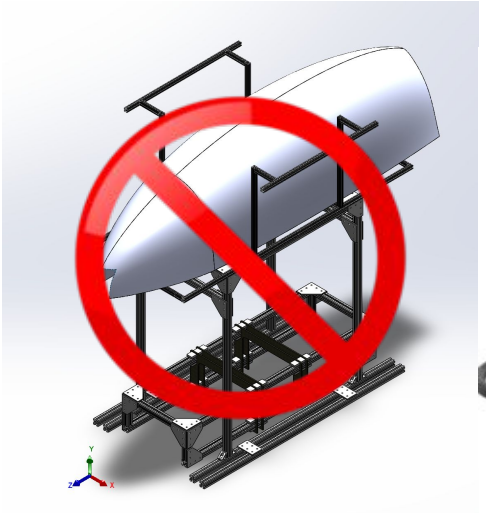



JC

# Design Decisions

Decisions Made:

- **Omit fairing mount**
  - Not enough budget for extra extrusions
- Mechanism for lifting will be **human-powered**
  - Not enough budget for motors, hydraulics, or pneumatics





JN

# Design Decisions

Decisions Made:

- **Will not be using farmer jacks** to lift pod (failed proof of concept)

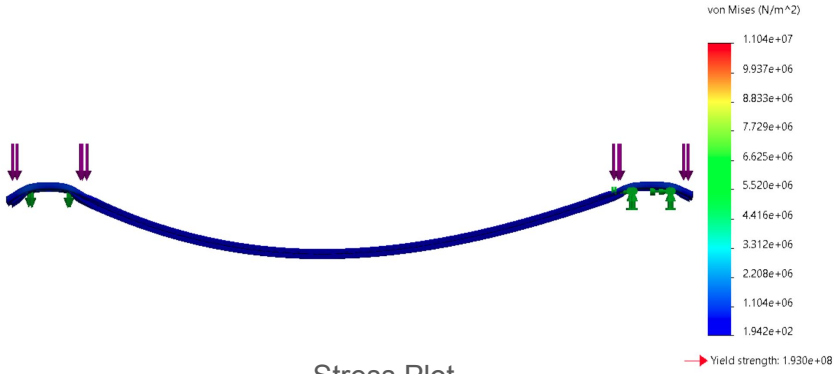
Subsystem: Jacks — Concept 1: Farmer Jacks

| Requirement | Compliant? | Verification | Notes |
|---|---|---|---|
| **JR1:** The device shall be capable of opening a .375 m gap between the chassis and the bottom of the pod frame | C | Physical testing with Hyperxite Pod 10 | |
| **JR2:** The device shall slowly and gently lift and lower the pod | NC | Physical testing with Hyperxite Pod 10 | Catastrophic failure on lowering |
| **JR3:**The device shall be simple to use | C | Physical testing with Hyperxite Pod 10 | |
| **JR4:** The device shall be consistently reliable in lifting and lowering the pod | NC | Physical testing with Hyperxite Pod 10 | Lowering has risk of collapsing when insufficient load is applied to jack |

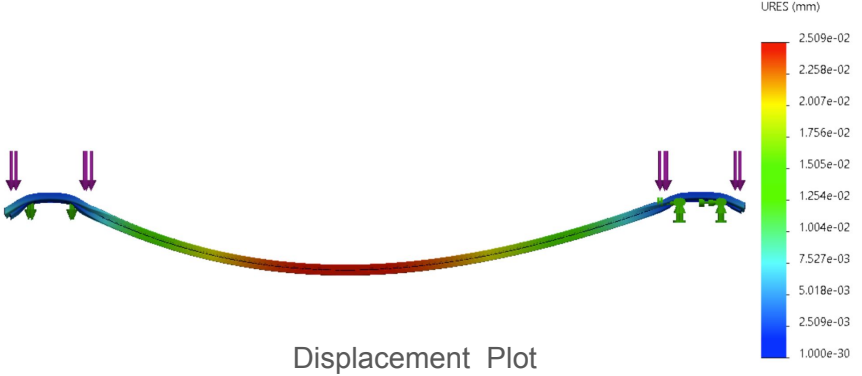
# Design Decisions

## Decisions Made:

- **Design Version 4** will be used with scrapped pieces (other designs yielded in FEA, also cheapest)
  - The longest beam in each version was tested using FEA, only version 4 give a desired factor of safety (FOS)
  - Beam type 3030, length = 2m, FOS = 17.5




Stress Plot




Displacement Plot



HL

# Bill of Materials

| Name | Description | Quantity | Price | Notes |
|---|---|---|---|---|
| 30-3030 X 650 | 3030 ALUMINUM EXTRUSION 650mm | 4 | | |
| 30-3030 X 900 | 3030 ALUMINUM EXTRUSION 900mm | 4 | | |
| 30-3030 X 1800 | 3030 ALUMINUM EXTRUSION 1800mm | 2 | | |
| 30-3030 X 2000 | 3030 ALUMINUM EXTRUSION 2000mm | 4 | $311.93 | |
| ESRS4X2TUMTBK | Castor Wheels | 4 | $0 | Reused |
| BJ-5000MSJ30 | Large Scissor Jacks | 4 | $134.99 | |
| 5537T659 | Extended Corner Gusset | 24 | $0 | |
| 5537T869 | Double T-Nut Fastener | 48 | $0 | |
| 5537T868 | Single Nut Fastener | 32 | $0 | |
| 4PFL27 | Swivel Locks | 2 | $32.00 | |
| | | | $478.92 | |

TT

# Manufacturing Expectations

- **UCI's Machine shop:**
  - Mill the 3030 extrusions to length
  - Tap holes and/or threads into extrusions
- **HyperXite Lab:**
  - Assemble the 3030 extrusions to create the frame using the following:
    - 4 hole corner plates (M6)
    - 4 hole corner gussets (M6)
    - Washers (M6 & M8)
    - Screws (M6)
  - Attach the 4 caster wheels to the frame
    - Implement the 2 swivel locks to each of the rear caster wheels
  - Attach the 4 scissor jacks to the frame

RK

# Technical Risk Analysis (FMEA)

| Component | Function | Failure Mode | Cause of Failure | Effect of Failure | Corrective Action Detection | Criteria / Rank |
|---|---|---|---|---|---|---|
| Jacks | Lifting / Lowering Pod | System Failure - Pod will fall during lowering | Jacks require a constant load, if there is no load the mechanism will slip | Pod Collapses if weight is not loaded onto jack | Pivoted from Farmer Jacks to Scissor Jacks | 1 |
| Jack Mounting | Support the weight of the pod & Provide Stability for jacks | Buckling | Due to the orientation of the screw on the jacks, the jacks must be offset | Potential buckling on jack mount | Add more bracing onto the bottom of the jacks to attach to the main system | 2 |
| Frame | Provide structure to PMTV | Buckling | Lack of Extrusion Cross Members | Potential buckling and collapsing of PMTV while | Include more internal supports to allow for the pod not to buckle | 1 |

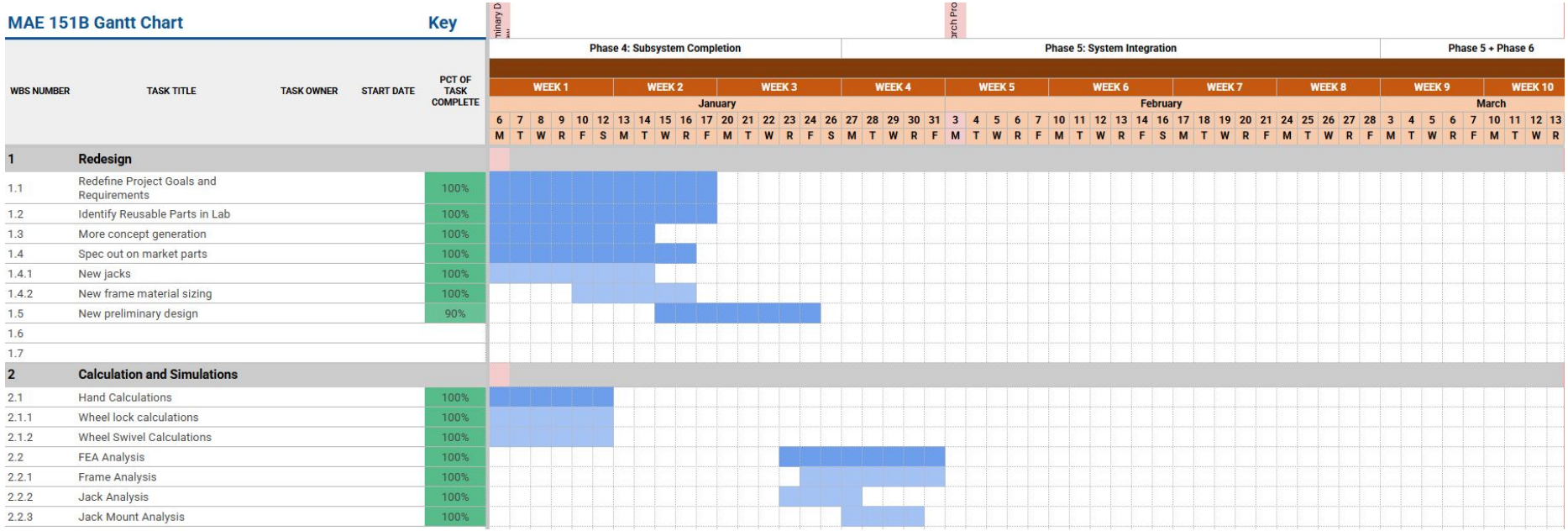
JN

# Missing Resources & Concerns

- TGIF funding
- Potential sponsorship for 3030 extrusions & hardware

JN

# Gantt Chart



**MAE 151B Gantt Chart** — Key

| WBS NUMBER | TASK TITLE | TASK OWNER | START DATE | PCT OF TASK COMPLETE |
|---|---|---|---|---|
| **1** | **Redesign** | | | |
| 1.1 | Redefine Project Goals and Requirements | | | 100% |
| 1.2 | Identify Reusable Parts in Lab | | | 100% |
| 1.3 | More concept generation | | | 100% |
| 1.4 | Spec out on market parts | | | 100% |
| 1.4.1 | New jacks | | | 100% |
| 1.4.2 | New frame material sizing | | | 100% |
| 1.5 | New preliminary design | | | 90% |
| 1.6 | | | | |
| 1.7 | | | | |
| **2** | **Calculation and Simulations** | | | |
| 2.1 | Hand Calculations | | | 100% |
| 2.1.1 | Wheel lock calculations | | | 100% |
| 2.1.2 | Wheel Swivel Calculations | | | 100% |
| 2.2 | FEA Analysis | | | 100% |
| 2.2.1 | Frame Analysis | | | 100% |
| 2.2.2 | Jack Analysis | | | 100% |
| 2.2.3 | Jack Mount Analysis | | | 100% |

Phase 4: Subsystem Completion | Phase 5: System Integration | Phase 5 + Phase 6

WEEK 1 | WEEK 2 | WEEK 3 | WEEK 4 | WEEK 5 | WEEK 6 | WEEK 7 | WEEK 8 | WEEK 9 | WEEK 10

January: 6 7 8 9 10 12 13 14 15 16 17 20 21 22 23 24 26 27 28 29 30 31

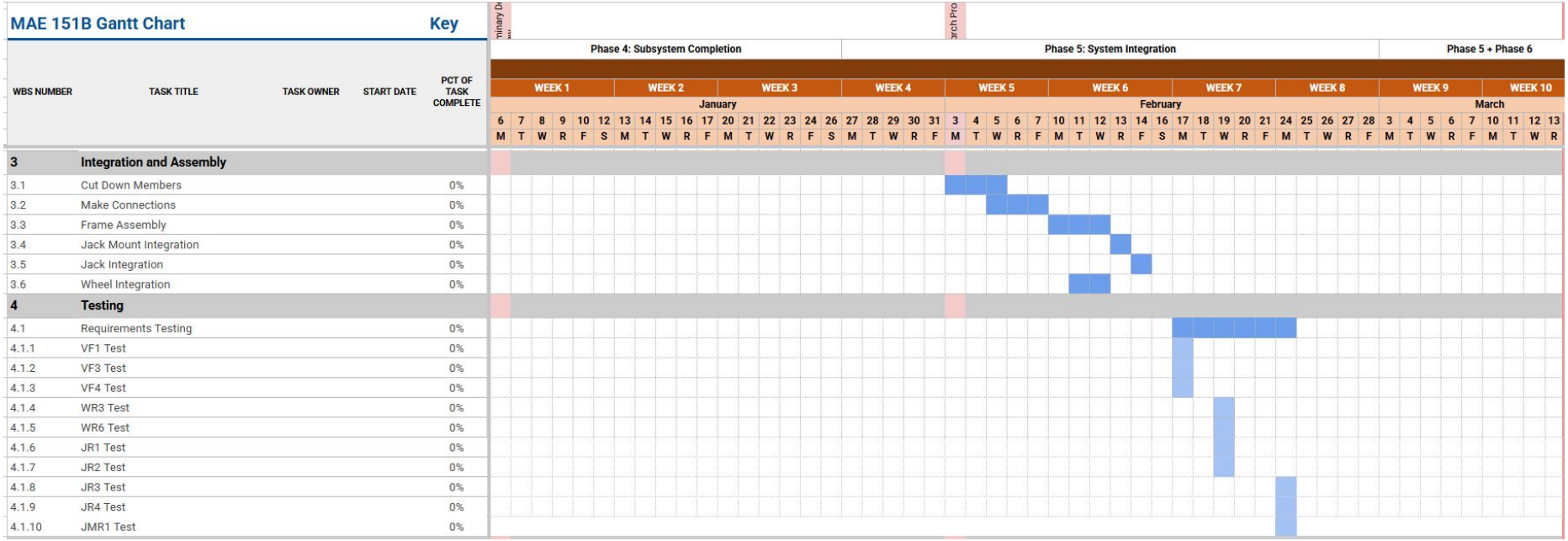
February: 3 4 5 6 7 10 11 12 13 14 16 17 18 19 20 21 24 25 26 27 28

March: 3 4 5 6 7 10 11 12 13

M T W R F S M T W R F M T W R F S M T W R F M T W R F S M T W R F M T W R F M T W R

JC

# Gantt Chart




| WBS NUMBER | TASK TITLE | TASK OWNER | START DATE | PCT OF TASK COMPLETE |
|---|---|---|---|---|
| **3** | **Integration and Assembly** | | | |
| 3.1 | Cut Down Members | | | 0% |
| 3.2 | Make Connections | | | 0% |
| 3.3 | Frame Assembly | | | 0% |
| 3.4 | Jack Mount Integration | | | 0% |
| 3.5 | Jack Integration | | | 0% |
| 3.6 | Wheel Integration | | | 0% |
| **4** | **Testing** | | | |
| 4.1 | Requirements Testing | | | 0% |
| 4.1.1 | VF1 Test | | | 0% |
| 4.1.2 | VF3 Test | | | 0% |
| 4.1.3 | VF4 Test | | | 0% |
| 4.1.4 | WR3 Test | | | 0% |
| 4.1.5 | WR6 Test | | | 0% |
| 4.1.6 | JR1 Test | | | 0% |
| 4.1.7 | JR2 Test | | | 0% |
| 4.1.8 | JR3 Test | | | 0% |
| 4.1.9 | JR4 Test | | | 0% |
| 4.1.10 | JMR1 Test | | | 0% |

JC