EML4551

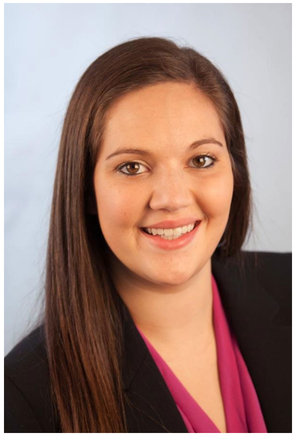
# Virtual Design Review #5

## Air Force Research Lab (AFRL) Polymer Infiltration Device

Jenkins, Stern

# The Team

Catherine Kent
Lead ME/Research Coordinator



Emily Stern
Lead Technologist

Michael Haimowitz
Team Leader

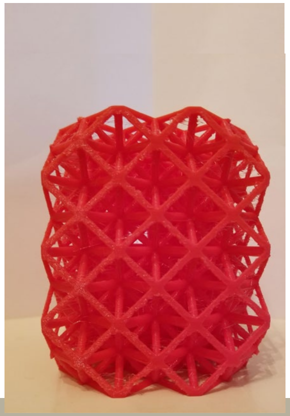
James Jenkins
Geometric Integrator

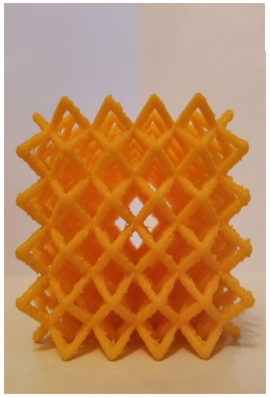
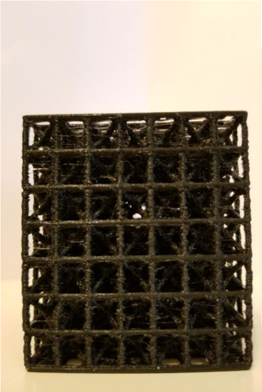
# Project Review

Emily Stern

# Project Scope

- Design and build a prototype to infiltrate open-cell lattice structures with silicone
- Evenly fill the lattices
- Eliminate air voids
- Achieve porosity of less than 1%




# Purpose for Project

- Filled lattices will be used to tailor the ballistic response of munitions
- Eliminate air voids to limit hot spots in munition composite
- Verify Rule of Mixtures is valid for filled lattices

# Previous Design Concepts

Emily Stern

# Prototype Iteration I

- Retractable tube starts above silicone to degas silicone, chamber, and lattice
- Tube lowered into silicone to make a vacuum in the lattice, tube and silicone
- Air reintroduced into system to help drive the silicone into the lattice.

Figure 1. Iteration I

# Prototype Iteration I

Pros:

- Lattice filled from the bottom to ensure no air becomes trapped

Cons:

- Flow of silicone has to fight gravity.
- Difficult to retract tube in a closed system.

Figure 1. Iteration I

# Prototype Iteration II

- Valve above jig will initially be closed, to restrict silicone from flowing.
- Vacuum is then pulled on chamber to degas silicone.
- Valve above jig is then opened to let silicone flow into lattice.
- Vacuum pump continues to draw silicone through the jig until lattice is full.

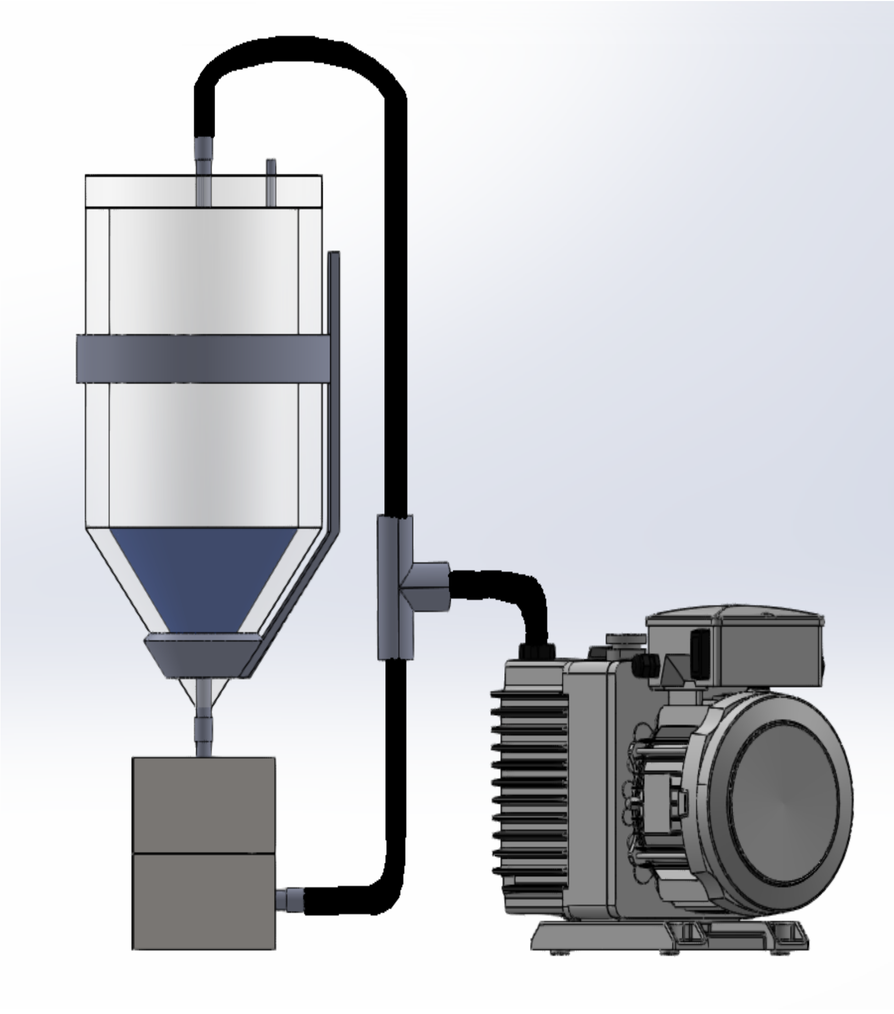


Figure 2. Iteration II

# Prototype Iteration II

Pros:

- Lattice is filled from top to help silicone flow
- Conical base to reduce amount of silicone wasted, also helps direct the flow
- Removes need for a retractable tube

Cons:

- Catch can needed to protect the pump
- Requires internal valves to control the flow of silicone

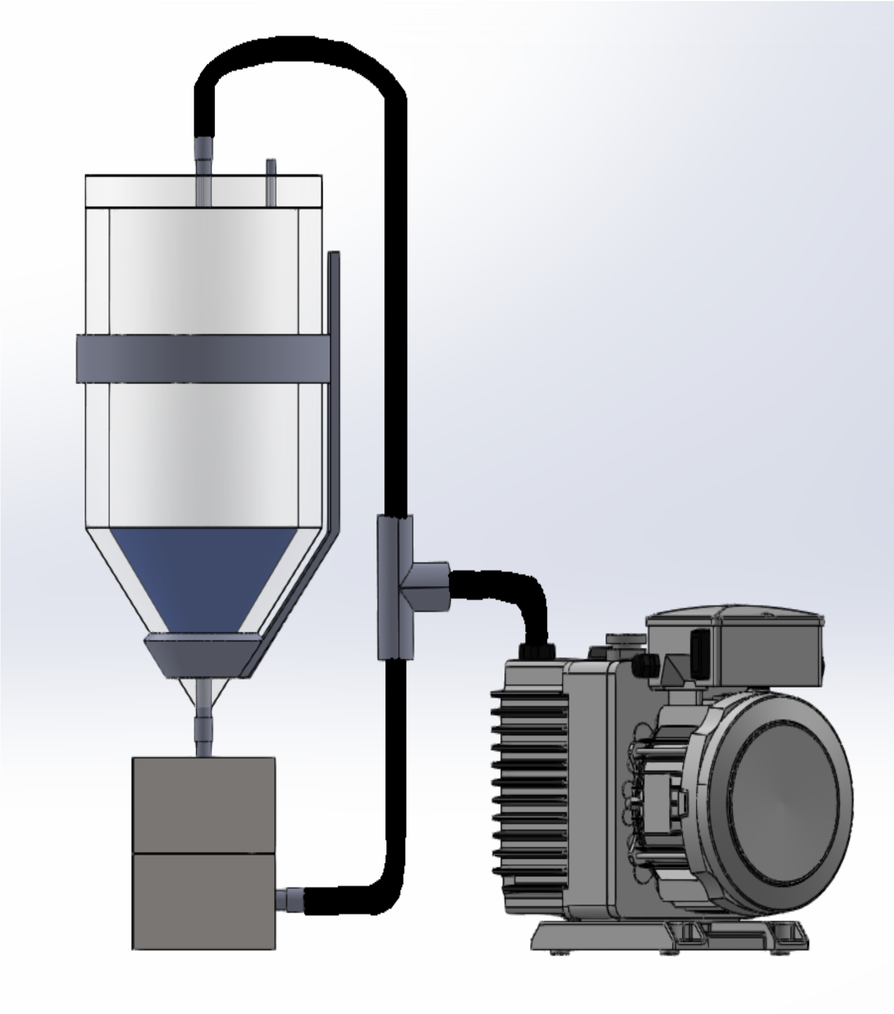


Figure 2. Iteration II

# Final Prototype Breakdown

James Jenkins

# Design Breakdown

- Dual ball valve control for pressure release when degassing silicone.
- Pressure gauge to monitor for faulty seals.
- Funnel to aid in flow, limit silicone waste, and easy cleanup/disposal.
- Square drilled base for mounting to a stand.

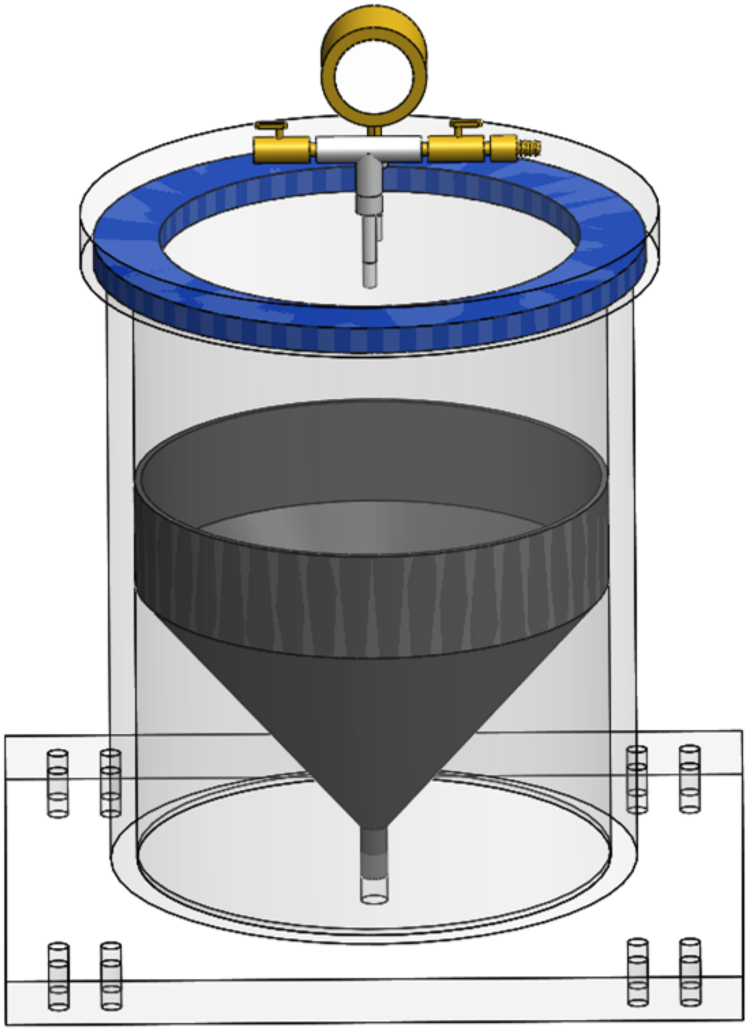


Figure 3. Vacuum chamber assembly.

# Rectangular Jig

- Top and bottom of jig are rubberized to hold a strong seal against acrylic walls.
- Edges are milled for flat surface seal.
- Hot glue used at seams to create a seal, and allow for jig to be easily broken apart to remove lattice.
- Jig walls are adjustable to accommodate lattices of varying lengths and widths.

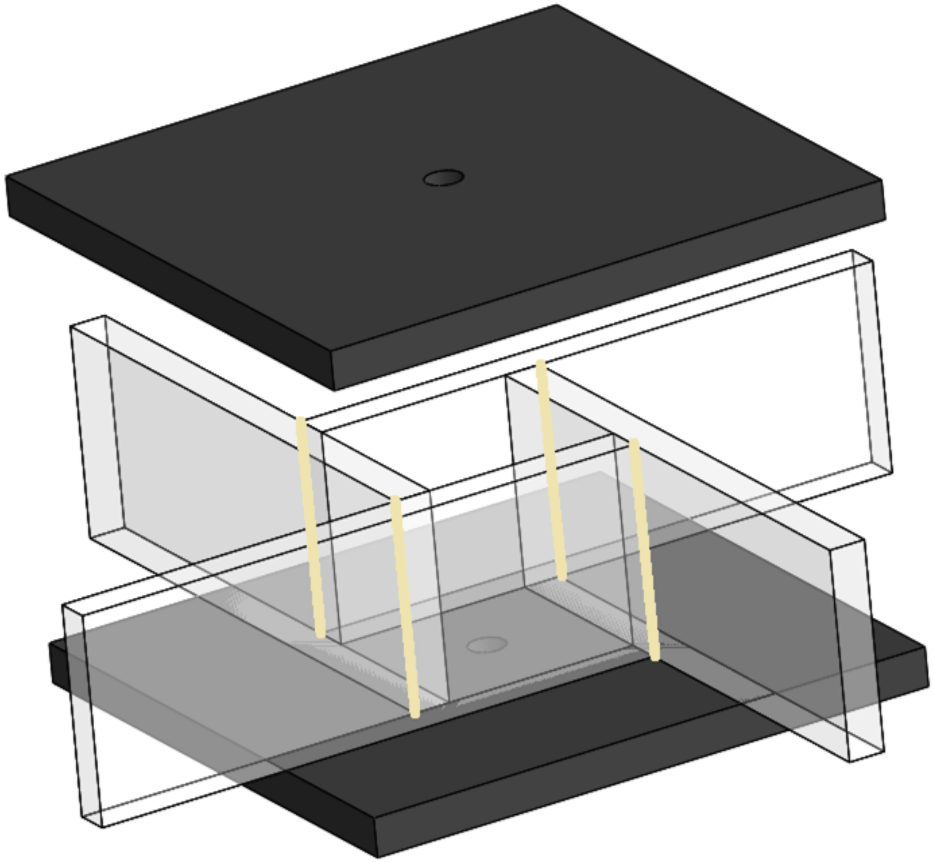


Figure 4. Jig used for filling cubic lattices.

# Cylindrical Jig

- Similar to the rectangular jig, the top and bottom mats are rubberized.
- Acrylic sides are held together by glue/silicone.
- Use of a release agent in order to remove the jig sides cleanly.

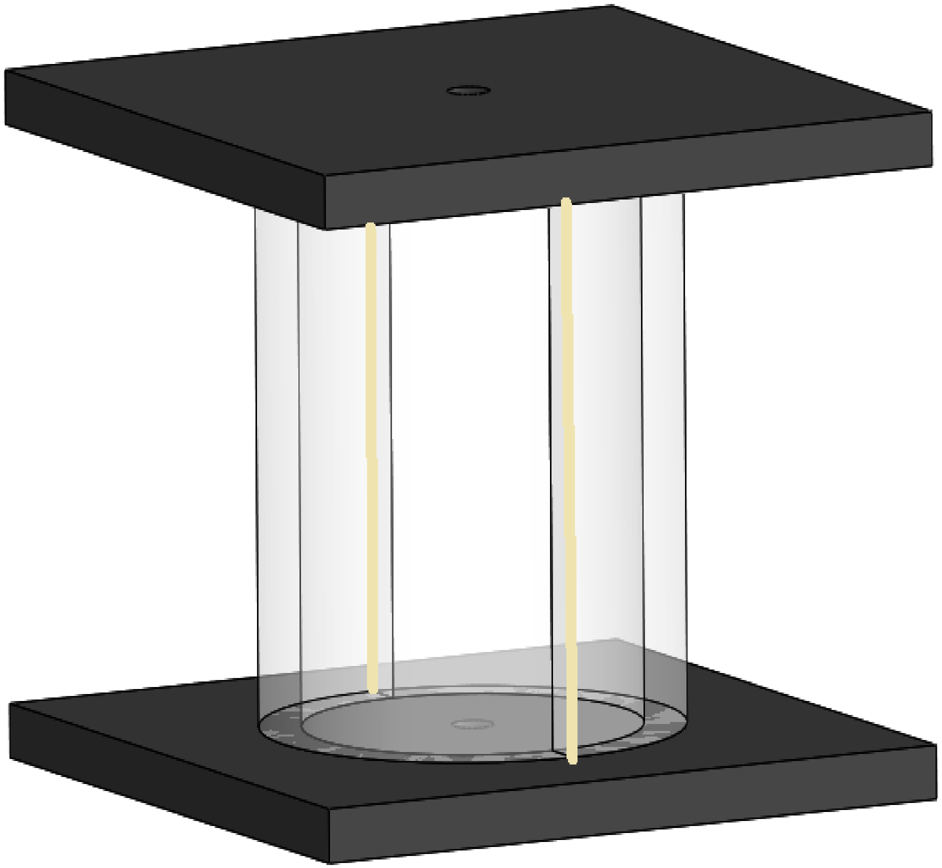


Figure 5. Jig used for filling cylindrical lattices.

# Catch Can

- Located in-line between the jig and vacuum pump.
- Allows excess silicone to drop into the catch can instead of being pulled into the vacuum pump.

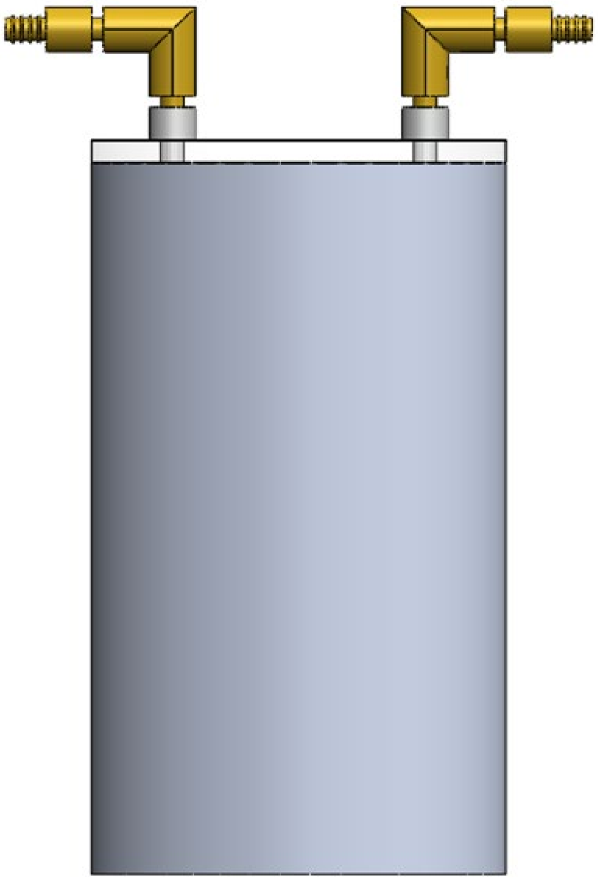


Figure 6. Catch Can.

# Additional Equipment

## Tubing and Gum Tape

Tubing transports silicone from vacuum chamber to the jig. Tape ensure strong seal.

Figure 7. Gum tape applied to vacuum tubing.

## Silicone Line Clamps

External line clamps will restrict the flow of silicone without getting plugged up.


Figure 8. Line clamp being used to slow fluid flow.

# Prototype Operation

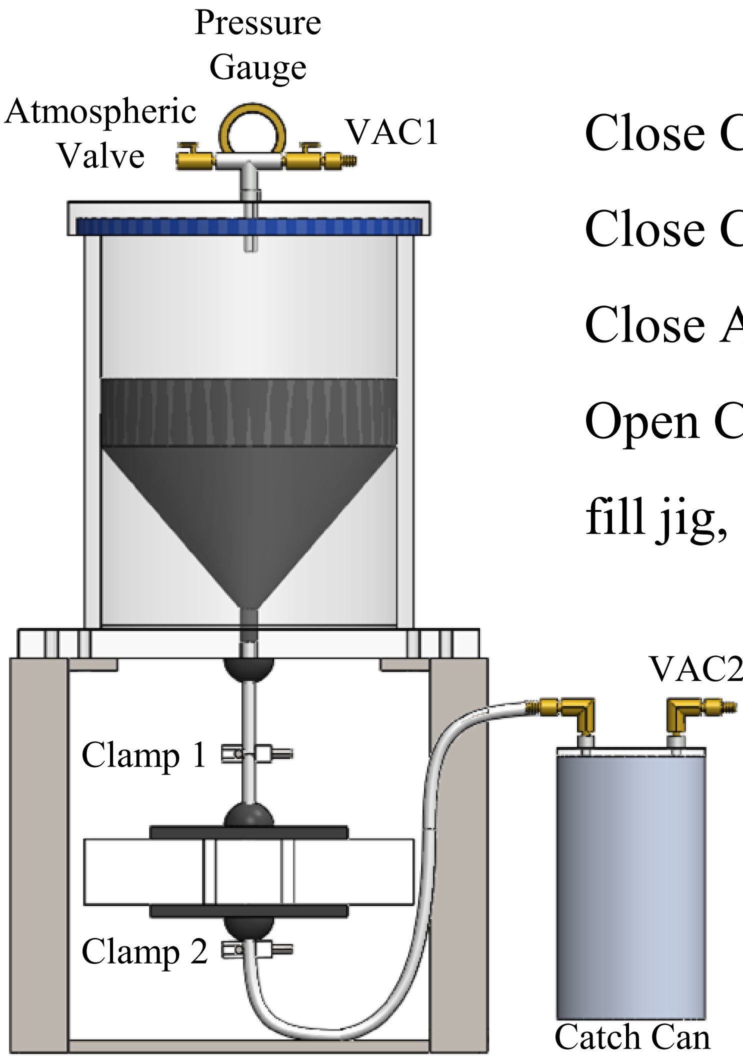


Figure 9. Full Assembly of infiltration prototype.

Close Clamp 2, Evacuate tank and jig via VAC1.

Close Clamp 1, Open Atmospheric Valve, Add silicone.

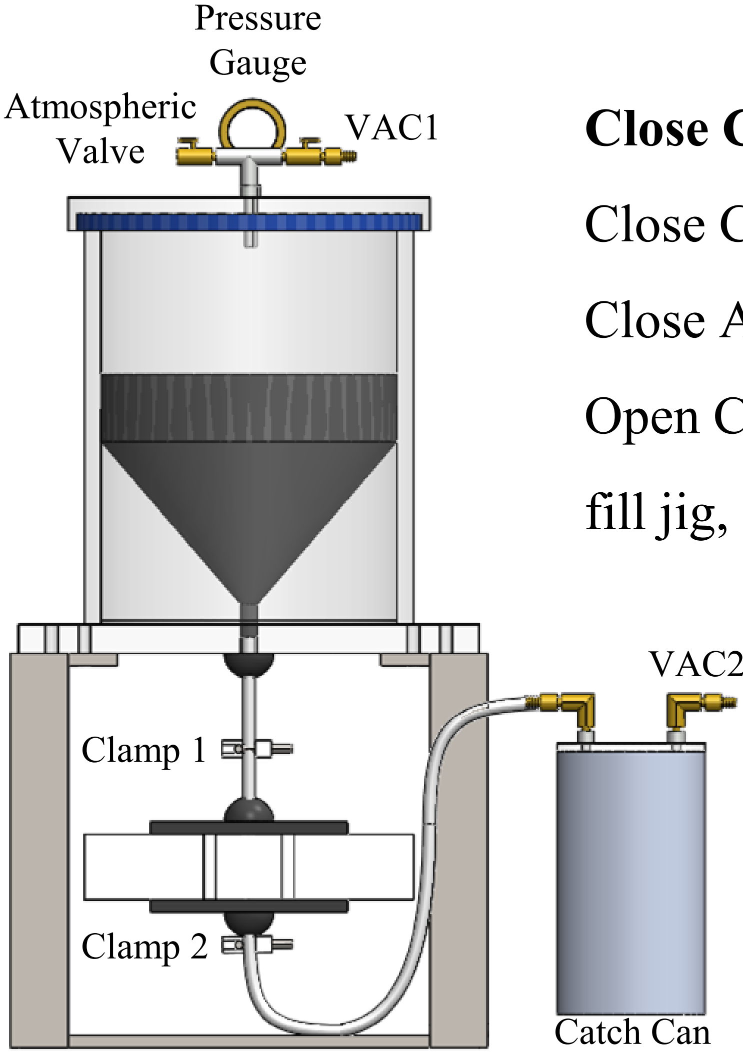
Close Atmospheric Valve, Degas via VAC1.

Open Clamp 1, Open Atmospheric Valve, Allow silicone to fill jig, Evacuate Catch Can via VAC2.

Open Clamp 2, Allow silicone to flow through jig into Catch Can.

Close Clamp 1 and Clamp 2, Detach jig, Allow silicone to cure.

# Prototype Operation



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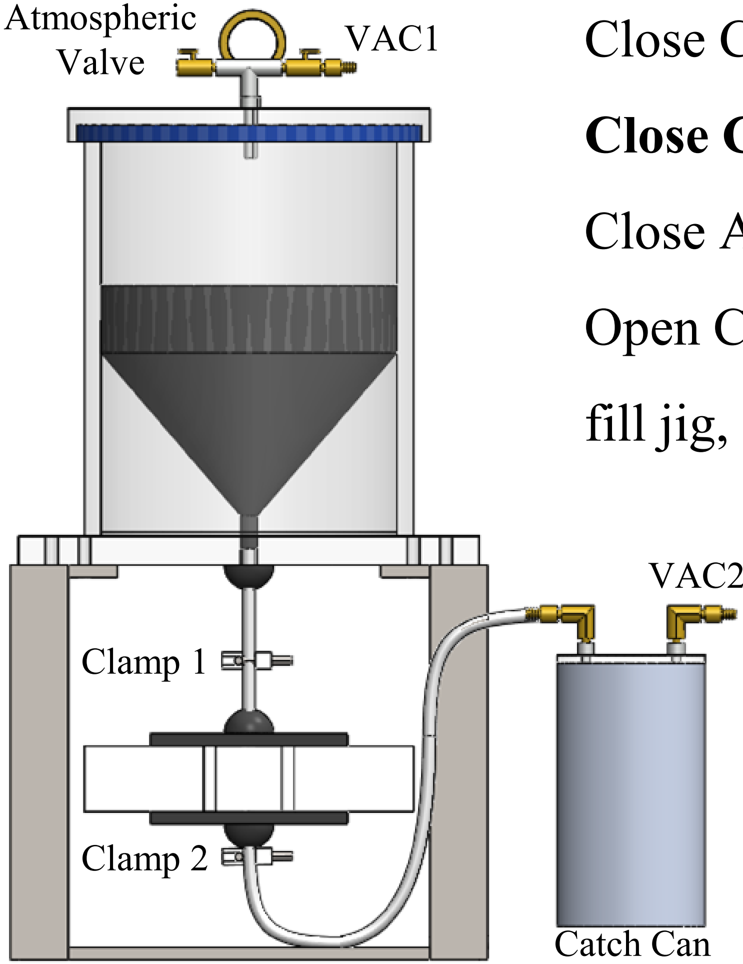

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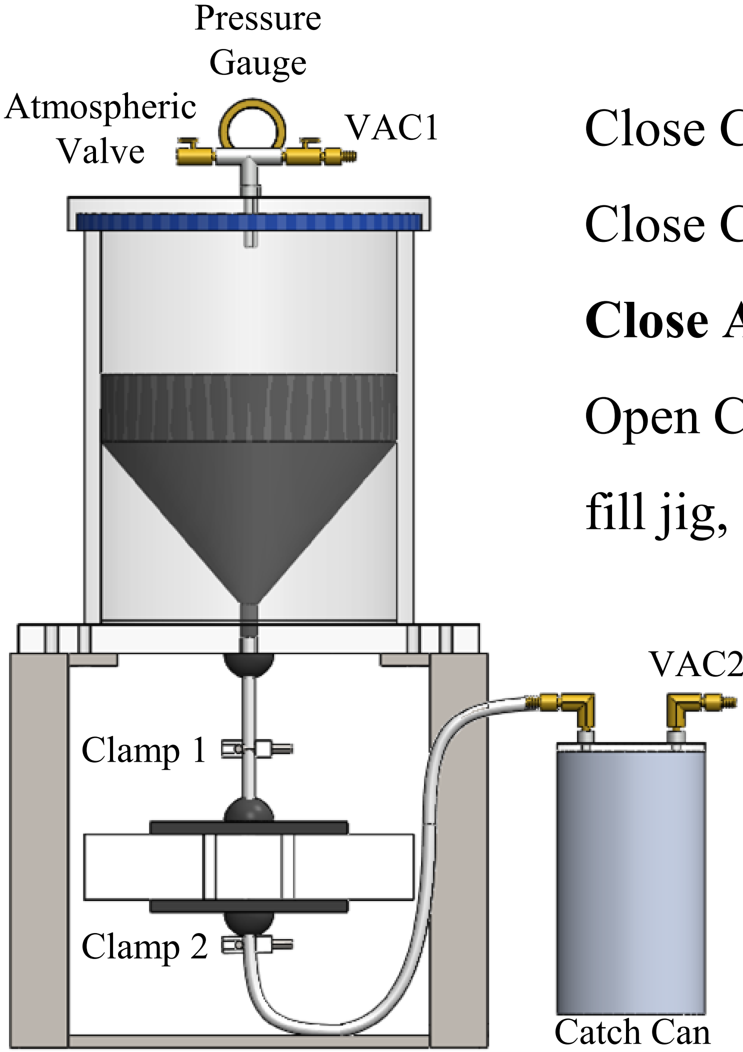

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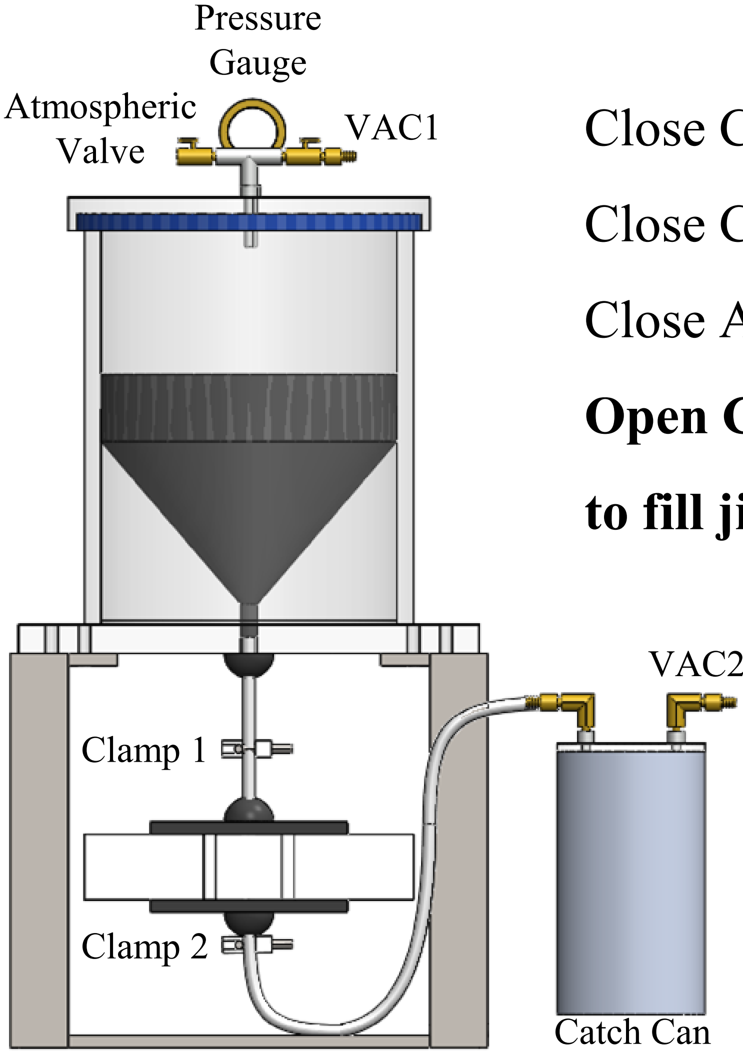

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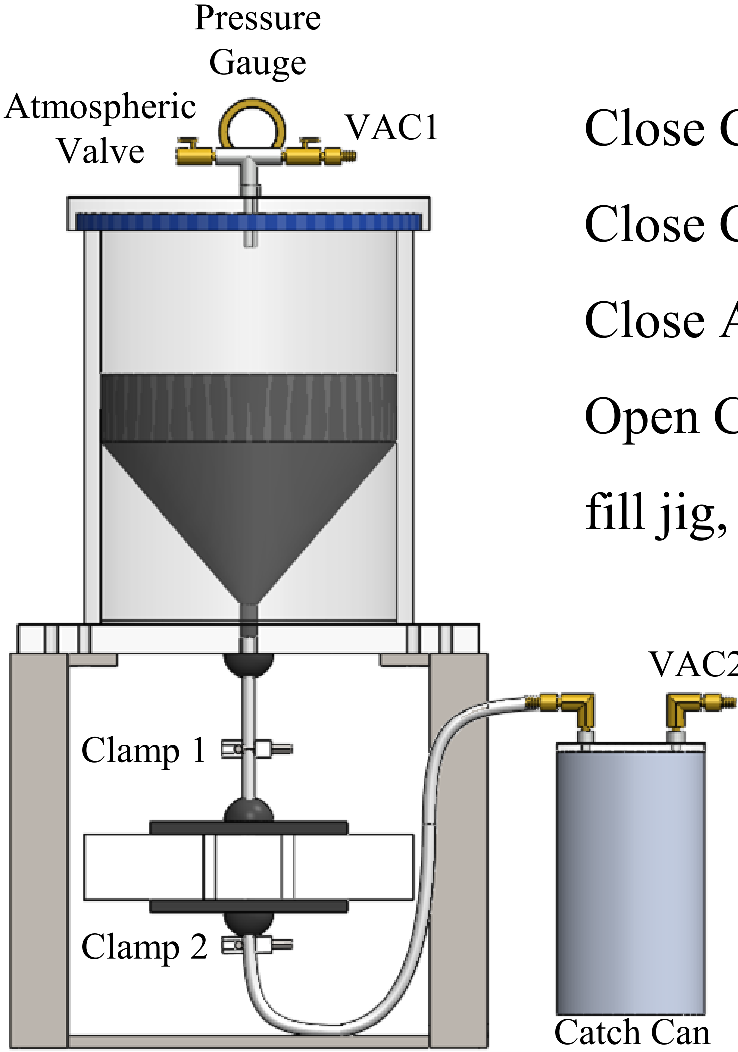

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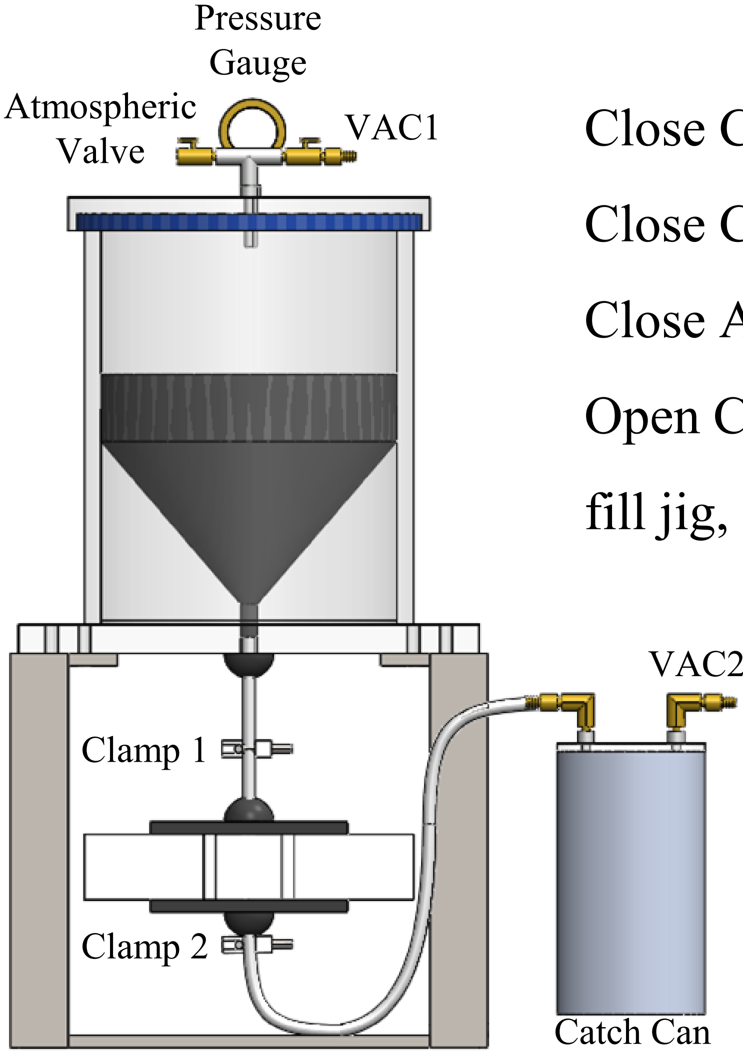

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# Project Status

# Parts Status

| Purchaser | Item | Quantity ordered | Quantity Received | Modification Required (Y/N) |
|---|---|---|---|---|
| FAMU-FSU COE | Sylgard 184 Silicone | 8kg | 8kg | N |
| | PLA | 1kg | 1kg | N |
| Eglin Airforce Base | Vacuum Resin Trap Catch | 1 | 1 | N |
| | Squeezee-Line Clamp | 2 | 2 | N |
| | Econo Tacky Tape | 1 | 1 | N |
| | vacuum tube 1/4 in | 2 | 2 | N |
| | pipe brass hose bard | 1 | 1 | N |
| | quick connect release kit | 1 | 1 | N |
| | quick connect nipple | 1 | 1 | N |
| | leak free bulkhead | 1 | 1 | N |
| | gas ptfe tape | 1 | 1 | N |
| | vac gauge 1/4 in | 1 | 1 | N |
| | hvac flare | 1 | 1 | N |
| | cast acrylic (14in x14in) | 2 | 2 | Y |
| | cast acrylic (12in. x36in.) | 1 | 1 | Y |
| | cast tubing | 1 | 1 | N |
| | vacuum pump | 1 | 1 | N |
| | plain steel angle | 2 | 2 | Y |
| | 3/16 A36 plate 2ftx2ft | 1 | 1 | Y |

Figure 10. Part Acquisition chart

# Assembly and Modification

- Acrylic plates - machined via router, clearance holes added for bolts, channels added to create vacuum seal
- Sheet metal - cut on water jet from stock plate to form brackets, welded to form stand
- Acrylic plates for jig
    - Machined
    - Rubberized

# Projected Spring Progression

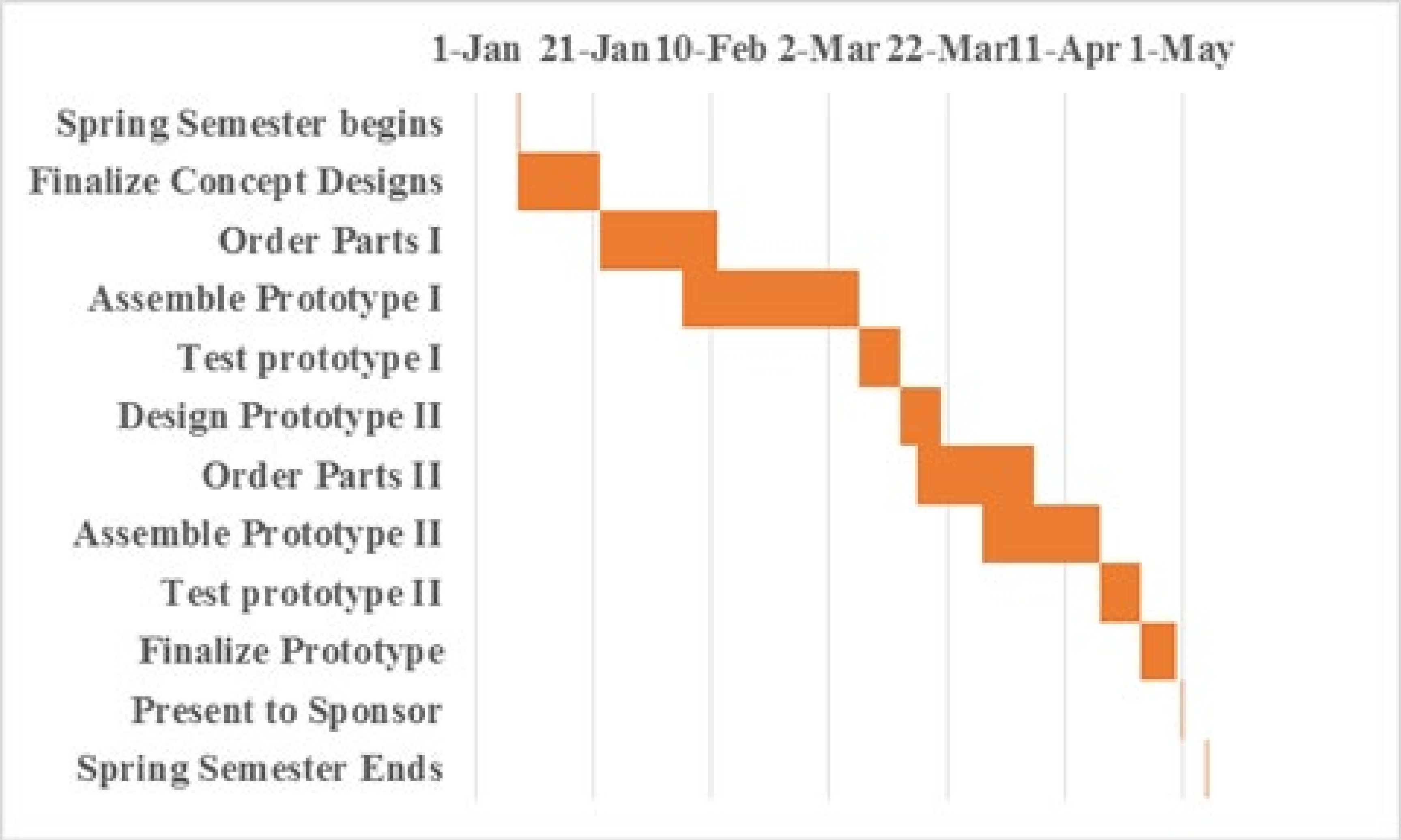


Figure 11. Spring Semester Gantt chart

# Actual Progression

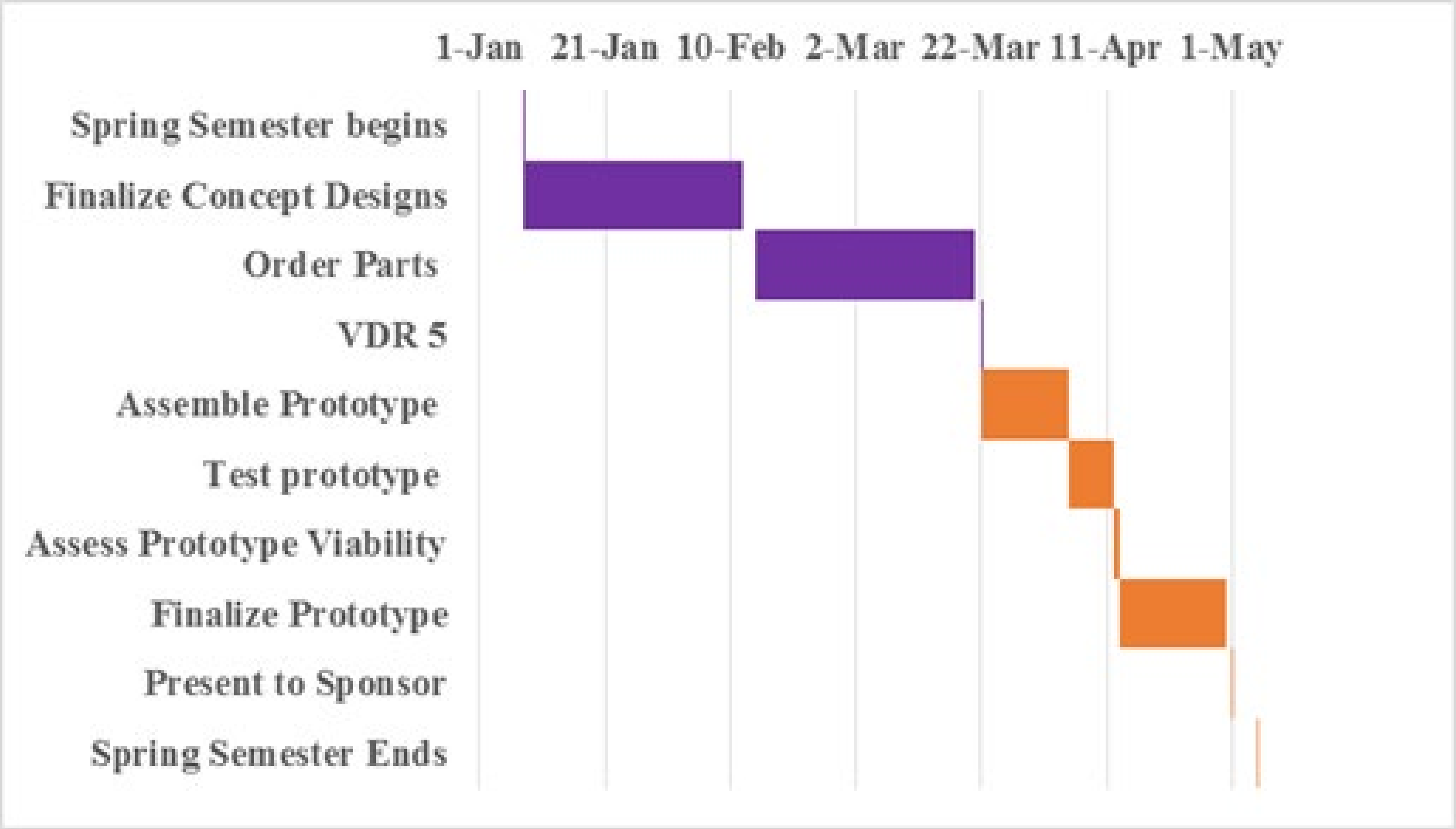


Figure 12. Actual Progression Chart

# What happened?

- Decision was made to consolidate to one prototype
    - Pros
        - Able to fully flesh out design
        - Able to commit full budget to one mechanism
        - Saves time in ordering parts
    - Cons
        - High cost of error

# What happened?

- Part acquisition was not as speedy as projected
    - Issues with budget allocation
    - Dividing purchase requests between institutions
- Utilized many different places for part modification

# Project Future

- Deliver finalized design to AFRL with operation and safety manual
- Hand off documentation to Dr. Okoli

# Summary

- Built prototype through iterative design
- Negotiated for adequate funding to finish project and obtained good results
- Learned valuable team working skills

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# Questions?