Matthew T. Wheeler, *Department of Mechanical and Aerospace Engineering*, Faculty Advisor: Dr. Jason Armstrong

---

### Design Requirements and Desired Outcomes

In order to achieve the proof of concept being sought careful consideration was utilized to ensure that the scaled model met the requirements of the design as well as accurately represented the full scale model.

**Requirements:**
- Utilize hinges to demonstrate functional rotation of system under loading
- Maintain structural integrity under loading
- Provide similar means of access to full scale model
- Utilize identical “spring locking” components as full scale

**Desired Outcomes:**
- Validate system operation
- Validate spring force calculations with real life loading application
- Identify areas of potential or necessary redesign
- Maintain an effective project budget

---

### Project Management

In order to maintain effective project management, time was also allocated to ensuring proper documentation and reporting of findings. Weekly goals were mapped and discussed to ensure the project remained on schedule. This especially became important when certain components in the machine shop required extended periods to manufacture due to their size or difficulty in machining. Furthermore, Microsoft Excel was used to track all component costs with suppliers and dates of order.

![Vendor Table](table.png)

---

### Technical Overview

#### Methodology

This project was firstly started in MAE 377 and progressed into MAE 498 with CURCA funding. The initial steps of the project surrounded generating a concept, creating a 3D model, conducting Finite Element Analyses, and finally creating component level detail drawings. Once funding was procured in MAE 498, a new scaled model was designed and analyzed.

1. Generate concept
2. Create 3D model using PTC Creo
3. Complete FEA of components
4. Generate detail drawings
5. Complete component cost analysis
   - Determine steel vs. aluminum components
6. Work with Engineering Machine Shop to create manufacturing plans
7. Manufacture and assemble components
8. Test and Validate System

---

### Results/Areas of Future Interest

After completing the digital analysis and physical testing a few main issues were noted that should be addressed moving forward.

- All components should be steel for toughness strength – aluminum began to displace after extended testing
- NC or CNC based machining is required to ensure tolerancing amongst components remains intact
- A “ratchet” or similar style system should be investigated to maintain spring position once it has been begun to be displaced
- Utilize additional screws in brackets to reduce prevent rotation as forces are applied (scaled model only)

---

### Analysis

The foremost analysis conducted in this proof of concept was done use PTC Creo’s Finite Element Analysis software. This analysis demonstrated that the maximum stresses applied to the “push guard” would not cause the material to yield while allowing the material thickness to be optimized to its smallest acceptable value.

- FEA demonstrated it was possible to optimize thickness from 0.5” to 0.25” while maintaining a maximum von Mises Stress of 600 PSI, well below the yield stress of mild steel.

Physical testing of the prototype demonstrated that although for small scale testing aluminum was an acceptable material choice, for actual production steels hardness and toughness would be required for component longevity.

Using a push/pull force gauge, an average force of 100lbs over a 30” moment arm (tool as seen in figure 3) was calculated, resulting in an applied force of about 3000lbs. This was used to generate necessary spring constants as well as material requirements.

---

### Recommendations

A special thank you to the following Faculty/Staff/Mentors for their support and guidance!

- Dr. Jason Armstrong
- Professor Phillip Cormier
- Jarvis Hall Engineering Machine Shop Staff
- Captain Mike Leiston, Chili Fire Department
- All the staff of CURCA