Miniature Bomb Rack Unit

Mechanical Engineering, COE

Casey Brown

Cyril John

Bryan Rickards

Sponsor: Russell Roberts, Safety Engineer

April 12, 2012

Overview

- Problem Statement
- Product Specifications
- Concept Generation
- Final Design
  - Pneumatics
  - Ejector
  - Safety Block
  - Sway Brace
- Prototype
- Results and Discussion
  - Velocity Analysis
  - Weight Analysis
  - Landing Shock
  - Safety Block
- Cost Analysis
- Problems
- Conclusion

Problem Statement

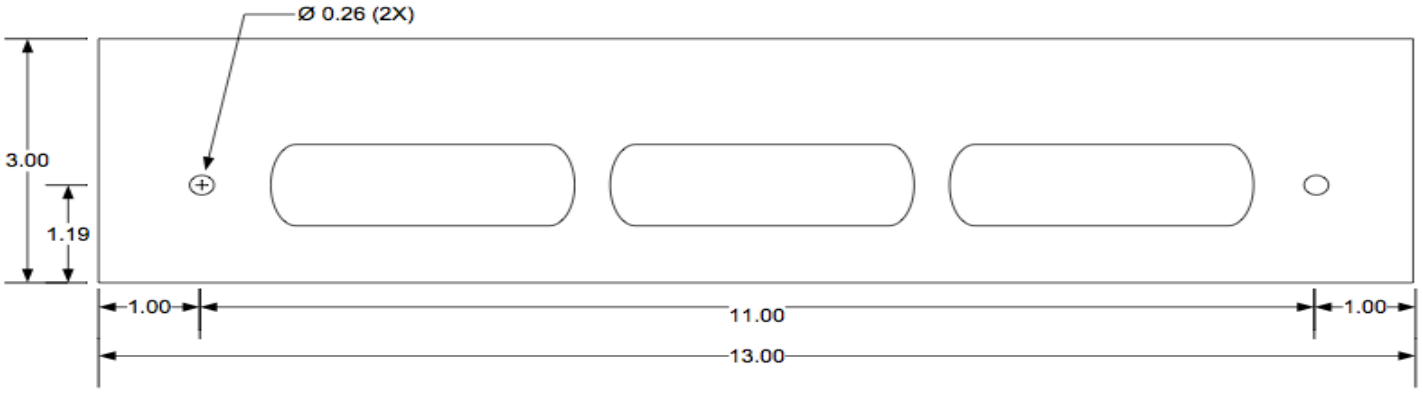
- Design and develop a Bomb Rack Unit (BRU) that is attached to the Tigershark UAV capable of housing and launching a cylindrical payload.
- BRU must contain an electrical interface that allows the user to go through a safety sequence before the payload is released
- Construct a working prototype

Tigershark UAV Platform

Specifications:

- Wing span 21 feet
- Empty airframe weight - 150 lbs.
- Gross take off weight - 300 lbs.
- Payload capacity – 50 lbs.
- One hard-point location per wing for launcher attachment

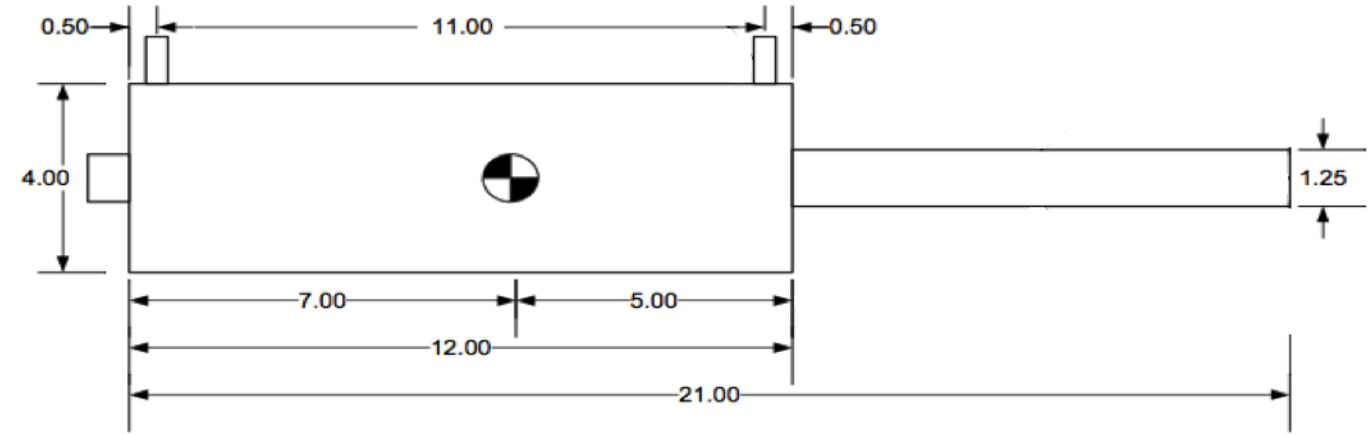
Pylon Location



Made from 1" thick Aluminum
Tolerance +/- 0.05"

Constraints

- BRU must not exceed 5 lbs
- Capable of holding a payload that is 10 lbs
- Achieve an ejection velocity of at least 4 ft/s
- Retain payload during aircraft maneuvers up to 2G lateral load and 1G landing shock.
- Use lanyard pull to arm payload
- Budget - $2000



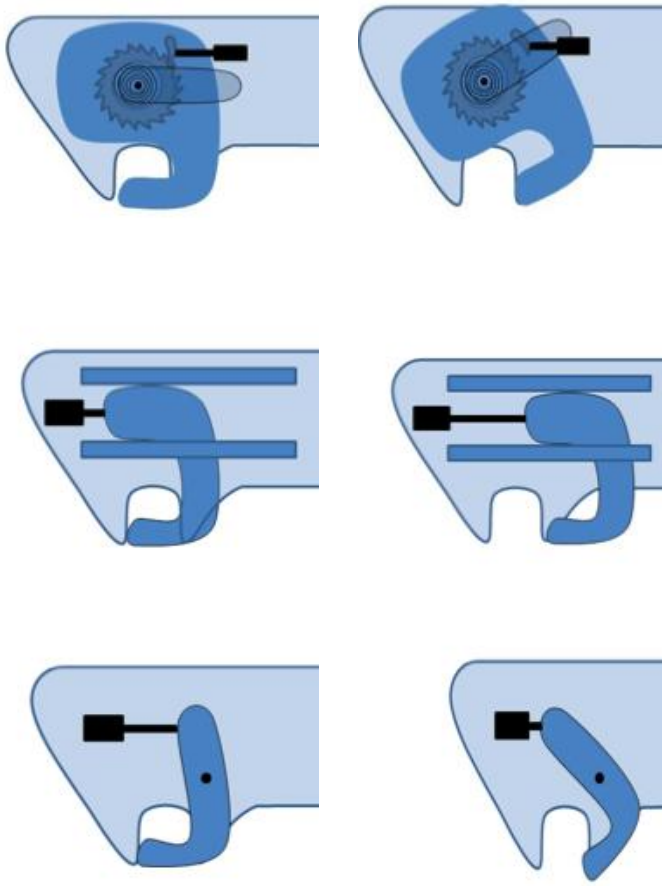
Weight = 10lbs

Concept Generation

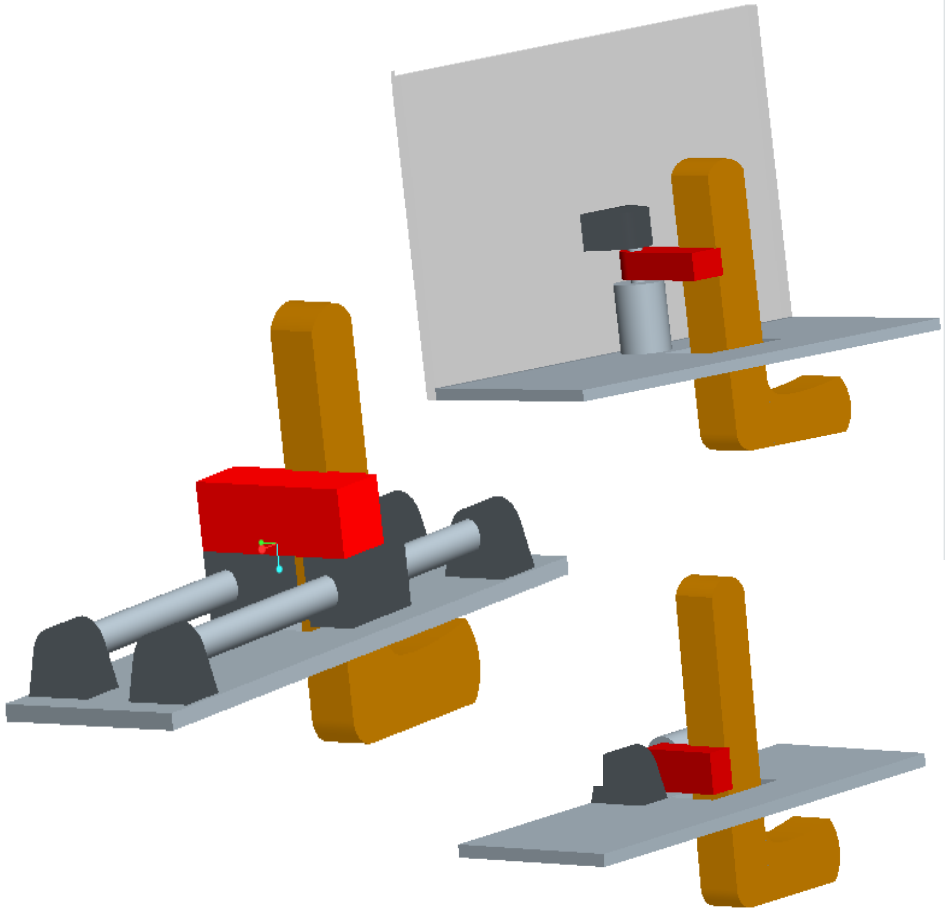
- Design was broken into 4 main subsystems
  - Hook Assembly
    - Carries/Releases Payload
  - Mechanical Safety
    - Prevents any misfires
  - Sway Brace
    - Stabilizes payload during airplane maneuvers
  - Ejector Mechanisms
    - Ejects payload safely from BRU

Concept Generation

Hook Release



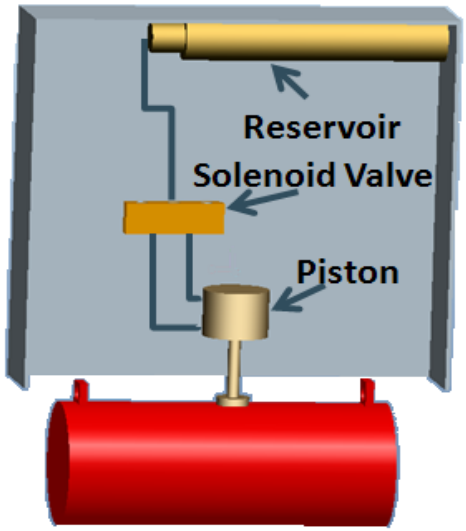
Safety Block

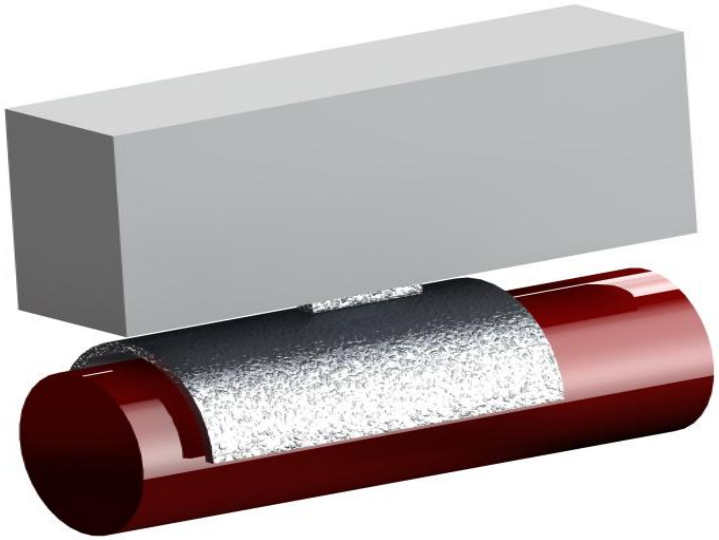


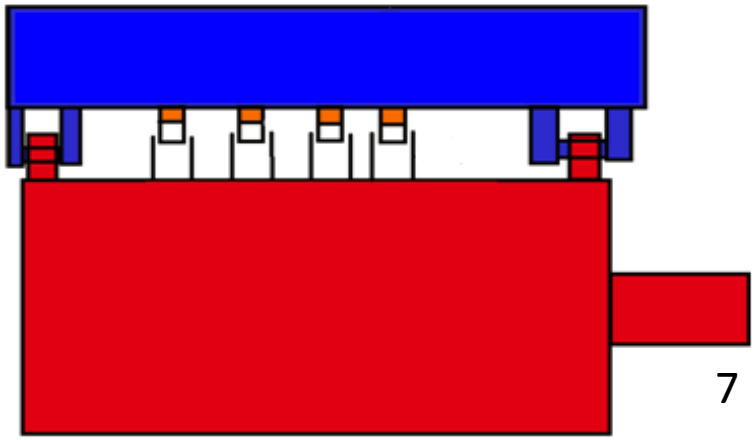
Concept Generation

Sway Brace

Ejector Mechanism





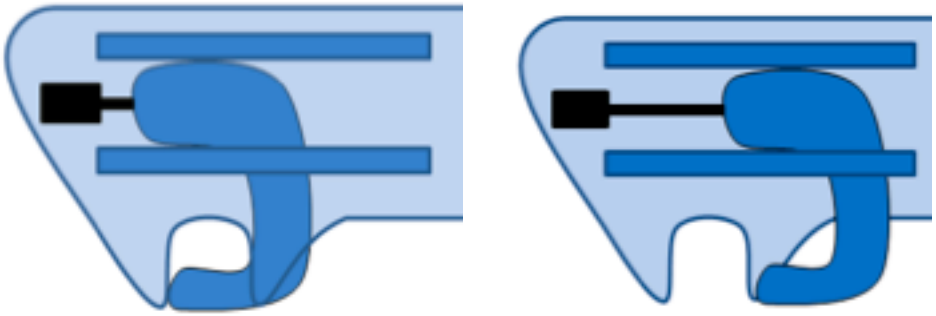


Selection Criterion

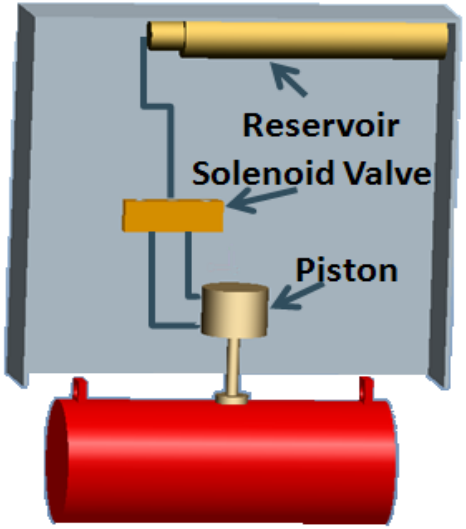
- **Hook Release**
  - Compactness
  - Weight
  - Strength
  - Operational Speed
- **Safety System**
  - Compactness
  - Weight
  - Strength
  - Speed
- **Sway Brace**
  - Weight
  - Load carrying
  - Size Flexibility
  - Simplicity
- **Ejector Mechanism**
  - Weight
  - Size
  - Cost
  - Safety
  - Simplicity

Final Concepts

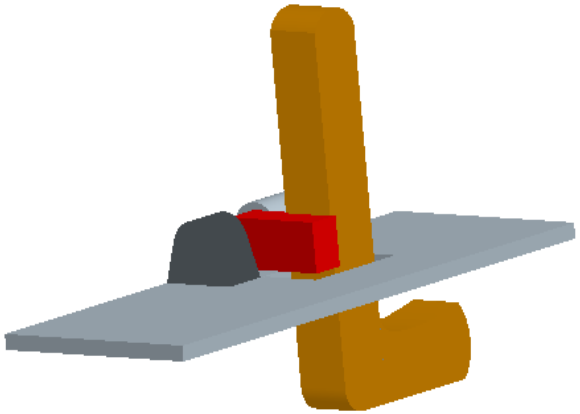
Hook Release



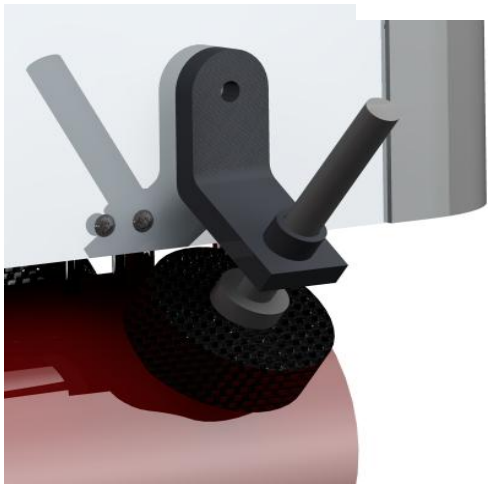
Ejector Mechanism



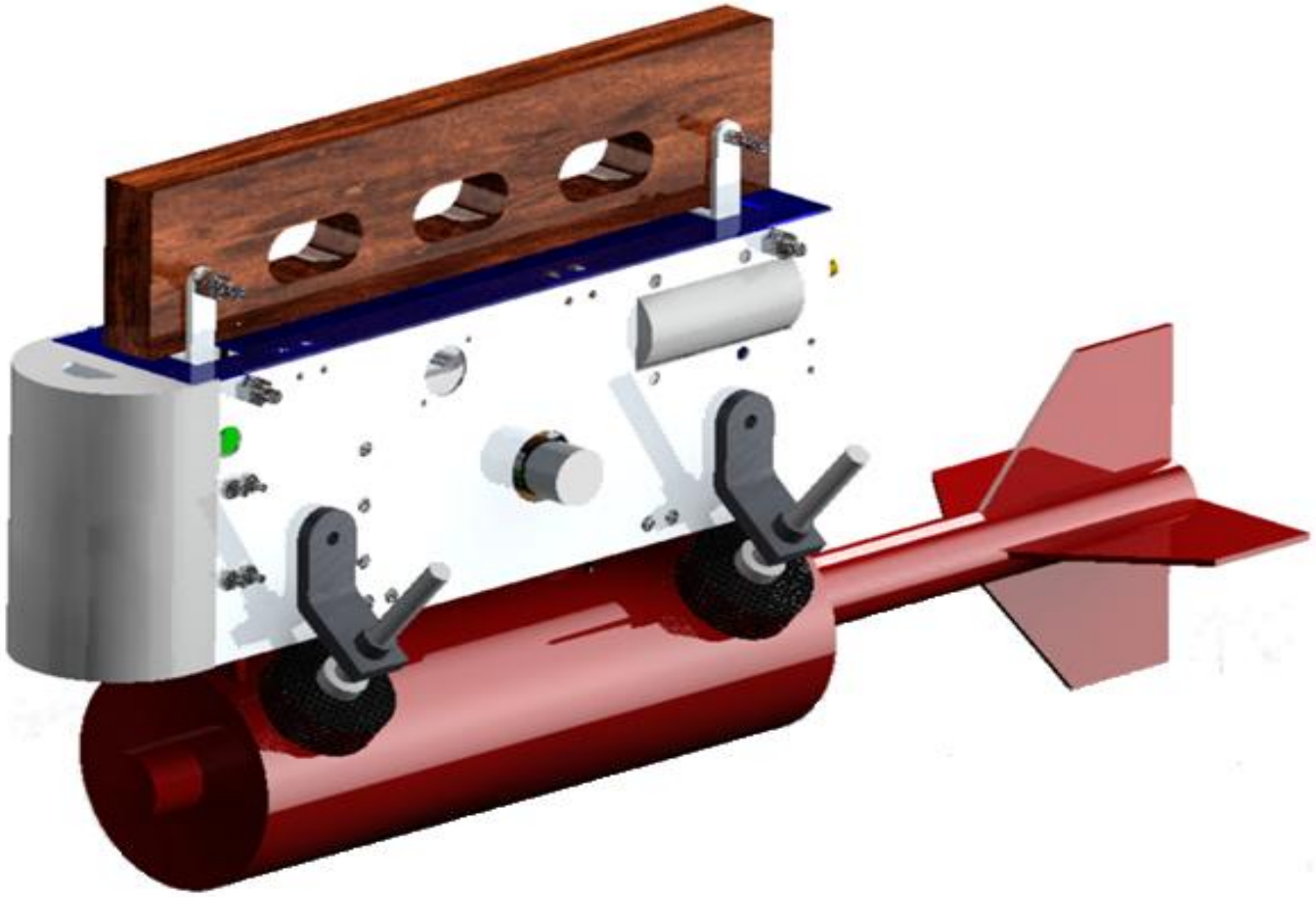
Safety Block



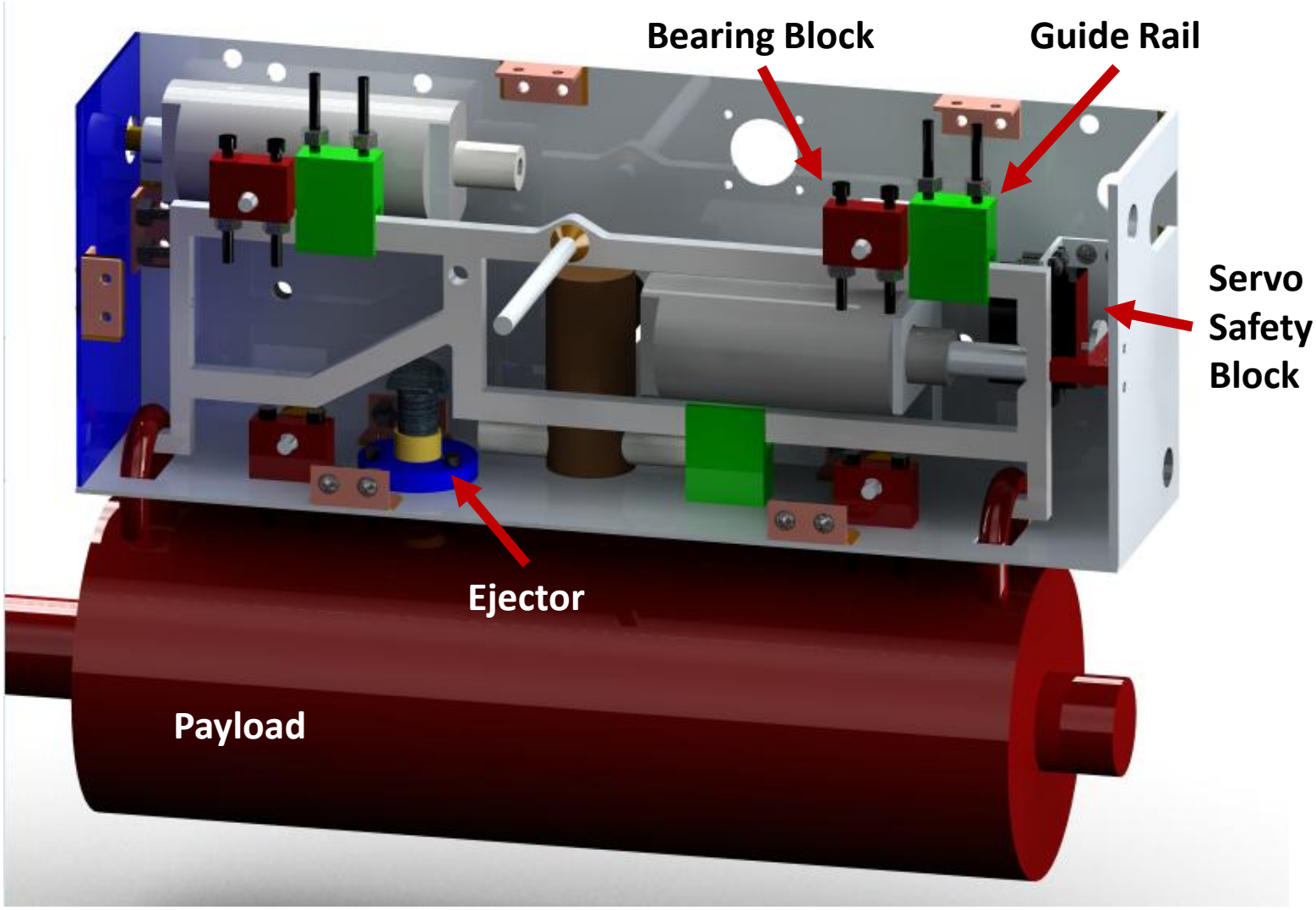
Sway Brace



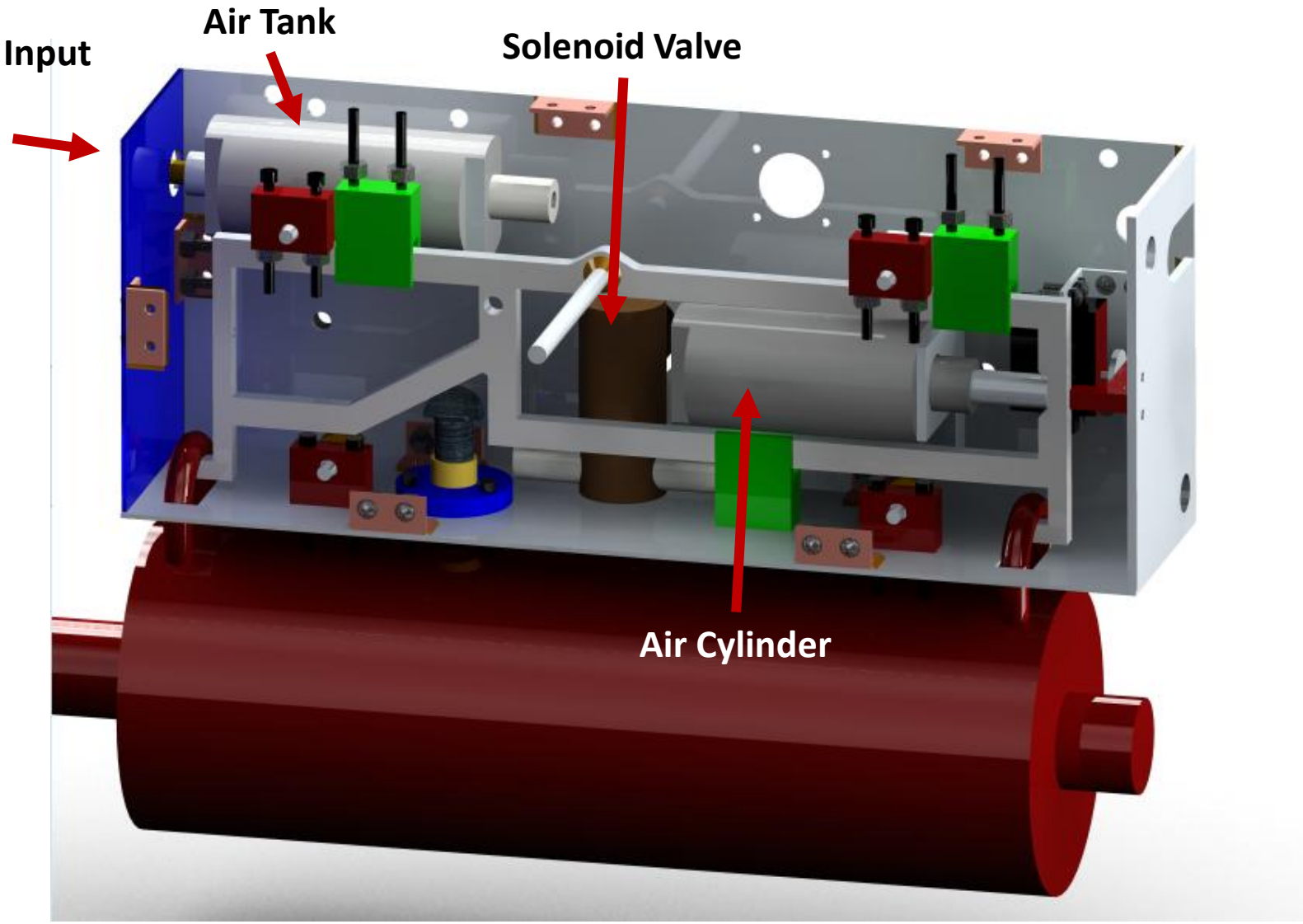
Final Design



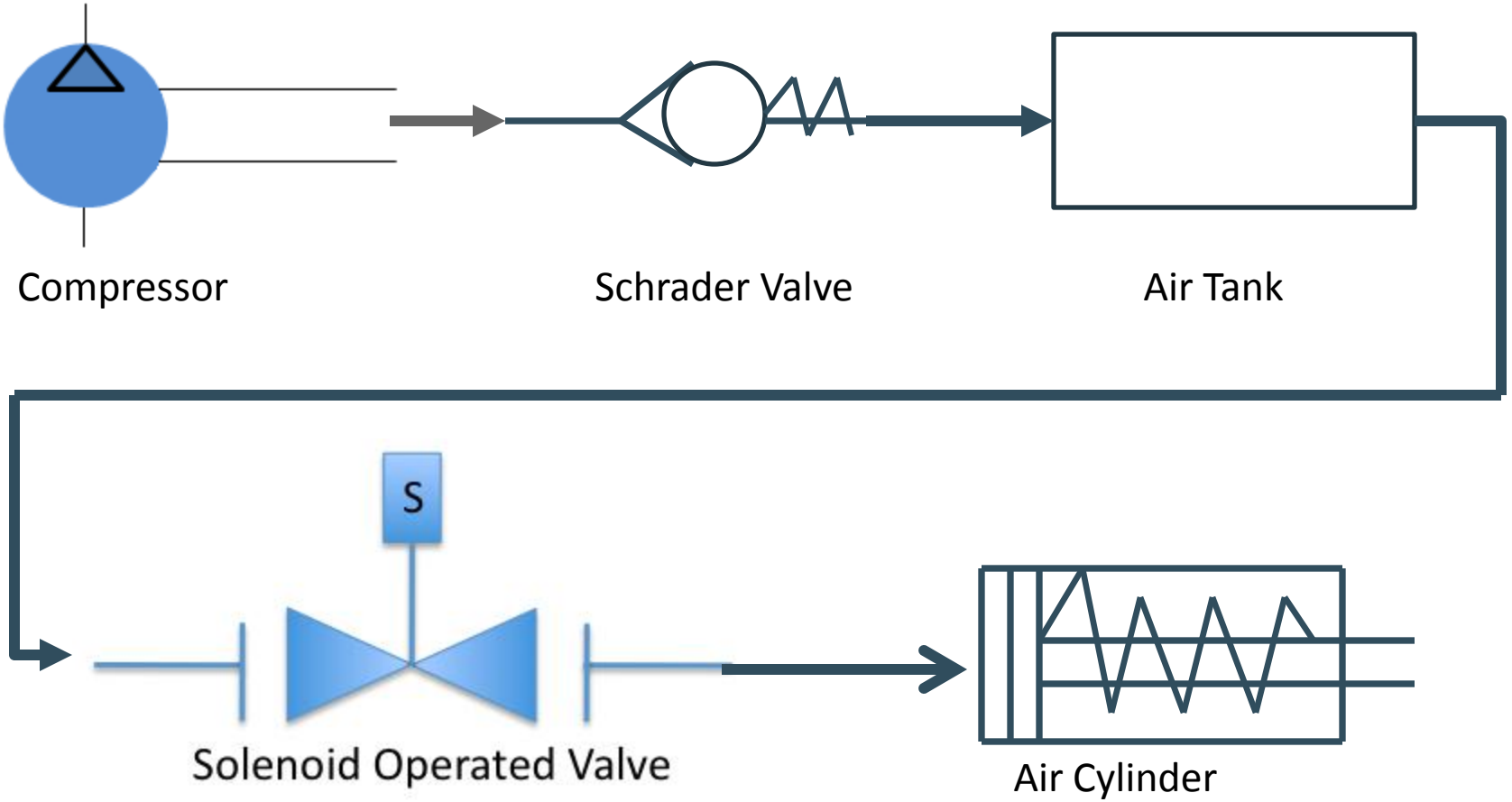
Final Design (Mechanics)



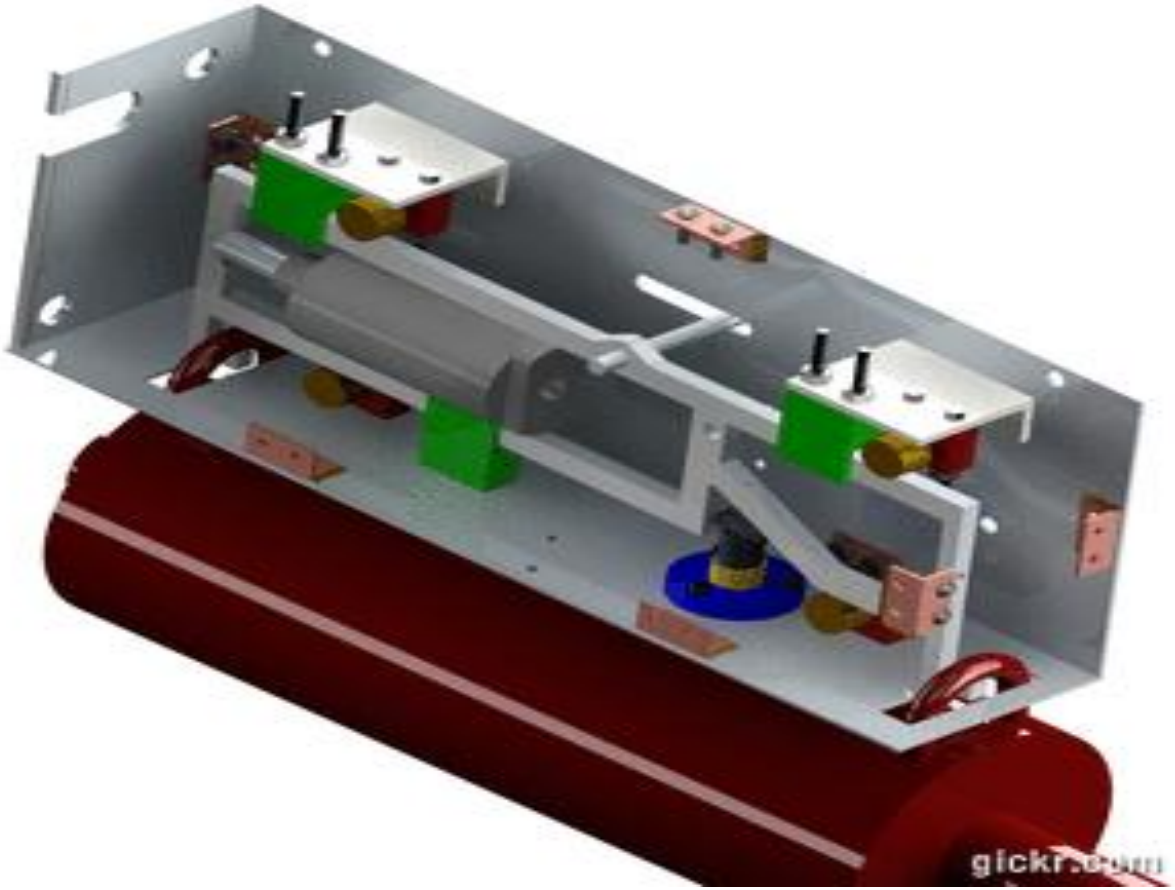
Final Design (Pneumatics)



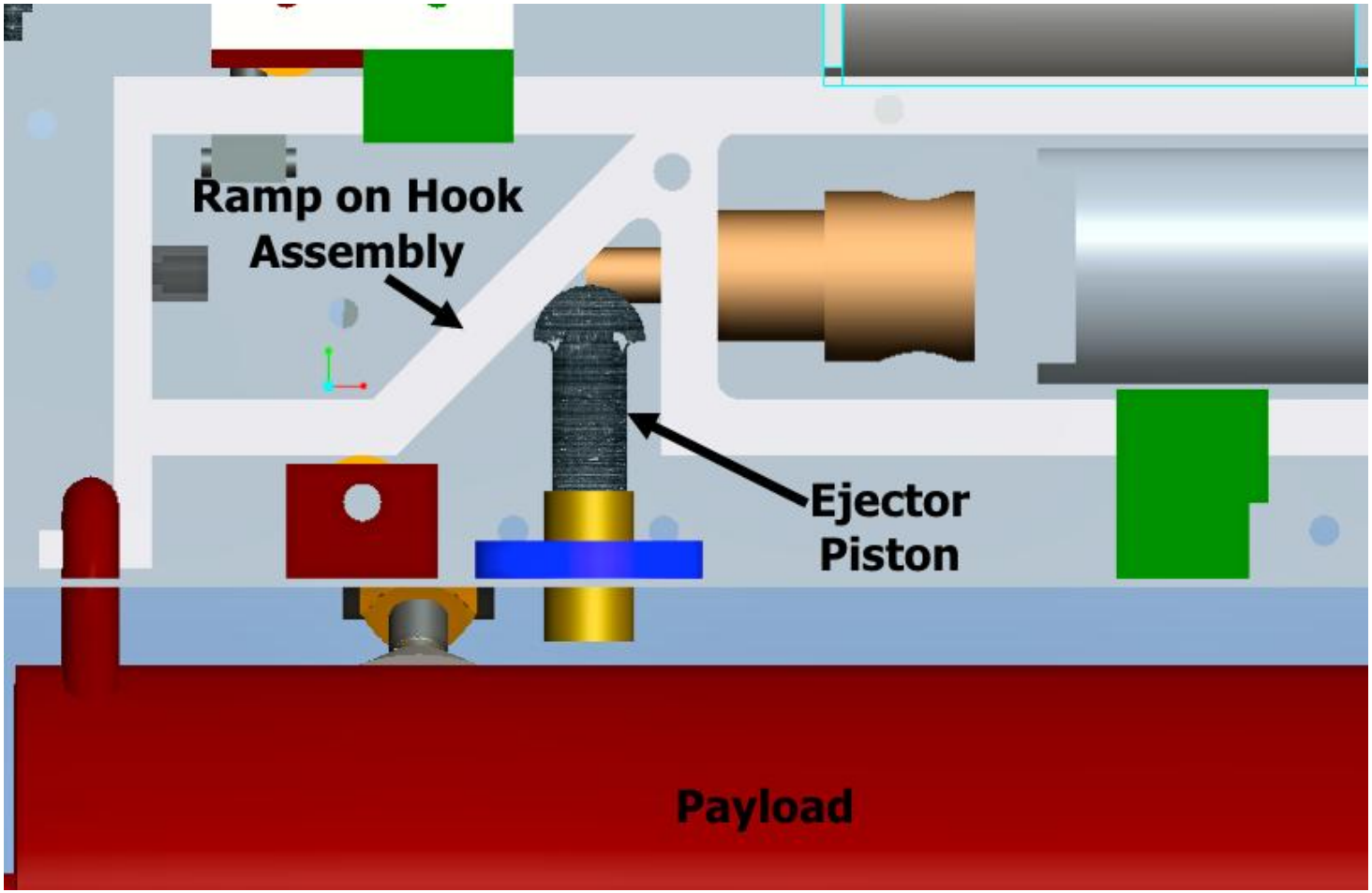
Pneumatic System



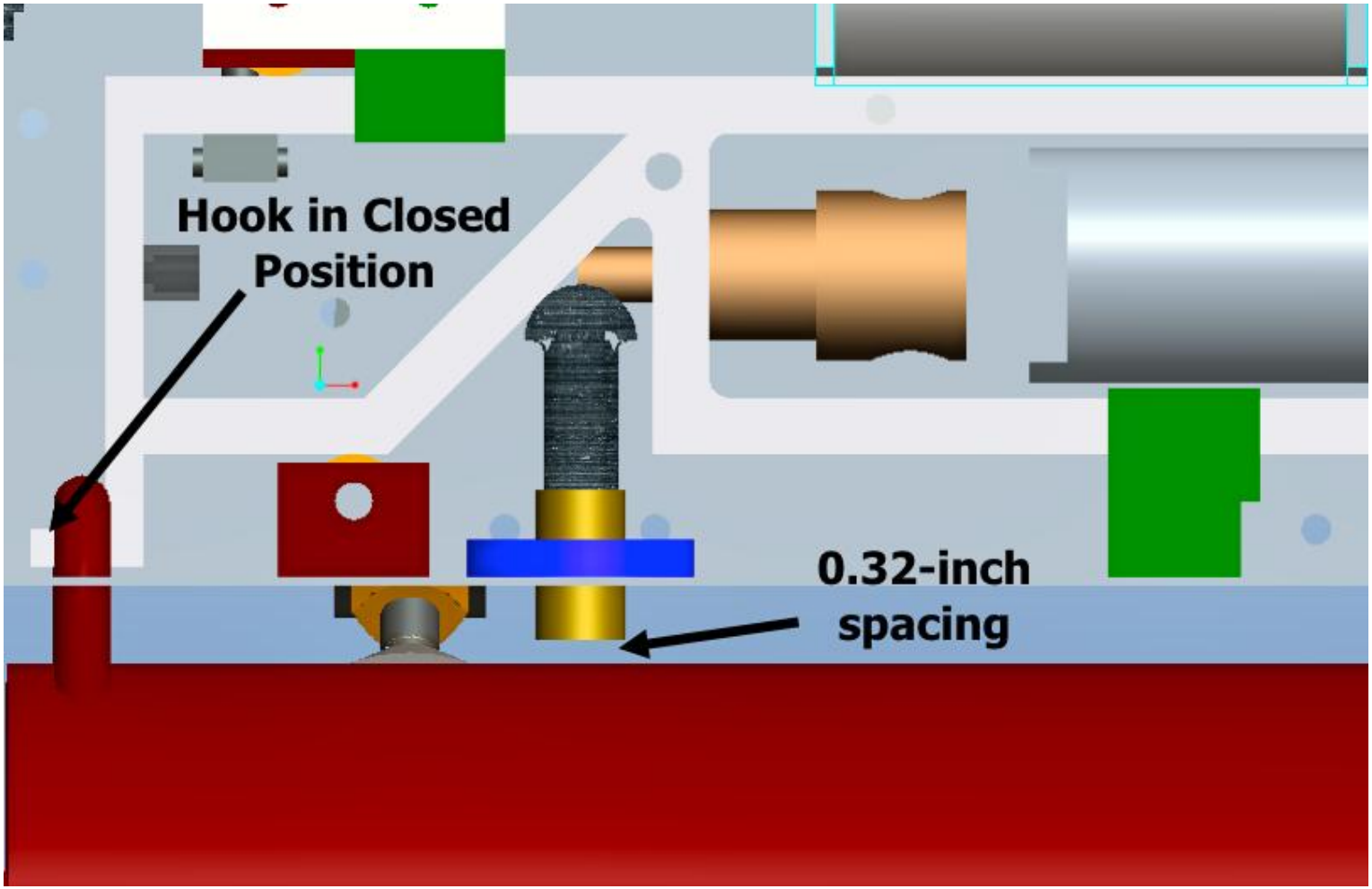
Hook Assembly



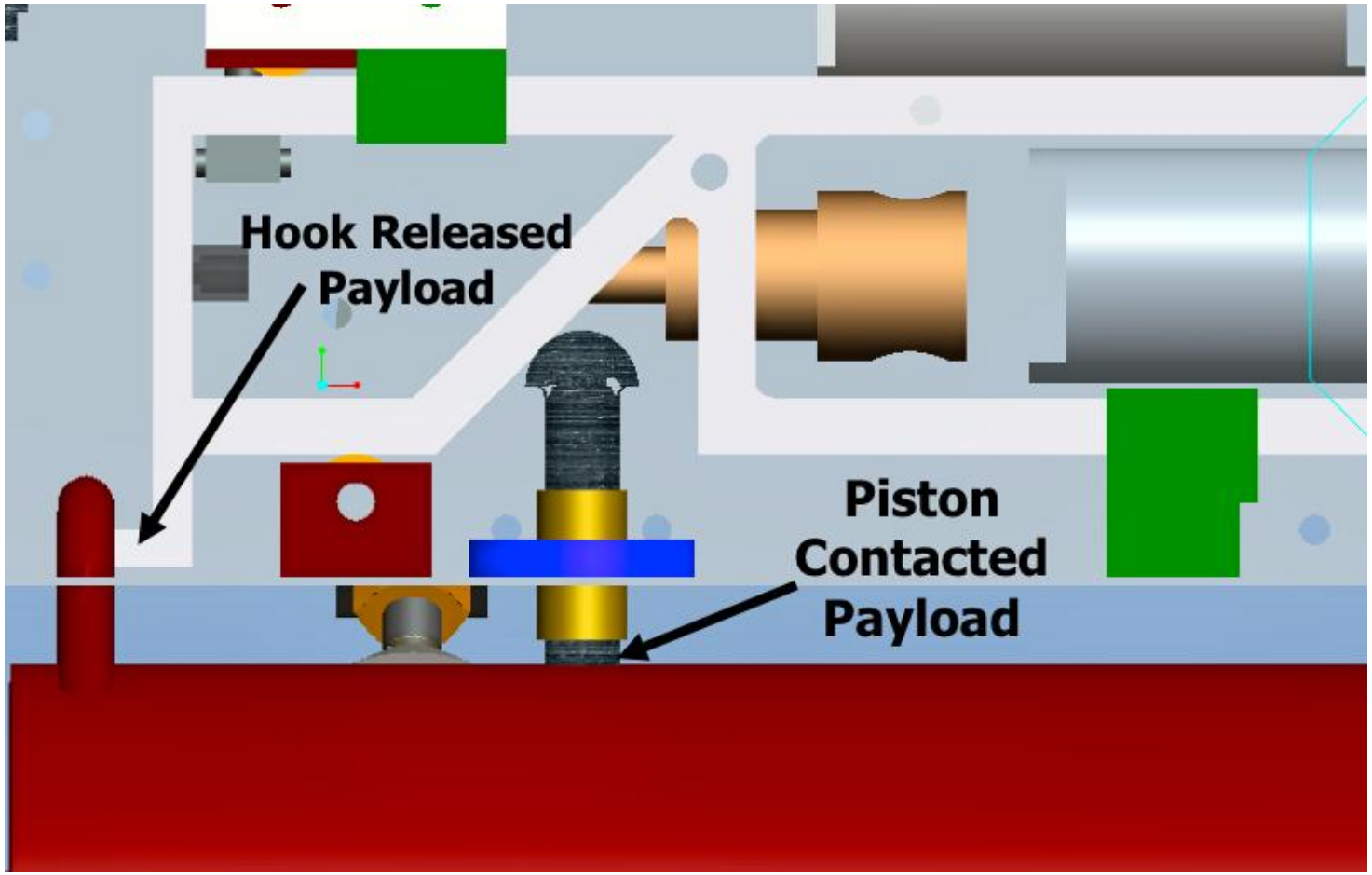
Ejector System



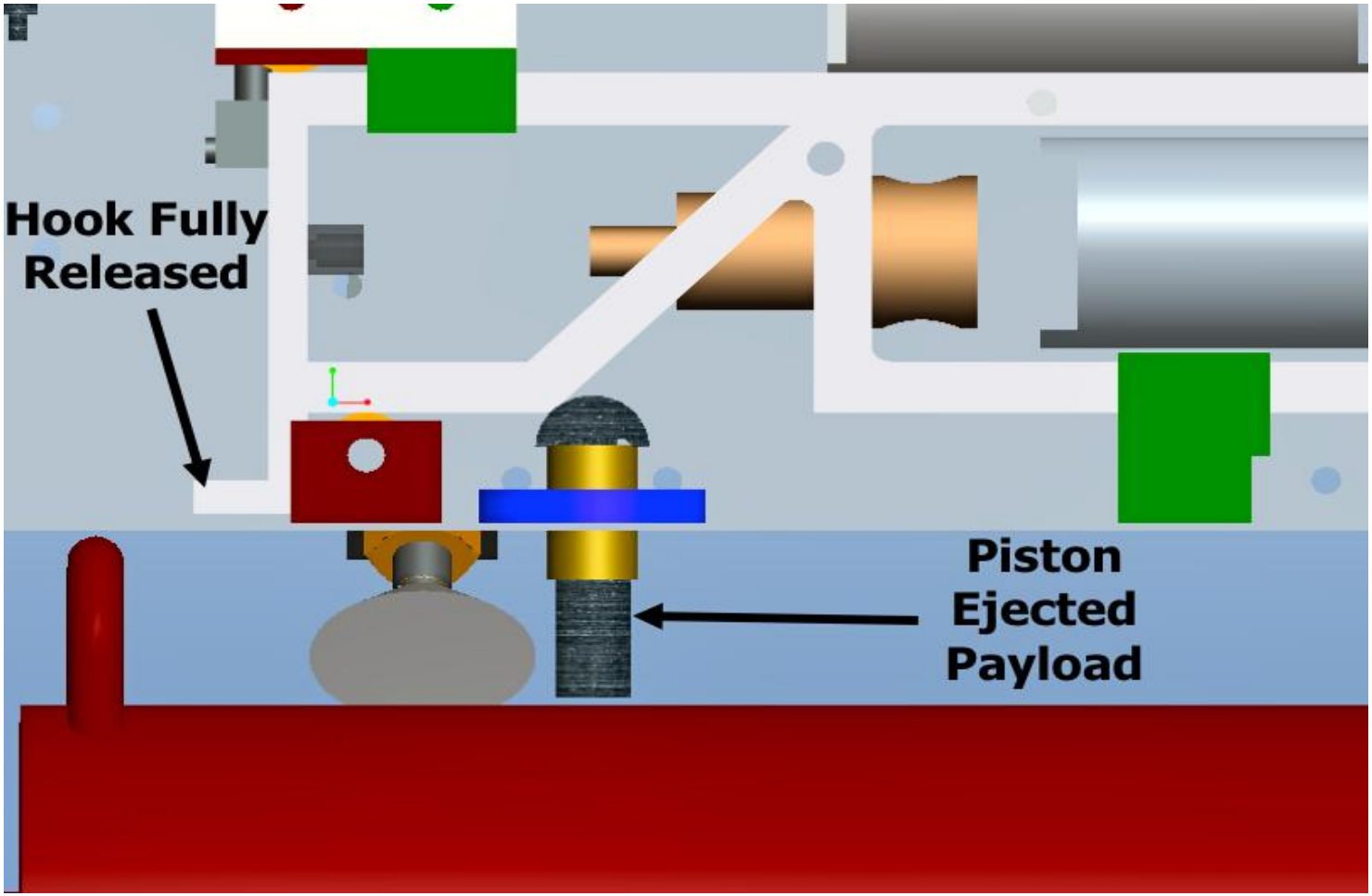
Ejector System



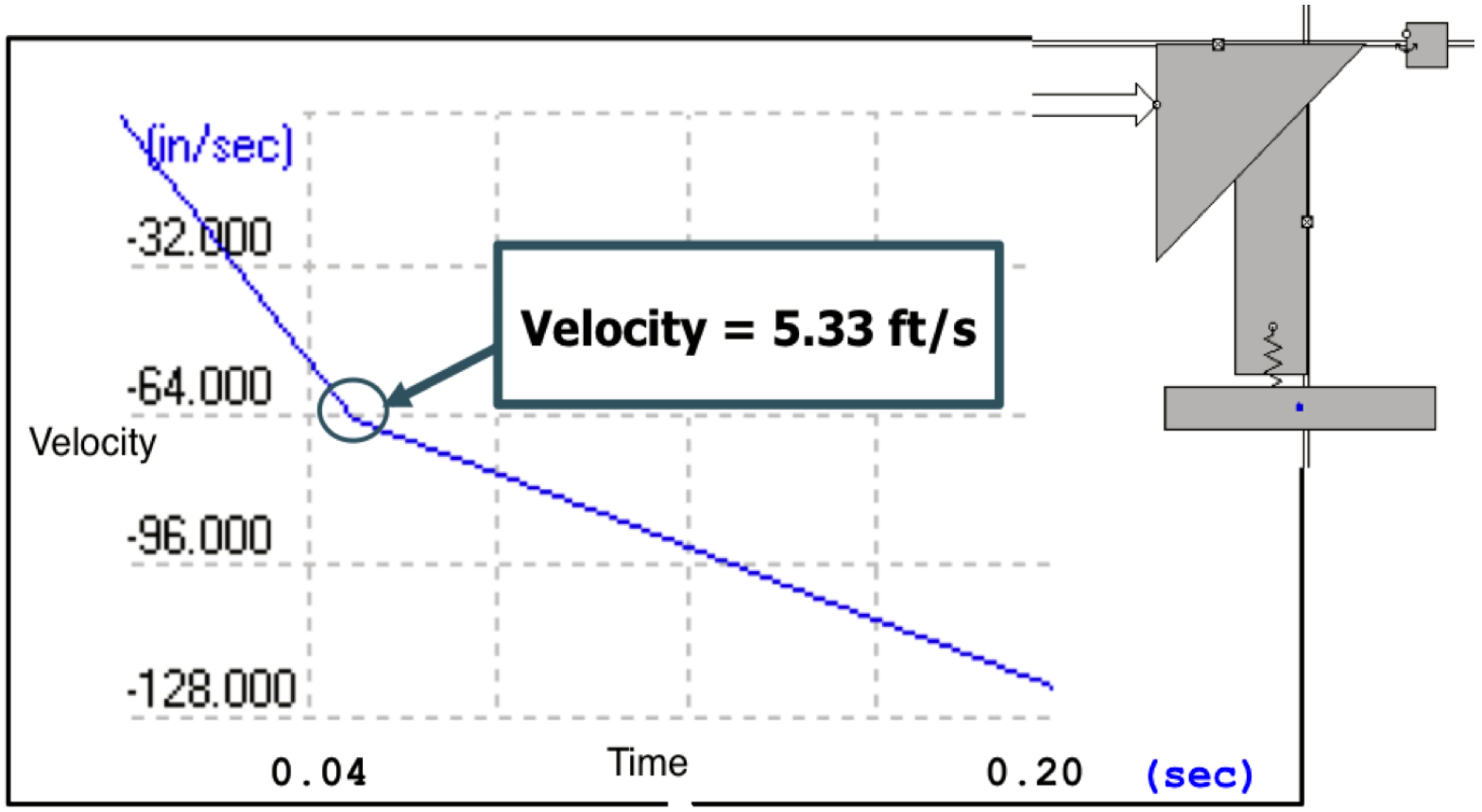
Ejector System



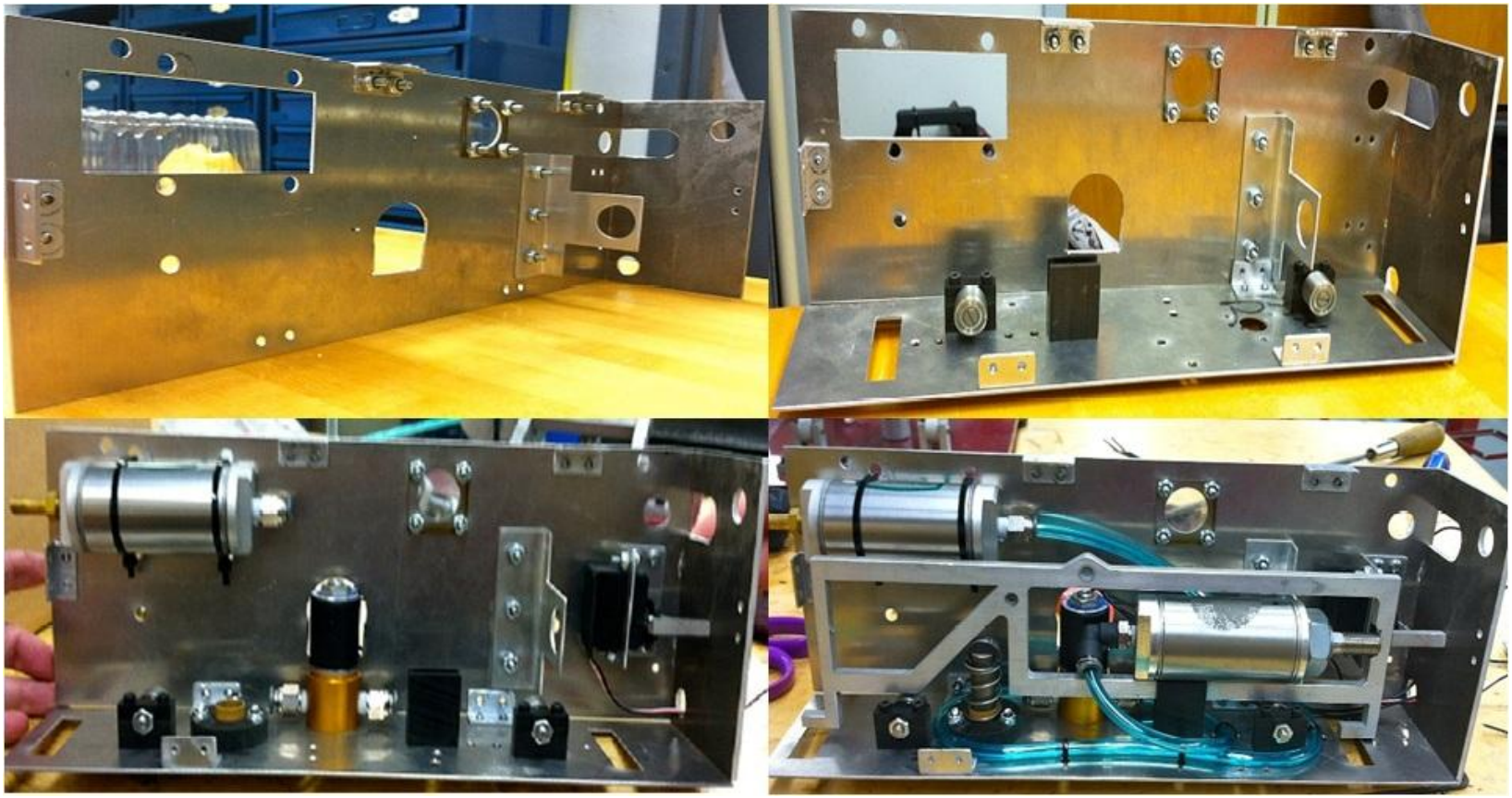
Ejector System



Ejector Mechanism Simulation



Prototype Assembly



Final Prototype

Payload Release

Velocity Analysis

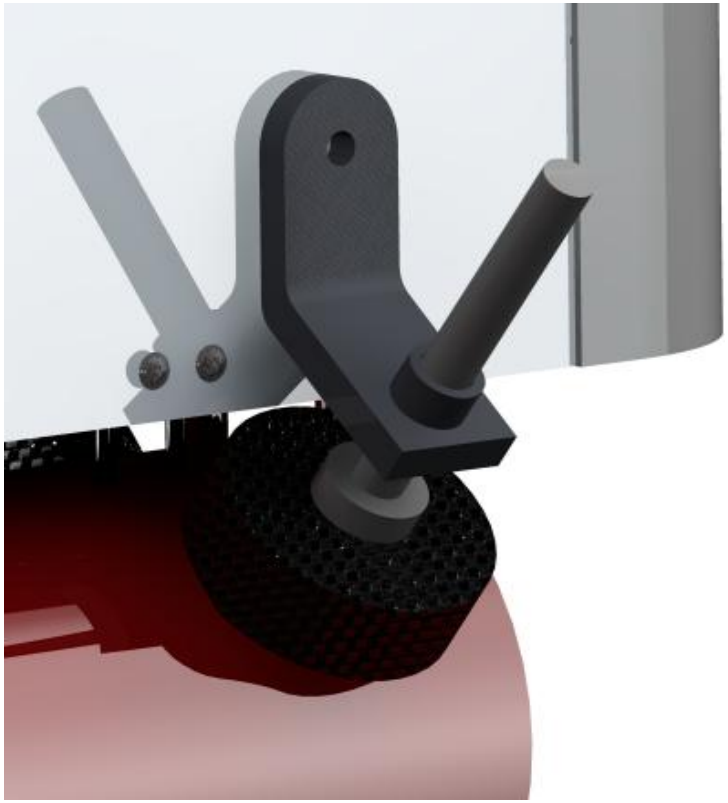
- Experimental velocity calculated 5.33 ft/s
- Initial velocity of 4.31 ft/s
- Pneumatic system filled between 60 – 70 psi
- High friction in ejector
- Measuring instruments
  - Apple iPhone 4
  - iMovie

Velocity Test	
	V.Initial (ft/s)
Test 1	3.50
Test 2	4.72
Test 3	4.72
Average	4.31

$$d = v_i t + \frac{1}{2} a t^2$$

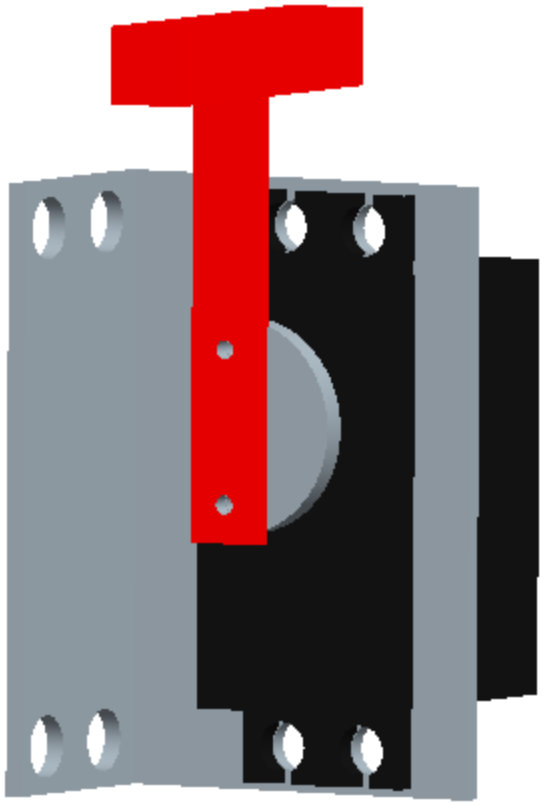
Sway Brace

- Withstand lateral and vertical loads
- Bracket machined AL6061
- Safety Factor of 1.5

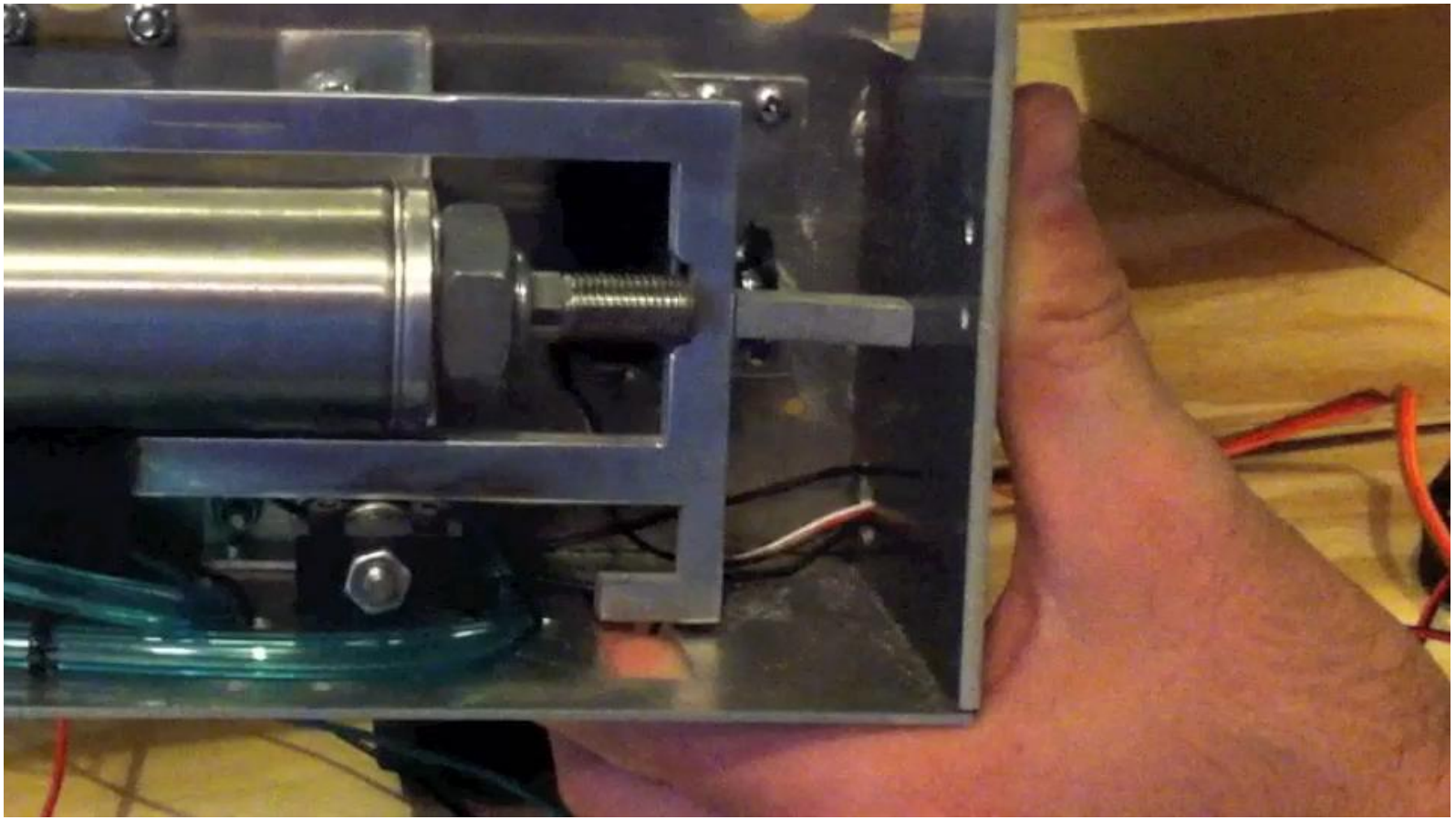


Safety System

- Required Torque= 0.0066 lb-in
- Output Torque= 4.75 lb-in
- Block made of Al6061
- Servo weighs 15/16 oz
- Requires 4.8V input



Safety System



Landing Shock Safety Block

- Tests were conducted, with no empirical data recorded
- With proper test rig a quantitative G-force can be found

$$A_{stop} = \frac{V^2}{x}$$

Safety Block

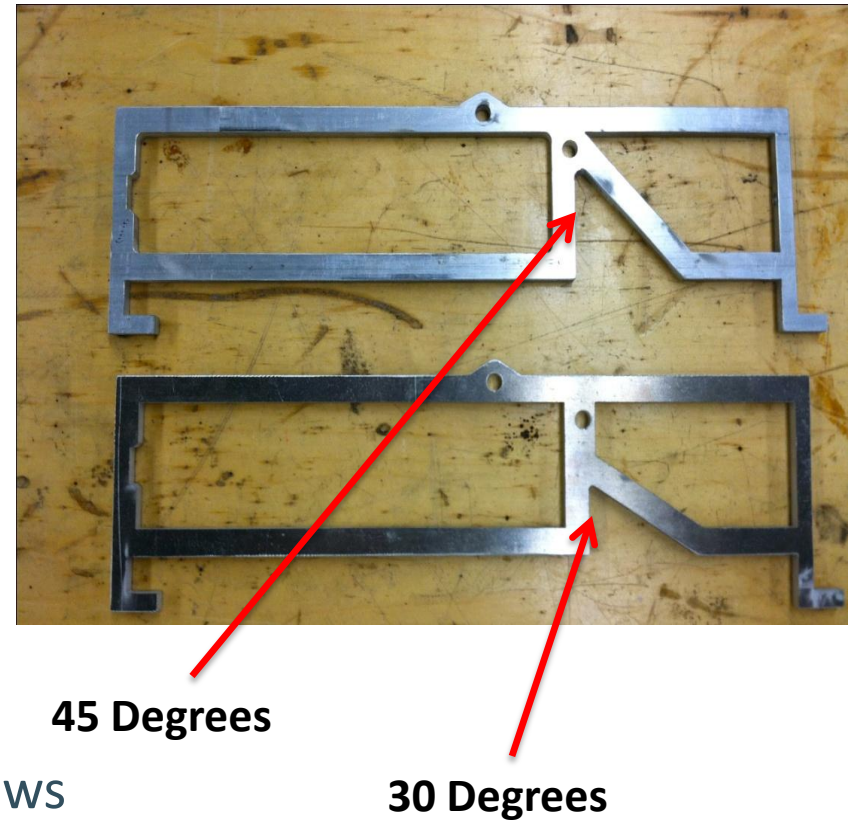
- Safety block easily rotates in out of position
- Stops BRU from any misfires

Weight Analysis

- Final weight of Prototype – 5.4 lb
  - Pneumatic system used stainless steel
  - Aluminum frame
- To lower weight for future designs
  - Composite materials
  - Increase overall budget

Issues and Solutions

- Ejector piston jamming
  - Slot angle reduction
- Minor hole tolerances
  - Increased with drill
- Safety block touching side walls
  - Filed stop block
- Assembly difficulties
  - Difficult to place nuts on screws
  - Suggest using threaded holes



Budget Analysis

- Overall spent $1304.55 out of $2000 budget
- Excluding testing and unused components total cost of BRU = **$688.74**
- Major Purchases
  - Raw Materials - $102.54
  - Pneumatic System - $147.22
  - Compressor/Tooling - $205.12
  - RC Controller -$107

Conclusion

- Prototype was an overall success
  - Achieved required ejection velocity
  - Met safety constraints
- Stayed well under provided budget
- Suggested future improvements
  - Composite materials
  - Bearing ejector

Acknowledgement

- Special Thanks to…
  - **Eglin Air Force Research Lab**
  - **Mr. Russell Roberts (Sponsor)**
  - **Dr. Clark (Faculty Advisor)**
  - **Dr. Shih (Course Instructor)**
  - **Dr. Kosaraju (Course Instructor)**
  - **Dr. Dalban-Canassy (Course Instructor)**

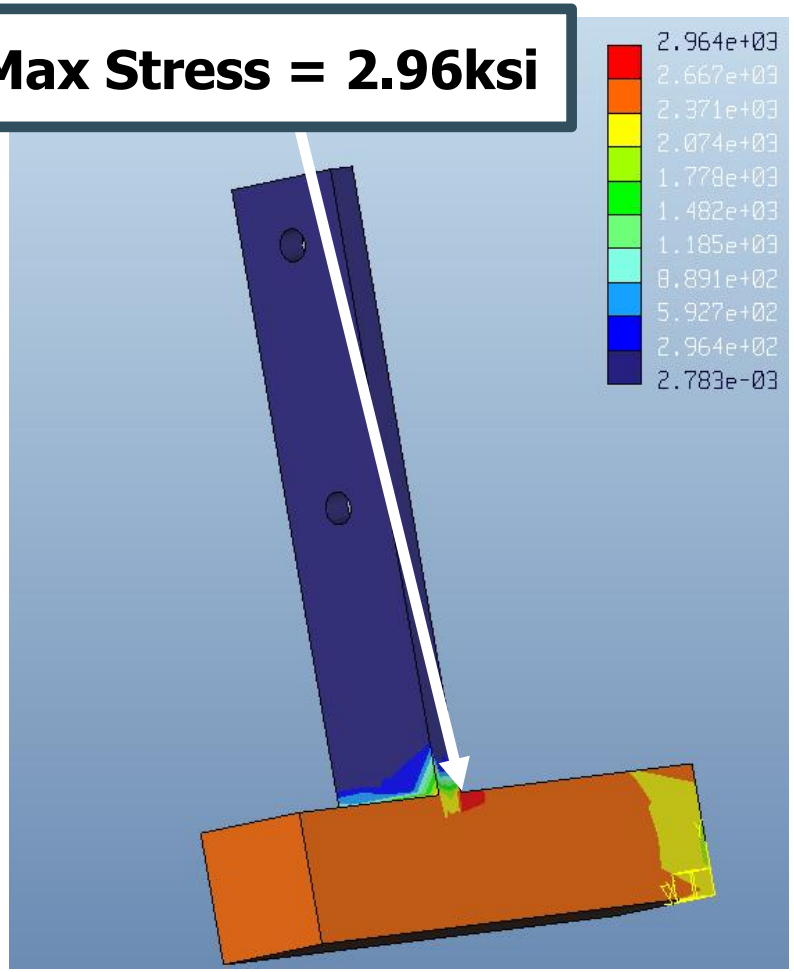
Questions ????

References

- Callister, William D. *Materials Science and Engineering.* 7th ed. New York: Wiley., 2006. Print.
- Hibbeler, R. C. *Engineering Mechanics Dynamics.* 12th ed. Singapore: Pearson/Prentice-Hall, 2009. Print.
- Hibbeler, R. C. *Engineering Mechanics: Statics*. Upper Saddle River, NJ: Prentice Hall, 2009. Print.
- Hawks, Chuck. ".22 Rimfire Cartridges." *CHUCKHAWKS.COM: Guns and Shooting Online; Motorcycles and Riding; Military History; Astronomy and Photography Online; Travel and Fishing Information Guide*. Web. 18 Oct. 2011. http://www.chuckhawks.com/22_rimfire_cartridges.htm.
- "HowStuffWorks "Airbag Inflation"" *HowStuffWorks "Auto"* Web. 13 Oct. 2011. <http://auto.howstuffworks.com/car-driving-safety/safety-regulatory-devices/airbag1.htm>.

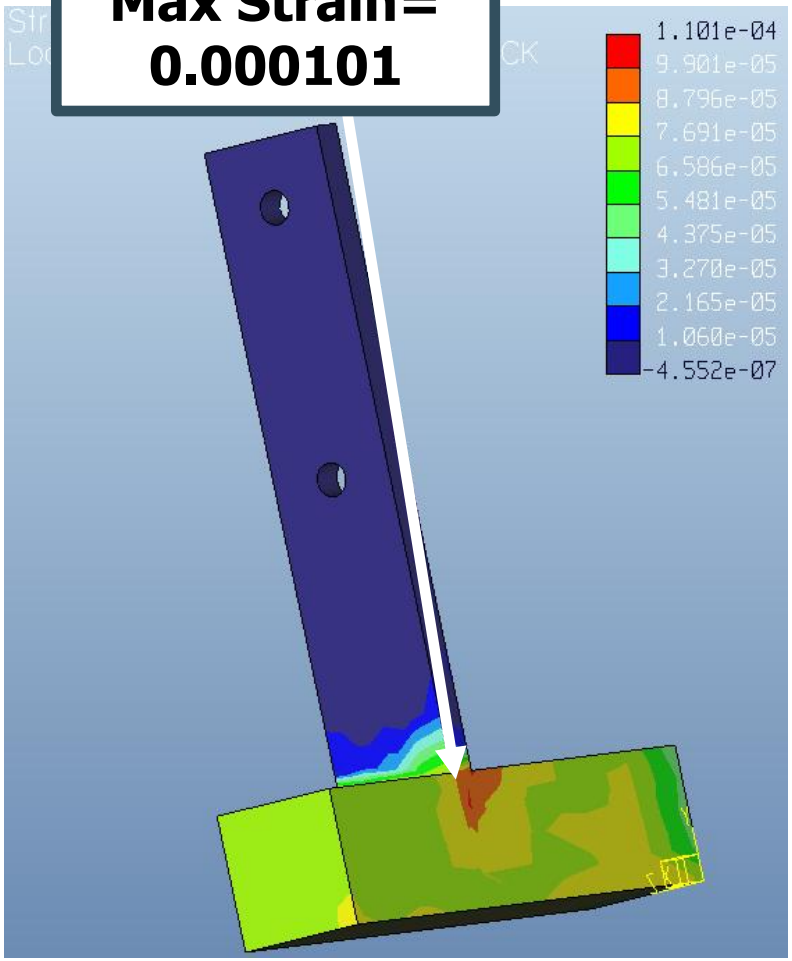
Safety System

Max Stress = 2.96ksi



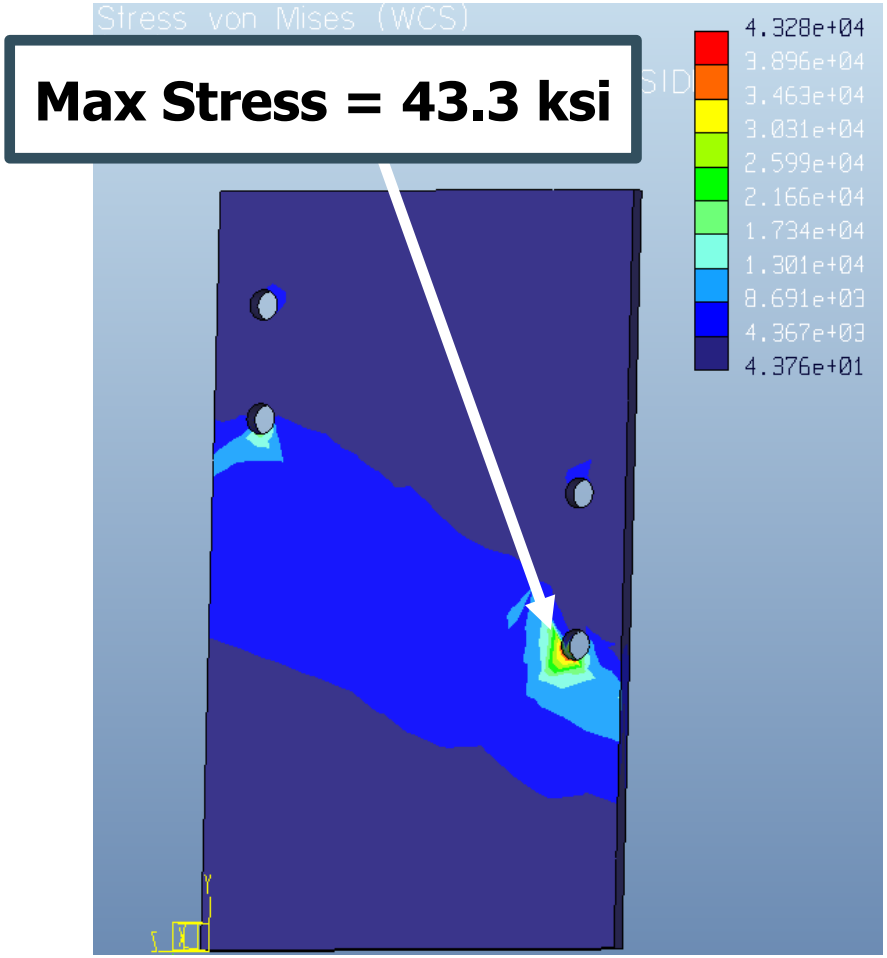
Von Mises Stress

Max Strain= 0.000101

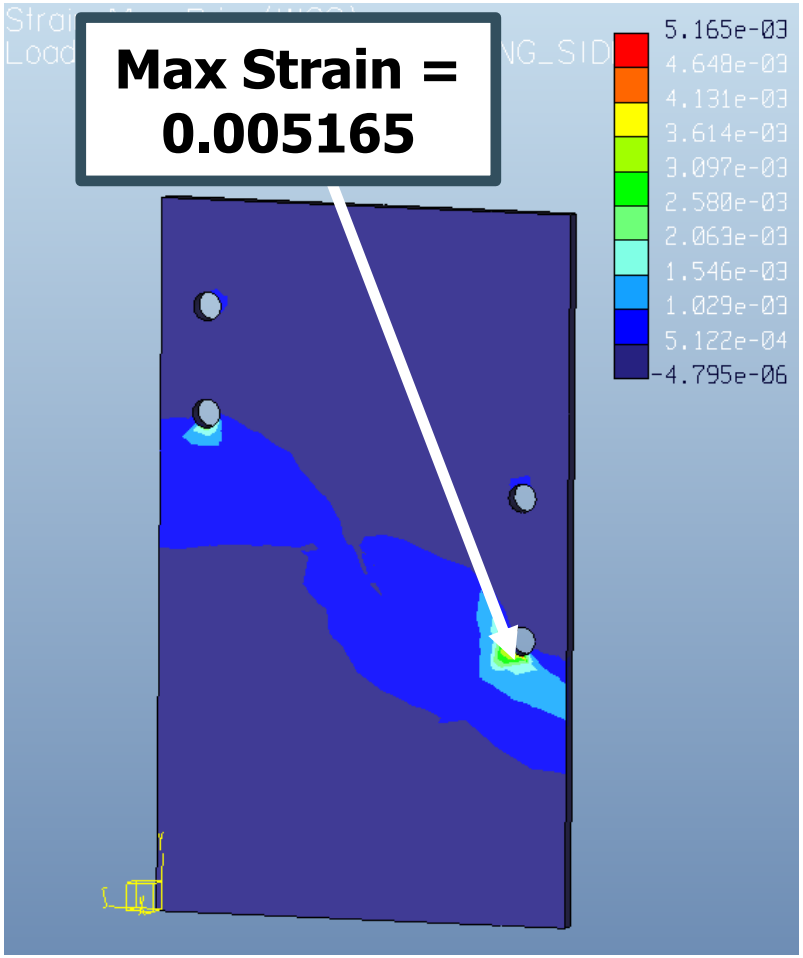


Strain

Safety System



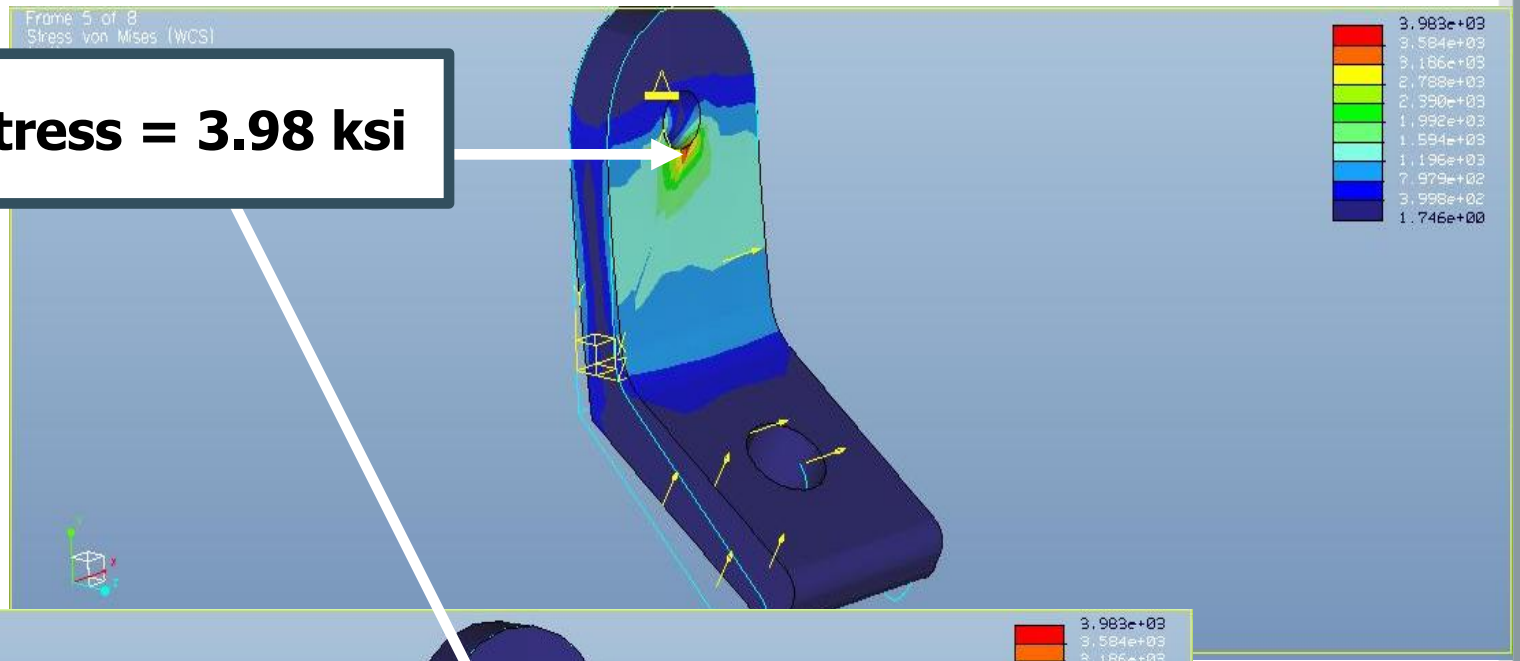
Von Mises Stress

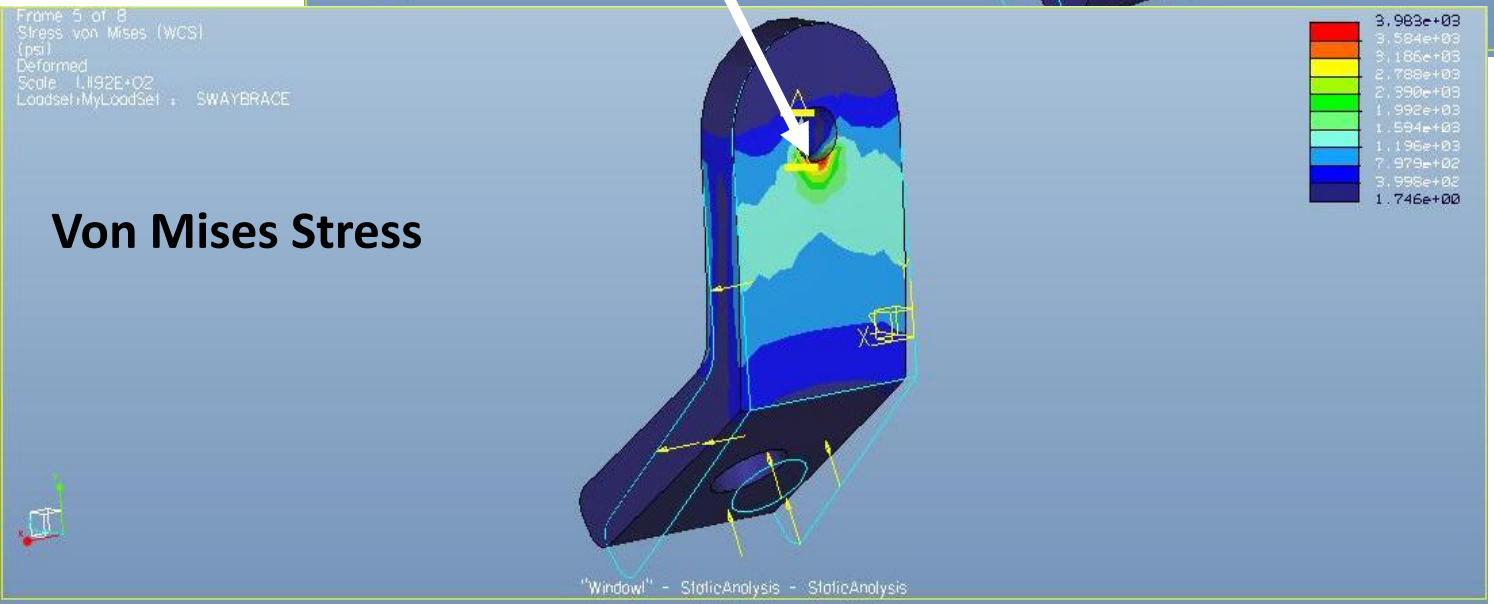


Strain

Sway Brace (Bracket)

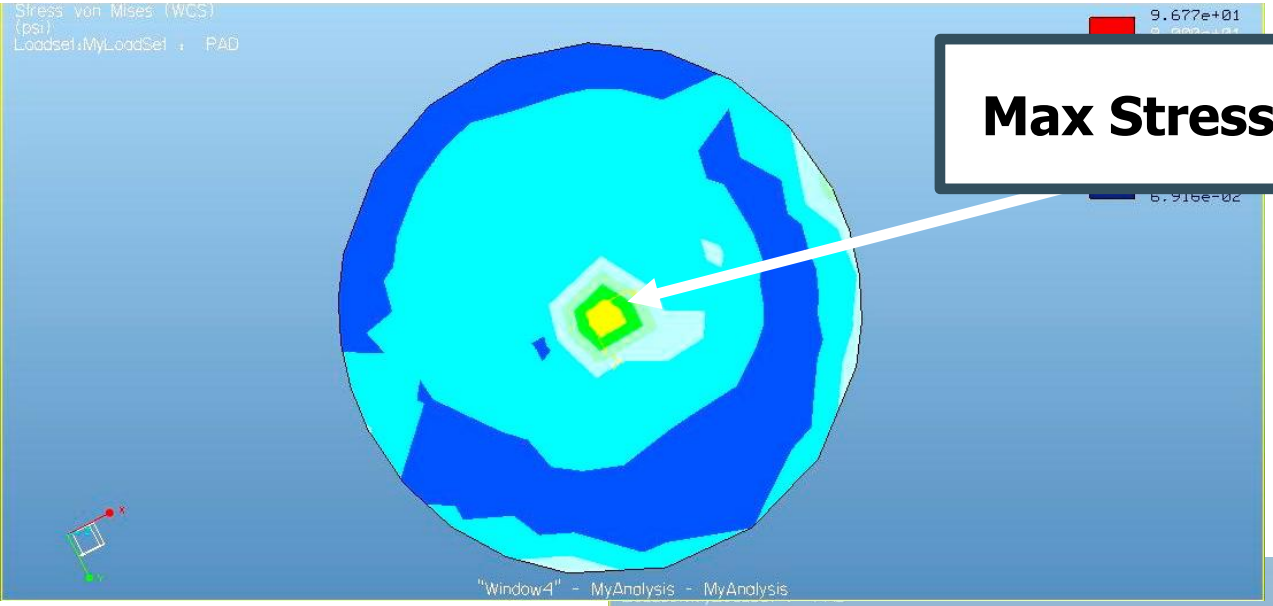
Max Stress = 3.98 ksi





Von Mises Stress

Sway Brace (Pad)



Max Stress = 96.8 psi

Von Mises Stress