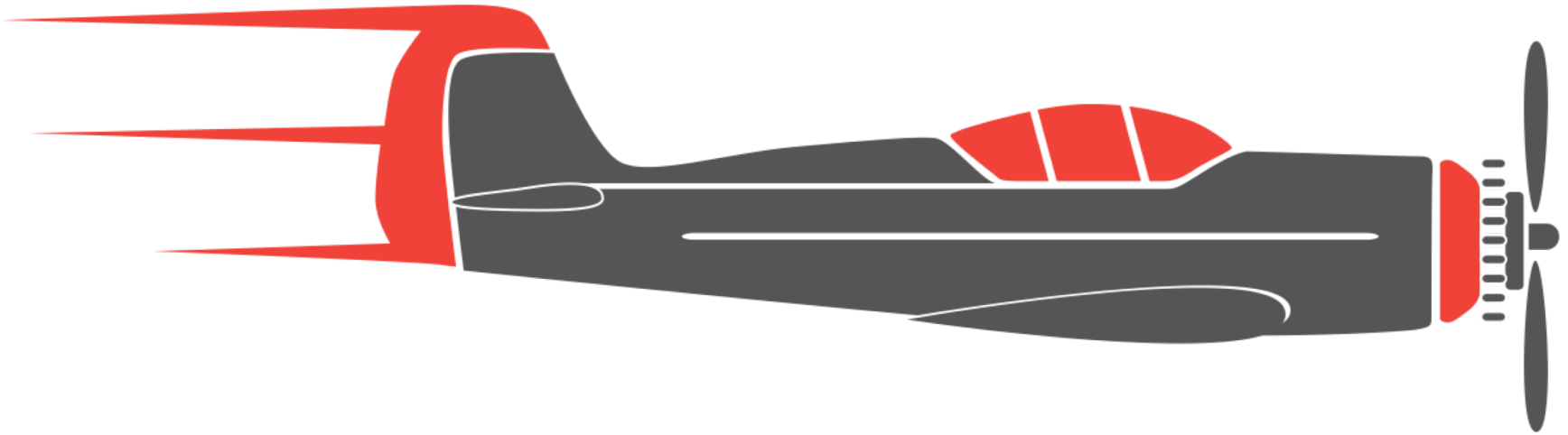


Team 508
SAE Aero Design: Geometric Integration
EML 4552C

Team Members

Jacob Pifer
Project Manager
Manufacturing Engineer

Lauren Chin
Lift & Control Surfaces Engineer
Meeting Coordinator
CAD Engineer

Joseph Figari
Fuselage and Payload Engineer
Financial Coordinator
CAD Engineer

Sponsors

Florida Space Grant Consortium
Financial Sponsor

Seminole RC Club
Equipment Provider

Shayne McConomy, PhD
Faculty Sponsor

Jacob Pifer

Advisors

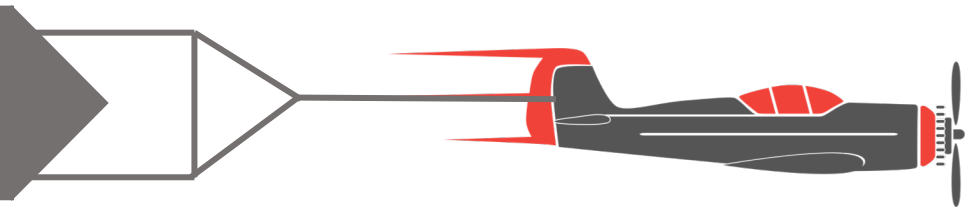
Simone Hruda, PhD
Faculty Advisor

Eric Adams
Fablab Supervisor

Dorr Campbell, PhD
Materials Advisor

Jacob Pifer

Project Objective

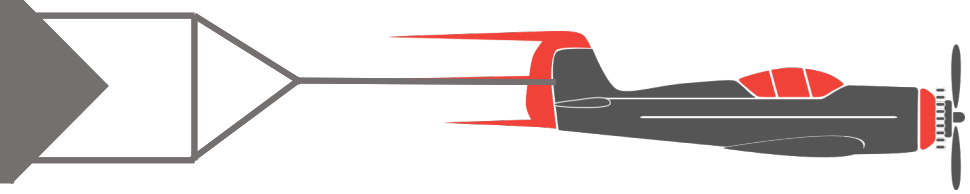


- The objective of this project is to design and manufacture a 3D printed remote control airplane within the rules of the SAE Aero Design Competition

- It will be able to take off, complete the needed flight path, and land while carrying the required cargo

Jacob Pifer

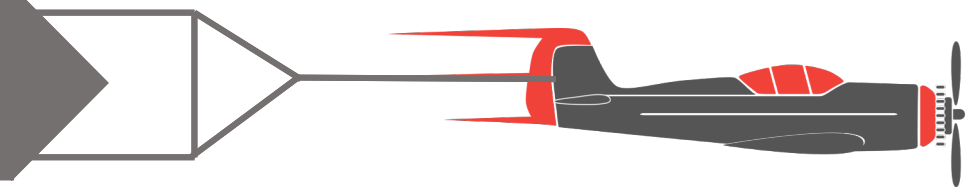
Project Brief Summary



- SAE hosts an annual RC airplane competition
- The college has been a part of it for multiple years
- Two Senior Design Teams working on this project
  - Team 507 working on the aero propulsion design
  - Our team oversees the manufacturing of the plane

Jacob Pifer

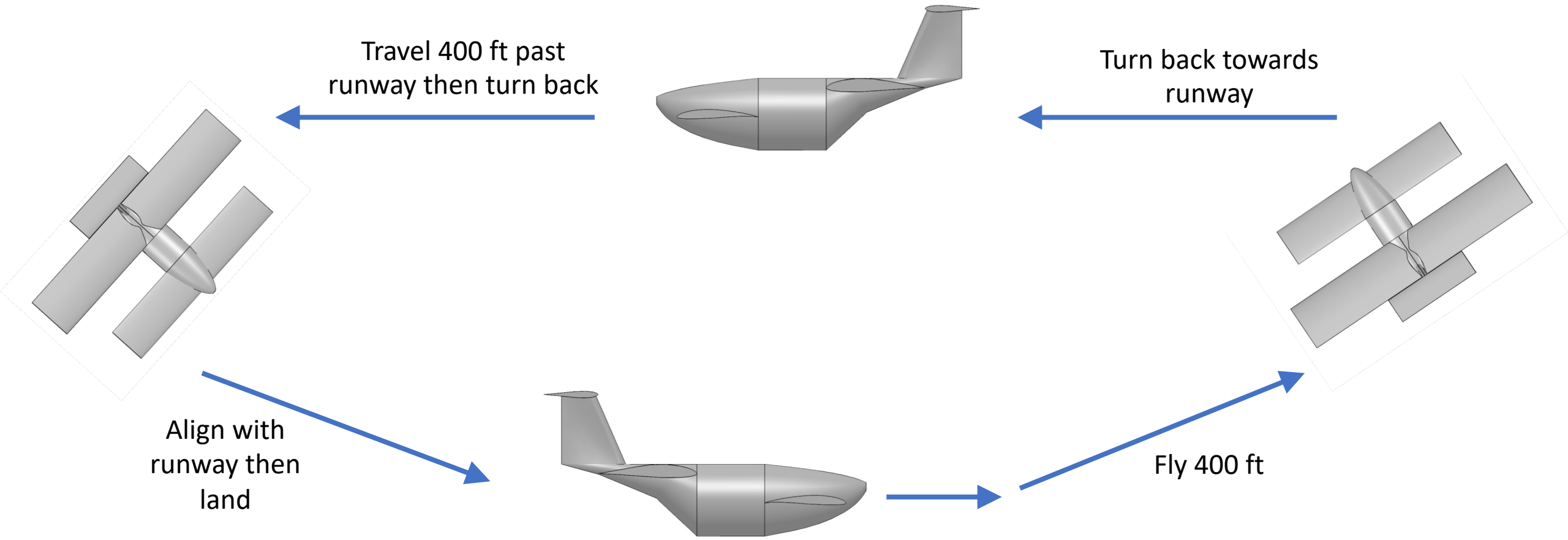
Project Brief Summary



- The plane was not flown at the competition
- Team is still a part of the competition
- Plane was still be built within competition rules
- Test flight will be done in Tallahassee with Seminole RC Club

Jacob Pifer

Project Brief Summary



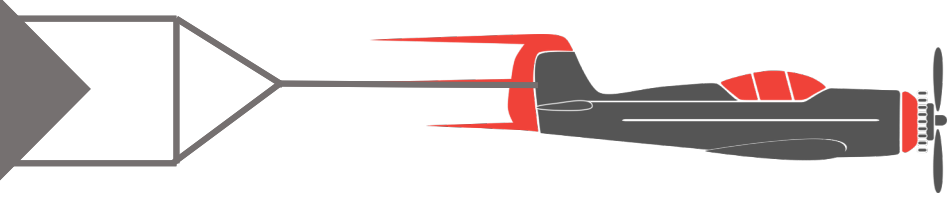
Jacob Pifer

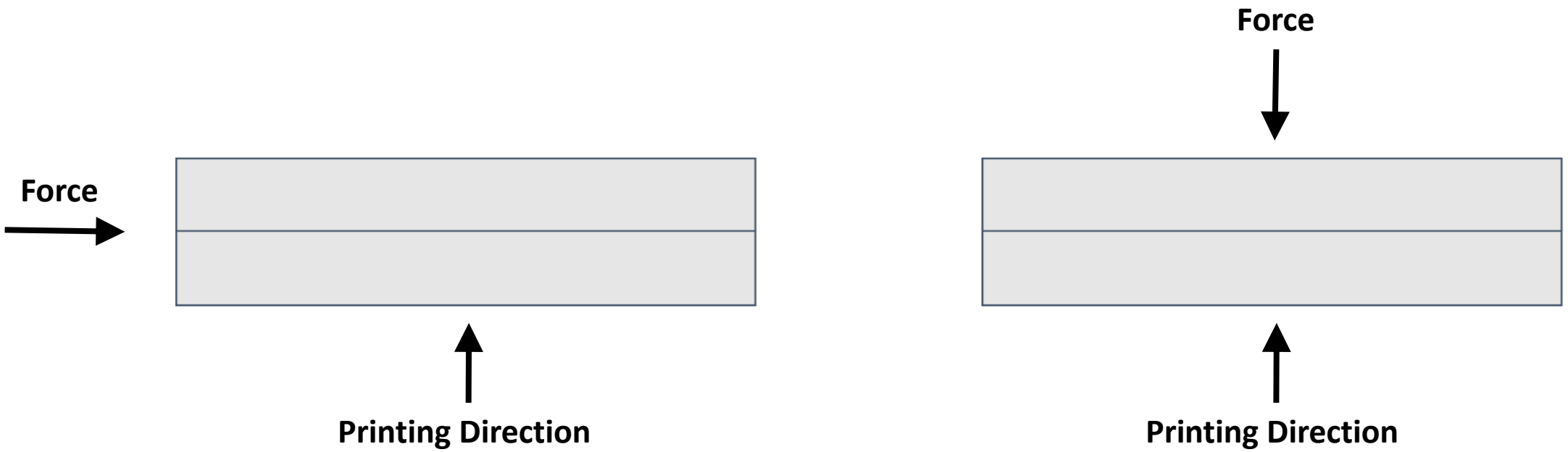
Material Selection

- House of Quality found weight to be most important design factor
- Two possible filaments could be used within budget and competition rules
  - PLA
  - LW-PLA
- Torsion and bending tests done to compare strengths

Jacob Pifer

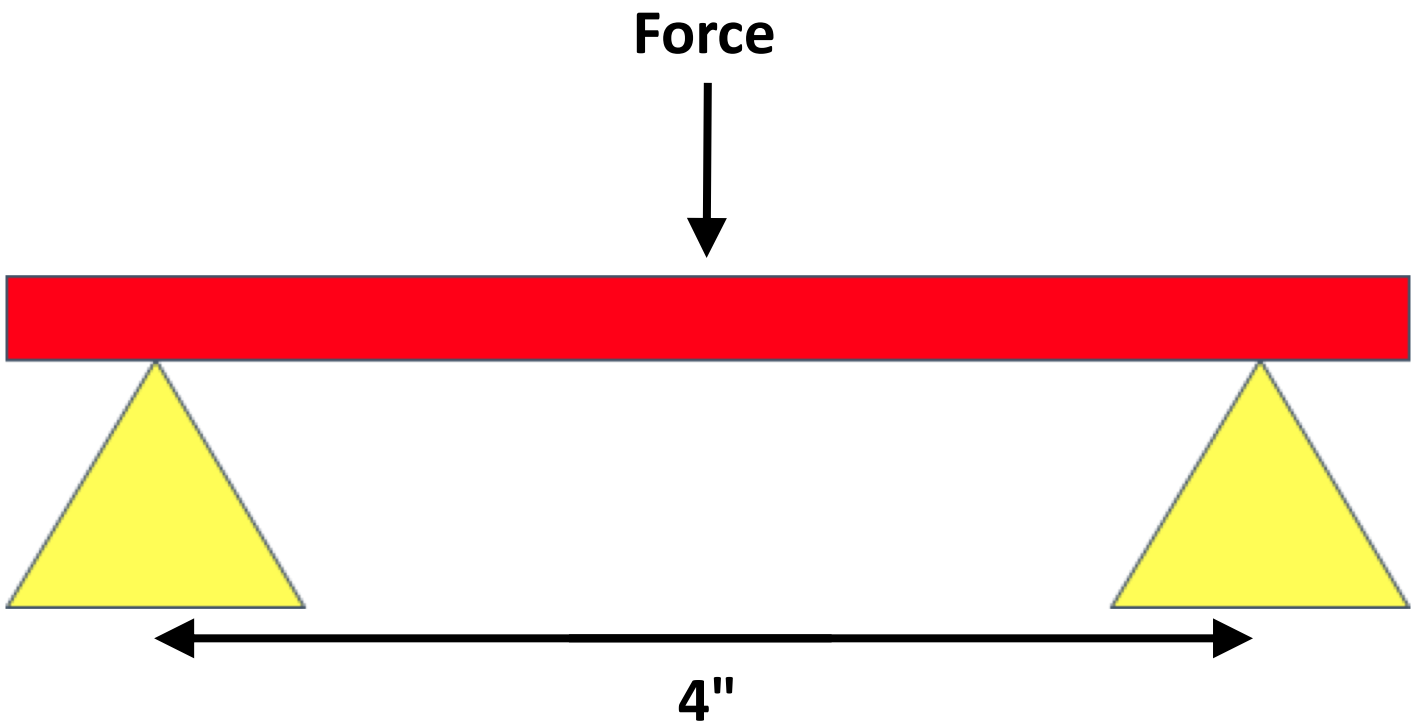
Force & Printing Direction





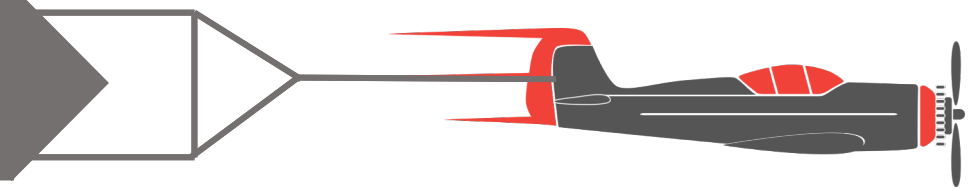
Jacob Pifer

Three-Point Bending Test

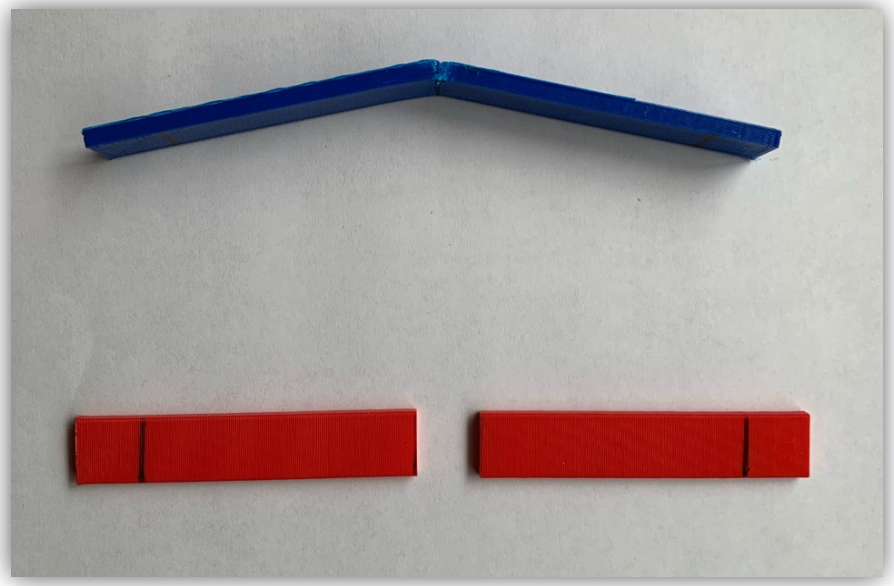


Jacob Pifer

Three-Point Bending Test

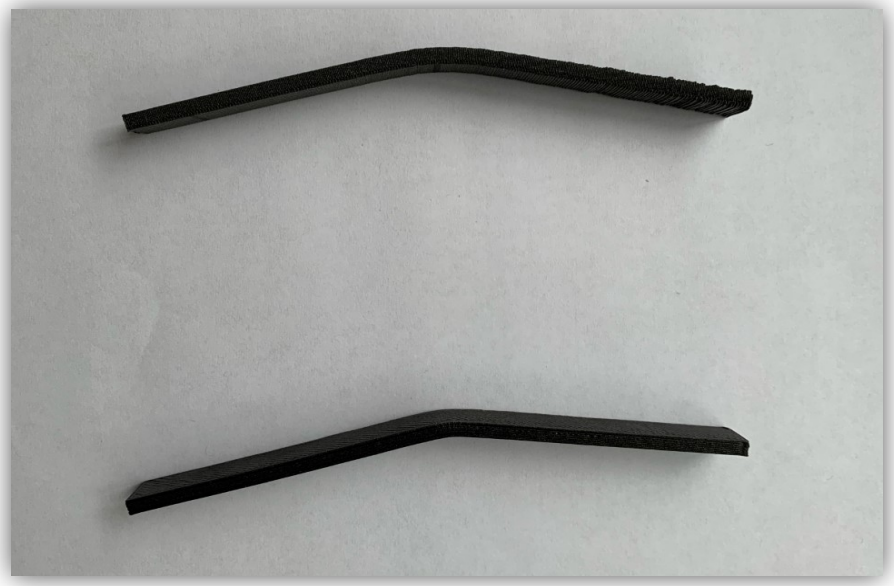


PLA



Stress parallel to printing direction: 8,350 psi
Stress perpendicular to printing direction: 3,360 psi

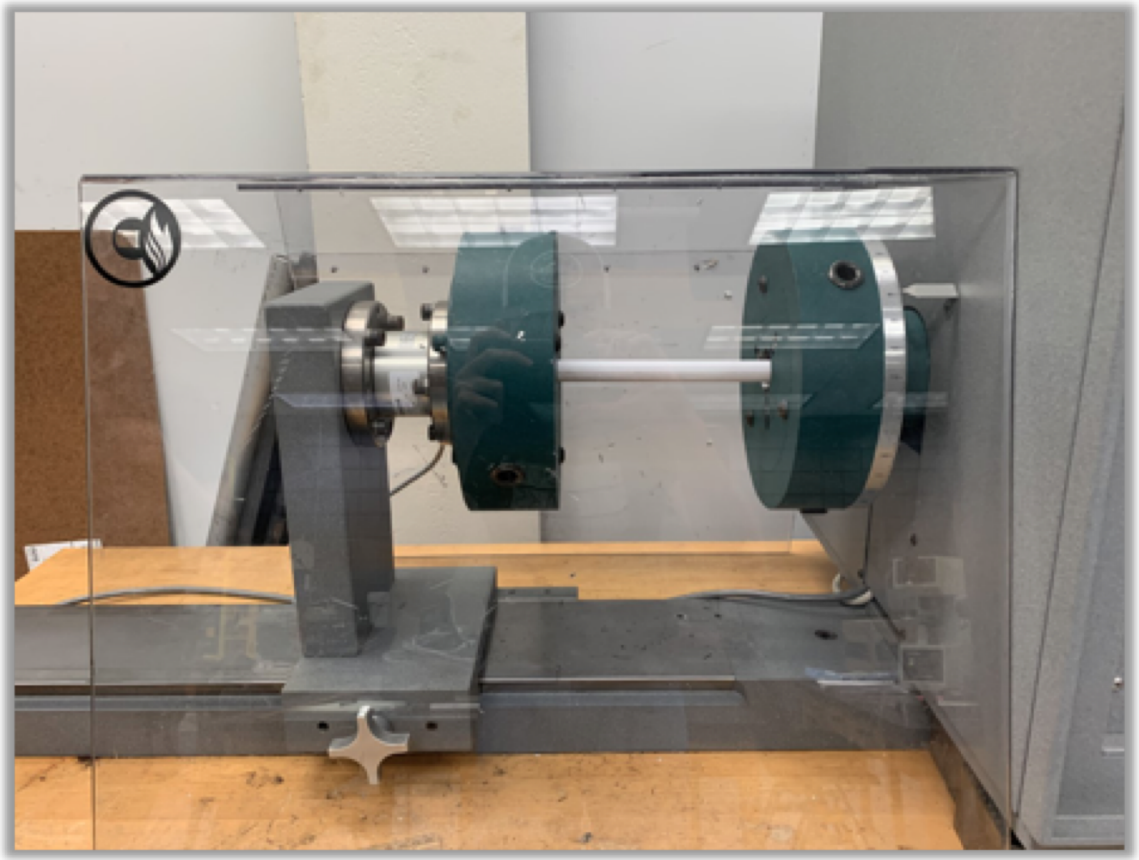
LW-PLA



Stress parallel to layering direction: 6,120 psi
Stress perpendicular to layering direction: 3,380 psi

Jacob Pifer

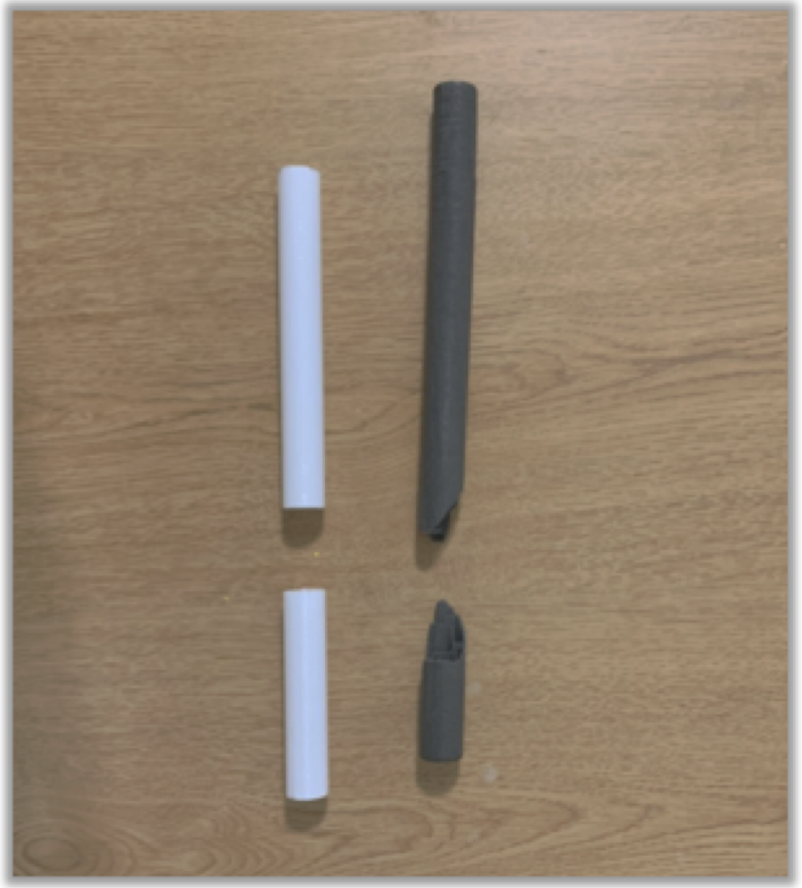
Torsion Test

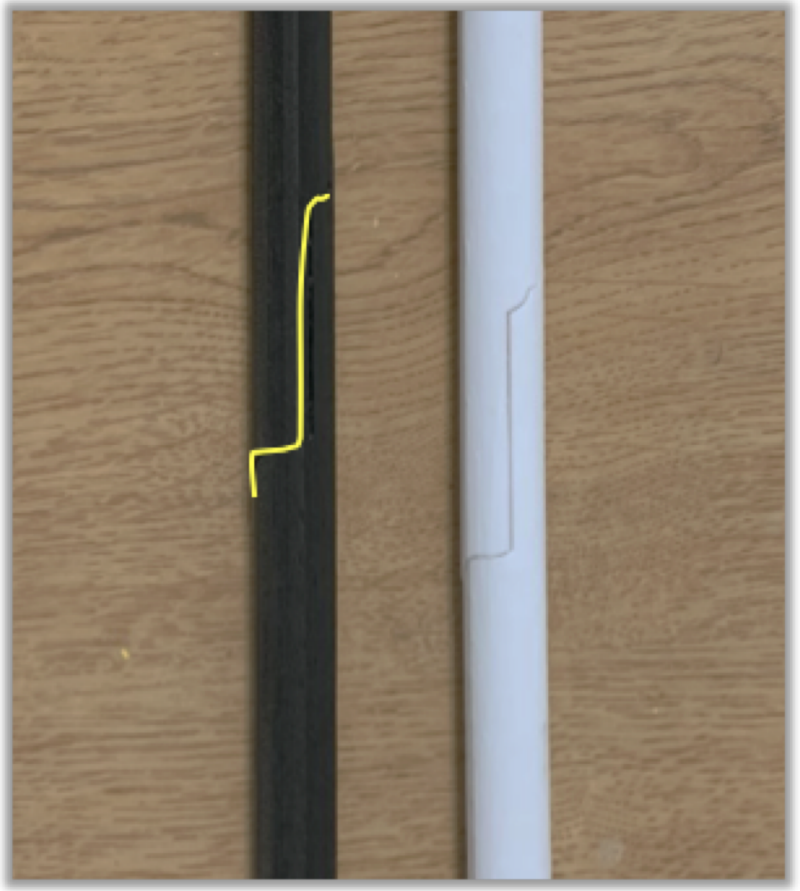


- Tinius – Olsen Machine used to collect data
- Same types of samples used

Jacob Pifer

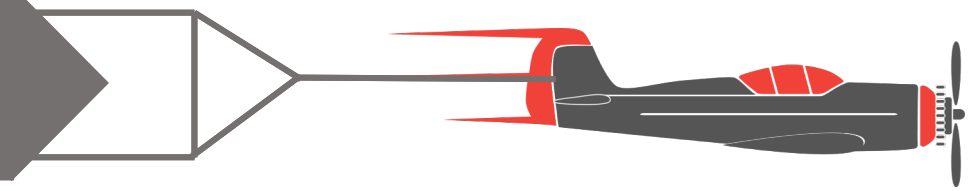
Torsion Test

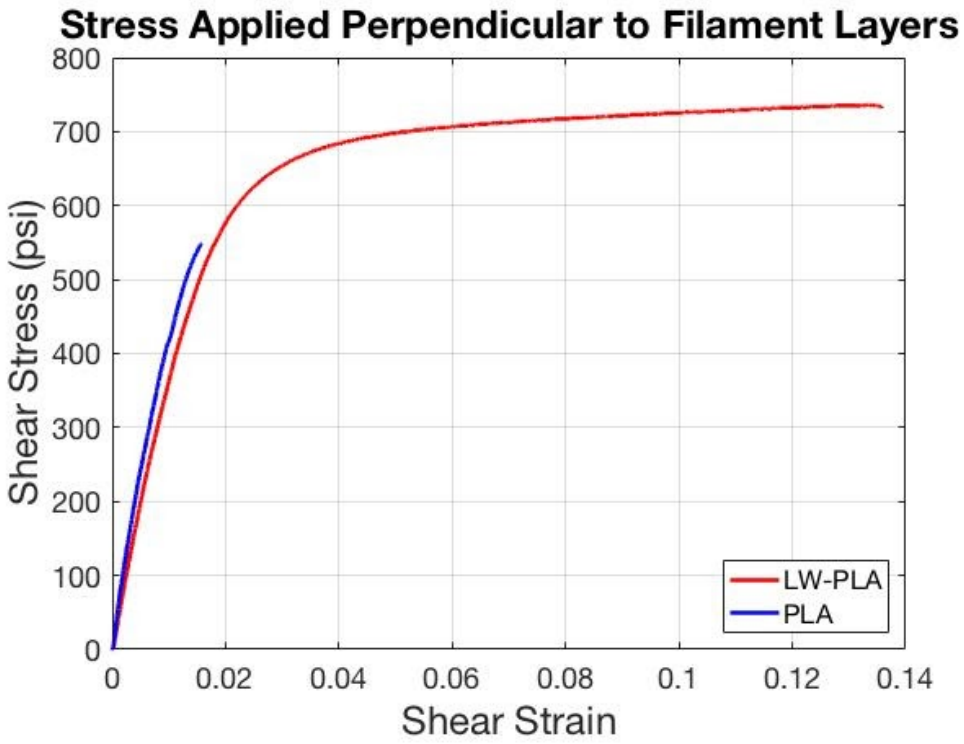




Jacob Pifer

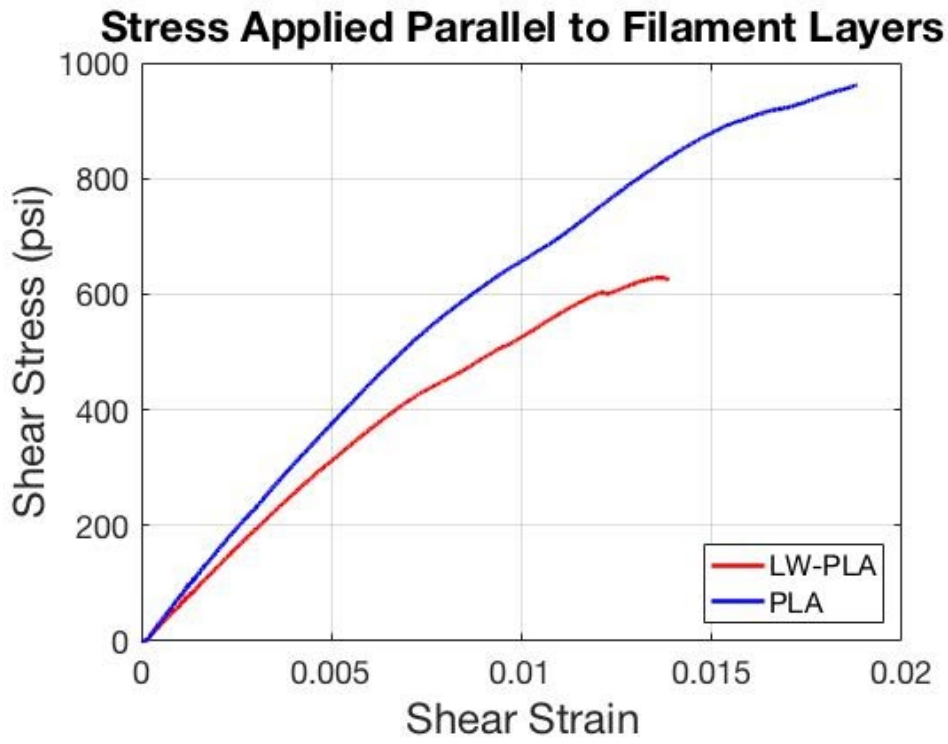
Torsion Test





PLA failure stress: 412 psi

LW-PLA failure stress: 552 psi

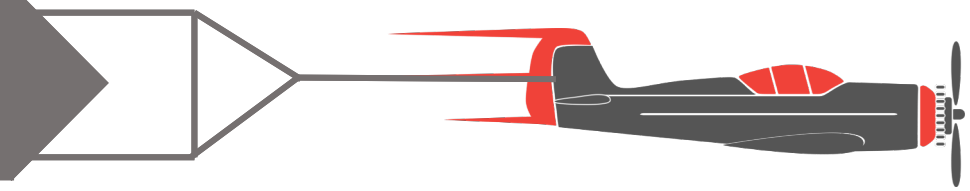


PLA failure stress: 721 psi

LW-PLA failure stress: 471 psi

Jacob Pifer

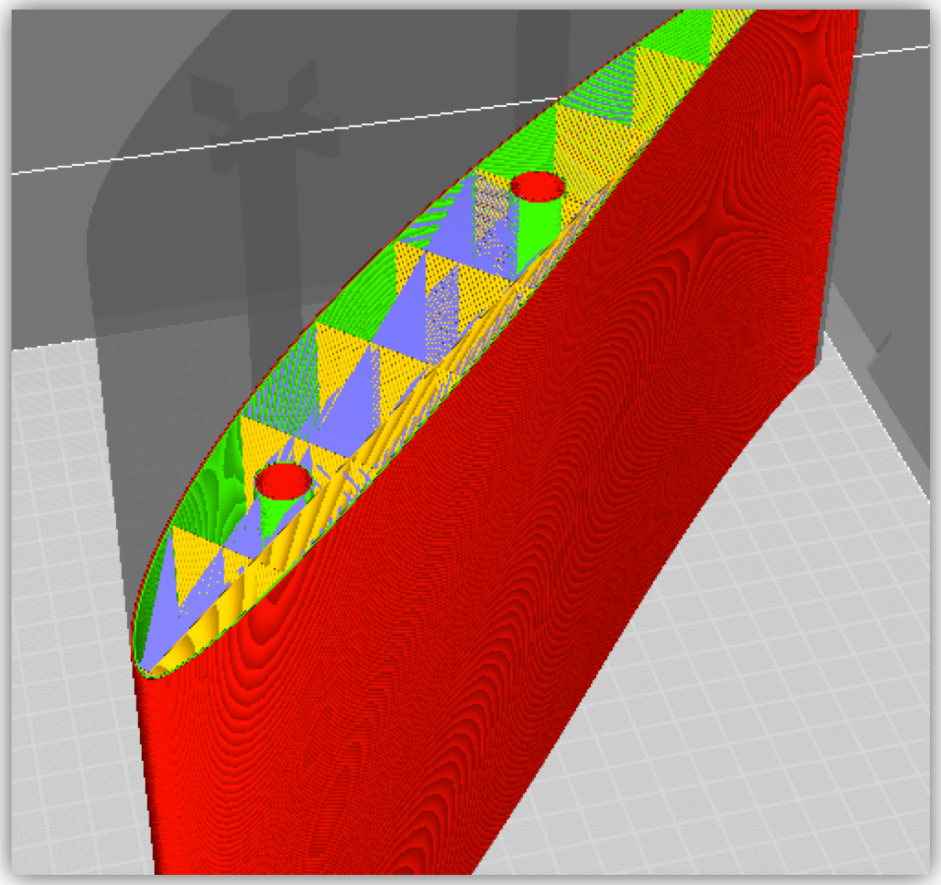
Printers



- Lulzbot TAZ printers are the main printers used
  - Design Lab has two and the Innovation Hub has one
- Any PLA parts were printed at the Innovation Hub
  - Small parts that DREMEL printers can make
- Cura-lulzbot used to queue prints
  - Helps in estimating print time, material used, and needed printing orientations

Jacob Pifer

Printing Parts



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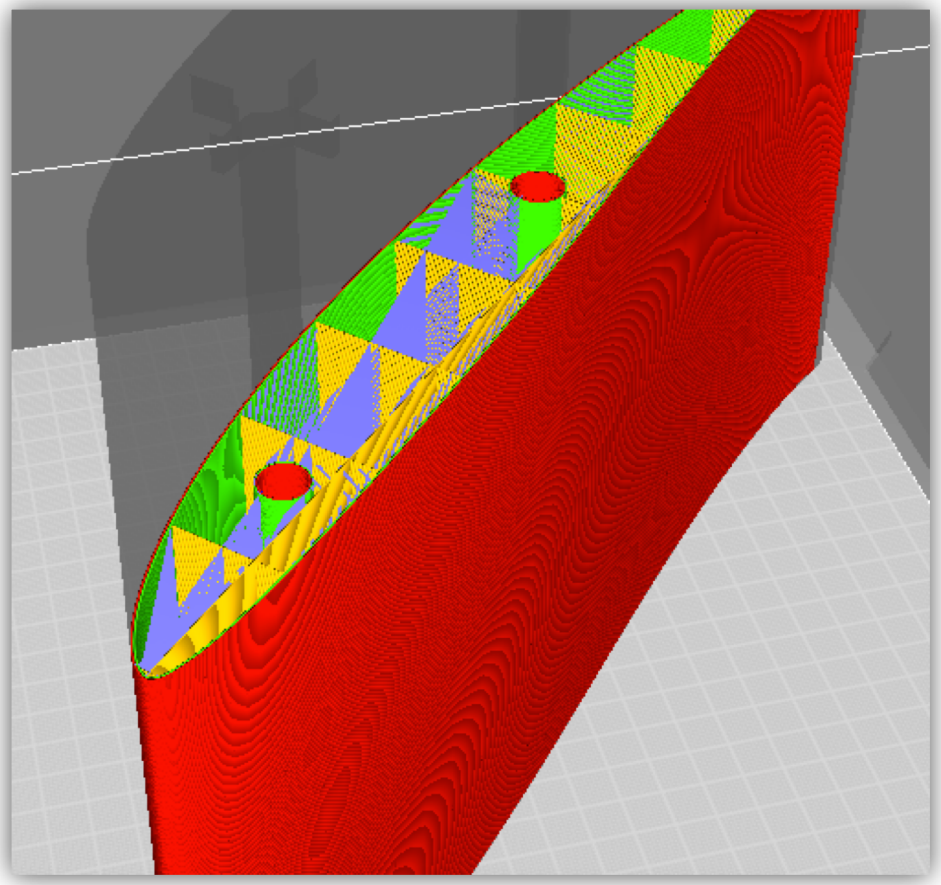
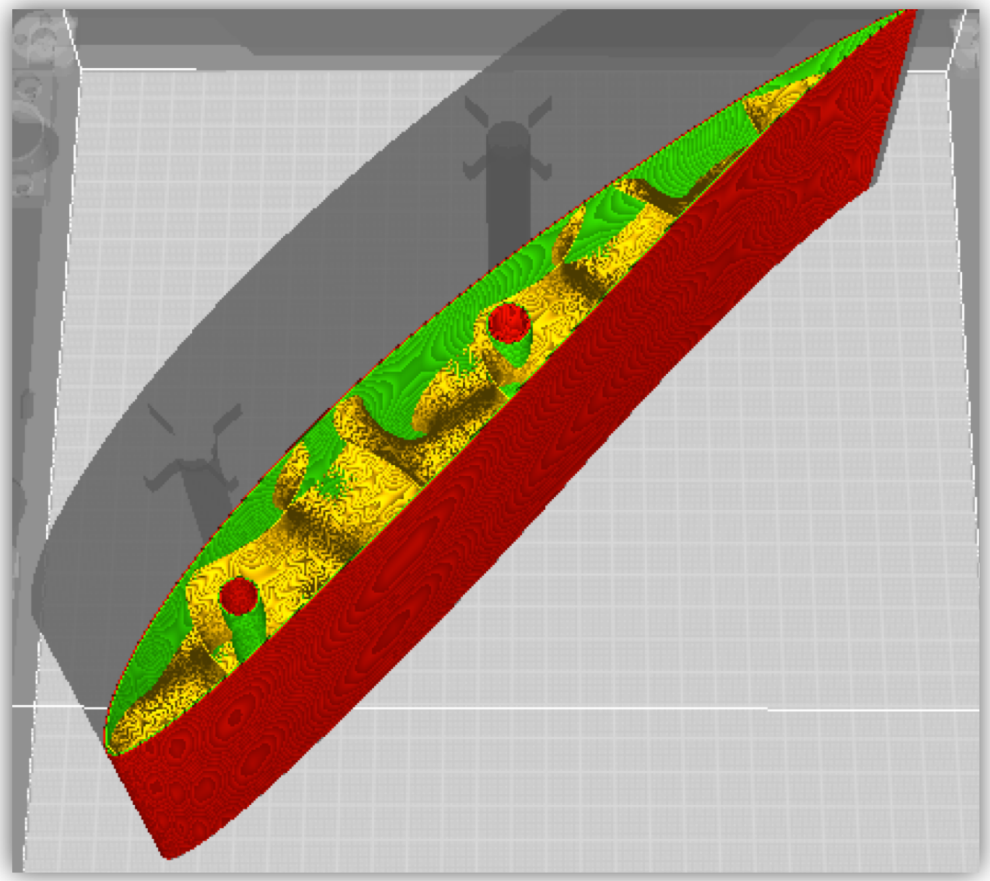
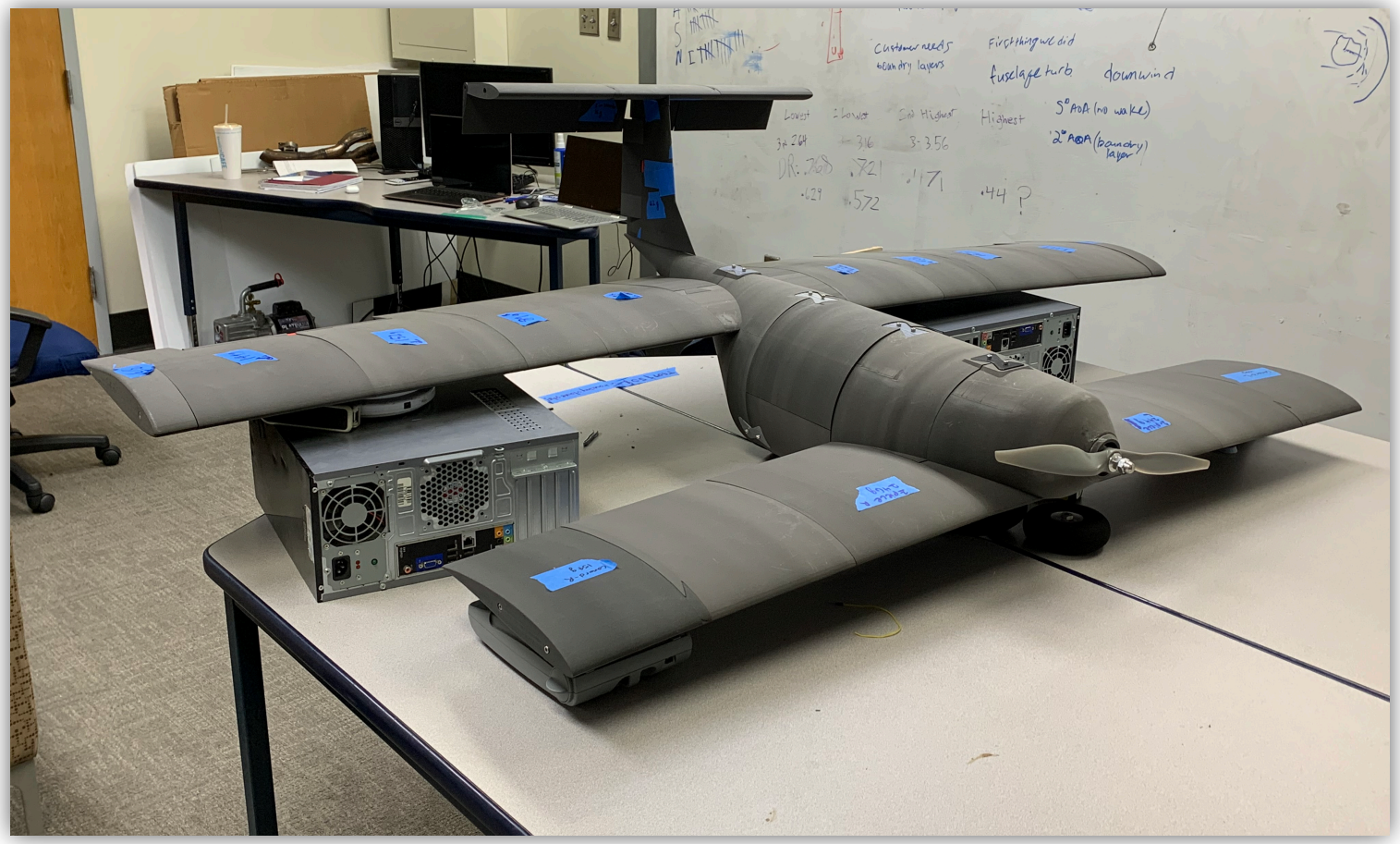
Printing Parts





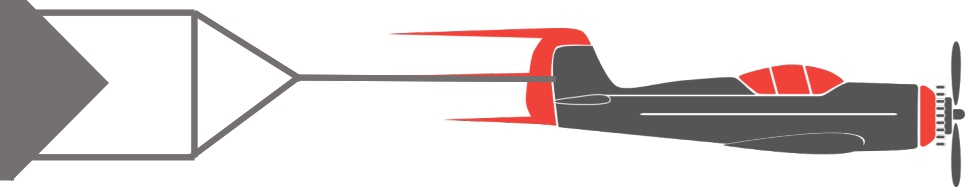
Jacob Pifer

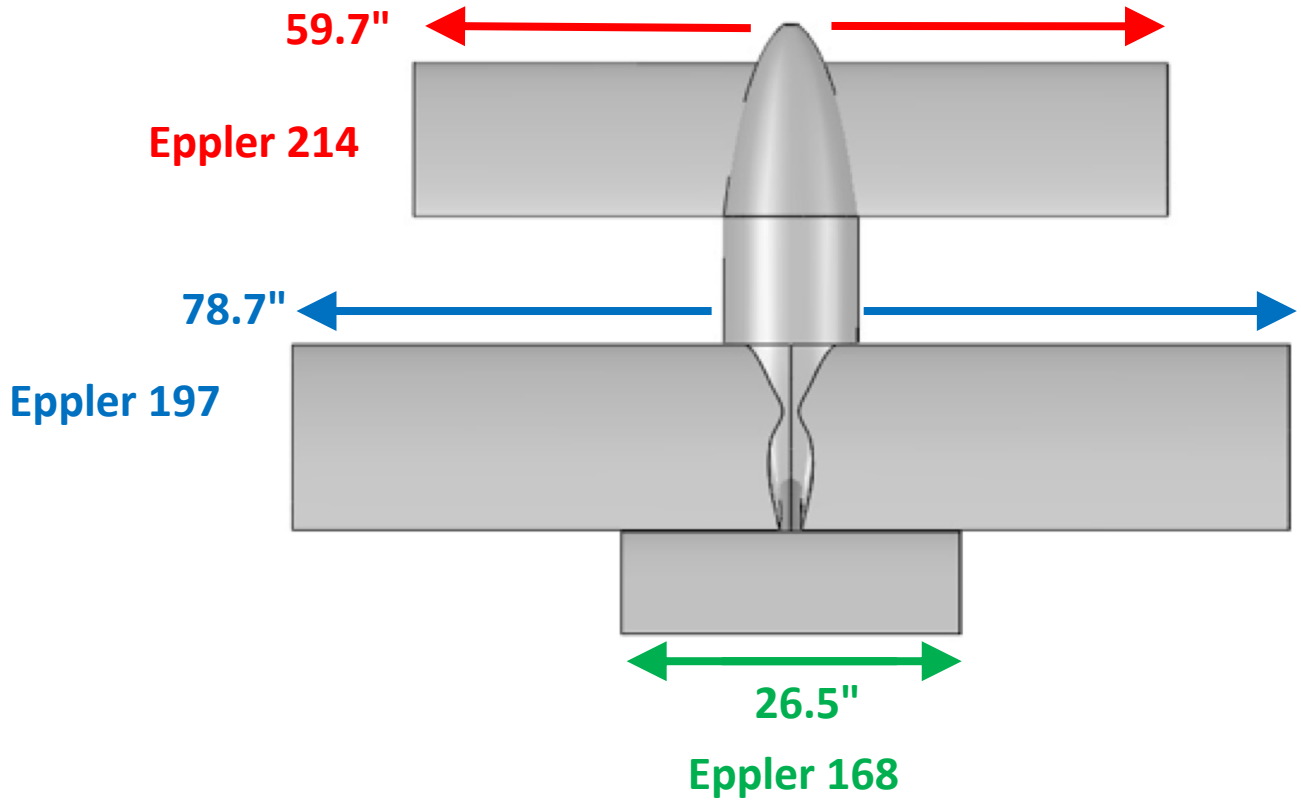
"The Golden Goose"



Jacob Pifer

"The Golden Goose"





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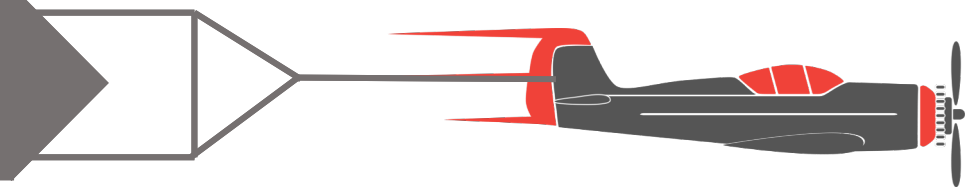
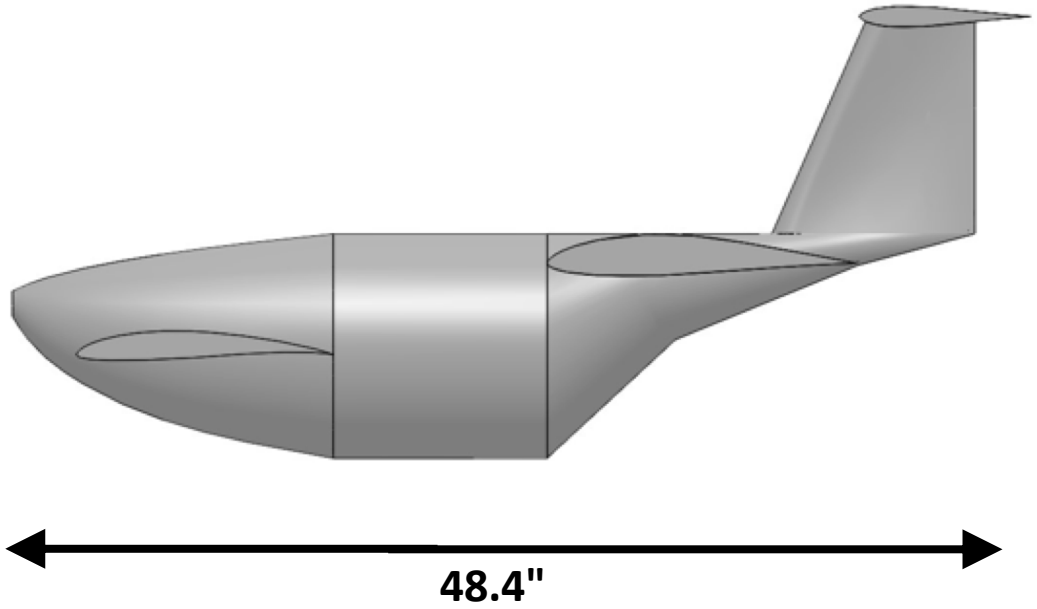
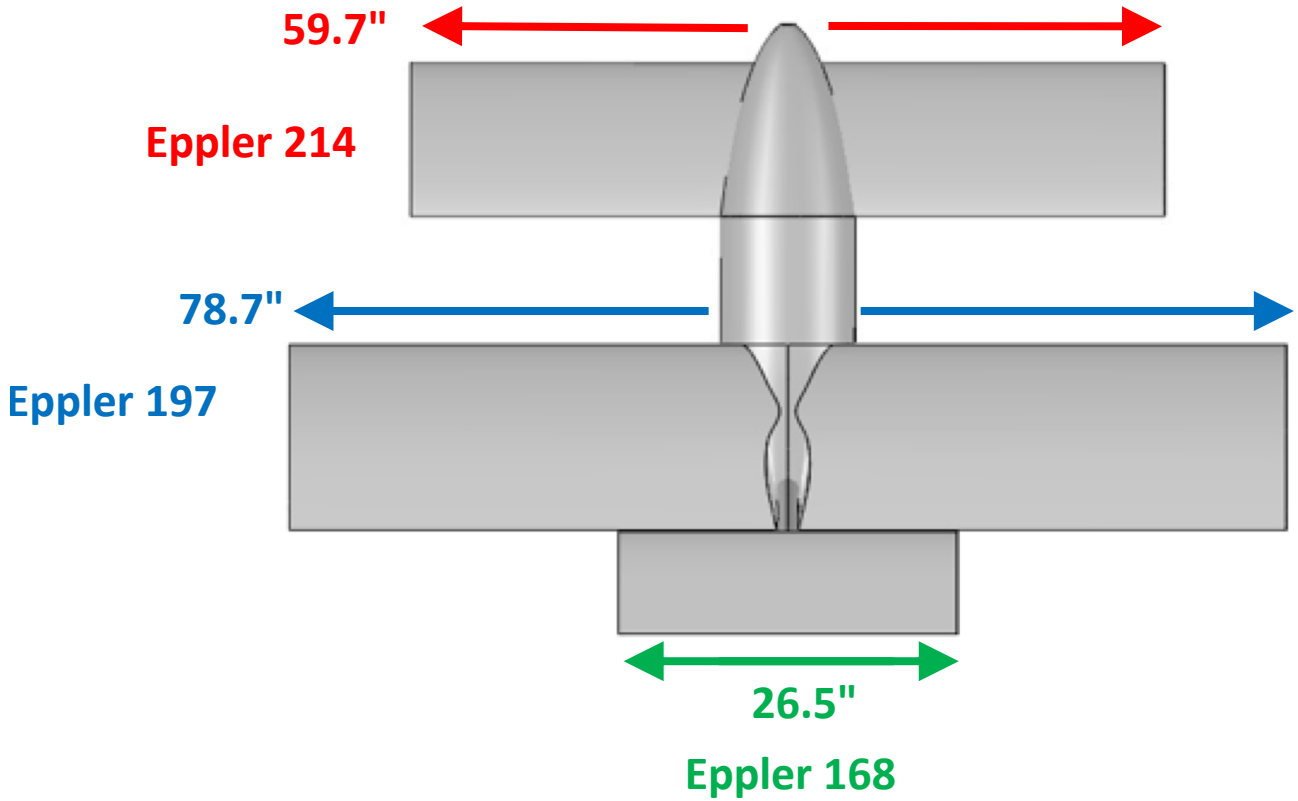
"The Golden Goose"







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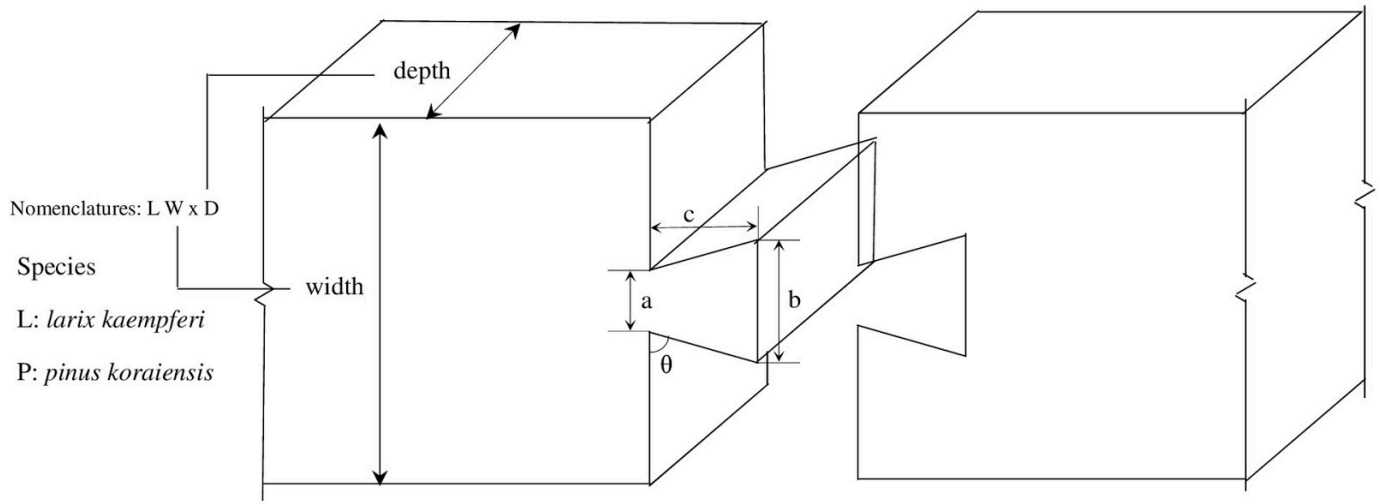
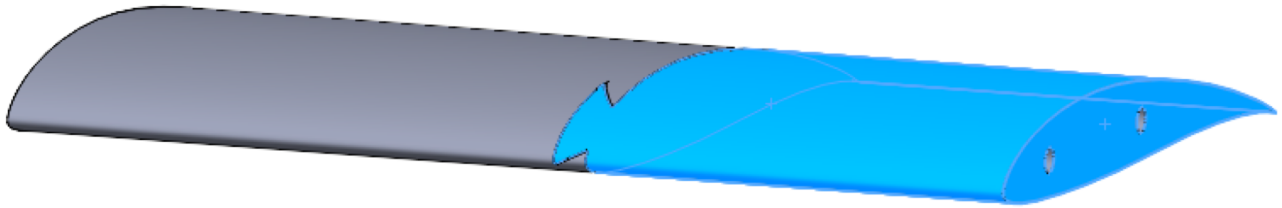
Assembling Methods: Woodworking

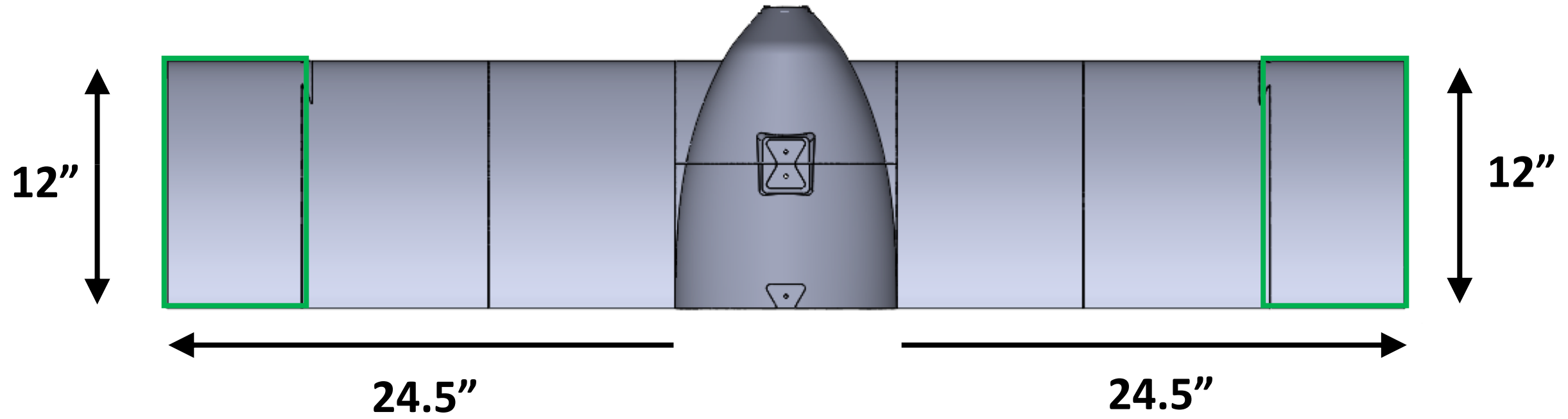




- The Dove Tail Connection
  - Consists of a male and female part
  - Prevents movement perpendicular to the connection
  - Prevents rotational movement

Lauren Chin

Canard Dimensions



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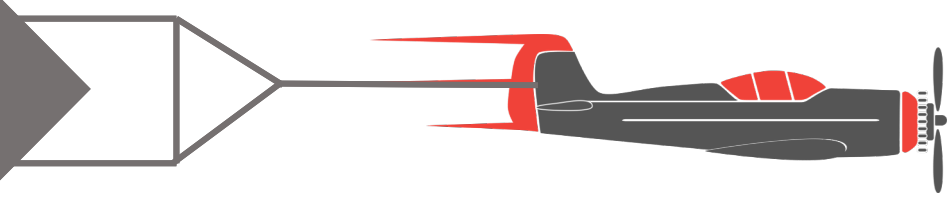
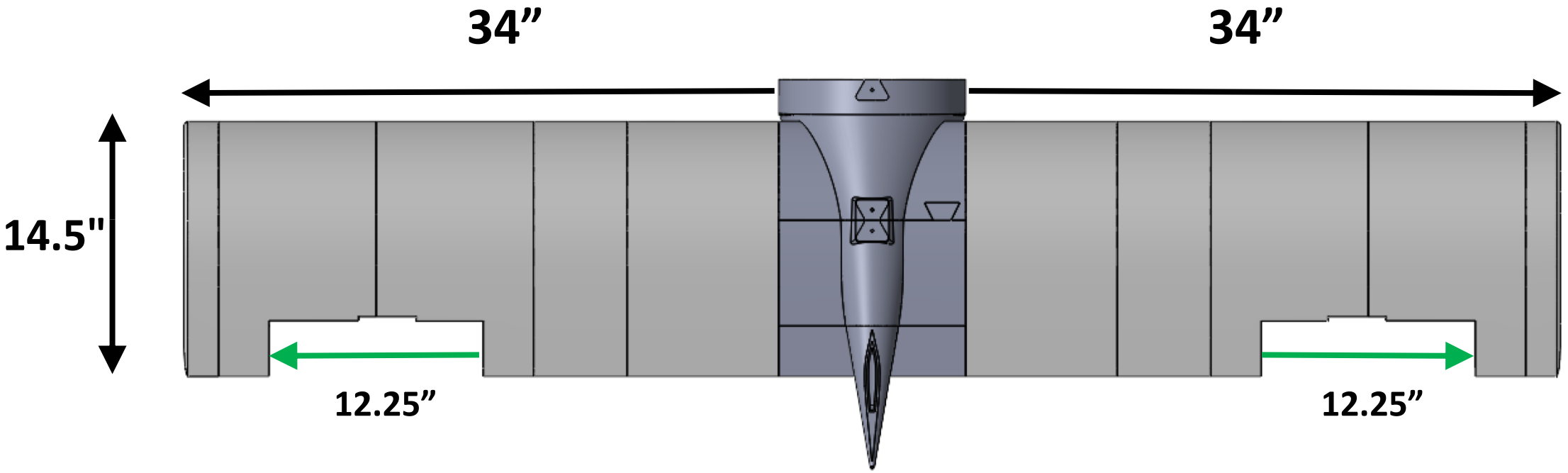
Main Wing Dimensions





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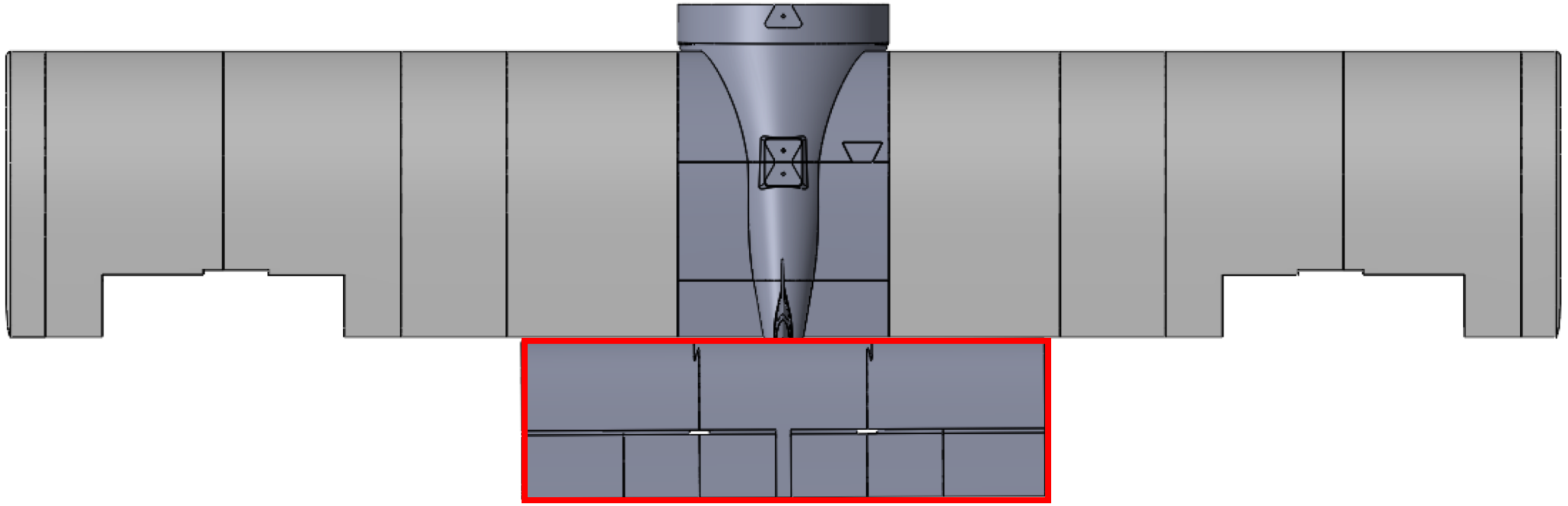
Horizontal Tail



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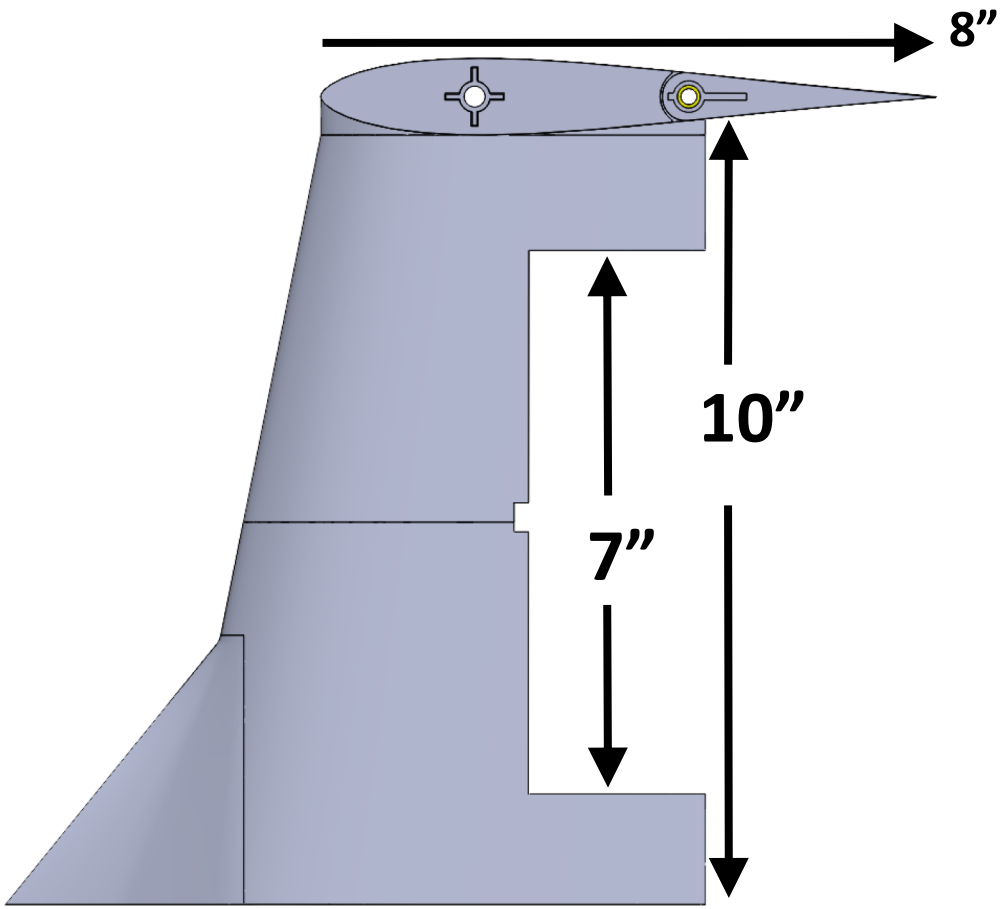
Vertical Tail



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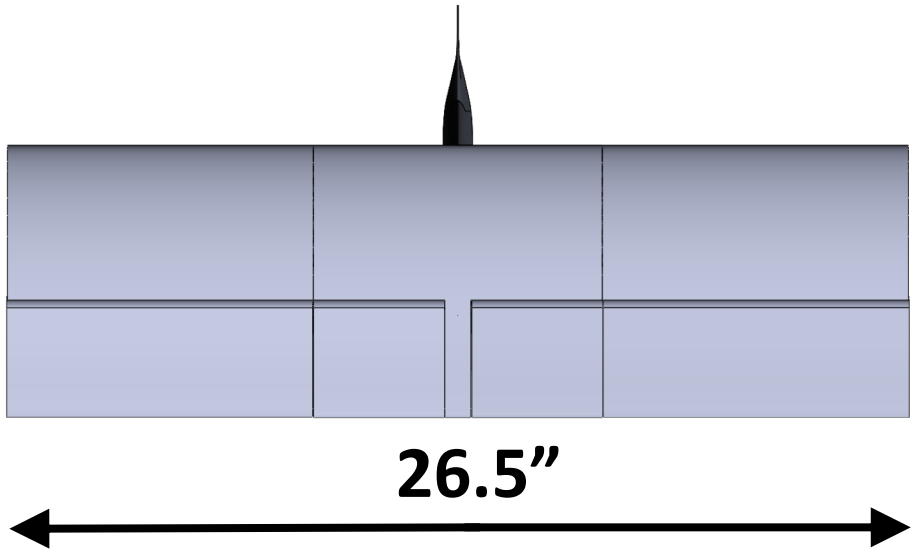
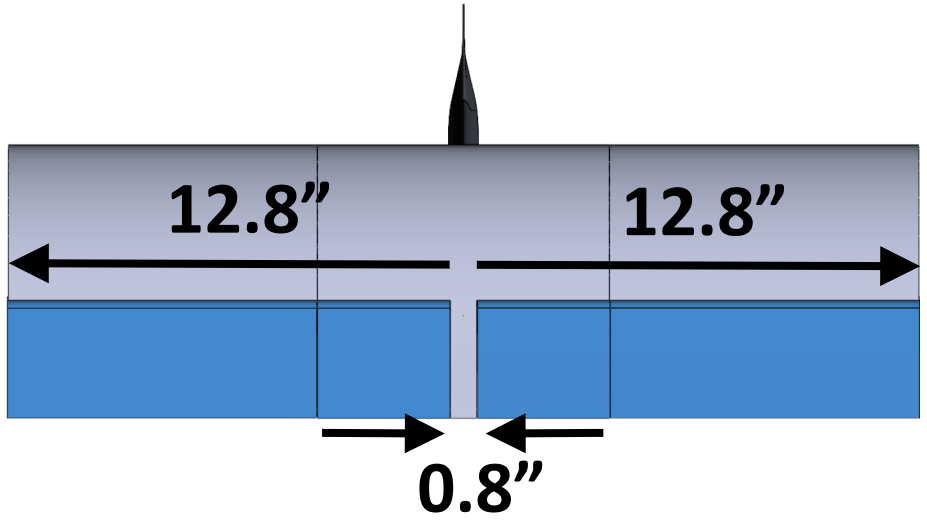
Horizontal Tail





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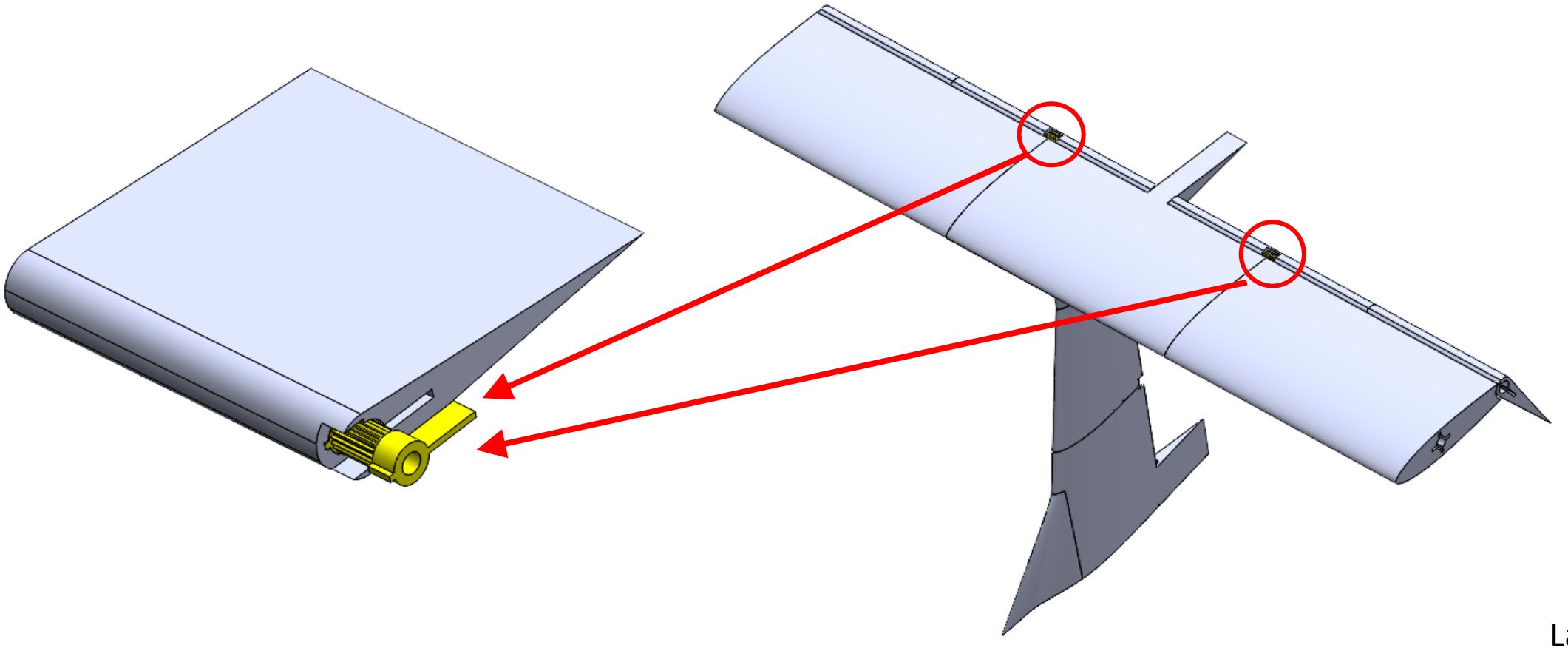
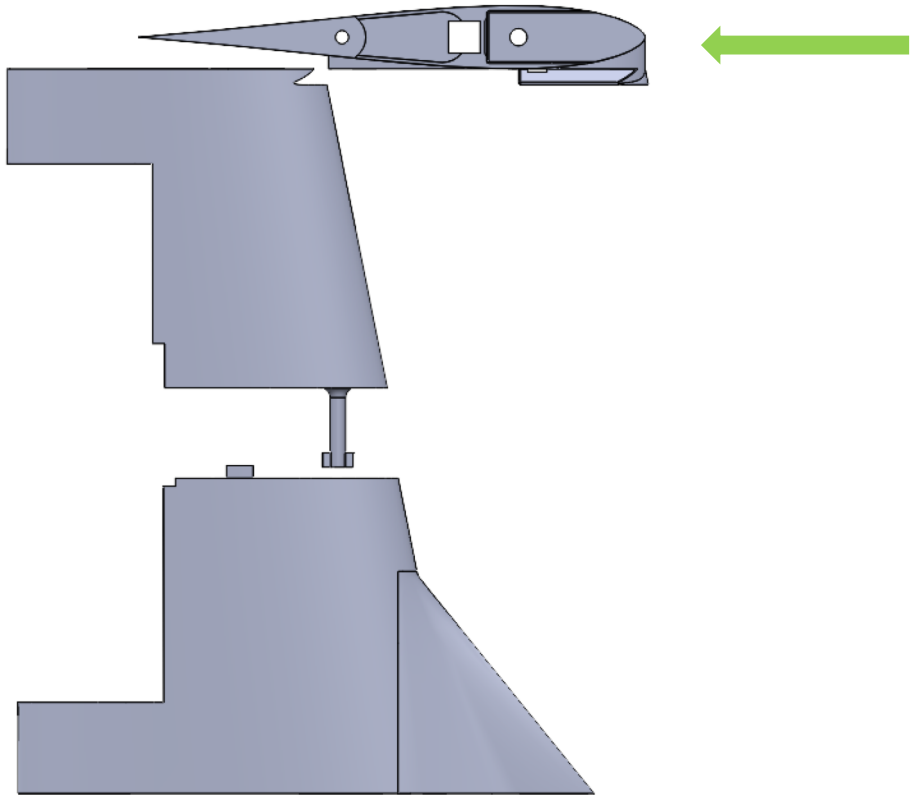
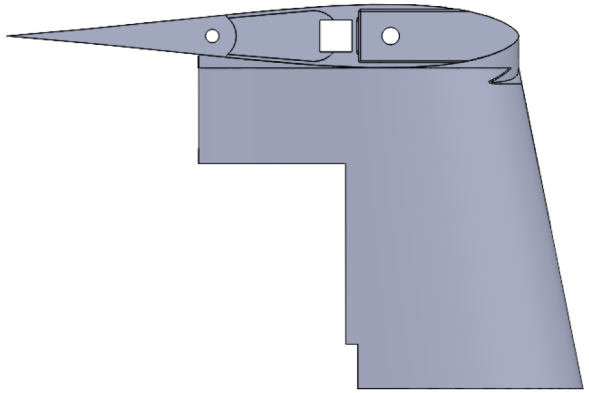
Control Surface Actuation



Lauren Chin

Re-designed Joints





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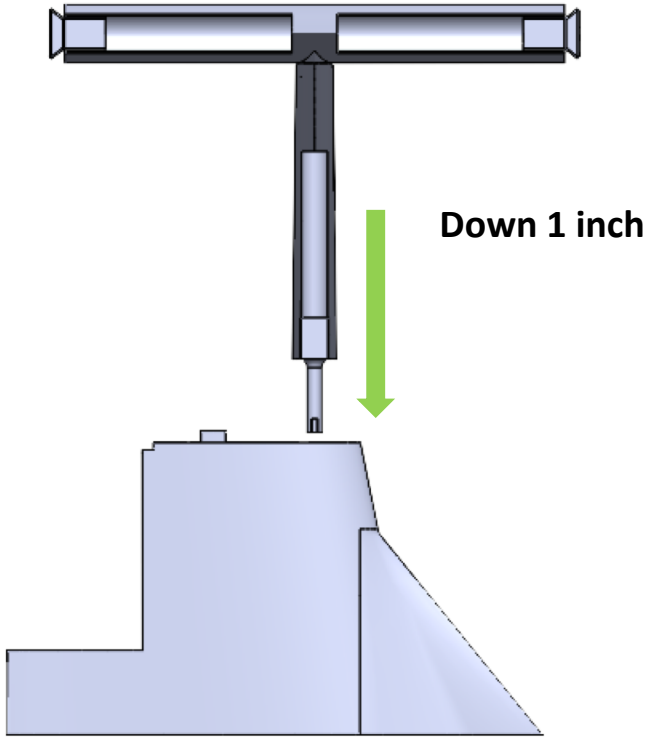
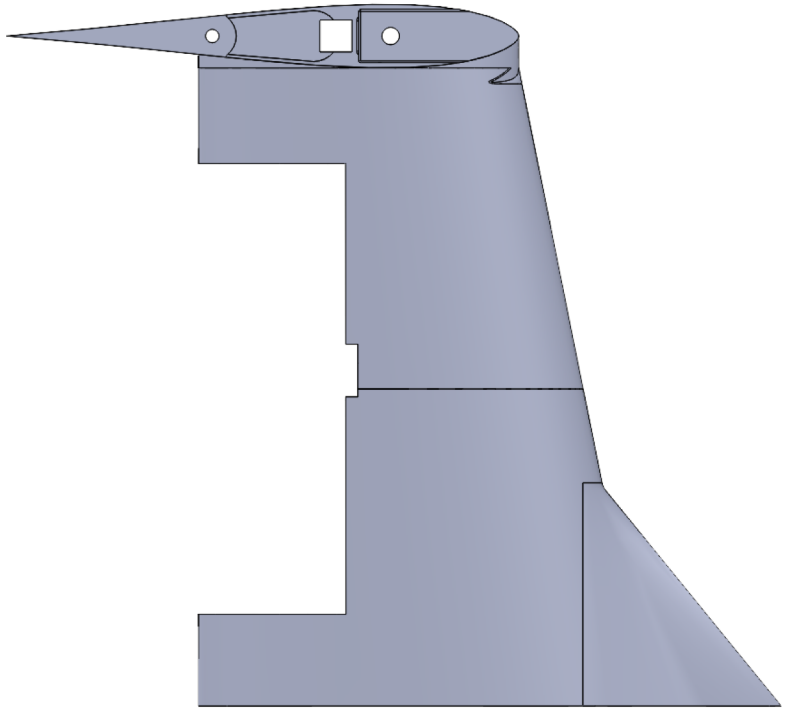
Re-designed Joints





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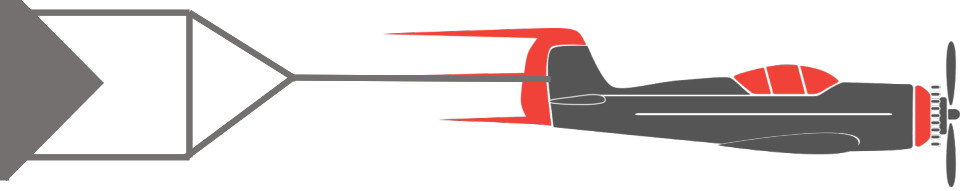
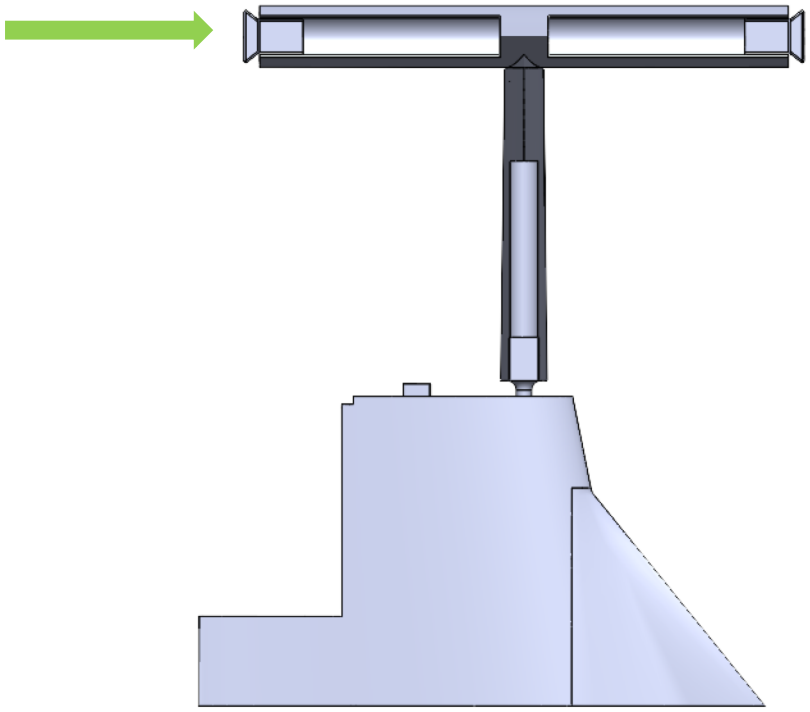
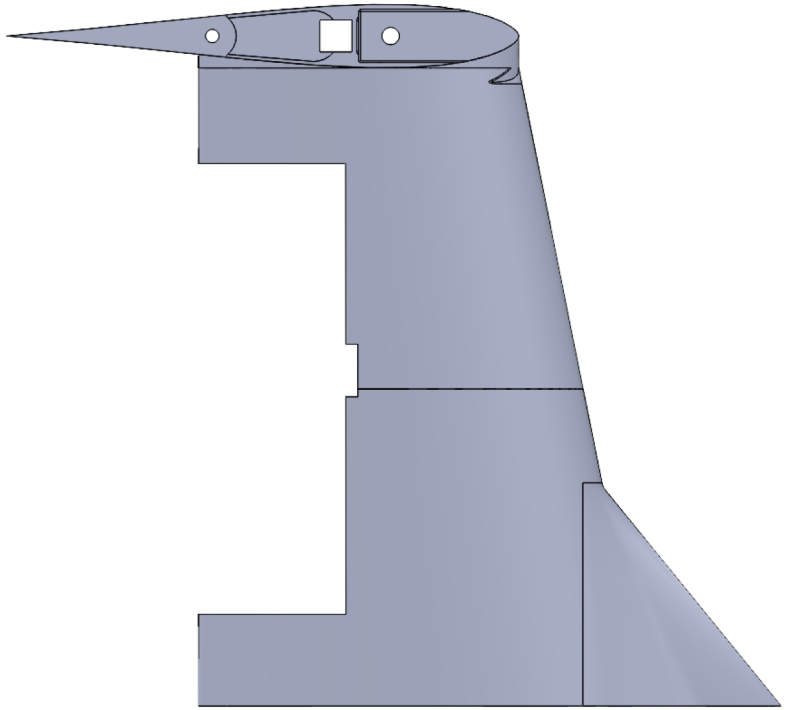
Re-designed Joints



Rotate 90°





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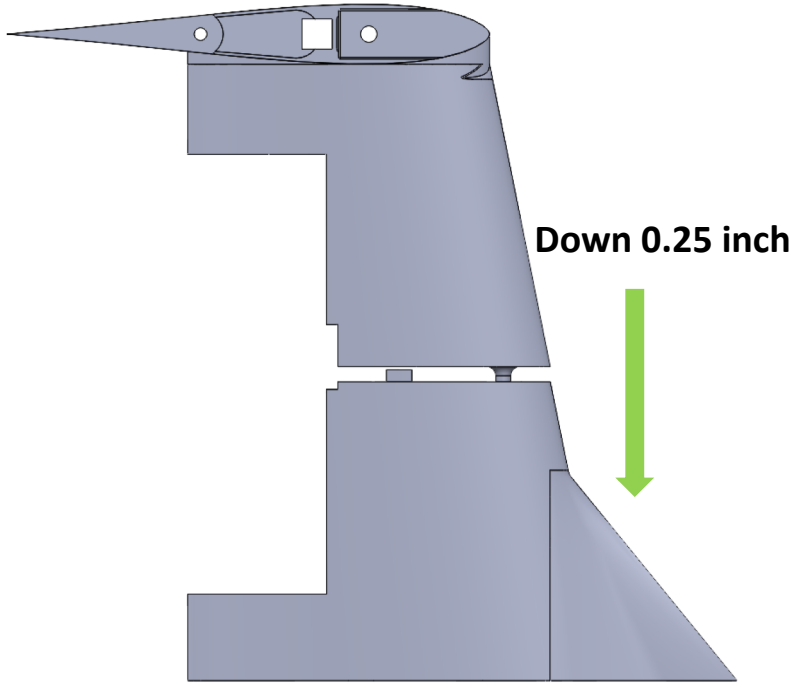
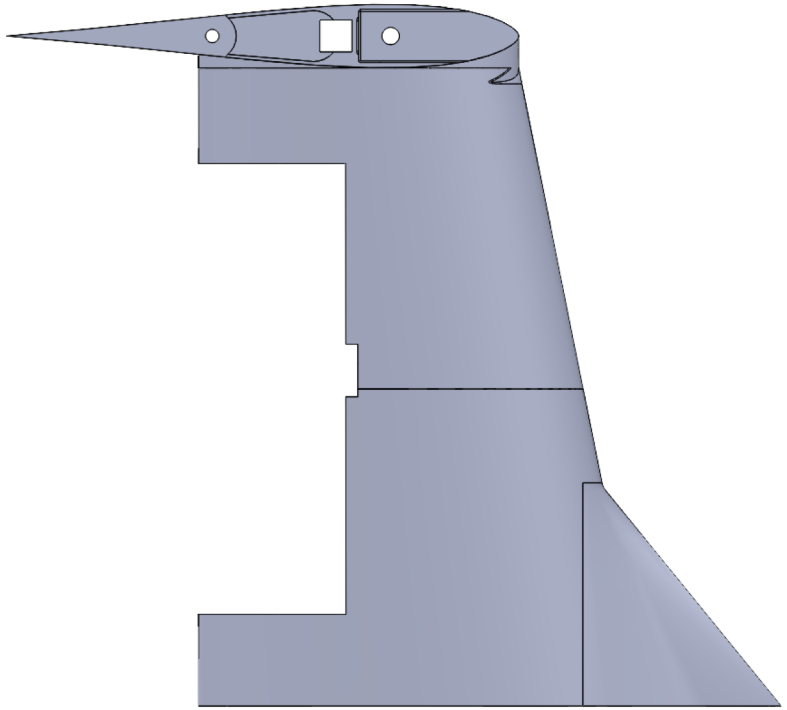
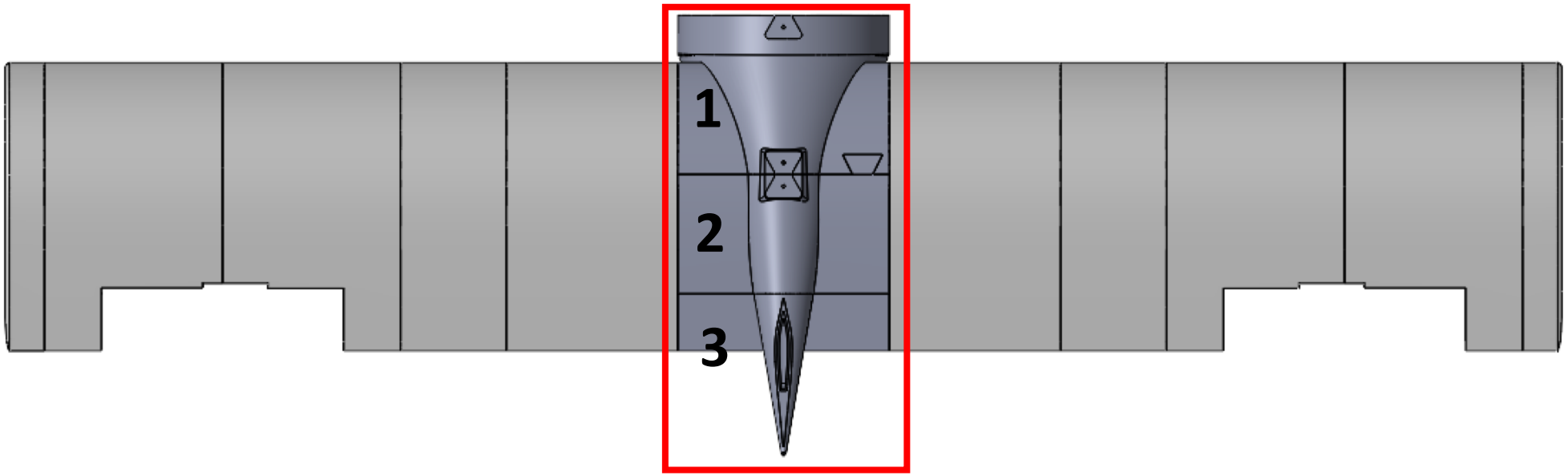
Re-designed Joints





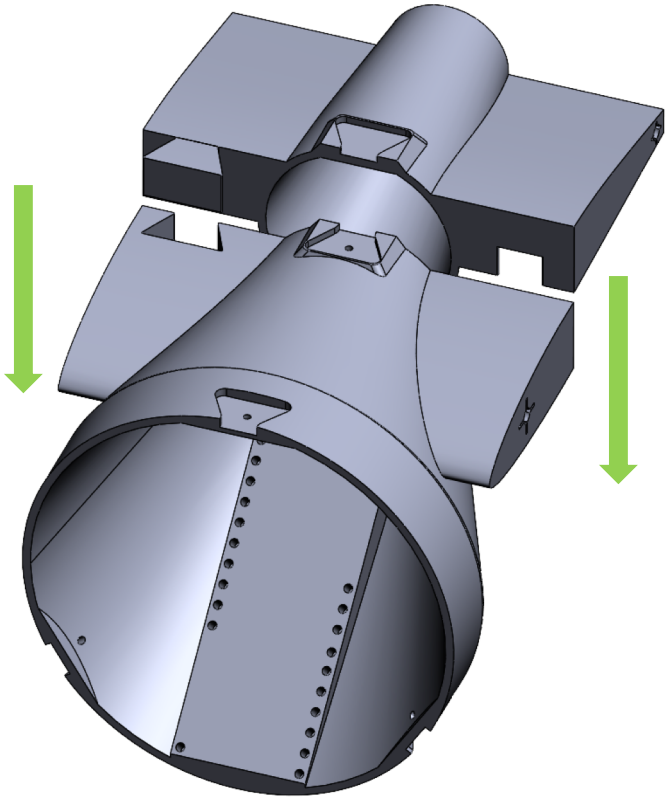
Lauren Chin

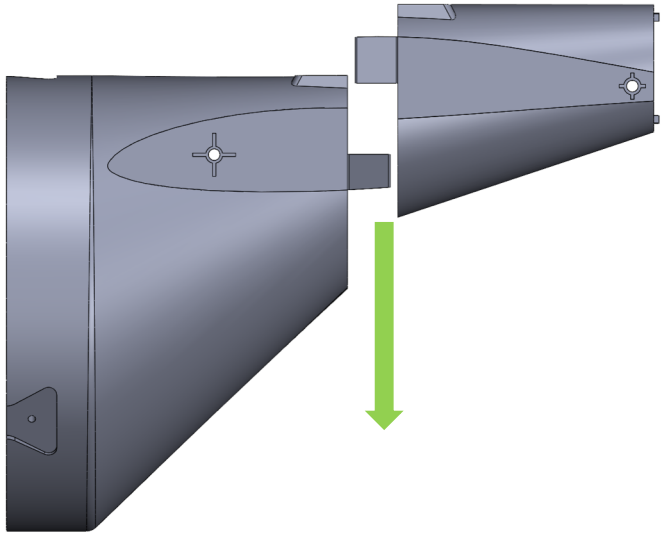
Alternative Fuselage Connections



Lauren Chin

Alternative Fuselage Connections





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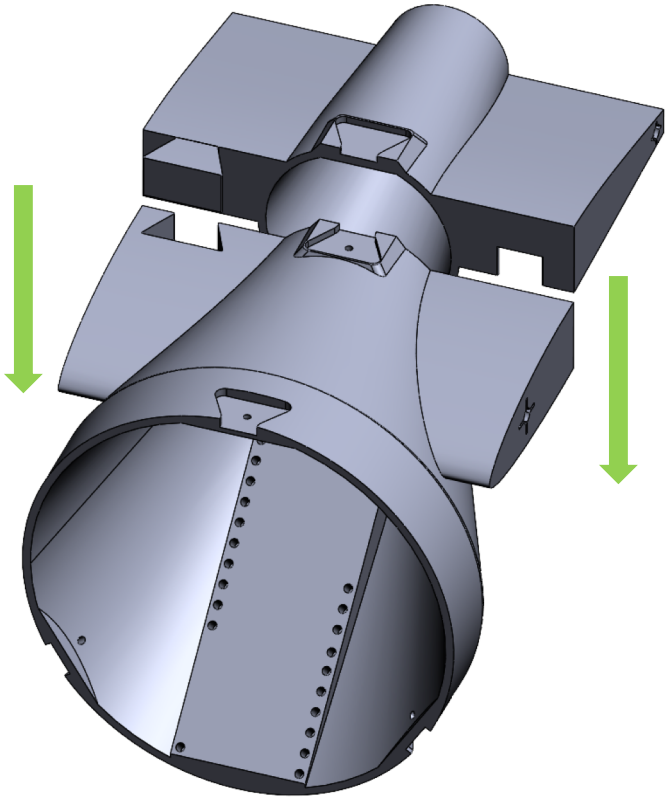
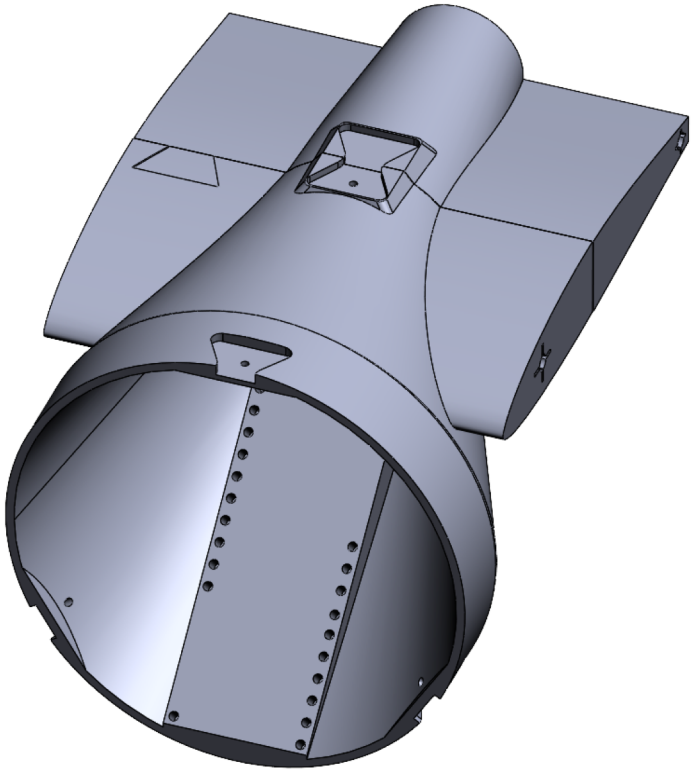
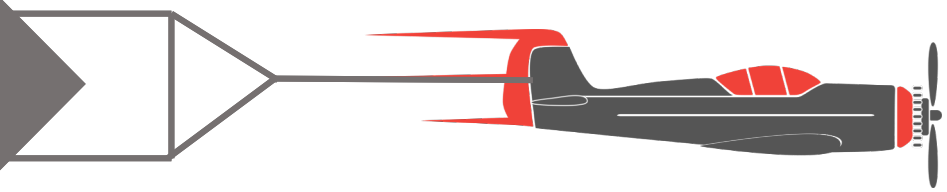
Alternative Fuselage Connections

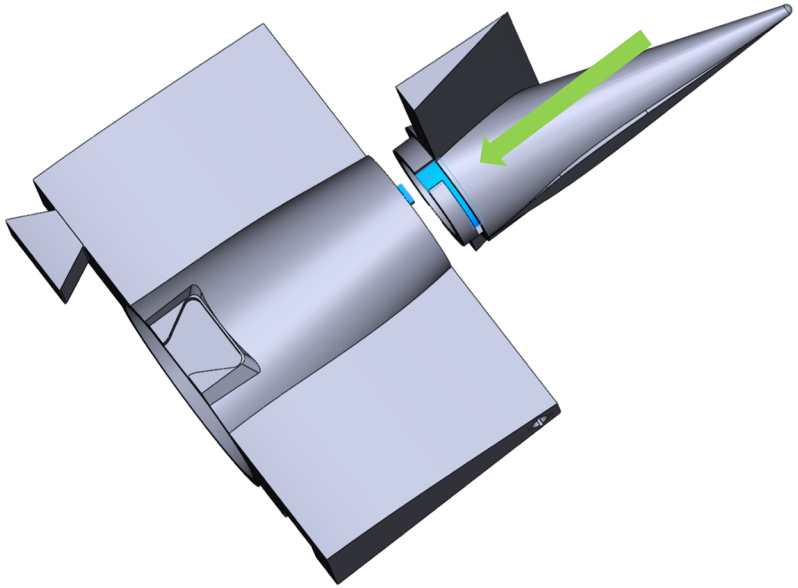




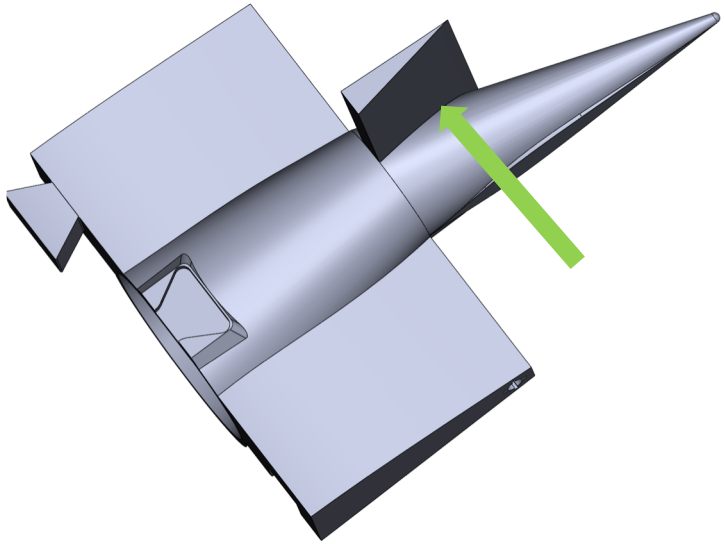
Lauren Chin

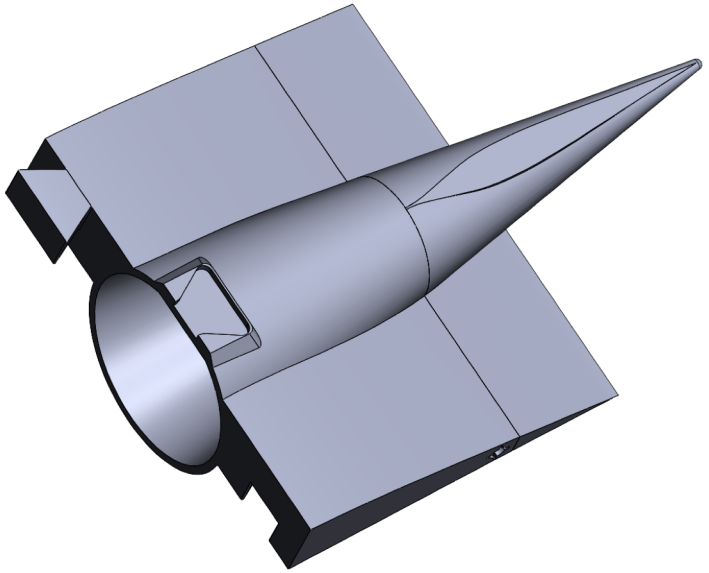
Fuselage Connections





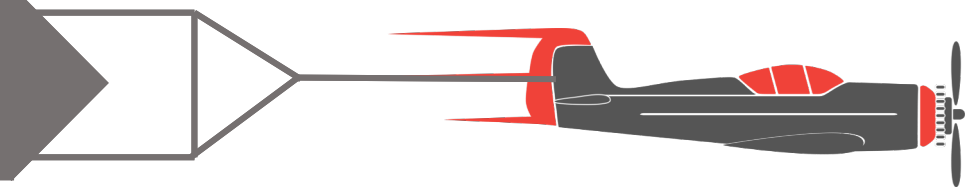
Rotate 90° counterclockwise





Lauren Chin

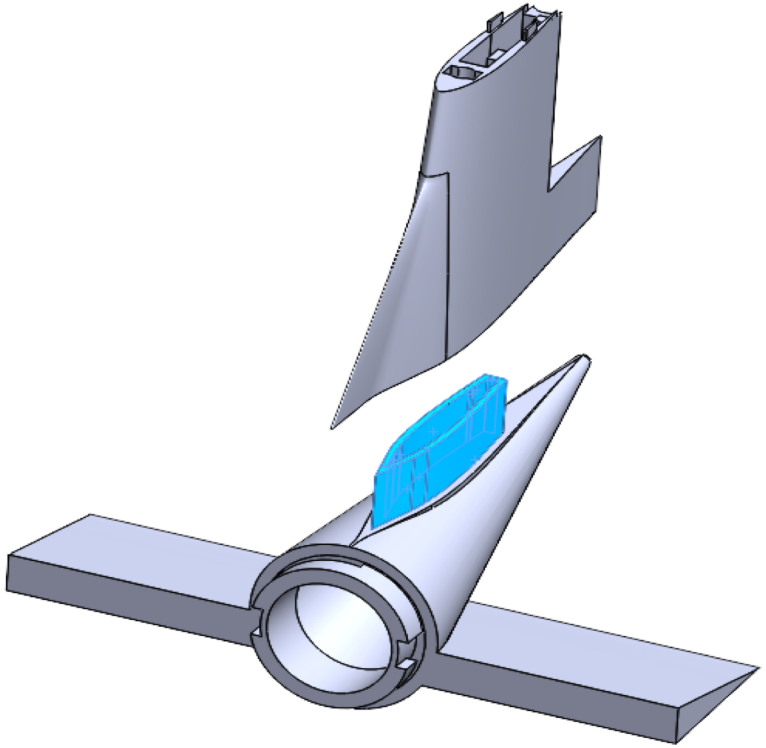
Fuselage Connections



- We used a slide in male/female end technique for our cargo hold so that we can take off the top 2 bowties and take off the top of the plane to load the cargo
- We used a similar method connecting the fuselage of the plane to the T-tail

Joseph Figari

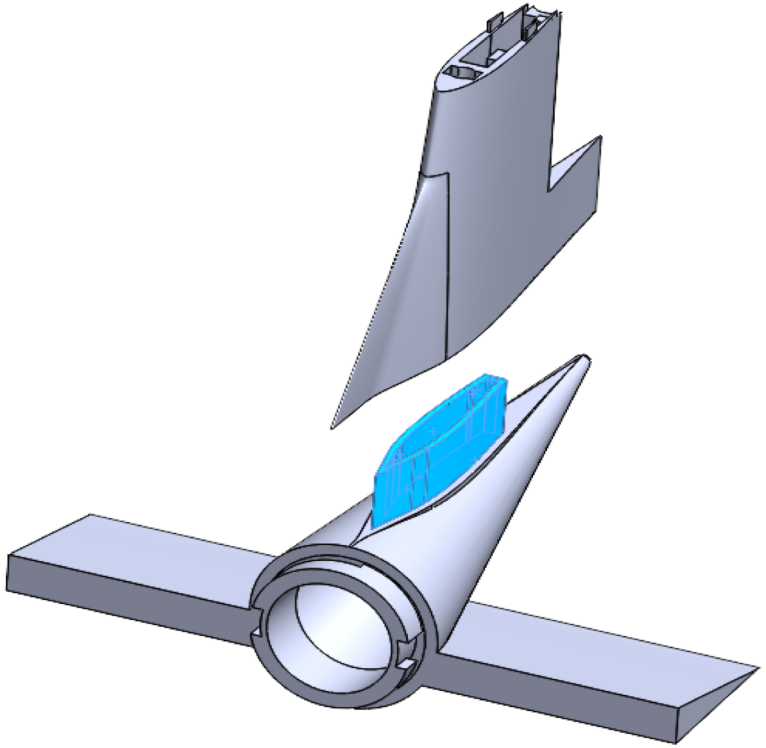
Fuselage Connections

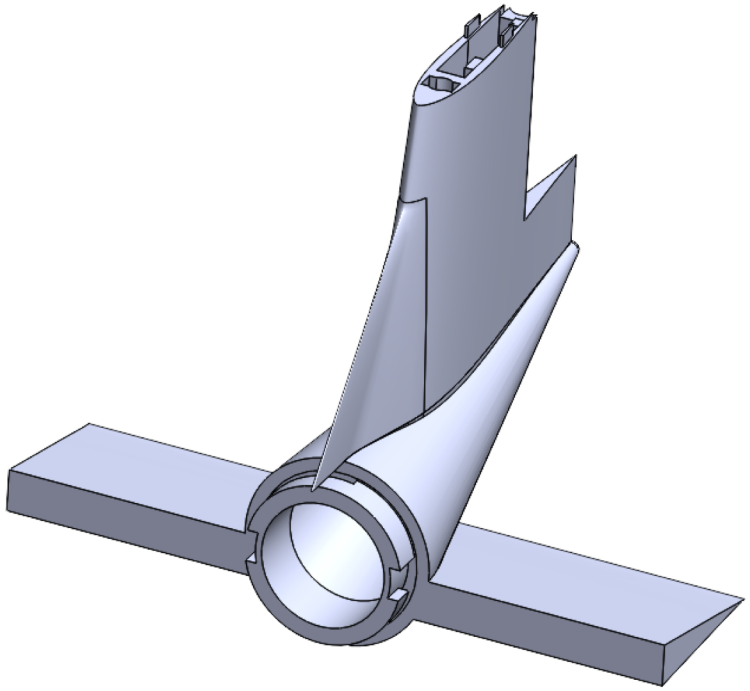


Tail connection

Joseph Figari

Fuselage Connections

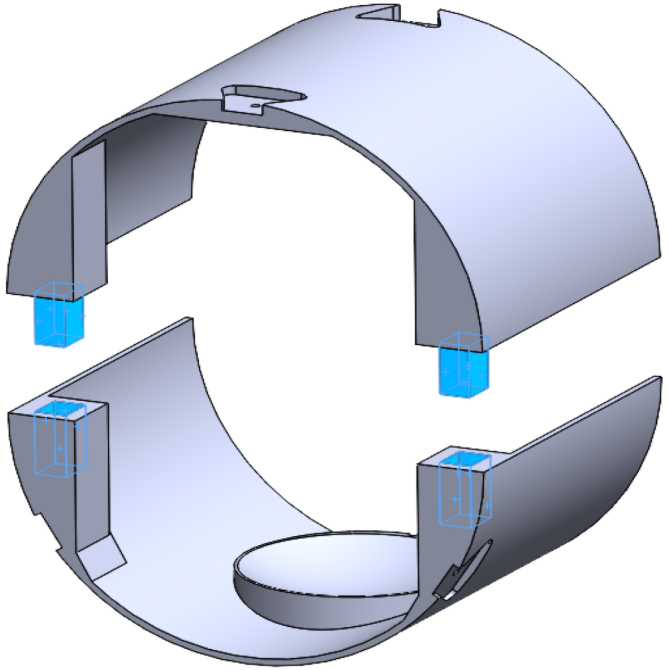




Tail connection

Joseph Figari

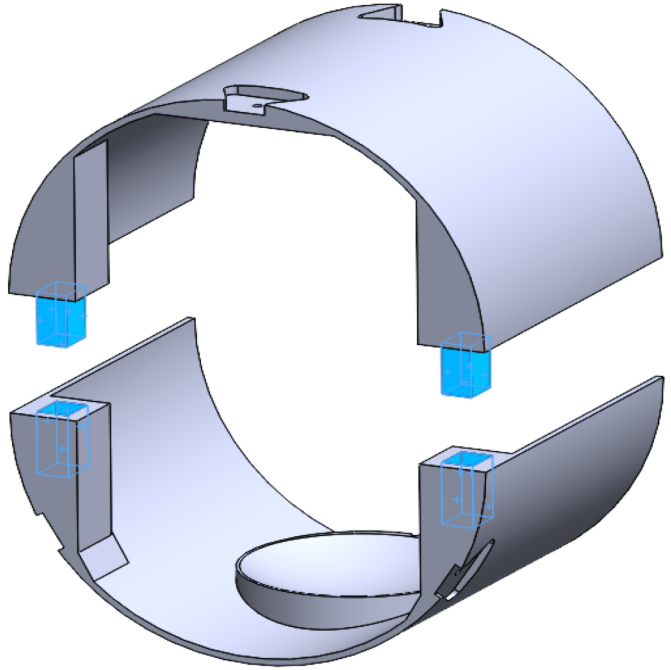
Fuselage Connections

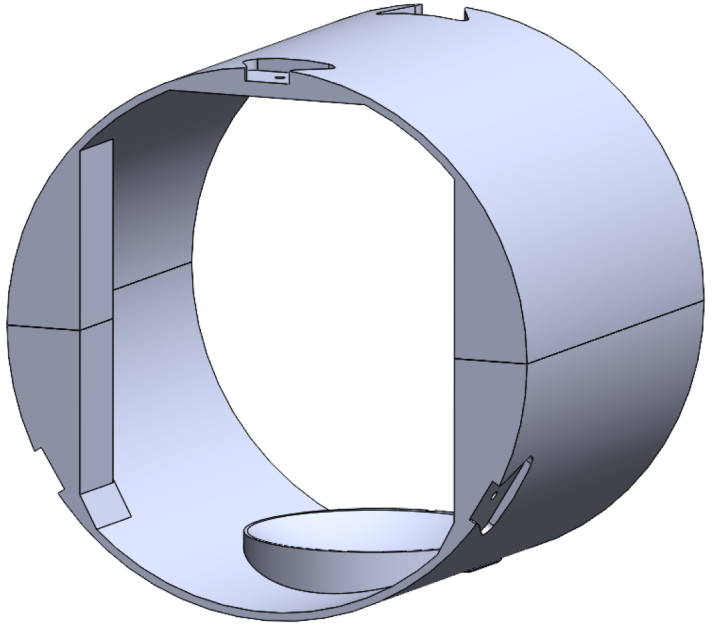


Fuselage connection

Joseph Figari

Fuselage Connections

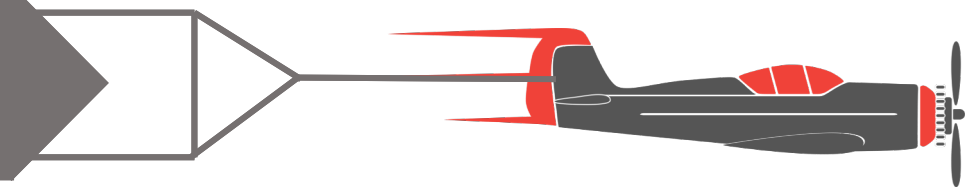




Fuselage connection

Joseph Figari

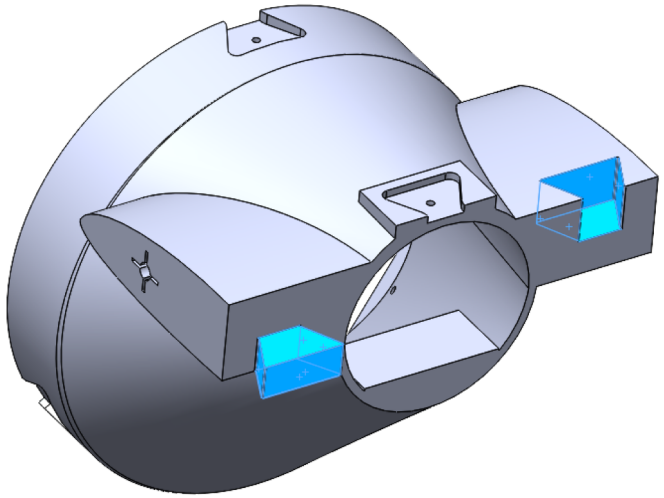
Fuselage Connections



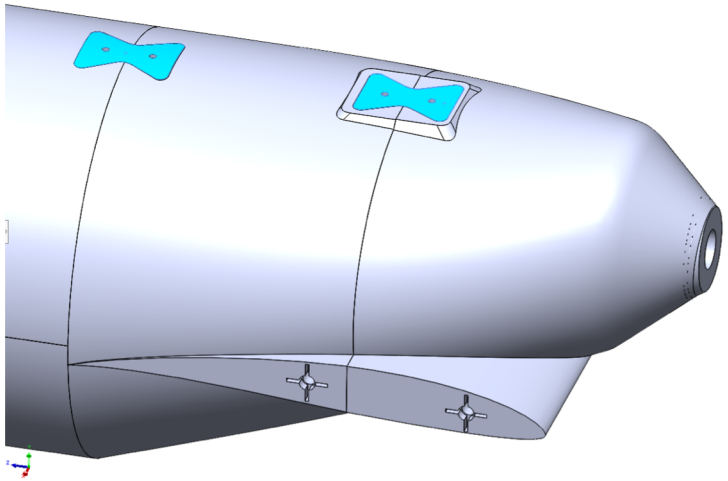
- We utilized 2 main connection methods when securing the fuselage
- The dove tail connection method was used to connect the tail parts of the fuselage together
- The bow ties were used throughout the whole fuselage to connect different sections of the fuselage

Joseph Figari

Fuselage Connections



Dovetail Connection



Bowtie Connection

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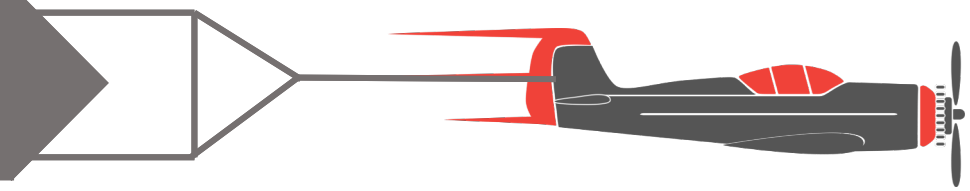
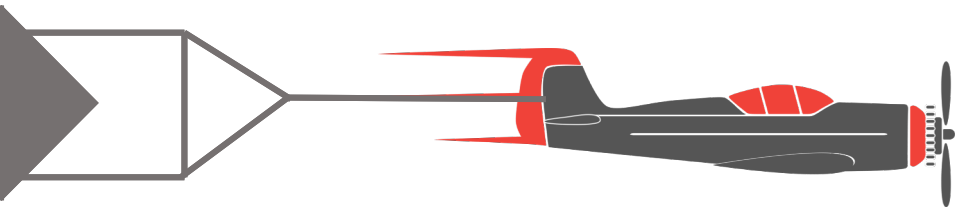
Fuselage Redesigned

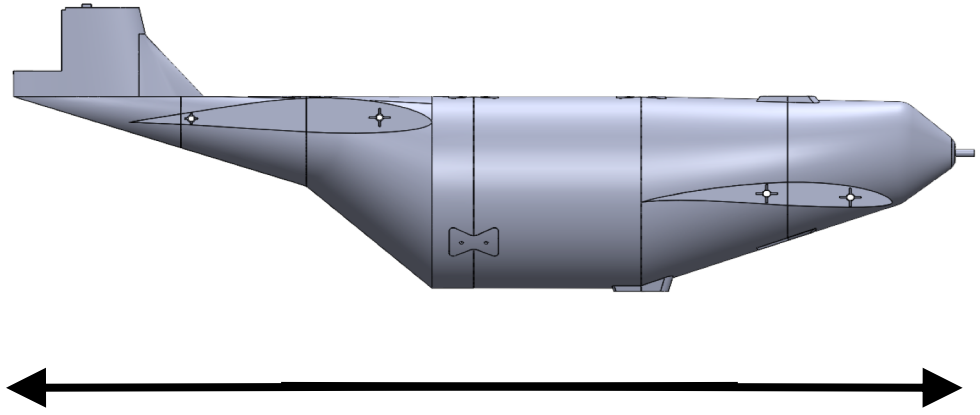


- Due to a wrong density value in our original CAD, we had to redesign our plane
- Plane came out 14 pounds heavier than expected
- Weight was cut by reducing the length of fuselage and reducing the size of the tail

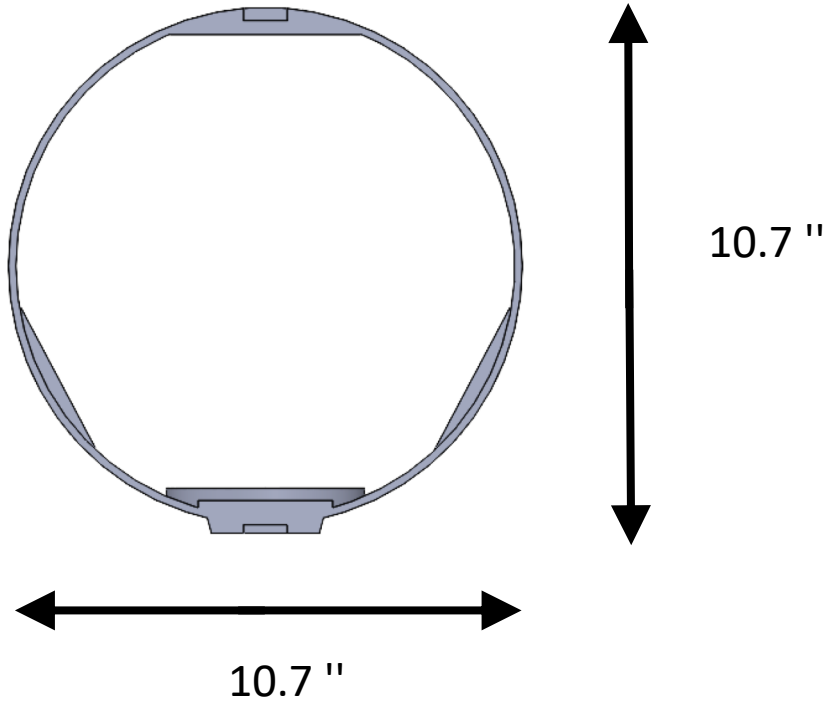
Joseph Figari

Fuselage Specifications



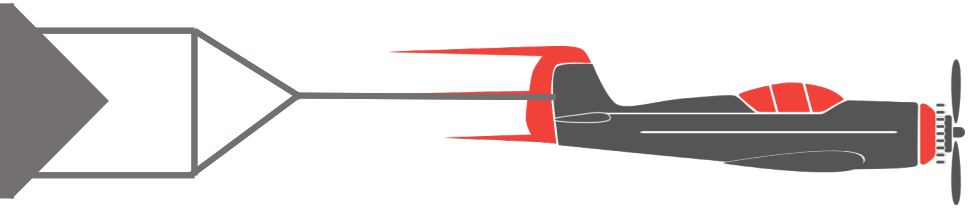


48.4''

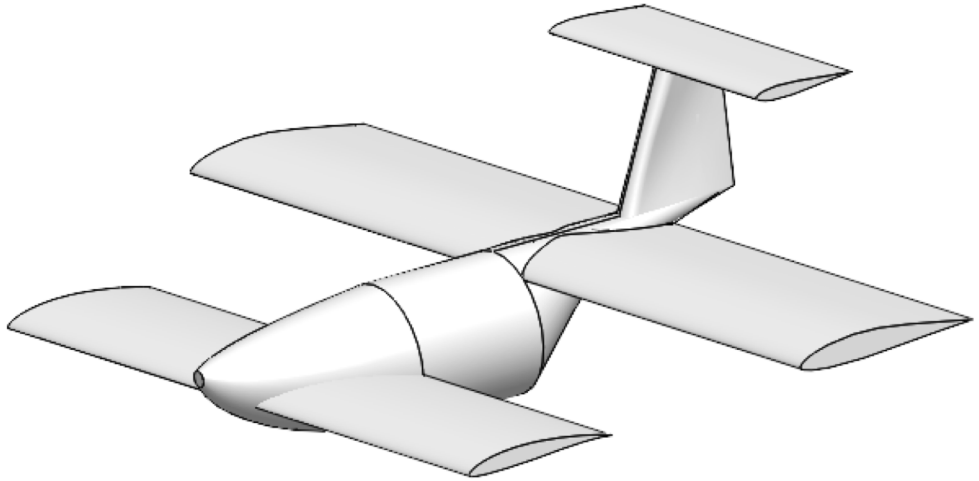


Joseph Figari

Fuselage Specifications



- Our plane is predicted to weigh 14.62 lbs
- This is lighter than our original plane which was predicted to weigh 28 pounds



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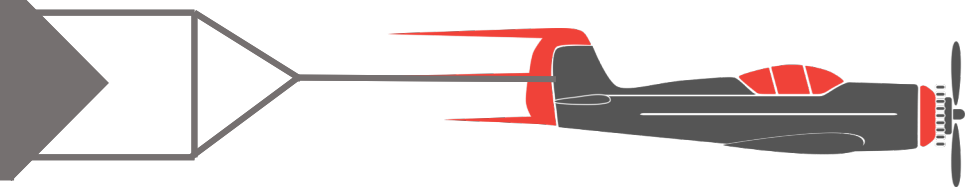
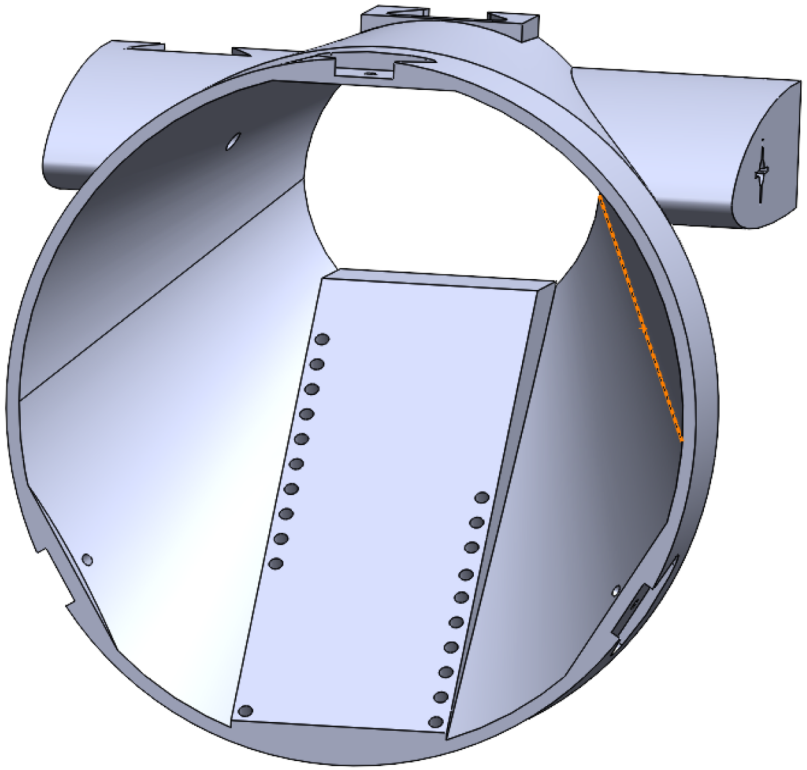
Cargo Hold



- We had to place our required cargo at 2 different points to balance the center of gravity
- The soccer ball will be placed 18 inches from the leading edge which puts it in the 3rd section of the fuselage
- The box weight sits at the beginning of the tail piece of the fuselage
  - We included multiple points where the box weight can be secured for flexibility

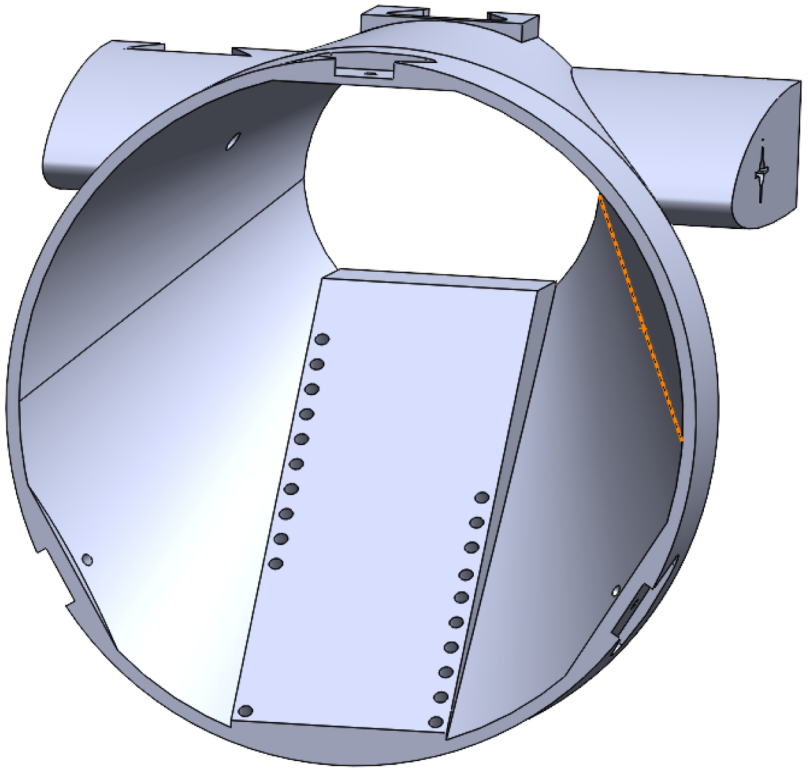
Joseph Figari

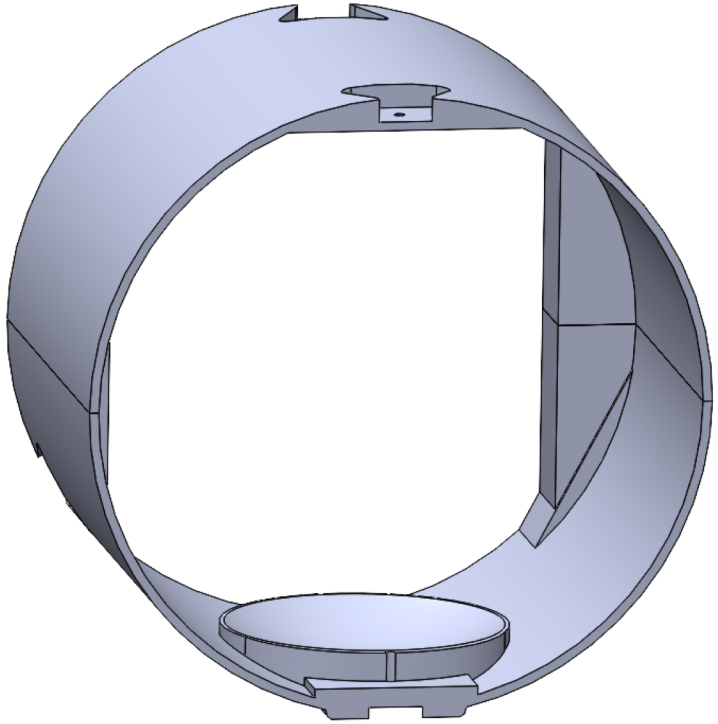
Cargo Hold



Joseph Figari

Cargo Hold

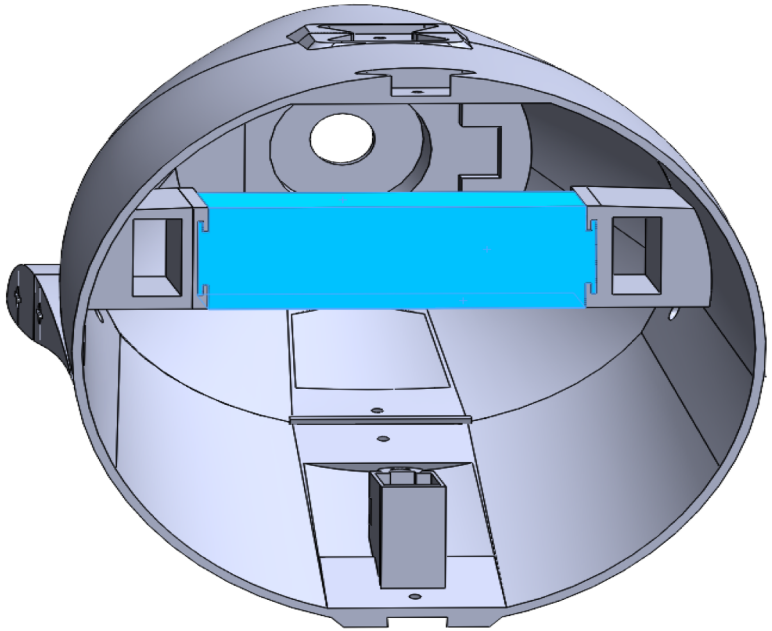


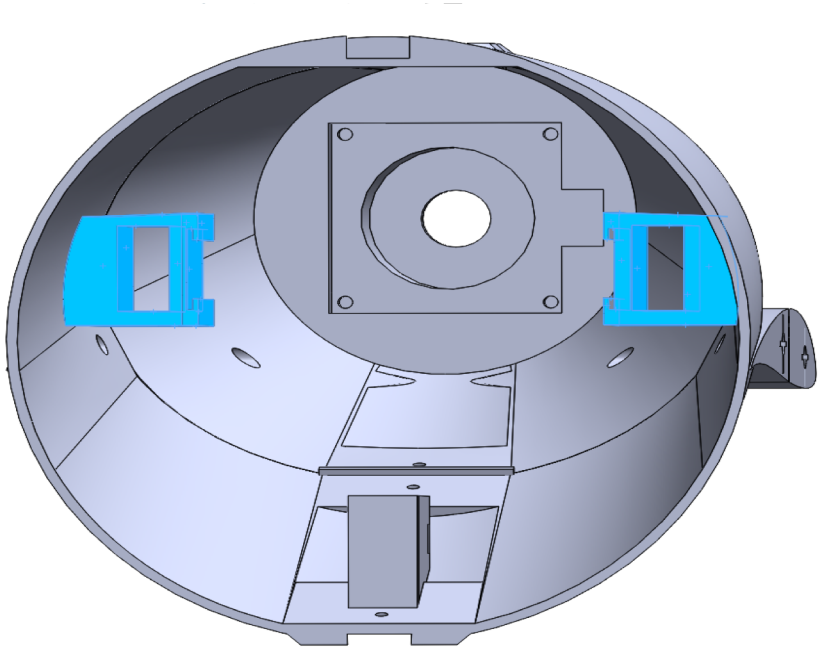


Joseph Figari

Cargo Hold

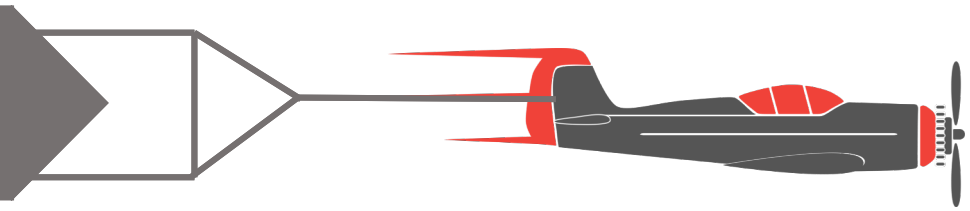
- We placed our battery in the nose of the plane as Seminole RC club informed us its more efficient for the motor to be closer to the battery



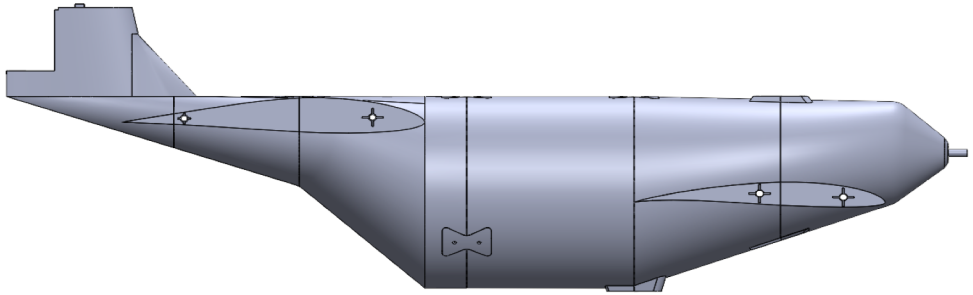


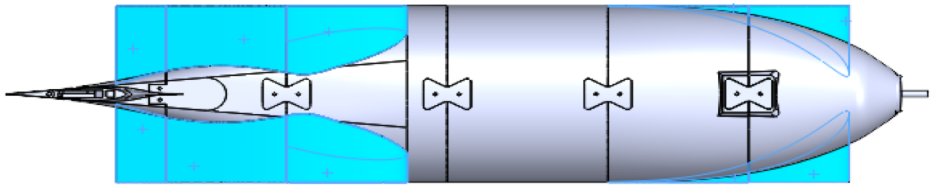
Joseph Figari

Connecting Wings



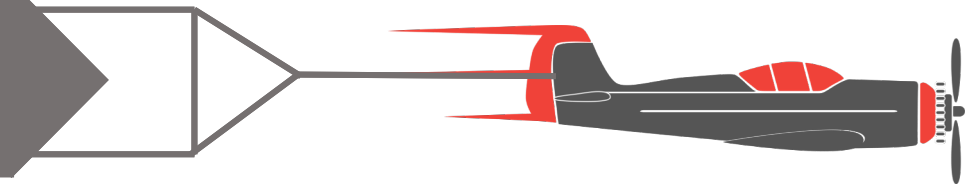
- The fuselage of the plane and the wings were connected through the 2 spars running through each wing
- We extruded the matching airfoil out of the plane to match the diameter of the fuselage





Joseph Figari

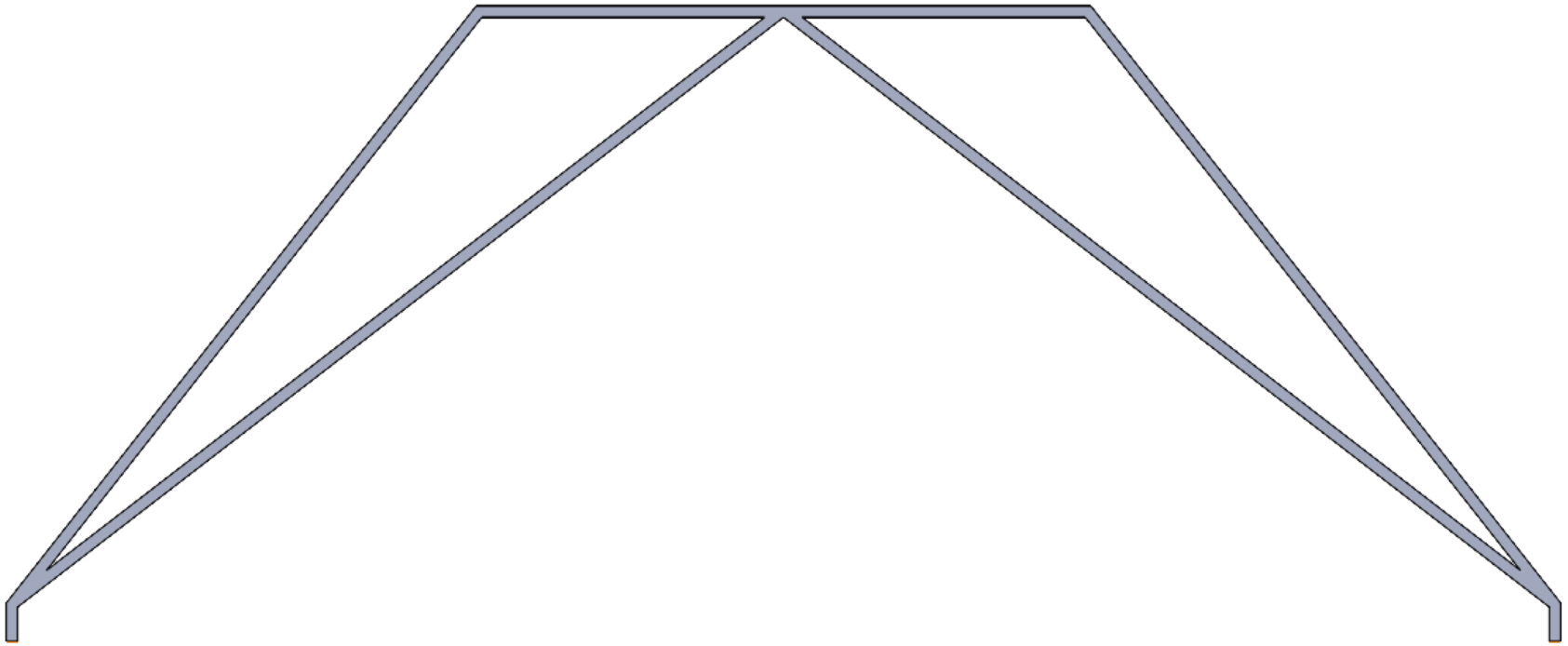
Landing Gear



- Seminole RC gave recommendations on designing the landing gear
- Back wheels should be set 20 inches apart
- Propellor should have a 2 – 5 inch ground clearance
- This will help in stabilizing the plane during take-off

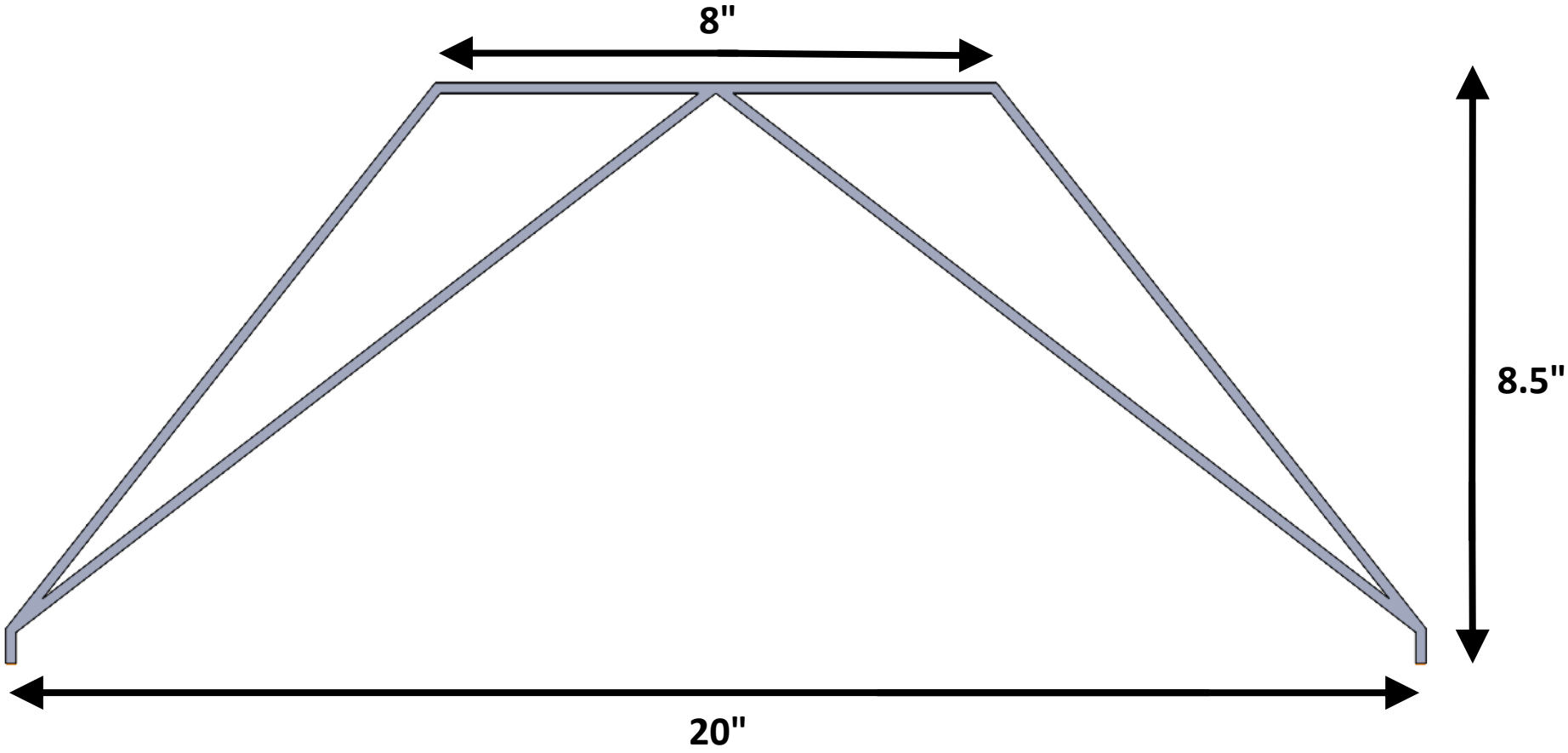
Jacob Pifer

Landing Gear



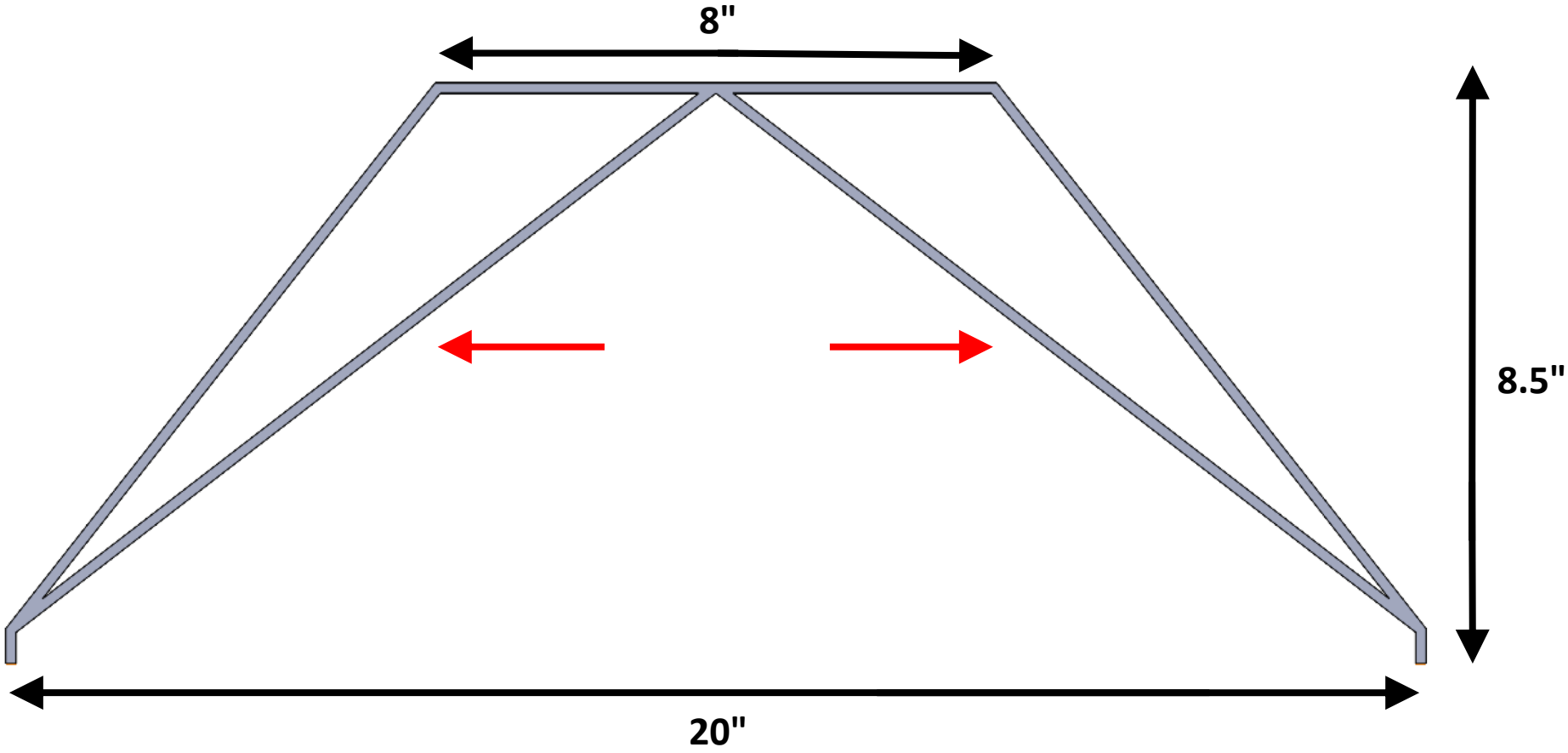
Jacob Pifer

Landing Gear



Jacob Pifer

Landing Gear



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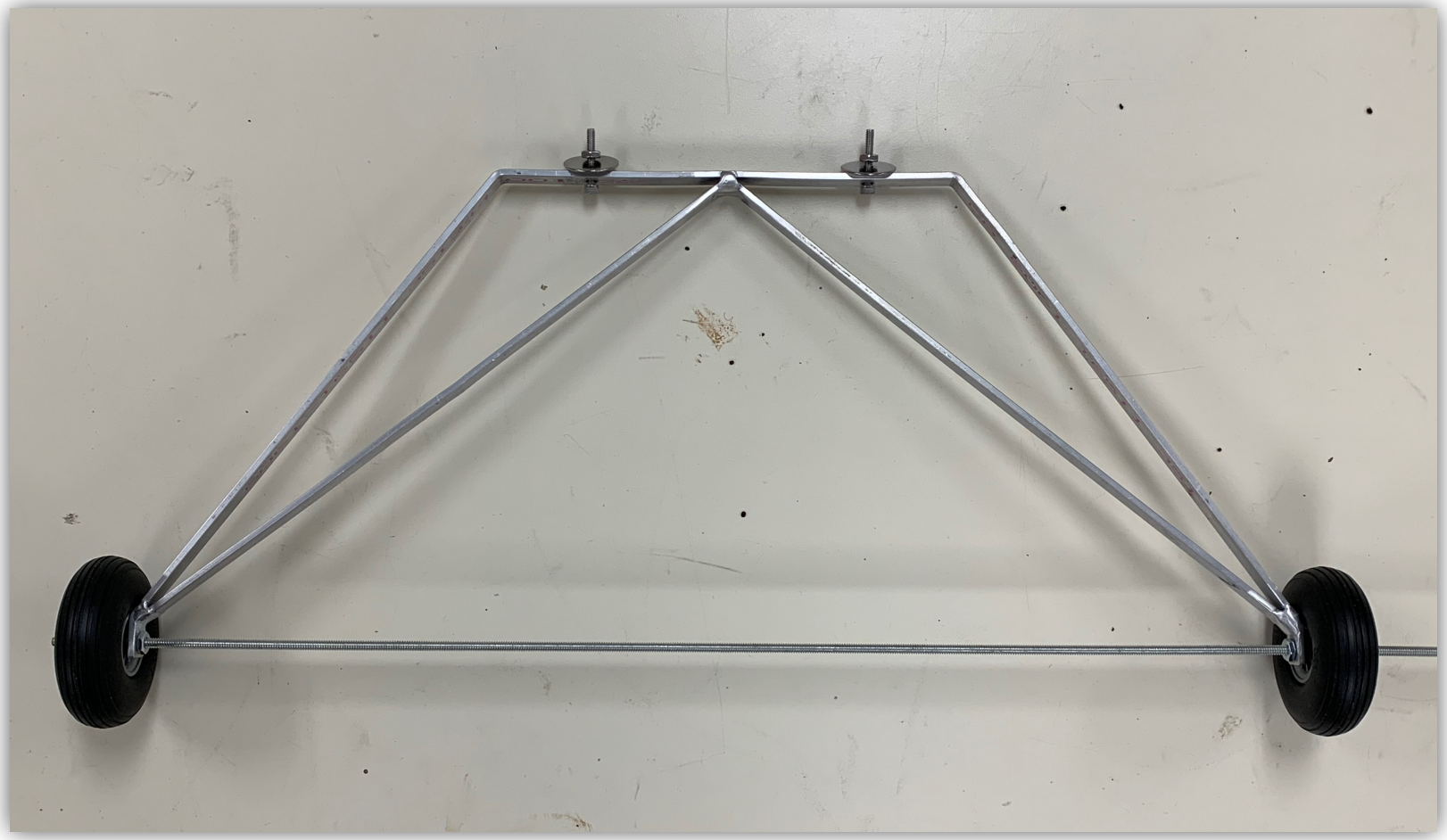
Landing Gear



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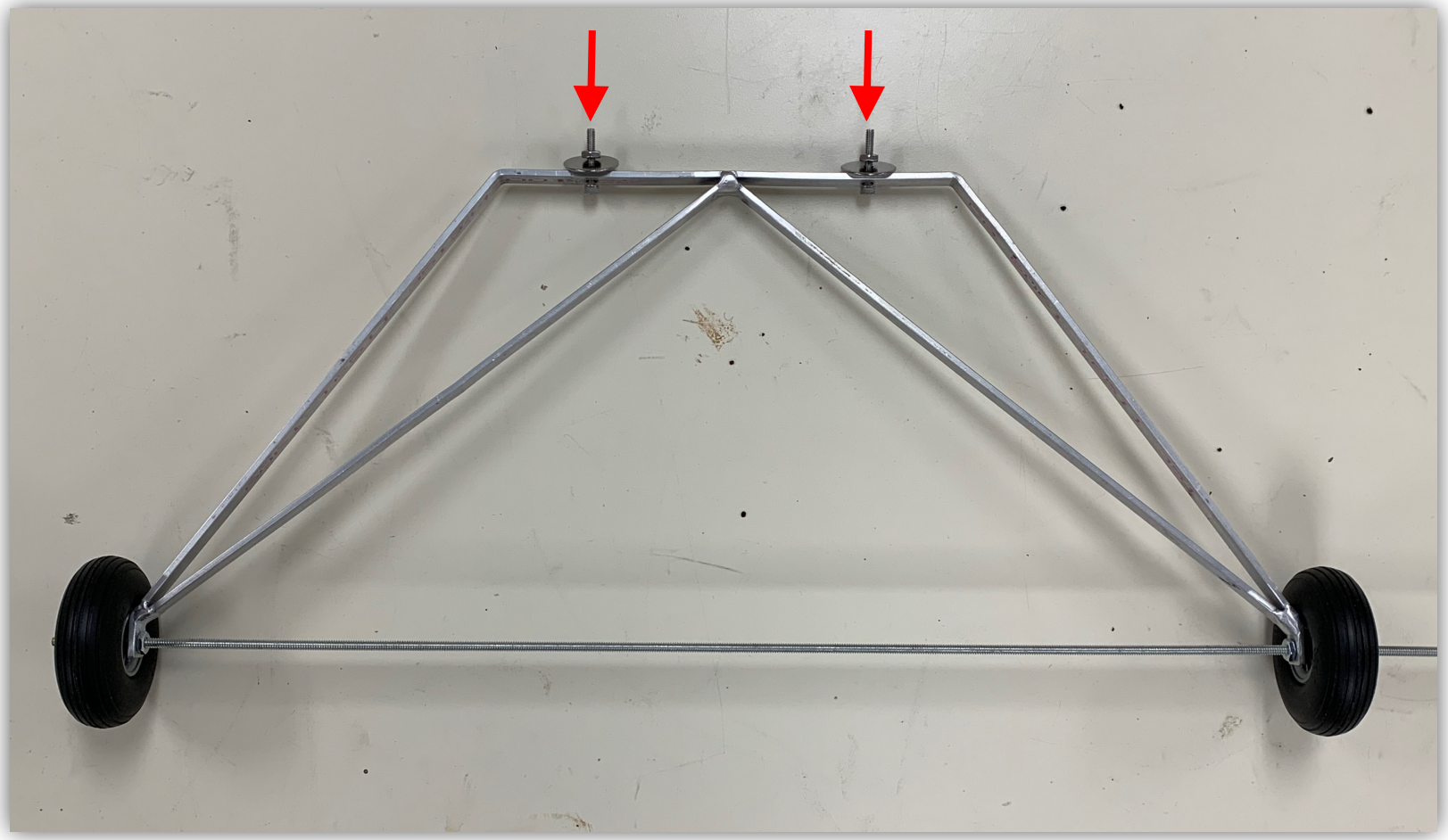
Landing Gear



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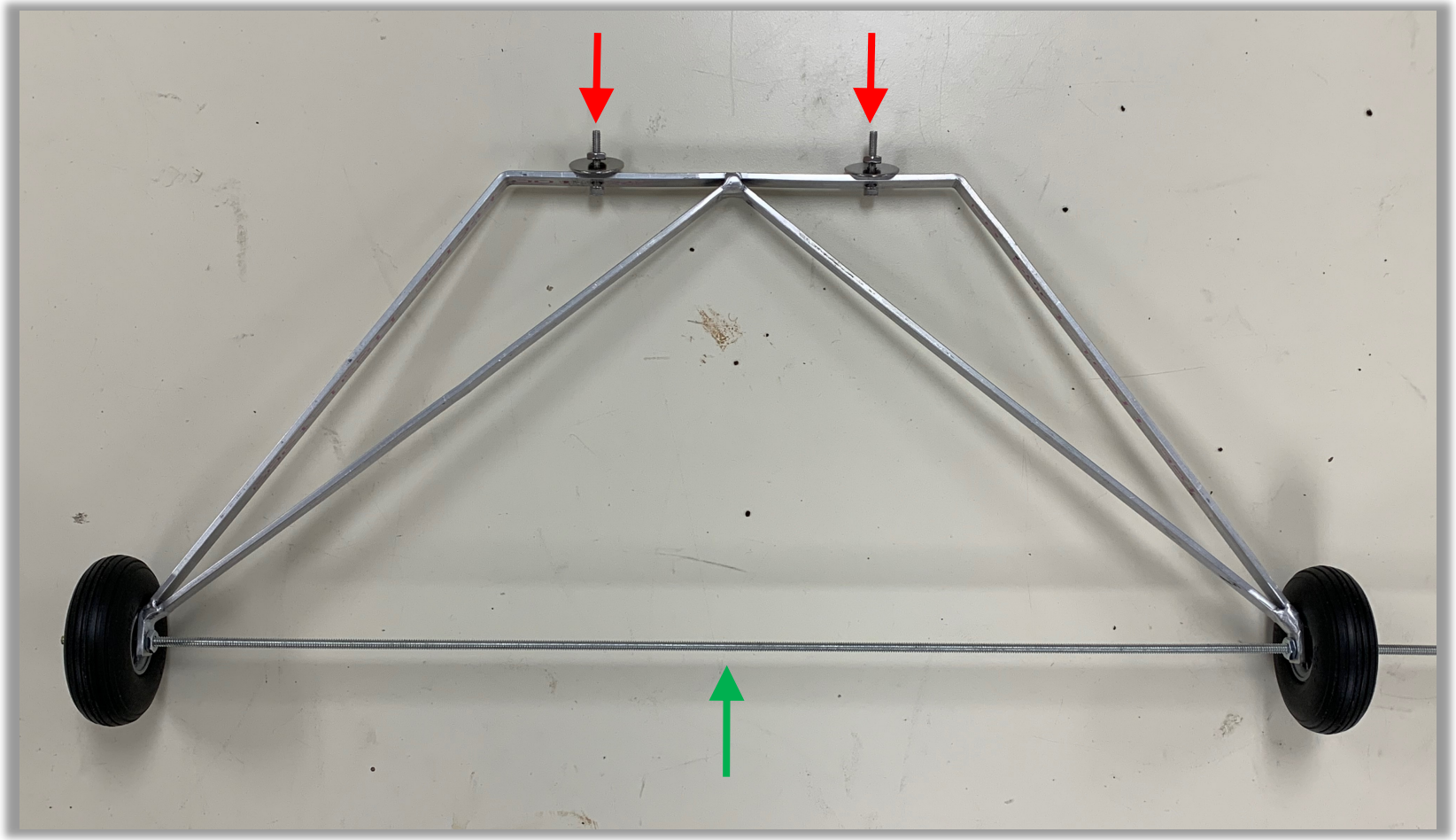
Landing Gear



Jacob Pifer

Landing Gear

Jacob Pifer

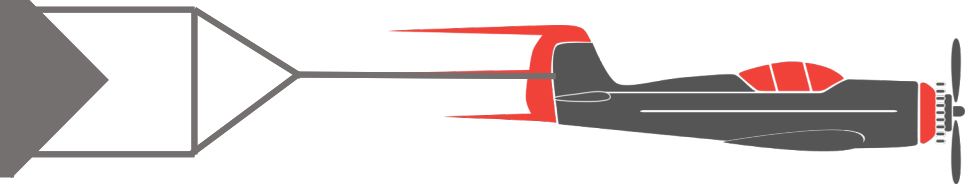
Landing Gear

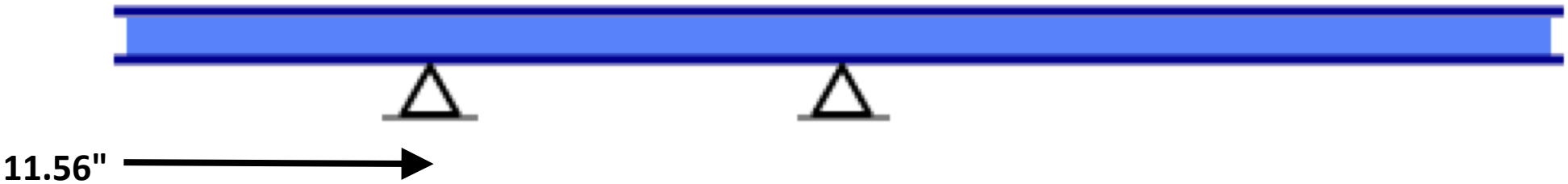
Jacob Pifer

Landing Gear Placement

Jacob Pifer

Landing Gear Placement





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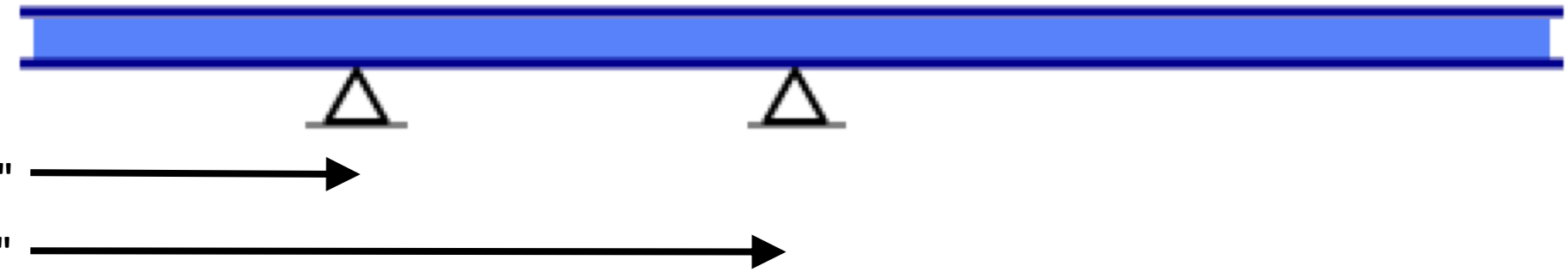
Landing Gear Placement



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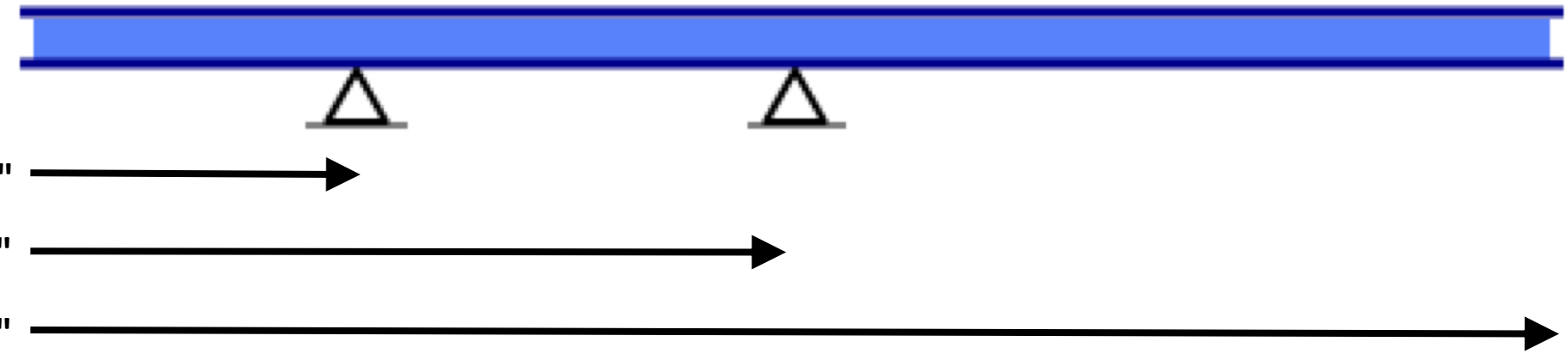
Landing Gear Placement



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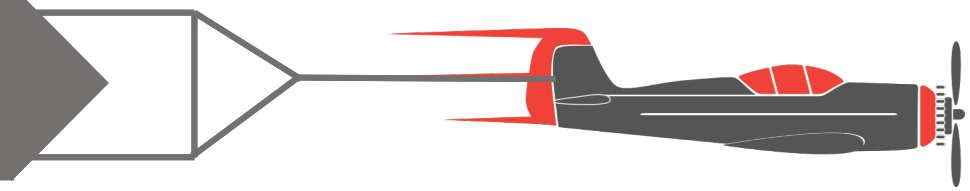
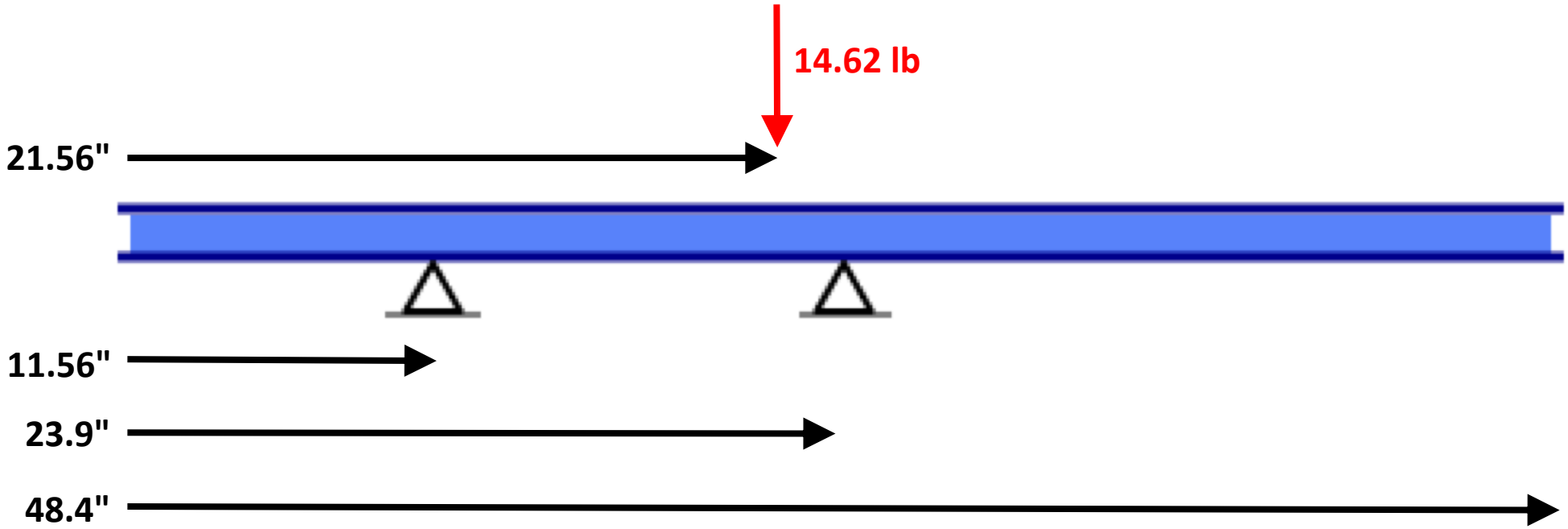
Landing Gear Placement





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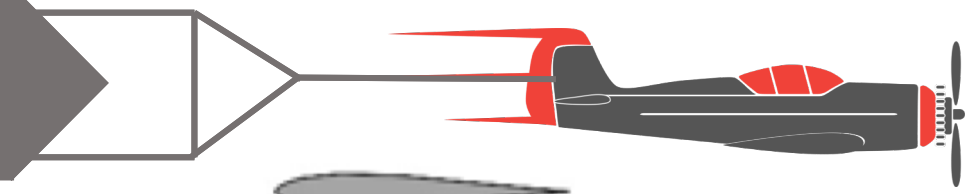
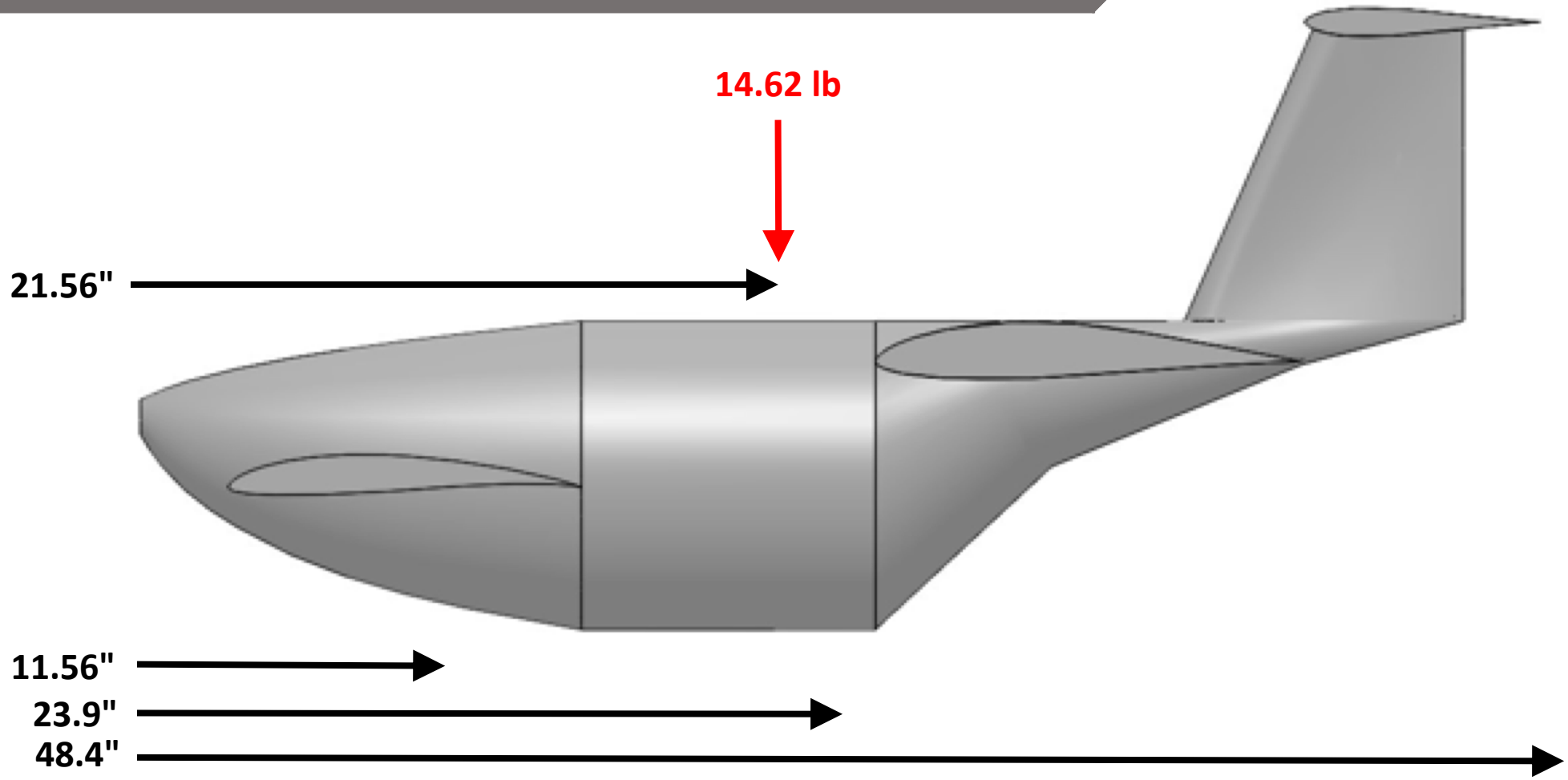
Landing Gear Placement





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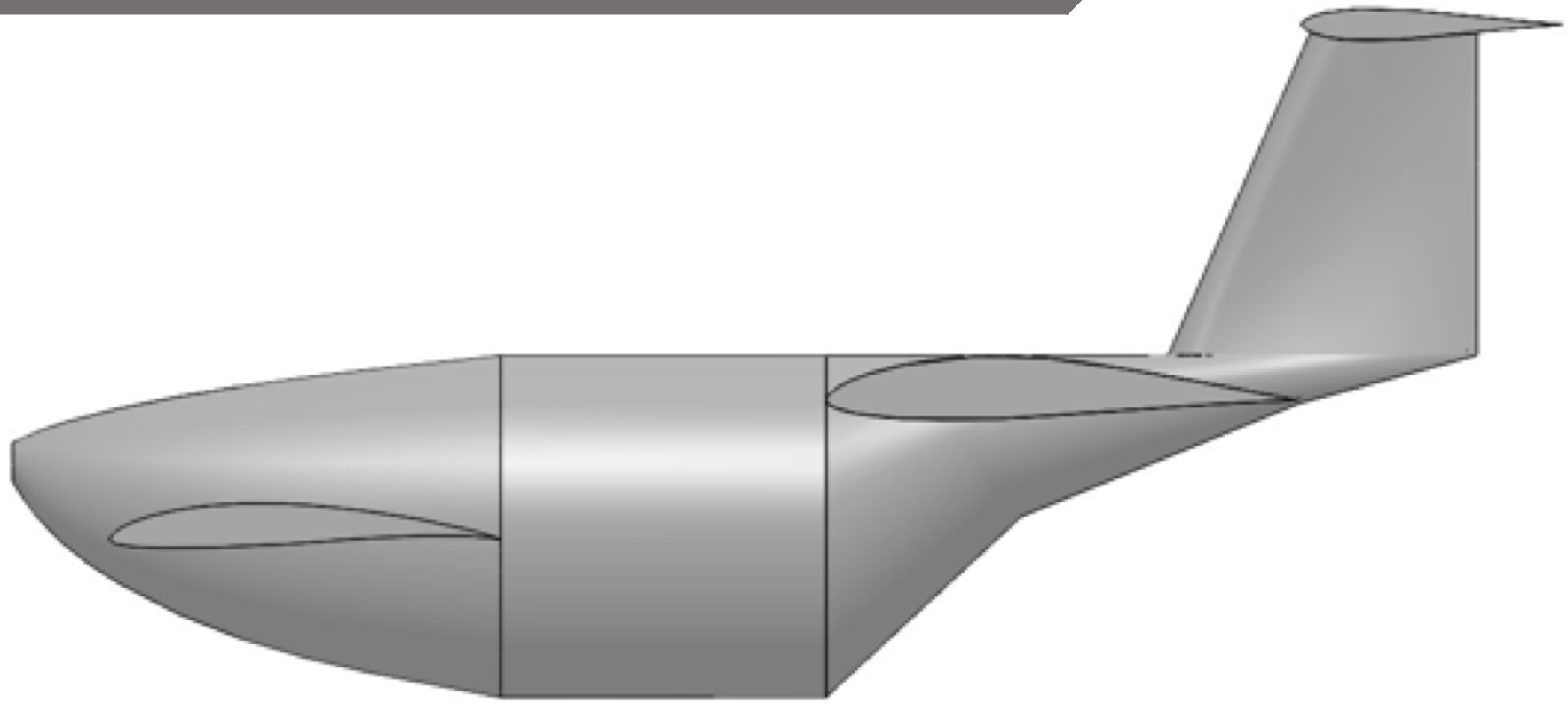
Landing Gear Placement



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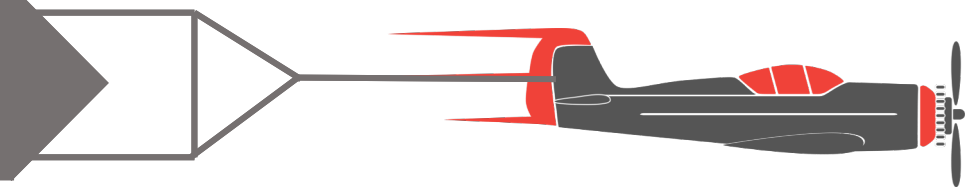
Future Work



- Work with Team 507 in wiring the plane
- Test flight with Seminole RC Club

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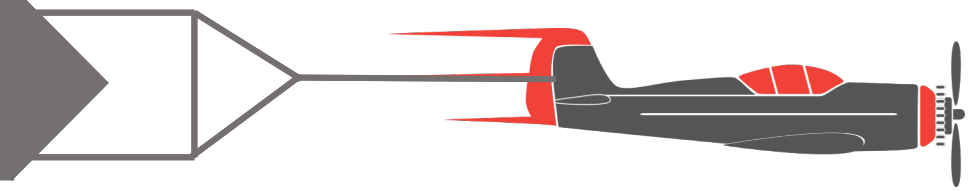
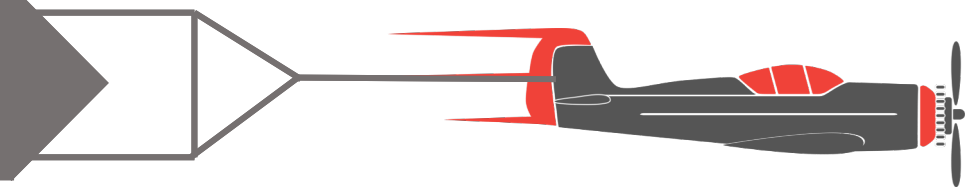
Key Takeaways



- Both PLA and LW-PLA used in printing the plane
- Fuselage design allows cargo to be moved to help change CG
- Both sections of the landing gear are holding the recommended weight
- We are working to get approval from the college to conduct a test flight

Jacob Pifer

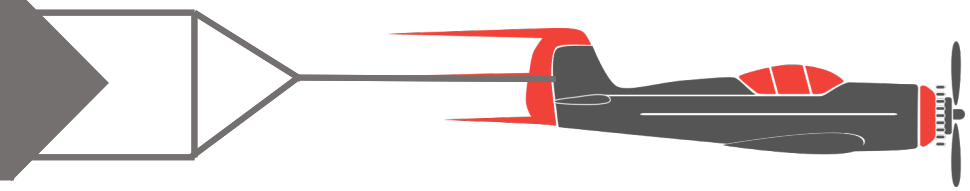
Lessons Learned



- Have printers up and running early
- Complete **all of** the CAD before printing begins
- Finish the plane in time for a test flight before competition
- Establish a professional relationships with the Innovation Hub and the Seminole RC Club

Jacob Pifer

References



- 2021 Collegiate Series SAE Design Rulebook (2021). *SAE Aero Design.* https://www.saeaerodesign.com/cdsweb/gen/DocumentResources.aspx
- Aguirre, N., Evans, L.,… Silver, Z. (2020). T513: SAE Aero Design Operations Manual. *Team 513: SAE Aero Design East Competition,* 47-56.
- Ozgen, S. (2015). *Landing Gear Sizing and Placement.* Middle East Technical University. Retrieved from http://www.ae.metu.edu.tr/~ae451/landing_gear.pdf
- Lennon, A. (1996). *R/C Model Aircraft Design.* Air Age Media Inc.
- *Flexural Properties.* (1996). Interek Plastics Technologies Laboratories. Retrieved from https://www.ptli.com/testlopedia/tests/Flex-D790.asp

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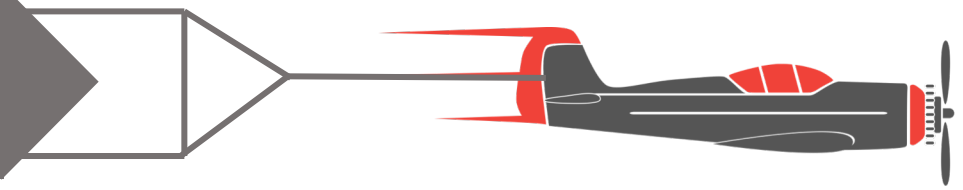
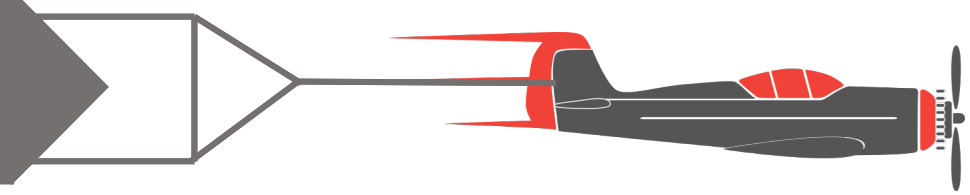
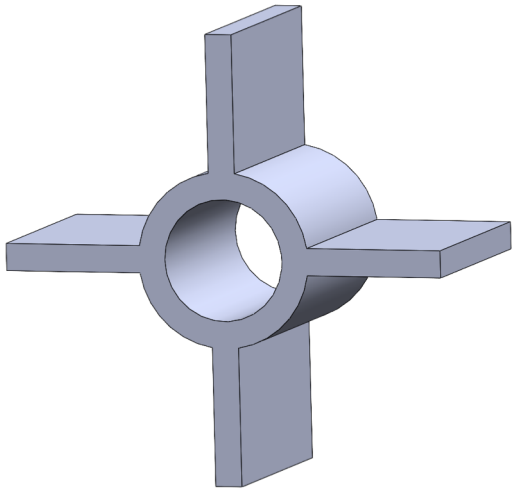
Back-Up Slides

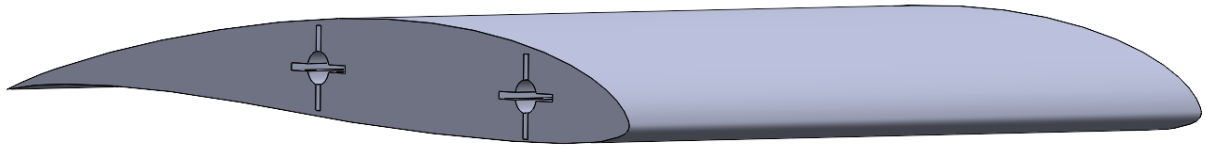


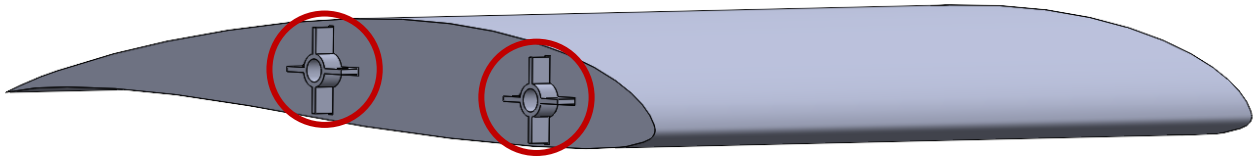
Assembling Methods: Spars



- Plane uses spars to assemble the wings
- Each wing set has two spars
- Small crosses are also used to help lock the wings together
- Ends of the spars are threaded so screws can be used to secure the parts







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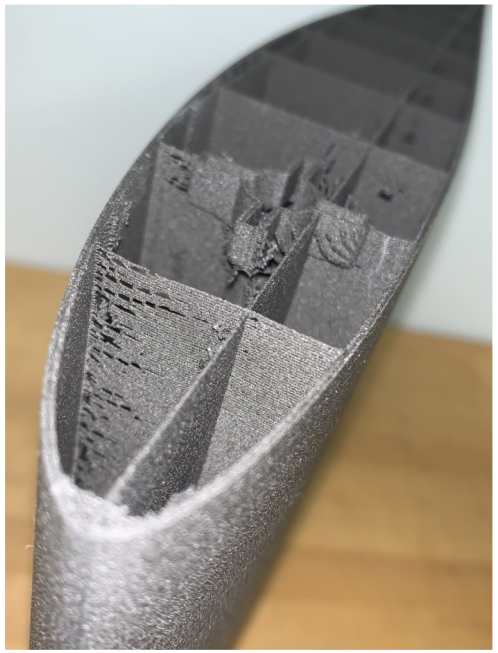
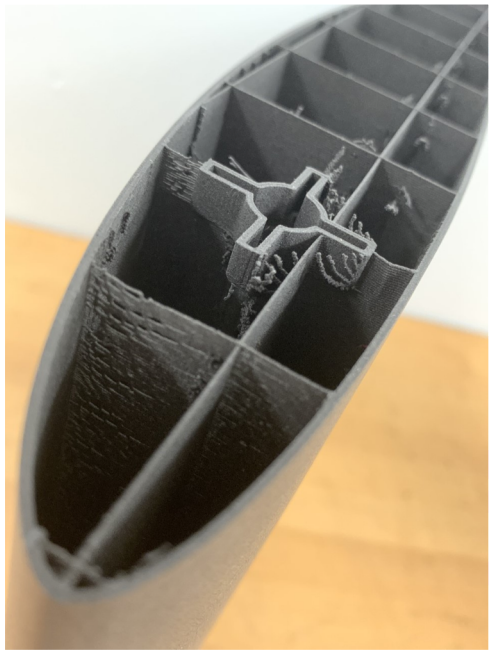
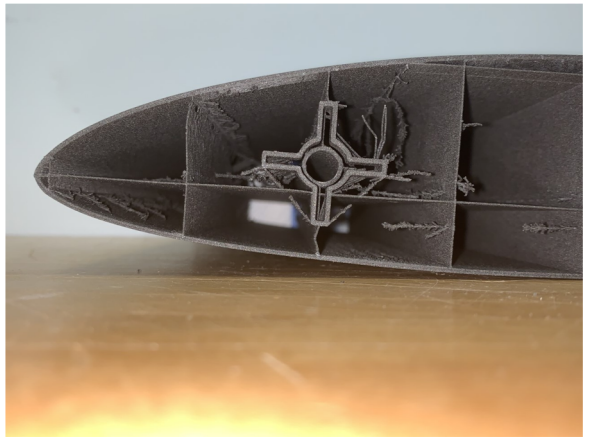
Infill/ Printing Methods



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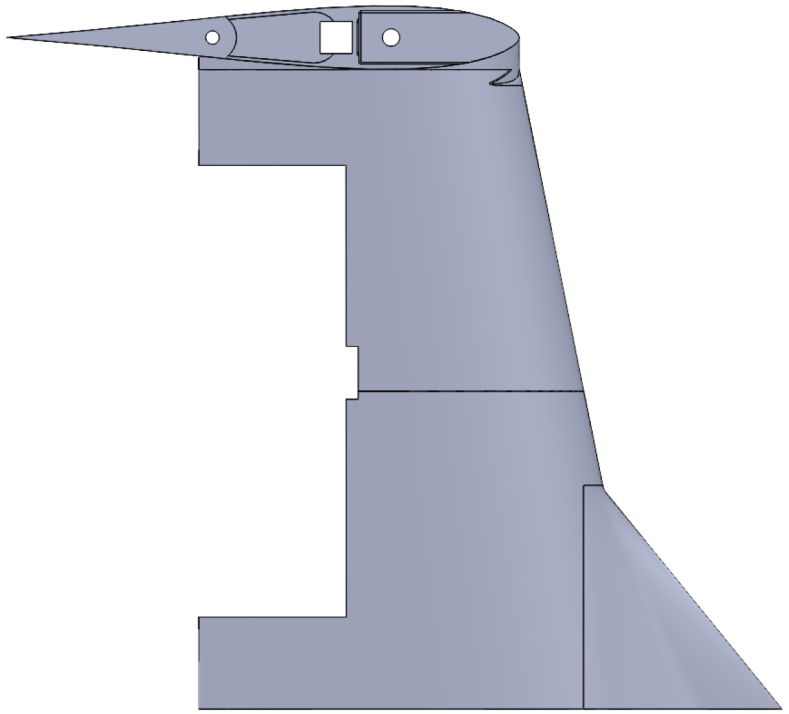
Re-designed Joints



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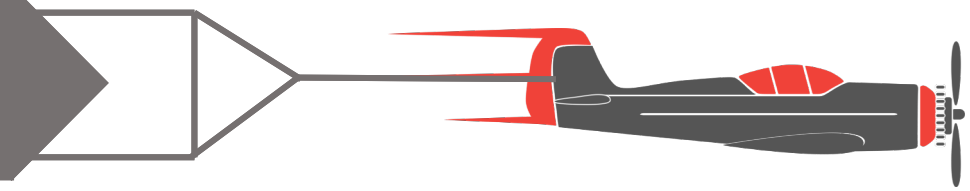
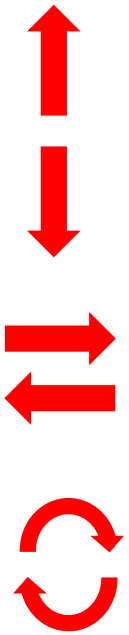
Alternative Fuselage Connections



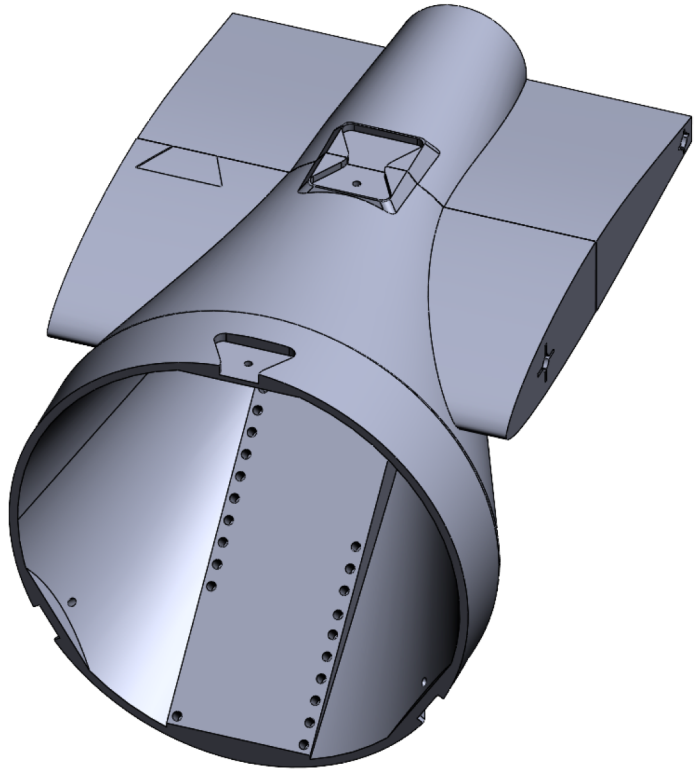


Upward motions is prohibited by the Bowtie

Downward motion is prohibited by the dovetail

Left and Right motion is prohibited by the Dovetail

Torsional Motion is prohibited by both the Dovetail and Bowtie



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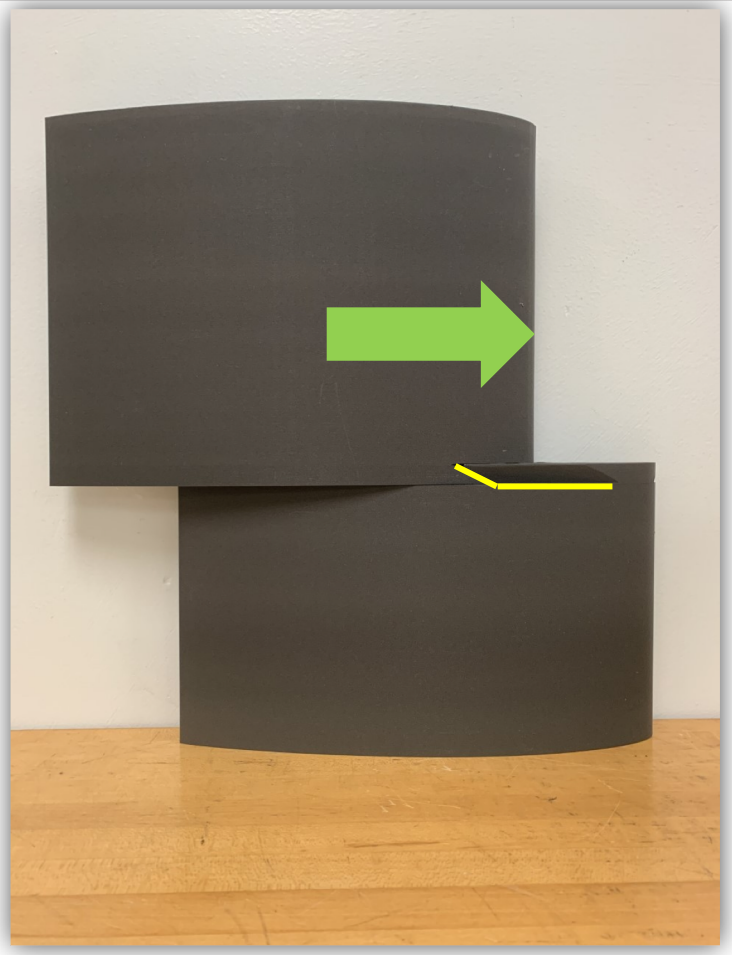
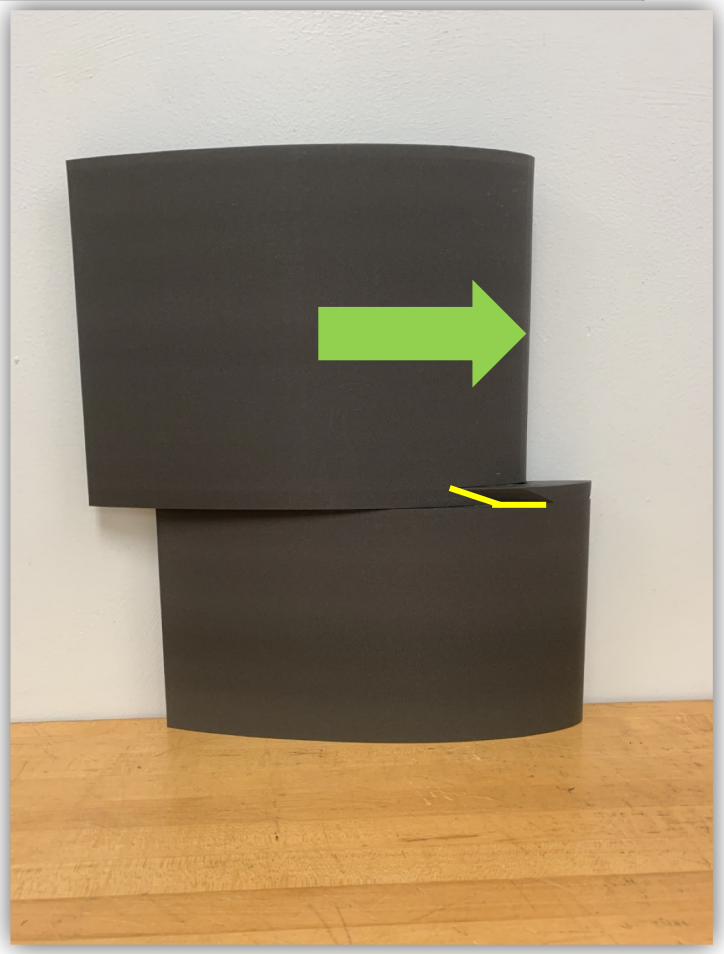
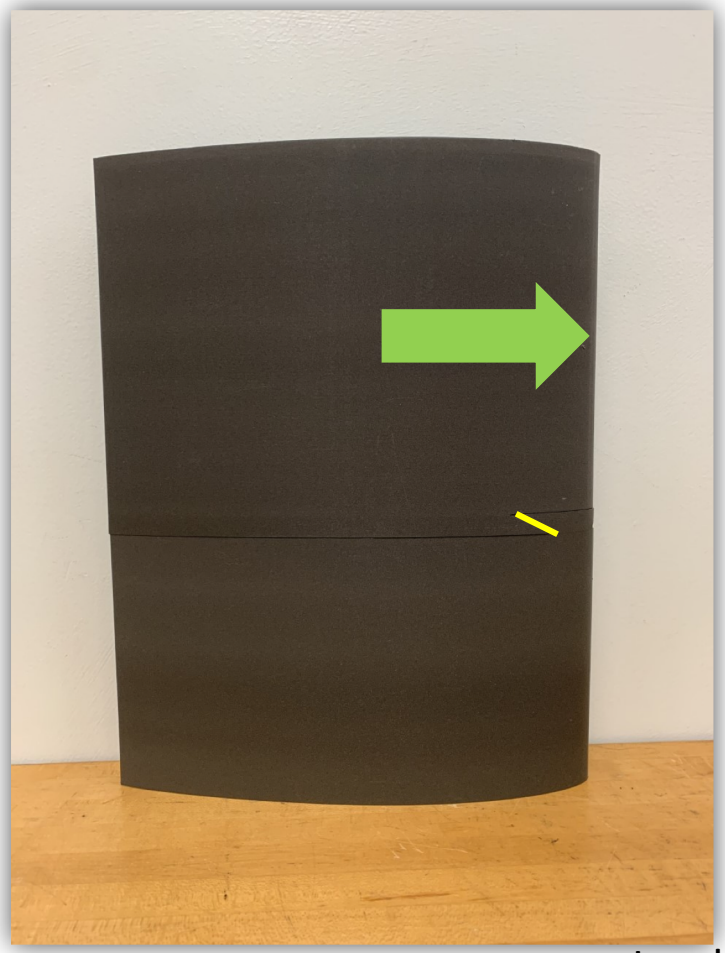
Canard Assembly







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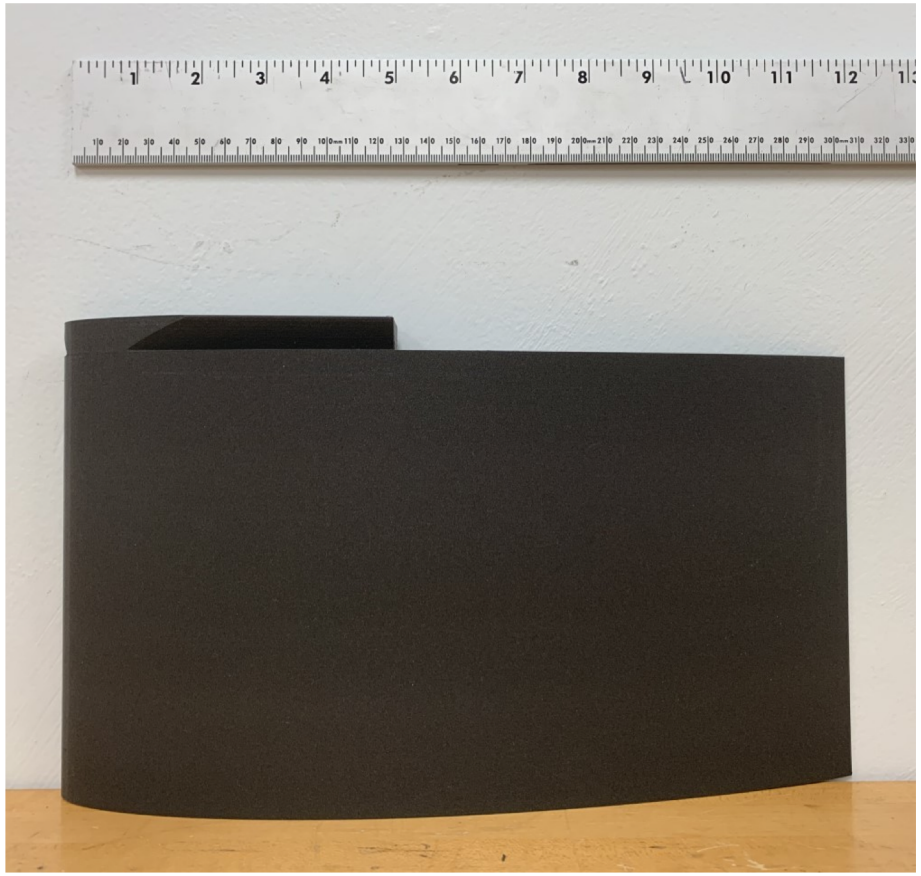
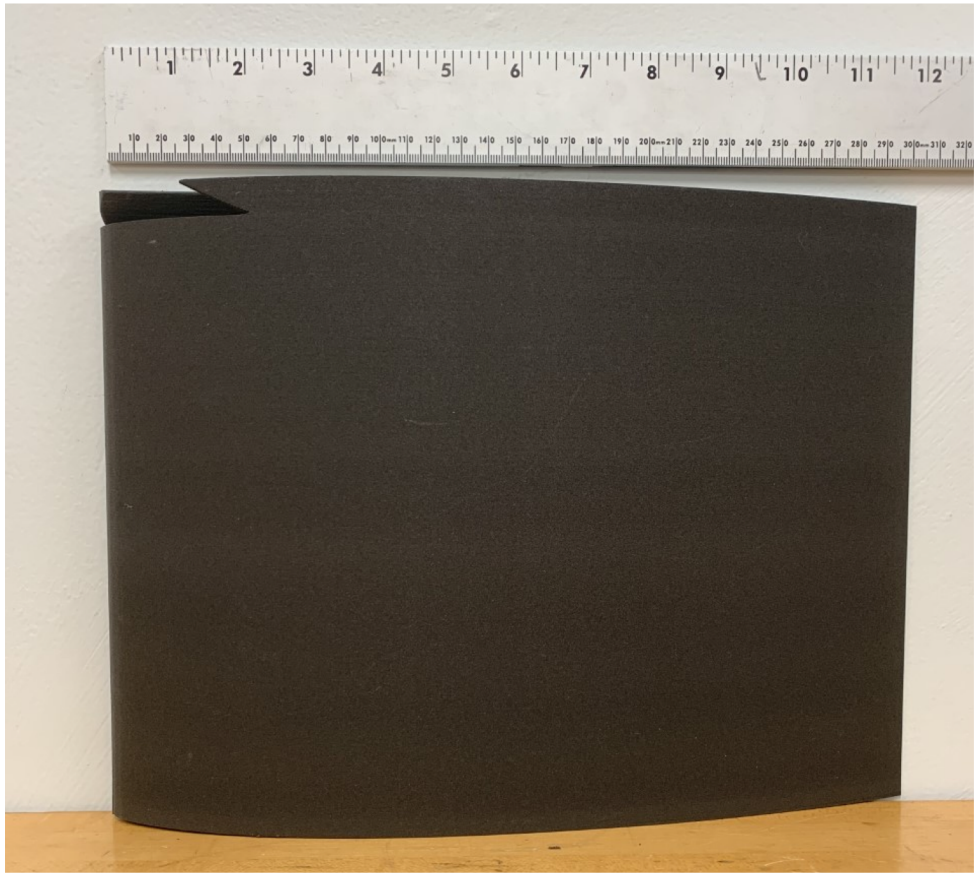
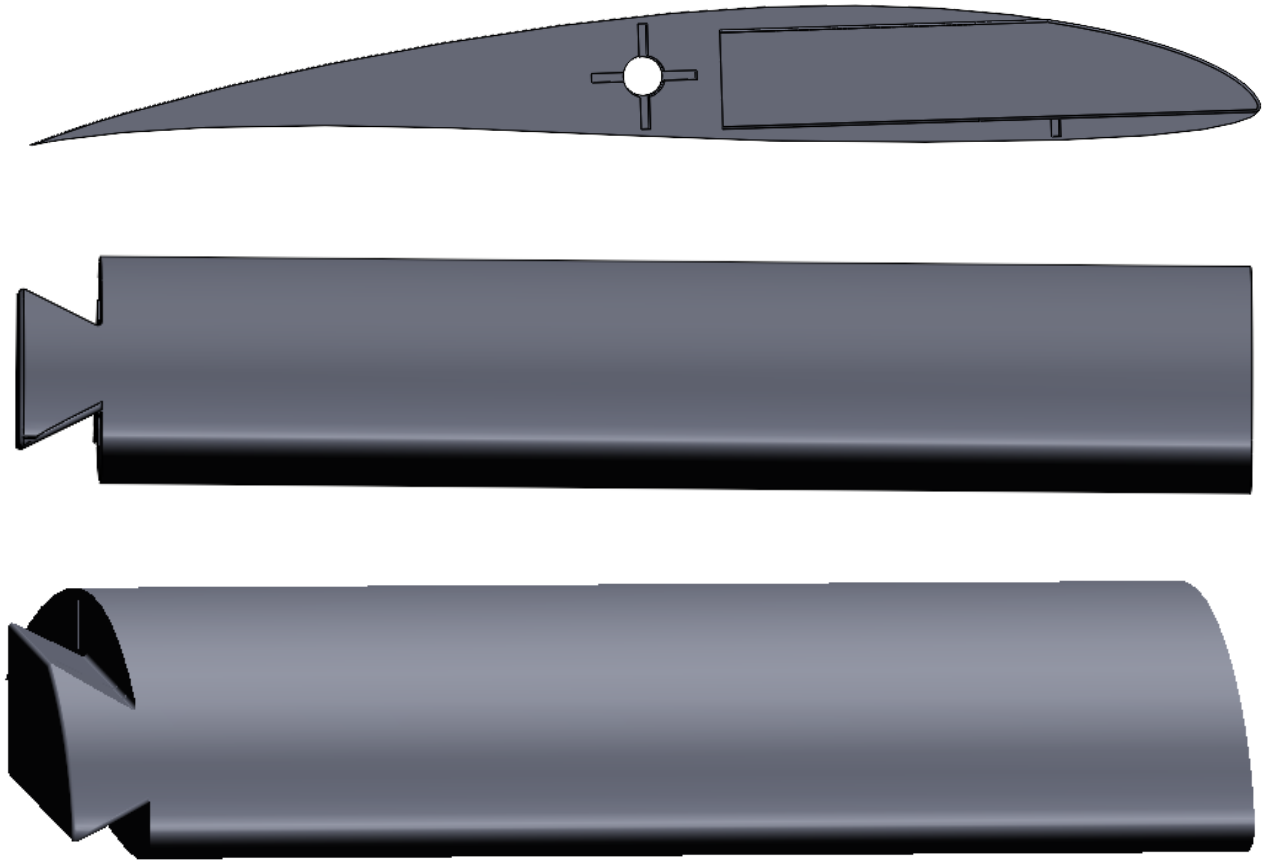




Dove Tail Male Construction

- Dimensions:
  - Minimum thickness: 0.5 inches
  - Maximum thickness: 1 inch
  - Length: 5.25 inches

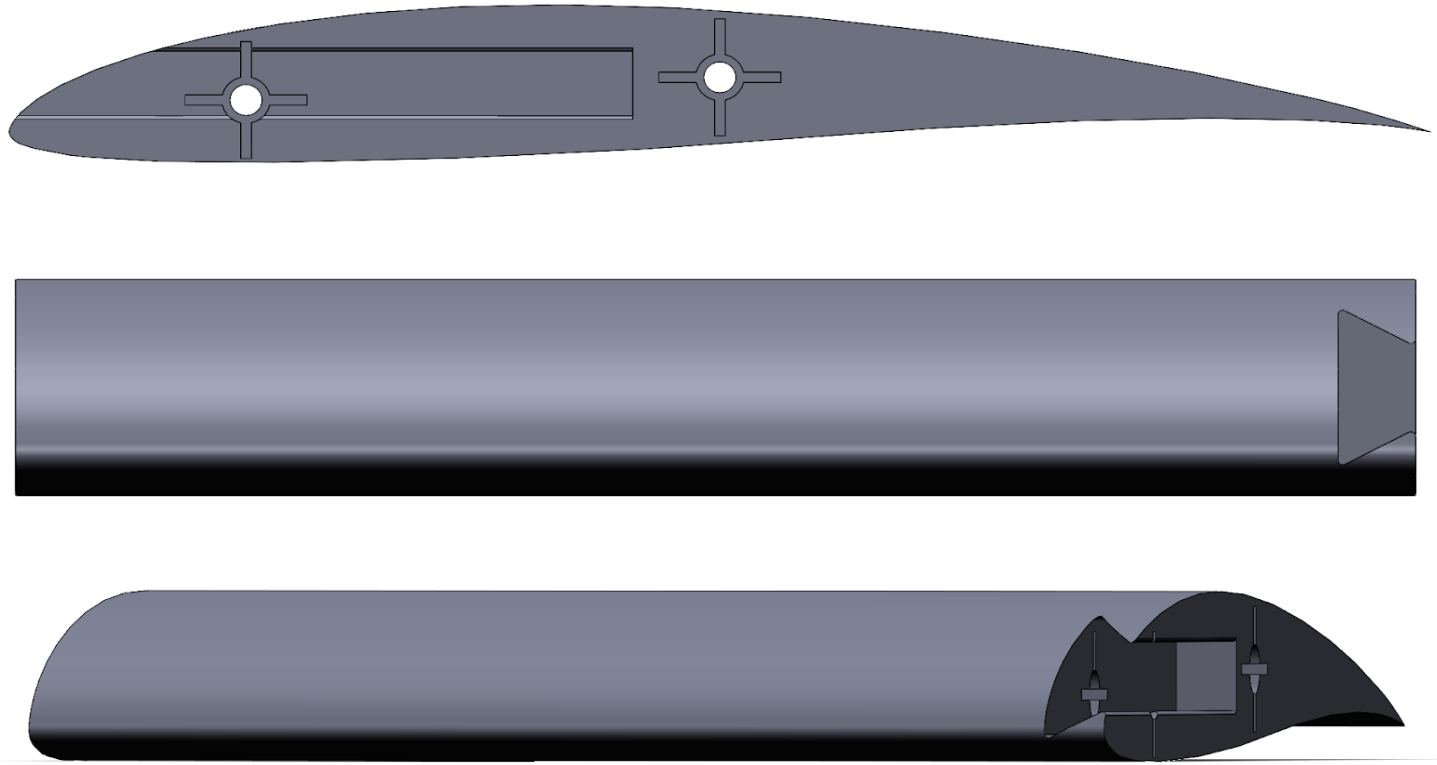
- Characteristics
  - Follows curvature of the airfoil
  - Edges are rounded



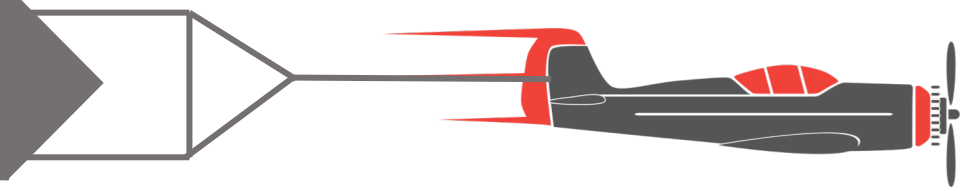
Dove Tail Female Construction

- Dimensions:
  - Minimum opening: 0.5001 inches
  - Maximum thickness: 1.001 inch
  - Length: 5.25 inches

- Characteristics
  - Follows curvature of the airfoil
  - Edges are rounded

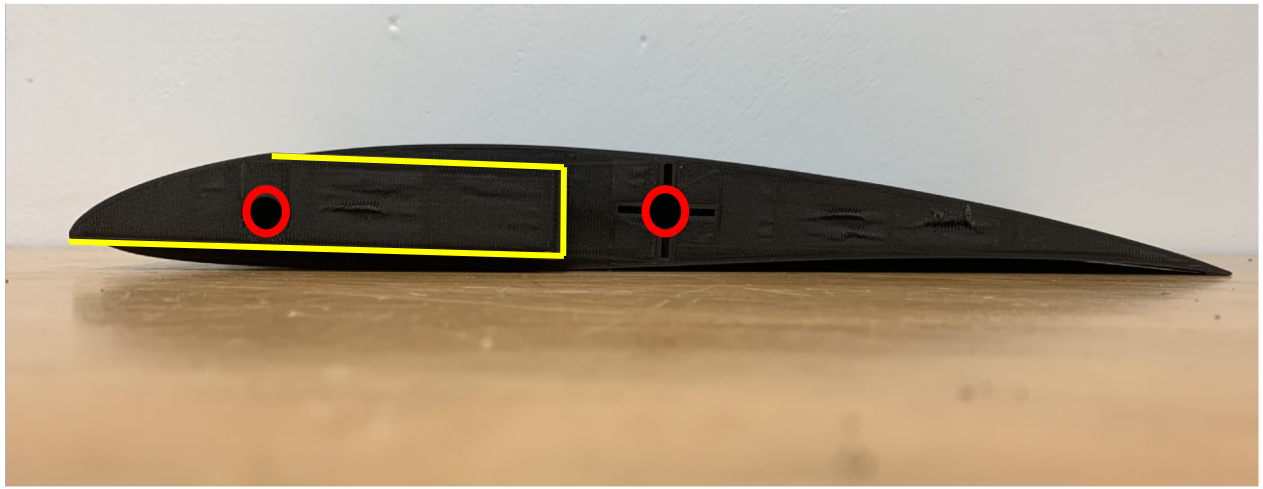


Project Brief Summary



- Dimensions:
  - Minimum thickness: 0.5 inches
  - Maximum thickness: 1 inch
  - Length: 5.25 inches

- Characteristics
  - Follows curvature of the airfoil
  - Edges are rounded



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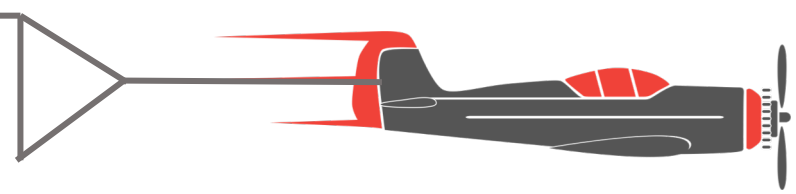
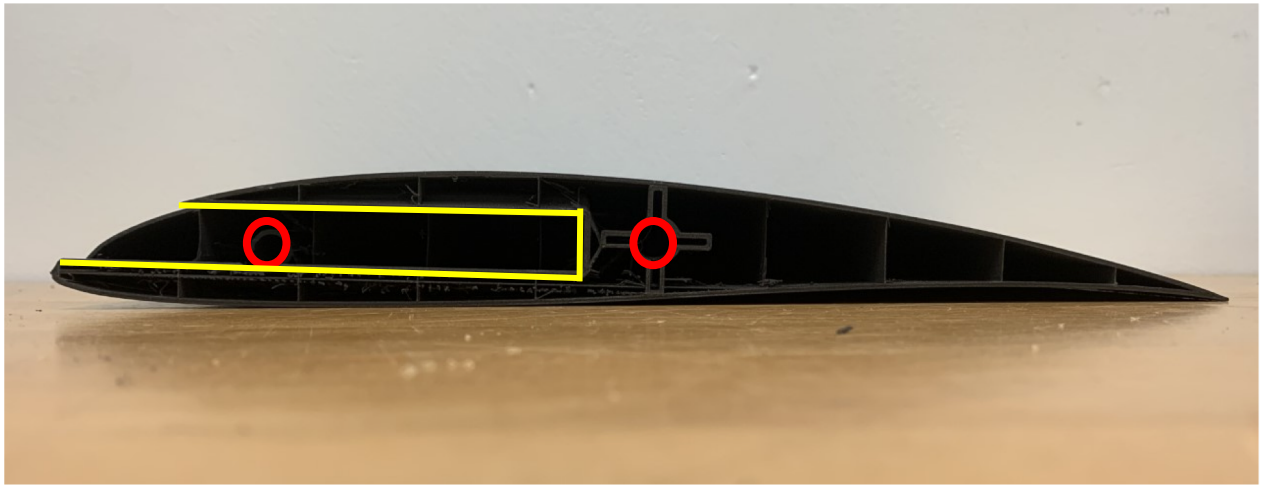
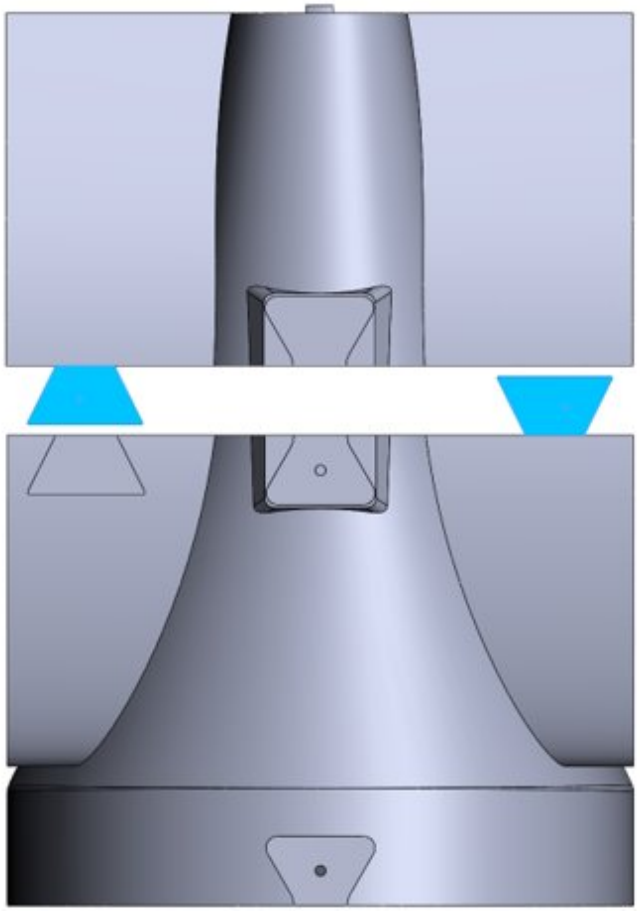


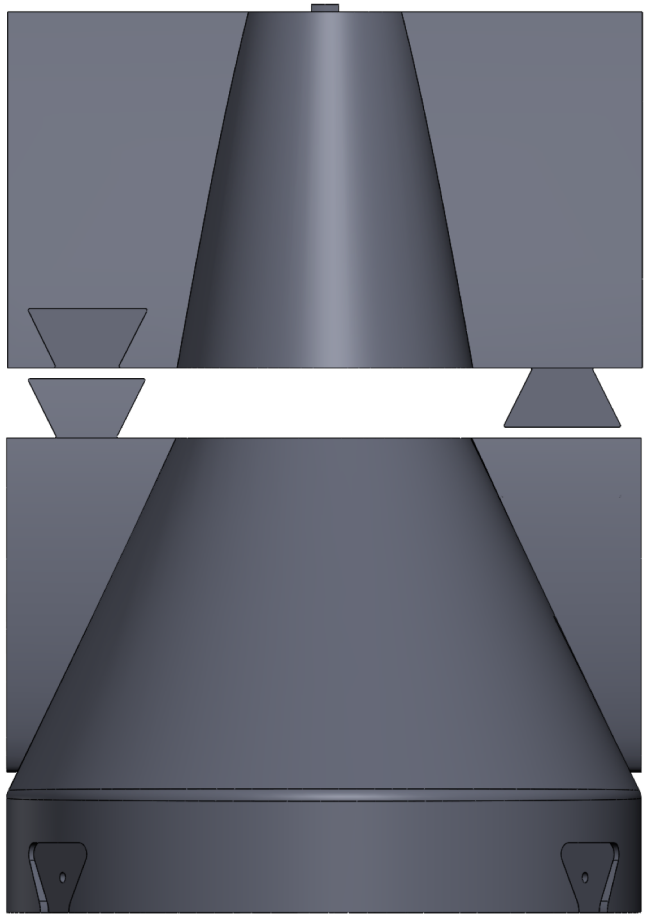
- Dimensions:
  - Minimum opening: 0.5001 inches
  - Maximum thickness: 1.001 inch
  - Length: 5.25 inches

- Characteristics
  - Follows curvature of the airfoil
  - Edges are rounded



Assembling Methods: Woodworking





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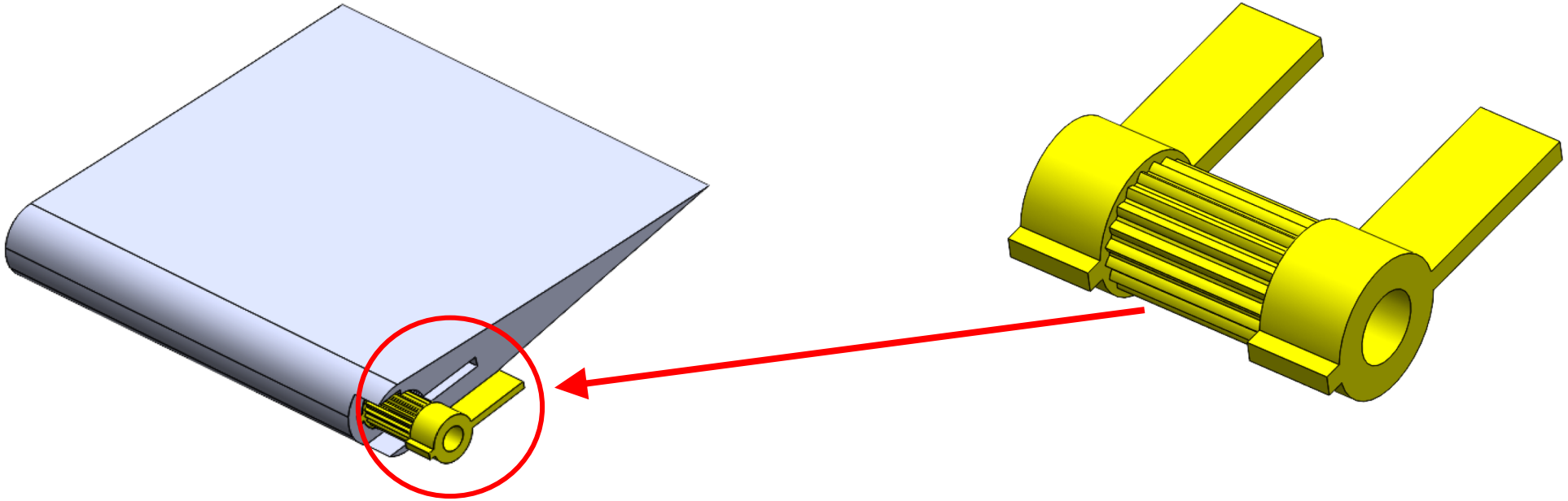
Horizontal Tail



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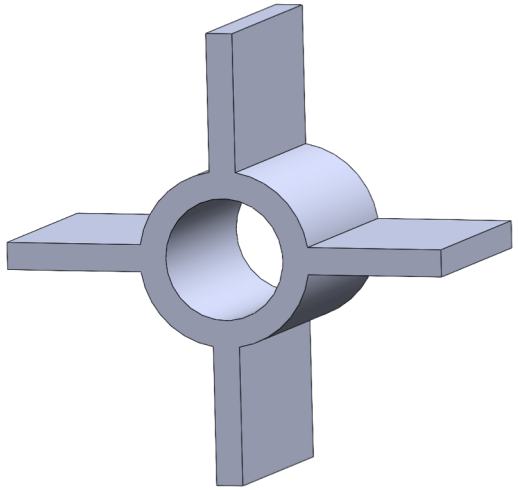

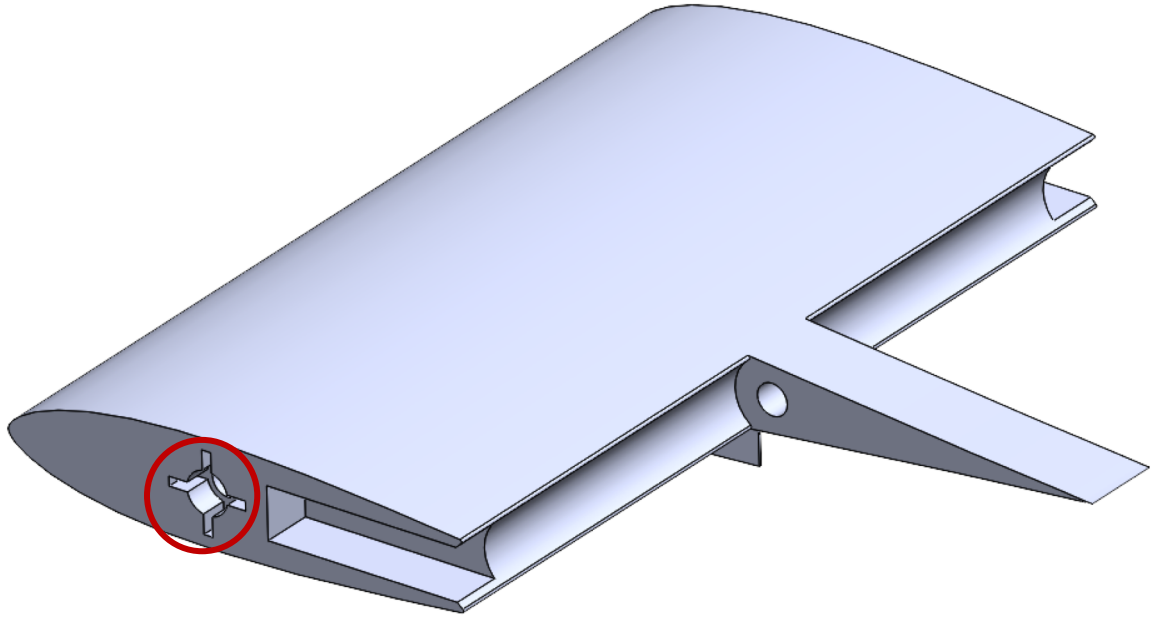

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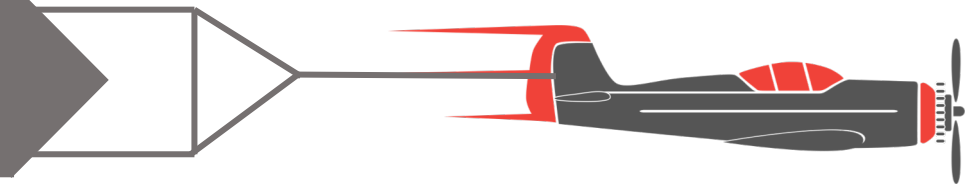
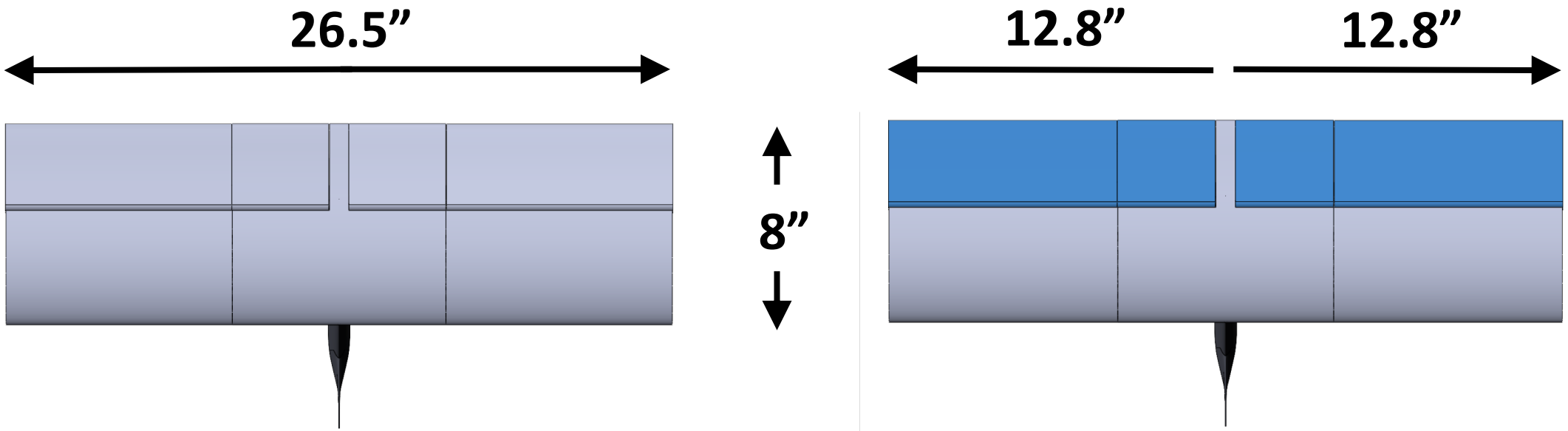
Horizontal Tail





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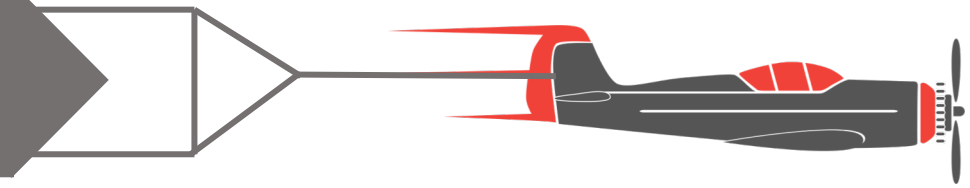
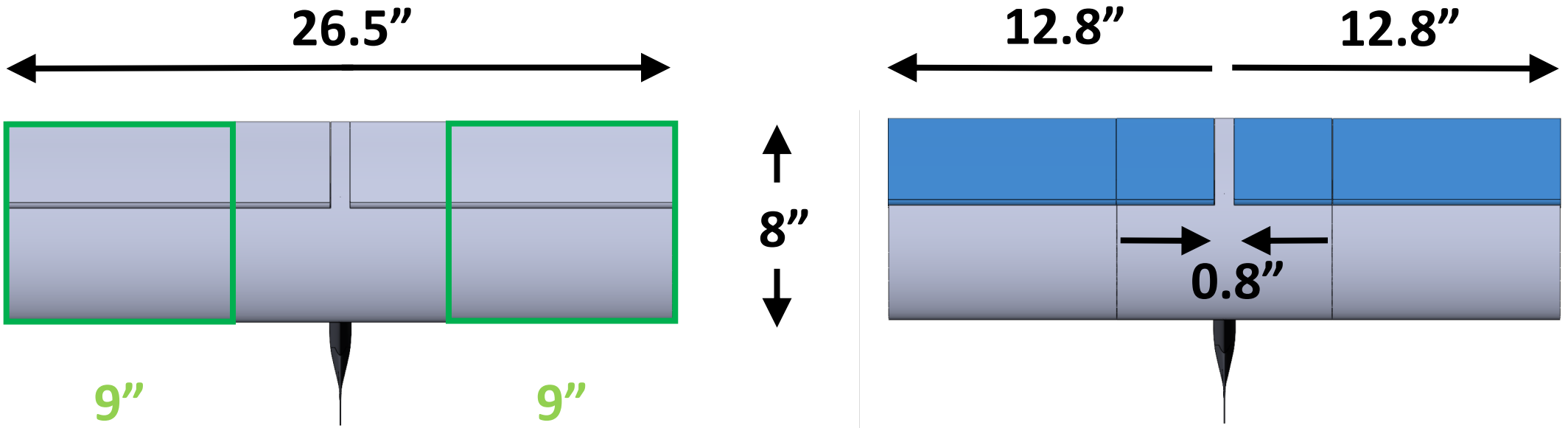
Horizontal Tail





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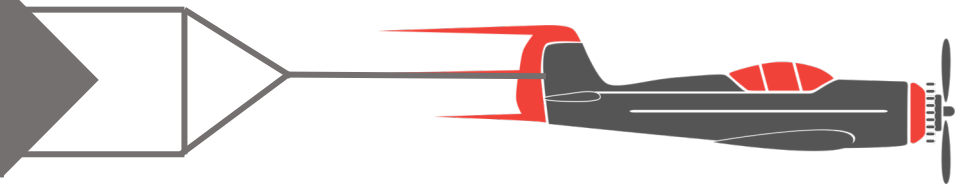
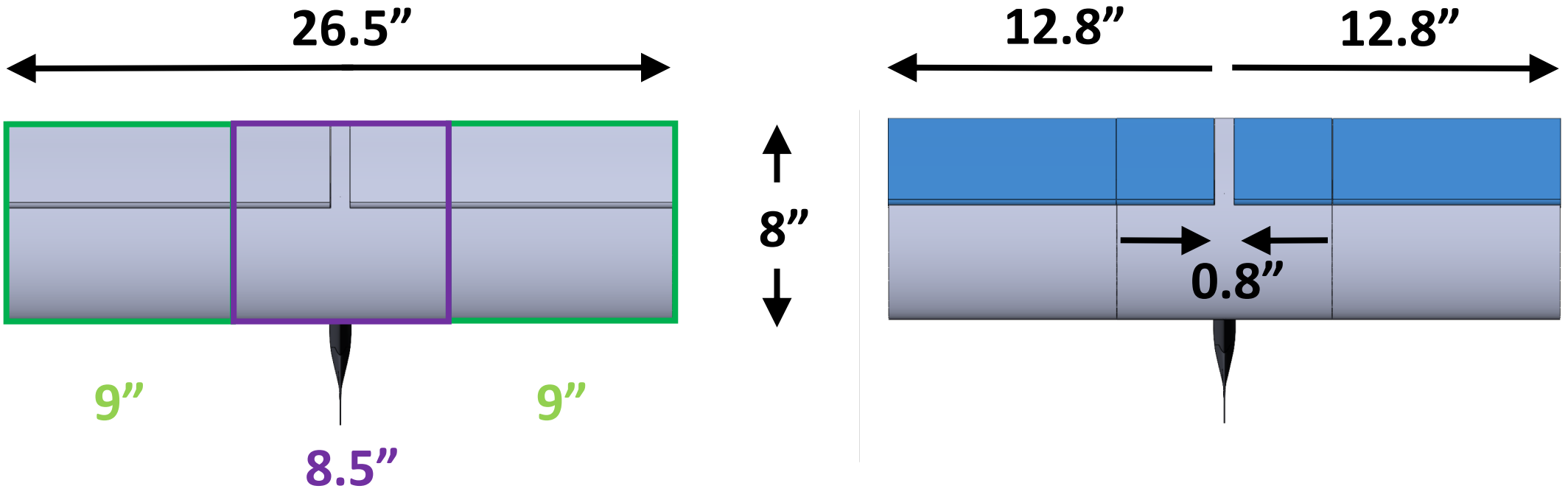
Horizontal Tail





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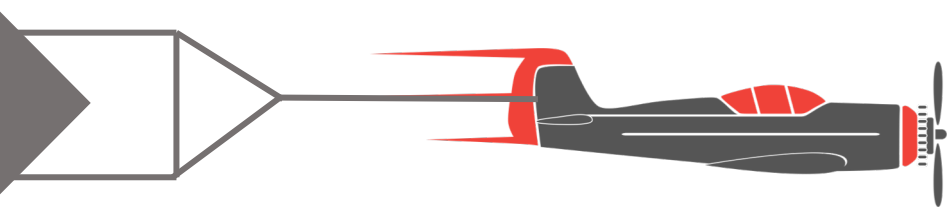
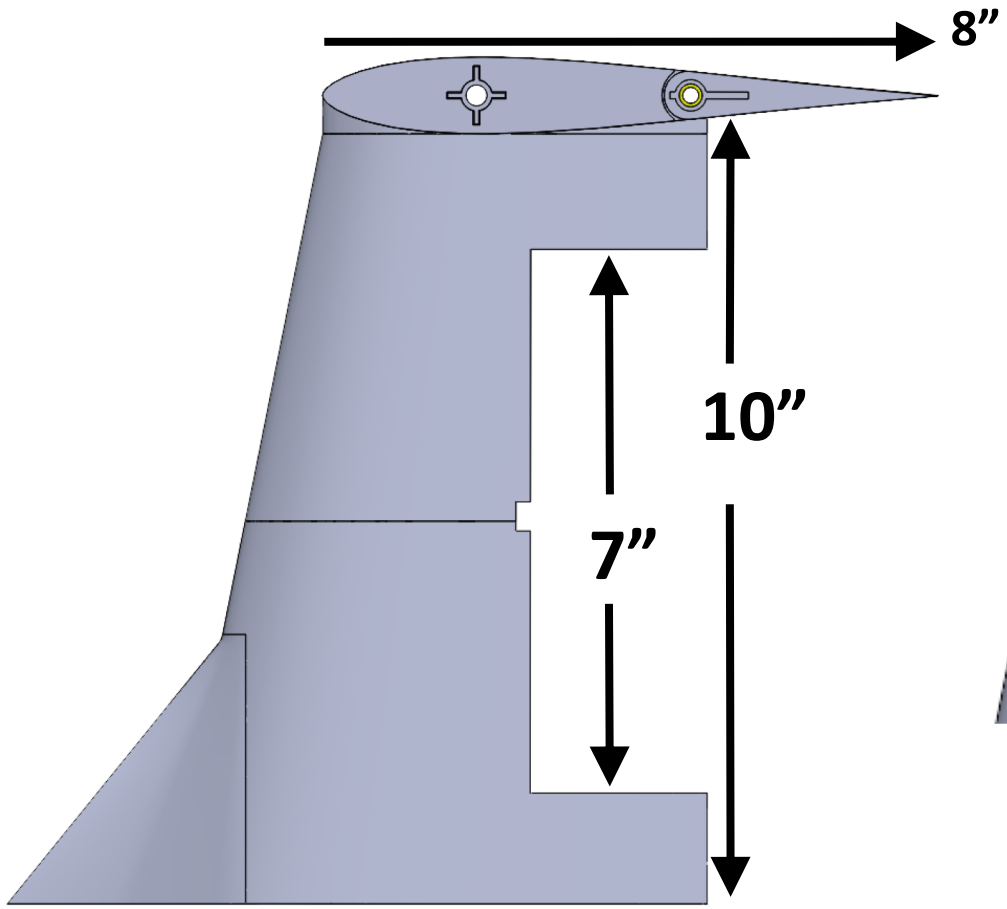
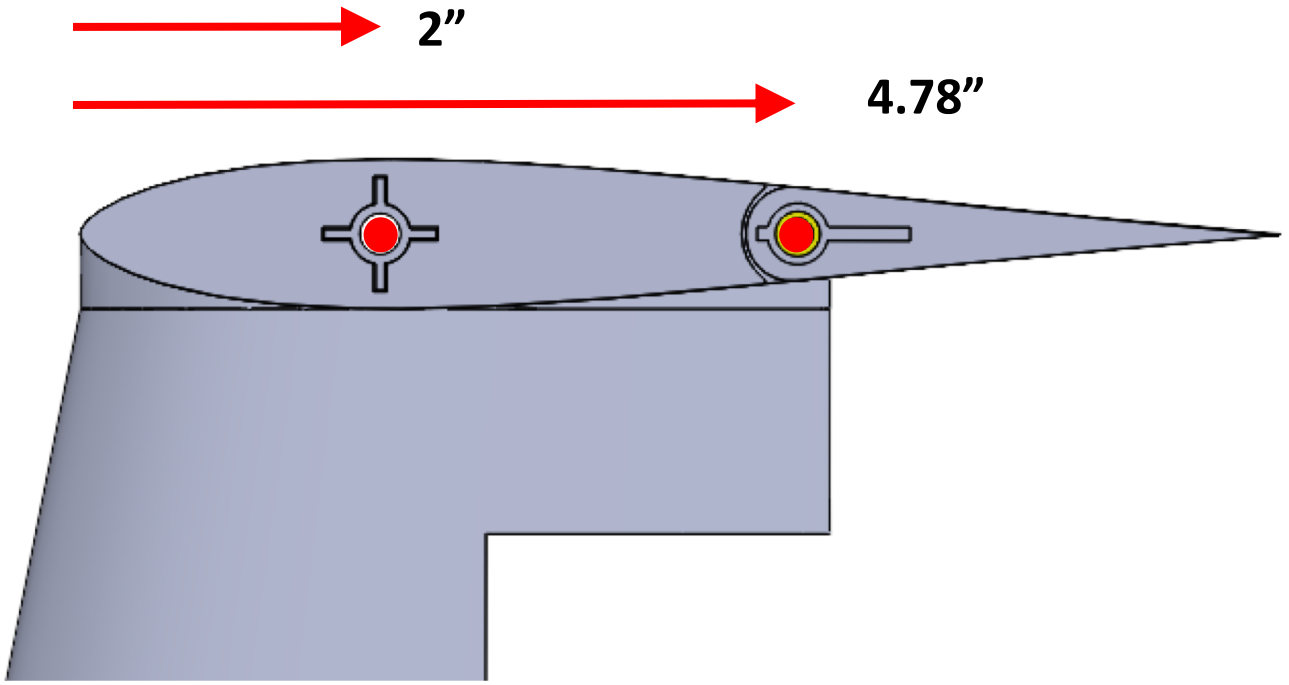
Vertical Tail







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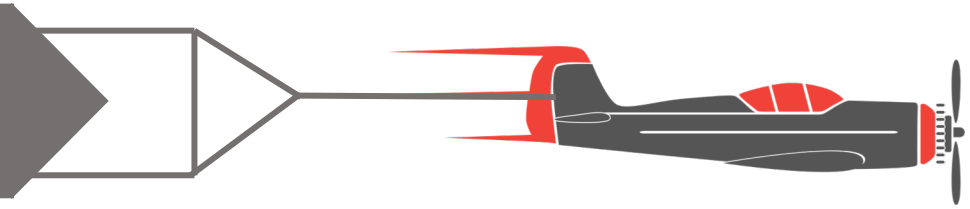
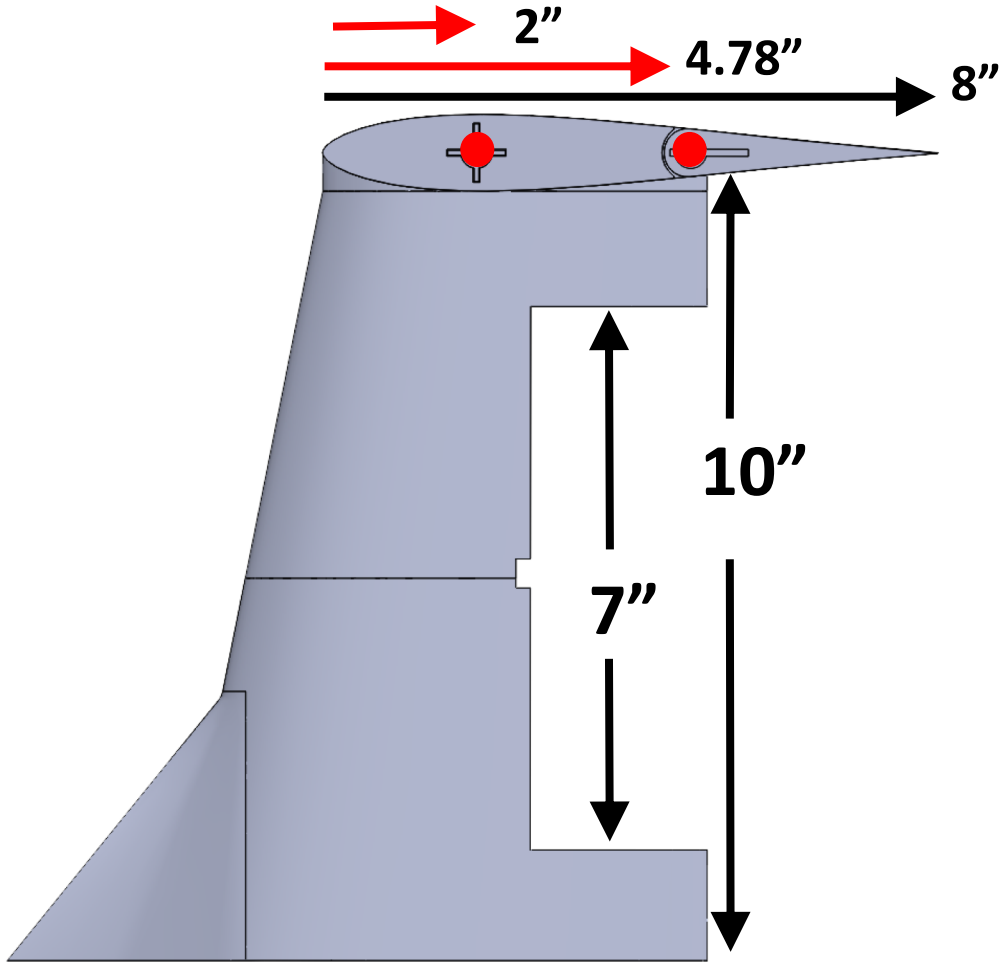
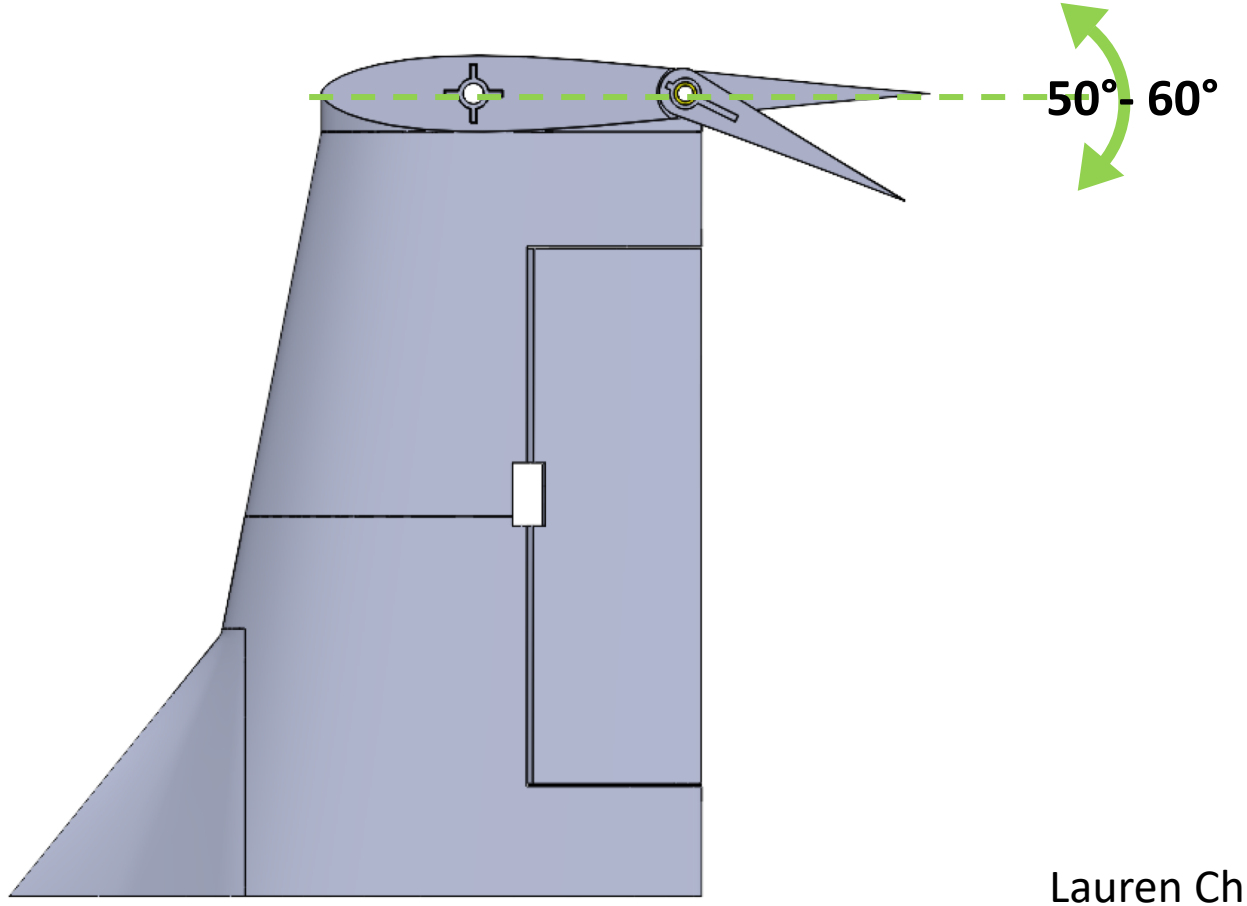
Vertical Tail







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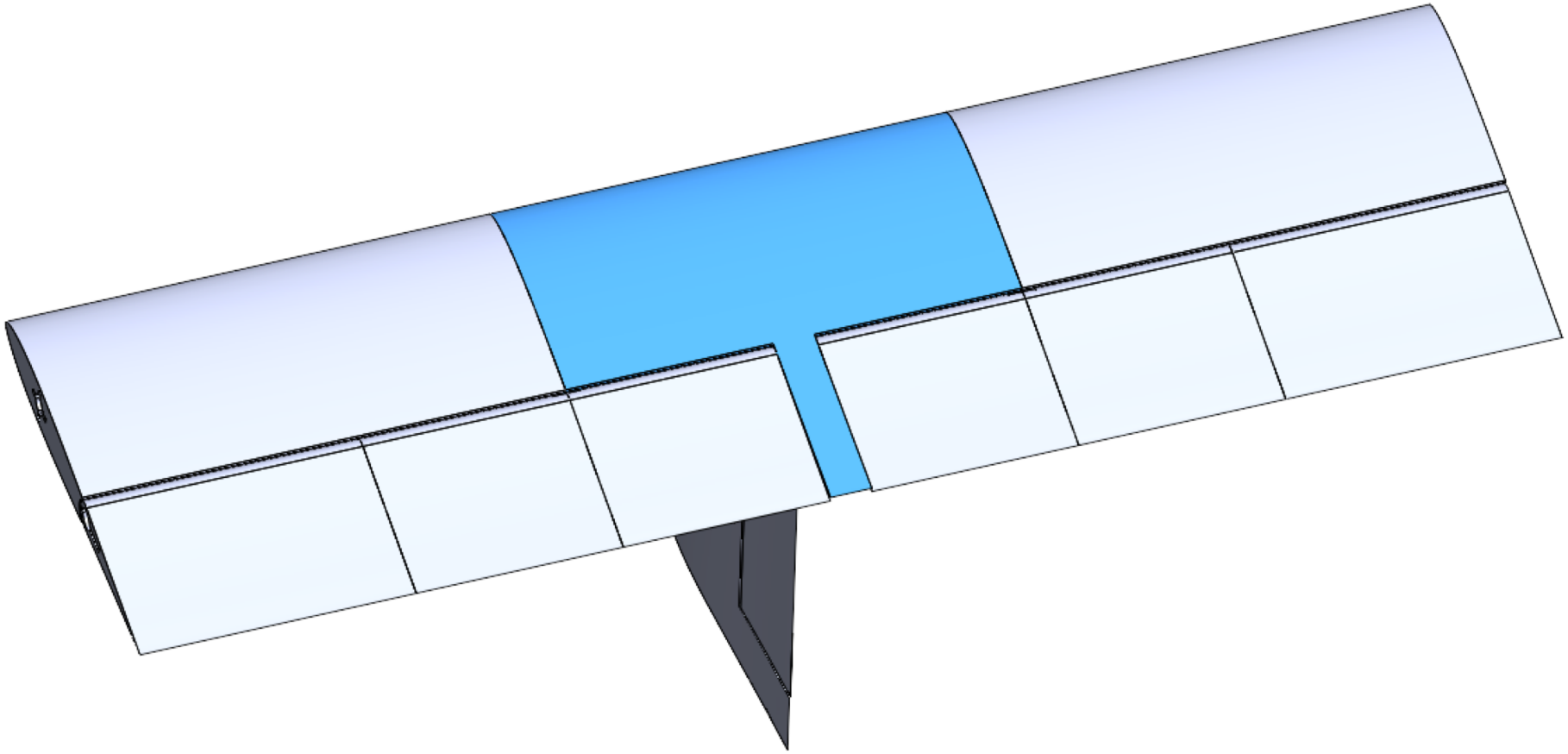
Vertical Tail



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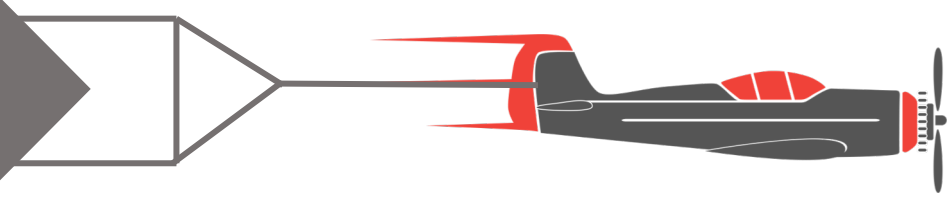
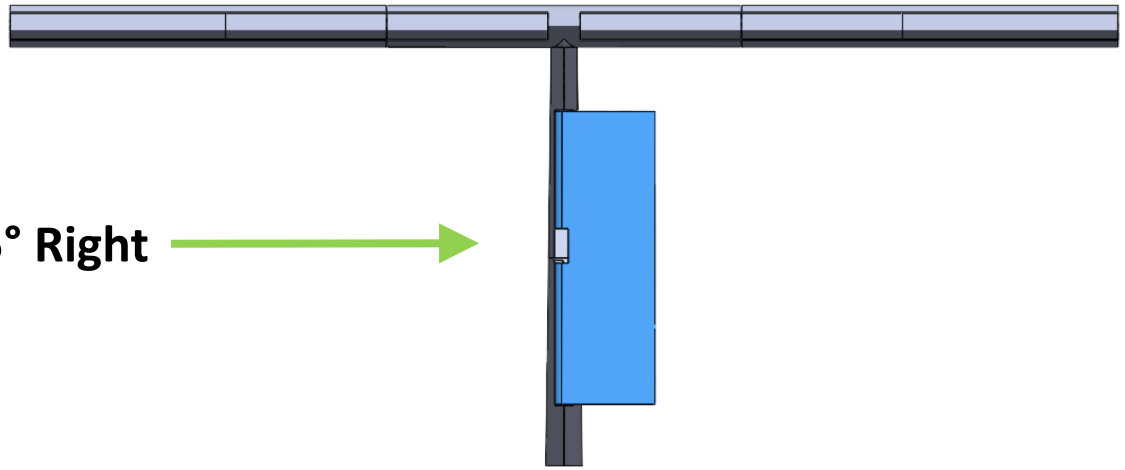
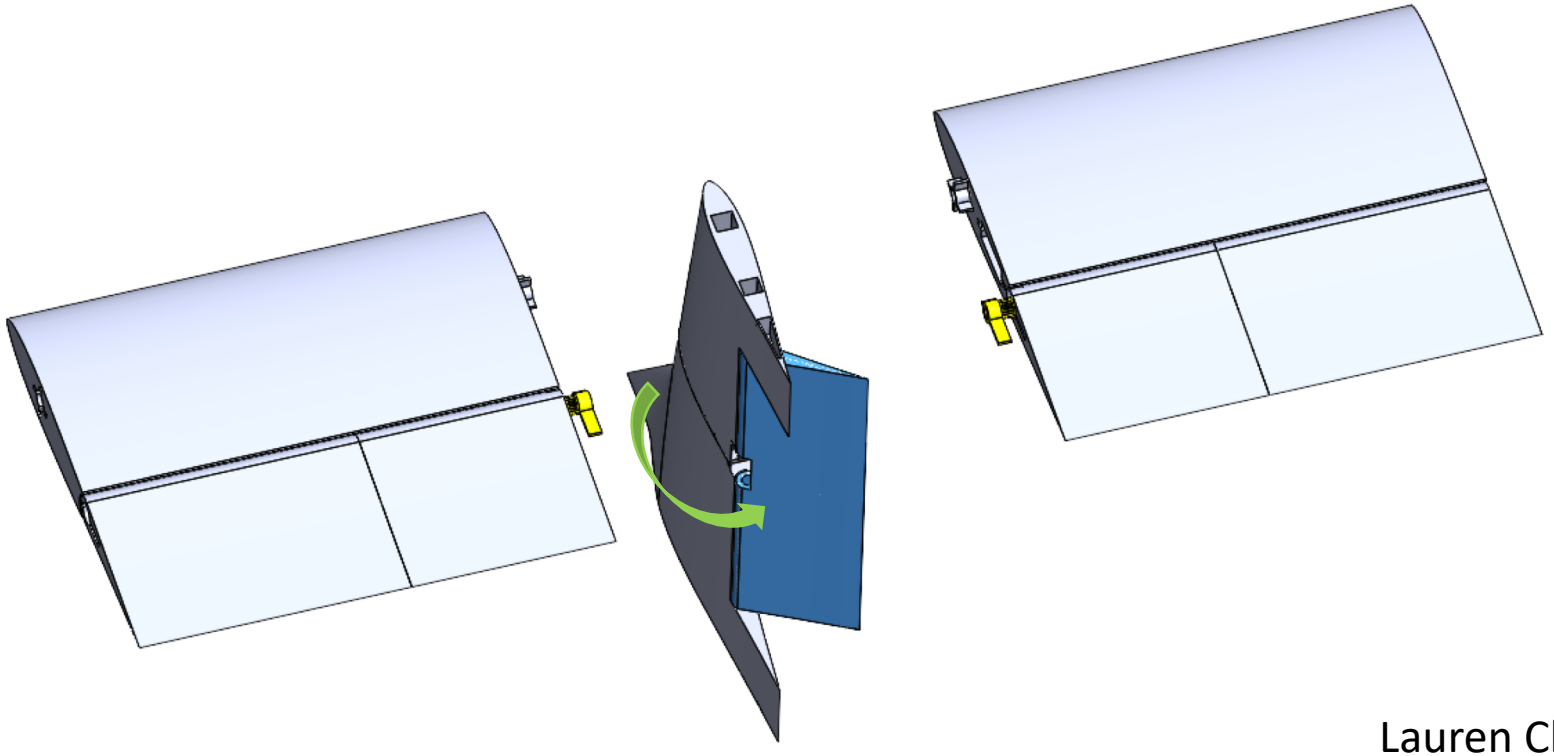
Rudder Motion







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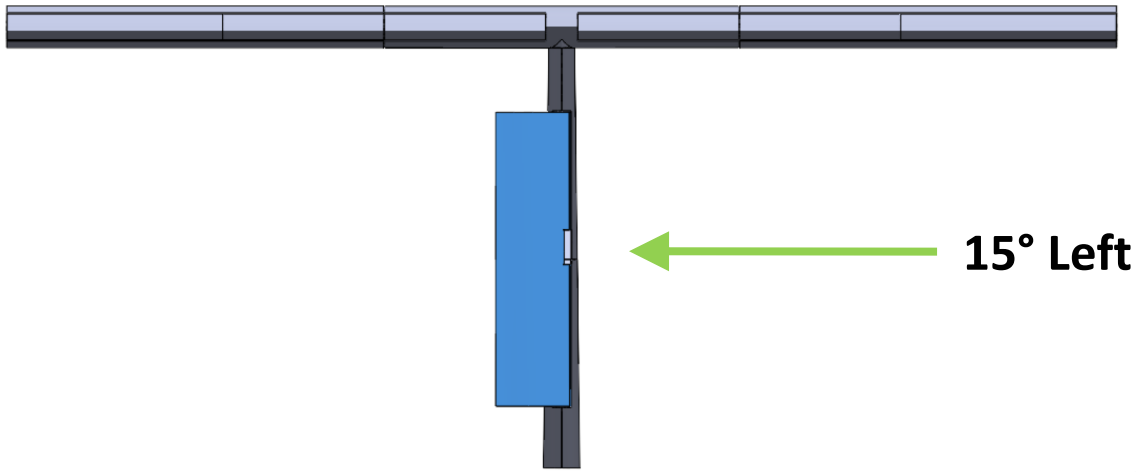
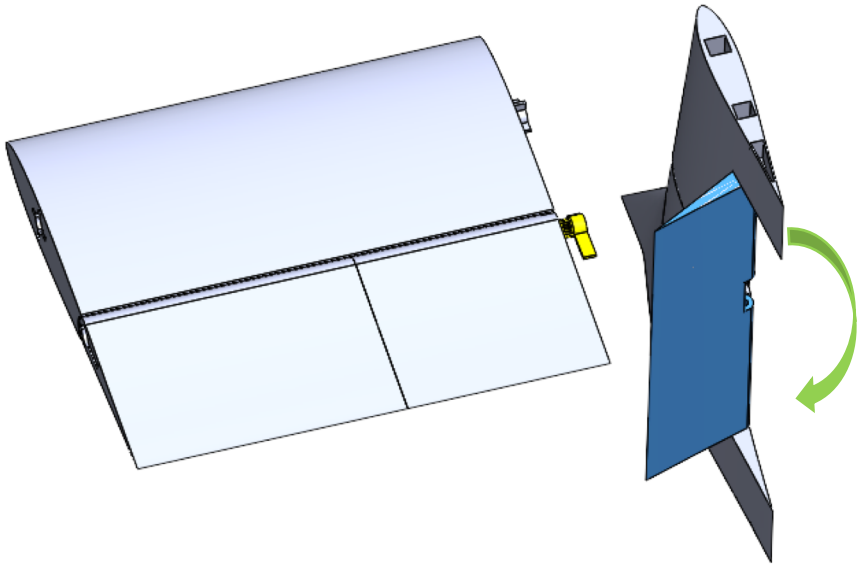
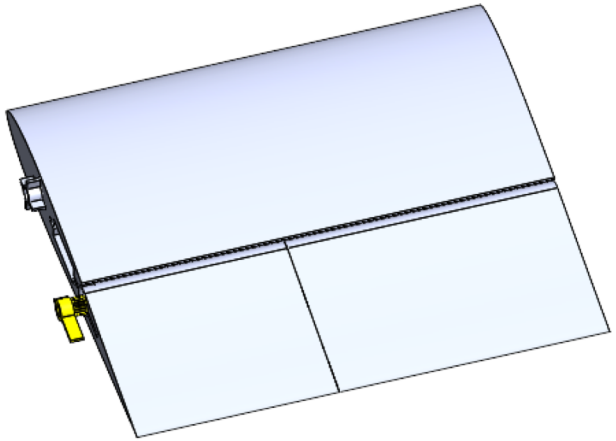
Rudder Motion



15° Left





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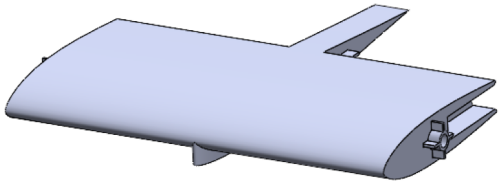
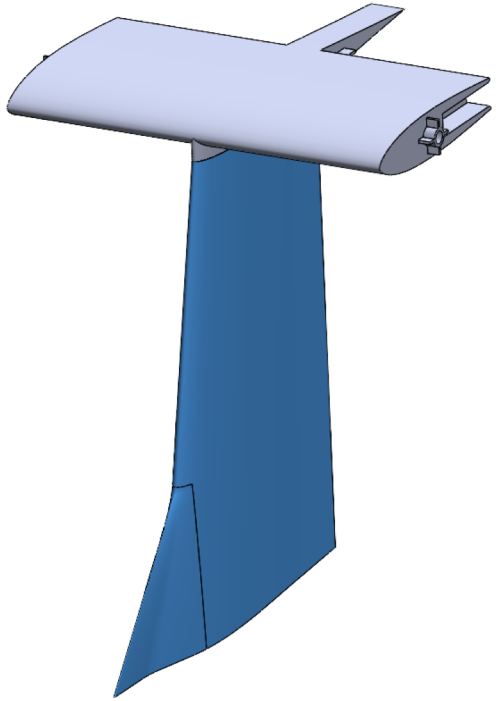
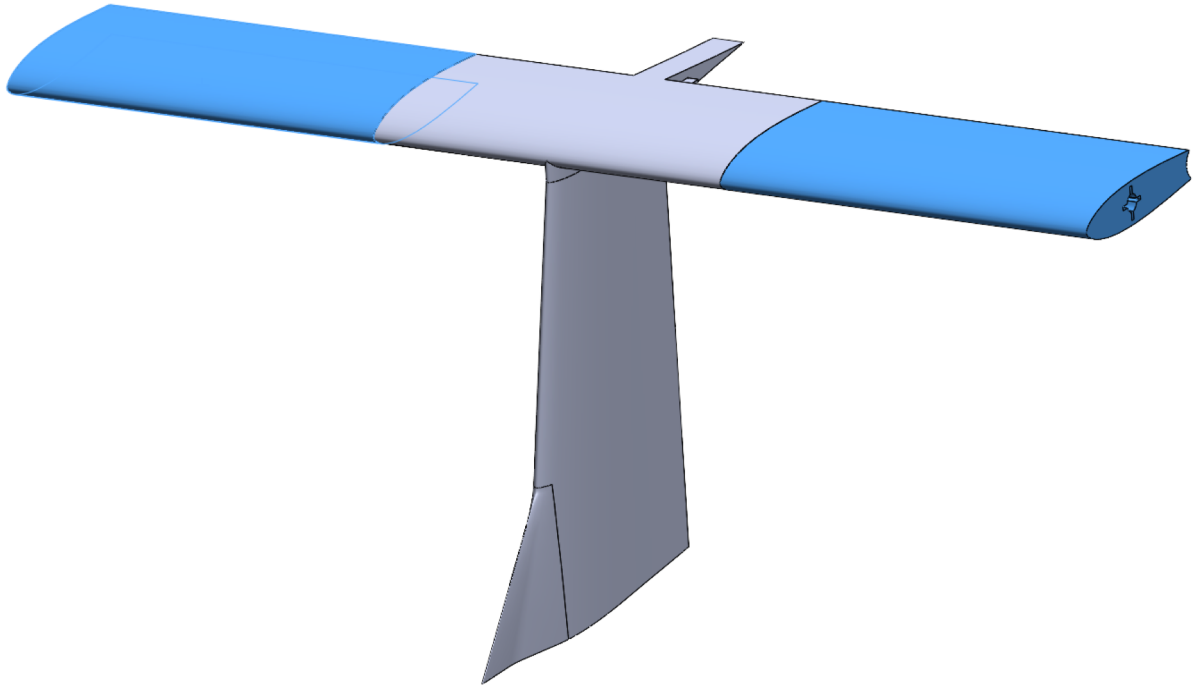
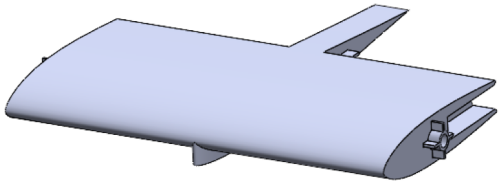
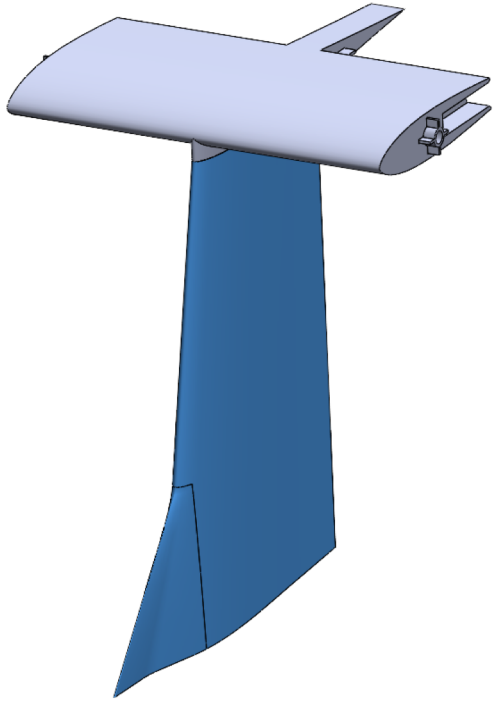


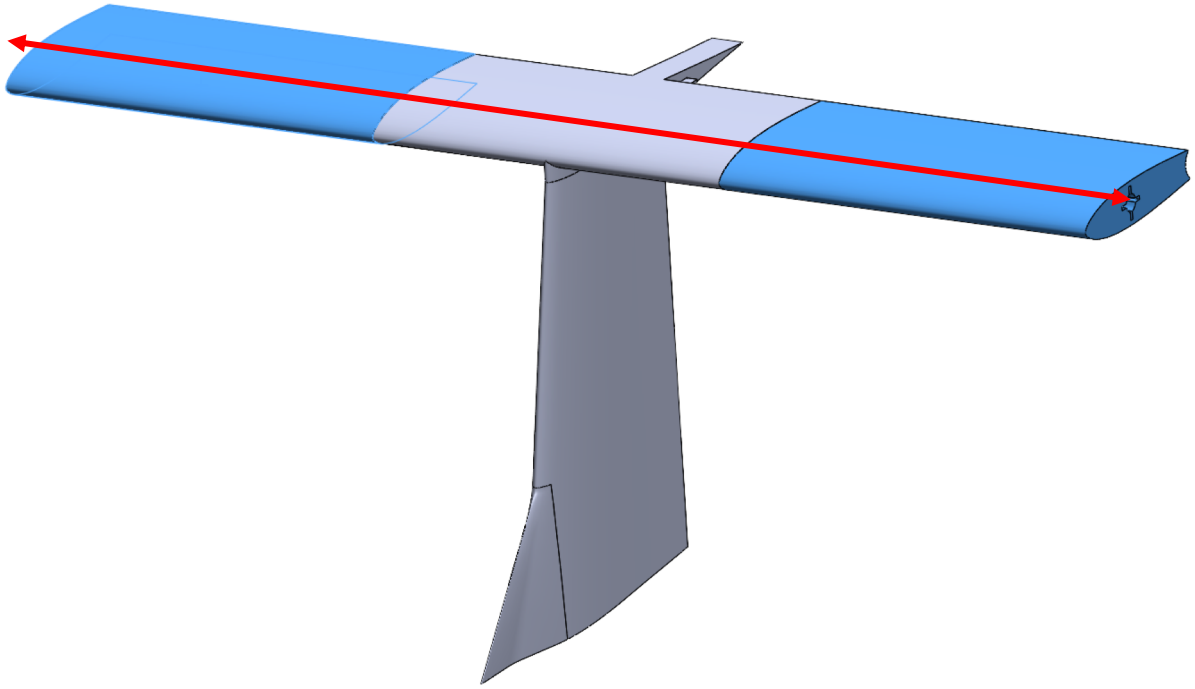




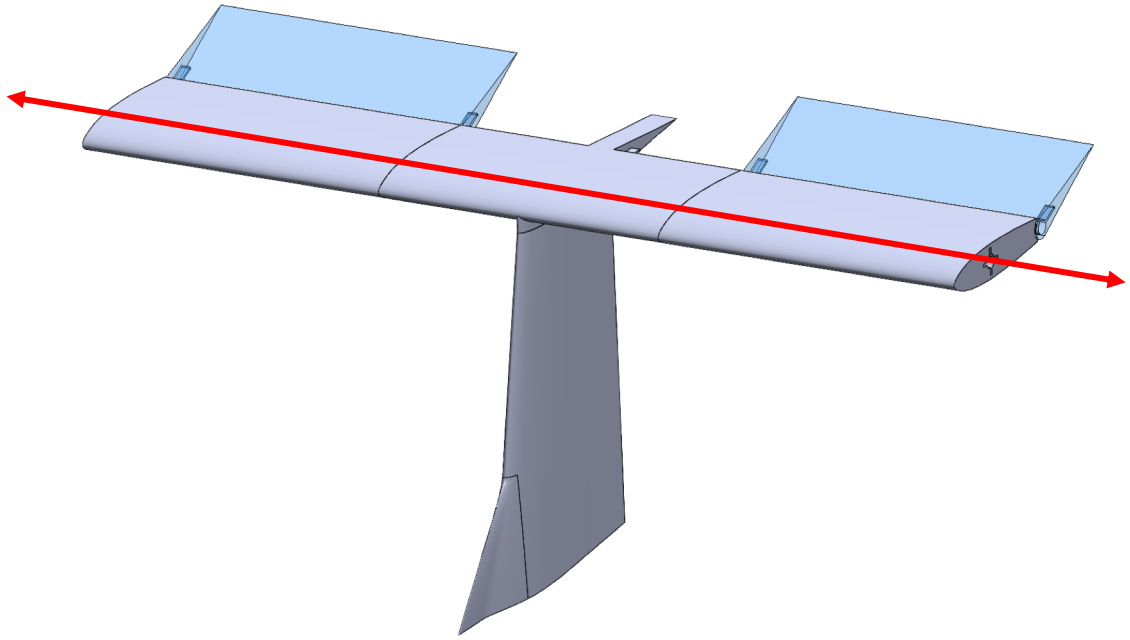
Project Brief Summary

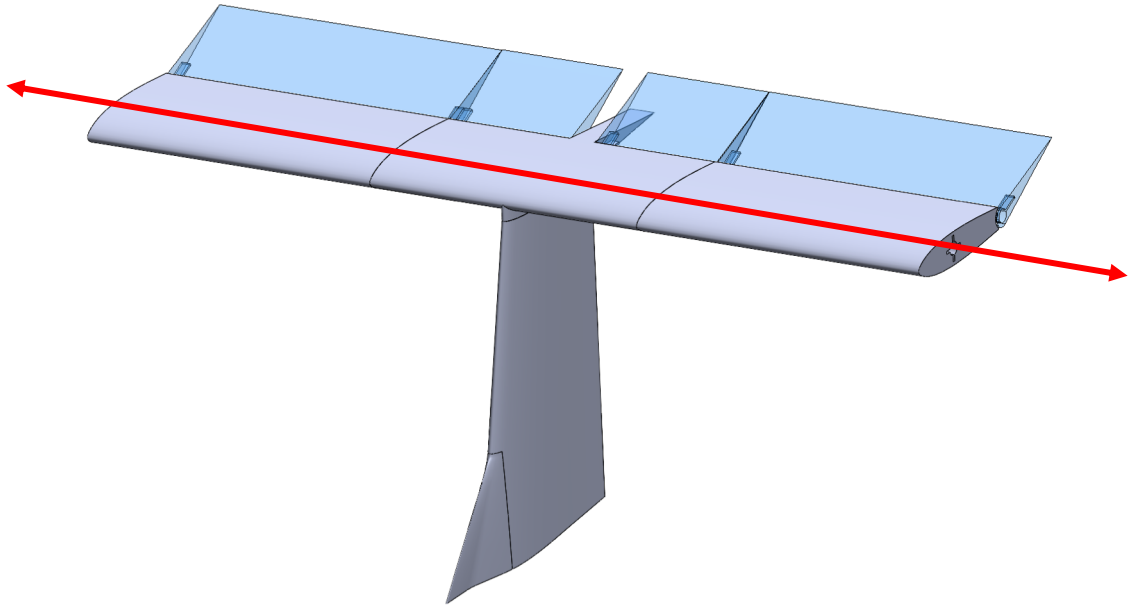






Project Brief Summary





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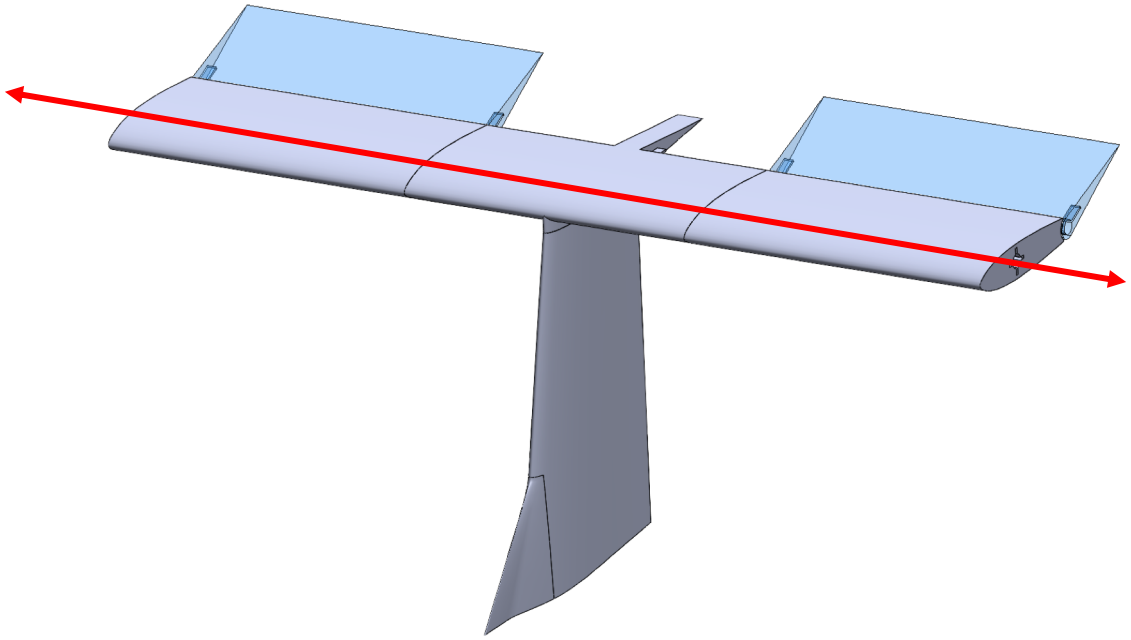
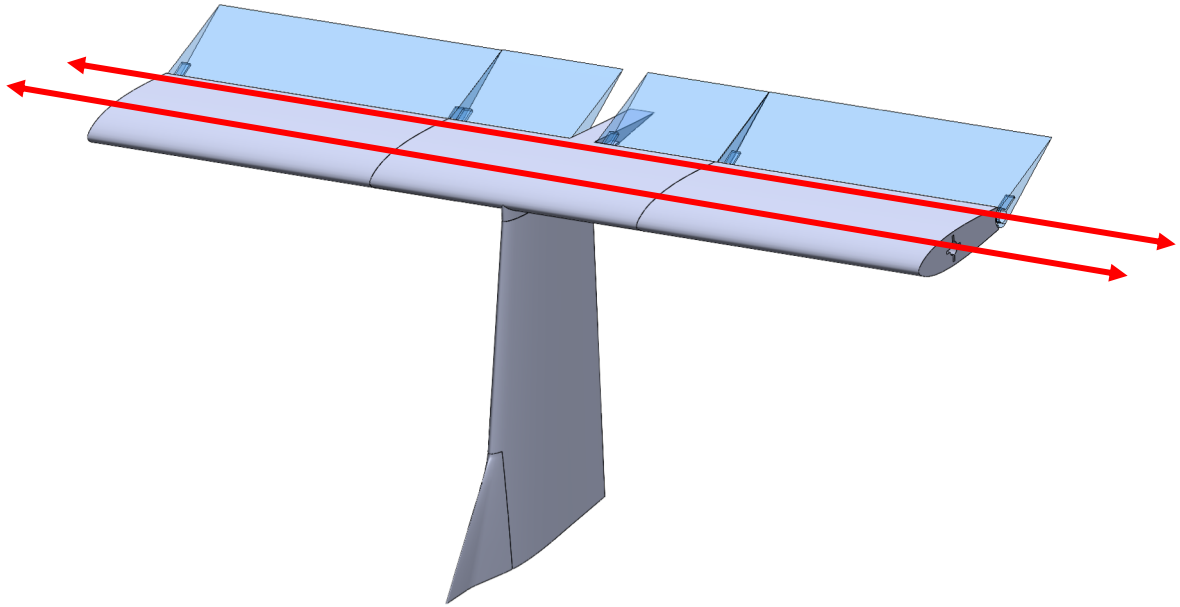
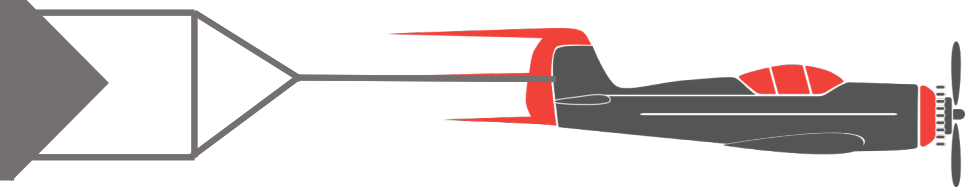


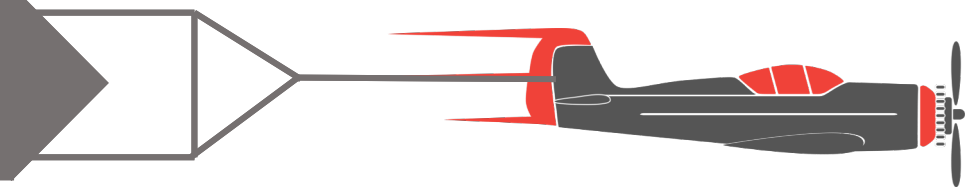


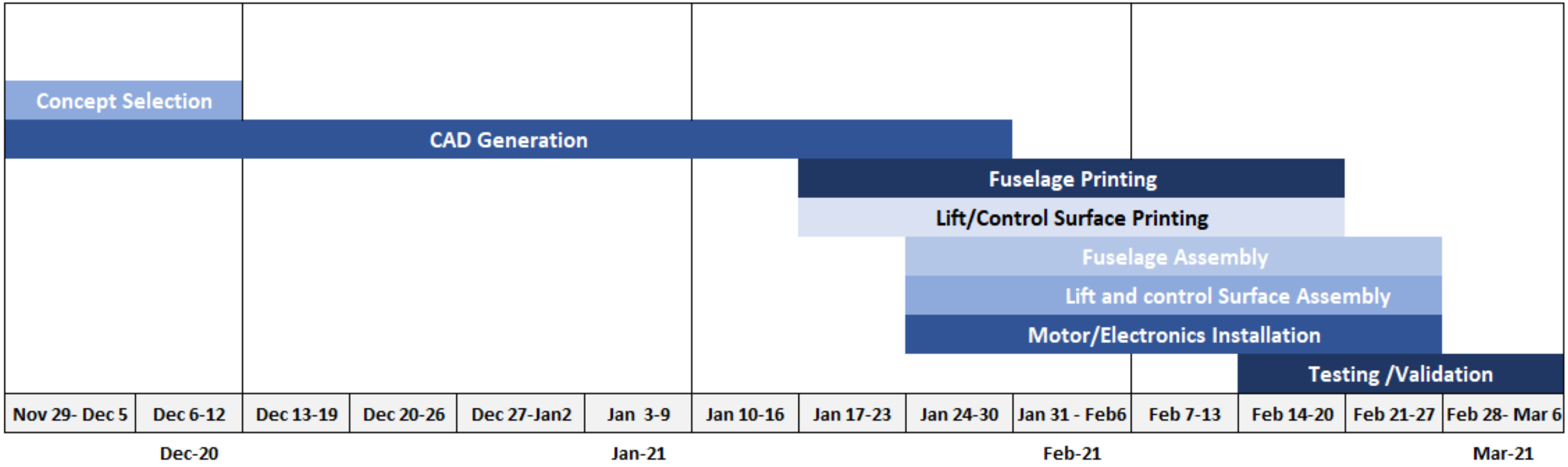
Fall Semester Timeline



Preliminary Research												
			Concept Generation									
										Concept Selection		
Aug 30- Sept 5	Sept 6-12	Sept 13 - 19	Sept 20-26	Sept 27- Oct 3	Oct 4-10	Oct 11- 17	Oct 18-24	Oct 25-31	Nov 1-7	Nov 8-14	Nov 18-21	Nov 22 -28
	Sep-20				Oct-20				Nov-20			

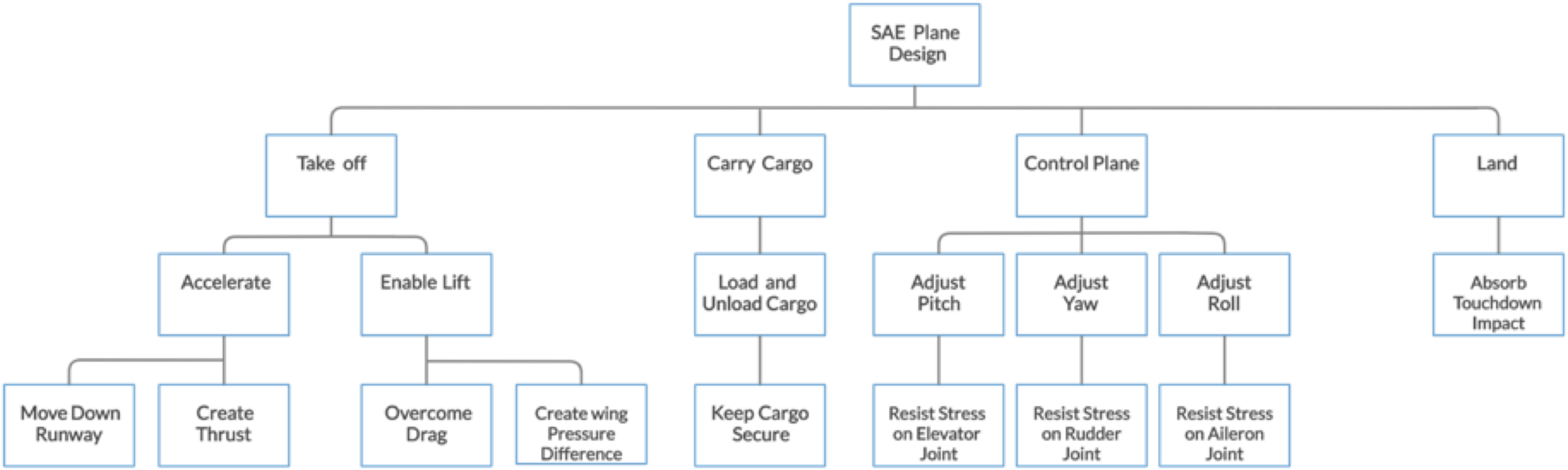
Winter & Spring Semester Timeline



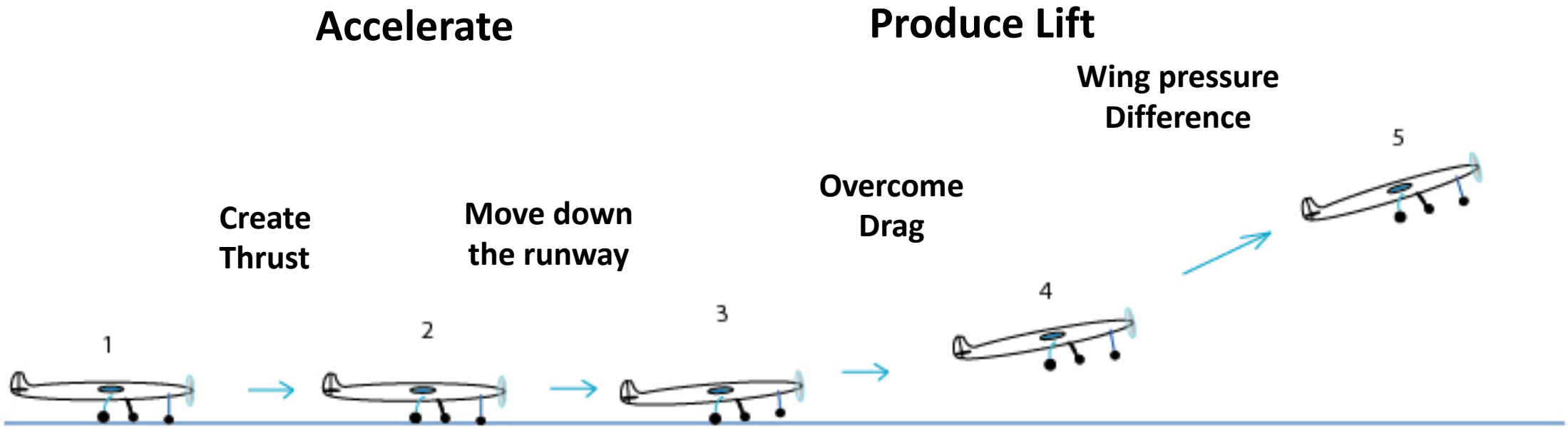


Jacob Pifer

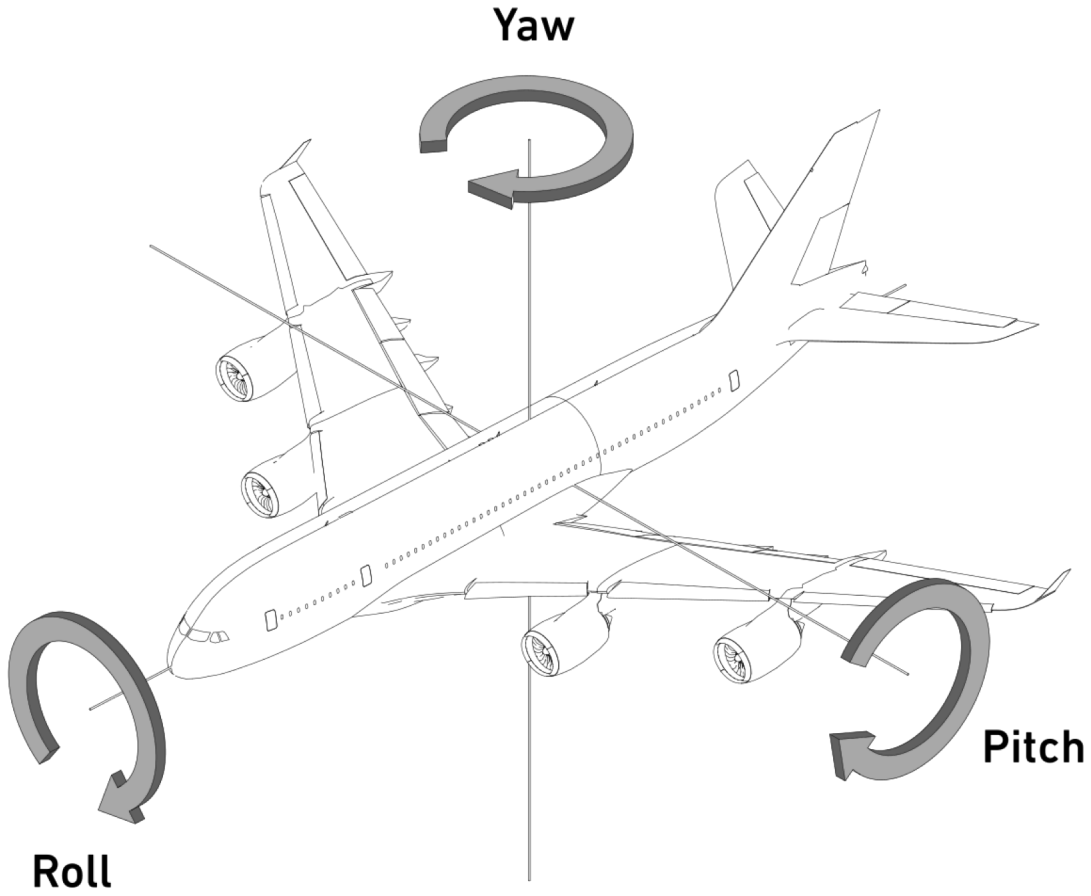
Functional Decomposition



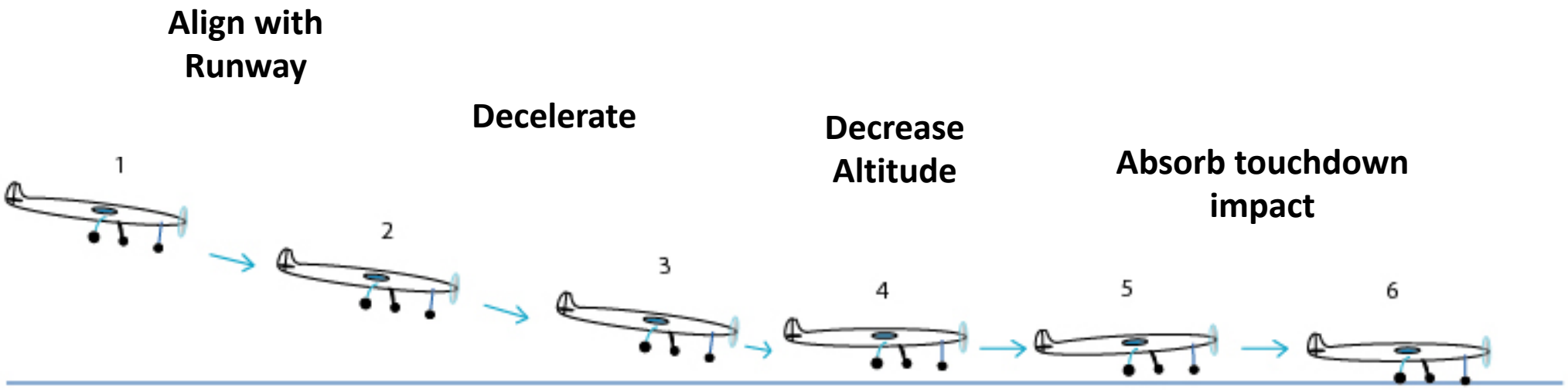
Takeoff

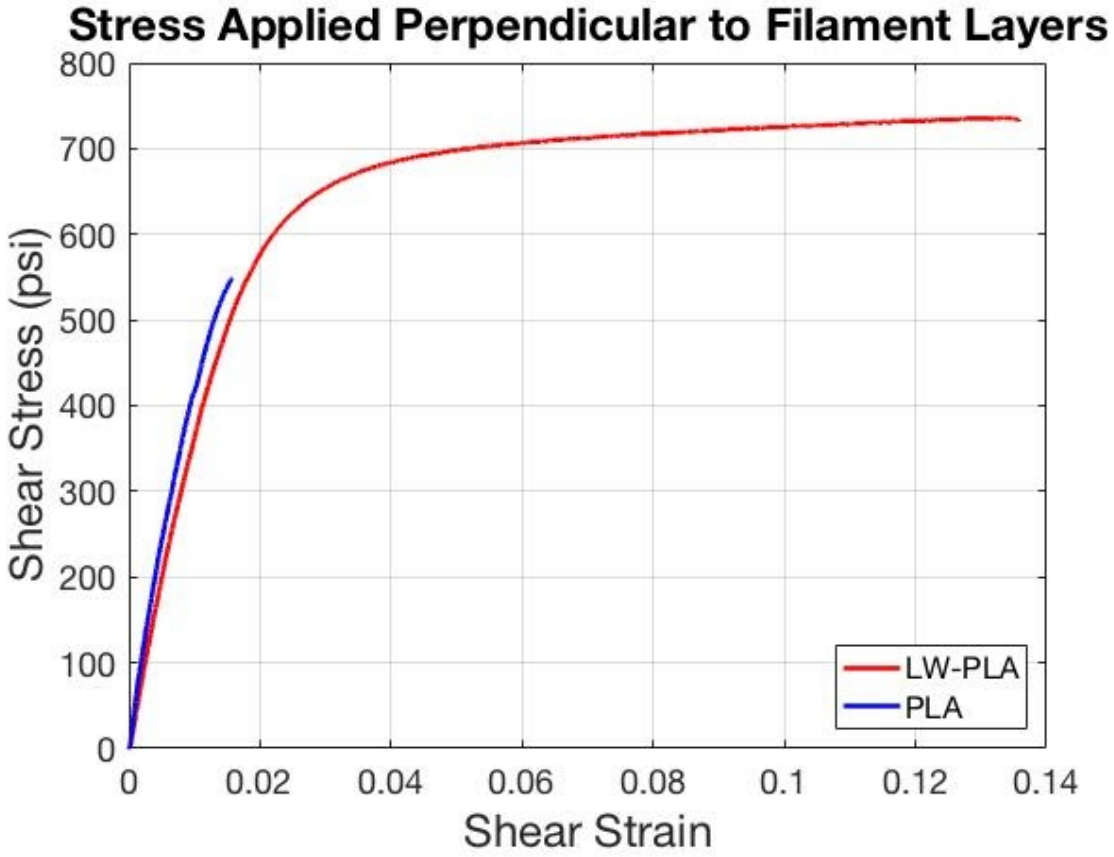

Accelerate
Produce Lift
Wing pressure
Difference
Overcome
Drag
Create
Thrust
Move down
the runway
1
2
3
4
5

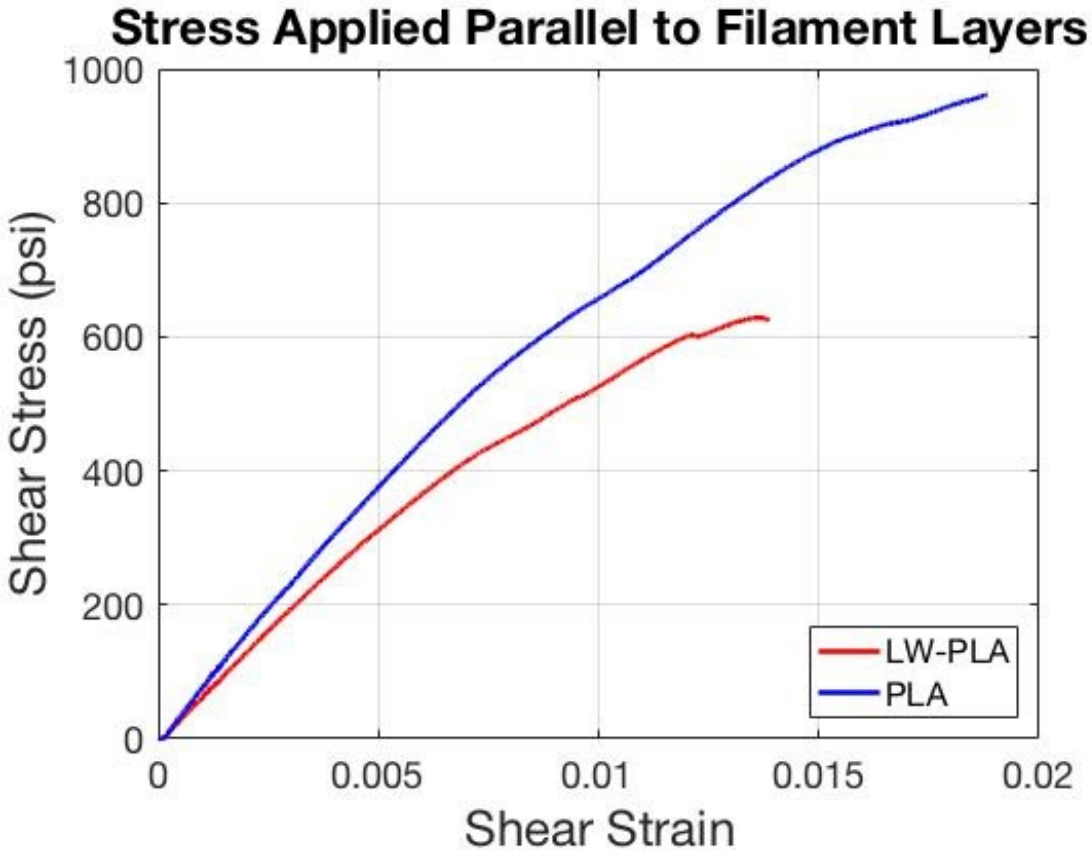
Control Plane



Landing


Align with Runway
Decelerate
Decrease Altitude
Absorb touchdown impact
1
2
3
4
5
6

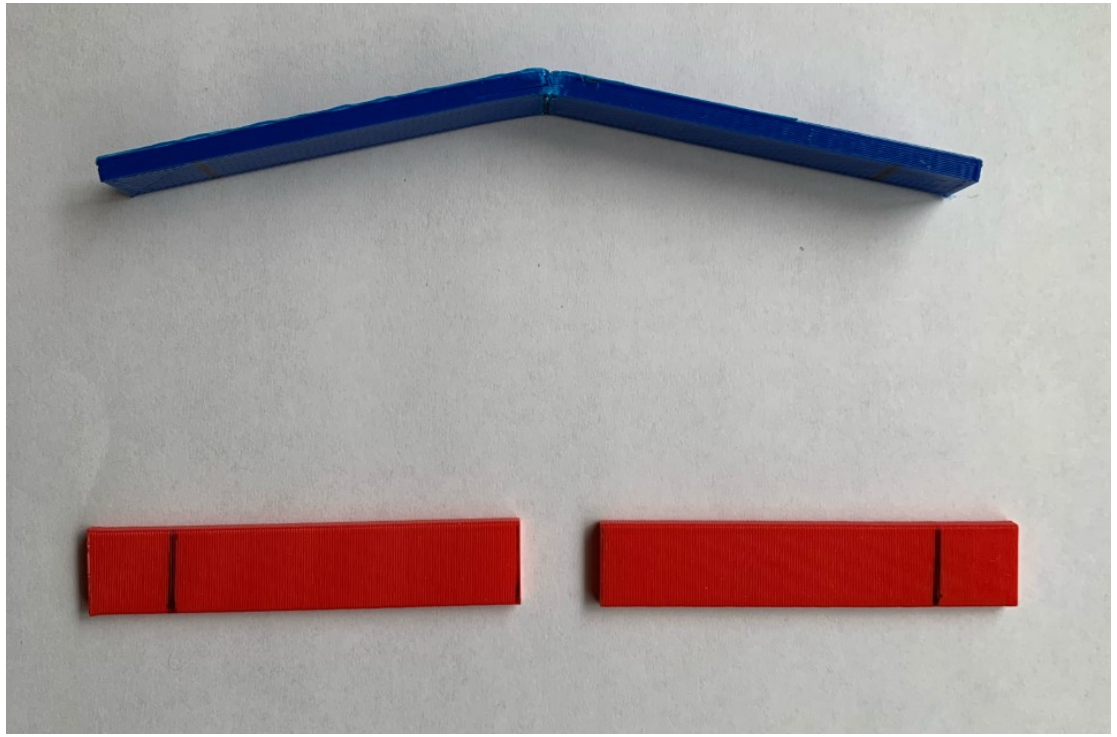




PLA failure stress: 412 psi
LW-PLA failure stress: 552 psi

PLA failure stress: 721 psi
LW-PLA failure stress: 471 psi

PLA

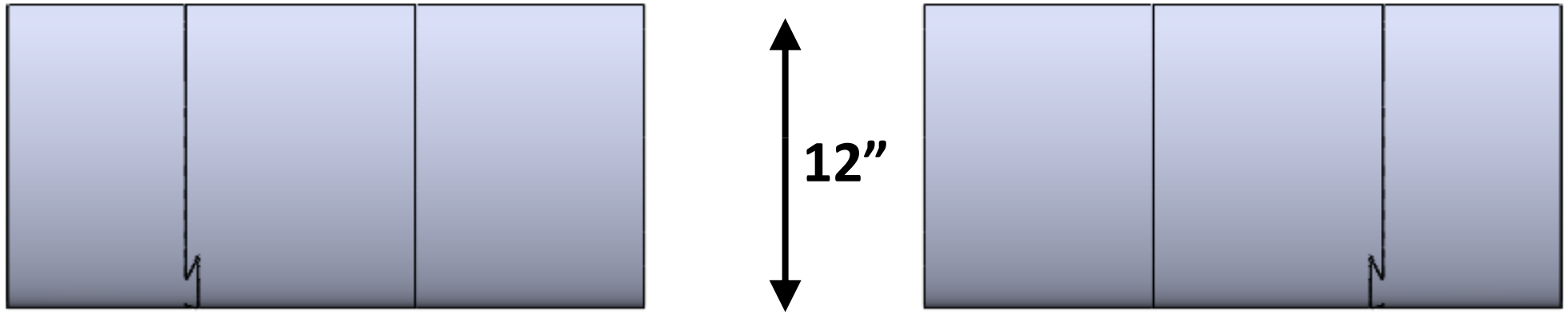


Stress perpendicular to printing direction: 3,360 psi
Stress parallel to printing direction: 8,350 psi

LW-PLA

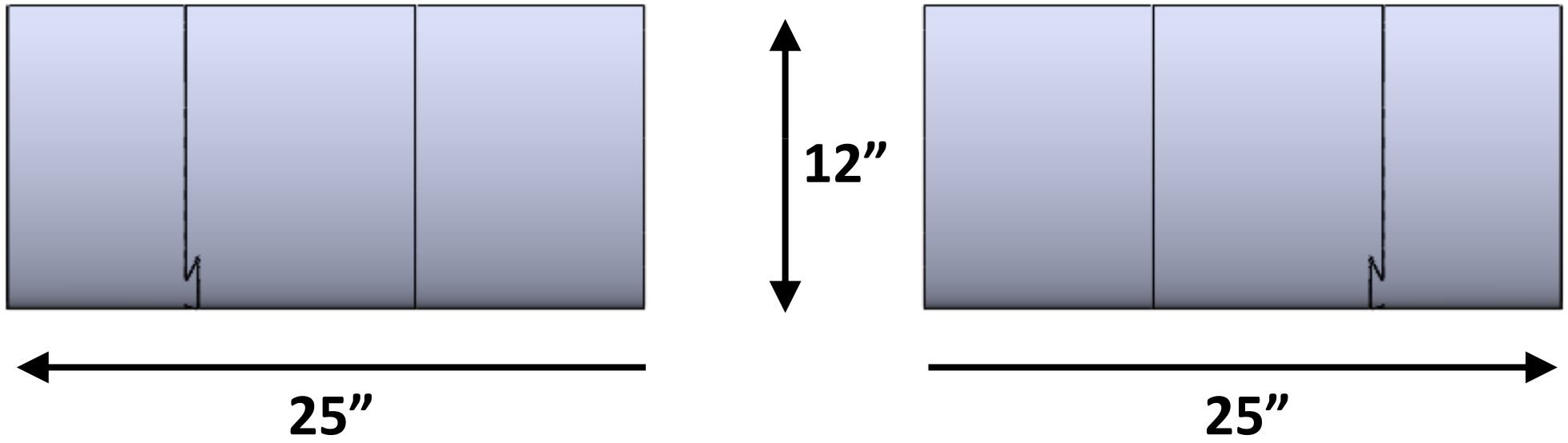
Stress perpendicular to layering direction: 3,380 psi
Stress parallel to layering direction: 6,120 psi

Canard Dimensions



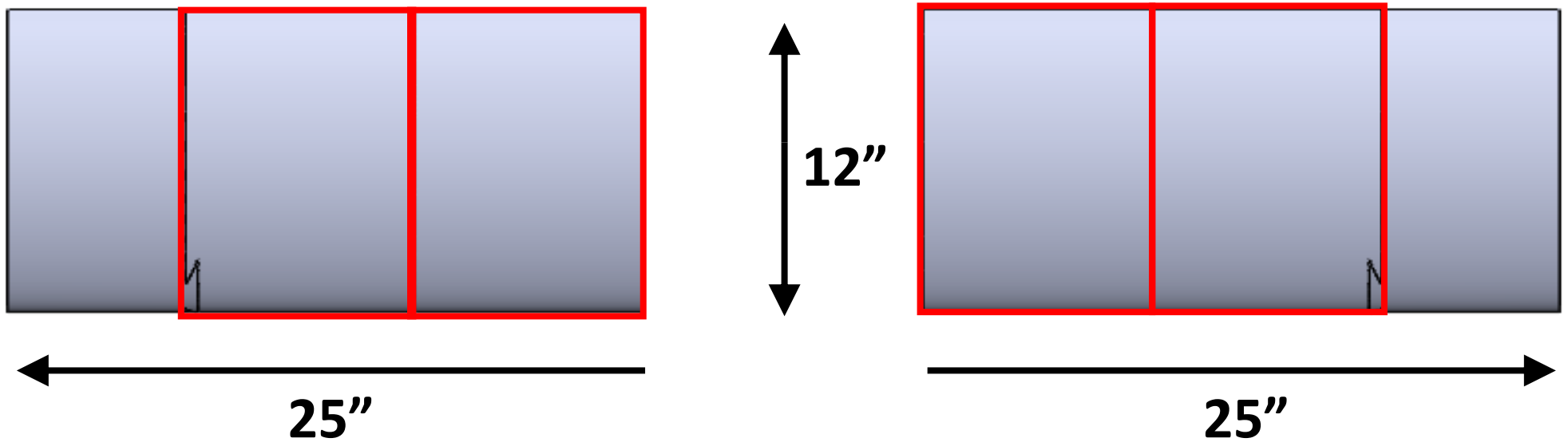
Lauren Chin

Canard Dimensions



Lauren Chin

Canard Dimensions



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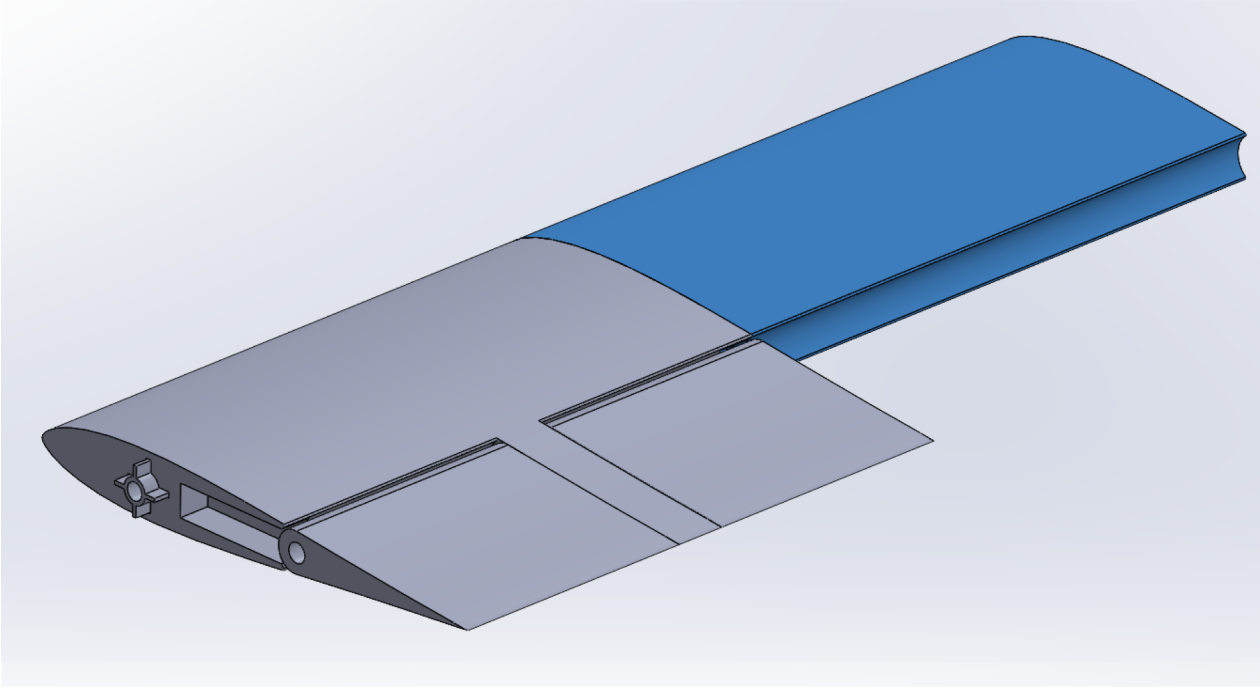

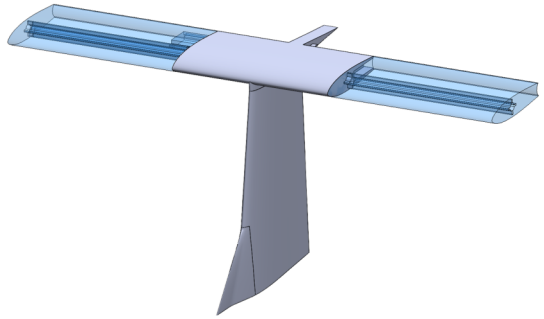
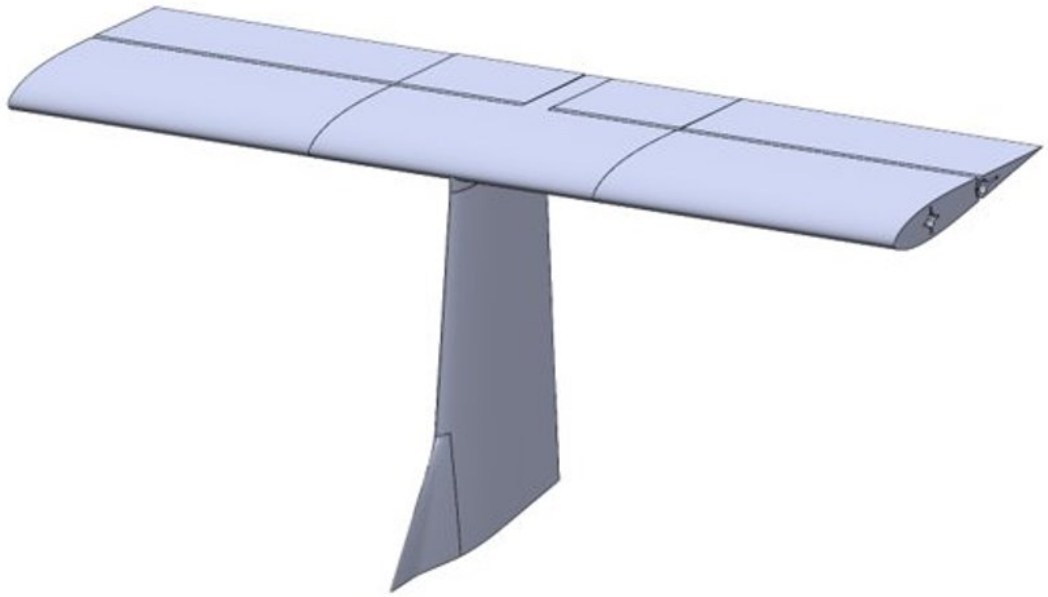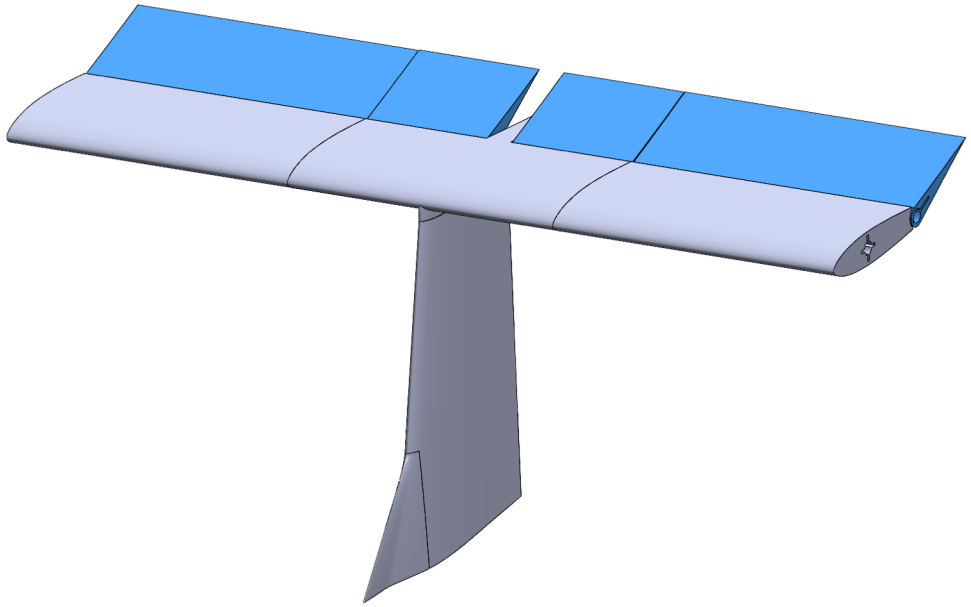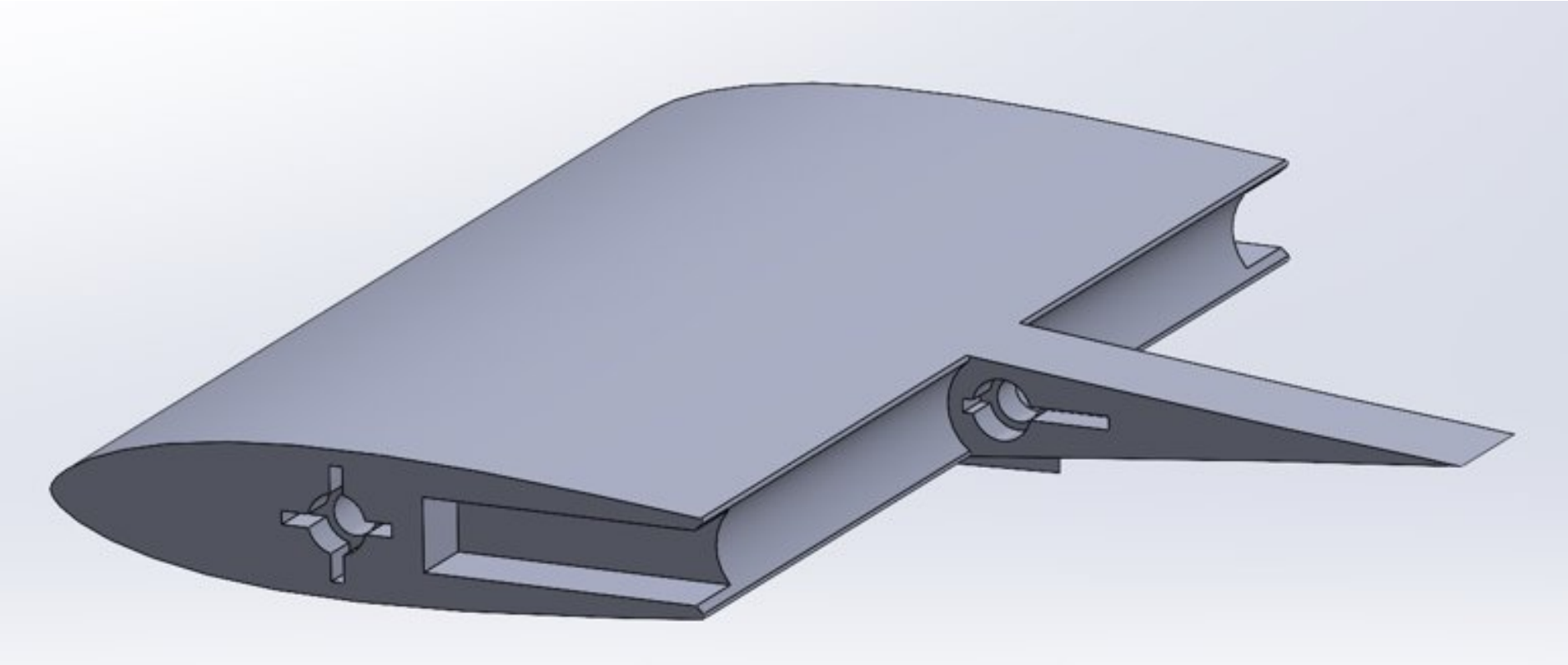
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