Weight Optimization of Rocket Components Using Filament Winding and Composite Materials

Team Members: Xavier Garcia, Alexander Gomez, Marvin Martinez
Zachary Morris, Doo Park
Faculty Advisor: Patrick Hartunian
Liaison: Eagle Rocketry
Department of Mechanical Engineering
College of Engineering, Computer Science, and Technology
California State University, Los Angeles

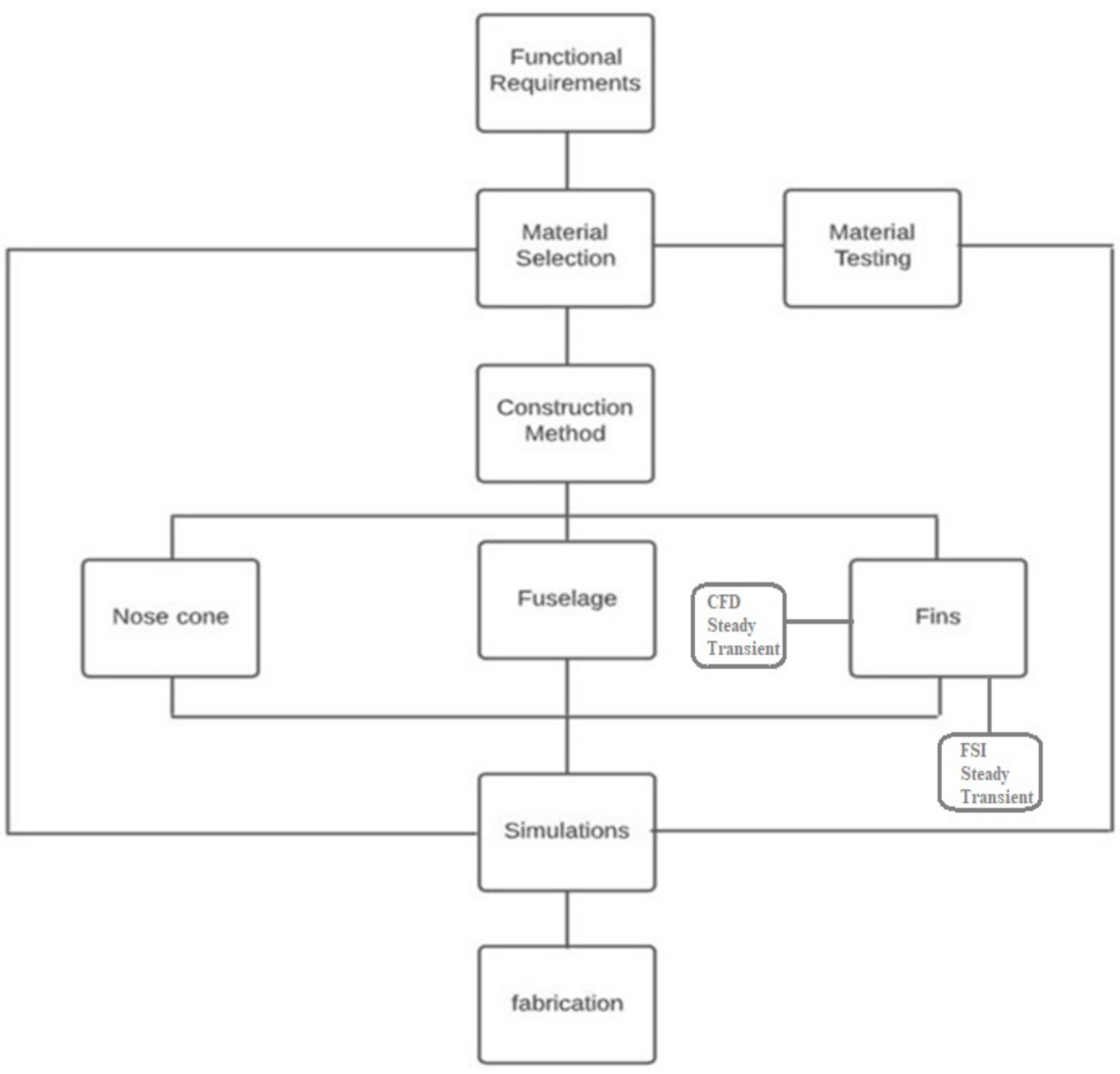
PROJECT OBJECTIVE

The objective is to redesign the fuselage and fins for the rocket of Eagle Rocketry. The strength to weight ratio of the rocket will be optimized by using composite construction techniques incorporating a filament winder. The team redesigned the new rocket structure by utilizing Finite Element Analysis (FEA) software to optimize the design considering aerodynamic, thermal, vibrational, and structural loads. The goal is to compete in the FAR 1030 competition held in June 2022.

REQUIREMENTS

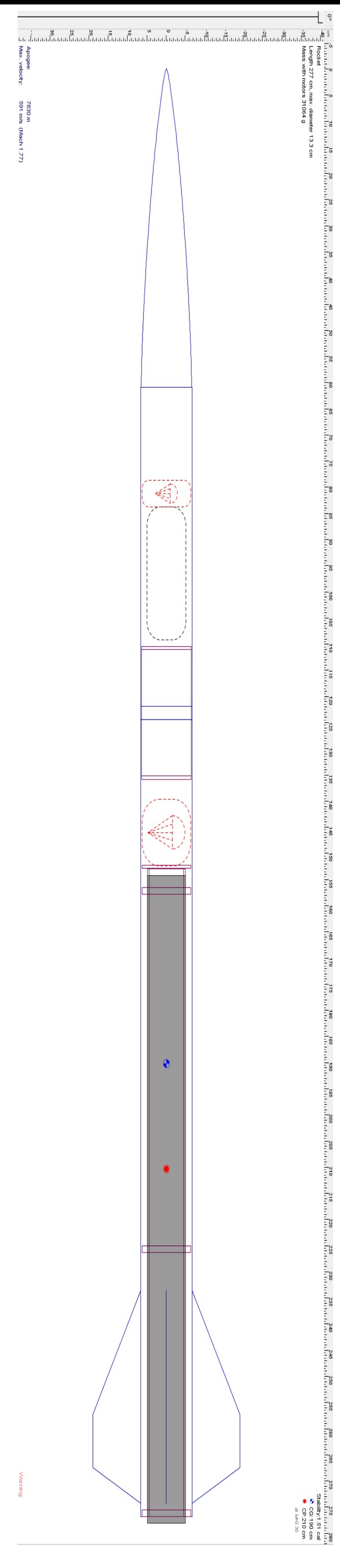
Composite structure	CarbonFiber/ X-winder	
Fuselage		
Low Mass Fraction	Mass	7.76 lbs
	Material H2550 12K	800 ksi
Stresses	Aerodynamic Load (max)	0.087 ksi
	Structural Load (max)	22.9 Ksi
Fins		
Low Mass Fraction	Mass	1.602 lbs
	Material Hexcell AS4	644 ksi
Vibration	Model Analysis	Pass
Stresses	Aerodynamic Load (max)	0.105ksi
Complete Rocket		
Apogee	Mass	68.3 lbs
	Apogee > 25000 ft	
	Motor:[21062-03400-IM-O]	25,688 ft
	Motor:[N3800-BS-O]	24,695 ft
	Motor:[N3800-BS-O]	21,850 ft

DESIGN APPROACH



CONCLUSIONS

- Carbon fiber offered superior strength-to-weight ratio compared to other commercial materials.
- The structural analysis suggests that the fuselage is in the elastic region of a stress-strain curve after undergoing compression.
- The results of modal and transient CFD analysis shows that the Fins will not experience flutter.



NOSE CONE

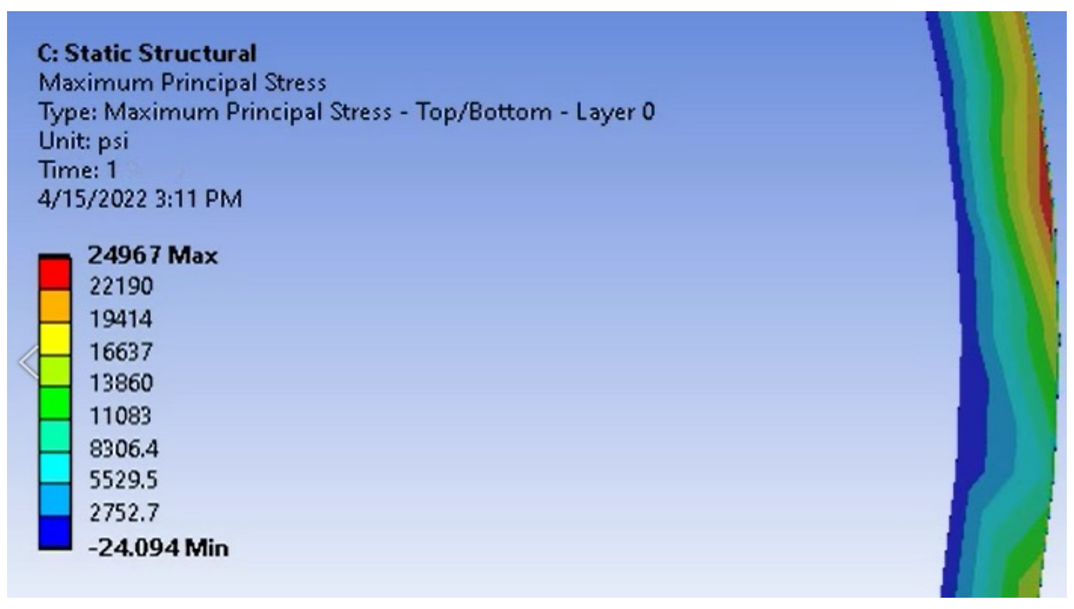
- Von Karman Nose Cone.
- Commercially available Recovery System.

PAYLOAD BAY

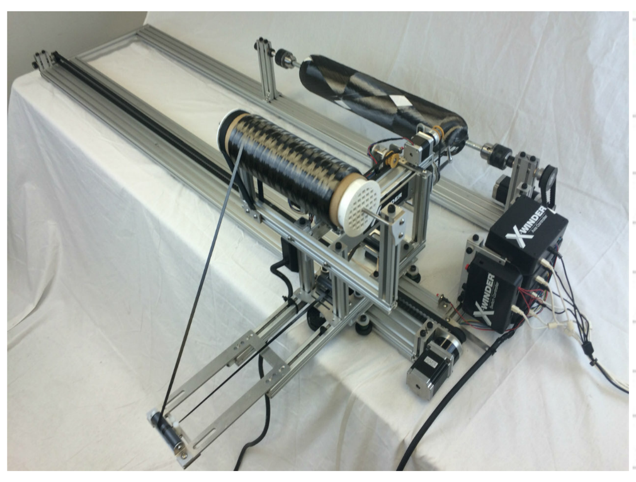
- Telemetry equipment by Eagle Rocketry.
- CubeSat by Eagle Rocketry.

FUSELAGE

- Motor affixed with G10 Centering Rings.
- Commercially available Nozzle.



Maximum equivalent stress of the fuselage's top face at winding angle of 60 degrees.



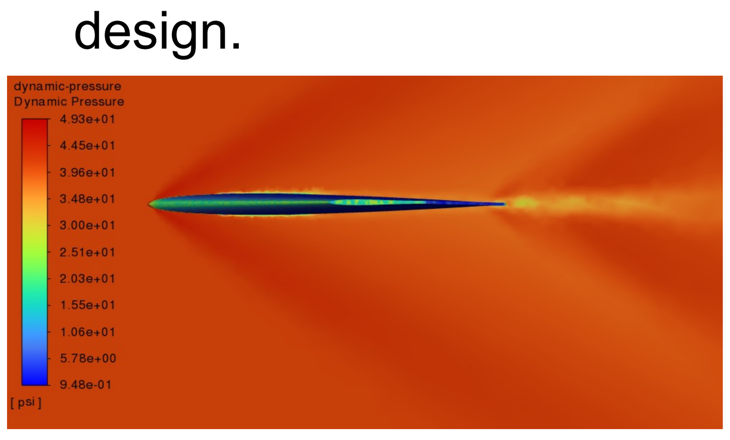
X-Winder Machine

Winding Angle (degrees)	Stress (psi)	Buckling Load (lbf)
15	20,298	216,616
30	28,060	179,765
45	29,294	194,089
60	22,932	456,007
52.5	26,104	315,206
55	24,967	384,024
54.75	25,078	376,527

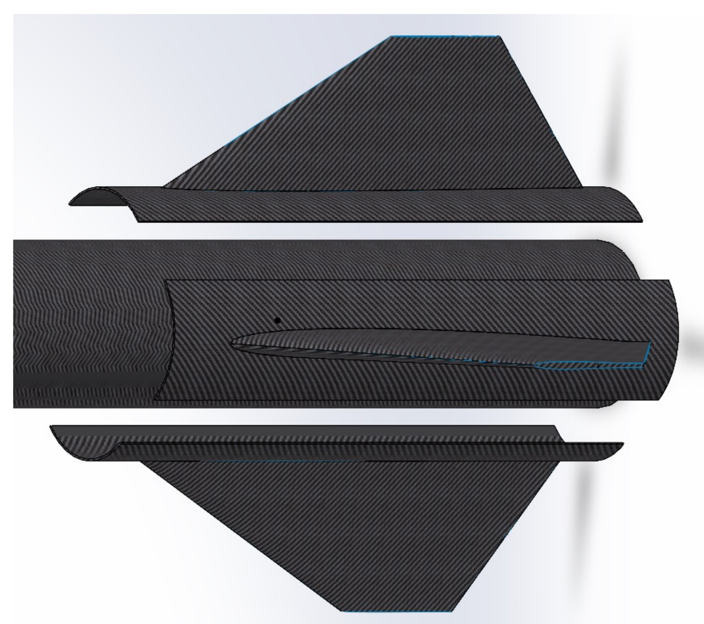
Structural Analysis

FIN CONSTRUCTION & ANALYSIS

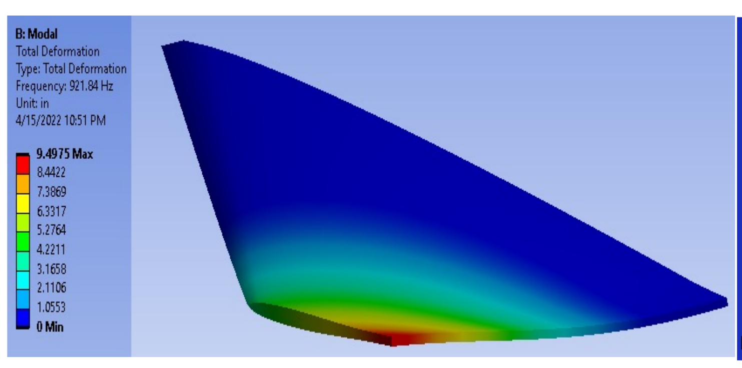
- Final fin design with NACA 0006 airfoil.
- Four-piece Clamshell design.



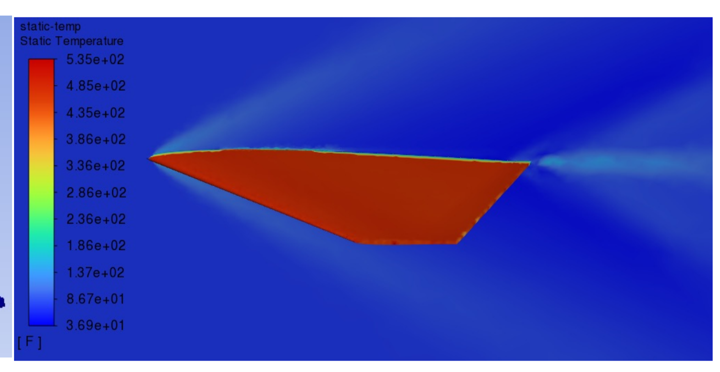
Dynamic Pressure Analysis



Fin Mounting Design



CFD Mode Shape



Thermal Analysis