

# MEM-10 Semi-Autonomous Loitering UAS

Ethan Shapiro, Gennadiy Smolskiy, Naveen Thomas Ninan, Eric Vibol, Andy Zhong, Dr. Matthew McCarthy

Department of Mechanical Engineering and Mechanics

## Monitoring Drones

Infrastructure and defense industries rely on persistent, real-time aerial surveillance to maintain situational awareness and support rapid decision-making. While platforms like the AeroVironment *Puma 3* demonstrate the value of long-endurance surveillance, barriers prevent broader accessibility.

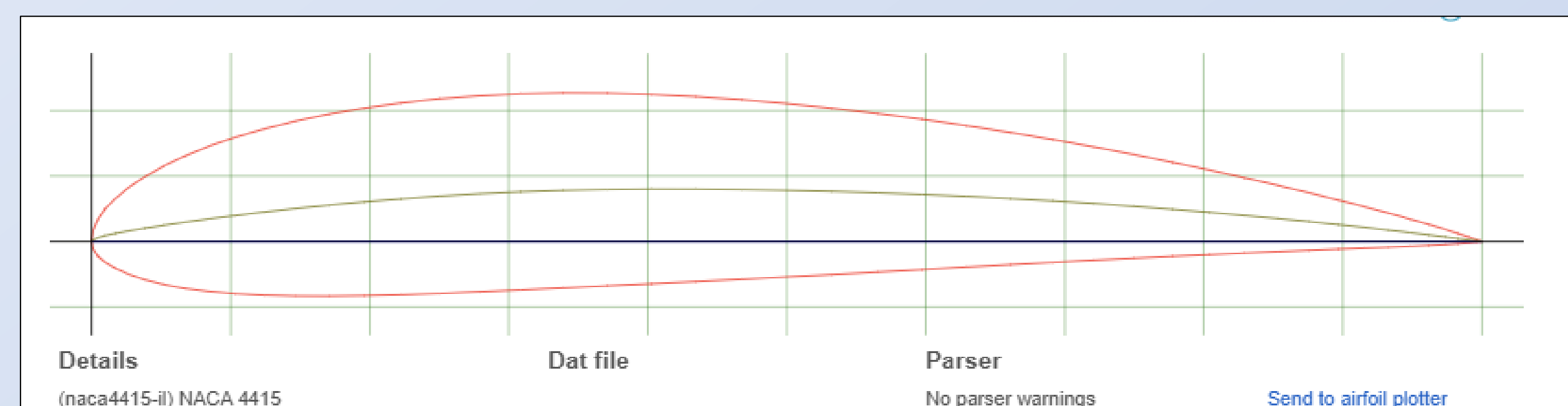
## Industry Challenge

Current solutions compromise between expensive, resource-intensive manned aircraft and small, manually controlled multirotor drones with limited battery life. Existing long endurance fixed-wing systems incur prohibitive costs and infrastructure requirements.

## Providing a Solution

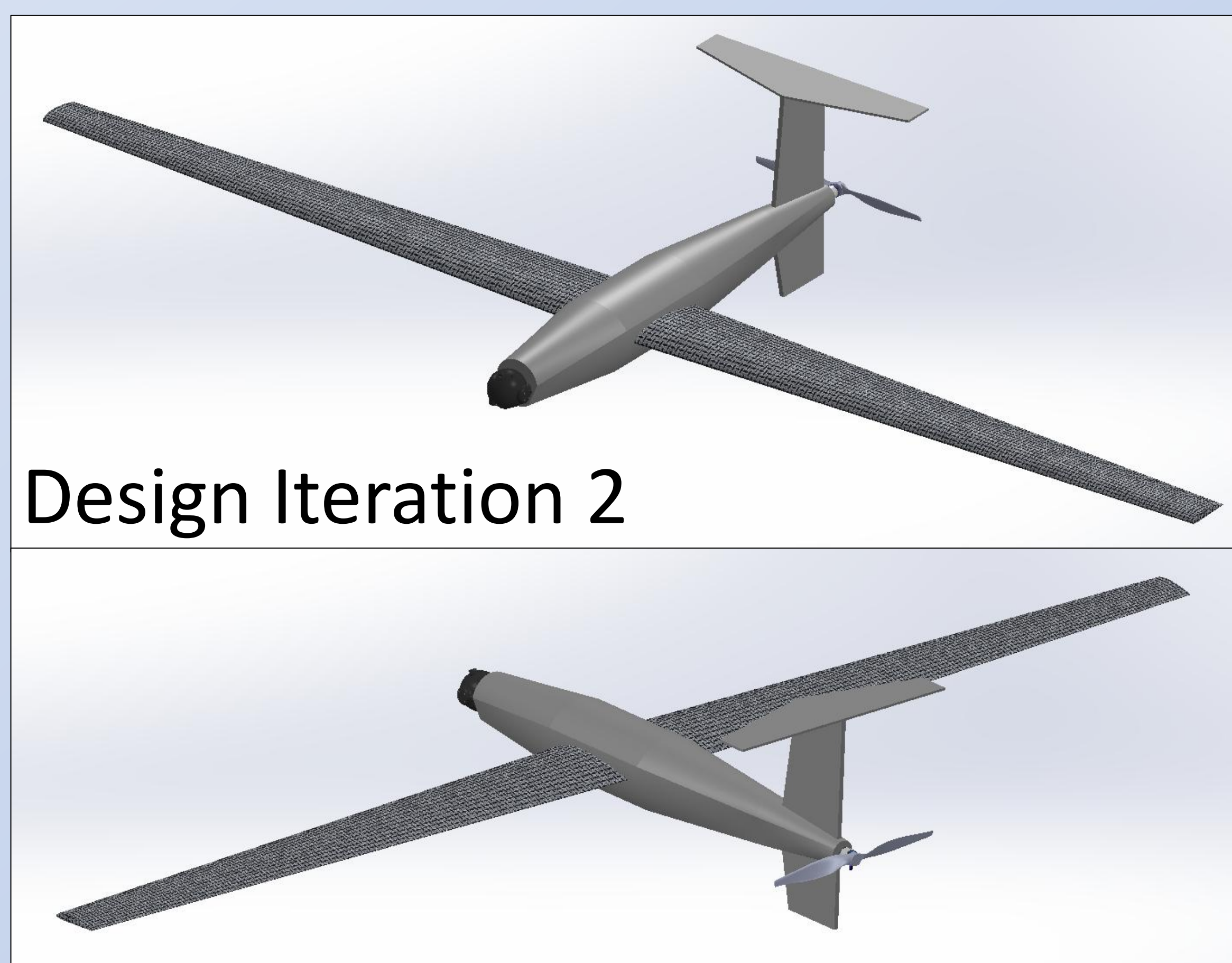
To address this gap, this project proposes the design of a modular, fixed-wing Group 1 Unmanned Aerial System (UAS) optimized for simple, cost-effective, semi-autonomous loitering. This configuration proposes a stable, efficient design capable of achieving an estimated 2.5-hour flight endurance while maintaining a prototype cost under \$900.

## Wing Design Parameters



Prioritizes Drag Minimum Flight:

The NACA 4415 features a  $C_{lmax}$  of 1.6 and  $C_{dmax}$  of 0.06. In flight,  $C_l = 0.7$  and  $C_d = 0.04$ .



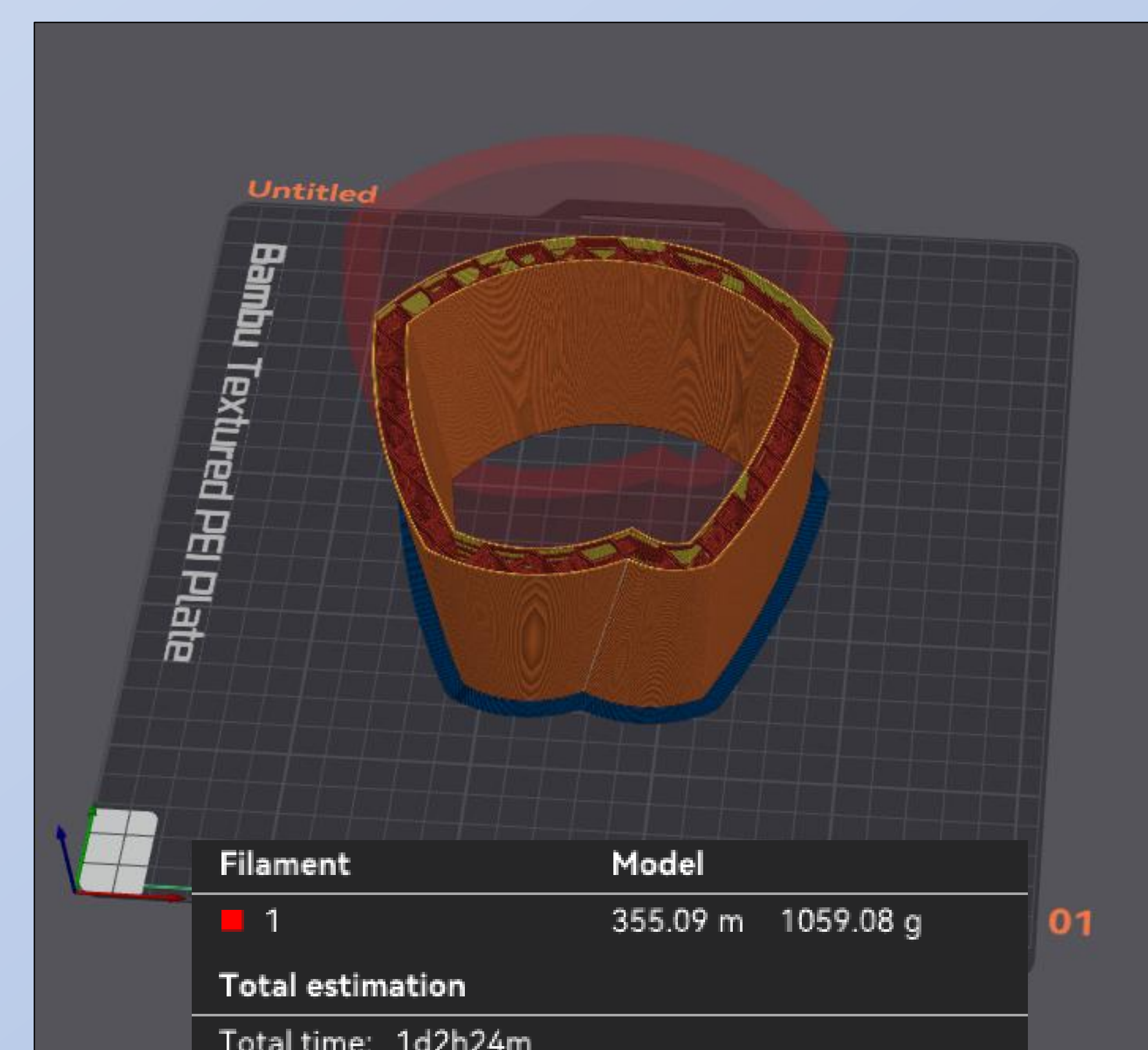
## Prototyping & Manufacturing



Wings are skinned with carbon fiber composite weave, with central spars to provide mass-efficient flexural rigidity.



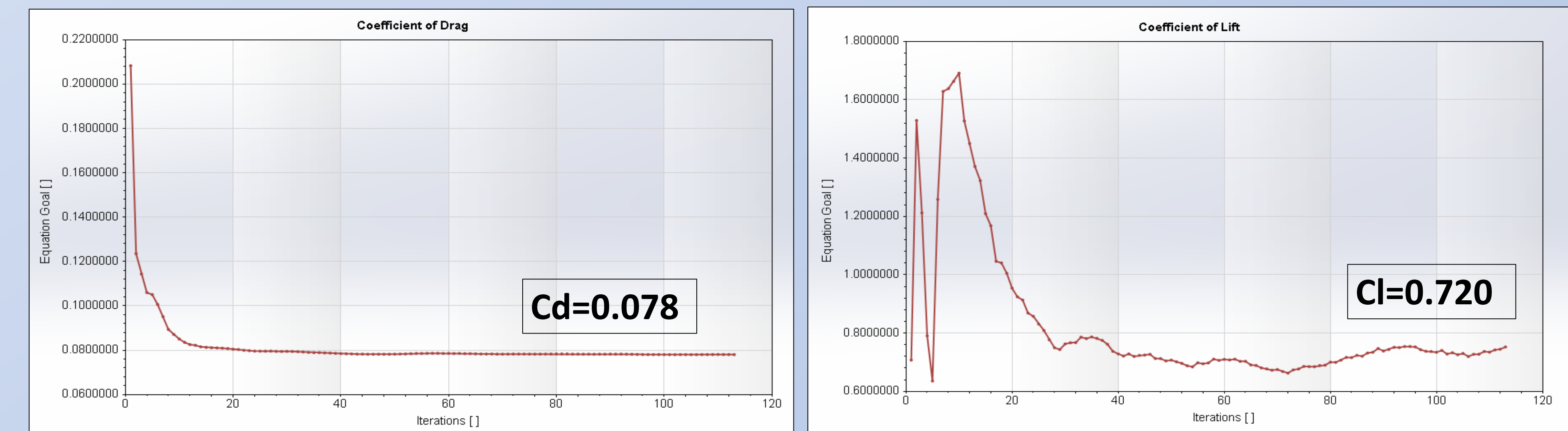
FDM 3D Printing is used to rapidly and cheaply produce parts while giving us room for quick iterations in design. 3D printing also allows for significant weight reductions and unique packaging solutions compared to traditional manufacturing processes.



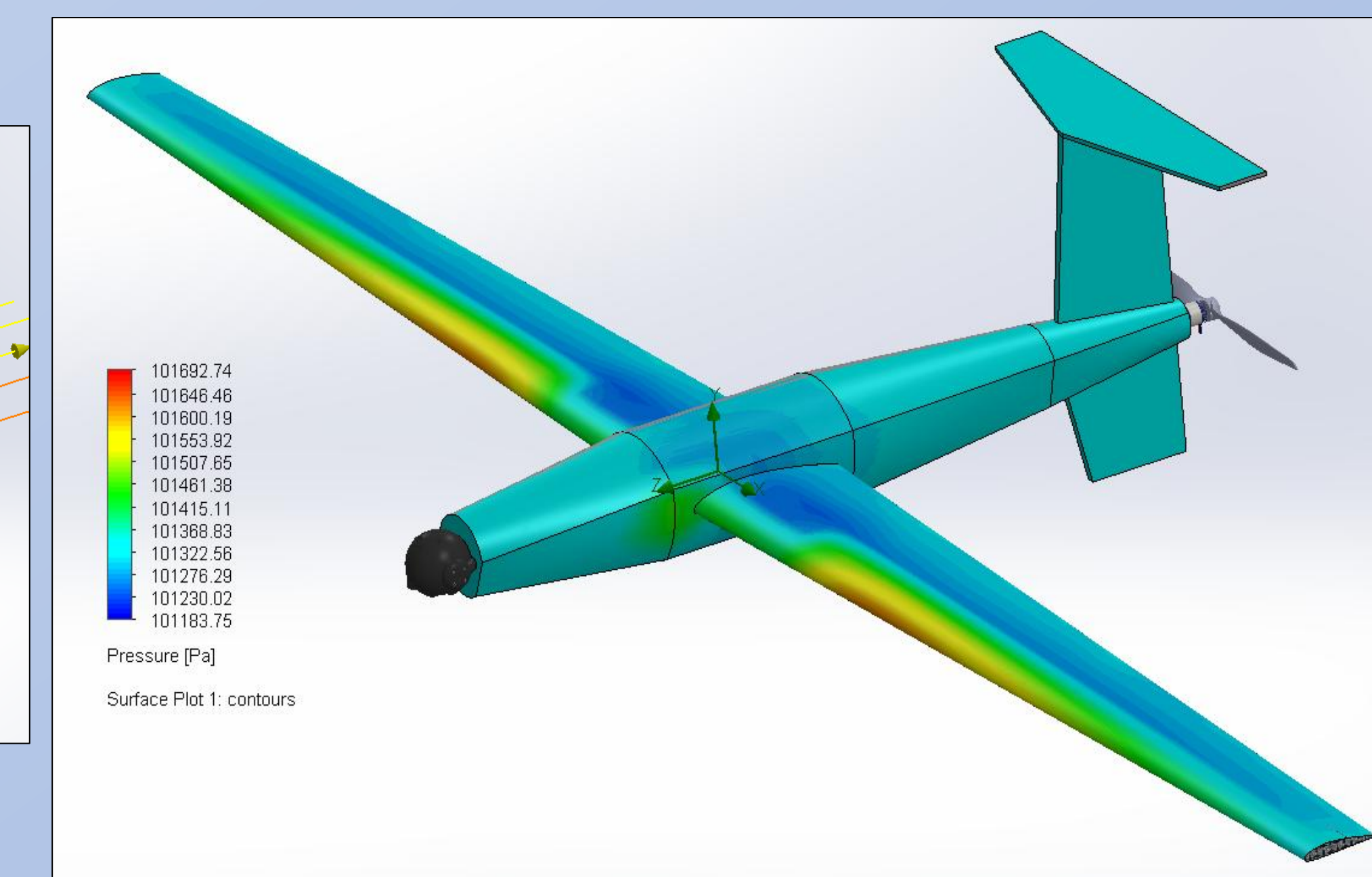
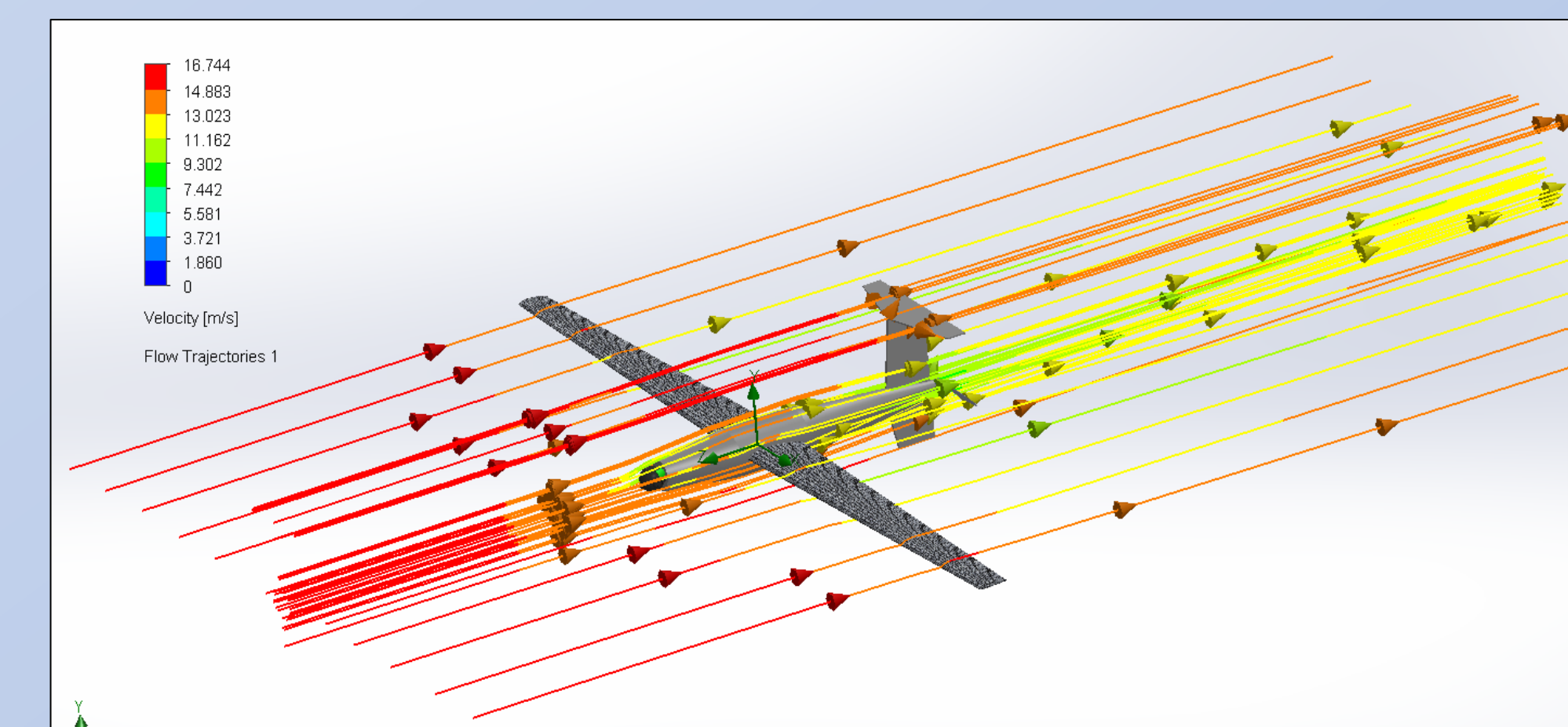
Low infill and gyroid infill pattern allows for maximum weight reduction and stiffness while keeping costs and manufacturing time down.

## Computational Fluid Dynamics (CFD) Modeling

CFD simulation was run using an input wind velocity of 15 m/s with the fluid as air. The equations goals calculate coefficients of drag and lift to validate the team's target values of 0.080 for  $C_d$  and 0.750 for  $C_l$  in level cruise:

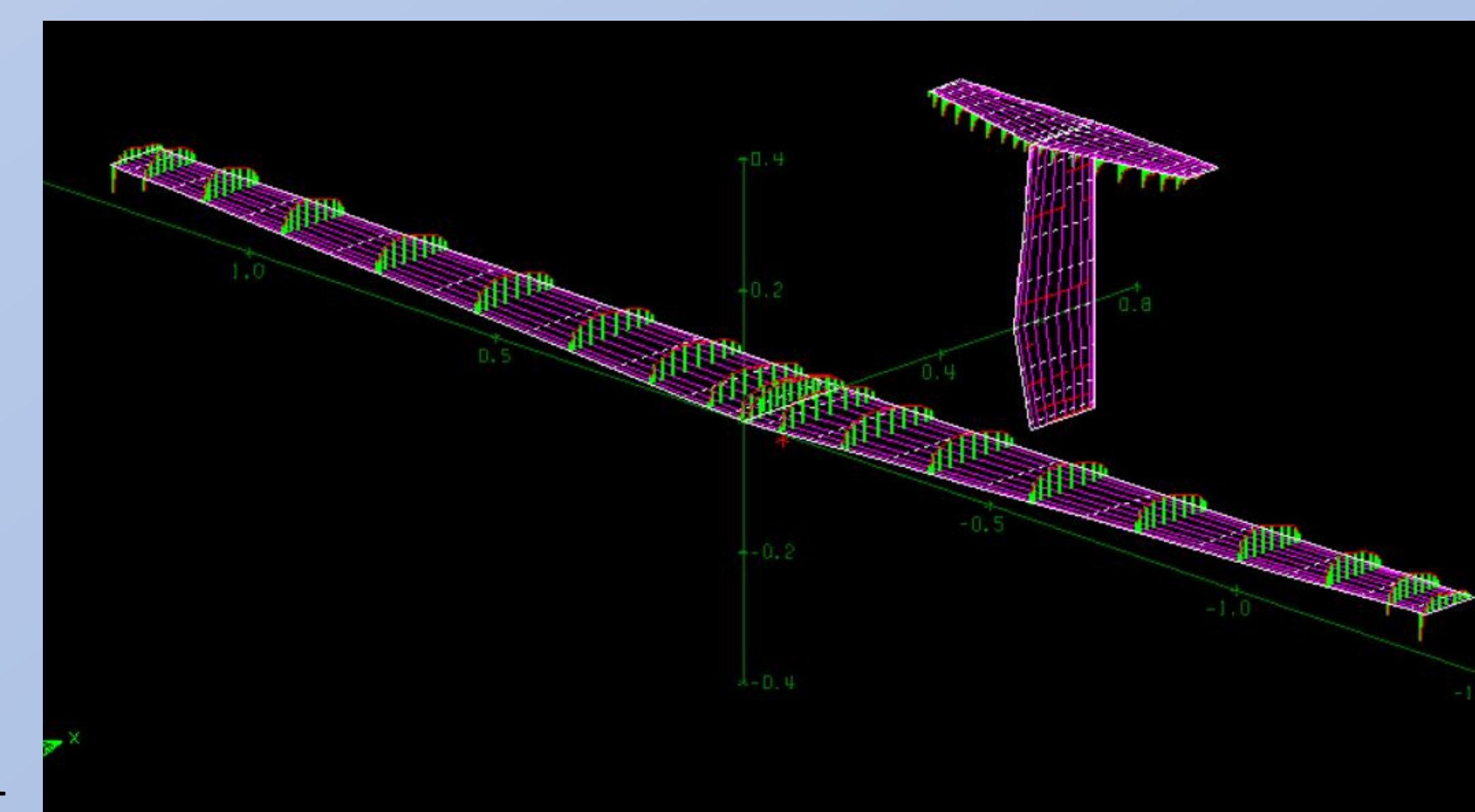


Further post-simulation visualizations of velocity interface with the fuselage and pressure-contour interface with the wings can be seen:



## Stability Modeling

Key features showing static stability are a Static Margin of 20% ( $-C_{la} / C_{ma}$ ) and negative, corrective stability derivatives. These represent a stable aircraft in all 3 axes, especially in cruise:



Stability-axis derivatives...

	alpha	beta	
z' force CL	CLa = 5.913288	CLb = -0.000000	
y force CY	CYa = -0.000000	CYb = -0.524401	
x' mom. CL'	CLa' = -0.000000	CLb' = -0.057139	
y mom. Cm	Cma = -0.967552	Cmb = -0.000000	
z' mom. Cn'	Cna = -0.000000	Cnb = 0.100103	
	roll rate p'	pitch rate q'	yaw rate r'
z' force CL	CLp = 0.000000	CLq = 7.752347	CLr = -0.000000
y force CY	CYp = -0.051501	CYq = -0.000000	CYr = 0.245012
x' mom. CL'	CLp' = -0.000000	CLq' = -0.000000	CLr' = 0.130518
y mom. Cm	Cmp = 0.000000	Cmq = -14.638303	Cmr = 0.000000
z' mom. Cn'	Cnp = -0.042620	Cnq = 0.000000	Cnr = -0.048222
	elevator d01	rudder d02	
z' force CL	CLd01 = 0.004001	CLd02 = -0.000000	
y force CY	CYd01 = -0.000000	CYd02 = 0.004924	
x' mom. CL'	CLd01' = -0.000000	CLd02' = 0.000300	
y mom. Cm	Cmd01 = -0.013531	Cmd02 = 0.000000	
z' mom. Cn'	Cnd01 = 0.000000	Cnd02 = -0.001009	
Trefftz drag	CDff01 = 0.000006	CDff02 = 0.000000	
span eff.	ed01 = 0.013771	ed02 = -0.000000	
Neutral point Xnp = 0.105525			
Clb Cnr / CLr Cnb = 0.198714 ( > 1 if spirally stable )			
Operation of run case 1/1: -unnamed-			

## Conclusions

We can achieve an increase in flight endurance while constructing a simple low-cost UAS that can readily accept a COTS autonomous flight controller and payload packages. The demonstration of this capability is a success and will serve to guide further iterations and analyses of this UAS design.

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