MANPADS

Man Portable Air Defense System

Fig.1 9K38 Igla

Objective of project

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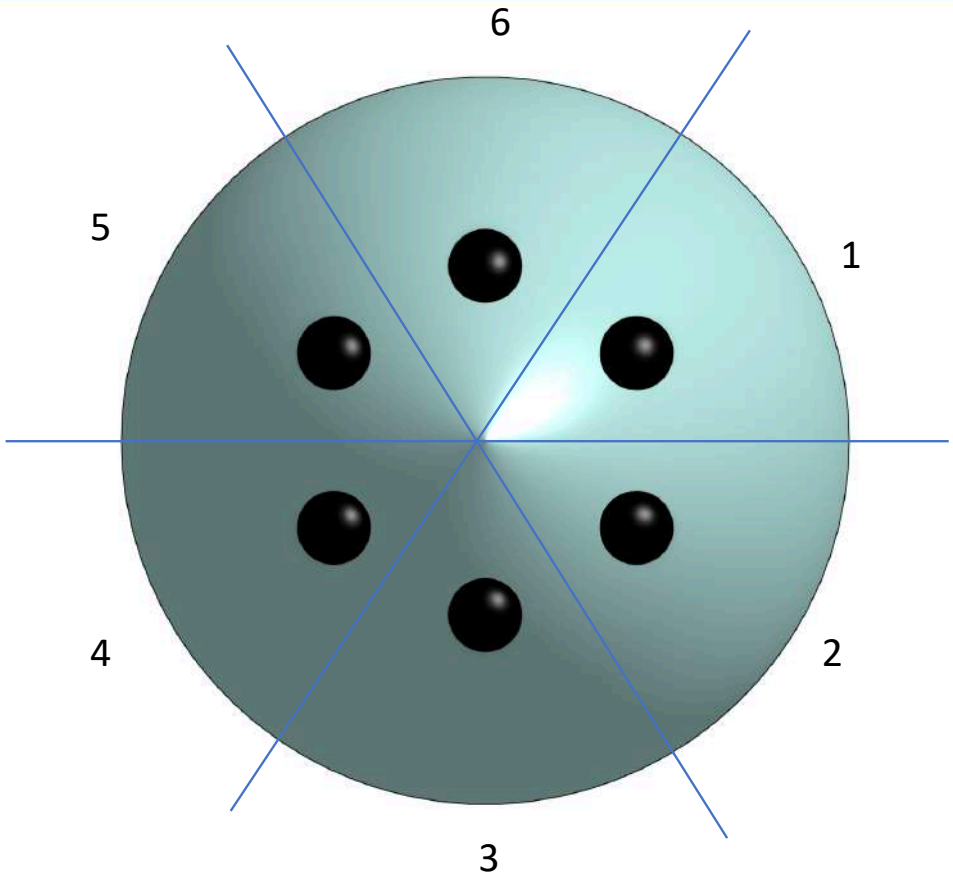
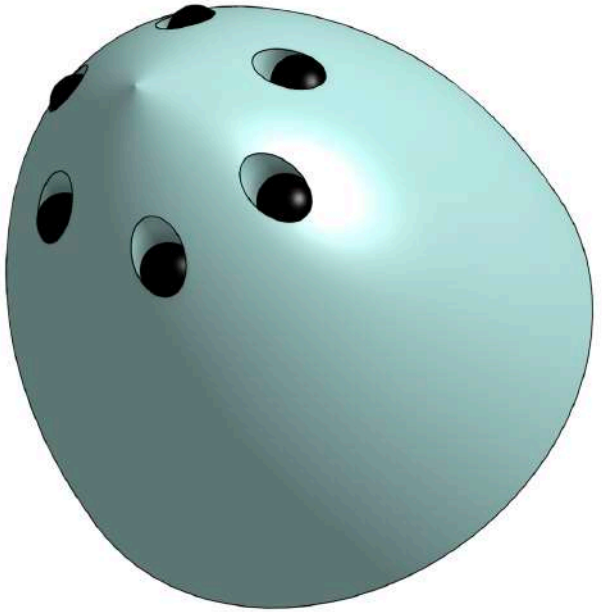
To create a reliable and precise MANPADS that can track and hit IR emitting source from a distance.

Tracking seeker head



Strapdown Array Seeker



Infrared	700 nm – 1 mm	300 GHz – 430 THz

Proportional Navigation

Proportional navigation (PN) is a guidance law widely used in missiles, particularly air-to-air, to steer them toward their target.

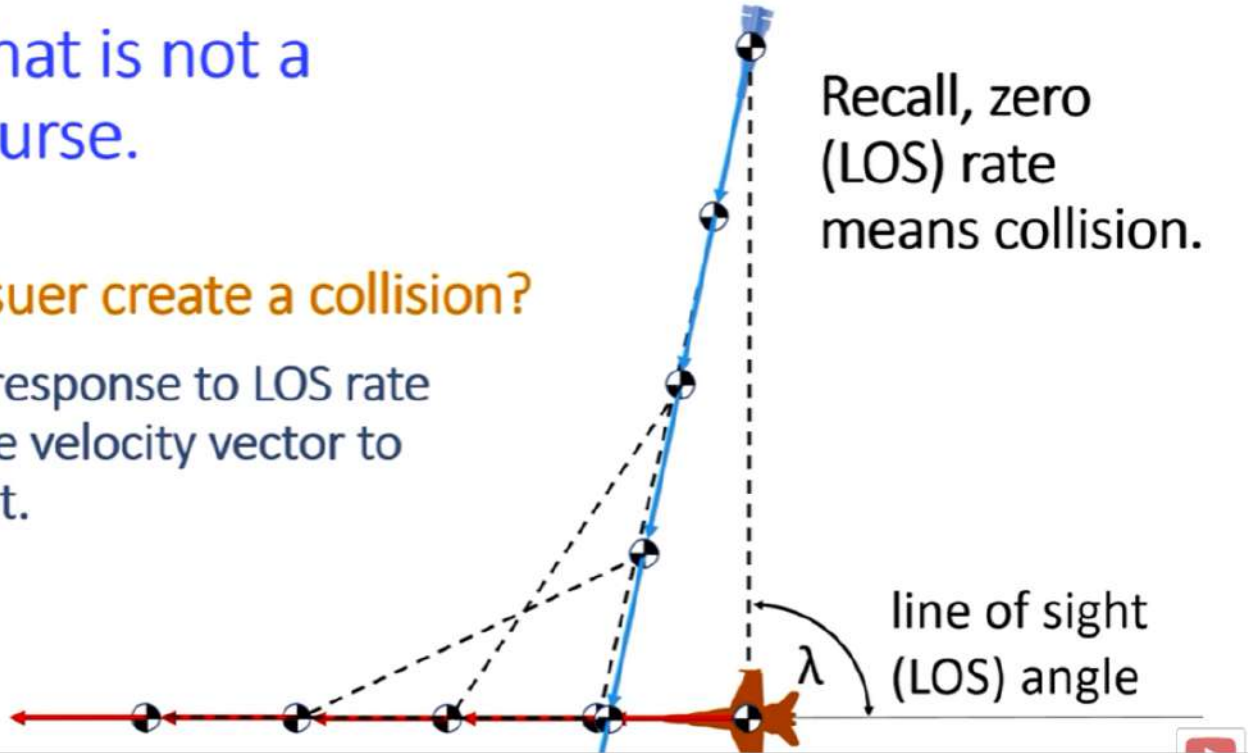
For Example:
Imagine a skilled archer aiming for a bullseye – PN works similarly, constantly adjusting the missile's course based on the target's movement, just like the archer fine-tunes their aim based on the wind or the target's distance.

Navigation

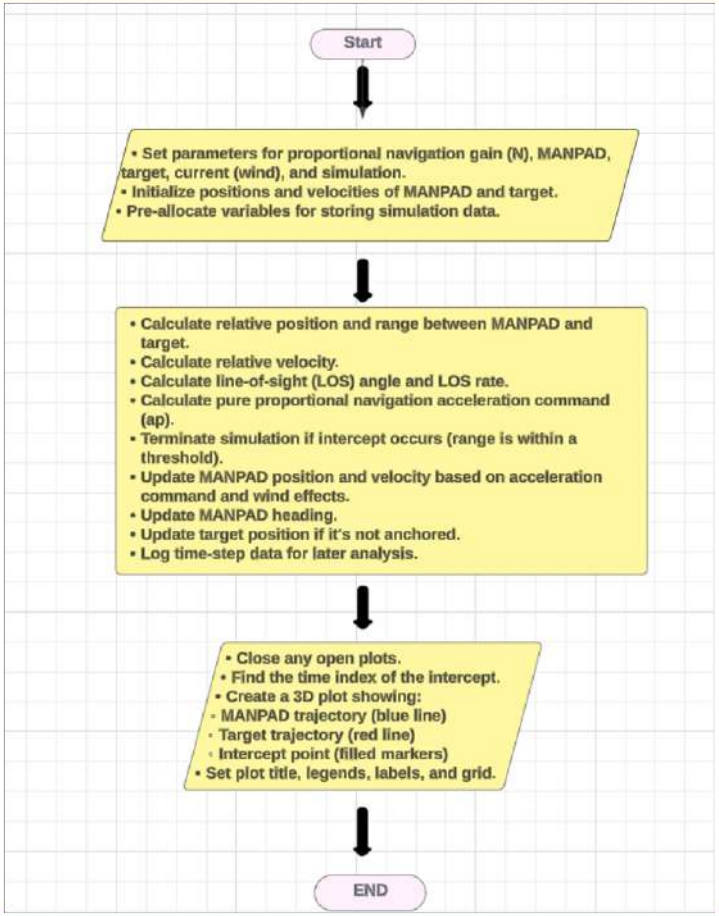
Observe what is not a collision course.

How can pursuer create a collision?

Maneuver in response to LOS rate by rotating the velocity vector to lead the target.



Navigation


Start
• Set parameters for proportional navigation gain (N), MANPAD, target, current (wind), and simulation.
• Initialize positions and velocities of MANPAD and target.
• Pre-allocate variables for storing simulation data.
• Calculate relative position and range between MANPAD and target.
• Calculate relative velocity.
• Calculate line-of-sight (LOS) angle and LOS rate.
• Calculate pure proportional navigation acceleration command (ap).
• Terminate simulation if intercept occurs (range is within a threshold).
• Update MANPAD position and velocity based on acceleration command and wind effects.
• Update MANPAD heading.
• Update target position if it's not anchored.
• Log time-step data for later analysis.
• Close any open plots.
• Find the time index of the intercept.
• Create a 3D plot showing:
- MANPAD trajectory (blue line)
- Target trajectory (red line)
- Intercept point (filled markers)
• Set plot title, legends, labels, and grid.
END

Navigation

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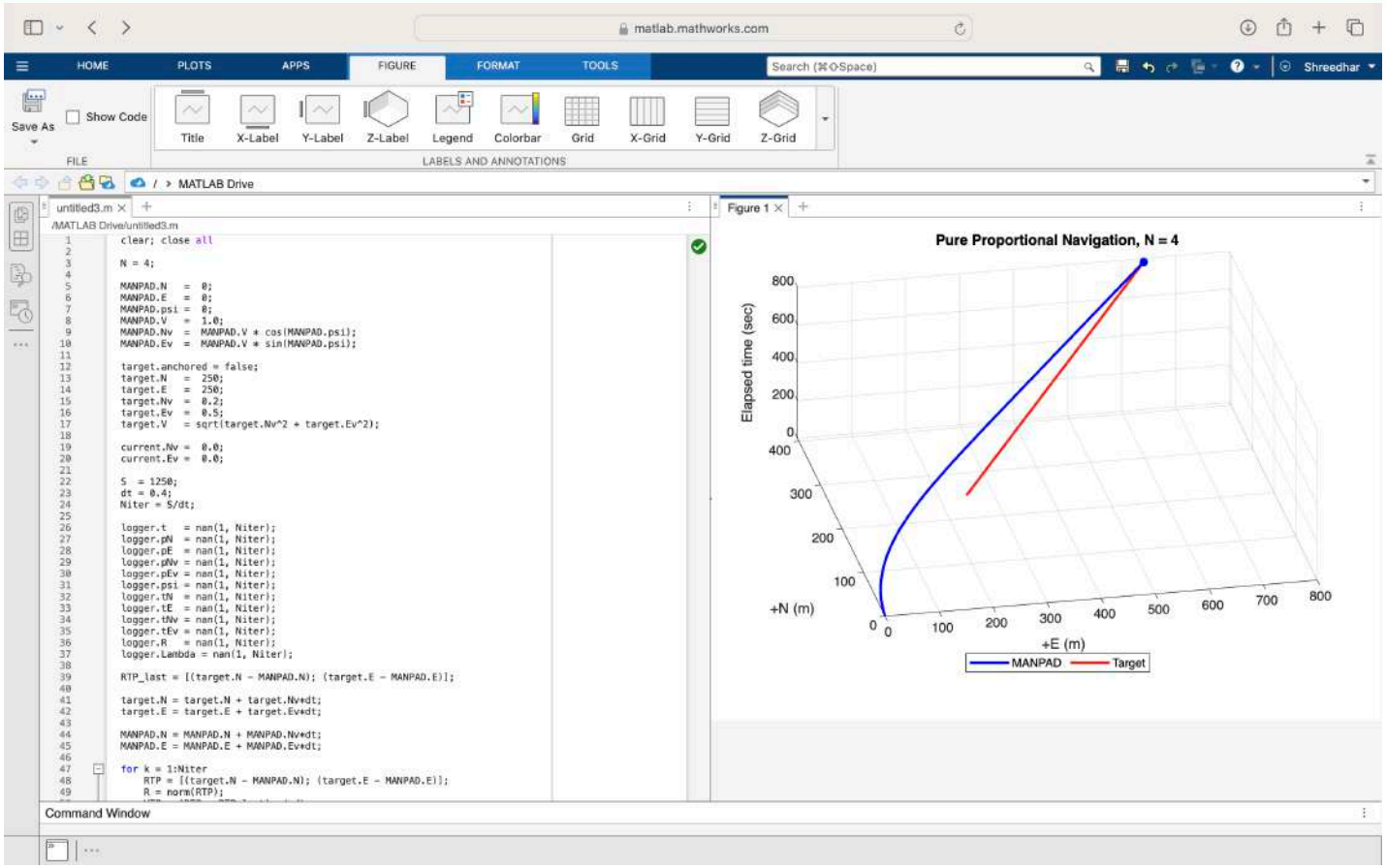
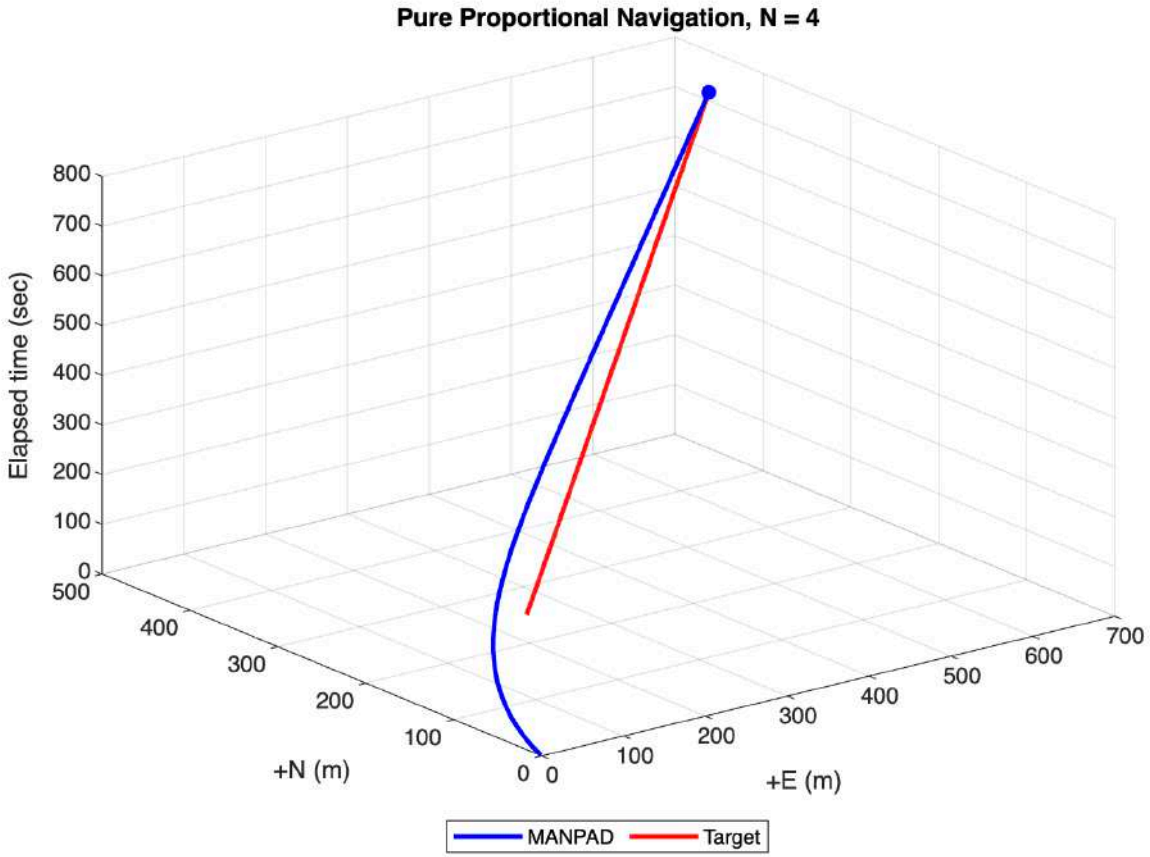
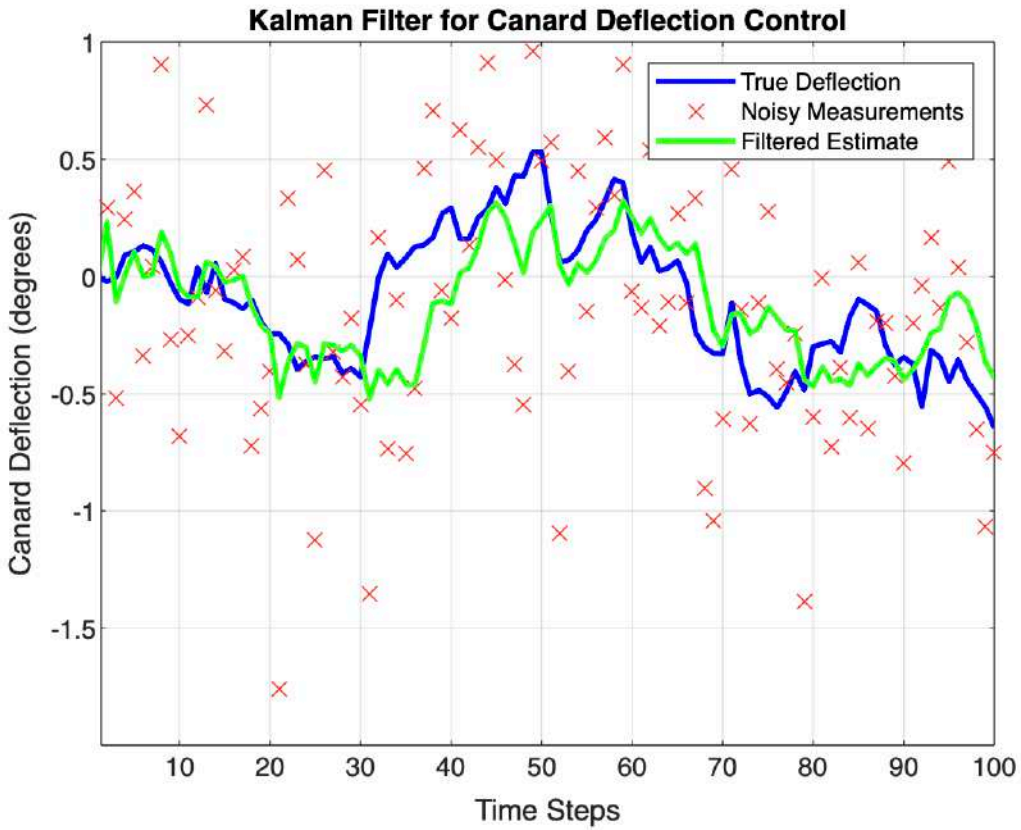


Navigation


Pure Proportional Navigation, N = 4
Elapsed time (sec)
800
700
600
500
400
300
200
100
0
500
400
300
200
100
0
+N (m)
0
100
200
300
400
500
600
700
+E (m)
MANPAD
Target

Kalman Filter



Parameters of rocket motor

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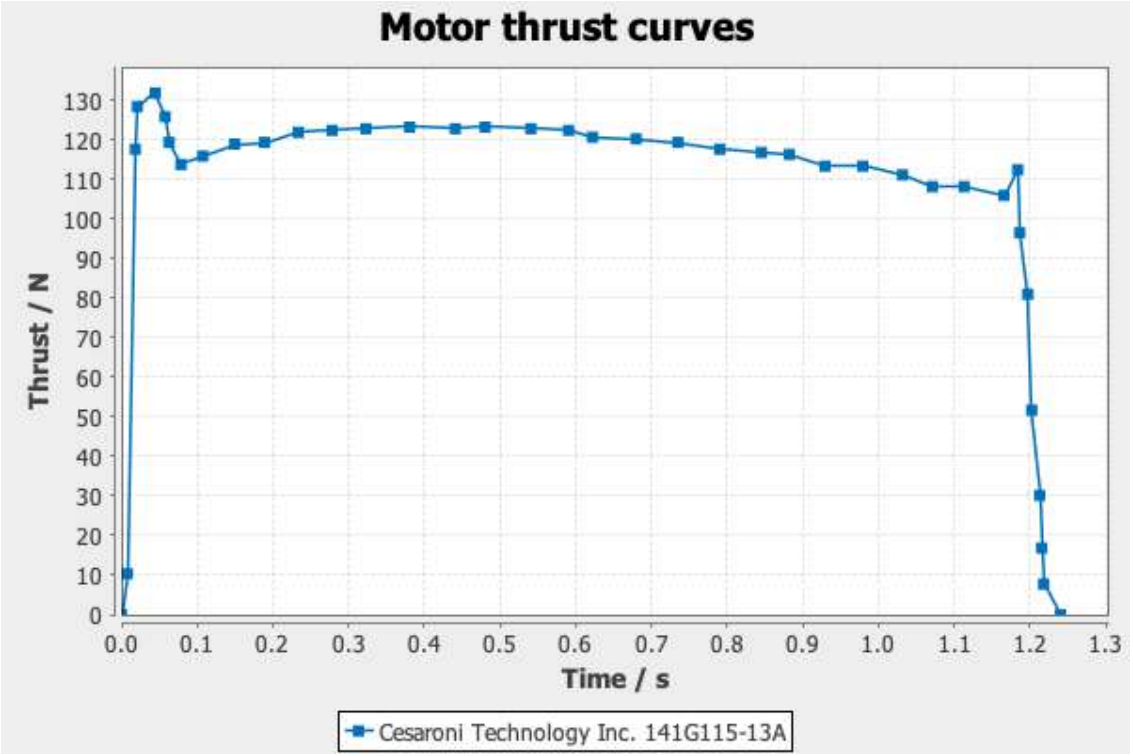
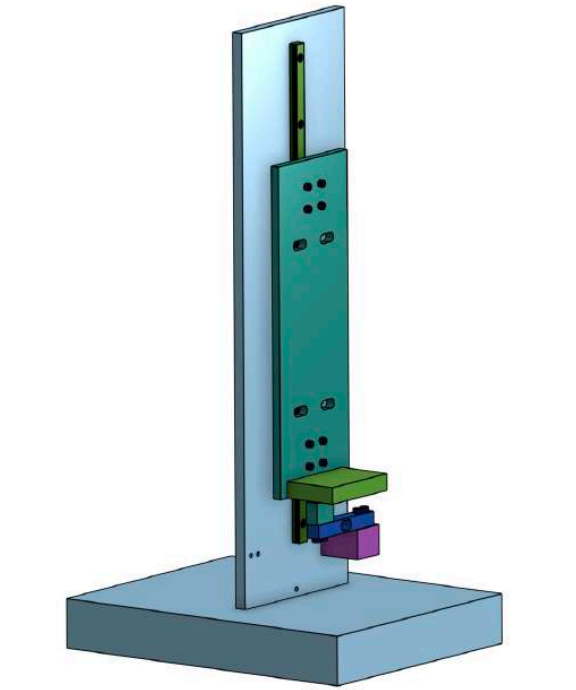
Manufacturer: Cesaroni Tech
Designation: 141G115-13A
Common name: G115
Total impulse: 141 Ns (76% G)
Avg. thrust: 116 N
Max. thrust: 132 N
Burn time: 1.22 s
Launch mass: 195 g
Empty mass: 133 g
Motor type: Reloadable
Case info: Pro38-1G



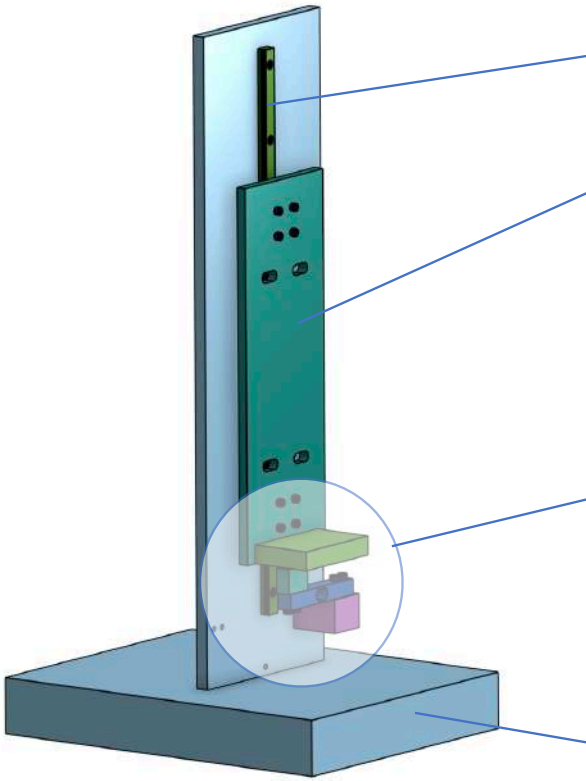
Rocket motor test rig

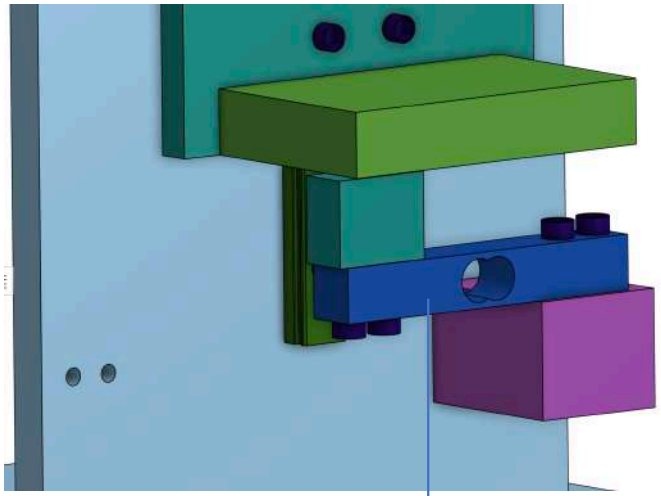


Digital twin

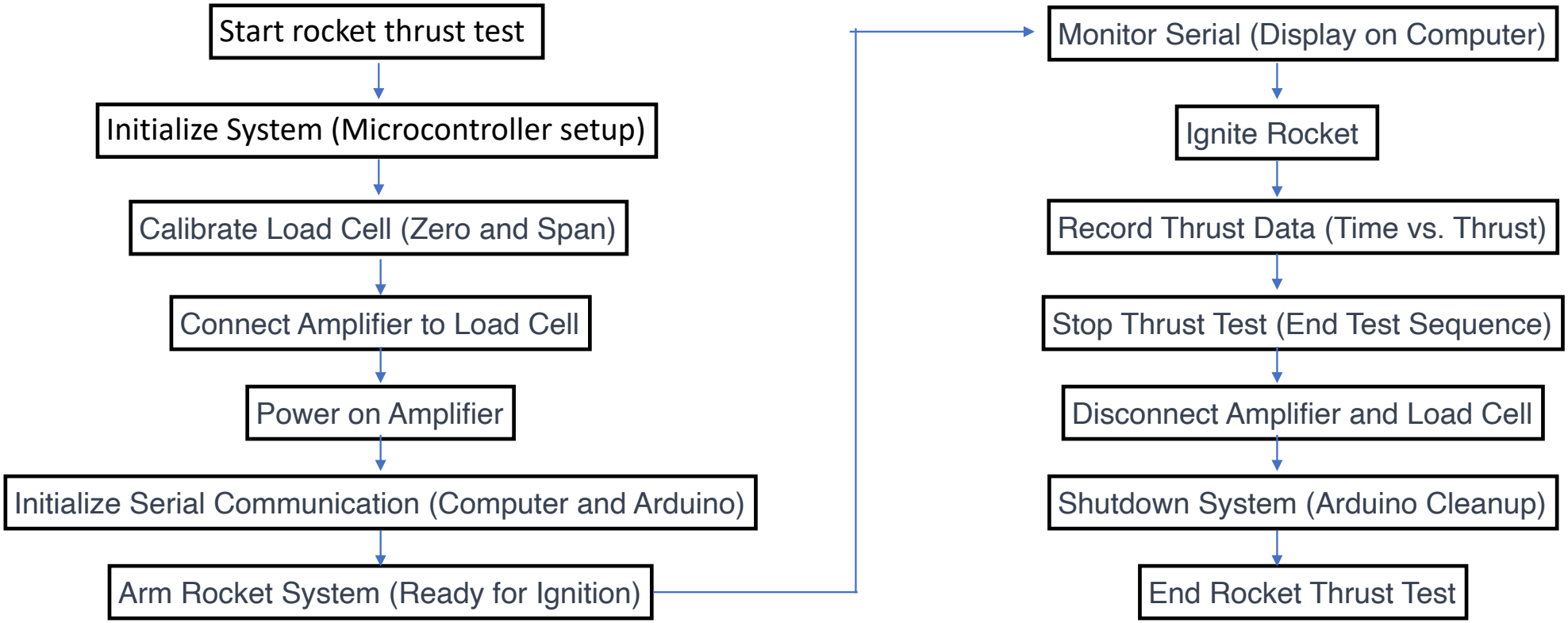
Real life

Rocket motor test rig

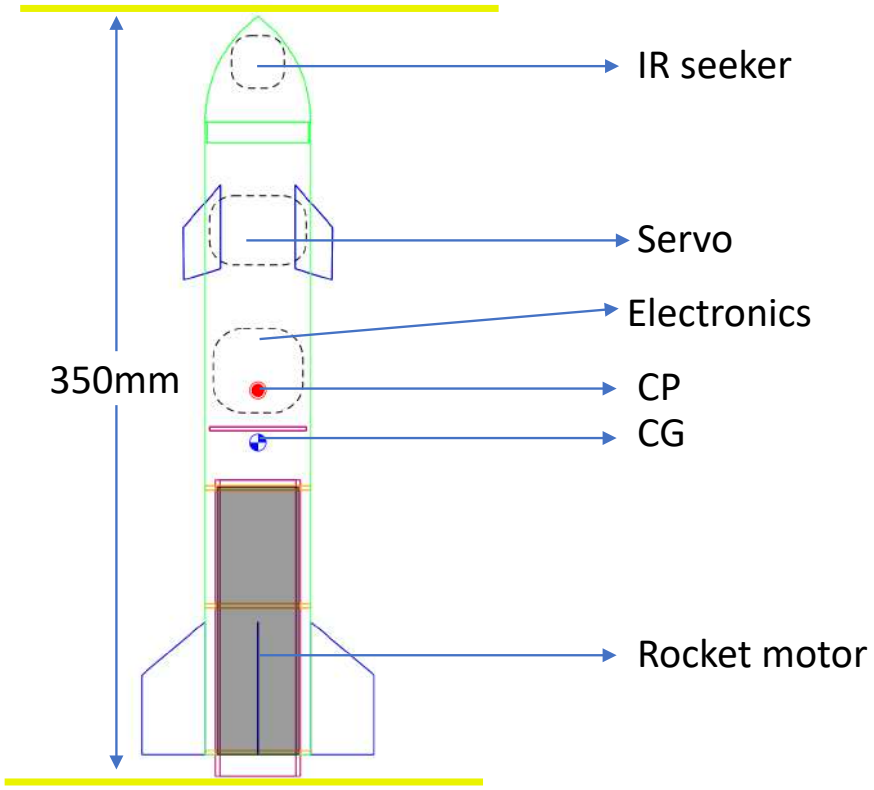


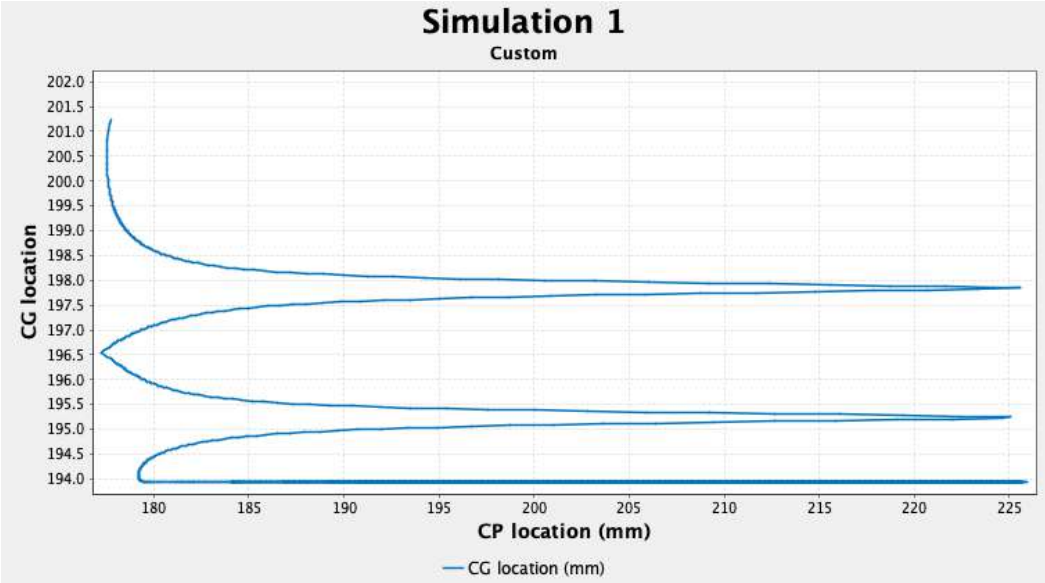



Load cell
Amplifier


Start rocket thrust test
Initialize System (Microcontroller setup)
Calibrate Load Cell (Zero and Span)
Connect Amplifier to Load Cell
Power on Amplifier
Initialize Serial Communication (Computer and Arduino)
Arm Rocket System (Ready for Ignition)
Monitor Serial (Display on Computer)
Ignite Rocket
Record Thrust Data (Time vs. Thrust)
Stop Thrust Test (End Test Sequence)
Disconnect Amplifier and Load Cell
Shutdown System (Arduino Cleanup)
End Rocket Thrust Test

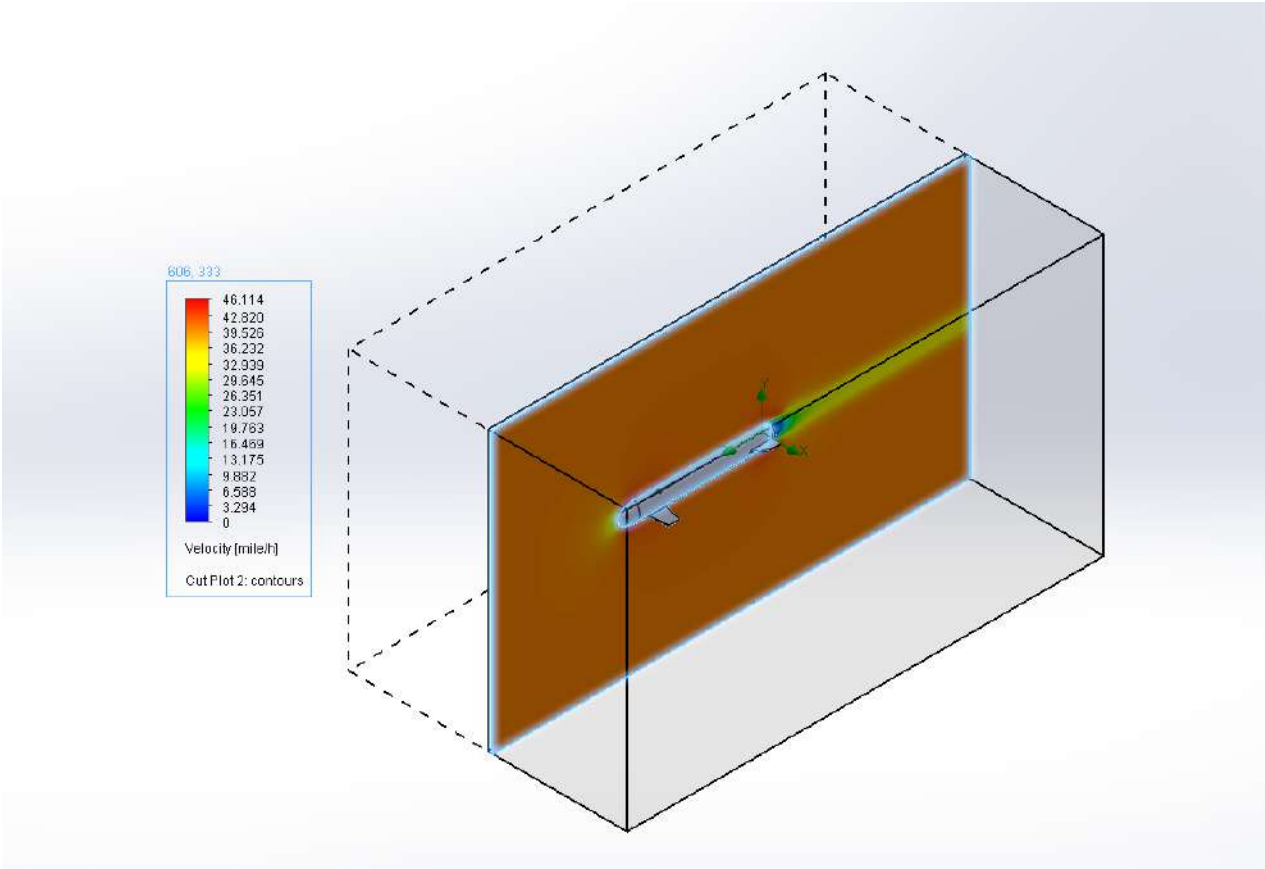
Stability



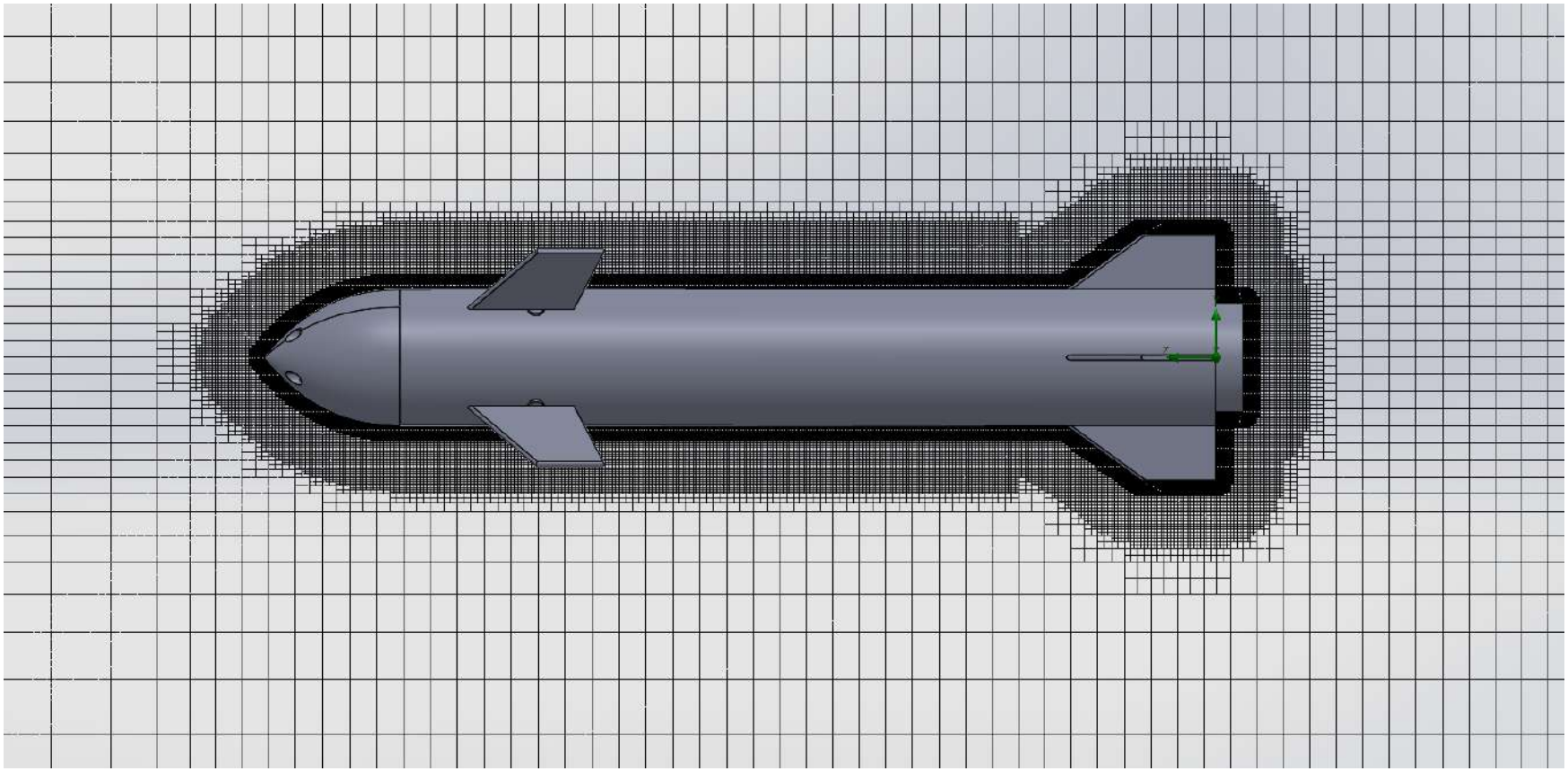


Unstable = Better maneuverability

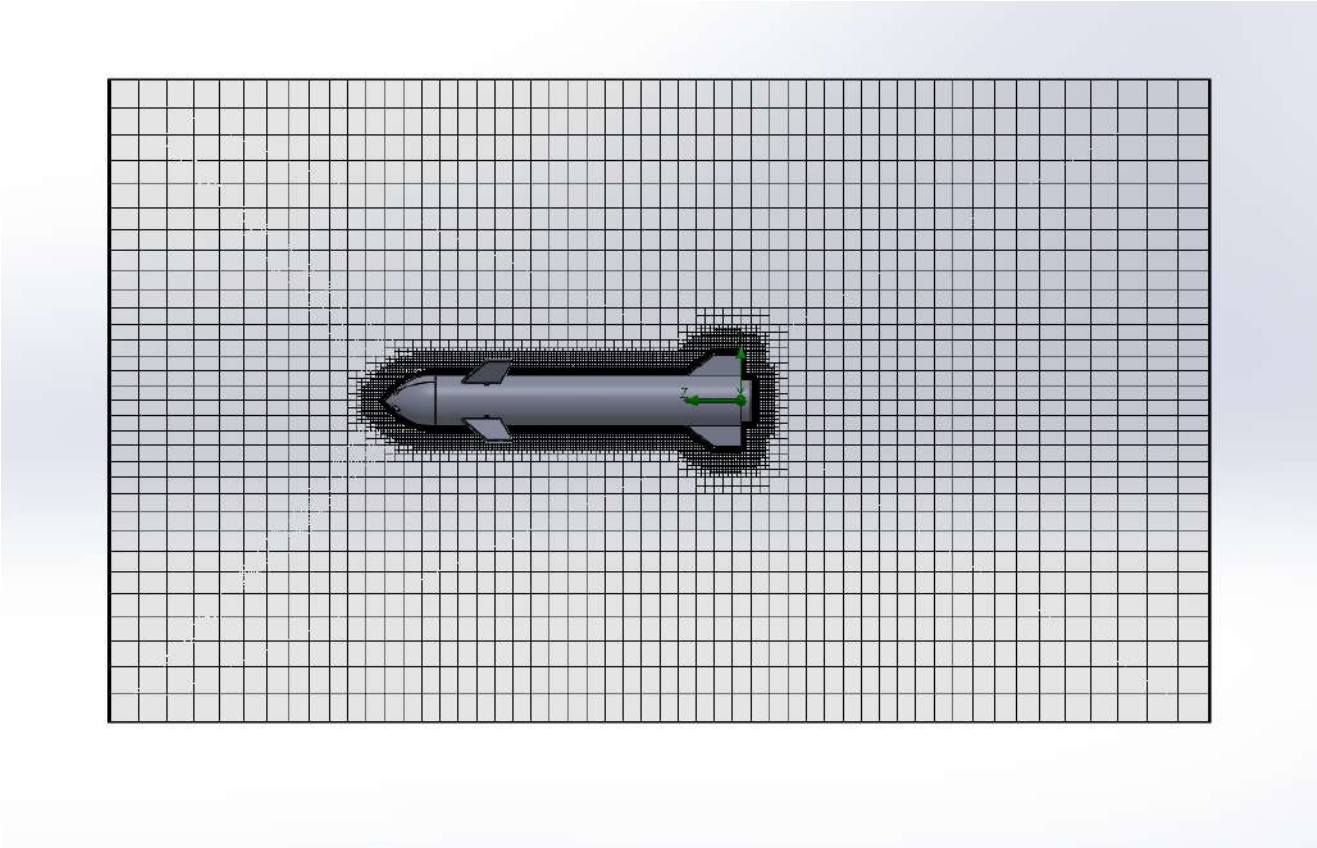
CFD simulation



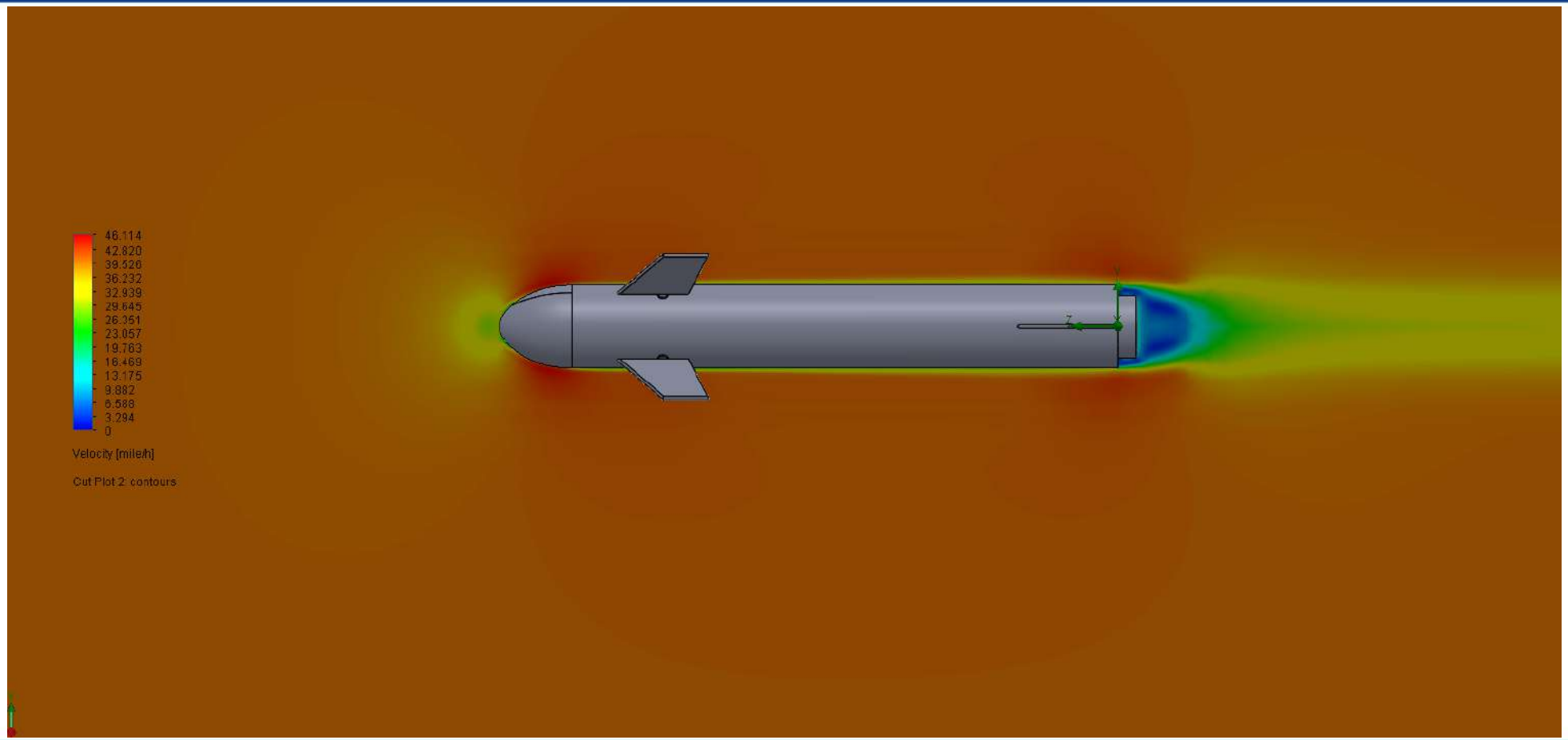
CFD simulation



CFD simulation



CFD simulation



Cd Calculation

$$c_d = \frac{2F_d}{\rho u^2 A}$$

c_d = drag coefficient

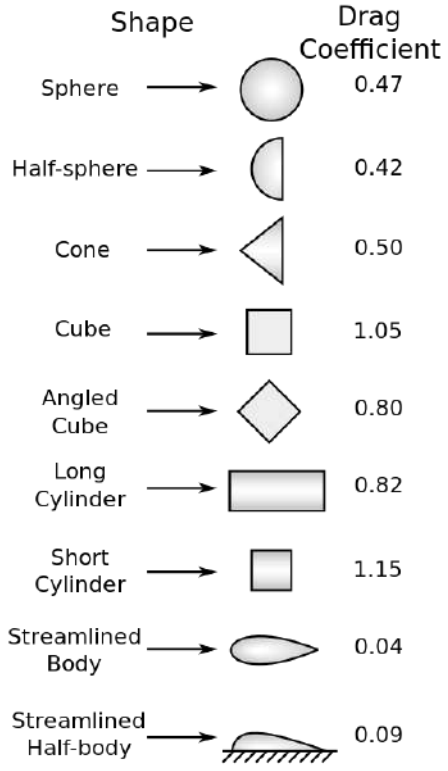
F_d = drag force

ρ = mass density of the fluid

u = flow speed of the object relative to the fluid

A = reference area

Density	1.293 kg/m^3
Velocity	17.8816 m/s
Area	0.00196349 m^2
Drag force (Taken from CFD simulation)	0.0787335223 N
Cd (Answer)	**0.19398**



Measured Drag Coefficients

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DEPARTMENT OF AERONAUTICAL ENGINEERING

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