

Flight Data Analysis Process

IREC Aerosciences & IREC Controls

Previous Revisions:

No previous official versions

University of Florida
Swamp Launch Rocket Team
Revision 1
June 2, 2026

Expected Results

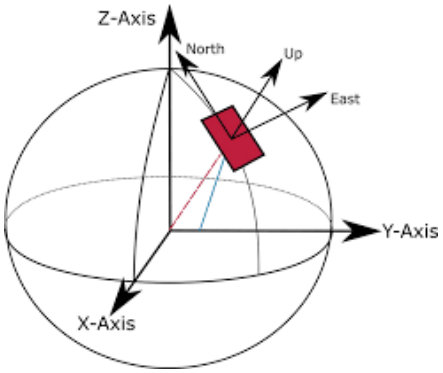
Purpose: This document walks you through how to turn the IMU data and other flight data from a rocket launch into C_d, AOA, Sideslip, and other information.

Necessary Inputs:

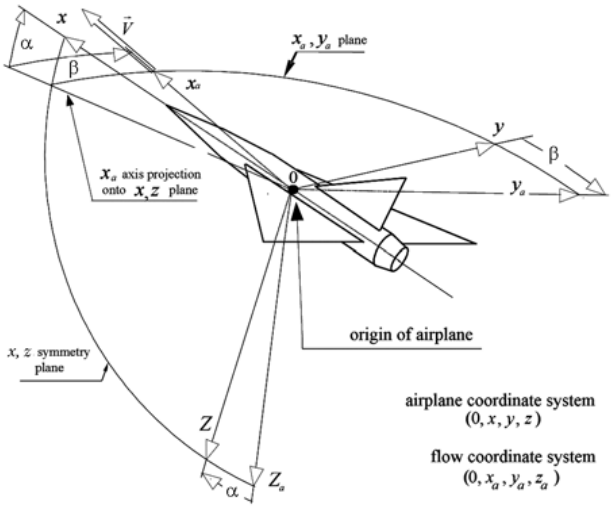
From IMU/Sensors: $t_i, {}^{I}a_{x,i}, {}^{I}a_{y,i}, {}^{I}a_{z,i}, P_{s,i}, T_i, \phi_i, \psi_i, \theta_i$ where $i = 1, \dots N$ data points in a csv:

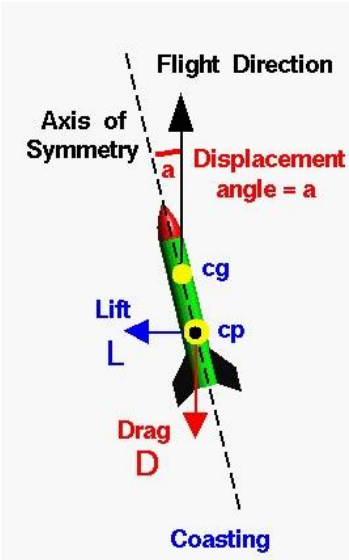
time	roll	pitch	yaw	ax	ay	az	pressure	temperature
1132.395	-1.51	1.51	-0.22	-7.117396	4.563705	68.002782	101881.4697	317.250174
1132.399	-1.51	1.51	-0.22	-7.117396	4.563705	68.002782	101881.4697	317.250174
1132.402	-1.51	1.51	-0.22	-7.117396	4.563705	68.002782	101881.4697	317.250174
1132.406	-1.6	1.51	-0.32	-6.27518	-1.903259	76.60239	101889.7827	317.250342

The ^{I} (Inertial) frame is assumed to be the ENU frame show below:



The ^{B} (Body) frame and angles are assumed to be defined as shown below. It is nice to know how IMU was orientated when installed otherwise it is painful to find out:





From the rocket you need $m \epsilon \mathbb{R}_1$ (dry mass after burnout) and A (reference area of rocket $A = \pi OD^2$)

How the Script Works

Key Assumptions

Velocity of rocket starts at 0

Air is Ideal Gas

Rectangular Integration is accurate enough

Wind is negligible

Only drag and lift forces acting on the rocket

Calculations done after burnout

What data do we get from IMU/Sensors/Rocket:

From IMU/Sensors: $t_i, {}^I a_{x,i}, {}^I a_{y,i}, {}^I a_{z,i}, P_{s,i}, T_i, \phi_i, \psi_i, \theta_i$ where $i = 1, \dots N$ data points

From Rocket: $m \epsilon \mathbb{R}_1$ (dry mass) and A (reference area of rocket)

Air Properties (Assume Ideal):

Ratio of specific heats: $\gamma = 1.4$ (assumed constant)

Specific gas constant: $R = 287.052874 \frac{J}{kg \cdot K}$ (assumed constant)

Speed of sound: $a_i = \sqrt{\gamma R T_i}$ where $\vec{a} \epsilon \mathbb{R}_N$

Density: $\rho_i = \frac{P_{s,i}}{R \cdot T_i}$ where $\vec{\rho} \epsilon \mathbb{R}_N$

Define acceleration:

${}^I \vec{a}_i = < {}^I \vec{a}_{z,i}, {}^I \vec{a}_{y,i}, {}^I \vec{a}_{z,i} >$

Do all in for loop with $i = 1, \dots, N - 1$

Perform Rectangular Integration on Velocity:

Rectangular integration:

$dt_i = t_{i+1} - t_i$ where $\overrightarrow{dt} \epsilon \mathbb{R}_{N-1}$ (no last point)

${}^I \vec{V}_{i+1} = {}^I \vec{V}_i + {}^I \vec{a}_i \cdot dt_i$ where ${}^I \vec{V}_1 = \vec{0}$ and ${}^I \vec{V} \epsilon \mathbb{R}_{Nx3}$

$V_i = norm({}^I \vec{V}_i)$ where $\vec{V} \epsilon \mathbb{R}_{N-1}$

$M_i = \frac{V_i}{a_i}$ where a is the speed of sound and $M \epsilon \mathbb{R}_{N-1}$

Find Drag Force on Rocket:

${}^{I}\hat{V}_i = \frac{{}^{I}\vec{V}_i}{V_i}$ where ${}^{I}\hat{V} \epsilon \mathbb{R}_{(N-1)x3}$ (skip operation when $V_i = 0$)

${}^{I}\hat{V}_i$ is the direction the rocket is traveling in ENU frame so the wind is traveling opposite the rocket direction:

${}^{I}\hat{V}_{wind,i} = -{}^{I}\hat{V}_i$

Project the accelerations of the rocket (only drag and lift) into wind direction which is drag definition:

$a_{drag,i} = {}^{I}\hat{V}_{wind,i} \cdot {}^{I}\vec{a}_i$ where $a_{drag} \epsilon \mathbb{R}_{(N-1)x1}$

*Filter out gravity in this step by adding $+[0,0,g]$ to ${}^{I}\vec{a}_i$.

Force comes from acceleration using Newton's 2nd law:

$$D_i = a_{drag,i} \cdot m \text{ where } \vec{D} \epsilon \mathbb{R}_{N-1}$$

$$Cd_i = \frac{2 \cdot D_i}{\rho_i \cdot {V_i}^2 \cdot A} \text{ where } \overrightarrow{Cd} \epsilon \mathbb{R}_{N-1}$$

Converting to Body Frame:

Roll (ϕ) Pitch (θ) Yaw (ψ) happens through a 3-2-1 Euler rotation meaning:

$$\bar{\bar{C}}_{B/I,i} = \bar{\bar{C}}_1(\phi_i) \cdot \bar{\bar{C}}_2(\theta_i) \cdot \bar{\bar{C}}_3(\psi_i) \text{ where } {}^{B}\vec{V}_i = \bar{\bar{C}}_{B/I,i} {}^{I}\vec{V}_i \text{ where } {}^{B}\vec{V} \epsilon \mathbb{R}_{Nx3}$$

$${}^{B}\vec{V}_i = < u_i, v_i, w_i >$$

Where:

$$\bar{\bar{C}}_3(\psi) = \begin{bmatrix} \cos(\psi) & \sin(\psi) & 0 \\ -\sin(\psi) & \cos(\psi) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

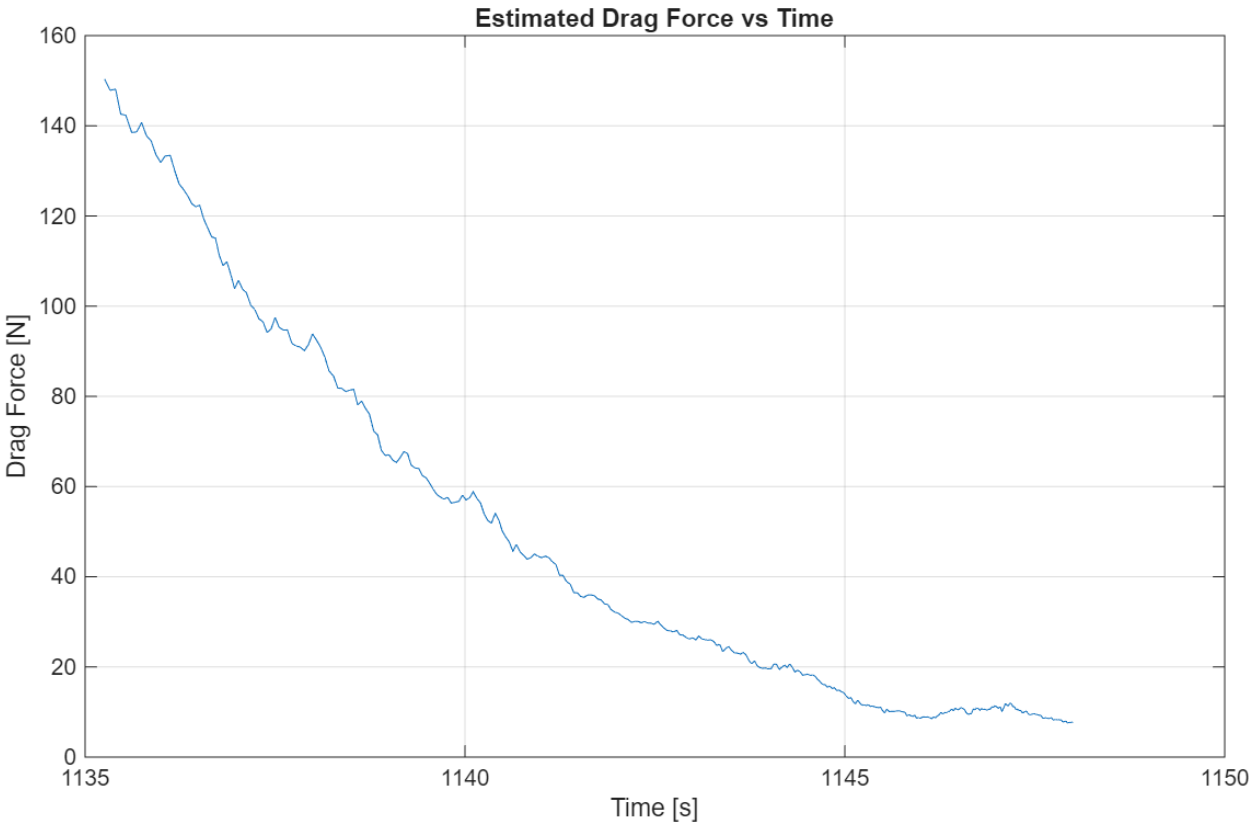
$$\bar{\bar{C}}_2(\theta) = \begin{bmatrix} \cos(\theta) & 0 & -\sin(\theta) \\ 0 & 1 & 0 \\ \sin(\theta) & 0 & \cos(\theta) \end{bmatrix}$$

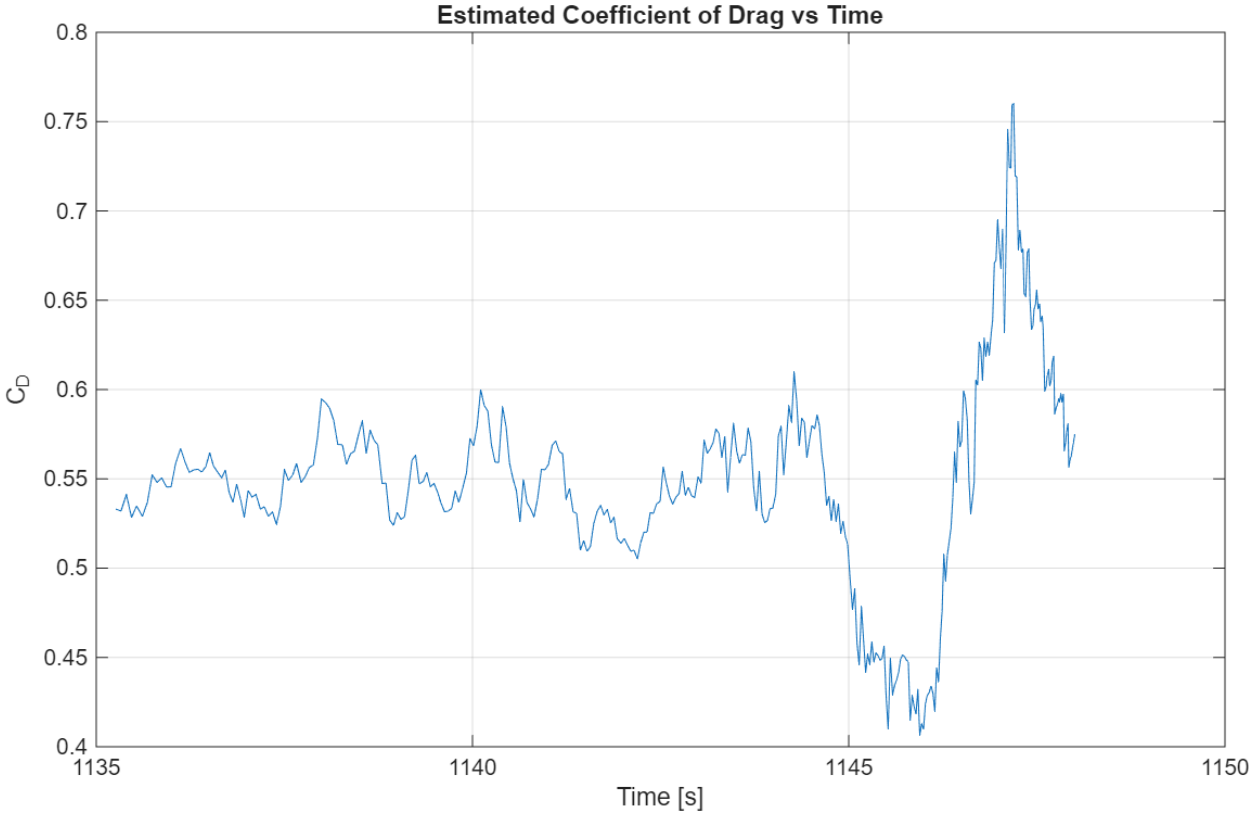
$$\bar{\bar{C}}_1(\phi) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\phi) & \sin(\phi) \\ 0 & -\sin(\phi) & \cos(\phi) \end{bmatrix}$$

Calculating Angles:

All defined for $\mathbb{R}_{N-1}$

Angle of Attack: $\alpha_i = atan2(w_i, u_i)$


Estimated Drag Force vs Time
Drag Force [N]
Time [s]
0
20
40
60
80
100
120
140
160
1135
1140
1145
1150


Estimated Coefficient of Drag vs Time
C_D
Time [s]
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
1135
1140
1145
1150