

2025-2026

Floating Gateway

The Prototyping and Iterative Optimization of a Balloon Assisted
Sounding Rocket

LOGBOOK

Sylvan Zheng

Entry Format

Week Of Date

Task	Category	Status
1. <i>Main Task</i>	Research ▾	Ongoing ▾
↳ 1a. <i>Subtask</i>	Research ▾	Completed ▾

Date

Task	Progress
1.	Notes For Tomorrow:
	Ongoing ▾
1a.	
	Completed ▾

Other Notes:

Date - Date *Important notes on days without logbook entries, like presentations or absences*

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Week Of September 08

Task	Category	Status
1. Whole-project background research	Research ▾	Ongoing ▾
↳ 1a. Existing solutions	Research ▾	Ongoing ▾
↳ 1b. Formal research on feasibility	Research ▾	Not Started ▾
2. Organize bill of materials spreadsheet and other files.	Other ▾	Completed ▾
3. Begin planning transition shape experiments	Airframe ▾	Not Started ▾
4. Start trifold slides, so that background research can be incorporated	Presentation ▾	Not Started ▾
5. Reply to John Graf's email	Other ▾	Completed ▾

September 11

Task	Progress
2.	Organized logbook structure today. I did some work before then, mostly messing around with OpenRocket and FreeCAD to test the feasibility of this idea, but logbook starts today. Notes For Tomorrow: Begin work on Bill of Materials
Ongoing ▾	

Other Notes:

Up to this point, I've been messing around with the software that I might use in this project. However, a lot of this work will likely be revamped or replaced. The folder structure is currently local, uploaded to the cloud via Google Drive desktop, and uses Git as a VCS.

September 12

Task	Progress
2.	Bill of materials created, will likely remain unused for a while. Also reorganized git to only track within rocket design folders.
Completed ▾	
1a.	Created a MyBib folder to store sources.
Ongoing ▾	

Other Notes:

I spent most of my time today cleaning up my likely >1000 Chrome tabs and 8 windows, which should streamline the research process.

September 13

Task	Progress
5.	Today, I got an email from NASA engineer John Graf , asking for contributions from USS 2025 alumni on a NIAC proposal. I replied, offering a future launch aboard my launch platform for testing his COG system.
Ongoing ▾	

Week Of September 22

Task	Category	Status
1. Whole-project background research	Research ▾	Ongoing ▾
↳ 1a. Market Research	Research ▾	Completed ▾
↳ 1b. Existing solutions	Research ▾	Ongoing ▾
↳ 1c. Formal research on feasibility	Research ▾	Not Started ▾
2. Begin planning transition shape experiments	Airframe ▾	Not Started ▾
3. Start trifold slides, so that background research can be incorporated	Presentation ▾	Not Started ▾

September 22

Task	Progress
1a.	<p>Took notes on https://dataintelo.com/report/space-rocket-suborbital-launch-market. Rough notes for myself can be found at ☰ Research Notes . I'll probably continue using this document, and it won't look pretty.</p> <p>Notes For Tomorrow:</p> <ul style="list-style-type: none"> • Look for other sources
	Ongoing ▾

September 24

Task	Progress
1b.	<p>Started some research on existing solutions, starting with hobby model rockets. I also need to know the relationship apogee and initial velocity for rough delta-v estimations, which I'll derive below</p>

Find initial velocity v_0 in terms of apogee or max height h_a and gravity g

First, find height $h(t)$ given time t

Start by finding velocity $v(t)$ by integrating gravity over time

$$\begin{aligned}v(t) &= \int g \, dt \\ &= gt + v_0\end{aligned}$$

Integrate again to find $h(t)$

$$\begin{aligned}h(t) &= \int v(t) \, dt \\ &= \int gt + v_0 \, dt \\ &= \frac{g}{2}t^2 + v_0t\end{aligned}$$

By power law. No initial height is added since we are assuming the initial height to be 0

Now, find t when $v_0(t) = 0$, as this will be the apogee

$$\begin{aligned}v_0(t) &= 0 \\ gt + v_0 &= 0 \\ gt &= -v_0 \\ t &= -\frac{v_0}{g}\end{aligned}$$

Plug this value of t into $h(t)$ to find h_a

$$\begin{aligned}h_a &= h\left(-\frac{v_0}{g}\right) \\ &= \frac{g}{2}\left(-\frac{v_0}{g}\right)^2 + v_0 \cdot -\frac{v_0}{g}\end{aligned}$$

	$= \frac{gv_0^2}{2g^2} - \frac{v_0^2}{g}$ $= \frac{v_0^2}{2g} - \frac{v_0^2}{g}$ $= \frac{v_0^2}{2g} - \frac{2v_0^2}{2g}$ $= -\frac{v_0^2}{2g}$ <p>Invert to isolate v_0</p> $h_a = -\frac{v_0^2}{2g}$ $v_0^2 = -2gh_a$ $v_0 = \sqrt{-2gh_a}$ <p style="text-align: center;">Graphics Created Using https://latex2image.joeraut.com/</p> <p>Using this formula, we can estimate the delta-v of the Estes Mayhem rocket to be around 110 m/s. Again, research is recorded in Research Notes, under the "Existing Solutions" section</p>
Ongoing ▾	

September 25

Task	Progress
1b.	Did research on meteorological and zero pressure research balloons in Research Notes . Super pressure balloons weren't included because there isn't much info on them, but I might look again.
Ongoing ▾	

September 27

Task	Progress
1b.	Added data on USCRPL's Aftershock II (Amateur built hobby rocket record), Black Brant I, and Black Brant XII. Also started on New Shepard Notes For Tomorrow: <ul style="list-style-type: none">• Add spinlaunch and virgin galactic, maybe orbital systems
Ongoing ▾	

Week Of September 29

Task	Category	Status
1. Whole-project background research	Research ▾	Ongoing ▾
↳ 1a. Existing solutions	Research ▾	Completed ▾
↳ 1b. Formal research on feasibility	Research ▾	Ongoing ▾
2. Begin planning transition shape experiments	Airframe ▾	Ongoing ▾

September 29

Task	Progress
1a.	<p>Added data on USCRPL's Aftershock II (Amateur built hobby rocket record), Black Brant I, and Black Brant XII. Also started on New Shepard</p> <p>Notes For Tomorrow:</p> <ul style="list-style-type: none"> • Add spinlaunch and virgin galactic, maybe orbital systems
Ongoing ▾	

September 30

Task	Progress
1a.	<p>Added data on New Shepard.</p> <p>Notes For Tomorrow:</p> <ul style="list-style-type: none"> • Add spinlaunch and virgin galactic, maybe orbital systems
Ongoing ▾	

October 01

Task	Progress
1a.	Added info on unconventional launch vehicles, without data. Will end background research for now
Completed ▾	

October 03

Task	Progress
2.	Wrote standardized lab report format. Subject to change
Ongoing ▾	

Week Of October 06

Task	Category	Status
1. Whole-project background research	Research ▾	Ongoing ▾
↳ 1a. Formal research on feasibility	Research ▾	Ongoing ▾
2. Begin planning transition shape experiments	Airframe ▾	Ongoing ▾

October 06

Task	Progress
1a.	Created and wrote a program for testing different launch heights, can be found in new folder
Ongoing ▾	

October 18 - October 25 *Competed in the International Olympiad on Astronomy and Astrophysics Junior (IOAA Jr.) In Romania. Many previous days were also dedicated to studying for the olympiad.*

Week Of October 27

Task	Category	Status
1. Whole-project background research	Research ▾	Ongoing ▾
↳ 1a. Formal research on feasibility	Research ▾	Ongoing ▾
2. Virtual proof of concept experiment	Research ▾	Ongoing ▾
↳ 2a. Aerodynamic properties of sample rocket	Research ▾	Completed ▾

October 27

Task	Progress
2.	Found formula for drag coefficient given inlet and outlet airspeeds and cross-sectional areas

Find drag force F_d given inlet and outlet airspeeds, air density, and wind tunnel cross-sectional area.

Start with equation

$$\Delta v = \frac{I}{m}$$

By definition

$$I = F \cdot t$$

And

$$m = K \cdot t$$

Where F is force, K is mass rate, and t is an unknown time. Plugging these in, we get

$$\Delta v = \frac{F \cdot t}{K \cdot t}$$

$$\Delta v = \frac{F}{K}$$

We also know that

$$K = \rho A_t v_{in}$$

Where ρ is density, A_t is the wind tunnel's cross-sectional area perpendicular to airflow, and v_{in} is the airspeed at the inlet. Plug this in and isolate F

$$\Delta v = \frac{F_d}{\rho A_t v_{in}}$$

$$F_d = \rho A_t v_{in} \Delta v$$

Aerodynamic drag forces can also be approximated from drag coefficient C_d and cross section A as

$$F_d = \frac{1}{2} \rho v_{in}^2 C_d A$$

Therefore,

	$\frac{1}{2}\rho v_{in}^2 C_d A = \rho A_t v_{in} \Delta v$ $\frac{1}{2}v_{in} C_d A = A_t \Delta v$ $C_d = \frac{2A_t \Delta v}{A v_{in}}$ <p>Δv is defined $v_{in} - v_{out}$ Plug that in</p> $C_d = \frac{2A_t(v_{in} - v_{out})}{A v_{in}}$
Ongoing ▾	

November 01

Task	Progress
2.	Figured out how to use a reporting function (to replace inlet-outlet measurements/approximations) , ran and debugged subsonic CFD simulation (v=100m/s). Still experiencing errors
Ongoing ▾	

November 02

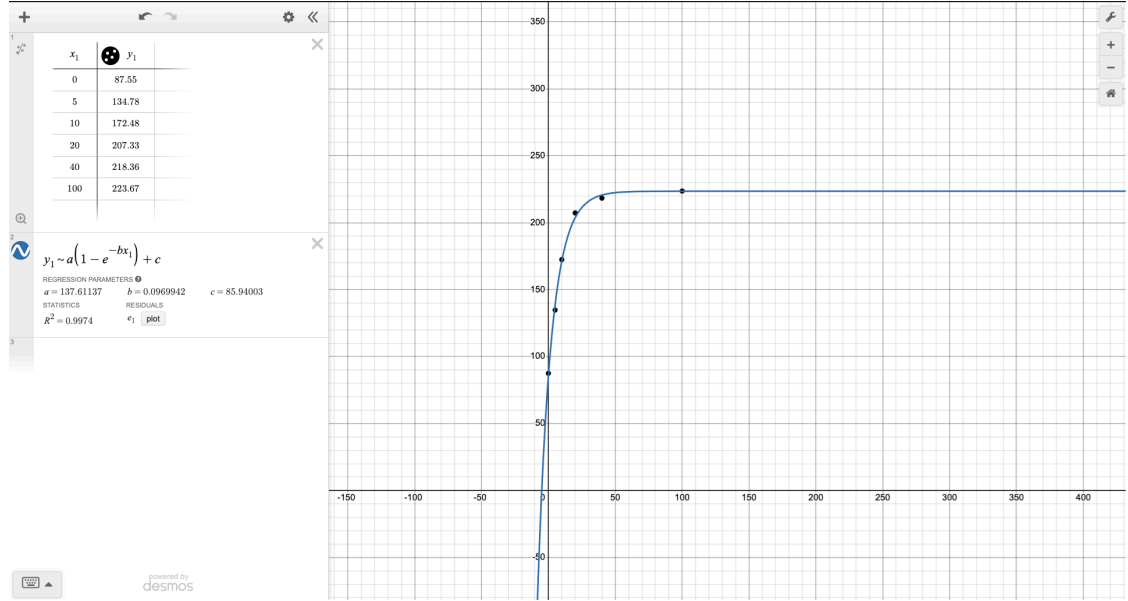
Task	Progress
2.	Fixed and ran subsonic CFD simulation. Also created and ran supersonic simulation (v=500m/s). Found following data $F_{d,sub} = 259.6382175102524N$ $F_{d,sup} = 7806.509181950465N\$$ Find C_ds tomorrow

Ongoing ▾

November 03

Task	Progress
2.	<p>Look for subsonic and supersonic drag coefficients $C_{d,sub}$ and $C_{d,sup}$ respectively</p> <p>Drag coefficient C_d is defined as</p> $F_d = \frac{1}{2} C_d A \rho v^2$ $C_d = \frac{2F_d}{A \rho v^2}$ <p>For both cases, the rocket's frontal area can be approximated to a circle with a radius of 17.5cm or 0.175m. Therefore</p> $A = \pi(0.175\text{m})^2$ $= 0.09621\text{m}^2$ <p>The simulations were also run at sea level and 20°, such that $\rho \approx 1.204\text{kg/m}^3$</p> <p>For the subsonic drag coefficient $C_{d,sub}$, plug in $F_{d,sub} = 259.6\text{N}$ and $v_{sub} = 100.0\text{m/s}$</p> $C_{d,sub} = \frac{2 \cdot 259.6\text{N}}{0.09621\text{m}^2 \cdot 1.204\text{kg/m}^3 (100.0\text{m/s})^2}$ $= 0.4482$ <p>Similarly, we can plug in $F_{d,sup} = 7807\text{N}$ and $v_{sup} = 500.0\text{m/s}$ to find the supersonic drag coefficient $C_{d,sup}$ as</p> $C_{d,sup} = \frac{2 \cdot 7807\text{N}}{0.09621\text{m}^2 \cdot 1.204\text{kg/m}^3 (500.0\text{m/s})^2}$ $= 0.5392$ <p>I edited some flightIntegrator.py code to use these values. The program switches between the two C_ds based on mach number found by Laplace's formula.</p>
	<p>Completed ▾</p>

November 05

Task	Progress
2.	<p>Ran simulation and recorded data in <i>Graphs.xlsx</i>. Started on graphs in same document. Also created regression for max altitude above launch given initial altitude in Desmos.</p>  <p>https://www.desmos.com/calculator/ows7gpwhua</p> <p>Fit to formula $y = 137.611 (1 - e^{-0.0969942x}) + 85.9400$ with fit of $R^2 = 0.9974$</p> <p>This means that this rocket will approach an optimal maximum performance as the initial altitude approaches infinity. I might calculate that asymptote value</p>
	Ongoing ▾

Week Of November 10

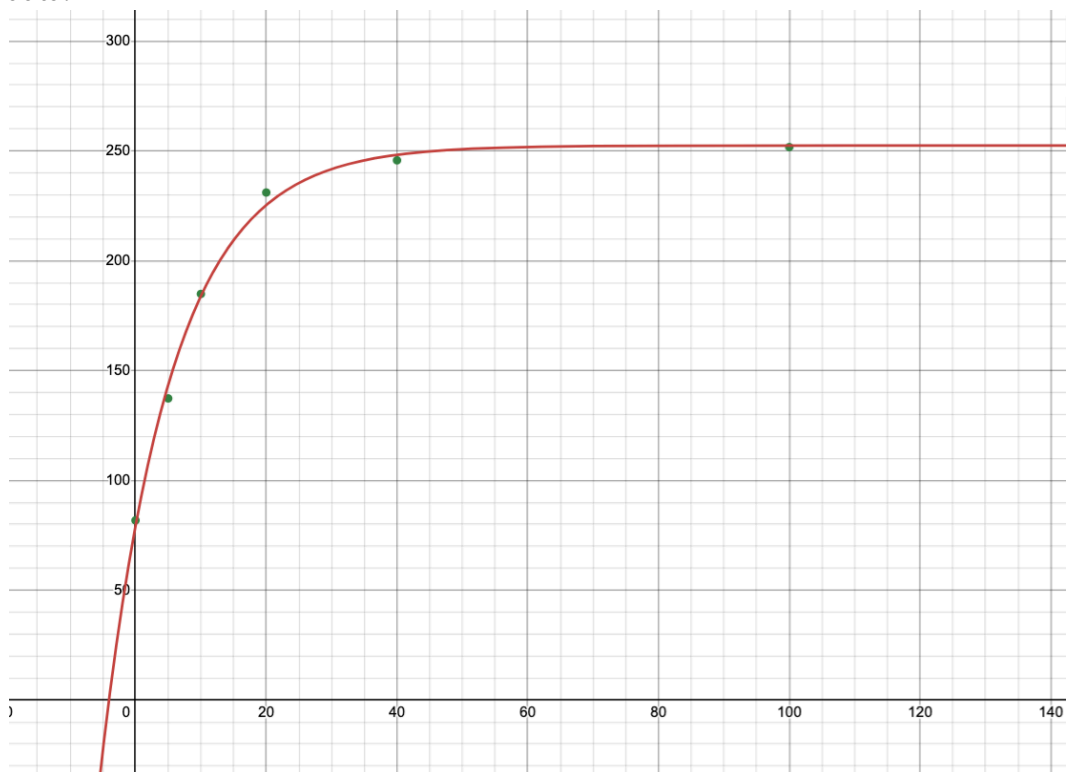
Task	Category	Status
1. Whole-project background research	Research ▾	Ongoing ▾
↳ 1a. Formal research on feasibility	Research ▾	Ongoing ▾

2. Virtual proof of concept experiment		Research ▾	Completed ▾
↳	2a. Aerodynamic properties of sample rocket	Research ▾	Completed ▾

November 10

Task	Progress
2.	Formatted graphs and added to lab report. Found new motor data http://www.astronautix.com/i/improvedorionengine.html , need to rerun experiment
Ongoing ▾	

November 11

Task	Progress
2.	Reran experiment with new motor data, and reregressed according to new simulation data.  https://www.desmos.com/calculator/yji0mbmj86

	Completed lab report, including analysis. Said lab report can be found at https://docs.google.com/document/d/1Di3WypIMcfS4e-kBo8DOEAJpvxJWnLytN6l9oPQq_HQ/edit?tab=t.0
Completed ▾	

November 13

Task	Progress
1a.	Quick Google Scholar query, Similar project (Thesis): https://www.researchgate.net/profile/Pankaj-Karna-2/publication/347134190_Designing_a_Rocket-Balloon_Hybrid_Launch_System_for_Affordable_Access_to_Suborbital_Space/links/5fd8418f92851c13fe892fd9/Designing-a-Rocket-Balloon-Hybrid-Launch-System-for-Affordable-Access-to-Suborbital-Space.pdf https://arc.aiaa.org/doi/abs/10.2514/8.6814?journalCode=jjp , try accessing using UC community card
Ongoing ▾	

Week Of December 01

Task	Category	Status
1. Start developing the communications subsystem	Electronics ▾	Ongoing ▾
↳ 1a. Determine an appropriate antenna type	Electronics ▾	Ongoing ▾

December 07

Task	Progress
1a.	Created a reference doc "Antenna Formulae Reference" of useful antenna formulae drawn from many sources, mostly fundamental physics.

	Back-of-the-envelope calculation of maximum range with two dipoles using https://www.waveshare.com/rp2040-lora.htm lora modules gives a range of 2000km, will recalculate more formally.
Ongoing ▾	

Week Of December 08

Task	Category	Status
1. Start developing the communications subsystem	Electronics ▾	Ongoing ▾
↳ 1a. Determine an appropriate antenna type	Electronics ▾	Ongoing ▾

December 10

Task	Progress
1a.	<p>Formal antenna calcs</p> <p>Isolate d given SNR ratio and antenna info</p> <p>Start with</p> $SNR = 10 \log_{10} \left(\frac{P_r}{P_{noise}} \right)$ <p>and</p> $P_r = \frac{P_t G_t A_{eff,r}}{4\pi d^2}$ <p>Plug in equations</p> $SNR = 10 \log_{10} \left(\frac{P_t G_t A_{eff,r}}{4\pi d^2 kTB} \right)$ <p>Isolate maximum range d</p> $\frac{SNR}{10} = \log_{10} \left(\frac{P_t G_t A_{eff,r}}{4\pi d^2 P_{noise}} \right)$ $10^{\frac{SNR}{10}} = \frac{P_t G_t A_{eff,r}}{4\pi d^2 P_{noise}}$

$$d^2 = \frac{P_t G_t A_{eff,r}}{4\pi P_{noise} 10^{\frac{SNR}{10}}}$$

$$d = \sqrt{\frac{P_t G_t A_{eff,r}}{4\pi P_{noise} 10^{\frac{SNR}{10}}}}$$

Plug in data for RP2040LoRa with antenna 2DB 850~930MHz antenna

From datasheets, assuming exact values

$$P_t[dBm] = 22dBm$$

$$G_t = G_r = 2dB$$

$$\lambda = \frac{c}{930mhz} = 32.23 \dots cm$$

Assume room temperature (20°C), so

$$T = 20^\circ C = 293.15^\circ K$$

Convert P_t to watts

$$\begin{aligned} P_t[W] &= \frac{10^{\frac{P_t[dBm]}{10}}}{1000} \\ &= \frac{10^{\frac{22}{10}}}{1000} \\ &= 0.16 \dots W \end{aligned}$$

Find $A_{eff,r}$ as

$$\begin{aligned} A_{eff} &= \frac{\lambda^2}{4\pi} G \\ &= \frac{(0.3223 \dots m)^2}{4\pi} \cdot 2 \\ &= 0.017 \dots m^2 \end{aligned}$$

Plug in all values to find d

	$d = \sqrt{\frac{0.16 \dots \cdot 2 \cdot 0.017 \dots}{4\pi P_{noise} \cdot 10^{\frac{SNR}{10}}}}$ $= \sqrt{\frac{4.17172597 \times 10^{-4}}{P_{noise} \cdot 10^{\frac{SNR}{10}}}}$ <p>Signal to noise ratio SNR and ambient noise P_{noise} may vary, and may need to be experimentally tested. In this specific calculation, identical antennas are used for uplink and downlink, but this may change depending on application.</p> <p>Plugging in rough numbers gives me some hope in the feasibility of dipole to dipole communication</p>
Ongoing ▾	

December 11

Task	Progress
1a.	<p>According to https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/devices-and-equipment/radio-equipment-standards/radio-standards-specifications-rss/rs-s-247-digital-transmission-systems-dtss-frequency-hopping-systems-fhss-and-licence-exempt-local, the transceivers cannot exceed 36 dBm eirp, and output power cannot exceed 1W (30 dBm). Eirp (Effective isotropic radiated power I think) is defined as power [dBm] + gain [dB]. After boosting the antennas to 30dBm, we can still add a 6dB antenna to the ground station, although the mobile station will have to use an isotropic antenna.</p> <p>For the mobile rocket transceiver, an omnidirectional rubber duck antenna should suffice. However, for the ground station, we need a directional 6dB antenna. This antenna https://www.amazon.ca/-/fr/Antenne-ext%C3%A9rieure-directionnelle-%C3%A9lev%C3%A9-N-femelle/dp/B0CPP17DLX?source=ps-sl-shoppingads-lpcontext&ref_=fplfs&mid=ANJPJRAH9QAFJ&th=1 or https://plianttechnologies.com/product/6dbi-900mhz-yagi-directional-antenna/ will likely work, although I might want to build my own Yagi antenna, like this one https://hackaday.com/2025/02/20/diy-yagi-antenna-sends-lora-signals-farther/.</p>
Ongoing ▾	

December 12

Task	Progress
1a.	<p>Many 22dbm-30dbm pa chips are priced at ~\$40 and may interfere with the quality of output signals, and it's best not to take that risk. Instead, I might use a dedicated microcontroller connected to a higher-power LoRa module. This means that I would be able to use either a raspberry pi pico, like planned, or just an arduino nano, which I have more experience with. The arduino nano would probably be easier in the short term, but when moving on to more complex components requiring trajectory calculations, the computational power may not be sufficient, and all components may need to go through another testing round.</p> <p>According to https://www.tomshardware.com/features/raspberry-pi-pico-vs-arduino, the rp pico consumes less current, and paired with its potential for future expansion and lower price, it is likely a better option. Bluetooth can also be used for pre-launch communications, and possibly the antenna-to-computer connection.</p>
Ongoing ▾	

Other Notes:

Parts will take around a month to arrive, holding work on electronics for now

Week Of December 22

Task	Category	Status
1. Start working on aerodynamic optimization methodology	Airframe ▾	Ongoing ▾
2. Start developing the communications subsystem	Electronics ▾	On Hold ▾

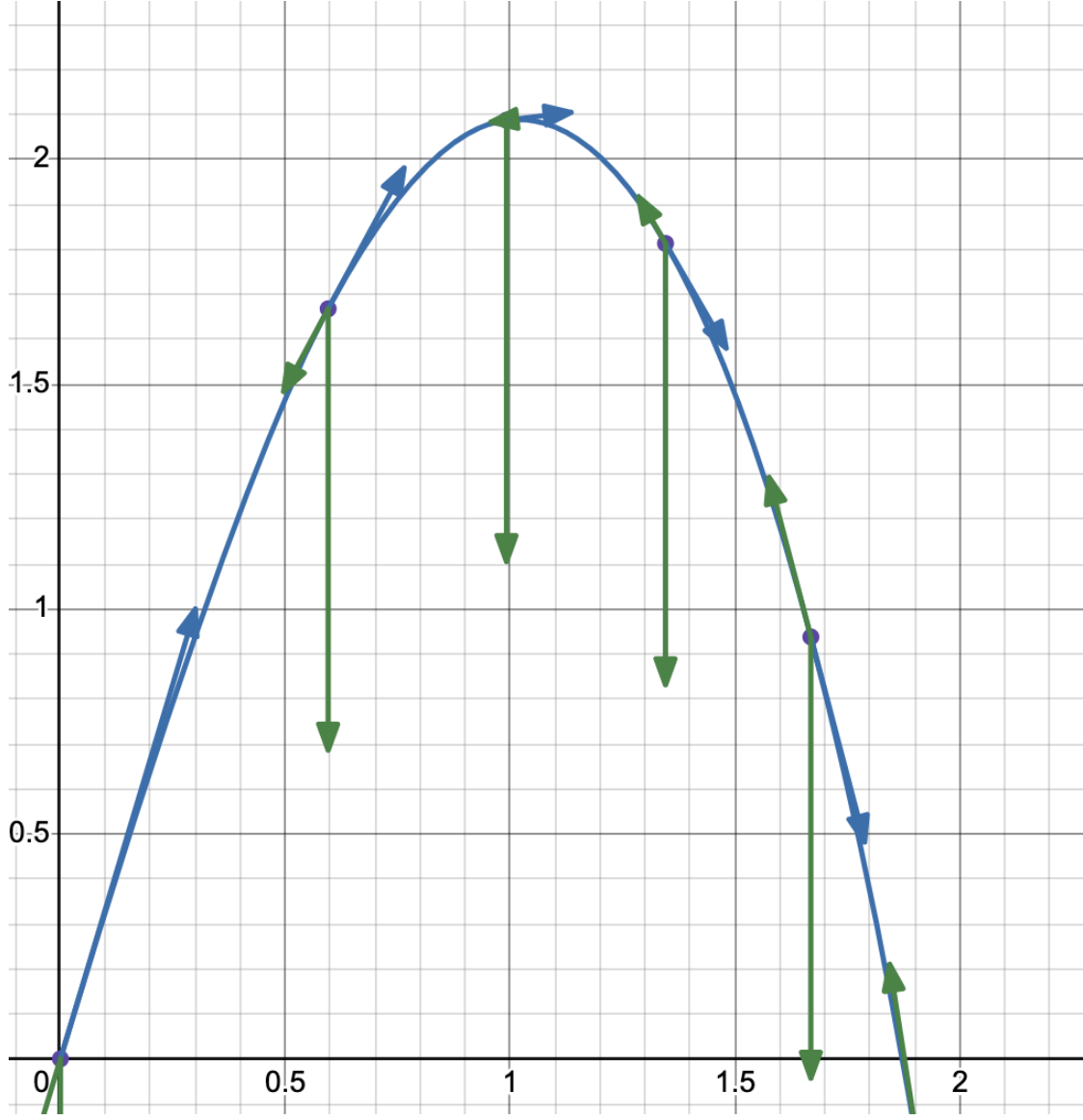
December 22

Task	Progress
1.	<p>After considering adjoint and evolution-based optimization, I settled on an ML based simulation selection and iteration. The basic idea is to train an ML algorithm on simple sample data, find the optimal input value given by the model by plugging in a grid of inputs, run that optimal suggestion through CFD, then retrain the model on the</p>

new data. I'm planning to first test transition shapes with two control points, and therefore two input params for the ML model, then move on to actually optimizing the rocket. Started on some code for the training and storage process today, with tensorflow for a conceptual experiment. I will need to generate the initial dataset tomorrow.

Ongoing ▾

December 24

Task	Progress																																								
1.	<p>Started experimenting with a new method of integration for simulations. Instead of directly adding/subtracting the acceleration or velocity, this one finds the change in velocity as the integral of a fixed acceleration, and displacement as the second integral. The acceleration is then updated every tick. Basically, it accounts for the change in velocity between ticks in the displacement calculation, and ends up looking like</p>  <p>The graph illustrates a parabolic trajectory of a rocket. The horizontal axis (time) ranges from 0 to 2, and the vertical axis (height) ranges from 0 to 2. Blue arrows along the curve represent velocity vectors, which increase in magnitude as the rocket ascends and decrease as it descends. Green vertical arrows pointing downwards represent acceleration vectors, which are constant in magnitude and direction throughout the flight, indicating a constant negative acceleration.</p> <table border="1"><caption>Approximate data points from the graph</caption><thead><tr><th>Time (s)</th><th>Height (m)</th><th>Velocity (m/s)</th><th>Acceleration (m/s²)</th></tr></thead><tbody><tr><td>0.0</td><td>0.0</td><td>0.0</td><td>-1.0</td></tr><tr><td>0.25</td><td>0.75</td><td>1.0</td><td>-1.0</td></tr><tr><td>0.5</td><td>1.5</td><td>1.5</td><td>-1.0</td></tr><tr><td>0.75</td><td>1.9</td><td>1.8</td><td>-1.0</td></tr><tr><td>1.0</td><td>2.1</td><td>1.8</td><td>-1.0</td></tr><tr><td>1.25</td><td>1.9</td><td>1.5</td><td>-1.0</td></tr><tr><td>1.5</td><td>1.5</td><td>1.0</td><td>-1.0</td></tr><tr><td>1.75</td><td>0.75</td><td>0.5</td><td>-1.0</td></tr><tr><td>2.0</td><td>0.0</td><td>0.0</td><td>-1.0</td></tr></tbody></table>	Time (s)	Height (m)	Velocity (m/s)	Acceleration (m/s ²)	0.0	0.0	0.0	-1.0	0.25	0.75	1.0	-1.0	0.5	1.5	1.5	-1.0	0.75	1.9	1.8	-1.0	1.0	2.1	1.8	-1.0	1.25	1.9	1.5	-1.0	1.5	1.5	1.0	-1.0	1.75	0.75	0.5	-1.0	2.0	0.0	0.0	-1.0
Time (s)	Height (m)	Velocity (m/s)	Acceleration (m/s ²)																																						
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2.0	0.0	0.0	-1.0																																						

	Hopefully, this will yield more accurate results with the same number of ticks. Using a differential equation, I might be able to account for the effect of velocity on drag, but for now, this seems sufficient.
Ongoing ▾	

December 25

Task	Progress
1.	Started work with the ML model, imported tensorflow but still had a few errors when attempting to train and run model. Began populating a sample dataset with cfd data, about halfway through.
Ongoing ▾	

December 26

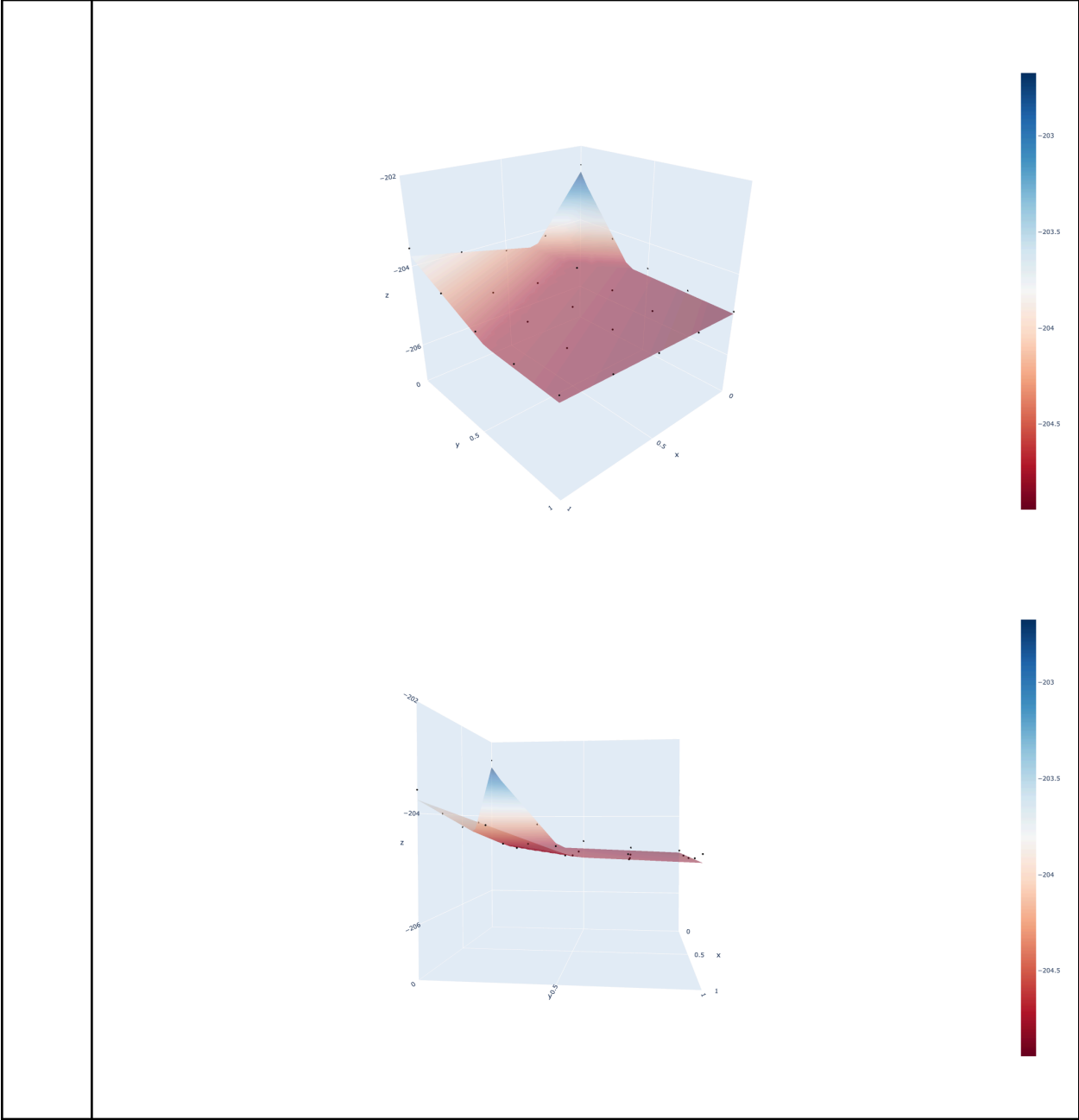
Task	Progress
1.	Finished populating dataset with grid of 0.25 steps as a test. Also figured out the error, I needed to train with batches. Model training now, but loss stops decreasing at ~0.14
Ongoing ▾	

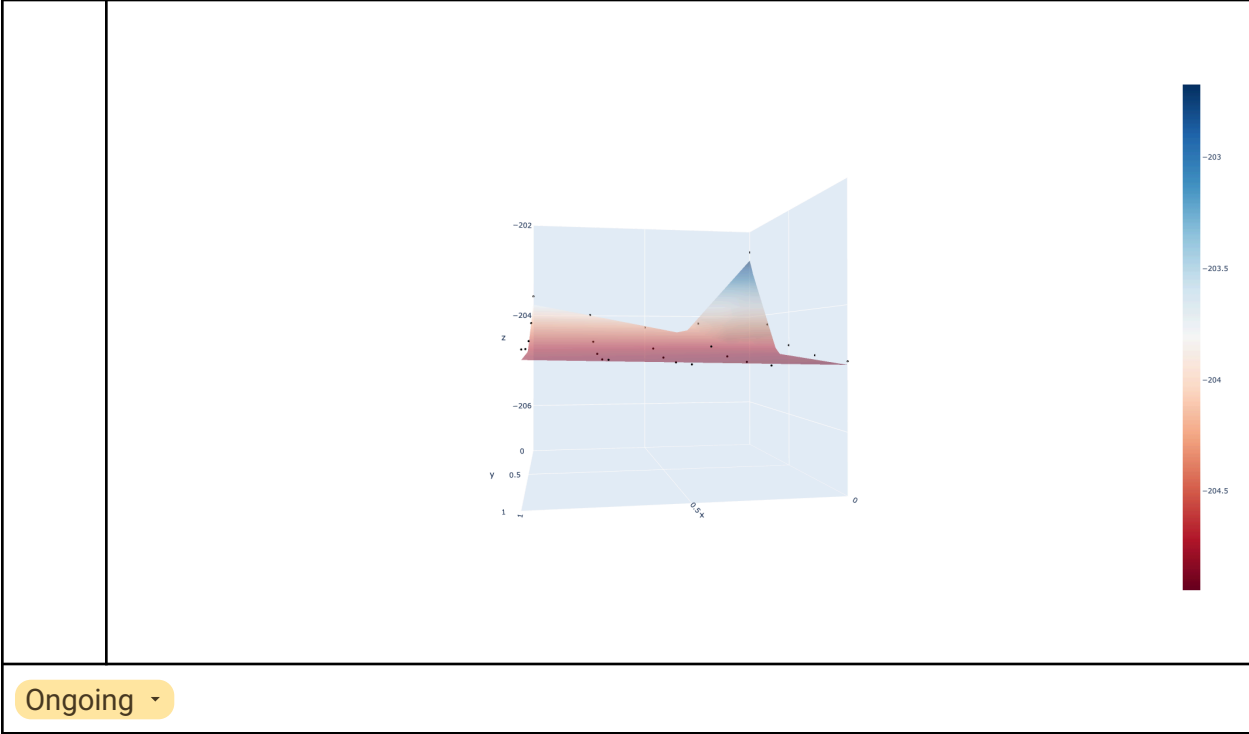
Week Of December 29

Task	Category	Status
1. Continue work on aerodynamic optimization methodology	Airframe ▾	Completed ▾
2. Begin airframe design	Airframe ▾	Ongoing ▾
3. Start developing the communications subsystem	Electronics ▾	On Hold ▾

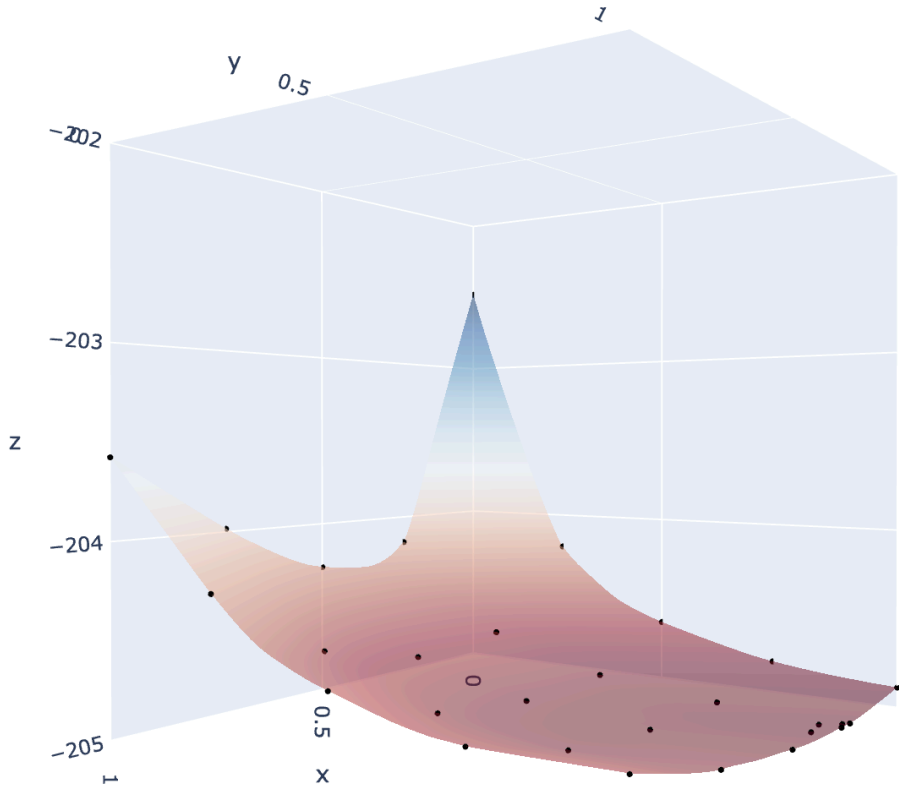
December 29

Task	Progress
1.	<p>Optimized code to work with n-dimensional inputs, to work with multiple inputs in the future. Also created gradient descent algorithm in the optimizer that moves along the slope of the model, to further refine the data.</p> <p>Added Plotly rendering to visualize data. In the visualizations, I noticed the model consisted of three planes, while the real data definitely makes up curves. I'll need to see if there are any ways of better fitting the data, as while the optimizer is effective at finding the minimum of the model, the model doesn't match the real data.</p>





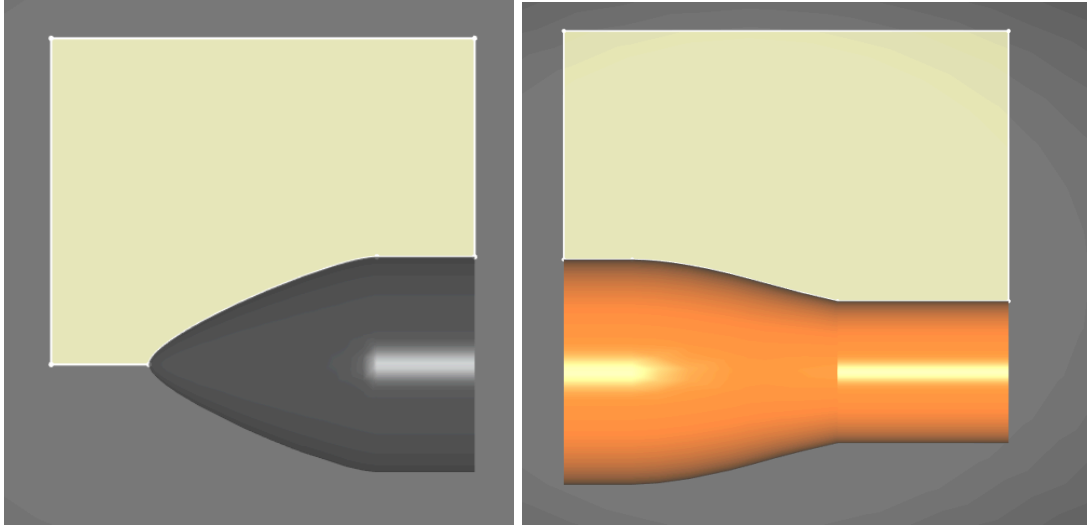
December 30

Task	Progress
1.	<p>Adjusted model to predict drag relative to the control (first row) to keep features and labels within the same order of magnitude ($\sim +2N$), resulting in a much more accurate model</p>  <p>Ongoing ▾</p>

December 31

Task	Progress
1.	Created a “ball rolling” visualization for gradient descent, and noticed that the derivative was being applied backward. After fixing, updated yesterday’s graphic
Ongoing ▾	

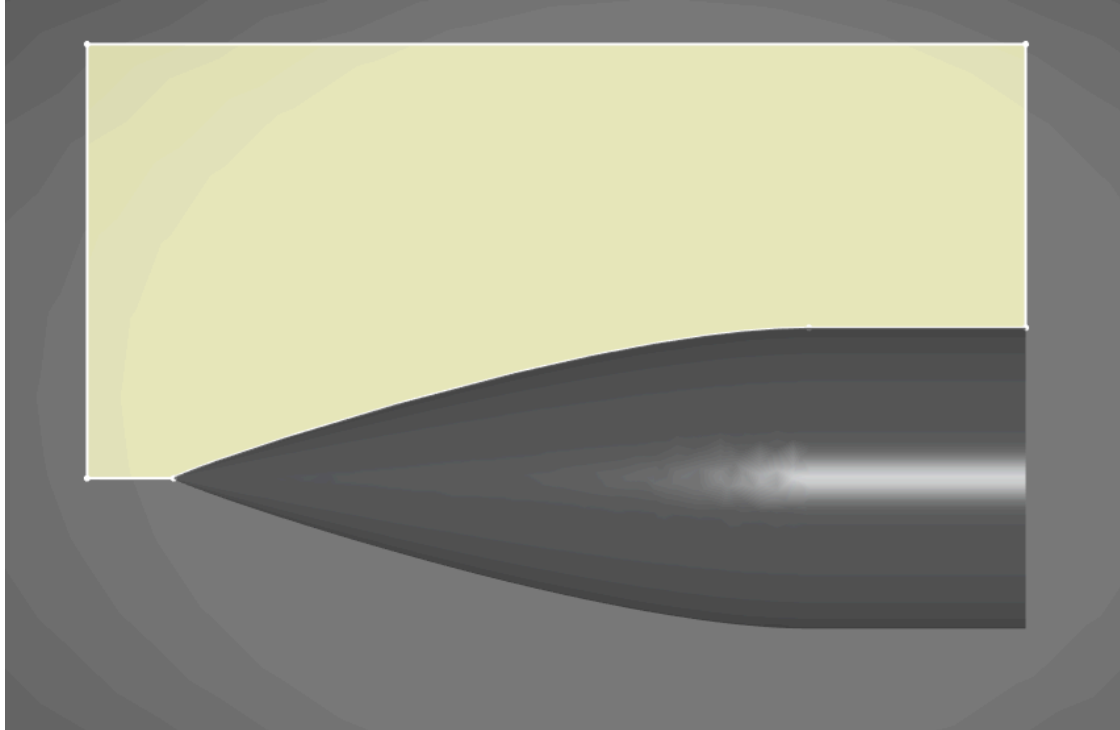
January 01

Task	Progress
1.	<p>Finished more labour-intensive shuttling for nose cone and transition shape optimizations, the algorithm is working as expected and saving almost a newton of drag after 7 iterations. Note that the nosecone was optimized with an extra length feature, meaning that the optimizer can adjust the length of the nosecone.</p>  <p>The methodology is mature and repeatable, and I’ll likely use this procedure with only a few tweaks to optimize for specific parameters. Other than that, the optimization algorithm should be fully developed.</p>
Completed ▾	

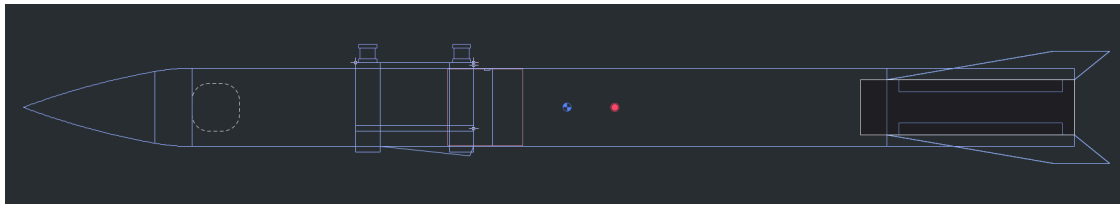
January 02

Task	Progress
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2. With pen and paper, noticed that the BT80 body tube results in a lot of empty space which could be slimmed down. Also found that a BT60 could potentially fit my ebay, but the margins are a bit too small for comfort. In the meantime, I ran an optimisation for a BT-60 nose cone, which saved 0.32N after 9 iterations as compared to a 6cm conical nosecone.



Created a simple openrocket model, for quick conceptualizations and testing without running a full simulation.

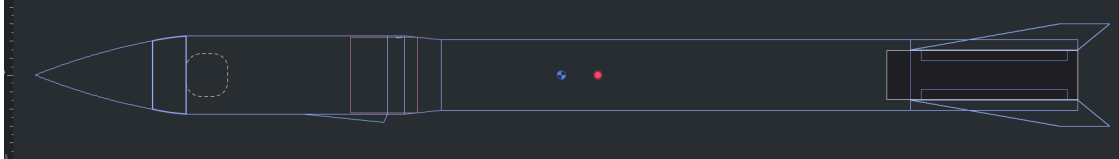
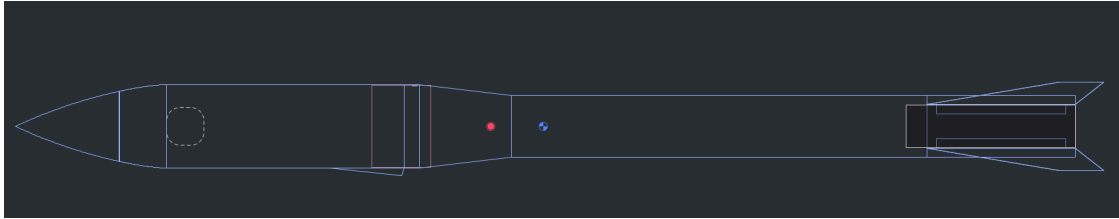


Ongoing ▾

Week Of January 05

Task	Category	Status
1. Lay groundwork for airframe design	Airframe ▾	Ongoing ▾
2. Begin work on experimental radiosonde, for 23-27 launch date	Other ▾	Ongoing ▾
↳ 2a. Start work on mounting electronics	Research ▾	Ongoing ▾
↳ 2b. Email TC, Nav Canada, and ISED about safety considerations	Research ▾	Not Started ▾
3. Start developing the communications subsystem	Electronics ▾	On Hold ▾

January 07

Task	Progress
1.	<p>Found a transparent BT65 body tube, which increases margins while not requiring a substantial transition. The tube walls are a bit thicker, which might increase weight and reduce payload capacity. Quickly conceptualized the design in OpenRocket</p>  <p>For comparison, a BT70 ebay, which offers the largest reasonable margins</p>  <p>Notice the smaller transition and nose cone. Also, although the fins haven't been optimized yet, it's to be expected that the concentration of wet area near the nose will require larger, draggier fins.</p> <p>Also created file structure for FreeCAD design files, in preparation for the actual design of the rocket. Will likely use FC Assembly 4</p>

Ongoing ▾

January 15

Task	Progress
2a.	Since Jan 26-27 will effectively be no-school days, I would like to try to fast-track development to meet that launch date, with the 30th as a weather redundancy. I laid some foundational assembly groundwork in FreeCAD, including a breadboard and pin system that will be the basis of all other mounting
Ongoing ▾	

January 17 - February 04 Very busy studying for ground school, entries are sparse and incomplete

January 30 - Call with ISED to clarify band use parameters. Can't launch without their approval

Week Of February 08

Task	Category	Status
1. Airframe Design	Airframe ▾	Ongoing ▾
↳ 1a. Write new optimizer to maximize altitude	Airframe ▾	Ongoing ▾

February 13

Task	Progress
1a.	<p>At high altitudes, the thinner atmosphere means that aerodynamic forces are less significant, and the mass of the rocket becomes a more important limiting factor. For this reason, I'd be more effective to optimize for higher altitudes rather than reduced drag, which is what the optimizer should be rewritten to do.</p> <p>Since the optimizer is being revamped, I also wanted to rewrite the flight simulator to improve accuracy, by integrating static gravitational and linearly approximated drag forces between ticks. I chose to use a linear approximation of drag, since quadratic drag would require solving a differential over the velocity vector, while the velocity vector in the linear approximation can be separated into its components.</p> <p>Let \vec{F} be the sum of all constant, static forces, and k be the sum of the coefficients at which forces proportional to the rocket's velocity act. Let m be the mass of the rocket</p> <p>Total acceleration \vec{a} can be defined as</p> $\vec{a} = \frac{\vec{F} + k\vec{v}}{m}$ <p>Total acceleration is the derivative of the velocity vector over time. Therefore,</p> $\frac{d\vec{v}}{dt} = \frac{\vec{F} + k\vec{v}}{m}$ <p>Separating the differential equation, we get</p> $\frac{m}{\vec{F} + k\vec{v}} d\vec{v} = dt$

$$\int \frac{m}{\vec{F} + k\vec{v}} d\vec{v} = \int dt$$

The right hand side can be solved easily. However, we need to use substitution to solve the left hand side. Define substitution variable u to be

$$u = \vec{F} + k\vec{v}$$

$$\frac{du}{d\vec{v}} = k$$

$$d\vec{v} = \frac{1}{k} du$$

Substituting, we get

$$\int \frac{m}{ku} du = t + C$$

$$\frac{m}{k} \int u^{-1} du = t + C$$

$$\ln(u) = \frac{k}{m} (t + C)$$

$$u = e^{\frac{k}{m}(t+C)}$$

Substitute out u , and isolate for \vec{v}

$$\vec{F} + k\vec{v} = e^{\frac{k}{m}(t+C)}$$

$$\vec{v} = \frac{e^{\frac{k}{m}(t+C)} - \vec{F}}{k}$$

By definition, $\vec{v} = \vec{v}_0$ when $t = 0$. Plug these values in and isolate C

$$\frac{e^{\frac{k}{m}C} - \vec{F}}{k} = \vec{v}_0$$

$$e^{\frac{k}{m}C} = k\vec{v}_0 + \vec{F}$$

$$\frac{k}{m}C = \ln(k\vec{v}_0 + \vec{F})$$

$$C = \frac{m}{k} \cdot \ln(k\vec{v}_0 + \vec{F})$$

Before substituting in the new value of C , rearrange the equation for \vec{v}

$$\vec{v} = \frac{e^{\frac{k}{m}t} \cdot e^{\frac{k}{m}C} - \vec{F}}{k}$$

Substitute out C

$$\begin{aligned} \vec{v} &= \frac{e^{\frac{k}{m}t} \cdot e^{\frac{k}{m} \cdot \frac{m}{k} \ln(k\vec{v}_0 + \vec{F})} - \vec{F}}{k} \\ &= \frac{e^{\frac{k}{m}t} \cdot (k\vec{v}_0 + \vec{F}) - \vec{F}}{k} \end{aligned}$$

Displacement \vec{d} can be found as the integral of \vec{v} .

$$\begin{aligned} \vec{d} &= \int \vec{v} dt \\ &= \int \frac{e^{\frac{k}{m}t} \cdot (k\vec{v}_0 + \vec{F}) - \vec{F}}{k} dt \\ &= \frac{(\int e^{\frac{k}{m}t} dt) (k\vec{v}_0 + \vec{F}) - \vec{F}t}{k} + C' \end{aligned}$$

Again, we can use substitution to solve the remaining integral. Define substitution variable u to be

$$u = \frac{kt}{m}$$

$$\frac{du}{dt} = \frac{k}{m}$$

$$dt = \frac{m}{k} du$$

To solve the remaining integral individually, substitute in u

$$\begin{aligned}\int e^{\frac{k}{m}t} dt &= \int \frac{m}{k} e^u du \\ &= \frac{m}{k} \cdot \int e^u du \\ &= \frac{m}{k} e^u \\ &= \frac{m}{k} e^{\frac{kt}{m}}\end{aligned}$$

Plug back into main equation

$$\vec{d} = \frac{\frac{me^{\frac{kt}{m}}(k\vec{v}_0 + \vec{F})}{k} - \vec{F}t}{k} + C'$$

By definition, $\vec{d} = \vec{d}_0$ when $t = 0$. Plug these values in and isolate C'

$$\begin{aligned}\frac{me^0(k\vec{v}_0 + \vec{F})}{k} + C' &= \vec{d}_0 \\ \frac{m(k\vec{v}_0 + \vec{F})}{k^2} + C' &= \vec{d}_0\end{aligned}$$

$$C' = \vec{d}_0 - \frac{m(k\vec{v}_0 + \vec{F})}{k^2}$$

Plug in C'

$$\begin{aligned}\vec{d} &= \frac{\frac{me^{\frac{kt}{m}}(k\vec{v}_0 + \vec{F})}{k} - \vec{F}t}{k} + \vec{d}_0 - \frac{m(k\vec{v}_0 + \vec{F})}{k^2} \\ \vec{d} &= \frac{\frac{me^{\frac{kt}{m}}(k\vec{v}_0 + \vec{F})}{k} - \vec{F}t - \frac{m(k\vec{v}_0 + \vec{F})}{k}}{k} + \vec{d}_0\end{aligned}$$

$$\vec{d} = \frac{me^{\frac{kt}{m}}(k\vec{v}_0 + \vec{F}) - m(k\vec{v}_0 + \vec{F})}{k} - \vec{F}t + \vec{d}_0$$

$$\vec{d} = \frac{m(e^{\frac{kt}{m}} - 1)(k\vec{v}_0 + \vec{F})}{k} - \vec{F}t + \vec{d}_0$$

$$\vec{d} = \frac{m(e^{\frac{kt}{m}} - 1)(k\vec{v}_0 + \vec{F})}{k^2} - \frac{\vec{F}t}{k} + \vec{d}_0$$

Results and numerically integrated baseline can be found at
<https://www.desmos.com/calculator/4eeyzffbbp>

Created a new package *RocketSimToolkit.py*, to make simulations more standardized and structured. These formulae have been added into the package.

Ongoing ▾

