6 Degrees of Freedom Rocket Trajectory Simulation with Stochastic Analysis

Jago Strong-Wright & Daniel Gibbons

Preliminary Results, December 2020

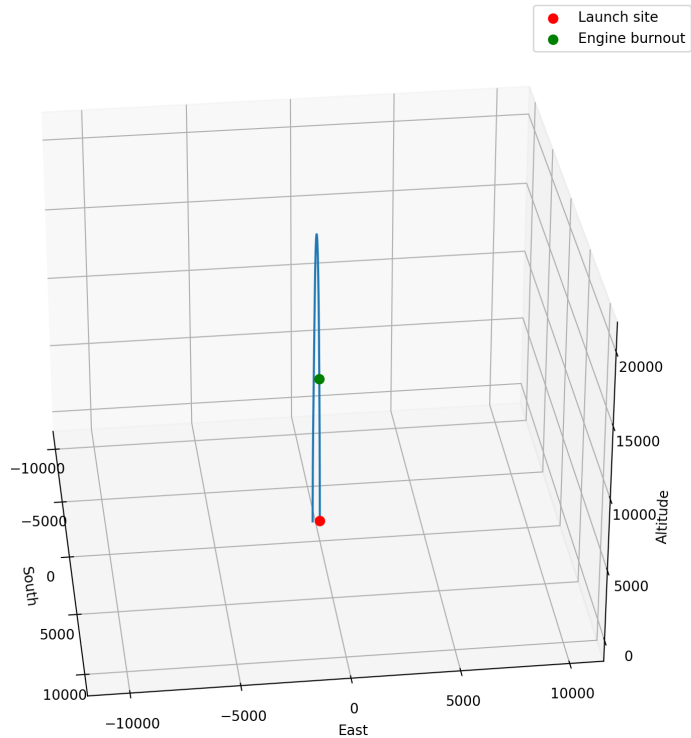
Summary

What we have made so far

- All 6 axes simulated for full flight
- Uses the engine data from Joe's simulation
- Calculates aero forces based on RASAero drag coefficients
- Includes parachute decent
- Designed to be as general as possible so it can be used for any flight
- Structed like a python library including documentation (hopefully finished soon)
- New module for Monte Carlo simulation to find trajectory error bounds

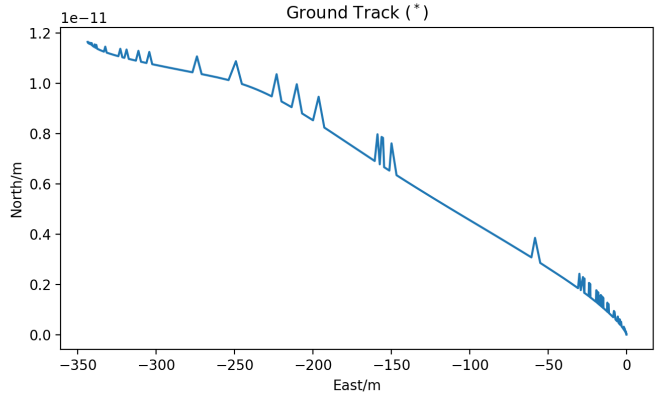
Nominal Flight 1

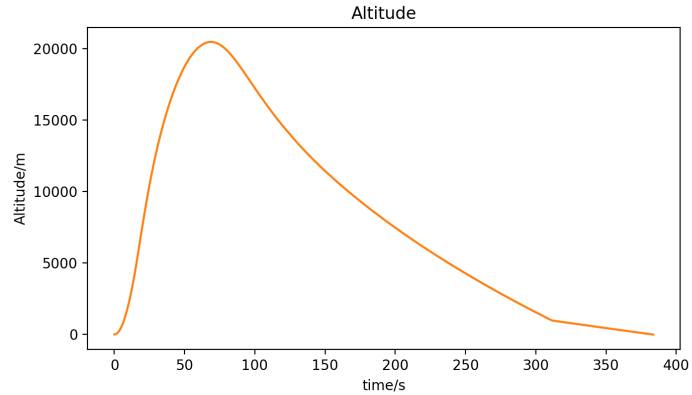
No wind, rail upright

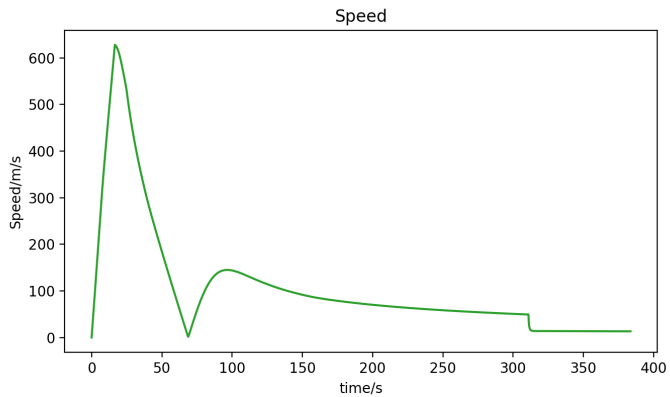


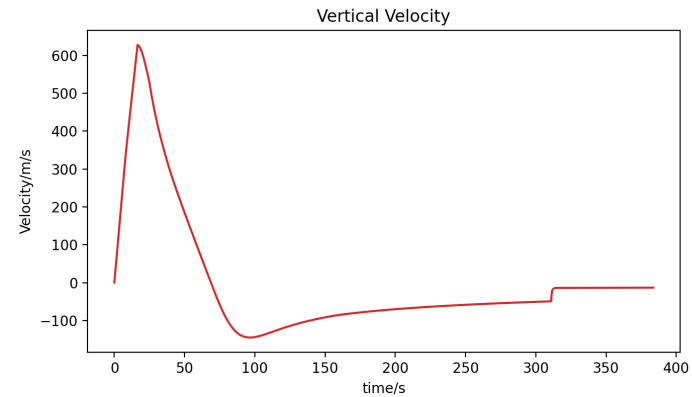
Nominal Flight 1

No wind, rail upright. Jaggedness from automatic step size reduction (note the scale on the downrange is 1×10^{-11})









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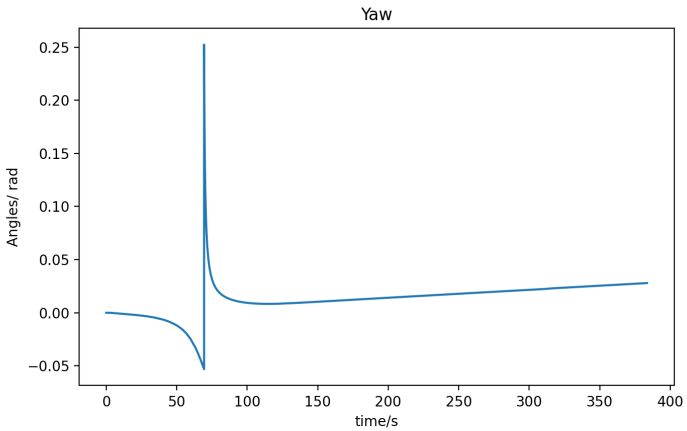
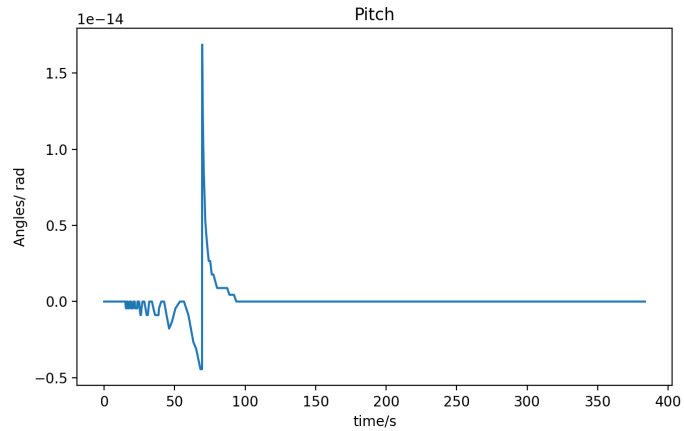
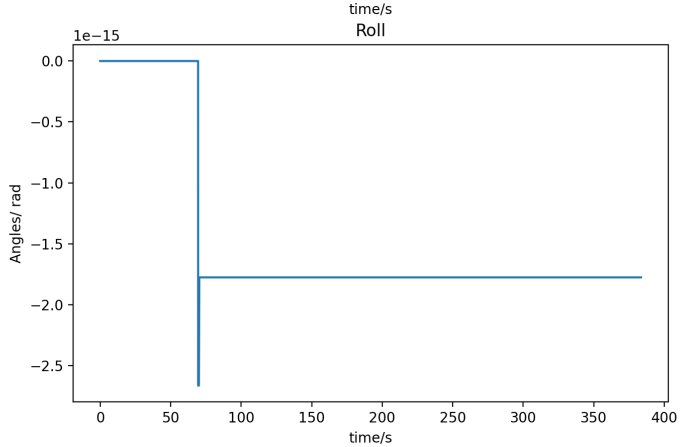
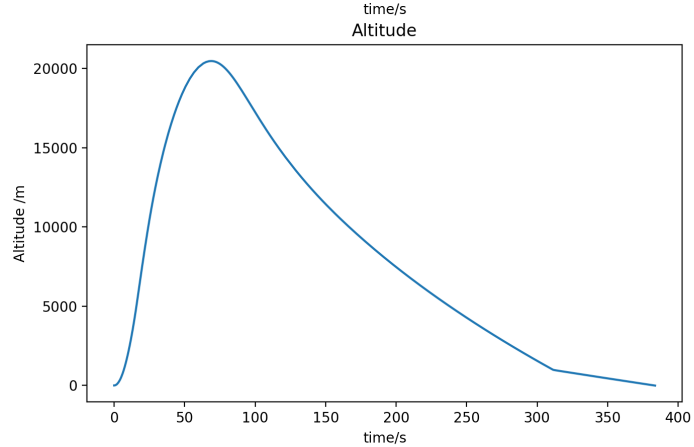


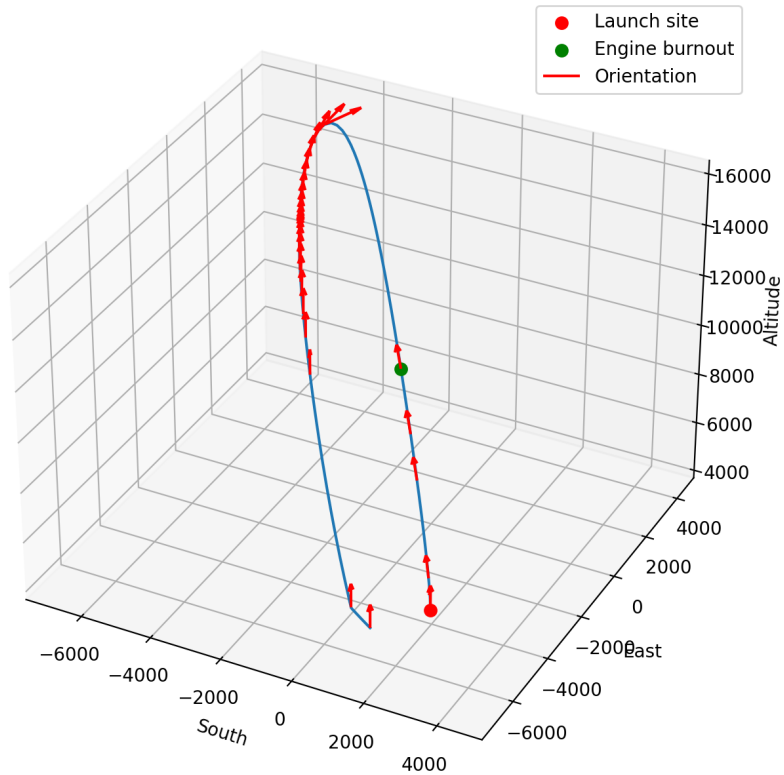






Nominal Flight 2

7m/s south east wind, rail upright. Goes back on its self as it weather cocks.



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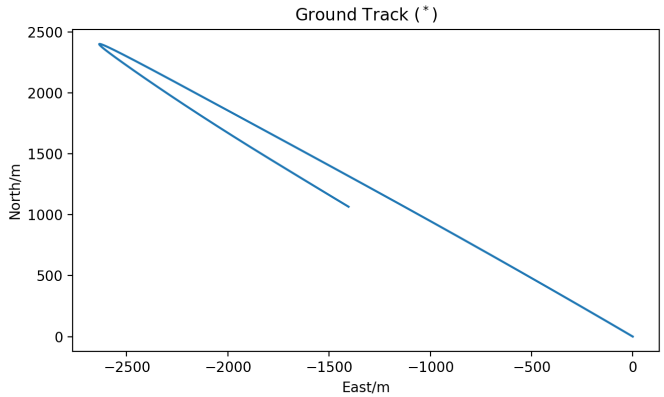

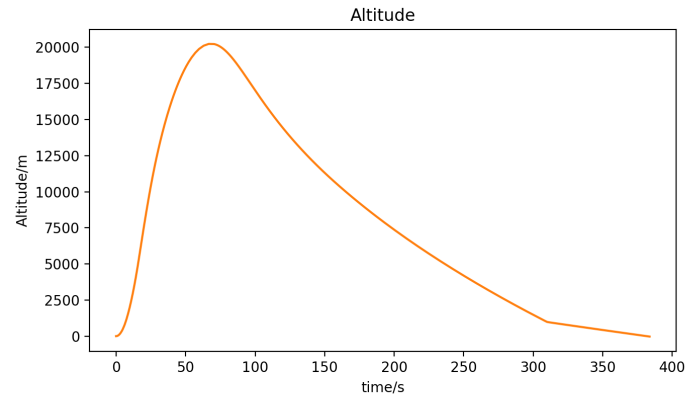

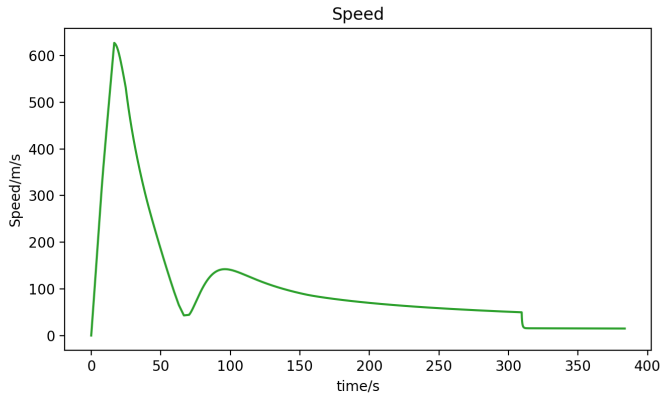

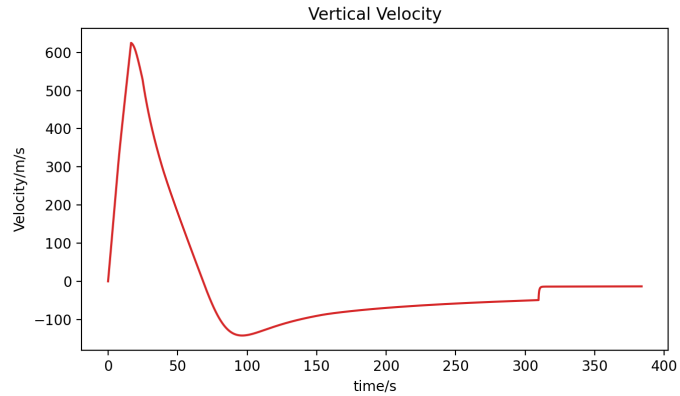

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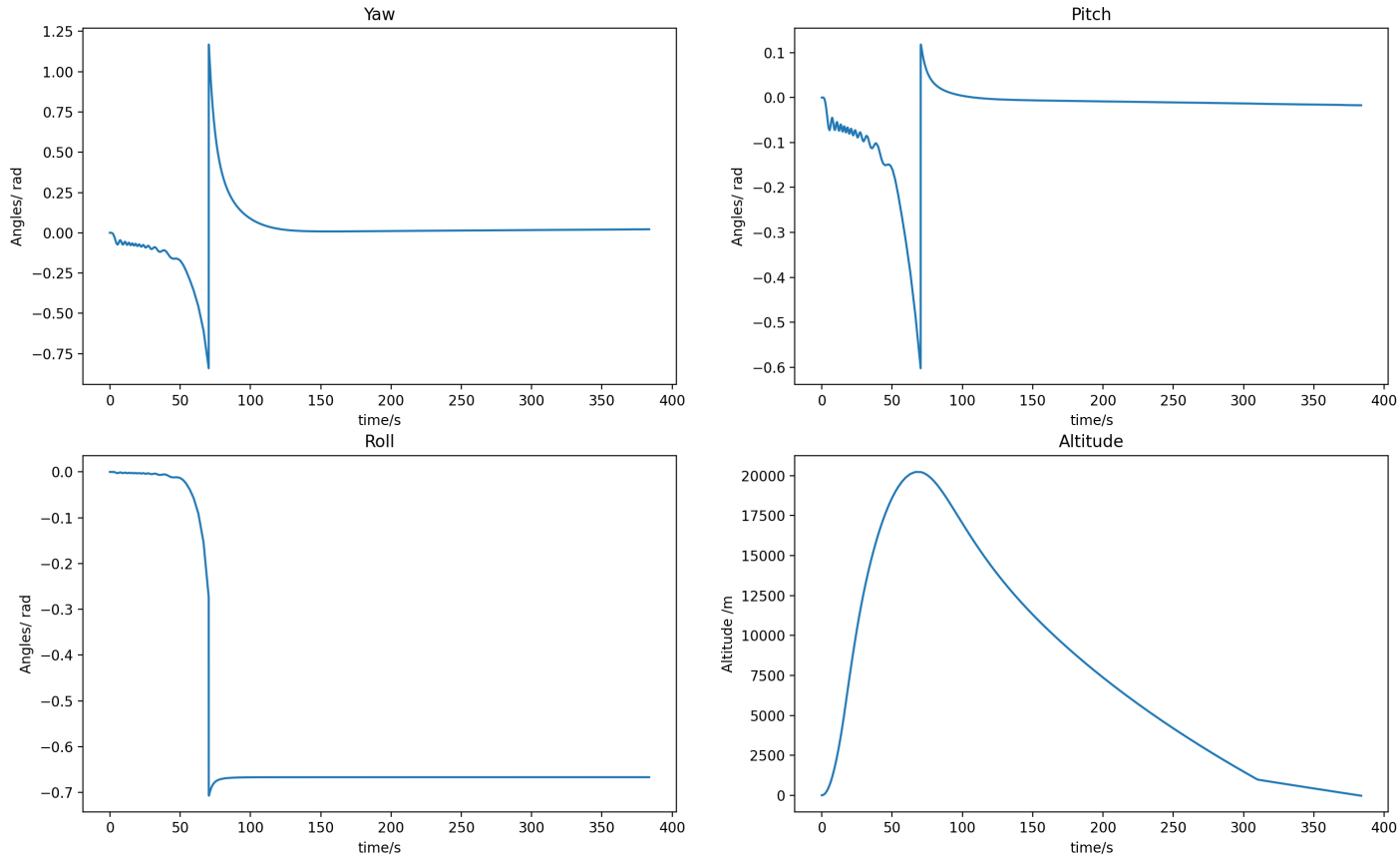
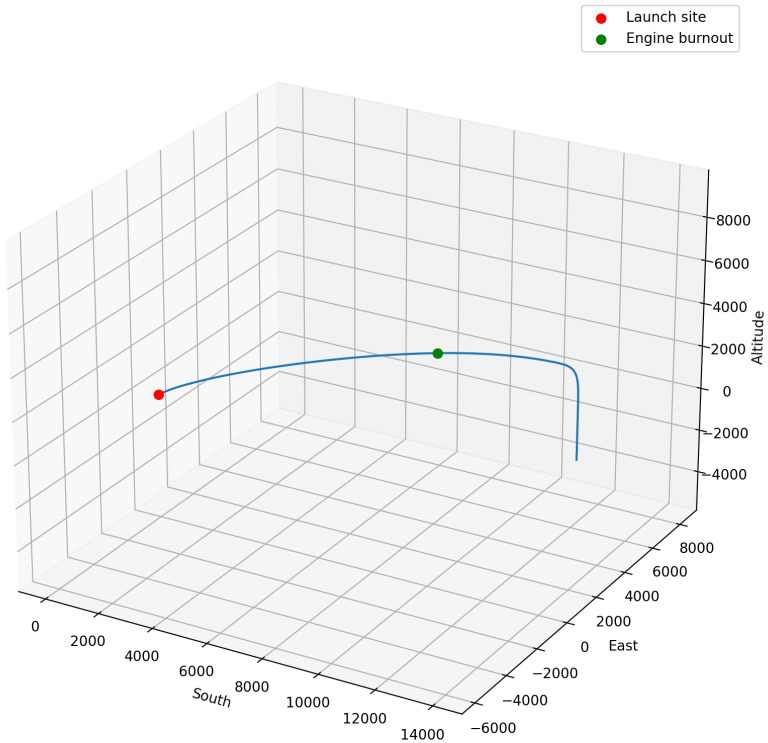


Nominal Flight 3

45 degree rail angle



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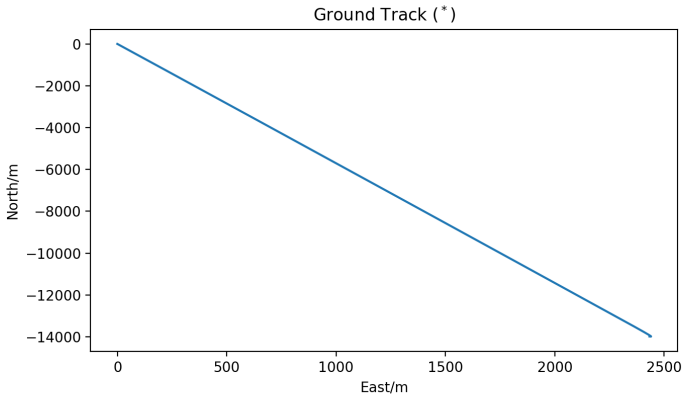

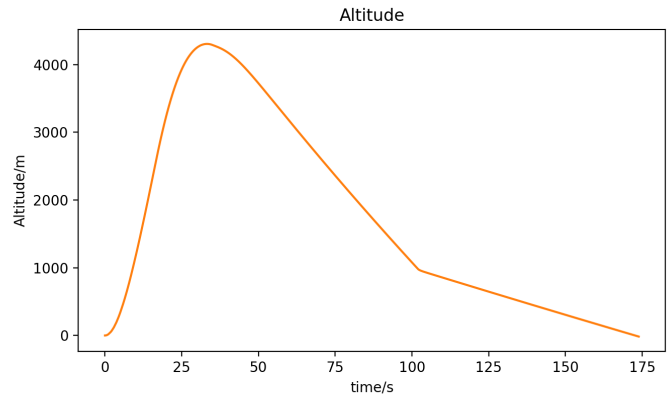

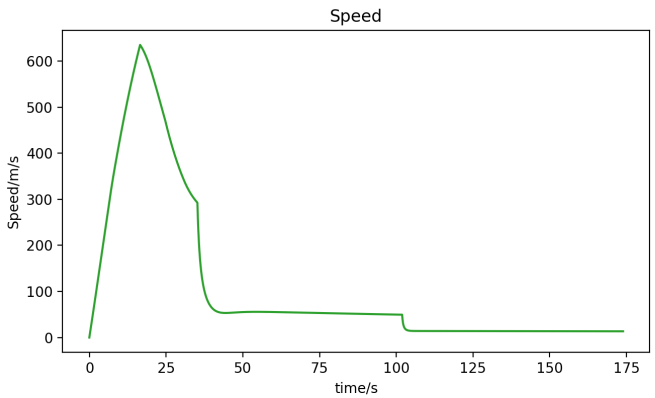

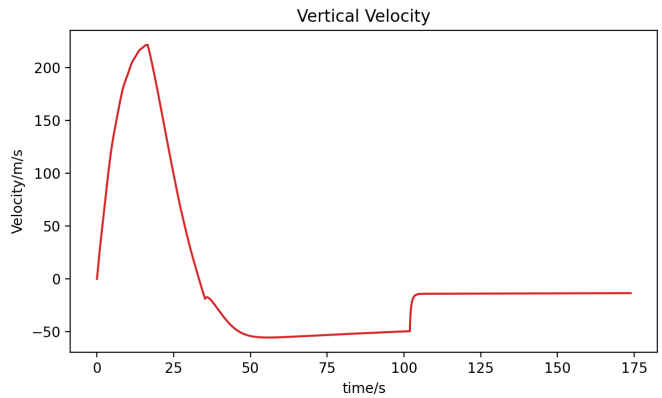

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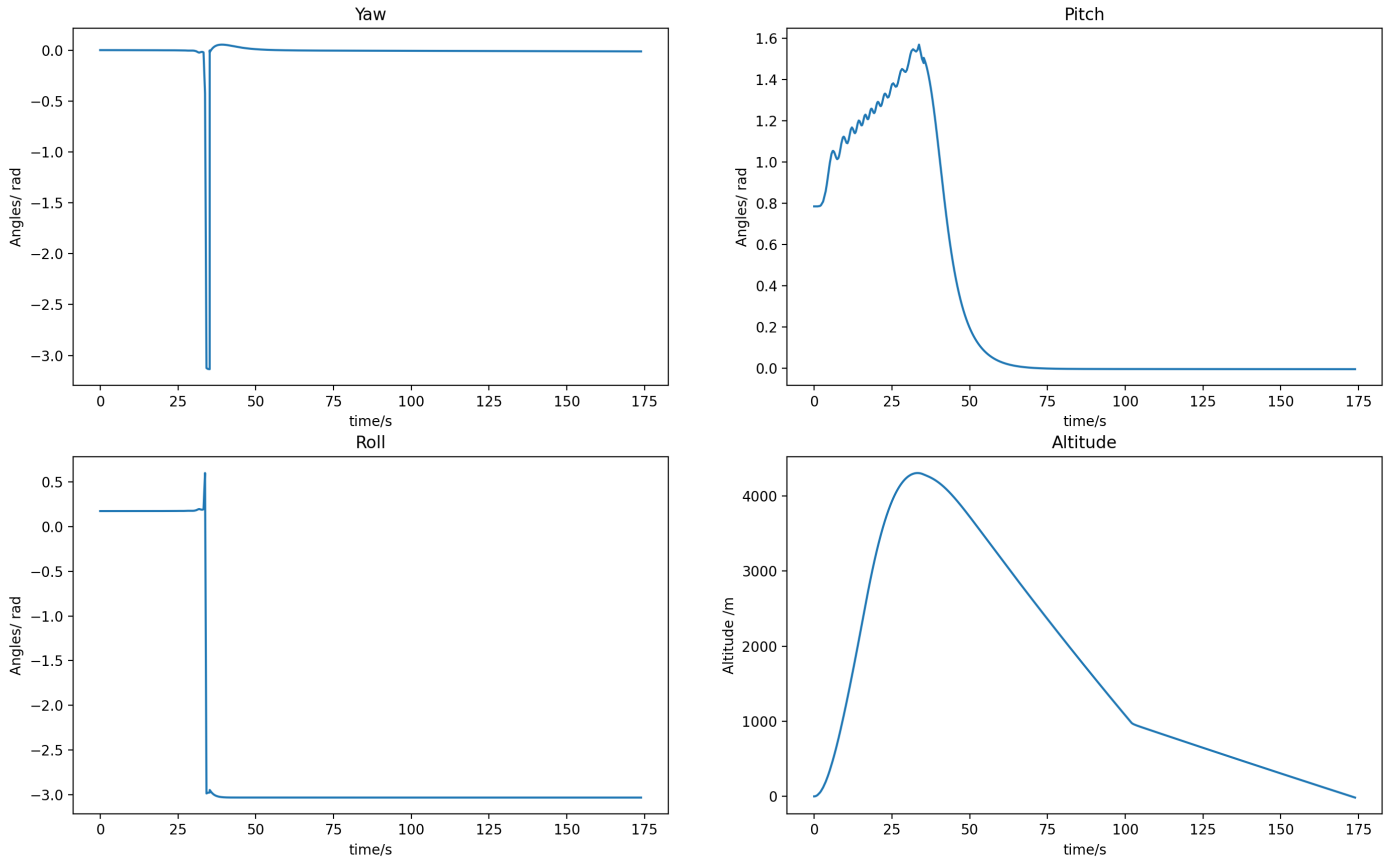


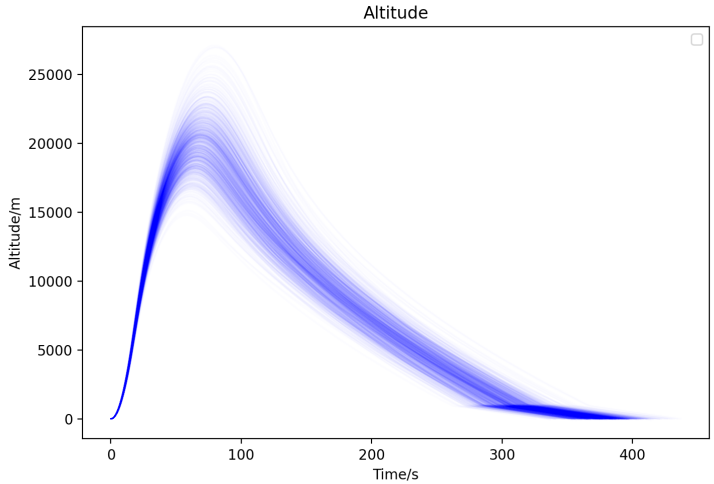
Monte Carlo Analysis

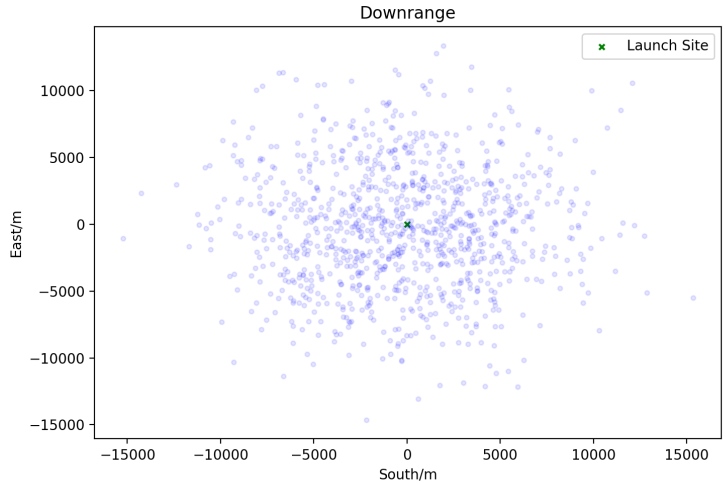
What is that

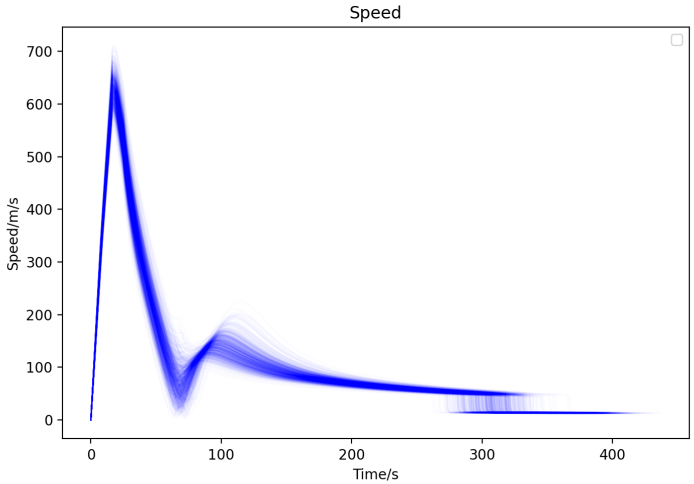
- Monte Carlo allows you to analyse the effects of variations on a highly non linear system
- Essentially randomly generating variations/error in the input parameters (e.g. thrust, drag coefficients, rail angle)
- Possible to calculate errors/confidence intervals for predicted trajectories (maths of this is yet to come)

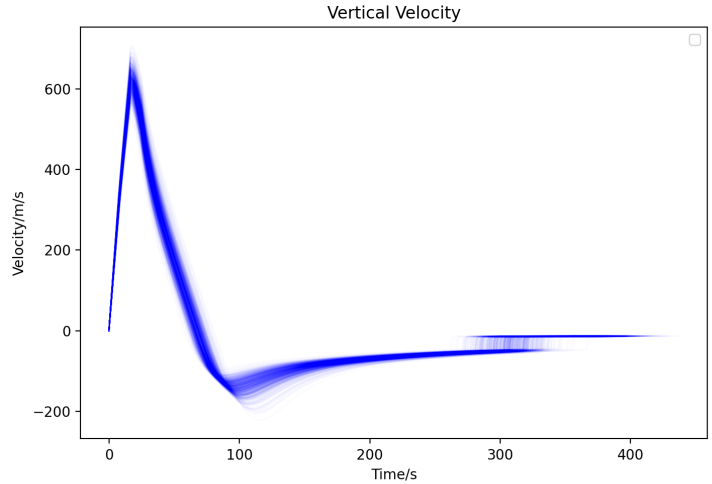
Monte Carlo Analysis

No rail angle or wind, 1000 itterations









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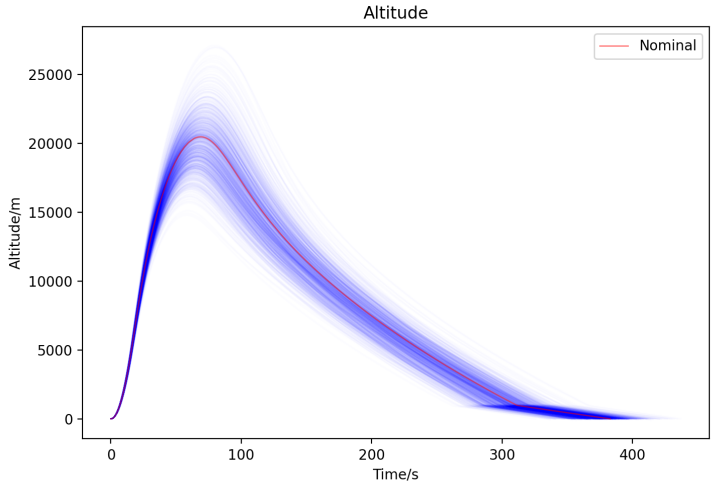

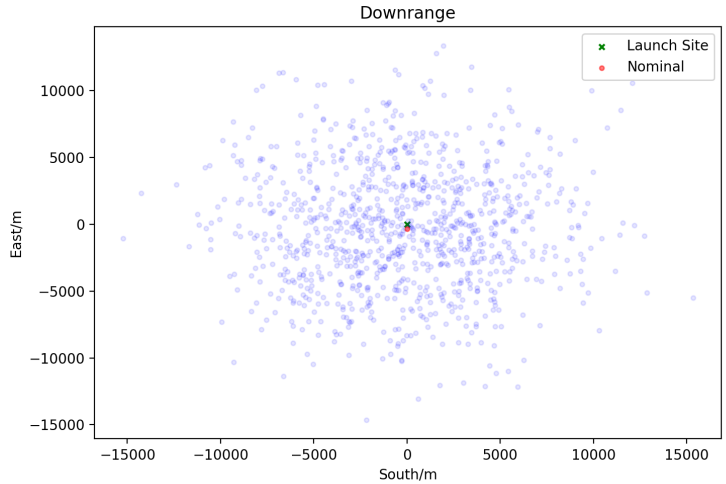

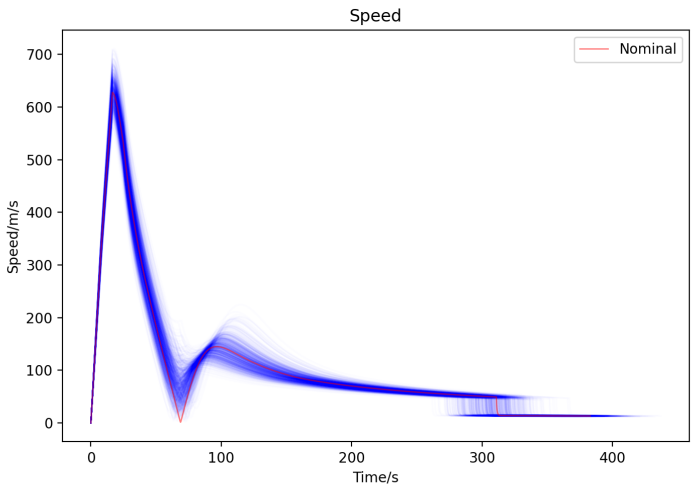

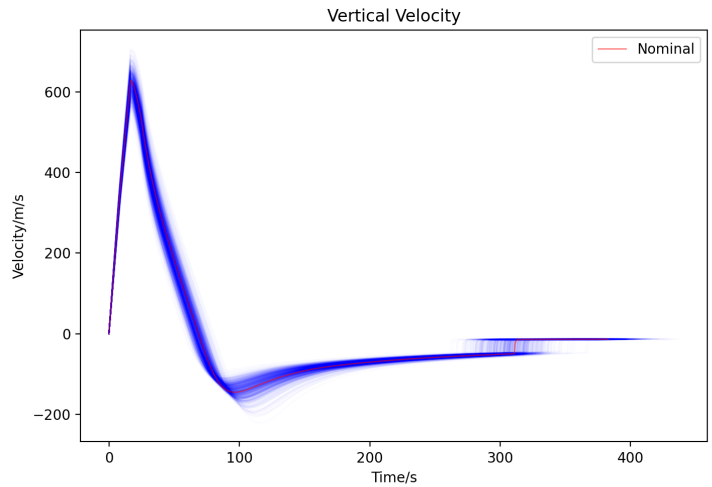

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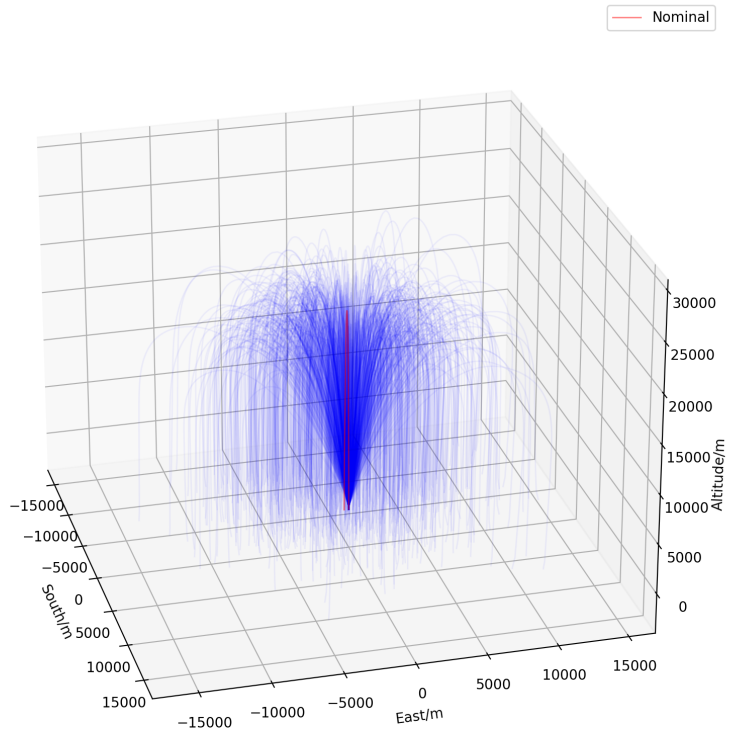

Final Notes

What we have left

- Proper analysis of the Monte Carlo Results
- New more accurate mass model (we currently just have a cylinder)
- Better aero model (i.e. including damping etc.)
- Aerodynamic heating analysis
- Slosh modeling
- Couple with CFD for more accurate results
- Finish documentation
- Think of a name