RR Target Simulation Model Design

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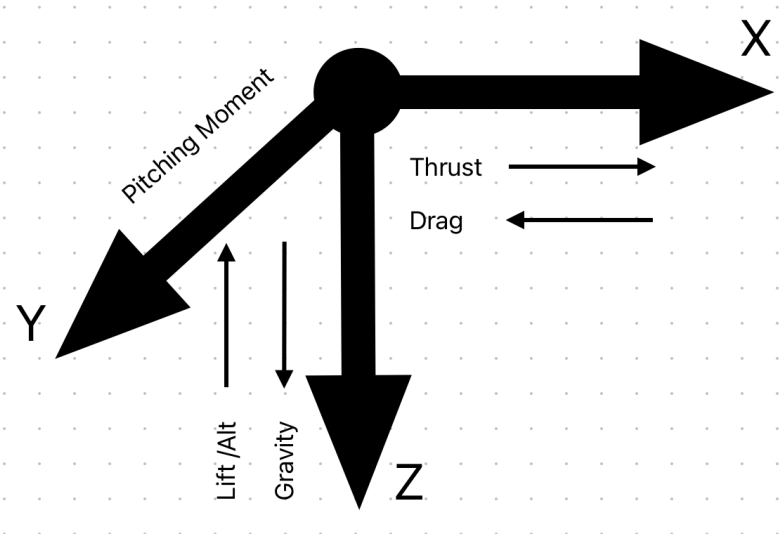
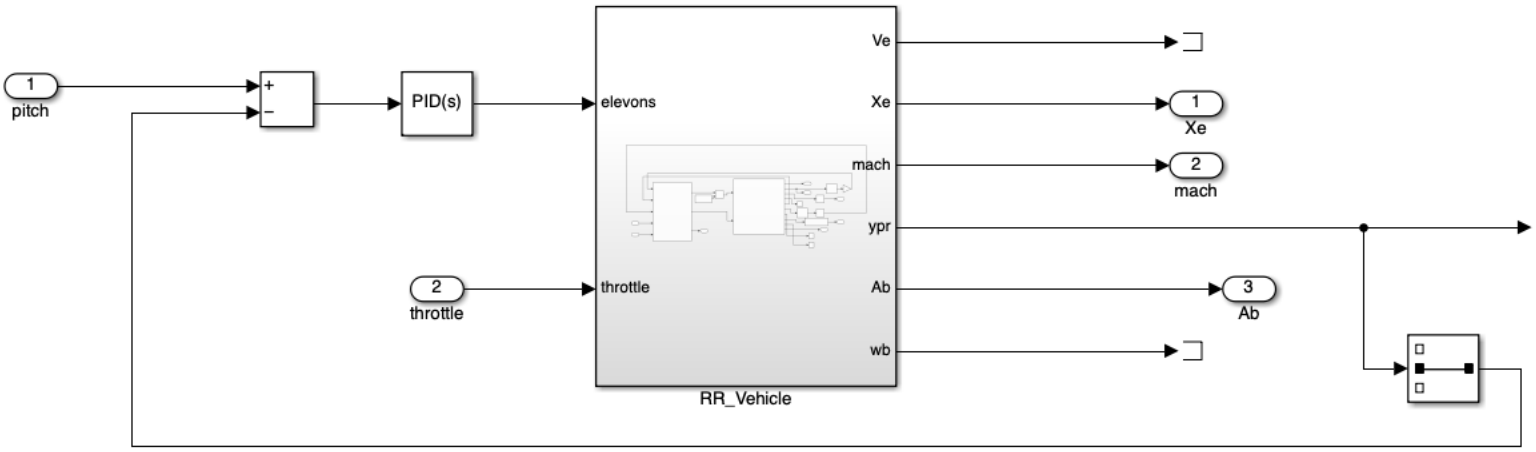
Simulation Overview



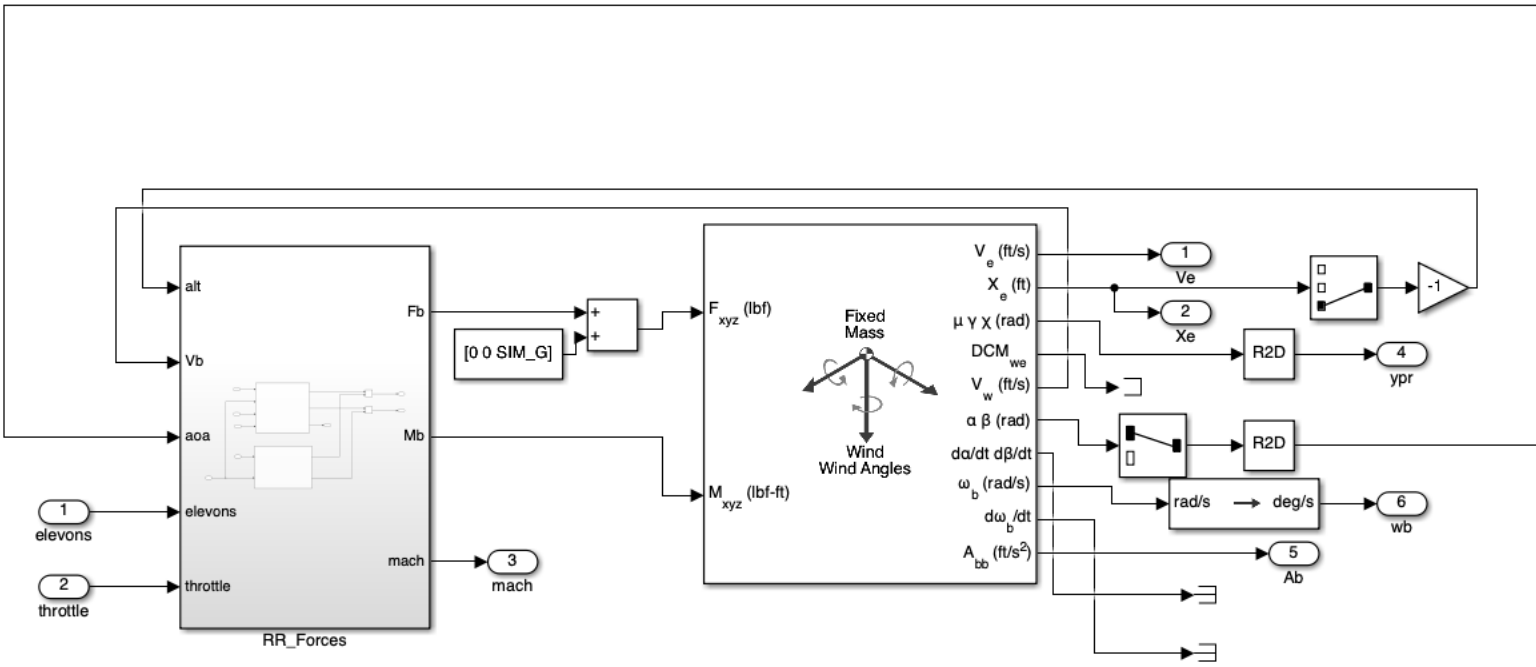
This document describes the Simulink model(s) used to test the RR vehicle performance in a scenario where launches and tracks a target. For the simulation the coordinate system used is shown above. Vehicle motion is allowed in the X(down range), Z (altitude) axis and Y (lateral) motion is fixed to 0. Rotation is allowed around the Y (pitch) axis, and X,Z rotation is fixed to 0. These constraints create a 3DOF simulation environment for modeling vehicle position and pitch.

Top level RR Vehicle Simulation



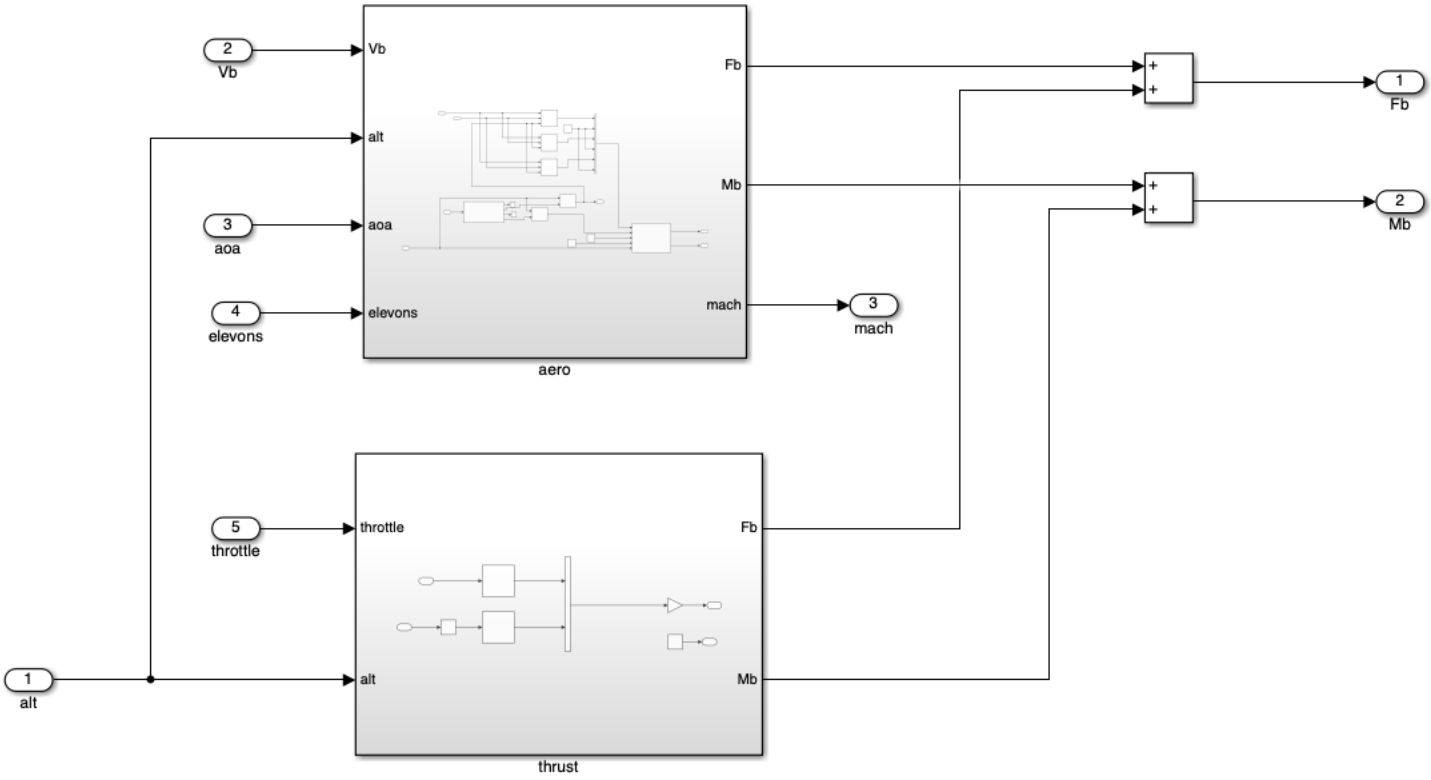
At the top level of the RR vehicle model is a PID controller block and the RR_Vehicle block. The PID controller used the automated tune feature to set the parameters for feedback pitch control using the elevons. The vehicle accepts throttle and pitch commands and outputs the vehicle position, mach, body acceleration, and measured pitch. If more time was available PID rate control and different PID settings for different flight modes like launch, cruise, and target would be added. Additionally, a linear actuator block would have been added to the model to move the elevons.

RR 6DOF



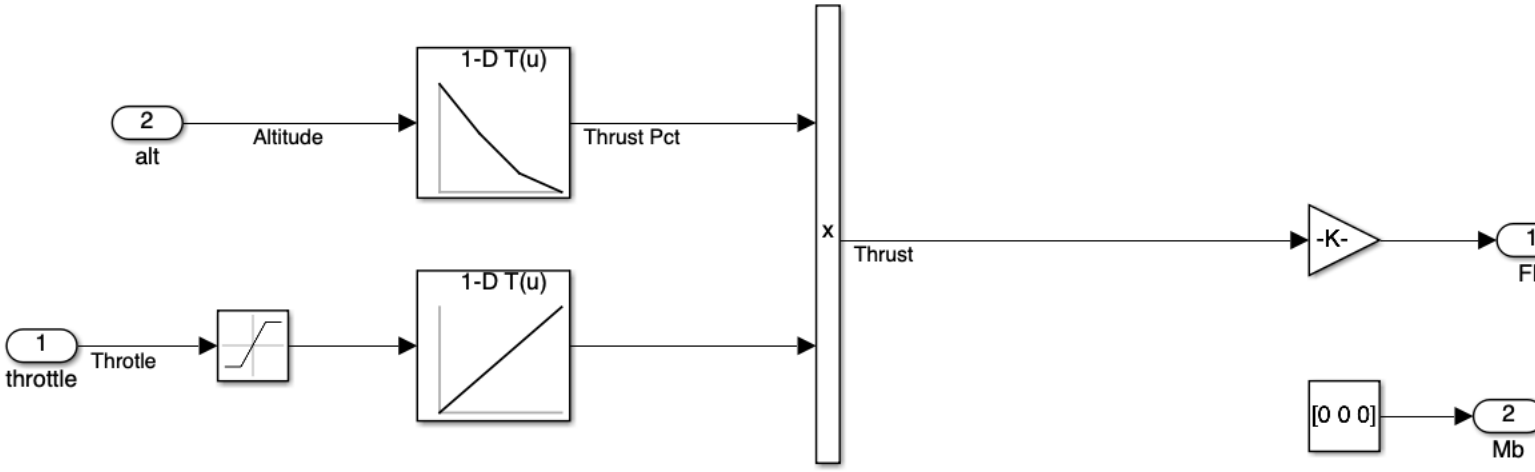
Inside the RR_Vehicle model, the 6DOF Wind Angles block is used to simulate vehicle motion. The RR_forces block with gravity added is used to generate all the forces and moments of the vehicle in the body axis. Forces in the Y direction are set to 0 and moments about the X,Z axis are set to 0 which creates a 3DOF simulation even though the 6DOF block is utilized. Elevon angle and throttle are input into the RR_Forces block. Altitude, velocity, and angle of attack are fed back into the RR_Forces block. Position, mach, body acceleration, and pitch are among the available outputs. If more time was available, the fuel consumption rate would have been added and variable mass simulated.

RR Forces



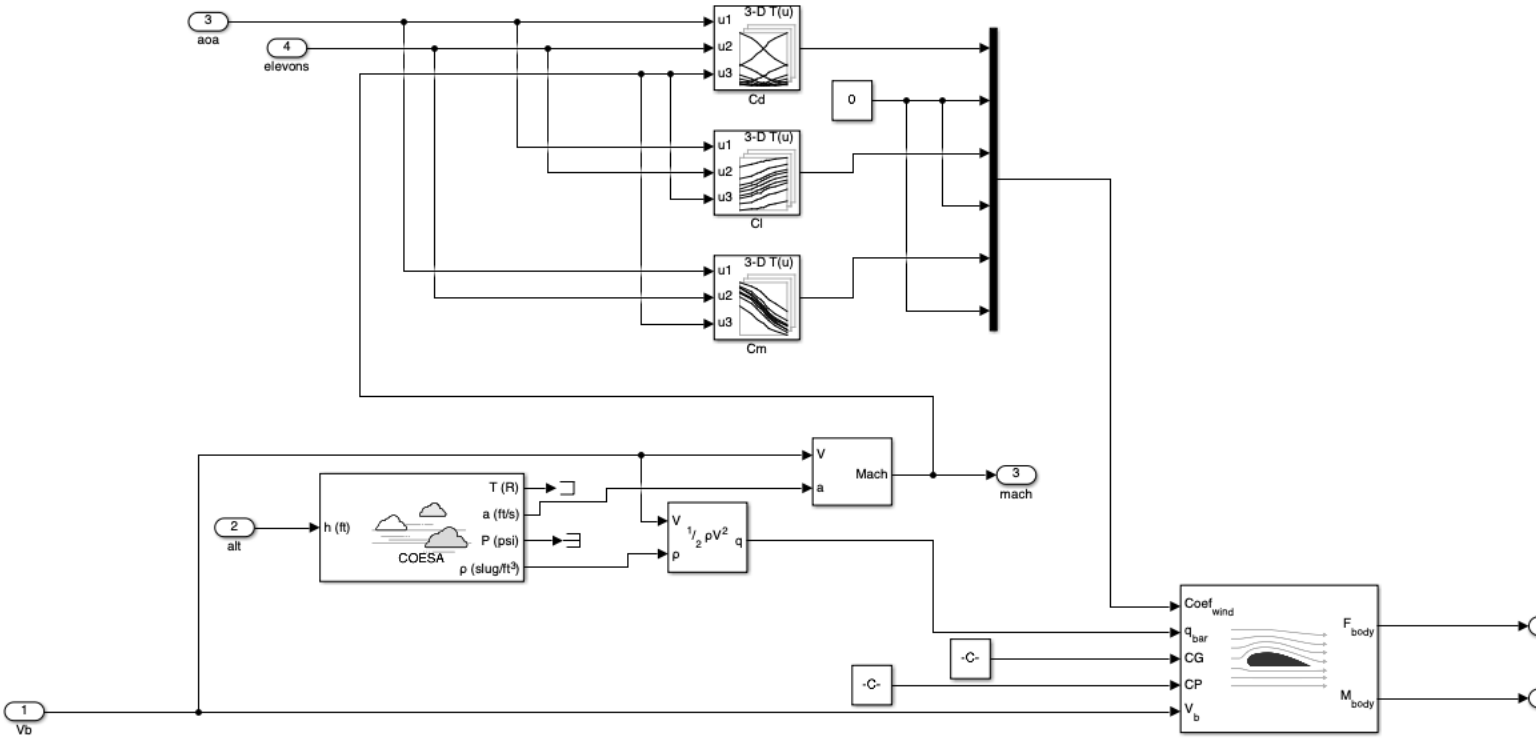
Inside RR_Forces block is the aero and thrust blocks which model the vehicle forces and moments. Inputs are altitude, velocity, angle of attack, elevons and throttle. X force, Z force, Y (pitching) moment, and mach is output in the body axis.

RR Thrust



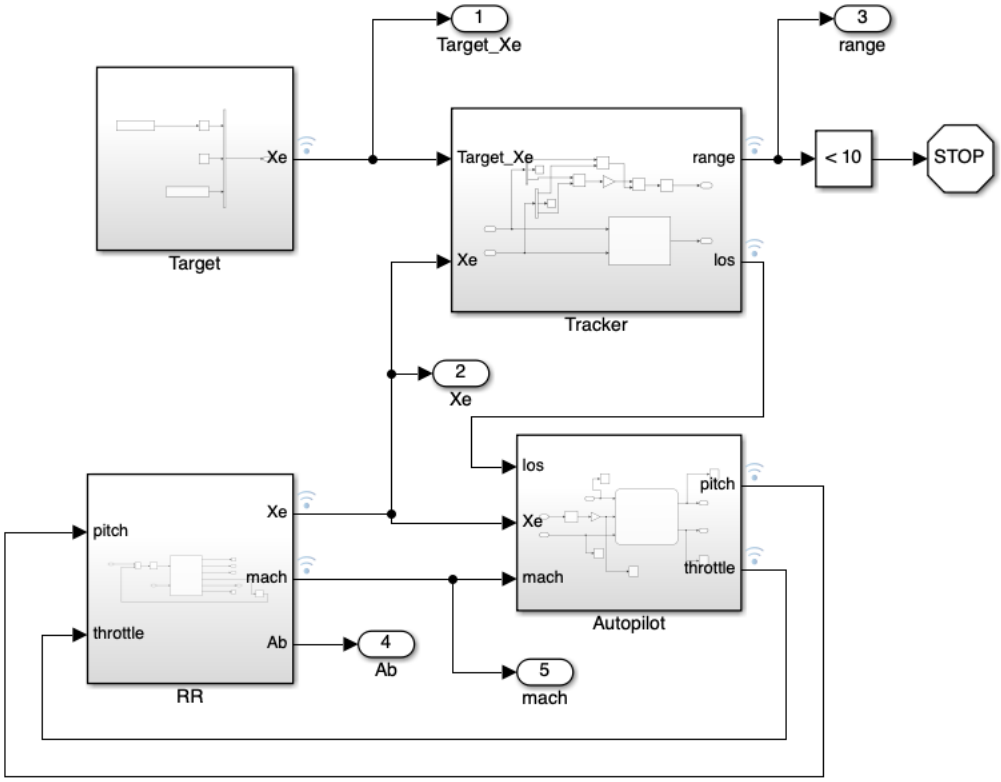
Inside the thrust block the throttle is limited 0 to 1 with a saturation block. The saturation block is connected to a 1D lookup table for motor thrust output. Altitude is connected to a 1D lookup table and thrust derating is selected. The derated thrust forces and zeroed moments are output. If more time was available mass consumption rate would have been output and the zero thrust out of fuel condition added.

RR Aero



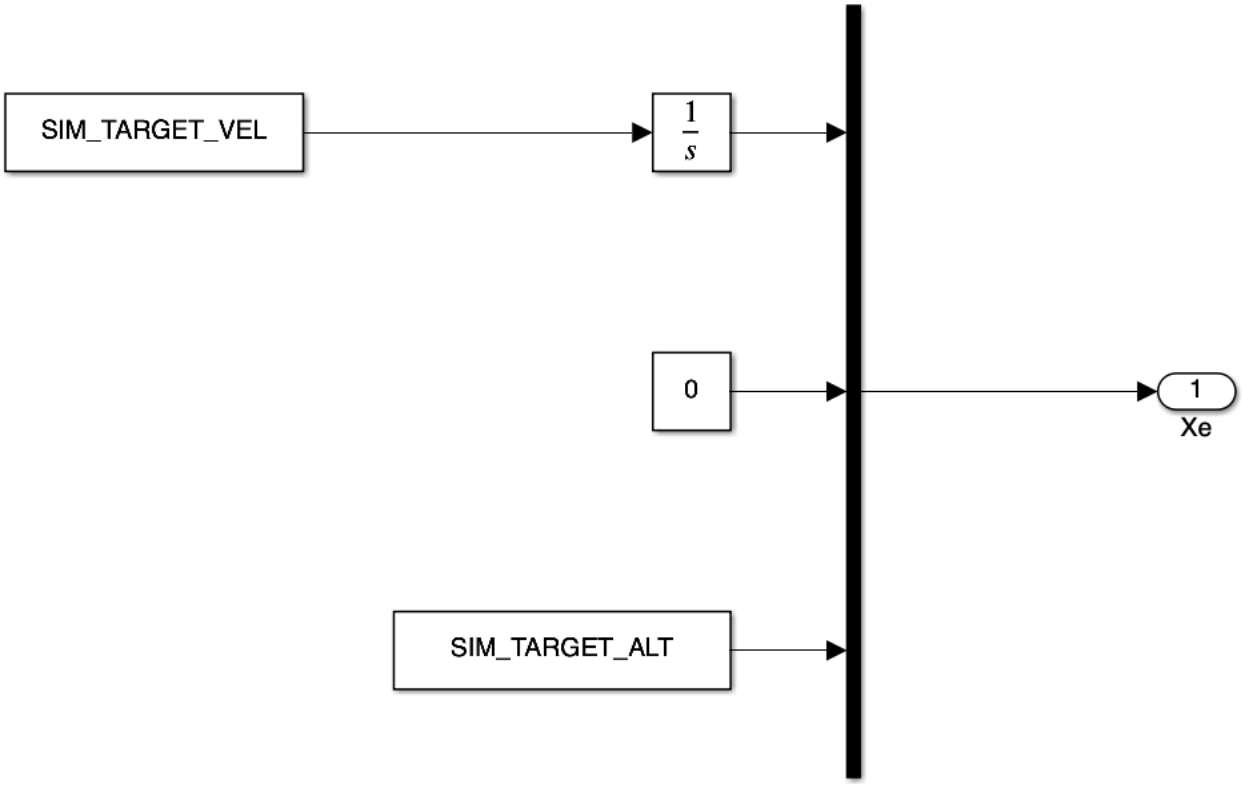
Inside the aero block the angle of attack, elevons position, and mach is used to look up drag, lift, and pitching moment coefficients from the OpenVSP simulation dataset. An atmosphere block, and velocity are fed into a dynamic pressure block. All these inputs are fed into the aerodynamic forces and moments block and the aerodynamic forces and moments are output.

Top Level Target Simulation



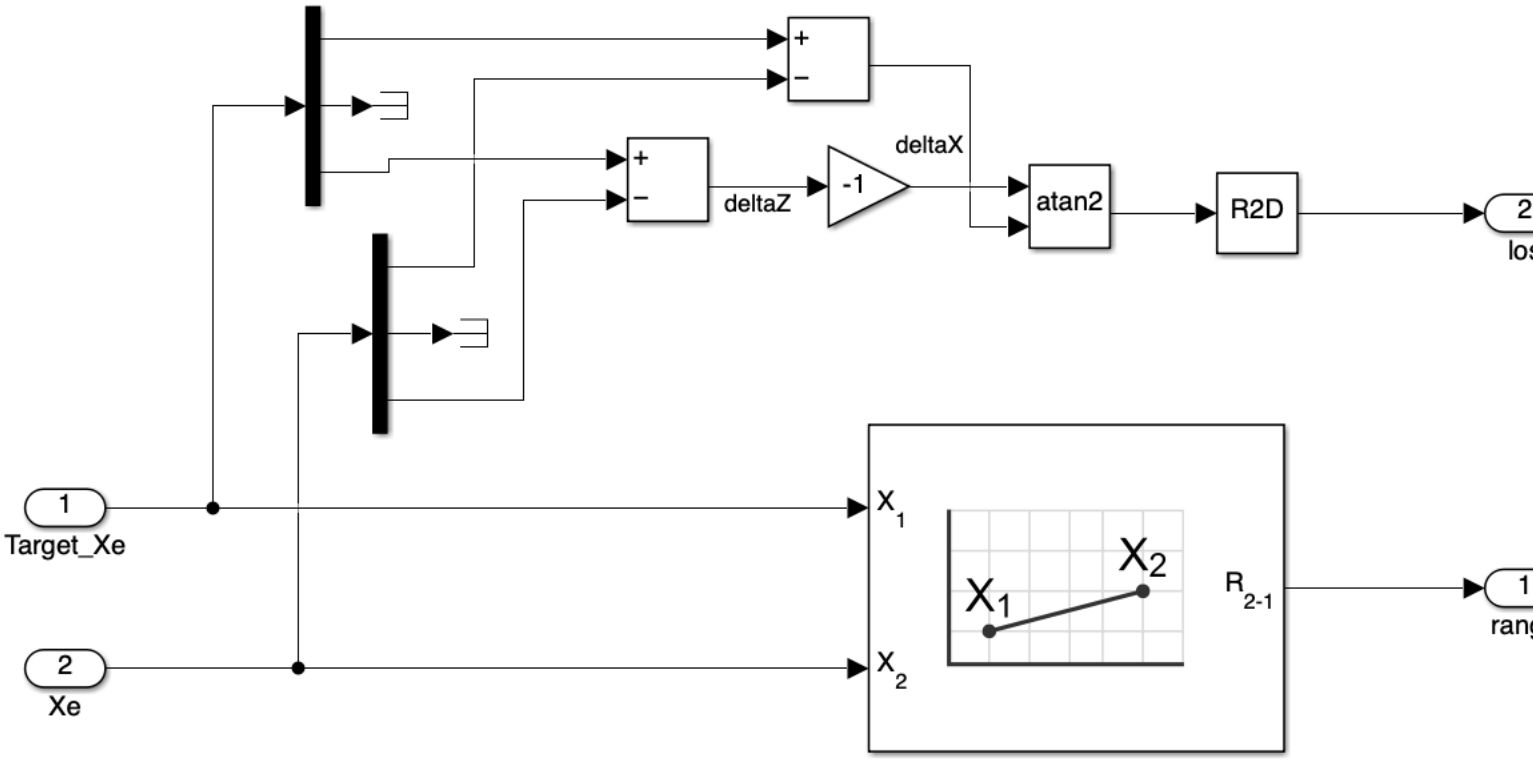
The top-level simulation includes blocks for the RR vehicle and target vehicle. The tracker block calculates the range and line of sight between the RR vehicle and the target vehicle. The autopilot takes the tracking and RR vehicle information and outputs commanded pitch and throttle for the RR vehicle.

Target



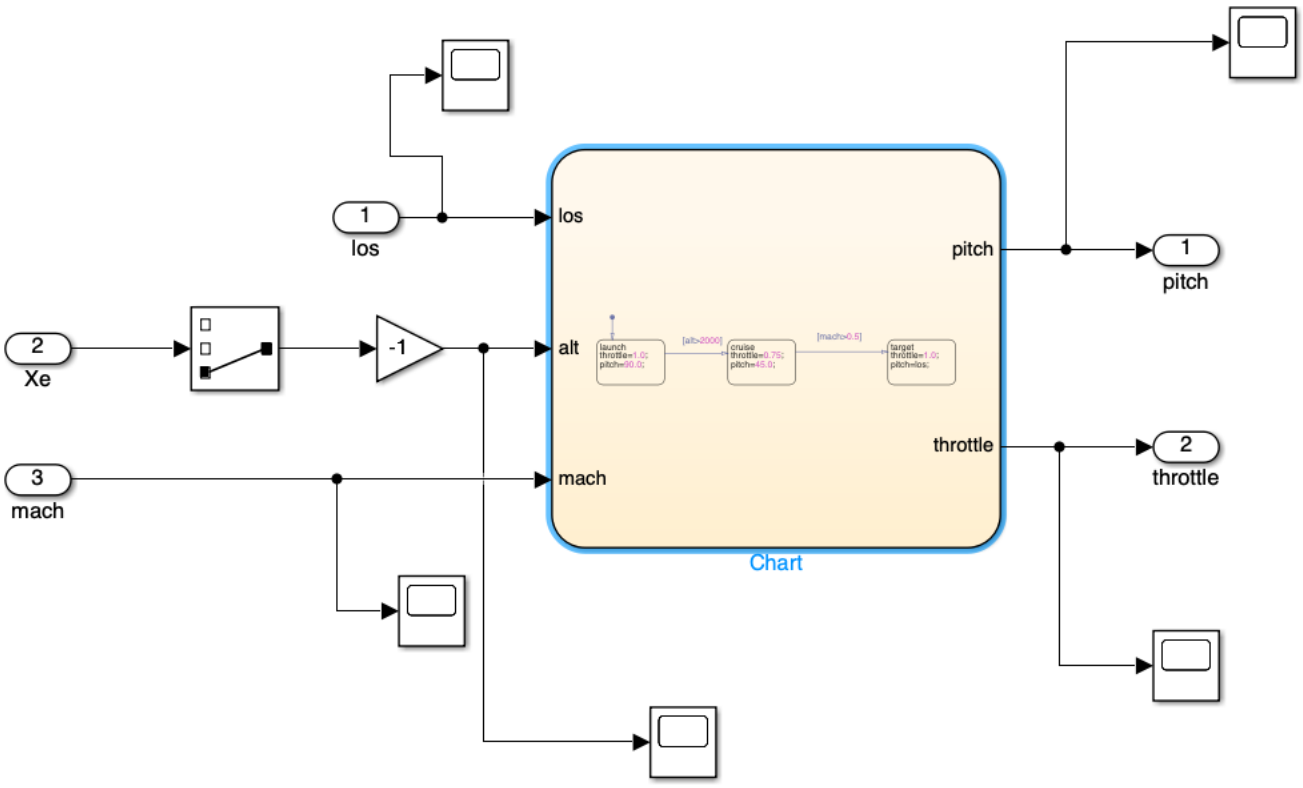
The target vehicle is modeled very simply with velocity and its altitude. An integral block is used to calculate down range position.

Tracker



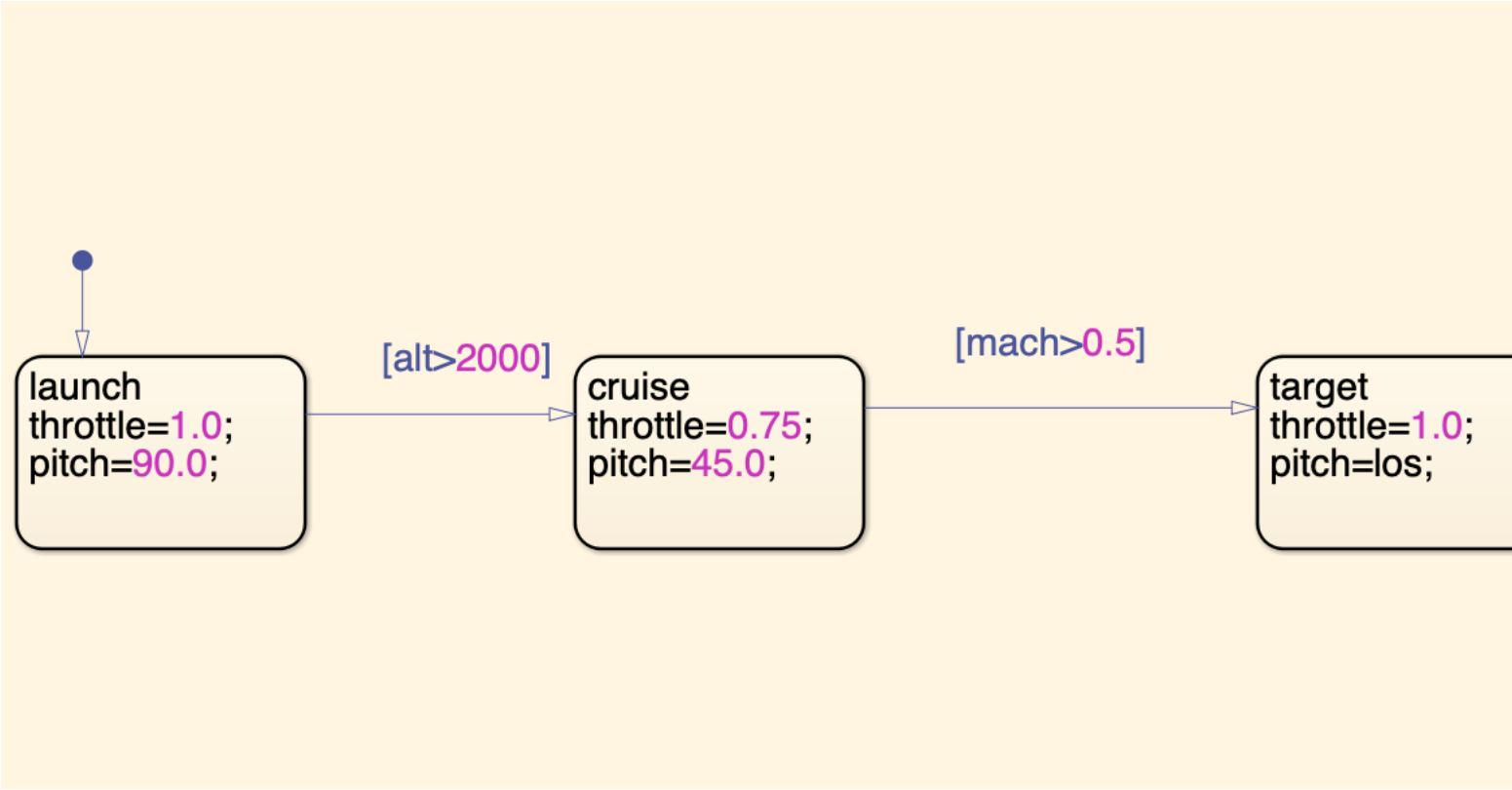
The tracker block takes the vehicle positions as inputs and calculates range and line of sight as outputs.

Autopilot



The autopilot is a very simple state machine.

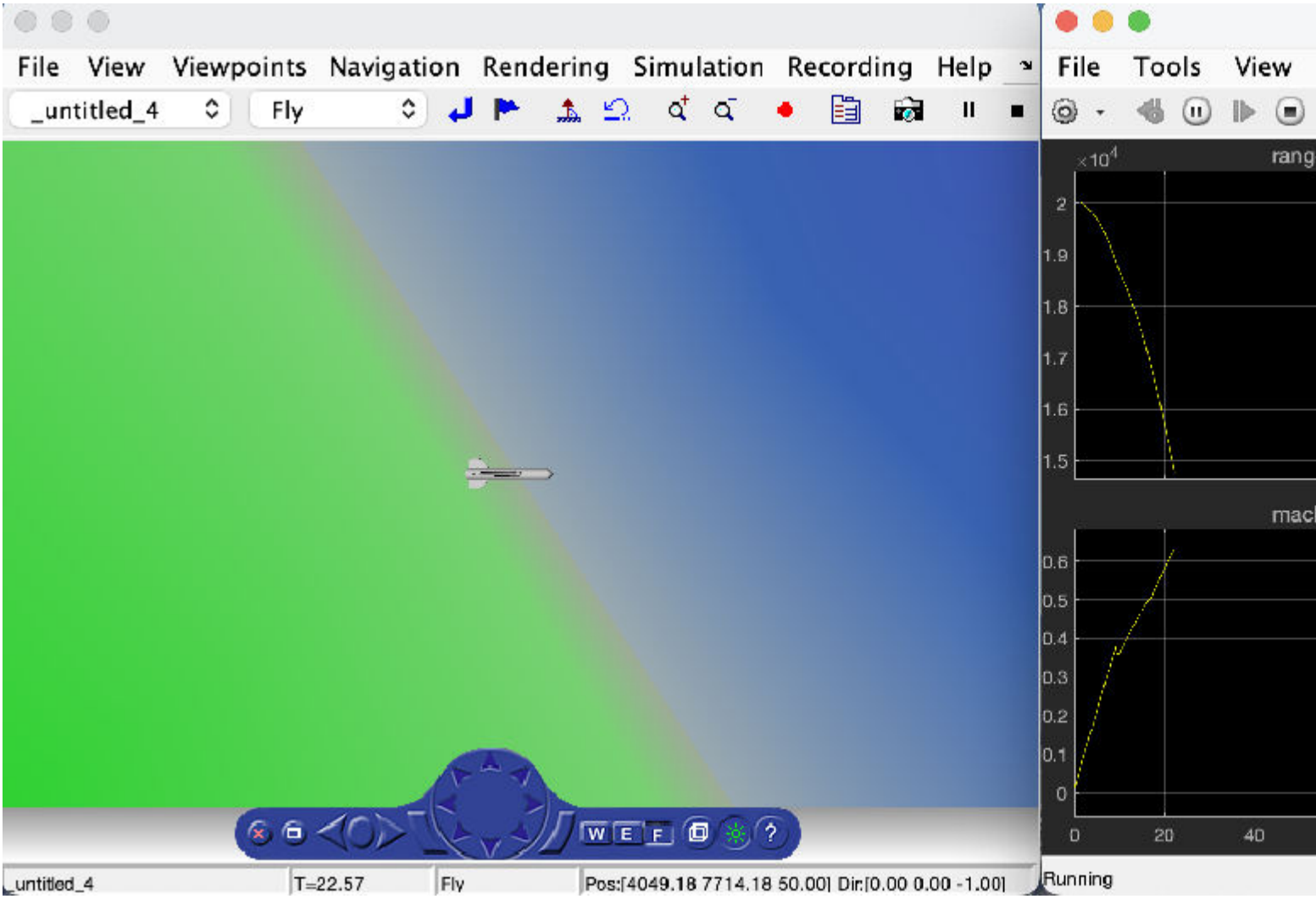
Autopilot State Machine



The autopilot starts in launch mode where the RR vehicle's pitch is set to vertical and full throttle is applied. Once the vehicles altitude is above 2000 feet it switches to cruise mode and it is commanded to a forty five degree climb with three quarters throttle. Once the vehicle speed passes mach 0.5 it switches to target mode where pitch tracks the line of sight to the target and full throttle is applied.

3D Simulation Visualization

A virtual reality output block was used to visualize the simulation, although in the case of such a simple simulation it wasn't much more informative than the simulation output data plots.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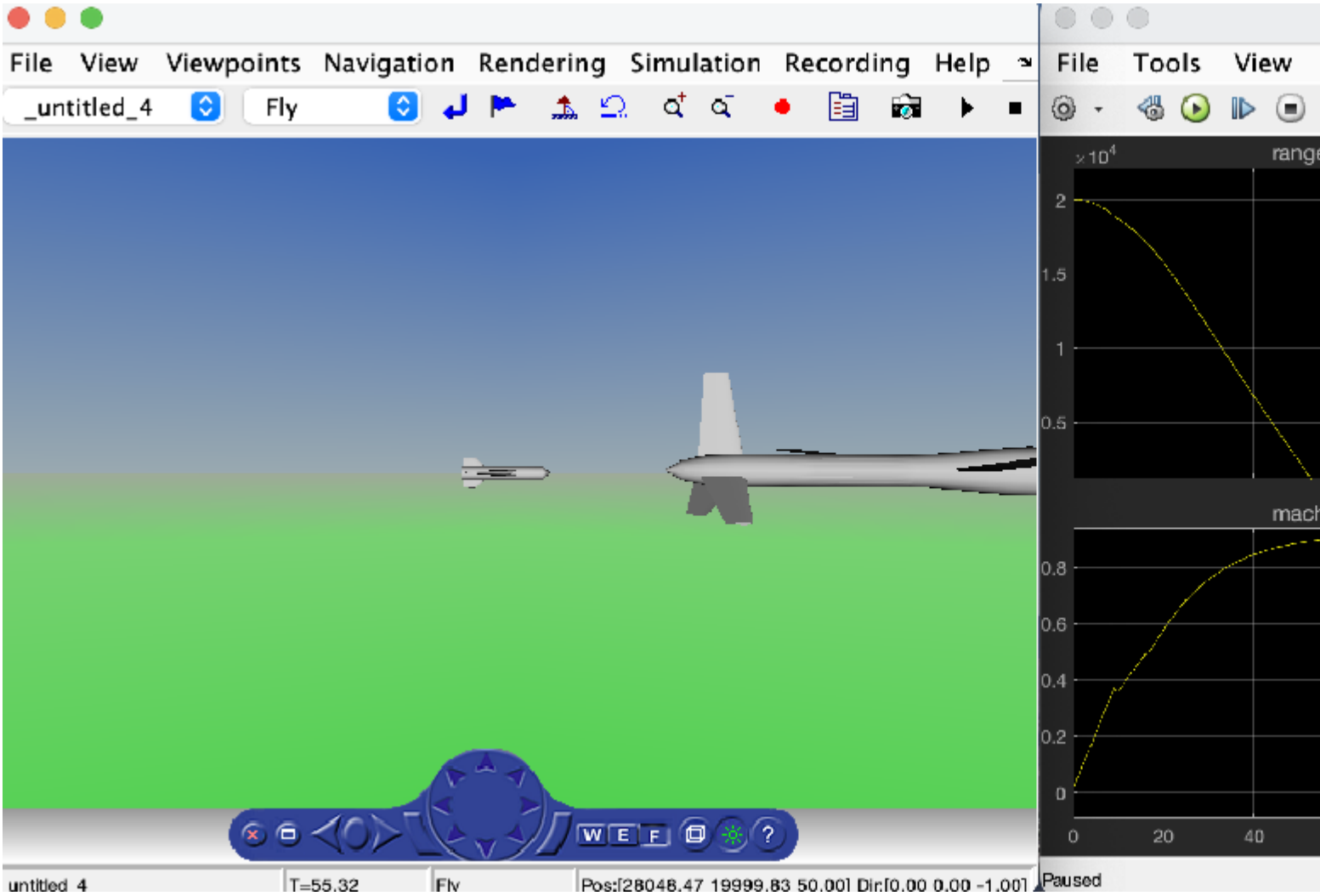
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