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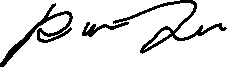
I pledge on my honor that I have not given or received any unauthorized assistance on this project.

As a Boilermaker pursuing academic excellence,

I pledge to be honest and true in all that I do.

Accountable together

We are Purdue.



Course Evaluation Proof

A screenshot of a computer

Description automatically generated

AAE 301 Final Project Technical Report

This Simulink model of longitudinal motion for an aircraft in flight is a cycle generating flight parameters that are used to calculate one another. These flight parameters (velocity (V), angle of attack (alpha), pitch angle (theta), and pitch rate (q), are functions of one another and all the other values in the model, which are initialized as constants given in the project instructions. As a result, the model does not act as a chronological flow chart. Instead, the initial conditions (the initial values of the flight parameters) and the constant values give Simulink a chronological starting point. The simulation calculates all flight parameters for each time step (each 0.01 second starting at 0) until the height requirement for the simulation to keep running (the height must be higher than 0) is no longer met or the time limit runs out (at 500 seconds). The height and horizontal range are functions of all the previously mentioned variables.

For Simulation 1, the model is required to stop when running the aircraft makes contact with the ground (when the height reaches zero). This is accomplished using the STOP function. The STOP function receives the value of the height and is configured to stop the simulation when the height value becomes less than or equal to zero.

For Simulation 2, the model runs until the sample time runs out. The sample time of 500 seconds was judged sufficient from visual inspection of plots to gauge whether the aircraft would eventually achieve horizontal level flight. This was determined by examining the plot of the flight path angle versus time and the plot of the height versus time. The requirements for success were a flight path angle that eventually stayed at 0 and a height that eventually stayed constant. Tests started with values between 1 and 2 degrees.

Initial elevator angles that were too large caused the flight path angle to eventually emerge from oscillation as a negative value and caused the height to eventually emerge from oscillation decreasing linearly over time.

Initial elevator angles that were too low caused the flight path angle to eventually emerge from oscillation as a positive value and caused the height to eventually emerge from oscillation increasingly linearly over time.

The aircraft managed to emerge from oscillation at a continuously level height when the initial elevator angle was 1.592 degrees. The resulting flight path angle was extremely close to 0 degrees. Without a loop to continuously check for better results from elevator angles, getting the exact value of the elevator angle that causes the flight path angle to eventually become zero would have taken too much time. More Simulink training would be required to write the loop to achieve that perfect result.

Although the model does not progress through distinct stages when the simulation is running, I have visually organized it as a progression of stages from left to right for convenience. Each stage is a column of square colored areas.

Each area contains the calculations for a single variable. The given set of constants from the project instructions used for calculating a given variable are initialized within the area that their corresponding variable is in. Any other variables that are being used to calculate the desired variable are routed through the area.

In the first stage, the model calculates the lift coefficient, the drag coefficient, the pitching moment coefficient, and the dynamic pressure.

In the second stage, the model uses the coefficients, the dynamic pressure, , and the reference area to calculate the lift, drag, and pitching moment.

In the third stage:

* The second derivative of the pitch angle with respect to time is calculated and integrated with respect to time to provide the pitch rate q. Then q is integrated with respect to time with an initial condition of 0 to provide the pitch angle as a function of time.
* The mass is initialized as a constant by dividing the weight by the acceleration due to gravity.
* The thrust is initialized as a function of constant values.
* The flight path angle is calculated by subtracting the angle of attack from the pitch angle.
* The acceleration is calculated using the mass, drag, weight, flight path angle, thrust, and angle of attack. The velocity is obtained by integrating the acceleration with respect to time and an initial condition of 100 mph converted to ~146.667 ft/s.
* The first derivative of the angle of attack with respect to time is calculated using the mass, velocity, lift, weight, flight path angle, angle of attack, and pitch rate. This result is integrated with respect to time with an initial condition of zero to obtain the angle of attack.

In the fourth stage, the derivative of the horizontal range with respect to time and the derivative of the height with respect to time are calculated as functions of the velocity and flight path angle.

The derivative of the horizontal range with respect to time is integrated with respect to time with the horizontal range getting an initial condition of 0 to obtain the horizontal range values.

The derivative of the height with respect to time is integrated with respect to time with the height getting an initial condition of 2000 ft to obtain the height values.

All variables to be plotted are sent to the MATLAB workspace as 2-D arrays dependent on time. The time has a step size, or sample time, of 0.01 second.

All files are included in the zipped folder.

Simulation 1 simulated gliding by setting elevator angle to 0 and thrust to 0.

The Simulation 1 files:

Simulink



MATLAB



Simulation 2 simulated flight with an engine output of 100 horsepower.

The Simulation 2 files:

Simulink



MATLAB



Simulation 1

A picture containing water, large, group, man

Description automatically generated

As the aircraft glides down, its velocity oscillates with decreasing amplitude over time until it hits the ground at about 146.741864315256 ft/s.

A close up of a map

Description automatically generated

As the aircraft glides down, its angle of attack rises sharply at first, then oscillates with decreasing amplitude until the aircraft hits the ground at with an angle of attack of about 3.7334 degrees. .A close up of a map

Description automatically generated

As the aircraft glides down, its flight path angle drops sharply before oscillating with decreasing amplitude. The aircraft hits the ground with a flight path angle of about -4.02780560044309 degrees.

A picture containing text, map, skiing, large

Description automatically generated

As the aircraft glides down, its altitude continuously drops with a decreasing oscillation that gives way to a linear decrease in height over time. The aircraft lands after about 194.5 seconds.

Aircraft TrajectoryA close up of a map

Description automatically generatedThe trajectory shows the aircraft’s height oscillating with decreasing amplitude as it continuously decreases with increasing horizontal range. The aircraft lands when it reaches a horizontal range of about 28425.1730573675 ft.

Simulation 2

This was achieved with an elevator angle of 1.592 degrees.

A close up of a map

Description automatically generated

As the aircraft stabilizes and achieves level horizontal flight, its velocity oscillates with decreasing amplitude over time until a constant velocity is achieved at about 182.944084699894 ft/s.

A picture containing bird

Description automatically generated As the aircraft stabilizes and achieves level horizontal flight, its angle of attack oscillates with decreasing amplitude over time until it remains constant at about 0.8248 degrees.

A picture containing large, bird, water, man

Description automatically generated As the aircraft stabilizes and achieves level horizontal flight, its flight path angle oscillates about 0 with decreasing amplitude over time until it remains constant at about 0.000190732354607677 degrees (ideally this would be zero).

A picture containing table, large, bird, water

Description automatically generated As the aircraft stabilizes and achieves level horizontal flight, its altitude oscillates with decreasing amplitude over time until settling at about 1792.76520984832 ft.

Aircraft TrajectoryA picture containing large, table, water, bird

Description automatically generated As the aircraft stabilizes and achieves level horizontal flight, its altitude oscillates with decreasing amplitude over time until settling at about 1793 ft for an indefinite time (in this case, when the simulation ends). While this occurs, the horizontal range increases indefinitely (in this case, until the simulation ends).