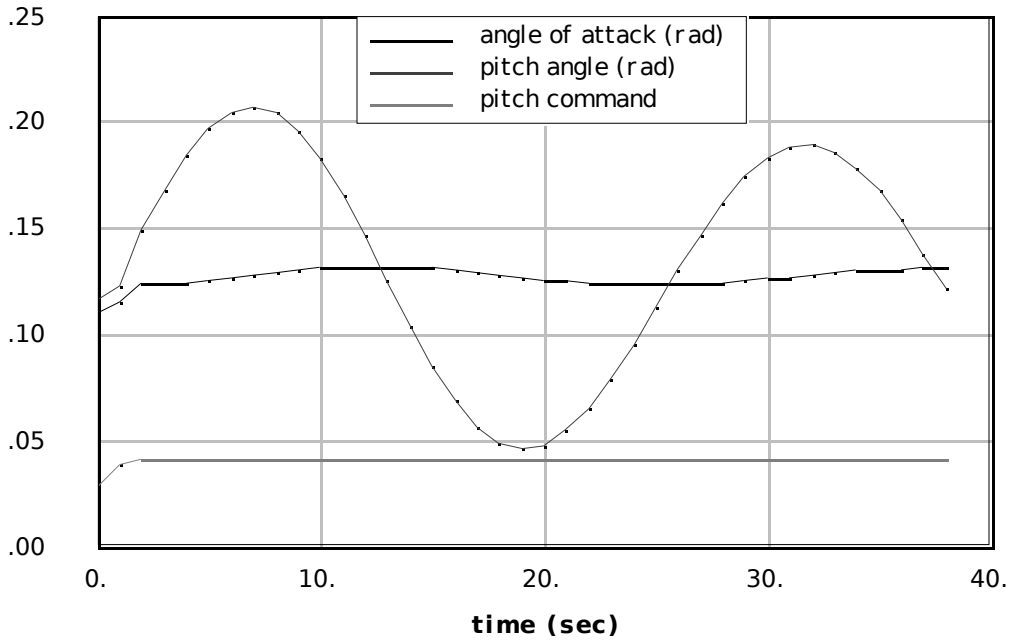
Capturing Dynamic Modes with EFS

Since EFS integrates full 6 degree of freedom equations of motion, several dynamic modes can be observed in the simulation, including phugoid and Dutch roll. Handling quality characteristics such as adverse yaw can also be seen. These motions can be captured using the data recording capabilities of the simulator and saved in a format compatible with many plotting programs. This note describes how to excite and capture a few of these dynamic modes.

Phugoid

The phugoid mode is characterized by very slow oscillations in pitch angle and velocity, and a nearly constant angle of attack. To excite this mode, begin with the airplane trimmed in level flight. Pull back slightly on the stick and maintain, or increase elevator trim. This pitches the airplane up into a climb. As the airplane climbs, it loses speed and lift, causing it to gradually pitch downward and enter a dive. During the dive, the airplane gains speed and lift, bringing it back into a climb.



Cessna 172 Phugoid

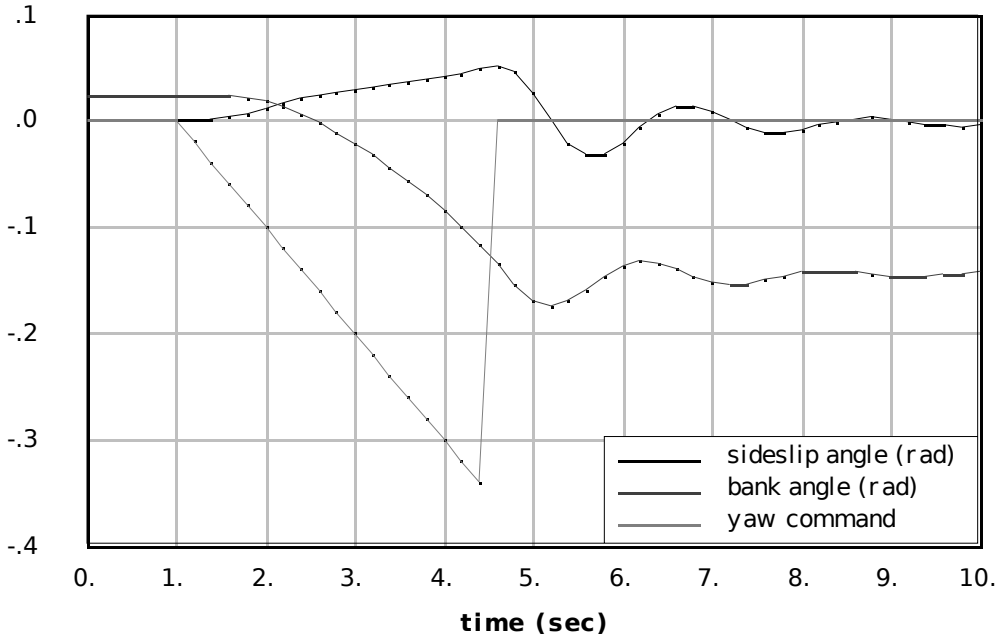
Short Period

The short period mode is usually fast and well damped. It is not noticeable in the Cessna 172 simulation. It is noticeable in a simulation of the F-4 Phantom. This mode is characterized by rapid oscillations in angle of attack about a nearly constant flight path. This mode is probably best excited by rapidly deflecting elevator.

Dutch Roll

The Dutch roll mode is moderately fast side to side swaying of the aircraft. It involves oscillations in bank, yaw, and sideslip angles. In the heads up display, Dutch roll will be indicated by the velocity vector circle oscillating from side to side. In the following plot,

Dutch roll was excited by applying left rudder, left arrow key, and then centering rapidly, left and right arrow keys simultaneously. The yaw command indicates the ratio of actual rudder deflection to the maximum deflection.



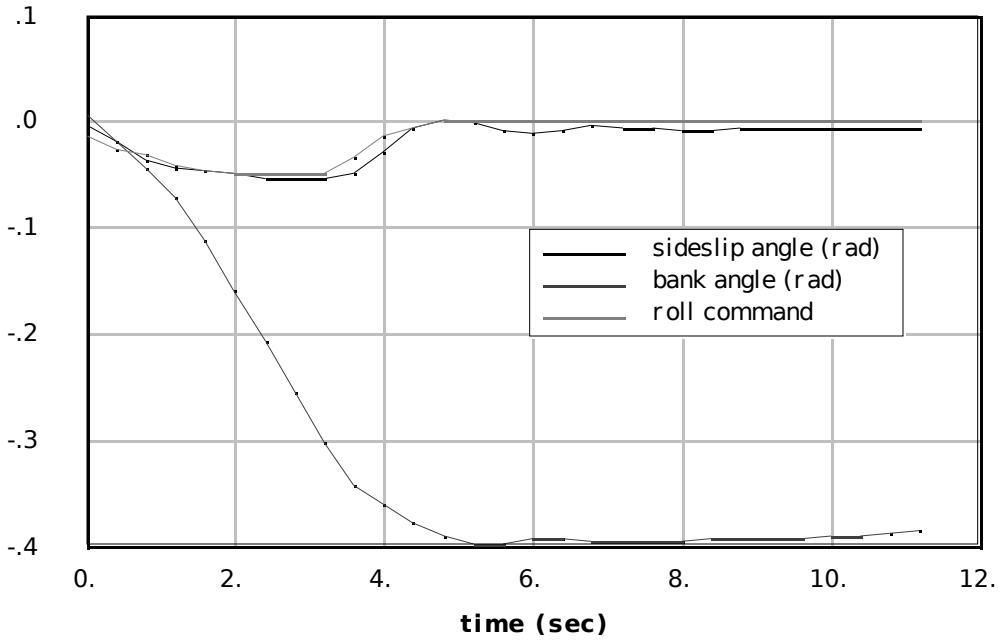
Cessna 172 Dutch Roll

Spiral Mode

The spiral mode is very slow and may be stable or unstable. This mode can be observed by starting the aircraft in straight and level flight and then applying aileron or rudder to bank the airplane slightly. With aileron and rudder set to neutral, the aircraft will either return to level flight, stable spiral mode, or experience increasing bank angle accompanied by a dive, spiral divergence.

Adverse Yaw

Adverse yaw is a handling characteristic that may be experienced when rolling the airplane with aileron. To execute a left turn, the pilot will apply left stick, dropping the right and raising the left aileron. The right wing generates more lift than the left wing, causing the airplane to roll to the left. While carrying extra lift, the right wing is also likely to produce more drag than the left wing. This causes the airplane to yaw to the right, opposite to the intended left turn. In the following figure, a left turn was initiated with aileron only. While the ailerons were deflected, the aircraft yawed to the right, generating a sideslip to the left. On the heads up display, adverse yaw is indicated by the velocity vector circle moving toward the direction of the turn. The nose of the aircraft points to the outside of the turn relative to the actual flight path.



Cessna 172 Adverse Yaw

Recording Dynamic Motion

The dynamic motions plotted in this document were captured with the EFS flight data recorder. To bring up the flight recorder, choose the Recorder option from the Preferences menu. A recorder dialog will appear. This dialog is organized like a double cassette deck with controls for recorder 1 on the left and controls for recorder 2 on the right.

Recorder 1 is constantly on during the simulation, saving all data for about the last minute. This last segment of flight can be replayed by pressing the Play button. The scroll bar permits rewinding and advancing the record. The Save Data button enables you to save data as text for export to plotting programs. A dialog box will appear asking what variables to output. The data is saved in QuickPlot format with the states tabulated in columns against time. You may export the data to programs like Excel by copying the text data in your favorite text editor and then pasting into your spreadsheet. QuickPlot is published by Desktop Aeronautics, P.O. Box 9937, Stanford, CA 94309.

For fast dynamics, it may be useful to clip out a section of the record. The Record toggle permits sections of data to be transferred from recorder 1 onto recorder 2. Advance to the start of the section you want to clip. Clear recorder 2. Toggle Record on, then press Play for recorder 1. When the playback reaches the end of the interesting segment, type Q to return to the recorder. Recorder 2 will contain a short clip of the action from recorder 1. This clip can be played or saved using the right hand Play or Save Data buttons.