Design and Control of Canard Aircraft

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Introduction

Canard aircrafts are aircrafts with a smaller fore wing in front of the main wing. Examples of canard aircraft include the Rutan Long-Ez and the Wright flyer. The project objective is to develop a competent method for designing and developing a canard aircraft and its control system. It also aims to build a better understanding of control canard, and its effects on design decisions and flight characteristics.

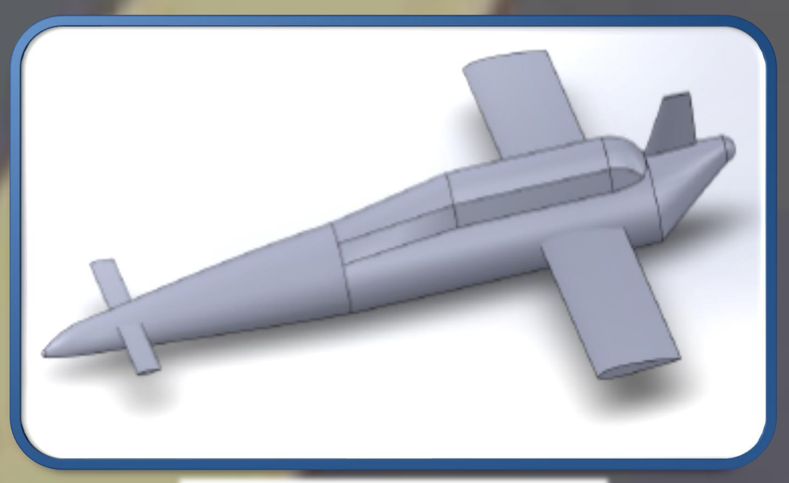
Conceptual Design

The conceptual design begins with analyzing the mission objective. The mission objective chosen is a small passenger transport aircraft. The AASI Jetcruzer is chosen as a reference aircraft to obtain the design requirements as it satisfies the mission objectives. The position of the center of gravity relative to the wings and the aspect ratio are the chosen parameters that dictates the design construction. The position of center of gravity can be determined by a ratio of h/l.

Reference Aircraft AASI Jetcruzer

Design Construction

- The body of the aircraft is constructed using the 3-view drawing of the AASI Jetcruzer.
- The chosen h/l is 0.1, canard aspect ratio is 10 and main aspect ratio is 7.
- The chosen parameters determine the size, shape and position of the wings.
- Winglets are replaced with a rudder for more control surfaces.
- The CAD model with the chosen parameters value is constructed in Solidworks.

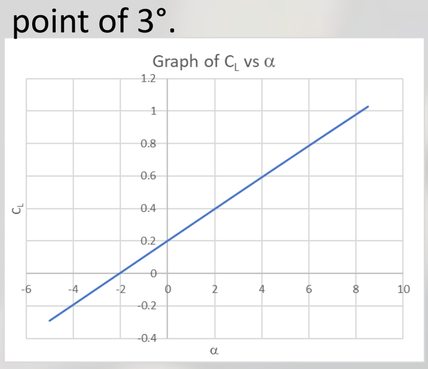


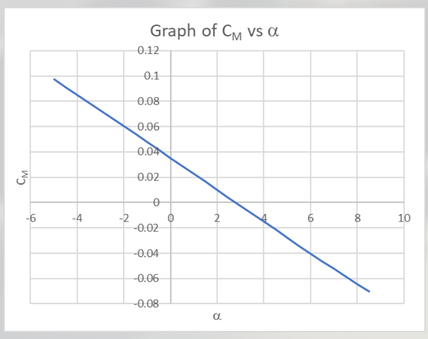
Completed CAD Model

Aircraft Performance Analysis (Xflr5)

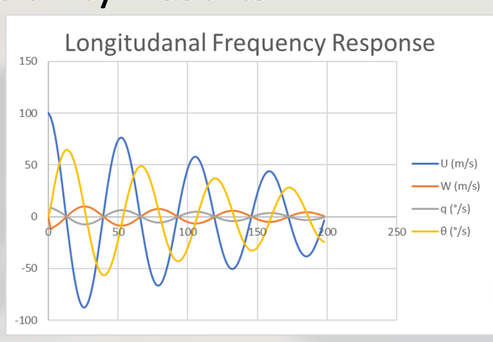
Performance Results

- C_L vs α Graph shows zero-lift angle of -2°.
- C_M vs α Graph shows pitching moment correction and an operating point of 3°.

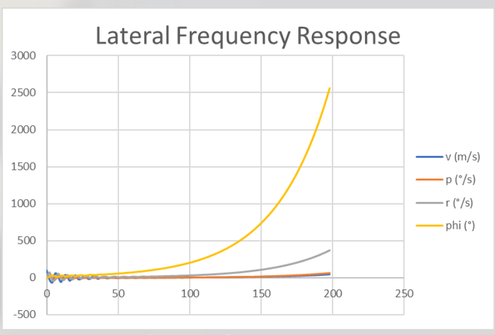




Stability Results



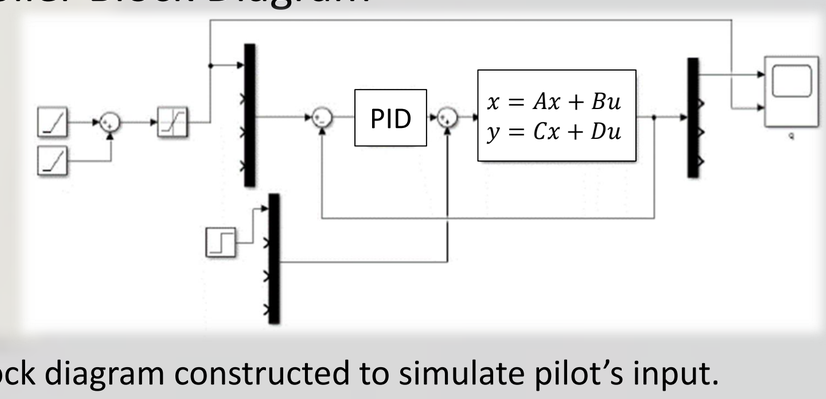
- Longitudinal modes are dynamically stable



- Lateral modes are dynamically unstable
- Spiral mode is not stable

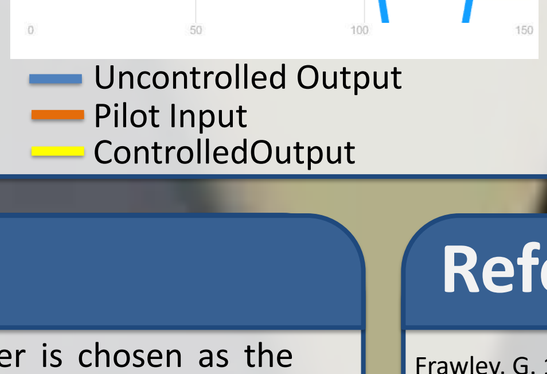
Control System Design (Simulink)

Controller Block Diagram



- Block diagram constructed to simulate pilot's input.
- PID Controller added to reach desired response quickly.
- Step input added to simulate sudden gust.

Controlled Response



- The controlled output closely follows input.
- The gain of the PID is adjusted so that the desired output is obtained.
- The controller corrects the oscillation and overshoot of the system.

Conclusion and Future Work

The mission objective chosen is of a small passenger aircraft. The AASI Jetcruzer is chosen as the reference aircraft. The chosen parameters are h/l is 0.1, canard aspect ratio is 10 and main aspect ratio is 7. The zero-lift angle is −2° and the operating point of the design is 3°. The control block diagram is constructed and a PID controller is introduced to obtain the desired response quickly. The input, desired output and uncontrolled signal is plotted and compared.

Introducing sweep, taper or twist to the main wing can help improve the design. Analysis should be done on a range of different design iterations to obtain the best design. Tuning methods such as the Ziegler-Nichols and the Cohen and Coon can be used to fine tune the PID control gains.

References

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Gudmundsson, Snorri. 2013. APPENDIX C2 : Design of Canard Aircraft. 1–20.

Anderson, Seth B. 1987. A look at handling qualities of canard configurations. Journal of Guidance, Control, and Dynamics, 10(2), 129–138.