Analyzing the Lateral Motion of a Convair 880

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# Introduction

During the 1960s, Convair, a subdivision of General Dynamics, designed the Convair 880, a narrow-body jet airliner designed to be a commercial airliner and a competitor to Boeing’s 707 airliner. Convair claimed the 880 to fly at speeds reaching 880 ft/s with a smaller formfactor than a Boeing 707. Unfortunately, despite its speed, the 880 was not successful in the commercial airline space.

In this project, I will use MATLAB and the Control System Toolbox to analyze the lateral dynamics of the Convair 880 and then use the results to design a feedback control system to improve the 880’s dynamics.

# Methods

## Computing Eigenvalues

I began my analysis of the Convair 880’s lateral dynamics by calculating the aircraft’s lateral motion derivatives using aircraft parameters such as the coefficient of yawing. With the derivatives calculated, I rearranged the lateral equations of motion into their space-state forms:

These equations can be represented as a set of matrices: , , , , & , as shown below:

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Description automatically generated

A close up of text on a white surface

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Entering the values for each matrix, we obtain the following matrices:

The A matrix is known as the lateral stability matrix. By expanding this matrix, we can obtain the respective functions that determine the stability derivatives, mass, & inertia of the aircraft. From these, we find that the A matrix provides us with four eigenvalues: two real roots and a pair of complex roots. The first real root denotes a spiral mode, a motion that is characteristically slow and either diverges or converges. The second real root denotes a rolling mode, a motion that is characteristically quick and only converges. The last roots are the pair of complex roots. These denote an oscillatory motion, known as the Dutch Roll, that is slightly damped and – as a result – is completely convergent.

# Appendix

## Appendix 1 | References

## Appendix 2 | Convair 880 Aircraft & Flight Parameters

|  |  |
| --- | --- |
| Gravity () | 32.17 |
| Altitude () | 35000 |
| Mach Number | 0.8 |
| Ambient Density () | 0.0007382 |
| Speed of Sound () | 973.14 |
| Initial Velocity () | 778.512 |
| Dynamic Pressure Q () | 223.704473 |
| theta\_0 () | 0 |
|  | -0.812 |
|  | -0.177 |
|  | 0.129 |
|  | -0.312 |
|  | -0.011 |
|  | 0.153 |
|  | -0.165 |
|  | -0.05 |
|  | 0.008 |
|  | 0.184 |
|  | 0.019 |
|  | -0.076 |
| Aircraft Weight () | 126000 |
| Aircraft Mass () | 3916.69257 |
| Moment of Inertia () | 115000 |
| Moment of Inertia () | 2450000 |
| Moment of Inertia () | 4070000 |
| Moment of Inertia () | 0 |
| Wing Planform Area () | 2000 |
| Wing Length () | 120 |
| Chord Length () | 18.94 |

## Appendix 3 | Convair 880 Aircraft Stability Derivatives

|  |  |
| --- | --- |
|  | -82.634486993282962 |
|  | -23.343075421831351 |
|  | 8.8703686602959131 |
|  | -11.226092132084871 |
|  | 5.505102872464696 |
|  | -23.343075421831351 |
|  | 8.8703686602959131 |
|  | -11.226092132084871 |
|  | 5.505102872464696 |
|  | -0.10614414035144347 |
|  | -0.10614414035144347 |
|  | 1.7016929920534056 |
|  | 0.10553134834439726 |
|  | -1.0025478092717739 |
|  | -0.011183303839135137 |
|  | -0.16774955758702706 |
|  | 0.10553134834439726 |
|  | -1.0025478092717739 |
|  | -0.011183303839135137 |
|  | -0.16774955758702706 |
|  | 0.0021858275685582309 |
|  | 0.0021858275685582309 |
|  | -92.75582835660181 |
|  | 0 |
|  | 21.018562090658534 |
|  | 0 |
|  | 0 |
|  | -0.11914502070180268 |