

FDA - CAD

FLIGHT DYNAMICS ANALYSIS – CONTROL AUGMENTATION DESIGN

Introduction

FDA-CAD is an interactive computer program designed to support the post graduate lecture courses *Flight Dynamics Principles* and *Flying Qualities and Flight Control* taught by the author in the School of Engineering at Cranfield University. The program has been developed in a piecemeal fashion by the author's students as MSc thesis projects over a period of about 15 years. The program is written in MATLAB and provides an easy to use tool for linear flight dynamics analysis, command and stability augmentation system design and handling qualities assessment. Version 3.01 of FDA-CAD is a slimmed down version of the program, tailored to support the third edition of *Flight Dynamics Principles*^[6], and is offered as a free download from the publishers web site to purchasers of the book.

History

First attempts at developing a set of computer software tools to support the courses in flight dynamics were made by Cruciani^[1], Sverkmo^[2] and Oakley^[3]. These were made at a time before MATLAB had become fully established locally as the software of choice for studies in flight dynamics. However, these early studies provided some ground rules for the design of relevant computational algorithms and set out the ideas for subsequent studies.

The first study to embrace fully the computational facilities of MATLAB was made by Spathopoulos^[4], and his work established the algorithms required for the routine solution and analysis of the linear equations of motion of an aircraft. This suite of software tools became the foundation for the subsequent development of FDA-CAD.

Some years later, the continuing development of MATLAB and the introduction of Graphical User Interface (GUI) tools opened up the possibility for an altogether more ambitious attempt at writing a software tool for flight dynamics analysis. Accordingly, Rees^[4] produced the first version of FDA-CAD. This was an exceptionally complex task and in the limited time available for the project, he established a framework for, and the basic functionality of the program, building on the work of Spathopoulos^[3].

From a satisfactory beginning, it was soon recognised that the first version of FDA-CAD had a few minor errors and imperfections, and that its scope could be expanded. A major revision and further development of Rees' program^[5] was undertaken by Siliverdis^[6], to result in version two of FDA-CAD. All of the known errors were corrected (and replaced with a few different errors!) and the functionality was expanded to include additional tools for stability augmentation design and analysis, and handling qualities assessment. Again, project time constraints prevented a complete development of the more advanced additions.

FDA-CAD Version 1.0

Written by Shane Rees^[5]. The user is presented with two GUI screens, an opening screen on which the basic analysis requirement can be selected – selection then opens the second screen configured either for longitudinal analysis or lateral-directional analysis. Access to stability augmentation design functions and some limited handling qualities

assessment is also made from either of these two screens. Interactive analysis then involves opening a variety of figure windows to show the results of the computations selected. Tools are included for entering and saving aircraft data, outputting the results of the computations and facilities for recording a variety of graphical plots. The program is personalised by Rees, who at the time was member of the Royal Australian Air Force, and the opening screen includes attractive aircraft imagery promoting the RAAF. Also, a distinctive feature of the GUI screens is the prominent display of a large button sporting the obsolete Cranfield College of Aeronautics logo.

FDA-CAD Version 2.0

Written by Konstantinos Siliverdis^[6]. This version of FDA-CAD builds on the first version developed by Rees^[4]. The basic functionality and structure remains unchanged and most of the computational routines are retained with only minor changes. The general appearance of the program is therefore very similar. The main structural difference concerns the way in which the analysis screens are presented. The user is now presented with an opening screen, transferring to a basic aircraft analysis screen, transferring to a stability augmentation screen, transferring to a handling qualities assessment screen. Each screen has been developed as a separate GUI, which simplifies the callback structure to a certain extent. Unfortunately, the handling qualities screen, which includes considerable complexity of choice has not been developed sufficient for reliable general utilisation. A central feature of the design is that the user can step back and forth between screens during the process of analysis or design. Again, the program has been personalised to reflect Siliverdis' affiliation, and in this instance the opening screen depicts attractive images of the F-16 aircraft as operated by the Hellenic Air Force.

FDA-CAD Version 3.0

Developed by the author by significantly editing version two to match the computational requirement of the book *Flight Dynamics Principles*^[7]. The main changes include removal of the handling qualities assessment screen and supporting functionality, replacement of the personalised opening screen, correction of computational errors, correction of functional 'bugs' and general refinement of the GUI screens. The general appearance of the screens remains as originally designed by Rees^[4] as these have been shown to be more than adequate for the task.

System Requirements

FDA-CAD v3.01 was developed on a laptop computer having the following specification:-

- Intel Pentium III processor.
- 512 MB RAM.
- Screen resolution 1024x768 pixels
- Screen physical size 12x9 inches (305x229mm)
- MS Windows XP

- MATLAB v7.0.4 with Service Pack 2
- MATLAB Control Systems Toolbox v6.2

Disclaimer

The original development of the software was intended as an exercise for students to demonstrate their ability to utilise computational tools for application to flight dynamics analysis problems. The contributing students were free to make and justify their own design choices during the course of the software writing process. It has not been

developed to professional standards and it is offered on the understanding that its performance, accuracy, suitability and reliability are not guaranteed. The user is therefore advised to confirm the plausibility of results obtained with FDA-CAD by standard flight dynamics analysis methods. FDA-CAD is sufficient to demonstrate the computational solution of many of the examples described in *Flight Dynamics Principles*^[6], but it is the responsibility of the user to establish the suitability of the software for other applications.

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The opening screen image is reproduced from the cover of *Flight Dynamics Principles*^[6], the copyright is owned by BAE Systems who kindly provided the image and permission to use it for this publishing project.

Bibliography

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Michael V Cook
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