Flight Simulation As An Aid To Advanced Project Design

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Abstract: The University of New South Wales aerospace engineering group maintains an advanced project capability that results in the project design of up to six aircraft per year. This not only acts as an educational tool, but also maintains a skill base that is utilized by the industry, defense organizations and regulators. We have recently incorporated flight simulation into this design process at an early stage of the projects. Almost as soon as the very basic parameters are defined and an initial shape generated in the design software 'CATIA', a model is built in the simulation software 'X-PLANE'. This allows the development of the flight characteristics to be monitored as the design progresses. It also allows engineering solutions to be compared and their effect on the flight characteristics explored. For example the engine size or elevator size can be modified on the model producing an instant measure of flight profile effects. We are still in the process of applying flight simulation to advanced project design. The results to date are promising and we would expect further improvements as the technology advances.

1. INTRODUCTION

Advanced project design within the aerospace industry is a unique and poorly understood area of activity. Unlike, other areas within the aerospace design activity its objective, for the main part, is not to lead to a product. Few if any of the projects undertaken by advanced project designers follow on to become the basis for actual aircraft yet the area is vital to the industry, for a number of reasons. Below are some:

1.1 Yard-sticking current product against current technology

Any existing aerospace vehicle is locked in the technology of the period, when it was designed and developed. As the technology advances, there becomes a point at which simply upgrading an existing vehicle is not viable and a new design is warranted. The advanced project design team is charged with identifying this point by carrying out studies of what might be the characteristics of a vehicle designed to cover and extend the missions of the current vehicle using the latest and developing technology. This process also identifies areas of existing vehicles that it might be economic to dedicate resource to extend their viable life.

1.2 Intelligence generation

From both a manufacturer and a customer, military or civil, it is important not only to be aware of a rivals current capability but also how this capability is likely to develop. In this case the advance project team attempts to reverse design others product and then apply current technology to enhance its capability.

1.3 Research area identification

In the process of carrying out an advanced project design those areas of technology that are limiting progress are easily identified. This can therefore be used to determine how research resource should be allocated.

1.3 Identification of design drivers

When projecting a future aerospace vehicle it is possible to identify design deliverables that would be vital to its success. This can be used as a basis for controlling the design of an actual vehicle.

1.4 False information

By selectively releasing material produced from advanced project design, it is possible to unnerve a commercial or military rival. Though they may suspect one has no intention of progressing from an advanced project design to a concept design they may never-the-less feel compelled to redirect resource to cover the possibility.

Most advanced project teams are imbedded within aerospace manufacturing companies and the information they generate has the highest level of security attached to it. This puts smaller companies and less well resourced defense organizations at a disadvantage. To address this we have carried out advanced project studies at the University of New South Wales over a number of years providing information, with varies levels of confidentiality, to those requiring it. We currently carry out up to six studies per year depending on the resources available, most of the work being carried out by under and post graduates.

2. BEHAVIOUR PREDICTION

To have value an advanced project study has two main requirements, to identify and find solutions to technical problems and offer a degree of certainty that operational requirements can be achieved. Essential to the later of these is predicting how the vehicle will behave in flight. This is extremely difficult to achieve using a standard approach, which is based on predicting the behavior at a number of points and extrapolating. The variables that determine the inflight behavior of an aircraft are numerous and the associated equations to a great extent non-linear thus making the predicted values few in number and of low reliability.

The other difficulty this raises is selecting the values of the variables. Should one choose the worst case, leading to an over design, a best case, leading to a high level of probability that the required characteristics will not be met or some point between. If some case other than the best or worst case is selected on what basis should it be selected?

The solution that we have selected is to use simulation from an early stage of the project design. Although simulation [1], [2], [3] is not new in aerospace or branches of engineering, a direct application of flight simulation to advanced project studies appears to be new. And as far as we are aware no documented material on this subject is available in the open literature.

We believe flight simulation can be used as aid in advanced project studies, the driving variables can be adjusted to mold the aircraft behavior targeted and in turn the vehicle design can be modified to generate the required variables. The flight simulation also identifies design targets that can then be examined. Once a fairly sophisticated design stage is reached the driving variables can be varied according to their statistical distribution to determine the ruggedness of the flight behavior, though this capability is still under development.

3. METHODOLOGY

The basic approach as to how we have incorporated flight simulation within the advanced project design studies in aerospace engineering is outlined in the following subsections below. We have broken down the process into six stages and described them accordingly.

Stage 1

As soon as the vehicle is crudely defined a virtual model of it is constructed within CATIA which is a high level computer aided design package, developed by Desault Systems and used by all major aircraft manufacturers.. This model is used to generate the initial X-PLANE model. X-Plane is a commercial flight simulation program produced by Laminar Systems, The advantage of using X-Plane, as against one of the other three systems we use, is that it is easy to build a unique vehicle within it, and of course modify the vehicle. Many of the parameters required by X-PLANE are unavailable at this stage and are estimated using values from similar vehicles, either from the X-PLANE library of from models we have previously generated. A virtual flight test program is established at this stage aimed at exploring the flight characteristics essential for the success of the study.

Stage 2

As the design develops each modification is incorporated into the CATIA model which is used to update the X-PLANE model. For example, when the fuel tanks are located, they modify the moment of inertia values calculated by CATIA which in turn when incorporated in X-PLANE change rate of roll etc. There is also a feedback associated with this process, where for example the change of moment of inertia in roll might lead to an increase in aileron size as determined by X-PLANE studies, which would then be incorporated in the CATIA model. After each significant modification the virtual flight test program is re-run to determine whether the flight characteristics have moved closer to the desired characteristics.

Stage 3

When the physical shape of the aircraft is sufficiently defined CATIA is used to generate machine code for a three or five axis milling machine. This is used to generate a physical model for wind-tunnel testing. The results of the wind tunnel test are compared with similar results generated by X-PLANE to ensure the reliability of the simulation.

Stage 4

The X-PLANE model is now utilised as a test bed to examine the effect of any changes and whether they are advantageous. For example the projected vehicle might have a different engine installation fitted and the effect of this examined in a typical mission. This would generate a whole number of parameters such as take-off distance, maneuverability, fuel consumption etc. It could then be determined whether the change was justified.

Stage 5

The final projected aircraft X-PLANE model is used to in a range of ways from determining flight deck requirements to operations outside weather minimums. Typical flight scenarios are also produced at this stage for presentation to our industry based master class who help evaluate our activity.

For the sake of illustration, below two figures (Figs 1 and 2) are produced from a recently completed advanced project design. Barra-Gi was the name given to the aircraft examined during this project. This is a high wing, light sports aircraft. Interesting structural features examined consisted, for example, of extremely large and unobstructed door compared with most other aircraft in this category for easy access, large windows for a good all-round visibility and a steel framed fuselage to provide a rugged structure while its wings were made of aluminum alloy.

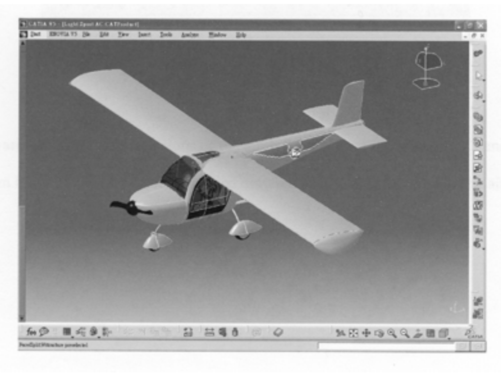

Figure.1: CATIA model of Barra-Gi

Figure.2 : Barra-Gi performing a crosswind circuit join using X-PLANE

4. CONCLUSION

Imbedding simulation into the aerospace advanced project design is a new process at the university, and judging from the interest from other universities and industry, our approach is unique.

We started the process in 2005 but the first full commitment was in 2006. We are still in the process of developing the tools and identifying how to maximize the advantages that can be gained. One of the main areas of interest being the transfer of data between CATIA and X-Plane, which we would like eventually to make automatic. That would mean any change in either the design model or the simulation model would update the other.

We are hoping to extend this capability into other sections of the school. In particular, we are also investigating the incorporation of simulation at an early stage of mechanical design and factory and plant design.

We hope eventually to incorporate simulation through the whole design practice. So that aircraft manufacturing simulations would be run alongside flight simulation the insights gained from both being fed back to the design team.

We are also developing the capability of extracting flight loads from the X-Plane model. These are then sent via CATIA to MSC Nastran for structural finite element analysis. This will be particularly valuable in the determination of cyclic loads and thus fatigue damage prediction both for life prediction and structural element modification.

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