OPTIMISATION OF THE DEVELOPMENT PROCESS FOR LIGHT AIRCRAFT

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Abstract

The development of a light aircraft can be an extremely costly, lengthy and risky endeavor. The market can change significantly during the time it takes to bring a design to market using traditional methods. This paper describes a development process and tools, which enable a faster time to market, lower overall investment and achievement of a more robust design. Examples are provided of how this development strategy is being implemented at Pilatus Aircraft in Switzerland on its latest designs.

1 The Problem

The development of an aircraft is an extremely costly, lengthy and risky business. A "clean sheet of paper" design has typically taken between five and seven years to bring to market. This is an enormous burden on a small company. The figure below demonstrates a typical return on investment curve for this industry, where cash flow is only positive after 10 years and a repayment of the development costs of a project launched today will only be realised in 14 years, assuming first deliveries seven years after project start. By the time the design is mature and profits can be gained, the design will be considered antiquated and the market could easily move towards another supplier. Even this assumes that there has not been a radical change in the market trends in the intervening years, due to newer technologies becoming available, changing regulations, changes in acquisition trends or increased competition.

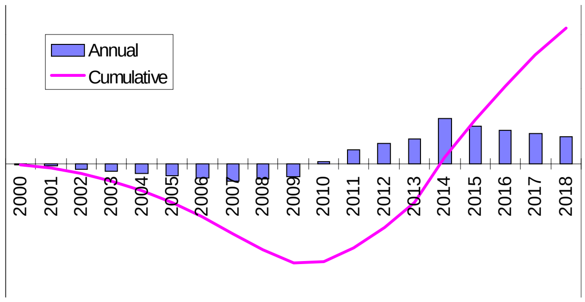

Fig 1. R&D Investment Returns

So, even assuming that the marketeers have got their predictions correct and that the market is prepared to wait almost a decade for this design, the prospects are still not very attractive to any investor.

The technical risk has to be added to this market risk: The development of a new aircraft will incorporate a large quantity of technologies, some of which will be critical to the success of the design, many of which may be on the "critical path" of the development timescales and spending. New suppliers will come together for the first time on such a project. Possibly not all of these will interact optimally and some could even produce unsatisfactory performance.

An enormous capital investment is accumulated towards the end of the development process. Any of the above problems could lead to delays in completing the design and achieving certification. The cost of a delay can easily exceed 1% of the total R&D expenditure for every month of delay (and even more if penalty clauses are involved). For a development cost of possibly between 100 and 300 million US dollars, these are large sums of money.

On the other hand, in an effort to contain these costs, a product can be delivered prematurely, before it is sufficiently mature. Rapid entry into service can result in very expensive modifications of the fleet to correct problems experienced in operation. Even if these costs can be sustained, the loss of reputation can result in a critical loss of market share.

Once the product is introduced, there is often a campaign to reduce the production costs and the bill of material, to make the aircraft more competitive, to earn a better return or as a reaction to a competitor's aggressive price reduction. The likelihood of success of such a campaign is small, as the fundamental cost of the aircraft is decided very early in the design process. The improvements in the manufacturing process and systems integration can be significant, but only a fraction of what could be achieved by a design which concentrates on this aspect early in the development cycle.

2 The Solution

The keys to a solution must be to accelerate the design process (time to market) and to achieve a more robust and mature design. We provide some guidelines below:

Let us examine the typical design process of a General Aviation aircraft. First the aerodynamic shape is defined. This allows the structures group to start their design process. The systems team and suppliers selection usually takes longer until they can get their criteria established and components sized. When they are ready to request component placement and the routing of air ducts, cables, pipes, etc, the structures team has already optimised those areas without these considerations. The first iteration of the design begins! Similarly, experience gained in building a mock-up and testing systems in environmental chambers or on a bench test, usually result in further modifications. Finally, the design can easily get considerably modified by experiences in the flight test campaign. Figure 2 illustrates these iterative loops. (A further potential iteration is not included but happens in some designs where production tooling is not used for the prototype aircraft. Unpleasant surprises can be experienced on the first production aircraft in these cases!)

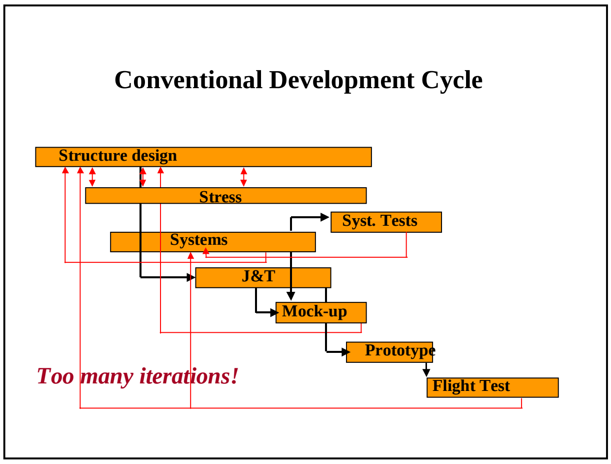

Fig 2. Iterations in the development process

So, how can we speed up whole R&D process?

The first step is to use fully the Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) tools that are available today. Investment in these tools, even though they are relatively expensive, pays for itself immediately. This allows trade studies to be conducted and components to be moved to suitable places. Maintenance aspects and pilot vision can also be simulated without problem. Consequential utilisation of these tools allows the step of the metal mock-up to be completely eliminated. This eliminates a complete iterative cycle and allows problems to be identified and cured at an early stage of the design. Encourage suppliers to provide models of their components to be incorporated into the design.

Simulation tools should be implemented wherever possible. Understanding the mathematics of systems and structures performance is the key to achieving a robust design.

Focus the limited resources towards achieving the programme goals. Any task which diverts from this main-stream approach should be examined for its value.

Spend more money in understanding the design and processes in the early stages of the design, rather than spending more money in the latter stages of the project in an attempt to recover a failure to achieve one or more of the primary goals.

Eliminate lengthy and unnecessary processes such as the building of a mock-up to verify a design that can be assessed in a computer simulation, or building a prototype that is not representative in areas which are critical for the test objective.

Form integrated teams which are capable of conducting concurrent engineering. These should include all disciplines of engineering as well as production engineering, jig & tool design and purchasing. Try to include also the local airworthiness authority and customer representatives.

Utilise risk reduction techniques on technologies which could be disruptive to the development process. Examples are parallel path development, strategic outsourcing and development testing.

3 Examples

The following examples illustrate how Pilatus Aircraft has implemented these principles to accelerate its design process:

Figure 3 shows how digital mock-up techniques are utilised to develop the structure of the aircraft and to evaluate systems integration and maintenance issues. In a recent development a conflict was found between a digital model of an engine and the mounting frame designed to accept it. The modification cost one day of a designer's time. If the problem had only been discovered on the shop-floor, it would have delayed the aircraft's first flight by three weeks.

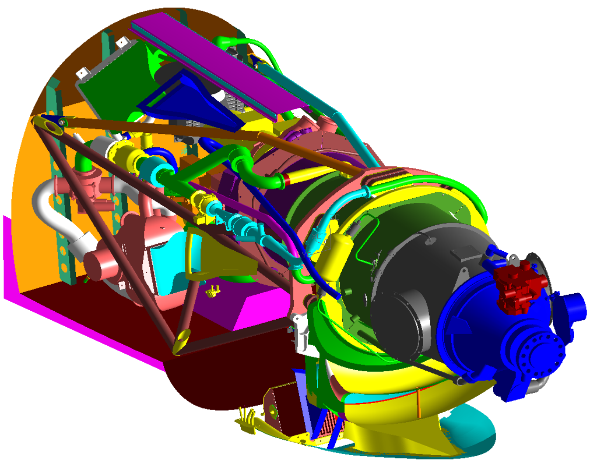

Fig. 3. Digital mock-up

Figures 4 and 5 show the Computational Fluid Dynamic (CFD) representation of an aircraft project and an engineering flight simulator, built in Pilatus. These tools were utilised and combined to assess the flight characteristics of a design long before the design had been "frozen". Using a pilot in the design process reduces modification at a phase of the project where the costs of modification are prohibitive.

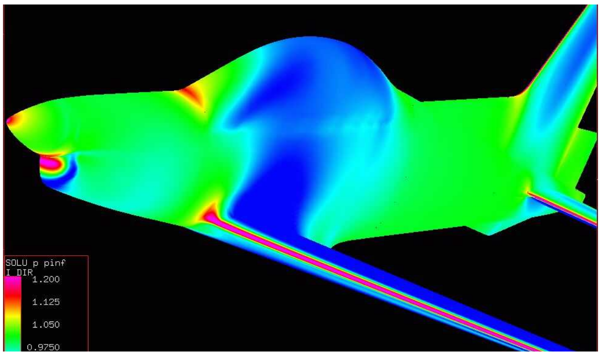

Fig. 4. CFD

Fig 5. Engineering Flight Simulator

Figure 6 shows a simulation of the bird-strike resistance of a military trainer canopy. In previous projects, the canopy was designed, built and the bird-strike resistance tested. Since this was very much a "trial & error" approach, inevitable costly modifications resulted. This simulation allows the design to be successful at first attempt.

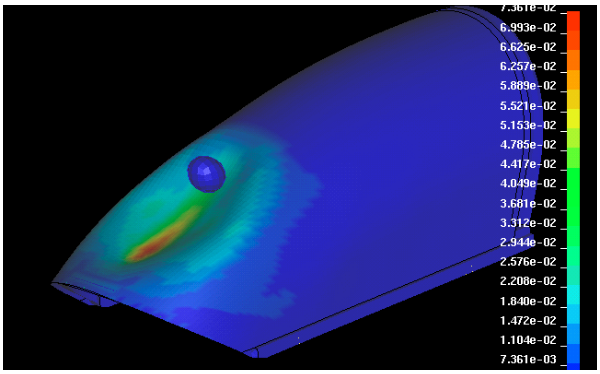

Fig 6. Bird-strike simulation

4 Conclusions

Maximum utilisation of CAD/CAM and simulation tools will result in:

- A faster time to market
- A lower overall investment in the programme by solving problems early
- Lower life cycle costs due to robust design

Both Pilatus Aircraft in Switzerland as well as Eclipse Aviation in the USA have implemented these tools and will achieve programme start to certification of their new products with a time saving in excess of 30% compared with traditional methods.