# *Introduction to Aircraft Design*

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# *Contents*

# 1

# *Introduction*

## 1.1 Why another aircraft design book?

Aircraft design is a complex and fascinating business and many books have been written about it. The very complexity and dynamic nature of the subject means that no one book can do it justice.

This book, therefore, will primarily act as an introduction to the whole field of aircraft design leading towards the subjects summarized in Fig. 1.1. It will not attempt to duplicate material found in existing design books, but will give information about the whole aircraft design environment together with descriptions of aircraft and component design. It also presents otherwise unpublished data and design methods that are suitable for aircraft conceptual, preliminary and detail design activities.

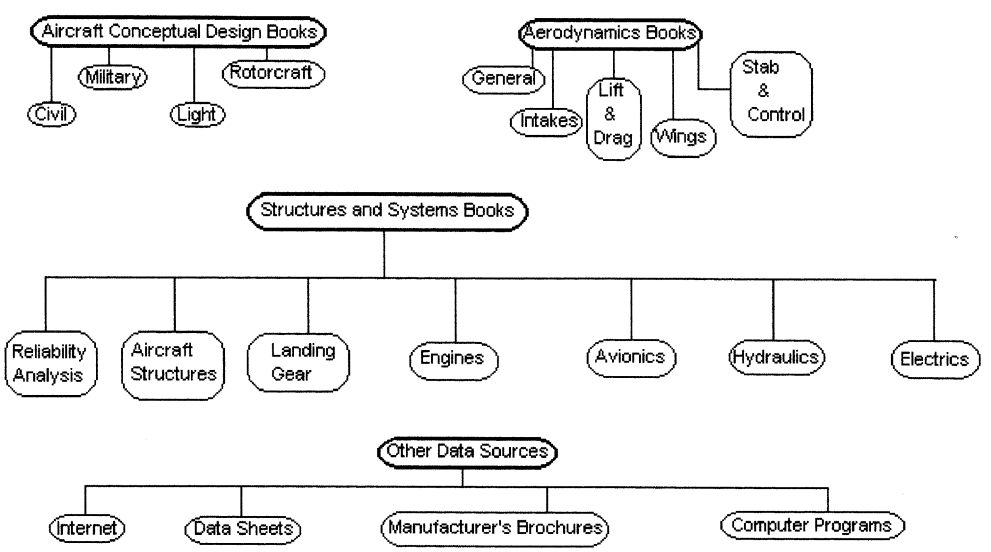


Fig. 1.1 Aircraft design data sources.

## 1.2 Topics

The following chapters are arranged as a series of questions about aircraft design, the answers to which give largely descriptive overviews of all aspects of aircraft design. This will provide an introduction into the conflicting requirements of aircraft design specialists in a design team, with a view to improving understanding, and the integration of a sound overall design.

The book is divided into chapters which answer a number of significant design questions.

The question 'why design a new aircraft?' is answered in Chapter 2 which shows the derivation of aircraft requirements for civil and military aircraft from market surveys, and gives examples of operator-derived specifications.

Chapters 3 and 4 answer the question 'why is it that shape?' with an initial discussion of aircraft wing and tail shapes, followed by descriptions of the configurations of a wide range of civil and military aircraft types.

The question 'what's under the skin?' is answered in Chapters 5, 6 and 7, which deal with structures and propulsion, airframe systems, avionics, flight controls and weapons, respectively. These chapters describe the interiors of aircraft, ranging from structures to weapon systems via airframe systems, avionic systems and landing gears.

In Chapter 8 the crucial areas of acquisition and operating costs are discussed and some prediction methods are described and the importance of good reliability and maintainability are stressed in order to answer the question, 'why do aircraft cost so much.'

The answer to the question 'what help can I get?' is provided in Chapter 9 which contains a bibliography of the most important current aircraft design books. It is followed by a description of some of the computer design analysis and computer-aided design (CAD) tools that are available. A summary of relevant data sheets is also given.

Chapter 10 draws together the information produced at the end of the conceptual stage and leads on to the preliminary and detail design stages in order to explain 'what happens next'. The question 'what can go wrong' is answered in Chapter 11 in which many unsuccessful or partially successful projects are examined and conclusions drawn from them.

The aircraft designer is bedeviled by lack of design data. Appendix A pulls together information that is not generally available, and includes simple aerodynamic and structural design formulae. It also provides a US/British translation list for aeronautical terms.

Appendix B presents a parametric study design example which describes the author's parametric study of a 500-seat transport aircraft. Appendix C considers reliability and maintainability targets by discussing targets for civil and military aircraft and describing a method to be used for the prediction of dispatch reliability.

## 1.3 The design process

There are a number of generally accepted stages in the design, development, manufacture and operation of aircraft, each with associated design methods and data requirements. These are shown schematically in Fig. 1.2, which also shows how the modern practice of concurrent engineering has reduced the overall timescale from conception to service.

Figure 1.3 gives some idea of how a designer's prejudice may affect his or her design to the detriment of others. It is an exaggeration, but not much of an exaggeration!!

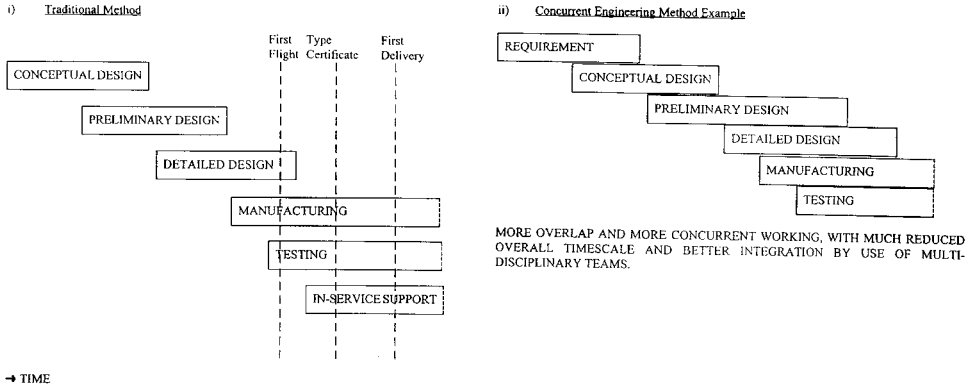


Fig. 1.2 Comparison of traditional and concurrent design approaches.

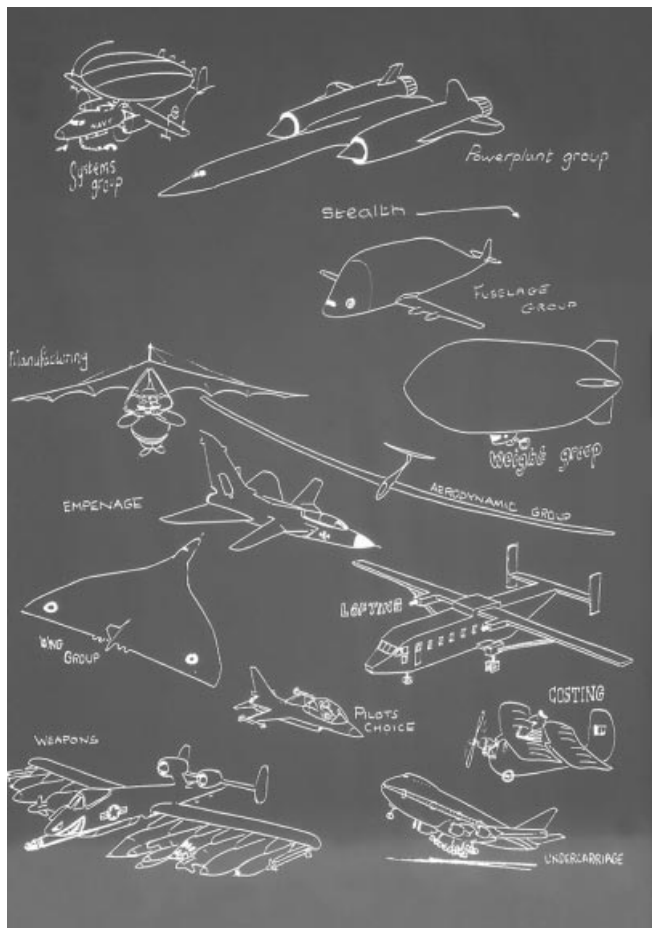


Fig. 1.3 Different specialist's views of an ideal aircraft.

The most crucial stage of any design process is to arrive at the correct set of requirements for the aircraft. These are summarized in design specifications for the particular aircraft type. Typical examples of design specifications are shown in Chapter 2. They are augmented by a large number of airworthiness requirements for civil aircraft or Defence Standards for military aircraft. These are distillations of decades of successful (and unsuccessful!) design, manufacturing and operational experience. Fig. 1.4, adapted from Haberland *et al.* [1], shows a very helpful illustration of what may happen after the issue of the design specifications, and illustrates the iterative design process that is not apparent in the simplified illustration in Fig. 1.2.

A converging iterative spiral of design stages, ending in the detail design, and ultimately manufacture and operation of the aircraft can be seen in Fig. 1.4.

It is a truism that 99% of the decisions which affect aircraft success are made on 1% of the facts available during the conceptual design phase. Very coarse methods have to be used which are then refined by progressively more accurate methods as the design evolves. This is true if the spiral is convergent, but there are occasions where the spiral is divergent and the design must be abandoned, and started again, unless significant modifications are made to the design.

Figure 1.5 shows the author's usual design procedure for conceptual design and the start of preliminary design process.

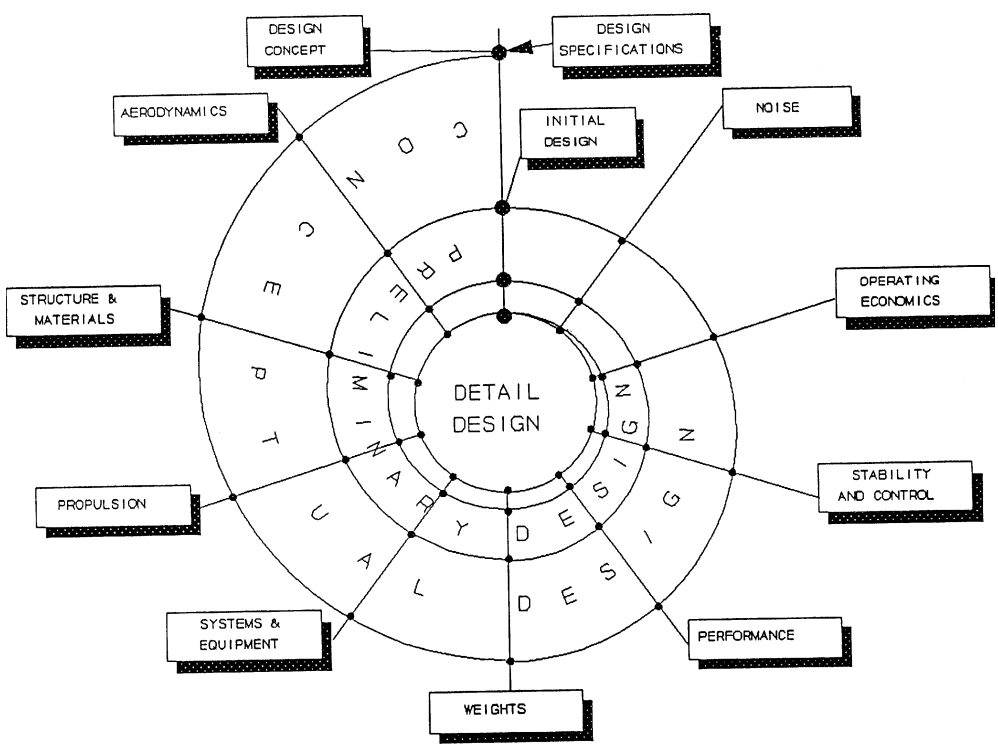


Fig. 1.4 The design spiral.

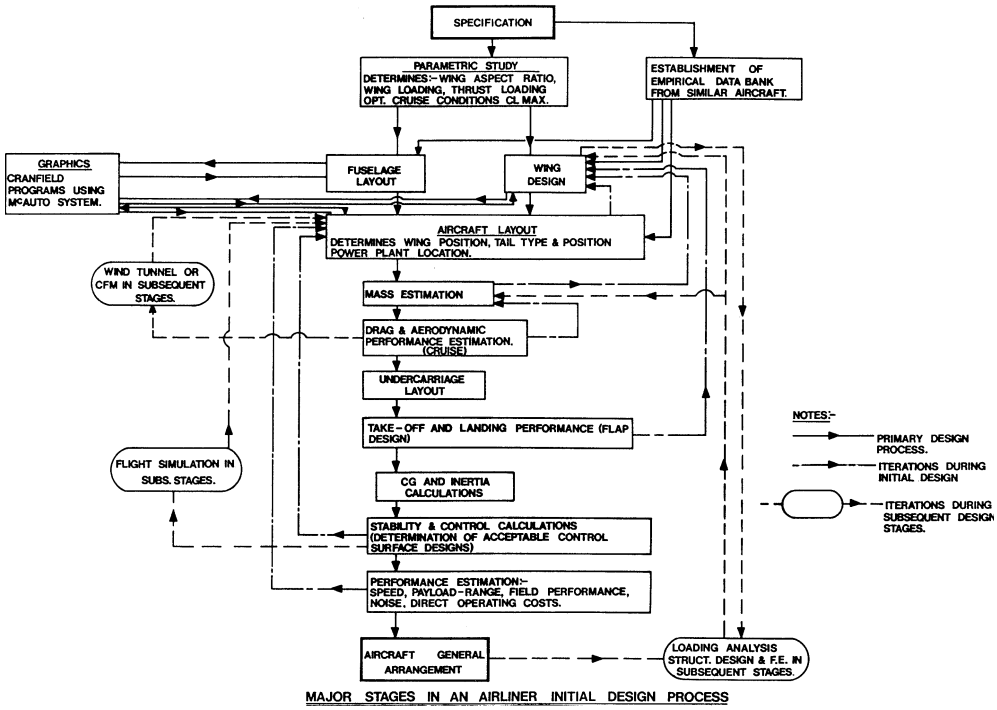


Fig. 1.5 Major stages in an airliner initial design process.