Design Methods

1 Introduction

Aircraft design is a multifaceted engineering discipline that integrates principles of aerodynamics, structural integrity, propulsion, systems engineering, ergonomics, regulatory compliance, environmental considerations, and economic factors. It involves crafting an aircraft that is aerodynamically efficient, structurally sound, and equipped with effective propulsion and various onboard systems for navigation, communication, and control. The design process prioritizes safety, performance, passenger comfort, and adherence to stringent aviation standards, while also considering environmental impacts and cost-efficiency. The characteristics of aircraft design include:

1. **Need**: The design process is both started by and constrained by an identified need.
2. **Non-unique Solutions**: Many legitimate solutions will exist for the same requirements. The final solution will always involve compromise and judgment.
3. **Systematic**: Use a systematic method to identify the best solution
4. **Iterative**: Often requires returning to an earlier step if assumptions are invalid
5. **Interdisciplinary**: Design process involves considerations and compromises between a variety of disciplines.

2 Design Phase

There are three main design phases, including conceptual design, preliminary design and detailed design.

2.1 Conceptual Design

First step in design process, usually include:

1. Response to a certain design goal or requirements
2. Overall shape, size, weight, performance of airplane configuration
3. Aerodynamics, propulsion and performance
4. Some consideration for stability/control, cost

2.2 Preliminary Design

Characteristics include:

1. Major design features locked in, only minor changes allowed
2. Substantial analysis, including CFD and wind tunnel tests
3. Specialists in areas will start design and analysis
4. Testing begins in aerodynamics, propulsion, structures and stability and control

2.3 Detailed Design

Characteristics include:

1. Precise and detailed decisions are made
2. All major disciplinary decisions locked in
3. Production design occurs
4. Increased testing efforts

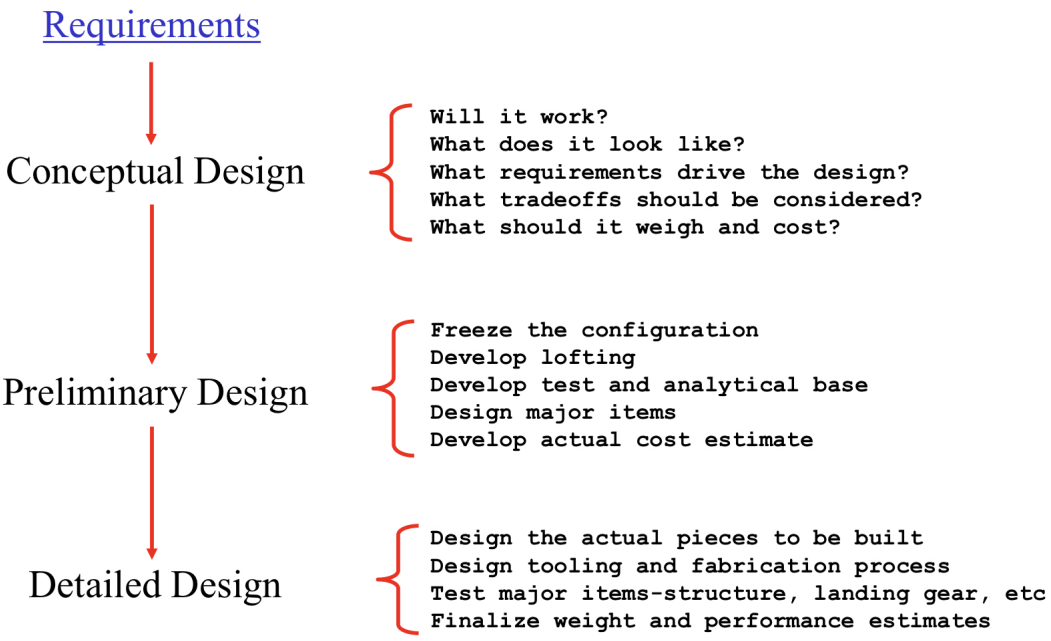

Figure 1: Design Phases

3 Conceptual Design

The overview of the conceptual design is shown below:

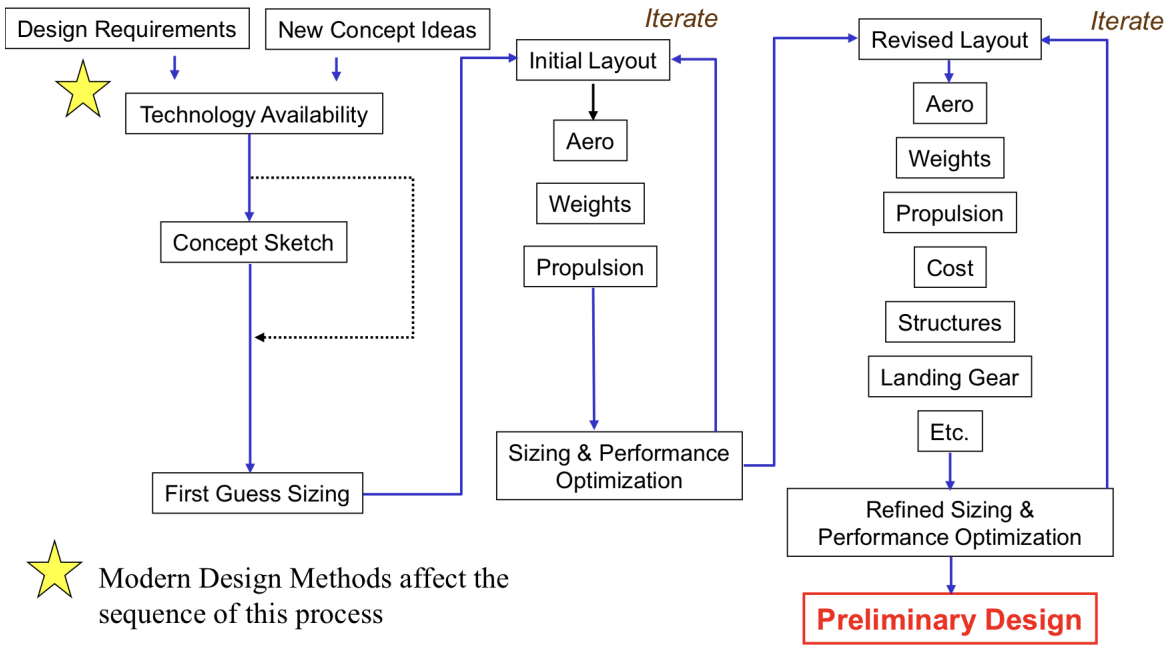

Figure 2: Conceptual Design Overview

3.1 Requirements

The conceptual design process begins with a defined set of requirements, including specific constraints and design goals. All of these will be in a document called **Request for Proposal (RFP)**, including:

1. Payload type of payload
2. Range/loiter requirements
3. Cruise speed and altitude
4. Field length for takeoff/landing
5. Fuel reserves
6. Cost goals
7. Climb requirements
8. Maneuvering requirements
9. Mission profile
10. Certification base

3.1.1 FAR

The **Federal Aviation Regulations (FARs)** is the body of regulations established and administered by the **Fedral Aviation Administration (FAA)** that governs civil aviation in U.S. Every new aircraft has a certification base, for example: FAR 23 is normal, utility, aerobatic and commuter; FAR 25 is commuters.

3.1.2 Mission Profile

The RFP will specify a **mission profile** or **sizing mission** for the aircraft, which is a series of chronological events or capabilities that the aircraft must complete. An example is shown below:

1. Engine start and warm up
2. Taxi
3. Takeoff
4. Climb
5. Cruise
6. Loiter
7. Descent
8. Dash
9. Drop bombs
10. Dash out
11. Landing, taxi, shutdown

3.2 Technology Availability

The decision must be made as to the technology level to be used, sometimes called **technology year**, often specified in the RFP. Technologies may only be incorporated that are robust in that year. The risk and uncertainty will increase with the technology year:

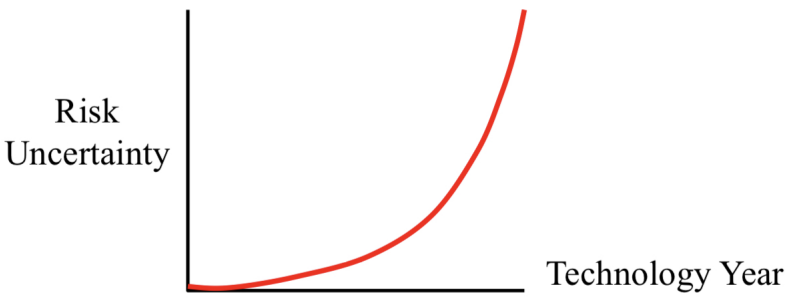

Figure 3: Risk vs Technology year