Lecture Notes

Short Course "Aircraft Design"

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1 Introduction
1.1 Requirements, Parameters, Constraints and Objectives
1.2 Aircraft Design: Part of Aircraft Development
1.3 General Approach to Aircraft Design

2 Aircraft Design Sequence
2.1 Preliminary Sizing
2.2 Conceptual Design

3 Requirements and Certification
3.1 Origin of Requirements for Aircrafts
3.1.1 Analysis of the Seat-Range Diagram
3.1.2 Analysis of the Route Network of an Airline
3.1.3 Analysis of a Full Market Survey
3.2 Calculation of Required Payload
3.3 Payload-Range Diagram
3.4 Certification

4 Aircraft Configurations
4.1 Three-View Drawings of Conventional Aircraft Configurations
4.2 Three-View Drawings of Unconventional Configurations

5 Preliminary Sizing
5.1 Landing Distance
5.2 Take-off Distance
5.3 Climb Rate during 2nd Segment
5.4 Lift-to-Drag Ratio with Extended Landing Gear and Extended Flaps
5.5 Climb Rate during Missed Approach
5.6 Cruise
5.6.1 Thrust-to-Weight Ratio
5.6.2 Wing Loading
5.7 Lift-to-Drag Ratio during Cruise
5.8 Matching Chart
5.9 Maximum Take-Off Mass
5.9.1 Operating Empty Mass and Useful Load
5.9.2 Fuel Fractions
5.10 Take-off Thrust and Wing Area
6 Fuselage and Cabin Conceptual Design
6.1 Fuselage Cross-Section and Cargo Compartment
6.2 Cockpit, Cabin and Fuselage Tail Section

7 Wing Design
7.1 Wing Parameters
7.2 Basic Principle and Design Equations
7.3 Flight and Operational Characteristics
7.4 Ailerons and Spoilers
7.5 Example: The Wing of the Airbus A310

8 High Lift Systems and Maximum Lift Coefficients
8.1 High Lift Systems
   Trailing edge high lift systems
   Leading edge high lift systems
   Generation of high lift
8.2 Calculation of Maximum Lift Coefficients
   The maximum lift coefficient of an airfoil
   The maximum lift coefficient of a wing
   Increase in maximum lift coefficient of an airfoil through high lift devices
   Increase in the maximum lift coefficient of a wing through high lift devices
8.3 Design of High Lift Systems

9 Empennage General Design
9.1 Functions of Empennages
   Trim
   Stability
   Control
9.2 Shapes of the Empennage
9.3 Design Rules
9.4 Design According to Tail Volume
9.5 Elevator and Rudder

10 Prediction of Mass and CG-Location
10.1 Mass Forecasts
10.2 Centre of Gravity Calculations
11 Empennage Sizing

11.1 Horizontal Tailplane Sizing
- Horizontal tailplane sizing according to control requirement
- Horizontal tailplane sizing according to stability requirement
- Horizontal tailplane sizing – overall picture

11.2 Parameters for Horizontal Tailplane Sizing
- Aerodynamic center
- Lift coefficient
- Zero lift angle of attack for a wing
- Downwash angle
- Pitching moment of the airfoil at the aerodynamic center
- Pitching moment of the wing at the aerodynamic center
- Downwash gradient

11.3 Vertical Tailplane Sizing
- Vertical tailplane sizing according to control requirement
- Vertical tailplane sizing according to stability requirement
- General assessment of vertical tailplane sizing

11.4 Parameters for Vertical Tailplane Sizing
- The rudder - a plain flap
- Stability coefficient
- Stability coefficient

12 Landing Gear Conceptual Design and Integration

- Stable stand on the ground
- Tail and bank angle clearance
- Nose landing gear load
- Integrate wing landing gear into wing plan form
- Prevent airport surface damage (ACN)
- Wheel load carrying capability
- Compact integration
- Free fall capability
- Absorb touch down energy
- Braking at take off and landing
- General layout of the landing gear
- Iterative process

13 Drag Prediction

13.1 Drag Polar
13.2 Drag
13.3 Zero-Lift Drag
13.4 Wave Drag
13.5 Induced Drag and Oswald Factor
14 Design Evaluation / DOC
14.1 Costing as an Assessment Method in Aircraft Design
14.1.1 Cost Analysis from the Perspective of the Aircraft Manufacturer
14.1.2 Cost Analysis from the Perspective of the Operator
14.2 Overview of Assessment Methods
14.3 Direct Operating Costs (DOC)
14.3.1 Calculation of DOC
14.3.2 Representation of DOC
14.3.3 Calculation of DOC Cost Elements - Depreciation
14.3.4 Calculation of DOC Cost Elements - Interest
14.3.5 Calculation of DOC Cost Elements - Insurance
14.3.6 Calculation of DOC Cost Elements – Fuel Costs
14.3.7 Calculation of DOC Cost Elements – Maintenance Costs
14.3.8 Calculation of DOC Cost Elements – Staff Costs
14.3.9 Calculation of DOC Cost Elements - Fees and Charges
14.3.10 Calculation of Aircraft Utilization
14.3.11 DOC Model Data
14.4 Final Comments

15 References