

Lecture Notes

Short Course "Aircraft Design"

Dieter Scholz
Bernd Trahmer

1	Introduction	<i>Dieter Scholz</i>
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	<i>Dieter Scholz</i>
2.1	Preliminary Sizing	
2.2	Conceptual Design	
3	Requirements and Certification	<i>Dieter Scholz</i>
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	<i>Dieter Scholz</i>
4.1	Three-View Drawings of Conventional Aircraft Configurations	
4.2	Three-View Drawings of Unconventional Configurations	
5	Preliminary Sizing	<i>Dieter Scholz</i>
5.1	Landing Distance	
5.2	Take-off Distance	
5.3	Climb Rate during 2 nd 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	<i>Dieter Scholz</i>
6.1	Fuselage Cross-Section and Cargo Compartment	
6.2	Cockpit, Cabin and Fuselage Tail Section	
7	Wing Design	<i>Dieter Scholz</i>
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	<i>Dieter Scholz</i>
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	<i>Dieter Scholz</i>
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	<i>Dieter Scholz</i>
10.1	Mass Forecasts	
10.2	Centre of Gravity Calculations	

11	Empennage Sizing	<i>Dieter Scholz</i>
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	<i>Bernd Trahmer</i>
	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	<i>Dieter Scholz</i>
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	<i>Dieter Scholz</i>
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	<i>Dieter Scholz</i>