Aerodynamic Design of Commercial Airplanes (AERO0041)

Instructor: Roelof Vos

Course Description

In this course participants learn how aerodynamics drive the detailed exterior design of transport aircraft. What aerodynamic phenomena play a role in the exterior design of a wing, a cockpit, or an engine intake? What is the effect of aerodynamic add-ons such as vortex generators, fairings, or winglets? What are the advantages and penalties of wing sweep and how can the penalties be mitigated by the aerodynamic design of the wing? Those are the type of questions that are being addressed in this course. Participants learn to understand how the various aircraft components should be shaped in order to fulfill aerodynamic requirements in all corners of the flight envelope. The strong ties between aircraft performance, aircraft aerodynamics, and aircraft exterior design are demonstrated through numerous historical and contemporary examples. Although the main focus is on jet aircraft, the course also covers the effects of propeller installation on the aerodynamic design of the empennage.

Course Highlights

- Causes for interference drag in high-subsonic conditions
- Effect of Reynolds number on shock-boundary-layer interaction
- Design characteristics of supercritical airfoils
- Mach number effects on flow over multi-element airfoils
- Design of root and tip of swept-wing aircraft
- Stability and control beyond the maximum operating Mach number
- Propeller slipstream effects on longitudinal stability and yawing moment
- Design constraints resulting from transonic buffet Stalling characteristics of wings with high-lift devices

Who Should Attend?

Designed for aeronautical engineers, pilots with some engineering background, government research laboratory personnel, engineering managers and educators.

Course Outline

Day One: Introduction and review of aerodynamic fundamentals:

- Introduction, classification, design requirements and objectives of transport aircraft, certification regulations and design rules, general goals in aerodynamic design

- Boundary-layer aerodynamics and subsonic cruise drag
- Relation between supervelocity and pressure coefficient. Relation between geometry and pressure distribution
- Interference drag and area ruling

Day Two: Airfoil design:

- Pressure distribution on airfoil sections at high and low speed. Development of the transonic airfoil
- Design of supercritical and sonic airfoils. Reynolds number effects
- Low-speed stalling characteristics of airfoil sections
- Reynolds number and Mach number effects on maximum lift coefficient
- High-speed stall (buffet) on airfoil sections
- Airfoils equipped with high-lift devices: mutual interaction, types of flow separation

Day Three: Wing design:

- Wing requirements
- Development of the swept-wing concept: historical background, principle of wing sweep, transonic flow characteristics, effect on boundary layer, effect on maximum lift coefficient, fences
- First generation of swept wing aircraft: tip-stall, aeroelastic deformation
- Pressure distribution on finite swept wings: spanwise drag distribution, forward sweep, fuselage interference, improving velocity distribution at root and tip, minimizing pitching moment
- Design considerations for pressure distributions on finite swept wings
- Discussion of examples of modern swept-wing designs

Day Four: Empennage design, control surface design and engine integration:

- Horizontal tail surface design: functions and requirements, planform shape, aeroelastic effects, elevator lock
- Vertical tail surface design: functions and requirements, planform shape, effect of dorsal fin
- Control surface design: functions and requirements, linearity, aeroelasticity, stall
- Spoiler panels: functions, effect on pressure distribution, interaction with flaps
- Engine intake design: lip design for take-off and cruise conditions, drag in OEI condition. Exhaust design: effect of ambient pressure, boat tail drag. Thrust reversers: types, interference with empennage

Day Five: Operation:

- Stalling characteristics of full scale aircraft: stall requirements, mechanism complexity vs. maximum lift coefficient, spanwise stall onset, deep stall
- Take-off performance: requirements, minimum unstick speed, lift-to-drag ratio in take-off and landing

- The buffet onset boundary: requirements, effect on flight envelope. Flight characteristics between MMO and MD: requirements, Mach tuck, Mach trim compensation

Classroom hours / CEUs
35.00 classroom hours
3.5 CEUs

Certificate Track
Aircraft Design

Course Fees
Early registration course fee: $2,595 if you register and pay by the early registration deadline (45 days out).

Regular registration course fee: $2,795 if you register and pay after the early registration deadline.

Course Materials
Course materials, including outlines, presentation copies, and supplementary materials, will be accessible through Canvas, KU's online learning system. Instructions to access Canvas will be provided upon completed registration. Students are required to bring a computer or other electronic device with PDF-viewing capabilities with them to class each day. If you require accommodation contact us at professionalprograms@ku.edu and we will work with you on an accessible solution.

U.S. Federal Employee Discount
This course is available to U.S. federal employees at 10% off the registration fee. To receive the federal employee discount, you must enter the code **FGVT116** during the checkout process. Please note that you must validate your eligibility to receive this discount by entering your U.S. government email address (ending in .gov or .mil) when creating your online registration profile. This discount is available for both the early registration and regular registration fees.

Instructor Bio
Roelof Vos is an assistant professor at the Aerospace Engineering Department of Delft University of Technology. He teaches undergraduate courses in conceptual airplane design and two graduate courses on aerodynamic design of transport aircraft and fighter aircraft. He obtained an MSc degree from Delft University of Technology and a Ph.D. degree from The University of Kansas. His research focuses on the development of physics-based analysis methods for the conceptual design of unconventional aircraft and on the assessment of emerging aviation technologies.

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