AEROSPACE
SHORT COURSES

Aerodynamic Design of Military Aircraft (AERO0640)

Instructors: Roelof Vos

Course Description

In this course it is demonstrated how the aerodynamic design of combat aircraft affect their overall performance. Particular topics that are treated are the effect of aerodynamics on trim, stability, control, and (supersonic) maneuverability. It is demonstrated what means are available to the designer in terms of the interposition of lifting surfaces, the use of high-lift devices, and the design of intake and exhaust to satisfy disparate requirements on high-g maneuvers, supersonic dash, and field performance. Through many historic and contemporary examples the participant learns to relate the functionality of the combat airplane to its aerodynamic design. In addition, it is shown how many technologies that were pioneered on combat aircraft have spilled over to civil aviation. This is an intermediate level course. To get the most out of this course, it is good to have a basic understanding of flight mechanics, flight dynamics, and aerodynamics. This course is of a qualitative nature and therefore does not require the participant to know the mathematical models that are used in each of these disciplines.

Course Highlights

- Supersonic and subsonic wing design for military fighter aircraft
- Wing planform characteristics in subsonic and supersonic flight
- Using the supersonic area rule in aerodynamic design
- The effect of artificial stability on flight performance
- The design and positioning of supersonic engine intakes
- Directional stability at high Mach number and at high angle-of-attack flight
- High-lift aerodynamics: strakes, canards, and high-lift devices
- Design for maneuverability: flap scheduling
- Variable-geometry exhaust design in subsonic and supersonic conditions

Who Should Attend?

This course is targeted to aeronautical engineers, pilots with some engineering background, government research laboratory personnel, engineering managers and educators.

Learning Objectives

- Recognize the aerodynamic phenomena occurring at a variety of conditions (Mach number, Reynolds numbers, angles of attack and sideslip)
- Derive how these phenomena can be affected by the detailed external shape and/or location of various airplane components such as the wing, tail, intake, and fuselage.
- Show how wing and tail movables can be applied to influence the aerodynamic characteristics of the airplane (i.e., maximum lift, aerodynamic efficiency).
- Explain the effect of the aerodynamic characteristics on the airplane's performance, stability, maneuverability, and controllability.
- Identify the advantages and disadvantages of various external design features on the airplane's aerodynamic characteristics and non-aerodynamic attributes such as stealth, aeroelasticity, weight, pilot's visibility, system complexity, etc.

Course Outline

Day 1

- Introduction, cross-fertilization between military and civil aviation, classification of combat aircraft, basic definitions, impact of flying supersonic on drag and drag components.
- An overview of airfoil design for subsonic, transonic and supersonic performance, review of subsonic and supersonic pressure distributions, two-dimensional wave drag and friction drag.
- Swept wing design: aspect ratio, taper ratio and sweep angle. Effect of design variables on stall behavior, supersonic drag, and maneuverability.
- Delta wing design: comparison to swept wing, wave drag, take-off performance, maneuverability, stability, interaction with canard or horizontal tail.

Day 2

- Variable-sweep (swing) wings: motivation, (dis-)advantages over fixed wings, challenges in terms of supersonic stability (pitch stiffness) and means to resolve this.
- High-lift devices I: their effect on field (or deck) performance
- High-lift devices II: flap scheduling, effect on transonic specific excess power and maneuverability.
- Ailerons and spoilers: design considerations with respect to positioning, roll reversal at high angle-of-attack, multi functionality of spoilers

Day 3

- Air intake design: aerodynamics of supersonic intakes, distinction between two-dimensional and three-dimensional intakes, advantages and disadvantages of variable-geometry intakes, lip stall and its effect on distortion and pressure recovery.
- Air intake location: effects of fuselage/wing shielding on effective angle-of-attack or side-slip angle at the intake plane, boundary-layer splitter plates, diverters, porous intake walls
- Forward fuselage design: effect of pilot visibility requirements on canopy design and aerodynamics, asymmetric vortex-shedding from the forebody at high angle-of-attack and means to suppress this.
- Fuselage design: application of transonic, supersonic, and differential area rule to the design of the fuselage and the effect on dash speed.

Day 4

- Horizontal tail design: effect of subsonic and supersonic aerodynamics on longitudinal stability and trim, control surface effectiveness with Mach number, elevator vs. stabilator design.
- Canard design: aerodynamics of close-coupled canards, trade-off canard vs. strake, trade-off canard vs. horizontal tail.
- Vertical tail design I: directional stability and control at subsonic and supersonic speeds, inertia cross-coupling, aeroelastic effects
- Vertical tail design II: Fin location, effectiveness at high angle-of-attack, single fin vs. twin fin, finless aircraft, ventral fins, aileron-rudder interconnect

Day 5

- Aft fuselage and nozzle design: convergent-divergent nozzles, variable-geometry nozzles, ejector nozzles, thrust vectoring, vertical take-off and landing
- On-site quiz on the aerodynamic design of Navy combat aircraft

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 Bios

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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