K. The Total Aircraft: Aerodynamic Drag

Content Area:	**Science**
Course(s):	**CAD Architect**
Time Period:	**Marking Period 1**
Length:	**1**
Status:	**Published**

Assessment

"Do Now" Activities

"Exit Ticket" Activities

Practice Problem Worksheets

Quizzes

Standards

SCI.9-12.HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
SCI.9-12.HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
SCI.9-12.HS-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
SCI.9-12.HS-PS2-1	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
SCI.9-12.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Enduring Understandings

Students will come to understand:

1. The total drag of an aircraft is based on the sum of the aircraft's parasite drag and induced drag, and that at different airspeeds different forms of drag dominate, which dictate the way that an aircraft is flown and designed.
2. The total drag of an aircraft governs the size of the engine required to power the aircraft, and the difference between the power available and the power required (due to drag) governs many of the aircraft's performance characteristics.
3. The flat plate area is a theoretical way of depicting the total drag of an aircraft and varies depending on the configuration of the aircraft (landing gear extended/retracted, configuration of high lift/high drag

devices, etc.)

Essential Questions

The following questions will guide student inquiry:

- How does the overall configuration of an aircraft affect the aircraft's total drag?
- How does the total drag of an aircraft affect the power required for the aircraft and the aircraft's ultimate performance?
- How does the relationship between induced drag and parasite drag change with airspeed?

Knowledge and Skills

Unit Content:

All components of an aircraft either function as aerodynamic surfaces intended to produce required aerodynamic forces, or they serve as structural components required to hold the aerodynamic surfaces in the proper orientation with respect to one another. All components designed to produce aerodynamic forces are in the form of an airfoil and wing. Thus, the course to this point has provided all of the background required to design and evaluate aerodynamic surfaces. Structural components contribute to the total drag of an aircraft. The drag associated with components that do not contribute to the lift of an aircraft is known as parasite drag. This unit combines everything taught to this point takes a global look at the whole aircraft. The unit explains how parasite drag is characterized and added to the profile and induced drag associated with all of the aerodynamic surfaces to find the total drag of an aircraft. Total drag is essential to determine the size of the engine required to power the aircraft, and the difference between the power available and the power required governs the performance characteristics of the aircraft. The units that follow will discuss aircraft powerplants in much greater detail.

- Definition and Explanation of Parasite drag (due to form and skin friction) (1 day)
- Estimates of total aircraft drag & flat plate area (1 day)
- Effect of Configuration on Parasite Drag
- Effect of Altitude on Parasite Drag
- Effect of Speed on Parasite Drag (2 days)
- Curves of Total Aircraft Drag & Total Aircraft L/D (2 days)

Science, Technology, Engineering, Mathematics, and/or Aerospace Skill(s):

The total drag associated with a design affects the glide ratio of the aircraft, or the distance an aircraft can glide without power for every unit of distance it descends. Gliders and sailplanes are unpowered aircraft that navigate from rising air current to rising air current, taking advantage of their sleek aerodynamic shape to maximize glide ratio when updrafts are not present. Data regarding glide characteristics for gliders and high altitude aircraft is typically given in the form of glide polars.

- Aerospace Example: Glider and Powerless Aircraft Glide Polars (2 days)

Resources

Textbook(s):

Hurt, H. H. (1965). *Aerodynamics for Naval aviators*. Washington, DC: Federal Aviation Administration.

Smith, H. C. (1992). *The illustrated guide to aerodynamics* (2nd ed.). Blue Ridge Summit, PA: McGraw-Hill, Inc.

Cessna Aircraft Company. (1977). *Pilots operating handbook: Cessna 172*. Wichita, KS: Cessna Aircraft Company.

Federal Aviation Administration. (2013). *The pilots handbook of aeronautical knowledge*. Washington, DC: Author.

Lab Equipment:

Pasco Low Speed Wind Tunnel

Balsa tools to create airfoil sections

Foam cutter and foam cutting tools to create airfoil sections

Balsa gliders

Video Camera/digital camera

Computer Software:

Microsoft Excel

Foilsim

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