

10.1 Primary Flight Controls

- Aircraft are maneuvered around their three axes using primary flight controls. These are
- typically "flap-type" surfaces positioned at the extremities of the aircraft to provide the
- longest possible moment arm from the CG.
- ☐ Elevator: Controls pitch around the lateral axis (longitudinal control). Located on the
- horizontal stabilizer.
- ☐ Ailerons: Control roll around the longitudinal axis (lateral control). Located on the outboard
- trailing edge of the wings.
- ☐ Rudder: Controls yaw around the normal axis (directional control). Located on the vertical
- stabilizer.

10.2 Control Balancing and Feel

- At high speeds, the aerodynamic forces on control surfaces can become very large, resulting
- in heavy stick forces for the pilot. Several methods are used to reduce these forces.
- ☐ Aerodynamic Balance: These methods use airflow to help move the control surface,
- reducing the pilot's effort.
- Inset Hinge: Setting the hinge line back from the leading edge of the control surface creates
- a balancing force.
- Horn Balance: A portion of the control surface extends forward of the hinge line.
- Internal Balance: An aerodynamic panel inside the wing moves with the control surface to
- use pressure differences for balancing.
- ☐ Tabs: These are small, secondary control surfaces hinged to the trailing edge of the main
- surface.
- Balance Tab: Moves in the opposite direction to the main control surface. The airflow on
- the tab creates a force that helps move the main surface.
- Anti-Balance Tab: Moves in the same direction as the main control surface. It increases the

- stick force and control effectiveness.
- Trim Tab: An adjustable tab that the pilot can set to hold the control surface in a specific position, relieving the need to maintain constant pressure on the controls ("trims" the aircraft).
- Servo Tab: The pilot's controls are connected only to the tab. Moving the tab causes an aerodynamic force that then moves the main control surface.

10.3 Secondary Effects of Controls

- Using one control surface often produces a secondary, unintended motion around another axis.
- ☐ Adverse Aileron Yaw: When ailerons are deflected to initiate a roll, the down-going aileron (on the rising wing) creates more lift but also significantly more induced drag than the up-going aileron. This difference in drag causes the aircraft to yaw in the opposite direction of the turn. It is corrected by using rudder in the direction of the turn or by design features like differential ailerons or Frise-type ailerons.
- ☐ Rolling Moment due to Yaw: Deflecting the rudder causes the aircraft to yaw. The outside wing travels faster through the air than the inside wing, generating more lift and causing the aircraft to roll in the direction of the yaw.

10.4 High-Speed Controls

- ☐ Spoilers: Panels on the upper surface of the wing that can be raised into the airflow. They "spoil" the lift and increase drag. They can be used for:
 - Roll Control: By raising the spoiler on one wing only (to assist or replace ailerons). They do not cause adverse yaw.
 - Speed Brakes: By raising the spoilers symmetrically on both wings to increase drag and allow for a steeper descent without increasing speed.
 - Ground Spoilers (Lift Dumpers): Deployed automatically on landing to dump all lift from

- the wings, placing the aircraft's full weight on the wheels for more effective braking.
- ☐ All-Moving Tailplane (Stabilator): For pitch control on high-speed aircraft, the entire horizontal stabilizer pivots, rather than just a hinged elevator. This is much more effective at
- supersonic speeds.

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