

9.1 Definitions of Stability

- Stability is the tendency of an aircraft to return to a steady state of flight without pilot intervention after being disturbed.
- ☐ Static Stability: The initial reaction of the aircraft after a disturbance. 195195
- Positive Static Stability: The aircraft initially tends to return to its original position.
- Neutral Static Stability: The aircraft tends to remain in the new, disturbed position.
- Negative Static Stability (Instability): The aircraft tends to diverge further from its original position.
- ☐ Dynamic Stability: The motion of the aircraft over time following the initial reaction. 199199199199
- Positive Dynamic Stability (Damped Oscillation): The oscillations get smaller and eventually cease. 200200200200
- Neutral Dynamic Stability (Undamped Oscillation): The oscillations continue with the same amplitude.
- Negative Dynamic Stability (Divergent Oscillation): The oscillations get progressively larger.
- For an aircraft to have positive dynamic stability, it must first have positive static stability.

9.2 The Three Axes of Motion

- An aircraft is free to rotate around three axes, all of which pass through its Center of Gravity (CG).
- 1. Longitudinal Axis (Roll): Runs from nose to tail.
- 2. Lateral Axis (Pitch): Runs from wingtip to wingtip.
- 3. Normal (Vertical) Axis (Yaw): Runs vertically through the fuselage.

9.3 Longitudinal Stability (Pitch Stability)

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- This is the stability of the aircraft around its lateral axis. It is crucial for maintaining a constant angle of attack.
- ☐ Main Contributor: The horizontal stabilizer (tailplane) is the primary component providing longitudinal stability.
- ☐ How it Works: The relationship between the aircraft's Center of Gravity (CG) and the Aerodynamic Center (AC) of the wing and tailplane is key.
- The wing's AC is typically ahead of the CG, creating an unstable nose-up pitching moment when AOA increases.
- The tailplane is positioned far behind the CG and produces a downward force in normal flight. If a gust increases the aircraft's AOA, the lift on both the wing and the tailplane increases. The increased lift on the tailplane creates a powerful nose-down moment that counteracts the wing's unstable moment and restores the aircraft to its original AOA.
- ☐ Static Margin: The distance between the aircraft's CG and its Neutral Point (the point where the aircraft would have neutral stability). A larger static margin (CG further forward of the neutral point) provides greater longitudinal stability. 209209
- ☐ Factors Affecting Longitudinal Stability:
- CG Position: Moving the CG aft decreases stability. The aft CG limit is set to maintain a minimum static margin. 210210210
- Power: Propeller slipstream increases dynamic pressure over the tail, which can increase stability.
- High-Lift Devices: Flaps increase downwash over the tail, which is destabilizing.

9.4 Directional Stability (Yaw Stability)

- This is the stability of the aircraft around its normal (vertical) axis, often described as "weathercock stability."
- ☐ Main Contributor: The vertical stabilizer (fin) is the primary source of directional stability.
- ☐ How it Works: If the aircraft yaws, creating a sideslip, the relative airflow strikes the side of the vertical fin. This creates a lift force on the fin that pushes the tail back into alignment with

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- the airflow, correcting the yaw. The large moment arm of the fin behind the CG makes this effect powerful.
- ☐ Other Factors:
- Fuselage: The fuselage ahead of the CG is generally destabilizing.
- Sweepback: A swept-back wing provides a positive contribution to directional stability.

9.5 Lateral Stability (Roll Stability)

- This is the stability of the aircraft around its longitudinal axis. It's the tendency to correct for a wing drop.
- ☐ Main Contributor: Dihedral is the primary design feature for lateral stability. Dihedral is the upward angle of the wings relative to the horizontal.
- ☐ How Dihedral Works: When a wing drops, the aircraft sideslips towards the low wing. Due to the dihedral angle, the low wing meets the relative airflow at a higher angle of attack than the high wing. This generates more lift on the low wing, causing it to rise and return the aircraft to a wings-level attitude.
- ☐ Other Factors:
- Sweepback: A swept wing also provides a strong positive "dihedral effect," contributing to lateral stability.
- Wing Position: A high-wing configuration (like on many trainers and cargo planes) provides additional lateral stability due to a pendulum effect.
- Fin: A large vertical fin above the CG also contributes positively to lateral stability.

9.6 Coupled Oscillations

- Because lateral and directional stability are interconnected, disturbances can lead to coupled oscillations.
- ☐ Dutch Roll: This occurs when lateral stability (dihedral effect) is strong compared to directional stability. It is a continuous, coupled rolling and yawing oscillation. Modern transport aircraft are fitted with a

- Yaw Damper to counteract this tendency. 226226226226
- ☐ Spiral Divergence: This occurs when directional stability is strong compared to lateral
- stability. A small disturbance can cause the aircraft to slowly enter a tightening, descending
- spiral. This is an unstable condition but is usually slow enough for the pilot to correct easily.

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