Lecture outline

- PDR feedback: Thinking about uncertainty
- Motivation for stability and controls (home movie!)
- Aircraft coordinate system, control surfaces, moments, static and dynamic stability
- Longitudinal stability conditions
- Control and stability for the LTA
Aircraft coordinate system
Control surfaces

- Vertical Stabilizer: Control Yaw
- Rudder: Change Yaw (Side-to-Side)
- Elevator: Change Pitch (Up-Down)
- Flaps: Change Lift and Drag
- Aileron: Change Roll (Rotate Body)
- Spoiler: Change Lift and Drag (Rotate Body)
- Wing: Generate Lift
- Horizontal Stabilizer: Control Pitch
- Jet Engine: Generate Thrust
- Cockpit: Command and Control
- Fuselage (Body): Hold Things Together (Carry Payload - Fuel)
- Slats: Change Lift
Control surfaces here?

Source: NASA
Performance vs. control?

- **Performance** – governed by *forces* along and perpendicular to flight path
  - Response: aircraft translation

- **Stability & control** – governed by *moments* about the center of gravity
  - Response: aircraft rotation
Rotational responses

Along the x-axis

Roll

Aileron down

Aileron up

L'

Along the y-axis

Pitch

Elevator up

Along the z-axis

Yaw

N

Rudder deflected
Static stability

Statically stable

Statically unstable
Dynamic stability

Dynamically stable

Dynamically unstable
Why do we have moments?
Moments on the aircraft

Moment coefficient about the center of gravity

\[ C_{M, cg} = \frac{M_{cg}}{q S c} \]

- \( q \) = dynamic pressure
- \( S \) = wing area
- \( c \) = chord length

Trimmed condition (aka pitch equilibrium):

\[ M_{cg} = 0 \]

Question: Are the wing and tail lift producing positive or negative moments?
Longitudinal static stability

Longitudinallly stable

Longitudinallly unstable

2 criteria for longitudinal stability:
- slope must be negative
- moment coefficient at 0 angle of attack must be > 0
Why do airplanes have horizontal stabilizers?

(Play movie file!)
Useful calculations

Wing

Tail
Control: ability to dictate the direction that the blimp flies
  • Essential to turning and gaining/losing altitude

Stability: ability to maintain a constant altitude without control inputs
  • Stable craft – cease to turn or change altitude once the control input is removed, returning to straight and level flight
  • Unstable craft – continues to change until an opposing command is issued
Controlling your LTA vehicle

- Yaw = movement about vertical axis
- Pitch = movement about lateral axis
- Roll = movement about longitudinal axis

Two methods
- Control surfaces
- Vectored thrust
Stabilizing your LTA

- Good test
  - Can your LTA fly straight and level with no control inputs?

- Consider horizontal and vertical stabilizers
  - Once control input force is removed, air resistance on stabilizer helps to slow the turning motion