Introduction to Fixed-wing Aerospace Vehicles

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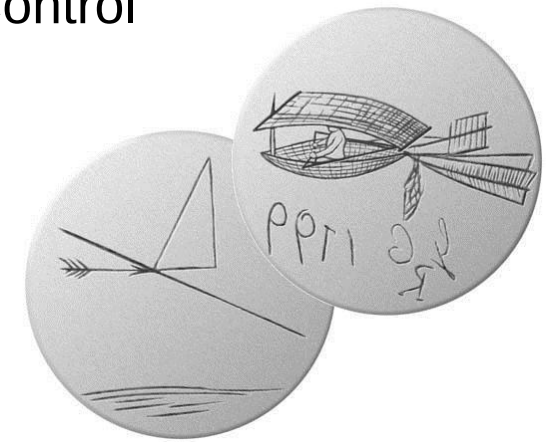
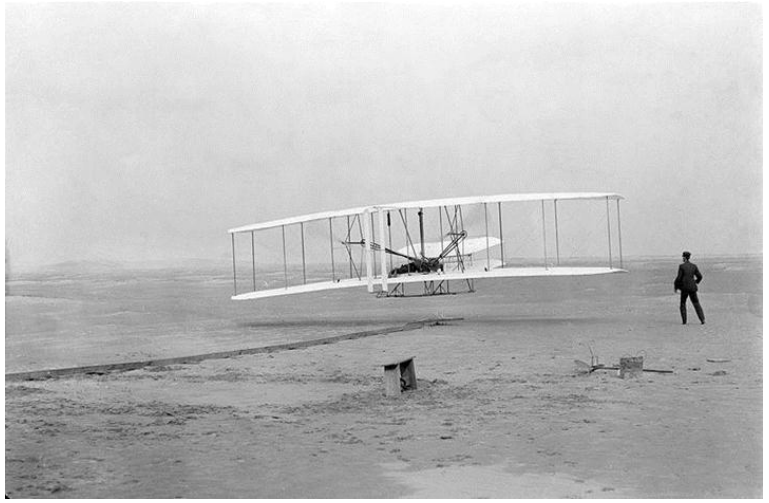
QB 2.9

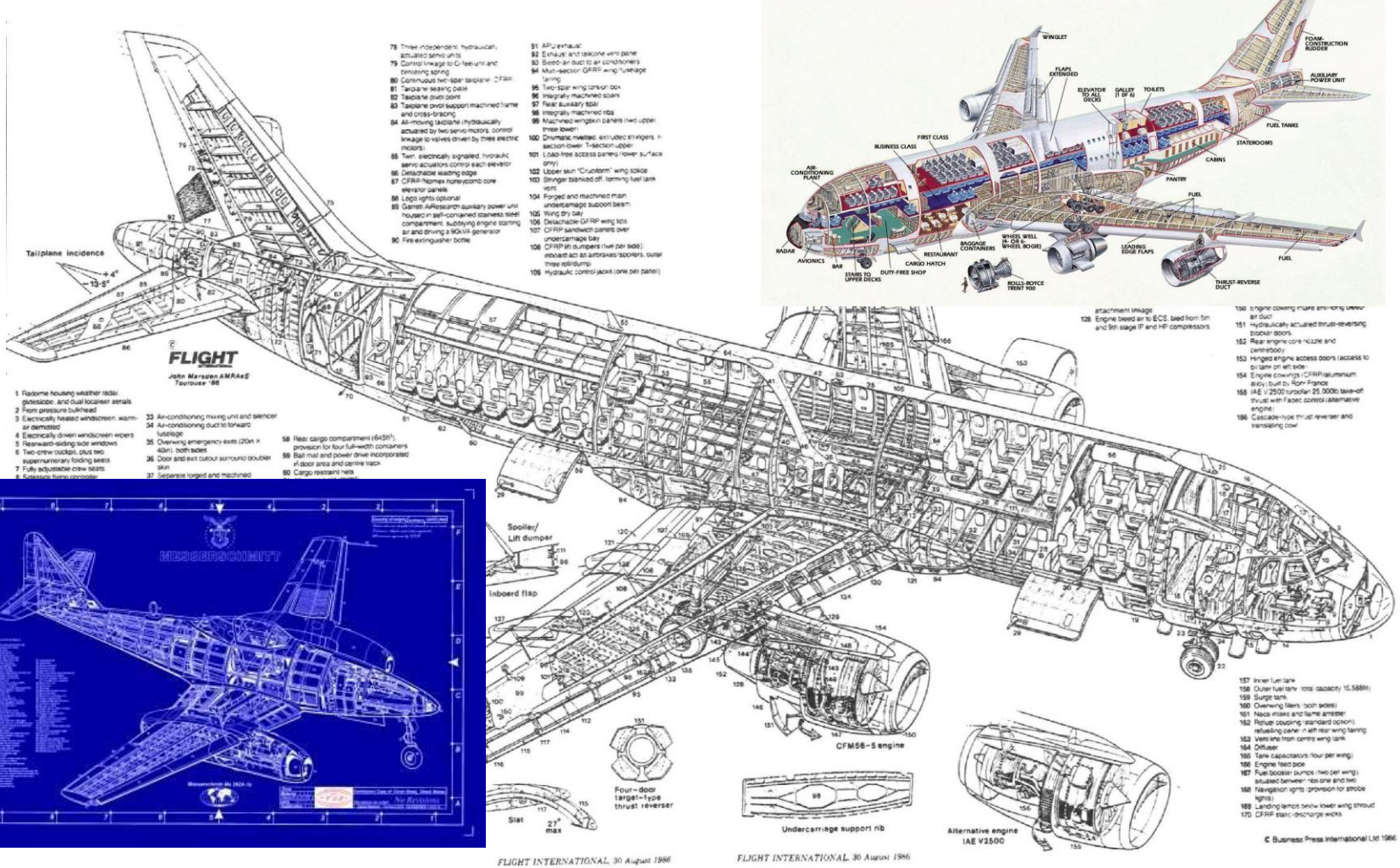
Learning Objectives

- Ensure a common understanding of the fundamental parts of an aircraft
  - Sub-assemblies: fuselage, undercarriage, tailplane, engines, wing
  - Form and function
  - Control





Highly Complex Systems



Many Different Forms……

- **Form dictated by mission requirements**
  - Range
  - Speed
  - Payload (Type and weight)
  - Take-Off & Landing Requirements

Many Different Forms……


Twin Fuselage


Canard


Flying Wing


Lifting Body


Mid Wing


High Wing


Spanloader


3-Surface


Forward Sweep


Delta Wing


Joined Wing


Twin Boom

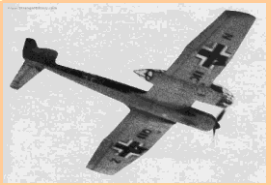

Variable Sweep


Inverse Delta Wing


Biplane
(an un-joined wing)

“Conventional”
Single fuselage
Low, aft-swept wing
Underwing engines


Oblique Wing


Asymmetric everything but the wing!





Wing-mounted engines
(Over-wing, Mid-wing, Root-mounted & Tip-mounted)



Rear Paired Engines
(Side & High)



Rear Centreline Engines
(Buried in fuselage & fin-mounted)

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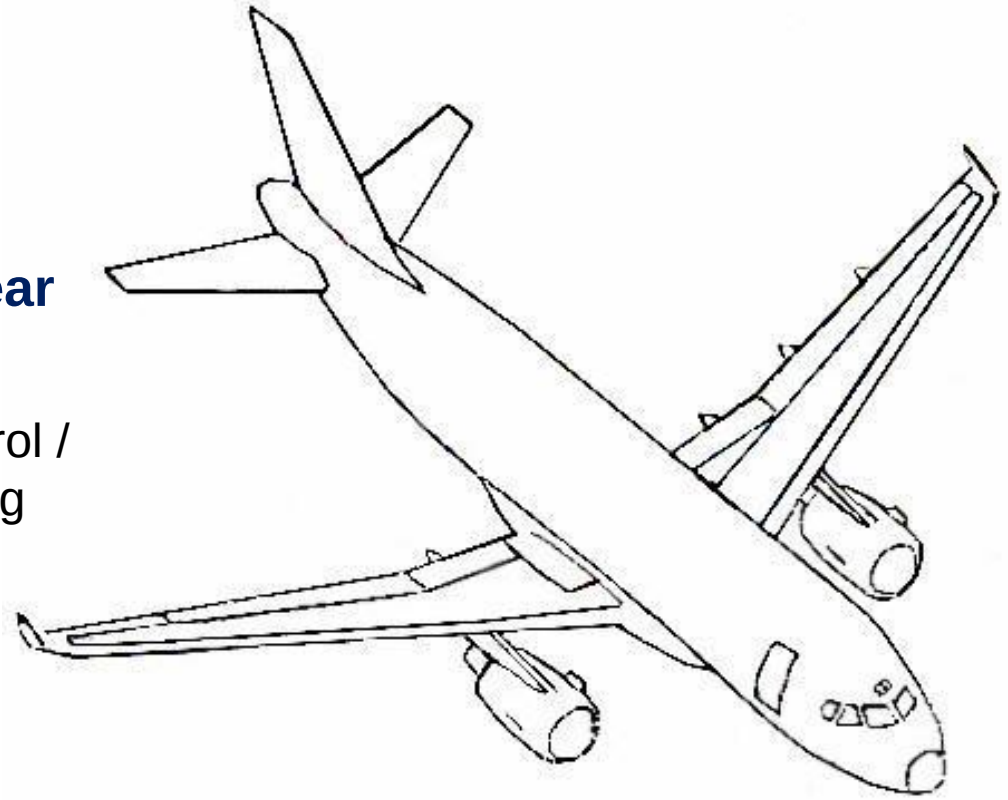
Common Features / Functions



Undercarriage / Landing Gear

- Functions
  - Ground support and control / Facilitate take-off and landing
  - Absorb kinetic energy
  - Braking
- Options
  - Fixed/retractable/float/ski
  - Configuration

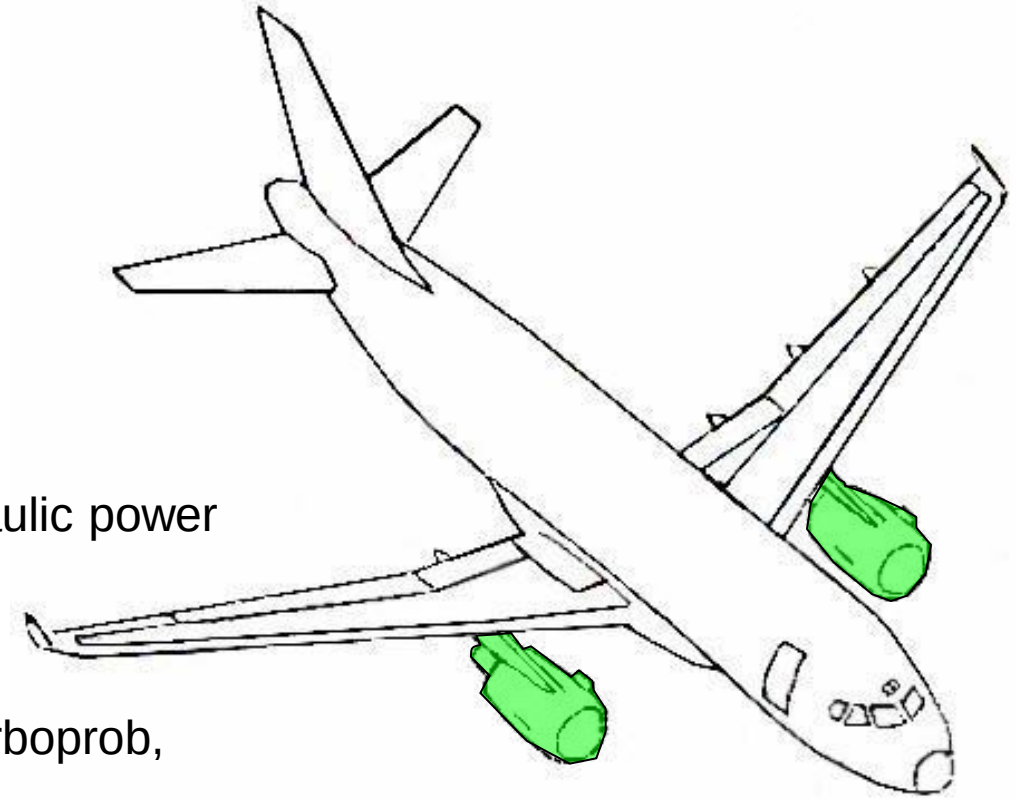
Undercarriage / Landing Gear

- Taildragger

- Tricycle

Undercarriage / Landing Gear

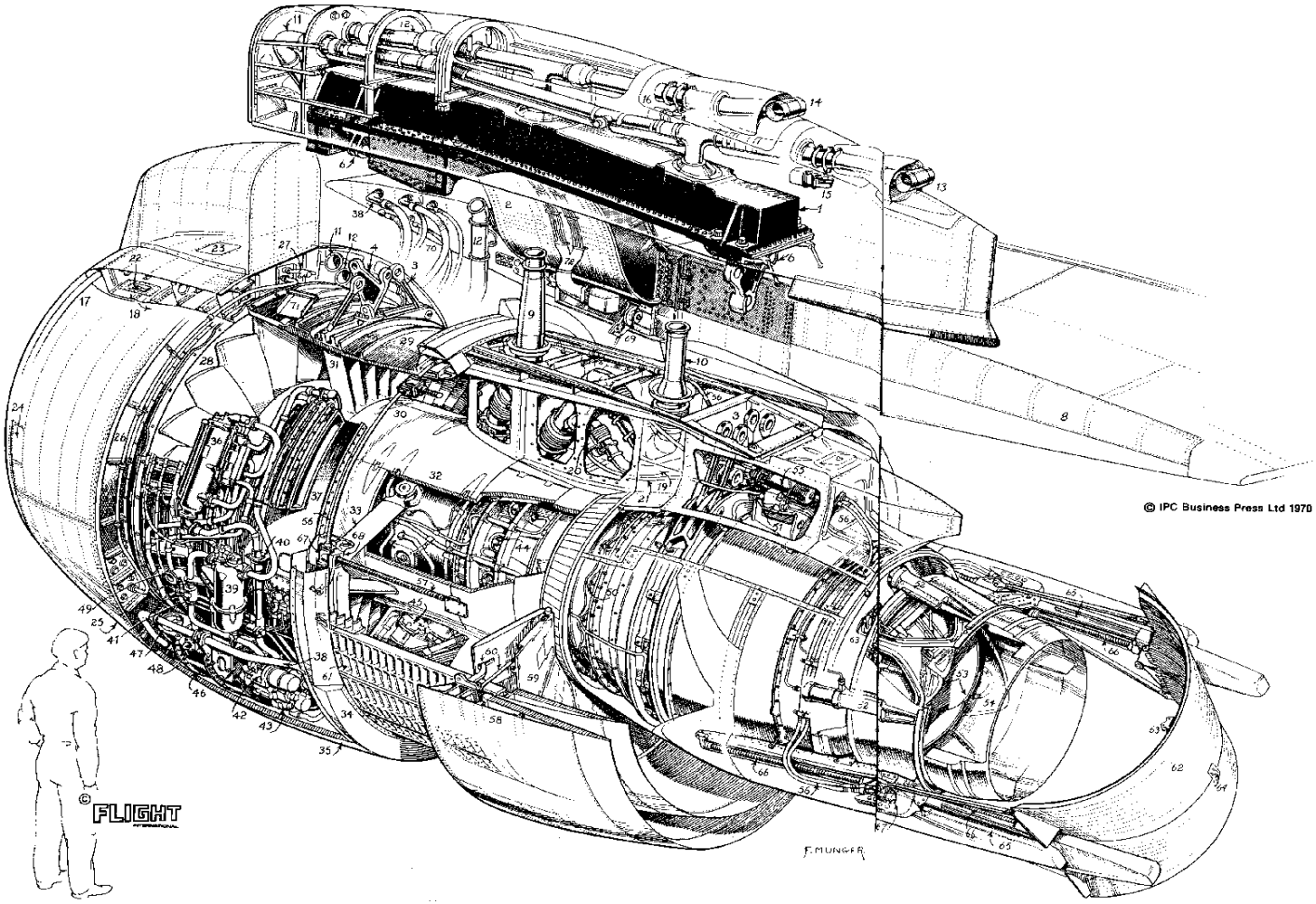
Common Features / Functions



Engines / Powerplant

- Functions
  - Provide thrust
  - Generate electrical/hydraulic power
- Options
  - Number
  - Type: human, electric, turboprob, turbofan, turbojet, rocket
  - Pusher/Tractor
  - Location

Engines / Powerplant



Engines / Powerplant

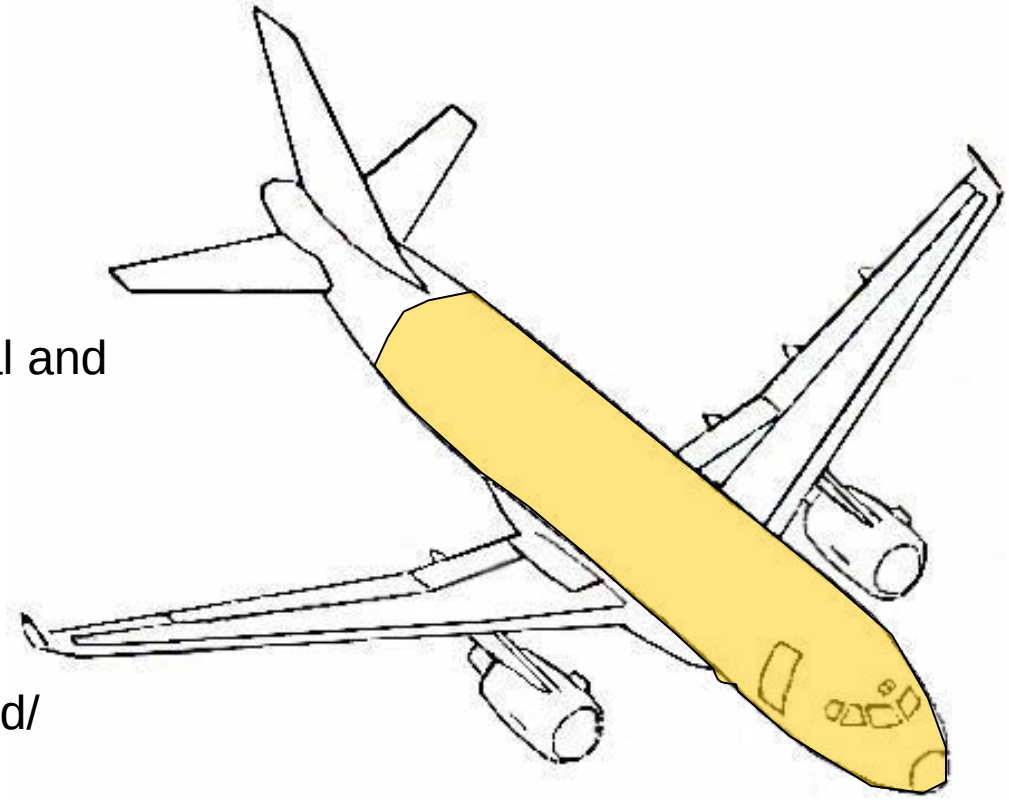
Engines / Powerplant

- Aerovelo
- LC130

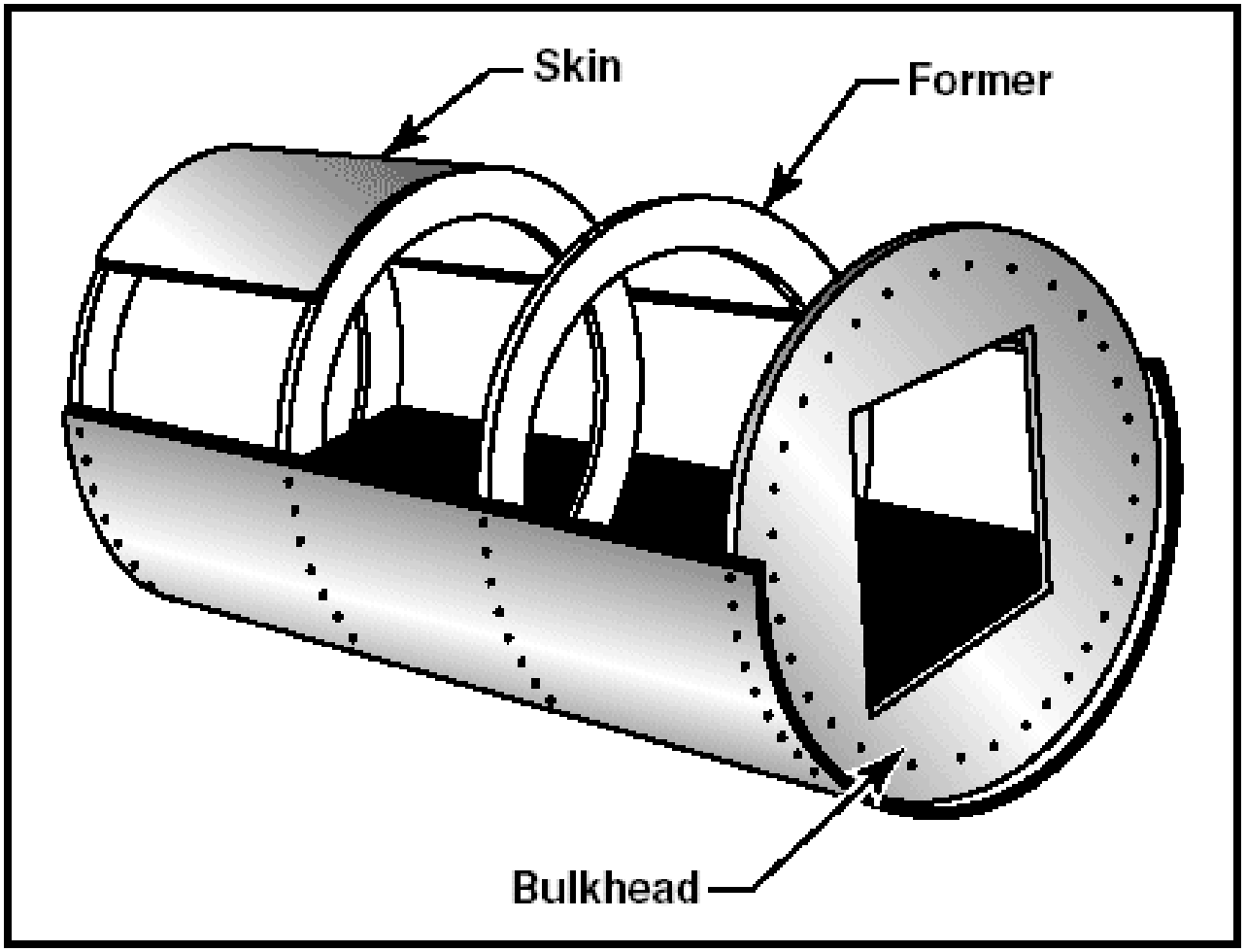
Common Features / Functions

Fuselage

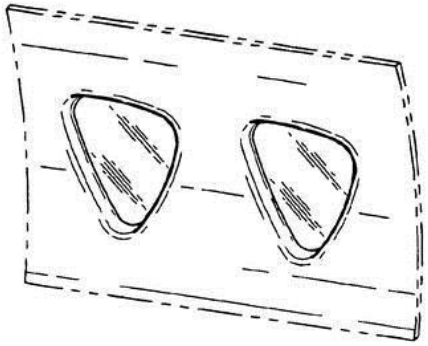
- Functions
  - Accommodate payload
  - Contributes to longitudinal and directional stability
- Options
  - Size
  - Cross-section
  - Pressurized/unpressurized/ pressurized hose

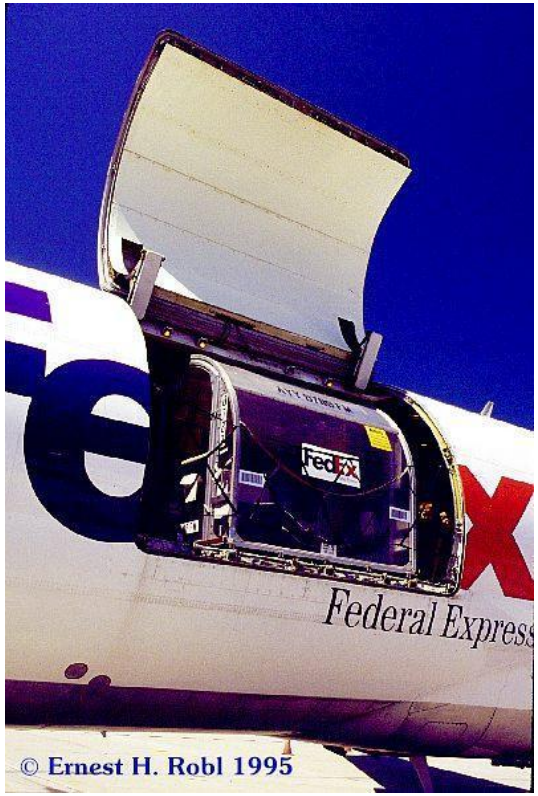


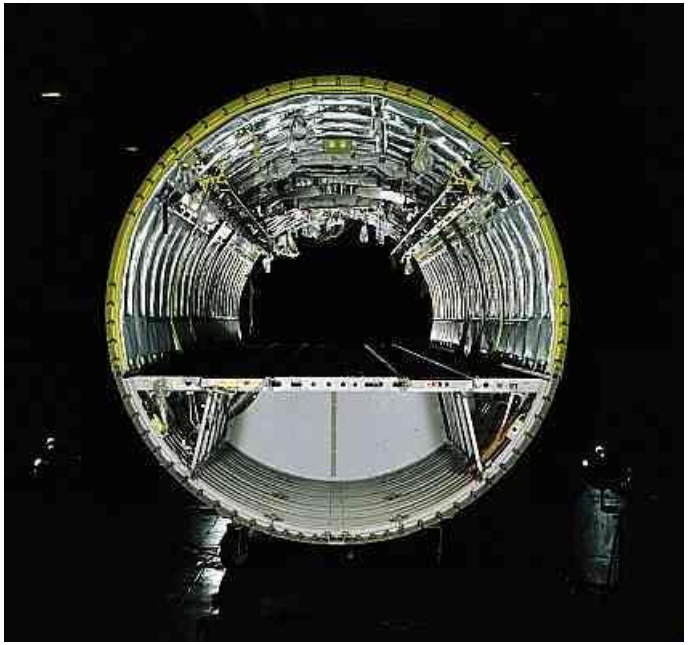
Fuselage



Fuselage

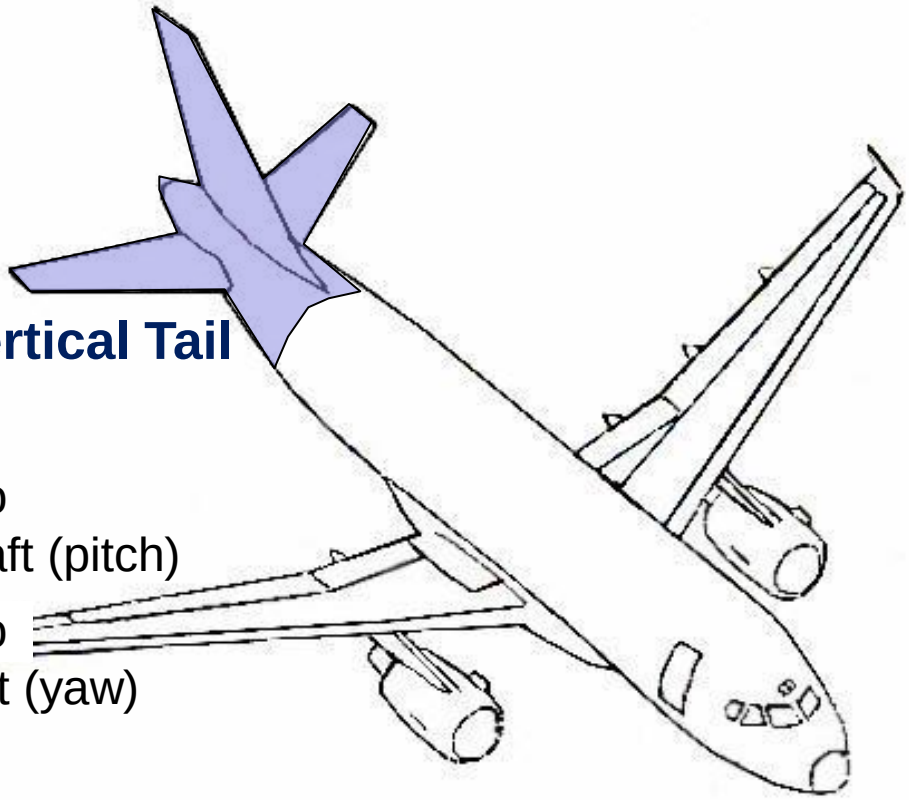






Fuselage, exceptions

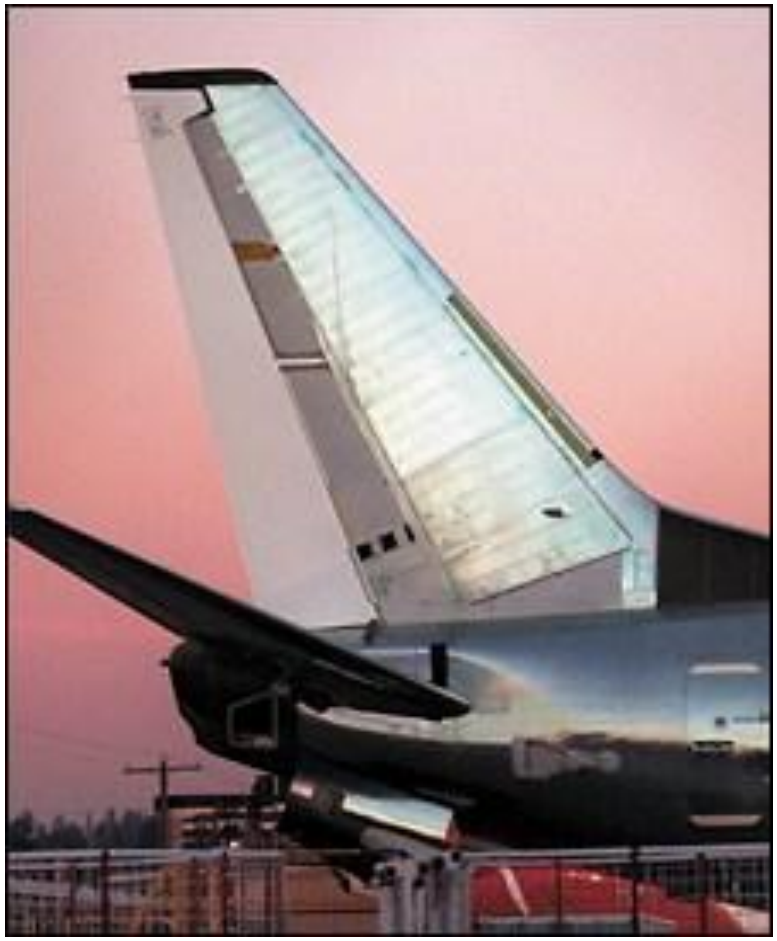
Common Features / Functions



Empennage / Horizontal and Vertical Tail

- Functions
  - Provide aerodynamic forces to longitudinally control the aircraft (pitch)
  - Provide aerodynamic forces to directionally control the aircraft (yaw)
- Options
  - Aft or forward
  - Configuration
  - Size

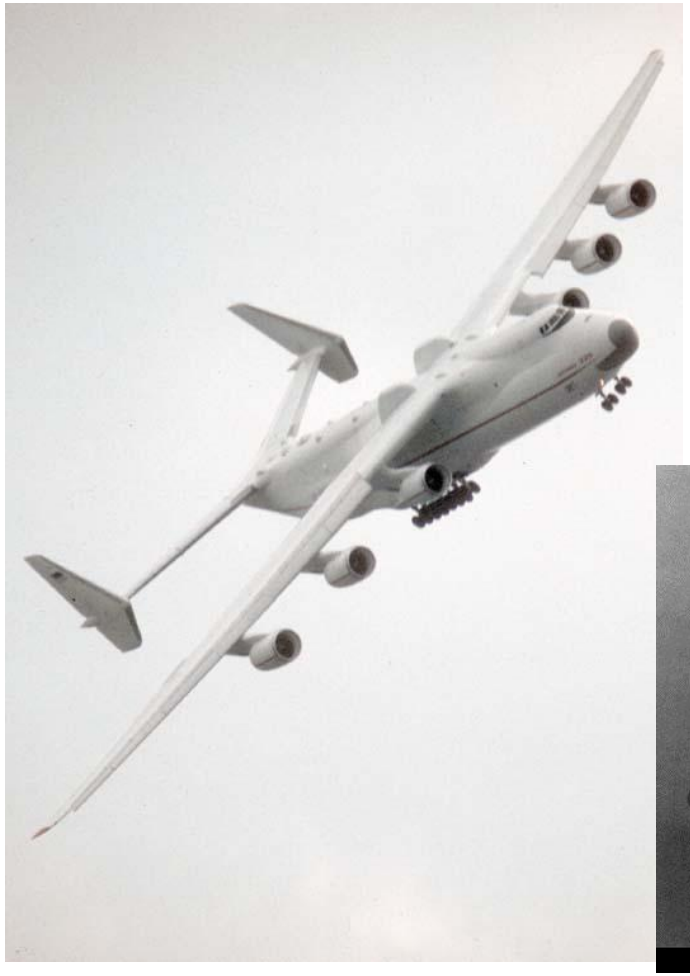
Empennage / Horizontal and Vertical Tail



Empennage: conventional

Empennage: T-Tail

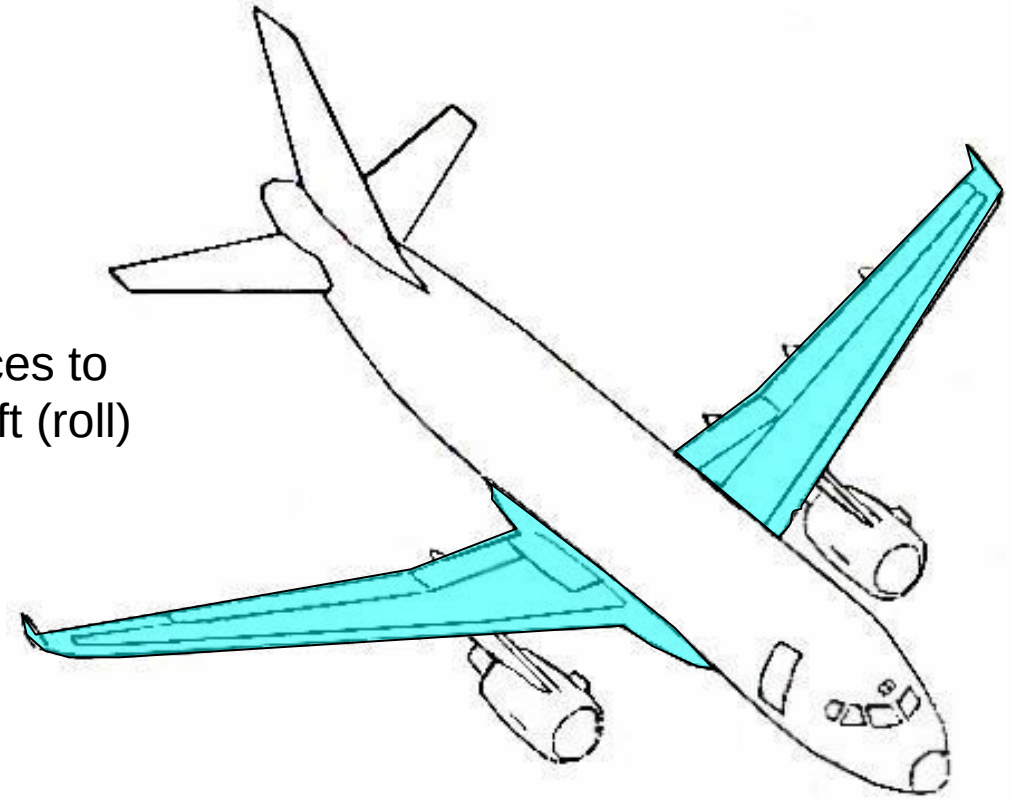
Empennage



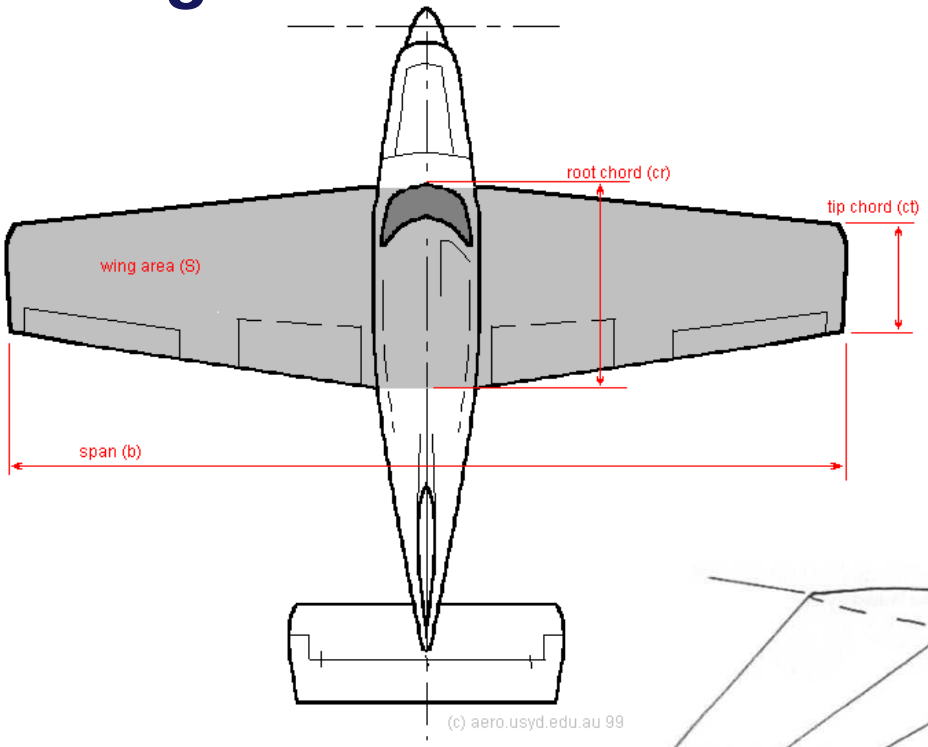
Common Features / Functions

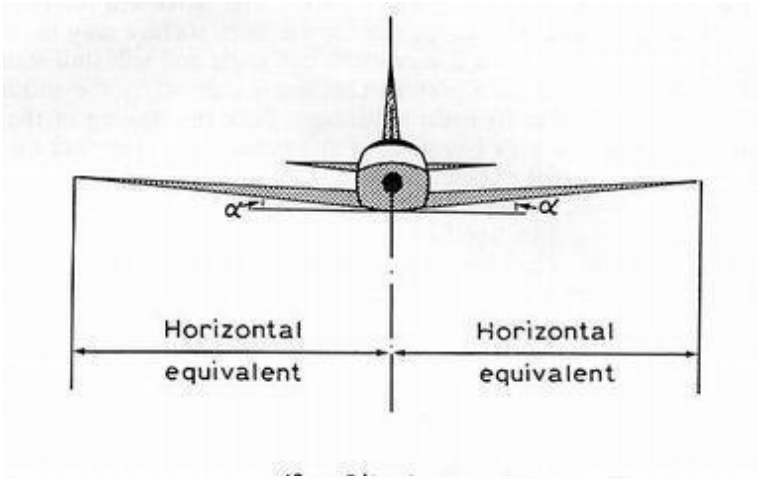
Wing

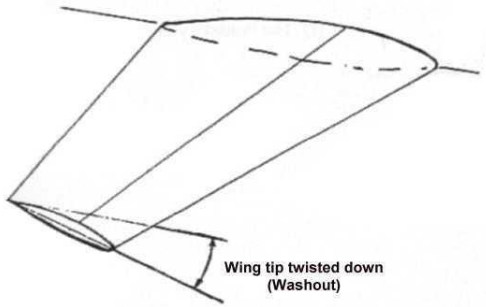
- Functions
  - Provide lift!
  - Provide aerodynamic forces to laterally control the aircraft (roll)
  - Store fuel
- Options
  - Number
  - Size
  - Location
  - Shape
  - Structural configuration

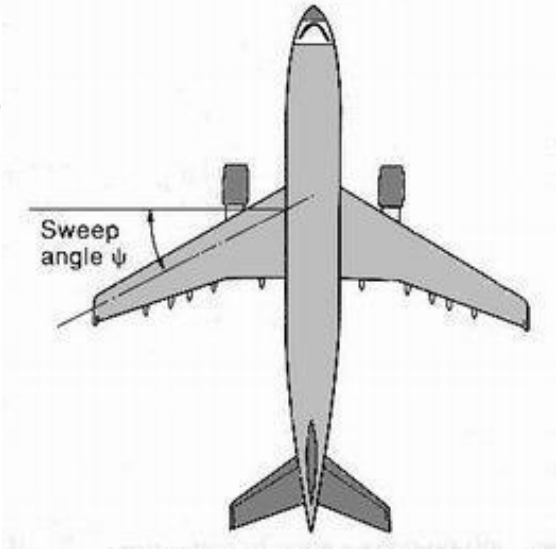


Wing


root chord (cr)
tip chord (ct)
wing area (S)
span (b)
(c) aero.usyd.edu.au 99


α
-α
Horizontal
equivalent
Horizontal
equivalent


Wing tip twisted down
(Washout)


Sweep
angle ψ

Wing

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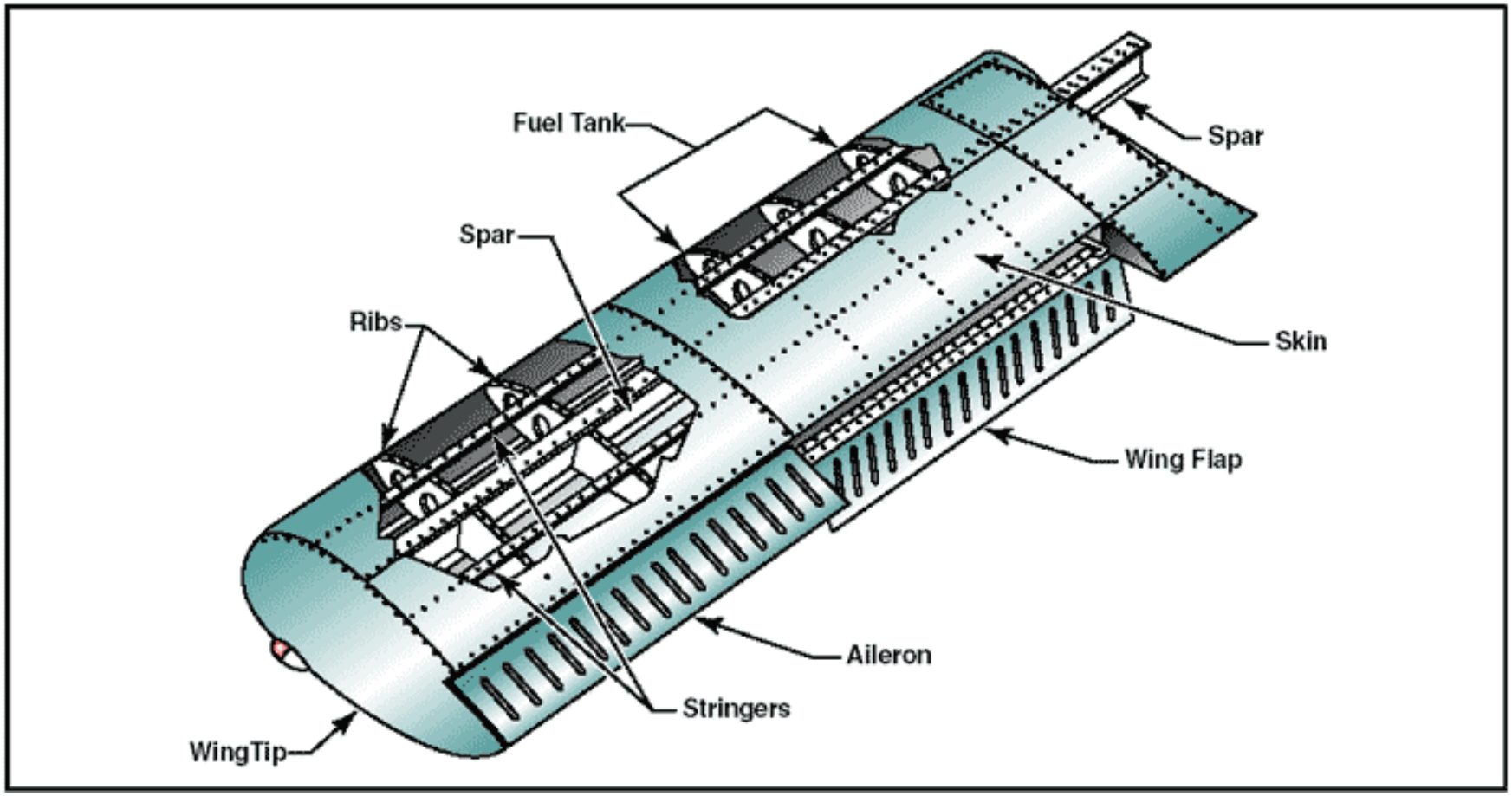
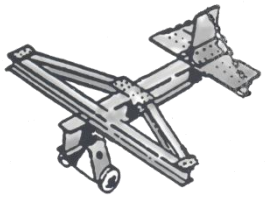
Wing Structure



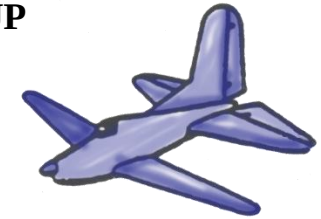
Design Integration is Vital…

WEIGHT GROUP

AERODYNAMICS GROUP

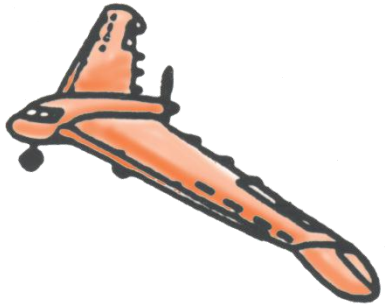


STRESS GROUP

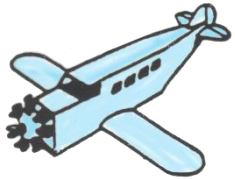


EMPENNAGE GROUP

WING GROUP

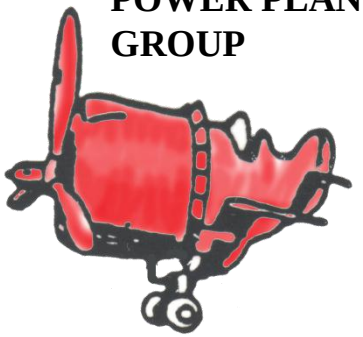


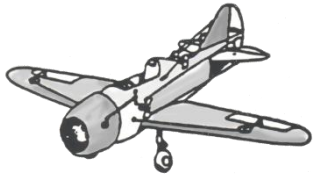
PRODUCTION ENGINEERING GROUP



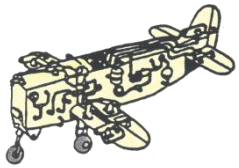
FUSELAGE GROUP

POWER PLANT GROUP





CONTROLS GROUP



HYDRAULICS GROUP

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Flight Control System

- A Flight Control System (FCS) consists of the flight ***control surfaces***, the respective ***cockpit controls***, ***connecting linkages***, and necessary operating ***mechanisms*** to control aircraft in flight.

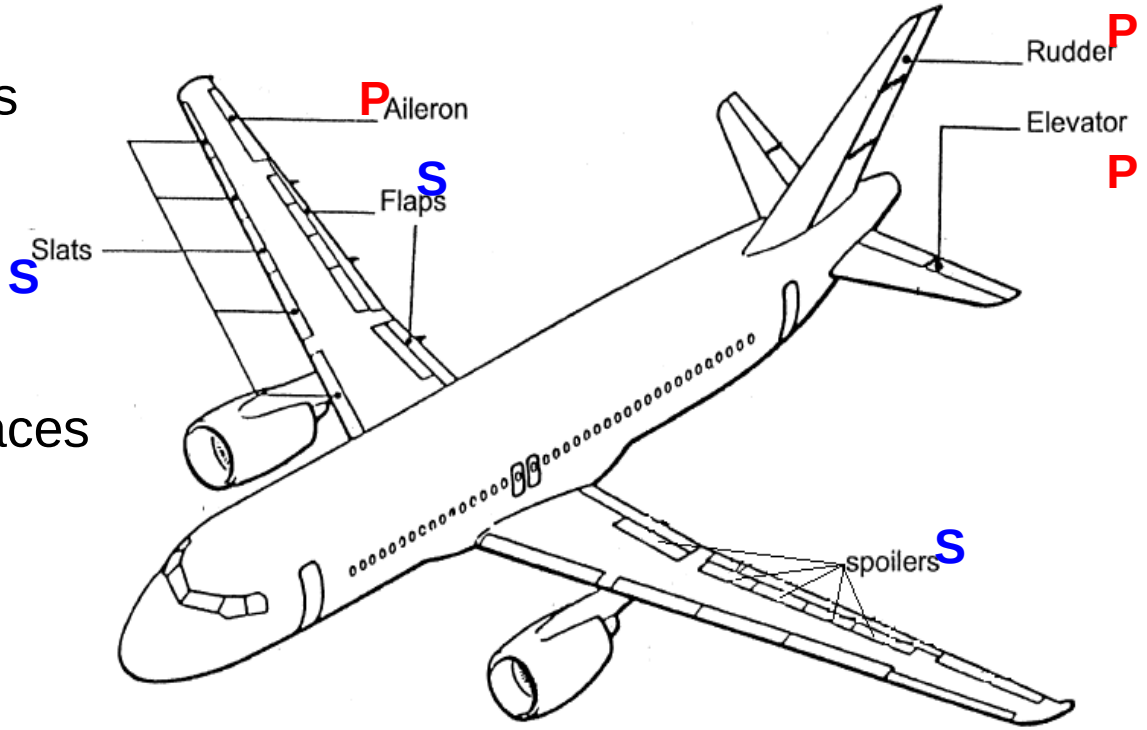
Control Surfaces

Primary control surfaces

- Elevator
- Aileron
- Rudder

Secondary control surfaces

- Flaps
- Slats
- Spoilers

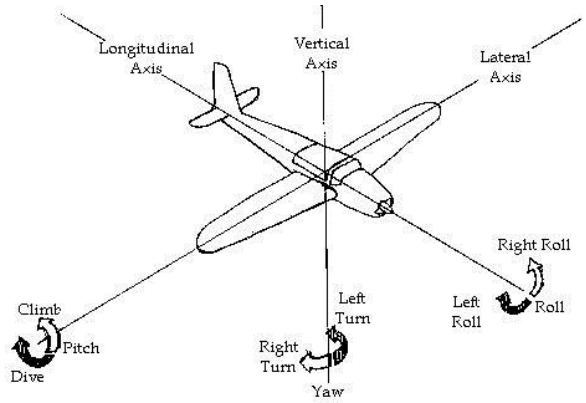


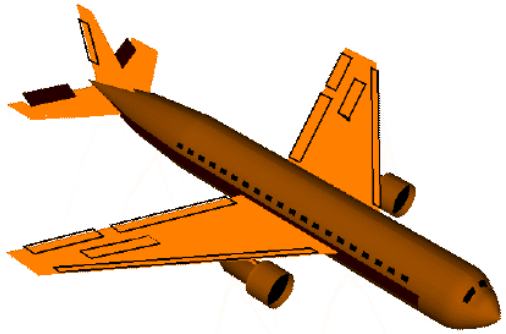
Alternative primary control surfaces

- Ruddervator, Elevon, Flaperon, Taileron, Canard

Primary Control Surfaces

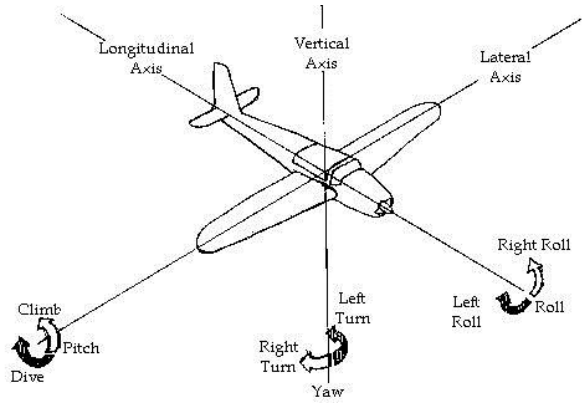
- **Elevators** are used to control the aircraft in **pitch**.

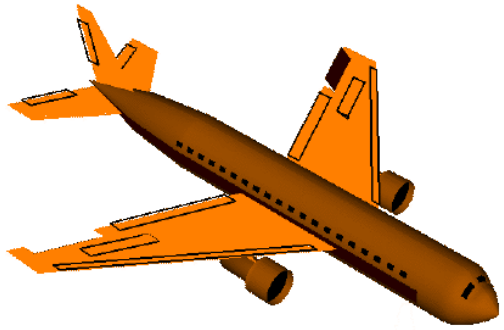




Primary Control Surfaces

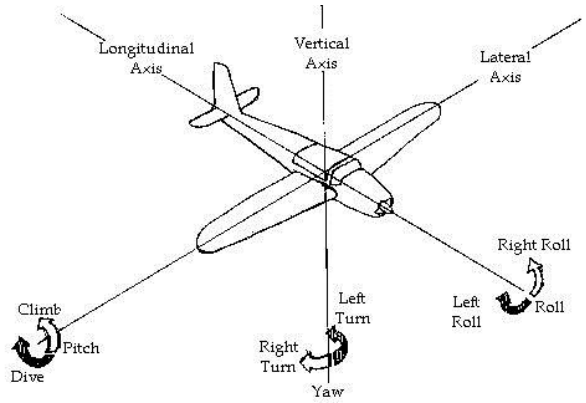
- **Elevators** are used to control the aircraft in **pitch**.
- **Ailerons** are used to control the aircraft in **roll**.
  - The two ailerons are typically interconnected so that one goes down when the other goes up

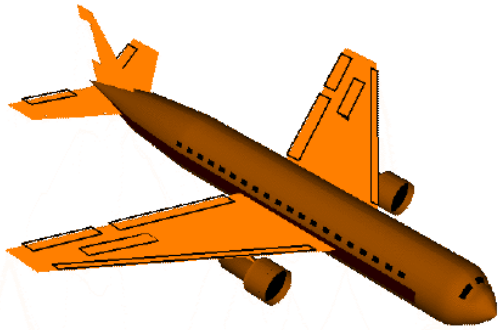




Primary Control Surfaces

- **Elevators** are used to control the aircraft in **pitch**.
- **Ailerons** are used to control the aircraft in **roll**.
  - The two ailerons are typically interconnected so that one goes down when the other goes up
- **Rudder** is used to control the aircraft in **yaw**.





Secondary Control Surfaces - Flaps

- Flaps are high-lift devices hinged on the *trailing edge* of the wings.
- Flaps occupy 25-30% of the wing trailing edge inboard of the ailerons
- As flaps are extended, the stalling speed of the aircraft is reduced.
  - Flaps *reduce the stalling speed by increasing the camber* of the wing and thereby *increasing the maximum lift coefficient*.
  - Some flaps also *increase the area* of the wing.
- A supplementary function is to increase drag during landing

Secondary Control Surfaces - Slats

- Slats are aerodynamic surfaces on the *leading edge* of the wings of which, when deployed, *allow the wing to operate at a higher angle of attack*.

- Slats are very powerful devices to *increase the maximum lift*.

- By deploying slats an aircraft can fly slower or take off and land in a shorter distance.

- They are used while landing or performing manoeuvres which take the aircraft close to the stall, but are retracted in normal flight to minimise drag.

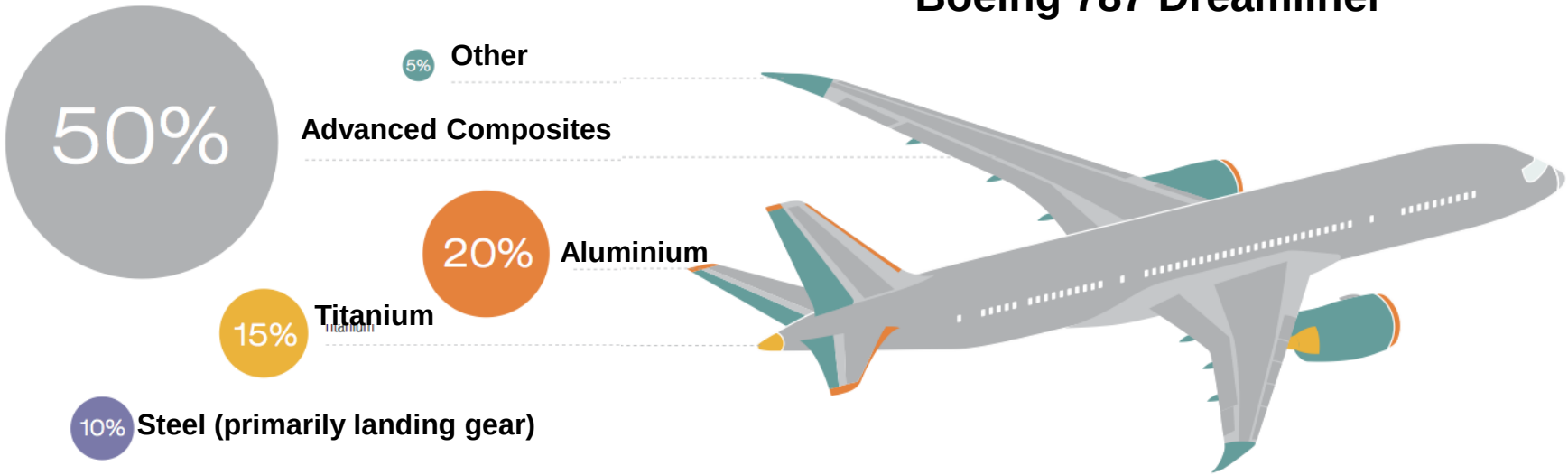
Secondary Control Surfaces - Spoilers

- Spoilers are used to disrupt airflow over the wing and *greatly reduce the amount of lift*. This allows:
  - Loss of altitude without gaining excessive airspeed
  - Wing load alleviation
- Some spoilers, termed *spoilerons*, may be used to *roll an aircraft* by reducing the lift of one wing but unlike ailerons not increasing the lift of the other wing.
  - A raised spoileron also increases the drag on one wing which causes the aircraft to yaw. This can be compensated with the rudder.

Form is not the only factor influencing aircraft design

- Materials: Increased use of composites is key to future weight reductions but poses significant challenges:
  - Failure Analysis (very difficult to predict how composites will fail)
  - Manufacturing & Assembly
  - Quality Assurance

Boeing 787 Dreamliner



A340 Assembly Video