



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

# Basics of transport and handling technology KKS/ZDMT

## Presentation 5

### Aeroplanes

### Aerodynamics and mechanics of flight, construction, etc.

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version 2011

This presentation is part of project CZ.1.07/2.2.00/15.0383  
Innovations of Study specialisation Transport Vehicles and Handling Machinery  
with respect to market needs

This project is co-financed by  
European Social Fund and the state budget of the Czech Republic

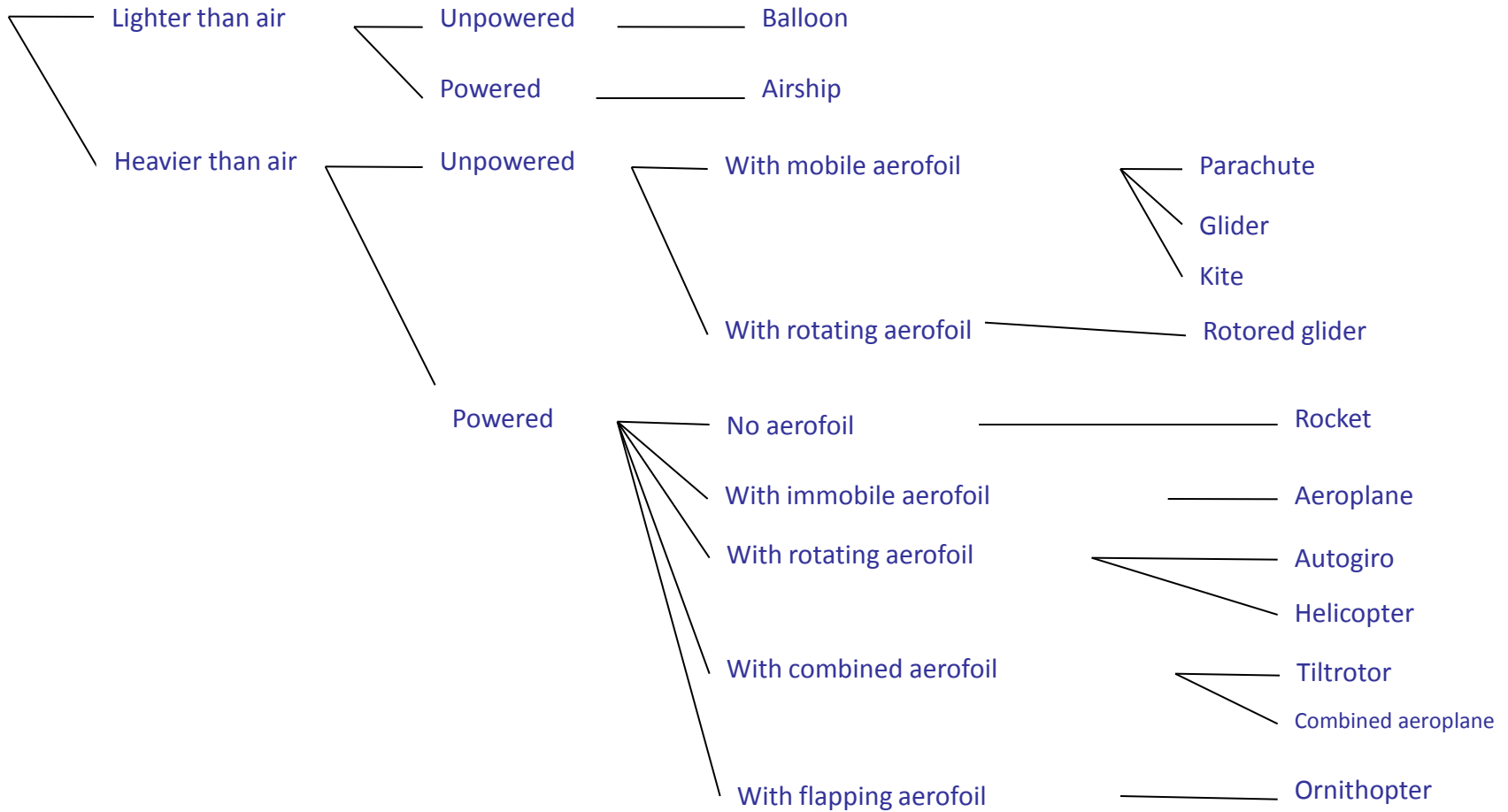
# Contents

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  - Mechanics of flight
  - Air traffic
- Presentation 2/3 (aeroplanes)
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  - Categories of aeroplanes
  - Construction of individual parts
- Presentation 3/3 (helicopters)

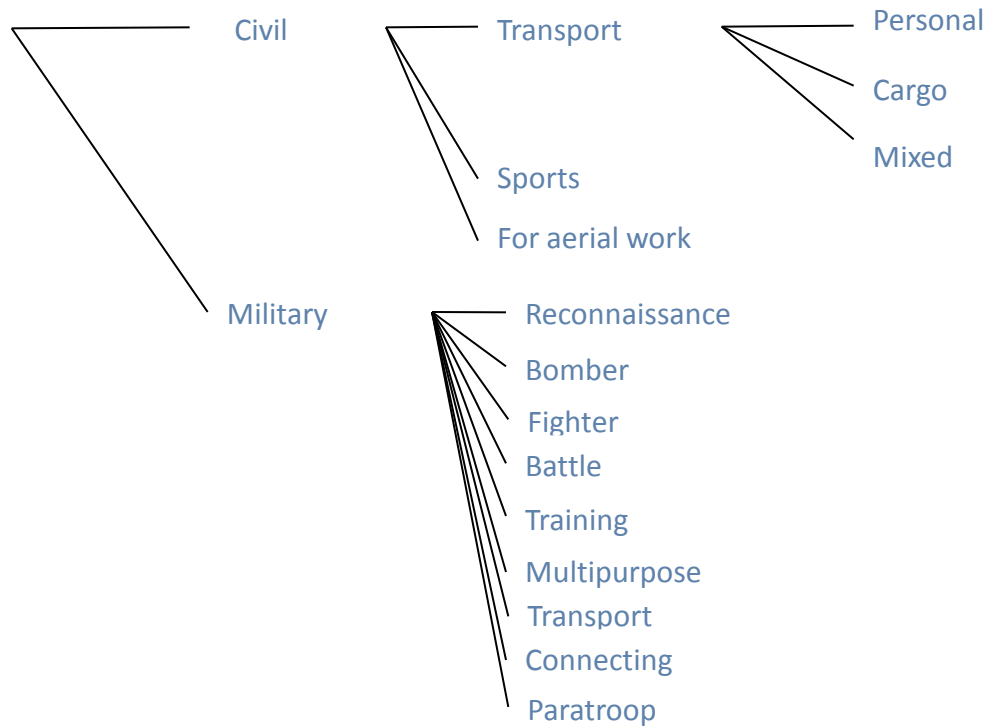
# Basic categories

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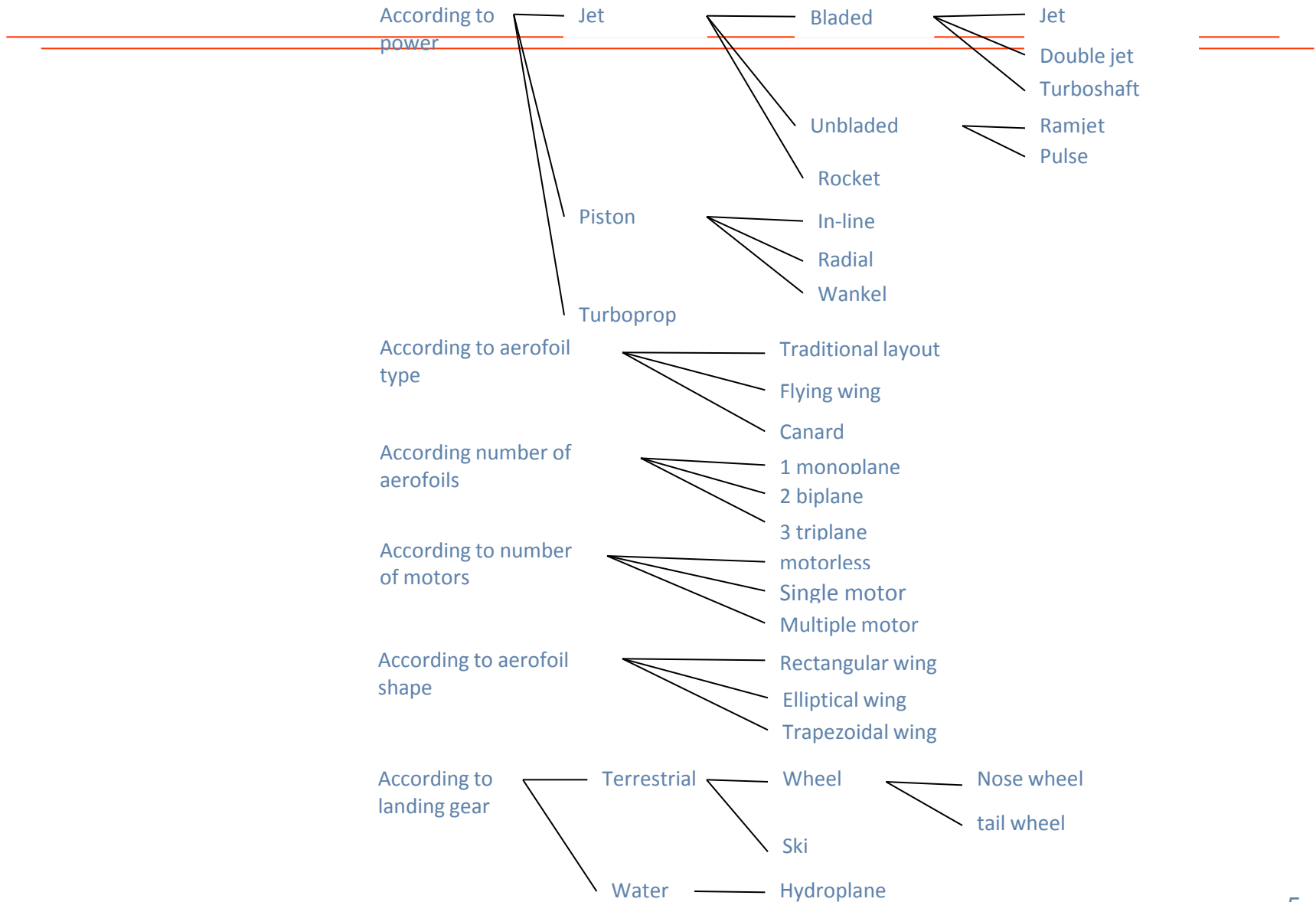


# Basic categories – according to use

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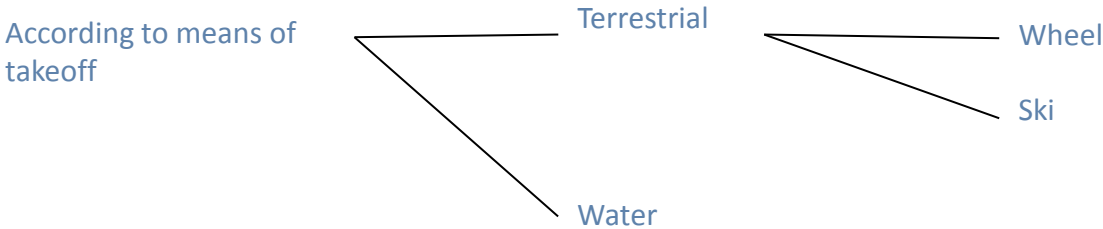
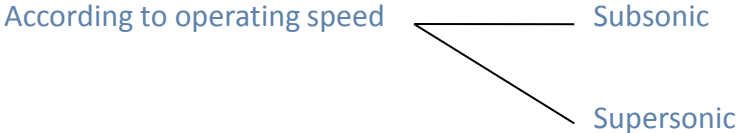


# Basic categories – according to construction



# Basic categories - miscellaneous

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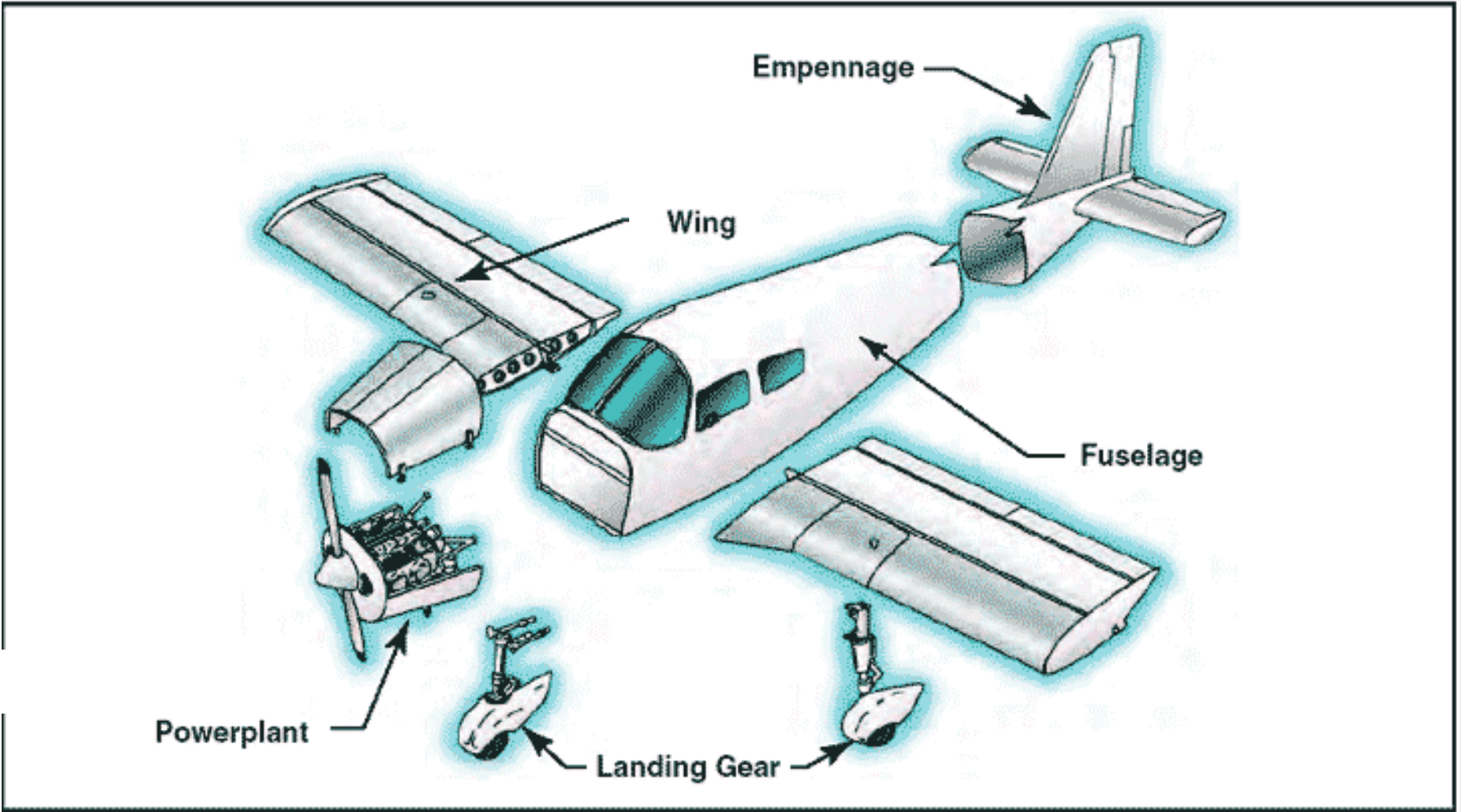


# Constructional parts

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- Construction of individual parts
  - Fuselage
  - Wings
  - Empennage
  - Landing gear
  - Systems for increasing/decreasing lift
  - Power plant

# Construction of an aeroplane



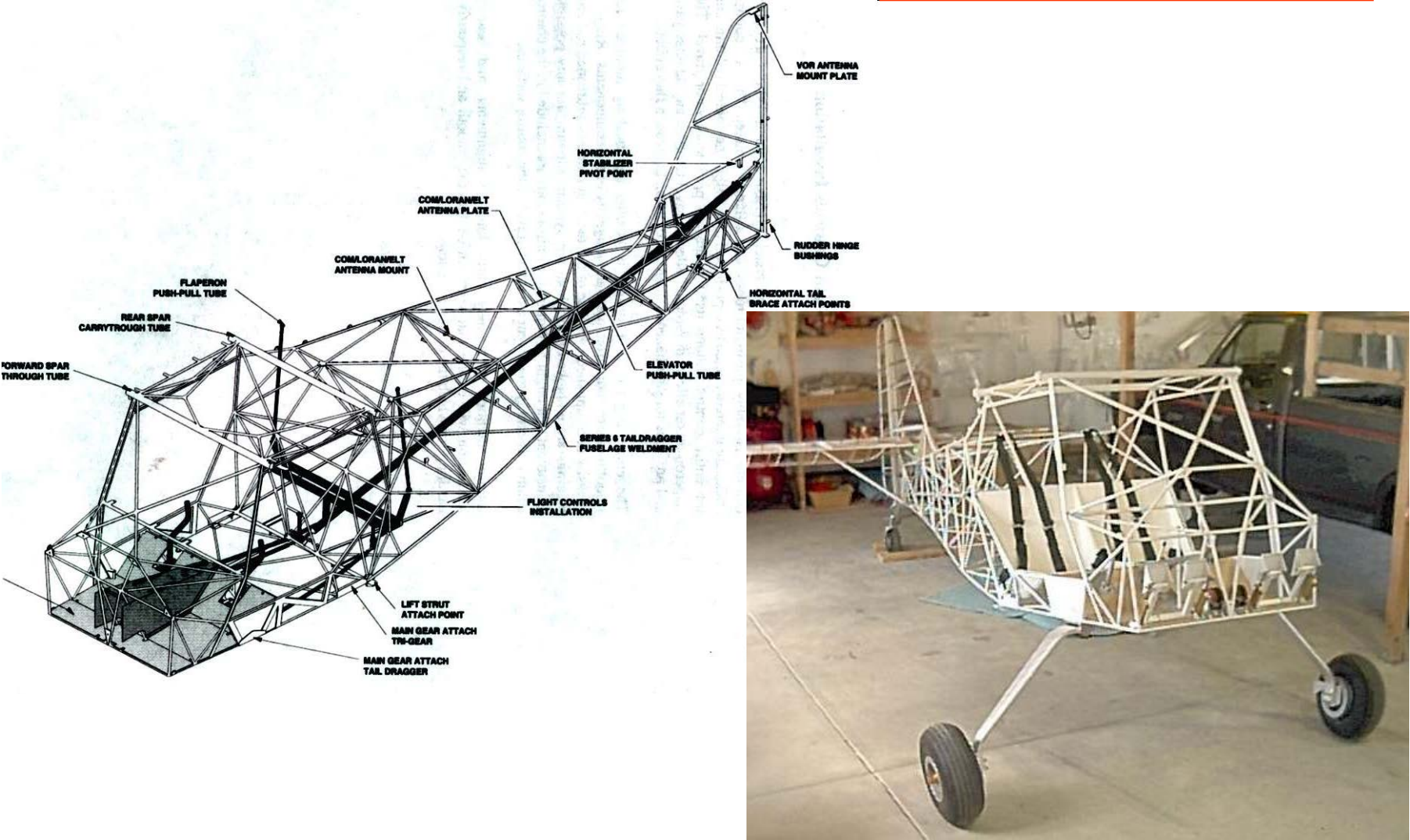


# Fuselage

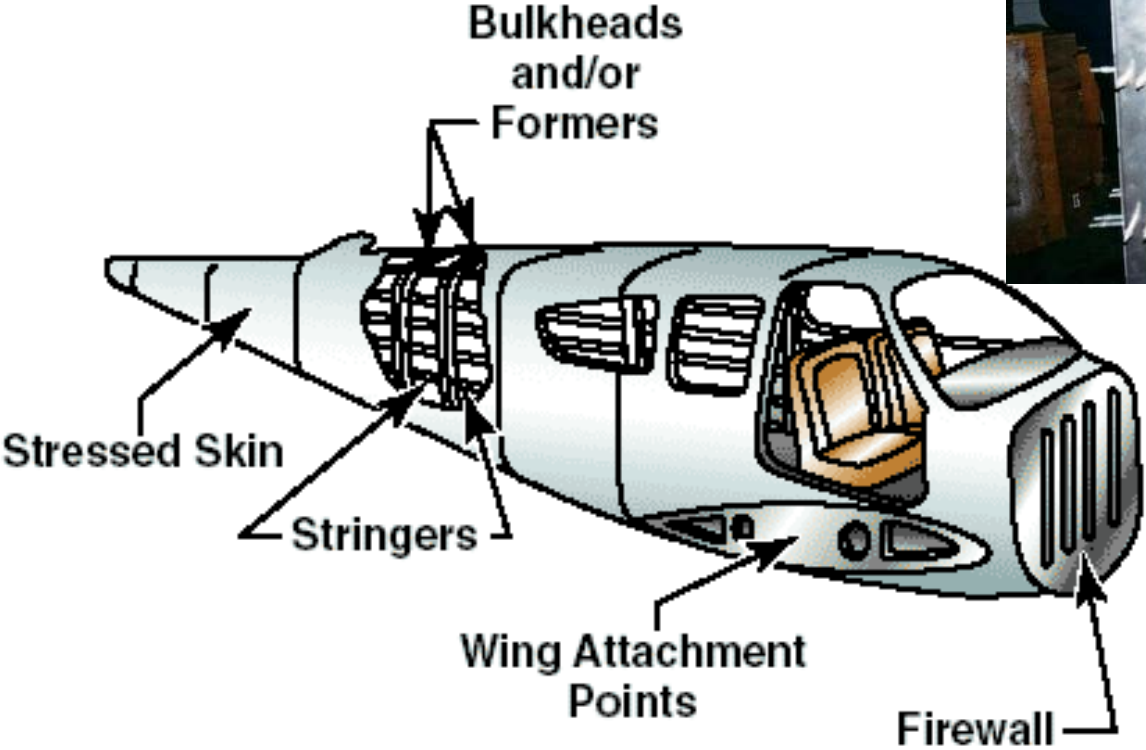
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- Central part of aeroplane construction
- Connects separate parts into a whole
- Provides space for avionics, crew, cargo
- In many cases power plant and fuel tank is here
  
- Basic types of construction
  - Trussed
  - Trussed semi-monocoque
  - Semi-monocoque
  - Monocoque
  - Combined construction
  - Sandwich construction

# Fuselage – truss structure



# Fuselage – trussed semi-monocoque



## Fuselage – mixed construction

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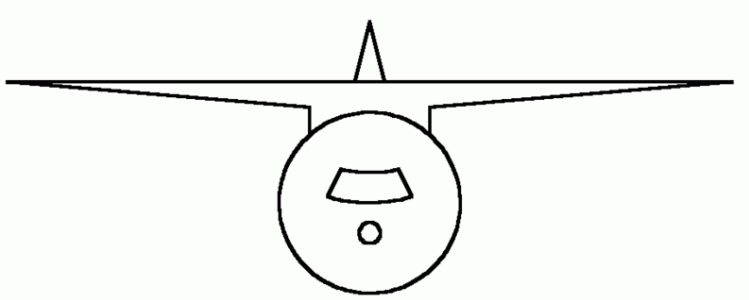
- Used in sports planes where the front section is trussed and behind the cockpit it is monocoque or semi-monocoque.
- Or the front section is composite monocoque and the rear is trussed semi-monocoque, or trussed – ULL (ultralight aeroplanes), in some gliders.
- Combination of trussed and composite surface panels – aerobatic planes.
- Multi-material solution- many transport and military planes.
- Front section monocoque, trussed, mixed and rear section is 1 or 2 truss tubes - ULL

# Wings - categories

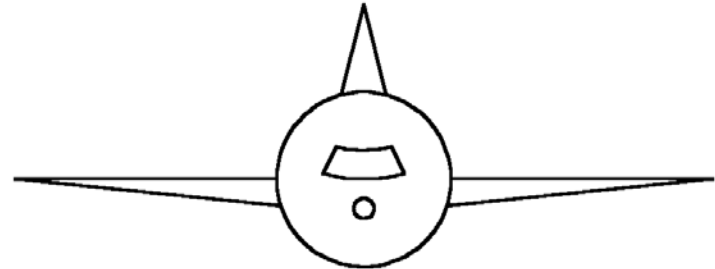
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- According to the degree of transfer of load from covering
  - Without bearing covering
  - With bearing covering
  - Geodesic construction
- According to the transfer of load from aerofoil
  - Self-supporting
  - Semi-self-supporting
  - Strutted
- According to the mode of connection to fuselage
  - Unseparated
  - Separated along line of symmetry
  - Separated at fuselage
  - With a wing root

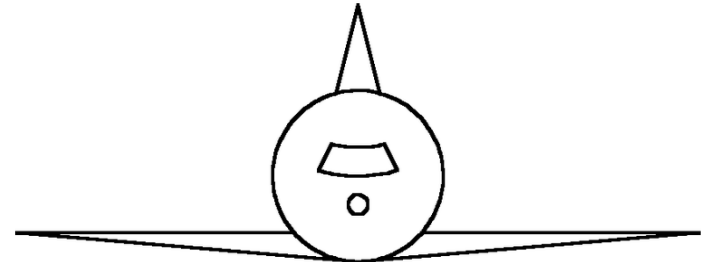
# Wings- position



High wing



Mid wing

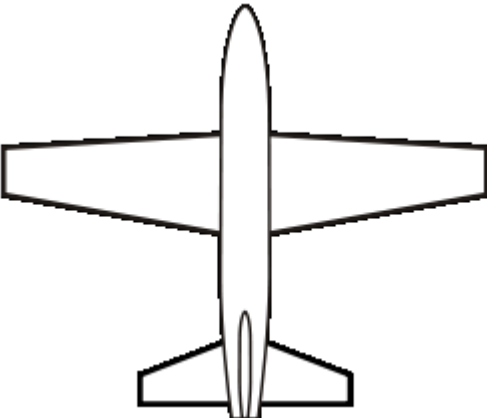


Low wing

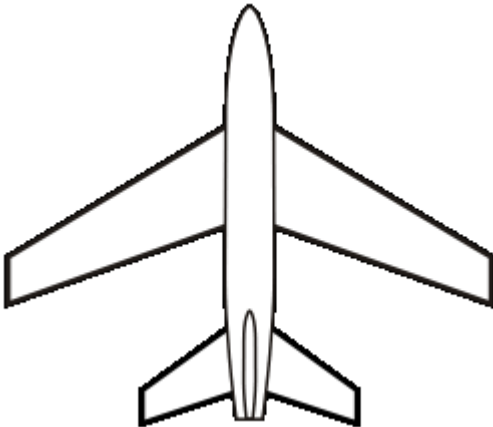


# Wings - shape

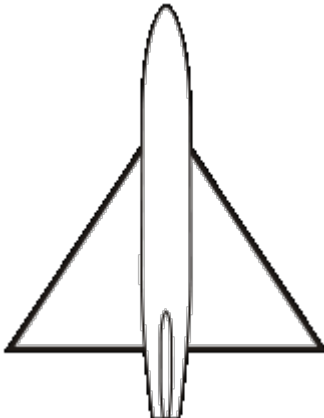
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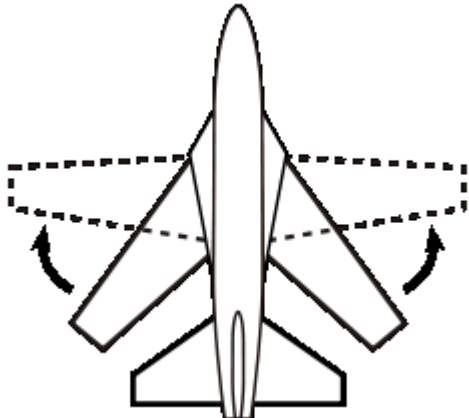
Straight



Swept



Delta



Variable

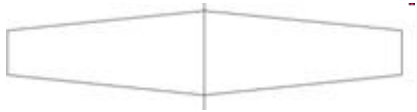
# Wings – straight

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## Constant chord–

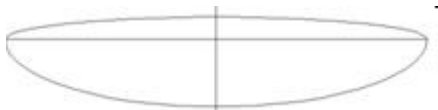
Has good properties in terms of stalling, which first separates at the fuselage. Aileron usually remains outside the stall area so efficiency is not lowered. It is also good in terms of manufacturability because of its simplicity, especially if the same profile is used along its length. This wing has the highest drag and mass.



**Tapered**– The most widespread. Relatively low mass and drag compared with constant chord. With taper  $h = 2$  drag is similar to elliptical wing. Stall point with increasing taper moves to end of wing and aileron. This can be avoided by suitable wing profile/aerofoil.



**Compound**– Frequently used combination of constant chord wing root and tapered outer wing .



**Elliptical**– Lowest drag. Main disadvantage is stalling occurs almost instantly and it is difficult to make. It is almost never used nowadays.

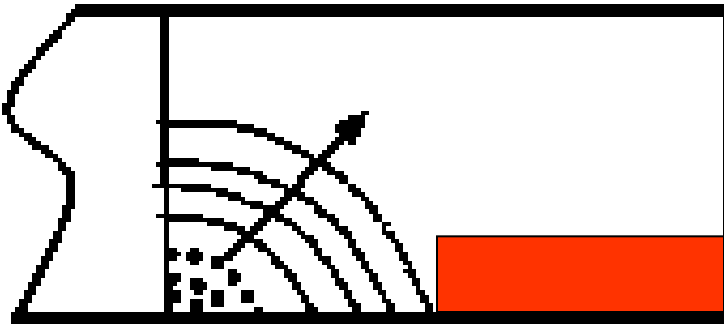


## Wings– straight wing, stalling

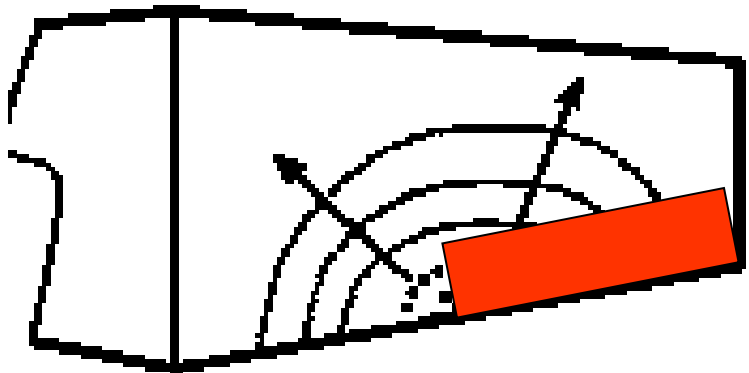
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Stalling occurs almost instantly along whole length. Best properties in terms of flight, but the most dangerous.

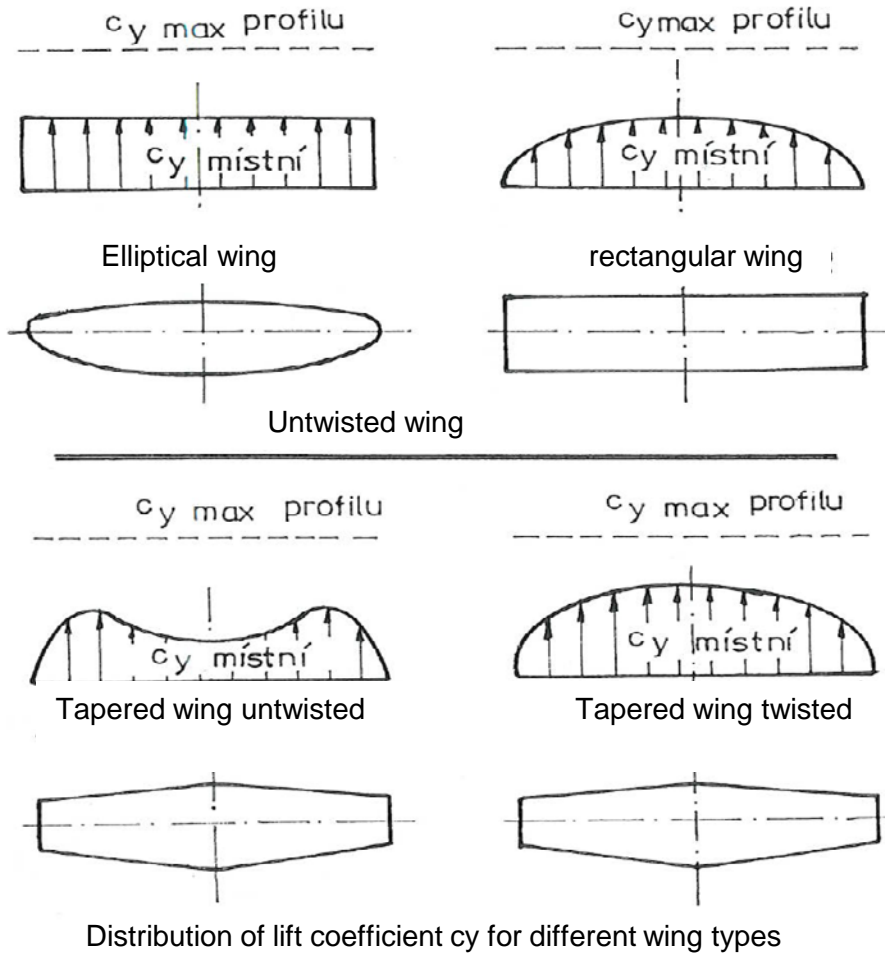


Good stalling properties which start at fuselage. Ailerons mostly stay out of stall area, so their efficiency is not reduced.



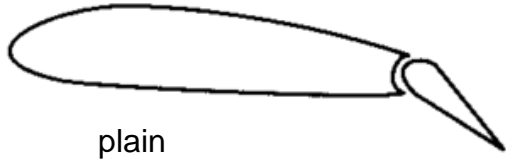
With increasing taper, stall point moves towards end of aileron and wing. This can be avoided by using suitable aerodynamic and geometric twisting of wing.

# Wings – straight wing, stalling

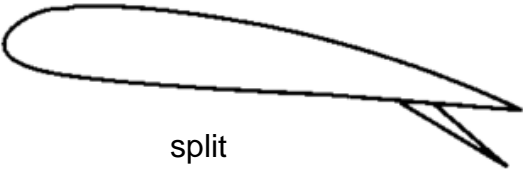


# Wings – devices for increasing lift - flaps

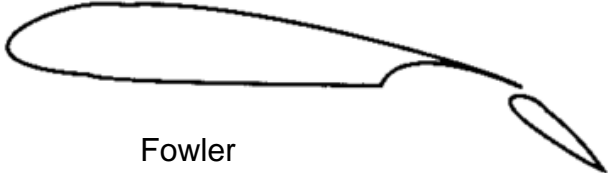
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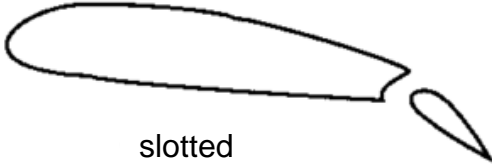
plain



split



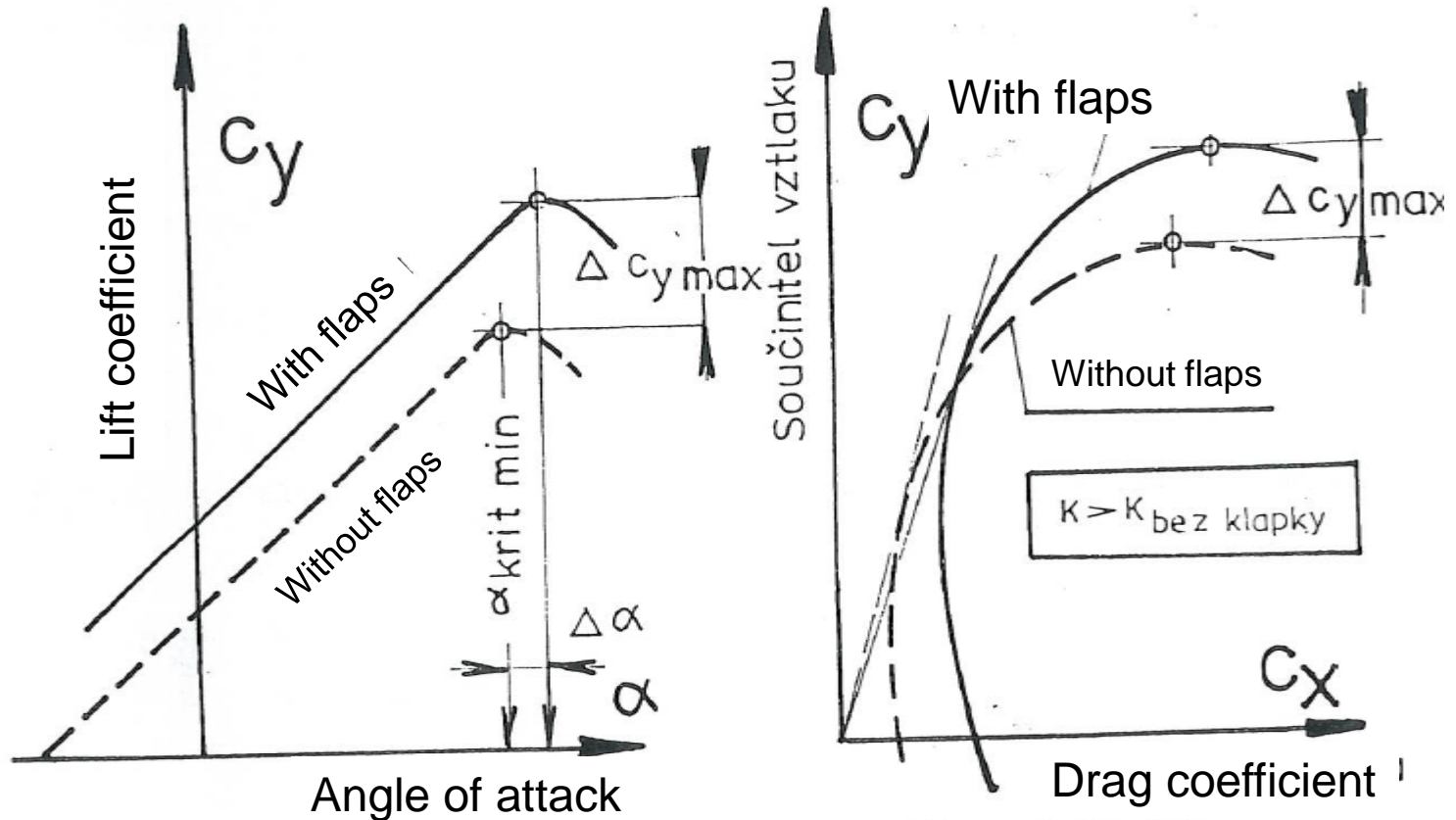
Fowler



slotted



# Wings – devices for increasing lift - flaps



Influence of flaps on aerodynamics of wings

# Wings – devices for increasing lift - slats

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**Ventilated slat**



**Sealed slat**



**Droop nose**

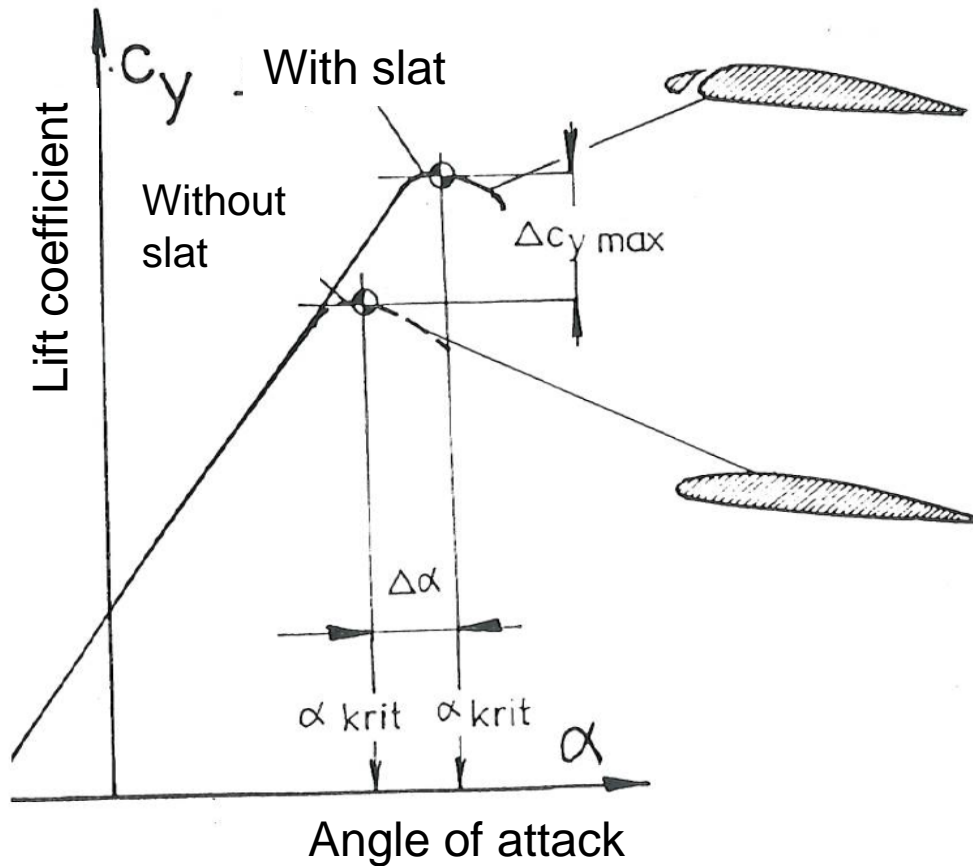


**Kruger slat**

©2000 How Stuff Works

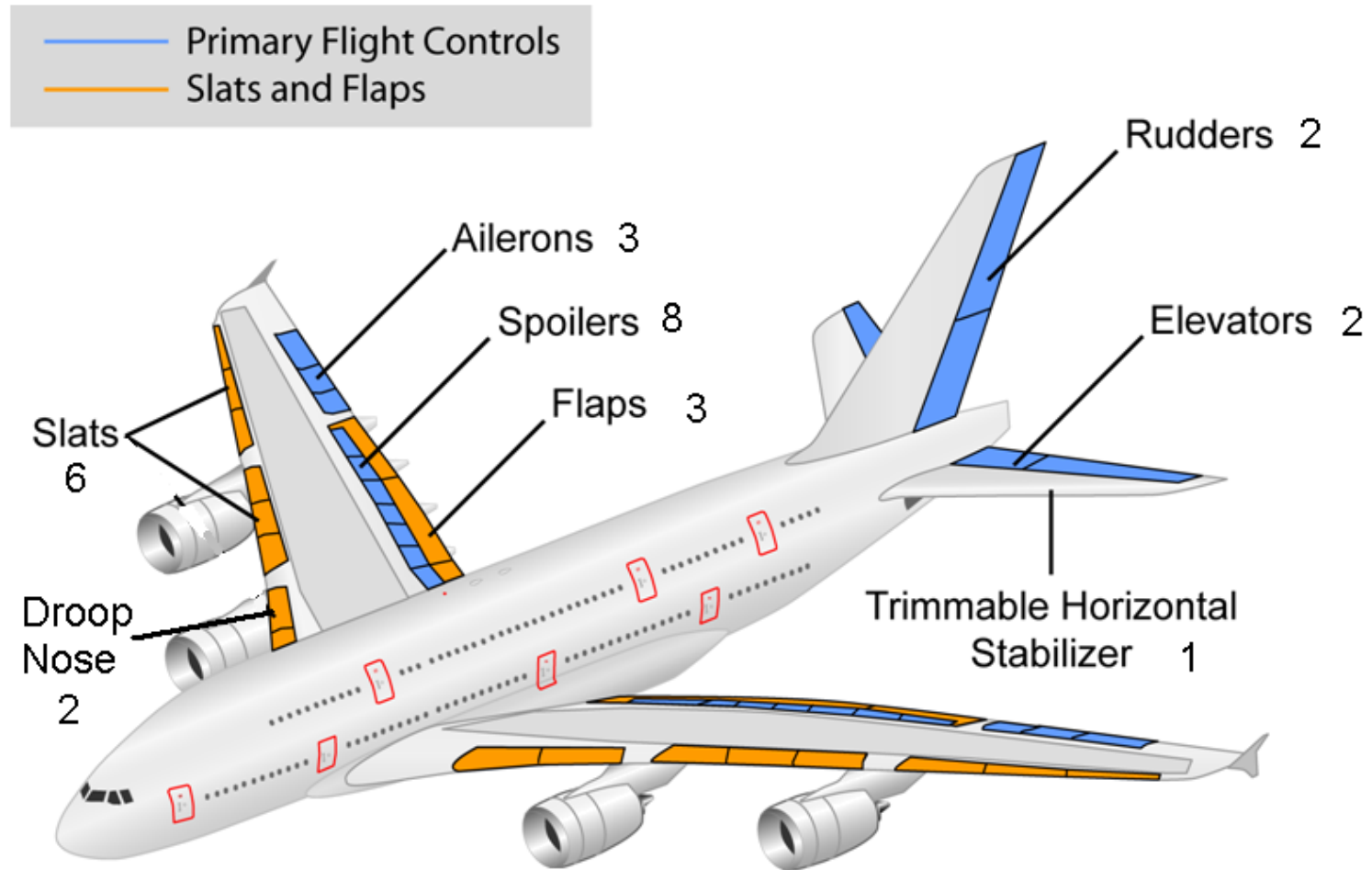


# Wings – devices for increasing lift - slats



Influence of slats on lift curve of wing

# Wings – devices for increasing lift and control surfaces



# Wings – devices for decreasing lift

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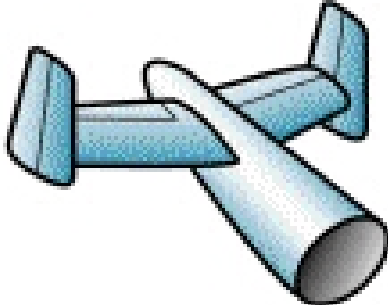
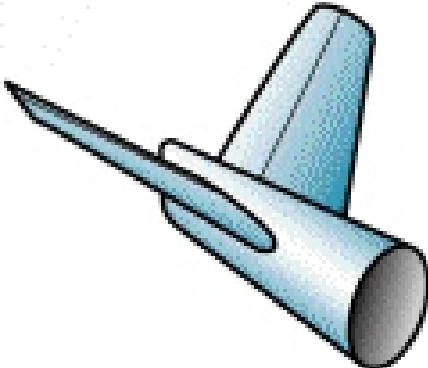
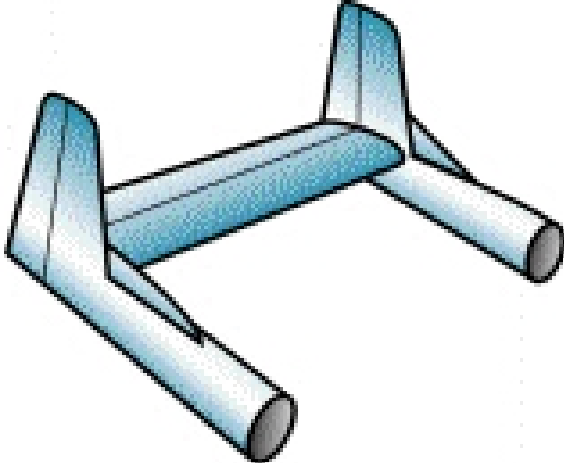
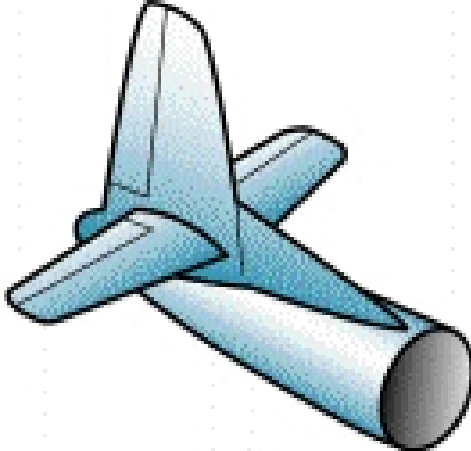
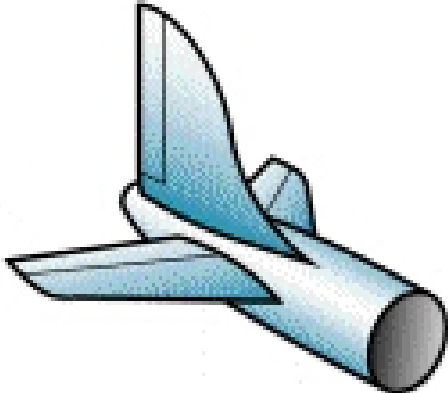


- Reverse thruster of jet engine
- Braking (reverse) propeller
- Aerodynamic brakes
- Drag parachute



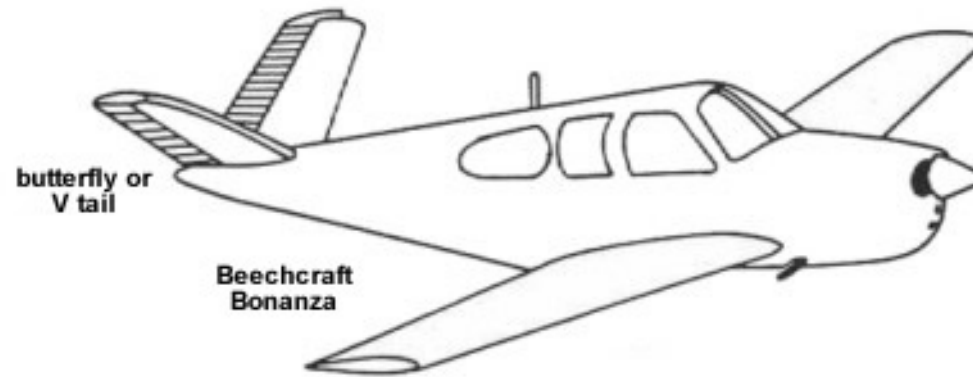
# Empennage

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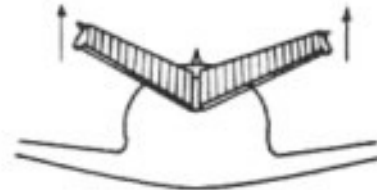


# Empennage - butterfly

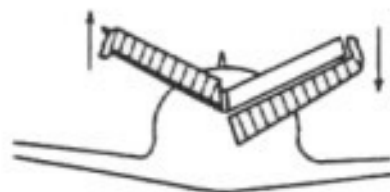
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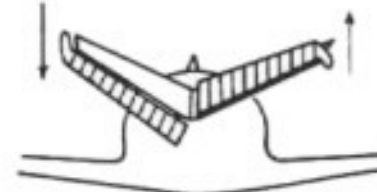
**both ruddervators down  
aircraft pitches down**



**both ruddervators up  
aircraft pitches up**



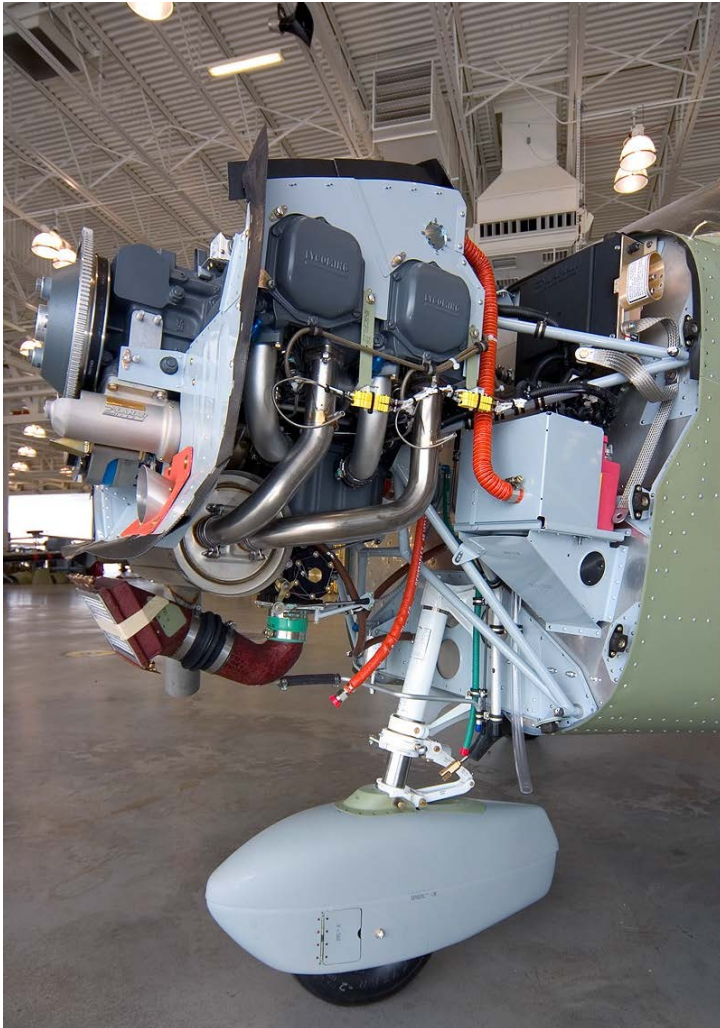
**right rudder  
aircraft yaws right**



**left rudder  
aircraft yaws left**

# Engines— piston engine

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# Engines – piston engine

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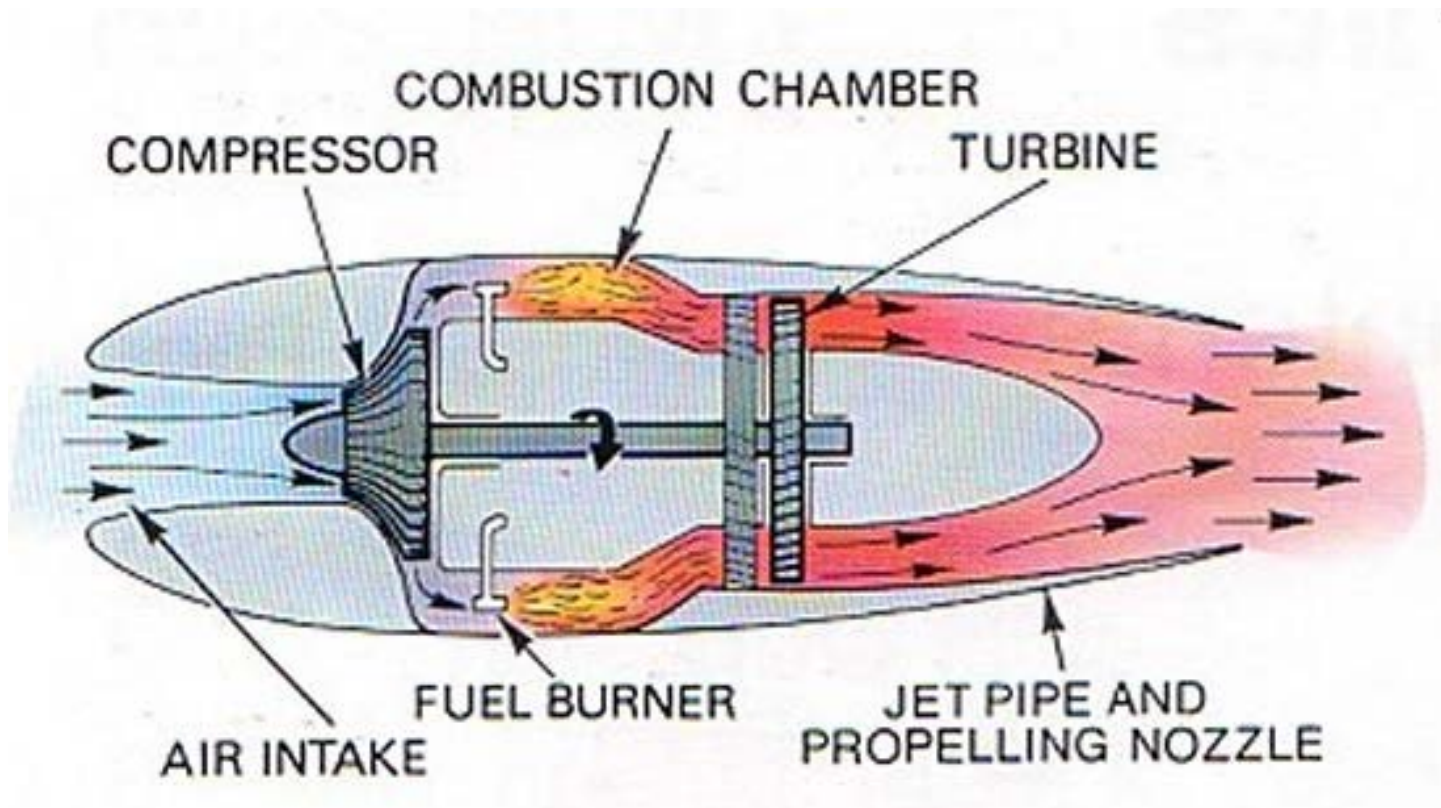
- Piston engine
- Turbojet
- Turboprop or turboshaft
- Turbofan
- Propfan
- Ramjet
- Pulsejet
- Scramjet
- Electric drive

Conventional, flight tested

Projects, visions and the future

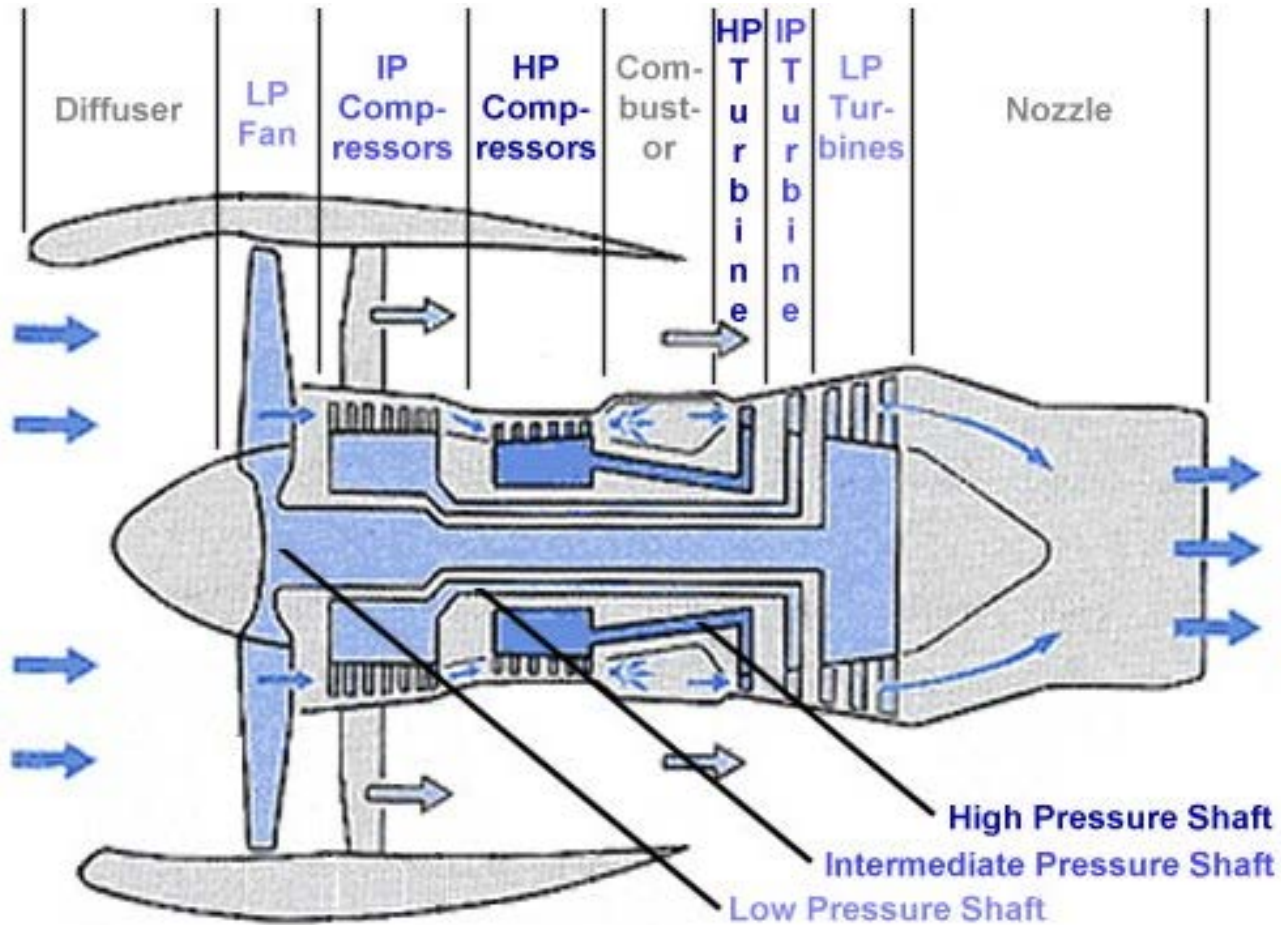
# Engines

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# Engines

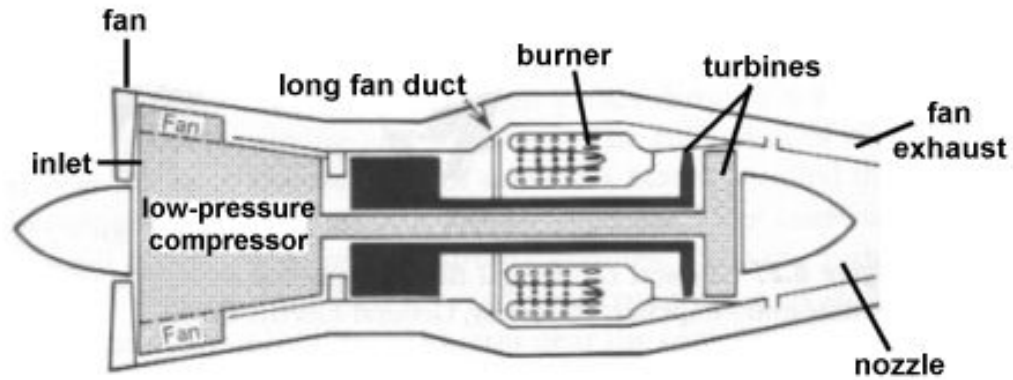
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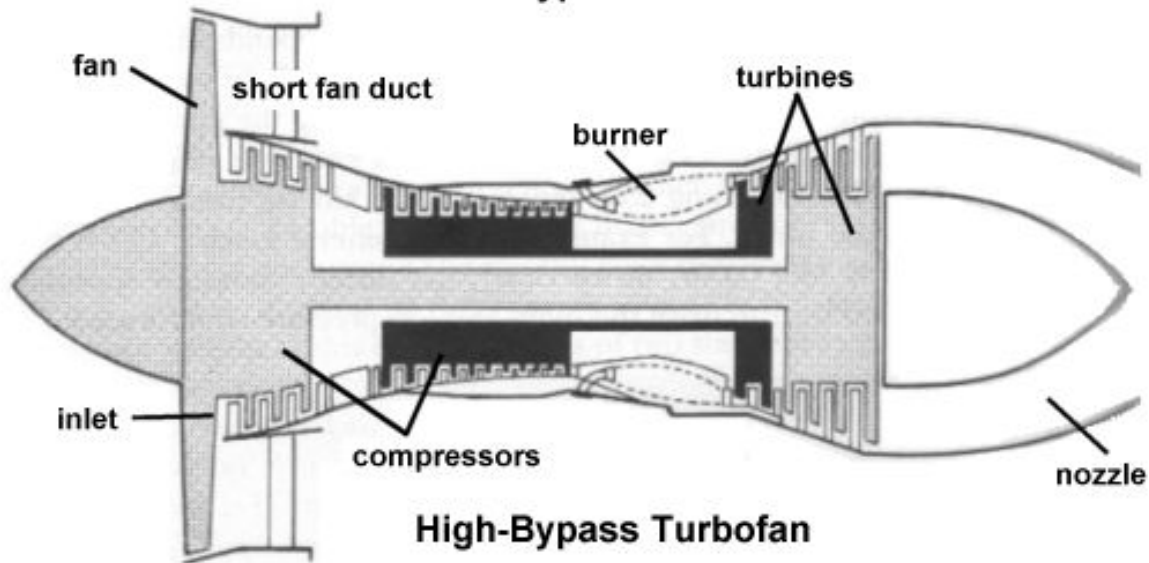
**Rolls-Royce RB211 Turbofan**

# Engines

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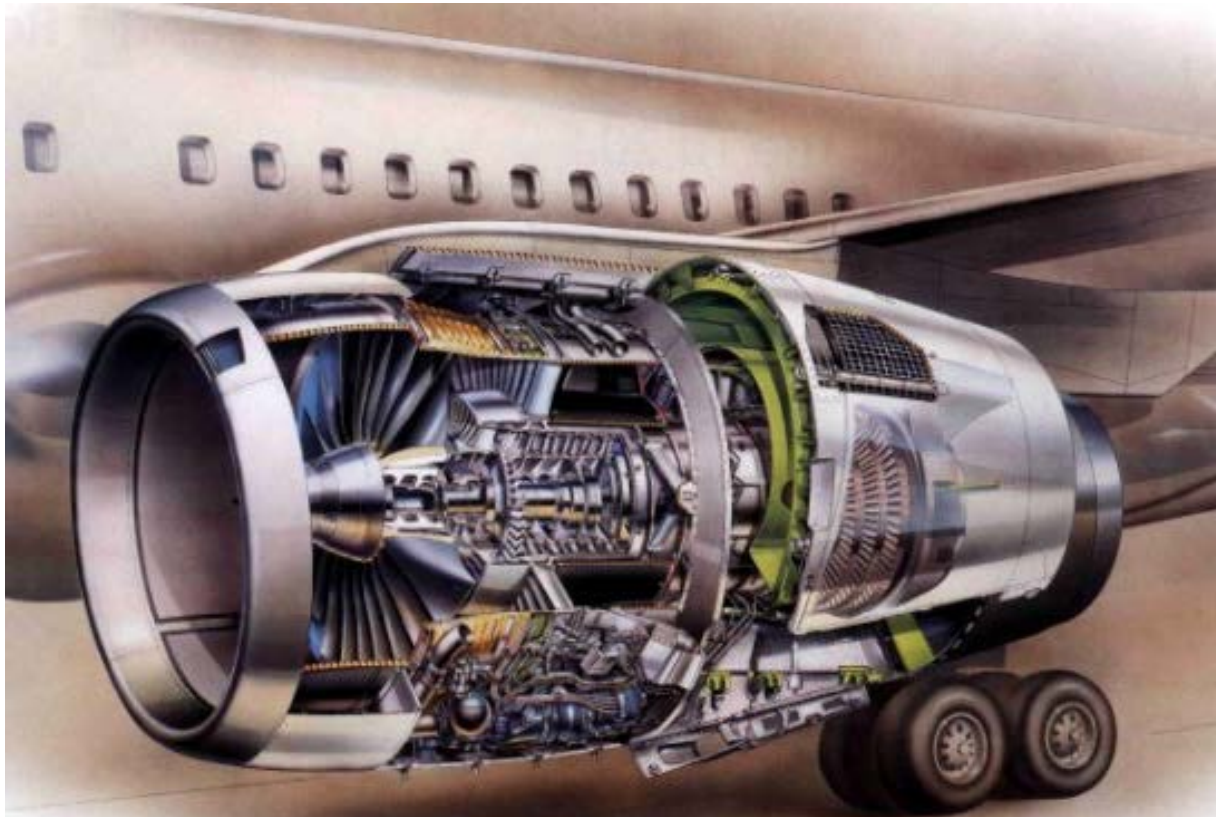
**Low-Bypass Turbofan**



**High-Bypass Turbofan**

# Engines

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Boeing 757



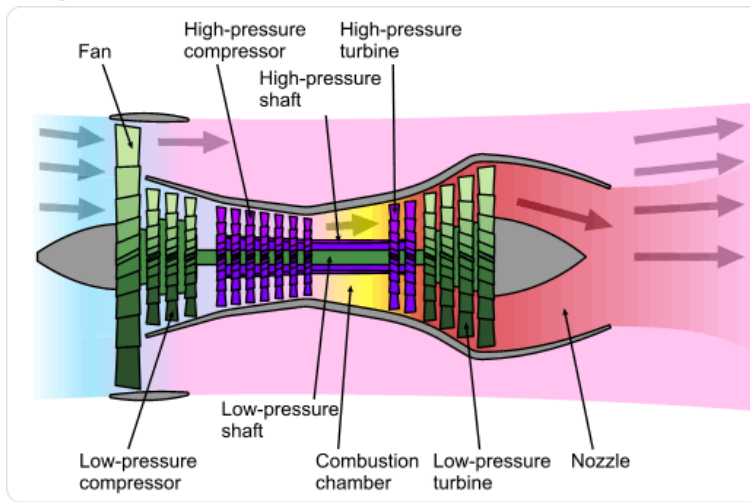
Rolls-Royce

RB211-535

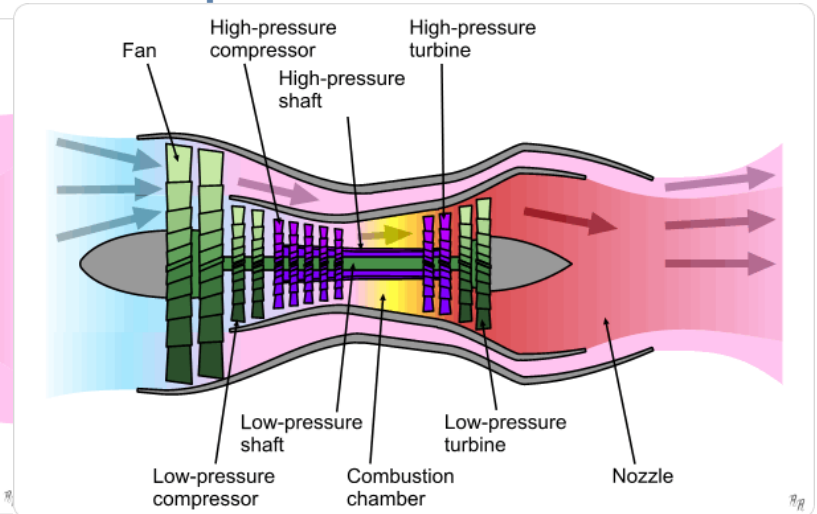


# Engines – turbine engines

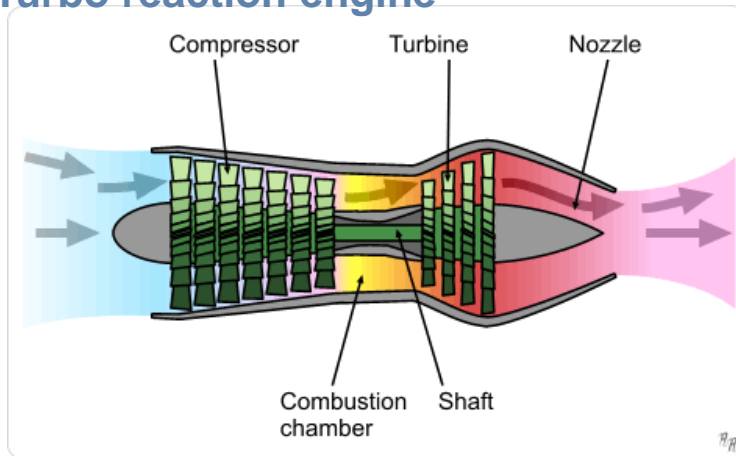
## High pressure turbofan



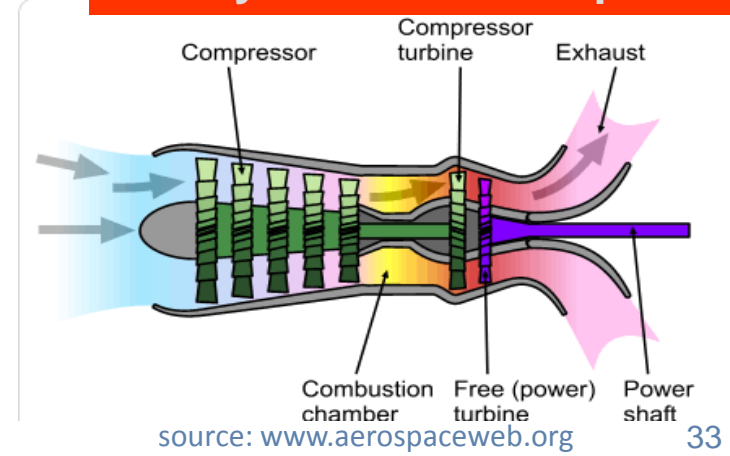
## Low-pressure turbofan



## Turbo reaction engine



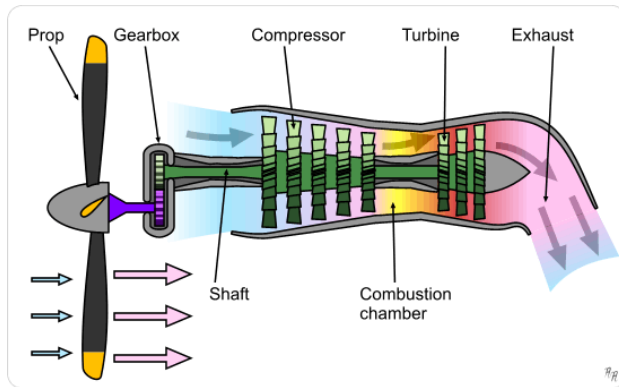
## Mostly used in helicopters



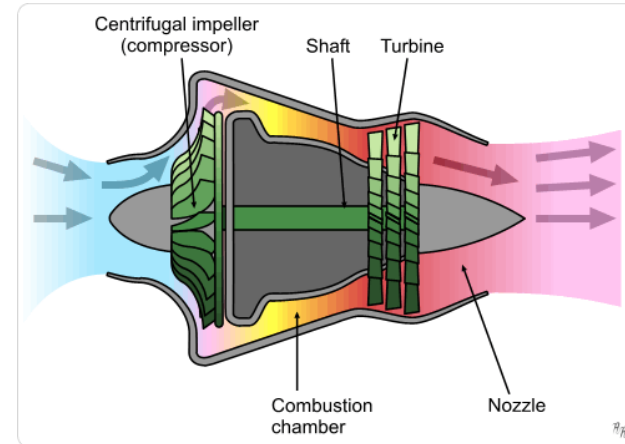
source: [www.aerospaceweb.org](http://www.aerospaceweb.org)

# Engines – turbine engines

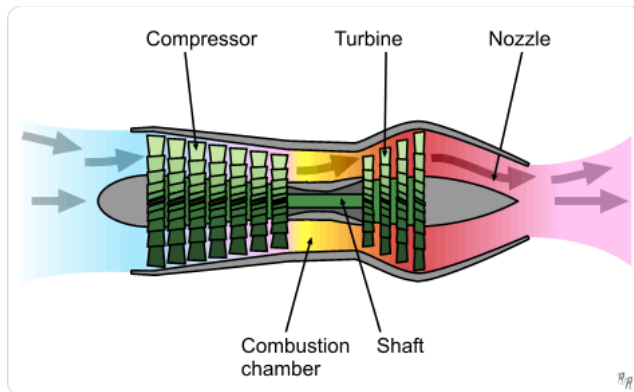
## Turboprop



## Jet engine with centrifugal compressor



## Jet engine with axial compressor



# Classification of landing gear- according to aerodynamic requirements

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- According to aerodynamic requirements
  - Fixed
  - Retractable – Including partially retractable variants.



# Classification of landing gear- according to aerodynamic requirements

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- According to aerodynamic requirements
  - Fixed
  - Retractable – Including partially retractable variants.



# Classification of landing gear- according to arrangement

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- Tail wheel
- Nose wheel
- Tandem landing gear– 2 landing gear struts at the fuselage axis, usually supplemented by stabilisers on the wings.



# Curiosities...

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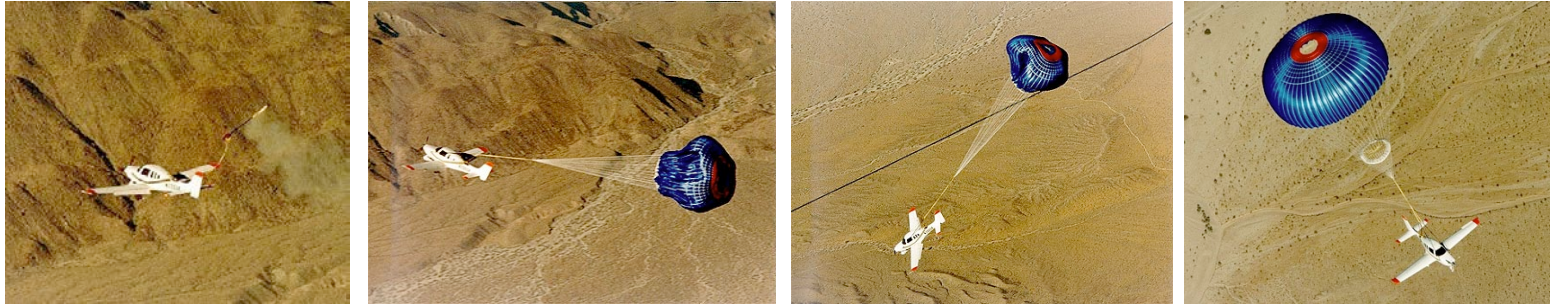


- solar
- fuel cells
- battery



# Aeroplane safety– rescue system

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BSR-SR20L



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## Acknowledgements

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