Agenda (1/3)

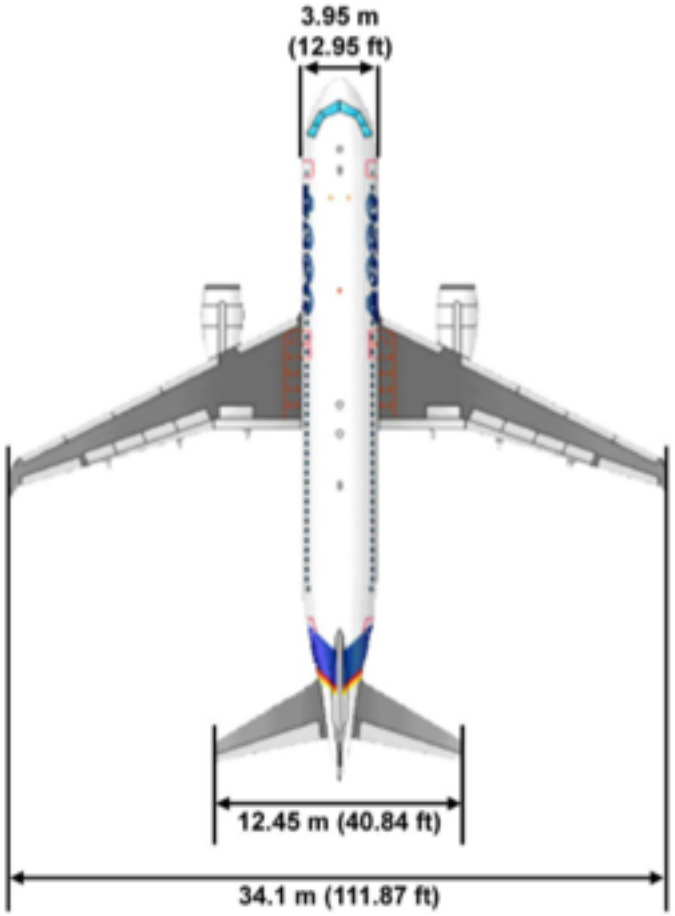
- **Module 1- Introduction** **(Day 1)**
  - 1-1 General Course Introduction (Day 1 Morning 1)
  - 1-2 Introduction of the Actuation session

- **Module 2 – Introduction to Aircraft Aerodynamics, stability and control** **(Day 1)**
  - 2-1 Aircraft Aerodynamics (Day 1 Morning 2,3,4)
  - 2-2 Aircraft Stability and Control (Day 1 Afternoon 1,2,3,4)

- **Module 3 - A/C Aircraft configuration for flight controls and high lift** **(Day 2)**
  - 3-1 **Aircraft Anatomy**
  - **Arrangement of flight control surfaces and high lift devices** (Day 2 Morning 1)
  - 3-2 Cockpit Controls (Day 2 Morning 2)

Aircraft Anatomy

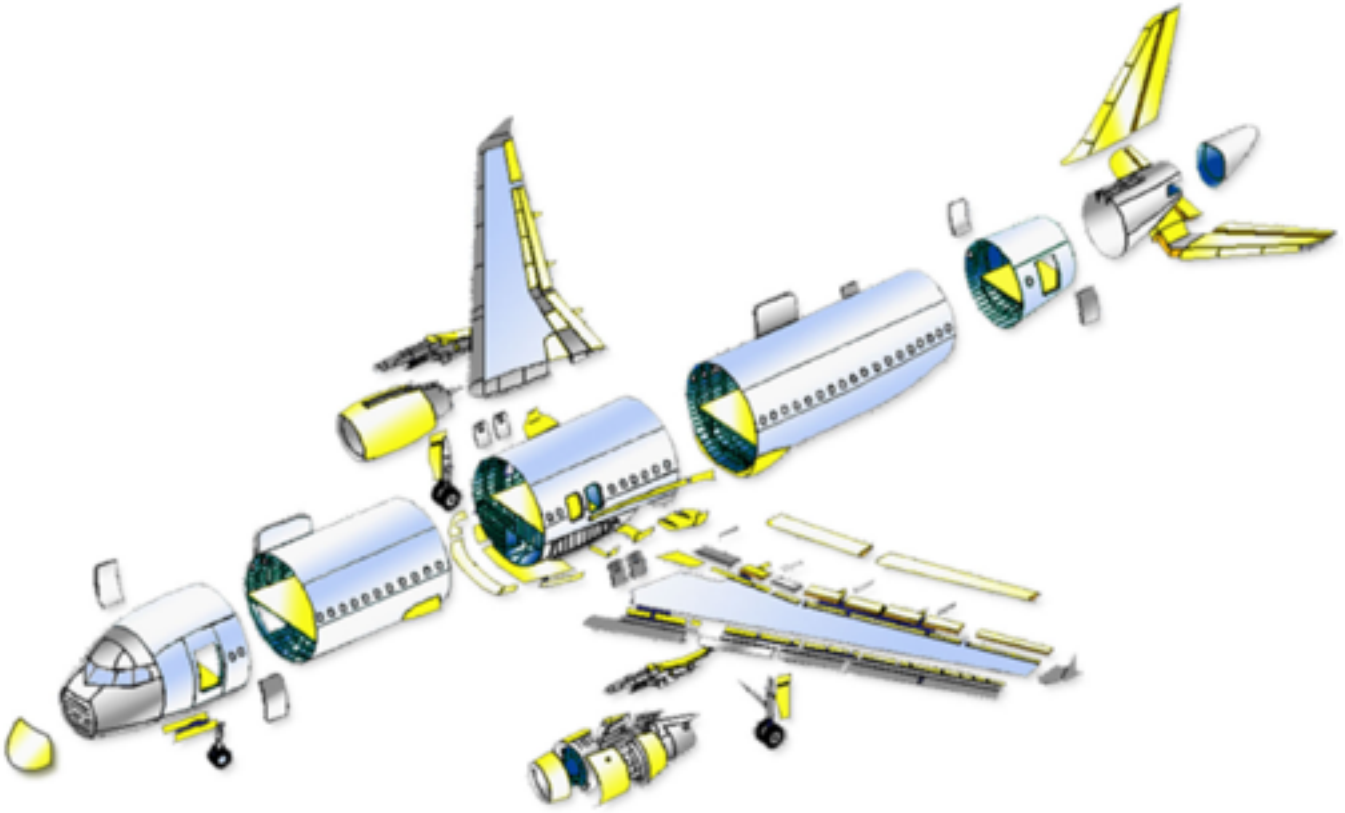
- An Airbus A320 is elected as an example to explain the anatomy of a typical Airframe
- Other Aircraft models will be shown as example
- High lift devices will be addressed in chapter 7.1



	A320	C919
Fuselage DiameterY	3.95m	3.96m
Fuselage DiameterZ	4.20m	4.17m
Wing Span	34.10m 35.99m	33.6m 35,4m
Wing Surface	122.6m 2	115m2
MTOW	77t 79t	77t

Aircraft anatomy

- The body or fuselage of the airplane holds the crew, passengers, and freight.
- It is carried in the air by the lift provided by the wing
- It is powered by the thrust produced by jet engines housed in nacelles mounted on pylons under the wings
- The fuel is carried in tanks located in the wing. (+ fuselage)
- For take off and landing additional lift (and drag) is provided by the high lift devices mounted at the wing leading edge and trailing edge
- Speed brake function is provided by Spoilers mounted on the upper side of the wing
- Landing gear: Airplanes require landing gear for taxiing, takeoff, and landing, and it supports the airplane when it is resting on the ground



Stability and control providers

- To provide static stability stabilizing elements are provided
  - Vertical stabilizer for the yaw axis (directional stability)
  - Horizontal stabilizer for the pitch axis (longitudinal stability)
  - The wing with its dihedral provides the roll axis stability (lateral stability)
- To control the rotation rate about the body axes, control surfaces are provided
  - Aileron (and Spoiler) for moment control in the Roll axis (not neutral)
  - Elevator for moment control in the Pitch axis (neutral)
  - Rudder for moment control in the yaw axis, (not neutral)

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Control surfaces (1/8)

- Most commonly used : trailing edge control surface

- Principle :
  - Profile camber modification
  - Local lift modification
  - Linear effect for small deflections
  - Little drag effect for small deflections
- Examples :
  - Elevators
  - Ailerons
  - Rudder
- Precaution :
  - Generally flutter critical if free to rotate
    - Mass-balanced,
    - Attached by servo controls

Control surfaces (2)

Ailerons : Roll command

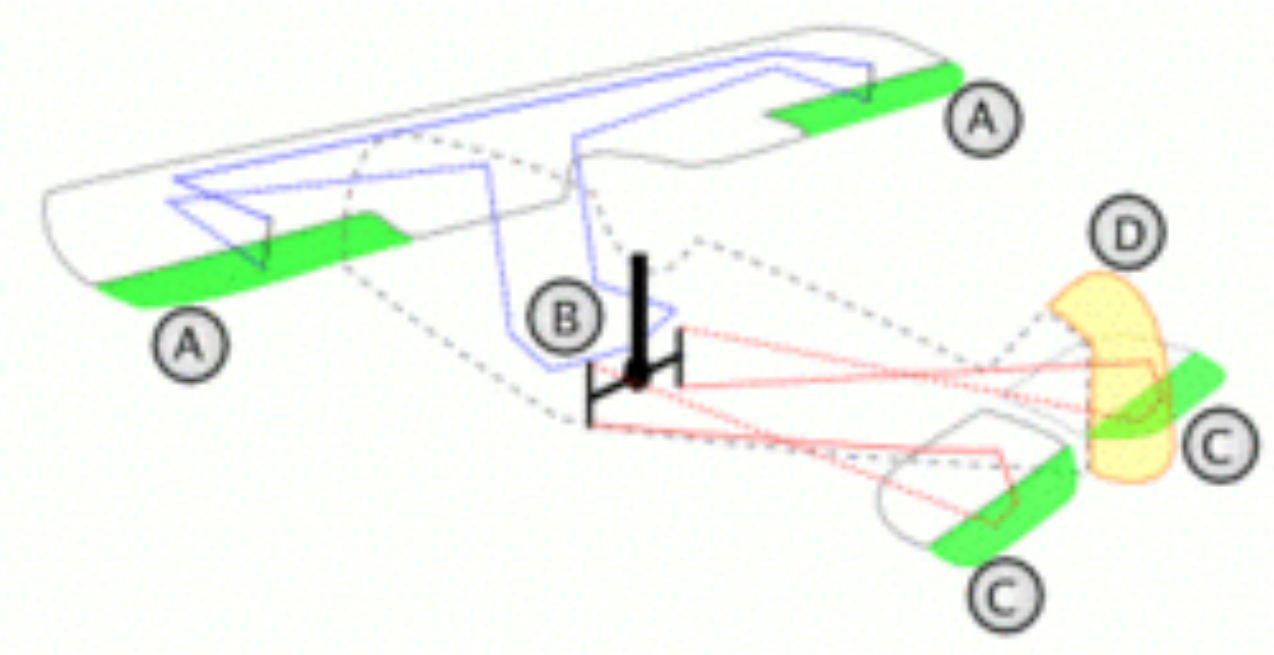
Due to the flexibility of the wing, at high speed ailerons movement can have an contrary effect (command inversion) for the large transport aircraft (A300, A340). In that case, wing tip ailerons must be inhibited at high speed.

Yaw : yaw command (rudder)

Practically, beside its principal function, each of these surfaces has secondary effects on the other axes , which must be taken into account (induced roll, pitch induced by the movement of the spoilers,..)

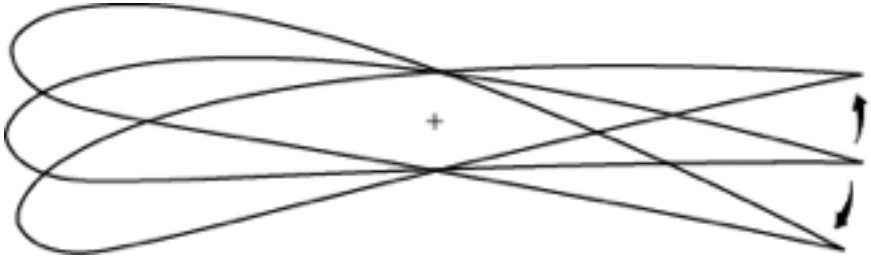
Elevator : short term longitudinal command

A nice animated picture form wikipedia



Control surfaces (3)

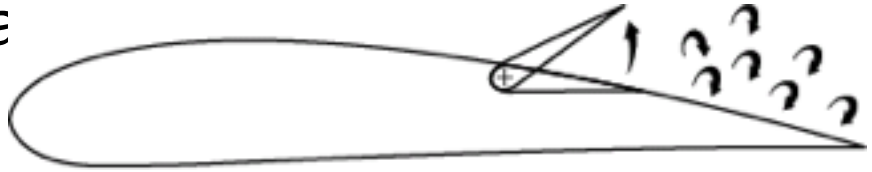
- Moving surface



- Principle :
  - Profile incidence modification
  - Total surface lift modification
- Examples :
  - Trimmable horizontal stabilizer
  - “Canard”
- Advantages
  - Keep full elevator authority
  - Reduce drag despite Aircraft variation of
    - speed,
    - balance and
    - configuration

Control surfaces (4)

- Upper wing surfa



- Principle :
  - Causes airflow separation in regions where most of the lift is created
  - Local lift loss
  - Local drag increase
  - Non linear effect

- Examples :
  - Spoilers used for airbraking (symmetrical)
  - Spoilers used for roll control (antisymetrical)
  - Lift dumper (symmetrical, on ground)

- Spoilers effectiveness is massively increased with flaps out

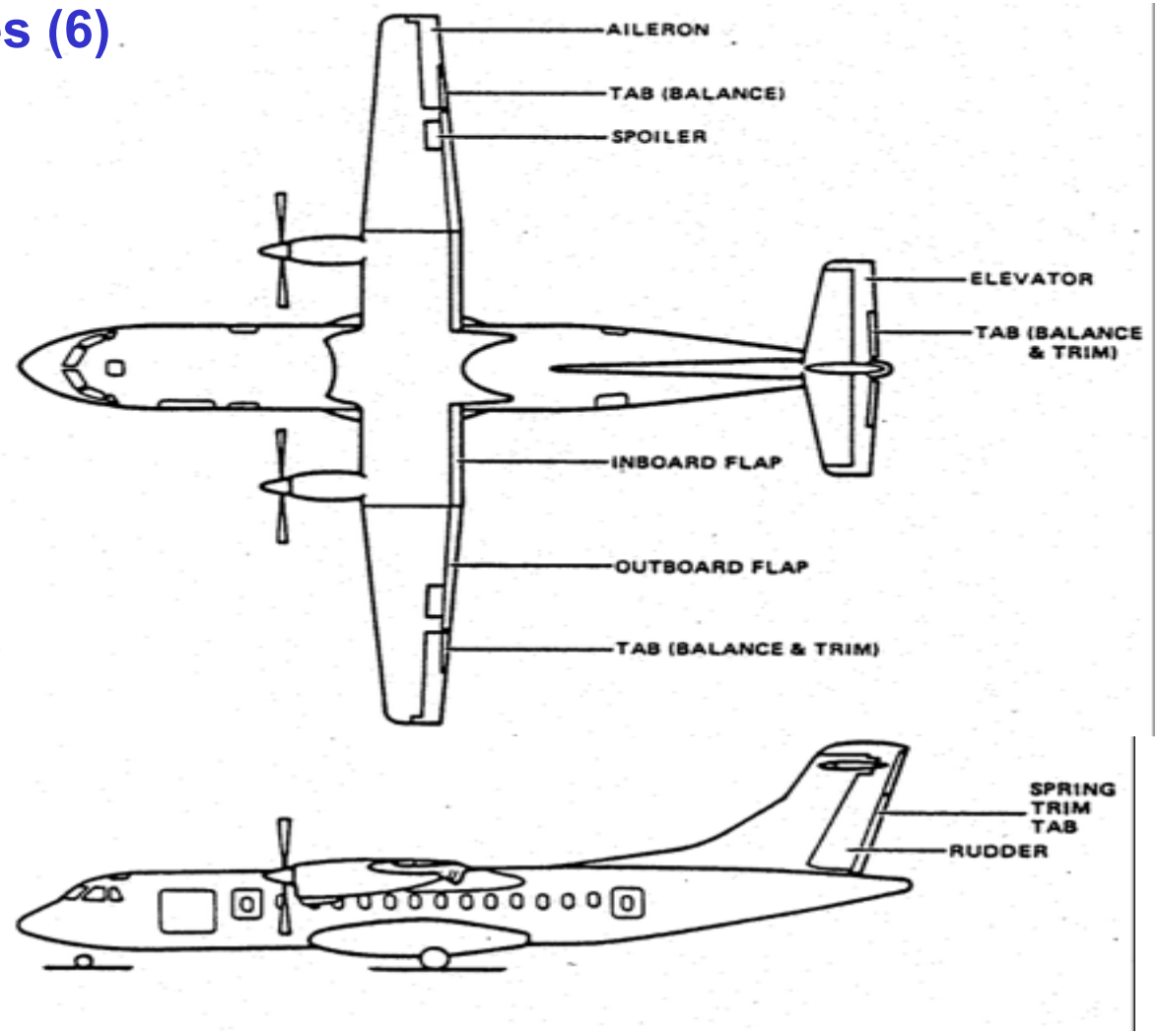
Control surfaces (5)

- **Spoiler**

- Symmetrical functions :
  - Ground spoilers :
    - reduce the lift on the ground to bring down the aircraft on the ground and to improve the wheel brakes efficiency
  - Speed brakes :
    - increase the drag to allow a rapid descent
  - Anti-symmetrical functions :
    - Roll additional control capability

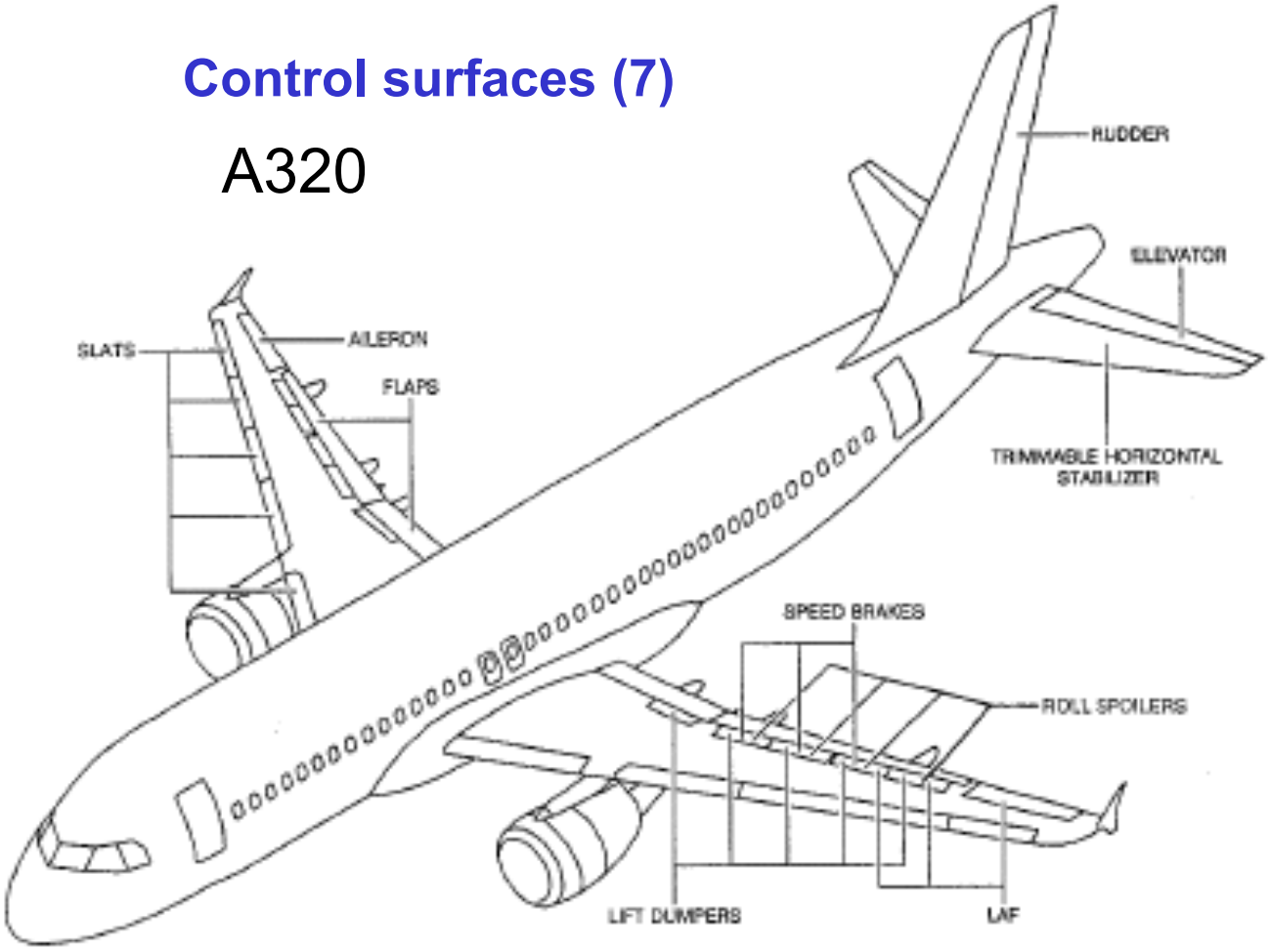
Control surfaces (6)

ATR



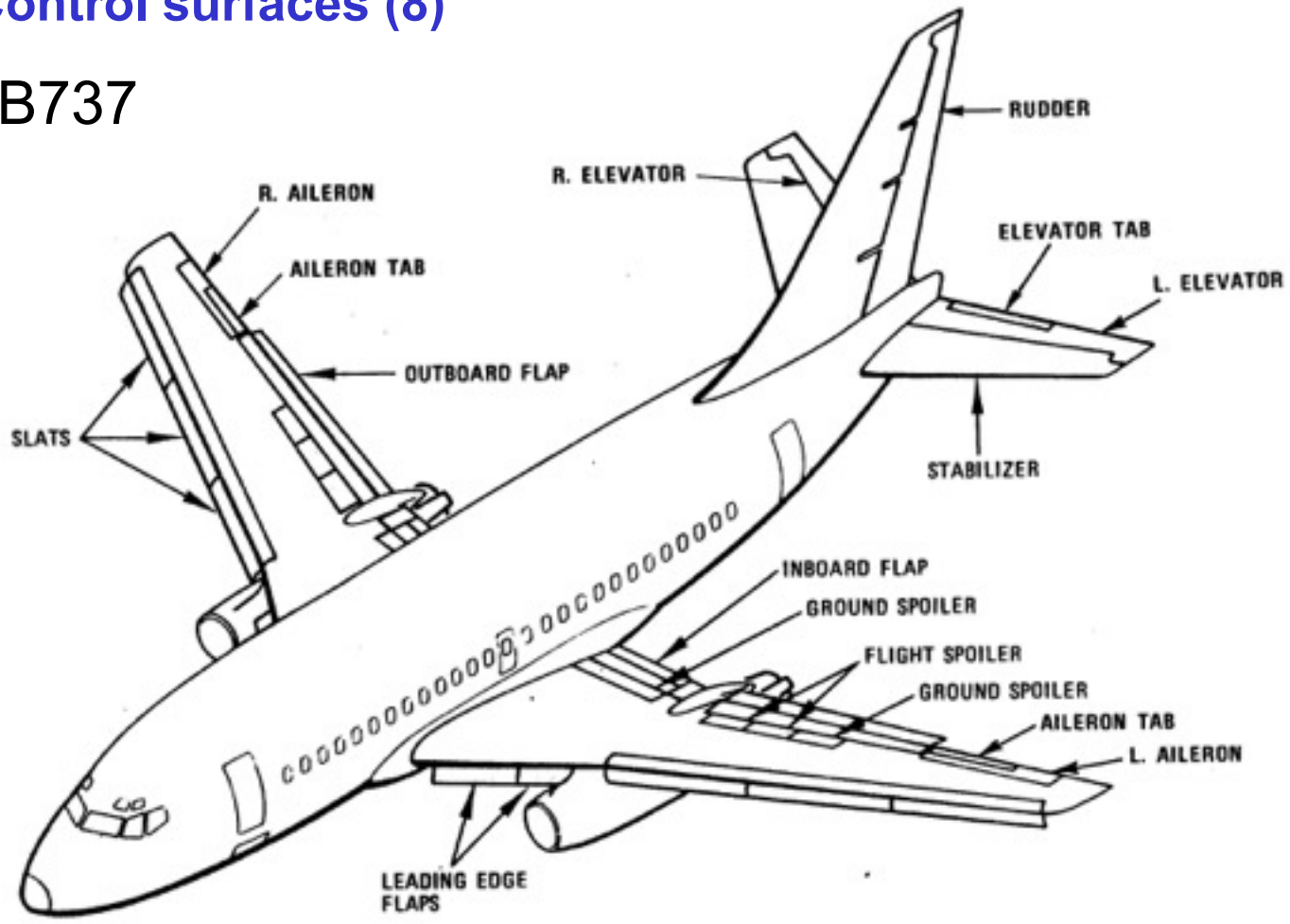
Control surfaces (7)

A320



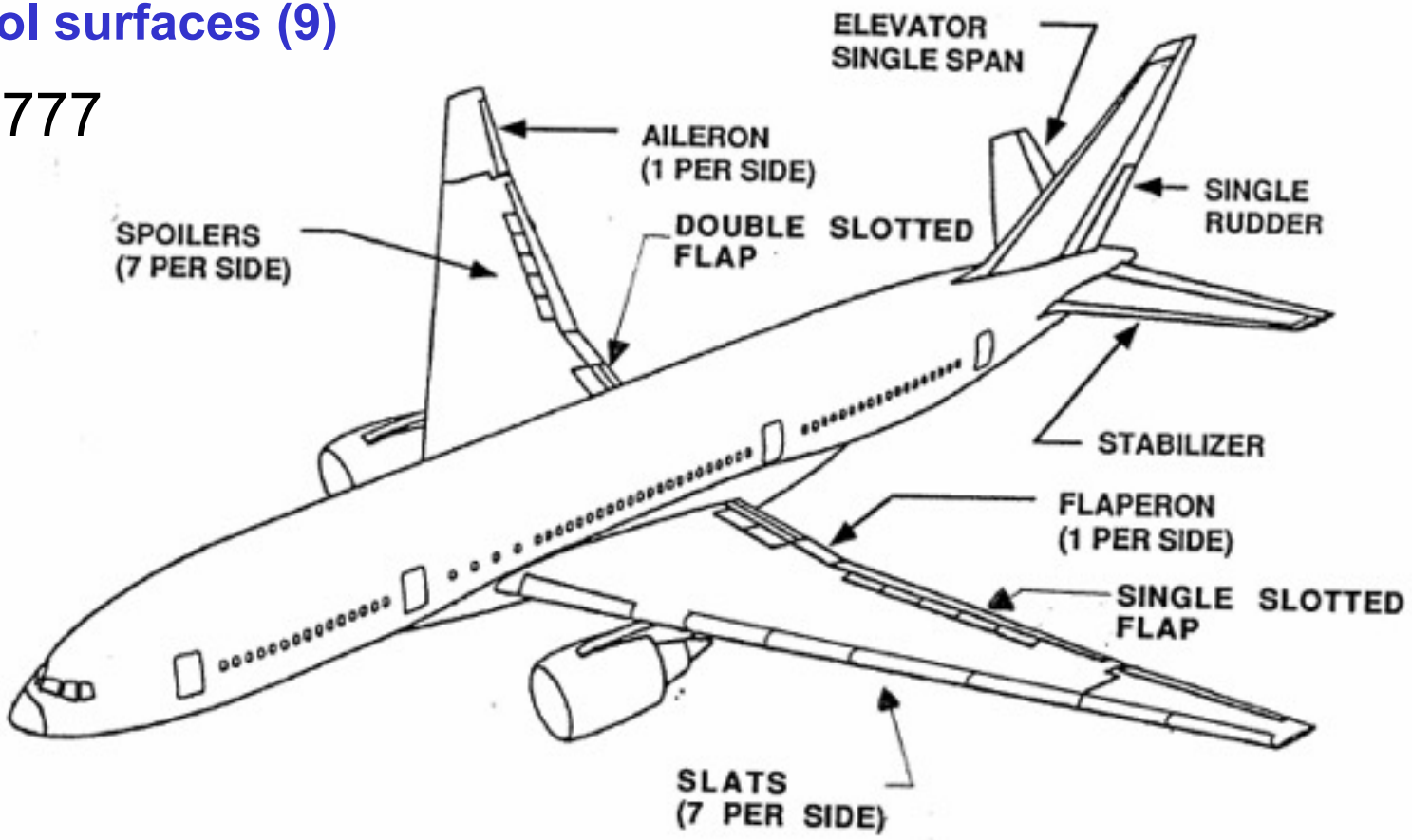
3-1 Control surfaces (8)

B737



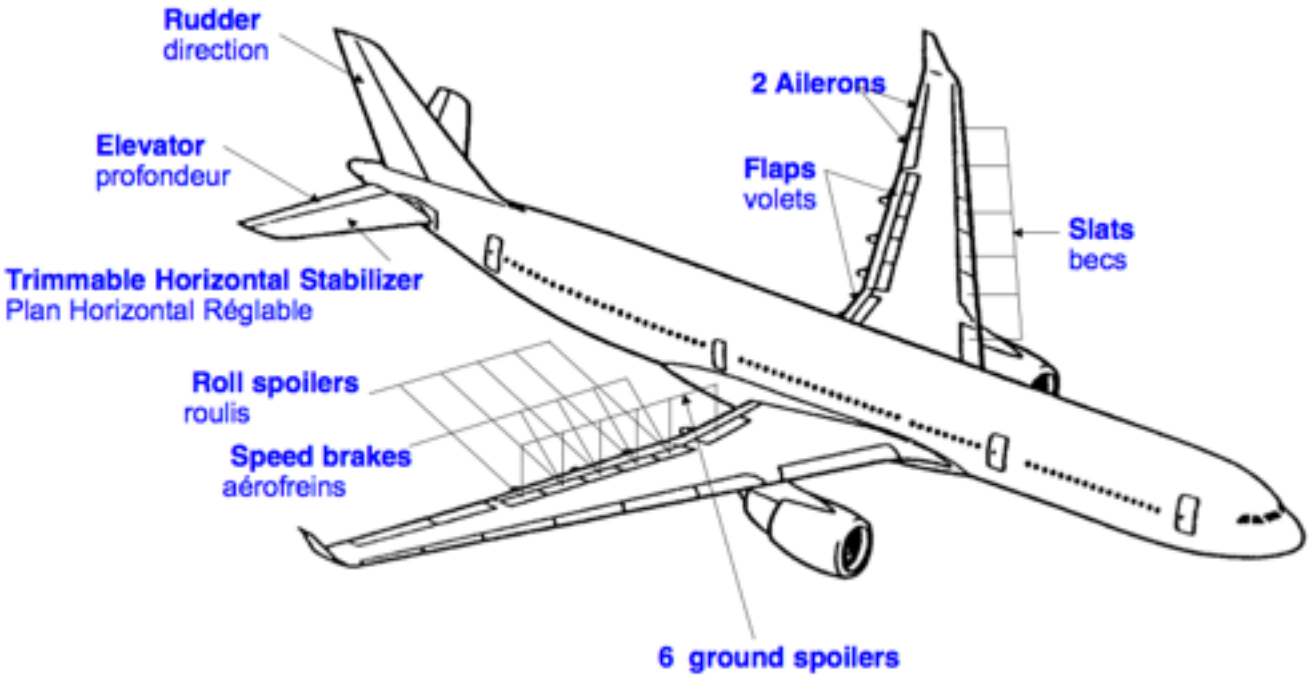
Control surfaces (9)

B777

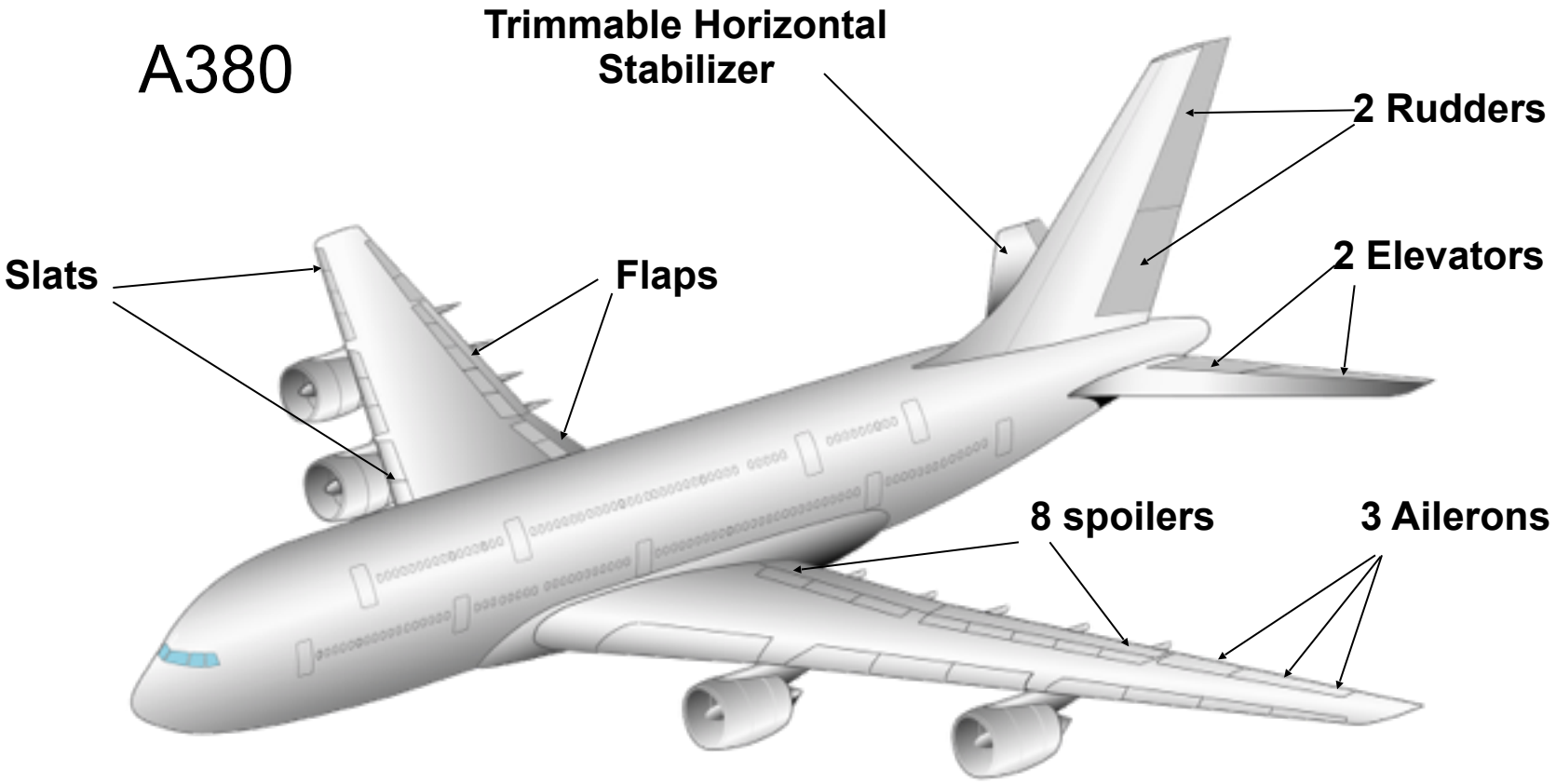


Control surfaces (11)

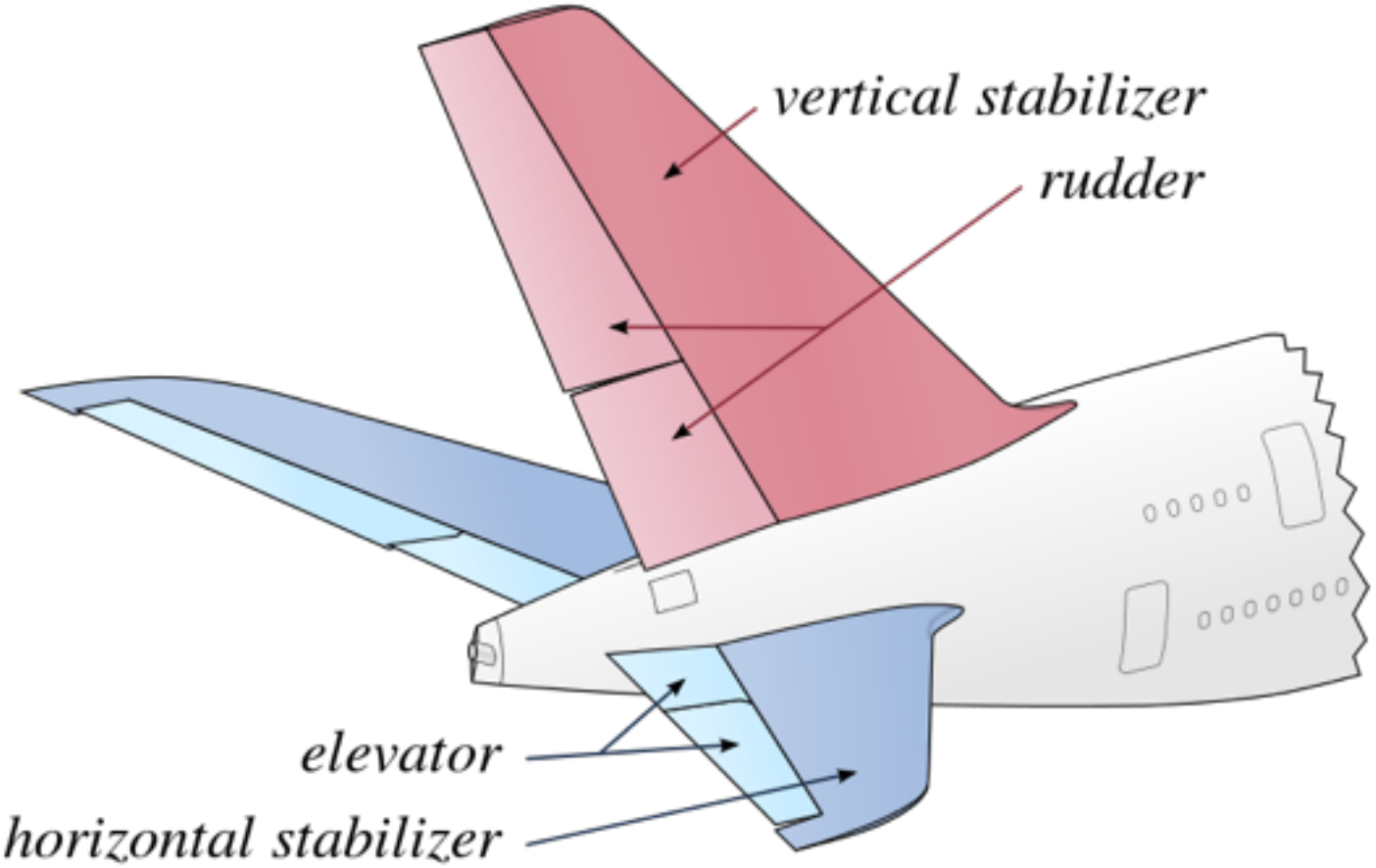
A330/340



Control surfaces (10)

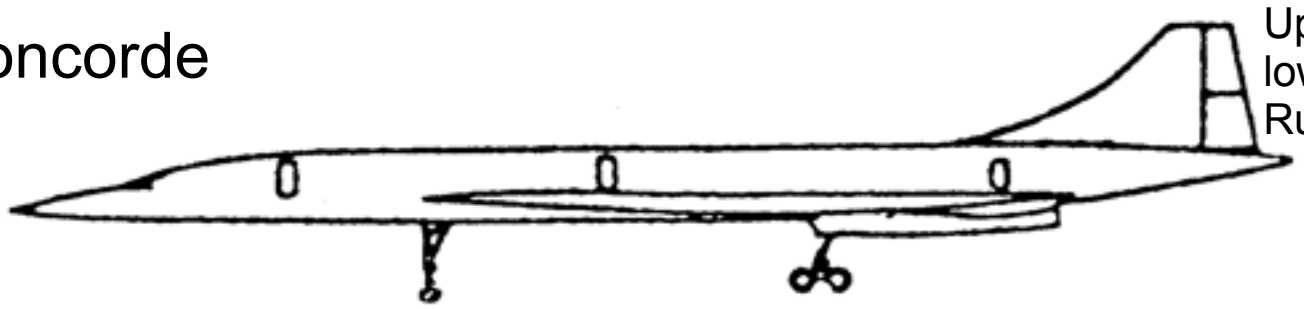


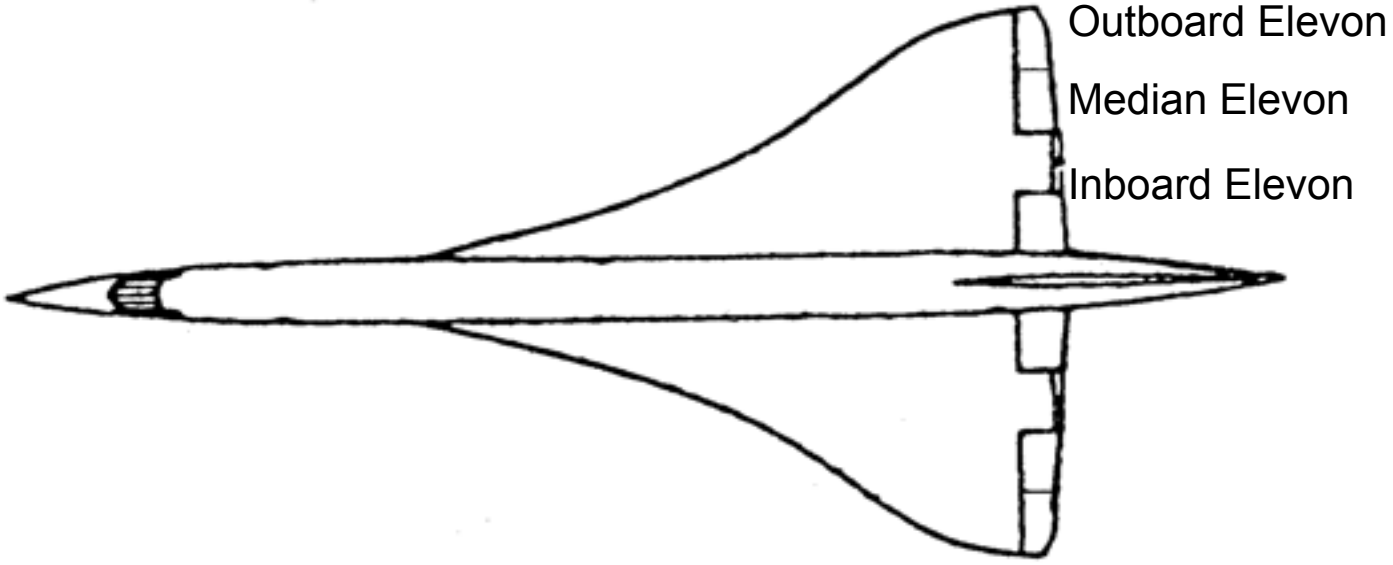
Tail A380


vertical stabilizer
rudder
elevator
horizontal stabilizer

Control surfaces (12)

Concorde





Design principals of control surfaces

- Commonly used Materials
  - Conventional aluminium structure
  - Composite material
    - Glas fibre
    - Kevlar
    - Carbon fibre
    - Sandwich structure