Introduction to aeronautics

Part 3. The era of the mature, propeller driven airplanes

3.1 The feature of the mature, propeller driven airplane

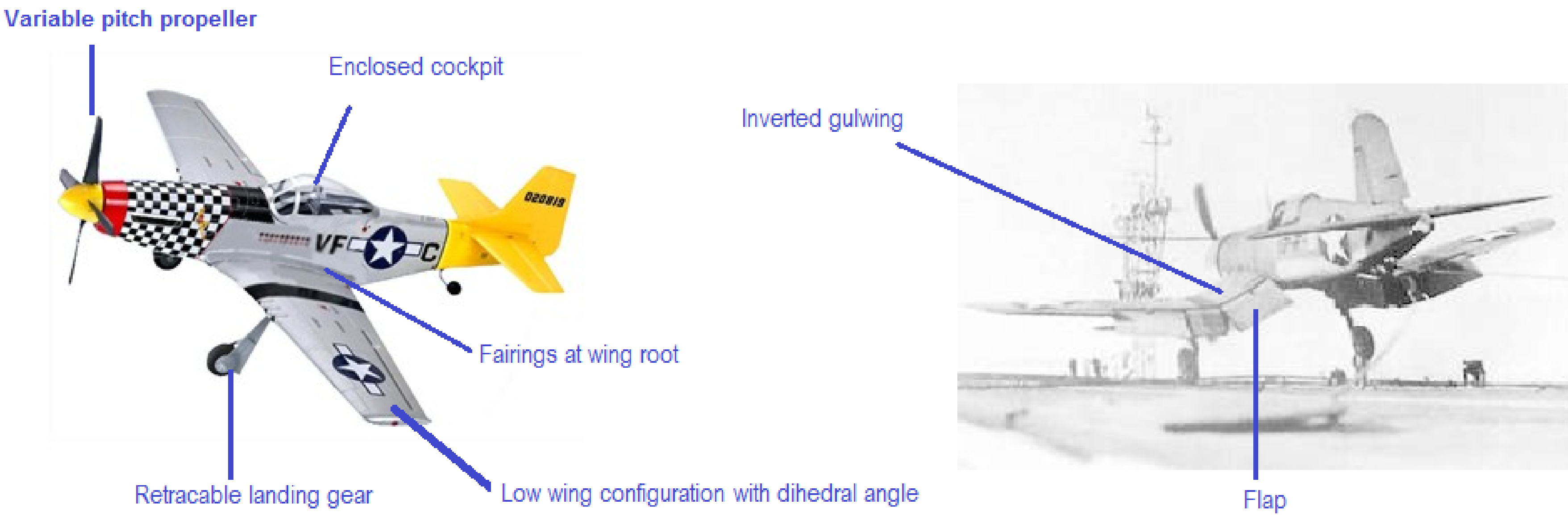
- **The performance of the airplane had been improved significantly**
  - **The monoplanes dominated the sky**
  - **The speed of propeller driven aircraft reached its maximum**
  - **The high lift device was invented**
  - **Large part of the aircraft structure was made of aluminum alloy**
  - **The tricycle landing gear gradually replaced the tail dragger**

3.2 The monoplanes

- **The monoplanes**
  - **A monoplane is a fixed wing aircraft with one main set of wing surfaces**

3.2 The monoplanes

- **The monoplanes**



3.2 The monoplanes

- The variable pitch propeller

$$\eta = \frac{T_A V_\infty}{P}$$

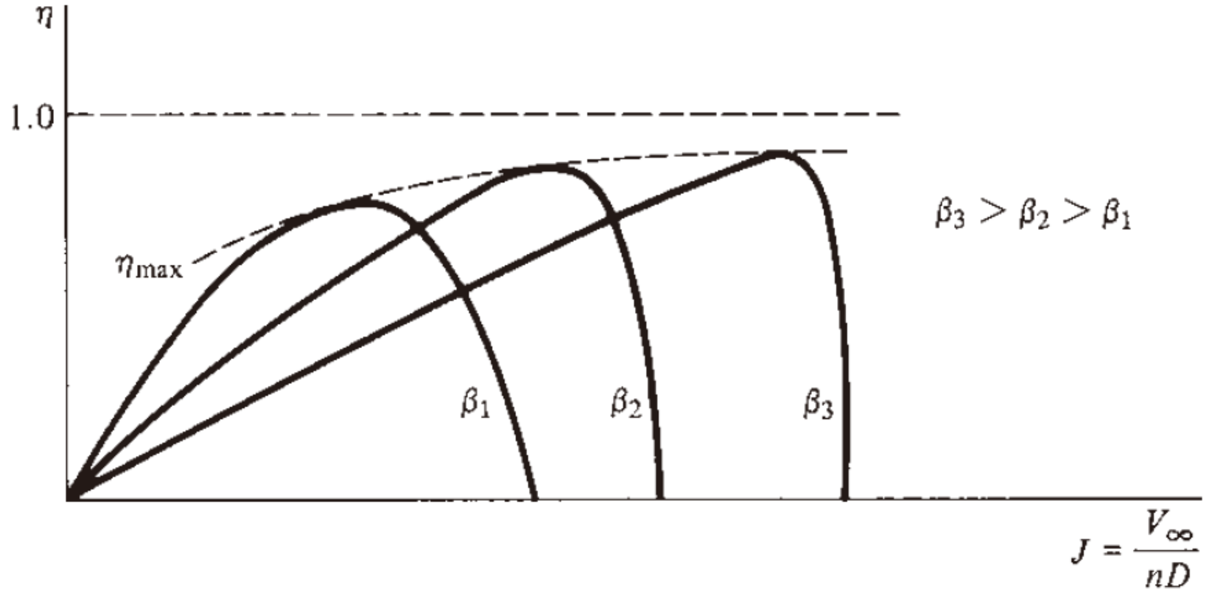
Efficiency of the propeller

$$J = \frac{V_\infty}{nD}$$

Advance ratio

3.2 The monoplanes

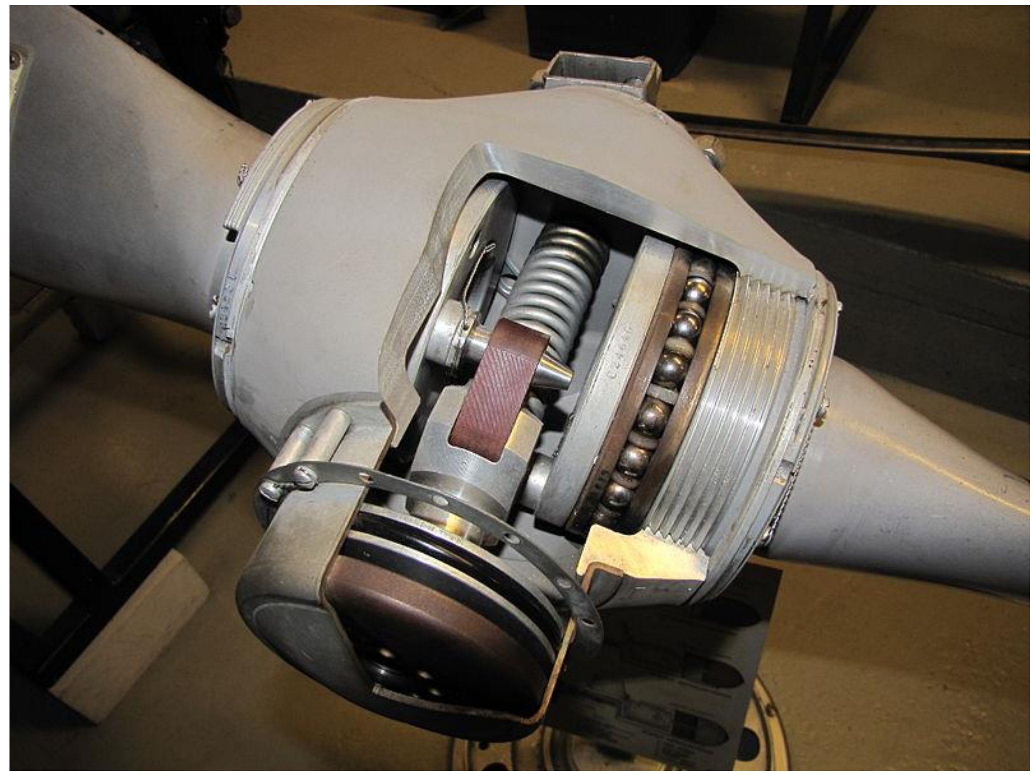
- The variable pitch propeller



- To guarantee high efficiency of the rotor, variable pitch propeller was developed
- To reduce the fuel consumption, constant speed propeller system was equipped

3.2 The monoplanes

- The variable pitch propeller



The variable-pitch propeller

3.2 The monoplanes

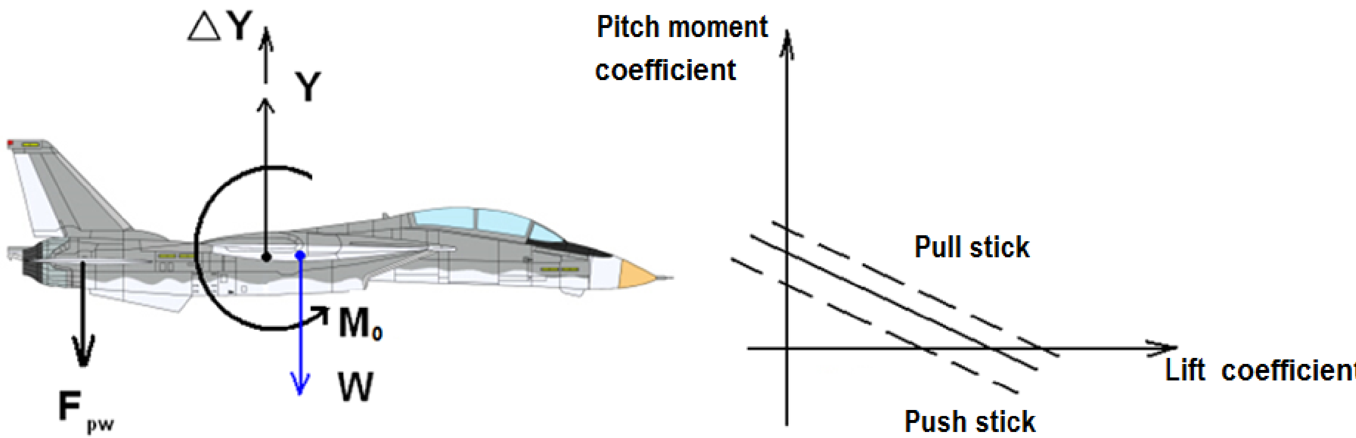
- The variable pitch propeller
  - The variable-pitch propeller can protect the engine when it fails
  - The variable-pitch propeller can reverse the thrust

3.3 The stability of the airplanes

- **The longitudinal static stability**
  - **The neutral point （N.P）**
    - **The increment of the lift acts on this point**
    - **If the C.G located exactly at the neutral point, the neutral stability is obtained**
    - **If the C.G lies in front of the N.P, the aircraft is longitudinally stable and vice versa**
    - **The distance between the neutral point and the C.G is called STATIC MARGIN**

3.3 The stability of the airplanes

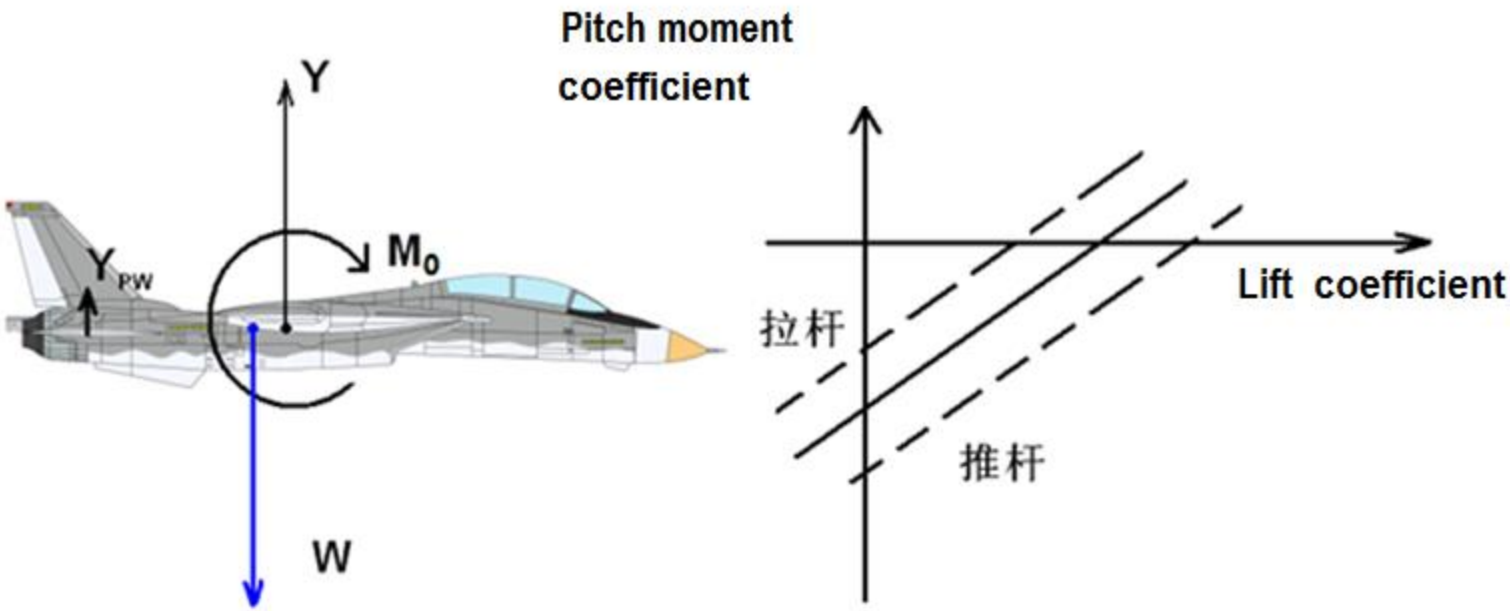
- **The longitudinal static stability**
  - **The condition to maintain longitudinal stability**



Conventional configuration, statically stable

3.3 The stability of the airplanes

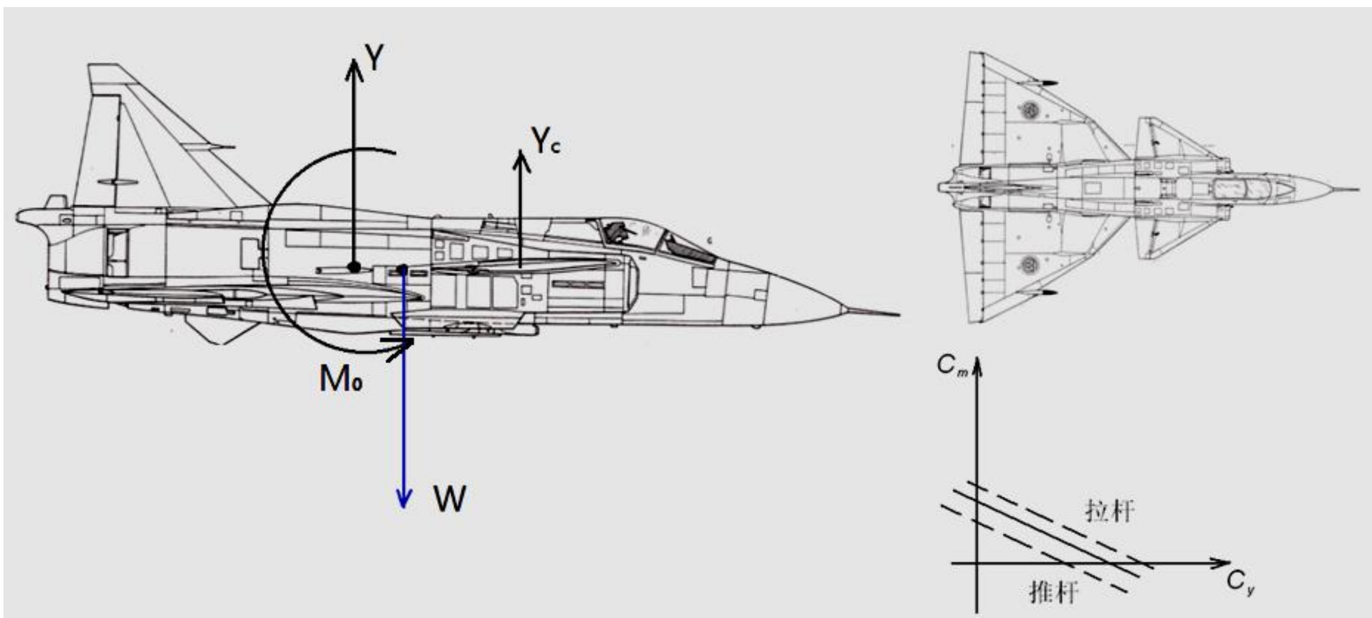
- **The longitudinal static stability**
  - **The condition to maintain longitudinal stability**



Unconventional configuration, statically unstable

3.3 The stability of the airplanes

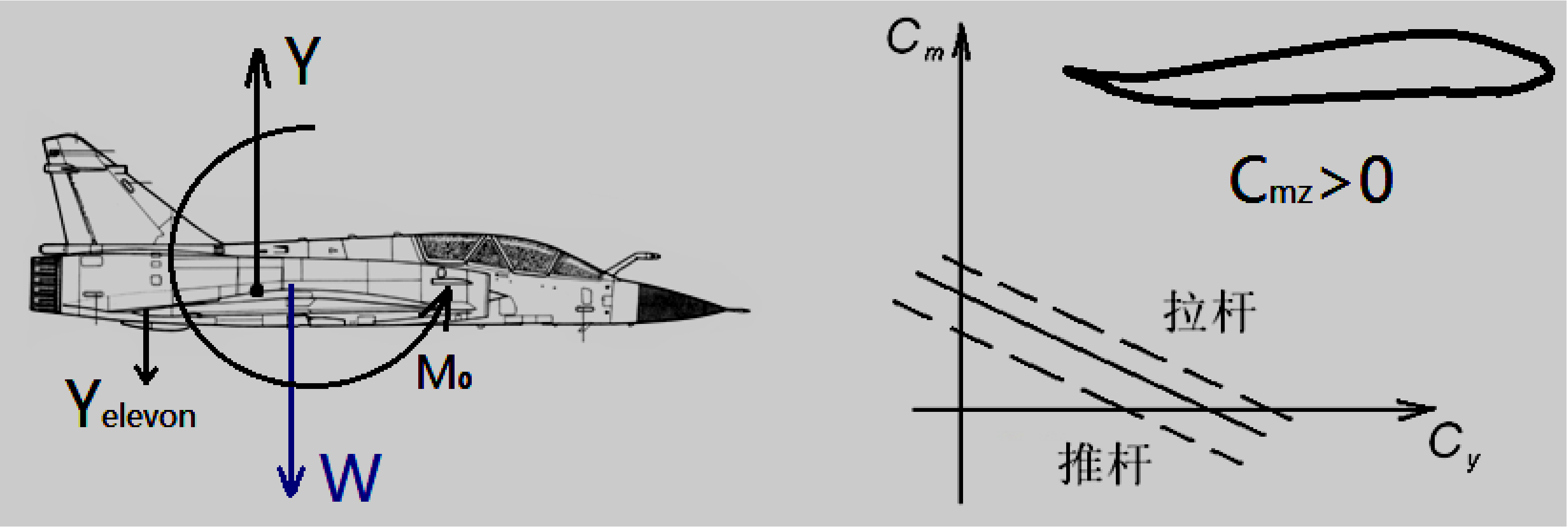
- **The longitudinal static stability**
  - **The condition to maintain longitudinal stability**



Canard configuration, statically unstable

3.3 The stability of the airplanes

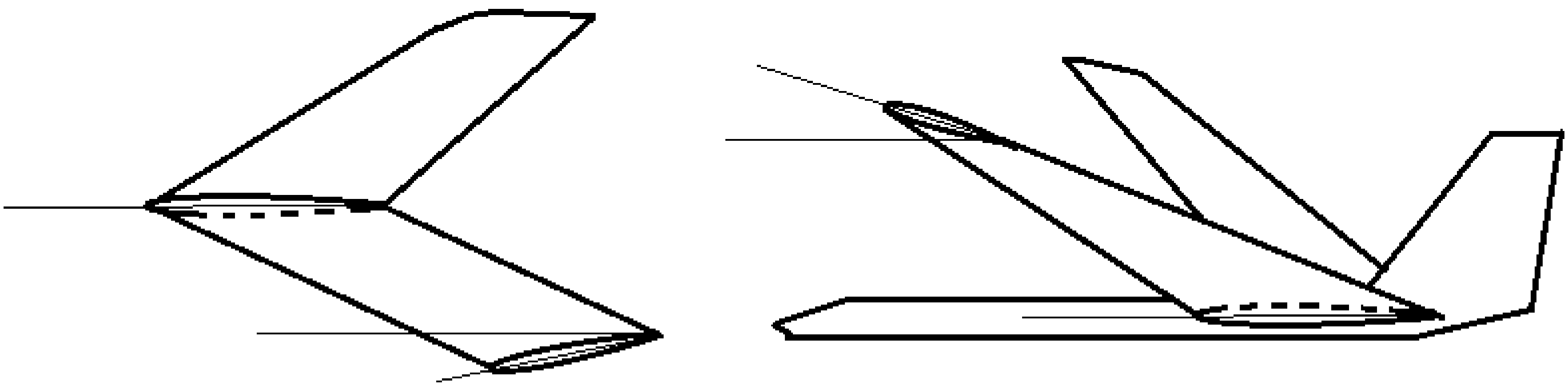
- **The longitudinal stability**
  - **The condition to maintain longitudinal stability**



Tailless configuration, stable

3.3 The stability of the airplanes

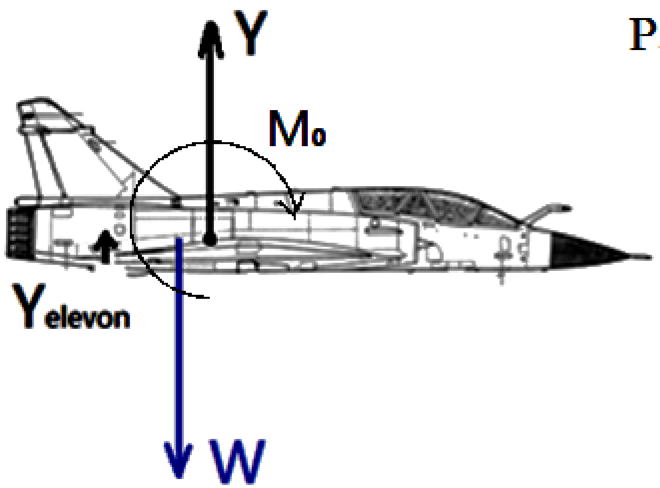
- **The longitudinal stability**
  - **The condition to maintain longitudinal stability**

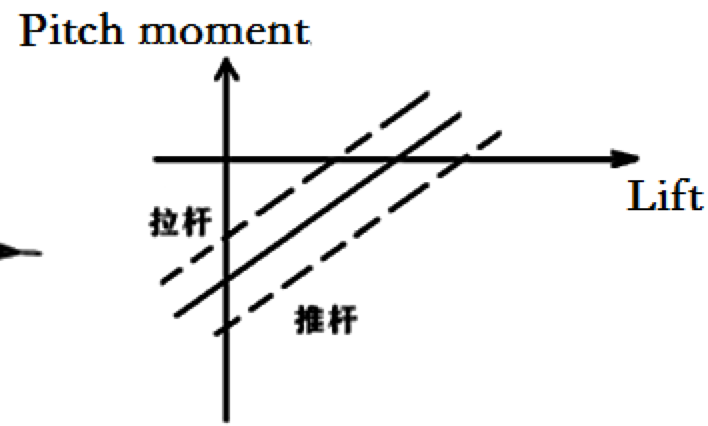


Tailless configuration, stable

3.3 The stability of the airplanes

- **The longitudinal stability**
  - **The condition to maintain longitudinal stability**



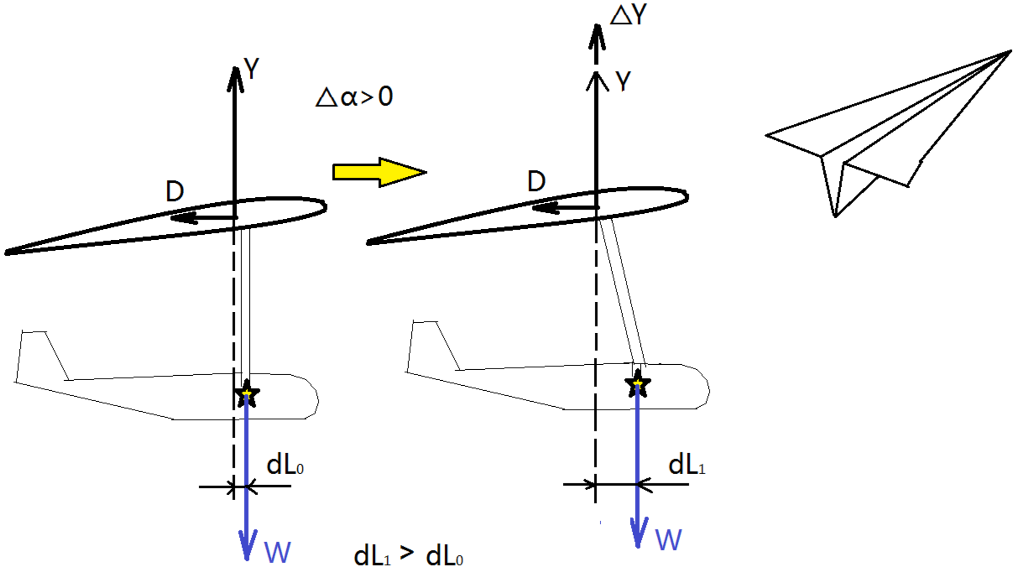


Statically unstable aircraft

- **Stability maintained by computer**

3.3 The stability of the airplanes

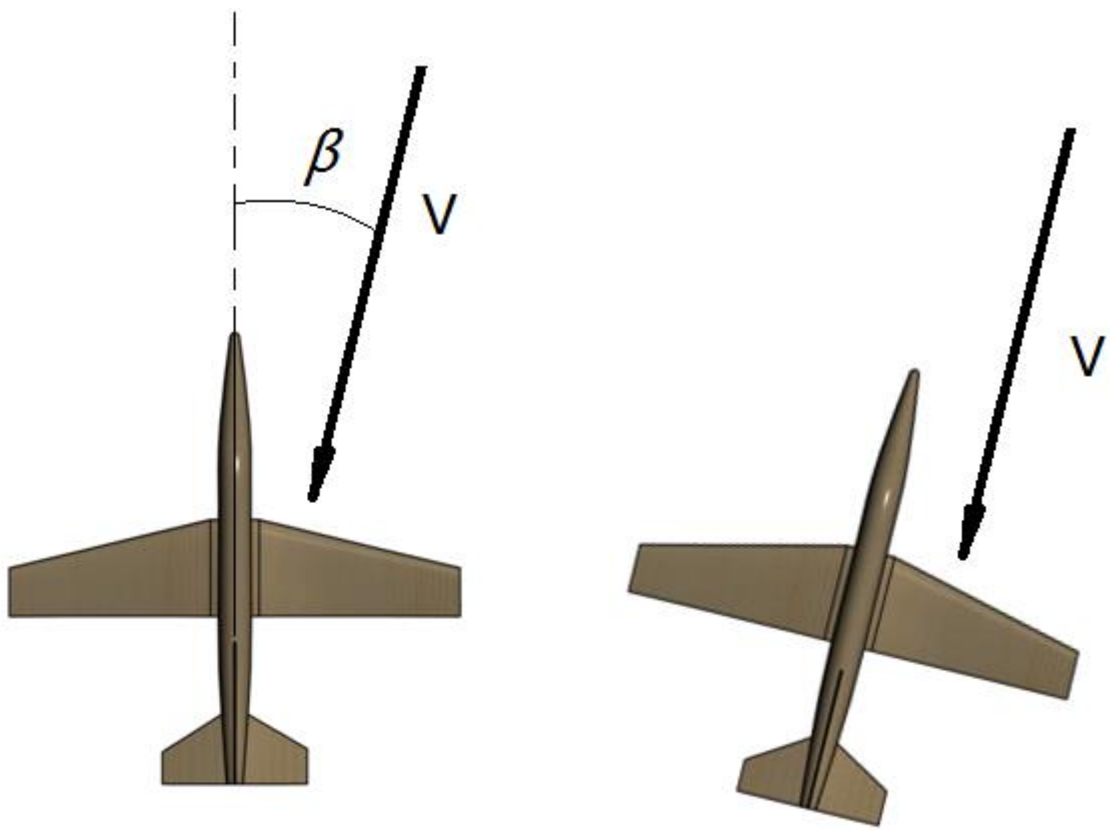
- **The longitudinal stability**
  - **The condition to maintain longitudinal stability**



The stability of the hang glider

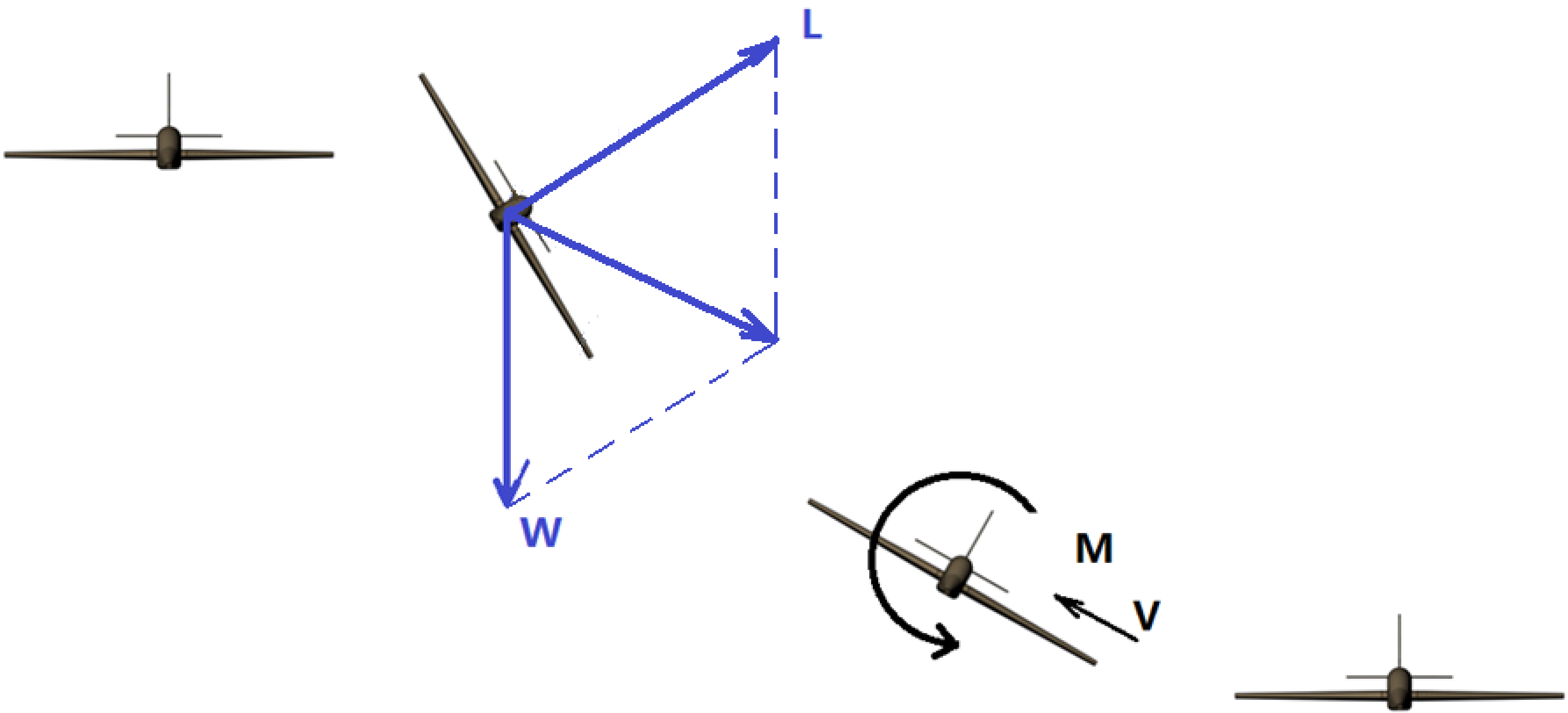
3.3 The stability of the airplanes

- **The direction stability**



3.3 The stability of the airplanes

- The lateral stability

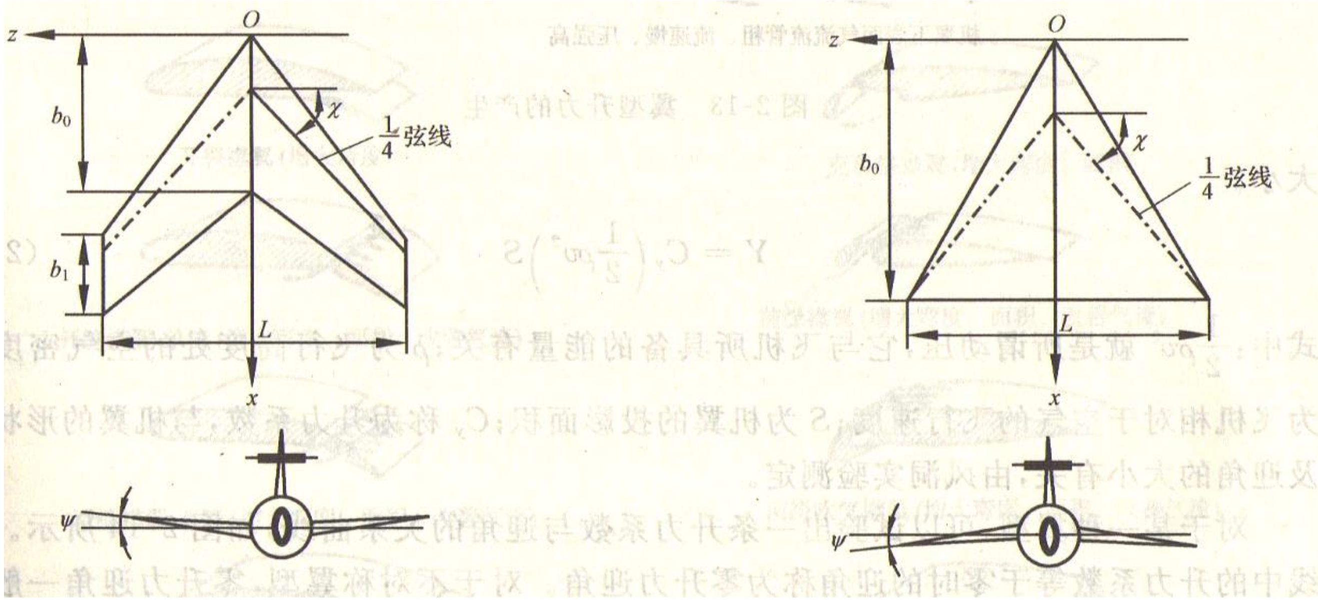


3.3 The stability of the airplanes

- **The directional stability and the lateral stability are coupled. They are always discussed together**

3.3 The stability of the aircraft

• **Geometries of the wing**



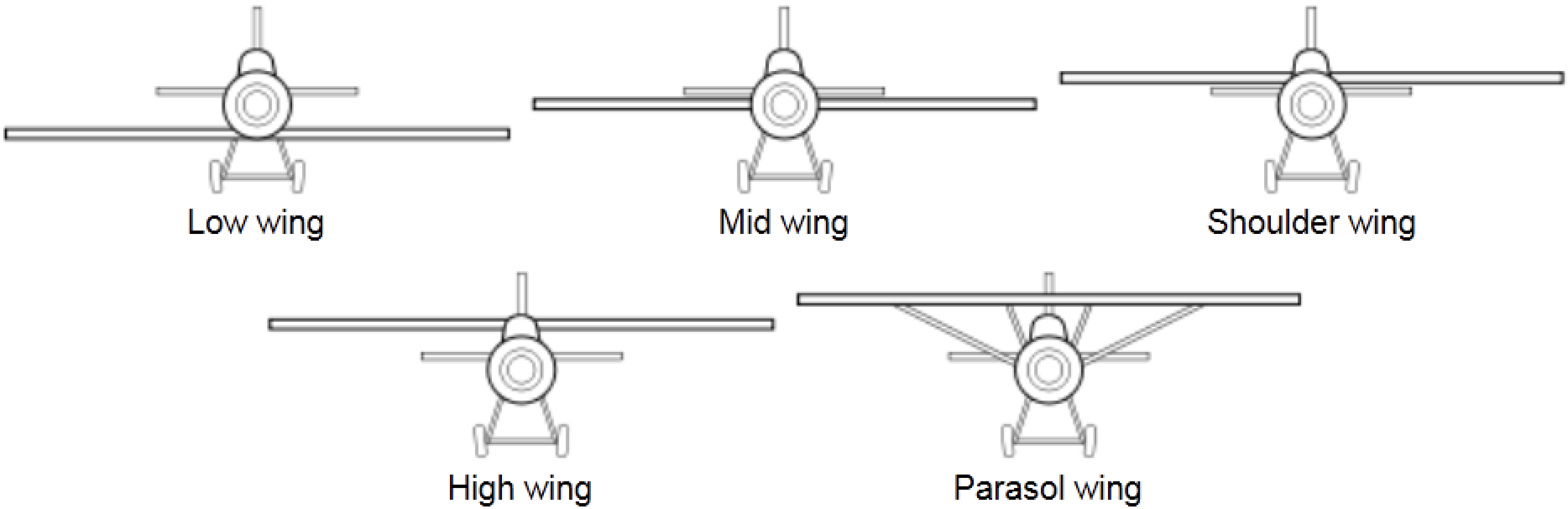
• **Swept angle**： The angle between the lateral axis and the quarter-chord line. It is sometimes also referred to as the *leading-edge sweep*.

• **Dihedral angle**： upward angle from horizontal of the wings

• **Anhedral angle**： downward angle from horizontal of the wings

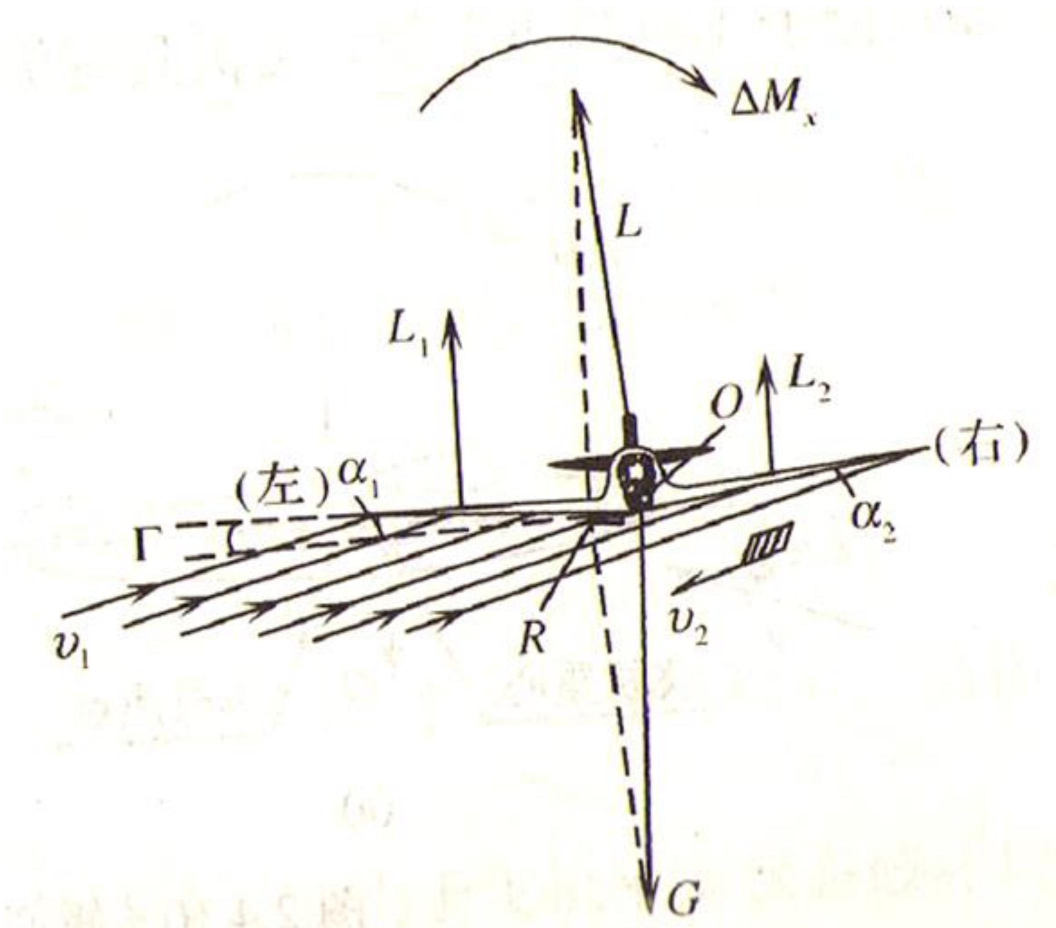
3.3 The stability of the aircraft

- **The wing position**



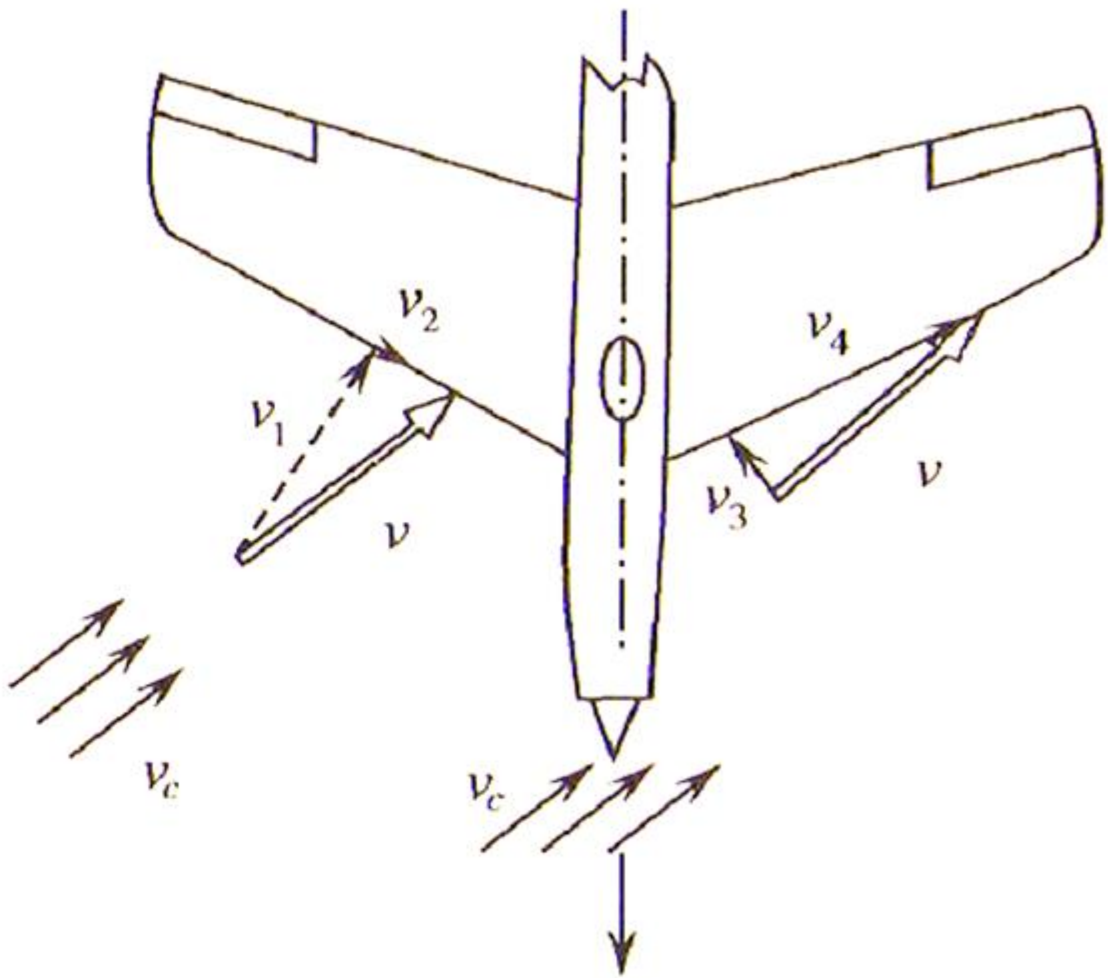
3.3 The stability of the aircraft

- **Effect of the dihedral/anhedral angle**



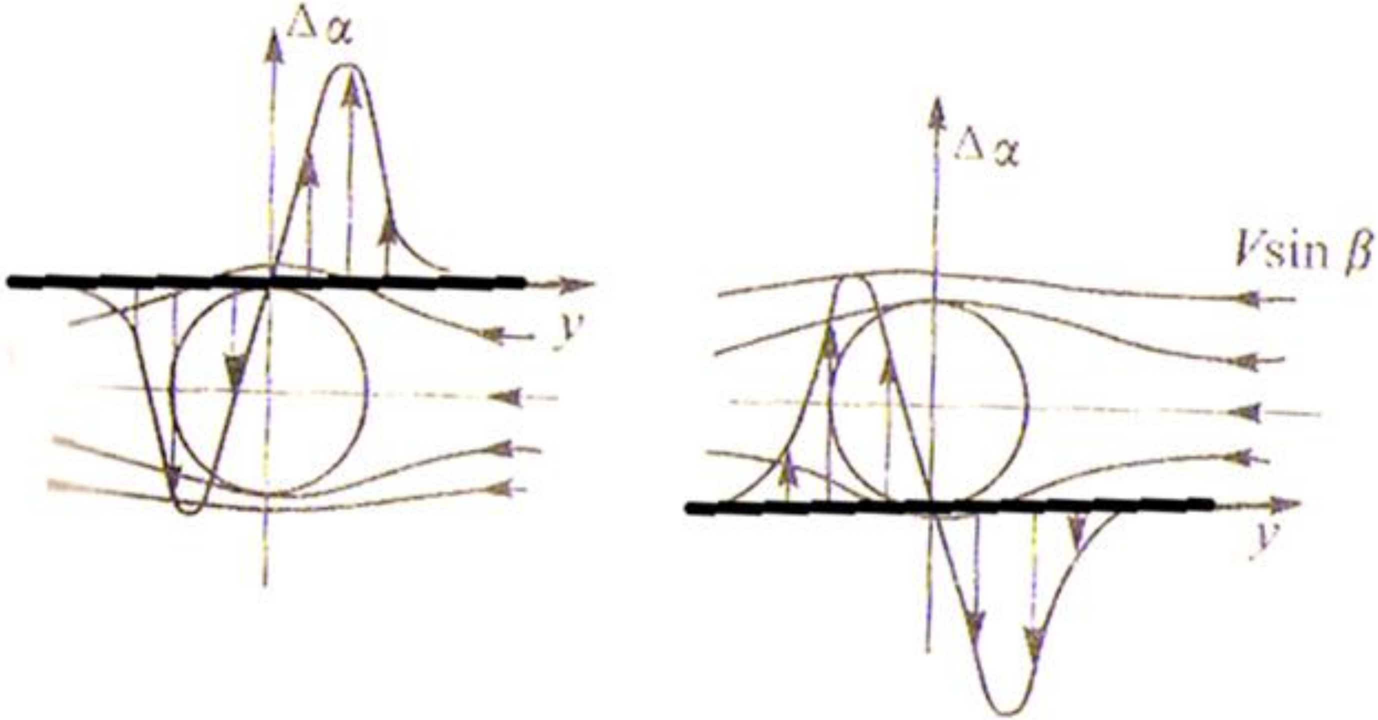
3.3 The stability of the aircraft

- **Effect of the sweep angle**



3.3 The stability of the aircraft

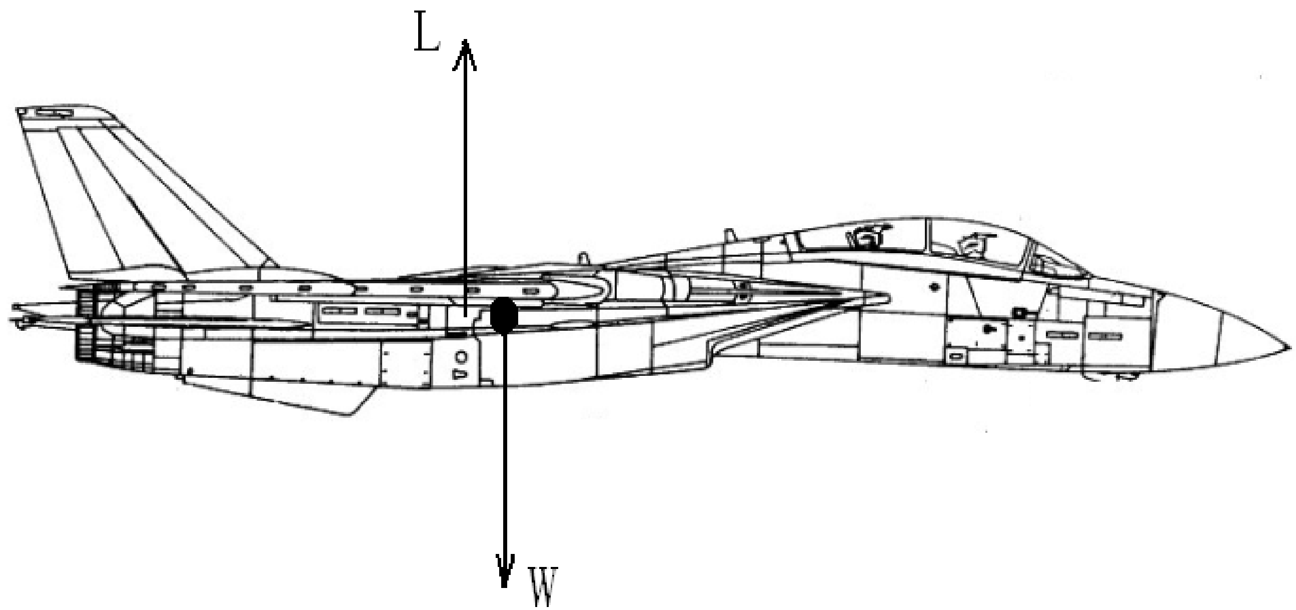
- **Effect of the wing position**



(a) High wing (b) Low wing

3.3 The stability of the aircraft

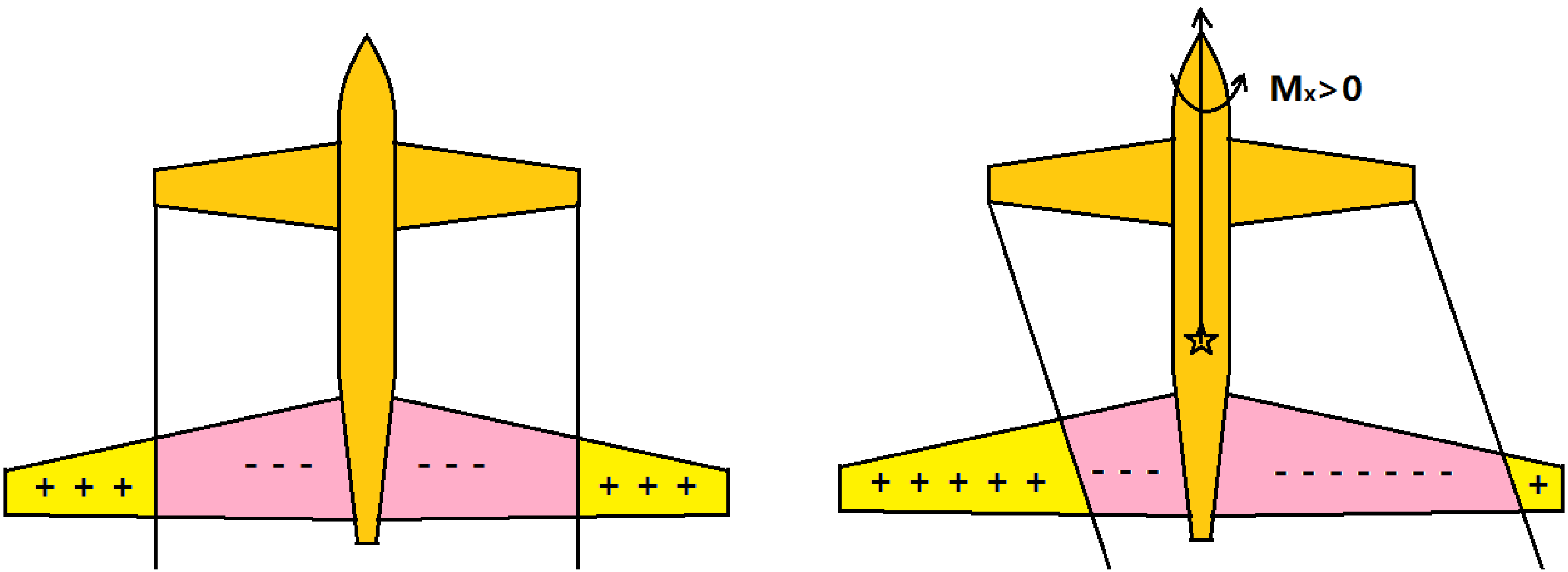
- **Effect of the C.G position**



Fuselage usually deteriorates the directional stability

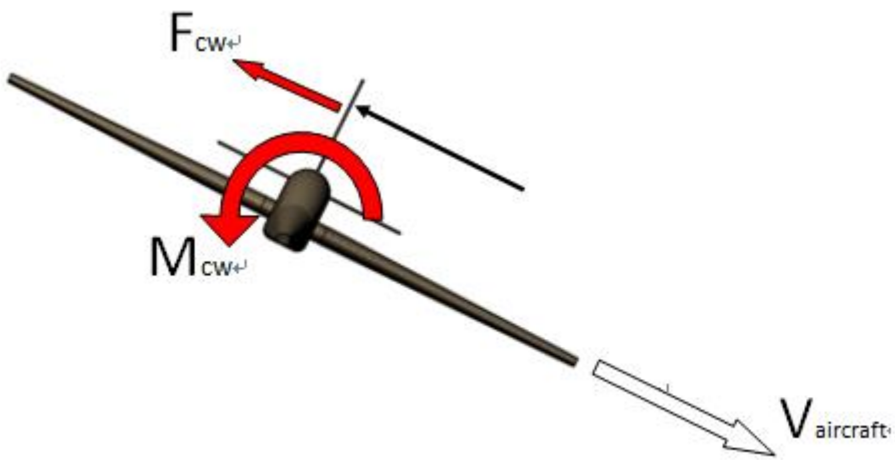
3.3 The stability of the aircraft

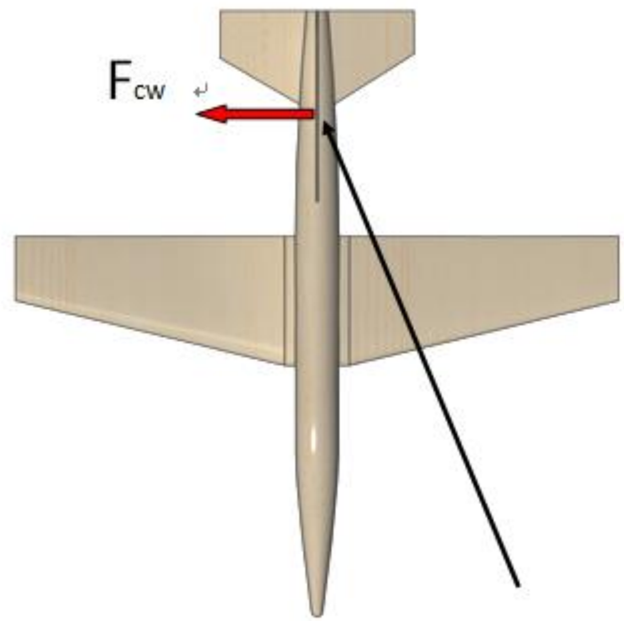
- **Effect of the canard**



3.3 The stability of the aircraft

- **Effect of the vertical stabilizer**





3.3 The stability of the aircraft

- **Summary on the lateral stability**

Configuration	Effect to lateral stability
Dihedral	Improve
Sweep back	Improve
High wing	Improve
Mid wing	Neutral
Anhidral	deteriorate
Sweep forward	deteriorate
Low wing	deteriorate

3.4 The dynamic modes of the aircraft

----The reaction of the aircraft upon the disturbance

Longitudinal modes

- **Long period oscillation**
  - **A large-amplitude variation of air-speed, pitch angle, and altitude, but almost no angle-of-attack variation**
- **Short period oscillation**
  - **A rapid pitching of the aircraft about the center of gravity**

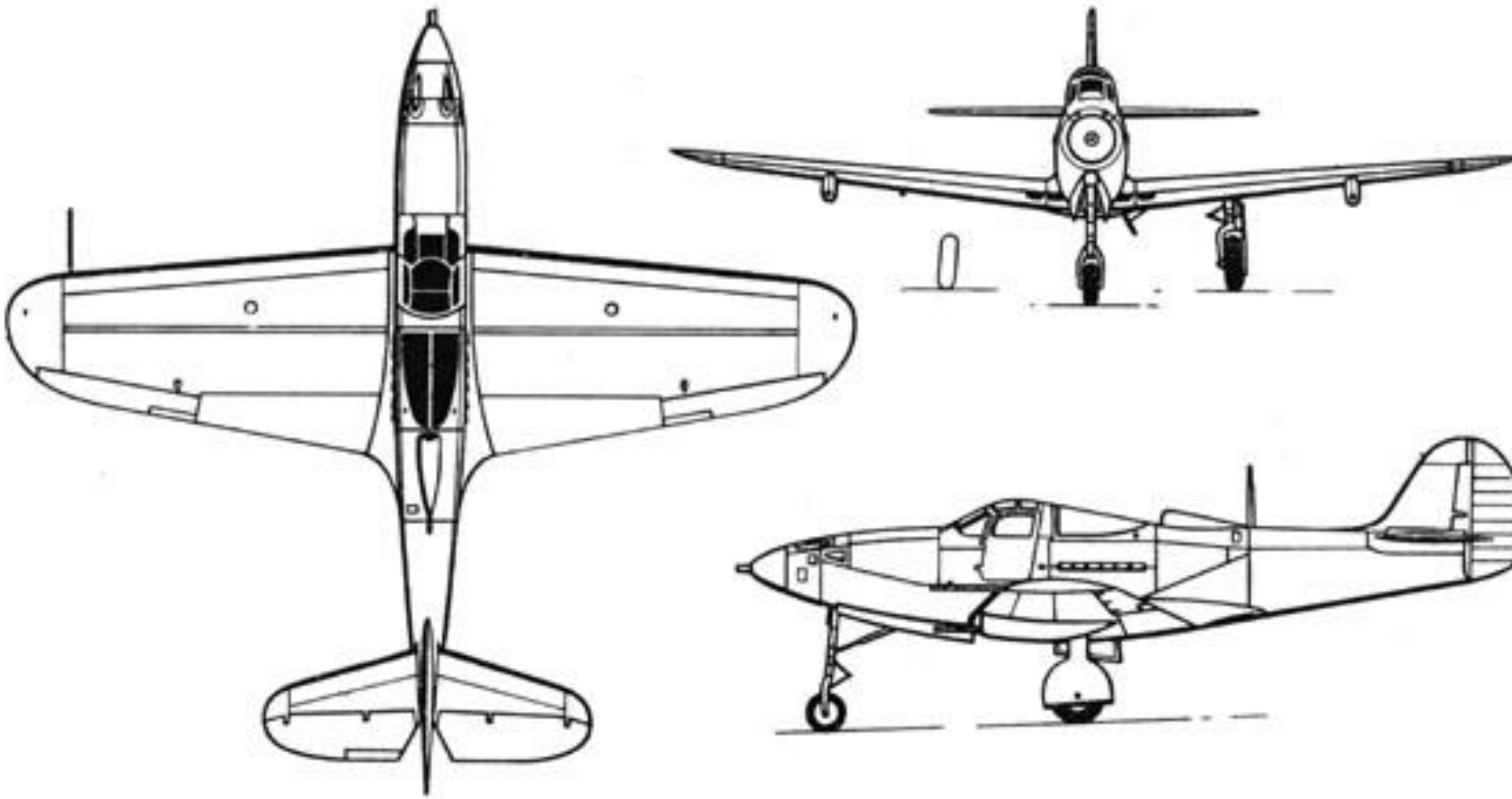
3.4 The dynamic modes of the aircraft

----The reaction of the aircraft upon the disturbance

Lateral-directional modes

- **Roll subsidence mode**
  - **The damping of the rolling motion**
- **Spiral mode**
  - **Caused by low dihedral and yaw damping**
- **Dutch roll mode**
  - **Caused by excessive large dihedral and small directional stability**

3.5 Understand the configuration of the WW2 aircraft



3.5 Understand the configuration of the WW2 aircraft

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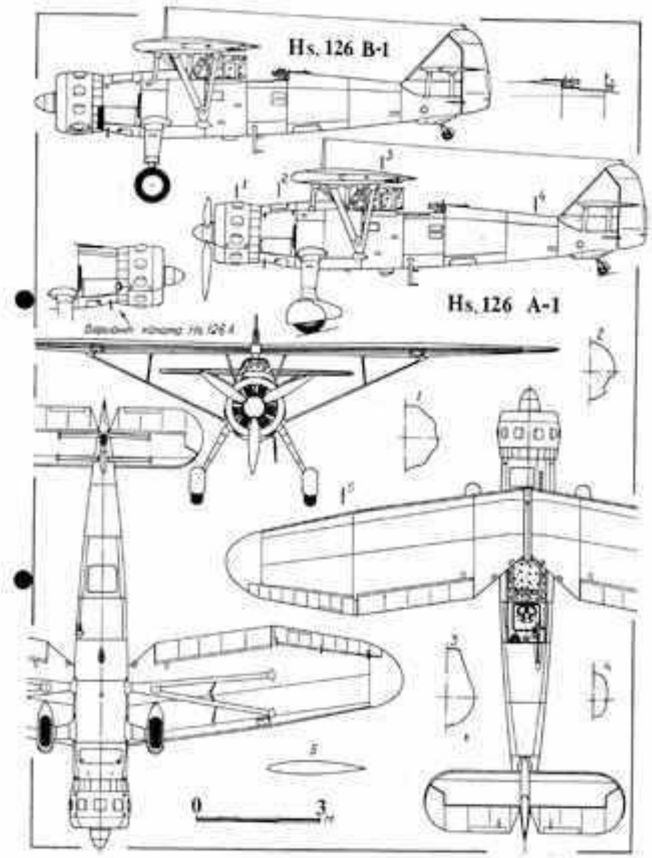

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