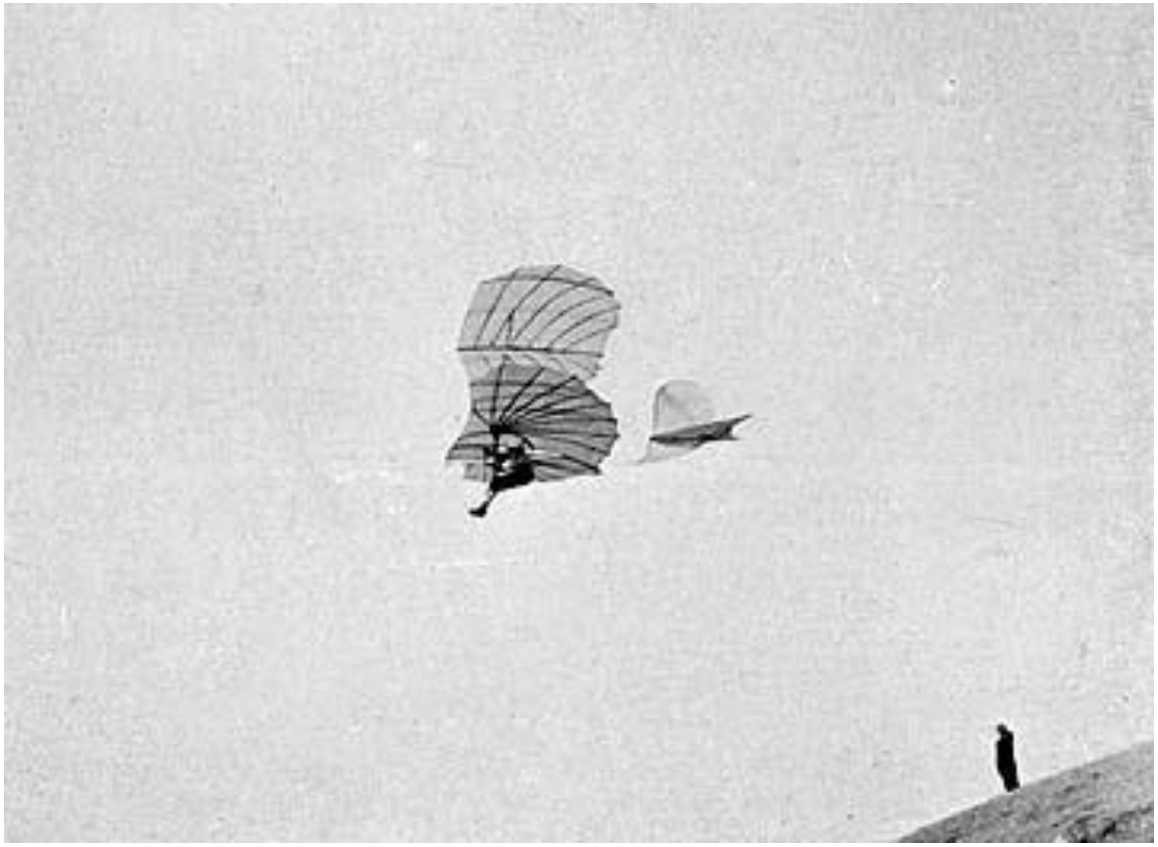
Introduction to aeronautics

Part 1. The pre-Wright era

1.2 The attempts of human carrying flight

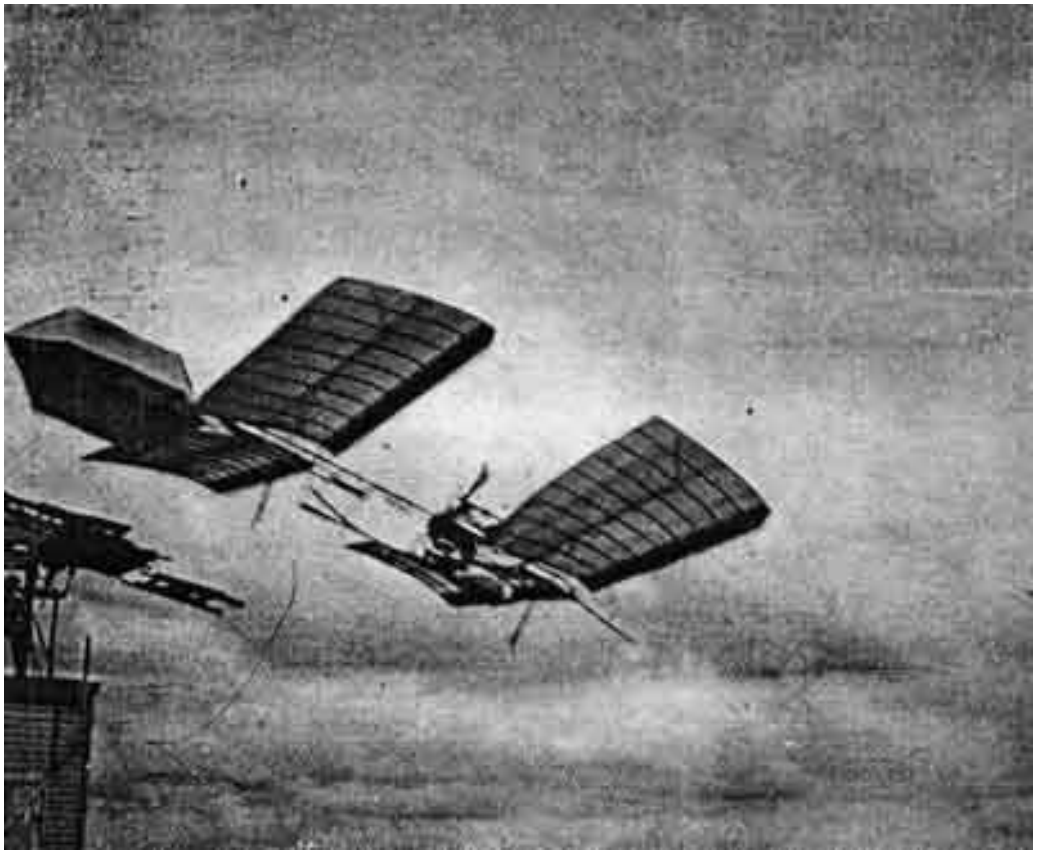
- The “airman’s” approach to flight
  - To learn to fly before putting an engine on the aircraft
  - The pioneer is Otto Lilienthal
    - He carried out aerodynamics experiments within 20 years
    - He found cambered airfoil performs better than flat surface
    - He presented the drag polar
    - He designed a number of gliders

1.2 The attempts of human carrying flight



Otto Lilienthal flying one of his monoplane gliders, 1894

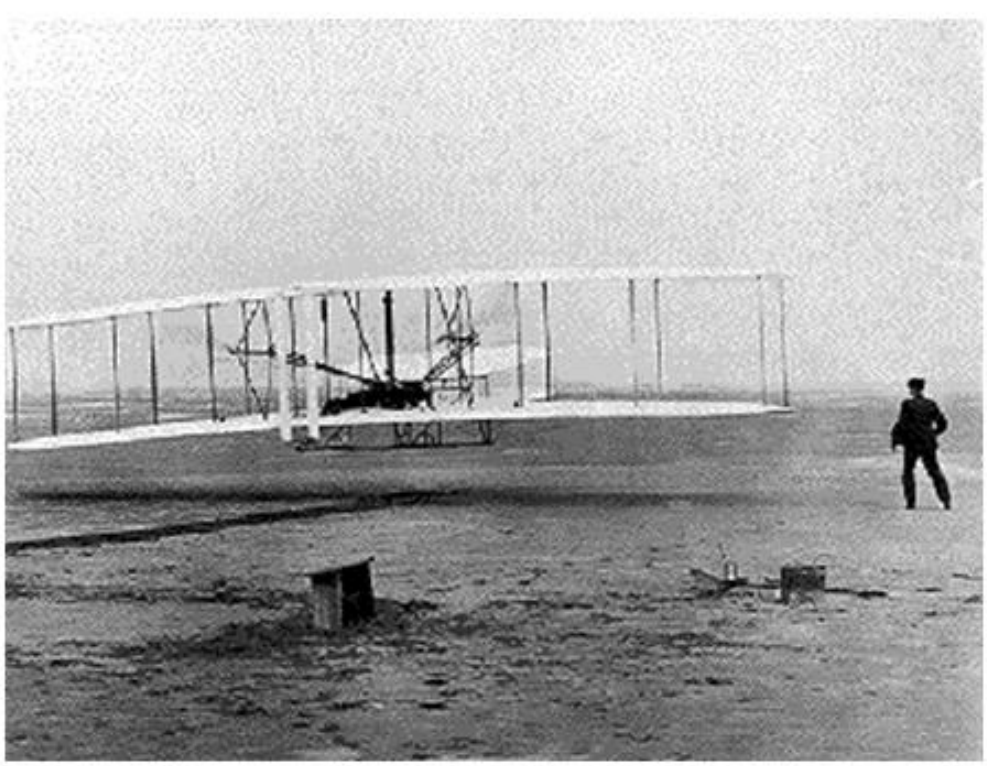
1.2 The attempts of human carrying flight

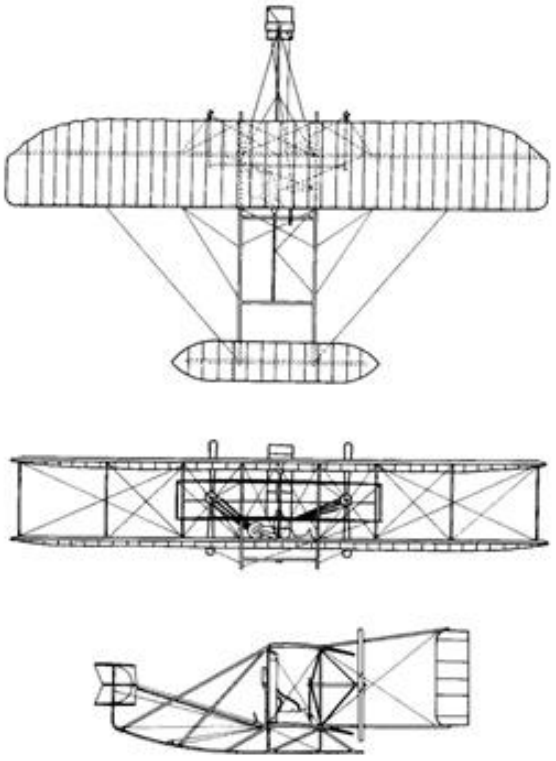


The Langley aerodrome on instant after launch, December 8, 1903

1.2 The attempts of human carrying flight

- **The success of the Wrights' flyer**





The wrights' flyer

1.2 The attempts of human carrying flight

- **The success of the wrights' flyer**
  - **They designed the propeller with efficiency as high as 70%**
  - **They invented the wind tunnel and they used the airfoil with 1/20 of camber ratio and max camber at quarter cord**
  - **They found that the wing with higher aspect ratio is more efficient**
  - **They chose lying prone to reduce parasite drag**
  - **They invented the approaches to control the airplane**

1.2 The attempts of human carrying flight

- **According to the early attempts and the success of the Wright's brother, to make a successful airplane, we need to solve the following problems:**
  - **How to improve the efficiency (L/D) of the aircraft? How to reduce drag?**
  - **How to trim and control the aircraft?**

1.2 The attempts of human carrying flight

- **Question 1: How to reduce drag?**
  - **The drag of the aircraft**

Drag=Parasite drag + Induced drag + Wave drag

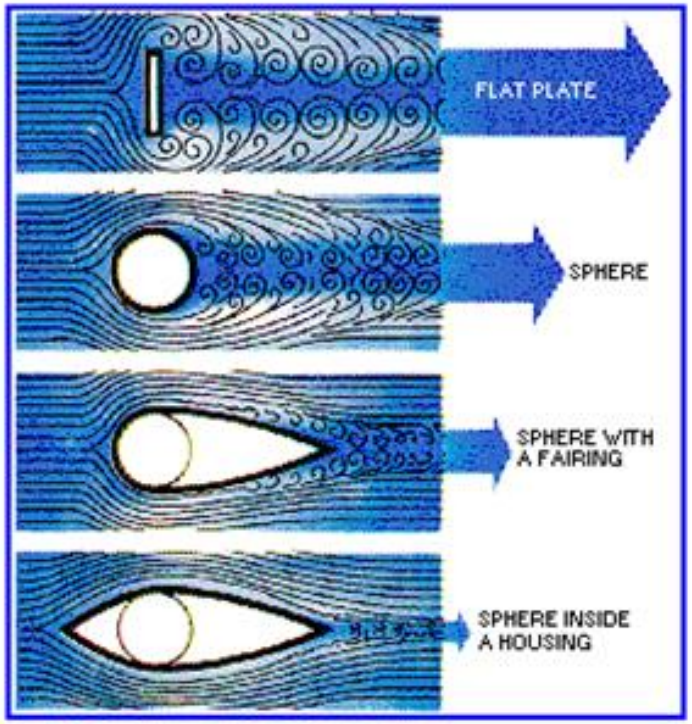
  - **Parasite drag:**
    - **Form drag**
    - **Friction drag**
    - **Interference drag**

1.2 The attempts of human carrying flight

- **Parasite drag:**
  - **Form drag**
    - **The shape of the object may create low-pressure areas and turbulence, which retard the forward movement of the aircraft**

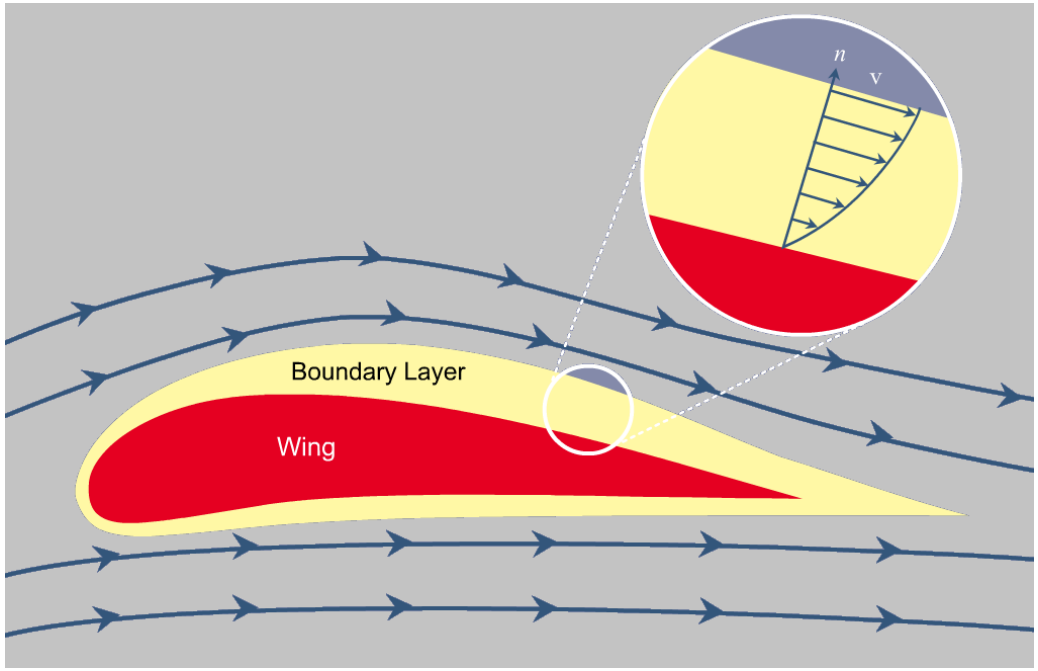
1.2 The attempts of human carrying flight

- **Parasite drag:**
  - **Form drag**
    - **Streamlining the aircraft may help eliminate the form drag**



1.2 The attempts of human carrying flight

- **Parasite drag:**
  - **Friction drag**
    - **Close to the body surface, there is a thin layer of air, which is called “Boundary layer”**

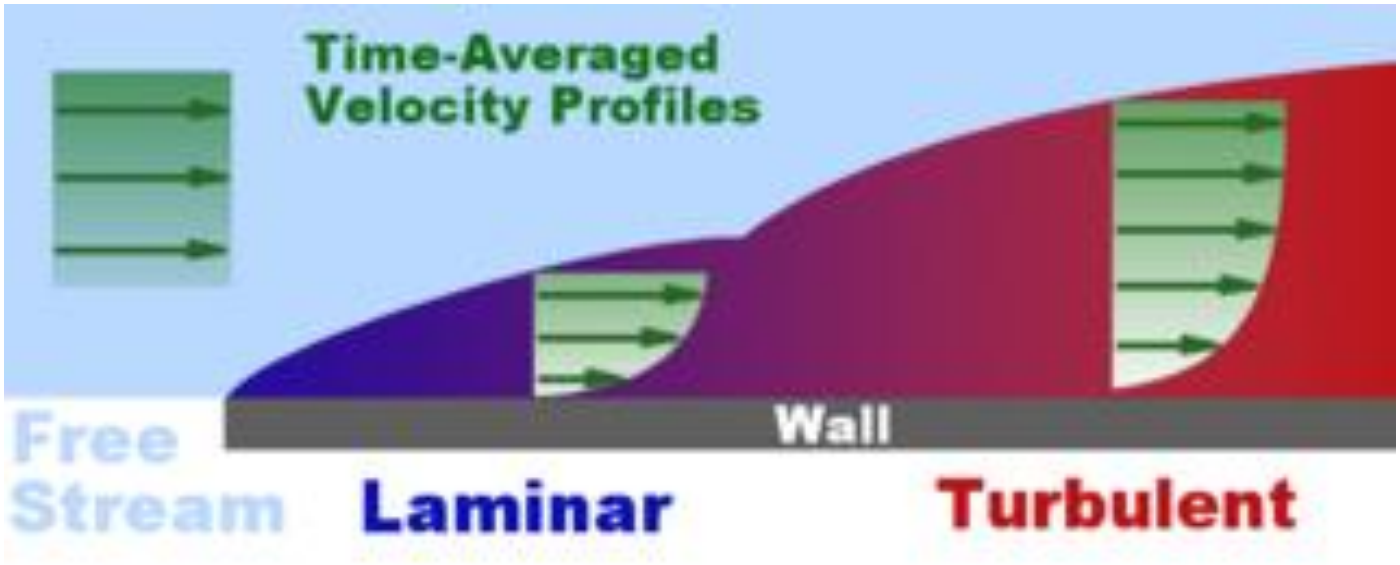


1.2 The attempts of human carrying flight

- **Parasite drag:**
  - **Friction drag**
    - **When an object moves through air, the air closest to the object's surface is dragged along with it, pulling or rubbing at the air that it passes. This rubbing exerts a force on the object opposite to the direction of motion.**

1.2 The attempts of human carrying flight

- **Parasite drag:**
  - **Friction drag**
    - **There are two types boundary layer:**
      - **Laminar boundary layer**
      - **Turbulent boundary layer**



1.2 The attempts of human carrying flight

- **Parasite drag:**
  - **Laminar boundary layer**
    - **The fluid flows in parallel layers, with no disruption between the layers**
  - **Turbulent boundary layer**
    - **In turbulent boundary layer, the flow is characterized by chaotic and stochastic property changes**
  - **The laminar flow can turn into turbulent flow, this process is called "laminar-turbulent transition"**

1.2 The attempts of human carrying flight

- **Parasite drag:**
  - **The laminar boundary layer causes less friction drag than turbulent boundary layer**
  - **The laminar boundary layer is more apt to separate, which causes form drag**

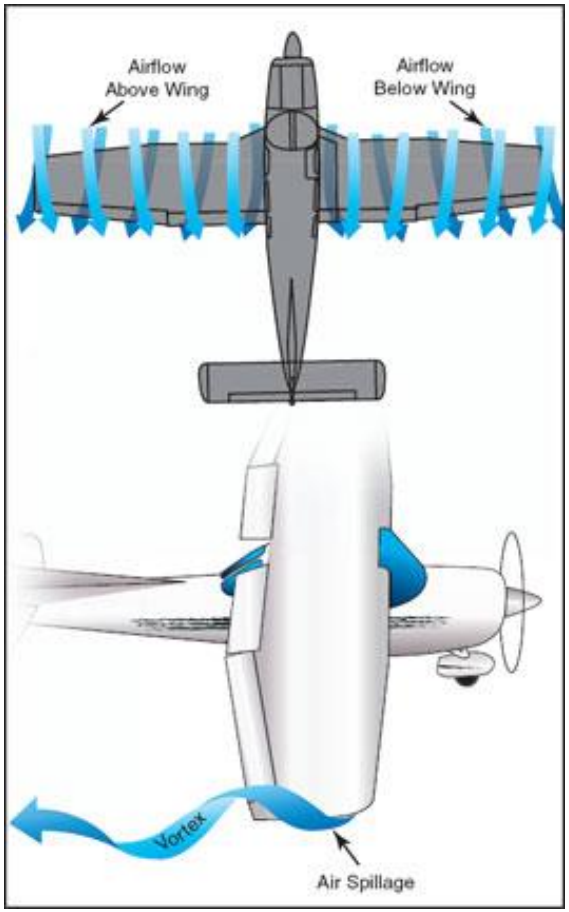
1.2 The attempts of human carrying flight

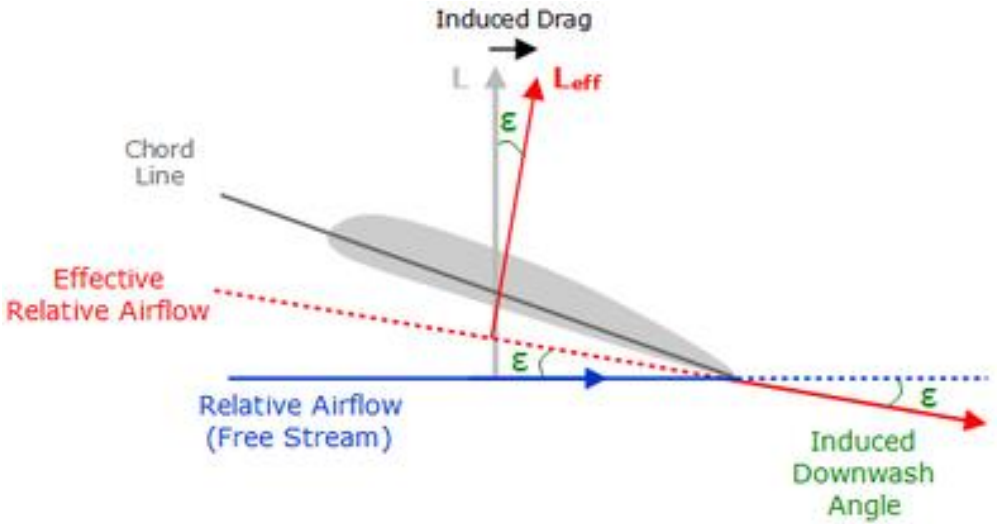
- **Parasite drag:**
  - **To reduce friction drag:**
    - **Reduce the wetted area of the aircraft**
      - **Blended wing-body**
    - **Try to maintain larger area of laminar boundary layer**
      - **Polish the skin**

Blended wing body

1.2 The attempts of human carrying flight

- **Induced drag**





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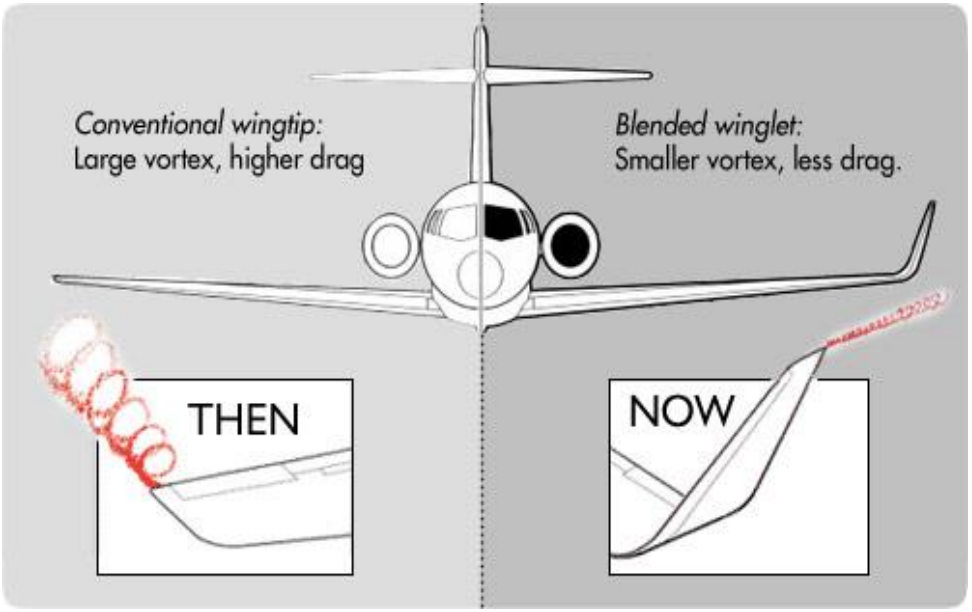
- **Induced drag**
  - **The airfoil can be deemed as a wing with infinite wing span, hence it does not have induced drag**
  - **To reduce the induced drag:**
    - **Increase the aspect ratio**
    - **Try to prevent the air below the wing surface flow towards the upper wing surface**

1.2 The attempts of human carrying flight

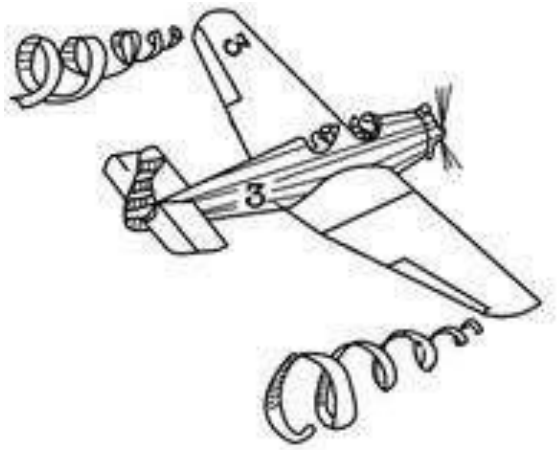
- **Induced drag**



The approaches to reduce the induced drag

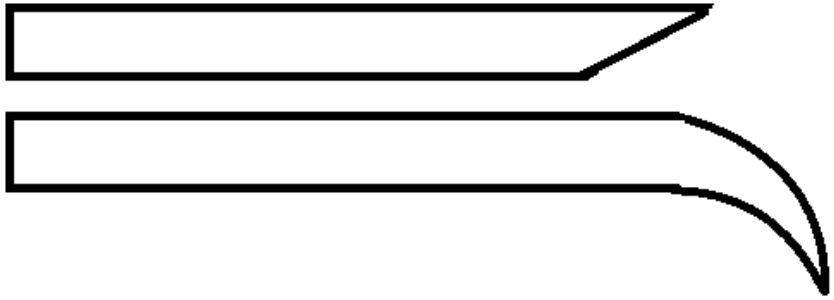
1.2 The attempts of human carrying flight

- **Induced drag**



1.2 The attempts of human carrying flight

- **Induced drag**



Horner wingtips

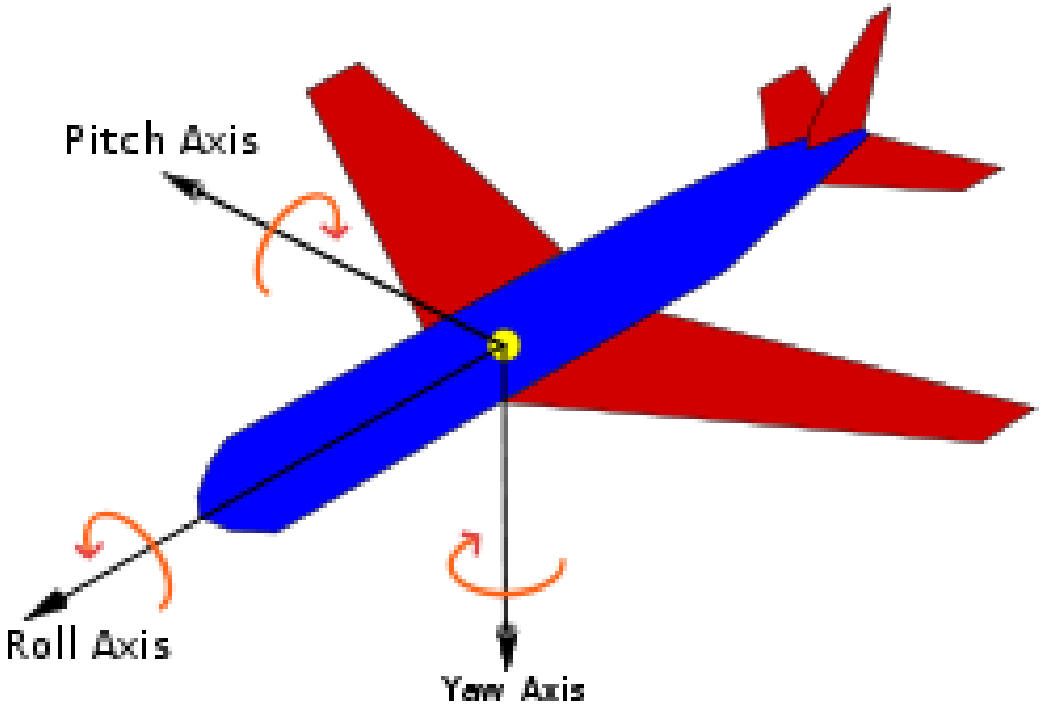
The approaches to reduce the induced drag

1.2 The attempts of human carrying flight

- **Wave drag**
  - **The drag caused by shock wave**
  - **We will discuss this later**

1.2 The attempts of human carrying flight

- **Question 2: How to trim and control the aircraft?**
  - **The aircraft is trimmed along 3 axis:**
    - **Pitch**
    - **Roll**
    - **Yaw**



1.2 The attempts of human carrying flight

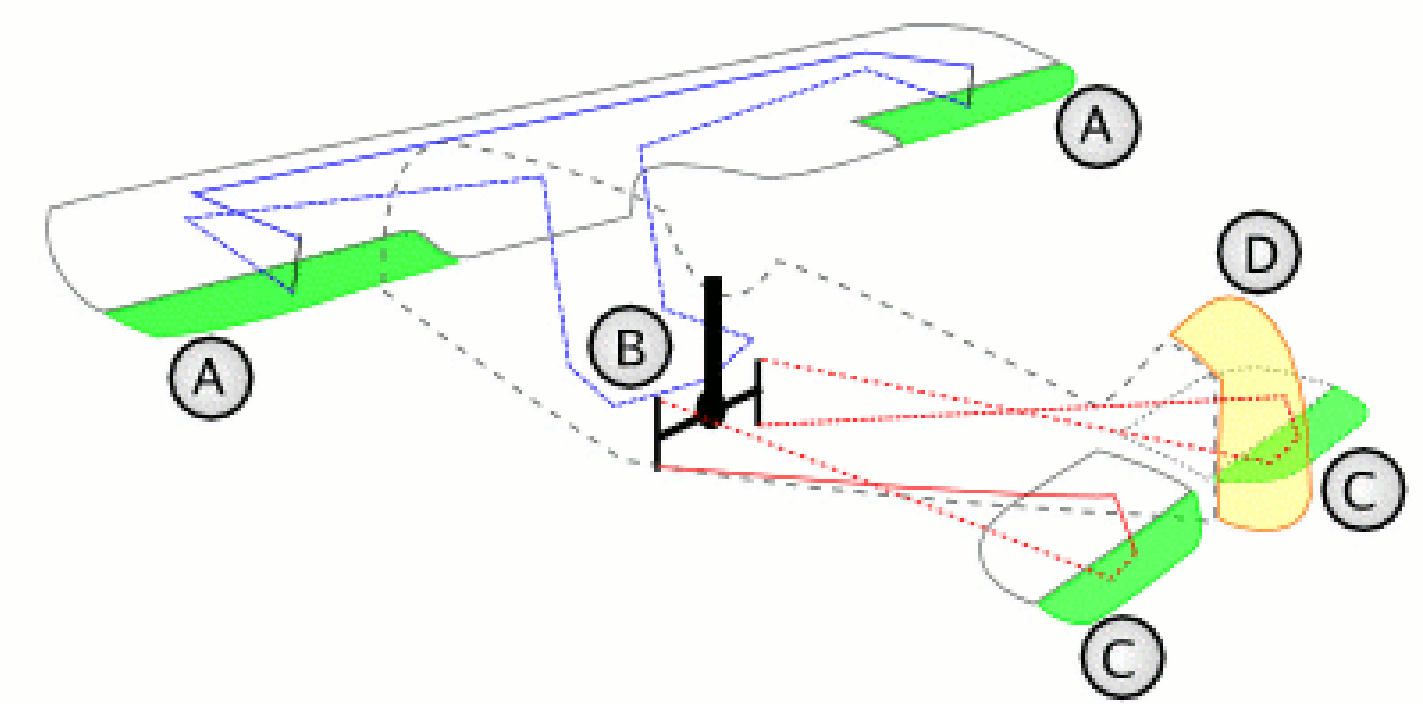
- **Question 2: How to trim and control the aircraft?**
  - The horizontal stabilizer is used to provide stability about pitch axis (longitudinal stability)
  - The vertical stabilizer is used to provide stability about yaw axis (direction stability)

1.2 The attempts of human carrying flight

- **Question 2: How to trim and control the aircraft?**
  - The elevator is used to provide pitch control
  - The aileron is used to provide roll control
  - The rudder is used to provide yaw control

1.2 The attempts of human carrying flight

- **Question 2: How to trim and control the aircraft?**

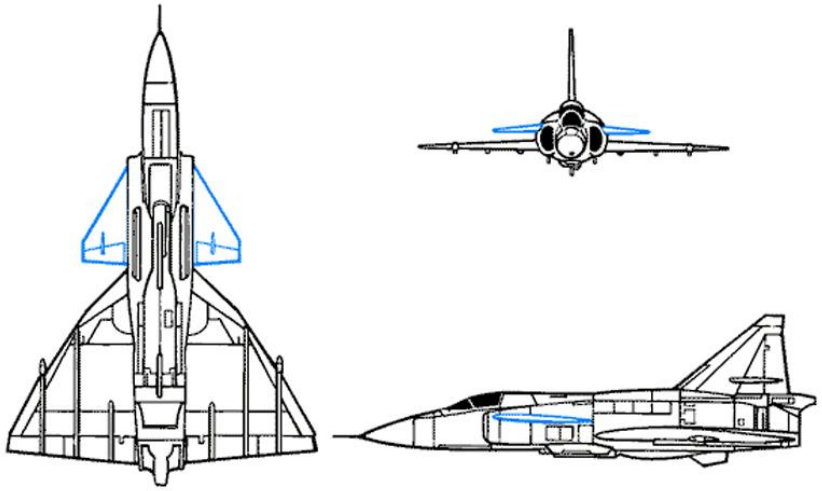


1.2 The attempts of human carrying flight

- **Question 2: How to trim and control the aircraft?**
  - For the canard configuration, the canard is used to provide longitudinal stability and lift

1.2 The attempts of human carrying flight

- **Question 2: How to trim and control the aircraft?**
  - For the canard configuration, the elevator is located on the canard

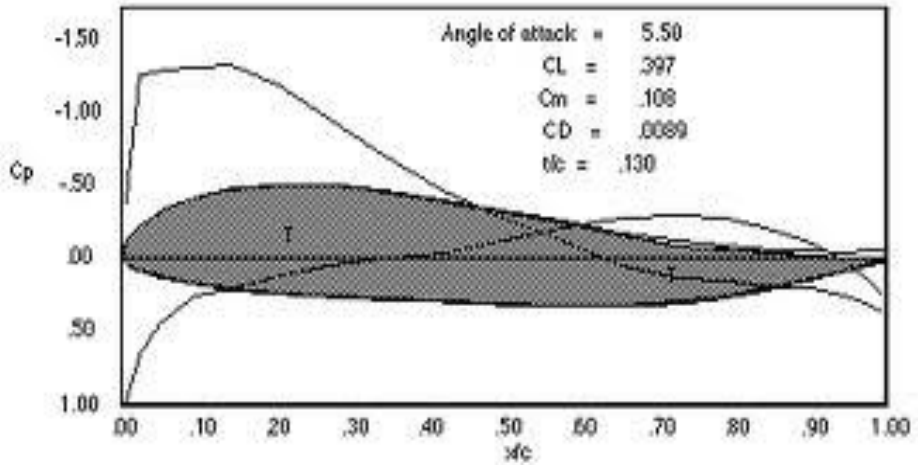


1.2 The attempts of human carrying flight

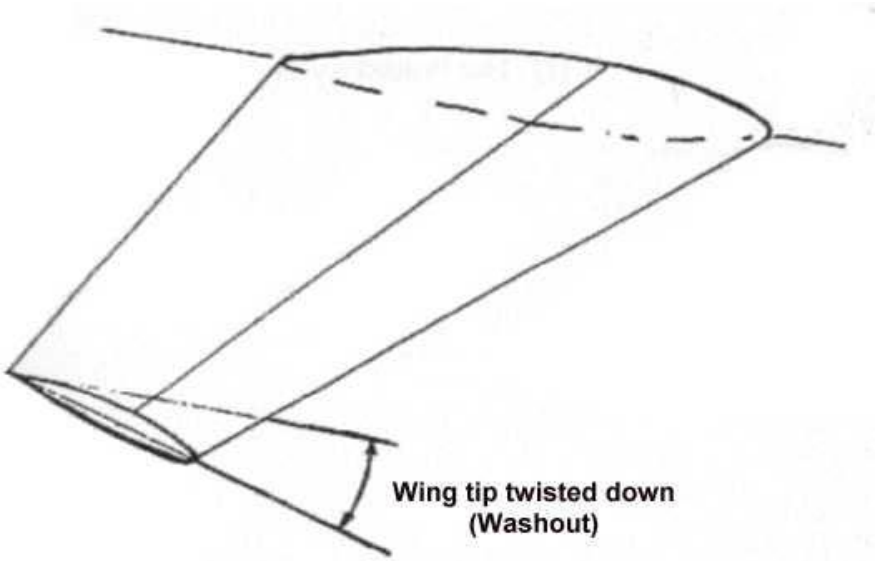
- **Question 2: How to trim and control the aircraft?**
  - For the tailless aircraft, the longitudinal stability is obtained by:
    - Airfoil with reflex camber line
    - Wash out
    - Swept wing

1.2 The attempts of human carrying flight

- **Question 2: How to trim and control the aircraft?**

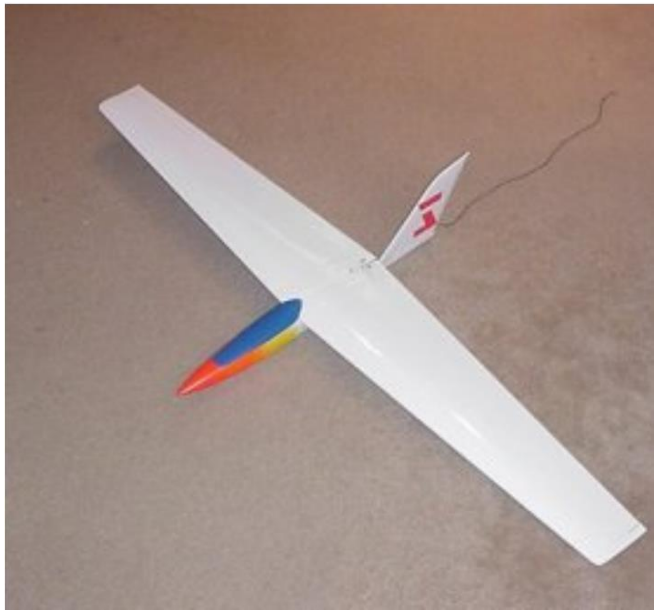


Reflex camber airfoil



1.2 The attempts of human carrying flight

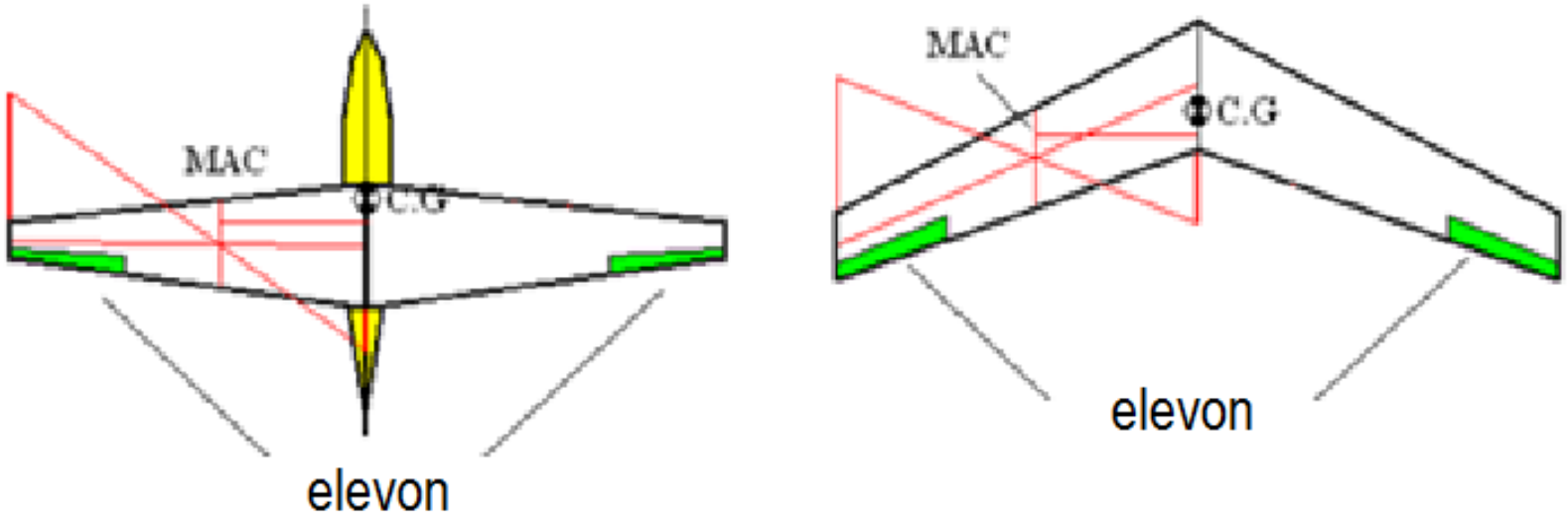
- **Question 2: How to trim and control the aircraft?**



Flying plank and swept wing tailless aircraft

1.2 The attempts of human carrying flight

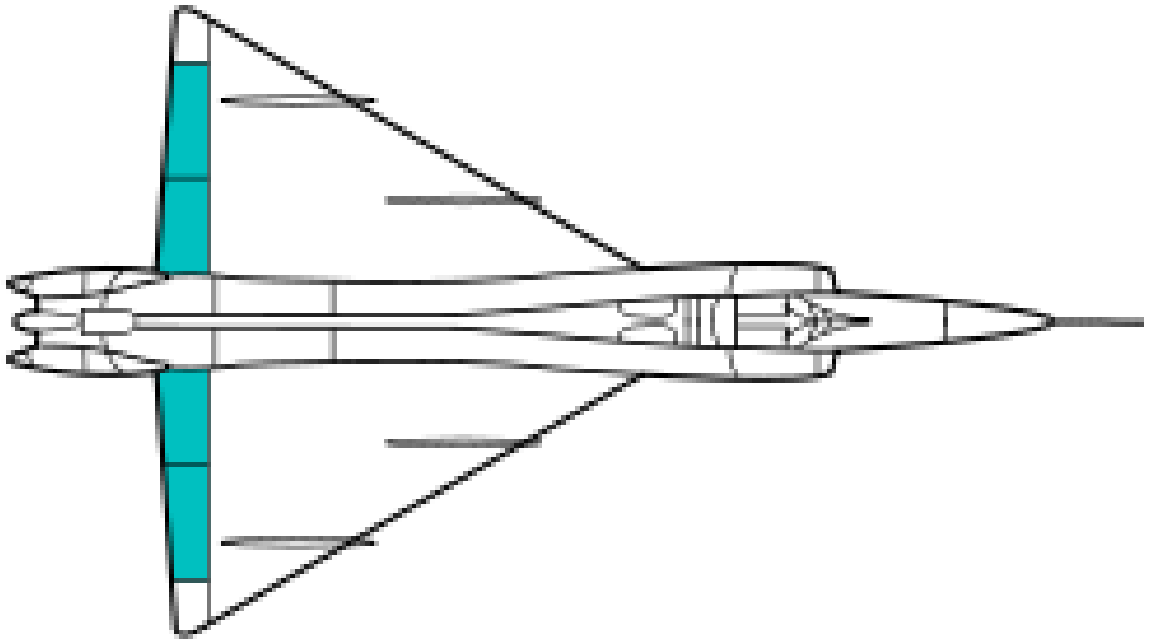
- **Question 2: How to trim and control the aircraft?**



Flying plank and swept wing tailless aircraft

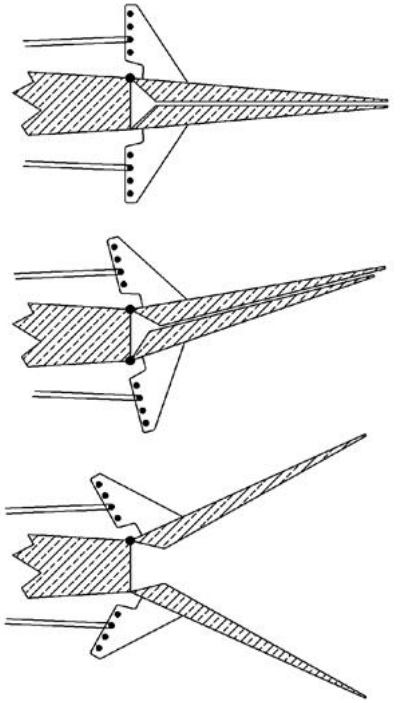
1.2 The attempts of human carrying flight

- **Question 2: How to trim and control the aircraft?**
  - For the tailless aircraft, the pitch and roll control is provided by elevon



1.2 The attempts of human carrying flight

- For the tailless aircraft, the yaw stability and control is provided by rudder or the split rudder (drag rudder)



1.2 The attempts of human carrying flight

- For the tailless aircraft, it is good to combine the function of the winglet and the vertical stabilizer