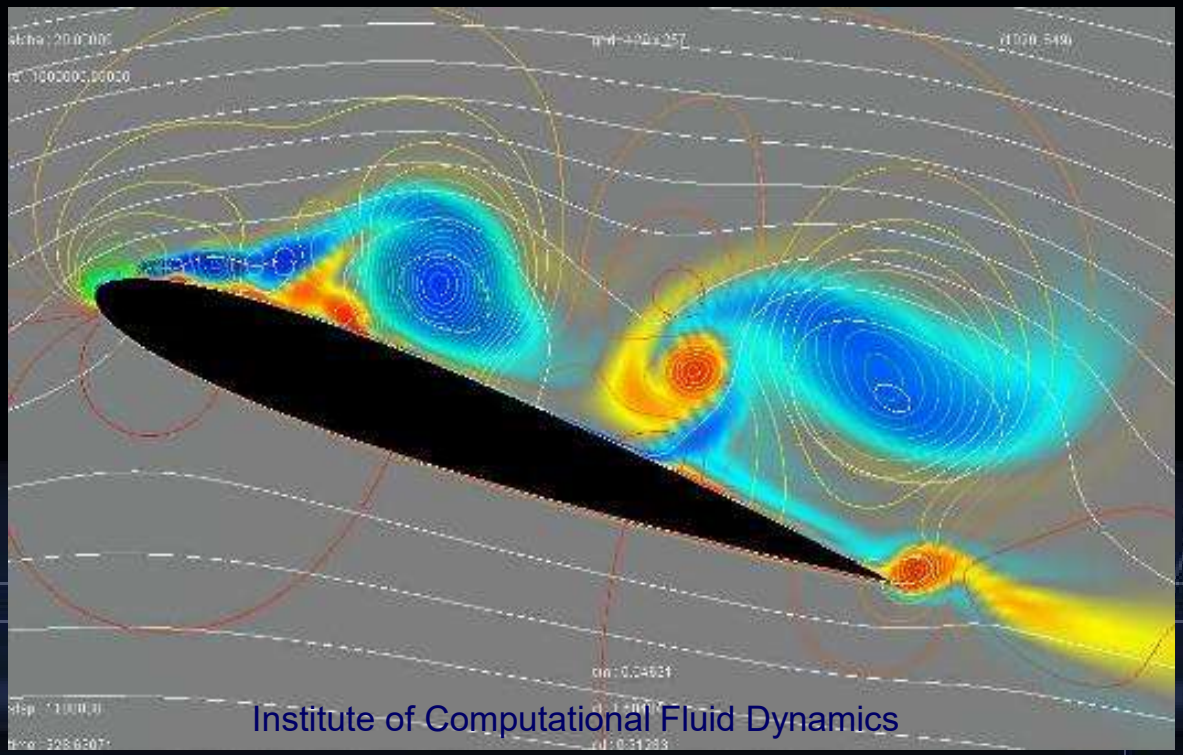
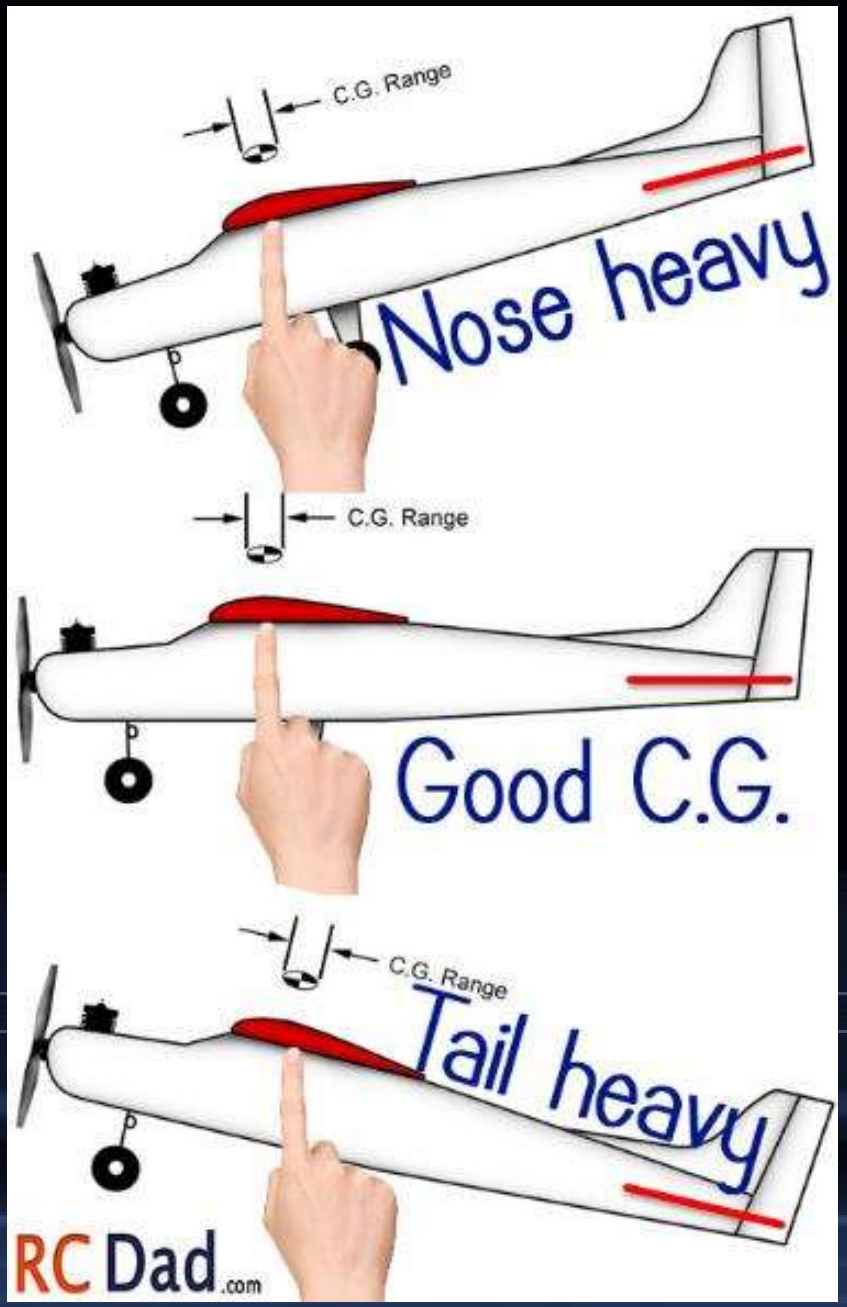
Why Airplanes Fly

Aerodynamics, Part 1 – Lift & Drag



Institute of Computational Fluid Dynamics

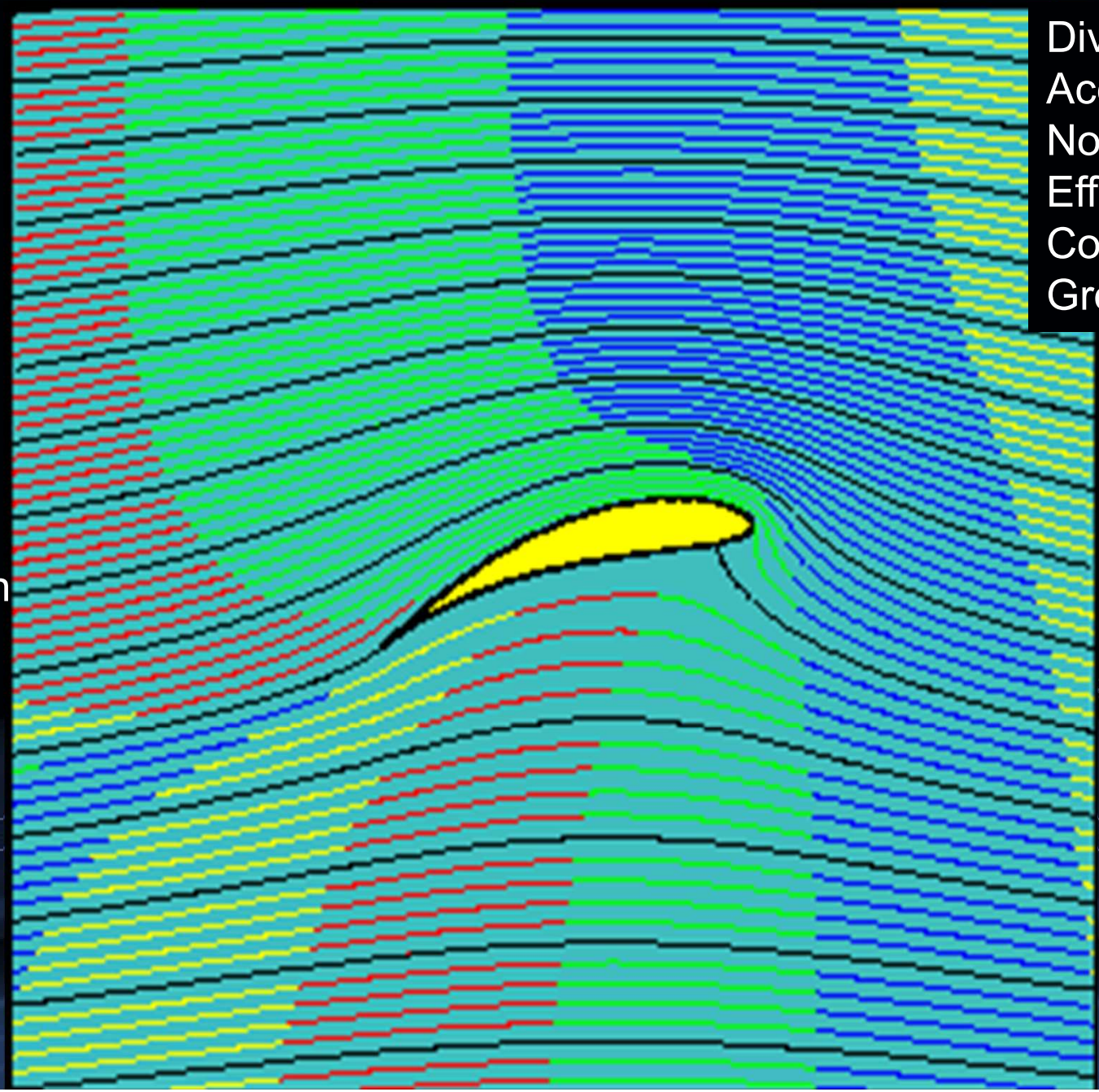
Center of Gravity



Center of Gravity

Lift? What Lift?

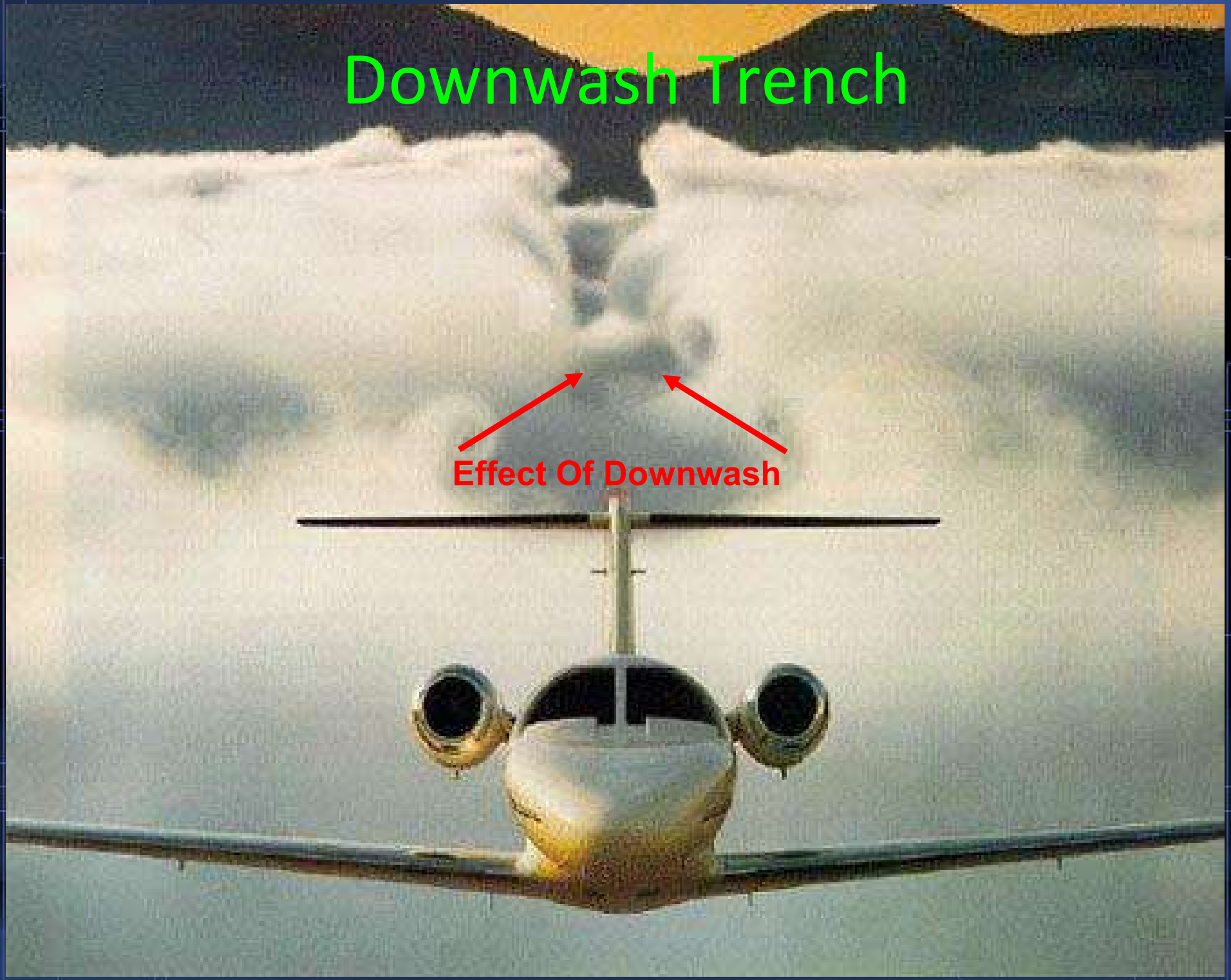
Streak Lines 10° AOA



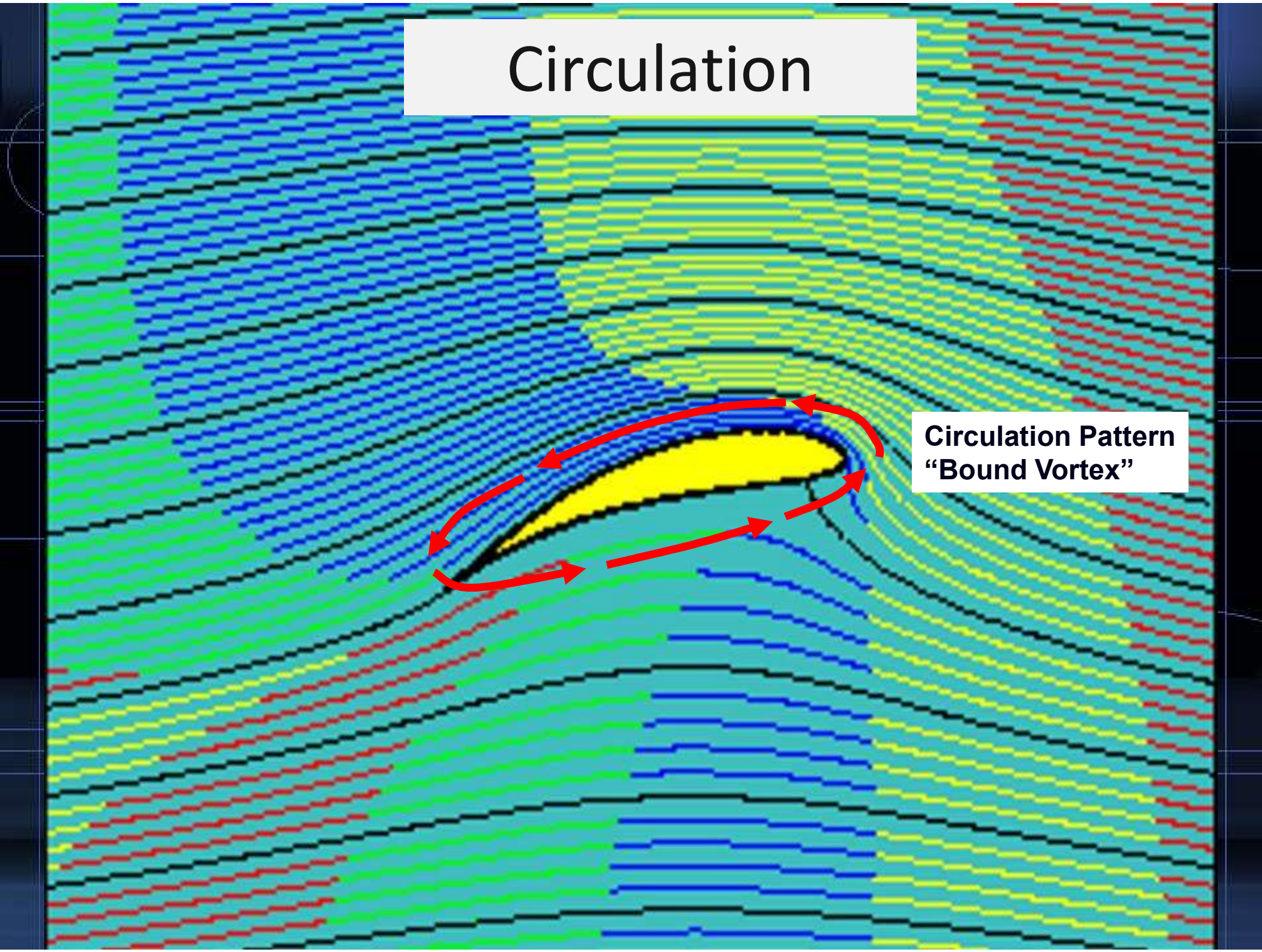
Divided flow
Accelerated flow
Not Bernoulli
Effects all around
Compressed flow
Ground effect

Note: Downwash Air Accelerated Down

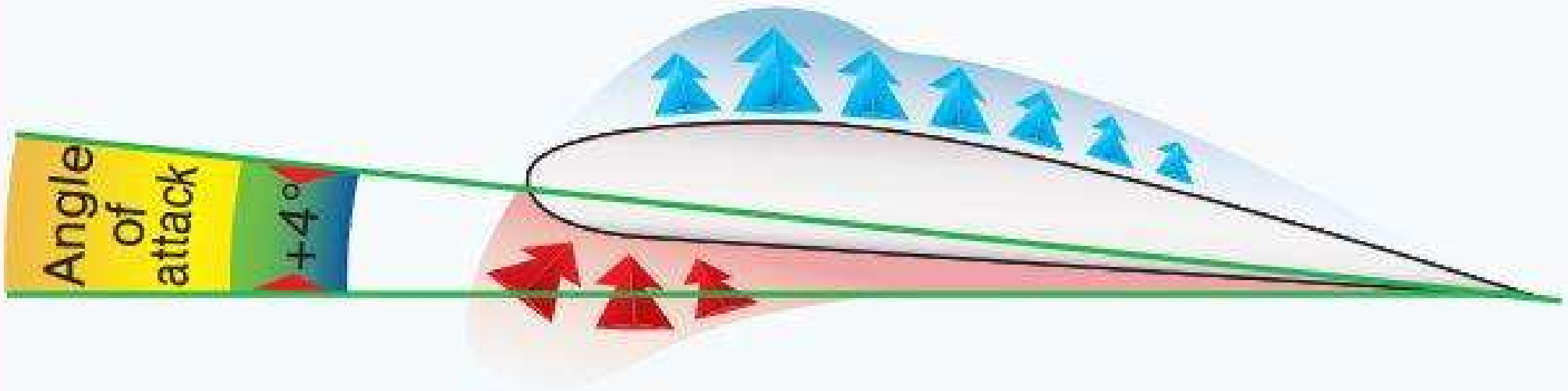
Downwash Trench



Circulation



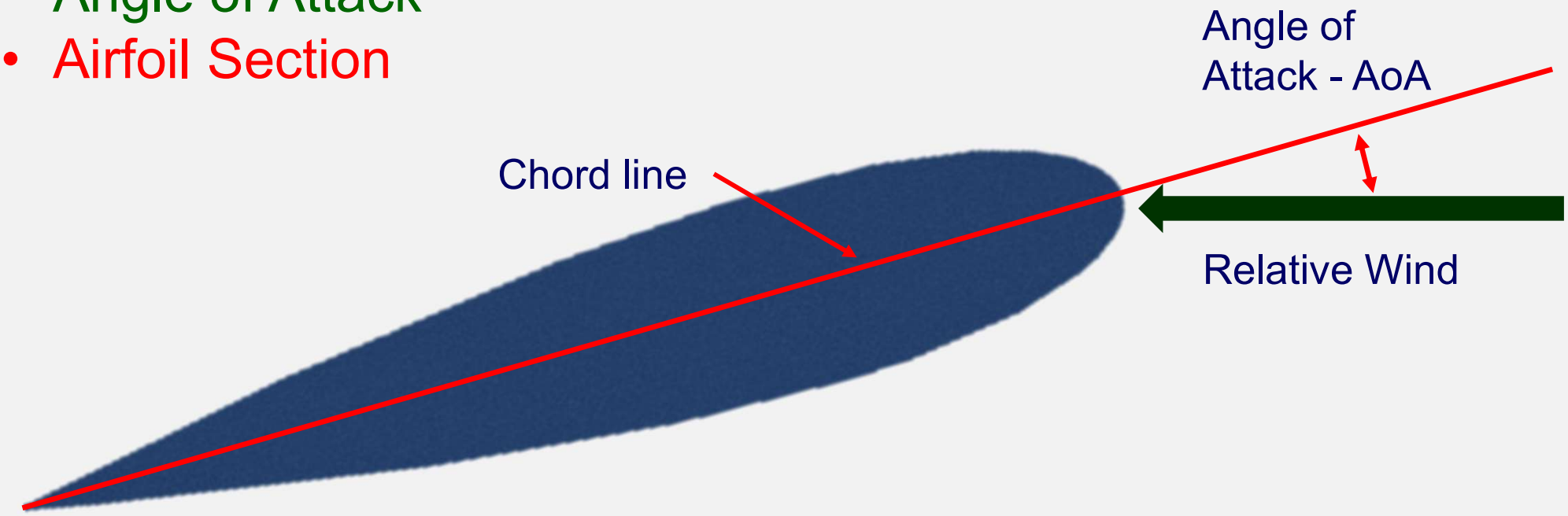
Center of Pressure or Lift



Actual Lift Generated

Total Lift Generated is a Function of

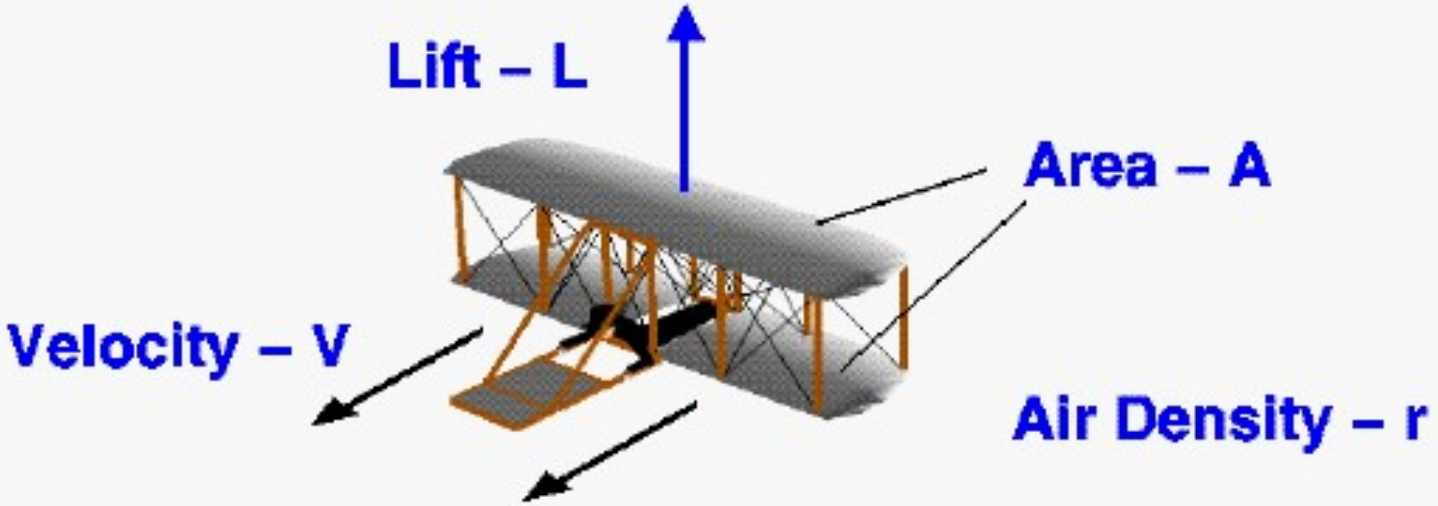
- Velocity
- Air Density
- Wing Area
- Angle of Attack
- Airfoil Section



How Much Lift?

Modern Lift Equation

Glenn Research Center



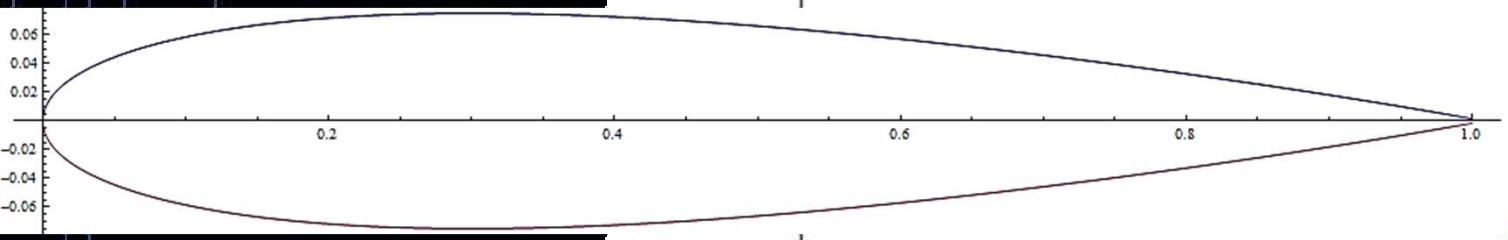
$$L = Cl \frac{r V^2}{2} A$$

Lift = Cl (airfoil coefficient) x $\frac{\text{density x velocity squared}}{\text{two}}$ x wing area

Coefficient **Cl** contains all the complex dependencies.

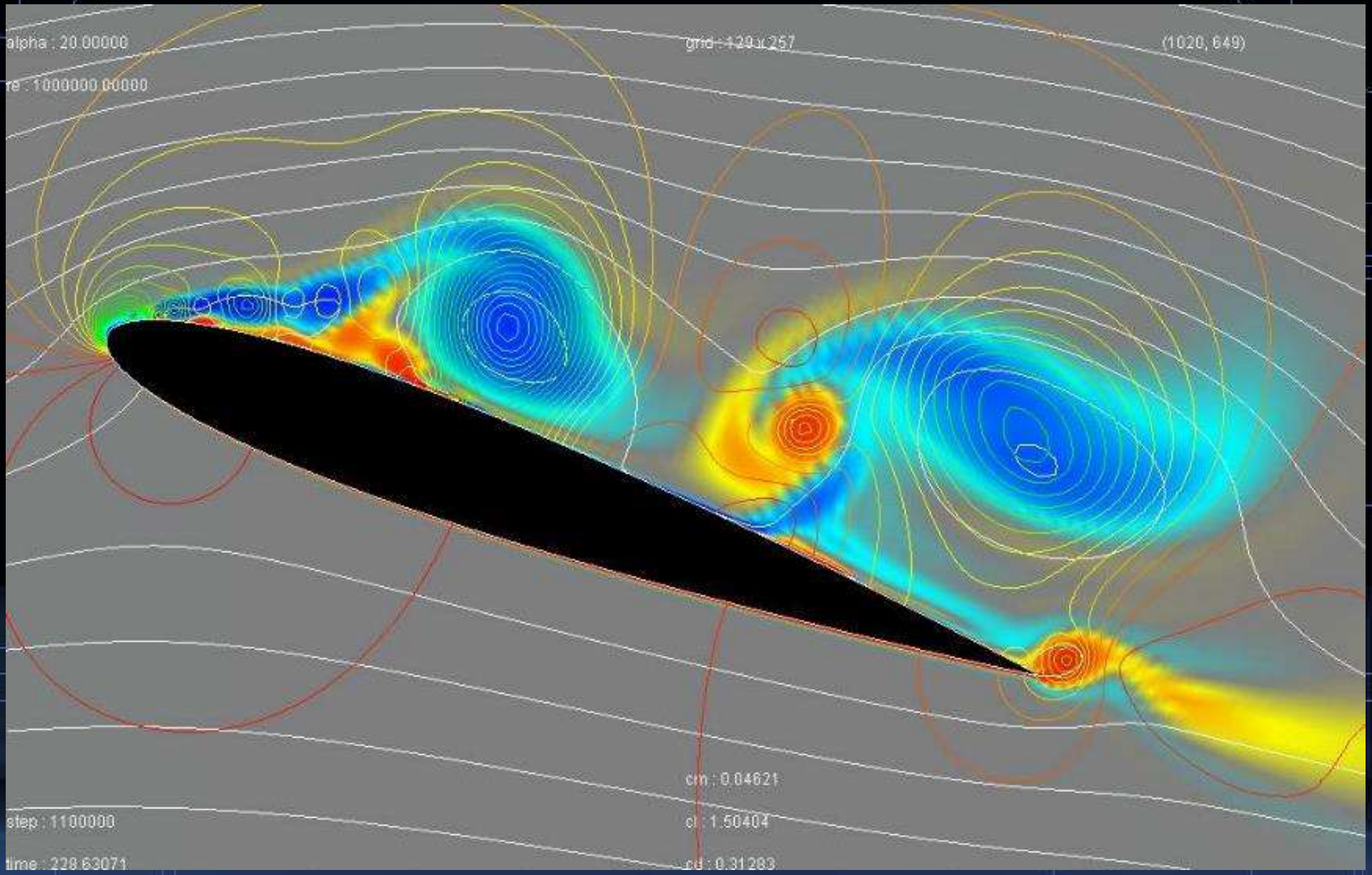
The lift coefficient Cl is a measure of the difference in pressure created above and below a vehicle's body as it moves through the surrounding air.

NACA 0015 Lift Curve



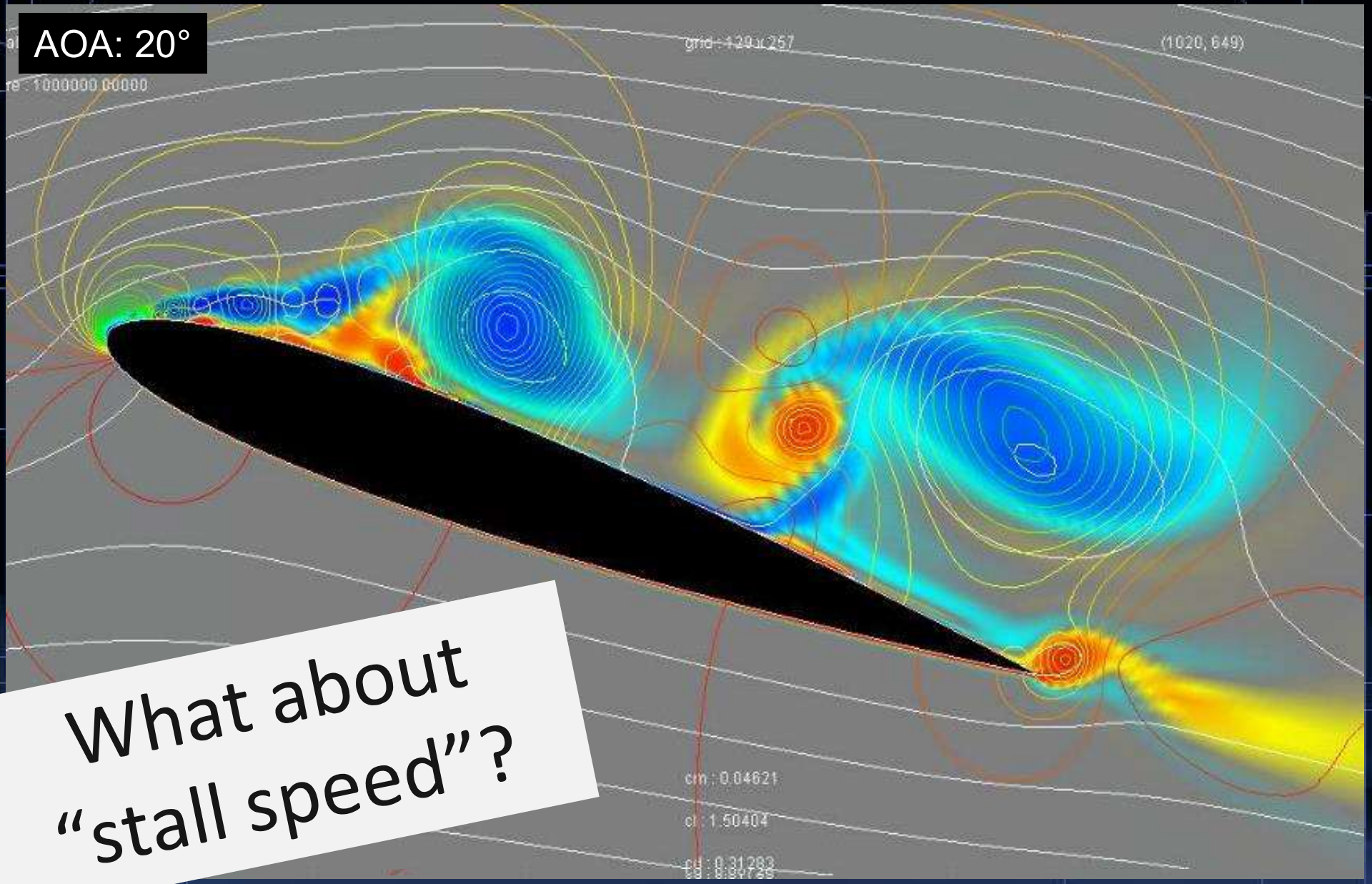
Stalls! Airflow Over an Airfoil

Institute of Computational Fluid Dynamics



Stalls! Airflow at Selected AOA

Institute of Computational Fluid Dynamics



What about "stall speed"?

Stalls

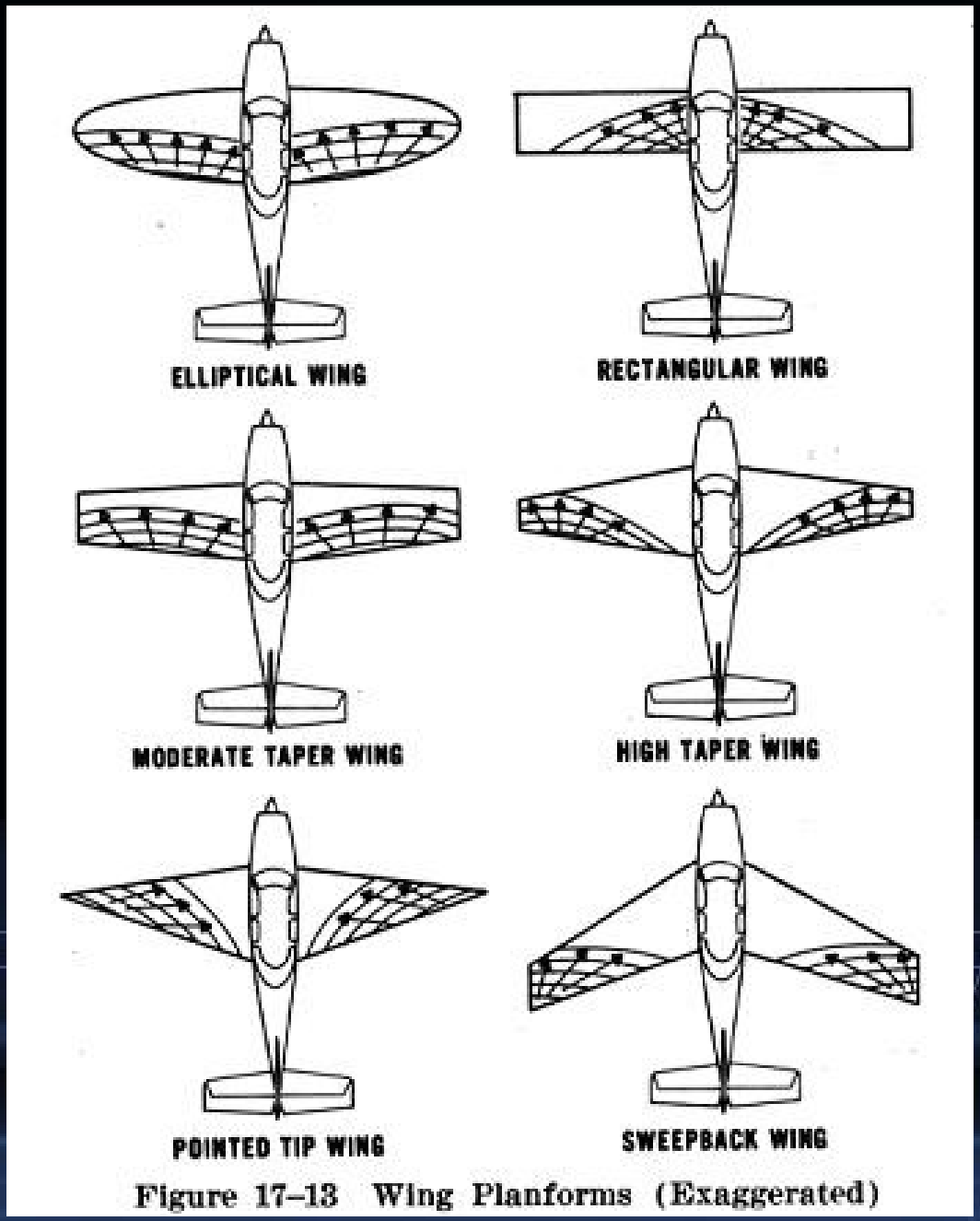
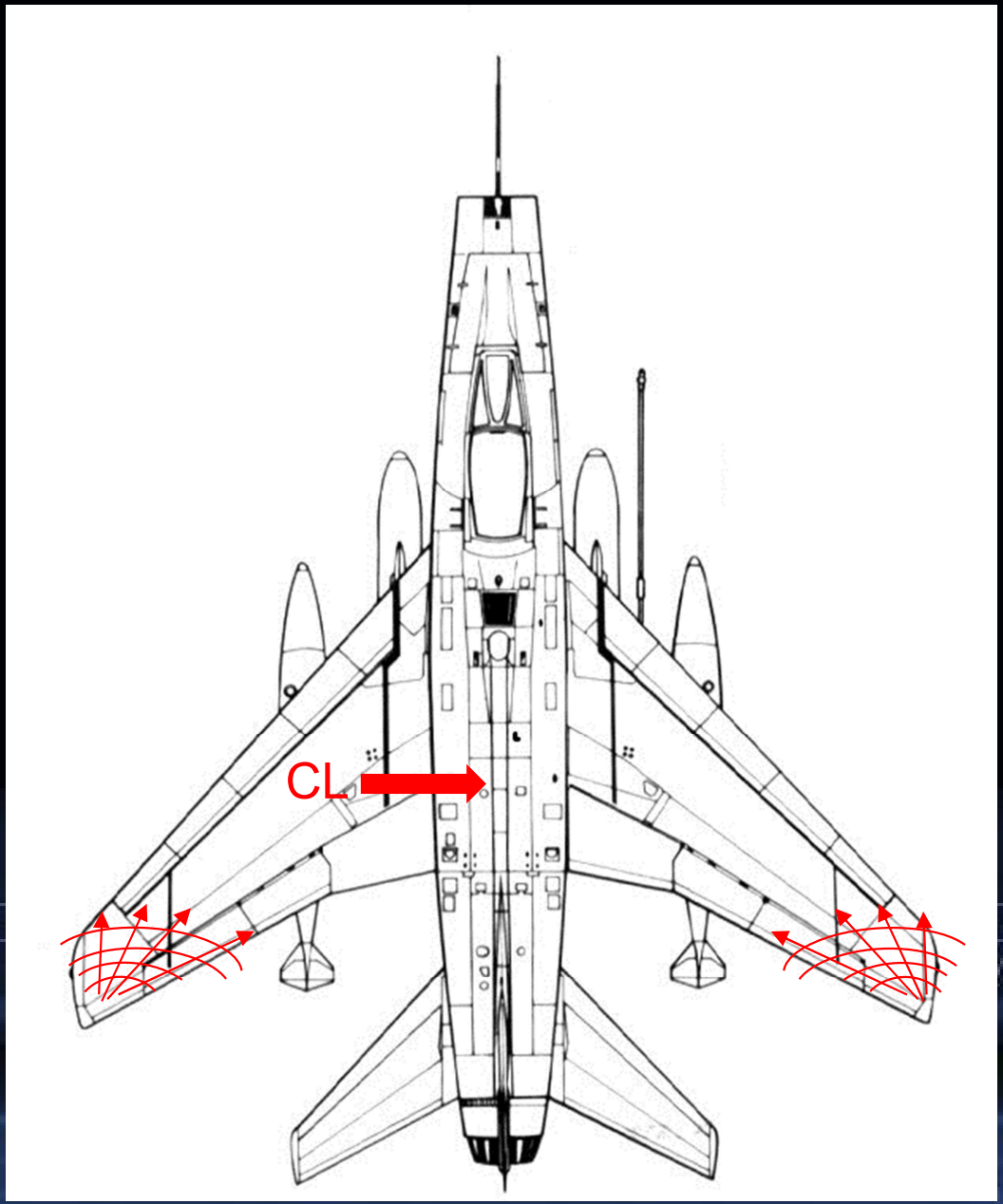


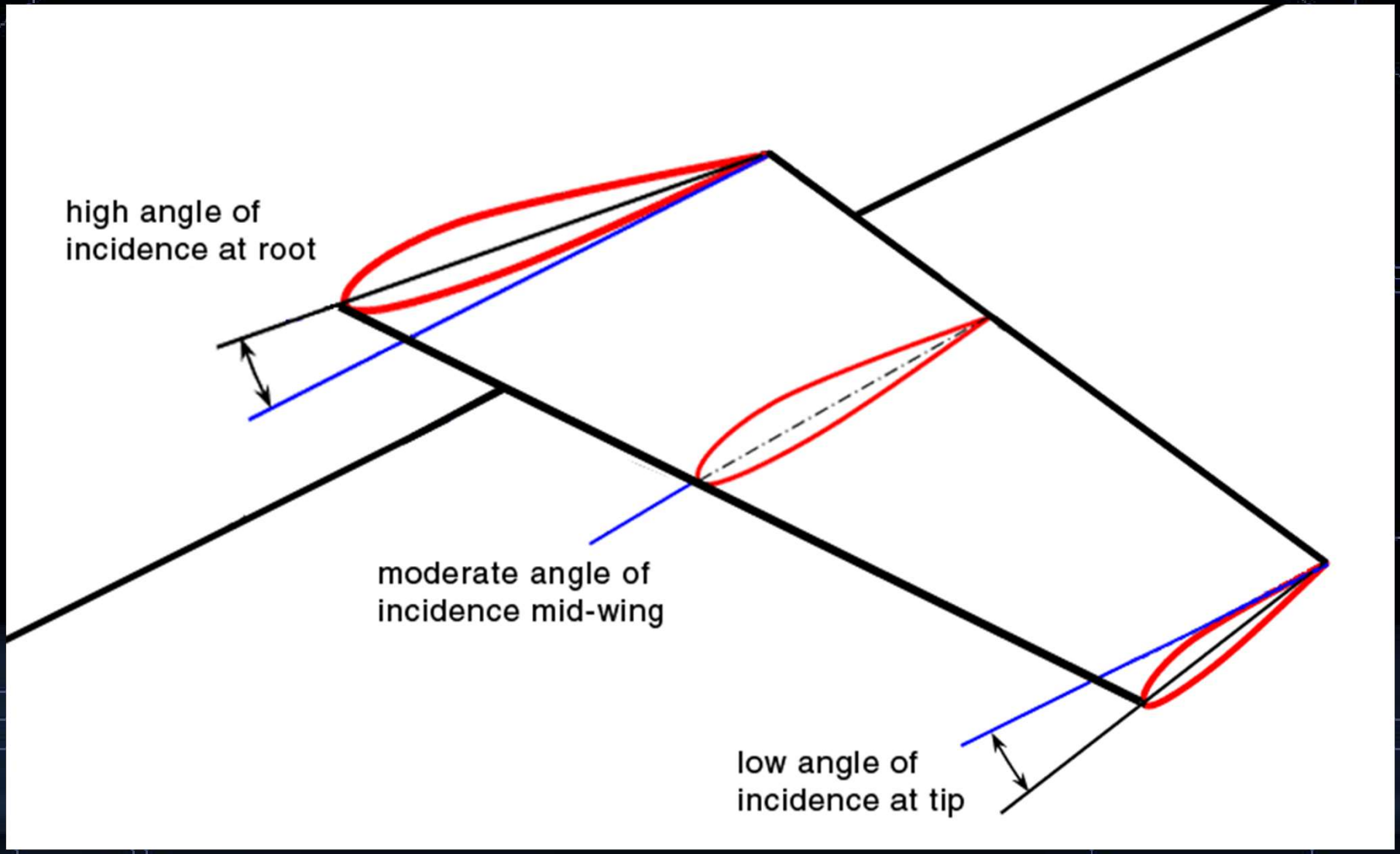
Figure 17–13 Wing Planforms (Exaggerated)

Swept Wing Stalls
A special case

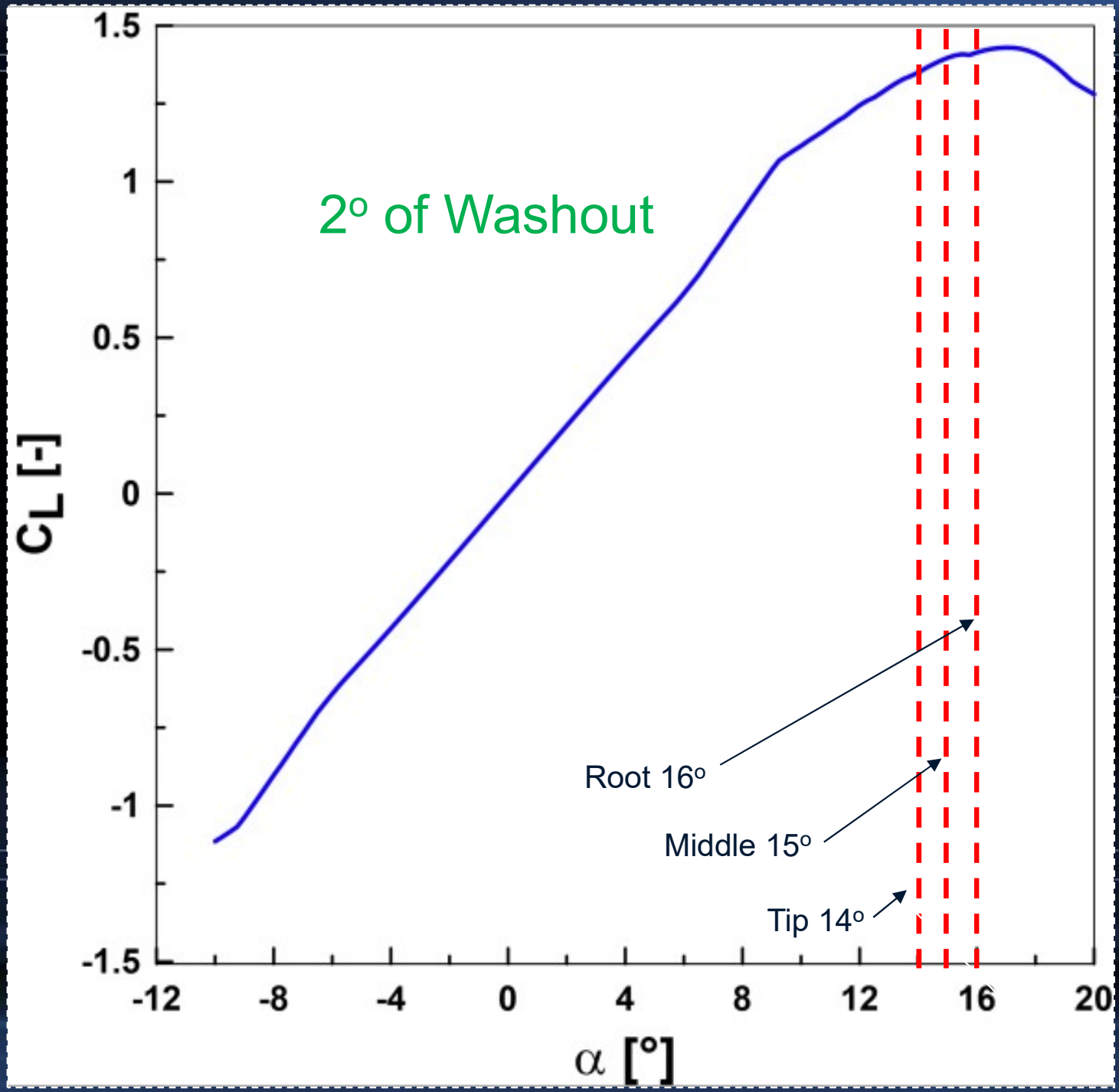


Saber Dance

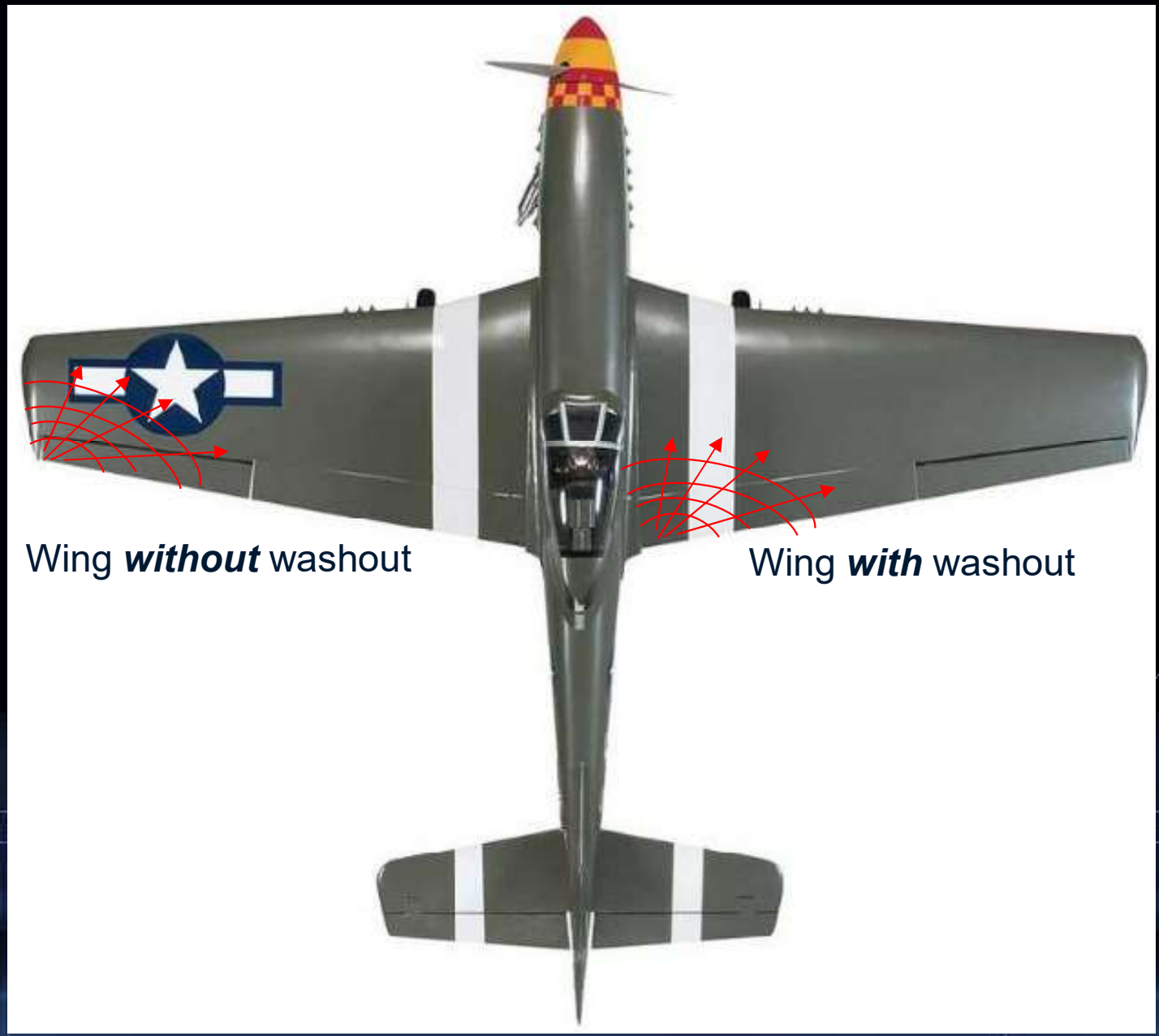
Washout


high angle of
incidence at root
moderate angle of
incidence mid-wing
low angle of
incidence at tip

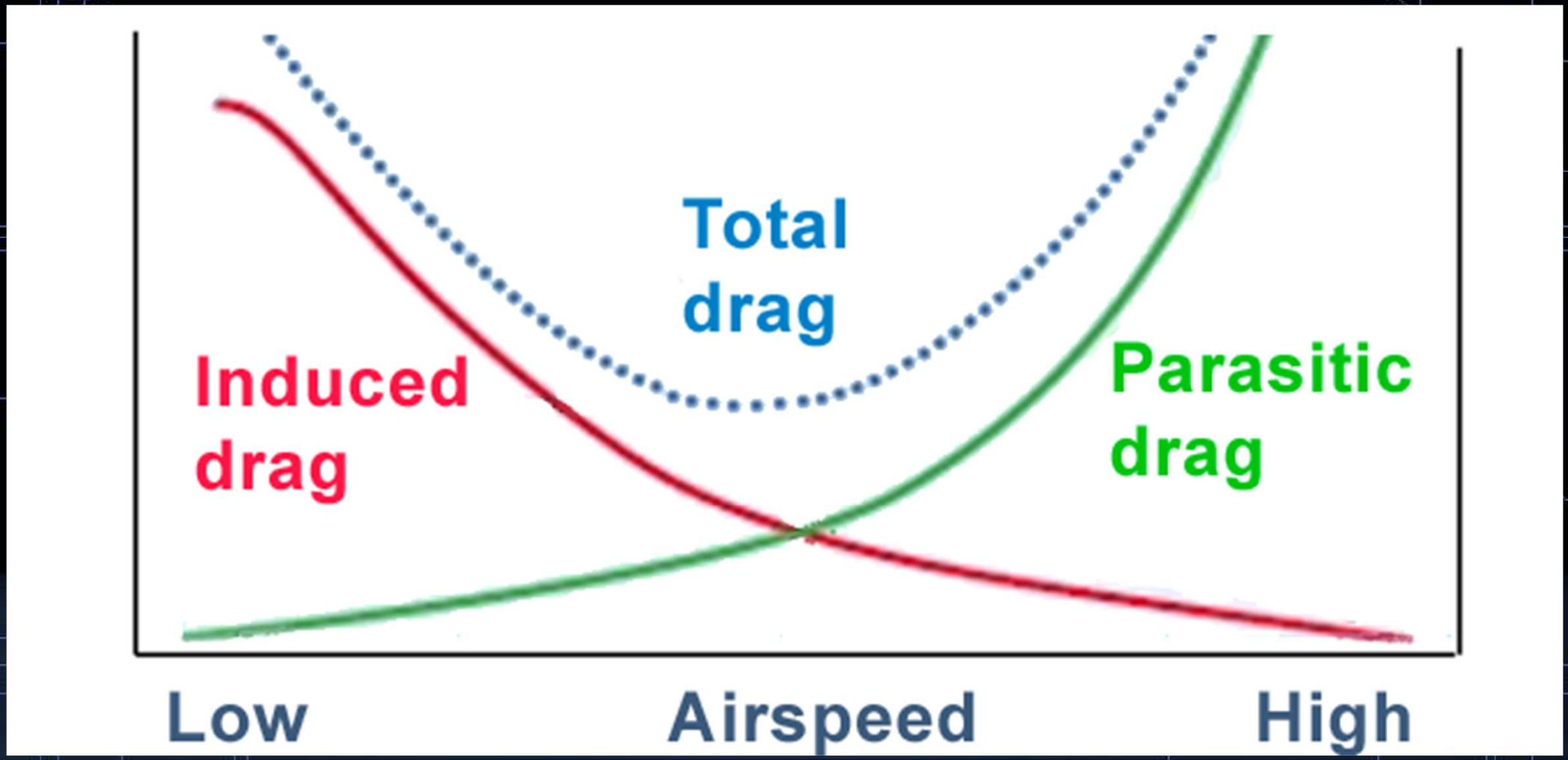
NACA 0015 Lift Curve



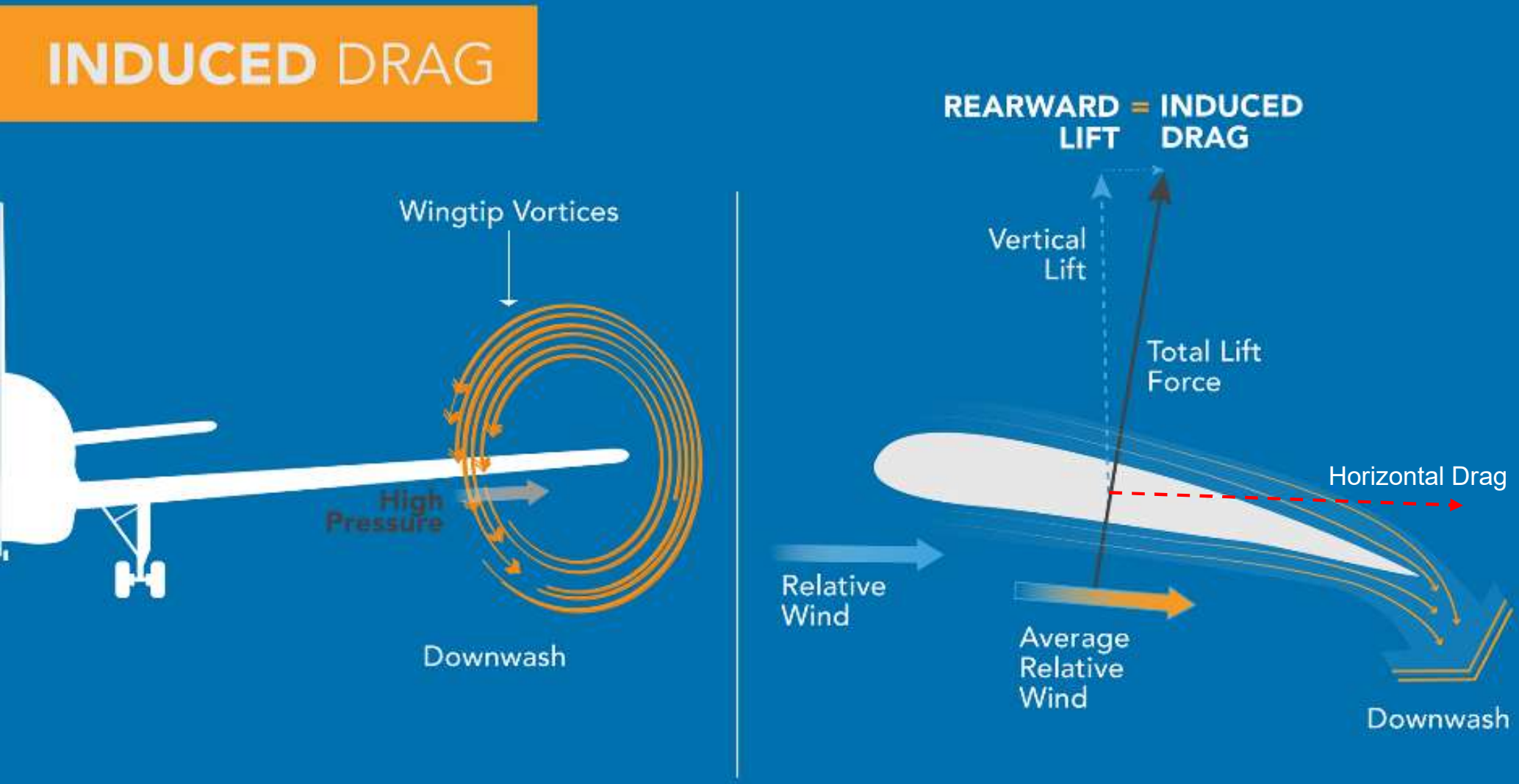
Stalls



DRAG!



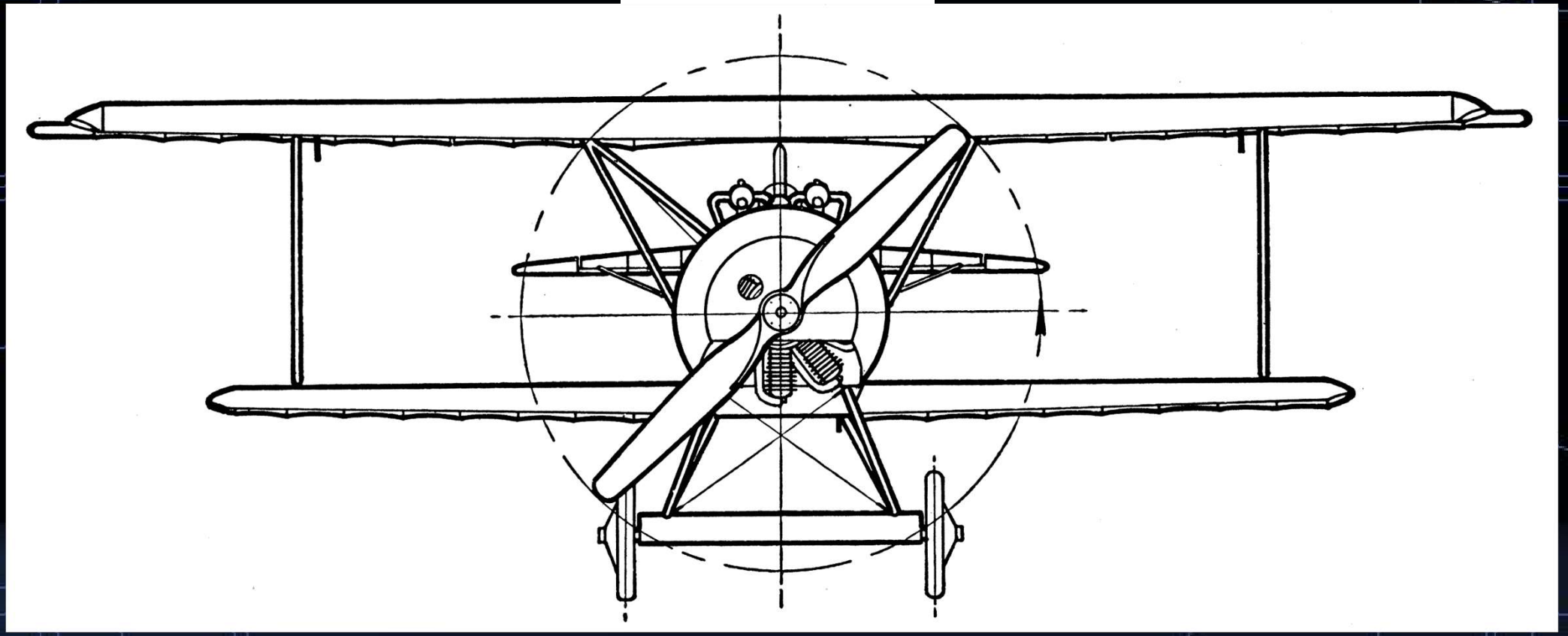
INDUCED DRAG



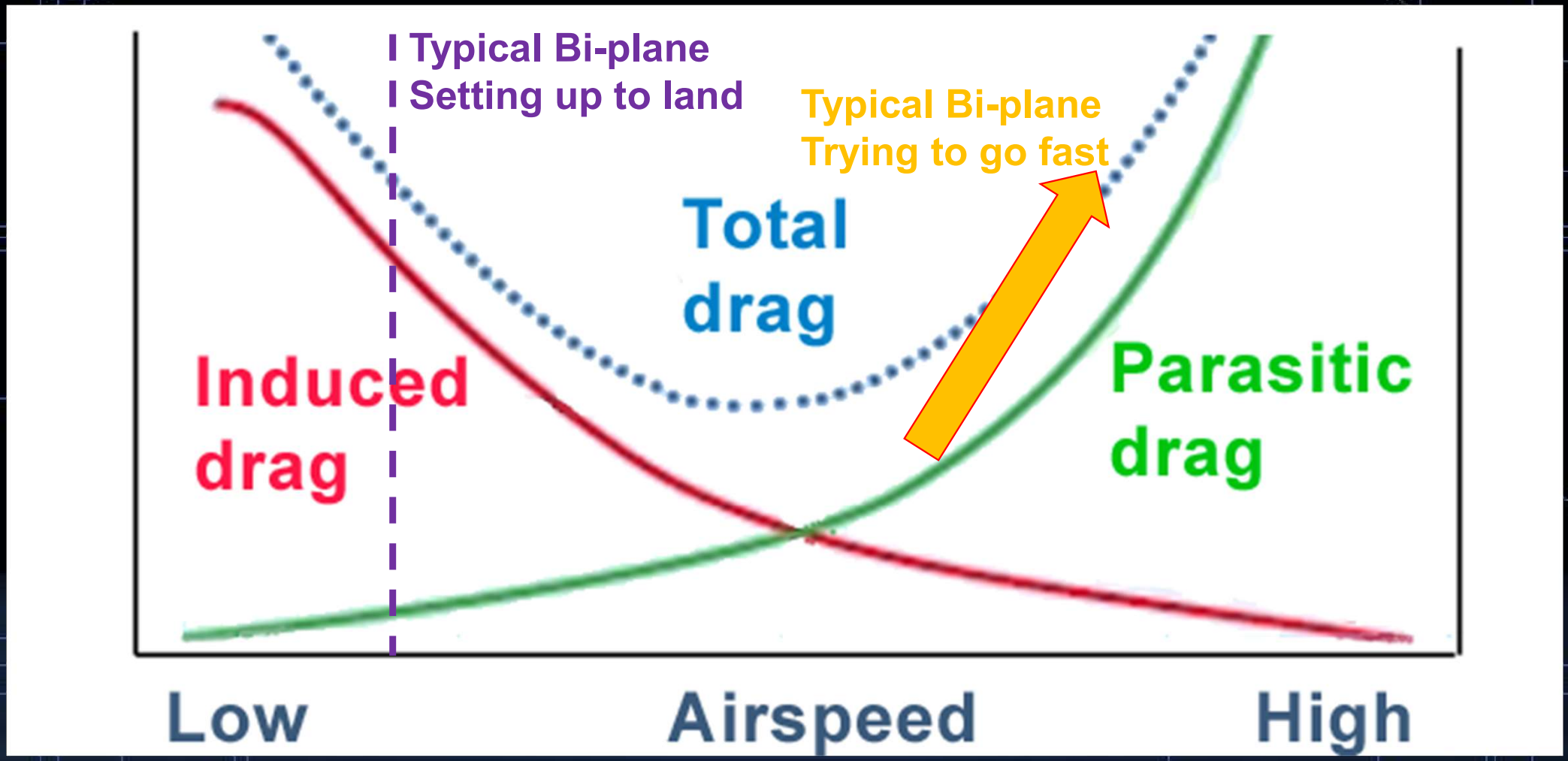
Wingtip Vortex

Drag … An Example

Fokker D VI

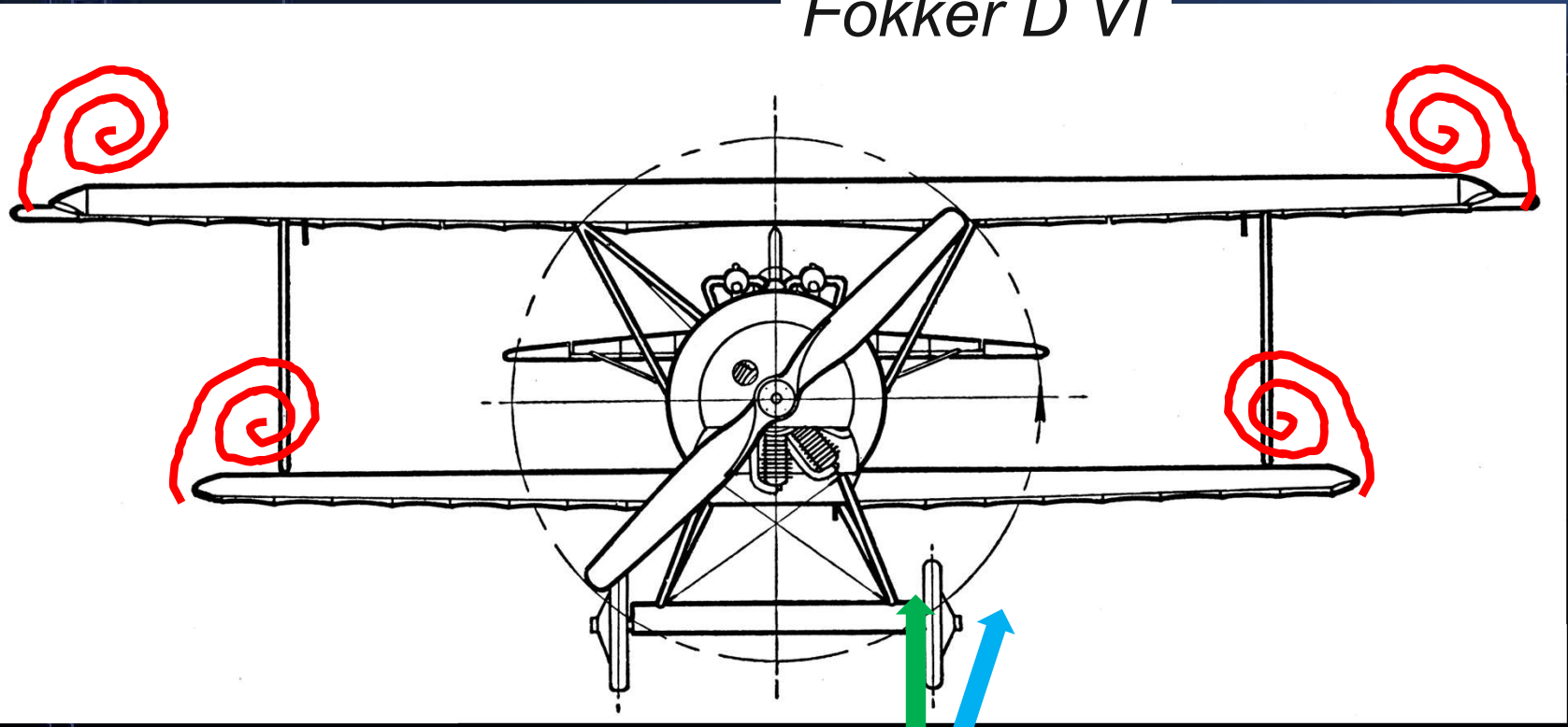


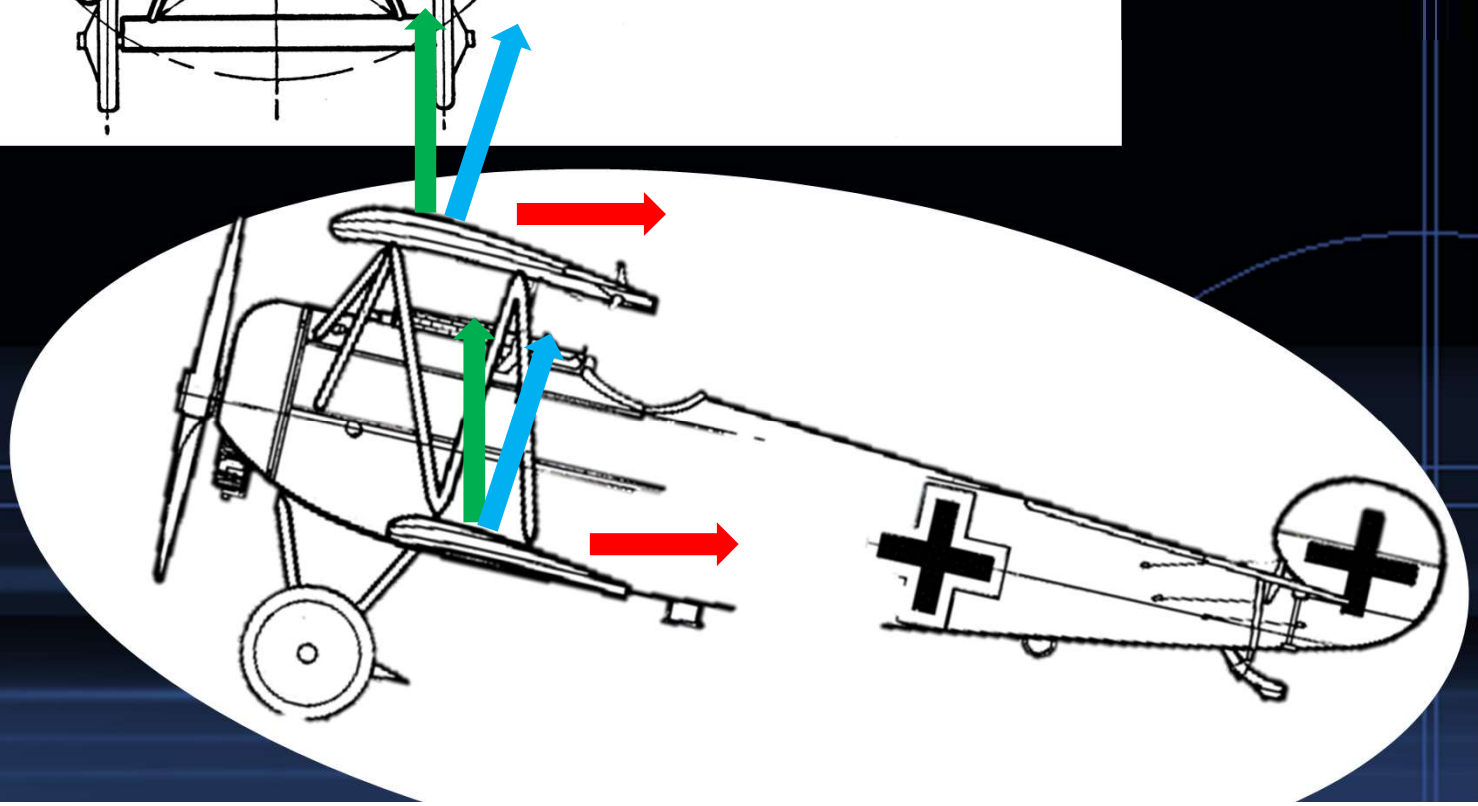
DRAG!


Typical Bi-plane
Setting up to land
Typical Bi-plane
Trying to go fast
Total
drag
Induced
drag
Parasitic
drag
Low
Airspeed
High

Drag ... An Example

Fokker D VI





Questions?

Next Month

Base topic: Stability / Instability

Other Possible Topics …

1. Estimating aircraft speeds (takeoff, cruise, landing)
2. Multi-engine dynamics
3. Something else?
4. Speed, flaps, stab sizing