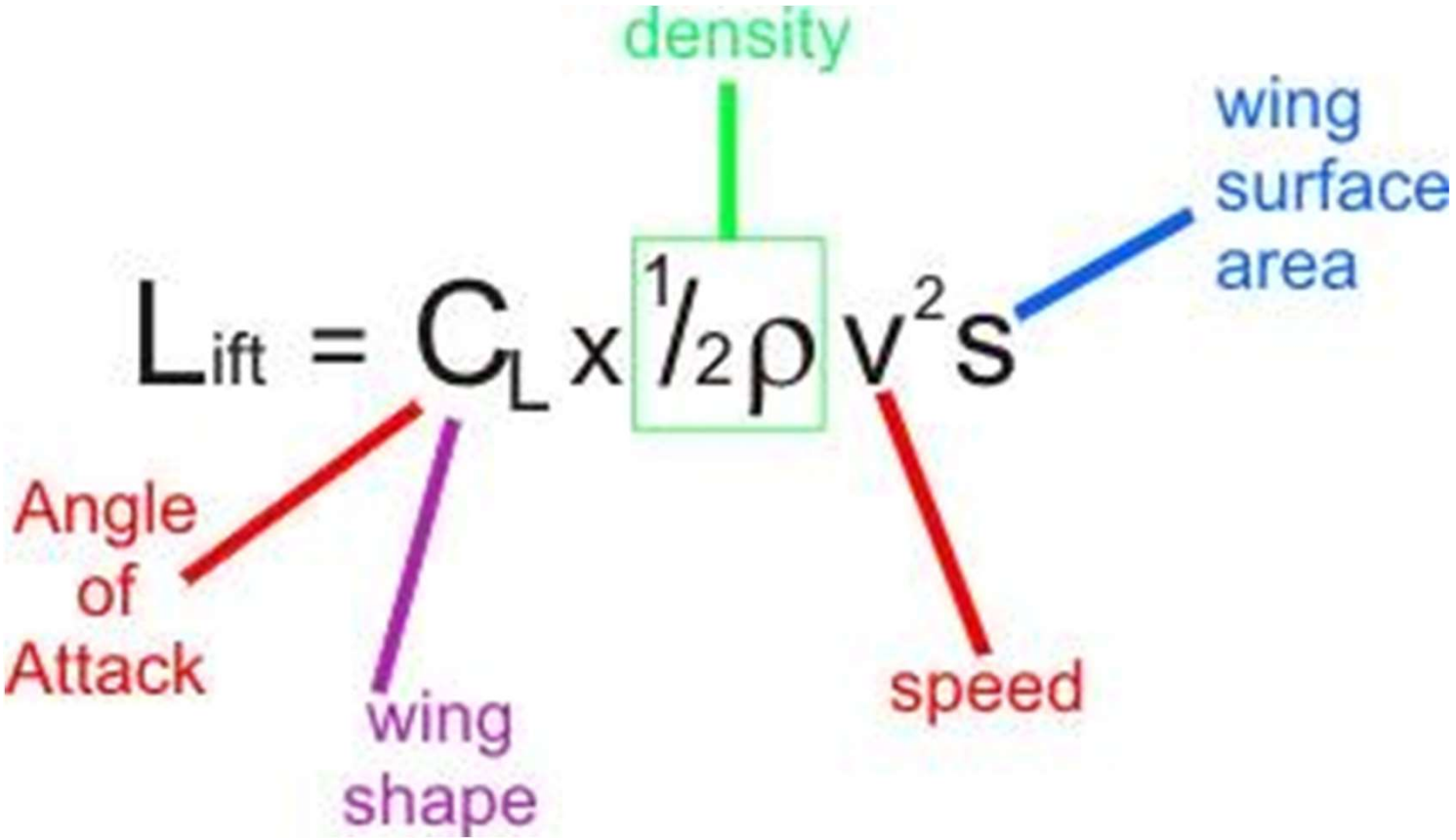
Unmanned Airplane Design

An overview of Designing and Constraints

The Lift Equation



The Drag Equation

Glenn Research Center

$$D = Cd \times r \times \frac{V^2}{2} \times A$$

Drag = coefficient x density x $\frac{\text{velocity squared}}{\text{two}}$ x reference area

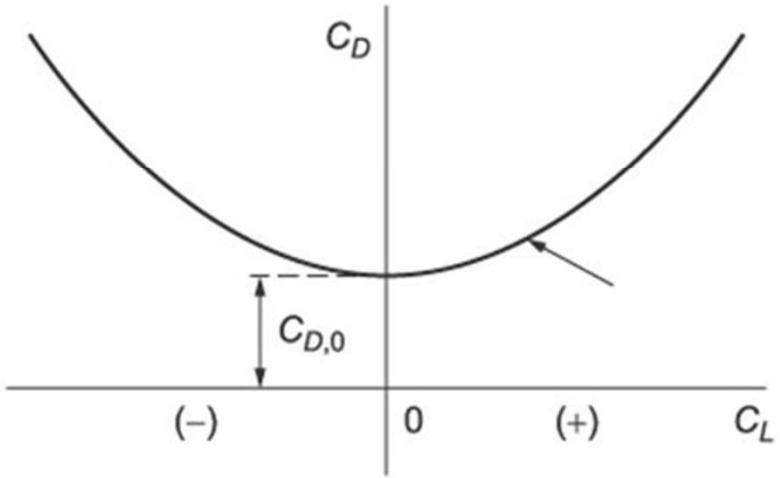
Coefficient **Cd** contains all the complex dependencies and is usually determined experimentally.

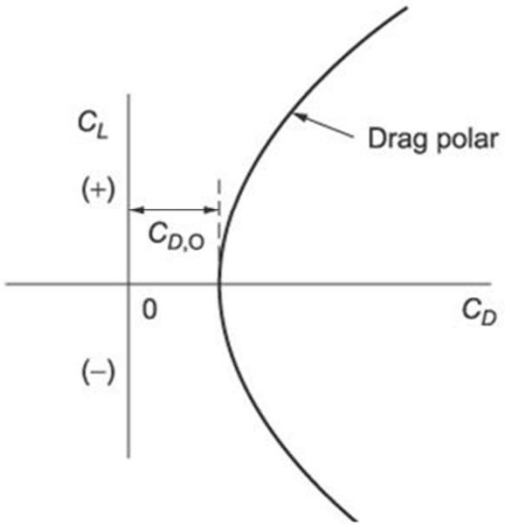
Choice of reference area **A** affects the value of **Cd**.

DRAG POLAR

- $C_{D,0}$ is parasite drag coefficient at zero lift (α_L=0)
- $C_{D,i}$ drag coefficient due to lift (induced drag)
- Oswald efficiency factor, e, includes all effects from airplane
- $C_{D,0}$ and e are known aerodynamics quantities of airplane

$$C_D = C_{D,0} + \frac{C_L^2}{\pi e AR} = C_{D,0} + C_{D,i}$$





Example of Drag Polar for complete airplane

Coefficient of lift	α
0.3	-2
0.45	0
0.54	1
0.62	2
0.79	4
0.96	6
1.12	8
1.28	10
1.33	12
1.20	15

Find:

- Maximum rate of climb, velocity for maximum rate of climb and corresponding angle of attack.
- Angle of attack during cruise for which aerodynamic efficiency is maximum.
- Minimum turn radius and its corresponding velocity and angle of attack.
- Maximum turn rate and its respective velocity and angle of attack.
- Minimum glide angle and respective velocity and angle of attack.
- Minimum sink rate and velocity and angle of attack to maintain that sink rate.