Aerodynamic Characteristics

General Form of Drag Polar

$$C_D = C_{D_0} + k\left|C_L\right|^n$$

Lift-to-Drag Ratio

$$E = \frac{L}{D} = \frac{C_L}{C_D} = \frac{C_L}{C_{D_0} + kC_L^n}$$

Maximum Lift-to-Drag Ratio

$$E^* = \frac{dE}{dC_L} = \frac{\left(C_{D_0} + kC_L^n\right) - C_L\left(nkC_L^{n-1}\right)}{\left(C_{D_0} + kC_L^n\right)^2} = 0$$

$$C_L^* = \sqrt[n]{\frac{C_{D_0}}{k\left(n-1\right)}}$$

$$C_D^* = \frac{nC_{D_0}}{\left(n-1\right)}$$

In general,

$$E^* = \frac{C_L^*}{C_D^*} = \frac{\sqrt[n]{\left(n-1\right)^{n-1}}}{n\sqrt[n]{kC_{D_0}^{n-1}}}$$

For a parabolic drag polar $\left(n = 2\right)$,

$$C_D = C_{D_0} + kC_L^2$$

where

C_D = drag coefficient

C_{D_0} = drag coefficient at 0° angle-of-attack

C_L = lift coefficient

k = constant

and

$$C_D^* = 2C_{D_0} = \text{ drag coefficient at maximum L/D}$$

$$C_L^* = \sqrt{C_{D_0}/k} = \text{ lift coefficient at maximum L/D}$$

$$E^* = \left(\frac{C_L}{C_D}\right)_{\max} = \frac{1}{2\sqrt{kC_{D_0}}} = \text{ maximum L/D}$$