

# Aircraft Sizing Algorithm Documentation

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# 1 Rationale

We need to determine 2 very important things:

1. The thrust to weight ratio affects:
  - acceleration:
  - climb rate:
  - maximum speed:
  - turn rate:
  - Aircraft Endurance:
2. The stall speed is directly determined by the wing loading and the maximum lift coefficient. Wing Loading will affect:
  - stall speed
  - induced drag
  - take-off distance

## 2 Sizing Methodology

1. First Method:
  - (a) Firstly use the stall speed to determine wing loading Stall speed should be independent of engine size
  - (b) After figuring out wing loading, determine the thrust to weight ratio based on takeoff distance  
Rate of climb
2. Second Alternative Method:
  - (a) Determine the Thrust to Weight Ratio
  - (b) Determine the wing loading by direct computation

## 3 Common Definitions

$q$  is the dynamic pressure of an aircraft flying. It is defined as

$$q = \frac{1}{2}\rho v^2$$

wherein  $\rho$  represents the density of the air,  $v$  represents the velocity the aircraft is flying at.

## 4 Stall Speed Constraint

Wing loading is basically the weight of the aircraft divided by the total wing area.

$$L_{wi} = \frac{W}{S} = \frac{1}{2}\rho v_{stall}^2 c_{L,max}$$

Our typical would be around  $c_{L,max} \approx 1.2 \rightarrow 1.5$ , Sweep only reduces your maximum coefficient of lift.

## 5 Climb Rate Constraint

The climb rate  $G$  is defined as the ratio between vertical and horizontal distance travelled when the aircraft is climbing  $D$  is going to represent drag.

$$\frac{D}{W} = \frac{T}{W} - G \quad (1)$$

There is also another relation for drag to weight ratio,

$$\frac{D}{W} = \frac{qc_{D,0}}{L_{wi}} + L_{wi} \frac{1}{q\pi A_r e} \quad (2)$$

wherein  $A_r$  is the aspect ratio of the wings, and  $e$  represents the efficiency factor due to deviating from the elliptic lift distribution. Substituting equation 1 into equation 2 and solving for  $\frac{T}{W}$ ,

$$\frac{D}{W} = \frac{T}{W} - G = \frac{qc_{D,0}}{L_{wi}} + L_{wi} \frac{1}{q\pi A_r e}$$

$$\frac{T}{W} = \frac{qc_{D,0}}{L_{wi}} + L_{wi} \frac{1}{q\pi A_r e} + G$$

## 6 Estimation of Motor Power Rating

The equation below was found in page 118,

$$\frac{T}{W} = \left( \frac{\eta_p}{V} \right) \left( \frac{P}{W} \right)$$

wherein  $\eta_p$  represents the propeller efficiency,  $P$  represents power of the engines,  $W$  represents the weight of the aircraft,  $V$  represents the true air speed of the aircraft.

## 7 Textual References

1. Page 117 has table for thrust to weight of typical aircrafts.
2. Page 119 has a table for power to weight ratio of typical aircrafts.
3. Page 124 has a tabel for typical wing loadings.
4. Page 126 has description on typical  $c_{L,max}$  values.