

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 ρ 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.
The `Matlab` implementation is shown below,

```
%This Matlab script is used to compute the wing loading using the stall speed of the aircraft.
%We are getting the stall speed from the Requirements for the aircraft
L_wi = 1/2*rho*(v_stall^2)*c_Lmax
```

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 $\frac{T}{W}$,

$$\begin{aligned} \frac{D}{W} = \frac{T}{W} - G &= \frac{qC_{D,0}}{L_{wi}} + L_{wi} \frac{1}{q\pi A_r e} \\ \frac{T}{W} &= \frac{qC_{D,0}}{L_{wi}} + L_{wi} \frac{1}{q\pi A_r e} + G \end{aligned}$$

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 η_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.