Aircraft Sizing Algorithm Documentation

Team 7:
Cooper LeComp, John A. Papas Dennerline,
Ian Greene, Christos Levy, Daniel Qi, Hans Suganda

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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 implementation

5 Climb Rate Constraint

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

$$\frac{D}{W} = \frac{T}{W} - G \tag{1}$$

There is also another relation for drag to weight ratio,

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

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 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.