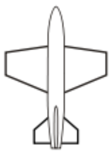
Lifting Surface Aspect Ratio (AR)

In selecting the lifting surface aspect ratio the designer must give considerations to several general requirements. These requirements are related to:

1. Aerodynamics
2. Structural weight
3. Safety

Introduction

When a wing is generating lift, the pressure on the upper surface is reduced and the pressure on the lower surface is increased. This pressure difference tends to move the air from the bottom of the wing, moving to the top. This is not possible for a 2D-flow (airfoil profile) but for a real 3D-flow (3D-wing) the air can escape around the wing tip. The air escaping around the wing tip lowers the pressure difference between the upper and lower surfaces. This reduces lift near the wing tip and generates vortices. A wing with a high aspect ratio has smaller tips, less sensitive, than a wing of equal area with a low aspect ratio.


Low aspect ratio


Moderate aspect ratio


High aspect ratio

Aerodynamics

AR as high as possible (➚) to reduce the induced drag.

Flight conditions concerned: climb, maxi range and maxi endurance

$$C_D = C_{D_0} + \frac{C_L^2}{\pi \cdot AR_w \cdot e}$$

Structural weight

AR as low as possible (➘) to reduce the structural weight of the lifting surface

$$W_w = fct\left(AR_w^{0,6}\right)$$

Δ(AR)	ΔW_w
-20%	-12.5%
-10%	-6.1%
10%	5.9%
20%	11.6%

Safety

AR changes modify the stalling angle. Surface with low aspect ratio will stall at a higher angle of attack than surface with high aspect ratio

<u>A canard surface</u> (➚) can be made to stall before the main wing by making it a very high aspect ratio surface.

<u>Horizontal tails</u> (➘) tend to be of lower aspect ratio.

References

Aircraft Design: A Conceptual Approach, Third Edition, Daniel P.Raymer
Synthesis of Subsonic Airplane Design, E.Torenbeek
Wikipedia. http://en.wikipedia.org/wiki/Wing_configuration

