Ex: What vertical stab size is necessary for $C_{n\beta} = 0.2$ 1/rad for the following aircraft

Assume.

Vertical $AR_{eff} \approx 4$

$b = 33.5$ ft

$l_f = 27.5$ ft

$S_w = 177$ ft^2

$V_\infty = 300$ ft/s

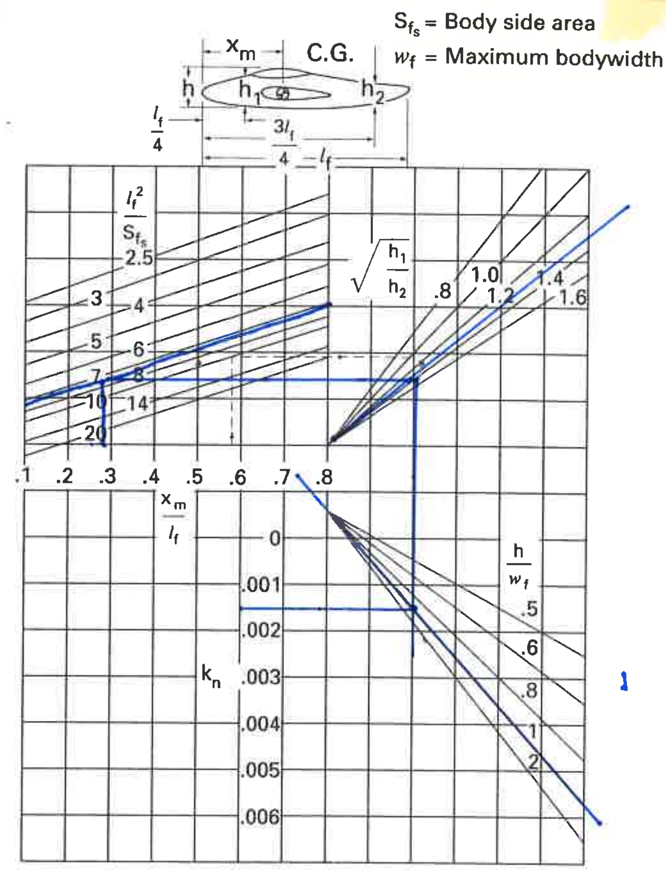


FIGURE 2.29
Wing body interference factor.

92 units = 27.5 ft $\Rightarrow$ 0.3 ft/unit

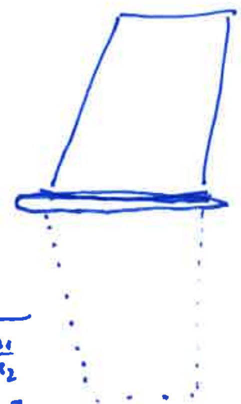
$\frac{dC_N}{d\beta}$ ↙

$C_{n_\beta} > 0$ $\qquad$ $C_{n_\beta} = C_{n_{\beta_v}} + C_{n_{\beta_{wf}}}$

$$0.2 = \eta V_v C_{L_\alpha}\left(1 + \frac{d\sigma}{d\beta}\right) + -K_n K_{RL}\frac{S_{fs}\, l_f}{S_w b}$$

($\eta \to 1$, $\frac{d\sigma}{d\beta} \to 0$; $V_v = \frac{l_v S_v}{S b}$)

$l_v \approx 57$ units $=$ 17 ft

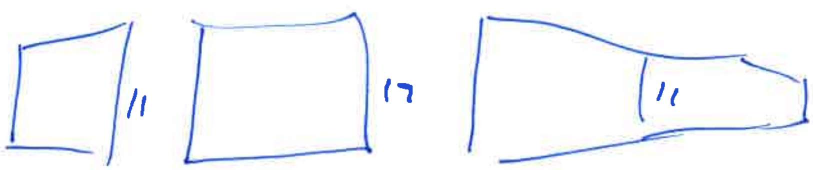


$$C_{L_\alpha} \approx \frac{2\pi}{1 + \frac{2\pi}{\pi AR}} < \frac{2\pi}{1 + \frac{2\pi}{\pi 4}} = 4.2\ 1/\text{rad}$$

$h_1 \approx 17$ units $= 5$ ft

$h_2 = 10$ units $= 3$ ft $\qquad \sqrt{\frac{h_1}{h_2}} \approx 1.3$

$h_{max} \approx 19$u $= 5.7$ ft



13 $\qquad$ 23 $\qquad$ 52

143

12.8 ft² $\qquad$ 39 ft² $\qquad$ 52 ft² $\qquad = 104$ ft²

$x_m \approx 26$ units $= 7.8$ ft $\approx \frac{x_m}{l_f} \approx 0.28$

$K_n \approx 0.0015$

$Re \approx 6350 \cdot 300\ \text{ft/s} \cdot 27.5 \approx 52$ million

$K_{RL} = 1.7$

$$0.2 = \frac{l_v S_v}{S\ b} C_{L_\alpha} - K_n K_{RL} \frac{S_{F_S}\ l_F}{S_w\ b}$$

$$0.2\left[\tfrac{1}{rad}\right] = \frac{17^{ft}\ |\ S_v\ [ft^2]}{177^{ft^2}\ |\ 33.5^{ft}} 4.2\ \tfrac{1}{rad} - 0.0015 \cdot 1.7 \cdot \frac{104^{ft^2} \cdot 27.5^{ft}}{177^{ft^2} \cdot 33.5^{ft}}$$

Solve for S_v

$$S_v = \frac{177\ |\ 33.5\ |\ \ |}{\ \ |\ \ |\ 4.2\ |\ 17} \cdot \left(0.2 + \frac{0.0015 \cdot 1.7 \cdot 104 \cdot 27.5}{177 \cdot 33.5}\right)$$

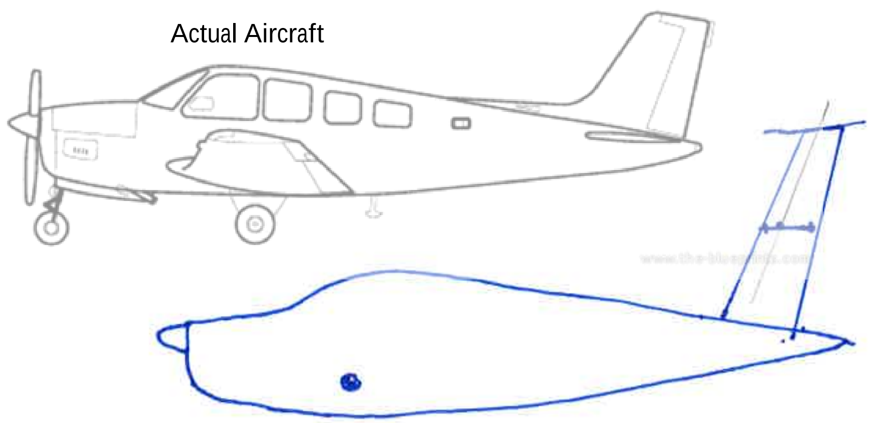
$$= 16.7\ ft^2$$

pick $AR = 4 = \frac{b^2}{S}$ $\Rightarrow b = \sqrt{4 \cdot 16.7} = 8.2^{ft}$

$\bar{c} = 2^{ft}$

pick $\lambda \approx 0.5$

and $\Lambda_{1/4} \approx 30°$

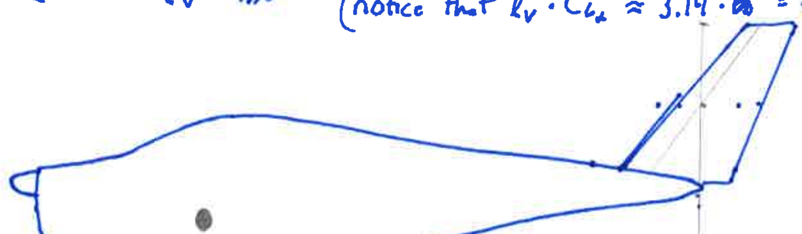


This looks bad.....

$AR \approx 4$ was a poor choice

- next iteration, pick $AR \approx 3$
- " " shift $l_v > 17^{ft}$

Redo with $AR = 2$ and $l_v = ~~18~~\ 20\ ft$ (notice that $l_v \cdot C_{L_\alpha} \approx 3.14 \cdot 20 = 62$ vs $4.2 \cdot 17 = 71$)



← I like this shape better than above.

Cla is likely larger b/c endplate effect

$$S_v = \frac{177\ |\ 33.5\ |\ \ |}{\ \ |\ \ |\ 3.14\ |\ 18} \cdot \left(0.2 + \frac{0.0015 \cdot 1.7 \cdot 104 \cdot 27.5}{177 \cdot 33.5}\right) = 21.1\ ft^2$$

$b = \sqrt{2 \cdot S} = 6.5^{ft}$ $\quad \bar{c} = 3.25^{ft}$ $\Rightarrow C_r = \frac{2\bar{c}}{1+\lambda} = \frac{2 \cdot 3.25}{1+.5} = 4.3^{ft}$

Next iteration should reduce AR by even more.