V Speed Determination for RW-11

The following worksheet documents the development of the V-n diagram or design performance envelope for a modified RW-11. The simplified procedure used here is defined in FAR 23 Appendix A

$kts := 1.151mph$ $\quad$ $nm := 1.151mi$ $\quad$ Useful unit definitions

$cor := kts \cdot \sqrt{\frac{ft^2}{lbf}}$ $\quad$ FAR equations neglect to include units in some of their multipliers. This custom unit allows MathCAD to intellegently handle the conversions

$S := 135ft^2$ $\quad$ Gross wing area

$W := 1200lbf$ $\quad$ Gross weight of aircraft

$C_L := 1.38$ $\quad$ Maximum wing lift coefficient

$n_1 := 3.8$ $\quad$ Normal category positive load factor

$n_2 := \frac{-n_1}{2}$

$n_3 := n_1$

$n_4 := \frac{-n_3}{2}$

$\rho := 1.2\frac{kg}{m^3}$ $\quad$ $\rho = 0.075\frac{lb}{ft^3}$ $\quad$ Density of air

$V_a := 15 \cdot \sqrt{\frac{n_1 \cdot W}{S}} \cdot cor$ $\quad$ $V_a = 87.178\,kts$ $\quad$ FAR A23.3

However, if we already know the maximum lift coefficient of the wing, we can find Va another way

$V_s := \sqrt{\frac{2 \cdot W}{\rho \cdot C_L \cdot S}}$ $\quad$ $V_s = 44.062\,kts$ $\quad$ From the definition of lift coefficient and dynamic pressure, we can rearrange the equation to find the stall speed

$V_a := V_s \cdot \sqrt{n_1}$ $\quad$ $V_a = 85.893\,kts$ $\quad$ FAR 23.335(c)(1)

By substituting the equation for Vs into the equation for Va and rearrangin, we get:

$V_a := \sqrt{\frac{2 \cdot n_1 \cdot W}{\rho \cdot C_L \cdot S}}$

$V_d := 24 \cdot \sqrt{\frac{n_1 \cdot W}{S}}\, cor$ $\quad$ $V_d = 139.485\,kts$ $\quad$ FAR A23.3

$$V_c := 17 \cdot \sqrt{\frac{n_1 \cdot W}{S}} \, cor \qquad V_c = 98.802\,kts \qquad \text{FAR A23.3}$$

$$V_f := 11 \cdot \sqrt{\frac{n_1 \cdot W}{S}} \, cor \qquad V_f = 63.931\,kts \qquad \text{FAR A23.3}$$

The following is simply set up so MathCAD can produce the V-n diagram from the information above.

$$Vn := \begin{pmatrix} 0 & 0 & 0 \\ \frac{V_s}{kts} & 1 & -0.5 \\ \frac{V_a}{kts} & n_1 & n_2 \\ \frac{V_c}{kts} & n_3 & n_4 \\ \frac{V_d}{kts} & n_1 & n_2 \end{pmatrix} \quad curve1 := \begin{pmatrix} 0 \\ 3 \\ 0 \\ 0 \\ 1.545 \times 10^{-3} \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad curve2 := \begin{pmatrix} 0 \\ 3 \\ 0 \\ 0 \\ -7.726 \times 10^{-4} \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

$$v1 := 0, 1 .. \frac{V_a}{kts} \qquad v2 := \frac{V_a}{kts} .. \frac{V_d}{kts} \qquad v3 := 0 .. \frac{V_f}{kts}$$

$$trace1(v1) := interp\left(curve1, Vn^{\langle 0 \rangle}, Vn^{\langle 1 \rangle}, v1\right) \qquad trace3(v1) := interp\left(curve2, Vn^{\langle 0 \rangle}, Vn^{\langle 2 \rangle}, v1\right)$$

$$trace2(v2) := linterp\left(Vn^{\langle 0 \rangle}, Vn^{\langle 1 \rangle}, v2\right) \qquad trace4(v2) := linterp\left(Vn^{\langle 0 \rangle}, Vn^{\langle 2 \rangle}, v2\right)$$

$$trace5 := \begin{pmatrix} \frac{V_d}{kts} & n_1 \\ \frac{V_d}{kts} & n_2 \end{pmatrix} \qquad trace7 := \begin{pmatrix} \frac{V_f}{kts} & \frac{n_1}{2} \\ \frac{V_f}{kts} & 0 \end{pmatrix}$$

$$Vnf := \begin{pmatrix} 0 & 0 \\ \frac{V_f}{\sqrt{\frac{n_1}{2}} \cdot kts} & 1 \\ \frac{V_f}{kts} & \frac{n_1}{2} \end{pmatrix}$$

$$curve3 := lspline\left(Vnf^{\langle 0 \rangle}, Vnf^{\langle 1 \rangle}\right)$$

$$trace6(v3) := interp\left(curve3, Vnf^{\langle 0 \rangle}, Vnf^{\langle 1 \rangle}, v3\right)$$

The data above produces the V-n diagram shown below. The red trace is the flaps down envelope.