Includi << ..\Default_Functions.mcdx

WING PARAMETERS INITIALIZATION

Hidden Area --> Import of Excel INPUT Wing Data

Hidden Area --> Preliminary Mapping of imported Data and Cranked Wing CHECK

Hidden Area --> Import and preliminary mapping of OTHER Excel Data

Hidden Area --> Calculation of a few Horizontal Tail parameters, needed to compute wing downwash gradient

INPUT WING PARAMETERS LIST

Wing global parameters

$b_W = 27.249\ m$

$i_W = 2\ deg$

$c_{W\_r} = 5.243\ m$

$c_{W\_kink} = 0\ m$

$c_{W\_t} = 1.189\ m$

$t\_over\_c_{W\_r} = 0.11$

$t\_over\_c_{W\_kink} = 0$

$t\_over\_c_{W\_t} = 0.11$

$\alpha_{0l\_W\_r} = -0.047$

$\alpha_{0l\_W\_kink} = 0$

$\alpha_{0l\_W\_t} = -0.047$

$C_{l\alpha\_W\_r} = 6.016$

$C_{l\alpha\_W\_kink} = 0$

$C_{l\alpha\_W\_t} = 6.016$

$C_{m\_ac\_W\_r} = -0.07$

$C_{m\_ac\_W\_kink} = 0$

$C_{m\_ac\_W\_t} = -0.07$

$\xi_{ac\_W\_r} = 0.256$

$\xi_{ac\_W\_kink} = 0$

$\xi_{ac\_W\_t} = 0.251$

$M_{cr\_W\_2D\_r} = 0.65$

$M_{cr\_W\_2D\_kink} = 0$

$M_{cr\_W\_2D\_t} = 0.68$

$\varepsilon_{W\_kink} = 0$

$\varepsilon_{W\_t} = -0.035$

$\eta_{a\_in} = 0.664$

$\eta_{a\_out} = 0.908$

$c_a = 0.792\ m$

$\eta_{flap\_in} = 0.179$

$\eta_{flap\_out} = 0.604$

$c_{flap} = 0.792\ m$

$\Delta\alpha_{0l\_W\_flaps} = 0.035$

Wing, inner panel parameters

$b_{W\_1} = 27.249\ m$ | $c_{W\_r\_1} = 5.243\ m$ | $c_{W\_t\_1} = 1.189\ m$

$t\_over\_c_{W\_r\_1} = 0.11$ | $t\_over\_c_{W\_t\_1} = 0.11$

$\Lambda_{W\_LE\_1} = 28\ deg$ | $\Gamma_{W\_1} = 2.2\ deg$ | $\varepsilon_{W\_t\_1} = -2\ deg$

$\alpha_{0l\_W\_r\_1} = -2.7\ deg$ | $\alpha_{0l\_W\_t\_1} = -2.7\ deg$

$C_{l\alpha\_W\_r\_1} = 0.105\ deg^{-1}$ | $C_{l\alpha\_W\_t\_1} = 0.105\ deg^{-1}$

$C_{m\_ac\_W\_r\_1} = -0.07$ | $C_{m\_ac\_W\_t\_1} = -0.07$

$\xi_{ac\_W\_r\_1} = 0.256$ | $\xi_{ac\_W\_t\_1} = 0.251$ | $\xi_{tmax\_W\_1} = 0.4$

$M_{cr\_W\_2D\_r\_1} = 0.65$ | $M_{cr\_W\_2D\_t\_1} = 0.68$

Wing, outer panel parameters

$b_{W\_2} = 0\ m$ | $c_{W\_r\_2} = 1.189\ m$ | $c_{W\_t\_2} = 1.189\ m$

$t\_over\_c_{W\_r\_2} = 0.11$ | $t\_over\_c_{W\_t\_2} = 0.11$

$\Lambda_{W\_LE\_2} = 0\ deg$ | $\Gamma_{W\_2} = 0\ deg$ | $\varepsilon_{W\_t\_2} = -2\ deg$

$\alpha_{0l\_W\_r\_2} = -2.7\ deg$ | $\alpha_{0l\_W\_t\_2} = -2.7\ deg$

$C_{l\alpha\_W\_r\_2} = 0.105\ deg^{-1}$ | $C_{l\alpha\_W\_t\_2} = 0.105\ deg^{-1}$

$C_{m\_ac\_W\_r\_2} = -0.07$ | $C_{m\_ac\_W\_t\_2} = -0.07$

$\xi_{ac\_W\_r\_2} = 0.251$ | $\xi_{ac\_W\_t\_2} = 0.251$ | $\xi_{tmax\_W\_2} = 0$

$M_{cr\_W\_2D\_r\_2} = 0.68$ | $M_{cr\_W\_2D\_t\_2} = 0.68$

Imported parameters

$M_1 = 0.696$ | $b_H = 11.217\ m$ | $\Delta X\_W_{LE}\_Nose = 11.125\ m$

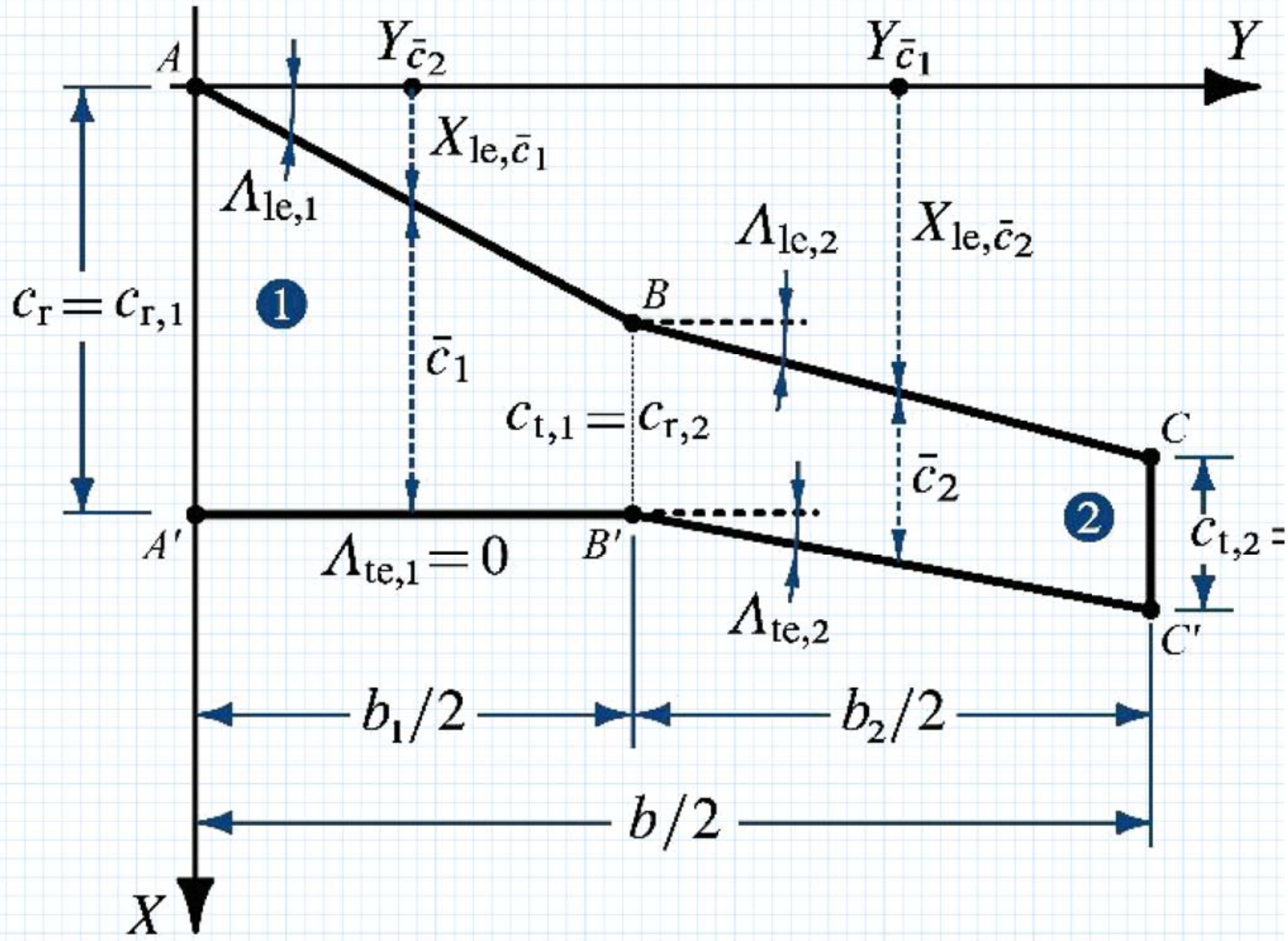
$\Lambda_{H\_LE} = 35\ deg$ | $\Delta X\_HT_{LE}\_Nose = 27.859\ m$

$\Gamma_H = 0\ deg$ | $\Delta Z\_W_{LE}\_Nose = -0.945\ m$

$c_{H\_r} = 3.322\ m$ | $\Delta Z\_HT_{LE}\_Nose = 6.096\ m$

$c_{H\_t} = 1.219\ m$

WING PARAMETERS CALCULATIONS



Wing, inner panel basic parameters

$\lambda_{W\_1} := \dfrac{c_{W\_t\_1}}{c_{W\_r\_1}} = 0.227$ $\qquad \lambda_{W\_1} = 0.227$

$S_{W\_1} := \dfrac{b_{W\_1}}{2} \cdot c_{W\_r\_1} \cdot (1 + \lambda_{W\_1}) = 87.623\ m^2$ $\qquad S_{W\_1} = 87.623\ m^2$

$AR_{W\_1} := \dfrac{b_{W\_1}^{\ 2}}{S_{W\_1}} = 8.474$ $\qquad AR_{W\_1} = 8.474$

$MAC_{W\_1} := \dfrac{2}{3} \cdot c_{W\_r\_1} \cdot \left(\dfrac{1 + \lambda_{W\_1}^{\ 2} + \lambda_{W\_1}}{1 + \lambda_{W\_1}} \right) = 3.642\ m$ $\qquad MAC_{W\_1} = 3.642\ m$

$X_{MAC\_LE\_W\_1} := \dfrac{b_{W\_1}}{6} \cdot \dfrac{(1 + 2 \cdot \lambda_{W\_1})}{(1 + \lambda_{W\_1})} \cdot \tan(\Lambda_{W\_LE\_1}) = 2.861\ m$ $\qquad X_{MAC\_LE\_W\_1} = 2.861\ m$

$Y_{MAC\_W\_1} := \dfrac{b_{W\_1}}{6} \cdot \dfrac{1 + 2 \cdot \lambda_{W\_1}}{1 + \lambda_{W\_1}} = 5.381\ m$ $\qquad Y_{MAC\_W\_1} = 5.381\ m$

$Z_{MAC\_W\_1} := Y_{MAC\_W\_1} \cdot \tan(\Gamma_{W\_1}) = 0.207\ m$ $\qquad Z_{MAC\_W\_1} = 0.207\ m$

Wing, outer panel basic parameters

$$\lambda_{W\_2} := \frac{c_{W\_t\_2}}{c_{W\_r\_2}} = 1$$ $\lambda_{W\_2} = 1$

$$S_{W\_2} := \frac{b_{W\_2}}{2} \cdot c_{W\_r\_2} \cdot \left(1 + \lambda_{W\_2}\right) = 0 \ \mathbf{m}^2$$ $S_{W\_2} = 0 \ \mathbf{m}^2$

$$AR_{W\_2} := \frac{2 \cdot b_{W\_2}}{c_{W\_r\_2} \cdot \left(1 + \lambda_{W\_2}\right)} = 0$$ $AR_{W\_2} = 0$

$$MAC_{W\_2} := \frac{2}{3} \cdot c_{W\_r\_2} \cdot \left(\frac{1 + \lambda_{W\_2}^{\ 2} + \lambda_{W\_2}}{1 + \lambda_{W\_2}}\right) = 1.189 \ \mathbf{m}$$ $MAC_{W\_2} = 1.189 \ \mathbf{m}$

$$X_{MAC\_LE\_W\_2} := \frac{b_{W\_2}}{6} \cdot \frac{\left(1 + 2 \cdot \lambda_{W\_2}\right)}{\left(1 + \lambda_{W\_2}\right)} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 0 \ \mathbf{m}$$ $X_{MAC\_LE\_W\_2} = 0 \ \mathbf{m}$

$$Y_{MAC\_W\_2} := \left(\frac{b_{W\_2}}{6} \cdot \frac{1 + 2 \cdot \lambda_{W\_2}}{1 + \lambda_{W\_2}}\right) = 0 \ \mathbf{m}$$ $Y_{MAC\_W\_2} = 0 \ \mathbf{m}$

$$Z_{MAC\_W\_2} := Y_{MAC\_W\_2} \cdot \tan\left(\Gamma_{W\_2}\right) = 0 \ \mathbf{m}$$ $Z_{MAC\_W\_2} = 0 \ \mathbf{m}$

Wing, global basic parameters

$$\lambda_{W} := \frac{c_{W\_t}}{c_{W\_r}} = 0.227$$ $\lambda_{W} = 0.227$

$$S_{W} := S_{W\_1} + S_{W\_2} = 87.623 \ \mathbf{m}^2$$ $S_{W} = 87.623 \ \mathbf{m}^2$

$$AR_{W} := \frac{\left(b_{W\_1} + b_{W\_2}\right)^2}{S_{W}} = 8.474$$ $AR_{W} = 8.474$

$$MAC_{W} := \frac{S_{W\_1} \cdot MAC_{W\_1} + S_{W\_2} \cdot MAC_{W\_2}}{S_{W\_1} + S_{W\_2}} = 3.642 \ \mathbf{m}$$ $MAC_{W} = 3.642 \ \mathbf{m}$

$$\xi_{tmax\_W} := \frac{\xi_{tmax\_W\_1} \cdot S_{W\_1} + \xi_{tmax\_W\_2} \cdot S_{W\_2}}{S_{W\_1} + S_{W\_2}} = 0.4$$ $\xi_{tmax\_W} = 0.4$

Hidden Area --> Wing, linear laws defined over inner/outer panel semi-span

Wing, linear laws defined over the whole wing semi-span

$$ {}_{f}c_{W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}c_{W\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}c_{W\_2}(y) \right. \end{array} \right. $$

$$ {}_{f}\alpha_{0l\_2D\_W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}\alpha_{0l\_W\_2D\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}\alpha_{0l\_W\_2D\_2}(y) \right. \end{array} \right. $$

$$ {}_{f}t\_over\_c_{W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}t\_over\_c_{W\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}t\_over\_c_{W\_2}(y) \right. \end{array} \right. $$

$$ {}_{f}\varepsilon_{g\_W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}\varepsilon_{g\_W\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}\varepsilon_{g\_W\_2}(y) \right. \end{array} \right. $$

$$ {}_{f}C_{l\alpha\_W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}C_{l\alpha\_W\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}C_{l\alpha\_W\_2}(y) \right. \end{array} \right. $$

$$ {}_{f}C_{m\_ac\_2D\_W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}C_{m\_ac\_2D\_W\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}C_{m\_ac\_2D\_W\_2}(y) \right. \end{array} \right. $$

$$ {}_{f}\xi_{ac\_2D\_W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}\xi_{ac\_2D\_W\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}\xi_{ac\_2D\_W\_2}(y) \right. \end{array} \right. $$

$$ {}_{f}M_{cr\_2D\_W}(y) := \left\| \begin{array}{l} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \left\| \text{return } {}_{f}M_{cr\_W\_2D\_1}(y) \right. \\ \text{else} \\ \quad \left\| \text{return } {}_{f}M_{cr\_W\_2D\_2}(y) \right. \end{array} \right. $$

Hidden Area --> Wing, data vectors for plotting linear laws in LaTeX

Wing, inner panel 2D mean quantities

$$t\_over\_c_{W\_mean\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y) \cdot {}_{f}t\_over\_c_W(y)\,dy = 0.11 \qquad t\_over\_c_{W\_mean\_1} = 0.11$$

$$C_{l\alpha\_W\_mean\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y) \cdot {}_{f}C_{l\alpha\_W}(y)\,dy = 6.016 \qquad C_{l\alpha\_W\_mean\_1} = 0.105\ deg^{-1}$$

$$\alpha_{0l\_W\_mean\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y) \cdot {}_{f}\alpha_{0l\_2D\_W}(y)\,dy = -0.047\ rad \qquad \alpha_{0l\_W\_mean\_1} = -2.7\ deg$$

$$C_{m\_ac\_W\_mean\_1} := \frac{2}{S_{W\_1} \cdot MAC_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y)^2 \cdot {}_{f}C_{m\_ac\_2D\_W}(y)\,dy = -0.07 \qquad C_{m\_ac\_W\_mean\_1} = -0.07$$

Wing, outer panel 2D mean quantities

$$t\_over\_c_{W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, t\_over\_c_{W\_t}, \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}t\_over\_c_W(y)\,dy\right) = 0.11 \qquad t\_over\_c_{W\_mean\_2} = 0.11$$

$$C_{l\alpha\_W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, C_{l\alpha\_W\_t}, \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}C_{l\alpha\_W}(y)\,dy\right) = 6.016\ rad^{-1} \qquad C_{l\alpha\_W\_mean\_2} = 0.105\ deg^{-1}$$

$$\alpha_{0l\_W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, \alpha_{0l\_W\_t}, \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}\alpha_{0l\_2D\_W}(y)\,dy\right) = -0.047\ rad \qquad \alpha_{0l\_W\_mean\_2} = -2.7\ deg$$

$$C_{m\_ac\_W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, C_{m\_ac\_W\_t}, \frac{2}{S_{W\_2} \cdot MAC_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y)^2 \cdot {}_{f}C_{m\_ac\_2D\_W}(y)\,dy\right) = -0.07 \qquad C_{m\_ac\_W\_mean\_2} = -0.07$$

Wing, global 2D mean quantities

$$t\_over\_c_{W\_mean} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}t\_over\_c_W(y)\,dy = 0.11 \qquad t\_over\_c_{W\_mean} = 0.11$$

$$C_{l\alpha\_W\_mean} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}C_{l\alpha\_W}(y)\,dy = 6.016 \qquad C_{l\alpha\_W\_mean} = 0.105\ deg^{-1}$$

$$\alpha_{0l\_W\_mean} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}\alpha_{0l\_2D\_W}(y)\,dy = -0.047\ rad \qquad \alpha_{0l\_W\_mean} = -2.7\ deg$$

$$C_{m\_ac\_W\_mean} := \frac{2}{S_W \cdot MAC_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}c_W(y)^2 \cdot {}_{f}C_{m\_ac\_2D\_W}(y)\,dy = -0.07 \qquad C_{m\_ac\_W\_mean} = -0.07$$

Wing, 3D alpha-zero-lift for inner panel, outer panel and whole wing

$$\alpha_{0L\_W\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_f c_W(y) \cdot \left({}_f\alpha_{0l\_2D\_W}(y) - {}_f\varepsilon_{g\_W}(y) \right) \mathrm{d}y = -0.033 \; rad \qquad \alpha_{0L\_W\_1} = -1.91 \; deg$$

$$\alpha_{0L\_W\_2} := \mathrm{if}\left({}_bCrk = 0 , \alpha_{0l\_W\_t} , \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_f c_W(y) \cdot \left({}_f\alpha_{0l\_2D\_W}(y) - {}_f\varepsilon_{g\_W}(y) \right) \mathrm{d}y \right) = -0.047 \; rad \qquad \alpha_{0L\_W\_2} = -2.7 \; deg$$

$$\alpha_{0L\_W} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_f c_W(y) \cdot \left({}_f\alpha_{0l\_2D\_W}(y) - {}_f\varepsilon_{g\_W}(y) \right) \mathrm{d}y = -0.033 \; rad \qquad \alpha_{0L\_W} = -1.91 \; deg$$

Wing, sweep angles for inner/outer panel

$${}_f\Lambda\left(x , \Lambda_{le} , AR , \lambda\right) := \mathrm{if}\left(AR = 0 , \Lambda_{le} , \mathrm{atan}\left(\tan\left(\Lambda_{le}\right) - \frac{4 \cdot x \cdot (1 - \lambda)}{AR \cdot (1 + \lambda)} \right) \right)$$

- **Sweep angle function**

$$\Lambda_{W\_LE\_1} := {}_f\Lambda\left(0 , \Lambda_{W\_LE\_1} , AR_{W\_1} , \lambda_{W\_1}\right) = 0.489 \qquad \Lambda_{W\_LE\_1} = 28 \; deg$$

$$\Lambda_{W\_TE\_1} := {}_f\Lambda\left(1 , \Lambda_{W\_LE\_1} , AR_{W\_1} , \lambda_{W\_1}\right) = 0.23 \qquad \Lambda_{W\_TE\_1} = 13.179 \; deg$$

$$\Lambda_{W\_c4\_1} := {}_f\Lambda\left(0.25 , \Lambda_{W\_LE\_1} , AR_{W\_1} , \lambda_{W\_1}\right) = 0.429 \qquad \Lambda_{W\_c4\_1} = 24.576 \; deg$$

$$\Lambda_{W\_c2\_1} := {}_f\Lambda\left(0.5 , \Lambda_{W\_LE\_1} , AR_{W\_1} , \lambda_{W\_1}\right) = 0.366 \qquad \Lambda_{W\_c2\_1} = 20.954 \; deg$$

$$\Lambda_{W\_tmax\_1} := {}_f\Lambda\left(\xi_{tmax\_W\_1} , \Lambda_{W\_LE\_1} , AR_{W\_1} , \lambda_{W\_1}\right) = 0.391 \qquad \Lambda_{W\_tmax\_1} = 22.426 \; deg$$

$$\Lambda_{W\_LE\_2} := {}_f\Lambda\left(0 , \Lambda_{W\_LE\_2} , AR_{W\_2} , \lambda_{W\_2}\right) = 0 \qquad \Lambda_{W\_LE\_2} = 0 \; deg$$

$$\Lambda_{W\_TE\_2} := {}_f\Lambda\left(1 , \Lambda_{W\_LE\_2} , AR_{W\_2} , \lambda_{W\_2}\right) = 0 \qquad \Lambda_{W\_TE\_2} = 0 \; deg$$

$$\Lambda_{W\_c4\_2} := {}_f\Lambda\left(0.25 , \Lambda_{W\_LE\_2} , AR_{W\_2} , \lambda_{W\_2}\right) = 0 \qquad \Lambda_{W\_c4\_2} = 0 \; deg$$

$$\Lambda_{W\_c2\_2} := {}_f\Lambda\left(0.5 , \Lambda_{W\_LE\_2} , AR_{W\_2} , \lambda_{W\_2}\right) = 0 \qquad \Lambda_{W\_c2\_2} = 0 \; deg$$

$$\Lambda_{W\_tmax\_2} := {}_f\Lambda\left(\xi_{tmax\_W\_2} , \Lambda_{W\_LE\_2} , AR_{W\_2} , \lambda_{W\_2}\right) = 0 \qquad \Lambda_{W\_tmax\_2} = 0 \; deg$$

Wing, Mean Aerodynamic Chord position with respect to Wing Apex

$$
{}_{f}Y_{MAC\_W}(MAC) := \begin{cases} \text{if } MAC \geq c_{W\_t\_1} \\ \quad \text{return } \dfrac{b_{W\_1} \cdot (MAC - c_{W\_r\_1})}{2 \cdot (c_{W\_t\_1} - c_{W\_r\_1})} \\ \text{else} \\ \quad \text{return } \dfrac{b_{W\_1}}{2} + \dfrac{b_{W\_2} \cdot (MAC - c_{W\_r\_2})}{2 \cdot (c_{W\_t\_2} - c_{W\_r\_2})} \end{cases}
$$

- **Function for Mean Aerodynamic Chord distance from wing apex, along Y axis**

$$
{}_{f}X_{MAC\_LE\_W}(MAC) := \begin{cases} \text{if } MAC > c_{W\_t\_1} \\ \quad \text{return } {}_{f}Y_{MAC\_W}(MAC) \cdot \tan(\Lambda_{W\_LE\_1}) \\ \text{else} \\ \quad \text{return } \dfrac{b_{W\_1}}{2} \cdot \tan(\Lambda_{W\_LE\_1}) + \dfrac{b_{W\_2} \cdot (MAC - c_{W\_r\_2})}{2 \cdot (c_{W\_t\_2} - c_{W\_r\_2})} \cdot \tan(\Lambda_{W\_LE\_2}) \end{cases}
$$

- **Function for Mean Aerodynamic Chord Leading Edge distance from wing apex, along X axis**

$$
{}_{f}Z_{MAC\_W}(MAC) := \begin{cases} \text{if } {}_{f}Y_{MAC\_W}(MAC) < \dfrac{b_{W\_1}}{2} \\ \quad \text{return } {}_{f}Y_{MAC\_W}(MAC) \cdot \tan(\Gamma_{W\_1}) \\ \text{else} \\ \quad \text{return } \dfrac{b_{W\_1}}{2} \cdot \tan(\Gamma_{W\_1}) + \left({}_{f}Y_{MAC\_W}(MAC) - \dfrac{b_{W\_1}}{2}\right) \cdot \tan(\Gamma_{W\_2}) \end{cases}
$$

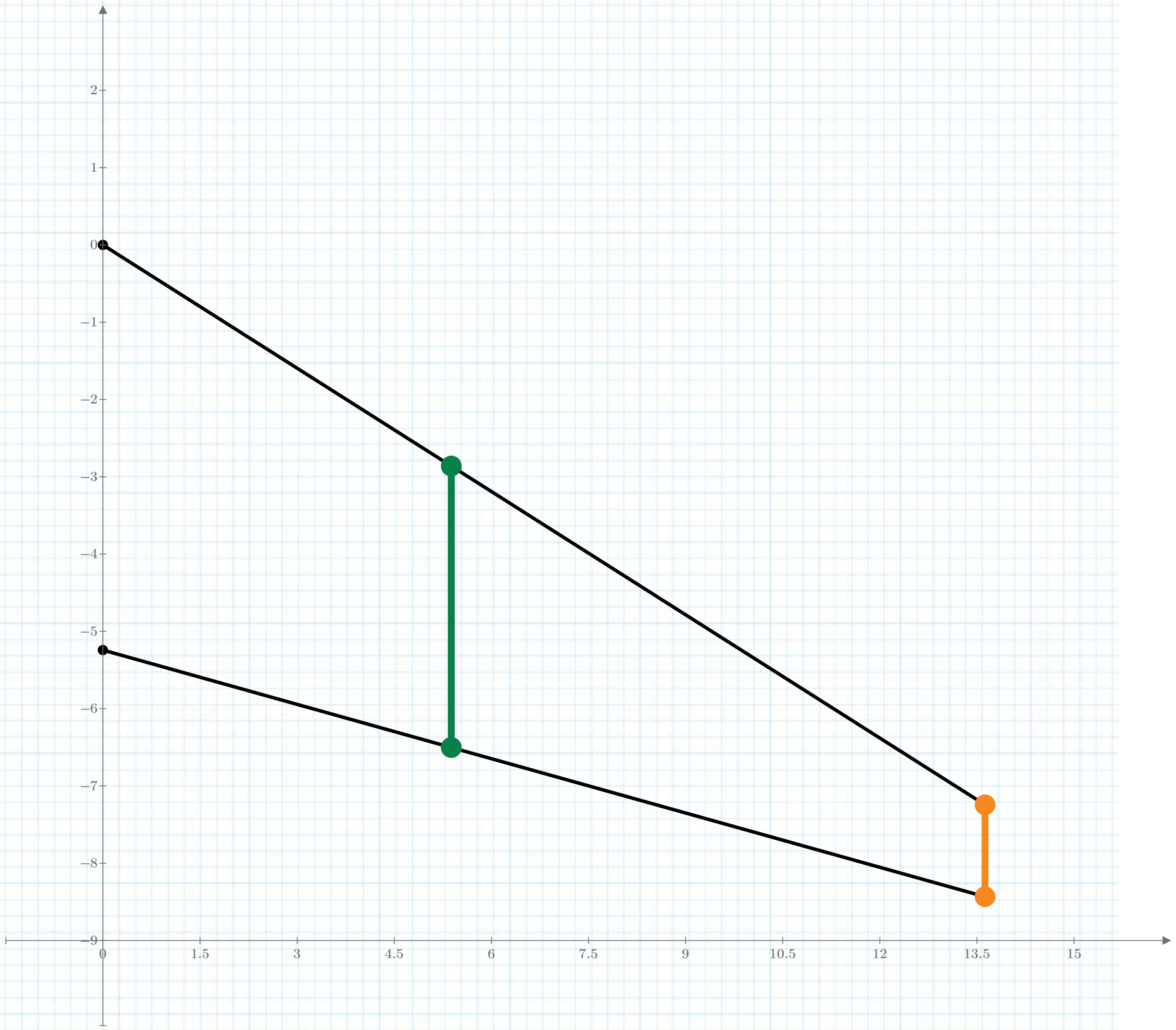
- **Function for Mean Aerodynamic Chord distance from wing apex, along Z axis**

$X_{MAC\_LE\_W} := {}_{f}X_{MAC\_LE\_W}(MAC_W) = 2.861\ m$

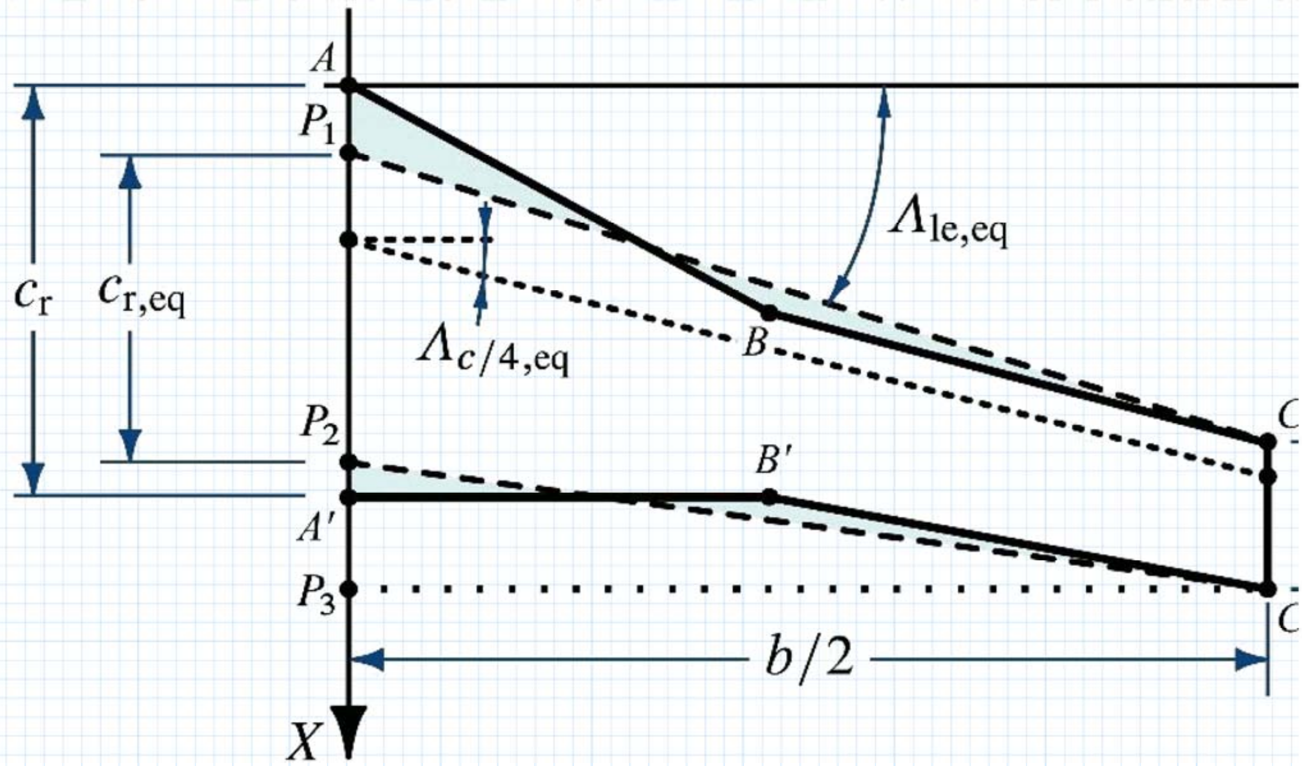
$Y_{MAC\_W} := {}_{f}Y_{MAC\_W}(MAC_W) = 5.381\ m$

$Z_{MAC\_W} := {}_{f}Z_{MAC\_W}(MAC_W) = 0.207\ m$

Wing planform with Mean Aerodynamic Chord



EQUIVALENT WING PARAMETERS CALCULATIONS



Equivalent Wing, geometric parameters

$X_B := \frac{b_{W\_1}}{2} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) = 7.244\ m$

$Y_B := \frac{b_{W\_1}}{2} = 13.625\ m$

$X_C := X_B + \frac{b_{W\_2}}{2} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 7.244\ m$

$Y_C := \frac{b_W}{2} = 13.625\ m$

$X_{C'} := X_C + c_{W\_t\_2} = 8.433\ m$

$Y_{C'} := Y_C$

$X_{B'} := X_B + c_{W\_t\_1} = 8.433\ m$

$Y_{B'} := Y_B = 13.625\ m$

$X_{A'} := c_{W\_r\_1} = 5.243\ m$

$Y_{A'} := 0\ m$

Hidden Area --> Equivalent Wing, equivalence of areas on leading edge

Hidden Area --> Equivalent Wing, equivalence of areas on trailing edge

Equivalent Wing, planform results

$X_{P1} = 0\ m$

$X_{P2} = 5.243\ m$

$X_{W\_r\_LE\_eqv} := X_{P1} = 0\ m$

$X_{W\_r\_TE\_eqv} := X_{P2} = 5.243\ m$

$c_{W\_r\_eqv} := \left|X_{P2} - X_{P1}\right| = 5.243\ m$

$\lambda_{W\_eqv} := \frac{c_{W\_t}}{c_{W\_r\_eqv}} = 0.227$

$AR_{W\_eqv} := \frac{{b_W}^2}{S_W} = 8.474$

$$\Lambda_{W\_LE\_eqv} := \operatorname{atan}\left(\frac{2 \cdot (X_C - X_{P1})}{b_{W\_1} + b_{W\_2}}\right) = 0.489 \ rad \qquad \Lambda_{W\_LE\_eqv} = 28 \ deg$$

$$\Lambda_{W\_TE\_eqv} := {}_f\Lambda\left(1.0, \Lambda_{W\_LE\_eqv}, AR_{W\_eqv}, \lambda_{W\_eqv}\right) = 0.23 \ rad \qquad \Lambda_{W\_TE\_eqv} = 13.179 \ deg$$

$$\Lambda_{W\_c4\_eqv} := {}_f\Lambda\left(0.25, \Lambda_{W\_LE\_eqv}, AR_{W\_eqv}, \lambda_{W\_eqv}\right) = 0.429 \ rad \qquad \Lambda_{W\_c4\_eqv} = 24.576 \ deg$$

$$\Lambda_{W\_c2\_eqv} := {}_f\Lambda\left(0.5, \Lambda_{W\_LE\_eqv}, AR_{W\_eqv}, \lambda_{W\_eqv}\right) = 0.366 \ rad \qquad \Lambda_{W\_c2\_eqv} = 20.954 \ deg$$

$$\Lambda_{W\_tmax\_eqv} := {}_f\Lambda\left(\xi_{tmax\_W}, \Lambda_{W\_LE\_eqv}, AR_W, \lambda_{W\_eqv}\right) = 0.391 \ rad \qquad \Lambda_{W\_tmax\_eqv} = 22.426 \ deg$$

$$\Gamma_{W\_eqv} := \frac{\Gamma_{W\_1} \cdot S_{W\_1} + \Gamma_{W\_2} \cdot S_{W\_2}}{S_{W\_1} + S_{W\_2}} = 0.038 \qquad \Gamma_{W\_eqv} = 2.2 \ deg$$

$$MAC_{W\_eqv} := \frac{2}{3} \cdot c_{W\_r\_eqv} \cdot \left(\frac{1 + \lambda_{W\_eqv}{}^2 + \lambda_{W\_eqv}}{1 + \lambda_{W\_eqv}}\right) = 3.642 \ m \qquad MAC_{W\_eqv} = 3.642 \ m$$

$$X_{MAC\_LE\_W\_eqv} := \frac{b_W}{6} \cdot \frac{(1 + 2 \cdot \lambda_{W\_eqv})}{(1 + \lambda_{W\_eqv})} \cdot \tan\left(\Lambda_{W\_LE\_eqv}\right) = 2.861 \ m \qquad X_{MAC\_LE\_W\_eqv} = 2.861 \ m$$

$$Y_{MAC\_W\_eqv} := \left(\frac{b_W}{6} \cdot \frac{1 + 2 \cdot \lambda_{W\_eqv}}{1 + \lambda_{W\_eqv}}\right) = 5.381 \ m \qquad Y_{MAC\_W\_eqv} = 5.381 \ m$$

$$Z_{MAC\_W\_eqv} := Y_{MAC\_W\_eqv} \cdot \tan\left(\Gamma_{W\_eqv}\right) = 0.207 \ m \qquad Z_{MAC\_W\_eqv} = 0.207 \ m$$

CONSTRUCTED OUTBOARD PANEL PARAMETERS CALCULATIONS (DATCOM METHOD)

Constructed Outboard Panel parameters calculation

$$\Delta y := \text{if}\left({}_b Crk = 0, 0 \cdot m, \frac{1}{2} \cdot \left(\frac{b_{W\_1}}{2}\right)\right) = 0\ m \qquad \Delta y = 0\ m$$

$$b'_{W\_2} := b_{W\_2} + 2\ \Delta y = 0\ m \qquad b'_{W\_2} = 0\ m \qquad b_{W\_2} = 0\ m$$

$$\frac{b'_{W\_2}}{2} = 0\ m \qquad \frac{b_{W\_2}}{2} = 0\ m$$

$$c'_{W\_r\_2} := {}_f c_{W\_2}\left(\frac{b_{W\_1}}{2} - \Delta y\right) = 1.189\ m \qquad c'_{W\_r\_2} = 1.189\ m \qquad c_{W\_r\_2} = 1.189\ m$$

$$\lambda'_{W\_2} := \frac{c_{W\_t\_2}}{c'_{W\_r\_2}} = 1 \qquad \lambda'_{W\_2} = 1 \qquad \lambda_{W\_2} = 1$$

$$S'_{W\_2} := \frac{b'_{W\_2}}{2} \cdot c'_{W\_r\_2} \cdot \left(1 + \lambda'_{W\_2}\right) = 0\ m^2 \qquad S'_{W\_2} = 0\ m^2 \qquad S_{W\_2} = 0\ m^2$$

$$AR'_{W\_2} := \frac{2 \cdot b'_{W\_2}}{c'_{W\_r\_2} \cdot \left(1 + \lambda'_{W\_2}\right)} = 0 \qquad AR'_{W\_2} = 0 \qquad AR_{W\_2} = 0$$

$$MAC'_{W\_2} := \frac{2}{3} \cdot c'_{W\_r\_2} \cdot \left(\frac{1 + {\lambda'_{W\_2}}^2 + \lambda'_{W\_2}}{1 + \lambda'_{W\_2}}\right) = 1.189\ m \qquad MAC'_{W\_2} = 1.189\ m \qquad MAC_{W\_2} = 1.189\ m$$

$$Y'_{MAC\_W\_2} := \frac{b'_{W\_2}}{6} \cdot \frac{1 + 2 \cdot \lambda'_{W\_2}}{1 + \lambda'_{W\_2}} = 0\ m \qquad Y'_{MAC\_W\_2} = 0\ m \qquad Y_{MAC\_W\_2} = 0\ m$$

$$X'_{MAC\_LE\_W\_2} := Y'_{MAC\_W\_2} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 0\ m \qquad X'_{MAC\_LE\_W\_2} = 0\ m \qquad X_{MAC\_LE\_W\_2} = 0\ m$$

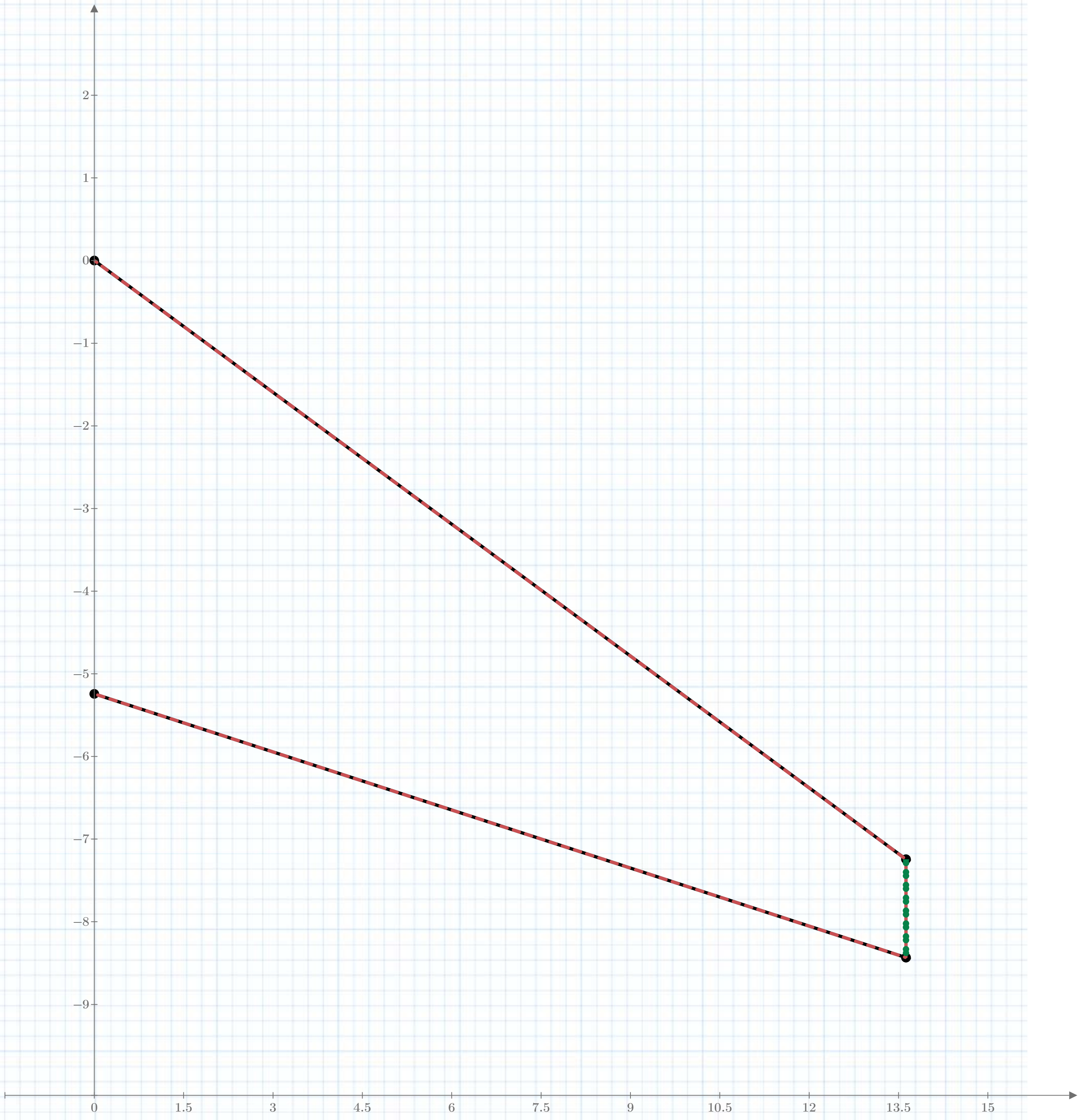
$$X'_{LE\_r\_W\_2} := \frac{b_{W\_1}}{2} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) - \Delta y \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 7.244\ m \qquad Y'_{LE\_r\_W\_2} := \frac{b_{W\_1}}{2} - \Delta y = 13.625\ m$$

$$X'_{LE\_t\_W\_2} := \frac{b_{W\_1}}{2} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) + \frac{b_{W\_2}}{2} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 7.244\ m \qquad Y'_{LE\_t\_W\_2} := \frac{b_{W\_1} + b_{W\_2}}{2} = 13.625\ m$$

$$X'_{TE\_t\_W\_2} := X'_{LE\_t\_W\_2} + c_{W\_t\_2} = 8.433\ m \qquad Y'_{TE\_t\_W\_2} := Y'_{LE\_t\_W\_2} = 13.625\ m$$

$$X'_{TE\_r\_W\_2} := X'_{LE\_r\_W\_2} + c'_{W\_r\_2} = 8.433\ m \qquad Y'_{TE\_r\_W\_2} := Y'_{LE\_r\_W\_2} = 13.625\ m$$

Comparison among Cranked, Equivalent, and Constructed Outboard Panel Wing planforms



MISCELLANEOUS DATA CALCULATIONS

Induced drag factors, only due to geometric effects

$$e_{W\_alt\_1} := \frac{2}{2 - AR_{W\_1} + \sqrt{4 + AR_{W\_1}^{\ 2}\left(1 + \tan\left(\Lambda_{W\_tmax\_1}\right)^2\right)}} = 0.688$$ $e_{W\_alt\_1} = 0.688$

$$e_{W\_alt\_2} := \frac{2}{2 - AR_{W\_2} + \sqrt{4 + AR_{W\_2}^{\ 2}\left(1 + \tan\left(\Lambda_{W\_tmax\_2}\right)^2\right)}} = 0.5$$ $e_{W\_alt\_2} = 0.5$

$$e_{W\_alt} := \frac{2}{2 - AR_{W} + \sqrt{4 + AR_{W}^{\ 2}\left(1 + \tan\left(\Lambda_{W\_tmax\_eqv}\right)^2\right)}} = 0.688$$ $e_{W\_alt} = 0.688$

$$e_{W\_1\_alt\_\Lambda0} := 1.78 \cdot \left(1 - 0.045 \cdot AR_{W\_1}^{\ 0.68}\right) - 0.64 = 0.797$$

$$e_{W\_2\_alt\_\Lambda0} := 1.78 \cdot \left(1 - 0.045 \cdot AR_{W\_2}^{\ 0.68}\right) - 0.64 = 1.14$$

$$e_{W\_alt\_\Lambda0} := 1.78 \cdot \left(1 - 0.045 \cdot AR_{W}^{\ 0.68}\right) - 0.64 = 0.797$$

- **Alternative formula: valid for unswept wings**

$$e_{W\_1\_alt\_\Lambda} := 4.61 \cdot \left(1 - 0.045 \cdot AR_{W\_1}^{\ 0.68}\right) \cdot \cos\left(\Lambda_{W\_LE\_1}\right)^{0.15} - 3.1 = 0.554$$

$$e_{W\_2\_alt\_\Lambda} := 4.61 \cdot \left(1 - 0.045 \cdot AR_{W\_2}^{\ 0.68}\right) \cdot \cos\left(\Lambda_{W\_LE\_2}\right)^{0.15} - 3.1 = 1.51$$

$$e_{W\_alt\_\Lambda} := 4.61 \cdot \left(1 - 0.045 \cdot AR_{W}^{\ 0.68}\right) \cdot \cos\left(\Lambda_{W\_LE\_eqv}\right)^{0.15} - 3.1 = 0.554$$

- **Alternative formula: valid for swept wings**

3d critical Mach number at mean aerodynamic chord

$$M_{cr\_W\_1\_3D\_@MAC\_1} := \frac{{}_{f}\mathrm{M}_{\mathrm{cr\_2D\_W}}\left(Y_{MAC\_W\_1}\right)}{\cos\left(\Lambda_{W\_LE\_1}\right)} = 0.784$$ $M_{cr\_W\_1\_3D\_@MAC\_1} = 0.784$

$$M_{cr\_W\_2\_3D\_@MAC\_2} := \frac{{}_{f}\mathrm{M}_{\mathrm{cr\_2D\_W}}\left(Y_{MAC\_W\_2}\right)}{\cos\left(\Lambda_{W\_LE\_2}\right)} = 0.68$$ $M_{cr\_W\_2\_3D\_@MAC\_2} = 0.68$

$$M_{cr\_W\_3D\_@MAC} := \frac{{}_{f}\mathrm{M}_{\mathrm{cr\_2D\_W}}\left(Y_{MAC\_W}\right)}{\cos\left(\Lambda_{W\_LE\_eqv}\right)} = 0.784$$ $M_{cr\_W\_3D\_@MAC} = 0.784$

Ailerons inner and outer stations and area

$$y_{a\_in} := \eta_{a\_in} \cdot \frac{b_W}{2} = 9.047\ m$$ $y_{a\_in} = 9.047\ m$

$$y_{a\_out} := \eta_{a\_out} \cdot \frac{b_W}{2} = 12.371\ m$$ $y_{a\_out} = 12.371\ m$

$$c_{W\_mean\_@a} := {}_{f}\mathrm{c}_{\mathrm{W}}\left(\frac{y_{a\_in} + y_{a\_out}}{2}\right) = 2.056\ m$$ $c_{W\_mean\_@a} = 2.056\ m$

$$S_a := 2 \cdot c_a \cdot \left(y_{a\_out} - y_{a\_in}\right) = 5.269\ m^2$$ $S_a = 5.269\ m^2$

Flaps inner and outer stations and area

$y_{flap\_in} := \eta_{flap\_in} \cdot \frac{b_W}{2} = 2.439\ m$ $\quad$ $y_{flap\_in} = 2.439\ m$

$y_{flap\_out} := \eta_{flap\_out} \cdot \frac{b_W}{2} = 8.229\ m$ $\quad$ $y_{flap\_out} = 8.229\ m$

$S_{flap} := 2 \cdot c_{flap} \cdot (y_{flap\_out} - y_{flap\_in}) = 9.178\ m^2$ $\quad$ $S_{flap} = 9.178\ m^2$

$\alpha_{0L\_W\_flaps\_open} := \alpha_{0L\_W} + \frac{S_{flap}}{S_W} \cdot \Delta\alpha_{0l\_W\_flaps} = -0.03$ $\quad$ $\alpha_{0L\_W\_flaps\_open} = -1.701\ deg$

WING LIFT CURVE SLOPE

Wing Lift Curve Slope, function definitions

- **Polhamus Formula Coefficient**

$$
f_{k_{Polhamus}}(M, M_{cr\_3D}, \Lambda_{LE}, \lambda, AR) := \begin{array}{l}
\text{if } (M < M_{cr\_3D}) \wedge (\Lambda_{LE} < 32\ deg) \wedge (\lambda > 0.4) \wedge (\lambda < 1) \wedge (AR > 3) \wedge (AR < 8) \\
\quad \text{if } AR < 4 \\
\quad\quad \text{return } 1 + \frac{AR \cdot (1.87 - 0.000233 \cdot \Lambda_{LE})}{100} \\
\quad \text{else} \\
\quad\quad \text{return } 1 + \frac{((8.2 - 2.3 \cdot \Lambda_{LE}) - AR \cdot (0.22 - 0.153 \cdot \Lambda_{LE}))}{100} \\
\text{else} \quad \text{(---> Polhamus Formula is not valid)} \\
\quad \text{return } 100
\end{array}
$$

- **General Formula for Lift Curve Slope**

$$
f_{C_{L\alpha\_W}}(M, k_P, AR, \Lambda_{c2}, C_{l\alpha@MAC}, \Lambda_{LE}) := \begin{array}{l}
\text{if } AR = 0 \\
\quad \text{return } C_{l\alpha@MAC} \\
\text{if } k_P \neq 100 \quad \text{(---> use Polhamus Formula)} \\
\quad \text{return } \frac{2 \cdot \pi \cdot AR}{2 + \sqrt{\left(\left(\frac{AR^2 \cdot (1 - M^2)}{k_P^2}\right)\left(1 + \frac{\tan(\Lambda_{c2})^2}{(1 - M^2)}\right)\right) + 4}} \\
\text{else} \quad \text{(---> use alternative formula)} \\
\quad a_0 \leftarrow \frac{C_{l\alpha@MAC}}{\sqrt{1 - M^2 \cdot \cos(\Lambda_{LE})^2}} \\
\quad \text{return } \frac{a_0 \cdot \cos(\Lambda_{LE})}{\sqrt{1 - (M \cdot \cos(\Lambda_{LE}))^2 + \left(\frac{a_0 \cdot \cos(\Lambda_{LE})}{\pi \cdot AR}\right)^2} + \frac{a_0 \cdot \cos(\Lambda_{LE})}{\pi \cdot AR}}
\end{array}
$$

Wing Lift Curve Slope, classic formula for inner/outer panel and whole wing

$$C_{L\alpha\_W\_1\_classic} := \frac{C_{l\alpha\_W\_mean\_1}}{\sqrt{1-M_1^{\ 2}} + \frac{C_{l\alpha\_W\_mean\_1}}{\pi \cdot AR_{W\_1} \cdot e_{W\_alt\_1}}} = 5.748$$

$$C_{L\alpha\_W\_1\_classic} = 0.1\ \mathbf{deg}^{-1}$$

$$C_{L\alpha\_W\_2\_classic} := \mathbf{if}\left({}_bCrk = 0, \frac{C_{l\alpha\_W\_mean\_2}}{\sqrt{1-M_1^{\ 2}}}, \frac{C_{l\alpha\_W\_mean\_2}}{\sqrt{1-M_1^{\ 2}} + \frac{C_{l\alpha\_W\_mean\_2}}{\pi \cdot AR_{W\_2} \cdot e_{W\_alt\_2}}}\right) = 8.378\ \mathbf{rad}^{-1}$$

$$C_{L\alpha\_W\_2\_classic} = 0.146\ \mathbf{deg}^{-1}$$

$$C_{L\alpha\_W\_classic} := \frac{C_{l\alpha\_W\_mean}}{\sqrt{1-M_1^{\ 2}} + \frac{C_{l\alpha\_W\_mean}}{\pi \cdot AR_{W} \cdot e_{W\_alt}}} = 5.748\ \mathbf{rad}^{-1}$$

$$C_{L\alpha\_W\_classic} = 0.1\ \mathbf{deg}^{-1}$$

Wing Lift Curve Slope, general formula for inner/outer panel and whole wing

$k_{Polhamus\_1} := {}_{\mathrm{f}}\mathrm{k}_{\mathrm{Polhamus}}\left(M_1, M_{cr\_W\_1\_3D\_@MAC\_1}, \Lambda_{W\_LE\_1}, \lambda_{W\_1}, AR_{W\_1}\right) = 100$ $\quad k_{Polhamus\_1} = 100$

$C_{l\alpha\_W\_1\_@MAC\_1} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{l\alpha\_W}}\left(Y_{MAC\_W\_1}\right) = 6.016\ \mathbf{rad}^{-1}$ $\quad C_{l\alpha\_W\_1\_@MAC\_1} = 0.105\ \mathbf{deg}^{-1}$

$C_{L\alpha\_W\_1\_@M0} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{L\alpha\_W}}\left(0, k_{Polhamus\_1}, AR_{W\_1}, \Lambda_{W\_c2\_1}, C_{l\alpha\_W\_1\_@MAC\_1}, \Lambda_{W\_LE\_1}\right)$

$C_{L\alpha\_W\_1\_@M0} = 4.357\ \mathbf{rad}^{-1}$ $\quad C_{L\alpha\_W\_1\_@M0} = 0.076\ \mathbf{deg}^{-1}$

$C_{L\alpha\_W\_1} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{L\alpha\_W}}\left(M_1, k_{Polhamus\_1}, AR_{W\_1}, \Lambda_{W\_c2\_1}, C_{l\alpha\_W\_1\_@MAC\_1}, \Lambda_{W\_LE\_1}\right)$

$C_{L\alpha\_W\_1} = 6.227\ \mathbf{rad}^{-1}$ $\quad C_{L\alpha\_W\_1} = 0.109\ \mathbf{deg}^{-1}$

$k_{Polhamus\_2} := {}_{\mathrm{f}}\mathrm{k}_{\mathrm{Polhamus}}\left(M_1, M_{cr\_W\_2\_3D\_@MAC\_2}, \Lambda_{W\_LE\_2}, \lambda_{W\_2}, AR_{W\_2}\right) = 100$ $\quad k_{Polhamus\_2} = 100$

$C_{l\alpha\_W\_2\_@MAC\_2} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{l\alpha\_W}}\left(Y_{MAC\_W\_2}\right) = 6.016\ \mathbf{rad}^{-1}$ $\quad C_{l\alpha\_W\_2\_@MAC\_2} = 0.105\ \mathbf{deg}^{-1}$

$C_{L\alpha\_W\_2\_@M0} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{L\alpha\_W}}\left(0, k_{Polhamus\_2}, AR_{W\_2}, \Lambda_{W\_c2\_2}, C_{l\alpha\_W\_2\_@MAC\_2}, \Lambda_{W\_LE\_2}\right)$

$C_{L\alpha\_W\_2\_@M0} = 6.016\ \mathbf{rad}^{-1}$ $\quad C_{L\alpha\_W\_2\_@M0} = 0.105\ \mathbf{deg}^{-1}$

$C_{L\alpha\_W\_2} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{L\alpha\_W}}\left(M_1, k_{Polhamus\_2}, AR_{W\_2}, \Lambda_{W\_c2\_2}, C_{l\alpha\_W\_2\_@MAC\_2}, \Lambda_{W\_LE\_2}\right)$

$C_{L\alpha\_W\_2} = 6.016\ \mathbf{rad}^{-1}$ $\quad C_{L\alpha\_W\_2} = 0.105\ \mathbf{deg}^{-1}$

$k_{Polhamus\_W} := {}_{\mathrm{f}}\mathrm{k}_{\mathrm{Polhamus}}\left(M_1, M_{cr\_W\_3D\_@MAC}, \Lambda_{W\_LE\_eqv}, \lambda_{W\_eqv}, AR_{W\_eqv}\right) = 100$ $\quad k_{Polhamus\_W} = 100$

$C_{l\alpha\_W\_@MAC} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{l\alpha\_W}}\left(Y_{MAC\_W}\right) = 6.016\ \mathbf{rad}^{-1}$ $\quad C_{l\alpha\_W\_@MAC} = 0.105\ \mathbf{deg}^{-1}$

$C_{L\alpha\_W\_@M0} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{L\alpha\_W}}\left(0, k_{Polhamus\_W}, AR_{W\_eqv}, \Lambda_{W\_c2\_eqv}, C_{l\alpha\_W\_@MAC}, \Lambda_{W\_LE\_eqv}\right)$

$C_{L\alpha\_W\_@M0} = 4.357\ \mathbf{rad}^{-1}$ $\quad C_{L\alpha\_W\_@M0} = 0.076\ \mathbf{deg}^{-1}$

$C_{L\alpha\_W} := {}_{\mathrm{f}}\mathrm{C}_{\mathrm{L\alpha\_W}}\left(M_1, k_{Polhamus\_W}, AR_{W\_eqv}, \Lambda_{W\_c2\_eqv}, C_{l\alpha\_W\_@MAC}, \Lambda_{W\_LE\_eqv}\right)$

$C_{L\alpha\_W} = 6.227\ \mathbf{rad}^{-1}$ $\quad C_{L\alpha\_W} = 0.109\ \mathbf{deg}^{-1}$

Wing lift coefficient at initial conditions

$C_{L0\_W\_1} := C_{L\alpha\_W\_1} \cdot \left(i_W - \alpha_{0L\_W\_1}\right) = 0.425$ $\qquad C_{L0\_W\_1} = 0.425$

$C_{L0\_W\_2} := C_{L\alpha\_W\_2} \cdot \left(i_W - \alpha_{0L\_W\_2}\right) = 0.494$ $\qquad C_{L0\_W\_2} = 0.494$

$C_{L0\_W} := C_{L\alpha\_W} \cdot \left(i_W - \alpha_{0L\_W}\right) = 0.425$ $\qquad C_{L0\_W} = 0.425$

Induced drag factor, due to both geometric and aerodynamic effects

$$
{}_{\mathrm{f}}\mathrm{e}\left(C_{L\alpha}, AR, \lambda, \Lambda_{LE}\right) := \left\| \begin{array}{l} \lambda_e \leftarrow \dfrac{AR \cdot \lambda}{\cos\left(\Lambda_{LE}\right)} \\ R \leftarrow 0.0004 \cdot {\lambda_e}^3 - 0.008 \cdot {\lambda_e}^2 + 0.0501 \cdot \lambda_e + 0.8642 \\ \text{return if}\left(AR = 0, 0, \dfrac{1.1 \cdot C_{L\alpha}}{R \cdot C_{L\alpha} + (1 - R)\,\pi \cdot AR}\right) \end{array} \right.
$$

- **Function for calculating wing induced drag factor, icluding aerodynamic and geometric effects**

$e_{W\_1} := {}_{\mathrm{f}}\mathrm{e}\left(C_{L\alpha\_W\_1}, AR_{W\_1}, \lambda_{W\_1}, \Lambda_{W\_LE\_1}\right) = 0.918$ $\qquad e_{W\_1} = 0.918$

$e_{W\_2} := {}_{\mathrm{f}}\mathrm{e}\left(C_{L\alpha\_W\_2}, AR_{W\_2}, \lambda_{W\_2}, \Lambda_{W\_LE\_2}\right) = 0$ $\qquad e_{W\_2} = 0$

$e_W := {}_{\mathrm{f}}\mathrm{e}\left(C_{L\alpha\_W}, AR_W, \lambda_W, \Lambda_{W\_LE\_eqv}\right) = 0.918$ $\qquad e_W = 0.918$

WING AERODYNAMIC CENTER - GRAPHICAL METHOD (DATCOM/NAPOLITANO)

@Aerodynamic Database ---> (x_bar_ac_w)_k1_vs_lambda

$K1_{ac\_W\_1\_Datcom} = 1.432$ $\qquad K1_{ac\_W\_2\_Datcom} = 1$ $\qquad K1_{ac\_W\_eqv\_Datcom} = 1.432$

@Aerodynamic Database ---> (x_bar_ac_w)_k2_vs_L_LE_(AR)_(lambda)

$K2_{ac\_W\_1\_Datcom} = 0.553$ $\qquad K2_{ac\_W\_2\_Datcom} = 0$ $\qquad K2_{ac\_W\_eqv\_Datcom} = 0.553$

@Aerodynamic Database ---> (x_bar_ac_w)_x'_ac_over_root_chord_vs_tan_(L_LE)_over_beta_(AR_times_tan_(L_LE))_(lambda)

$X_{ac\_over\_c_{r\_W\_1\_Datcom}} = 0.757$ $\qquad X_{ac\_over\_c_{r\_W\_2\_Datcom}} = 0.256$ $\qquad X_{ac\_over\_c_{r\_W\_eqv\_Datcom}} = 0.757$

$$X_{ac\_over\_c_{r\_W\_Datcom}} := \frac{X_{ac\_over\_c_{r\_W\_1\_Datcom}} \cdot S_{W\_1} \cdot C_{L\alpha\_W\_1} + X_{ac\_over\_c_{r\_W\_2\_Datcom}} \cdot S_{W\_2} \cdot C_{L\alpha\_W\_2}}{S_{W\_1} \cdot C_{L\alpha\_W\_1} + S_{W\_2} \cdot C_{L\alpha\_W\_2}} = 0.757$$

Adimensional aerodynamic center position with respect to MAC leading edge

$\xi_{ac\_W\_1} := K1_{ac\_W\_1\_Datcom} \cdot \left(X_{ac\_over\_c_{r\_W\_1\_Datcom}} - K2_{ac\_W\_1\_Datcom}\right) = 0.293$ $\qquad \xi_{ac\_W\_1} = 0.293$

$\xi_{ac\_W\_2} := K1_{ac\_W\_2\_Datcom} \cdot \left(X_{ac\_over\_c_{r\_W\_2\_Datcom}} - K2_{ac\_W\_2\_Datcom}\right) = 0.256$ $\qquad \xi_{ac\_W\_2} = 0.256$

$\xi_{ac\_W\_eqv} := K1_{ac\_W\_eqv\_Datcom} \cdot \left(X_{ac\_over\_c_{r\_W\_eqv\_Datcom}} - K2_{ac\_W\_eqv\_Datcom}\right) = 0.293$ $\qquad \xi_{ac\_W\_eqv} = 0.293$

$$\xi_{ac\_W} := \frac{\xi_{ac\_W\_1} \cdot S_{W\_1} \cdot C_{L\alpha\_W\_1} + \xi_{ac\_W\_2} \cdot S_{W\_2} \cdot C_{L\alpha\_W\_2}}{S_{W\_1} \cdot C_{L\alpha\_W\_1} + S_{W\_2} \cdot C_{L\alpha\_W\_2}} = 0.293$$

Aerodynamic center position with respect to wing apex

$X_{ac\_W\_1} := \xi_{ac\_W\_1} \cdot MAC_{W\_1} + X_{MAC\_LE\_W\_1} = 3.928\ m$ $\qquad X_{ac\_W\_1} = 3.928\ m$

$X_{ac\_W\_2} := \xi_{ac\_W\_2} \cdot MAC_{W\_2} + X_{MAC\_LE\_W\_2} = 0.304\ m$ $\qquad X_{ac\_W\_2} = 0.304\ m$

$X_{ac\_W\_eqv} := \xi_{ac\_W\_eqv} \cdot MAC_{W\_eqv} + X_{MAC\_LE\_W\_eqv} = 3.928\ m$ $\qquad X_{ac\_W\_eqv} = 3.928\ m$

$X_{ac\_W} := \xi_{ac\_W} \cdot MAC_{W} + X_{MAC\_LE\_W} = 3.928\ m$ $\qquad X_{ac\_W} = 3.928\ m$

Aerodynamic center position with respect to MAC leading edge

$x_{ac\_W\_1} := X_{ac\_W\_1} - X_{MAC\_LE\_W\_1} = 1.067\ m$ $\qquad x_{ac\_W\_1} = 1.067\ m$

$x_{ac\_W\_2} := X_{ac\_W\_2} - X_{MAC\_LE\_W\_2} = 0.304\ m$ $\qquad x_{ac\_W\_2} = 0.304\ m$

$x_{ac\_W\_eqv} := X_{ac\_W\_eqv} - X_{MAC\_LE\_W\_eqv} = 1.067\ m$ $\qquad x_{ac\_W\_eqv} = 1.067\ m$

$x_{ac\_W} := X_{ac\_W} - X_{MAC\_LE\_W} = 1.067\ m$ $\qquad x_{ac\_W} = 1.067\ m$

Wing planform with 2D aerodynamic center distribution and 3D wing aerodynamic center

SHRENK'S METHOD FOR BASIC AND ADDITIONAL WING LOADING

Loading function definitions and remarkable values

$$_{\mathrm{f}}\mathrm{c}_{\mathrm{eff}}(y) := \frac{_{\mathrm{f}}\mathrm{c}_{\mathrm{W}}(y) \cdot {_{\mathrm{f}}\mathrm{C}_{\mathrm{l\alpha\_W}}}(y)}{C_{l\alpha\_W\_mean}}$$

- Effective chord distribution function

$$c_{ell\_0} := \frac{4 \cdot S_W}{\pi \cdot b_W} \qquad {_{\mathrm{f}}\mathrm{c}_{\mathrm{ell}}}(y) := c_{ell\_0} \cdot \sqrt{1 - \left(\frac{y}{\frac{b_W}{2}}\right)^2}$$

- Elliptic chord distribution function

$$_{\mathrm{f}}\alpha_{\mathrm{b}}(y) := \alpha_{0L\_W} - \left({_{\mathrm{f}}\alpha_{\mathrm{0l\_2D\_W}}}(y) - {_{\mathrm{f}}\varepsilon_{\mathrm{g\_W}}}(y)\right)$$

- "Basic" angle of attack function

$$_{\mathrm{f}}\mathrm{cC}_{\mathrm{l\_b}}(y) := \frac{1}{2} \cdot {_{\mathrm{f}}\mathrm{c}_{\mathrm{W}}}(y) \cdot {_{\mathrm{f}}\mathrm{C}_{\mathrm{l\alpha\_W}}}(y) \cdot {_{\mathrm{f}}\alpha_{\mathrm{b}}}(y)$$

- Basic wing loading

$$_{\mathrm{f}}\mathrm{cC}_{\mathrm{l\_a}}(y) := \frac{1}{2} \cdot \left({_{\mathrm{f}}\mathrm{c}_{\mathrm{eff}}}(y) + {_{\mathrm{f}}\mathrm{c}_{\mathrm{ell}}}(y)\right)$$

- Additional wing loading function

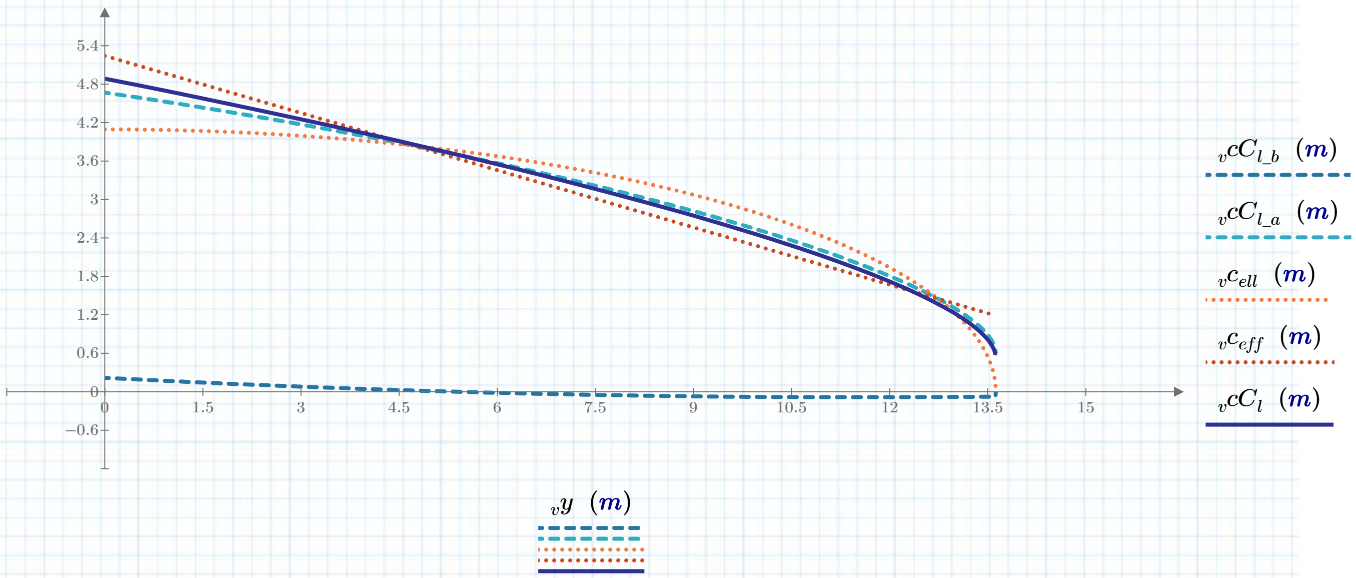
$$_{\mathrm{f}}\mathrm{cC}_{\mathrm{l}}(y) := {_{\mathrm{f}}\mathrm{cC}_{\mathrm{l\_b}}}(y) + {_{\mathrm{f}}\mathrm{cC}_{\mathrm{l\_a}}}(y)$$

- Wing loading function

$$C_{L\_b} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {_{\mathrm{f}}\mathrm{cC}_{\mathrm{l\_b}}}(y)\, \mathrm{d}y = -2.697 \cdot 10^{-19} \qquad C_{L\_a} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {_{\mathrm{f}}\mathrm{cC}_{\mathrm{l\_a}}}(y)\, \mathrm{d}y = 1$$

- **REMARK:** the effects of wing sweep angle are neglected

Spanwise loading curve plots



3D PITCHING MOMENT COEFFICIENT ABOUT WING AERODYNAMIC CENTER

Exact formulation

$$ {}_{f}x_{b\_W}(y) := \text{if } y \le \frac{b_{W\_1}}{2} $$
$$ \quad \text{return } X_{ac\_W} - \left(y \cdot \tan\left(\Lambda_{W\_LE\_1}\right) + {}_{f}c_{W}(y) \cdot {}_{f}\xi_{ac\_2D\_W}(y)\right) $$
$$ \text{else} $$
$$ \quad \text{return } X_{ac\_W} - \left(\frac{b_{W\_1}}{2} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) + \left(y - \frac{b_{W\_1}}{2}\right) \cdot \tan\left(\Lambda_{W\_LE\_2}\right) + {}_{f}c_{W}(y) \cdot {}_{f}\xi_{ac\_2D\_W}(y)\right) $$

- Moment arm from section's aerodynamic center to wing 3D aerodynamic center

$$ C_{M\_ac\_W\_b} := \frac{2}{S_W \cdot MAC_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}cC_{l\_b}(y) \cdot {}_{f}x_{b\_W}(y) \, dy = 0.013 \qquad C_{M\_ac\_W\_b} = 0.013 $$

$$ C_{M\_ac\_W\_a} := \frac{2}{S_W \cdot MAC_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}C_{m\_ac\_2D\_W}(y) \cdot {}_{f}c_{W}(y)^2 \, dy = -0.07 \qquad C_{M\_ac\_W\_a} = -0.07 $$

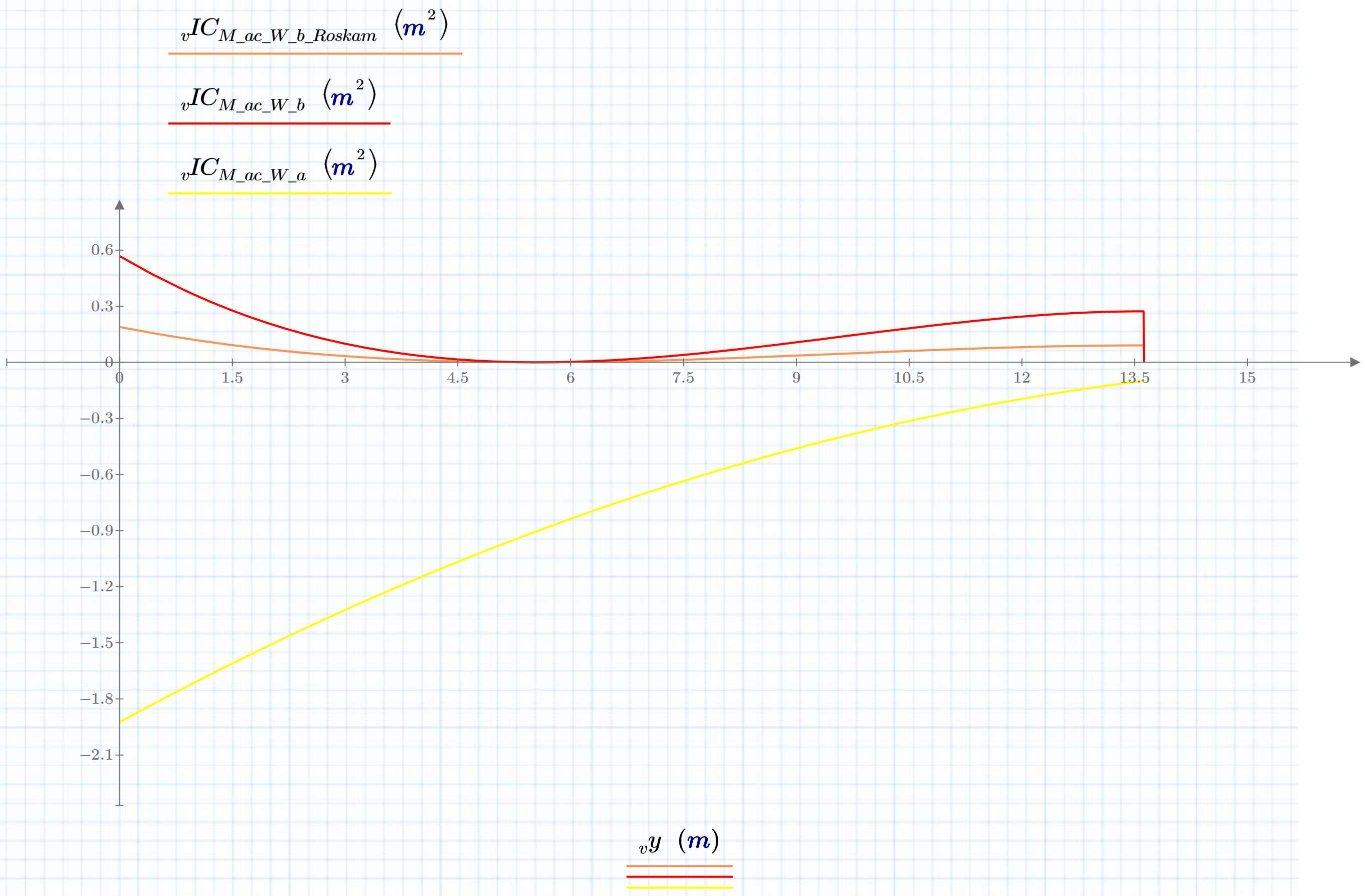
$$ C_{M\_ac\_W} := C_{M\_ac\_W\_b} + C_{M\_ac\_W\_a} = -0.057 \qquad C_{M\_ac\_W} = -0.05704 $$

Approximated formulation (Roskam)

$$ C_{M\_ac\_W\_b\_Roskam} := \frac{2 \cdot \pi}{S_W \cdot MAC_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}\alpha_{b}(y) \cdot {}_{f}c_{W}(y) \cdot {}_{f}x_{b\_W}(y) \, dy = 0.014 \qquad C_{M\_ac\_W\_b\_Roskam} = 0.014 $$

$$ C_{M\_ac\_W\_Roskam} := C_{M\_ac\_W\_b\_Roskam} + C_{M\_ac\_W\_a} = -0.056 \qquad C_{M\_ac\_W\_Roskam} = -0.056 $$

Integrand functions plot



DOWNWASH

Prandtl Lifting Line Theory (LLT)

$$_f\varepsilon_{\alpha\_LLT\_W}\left(C_{L\alpha}, AR, e, M\right) := \text{if}\left(AR = 0, 0, 2 \cdot \frac{C_{L\alpha}}{\pi \cdot AR \cdot e} \cdot \frac{1}{\sqrt{1-M^2}}\right)$$

• Downwash gradient according to linear theory

$$\varepsilon_{\alpha\_LLT\_@M0\_W} := {_f\varepsilon_{\alpha\_LLT\_W}}\left(C_{L\alpha\_W}, AR_W, e_W, 0\right) = 0.51$$

$$\varepsilon_{\alpha\_LLT\_@M0\_W} = 0.51$$

$$\varepsilon_{\alpha\_LLT\_W} := {_f\varepsilon_{\alpha\_LLT\_W}}\left(C_{L\alpha\_W}, AR_W, e_W, M_1\right) = 0.71$$

$$\varepsilon_{\alpha\_LLT\_W} = 0.71$$

$$\varepsilon_{0\_LLT\_W} := \varepsilon_{\alpha\_LLT\_W} \cdot \left(i_W - \alpha_{0L\_W}\right) = 0.048$$

$$\varepsilon_{0\_LLT\_W} = 2.775\ deg$$

DATCOM Method

$$\Delta X\_HT_{LE}\_W_{LE} := \Delta X\_HT_{LE}\_Nose - \Delta X\_W_{LE}\_Nose = 16.734\ m$$

$\Delta X\_HT_{LE}\_W_{LE} = 16.7$ [redacted] m

$$\Delta Z\_HT_{LE}\_W_{LE} := \Delta Z\_HT_{LE}\_Nose - \Delta Z\_W_{LE}\_Nose = 7.041\ m$$

$\Delta Z\_HT_{LE}\_W_{LE} = 7.04$ [redacted] m

$$\xi_{ac\_H} := K1_{ac\_H\_Datcom} \cdot \left(X_{ac\_over\_c_{r\_H\_Datcom}} - K2_{ac\_H\_Datcom}\right) = 0.264$$

$\xi_{ac\_H} = 0.264$

$$\Delta Z\_HT_{MAC4}\_W_{MAC4} := \Delta Z\_HT_{LE}\_W_{LE} + Y_{MAC\_H} \cdot \tan\left(\Gamma_H\right) - Y_{MAC\_W} \cdot \tan\left(\Gamma_{W\_eqv}\right) = 6.834\ m$$

• Normal to FRL

$$\Delta X\_HT_{MAC4}\_W_{MAC4} := \Delta X\_HT_{LE}\_W_{LE} + \left(X_{MAC\_LE\_H} + \frac{MAC_H}{4}\right) - \left(X_{MAC\_LE\_W} + \frac{MAC_W}{4}\right) = 15.231\ m$$

• Parallel to FRL

$$\Delta Z'\_HT_{MAC4}\_W_{MAC4} := \Delta X\_HT_{MAC4}\_W_{MAC4} \cdot \sin\left(i_W\right) + \Delta Z\_HT_{MAC4}\_W_{MAC4} \cdot \cos\left(i_W\right) = 7.362\ m$$

• Normal to root chord

$$\Delta X'\_HT_{MAC4}\_W_{MAC4} := \Delta X\_HT_{MAC4}\_W_{MAC4} \cdot \cos\left(i_W\right) - \Delta Z\_HT_{MAC4}\_W_{MAC4} \cdot \sin\left(i_W\right) = 14.983\ m$$

• Parallel to root chord

$$\Delta X\_HT_{ac}\_W_{ac} := \Delta X\_HT_{LE}\_W_{LE} + \left(X_{MAC\_LE\_H} + \xi_{ac\_H} \cdot MAC_H\right) - X_{ac\_W} = 15.107\ m$$

$\Delta X\_HT_{ac}\_W_{ac} = 15.10$ [redacted] m

$$\Delta Z\_HT_{ac}\_W_{ac} := \Delta Z\_HT_{MAC4}\_W_{MAC4} = 6.834\ m$$

$\Delta Z\_HT_{ac}\_W_{ac} = 6.834$ [redacted] m

• Empirical coefficients function definitions

$${}_{f}K_{AR}\left(AR\right) := \frac{1}{AR} - \frac{1}{1 + \left(AR\right)^{1.7}}$$

$${}_{f}K_{\lambda}\left(\lambda\right) := \frac{10 - 3 \cdot \lambda}{7}$$

$$K_M\left(M, C_{L\alpha\_@M0}, C_{L\alpha}\right) := \begin{array}{l} \text{if } M \le 0.7 \\ \quad \left\| \text{return } \sqrt{1 - M^2} \right. \\ \text{else} \\ \quad \left\| \text{return } \dfrac{C_{L\alpha}}{C_{L\alpha\_@M0}} \right. \end{array}$$

$${}_{f}K_{MAC4}\left(\Delta Z', \Delta X', b\right) := \frac{1 - \dfrac{\Delta Z'}{b}}{\sqrt[3]{2 \cdot \dfrac{\Delta X'}{b}}}$$

$$K_{AR\_W} := {}_{f}K_{AR}\left(AR_W\right) = 0.092$$

$K_{AR\_W} = 0.092$

$$K_{\lambda\_W} := {}_{f}K_{\lambda}\left(\lambda_W\right) = 1.331$$

$K_{\lambda\_W} = 1.331$

$$K_{MAC4\_WH} := {}_{f}K_{MAC4}\left(\Delta Z'\_HT_{MAC4}\_W_{MAC4}, \Delta X'\_HT_{MAC4}\_W_{MAC4}, b_W\right) = 0.707$$

$K_{MAC4\_WH} = 0.707$

$$K_{M\_W} := K_M\left(M_1, C_{L\alpha\_W\_@M0}, C_{L\alpha\_W}\right) = 0.718$$

$K_{M\_W} = 0.718$

$$\varepsilon_{\alpha\_@M0\_W} := 4.44 \cdot \left(K_{AR\_W} \cdot K_{\lambda\_W} \cdot K_{MAC4\_WH} \cdot \sqrt{\cos\left(\Lambda_{W\_c4\_eqv}\right)}\right)^{1.19} = 0.229$$

$\varepsilon_{\alpha\_@M0\_W} = 0.229$

$$\varepsilon_{\alpha\_W} := \varepsilon_{\alpha\_@M0\_W} \cdot \sqrt{1 - M_1^{\ 2}}$$

$\varepsilon_{\alpha\_W} = 0.164$

$$\varepsilon_{0\_W} := \varepsilon_{\alpha\_W} \cdot \left(i_W - \alpha_{0L\_W}\right) = 0.011$$

$\varepsilon_{0\_W} = 0.643\ deg$

MISCELLANEOUS PARAMETERS PLOT

MAPPING AND OUTPUT CREATION

Includi << ../Default_Map_Wing.mcdx

Excel Writing

$First\_Row_{W\_1} := 4$

$Block_{W\_1} := {}_f\mathrm{map\_matrix\_transform}\left({}_m Wing\_Data\_Map_{imported}\right)$

$Excel\_Output_{W\_1} := {}_f\mathrm{write\_full\_output}\left({}_s Output\_Excel\_File, Block_{W\_1}, n_{sheet}, First\_Row_{W\_1}\right)$

$First\_Row_{W\_2} := First\_Row_{W\_1} + \mathrm{rows}\left(Block_{W\_1}\right) + 2 = 25$

$Block_{W\_2} := {}_f\mathrm{map\_matrix\_transform}\left({}_m Wing\_Data\_Map_{input}\right)$

$Excel\_Output_{W\_2} := {}_f\mathrm{write\_full\_output}\left({}_s Output\_Excel\_File, Block_{W\_2}, n_{sheet}, First\_Row_{W\_2}\right)$

$First\_Row_{W\_3} := First\_Row_{W\_2} + \mathrm{rows}\left(Block_{W\_2}\right) + 2 = 87$

$Block_{W\_3} := {}_f\mathrm{map\_matrix\_transform}\left({}_m Wing\_Data\_Map\right)$

$Excel\_Output_{W\_3} := {}_f\mathrm{write\_full\_output}\left({}_s Output\_Excel\_File, Block_{W\_3}, n_{sheet}, First\_Row_{W\_3}\right)$

$First\_Row_{W\_4} := First\_Row_{W\_3} + \mathrm{rows}\left(Block_{W\_3}\right) + 2 = 373$

$Block_{W\_4} := {}_f\mathrm{map\_matrix\_transform}\left({}_m Wing\_Data\_Map_{COP}\right)$

$Excel\_Output_{W\_4} := {}_f\mathrm{write\_full\_output}\left({}_s Output\_Excel\_File, Block_{W\_4}, n_{sheet}, First\_Row_{W\_4}\right)$

$First\_Row_{W\_5} := First\_Row_{W\_4} + \mathrm{rows}\left(Block_{W\_4}\right) + 2 = 407$

$Block_{W\_5} := {}_f\mathrm{map\_matrix\_transform}\left({}_m Wing\_Data\_Map_{LLCoeffs}\right)$

$Excel\_Output_{W\_5} := {}_f\mathrm{write\_full\_output}\left({}_s Output\_Excel\_File, Block_{W\_5}, n_{sheet}, First\_Row_{W\_5}\right)$

$First\_Row_{W\_6} := First\_Row_{W\_5} + \mathrm{rows}\left(Block_{W\_5}\right) + 2 = 475$

$Block_{W\_6} := {}_f\mathrm{map\_matrix\_transform}\left({}_m Wing\_Data\_Map_{Misc}\right)$

$Excel\_Output_{W\_6} := {}_f\mathrm{write\_full\_output}\left({}_s Output\_Excel\_File, Block_{W\_6}, n_{sheet}, First\_Row_{W\_6}\right)$

CSV Tabs Writing

$${}_m CSV_{W\_1} := \mathrm{augment}\left({}_v y, {}_v c_{ell}, {}_v c_{eff}, {}_v cC_{l\_a}, {}_v cC_{l\_b}\right) \cdot \frac{1}{m}$$

$CSV\_Output_{W\_1} := \mathrm{WRITECSV}\left(\text{“.\textbackslash Output\textbackslash WING\_shrenk\_loading(y,c\_ell,c\_eff,cCl\_a,cCl\_b).csv”}, {}_m CSV_{W\_1}\right)$

$${}_m CSV_{W\_2} := \mathrm{augment}\left({}_v y \cdot \frac{1}{m}, {}_v x_{b\_W} \cdot \frac{1}{m}, {}_v IC_{M\_ac\_W\_b} \cdot \frac{1}{m^2}, {}_v IC_{M\_ac\_W\_b\_Roskam} \cdot \frac{1}{m^2}\right)$$

$CSV\_Output_{W\_2} := \mathrm{WRITECSV}\left(\text{“.\textbackslash Output\textbackslash WING\_shrenk−roskam\_loading(y,x\_b,IC\_M\_b,IC\_M\_b\_Roskam).csv”}, {}_m CSV_{W\_2}\right)$

$${}_m CSV_{W\_3} := \mathrm{augment}\left({}_v y \cdot \frac{1}{m}, {}_v c_W \cdot \frac{1}{m}, {}_v \alpha_{0l\_2D}, {}_v \varepsilon_g, {}_v C_{l\alpha\_W}, {}_v C_{m\_ac\_2D\_W}, {}_v \xi_{ac\_2D\_W}\right)$$

$CSV\_Output_{W\_3} := \mathrm{WRITECSV}\left(\text{“.\textbackslash Output\textbackslash WING\_linear\_laws(y,c,alphazl,epsilon,Clalpha,Cmac,Csiac).csv”}, {}_m CSV_{W\_3}\right)$

$${}_{m}CSV_{W\_4} := \text{augment}\left({}_{v}X_{W}, {}_{v}Y_{W}\right) \cdot \frac{1}{m}$$

$$CSV\_Output_{W\_4} := \text{WRITECSV}\left(\text{“.\textbackslash Output\textbackslash WING\_planform(X\_W,Y\_W).csv”}, {}_{m}CSV_{W\_4}\right)$$

$${}_{m}CSV_{W\_5} := \text{augment}\left({}_{v}X_{mac.1}, {}_{v}Y_{mac.1}, {}_{v}X_{mac.2}, {}_{v}Y_{mac.2}, {}_{v}X_{mac.W}, {}_{v}Y_{mac.W}, {}_{v}X_{ac\_W}, {}_{v}Y_{ac\_W}\right) \cdot \frac{1}{m}$$

$$CSV\_Output_{W\_5} := \text{WRITECSV}\left(\text{“.\textbackslash Output\textbackslash WING\_planform\_MAC\_and\_AC(Xmac1,Ymac1,Xmac2,Ymac2,XmacW,YmacW).csv”}, {}_{m}CSV_{W\_5}\right)$$

$${}_{m}CSV_{W\_6} := \text{augment}\left({}_{v}X_{ac\_2D}, {}_{v}Y_{ac\_2D}\right) \cdot \frac{1}{m}$$

$$CSV\_Output_{W\_6} := \text{WRITECSV}\left(\text{“.\textbackslash Output\textbackslash WING\_planform\_ac2D(Xac2D,Yac2D).csv”}, {}_{m}CSV_{W\_6}\right)$$

TeX Macro writing on .tex

$${}_{v}complete\_macros_{W} := \text{stack}\left(Block_{W\_1}^{\langle 2\rangle}, Block_{W\_2}^{\langle 2\rangle}, Block_{W\_3}^{\langle 2\rangle}, Block_{W\_4}^{\langle 2\rangle}, Block_{W\_5}^{\langle 2\rangle}, Block_{W\_6}^{\langle 2\rangle}\right)$$

$${}_{v}tex_{W} := {}_{f}\text{write\_matrix}\left(\text{“.\textbackslash Output\textbackslash WING\_TeX\_Macros.tex”}, {}_{v}complete\_macros_{W}, \text{“ ”}\right)$$