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

$b_W = 60.92\ m$ $\quad i_W = 2\ deg$

$c_{W\_r} = 15.57\ m$ $\quad c_{W\_kink} = 8.51\ m$ $\quad c_{W\_t} = 2.15\ m$

$t\_over\_c_{W\_r} = 0.16$ $\quad t\_over\_c_{W\_kink} = 0.118$ $\quad t\_over\_c_{W\_t} = 0.1$

$\alpha_{0l\_W\_r} = -0.032$ $\quad \alpha_{0l\_W\_kink} = -0.038$ $\quad \alpha_{0l\_W\_t} = -0.027$

$C_{l\alpha\_W\_r} = 7.105$ $\quad C_{l\alpha\_W\_kink} = 6.876$ $\quad C_{l\alpha\_W\_t} = 6.79$

$C_{m\_ac\_W\_r} = -0.035$ $\quad C_{m\_ac\_W\_kink} = -0.03$ $\quad C_{m\_ac\_W\_t} = -0.04$

$\xi_{ac\_W\_r} = 0.27$ $\quad \xi_{ac\_W\_kink} = 0.26$ $\quad \xi_{ac\_W\_t} = 0.25$

$M_{cr\_W\_2D\_r} = 0.63$ $\quad M_{cr\_W\_2D\_kink} = 0.65$ $\quad M_{cr\_W\_2D\_t} = 0.66$

$\varepsilon_{W\_kink} = 0$ $\quad \varepsilon_{W\_t} = -0.061$

$\eta_{a\_in} = 0.73$ $\quad \eta_{a\_out} = 0.95$ $\quad c_a = 0.95\ m$

$\eta_{flap\_in} = 0.3$ $\quad \eta_{flap\_out} = 0.6$ $\quad c_{flap} = 0.75\ m$

$\Delta\alpha_{0l\_W\_flaps} = 0.14$

Wing, inner panel parameters

$b_{W\_1} = 21.48\ \mathbf{m}$

$c_{W\_r\_1} = 15.57\ \mathbf{m}$

$c_{W\_t\_1} = 8.51\ \mathbf{m}$

$t\_over\_c_{W\_r\_1} = 0.16$

$t\_over\_c_{W\_t\_1} = 0.118$

$\Lambda_{W\_LE\_1} = 34.5\ \mathbf{deg}$

$\Gamma_{W\_1} = 7\ \mathbf{deg}$

$\varepsilon_{W\_t\_1} = 0\ \mathbf{deg}$

$\alpha_{0l\_W\_r\_1} = -1.845\ \mathbf{deg}$

$\alpha_{0l\_W\_t\_1} = -2.175\ \mathbf{deg}$

$C_{l\alpha\_W\_r\_1} = 0.124\ \mathbf{deg}^{-1}$

$C_{l\alpha\_W\_t\_1} = 0.12\ \mathbf{deg}^{-1}$

$C_{m\_ac\_W\_r\_1} = -0.035$

$C_{m\_ac\_W\_t\_1} = -0.03$

$\xi_{ac\_W\_r\_1} = 0.27$

$\xi_{ac\_W\_t\_1} = 0.26$

$\xi_{tmax\_W\_1} = 0.368$

$M_{cr\_W\_2D\_r\_1} = 0.63$

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

Wing, outer panel parameters

$b_{W\_2} = 39.44\ \mathbf{m}$

$c_{W\_r\_2} = 8.51\ \mathbf{m}$

$c_{W\_t\_2} = 2.15\ \mathbf{m}$

$t\_over\_c_{W\_r\_2} = 0.118$

$t\_over\_c_{W\_t\_2} = 0.1$

$\Lambda_{W\_LE\_2} = 34.5\ \mathbf{deg}$

$\Gamma_{W\_2} = 7\ \mathbf{deg}$

$\varepsilon_{W\_t\_2} = -3.5\ \mathbf{deg}$

$\alpha_{0l\_W\_r\_2} = -2.175\ \mathbf{deg}$

$\alpha_{0l\_W\_t\_2} = -1.525\ \mathbf{deg}$

$C_{l\alpha\_W\_r\_2} = 0.12\ \mathbf{deg}^{-1}$

$C_{l\alpha\_W\_t\_2} = 0.119\ \mathbf{deg}^{-1}$

$C_{m\_ac\_W\_r\_2} = -0.03$

$C_{m\_ac\_W\_t\_2} = -0.04$

$\xi_{ac\_W\_r\_2} = 0.26$

$\xi_{ac\_W\_t\_2} = 0.25$

$\xi_{tmax\_W\_2} = 0.3$

$M_{cr\_W\_2D\_r\_2} = 0.65$

$M_{cr\_W\_2D\_t\_2} = 0.66$

Imported parameters

$M_1 = 0.65$

$b_H = 21.96\ \mathbf{m}$

$\Delta X\_W_{LE}\_Nose = 25.05\ \mathbf{m}$

$\Lambda_{H\_LE} = 39\ \mathbf{deg}$

$\Delta X\_HT_{LE}\_Nose = 63.4\ \mathbf{m}$

$\Gamma_H = 8.5\ \mathbf{deg}$

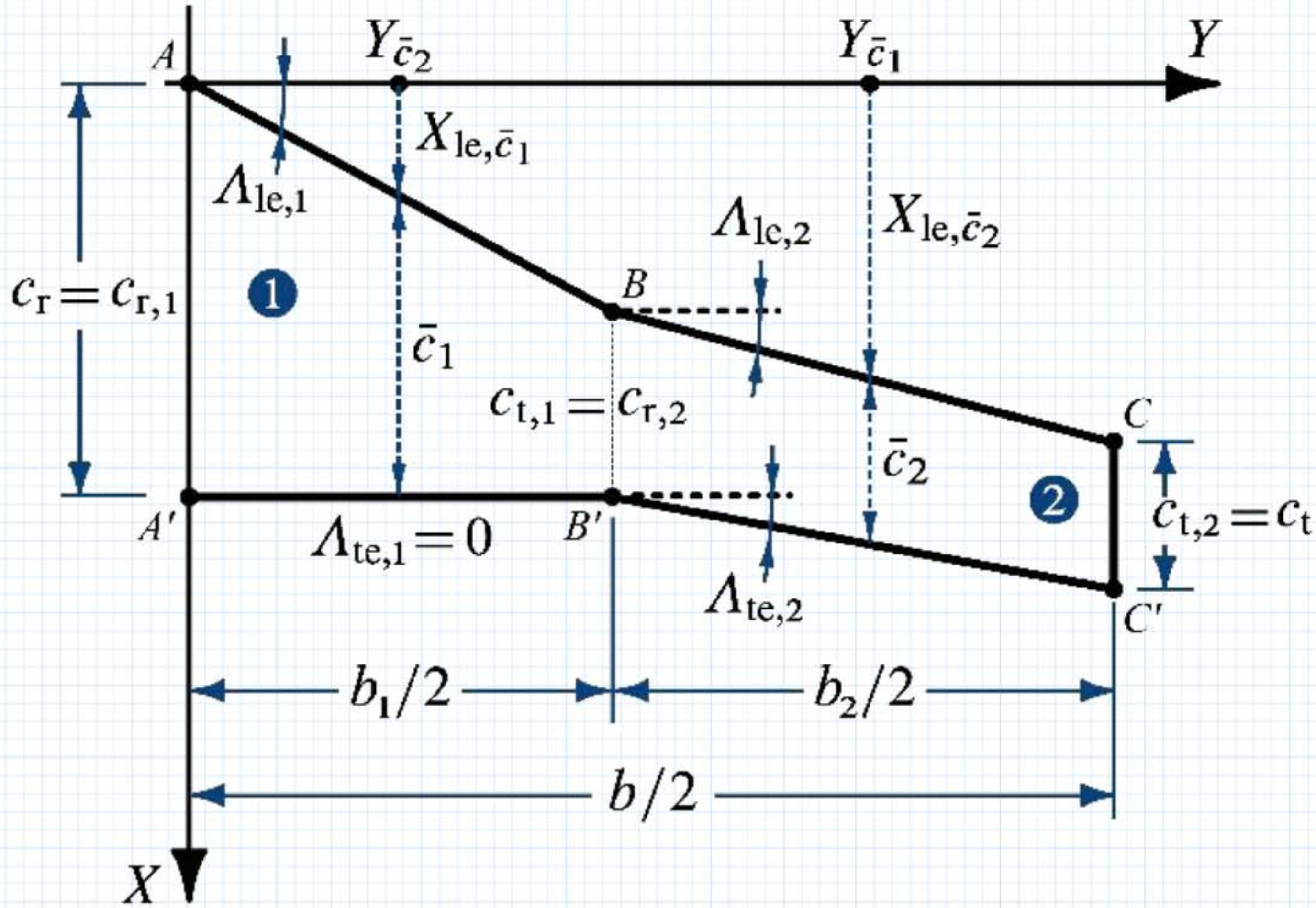
$\Delta Z\_W_{LE}\_Nose = -0.75\ \mathbf{m}$

$c_{H\_r} = 7.2\ \mathbf{m}$

$\Delta Z\_HT_{LE}\_Nose = 1.35\ \mathbf{m}$

$c_{H\_t} = 2.4\ \mathbf{m}$

WING PARAMETERS CALCULATIONS



Wing, inner panel basic parameters

$\lambda_{W\_1} := \dfrac{c_{W\_t\_1}}{c_{W\_r\_1}} = 0.547$	$\lambda_{W\_1} = 0.547$
$S_{W\_1} := \dfrac{b_{W\_1}}{2} \cdot c_{W\_r\_1} \cdot \left(1 + \lambda_{W\_1}\right) = 258.619\ m^2$	$S_{W\_1} = 258.619\ m^2$
$AR_{W\_1} := \dfrac{{b_{W\_1}}^2}{S_{W\_1}} = 1.784$	$AR_{W\_1} = 1.784$
$MAC_{W\_1} := \dfrac{2}{3} \cdot c_{W\_r\_1} \cdot \left(\dfrac{1 + {\lambda_{W\_1}}^2 + \lambda_{W\_1}}{1 + \lambda_{W\_1}}\right) = 12.385\ m$	$MAC_{W\_1} = 12.385\ m$
$X_{MAC\_LE\_W\_1} := \dfrac{b_{W\_1}}{6} \cdot \dfrac{\left(1 + 2 \cdot \lambda_{W\_1}\right)}{\left(1 + \lambda_{W\_1}\right)} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) = 3.33\ m$	$X_{MAC\_LE\_W\_1} = 3.33\ m$
$Y_{MAC\_W\_1} := \dfrac{b_{W\_1}}{6} \cdot \dfrac{1 + 2 \cdot \lambda_{W\_1}}{1 + \lambda_{W\_1}} = 4.845\ m$	$Y_{MAC\_W\_1} = 4.845\ m$
$Z_{MAC\_W\_1} := Y_{MAC\_W\_1} \cdot \tan\left(\Gamma_{W\_1}\right) = 0.595\ m$	$Z_{MAC\_W\_1} = 0.595\ m$

Wing, outer panel basic parameters

$\lambda_{W\_2} := \frac{c_{W\_t\_2}}{c_{W\_r\_2}} = 0.253$ $\lambda_{W\_2} = 0.253$

$S_{W\_2} := \frac{b_{W\_2}}{2} \cdot c_{W\_r\_2} \cdot (1 + \lambda_{W\_2}) = 210.215\ m^2$ $S_{W\_2} = 210.215\ m^2$

$AR_{W\_2} := \frac{2 \cdot b_{W\_2}}{c_{W\_r\_2} \cdot (1 + \lambda_{W\_2})} = 7.4$ $AR_{W\_2} = 7.4$

$MAC_{W\_2} := \frac{2}{3} \cdot c_{W\_r\_2} \cdot \left(\frac{1 + \lambda_{W\_2}{}^2 + \lambda_{W\_2}}{1 + \lambda_{W\_2}} \right) = 5.962\ m$ $MAC_{W\_2} = 5.962\ m$

$X_{MAC\_LE\_W\_2} := \frac{b_{W\_2}}{6} \cdot \frac{(1 + 2 \cdot \lambda_{W\_2})}{(1 + \lambda_{W\_2})} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 5.429\ m$ $X_{MAC\_LE\_W\_2} = 5.429\ m$

$Y_{MAC\_W\_2} := \left(\frac{b_{W\_2}}{6} \cdot \frac{1 + 2 \cdot \lambda_{W\_2}}{1 + \lambda_{W\_2}} \right) = 7.899\ m$ $Y_{MAC\_W\_2} = 7.899\ m$

$Z_{MAC\_W\_2} := Y_{MAC\_W\_2} \cdot \tan\left(\Gamma_{W\_2}\right) = 0.97\ m$ $Z_{MAC\_W\_2} = 0.97\ m$

Wing, global basic parameters

$\lambda_W := \frac{c_{W\_t}}{c_{W\_r}} = 0.138$ $\lambda_W = 0.138$

$S_W := S_{W\_1} + S_{W\_2} = 468.834\ m^2$ $S_W = 468.834\ m^2$

$AR_W := \frac{\left(b_{W\_1} + b_{W\_2}\right)^2}{S_W} = 7.916$ $AR_W = 7.916$

$MAC_W := \frac{S_{W\_1} \cdot MAC_{W\_1} + S_{W\_2} \cdot MAC_{W\_2}}{S_{W\_1} + S_{W\_2}} = 9.505\ m$ $MAC_W = 9.505\ m$

$\xi_{tmax\_W} := \frac{\xi_{tmax\_W\_1} \cdot S_{W\_1} + \xi_{tmax\_W\_2} \cdot S_{W\_2}}{S_{W\_1} + S_{W\_2}} = 0.338$ $\xi_{tmax\_W} = 0.338$

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

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

$$_{f}c_{W}(y) := \begin{cases} \text{if } y \le \dfrac{b_{W\_1}}{2} \\ \quad \text{return } _{f}c_{W\_1}(y) \\ \text{else} \\ \quad \text{return } _{f}c_{W\_2}(y) \end{cases}$$

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

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

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

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

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

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

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

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

Wing, inner panel 2D mean quantities

$$t\_over\_c_{W\_mean\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y) \cdot {}_{f}t\_over\_c_W(y)\, dy = 0.141 \qquad t\_over\_c_{W\_mean\_1} = 0.141$$

$$C_{l\alpha\_W\_mean\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y) \cdot {}_{f}C_{l\alpha\_W}(y)\, dy = 7.002 \qquad C_{l\alpha\_W\_mean\_1} = 0.122\ \mathbf{deg}^{-1}$$

$$\alpha_{0l\_W\_mean\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y) \cdot {}_{f}\alpha_{0l\_2D\_W}(y)\, dy = -0.035\ \mathbf{rad} \qquad \alpha_{0l\_W\_mean\_1} = -1.994\ \mathbf{deg}$$

$$C_{m\_ac\_W\_mean\_1} := \frac{2}{S_{W\_1} \cdot MAC_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{f}c_W(y)^2 \cdot {}_{f}C_{m\_ac\_2D\_W}(y)\, dy = -0.033 \qquad C_{m\_ac\_W\_mean\_1} = -0.033$$

Wing, outer panel 2D mean quantities

$$t\_over\_c_{W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, t\_over\_c_{W\_t}, \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}t\_over\_c_W(y)\, dy\right) = 0.111 \qquad t\_over\_c_{W\_mean\_2} = 0.111$$

$$C_{l\alpha\_W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, C_{l\alpha\_W\_t}, \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}C_{l\alpha\_W}(y)\, dy\right) = 6.842\ \mathbf{rad}^{-1} \qquad C_{l\alpha\_W\_mean\_2} = 0.119\ \mathbf{deg}^{-1}$$

$$\alpha_{0l\_W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, \alpha_{0l\_W\_t}, \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}\alpha_{0l\_2D\_W}(y)\, dy\right) = -0.033\ \mathbf{rad} \qquad \alpha_{0l\_W\_mean\_2} = -1.915\ \mathbf{deg}$$

$$C_{m\_ac\_W\_mean\_2} := \text{if}\left({}_{b}Crk = 0, C_{m\_ac\_W\_t}, \frac{2}{S_{W\_2} \cdot MAC_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{f}c_W(y)^2 \cdot {}_{f}C_{m\_ac\_2D\_W}(y)\, dy\right) = -0.033 \qquad C_{m\_ac\_W\_mean\_2} = -0.033$$

Wing, global 2D mean quantities

$$t\_over\_c_{W\_mean} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}t\_over\_c_W(y)\, dy = 0.127 \qquad t\_over\_c_{W\_mean} = 0.127$$

$$C_{l\alpha\_W\_mean} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}C_{l\alpha\_W}(y)\, dy = 6.93 \qquad C_{l\alpha\_W\_mean} = 0.121\ \mathbf{deg}^{-1}$$

$$\alpha_{0l\_W\_mean} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}c_W(y) \cdot {}_{f}\alpha_{0l\_2D\_W}(y)\, dy = -0.034\ \mathbf{rad} \qquad \alpha_{0l\_W\_mean} = -1.958\ \mathbf{deg}$$

$$C_{m\_ac\_W\_mean} := \frac{2}{S_W \cdot MAC_W} \cdot \int^{\frac{b_W}{2}} {}_{f}c_W(y)^2 \cdot {}_{f}C_{m\_ac\_2D\_W}(y)\, dy = -0.033 \qquad C_{m\_ac\_W\_mean} = -0.033$$

$S_W \cdot MAC_W \quad \int_0$

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

$$\alpha_{0L\_W\_1} := \frac{2}{S_{W\_1}} \cdot \int_0^{\frac{b_{W\_1}}{2}} {}_{\mathrm{f}}c_{\mathrm{W}}(y) \cdot \left({}_{\mathrm{f}}\alpha_{\mathrm{0l\_2D\_W}}(y) - {}_{\mathrm{f}}\varepsilon_{\mathrm{g\_W}}(y)\right) \mathrm{d}y = -0.035 \ \textbf{\textit{rad}} \qquad \alpha_{0L\_W\_1} = -1.994 \ \textbf{\textit{deg}}$$

$$\alpha_{0L\_W\_2} := \mathbf{if}\left({}_bCrk = 0, \alpha_{0l\_W\_t}, \frac{2}{S_{W\_2}} \cdot \int_{\frac{b_{W\_1}}{2}}^{\frac{b_W}{2}} {}_{\mathrm{f}}c_{\mathrm{W}}(y) \cdot \left({}_{\mathrm{f}}\alpha_{\mathrm{0l\_2D\_W}}(y) - {}_{\mathrm{f}}\varepsilon_{\mathrm{g\_W}}(y)\right) \mathrm{d}y\right) = -0.009 \ \textbf{\textit{rad}} \qquad \alpha_{0L\_W\_2} = -0.513 \ \textbf{\textit{deg}}$$

$$\alpha_{0L\_W} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{\mathrm{f}}c_{\mathrm{W}}(y) \cdot \left({}_{\mathrm{f}}\alpha_{\mathrm{0l\_2D\_W}}(y) - {}_{\mathrm{f}}\varepsilon_{\mathrm{g\_W}}(y)\right) \mathrm{d}y = -0.023 \ \textbf{\textit{rad}} \qquad \alpha_{0L\_W} = -1.33 \ \textbf{\textit{deg}}$$

Wing, sweep angles for inner/outer panel

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

• **Sweep angle function**

$\Lambda_{W\_LE\_1} := {}_{\mathrm{f}}\Lambda(0, \Lambda_{W\_LE\_1}, AR_{W\_1}, \lambda_{W\_1}) = 0.602$ $\qquad \Lambda_{W\_LE\_1} = 34.5$ ***deg***

$\Lambda_{W\_TE\_1} := {}_{\mathrm{f}}\Lambda(1, \Lambda_{W\_LE\_1}, AR_{W\_1}, \lambda_{W\_1}) = 0.03$ $\qquad \Lambda_{W\_TE\_1} = 1.714$ ***deg***

$\Lambda_{W\_c4\_1} := {}_{\mathrm{f}}\Lambda(0.25, \Lambda_{W\_LE\_1}, AR_{W\_1}, \lambda_{W\_1}) = 0.482$ $\qquad \Lambda_{W\_c4\_1} = 27.607$ ***deg***

$\Lambda_{W\_c2\_1} := {}_{\mathrm{f}}\Lambda(0.5, \Lambda_{W\_LE\_1}, AR_{W\_1}, \lambda_{W\_1}) = 0.344$ $\qquad \Lambda_{W\_c2\_1} = 19.728$ ***deg***

$\Lambda_{W\_tmax\_1} := {}_{\mathrm{f}}\Lambda(\xi_{tmax\_W\_1}, \Lambda_{W\_LE\_1}, AR_{W\_1}, \lambda_{W\_1}) = 0.419$ $\qquad \Lambda_{W\_tmax\_1} = 24.007$ ***deg***

$\Lambda_{W\_LE\_2} := {}_{\mathrm{f}}\Lambda(0, \Lambda_{W\_LE\_2}, AR_{W\_2}, \lambda_{W\_2}) = 0.602$ $\qquad \Lambda_{W\_LE\_2} = 34.5$ ***deg***

$\Lambda_{W\_TE\_2} := {}_{\mathrm{f}}\Lambda(1, \Lambda_{W\_LE\_2}, AR_{W\_2}, \lambda_{W\_2}) = 0.35$ $\qquad \Lambda_{W\_TE\_2} = 20.04$ ***deg***

$\Lambda_{W\_c4\_2} := {}_{\mathrm{f}}\Lambda(0.25, \Lambda_{W\_LE\_2}, AR_{W\_2}, \lambda_{W\_2}) = 0.545$ $\qquad \Lambda_{W\_c4\_2} = 31.243$ ***deg***

$\Lambda_{W\_c2\_2} := {}_{\mathrm{f}}\Lambda(0.5, \Lambda_{W\_LE\_2}, AR_{W\_2}, \lambda_{W\_2}) = 0.484$ $\qquad \Lambda_{W\_c2\_2} = 27.745$ ***deg***

$\Lambda_{W\_tmax\_2} := {}_{\mathrm{f}}\Lambda(\xi_{tmax\_W\_2}, \Lambda_{W\_LE\_2}, AR_{W\_2}, \lambda_{W\_2}) = 0.533$ $\qquad \Lambda_{W\_tmax\_2} = 30.563$ ***deg***

Wing, Mean Aerodynamic Chord position with respect to Wing Apex

$$ {}_{f}\mathrm{Y}_{\mathrm{MAC\_W}}(MAC) := \begin{array}{l} \text{if } MAC \ge c_{W\_t\_1} \\ \quad \text{return } \dfrac{b_{W\_1} \cdot (MAC - c_{W\_r\_1})}{2 \cdot (c_{W\_t\_1} - c_{W\_r\_1})} \\ \text{else} \\ \quad \text{return } \dfrac{b_{W\_1}}{2} + \dfrac{b_{W\_2} \cdot (MAC - c_{W\_r\_2})}{2 \cdot (c_{W\_t\_2} - c_{W\_r\_2})} \end{array} $$

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

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

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

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

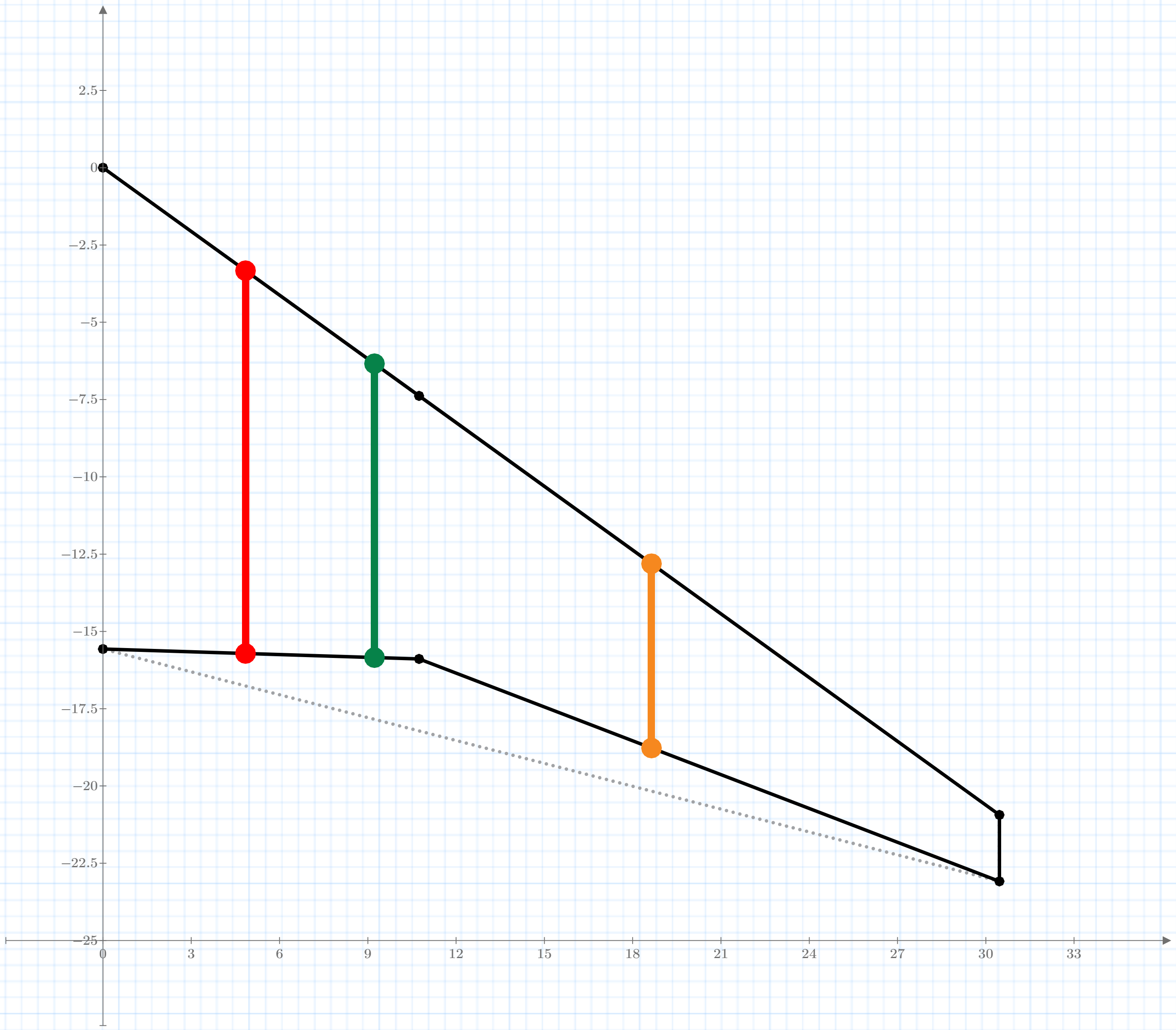
- **Function for Mean Aerodynamic Chord distance from wing apex, along Z axis**

$$ X_{MAC\_LE\_W} := {}_{f}\mathrm{X}_{\mathrm{MAC\_LE\_W}}(MAC_W) = 6.341\ \boldsymbol{m} $$

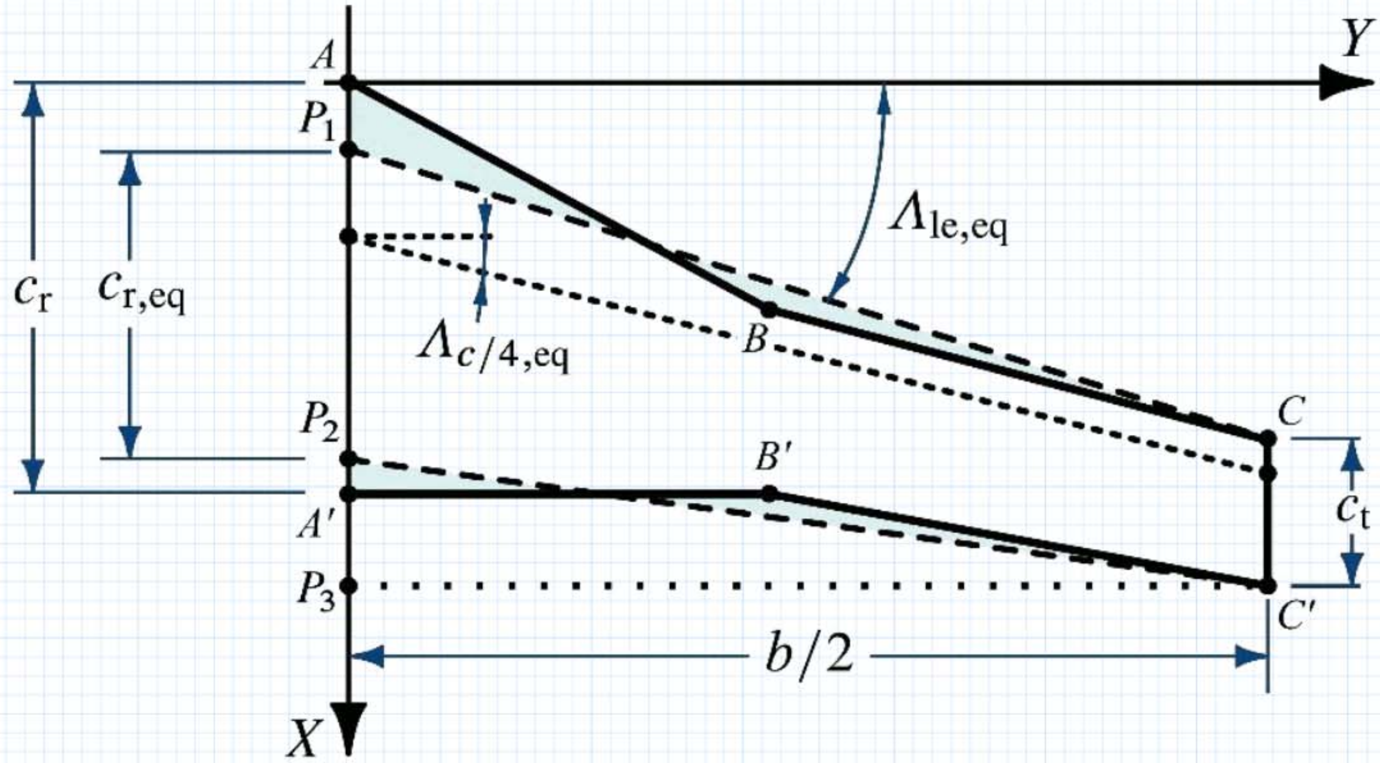
$$ Y_{MAC\_W} := {}_{f}\mathrm{Y}_{\mathrm{MAC\_W}}(MAC_W) = 9.226\ \boldsymbol{m} $$

$$ Z_{MAC\_W} := {}_{f}\mathrm{Z}_{\mathrm{MAC\_W}}(MAC_W) = 1.133\ \boldsymbol{m} $$

Wing planform with Mean Aerodynamic Chord



EQUIVALENT WING PARAMETERS CALCULATIONS



Equivalent Wing, geometric parameters

$X_B := \frac{b_{W\_1}}{2} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) = 7.381\ m$

$Y_B := \frac{b_{W\_1}}{2} = 10.74\ m$

$X_C := X_B + \frac{b_{W\_2}}{2} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 20.935\ m$

$Y_C := \frac{b_W}{2} = 30.46\ m$

$X_{C'} := X_C + c_{W\_t\_2} = 23.085\ m$

$Y_{C'} := Y_C$

$X_{B'} := X_B + c_{W\_t\_1} = 15.891\ m$

$Y_{B'} := Y_B = 10.74\ m$

$X_{A'} := c_{W\_r\_1} = 15.57\ m$

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

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

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

Equivalent Wing, planform results

$X_{P1} = 0\ m$

$X_{P2} = 13.242\ m$

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

$X_{W\_r\_TE\_eqv} := X_{P2} = 13.242\ m$

$c_{W\_r\_eqv} := \left|X_{P2} - X_{P1}\right| = 13.242\ m$

$\lambda_{W\_eqv} := \frac{c_{W\_t}}{c_{W\_r\_eqv}} = 0.162$

$AR_{W\_eqv} := \frac{{b_W}^2}{S_W} = 7.916$

$$\Lambda_{W\_LE\_eqv} := \mathrm{atan}\left(\frac{2 \cdot (X_C - X_{P1})}{b_{W\_1} + b_{W\_2}}\right) = 0.602\ \boldsymbol{rad}$$

$$\Lambda_{W\_LE\_eqv} = 34.5\ \boldsymbol{deg}$$

$$\Lambda_{W\_TE\_eqv} := {}_{\mathrm{f}}\Lambda\left(1.0, \Lambda_{W\_LE\_eqv}, AR_{W\_eqv}, \lambda_{W\_eqv}\right) = 0.313\ \boldsymbol{rad}$$

$$\Lambda_{W\_TE\_eqv} = 17.908\ \boldsymbol{deg}$$

$$\Lambda_{W\_c4\_eqv} := {}_{\mathrm{f}}\Lambda\left(0.25, \Lambda_{W\_LE\_eqv}, AR_{W\_eqv}, \lambda_{W\_eqv}\right) = 0.538\ \boldsymbol{rad}$$

$$\Lambda_{W\_c4\_eqv} = 30.805\ \boldsymbol{deg}$$

$$\Lambda_{W\_c2\_eqv} := {}_{\mathrm{f}}\Lambda\left(0.5, \Lambda_{W\_LE\_eqv}, AR_{W\_eqv}, \lambda_{W\_eqv}\right) = 0.468\ \boldsymbol{rad}$$

$$\Lambda_{W\_c2\_eqv} = 26.803\ \boldsymbol{deg}$$

$$\Lambda_{W\_tmax\_eqv} := {}_{\mathrm{f}}\Lambda\left(\xi_{tmax\_W}, \Lambda_{W\_LE\_eqv}, AR_{W}, \lambda_{W\_eqv}\right) = 0.514\ \boldsymbol{rad}$$

$$\Lambda_{W\_tmax\_eqv} = 29.439\ \boldsymbol{deg}$$

$$\Gamma_{W\_eqv} := \frac{\Gamma_{W\_1} \cdot S_{W\_1} + \Gamma_{W\_2} \cdot S_{W\_2}}{S_{W\_1} + S_{W\_2}} = 0.122$$

$$\Gamma_{W\_eqv} = 7\ \boldsymbol{deg}$$

$$MAC_{W\_eqv} := \frac{2}{3} \cdot c_{W\_r\_eqv} \cdot \left(\frac{1 + {\lambda_{W\_eqv}}^{2} + \lambda_{W\_eqv}}{1 + \lambda_{W\_eqv}}\right) = 9.028\ \boldsymbol{m}$$

$$MAC_{W\_eqv} = 9.028\ \boldsymbol{m}$$

$$X_{MAC\_LE\_W\_eqv} := \frac{b_W}{6} \cdot \frac{(1 + 2 \cdot \lambda_{W\_eqv})}{(1 + \lambda_{W\_eqv})} \cdot \tan\left(\Lambda_{W\_LE\_eqv}\right) = 7.953\ \boldsymbol{m}$$

$$X_{MAC\_LE\_W\_eqv} = 7.953\ \boldsymbol{m}$$

$$Y_{MAC\_W\_eqv} := \left(\frac{b_W}{6} \cdot \frac{1 + 2 \cdot \lambda_{W\_eqv}}{1 + \lambda_{W\_eqv}}\right) = 11.572\ \boldsymbol{m}$$

$$Y_{MAC\_W\_eqv} = 11.572\ \boldsymbol{m}$$

$$Z_{MAC\_W\_eqv} := Y_{MAC\_W\_eqv} \cdot \tan\left(\Gamma_{W\_eqv}\right) = 1.421\ \boldsymbol{m}$$

$$Z_{MAC\_W\_eqv} = 1.421\ \boldsymbol{m}$$

CONSTRUCTED OUTBOARD PANEL PARAMETERS CALCULATIONS (DATCOM METHOD)

Constructed Outboard Panel parameters calculation

$\Delta y := \text{if}\left({}_{b}Crk = 0, 0 \cdot m, \frac{1}{2} \cdot \left(\frac{b_{W\_1}}{2}\right)\right) = 5.37\ m$ $\Delta y = 5.37\ m$

$b'_{W\_2} := b_{W\_2} + 2\ \Delta y = 50.18\ m$ $b'_{W\_2} = 50.18\ m$ $b_{W\_2} = 39.44\ m$

$\frac{b'_{W\_2}}{2} = 25.09\ m$ $\frac{b_{W\_2}}{2} = 19.72\ m$

$c'_{W\_r\_2} := {}_{f}c_{W\_2}\left(\frac{b_{W\_1}}{2} - \Delta y\right) = 10.242\ m$ $c'_{W\_r\_2} = 10.242\ m$ $c_{W\_r\_2} = 8.51\ m$

$\lambda'_{W\_2} := \frac{c_{W\_t\_2}}{c'_{W\_r\_2}} = 0.21$ $\lambda'_{W\_2} = 0.21$ $\lambda_{W\_2} = 0.253$

$S'_{W\_2} := \frac{b'_{W\_2}}{2} \cdot c'_{W\_r\_2} \cdot \left(1 + \lambda'_{W\_2}\right) = 310.913\ m^2$ $S'_{W\_2} = 310.913\ m^2$ $S_{W\_2} = 210.215\ m^2$

$AR'_{W\_2} := \frac{2 \cdot b'_{W\_2}}{c'_{W\_r\_2} \cdot \left(1 + \lambda'_{W\_2}\right)} = 8.099$ $AR'_{W\_2} = 8.099$ $AR_{W\_2} = 7.4$

$MAC'_{W\_2} := \frac{2}{3} \cdot c'_{W\_r\_2} \cdot \left(\frac{1 + {\lambda'_{W\_2}}^2 + \lambda'_{W\_2}}{1 + \lambda'_{W\_2}}\right) = 7.077\ m$ $MAC'_{W\_2} = 7.077\ m$ $MAC_{W\_2} = 5.962\ m$

$Y'_{MAC\_W\_2} := \frac{b'_{W\_2}}{6} \cdot \frac{1 + 2 \cdot \lambda'_{W\_2}}{1 + \lambda'_{W\_2}} = 9.814\ m$ $Y'_{MAC\_W\_2} = 9.814\ m$ $Y_{MAC\_W\_2} = 7.899\ m$

$X'_{MAC\_LE\_W\_2} := Y'_{MAC\_W\_2} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 6.745\ m$ $X'_{MAC\_LE\_W\_2} = 6.745\ m$ $X_{MAC\_LE\_W\_2} = 5.429\ m$

$X'_{LE\_r\_W\_2} := \frac{b_{W\_1}}{2} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) - \Delta y \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 3.691\ m$ $Y'_{LE\_r\_W\_2} := \frac{b_{W\_1}}{2} - \Delta y = 5.37\ m$

$X'_{LE\_t\_W\_2} := \frac{b_{W\_1}}{2} \cdot \tan\left(\Lambda_{W\_LE\_1}\right) + \frac{b_{W\_2}}{2} \cdot \tan\left(\Lambda_{W\_LE\_2}\right) = 20.935\ m$ $Y'_{LE\_t\_W\_2} := \frac{b_{W\_1} + b_{W\_2}}{2} = 30.46\ m$

$X'_{TE\_t\_W\_2} := X'_{LE\_t\_W\_2} + c_{W\_t\_2} = 23.085\ m$ $Y'_{TE\_t\_W\_2} := Y'_{LE\_t\_W\_2} = 30.46\ m$

$X'_{TE\_r\_W\_2} := X'_{LE\_r\_W\_2} + c'_{W\_r\_2} = 13.933\ m$ $Y'_{TE\_r\_W\_2} := Y'_{LE\_r\_W\_2} = 5.37\ m$

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

MISCELLANEOUS DATA CALCULATIONS

Induced drag factors, only due to geometric effects

$$e_{W\_alt\_1} := \frac{2}{2 - AR_{W\_1} + \sqrt{4 + AR_{W\_1}^{2}\left(1 + \tan\left(\Lambda_{W\_tmax\_1}\right)^{2}\right)}} = 0.664$$

$e_{W\_alt\_1} = 0.664$

$$e_{W\_alt\_2} := \frac{2}{2 - AR_{W\_2} + \sqrt{4 + AR_{W\_2}^{2}\left(1 + \tan\left(\Lambda_{W\_tmax\_2}\right)^{2}\right)}} = 0.584$$

$e_{W\_alt\_2} = 0.584$

$$e_{W\_alt} := \frac{2}{2 - AR_{W} + \sqrt{4 + AR_{W}^{2}\left(1 + \tan\left(\Lambda_{W\_tmax\_eqv}\right)^{2}\right)}} = 0.59$$

$e_{W\_alt} = 0.59$

$$e_{W\_1\_alt\_\Lambda 0} := 1.78 \cdot \left(1 - 0.045 \cdot AR_{W\_1}^{0.68}\right) - 0.64 = 1.021$$

$$e_{W\_2\_alt\_\Lambda 0} := 1.78 \cdot \left(1 - 0.045 \cdot AR_{W\_2}^{0.68}\right) - 0.64 = 0.828$$

$$e_{W\_alt\_\Lambda 0} := 1.78 \cdot \left(1 - 0.045 \cdot AR_{W}^{0.68}\right) - 0.64 = 0.813$$

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

$$e_{W\_1\_alt\_\Lambda} := 4.61 \cdot \left(1 - 0.045 \cdot AR_{W\_1}^{0.68}\right) \cdot \cos\left(\Lambda_{W\_LE\_1}\right)^{0.15} - 3.1 = 1.079$$

$$e_{W\_2\_alt\_\Lambda} := 4.61 \cdot \left(1 - 0.045 \cdot AR_{W\_2}^{0.68}\right) \cdot \cos\left(\Lambda_{W\_LE\_2}\right)^{0.15} - 3.1 = 0.592$$

$$e_{W\_alt\_\Lambda} := 4.61 \cdot \left(1 - 0.045 \cdot AR_{W}^{0.68}\right) \cdot \cos\left(\Lambda_{W\_LE\_eqv}\right)^{0.15} - 3.1 = 0.555$$

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

3d critical Mach number at mean aerodynamic chord

$$M_{cr\_W\_1\_3D\_@MAC\_1} := \frac{{}_{\mathrm{f}}\mathrm{M}_{\mathrm{cr\_2D\_W}}\left(Y_{MAC\_W\_1}\right)}{\cos\left(\Lambda_{W\_LE\_1}\right)} = 0.8$$

$M_{cr\_W\_1\_3D\_@MAC\_1} = 0.8$

$$M_{cr\_W\_2\_3D\_@MAC\_2} := \frac{{}_{\mathrm{f}}\mathrm{M}_{\mathrm{cr\_2D\_W}}\left(Y_{MAC\_W\_2}\right)}{\cos\left(\Lambda_{W\_LE\_2}\right)} = 0.807$$

$M_{cr\_W\_2\_3D\_@MAC\_2} = 0.807$

$$M_{cr\_W\_3D\_@MAC} := \frac{{}_{\mathrm{f}}\mathrm{M}_{\mathrm{cr\_2D\_W}}\left(Y_{MAC\_W}\right)}{\cos\left(\Lambda_{W\_LE\_eqv}\right)} = 0.81$$

$M_{cr\_W\_3D\_@MAC} = 0.81$

Ailerons inner and outer stations and area

$$y_{a\_in} := \eta_{a\_in} \cdot \frac{b_W}{2} = 22.236\ \boldsymbol{m}$$

$y_{a\_in} = 22.236\ \boldsymbol{m}$

$$y_{a\_out} := \eta_{a\_out} \cdot \frac{b_W}{2} = 28.937\ \boldsymbol{m}$$

$y_{a\_out} = 28.937\ \boldsymbol{m}$

$$c_{W\_mean\_@a} := {}_{\mathrm{f}}\mathrm{c}_{\mathrm{W}}\left(\frac{y_{a\_in} + y_{a\_out}}{2}\right) = 3.722\ \boldsymbol{m}$$

$c_{W\_mean\_@a} = 3.722\ \boldsymbol{m}$

$$S_a := 2 \cdot c_a \cdot \left(y_{a\_out} - y_{a\_in}\right) = 12.732\ \boldsymbol{m}^2$$

$S_a = 12.732\ \boldsymbol{m}^2$

Flaps inner and outer stations and area

$$y_{flap\_in} := \eta_{flap\_in} \cdot \frac{b_W}{2} = 9.138\ m$$ $y_{flap\_in} = 9.138\ m$

$$y_{flap\_out} := \eta_{flap\_out} \cdot \frac{b_W}{2} = 18.276\ m$$ $y_{flap\_out} = 18.276\ m$

$$S_{flap} := 2 \cdot c_{flap} \cdot (y_{flap\_out} - y_{flap\_in}) = 13.707\ m^2$$ $S_{flap} = 13.707\ m^2$

$$\alpha_{0L\_W\_flaps\_open} := \alpha_{0L\_W} + \frac{S_{flap}}{S_W} \cdot \Delta\alpha_{0l\_W\_flaps} = -0.019$$ $\alpha_{0L\_W\_flaps\_open} = -1.096\ deg$

WING LIFT CURVE SLOPE

Wing Lift Curve Slope, function definitions

- **Polhamus Formula Coefficient**

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

- **General Formula for Lift Curve Slope**

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

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

$$C_{L\alpha\_W\_1\_classic} := \frac{C_{l\alpha\_W\_mean\_1}}{\sqrt{1-{M_1}^2} + \frac{C_{l\alpha\_W\_mean\_1}}{\pi \cdot AR_{W\_1} \cdot e_{W\_alt\_1}}} = 2.651 \qquad C_{L\alpha\_W\_1\_classic} = 0.046\ deg^{-1}$$

$$C_{L\alpha\_W\_2\_classic} := \text{if}\left({}_bCrk = 0, \frac{C_{l\alpha\_W\_mean\_2}}{\sqrt{1-{M_1}^2}}, \frac{C_{l\alpha\_W\_mean\_2}}{\sqrt{1-{M_1}^2} + \frac{C_{l\alpha\_W\_mean\_2}}{\pi \cdot AR_{W\_2} \cdot e_{W\_alt\_2}}}\right) = 5.414\ rad^{-1} \qquad C_{L\alpha\_W\_2\_classic} = 0.094\ deg^{-1}$$

$$C_{L\alpha\_W\_classic} := \frac{C_{l\alpha\_W\_mean}}{\sqrt{1-{M_1}^2} + \frac{C_{l\alpha\_W\_mean}}{\pi \cdot AR_W \cdot e_{W\_alt}}} = 5.623\ rad^{-1} \qquad C_{L\alpha\_W\_classic} = 0.098\ deg^{-1}$$

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

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

$$C_{l\alpha\_W\_1\_@MAC\_1} := {}_f\mathrm{C_{l\alpha\_W}}\left(Y_{MAC\_W\_1}\right) = 7.002\ rad^{-1} \qquad C_{l\alpha\_W\_1\_@MAC\_1} = 0.122\ deg^{-1}$$

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

$$C_{L\alpha\_W\_1\_@M0} = 2.341\ rad^{-1} \qquad C_{L\alpha\_W\_1\_@M0} = 0.041\ deg^{-1}$$

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

$$C_{L\alpha\_W\_1} = 2.529\ rad^{-1} \qquad C_{L\alpha\_W\_1} = 0.044\ deg^{-1}$$

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

$$C_{l\alpha\_W\_2\_@MAC\_2} := {}_f\mathrm{C_{l\alpha\_W}}\left(Y_{MAC\_W\_2}\right) = 6.937\ rad^{-1} \qquad C_{l\alpha\_W\_2\_@MAC\_2} = 0.121\ deg^{-1}$$

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

$$C_{L\alpha\_W\_2\_@M0} = 4.481\ rad^{-1} \qquad C_{L\alpha\_W\_2\_@M0} = 0.078\ deg^{-1}$$

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

$$C_{L\alpha\_W\_2} = 5.716\ rad^{-1} \qquad C_{L\alpha\_W\_2} = 0.1\ deg^{-1}$$

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

$$C_{l\alpha\_W\_@MAC} := {}_f\mathrm{C_{l\alpha\_W}}\left(Y_{MAC\_W}\right) = 6.908\ rad^{-1} \qquad C_{l\alpha\_W\_@MAC} = 0.121\ deg^{-1}$$

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

$$C_{L\alpha\_W\_@M0} = 4.537\ rad^{-1} \qquad C_{L\alpha\_W\_@M0} = 0.079\ deg^{-1}$$

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

$$C_{L\alpha\_W} = 5.822\ rad^{-1} \qquad C_{L\alpha\_W} = 0.102\ deg^{-1}$$

Wing lift coefficient at initial conditions

$C_{L0\_W\_1} := C_{L\alpha\_W\_1} \cdot (i_W - \alpha_{0L\_W\_1}) = 0.176$ $C_{L0\_W\_1} = 0.176$

$C_{L0\_W\_2} := C_{L\alpha\_W\_2} \cdot (i_W - \alpha_{0L\_W\_2}) = 0.251$ $C_{L0\_W\_2} = 0.251$

$C_{L0\_W} := C_{L\alpha\_W} \cdot (i_W - \alpha_{0L\_W}) = 0.338$ $C_{L0\_W} = 0.338$

Induced drag factor, due to both geometric and aerodynamic effects

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

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

$e_{W\_1} := {}_{f}e(C_{L\alpha\_W\_1}, AR_{W\_1}, \lambda_{W\_1}, \Lambda_{W\_LE\_1}) = 0.995$ $e_{W\_1} = 0.995$

$e_{W\_2} := {}_{f}e(C_{L\alpha\_W\_2}, AR_{W\_2}, \lambda_{W\_2}, \Lambda_{W\_LE\_2}) = 0.932$ $e_{W\_2} = 0.932$

$e_W := {}_{f}e(C_{L\alpha\_W}, AR_W, \lambda_W, \Lambda_{W\_LE\_eqv}) = 0.866$ $e_W = 0.866$

WING AERODYNAMIC CENTER - GRAPHICAL METHOD (DATCOM / NAPOLITANO)

@Aerodynamic Database ---> (x_bar_ac_w)_k1_vs_lambda

$K1_{ac\_W\_1\_Datcom} = 1.254$ $K1_{ac\_W\_2\_Datcom} = 1.42$ $K1_{ac\_W\_eqv\_Datcom} = 1.457$

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

$K2_{ac\_W\_1\_Datcom} = 0.134$ $K2_{ac\_W\_2\_Datcom} = 0.646$ $K2_{ac\_W\_eqv\_Datcom} = 0.602$

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

$X_{ac\_over\_c_{r\_W\_1\_Datcom}} = 0.39$ $X_{ac\_over\_c_{r\_W\_2\_Datcom}} = 0.862$ $X_{ac\_over\_c_{r\_W\_eqv\_Datcom}} = 0.829$

$$X_{ac\_over\_c_{r\_W\_Datcom}} := \frac{X_{ac\_over\_c_{r\_W\_1\_Datcom}} \cdot S_{W\_1} \cdot C_{L\alpha\_W\_1} + X_{ac\_over\_c_{r\_W\_2\_Datcom}} \cdot S_{W\_2} \cdot C_{L\alpha\_W\_2}}{S_{W\_1} \cdot C_{L\alpha\_W\_1} + S_{W\_2} \cdot C_{L\alpha\_W\_2}} = 0.695$$

Adimensional aerodynamic center position with respect to MAC leading edge

$\xi_{ac\_W\_1} := K1_{ac\_W\_1\_Datcom} \cdot \left(X_{ac\_over\_c_{r\_W\_1\_Datcom}} - K2_{ac\_W\_1\_Datcom}\right) = 0.32$ $\qquad \xi_{ac\_W\_1} = 0.32$

$\xi_{ac\_W\_2} := K1_{ac\_W\_2\_Datcom} \cdot \left(X_{ac\_over\_c_{r\_W\_2\_Datcom}} - K2_{ac\_W\_2\_Datcom}\right) = 0.307$ $\qquad \xi_{ac\_W\_2} = 0.307$

$\xi_{ac\_W\_eqv} := K1_{ac\_W\_eqv\_Datcom} \cdot \left(X_{ac\_over\_c_{r\_W\_eqv\_Datcom}} - K2_{ac\_W\_eqv\_Datcom}\right) = 0.332$ $\qquad \xi_{ac\_W\_eqv} = 0.332$

$$\xi_{ac\_W} := \frac{\xi_{ac\_W\_1} \cdot S_{W\_1} \cdot C_{L\alpha\_W\_1} + \xi_{ac\_W\_2} \cdot S_{W\_2} \cdot C_{L\alpha\_W\_2}}{S_{W\_1} \cdot C_{L\alpha\_W\_1} + S_{W\_2} \cdot C_{L\alpha\_W\_2}} = 0.311$$

Aerodynamic center position with respect to wing apex

$X_{ac\_W\_1} := \xi_{ac\_W\_1} \cdot MAC_{W\_1} + X_{MAC\_LE\_W\_1} = 7.296\ m$ $\qquad X_{ac\_W\_1} = 7.296\ m$

$X_{ac\_W\_2} := \xi_{ac\_W\_2} \cdot MAC_{W\_2} + X_{MAC\_LE\_W\_2} = 7.256\ m$ $\qquad X_{ac\_W\_2} = 7.256\ m$

$X_{ac\_W\_eqv} := \xi_{ac\_W\_eqv} \cdot MAC_{W\_eqv} + X_{MAC\_LE\_W\_eqv} = 10.948\ m$ $\qquad X_{ac\_W\_eqv} = 10.948\ m$

$X_{ac\_W} := \xi_{ac\_W} \cdot MAC_{W} + X_{MAC\_LE\_W} = 9.3\ m$ $\qquad X_{ac\_W} = 9.3\ m$

Aerodynamic center position with respect to MAC leading edge

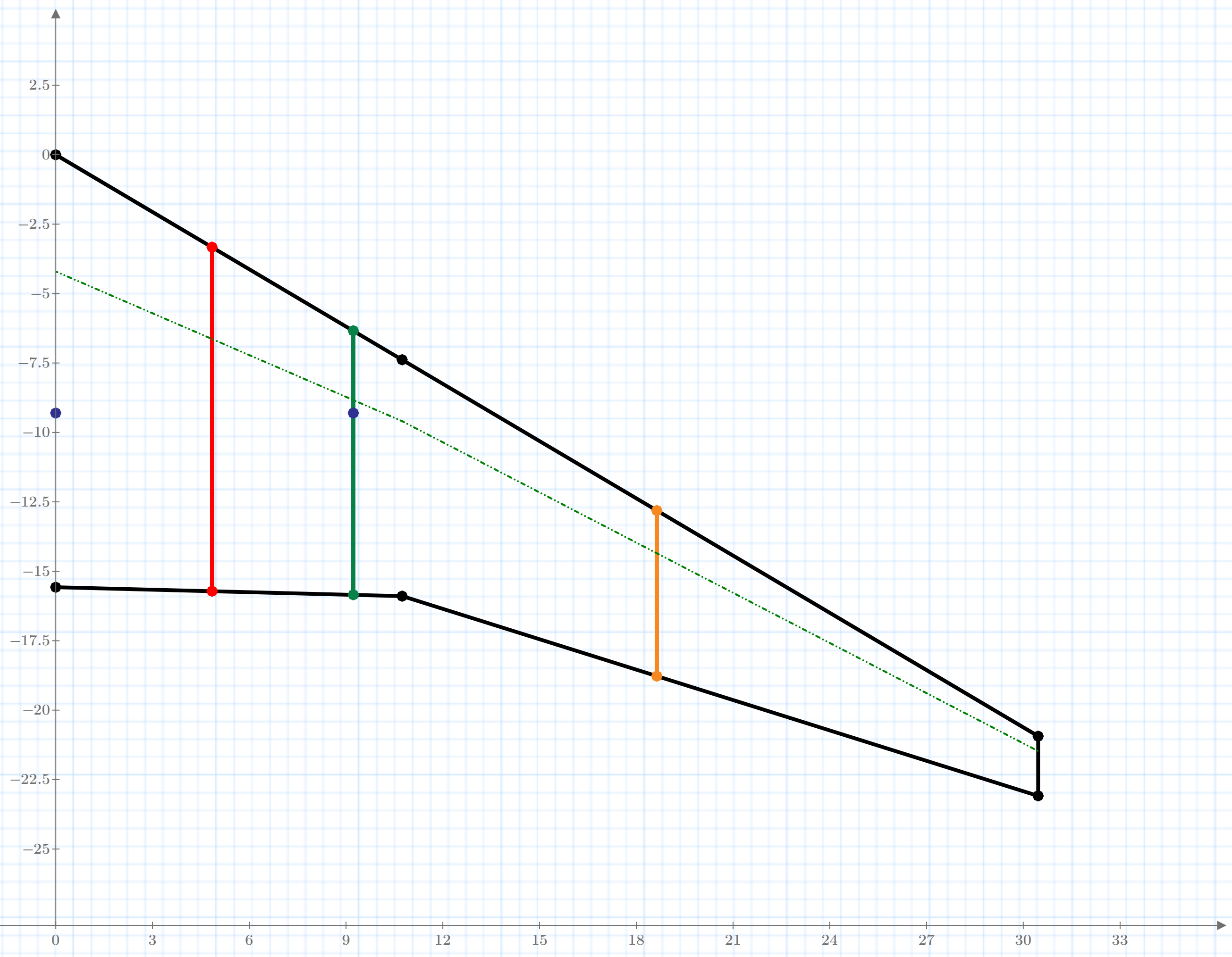
$x_{ac\_W\_1} := X_{ac\_W\_1} - X_{MAC\_LE\_W\_1} = 3.966\ m$ $\qquad x_{ac\_W\_1} = 3.966\ m$

$x_{ac\_W\_2} := X_{ac\_W\_2} - X_{MAC\_LE\_W\_2} = 1.828\ m$ $\qquad x_{ac\_W\_2} = 1.828\ m$

$x_{ac\_W\_eqv} := X_{ac\_W\_eqv} - X_{MAC\_LE\_W\_eqv} = 2.995\ m$ $\qquad x_{ac\_W\_eqv} = 2.995\ m$

$x_{ac\_W} := X_{ac\_W} - X_{MAC\_LE\_W} = 2.959\ m$ $\qquad x_{ac\_W} = 2.959\ m$

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

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

- **Effective chord distribution function**

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

- **Elliptic chord distribution function**

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

- **"Basic" angle of attack function**

$${}_{f}cC_{l\_b}(y) := \frac{1}{2} \cdot {}_{f}c_{W}(y) \cdot {}_{f}C_{l\alpha\_W}(y) \cdot {}_{f}\alpha_{b}(y)$$

- **Basic wing loading**

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

- **Additional wing loading function**

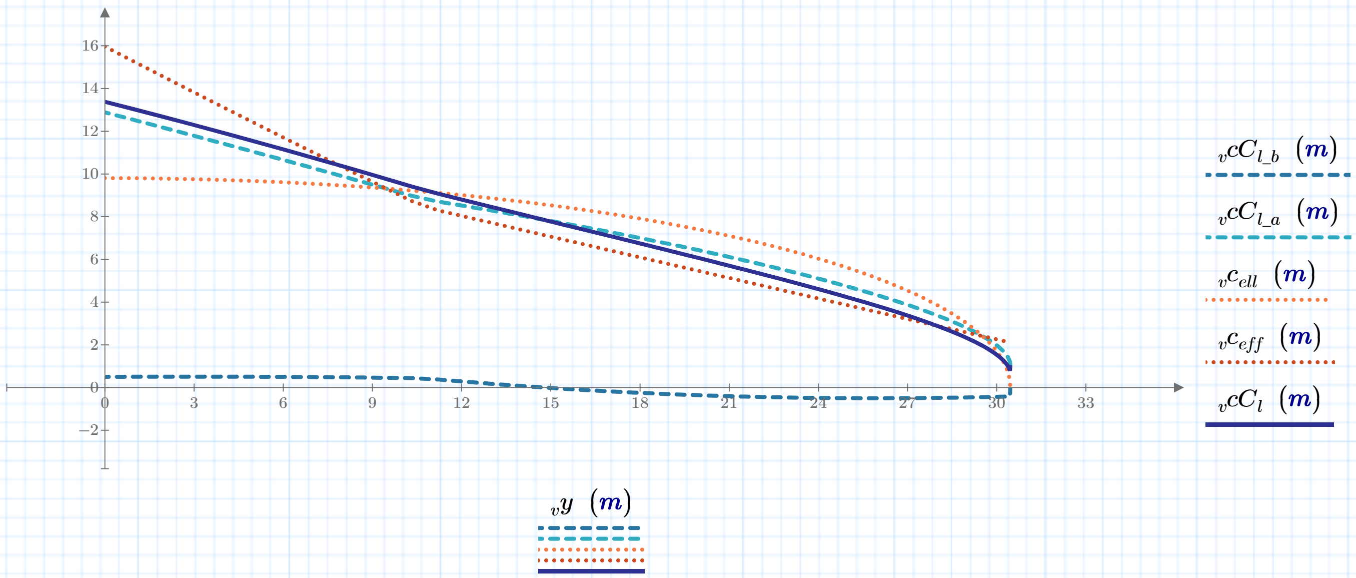
$${}_{f}cC_{l}(y) := {}_{f}cC_{l\_b}(y) + {}_{f}cC_{l\_a}(y)$$

- **Wing loading function**

$$C_{L\_b} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}cC_{l\_b}(y)\, dy = 5.857 \cdot 10^{-4} \qquad C_{L\_a} := \frac{2}{S_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}cC_{l\_a}(y)\, dy = 1$$

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

Spanwise loading curve plots



3D PITCHING MOMENT COEFFICIENT ABOUT WING AERODYNAMIC CENTER

Exact formulation

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

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

$$ C_{M\_ac\_W\_b} := \frac{2}{S_W \cdot MAC_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}cC_{l\_b}(y) \cdot {}_{f}x_{b\_W}(y) \, dy = 0.028 $$

$$ C_{M\_ac\_W\_b} = 0.028 $$

$$ C_{M\_ac\_W\_a} := \frac{2}{S_W \cdot MAC_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}C_{m\_ac\_2D\_W}(y) \cdot {}_{f}c_W(y)^2 \, dy = -0.033 $$

$$ C_{M\_ac\_W\_a} = -0.033 $$

$$ C_{M\_ac\_W} := C_{M\_ac\_W\_b} + C_{M\_ac\_W\_a} = -0.005 $$

$$ C_{M\_ac\_W} = -0.00532 $$

Approximated formulation (Roskam)

$$ C_{M\_ac\_W\_b\_Roskam} := \frac{2 \cdot \pi}{S_W \cdot MAC_W} \cdot \int_0^{\frac{b_W}{2}} {}_{f}\alpha_b(y) \cdot {}_{f}c_W(y) \cdot {}_{f}x_{b\_W}(y) \, dy = 0.025 $$

$$ C_{M\_ac\_W\_b\_Roskam} = 0.025 $$

$$ C_{M\_ac\_W\_Roskam} := C_{M\_ac\_W\_b\_Roskam} + C_{M\_ac\_W\_a} = -0.008 $$

$$ C_{M\_ac\_W\_Roskam} = -0.008 $$

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

$$\varepsilon_{\alpha\_LLT\_@M0\_W} := {}_f\varepsilon_{\alpha\_LLT\_W}\left(C_{L\alpha\_W}, AR_W, e_W, 0\right) = 0.541$$

$$\varepsilon_{\alpha\_LLT\_@M0\_W} = 0.541$$

$$\varepsilon_{\alpha\_LLT\_W} := {}_f\varepsilon_{\alpha\_LLT\_W}\left(C_{L\alpha\_W}, AR_W, e_W, M_1\right) = 0.711$$

$$\varepsilon_{\alpha\_LLT\_W} = 0.711$$

$$\varepsilon_{0\_LLT\_W} := \varepsilon_{\alpha\_LLT\_W} \cdot \left(i_W - \alpha_{0L\_W}\right) = 0.041$$

$$\varepsilon_{0\_LLT\_W} = 2.368\ deg$$

DATCOM Method

$$\Delta X\_HT_{LE}\_W_{LE} := \Delta X\_HT_{LE}\_Nose - \Delta X\_W_{LE}\_Nose = 38.35\ m$$ $\Delta X\_HT_{LE}\_W_{LE} = 38.35\ m$

$$\Delta Z\_HT_{LE}\_W_{LE} := \Delta Z\_HT_{LE}\_Nose - \Delta Z\_W_{LE}\_Nose = 2.1\ m$$ $\Delta Z\_HT_{LE}\_W_{LE} = 2.1\ m$

$$\xi_{ac\_H} := K1_{ac\_H\_Datcom} \cdot \left(X_{ac}\_over\_c_{r\_H\_Datcom} - K2_{ac\_H\_Datcom}\right) = 0.277$$ $\xi_{ac\_H} = 0.277$

$$\Delta Z\_HT_{MAC4}\_W_{MAC4} := \Delta Z\_HT_{LE}\_W_{LE} + Y_{MAC\_H} \cdot \tan\left(\Gamma_H\right) - Y_{MAC\_W} \cdot \tan\left(\Gamma_{W\_eqv}\right) = 1.651\ m$$

$$\Delta X\_HT_{MAC4}\_W_{MAC4} := \Delta X\_HT_{LE}\_W_{LE} + \left(X_{MAC\_LE\_H} + \frac{MAC_H}{4}\right) - \left(X_{MAC\_LE\_W} + \frac{MAC_W}{4}\right) = 34.638\ m$$

- Normal to FRL
- Parallel to FRL

$$\Delta Z'\_HT_{MAC4}\_W_{MAC4} := \Delta X\_HT_{MAC4}\_W_{MAC4} \cdot \sin\left(i_W\right) + \Delta Z\_HT_{MAC4}\_W_{MAC4} \cdot \cos\left(i_W\right) = 2.859\ m$$

$$\Delta X'\_HT_{MAC4}\_W_{MAC4} := \Delta X\_HT_{MAC4}\_W_{MAC4} \cdot \cos\left(i_W\right) - \Delta Z\_HT_{MAC4}\_W_{MAC4} \cdot \sin\left(i_W\right) = 34.559\ m$$

- Normal to root chord
- Parallel to root chord

$$\Delta X\_HT_{ac}\_W_{ac} := \Delta X\_HT_{LE}\_W_{LE} + \left(X_{MAC\_LE\_H} + \xi_{ac\_H} \cdot MAC_H\right) - X_{ac\_W} = 34.197\ m$$ $\Delta X\_HT_{ac}\_W_{ac} = 34.197\ m$

$$\Delta Z\_HT_{ac}\_W_{ac} := \Delta Z\_HT_{MAC4}\_W_{MAC4} = 1.651\ m$$ $\Delta Z\_HT_{ac}\_W_{ac} = 1.651\ m$

$${}_f\mathrm{K}_{\mathrm{AR}}(AR) := \frac{1}{AR} - \frac{1}{1 + (AR)^{1.7}}$$

$${}_f\mathrm{K}_{\lambda}(\lambda) := \frac{10 - 3 \cdot \lambda}{7}$$

- Empirical coefficients function definitions

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

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

$$K_{AR\_W} := {}_f\mathrm{K}_{\mathrm{AR}}\left(AR_W\right) = 0.097$$ $K_{AR\_W} = 0.097$

$$K_{\lambda\_W} := {}_f\mathrm{K}_{\lambda}\left(\lambda_W\right) = 1.369$$ $K_{\lambda\_W} = 1.369$

$$K_{MAC4\_WH} := {}_f\mathrm{K}_{\mathrm{MAC4}}\left(\Delta Z'\_HT_{MAC4}\_W_{MAC4}, \Delta X'\_HT_{MAC4}\_W_{MAC4}, b_W\right) = 0.914$$ $K_{MAC4\_WH} = 0.914$

$$K_{M\_W} := K_M\left(M_1, C_{L\alpha\_W\_@M0}, C_{L\alpha\_W}\right) = 0.76$$ $K_{M\_W} = 0.76$

$$\varepsilon_{\alpha\_@M0\_W} := 4.44 \cdot \left(K_{AR\_W} \cdot K_{\lambda\_W} \cdot K_{MAC4\_WH} \cdot \sqrt{\cos\left(\Lambda_{W\_c4\_eqv}\right)}\right)^{1.19} = 0.332$$ $\varepsilon_{\alpha\_@M0\_W} = 0.332$

$$\varepsilon_{\alpha\_W} := \varepsilon_{\alpha\_@M0\_W} \cdot \sqrt{1 - {M_1}^2}$$ $\varepsilon_{\alpha\_W} = 0.252$

$$\varepsilon_{0\_W} := \varepsilon_{\alpha\_W} \cdot \left(i_W - \alpha_{0L\_W}\right) = 0.015$$ $\varepsilon_{0\_W} = 0.84\ deg$

MISCELLANEOUS PARAMETERS PLOT

MAPPING AND OUTPUT CREATION

Includi << ../Default_Map_Wing.mcdx

Excel Writing

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CSV Tabs Writing

$${}_mCSV_{W\_1} := \mathrm{augment}\left({}_vy, {}_vc_{ell}, {}_vc_{eff}, {}_vcC_{l\_a}, {}_vcC_{l\_b}\right) \cdot \frac{1}{m}$$

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

$${}_mCSV_{W\_2} := \mathrm{augment}\left({}_vy \cdot \frac{1}{m}, {}_vx_{b\_W} \cdot \frac{1}{m}, {}_vIC_{M\_ac\_W\_b} \cdot \frac{1}{m^2}, {}_vIC_{M\_ac\_W\_b\_Roskam} \cdot \frac{1}{m^2}\right)$$

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

$${}_mCSV_{W\_3} := \mathrm{augment}\left({}_vy \cdot \frac{1}{m}, {}_vc_W \cdot \frac{1}{m}, {}_v\alpha_{0l\_2D}, {}_v\varepsilon_g, {}_vC_{l\alpha\_W}, {}_vC_{m\_ac\_2D\_W}, {}_v\xi_{ac\_2D\_W}\right)$$

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

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

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

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

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

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

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

TeX Macro writing on .tex

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

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