Includi << ..\Default_Functions.mcdx

# LATERAL-DIRECTIONAL PARAMETERS INITIALIZATION

## Hidden Area --> Import of Excel INPUT Data

## Hidden Area --> Preliminary Mapping of imported Data

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

## Other input parameters to be defined here

$C_{Roll} := 0$ $C_N := 0$ $C_{Roll0} := 0$ $C_{N0} := 0$

$\beta := 2\ deg = 0.035$

$p := -0.274\ \frac{deg}{s} = -0.005\ \frac{rad}{s}$

$r := 0.261\ \frac{deg}{s} = 0.005\ \frac{1}{s}$

$p_{bar} := \frac{p \cdot b_W}{2 \cdot V_1} = -0.000723$ $p_{bar} = -0.041399\ deg$

$r_{bar} := \frac{r \cdot b_W}{2 \cdot V_1} = 0.000688$ $r_{bar} = 0.039435\ deg$

# LATERAL-DIRECTIONAL PARAMETERS

## Input parameters

$mass = (2.853 \cdot 10^5)\ kg$

$C_{D0} = 0.031$

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

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

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

$\Delta X\_VT_{LE}\_Nose = 61.96\ m$

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

$\Delta Z\_VT_{LE}\_Nose = 2.2\ m$

## Imported parameters

$M_1 = 0.65$

$V_1 = 201.6\ \frac{m}{s}$

$p_{dyn} = (1.131 \cdot 10^4)\ Pa$

$Re_{per.unit.len} = (7.267 \cdot 10^6)\ \frac{1}{m}$

$d_B = 6.33\ m$

$Z_1 = 6.33\ m$

$Z_2 = 6.33\ m$

$r_1 = 3.9\ m$

$l_B = 73.9\ m$

$S_{B\_side} = 460.32\ m^2$

$Z_{MAX} = 6.33\ m$

$\omega_{MAX} = 6.33\ m$

$b_V = 10.68\ m$

$C_{L\alpha\_V} = 4.761$

$\eta_V\_times\_1\_plus\_d\sigma\_over\_d\beta = 0.941$

$S_V = 56.66\ m^2$

$X_{MAC\_LE\_V} = 4.326\ m$

$Y_{MAC\_V} = 4.402\ m$

$MAC_V = 5.796\ m$

$\tau_{rd} = 0.793$

$\eta_{rd\_in} = 0$

$\eta_{rd\_out} = 0.95$

$\lambda_V = 0.31$

$\eta_V = 1$

$MAC_H = 5.2\ m$

$\alpha_{0L\_H} = -2.865\ deg$

$S_H = 105.41\ m^2$

$\eta_H = 0.9$

$AR_H = 4.575$

$b_H = 21.96\ m$

$\Lambda_{H\_c2} = 30.59\ deg$

$\lambda_H = 0.333$

$\Lambda_{H\_c4} = 35.013\ deg$

$\Gamma_H = 8.48\ deg$

$\alpha_{0l\_H\_r} = -2.865\ deg$

$\alpha_{0l\_H\_t} = -2.865\ deg$

$C_L = 0.528$

$\alpha_{WB} = 3.002\ deg$

$C_{LH} = -0.11$

$N_{eng\_1} = 2$

$N_{eng\_2} = 0$

$N_{eng} = 2$

$S_{eng} = 7.55\ m^2$

$C_{N\alpha\_eng} = 0.334$

$x_{CG} = 2.614\ m$

$\Delta X\_CG\_eng_1 = 7.97\ m$

$\Delta X\_CG\_eng_2 = 0\ m$

$\Delta X\_CG\_Nose = 34\ m$

$\Delta Z\_W_{c4\_r}\_B_{CL} = -0.614\ m$

$\Delta Z\_HT_{c4\_r}\_B_{CL} = -2.264\ m$

$MAC_W = 9.505\ m$

$X_{MAC\_LE\_W} = 6.341\ m$

$b_W = 60.92\ m$

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

$i_W = 2\ deg$

$\Lambda_{W\_c4\_eqv} = 34.492\ deg$

$\xi_{ac\_W} = 17.819\ deg$

$S_W = 468.83\ m^2$

$AR_W = 7.916$

$e_W = 0.866$

$\Lambda_{W\_c2\_eqv} = 26.814\ deg$

$\lambda_W = 0.138$

$\lambda_{W\_eqv} = 0.162$

$\Gamma_{W\_eqv} = 6.99\ deg$

$\alpha_{0l\_W\_r} = -0.032$

$\alpha_{0l\_W\_t} = -0.027$

$X_{ac\_W} = 9.3\ m$

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

$\eta_{aileron\_in} = 0.73$

$\eta_{aileron\_out} = 0.95$

$c_{aileron} = 0.95\ m$

$Z_{MAC\_W} = 1.133\ m$

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

# ENGINES CONTRIBUTION

$C_{Y\beta} := C_{N\alpha\_eng}$

$C_{Y\beta} = 0.006\ deg^{-1}$

$C_{N\beta\_eng\_1} := -C_{Y\beta} \cdot \frac{S_{eng}}{S_W} \cdot \frac{\Delta X\_CG\_eng_1}{MAC_W} \cdot \frac{N_{eng\_1}}{N_{eng}} = -0.005$

$C_{N\beta\_eng\_1} = -7.872 \cdot 10^{-5}\ deg^{-1}$

$C_{N\beta\_eng\_2} := -C_{Y\beta} \cdot \frac{S_{eng}}{S_W} \cdot \frac{\Delta X\_CG\_eng_2}{MAC_W} \cdot \frac{N_{eng\_2}}{N_{eng}} = 0$

$C_{N\beta\_eng\_2} = 0\ deg^{-1}$

- **REMARK: This is the Yawing Moment Coefficient due to sideslip angle**

# LATERAL-DIRECTIONAL CALCULATIONS

## Wing - Body - Horizontal Tail - Vertical Tail Dihedral Effect

$S_{fAVG} := \pi \cdot d_B \cdot \left(\frac{Z_1 + Z_2}{2}\right) = 125.88\ m^2$

$S_{fAVG} = 125.88\ m^2$

$\Delta C_{Roll\beta}\_over\_\Gamma_W := -\frac{(0.0005)}{deg^2} \cdot AR_W \cdot \left(\left(\frac{\sqrt{\frac{4 \cdot S_{fAVG}}{\pi}}}{b_W}\right)^2\right) = -0.561$

$\Delta C_{Roll\beta}\_over\_\Gamma_W = -1.709 \cdot 10^{-4}\ \frac{1}{deg^2}$

$\Delta C_{Roll\beta}\_over\_\Gamma_H := -\frac{(0.0005)}{deg^2} \cdot AR_H \cdot \left(\left(\frac{\sqrt{\frac{4 \cdot S_{fAVG}}{\pi}}}{b_H}\right)^2\right) = -2.496$

$\Delta C_{Roll\beta}\_over\_\Gamma_H = -7.603 \cdot 10^{-4}\ \frac{1}{deg^2}$

$\Delta C_{Roll\beta\_ZW} := \frac{1.2 \cdot \sqrt{AR_W}}{57.3} \cdot \frac{\Delta Z\_W_{c4\_r}\_B_{CL}}{b_W} \cdot 2 \cdot \frac{\sqrt{\frac{4 \cdot S_{fAVG}}{\pi}}}{b_W} \cdot \frac{1}{deg} = -0.014$

$\Delta C_{Roll\beta\_ZW} = -2.468 \cdot 10^{-4}\ \frac{1}{deg}$

$\Delta C_{Roll\beta\_ZH} := \frac{1.2 \cdot \sqrt{AR_H}}{57.3} \cdot \frac{\Delta Z\_HT_{c4\_r}\_B_{CL}}{b_H} \cdot 2 \cdot \frac{\sqrt{\frac{4 \cdot S_{fAVG}}{\pi}}}{b_H} \cdot \frac{1}{deg} = -0.305$

$\Delta C_{Roll\beta\_ZH} = -9.293 \cdot 10^{-5}\ \frac{1}{deg^2}$

## @Aerodynamic Database ---> (C_l_beta_w_b)_k_M_Gamma_vs_Mach_times_cos(L_c2)_(AR_over_cos(L_c2))

$K_{M\Gamma\_W} = 1.118$

$K_{M\Gamma\_H} = 1.071$

## @Aerodynamic Database ---> (C_l_beta_w_b)_C_l_beta_over_Gamma_w_vs_AR_(L_c2)_(lambda)

$C_{Roll\beta}\_over\_\Gamma_W = -0.57$

$C_{Roll\beta}\_over\_\Gamma_W = -1.737 \cdot 10^{-4}\ deg^{-2}$

$C_{Roll\beta}\_over\_\Gamma_H = -0.493$

$C_{Roll\beta}\_over\_\Gamma_H = -1.503 \cdot 10^{-4}\ deg^{-2}$

## @Aerodynamic Database ---> (C_l_beta_w_b)_dC_l_beta_over_eps_w_times_tan_(L_c4)_vs_AR_(lambda)

$\Delta C_{Roll\beta}\_over\_\varepsilon_W\_times\_tan\Lambda c4_W = -0.118$

$\Delta C_{Roll\beta}\_over\_\varepsilon_W\_times\_tan\Lambda c4_W = -3.604 \cdot 10^{-5}\ deg^{-2}$

$\Delta C_{Roll\beta}\_over\_\varepsilon_H\_times\_tan\Lambda c4_H = -0.103$

$\Delta C_{Roll\beta}\_over\_\varepsilon_H\_times\_tan\Lambda c4_H = -3.132 \cdot 10^{-5}\ deg^{-2}$

## @Aerodynamic Database ---> (C_l_beta_w_b)_C_l_beta_over_C_Lift1_(L_c2)_vs_L_c2_(AR)_(lambda)

$C_{Roll\beta W}\_over\_C_L@\Lambda_{c2} = -0.133$

$C_{Roll\beta W}\_over\_C_L@\Lambda_{c2} = -2.325 \cdot 10^{-3}\ deg^{-1}$

$C_{Roll\beta H}\_over\_C_L@\Lambda_{c2} = -0.147$

$C_{Roll\beta H}\_over\_C_L@\Lambda_{c2} = -2.574 \cdot 10^{-3}\ deg^{-1}$

## @Aerodynamic Database ---> (C_l_beta_w_b)_C_l_beta_over_C_Lift1_(L_c2)_vs_L_c2_(AR)_(lambda)

$C_{Roll\beta W}\_over\_C_L@AR_W = 0.014$

$C_{Roll\beta W}\_over\_C_L@AR_W = \left(2.494 \cdot 10^{-4}\right)\ deg^{-1}$

$C_{Roll\beta H}\_over\_C_L@AR_H = -0.053$

$C_{Roll\beta H}\_over\_C_L@AR_H = -9.164 \cdot 10^{-4}\ deg^{-1}$

## @Aerodynamic Database ---> (C_l_beta_w_b)_k_M_L_vs_Mach_times_cos(L_c2)_(AR_over_cos(L_c2))

$K_{M\_\Lambda W} = 1.193$

$K_{M\_\Lambda H} = 1.082$

## @Aerodynamic Database ---> (C_l_beta_w_b)_k_M_L_vs_Mach_times_cos(L_c2)_(AR_over_cos(L_c2))

$A_W := \Delta X\_W_{LE}\_Nose + \frac{b_W}{2} \cdot \tan\left(\Lambda_{W\_c2\_eqv}\right) = 40.446\ m$ $\qquad A_W = 40.446\ m$

$A_H := \Delta X\_HT_{LE}\_Nose + \frac{b_H}{2} \cdot \tan\left(\Lambda_{H\_c2}\right) = 69.891\ m$ $\qquad A_H = 69.891\ m$

$K_{fW} = 0.873$ $\qquad K_{fH} = 0.924$

## Wing - Body - Horizontal Tail - Vertical Tail Dihedral Effect Calculations

$C_{Roll\beta\_WB\_\Lambda\_c2\_AR} := C_L \cdot \left(C_{Roll\beta W}\_over\_C_L@\Lambda_{c2} \cdot K_{M\_\Lambda W} \cdot K_{fW} + C_{Roll\beta W}\_over\_C_L@AR_W\right) = -0.066$

$C_{Roll\beta\_WB\_\Gamma\_W\_eqv} := C_L \cdot \Gamma_{W\_eqv} \cdot \left(C_{Roll\beta}\_over\_\Gamma_W \cdot K_{M\Gamma\_W} + \Delta C_{Roll\beta}\_over\_\Gamma_W\right) = -0.077$

$C_{Roll\beta\_WB\_\varepsilon\_W} := C_L \cdot \left(\Delta C_{Roll\beta\_ZW} + \left(\alpha_{0l\_W\_t} - \alpha_{0l\_W\_r}\right) \cdot \tan\left(\Lambda_{W\_c4\_eqv}\right) \cdot \Delta C_{Roll\beta}\_over\_\varepsilon_W\_times\_tan\Lambda c4_W\right) = -0.008$

$C_{Roll\beta\_WB} := C_{Roll\beta\_WB\_\Lambda\_c2\_AR} + C_{Roll\beta\_WB\_\Gamma\_W\_eqv} + C_{Roll\beta\_WB\_\varepsilon\_W} = -0.151$

$C_{Roll\beta\_WB} = -0.151$ $\qquad C_{Roll\beta\_WB} = -0.00263\ deg^{-1}$

$C_{Roll\beta\_H\_\Lambda\_c2\_AR} := \eta_H \cdot \frac{S_H}{S_W} \cdot \frac{b_H}{b_W} \cdot C_{LH} \cdot \left(C_{Roll\beta H}\_over\_C_L@\Lambda_{c2} \cdot K_{M\_\Lambda H} \cdot K_{fH} + C_{Roll\beta H}\_over\_C_L@AR_H\right) = 0.002$

$C_{Roll\beta\_H\_\Gamma\_H} := \eta_H \cdot \frac{S_H}{S_W} \cdot \frac{b_H}{b_W} \cdot C_{LH} \cdot \Gamma_H \cdot \left(C_{Roll\beta}\_over\_\Gamma_H \cdot K_{M\Gamma\_H} + \Delta C_{Roll\beta}\_over\_\Gamma_H\right) = 0.004$

$C_{Roll\beta\_H\_\varepsilon\_H} := \eta_H \cdot \frac{S_H}{S_W} \cdot \frac{b_H}{b_W} \cdot C_{LH} \cdot \left(\Delta C_{Roll\beta\_ZH} + \left(\alpha_{0l\_H\_t} - \alpha_{0l\_H\_r}\right) \cdot \tan\left(\Lambda_{H\_c4}\right) \cdot \Delta C_{Roll\beta}\_over\_\varepsilon_H\_times\_tan\Lambda c4_H\right) = 0.002$

$C_{Roll\beta\_H} := C_{Roll\beta\_H\_\Lambda\_c2\_AR} + C_{Roll\beta\_H\_\Gamma\_H} + C_{Roll\beta\_H\_\varepsilon\_H} = 0.008$

$C_{Roll\beta\_H} = 0.008$ $\qquad C_{Roll\beta\_H} = \left(1.331 \cdot 10^{-4}\right)\ deg^{-1}$

$\Delta X\_VT_{ac}\_CG := \Delta X\_VT_{LE}\_Nose + X_{MAC\_LE\_V} + \frac{MAC_V}{4} - \Delta X\_CG\_Nose = 33.735\ m$

$X_V := \Delta X\_VT_{ac}\_CG = 33.735\ m$

$\Delta Z\_VT_{ac}\_W_{ac} := Y_{MAC\_V} + \Delta Z\_VT_{LE}\_Nose - \Delta Z\_W_{LE}\_Nose - Z_{MAC\_W} = 6.219\ m$ $\qquad \Delta Z\_VT_{ac}\_W_{ac} = 6.219\ m$

$\Delta Z\_VT_{ac}\_CG := \Delta Z\_VT_{ac}\_W_{ac} + \Delta Z\_W_{LE}\_Nose \cdot \frac{X_{ac\_W}}{c_{W\_r} \cdot \cos\left(i_W\right)} = 5.771\ m$

$Z_V := \Delta Z\_VT_{ac}\_CG = 5.771\ m$

## @Aerodynamic Database ---> (C_y_beta_v)_K_Y_V_vs_b_v_over_2_times_r1

$K_{Y\_V} = 0.76$

$$C_{Roll\beta\_V} := -K_{Y\_V} \cdot C_{L\alpha\_V} \cdot \eta_{V}\_times\_1\_plus\_d\sigma\_over\_d\beta \cdot \frac{S_V}{S_W} \cdot \frac{Z_V \cdot \cos(\alpha_{WB}) - X_V \cdot \sin(\alpha_{WB})}{b_W} = -0.027$$

$$C_{Roll\beta} := C_{Roll\beta\_WB} + C_{Roll\beta\_H} + C_{Roll\beta\_V} = -0.17 \qquad C_{Roll\beta} = -0.00297\ deg^{-1}$$

## Wing - Body - Horizontal Tail - Vertical Tail Rolling Moment Coefficient due to Ailerons Deflection

$$k_M := \frac{C_{L\alpha\_W} \cdot \sqrt{1-M_1^2}}{2 \cdot \pi} = 0.704 \qquad \Lambda_M := \operatorname{atan}\left(\frac{\tan(\Lambda_{W\_c4\_eqv})}{\sqrt{1-M_1^2}}\right) = 42.118\ deg$$

$$\beta\_times\_AR\_over\_k := \frac{\sqrt{1-M_1^2} \cdot AR_W}{k_M} = 8.543$$

## @Aerodynamic Database ---> (C_l_delta_a)_RME_vs_eta_(Lambda_beta)_(beta_times_AR_over_k)_(lambda)

$RME_{in} = 0.51$ $\qquad$ $RME_{out} = 0.651$

$$\Delta RME := RME_{out} - RME_{in} = 0.141$$

$$C_{Roll\delta}' := -\frac{\Delta RME \cdot k_M}{\sqrt{1-M_1^2}} = -0.1303$$

## @Aerodynamic Database ---> (control_surface)_tau_e_vs_c_control_surface_over_c_horizontal_tail

$\tau_a = 0.453$

$$C_{Roll\delta a} := C_{Roll\delta}' \cdot \tau_a = -0.059 \qquad C_{Roll\delta a} = -0.001\ \frac{1}{deg}$$

## Wing - Body - Horizontal Tail - Vertical Tail Rolling Moment Coefficient due to Rudder Deflection

$$Z_r := 0.95 \cdot Z_V = 5.482\ m \qquad X_r := 1.05 \cdot X_V = 35.422\ m$$

## @Aerodynamic Database ---> (C_n_delta_r)_K_R_vs_eta_(lambda_v)

$K_r = 0.99$

$$C_{Roll\delta r} := C_{L\alpha\_V} \cdot \eta_V \cdot \frac{S_V}{S_W} \cdot K_r \cdot \tau_{rd} \cdot \left(\frac{Z_r \cdot \cos(\alpha_{WB}) - X_r \cdot \sin(\alpha_{WB})}{b_W}\right) = 0.027$$

## Wing - Body - Horizontal Tail - Vertical Tail    Yawing Moment Coefficient due to Sideslip Angle

$C_{N\beta\_W} := 0$    $C_{N\beta\_H} := 0$

## @Aerodynamic Database ---> (C_n_beta_b)_K_N_times_1e-3_vs_x_cg_over_l_b_(squared_l_b_over_S_b_s)_(square_root_(h1_over_h2))_(h_b_over_w_b)

$K_N = 8.855 \cdot 10^{-4}$

## @Aerodynamic Database ---> (C_n_beta_b)_K_Re_b_vs_Re_l_b_times_1e-6

$Re_{l\_B} := Re_{per.unit.len} \cdot l_B = 5.37 \cdot 10^{8}$

$K_{Re\_B} = 2.343$

$C_{N\beta\_B} := -57.3 \cdot K_N \cdot K_{Re\_B} \cdot \frac{S_{B\_side}}{S_W} \cdot \frac{l_B}{b_W} = -0.142$    $C_{N\beta\_B} = -0.002\ \frac{1}{deg}$

$C_{N\beta\_V} := K_{Y\_V} \cdot C_{L\alpha\_V} \cdot \eta_V\_times\_1\_plus\_d\sigma\_over\_d\beta \cdot \frac{S_V}{S_W} \cdot \frac{Z_V \cdot \sin(\alpha_{WB}) + X_V \cdot \cos(\alpha_{WB})}{b_W} = 0.23$    $C_{N\beta\_V} = 0.004\ \frac{1}{deg}$

$C_{N\beta} := C_{N\beta\_W} + C_{N\beta\_H} + C_{N\beta\_B} + C_{N\beta\_V} + C_{N\beta\_eng\_1} + C_{N\beta\_eng\_2} = 0.083$    $C_{N\beta} = 0.001\ \frac{1}{deg}$

## Wing - Body - Horizontal Tail - Vertical Tail    Yawing Moment Coefficient due to Ailerons Deflection

## @Aerodynamic Database ---> (C_n_delta_a)_k_n_a_vs_eta_(AR)_(lambda)

$\Delta K_{n\_A} = 0.02$

$C_{N\delta a} := -\Delta K_{n\_A} \cdot C_L \cdot C_{Roll\delta a} = 6.127 \cdot 10^{-4}$    $C_{N\delta a} = \left(1.069 \cdot 10^{-5}\right)\ \frac{1}{deg}$

## Wing - Body - Horizontal Tail - Vertical Tail    Yawing Moment Coefficient due to Rudder Deflection

$C_{N\delta r} := -C_{L\alpha\_V} \cdot \eta_V \cdot \frac{S_V}{S_W} \cdot K_r \cdot \tau_{rd} \cdot \left(\frac{Z_r \cdot \sin(\alpha_{WB}) + X_r \cdot \cos(\alpha_{WB})}{b_W}\right) = -0.264$    $C_{N\delta r} = -4.614 \cdot 10^{-3}\ \frac{1}{deg}$

# UNSTEADY LATERAL-DIRECTIONAL FLIGHT COEFFICIENTS

## Wing - Body - Horizontal Tail - Vertical Tail     Rolling Moment Coefficient due to Roll Rate

$$k_{Roll\_Rate\_W} := \frac{C_{L\alpha\_W} \cdot \sqrt{1 - {M_1}^2}}{2 \cdot \pi} = 0.704$$

$$k_{Roll\_Rate\_H} := \frac{C_{L\alpha\_H} \cdot \sqrt{1 - {M_1}^2}}{2 \cdot \pi} = 0.511$$

## @Aerodynamic Database ---> (C_l_p_w)_RDP_vs_Lambda_beta_(beta_times_AR_over_k)_(lambda)

$RDP_W = -0.355$     $RDP_H = -0.364$

$$C_{Rollp\_W} := RDP_W \cdot \frac{k_{Roll\_Rate\_W}}{\sqrt{1 - {M_1}^2}} = -0.329$$

$$C_{Rollp\_H} := \frac{1}{2} \cdot RDP_H \cdot \frac{k_{Roll\_Rate\_H}}{\sqrt{1 - {M_1}^2}} \cdot \frac{S_H}{S_W} \cdot \left(\frac{b_H}{b_W}\right)^2 = -0.004$$

$$C_{Rollp\_V} := -2 \cdot K_{Y\_V} \cdot C_{L\alpha\_V} \cdot \eta_V\_times\_1\_plus\_d\sigma\_over\_d\beta \cdot \frac{S_V}{S_W} \cdot \left(\frac{Z_V}{b_W}\right)^2 = -7.385 \cdot 10^{-3}$$

$$C_{Rollp} := C_{Rollp\_W} + C_{Rollp\_H} + C_{Rollp\_V} = -0.34$$

## Wing - Body - Horizontal Tail - Vertical Tail     Yawing Moment Coefficient due to Roll Rate

$$B := -\frac{1}{6} \cdot \frac{AR_W + 6 \cdot \left(AR_W + \cos\left(\Lambda_{W\_c4\_eqv}\right)\right) \cdot \left(\left(\xi_{CG} - \xi_{ac\_W}\right) \cdot \frac{\tan\left(\Lambda_{W\_c4\_eqv}\right)}{AR_W} + \frac{\tan\left(\Lambda_{W\_c4\_eqv}\right)^2}{12}\right)}{AR_W + \cos\left(\Lambda_{W\_c4\_eqv}\right)} = -0.187$$

$$C_{Np}\_over\_C_L@M_0\_C_{L\_ZL} := \frac{B}{\sqrt{1 - {M_1}^2 \cdot \cos\left(\Lambda_{W\_c4\_eqv}\right)^2}} = -0.222$$

$$C := \frac{AR_W + 4 \cdot \cos\left(\Lambda_{W\_c4\_eqv}\right)}{AR_W \cdot B + 4 \cdot \cos\left(\Lambda_{W\_c4\_eqv}\right)} \cdot \frac{AR_W \cdot B + 0.5 \cdot \left(AR_W \cdot B + 4 \cdot \cos\left(\Lambda_{W\_c4\_eqv}\right) \cdot \tan\left(\Lambda_{W\_c4\_eqv}\right)^2\right)}{AR_W + 0.5 \cdot \left(AR_W \cdot B + 4 \cdot \cos\left(\Lambda_{W\_c4\_eqv}\right) \cdot \tan\left(\Lambda_{W\_c4\_eqv}\right)^2\right)} = -1.122$$

$$C_{Np}\_over\_C_L@M_1\_C_{L\_ZL} := C \cdot C_{Np}\_over\_C_L@M_0\_C_{L\_ZL} = 0.249$$

## @Aerodynamic Database ---> (C_n_p_w)_dC_n_p_over_eps_w_vs_AR_(lambda)

$\Delta C_{Np}\_over\_\varepsilon_W = 5.394 \cdot 10^{-4}$

$$C_{Np\_W} := -C_{Rollp\_W} \cdot \tan(\alpha_{WB}) + C_{Rollp} \cdot \tan(\alpha_{WB}) + C_{Np\_over\_C_L@M_1\_C_{L\_ZL}} \cdot C_L + \Delta C_{Np\_over\_\varepsilon_W} \cdot (\alpha_{0l\_W\_t} - \alpha_{0l\_W\_r}) = 0.131$$

$$C_{Np\_V} := -2 \cdot K_{Y\_V} \cdot C_{L\alpha\_V} \cdot \eta_{V\_times\_1\_plus\_d\sigma\_over\_d\beta} \cdot \frac{S_V}{S_W} \cdot \left(\frac{Z_V \cdot \sin(\alpha_{WB}) + X_V \cdot \cos(\alpha_{WB})}{b_W}\right) \cdot \left(\frac{Z_V \cdot \cos(\alpha_{WB}) - X_V \cdot \sin(\alpha_{WB}) - Z_V}{b_W}\right)$$

$$C_{Np\_V} = 13.379 \cdot 10^{-3}$$

$$C_{Np} := C_{Np\_W} + C_{Np\_V} = 0.144$$

## Wing - Body - Horizontal Tail - Vertical Tail Rolling Moment Coefficient due to Yaw Rate

$$B := \sqrt{1 - M_1^{2} \cdot \cos(\Lambda_{W\_c4\_eqv})^{2}} = 0.844$$

$$D := \frac{1 + \frac{AR_W \cdot (1 - B^2)}{2 \cdot B \cdot (AR_W \cdot B + 2 \cdot \cos(\Lambda_{W\_c4\_eqv}))} + \frac{AR_W \cdot B + 2 \cdot \cos(\Lambda_{W\_c4\_eqv})}{AR_W \cdot B + 4 \cdot \cos(\Lambda_{W\_c4\_eqv})} \cdot \frac{\tan(\Lambda_{W\_c4\_eqv})^{2}}{8}}{1 + \frac{AR_W + 2 \cdot \cos(\Lambda_{W\_c4\_eqv})}{AR_W + 4 \cdot \cos(\Lambda_{W\_c4\_eqv})} \cdot \frac{\tan(\Lambda_{W\_c4\_eqv})^{2}}{8}} = 1.153$$

## @Aerodynamic Database ---> (C_l_r_w)_C_l_r_over_C_Lift1_vs_AR_(lambda)_(L_c2)

$$C_{Rollr\_over\_C_L@M_0\_C_{L\_ZL}} = 0.313$$

$$C_{Rollr\_over\_C_L@M_1\_C_{L\_ZL}} := D \cdot C_{Rollr\_over\_C_L@M_0\_C_{L\_ZL}} = 0.361$$

$$\Delta C_{Rollr\_over\_\Gamma} := \frac{1}{12} \cdot \frac{\pi \cdot AR_W \cdot \sin(\Lambda_{W\_c4\_eqv})}{AR_W + 4 \cdot \cos(\Lambda_{W\_c4\_eqv})} = 0.105$$

## @Aerodynamic Database ---> (C_l_r_w)_dC_l_r_over_eps_w_vs_AR_(lambda)

$$\Delta C_{Rollr\_over\_\varepsilon} = 0.012$$

$$C_{Rollr\_W} := C_{Rollr\_over\_C_L@M_1\_C_{L\_ZL}} \cdot C_L + \Delta C_{Rollr\_over\_\Gamma} \cdot \Gamma_{W\_eqv} + \Delta C_{Rollr\_over\_\varepsilon} \cdot (\alpha_{0l\_W\_t} - \alpha_{0l\_W\_r}) = 0.203$$

$$C_{Rollr\_V} := -2 \cdot K_{Y\_V} \cdot C_{L\alpha\_V} \cdot \eta_{V\_times\_1\_plus\_d\sigma\_over\_d\beta} \cdot \frac{S_V}{S_W} \cdot \left(\frac{Z_V \cdot \sin(\alpha_{WB}) + X_V \cdot \cos(\alpha_{WB})}{b_W}\right) \cdot \left(\frac{Z_V \cdot \cos(\alpha_{WB}) - X_V \cdot \sin(\alpha_{WB}) - Z_V}{b_W}\right)$$

$$C_{Rollr\_V} = 13.379 \cdot 10^{-3}$$

$$C_{Rollr} := C_{Rollr\_W} + C_{Rollr\_V} = 0.217$$

## Wing - Body - Horizontal Tail - Vertical Tail    Yawing Moment Coefficient due to Yaw Rate

@Aerodynamic Database ---> (C_n_r_w)_C_n_r_over_squared_(C_Lift1)_vs_AR_(lambda)_(L_c4)_(x_bar_ac_minus_x_bar_cg)

$C_{Nr\_over\_squared\_C_L} = 0.24$

@Aerodynamic Database ---> (C_n_r_w)_C_n_r_over_C_D0_bar_vs_AR_(L_c4)_(x_bar_ac_minus_x_bar_cg)

$C_{Nr\_over\_C_{D0}} = -0.446$

$$C_{Nr\_W} := C_{Nr\_over\_squared\_C_L} \cdot {C_L}^2 + C_{Nr\_over\_C_{D0}} \cdot C_{D0} = 0.053$$

$$C_{Nr\_V} := -2 \cdot K_{Y\_V} \cdot C_{L\alpha\_V} \cdot \eta_{V\_times\_1\_plus\_d\sigma\_over\_d\beta} \cdot \frac{S_V}{S_W} \cdot \left( \frac{Z_V \cdot \sin\left(\alpha_{WB}\right) + X_V \cdot \cos\left(\alpha_{WB}\right)}{b_W} \right)^2 = -0.256$$

$$C_{Nr} := C_{Nr\_W} + C_{Nr\_V} = -0.203$$

## Equilibrium system solution and results

$\delta_a = -5.115\ \boldsymbol{deg}$    $\delta_{rd} = 0.567\ \boldsymbol{deg}$

# MAPPING AND OUTPUT CREATION

Includi << ..\Default_Map_Lateral_Directional.mcdx

## Excel Writing

$n_{sheet} := 7$

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

$Block_{LD\_1} := {}_{f}\mathrm{map\_matrix\_transform}\left({}_{m}LatDir\_Data\_Map_{imported}\right)$

$Excel\_Output_{LD\_1} := {}_{f}\mathrm{write\_full\_output}\left({}_{s}Output\_Excel\_File, Block_{LD\_1}, n_{sheet}, First\_Row_{LD\_1}\right)$

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

$Block_{LD\_2} := {}_{f}\mathrm{map\_matrix\_transform}\left({}_{m}LatDir\_Data\_Map_{input}\right)$

$Excel\_Output_{LD\_2} := {}_{f}\mathrm{write\_full\_output}\left({}_{s}Output\_Excel\_File, Block_{LD\_2}, n_{sheet}, First\_Row_{LD\_2}\right)$

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

$Block_{LD\_3} := {}_{f}\mathrm{map\_matrix\_transform}\left({}_{m}LatDir\_Data\_Map\right)$

$Excel\_Output_{LD\_3} := {}_{f}\mathrm{write\_full\_output}\left({}_{s}Output\_Excel\_File, Block_{LD\_3}, n_{sheet}, First\_Row_{LD\_3}\right)$

## TeX Macro writing on .tex

${}_{v}complete\_macros_{LD} := \mathrm{stack}\left(Block_{LD\_1}{}^{\langle 2\rangle}, Block_{LD\_2}{}^{\langle 2\rangle}, Block_{LD\_3}{}^{\langle 2\rangle}\right)$

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