Strike Fighters 2 Flight Dynamic Model

That's my attempt at reconstructing the SF2 FDM. It's mostly based on information I found at the TW forum. Beware: I don't have an aerodynamic engineering background. So use the information at your own risk!
Mue

Aircraft Data

Aircraft data	Ini entry	Description
S	ReferenceArea	Reference wing area
b	ReferenceSpan	Reference wing span
$\bar{c}$	ReferenceChord	Reference wing chord

Coefficients

Coefficient	Ini entry	Factor Table	Description
C_{L0}	CL0	Mach	Lift coefficient at zero alpha
C_{Lmax}	CLmax	No	Maximum lift coefficient (at alpha max)
C_{D0}	CD0	Mach	Drag coefficient at zero lift (or alpha?)
C_{DL}	CDL	Alpha	Drag coefficient due to lift
C_{Dstall}	StallDrag	Alpha	Drag coefficient at stall
C_{mstall}	StallMoment	No	Pitch moment coefficient at stall
C_{L0}	CL0	Mach	Lift coefficient at zero alpha

Derivatives

Derivatives	Ini entry	Factor Table	Description
C_{L_α}	CLa	Mach	Lift coefficient due to Alpha (lift curve slope)
C_{m_q}	Cmq	No	Pitching moment due to pitch rate (pitch damping)
$C_{m_{\dot{\alpha}}}$	Cmad	No	Pitching moment due alpha rate (aero interaction between wings and horiz tail)
C_{Y_b}	Cyb	?	Side force due to beta
C_{Y_p}	Cyp	?	Side force due to roll rate

Derivatives	Ini entry	Factor Table	Description
C_{Y_r}	Cyr	?	Side force due to yaw rate
C_{l_b}	Clb		Roll moment due to sideslip
C_{l_p}	Clp		Roll moment due to roll rate (roll damping)
C_{l_r}	Clr		Roll moment due to yaw rate
C_{n_b}	Cnb		Yaw moment due to sideslip
C_{n_p}	Cnp		Yaw moment due to roll rate
C_{n_r}	Cnr		Yaw moment due to yaw rate (yaw damping)
$C_{L_{\delta c}}$	CLiftdc		Lift due to control surface deflection
$C_{D_{\delta c}}$	CDdc		Drag due to control surface deflection
$C_{y_{\delta c}}$	Cydc	Alpha, Mach	Side force due to control surface deflection
$C_{l_{\delta c}}$	Cldc	Alpha, Mach	Roll moment due to control surface deflection
$C_{m_{\delta c}}$	Cmdc		Pitch moment due to control surface deflection
$C_{n_{\delta c}}$	Cndc	Alpha, Mach	Yaw moment due to control surface deflection

Other Parameter

Parameter	Ini entry	Factor Table	Description
α_{stall}	AlphaStall	No	Alpha at which stall starts
α_{max}	AlphaMax	No	Alpha with maximum lift
α_{depart}	AlphaDepart	No	Alpha were departure starts
$\Delta\alpha_{stall}$	DeltaStallAlpha	No	Increase in max angle-of-attack before stall
X_{ac}	Xac	Mach	X-location of aerodynamic center
Y_{mac}	Ymac	No	X-location of mean area chord
?	AreaRatio	?	?
?	Chord	?	?

Tables

Parameter	Ini entry	Description
$f_{Xac}(M)$	XacMachTable*	X position of aerodynamic center
$f_{\epsilon}(\alpha)$	DownwashAlpha*	Downwash angle
$f_{StallLift}(\alpha)$	StallLiftTable*	Modifier factor for lift coefficient (in stall)
$f_{StallDrag}(\alpha)$	StallDragTable*	Modifier factor for drag coefficient (in stall)
$f_{StallXacShift}(\alpha)$	StallXacShiftTable*	Shift of aerodynamic center (in stall)

Modifier Factor Tables

Parameter	Ini entry	Description
$f_{C_{L0}}(M)$	CL0MachTable*	Modifier factor for Lift coefficient dependent on Mach
$f_{C_{La}}(M)$	CLaMachTable*	Modifier factor for Lift slope dependent on Mach
$f_{C_{D0}}(M)$	CD0MachTable*	Modifier factor for Drag (zero lift) coefficient dependent on Mach
$f_{C_{DL}}(\alpha)$	CDLAlphaTable*	Modifier factor for Drag (due to lift) coefficient dependent on Alpha
...	...	...

Most coefficients and derivatives are modified by a factor read from Mach and/or Alpha tables if those are defined. E.g. in the formulas below

- C_{L0} has to be multiplied by $f_{C_{L0}}(M)$
- C_{L_α} and C_{Lmax} has to be multiplied by $f_{C_{L\alpha}}(M)$
- ...

Input Paramters

Parameter	Ini entry	Description
α_{frl}	-	alpha measured to fuselage reference line
β	-	sideslip angle beta
δ	-	control surface deflection
V_T	-	free stream air velocity
ρ	-	free stream mass density (standard atmosphere model?)

In the formulas below **local** alpha is used:

$$\alpha = \alpha_{frl} - f_{\epsilon}(\alpha_{frl})$$

Question: Lift and drag direction based on local alpha, i.e. rotated with downwash alpha?

If the component has HIGHLIFT_DEVICEs then α_{stall}, α_{max} and α_{depart} must be corrected by $\Delta\alpha_{stall}$ multiplied with the fraction of deflection of the highlift device f_δ (0.0 for no deflection, 1.0 for full deflection):

$$\begin{aligned}\alpha_{stall} &= \alpha_{stall} + f_\delta \Delta\alpha_{stall}\\ \alpha_{max} &= \alpha_{max} + f_\delta \Delta\alpha_{stall}\\ \alpha_{depart} &= \alpha_{depart} + f_\delta \Delta\alpha_{stall}\end{aligned}$$

Dynamic pressure:

$$\bar{q} = \frac{1}{2}\rho V_T^2$$

Lift

Beware: Post stall behaviour ($\alpha > \alpha_{depart}$) is only guess work from my side!

$$\begin{aligned}C_L &= \begin{cases} C_{L0} + C_{L_a}\alpha & \text{if } \alpha < \alpha_{stall}\\ a\alpha^2 + b\alpha + c & \text{if } \alpha_{stall} < \alpha < \alpha_{max}\\ C_{Lmax} & \text{if } \alpha_{max} < \alpha < \alpha_{depart}\\ C_{Lmax} f_{StallLift}(\alpha) & \text{if } \alpha > \alpha_{depart}\end{cases} + C_{L_{\delta c}}\delta\\ L &= \bar{q} S C_L\end{aligned}$$

Drag

Beware: Post stall behaviour ($\alpha > \alpha_{depart}$) is only guess work from my side!

$$\begin{aligned}C_D &= \begin{cases} C_{D0} + C_{DL} & \text{if } \alpha < \alpha_{depart}\\ f_{StallDrag}(\alpha) C_{StallDrag} & \text{if } \alpha > \alpha_{depart}\end{cases} + C_{D_{\delta c}}\delta\\ D &= \bar{q} S C_D\end{aligned}$$

Sideforce

$$\begin{aligned}C_Y &= C_{yb}\beta + \frac{b}{2V_T}[C_{Y_p}P + C_{Y_r}R] + C_{Y_{\delta c}}\delta\\ D &= \bar{q} S C_Y\end{aligned}$$

Pitch Moment

$$\begin{aligned}C_m &= \frac{b}{2V_T}[C_{mq}Q + C_{m\dot{\alpha}}\dot{\alpha}] + \frac{f_{XacMach}(M)}{\bar{c}}(C_L\cos(\alpha) + C_D\sin(\alpha)) + C_{m_{\delta c}}\delta\\ m &= \bar{q} S \bar{c} C_m\end{aligned}$$

Roll Moment

$$C_l = C_{lb}\beta + \frac{b}{2V_T}[C_{lp}P + C_{lr}R] + \frac{Y_{mac}}{b}(C_L \cos(\alpha) + C_D \sin(\alpha)) + C_{l_{\delta c}}\delta$$
$$l = \bar{q}S\bar{b}C_l$$

Yaw Moment

$$C_n = C_{nb}\beta + \frac{b}{2V_T}[C_{np}P + C_{nr}R] + C_{n_{\delta c}}\delta$$
$$n = \bar{q}S\bar{b}C_n$$