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Documentation of OpenVSP Connect

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Technical Note

List of abbreviations

x	X - position
y	Y - position
z	Z - position
phi	Sweep
gamma	Dihedral angle
l	Length
h	Height
w	Width
r	Root
t	Tip
c	Chord
C	Coefficient
W	Wing
F	Fuselage
H	Horizontal Tail
V	Vertical Tail
E	Elevator
R	Rudder
E	Engine
j	Jet
p	Propeller
delta	Difference
A	Aspect ratio
lambda	Taper ratio
b	Span
epsilon	Twist
i	Incidence angle
df	Dorsal fin
re	Rounded edge (at VT edge)
k	Constant
L	Lever arm
M	Mach number
S	Area
name	Name
type	Type
i/o	Inner/outer
d	Diameter
LG	Landing Gear

eta_k	Kink_ratio
T	Thrust
P	Power
TO	Take off

Greek symbols

φ	Sweep
Γ	Dihedral angle
Δ	Difference
λ	Taper ratio
ε	Twist
η_k	Kink_ratio

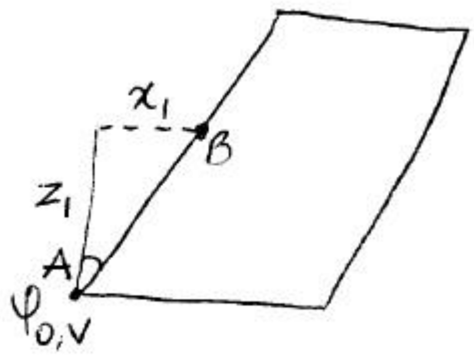
Table of Contents

1 Horizontal Tail

X-position without Dorsal fin (DF)

$$posh_x = \frac{\mathrm{Re}\,lPosh_x}{100} l_F + (posh_z - posv_z)\ tan(\varphi_{0,\,\mathrm{v}}) \tag{1.1}$$

i1 i2



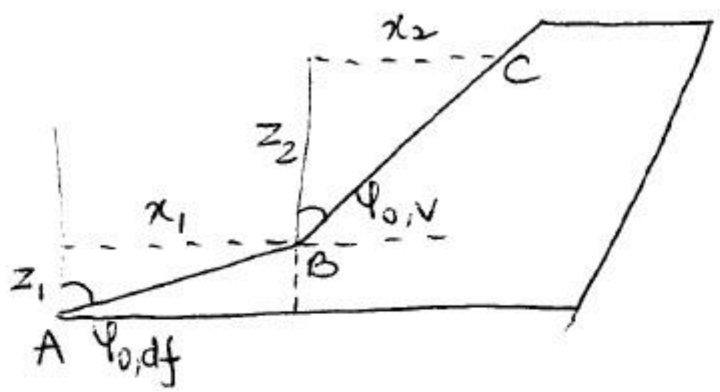
$\mathrm{x}_1 = \mathrm{z}_1 \cdot tan(\varphi_{0,\,\mathrm{v}})$
$z_1 = (posh_z - posv_z)$

$posh_z$ and $posv_z$ are measured from centre line of fuselage.

i1 of Equation 1.1 gives the x-pos^n of Horizontal Tail (HT) along the fuselage.
i2 of Equation 1.1 accounts for the x-pos^n variation due to vertical tail sweep, $\varphi_{0,\,v}$.

X-position with Dorsal fin

$$posh_x = i1 + b_{df} \cdot tan(\varphi_{0,df}) + (pos_{h,z} - pos_{v,z} - b_{df})\ tan(\varphi_{0,v}) \tag{1.2}$$



$x_1 = z_1 \cdot \tan(\varphi_{0,df})$
$z_1 = b_{df}$
$x_2 = z_2 \cdot tan(\varphi_{0,v})$
$z_2 = posh_z - posv_z - b_{df}$

In Equation 1.2, the sweep of the DF is considered too.

Y–position of Horizontal Tail

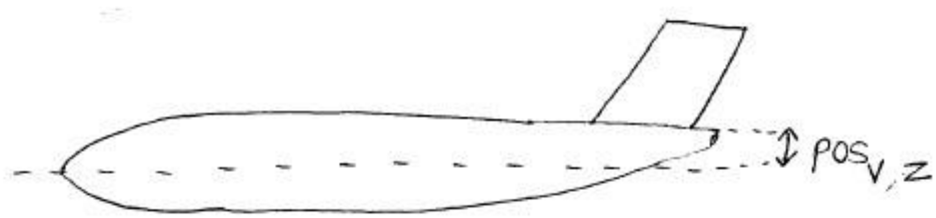
This is considered equal to 0 to be symmetrical about the xz plane

$$posh_y = 0 \tag{1.3}$$

Z-position of Horizontal Tail

$$posh_z = posv_z + \left(\frac{\mathrm{Re}lPosh_z}{100} \right) b_v \qquad (1.4)$$

Relposh$_z$ is measured of a percentage factor of Vertical Tail (VT) span, b_v.



2 Vertical Tail

X-position of Vertical Tail

$$posv_x = \left(\frac{\mathrm{Re}\, lPosv_x}{100} \right) l_F \tag{2.1}$$

Relposv$_x$ is measured as a percentage factor of fuselage length, l$_F$.

Y-position of Vertical Tail

$$posv_y = 0 \tag{2.2}$$

Like in Equation 1.3, this is done to maintain symmetry of the aircraft along xz plane.

Z-position of Vertical Tail

$$posv_z = \frac{d_f}{2} \tag{2.3}$$

This is because, we adopt a VT definition that states that there is no part of the VT inside the fuselage area. Rather, it begins from the Top surface of fuselage. Also, for simplicity reasons, we assume that the fuselage top does not bend downwards at the tail cone.

3 Wing

X-position of wing

$$posw_x = \left(\frac{\mathrm{Re}\,lPosw_x}{100}\right) l_F \tag{3.1}$$

This is similar to Equation 2.1

Y-position of wing

$$posw_y = 0 \tag{3.2}$$

This is similar to Equation 2.2

Z-position of wing

$$posw_z = -\frac{d_F}{2} + \left(\frac{\mathrm{Re}\,lPosw_z}{100}\right) d_F \tag{3.3}$$

As $Relposw_z$ varies from 0 – 100%, the wing moves from low wing to high wing configuration i.e. $posw_z \in [-d_F, d_F]$

4 Fuselage

The x, y and z positions of the fuselage are taken as reference positions for all the other aircraft Components. Thus, it is most appropriate to equate these values to 0.

X-position

$$posf_x = 0 \tag{4.1}$$

Y-position

$$posf_y = 0 \tag{4.2}$$

Z-position

$$posf_z = 0 \tag{4.3}$$

5 Jet Engine 1

X-position when $n_e = 1$

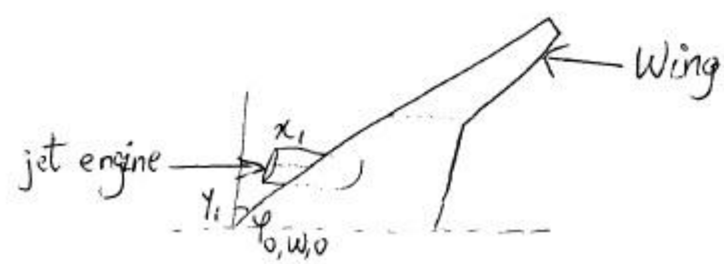
This is a very rare case as we did not find any aircraft which runs on only one jet engine.
We assume therefore, that if this case should exist, this single engine should be mounted at the tail.

$$pos_{e,j1,x} = posv_x \tag{5.1}$$

This value does not account for VT sweep. If used, the user is suggested to alter this value based on engine holding unit (extra) dimensions, poss.

X-position when $n_e \neq 1$

$$pos_{e,j1,x} = \underbrace{posw_x}_{i1} + \underbrace{pos_{e,j1,y} \cdot tan(\varphi_{0,w,o})}_{i2} \tag{5.2}$$



$x_1 = y_1 \cdot tan(\varphi_{0,w,o})$

$y_1 = pos_{e,j1,y}$

Note: In the default version of OpenVSP Connect, the inboard LE sweep = outboard LE sweep.
In case this is changed by the user, i2 of Equation 5.2 has to be modified depending whether the y-position is within the inboard/outboard segment of the wing (only in case of double-trapezoidal wing).

Y-position when $n_e = 1$

$$pos_{e,j1,y} = 0 \tag{5.3}$$

This is done in order to maintain symmetry of the aircraft along the XZ plane.

Y-position when n_e = 2 or 3

$$pos_{e,j1,y} = \left(\frac{32 \cdot 59}{100}\right)\left(\frac{b_w}{2}\right) \tag{5.4}$$

This is according to statistical results of aircraft having two or three engines.

Z-position when n_e = 4

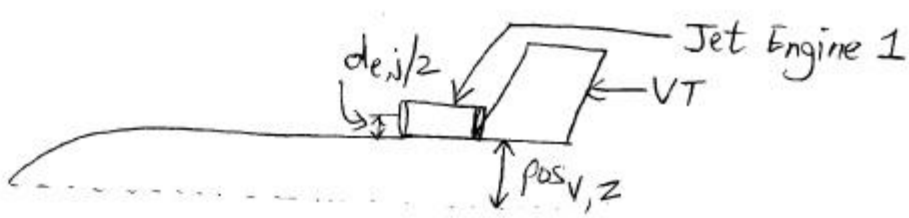
$$pos_{e,j1,y} = \left(\frac{39 \cdot 3}{100}\right)\left(\frac{b_w}{2}\right) \tag{5.5}$$

This is according to statistical results of aircraft having 4 engines.

Z-position when n_e = 1

$$pos_{e,j1,z} = posv_z + \left(\frac{d_{e,j}}{2}\right) \tag{5.6}$$

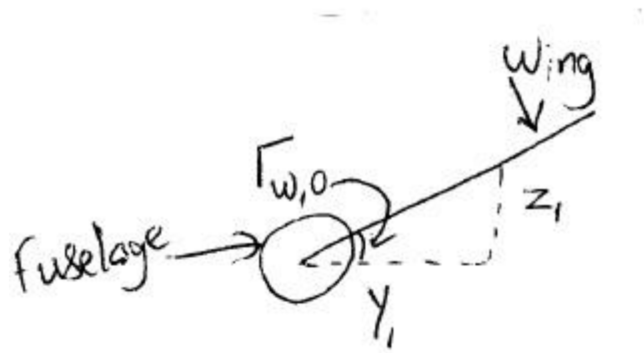
I2 of Equation 5.2 is added to align the bottom of the engine with the fuselage top and not the center.



Z-position when $n_e \neq 1$

$$pos_{e,j1,z} = posw_z + pos_{e,j1,y} \cdot tan(\Gamma_{w,o}) - \left(\frac{d_{e,j}}{2}\right) - 0{,}6 \cdot l_{e,j,pylon} \tag{5.7}$$

i1 i2 i3 i4



$z_1 = y_1 \cdot tan(\Gamma_{w,o})$

$y_1 = pos_{e,j1,y}$

i3 and i4 of Equation 5.7 are considered to offset the engine diameter and pylon length respectively. The constant 0,6 is taken arbitrarily and may be changed if not appropriate to the user. In the default version of OpenVSP Connect, $\Gamma_{w,i} = \Gamma_{w,o}$ (inboard and outboard dihedral angles are equal). This is assumed in i2 of Equation 5.7.

6 Jet Engine 2

position^{ns} when $n_e = 1$

$$pos_{e,j2,x} = pos_{e,j2,y} = pos_{e,j2,z} = "N/A" \tag{6.1}$$

Engine 2 is not present as $n_e = 1$

X-position when $n_e \neq 1$

$$pos_{e,j2,x} = pos_{w,x} - pos_{e,j2,y} \cdot tan(\varphi_{0,w,0}) \tag{6.2}$$

This is similar to Equation 5.2. The ‘-‘sign instead of ‘+’ is because $pos_{e,j2,x}$ is negative and $pos_{e,j1,y}$ is positive.

Y-position

Similar to Equation 5.4 and 5.5

Z-position

Similar to Equation 5.7

7 Jet Engine 3

Position^{ns} when $n_e = 1$ or $n_e = 2$

Like Equation 6.1, engine 3 is not present. Hence, all these values (x,y,z) = “N/A”.

X-position when $n_e = 3$

$$pos_{e,j3,x} = pos_{v,x} \tag{7.2}$$

See Equation 5.1
Unlike Equation 5.1 however, this case is very much possible and does exist.

X-position when $n_e = 4$

$$pos_{e,j3,x} = posw_x + pos_{e,j3,y} \cdot tan(\varphi_{0,\,w,0}) \tag{7.3}$$

This is similar to Equation 5.2

Y-position when $n_e = 3$

$$pos_{e,j3,y} = 0 \tag{7.4}$$

Similar to Equation 5.3

Y-position when $n_e = 4$

$$pos_{e,j3,y} = \left(\frac{67 \cdot 27}{100}\right)\left(\frac{b_w}{2}\right) \tag{7.5}$$

This is based on statistics.

Z-position when $n_e = 3$

$$pos_{e,j3,z} = pos_{v,z} + \left(\frac{d_{e,j}}{2}\right) \tag{7.6}$$

Similar to Equation 5.6

Z-position when $n_e = 4$

Similar to Equation 5.7

8 Jet Engine 4

Position^{ns} when $n_e \neq 4$

Similar to Equation 7.1

X-position when $n_e = 4$

Similar to Equation 6.2

Y-position when $n_e = 4$

$$pos_{e,j4,y} = \left(\frac{67 \cdot 27}{100}\right)\left(\frac{b_w}{2}\right) \tag{8.3}$$

Similar to Equation 7.5

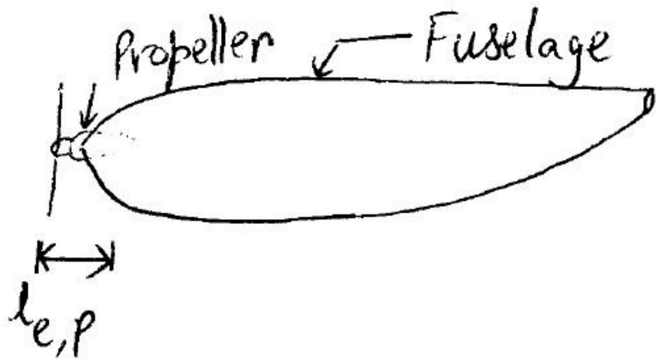
Z-position when $n_e = 4$

Similar to Equation 5.7

9 Propeller Engine 1

X-position when $n_e = 1$

$$pos_{e,p1,x} = -0{,}3 l_{e,p} \tag{9.1}$$



The constant -0,3 is arbitrarily chosen and the user should change this constant, if found inappropriate.

X-position when $n_e \neq 1$

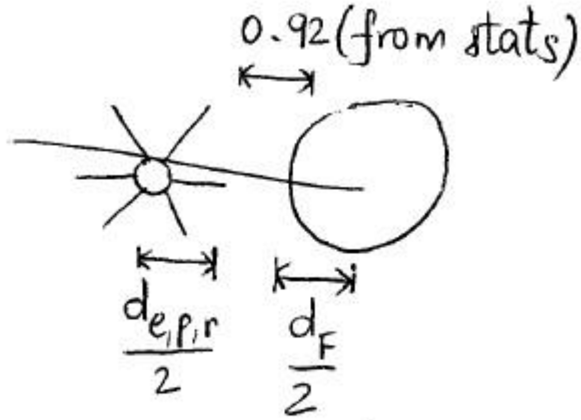
Similar to Equation 5.2

Y-position when $n_e = 1$

Similar to Equation 5.3

Y-position when $n_e = 2$ or $n_e = 3$

$$pos_{e,p1,y} = \left(\frac{d_F}{2}\right) + \left(\frac{d_{e,p,r}}{2}\right) + 0{,}92 \tag{9.4}$$



The constant 0,92 has been obtained from statistics of propeller aircraft. It is an absolute value.

Y-position when $n_e = 4$

$$pos_{e,p1,y} = \left(\frac{d_F}{2}\right) + \left(\frac{d_{e,p,r}}{2}\right) + 1{,}01 \tag{9.5}$$

This is similar to Equation 9.4 except the constant. The constant, 1,01 is obtained from statistical of propeller aircraft having 4 engines.

Z-position when $n_e = 1$

$$\mathrm{pos}_{e,\,p1,\,z} = 0 \tag{9.6}$$

This is to maintain concentricity between the propeller engine and the fuselage nose.

Z-position when $n_e \neq 1$

$$pos_{e,p1,z} = posw_z + pos_{e,p1,y} \cdot tan(\Gamma_{w,0}) - \frac{d_{e,p}}{2} \tag{9.7}$$

This is similar to Equation 5.7

In the default version of OpenVSP Connect, pylons are not included for propeller engines. Thus, this factor does not feature in the equation.

10 Propeller Engine 2

position^{ns} when $n_e = 1$

All these values = 0
Similar to Equation 6.1

X-position when $n_e \neq 1$

Similar to Equation 6.2

Y-position when $n_e = 2$ or $n_e = 3$

Similar to Equation 9.4

Y-position when $n_e = 4$

Similar to Equation 9.5

Z-position when $n_e \neq 1$

Similar to Equation 9.7

11 Propeller Engine 3

position^{ns} when $n_e = 1$ or $n_e = 2$

Similar to Equation 6.1

X-position when $n_e = 3$

Similar to Equation 7.2

X-position when $n_e = 4$

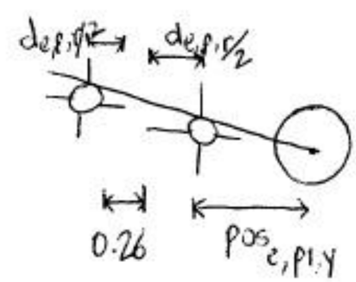
Similar to Equation 7.3

Y-position when $n_e = 3$

Similar to Equation 5.3

Y-position when $n_e = 4$

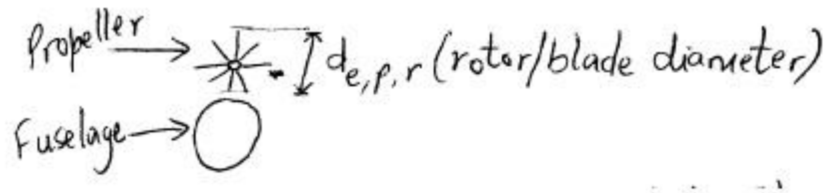
$$pos_{e,p3,y} = pos_{e,p1,y} + d_{e,p,r} + 0{,}26 \tag{11.5}$$



The constant 0,26 has been obtained from statistics of propeller aircraft having 4 engines.

Z-position when $n_e = 3$

$$pos_{e,p3,z} = pos_{v,z} + 0{,}6\, d_{e,p,r} \tag{11.6}$$



The constant 0,6 is arbitrarily chosen and may be changed, if found inappropriate.

Z-position when $n_e = 4$

Similar to Equation 9.7

12 Propeller Engine 4

Position^{ns} when $n_e \neq 4$

Similar to Equation 6.1

X-position when $n_e = 4$

Similar to Equation 6.2

Y-position when $n_e = 4$

Similar to Equation 11.5

Z-position when $n_e = 4$

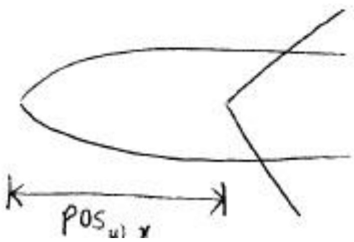
Similar to Equation 9.7

13 Landing Gear 1 (main-Gear 1)

X-position

$$pos_{LG1,x} = posw_x + \frac{s_w}{b_w} \tag{13.1}$$

i1 i2



II is the measure of the average chord of the wing.

Y-position

$$pos_{LG1,y} = 0{,}111 \cdot b_w - \frac{W_{LG}}{2} \tag{13.2}$$

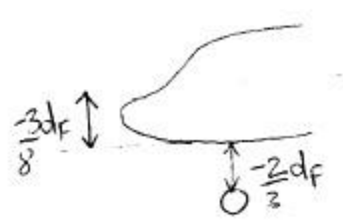
i1 i2

The constant 0,111 is obtained as the corresponding value as measured from A-320 3-view.
I2 of Equation takes care of the width of the LG. This factor maintains the centerline of the LG at correct pos.

Z-position of Landing Gear 1, Landing Gear 2, Landing Gear 3

$$pos_{LG1,z} = \left(-\frac{25}{24}\right) d_F \tag{13.3}$$

From statistical equation[ns], this value equals $\frac{2}{3} d_F$ from the bottom of fuselage (when considering the nose gear). But, average distance from fuselage center-line to bottom of fuselage at that point = $\frac{3}{8} d_F$. Thus, the final value = $-\left(\frac{2}{3}+\frac{3}{8}\right) d_F = \left(-\frac{25}{24}\right) d_F$



14 Landing Gear 2 (main-Gear3)

X-position

Similar to Equation 13.1

Y-position

Similar to Equation 13.2

Z-position

Similar to Equation 13.3

15 Landing Gear 3

X-position

$$pos_{LG3,x} = d_F \tag{15.1}$$

This comes from a statistical equation.

Y-position

$$pos_{LG3,y} = -\frac{W_{LG}}{2} \tag{15.2}$$

Similar to Equation 13.2

Z-position

Similar to Equation 13.3

Naming convention used

1) Underscore for subscript
Ex.: A_v is written as A_V

2) Dot (.) is used in place of comma (,)
Ex.: c_r,v → c_r.V

3) First 3 alphabets are used for small-case greek letters.
Ex.: $\varphi_{25,\,H}$ → phi_25.H

4) The 1st alphabet is doubled for capital-case Greek letters.
Ex.: Γ_H → ggam_H

5) Backslash (\) is used for ratios.
Ex.: t/c → t\c