**Fx Drag** as a Function of **AoA and Airspeed**

Completed on 30/03/2023

Using lift\_body.m

## Wind Tunnels Test Data Used:

* -(LP1-LP4-LP5)

With

* LP1: a/c w/o pusher
* LP4: a/c w/o pusher w/o wing w/o hover props
* LP5: a/c w/o pusher w/o elevator w/o hover props

## Modifications to data

* Removing entries with non-zero control surfaces
* Removing entries with non-zero pusher motor
* Removing entries with non-zero hover motor command
* Removing entries with angle of attack higher than 15 deg --> Remove stall condition (non-linear)

## Fit for Drag vs Fx Drag

Lift and drag are always respectively perpendicular and parallel to airspeed. They are defined as:

CL = (CL\_0+CL\_alpha\*alpha)

and

CD = (CD\_0+CL^2/(Pi\*AR\*e)

CD = (CD\_0+(CL\_0+CL\_alpha\*alpha)^2/(Pi\*AR\*e)

CD = (CD\_0+(CL\_0^2+2\*CL\_0\*CL\_alpha\*alpha+CL\_alpha^2\*alpha^2)/(Pi\*AR\*e)

CD = CD\_0+CL\_0^2/(Pi\*AR\*e)+ (2CL\_0\*CL\_alpha/(Pi\*AR\*e))\*alpha+(CL\_alpha^2\*alpha^2)/(Pi\*AR\*e)

CD = K1 + K2\*alpha + K3\*alpha^2

where K1,K2 and K3 > 0

To see forces in the body frame, need to project drag and lift using the angle of attack:

Fx = L sin(alpha) – D cos(alpha)

By using the small angle approximation:

Fx/rho\*S\*V^2 = L\*alpha – D

= (CL\_0+CL\_alpha\*alpha)\*alpha -D

= (CL\_0\*alpha+CL\_alpha^2) -D

= (CL\_0\*alpha+CL\_alpha^2)– CD\_0-CL\_0^2/(Pi\*AR\*e)- (2CL\_0\*CL\_alpha/(Pi\*AR\*e))\*alpha-(CL\_alpha^2\*alpha^2)/(Pi\*AR\*e)

= – CD\_0-CL\_0^2/(Pi\*AR\*e) + (CL\_0-2CL\_0\*CL\_alpha/(Pi\*AR\*e))\*alpha + (CL\_alpha^2-CL\_alpha^2\*alpha^2)/(Pi\*AR\*e))\*alpha^2

Fx =( K1 + K2\*alpha **+** K3\*alpha^2 ) rho\*S\*V^2

Fx = ( K1 + K2\*alpha **+** K3\*alpha^2 ) V^2 (because rho and S are constant and can be captured by K1, K2 and K3)

Where K1 <0, K2 and K3 >0 (because AR >2)

## Fit with variable skew

Fx = (k1\*cos(skew)+k2+k3\*alpha+k4\*alpha^2)\*V^2

% s\_skew =

%

% -0.008111212221499

% -0.024771353274546

% -0.008297633291171

% 0.177246306723145

%

%

% RMS\_skew =

%

% 0.323963710192727

for fitting on whole skew enveloppe, not a big penalty on RMS (from 0.2 -->0.24)

It can be seen that the skew angle mostly modifies the intercept of the curves

