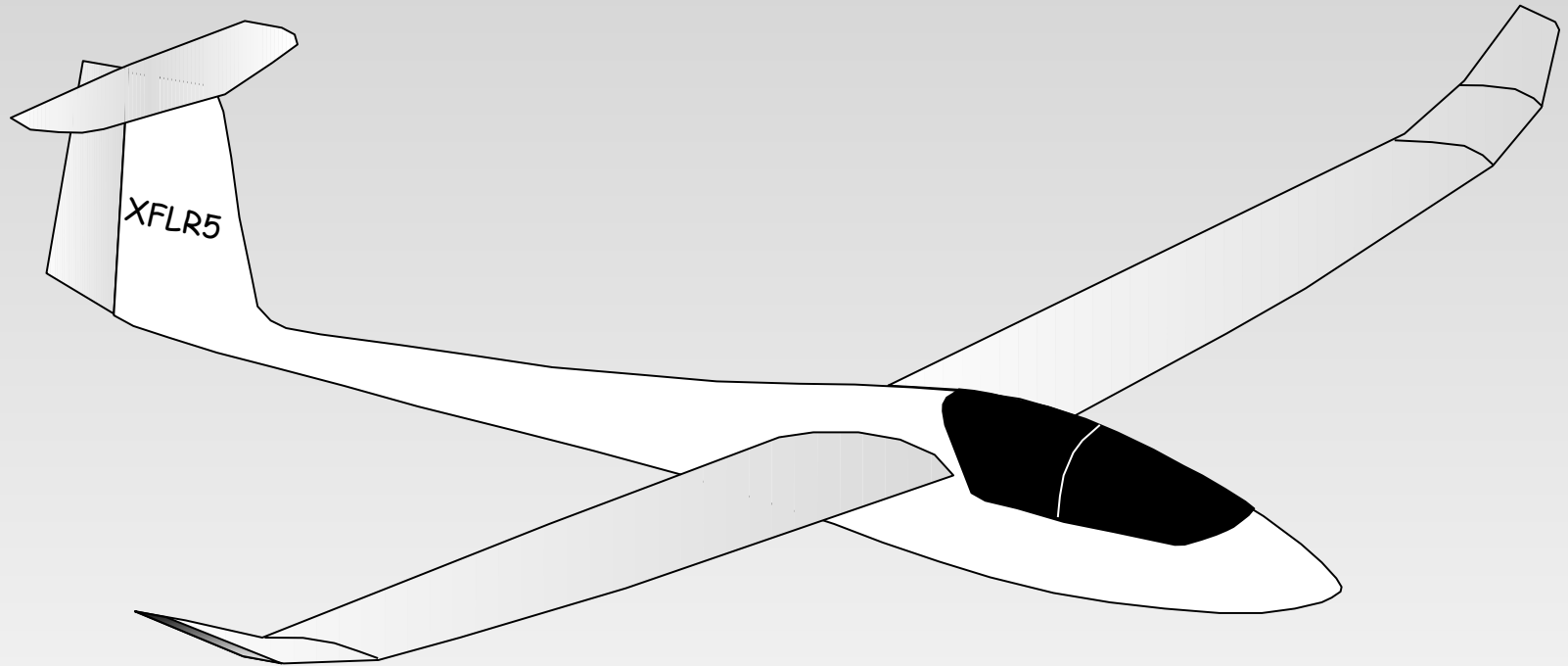


About XFLR5 calculations and experimental measurements



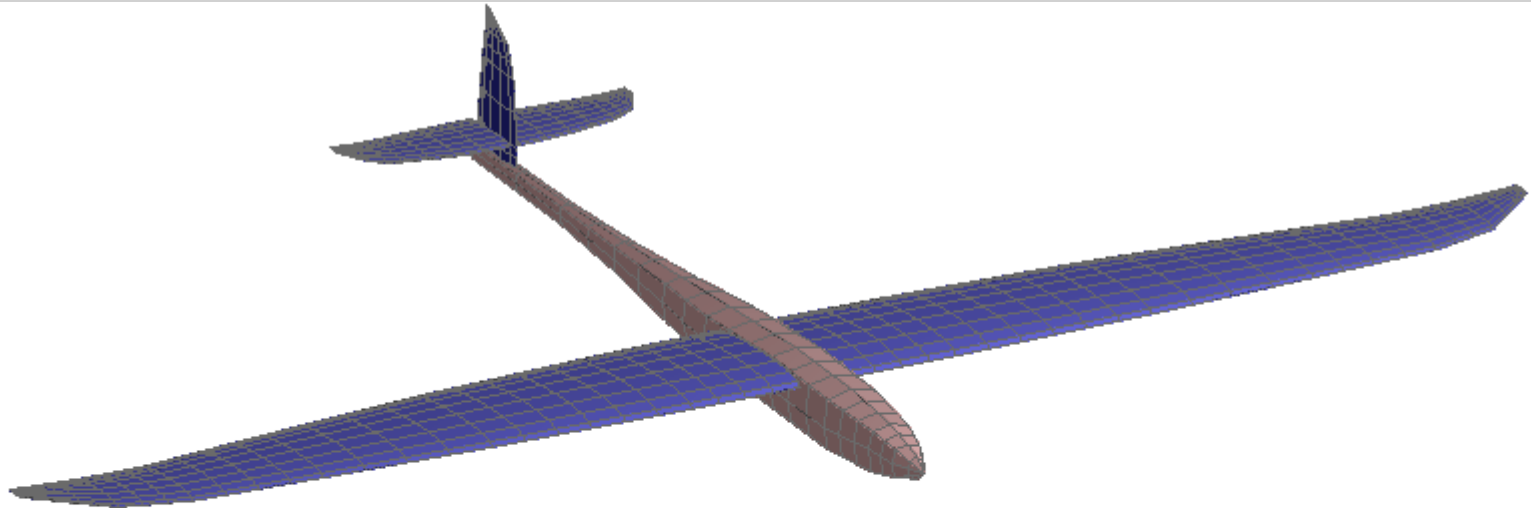
The experiment - General comments

- The experiment has been set up and carried out by Matthieu Scherrer's team at the CEAT in Toulouse, France, beginning of 2008 - thanks to them all
- Details can be found at <http://sailplane-matscherrer.blogspot.com/>
- The predictions published at the address above had been provided before the measurements were available
- Francesco Meschia used XFLR5 V3.21 / VLM - his results are referred to as "FMe" - thanks, Francesco
- The author used XFLR5 V4.00, which unfortunately was finished in a hurry and was not totally reliable at the time - and it's an understatement
- Since then, the code has been debugged and improved, the new results with comments are provided in the following slides
- The validity of the measurements has not been questioned

The test sailplane



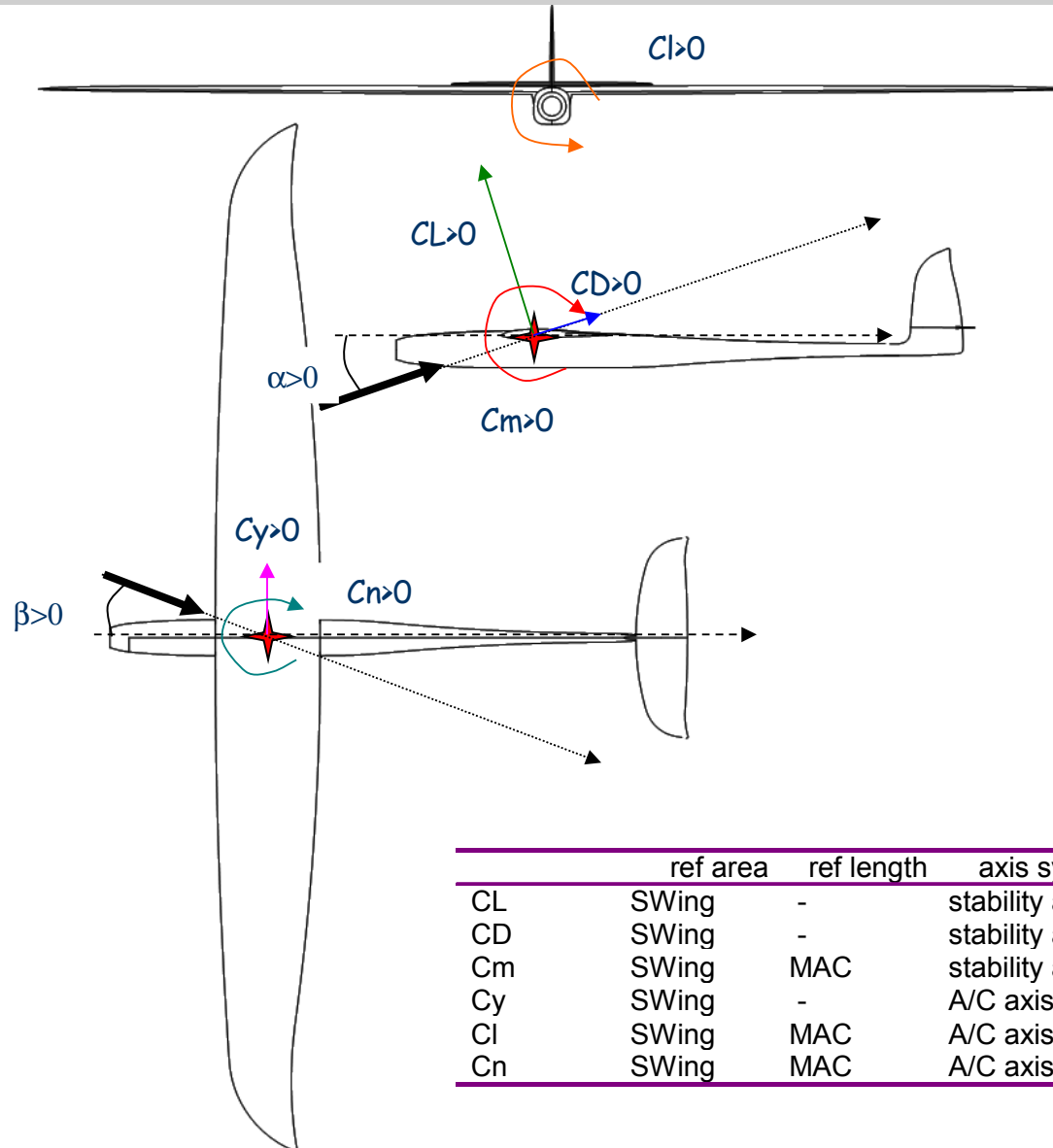
The model



```
Jibe2 Plane with Body
Wing span      = 1370.00 mm
Wing area      = 15.15 dm²
Plane weight   = 800.00 g
Wing load      = 52.788 g/dm²
Tail Volume    = 0.56
Root chord     = 140.00 mm
M.A.C.         = 118.32 mm
Twist at tip   = 0.0 °
Aspect Ratio   = 12.4
Taper Ratio    = 7.6
Rt-Tip sweep   = 5.0 °
```

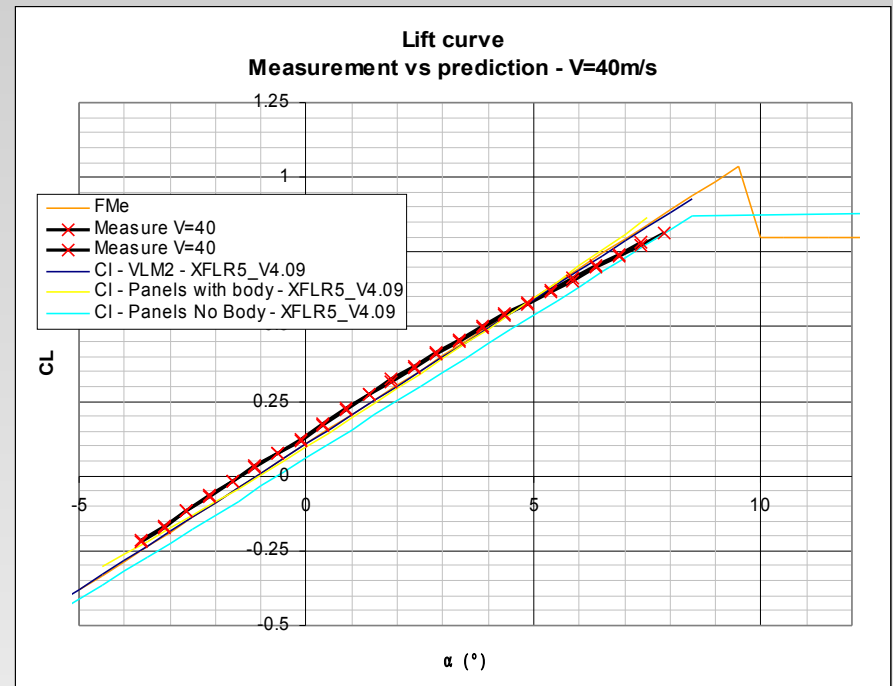
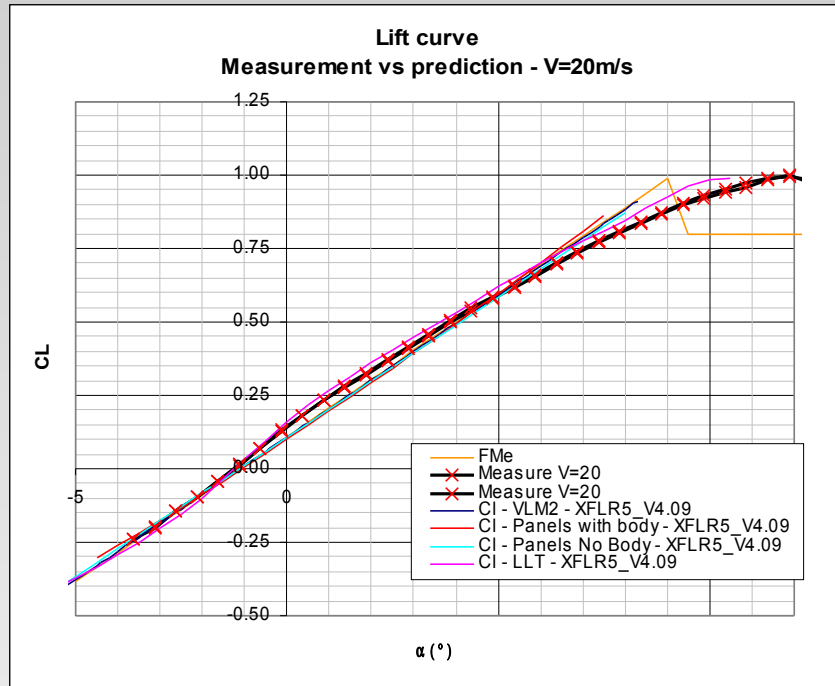
The analysis has been run with and without the body,
using either LLT, 3D panels or VLM methods

The sign conventions



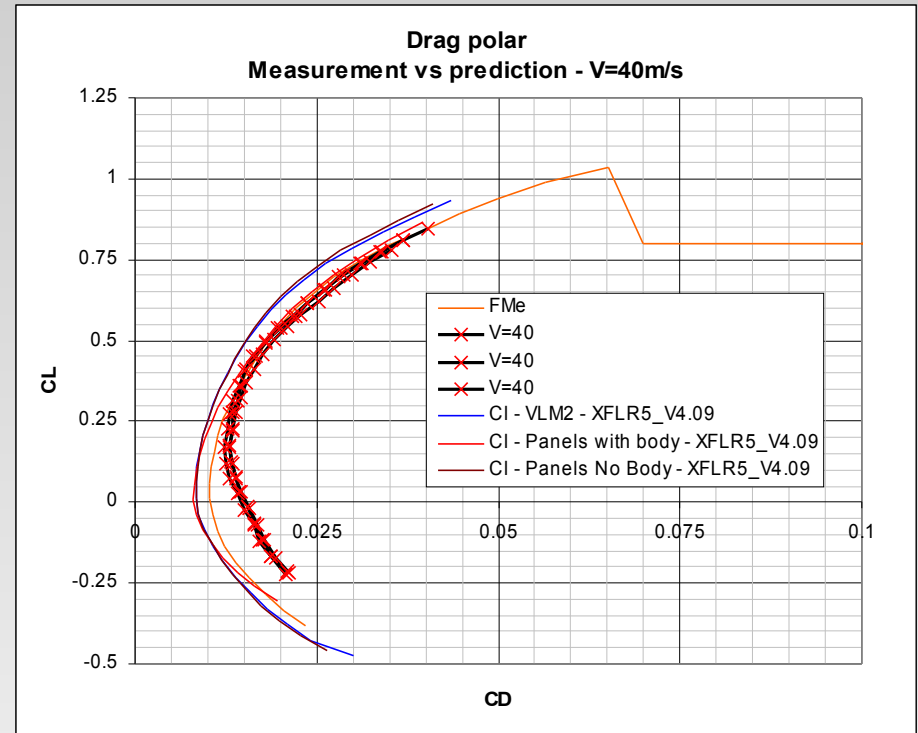
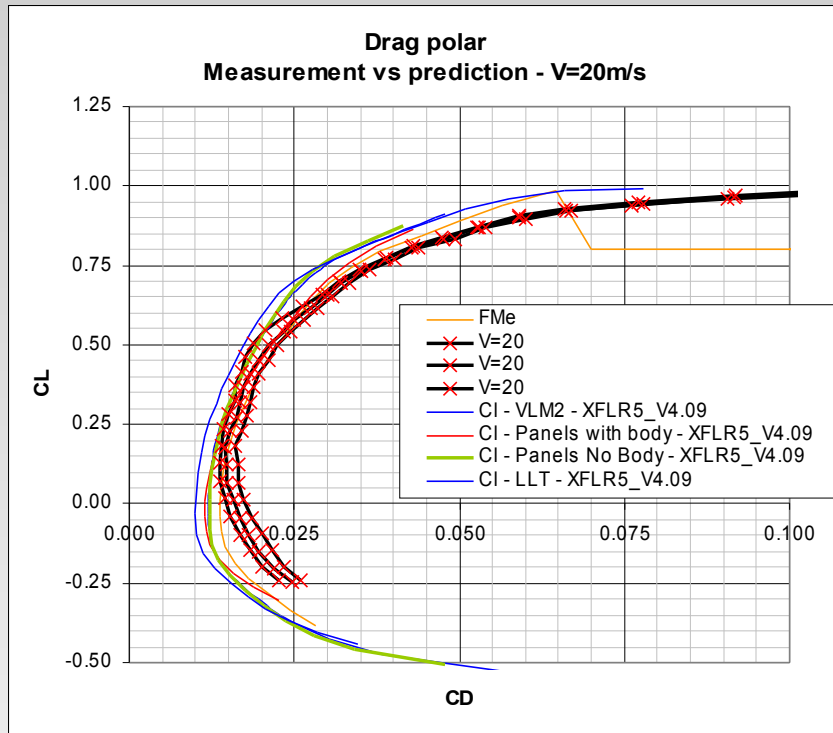
	ref area	ref length	axis system
CL	SWing	-	stability axis
CD	SWing	-	stability axis
Cm	SWing	MAC	stability axis
Cy	SWing	-	A/C axis
Cl	SWing	MAC	A/C axis
Cn	SWing	MAC	A/C axis

Lift Curve - No sideslip



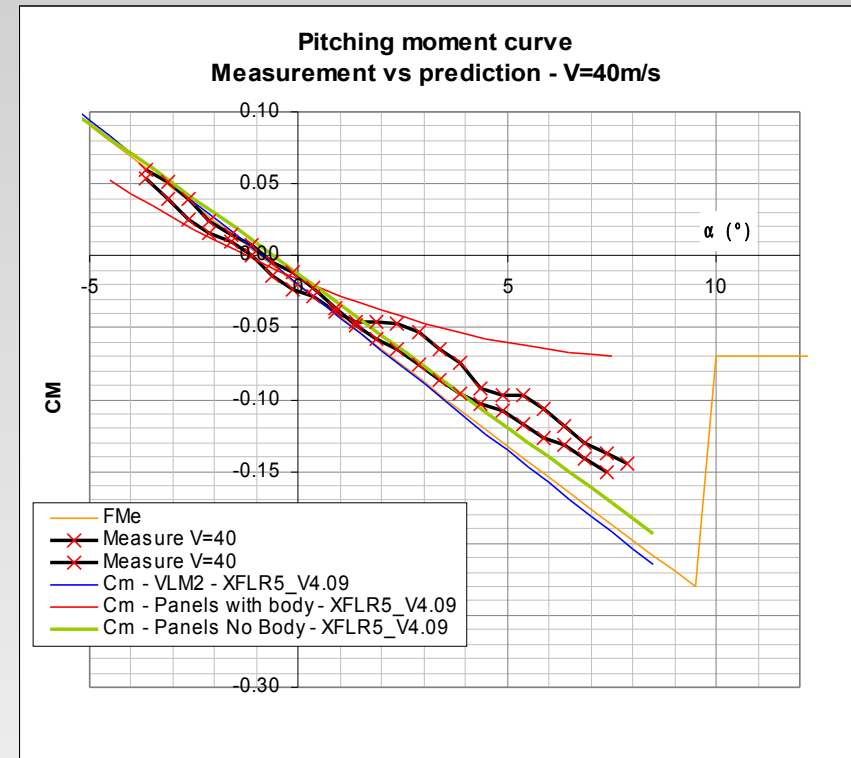
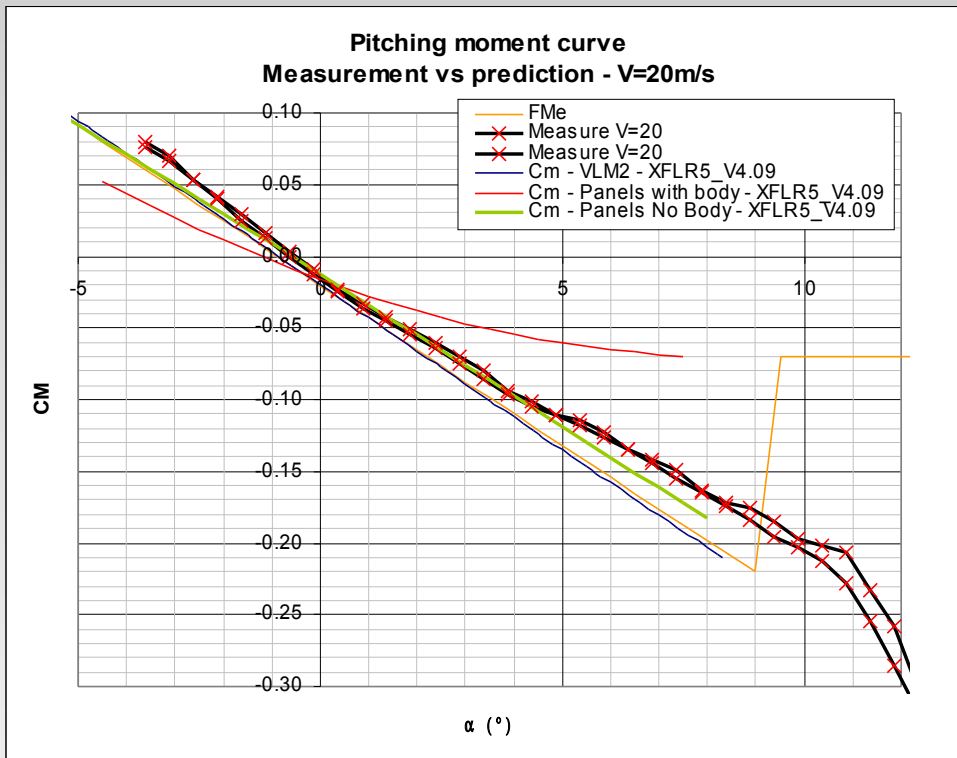
- All methods LLT, VLM and Panels predict correctly the value of the zero-lift angle, in this case $\sim -1.25^{\circ}$
- The LLT is the method which fits best the non-linearity of the lift curve
- All methods tend to underestimate the decrease in lift at high a.o.a. ; the LLT is the method which gives the most realistic trend

Drag Polar - No sideslip



- All methods, LLT, VLM and Panels tend to underestimate the total drag
- It is difficult to tell which of the induced or viscous drag is underestimated, but my guess would be that it's the viscous part
- This could be due to several causes :
 - the conditions in the wind tunnel are not as laminar as expected,
 - the flow transitions from laminar to turbulent at some point along the wing's chord
 - inadequate values for NCrit are used in XFOIL when building the foil polar mesh
 - The 3D interpolation of 2D viscous results underestimates the viscous drag

Pitching moment - No sideslip

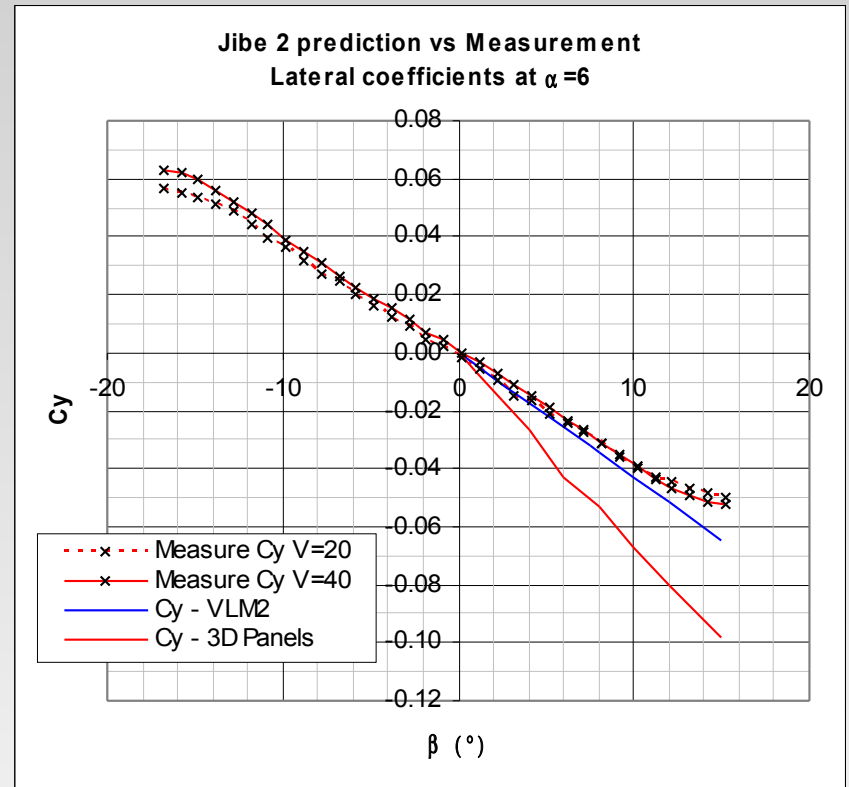
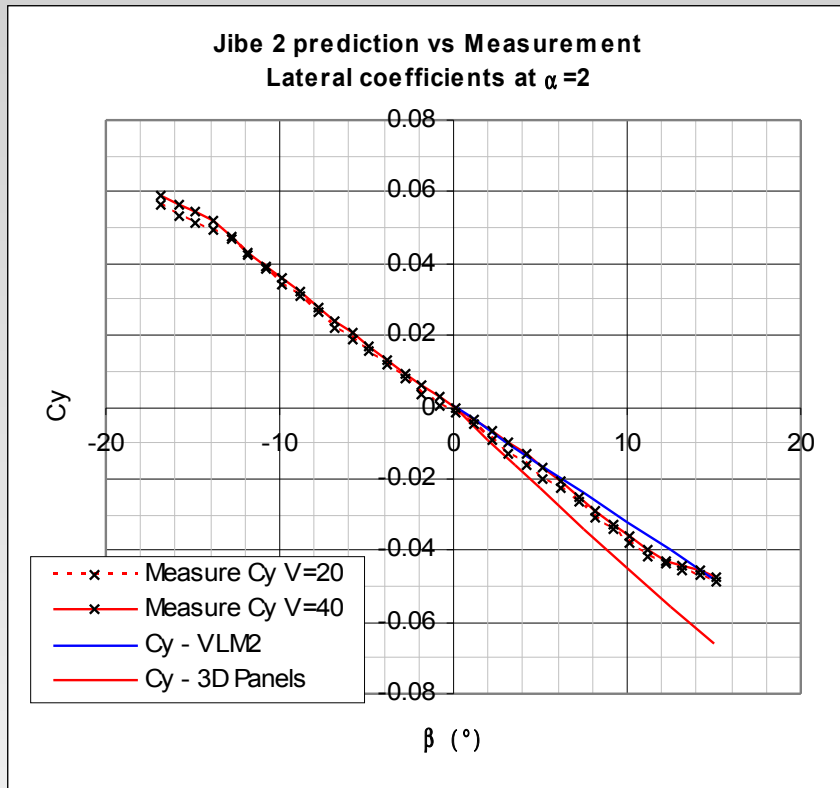


- All methods, LLT, VLM and Panels predict correctly the moment coefficient Cm_0 at zero lift, and the lift coefficient Cl_0 at zero-moment except for the model which includes the body
- Except for the Panel method with body, all methods give an adequate trend for the slope $Cm = f(\alpha)$
- The modeling of the body seems to generate considerable numerical noise ; this could be due to the difficulty to model connections between wing and body

Notes about sideslip

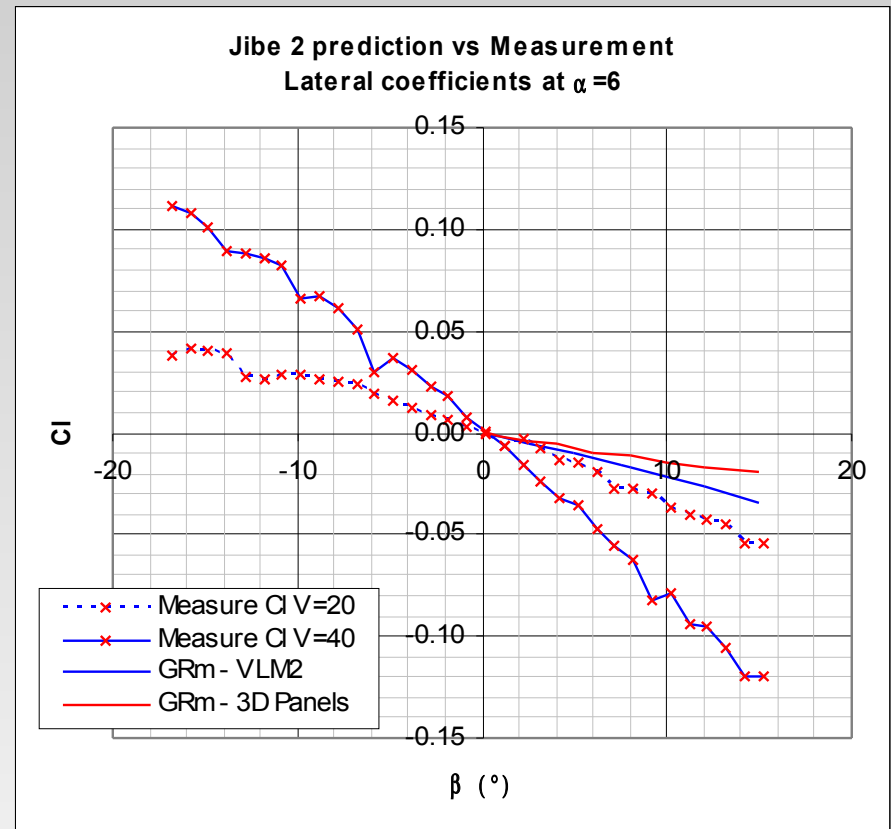
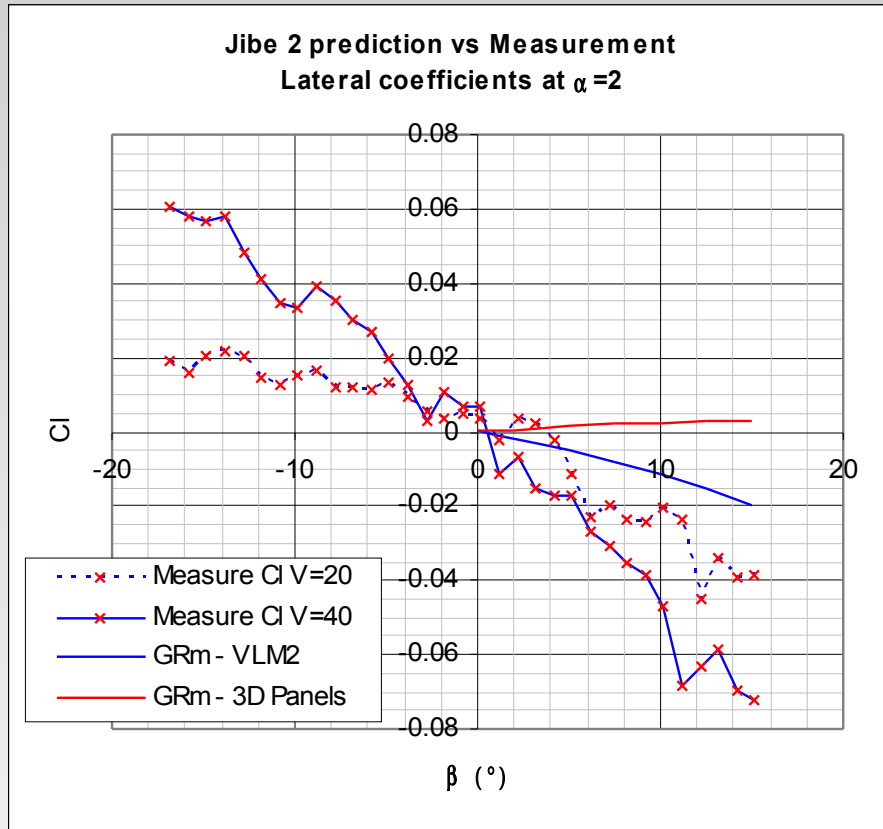
- The simulation of sideslip has been introduced in XFLR5 v4.09
- The order in which a.o.a. and sideslip are applied has its importance
 - In XFLR5, sideslip is modeled by rotating the model about the z-axis
 - The resulting model is analyzed using the conventional VLM and panel methods
 - This method has been preferred because it is simple to implement, however the usual convention is to apply the angle of attack first, then the sideslip rotation
 - As a result, the model's position is not exactly the same at high a.o.a. or sideslip angles than it is in the experiment
- The rolling moment, yawing moment and lateral force coefficients are issued from the non-viscous part of the VLM and Panel analysis, hence are the same for all speeds; experimentally though, a difference has been measured which would tend to show that the viscosity influences the distribution of pressure forces

Results for sideslip - lateral force



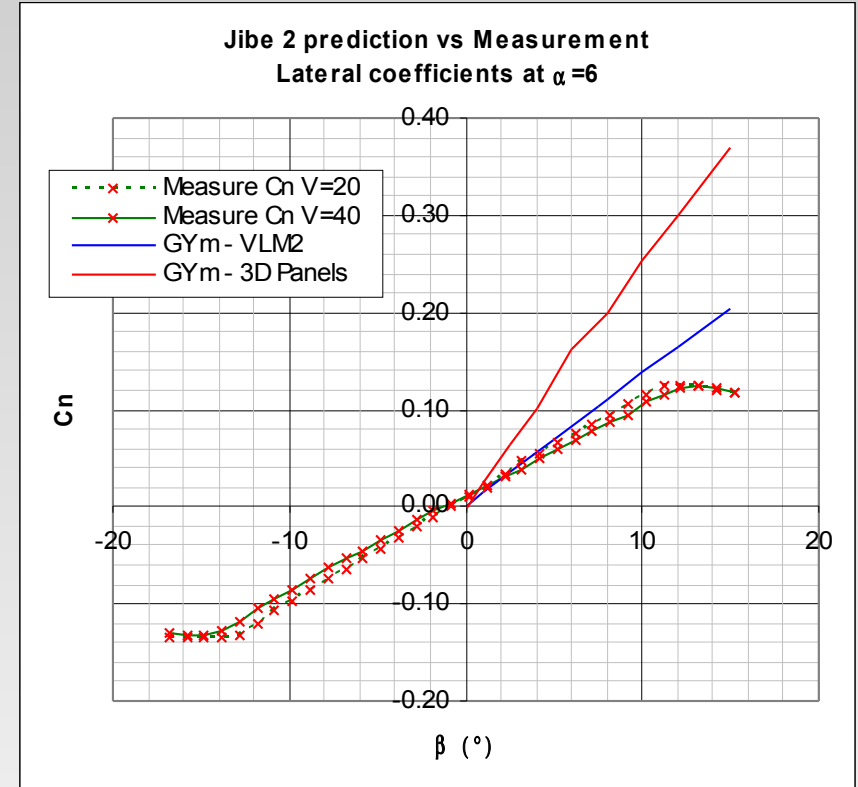
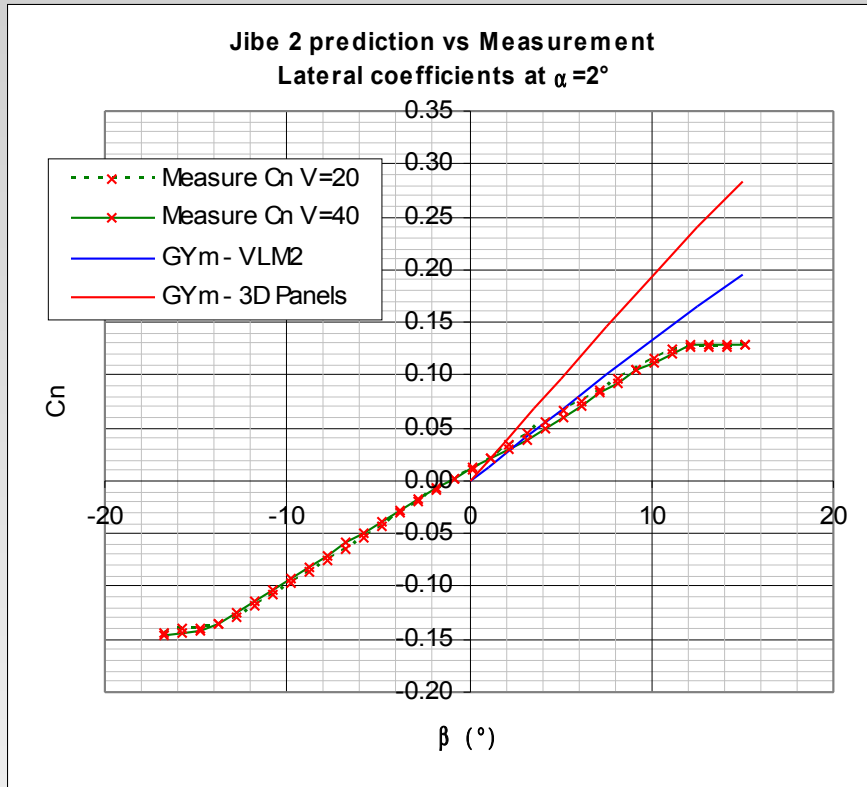
- Lateral force prediction is satisfactory although not as precise as lift coefficient prediction

Results for sideslip - Rolling moment



- Sideslip generates a rolling moment ; this is the basis of 2 axis rudder-elevator flight
- For this particular plane with no dihedral, this moment is low and thus difficult to predict

Results for sideslip - yawing moment



- o Yawing moment predictions give the correct trend - no more

General conclusions

- The VLM analysis is precise enough for most applications
- LLT is useful where precise lift curves are required, especially to account for viscous effects
- The 3D Panel method does not improve notably the accuracy of the results
- All methods tend to underestimate the drag - probably its viscous part
- The simulation of the body is more a nuisance than a help

In the hope that
this helped !

