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Meeting #6
Turin 4-5 February 2003

"The Use of VSAero CFD Tool in the UAV Aerodynamic Project "

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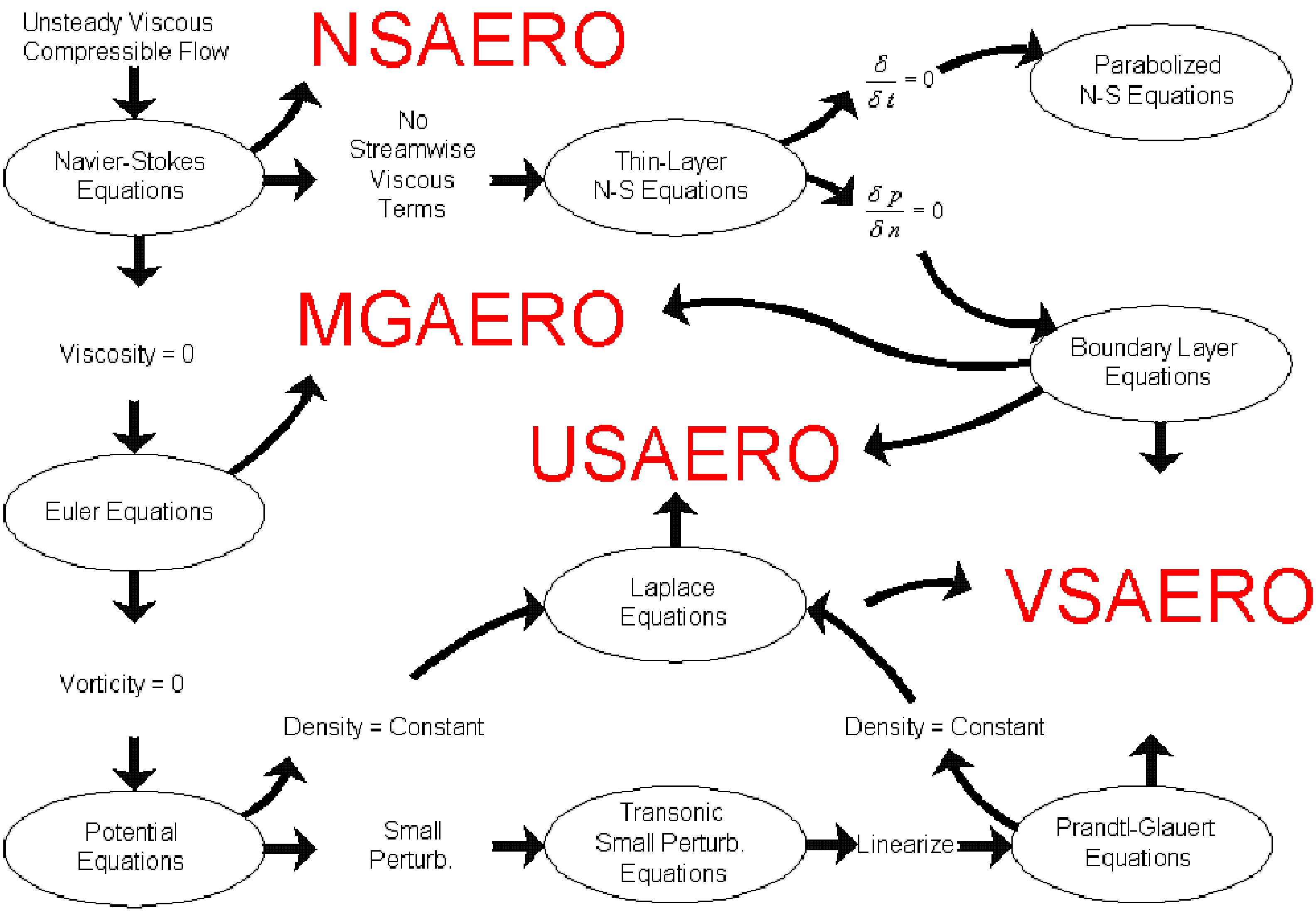
Porto Ricerca S.n.c.
Monza, (Milano)
Italy

- **Providers of CFD Software**
- **Engineering Research**
- **Consulting Services**

Equations of Fluid Dynamics



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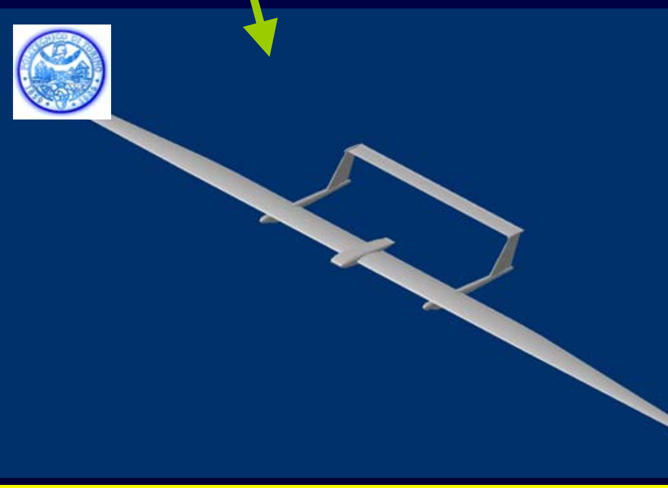
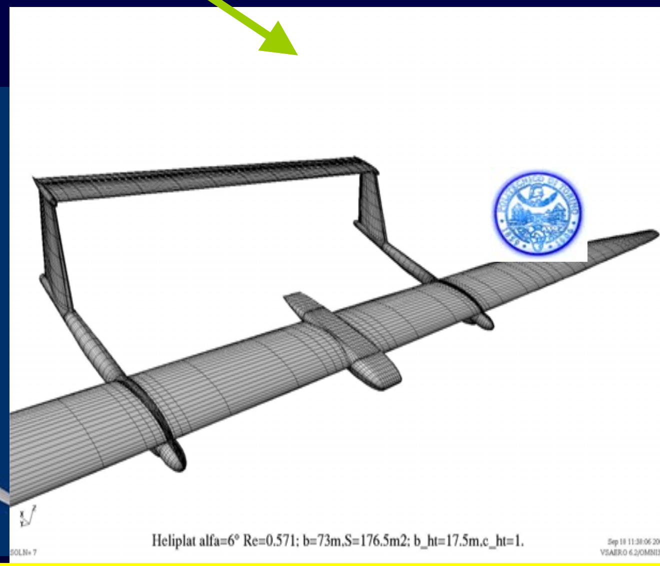
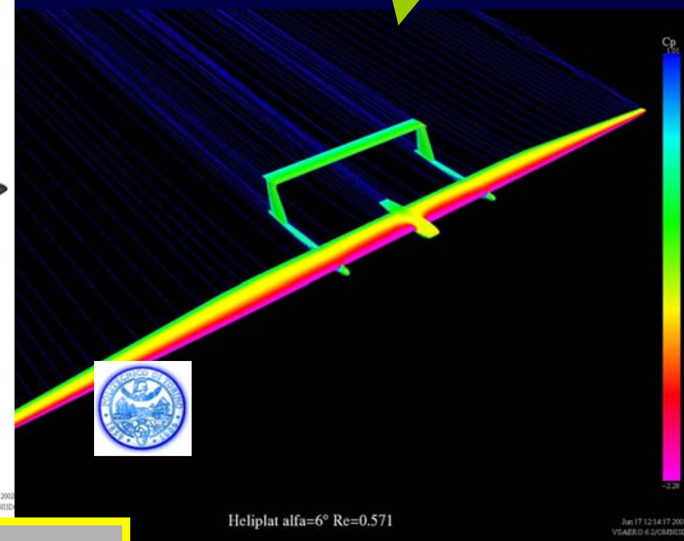
Flow Analysis Components

CAD → **GRID GENERATION** (AMIGRID, SPIN, GRIDALL) → **FLOW SOLUTION** (VSAERO, USAERO, MGAERO, NSAERO) → **POST PROCESSING** (OMNIPLOT, OMNI3D, TECPLOT)





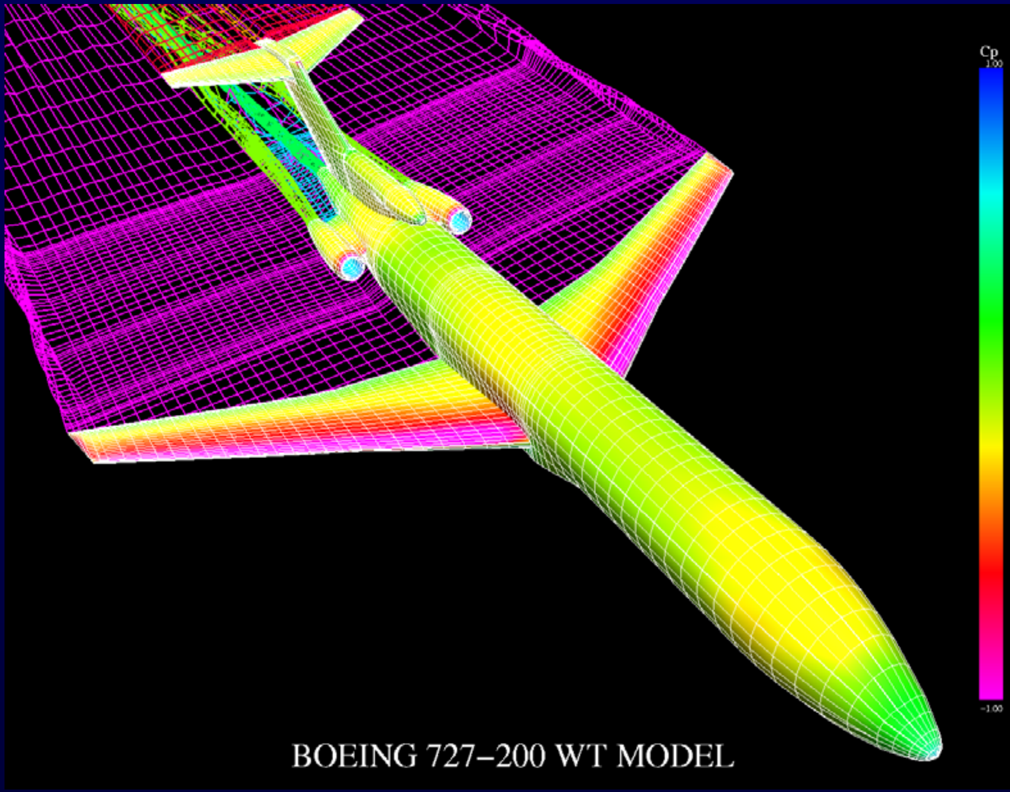


VSAERO

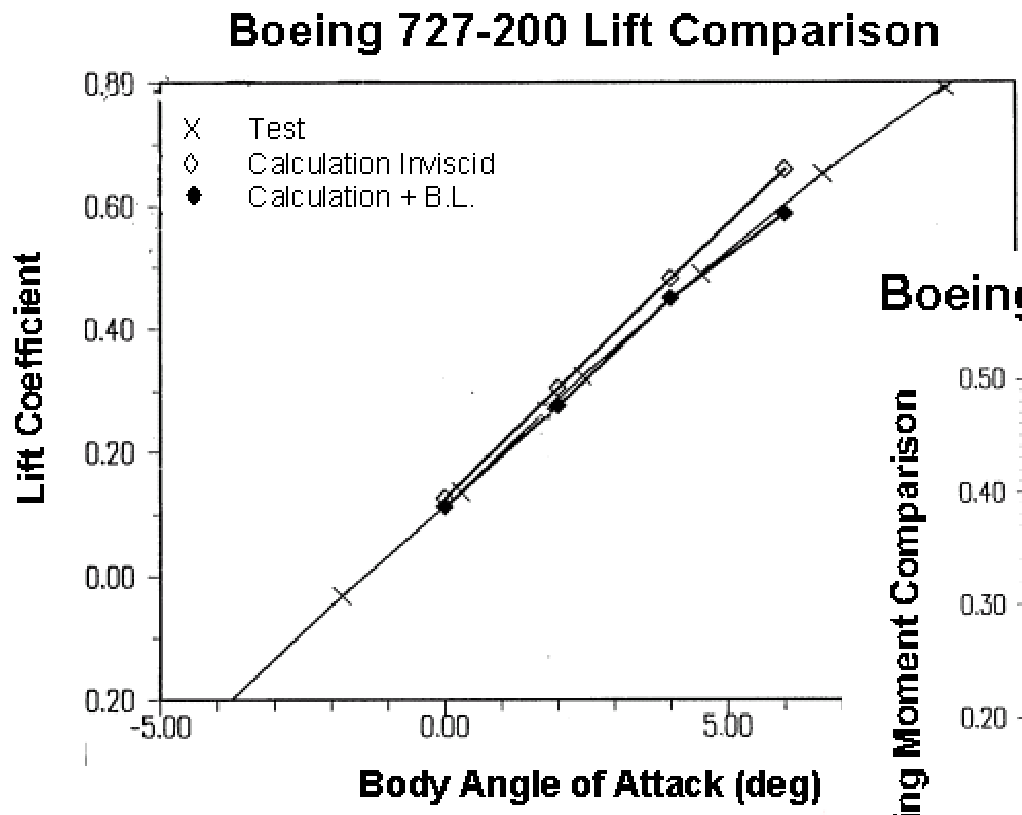
- Subsonic, Quasi-Steady Flow
- Integral Panel/Boundary Layer Method
- Complex Geometries
  - ✓ Thick and Vortex Lattice Surfaces
- Wake Modeling
- Performance
- Stability and Control

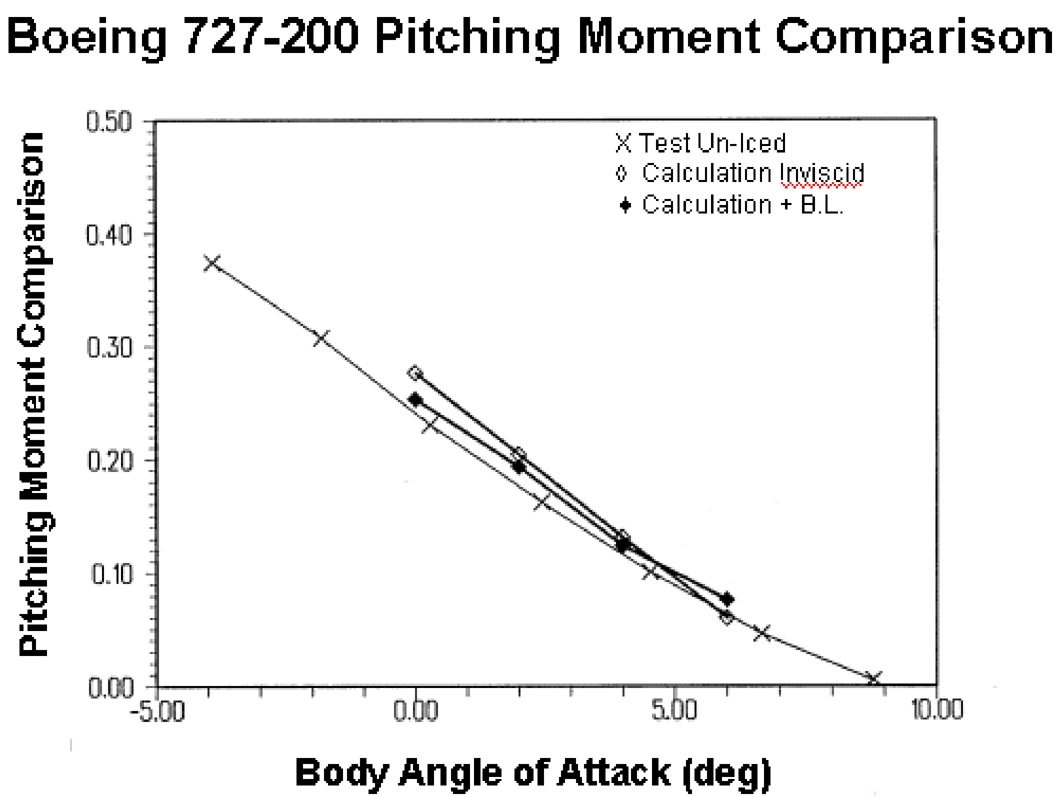
Boeing 727-200

- Lateral Symmetry
- 4100 Body Panels
- 3900 Wake Panels
- 1 Wake Iteration
- 3 Viscous Iterations
- CPU Requirement:
  - SGI 4D/35 (R3000) 1.5 Hours
  - SGI (R10000) 5 Minutes



Boeing 727-200





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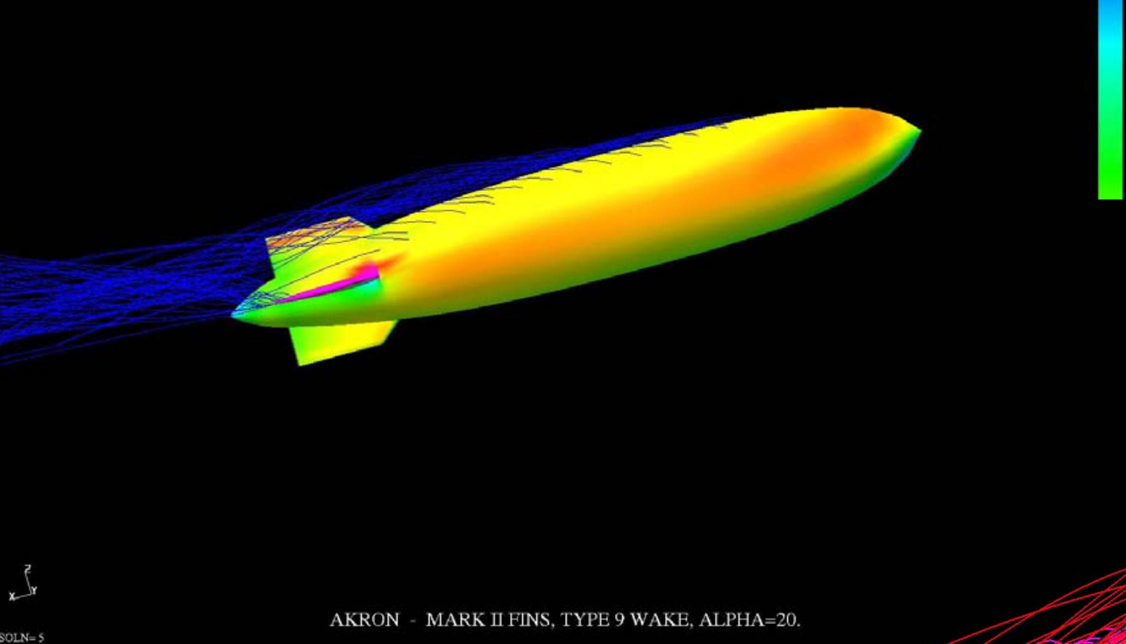
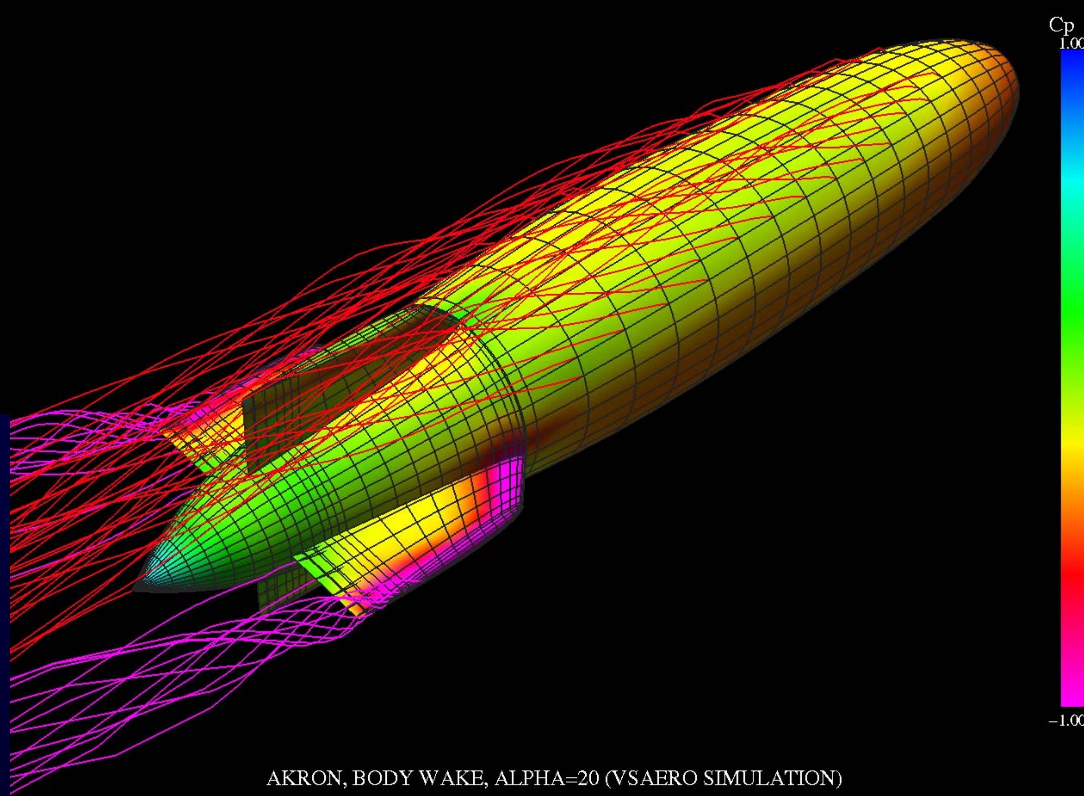
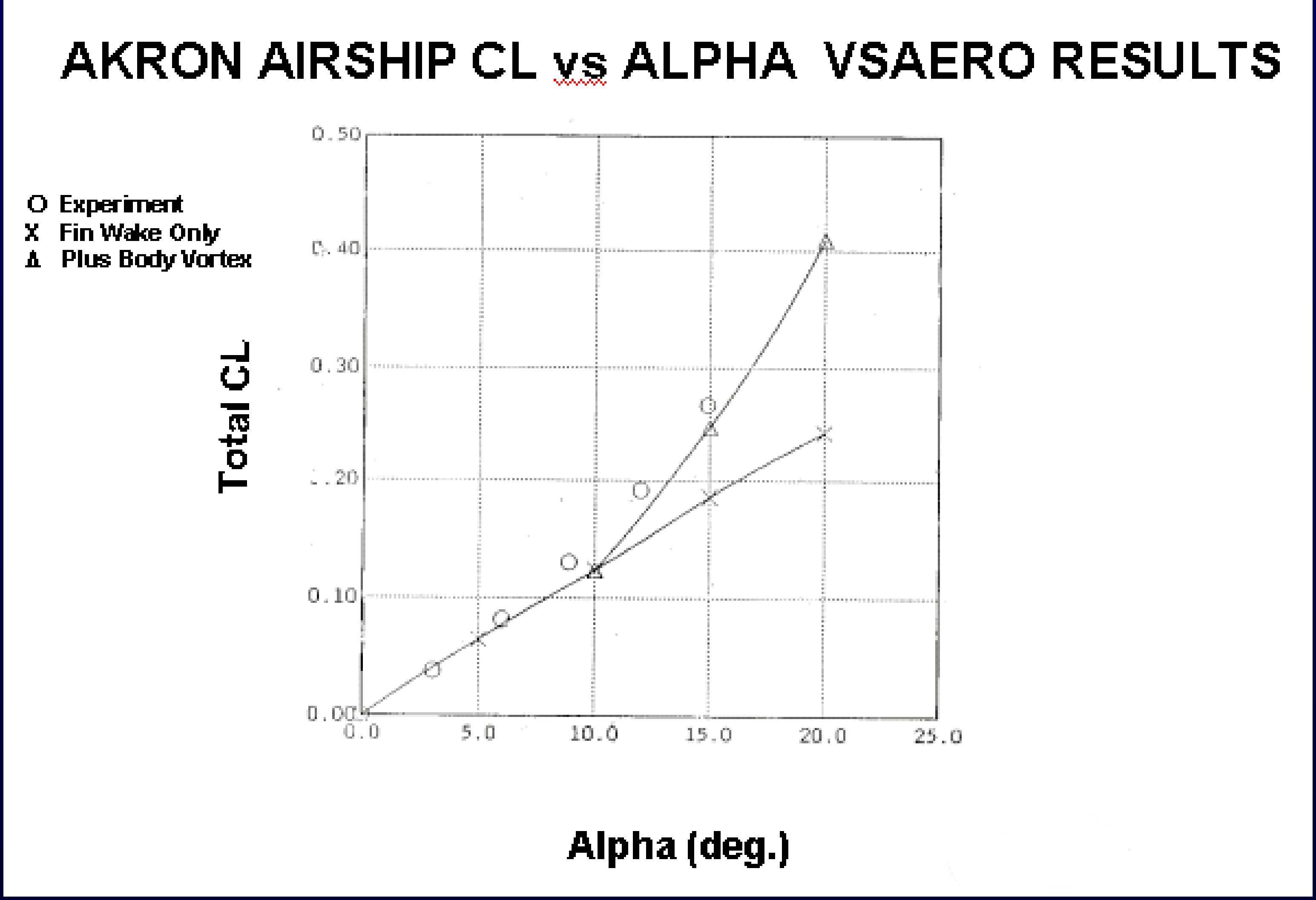
Akron - Airship



the modified Stratford criteria of Mendenhall35 have been added to VSAERO to find the cross flow separation line.

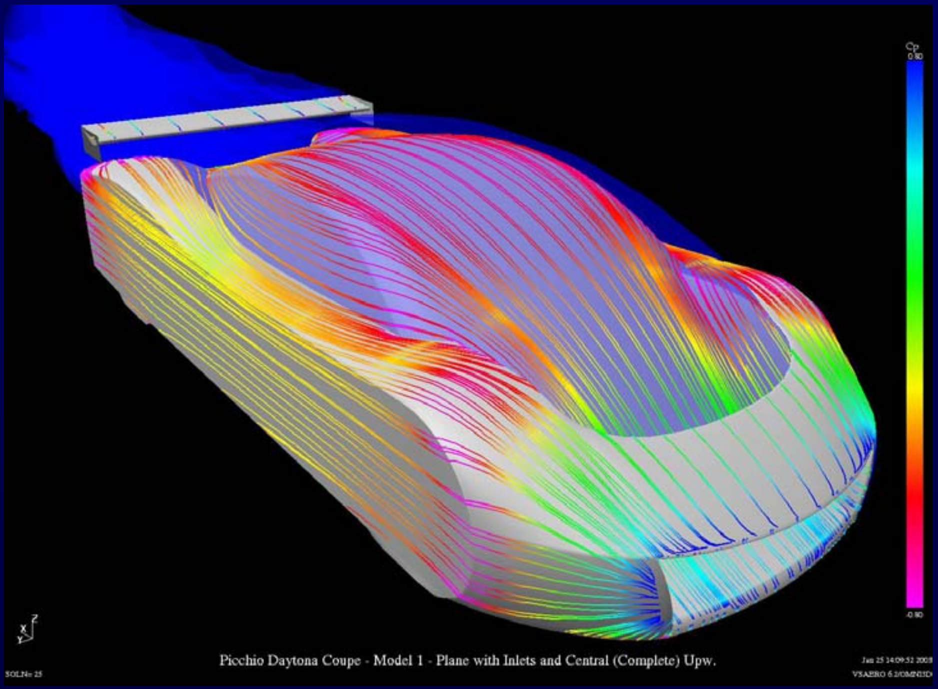


Akron - Airship



Racing car

LANGLEY FULL SCALE WIND TUNNEL LFST



CFD analysis during the designee process research

Wing tunnel drag coefficient: 0.372

CFD drag coefficient prediction: 0.358

Drag coefficient error: 4%

VICTORY Challenge Americas Cup Sailboat

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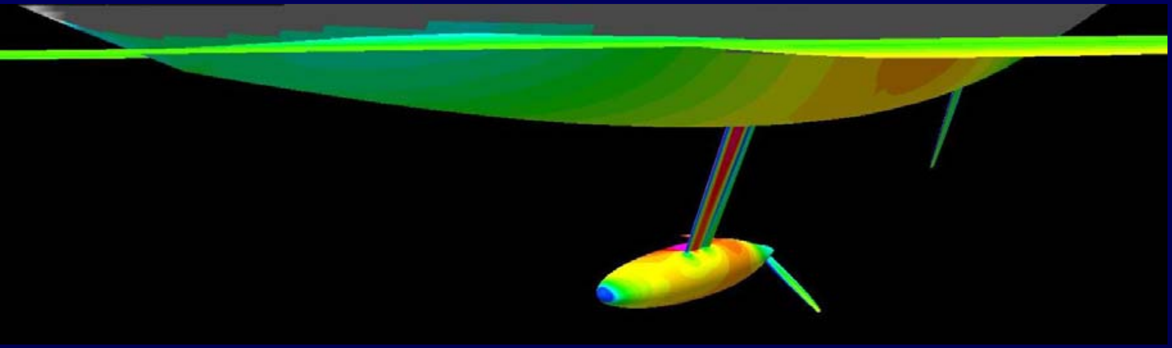
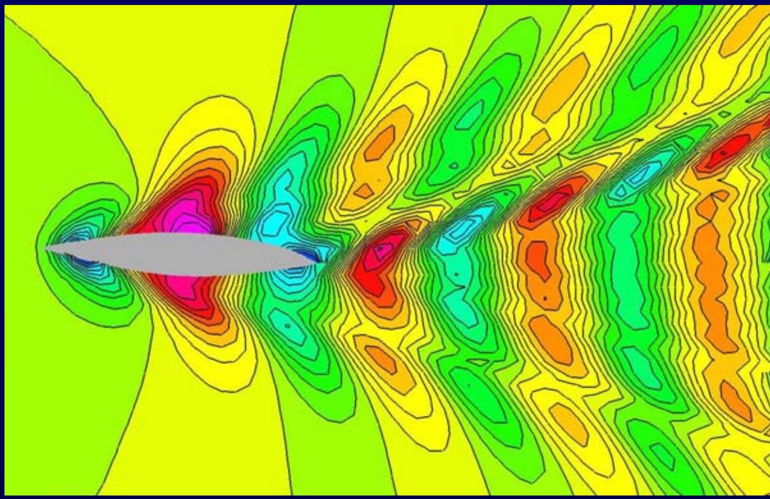
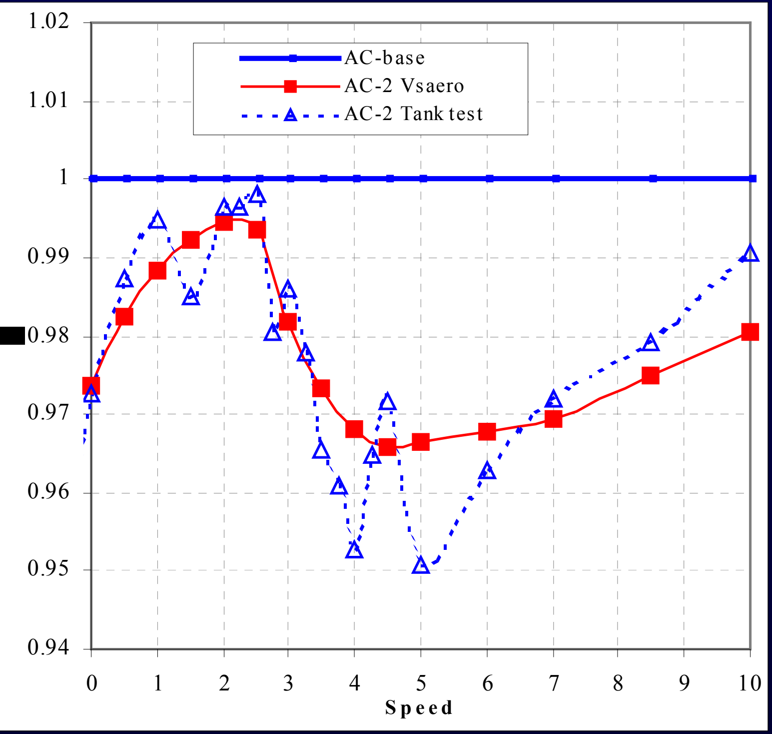


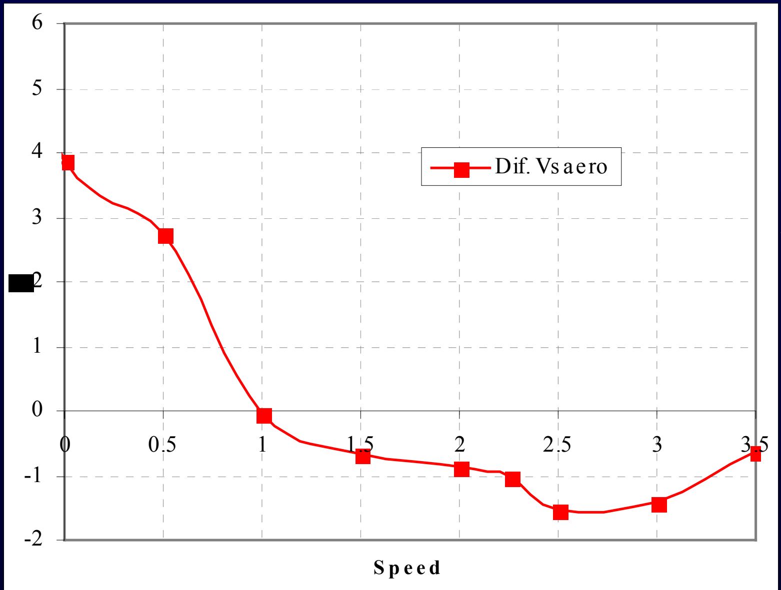
CFD analysis during the designed process research



CFD Wave height calculation



Percentage difference in drag on two different Americas Cup yachts calculated with VSAERO and tested in a towing tank.



% error in drag vs. speed for the an upwind case

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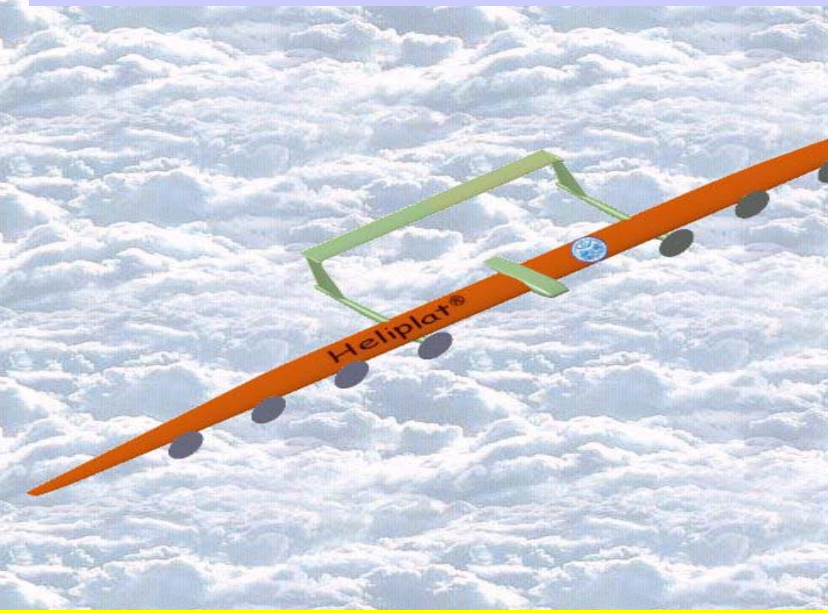
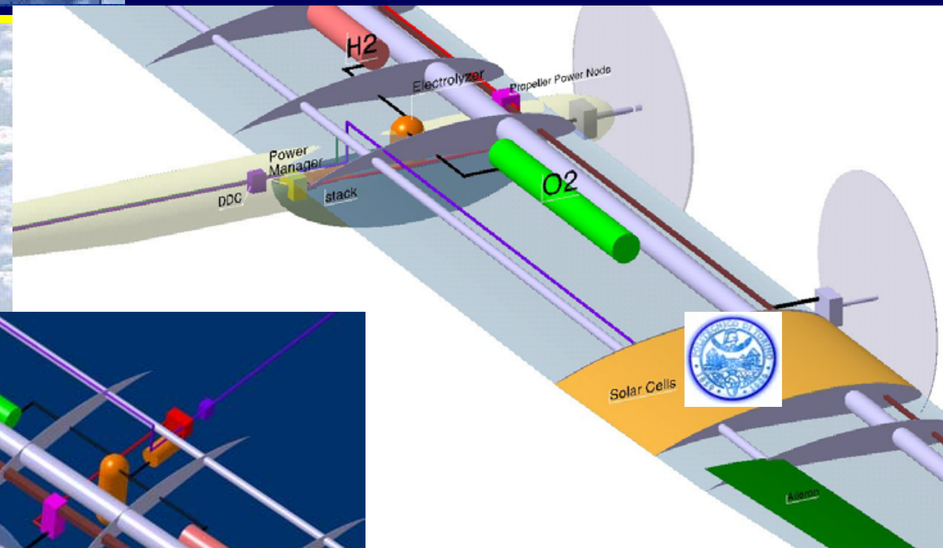
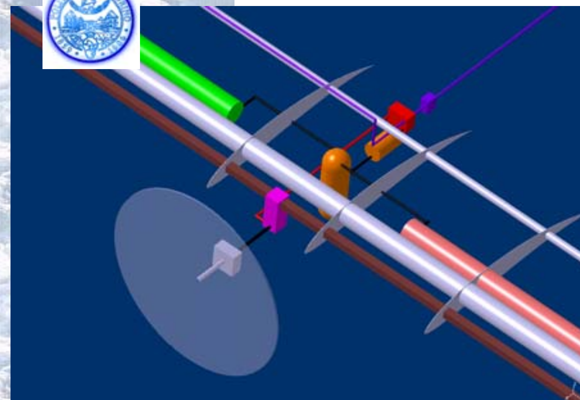
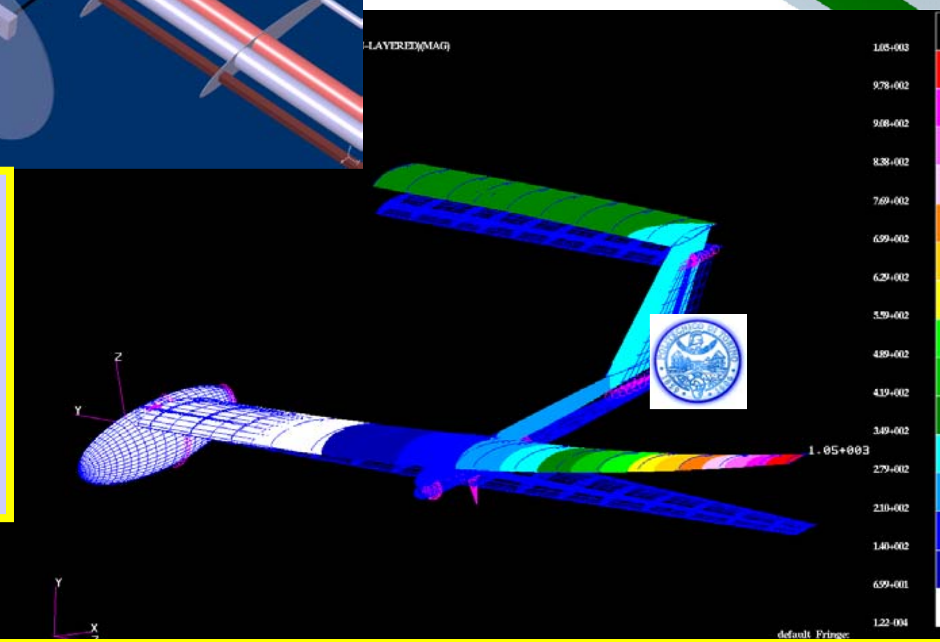
Solar-powered UAV

ASI & EC (Helinet) projects









Span:73m; TOGM:750kg; Mass $_{PL}$:100kg
Power $_{PL}$:1kW; Req. Power=6 kW;
TAS=71 km/h; Altitude: 17km;
Endurance: 6 months
Effic. s.c.:20%; Effic. f.c.+elect:60%

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CASA Space- EADS

POLITO / ARCHEMIDE

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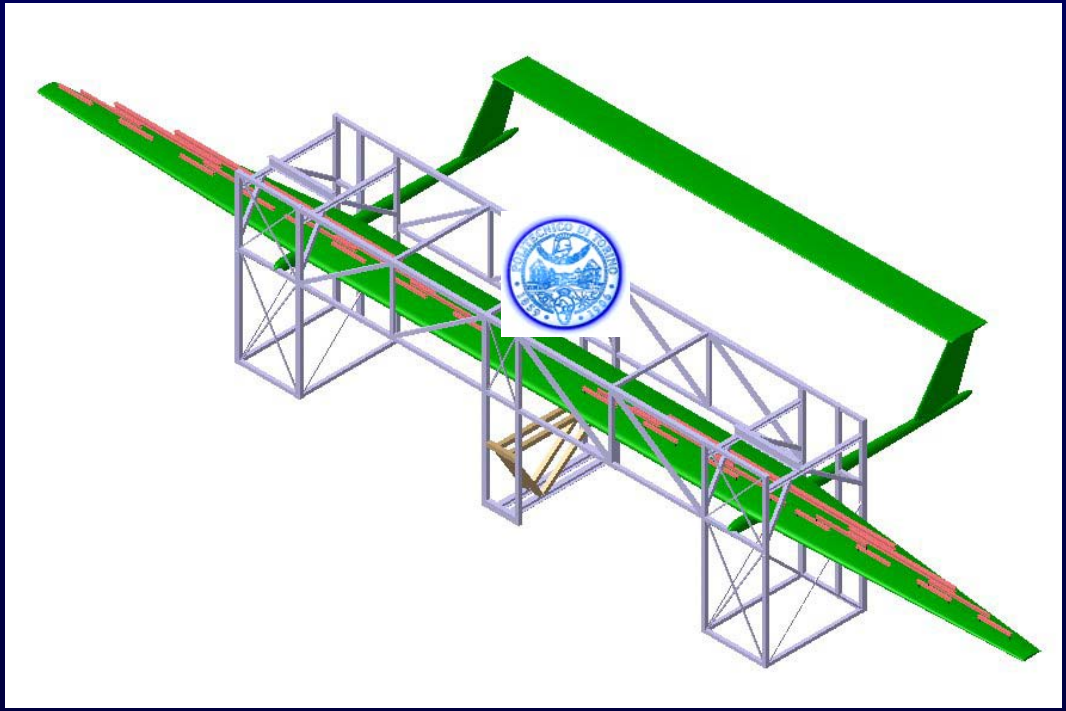

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Preliminary wing - optimization

In the preliminary wing analysis we have tested with VSAERO three airfoils on wing solo configuration

MH32, E216, FX63137

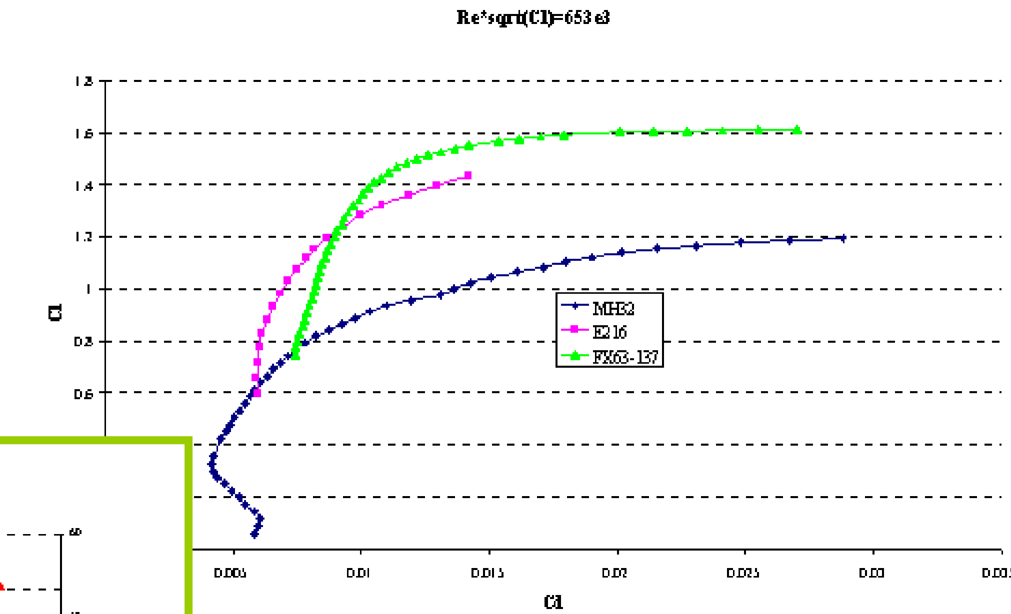

Figure 1 – Wing Profile Polar

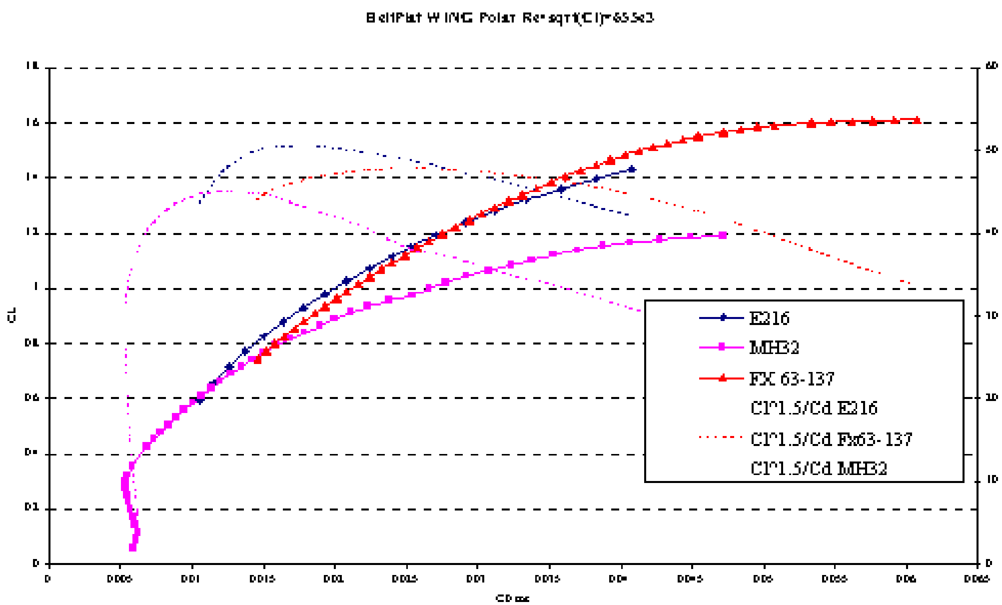

Figure 2 – HeliPlat Wing solo Polar

E216 show a better compromise between the airfoil Drag and the induced wing Drag

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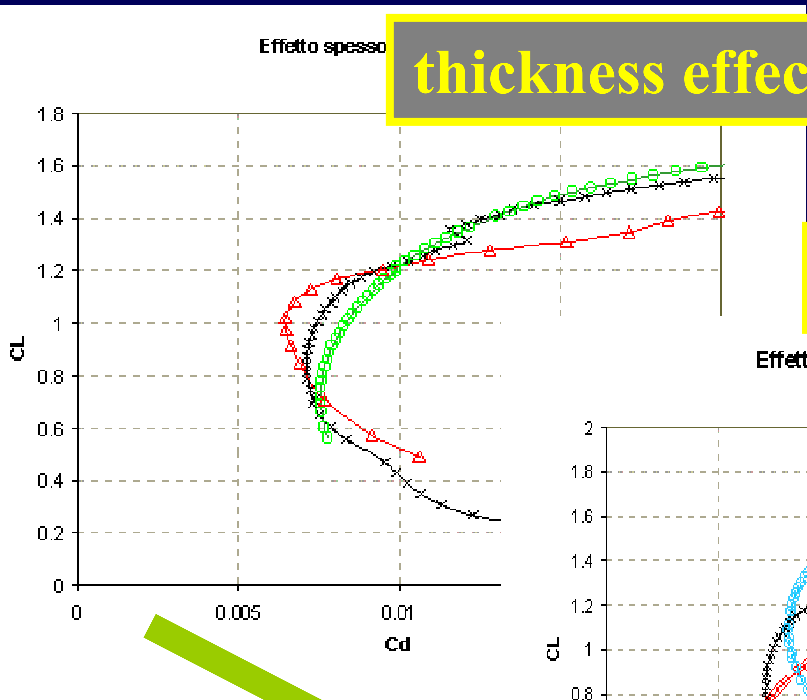
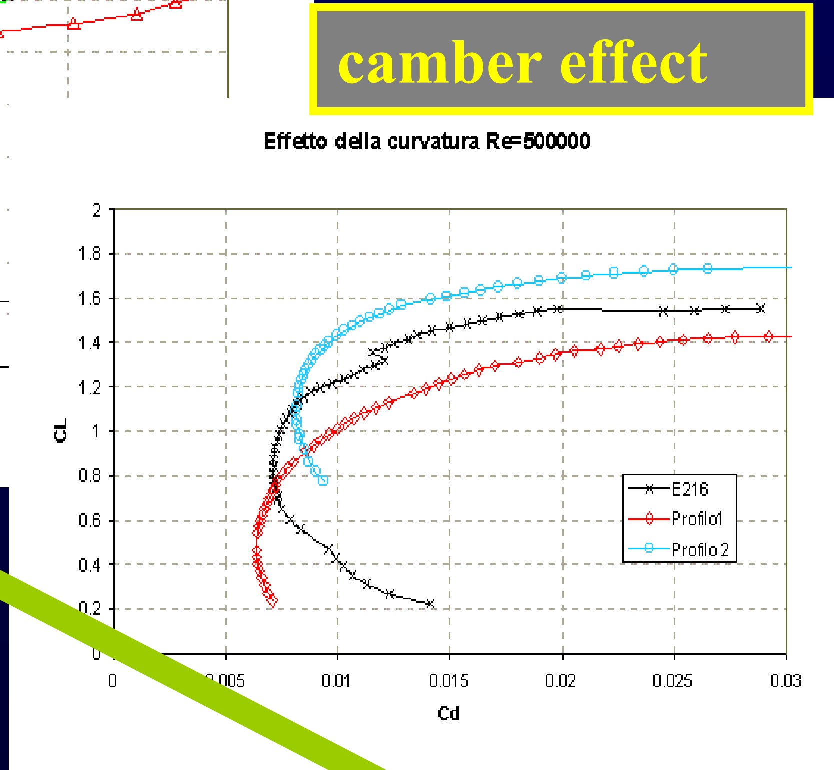
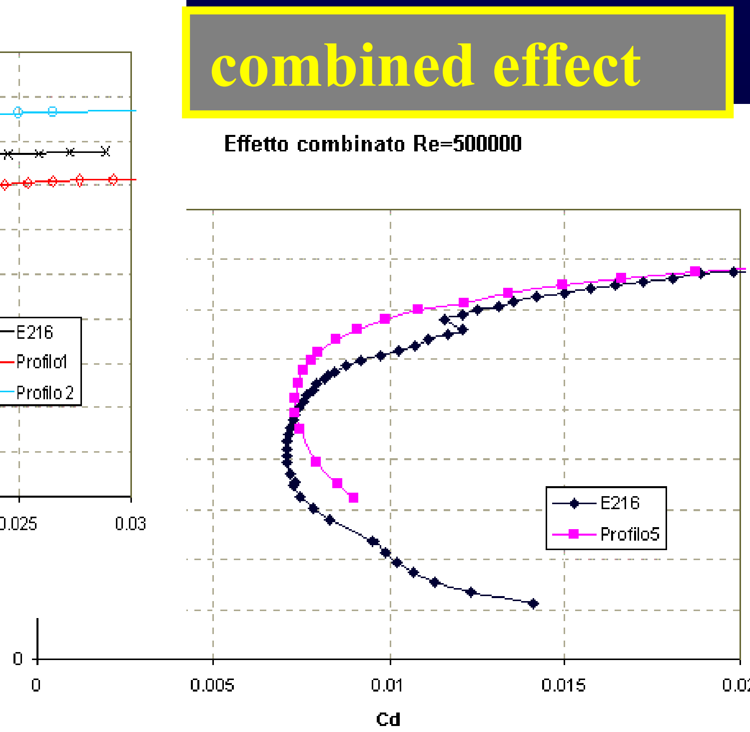
Wing airfoil geometry–2D XFOIL optimization







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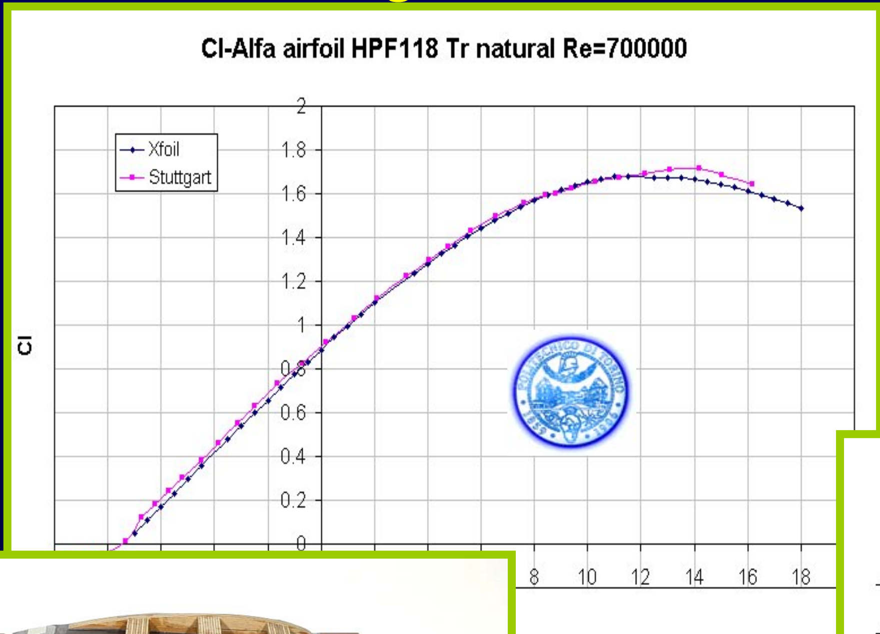
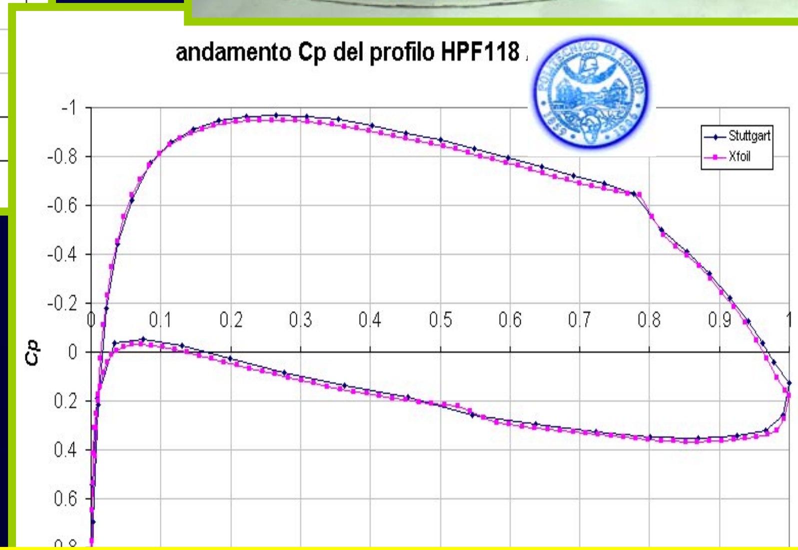
By Using XFOIL, the optimal airfoil HPF118 has been designed instead of E216.The good performances of HPF118 are also demonstrated by experimental investigation in the Laminar Wind Tunnel in Stuttgart.





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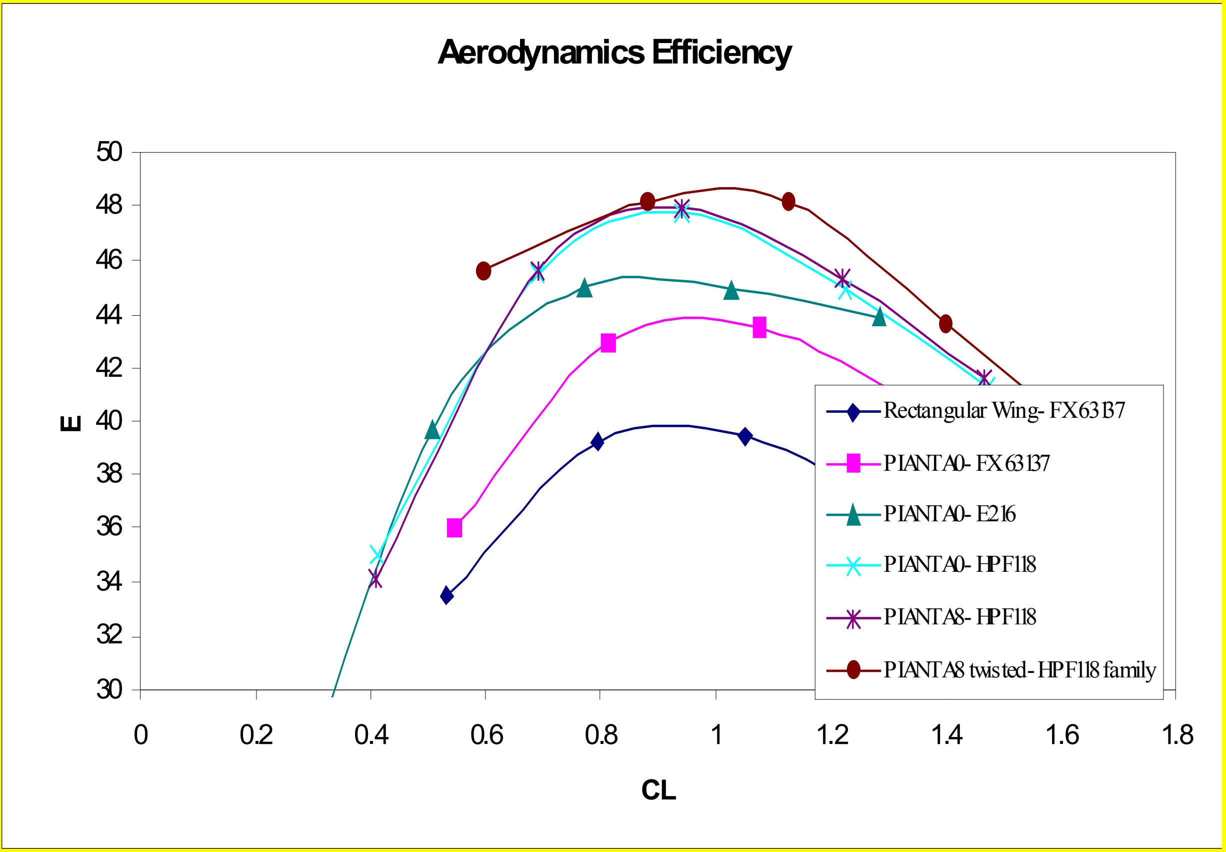
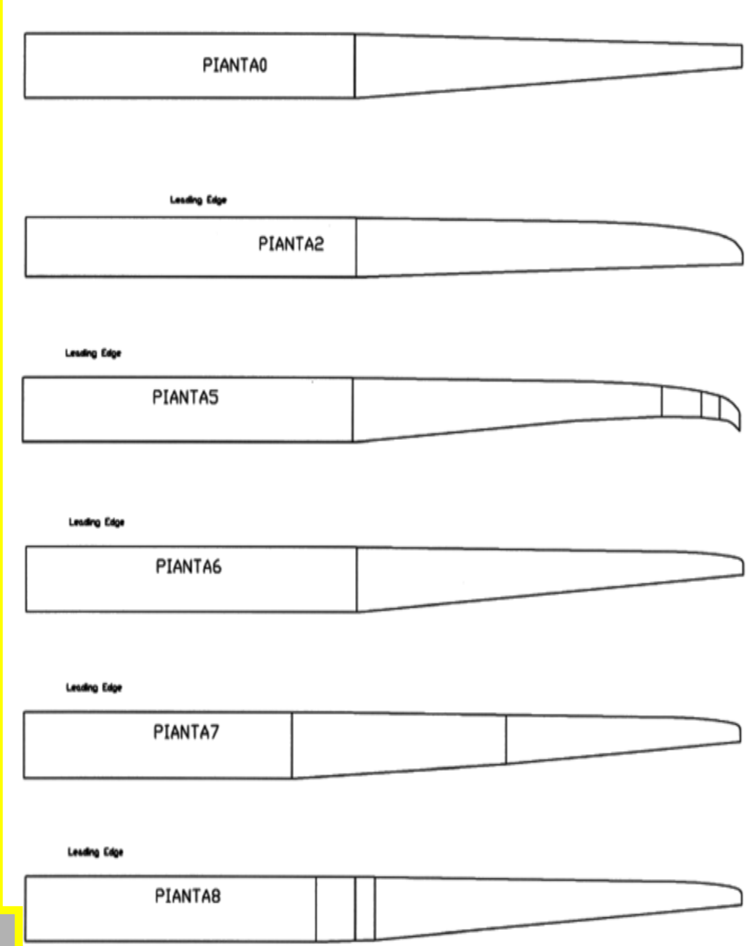
The optimization of wing planform have the intention to minimize induced drag. Indeed it was found that some wing planforms increase the friction drag more than the induced drag reduction. Each wing have constant span and equal surface, i.e. AR=cost.





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Why we have choose to use Vsaero panel methods technology?

- Contain the right physics
- Handle complex & arbitrary geometry
- Resolve all important physical & geometric length scale
- Reliably accurate numerics
- Timely
- Properly validated
- Can be run many, many times

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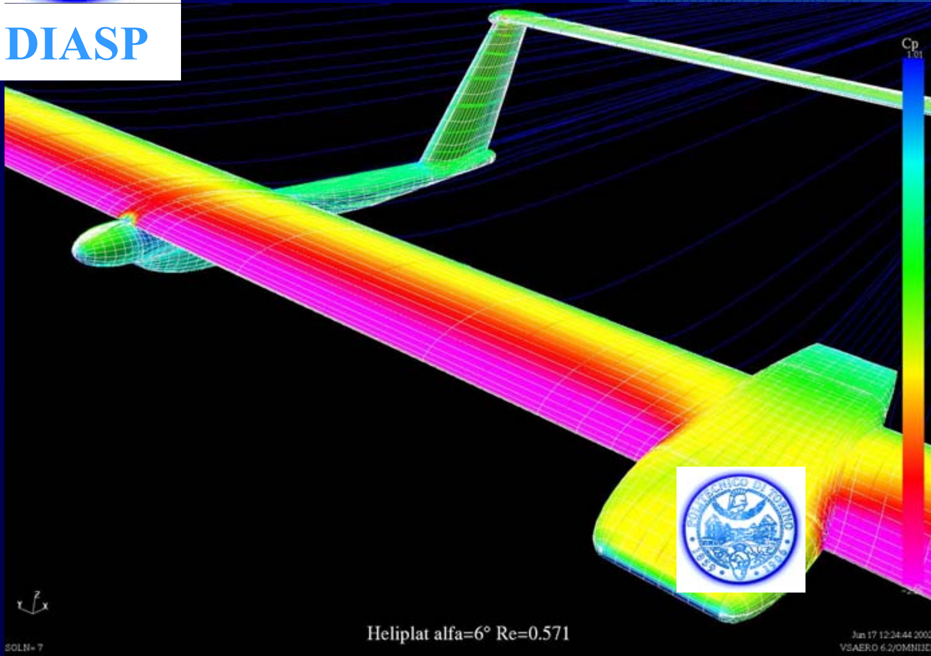
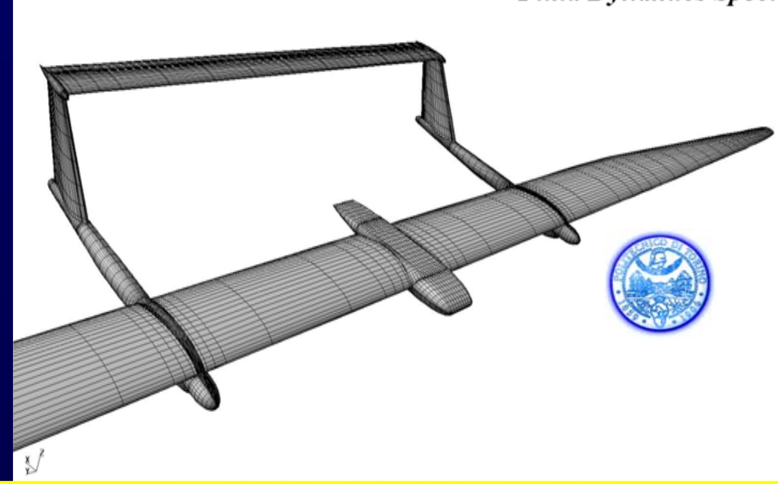
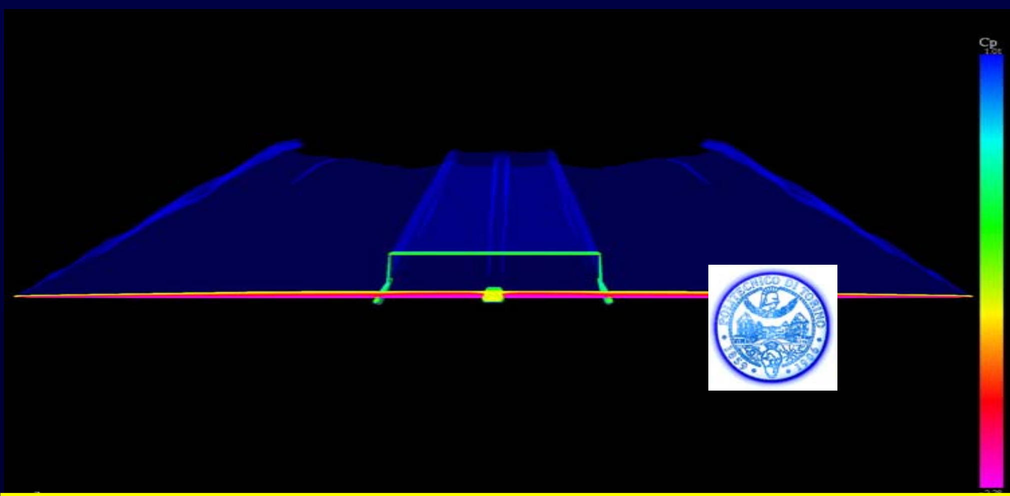
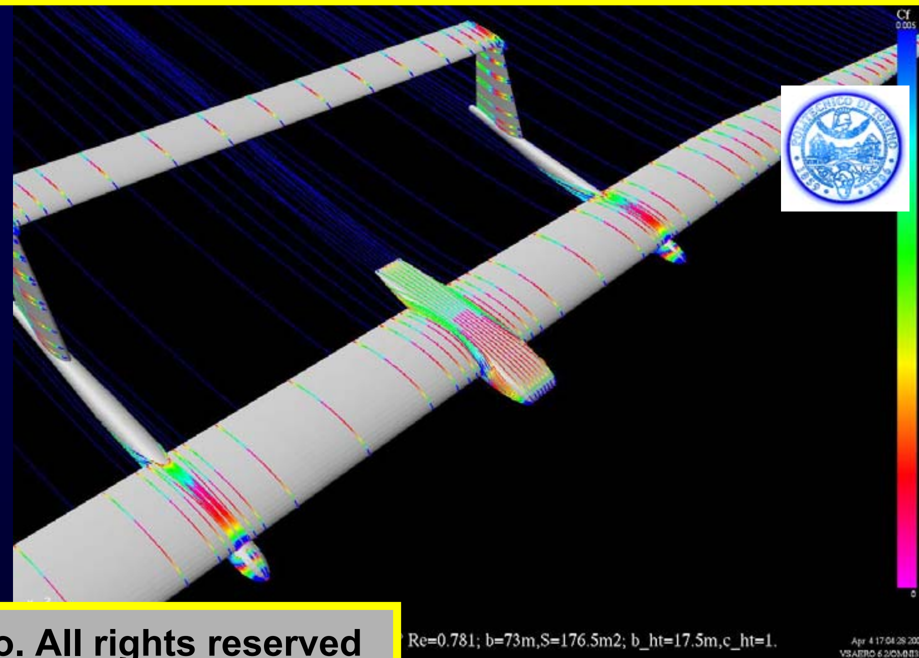




CP Cf visualization all over the Airplane





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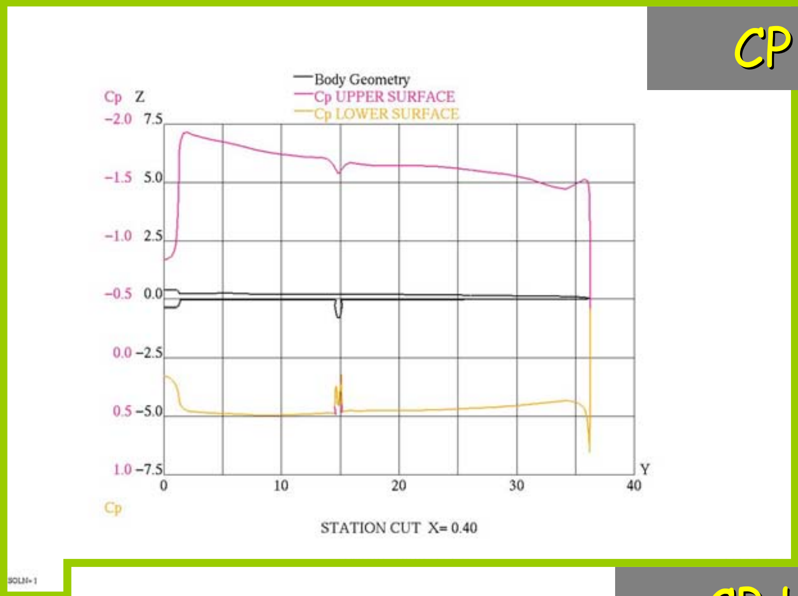
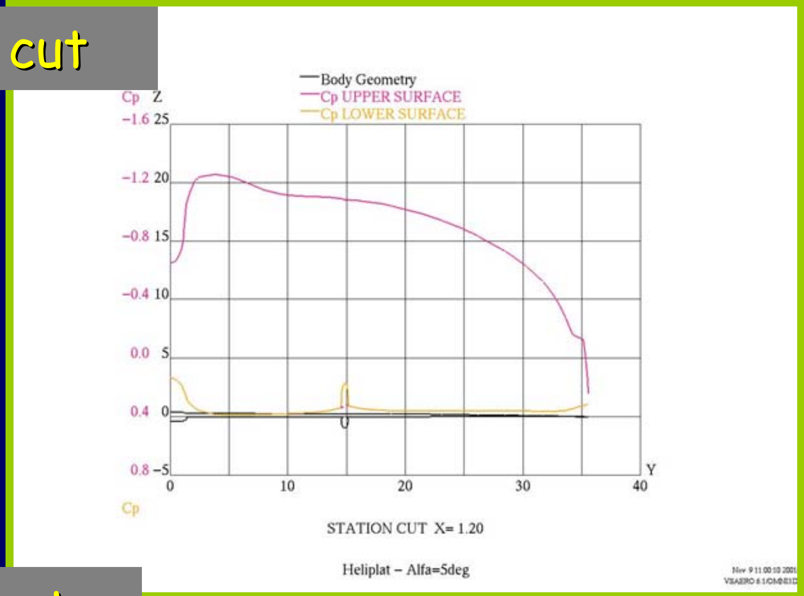
Accurate pressure distribution on Heliplat complete configuration

CP Station cut





CP buttline cut

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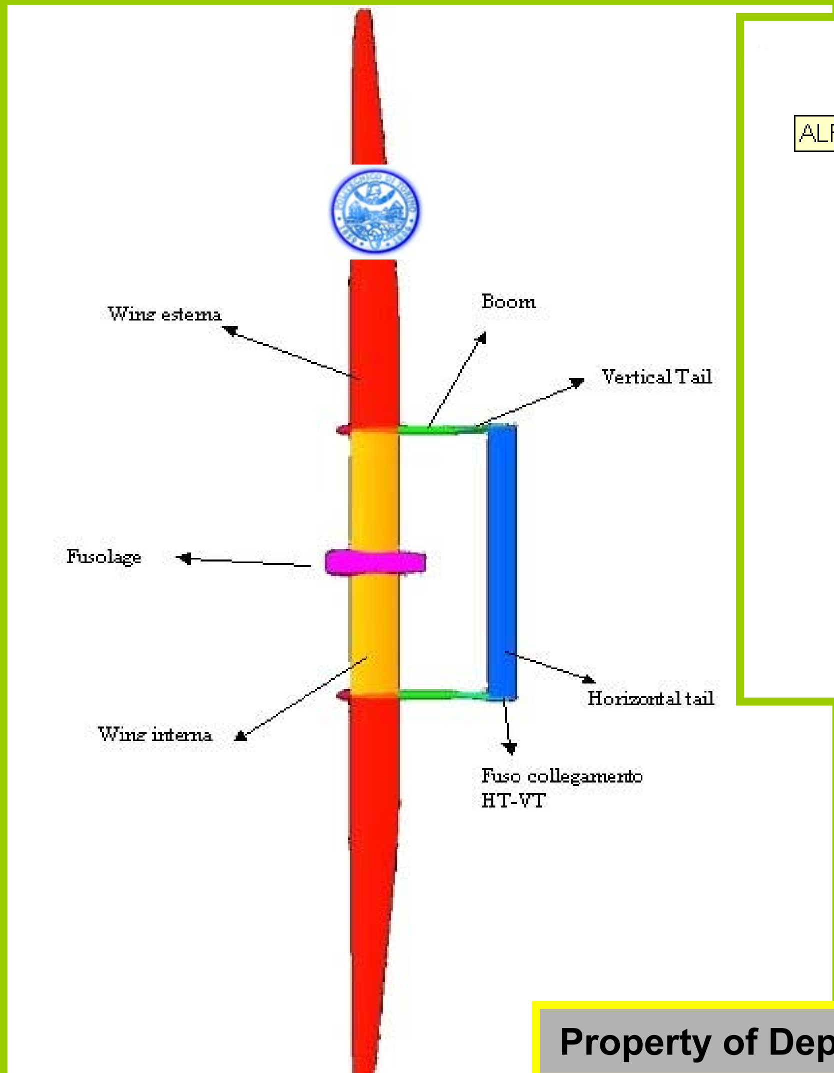
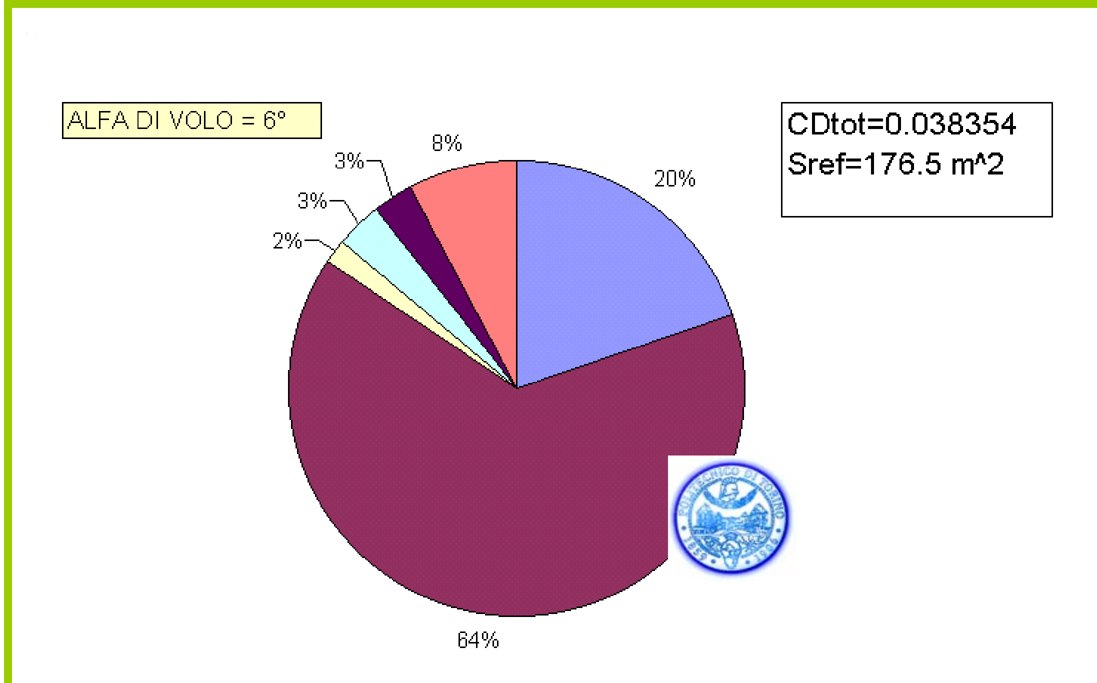
The geometry panels are divided into several groups in order to identify the single part contribution to the total DRAG and LIFT coefficient





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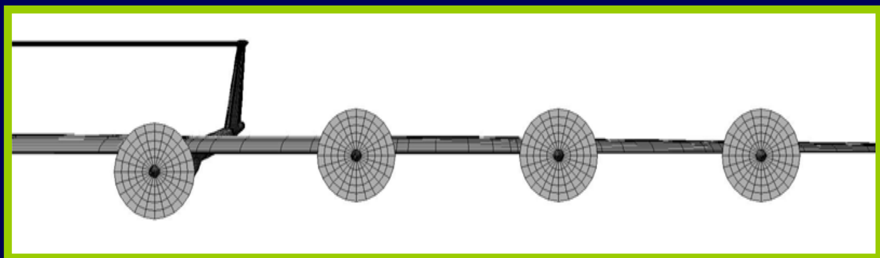
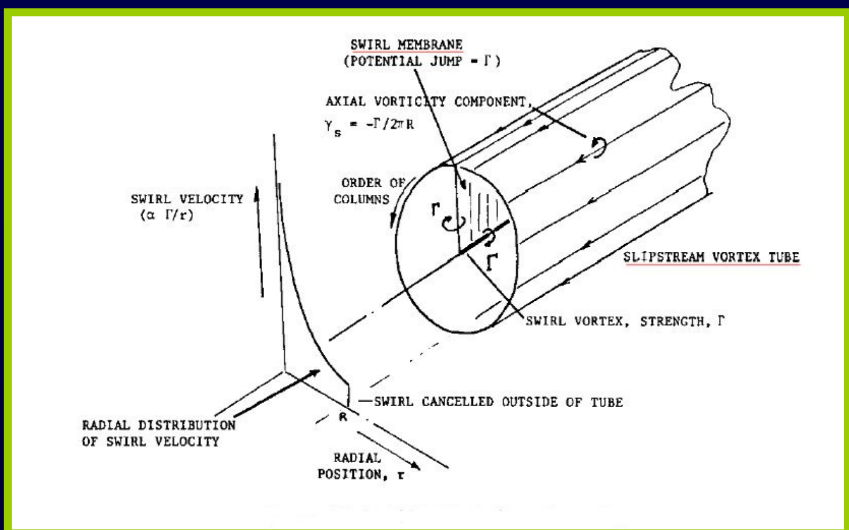
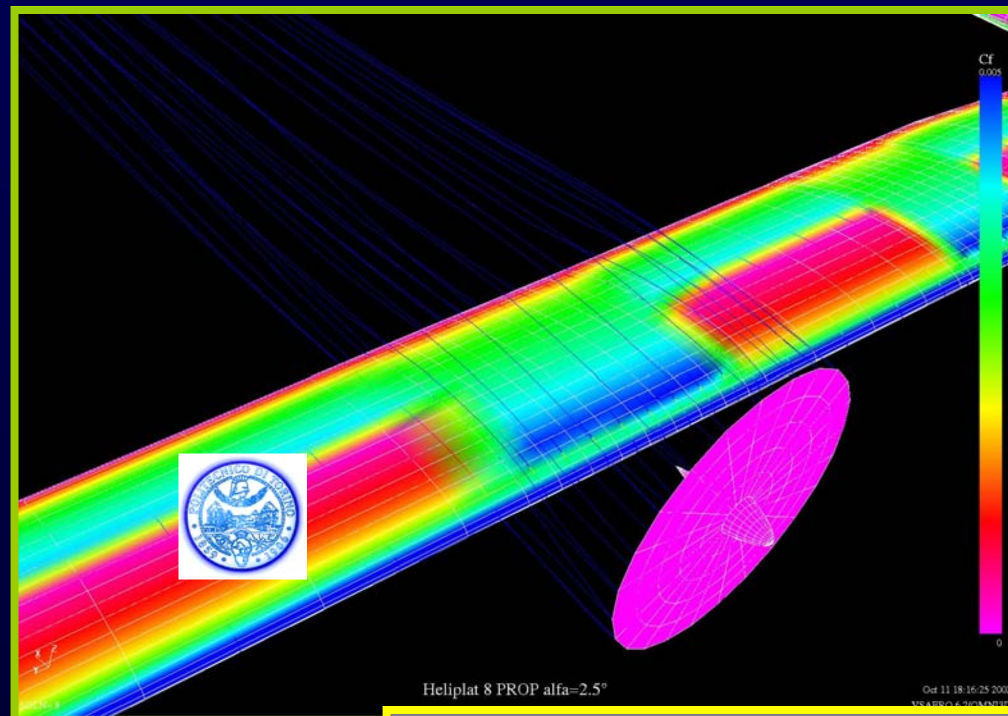
Propeller - analysis







Skin friction coefficient

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Derivatives study

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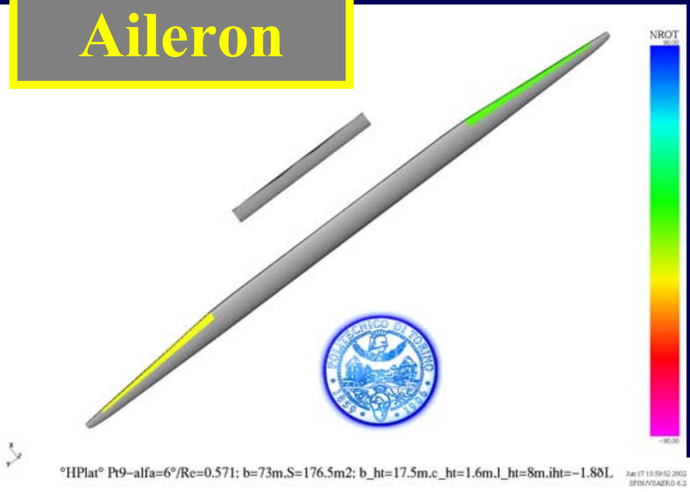
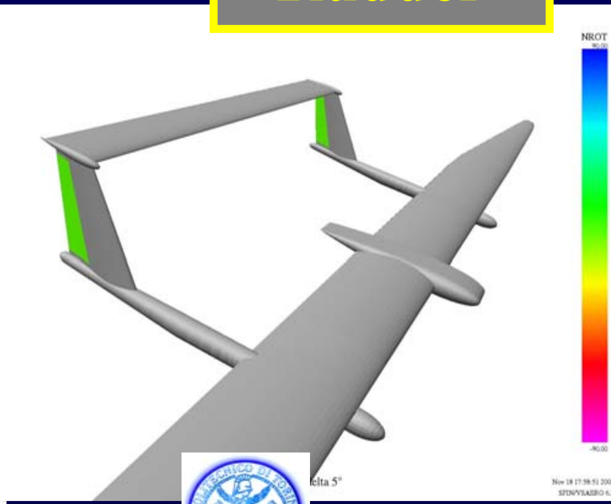
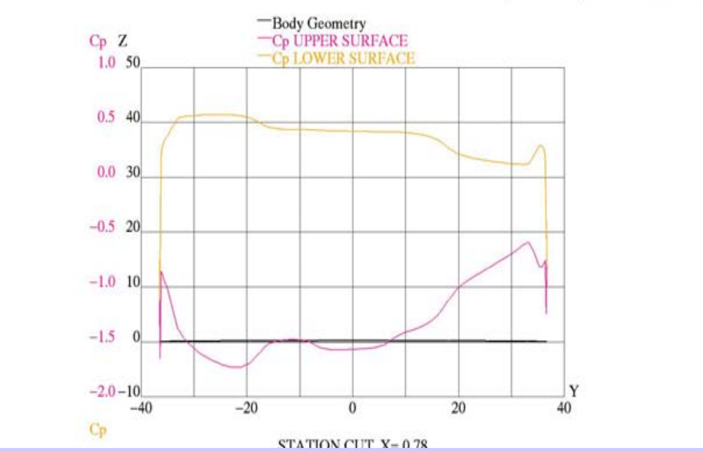
Aileron

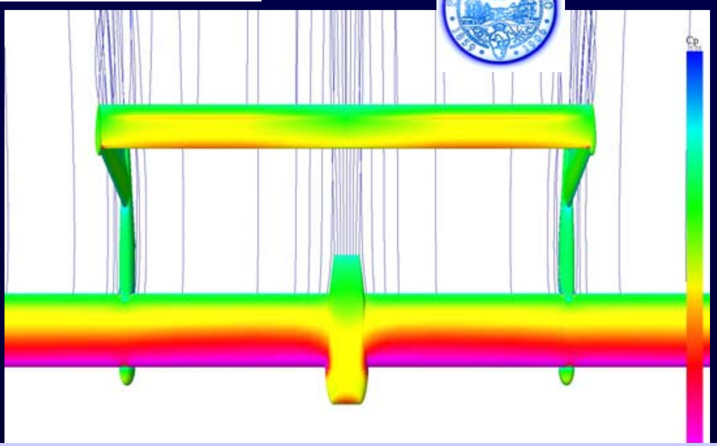


Stabilizer

Rudder







Static derivatives Cm_δe ; CL_δe ; CFy_δa ; Cl_δa ; Cn_δa ; CFy_δr ; Cl_δr ; Cn_δr

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Derivatives study

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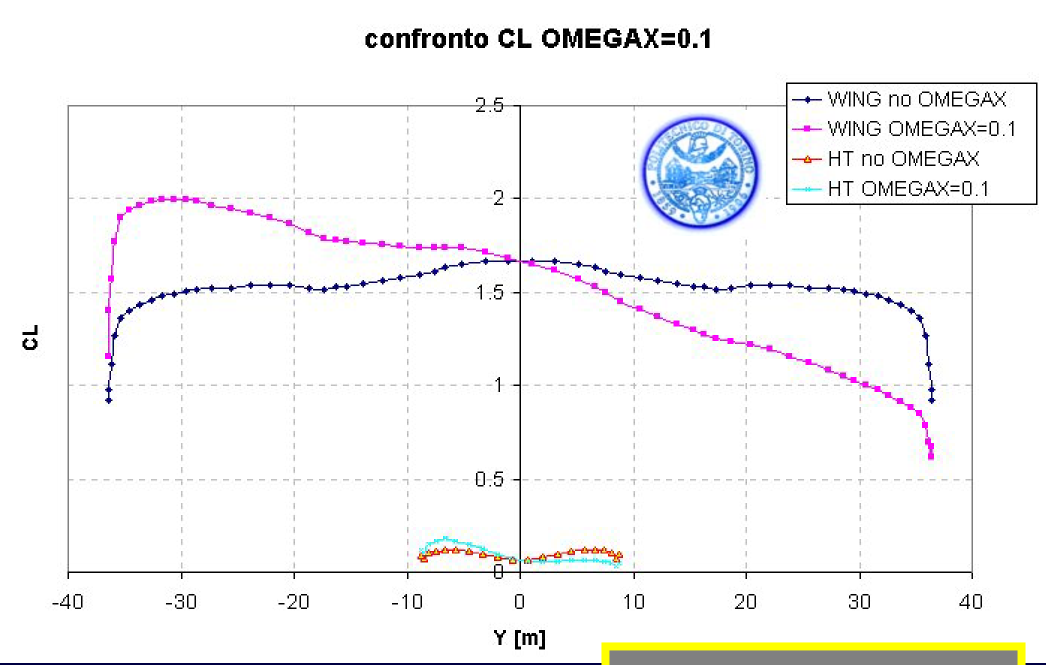

Roll rate p

Pitch rate q

Dynamic derivatives (p q r): Cl_p ; Cn_p ; Cy_p; CL_q ; Cm_q ; Cn_r ; Cy_r ;Cl_r

Conclusions

• Vsaero is an excellent tool in order to design the best package to fulfil the design targets.

• Good correlation between numeric and experimental data.

• calculation quickness