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World Solar Challenge 2013

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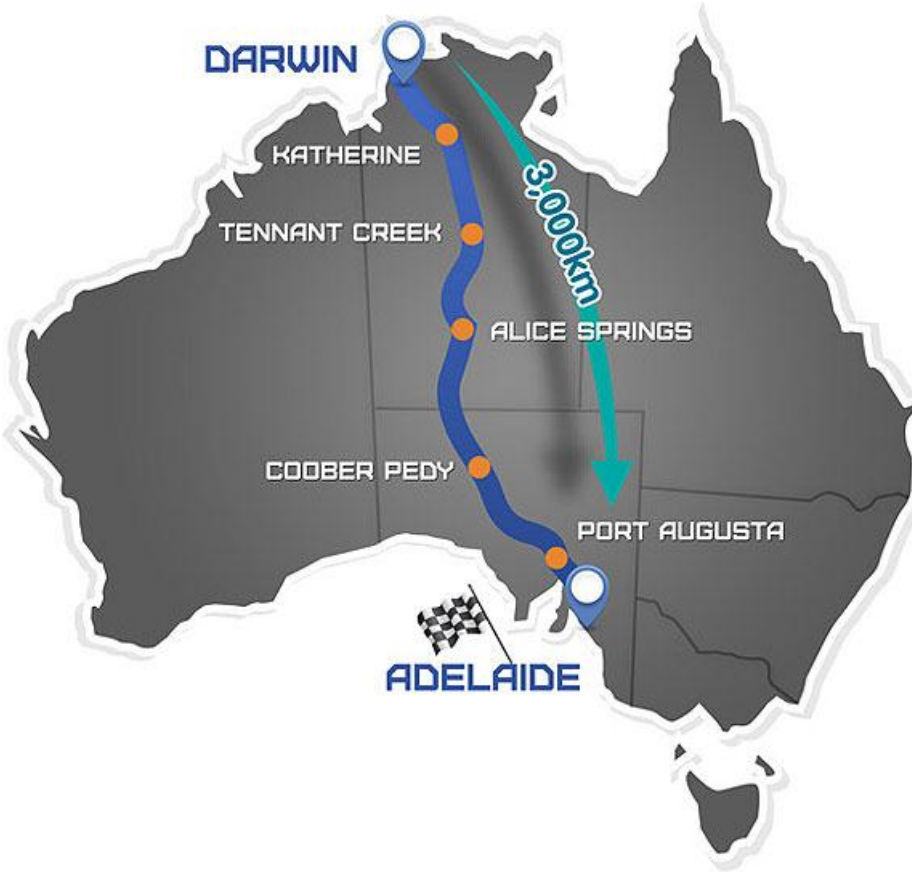

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CAR NAME: EMILIA 3

DAILY EVENT RESULTS

	Pos	Arrival Time	Control Stop	Kms from Darwin
Day 1	24th	13:50:00	Katherine	321
Day 2	12th	16:34:00	Tennant Creek	988
Day 3	10th	16:23:00	Alice Springs	1493
Day 4	10th	11:45:00	Kulgera	1766
Day 5	10th	14:45:00	Glendambo	2432
Day 6	10th		Not reached finish of timing	0
Day 7	10th	16:25:00	Friday	3020

Emilia3

is the Italian challenge to the "World Solar Challenge" competition for solar-powered cars which takes place every two years in Australia. From Darwin to Adelaide through the Australian landscape with 1300 Watts available and a week to complete the course of 3000 km. With this background, as it can be easily understood, aerodynamics plays an important role

In 2014 some changes in the technical rules have made useless the majority of the previous experiences

- the 2014 car has four wheels (instead of three)
- the driver must be able to move his head in the cockpit without any limitation
- the driver, when sitting in his natural position, must be able to see any small obstacle in front of the car.


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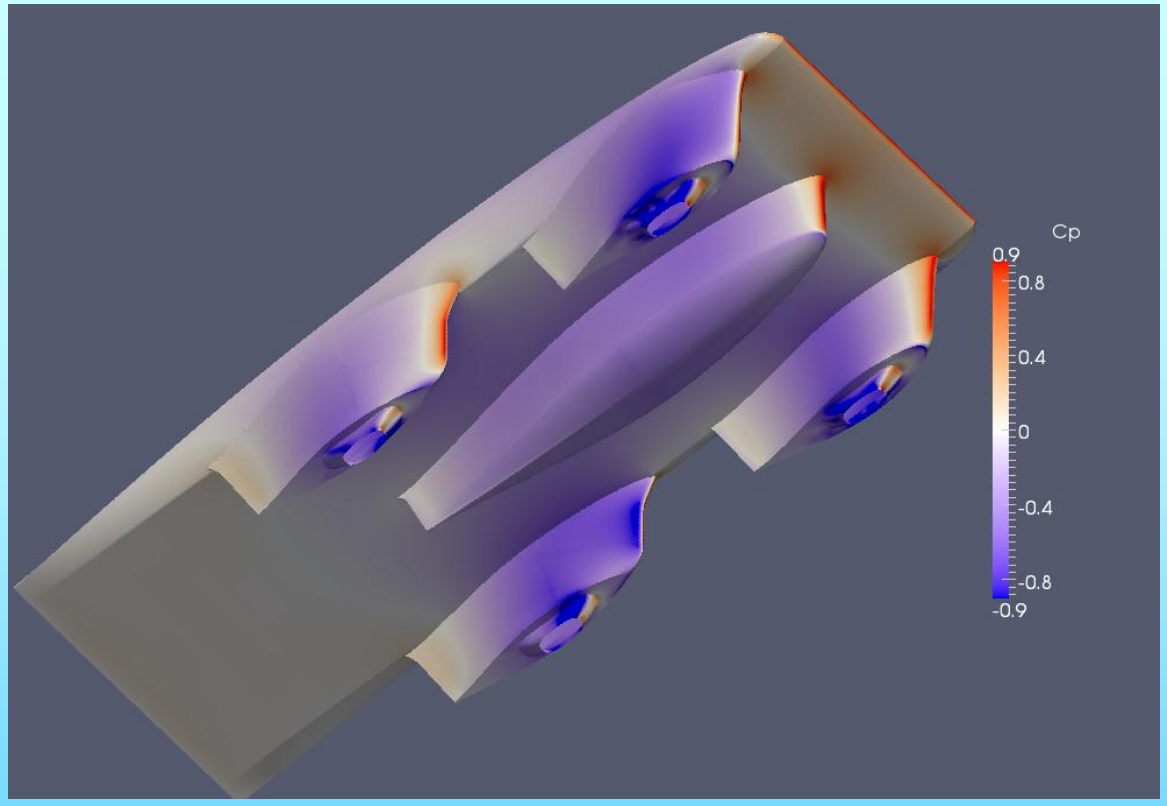
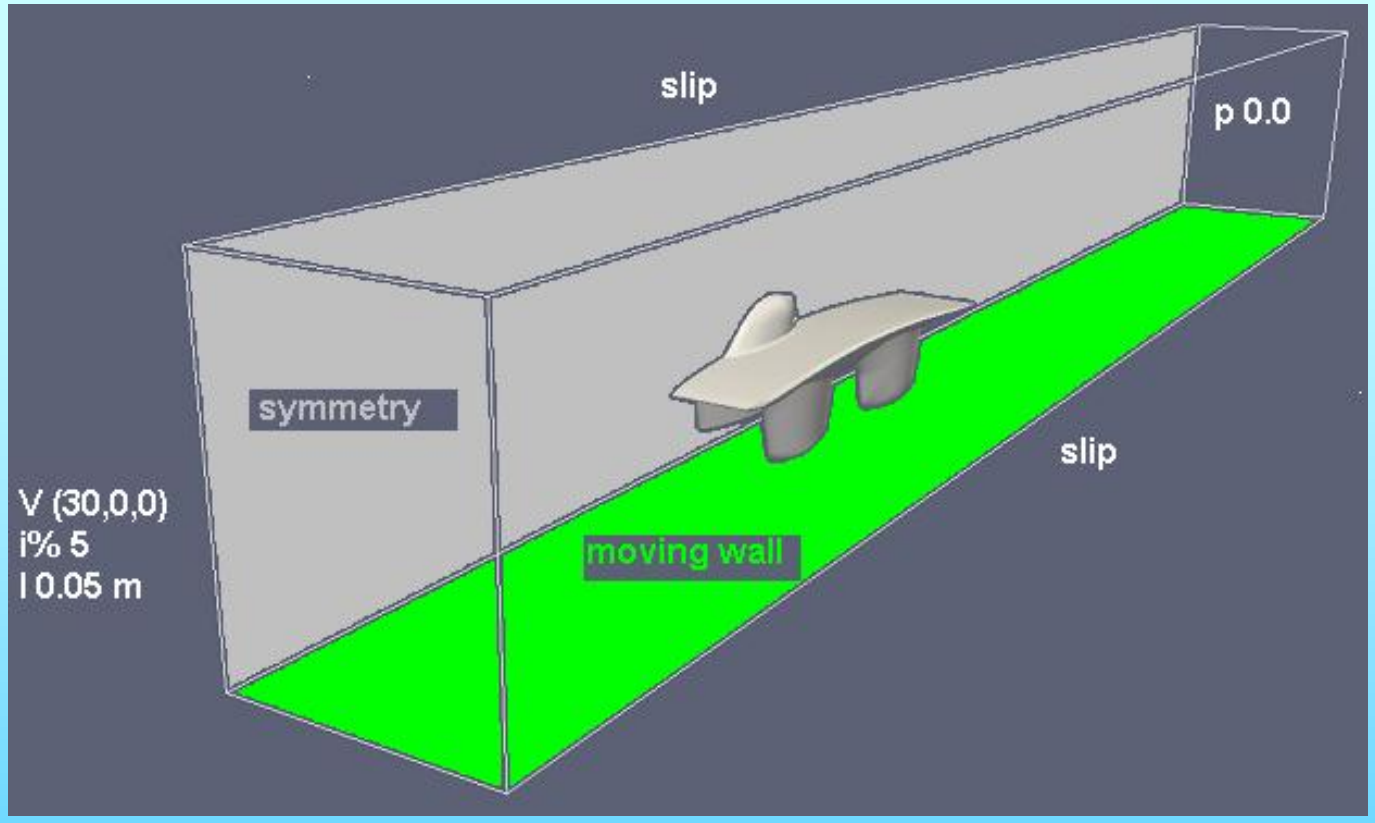


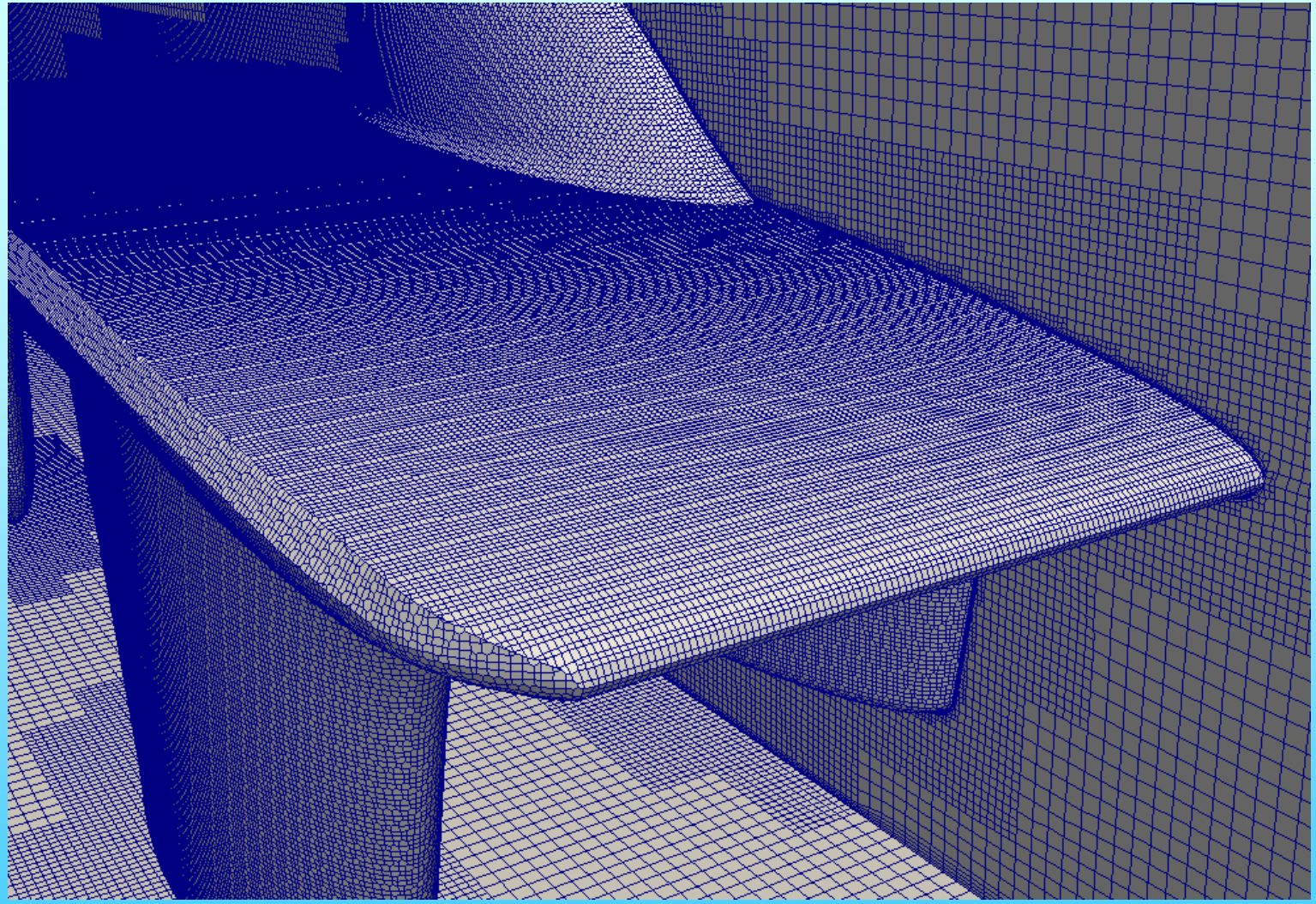
Aero-design criteria (focus on interference and ground effect)

- the stagnation points on the airfoils must be correctly aligned with the mean line and the pressure distribution must be free from any suction peaks
- no reverse flow around the body (i.e. no flow separations around airfoils)
- the lift coefficient must be negative (for stability and safety reasons) and close to zero (to avoid tyres extra friction due to downforce)



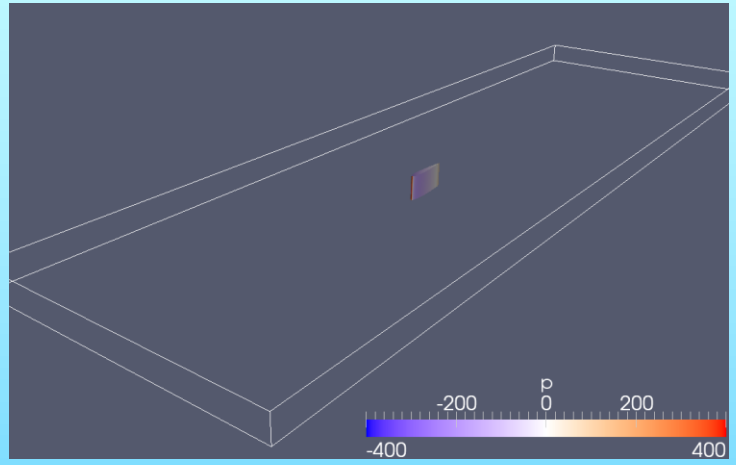
The team is using OpenFOAM driven by the suite HELIX-OS- for pre/post-processing

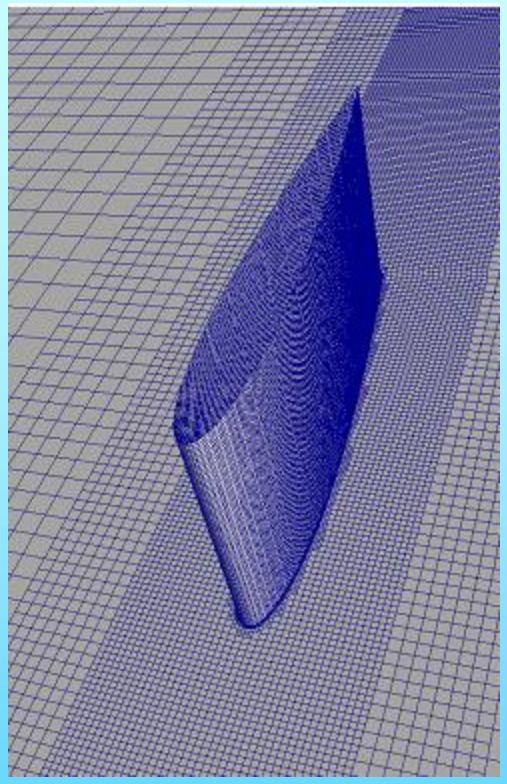
The simulation does not resolve the boundary layer and makes use of the wall funtions technique to simulate the flow close to the wall. Three refinement volumes are used to reduce the cell size from the 0.1 m far upstream to 0.006 m close to the body and five prismatic layers are introduced, with a growth factor of 1.2, to get an overall thickness in the order of 0.005 mm. The model (half) is made of 4.0 millions elements. The resulting y+ is in the range 50 to 100 and the turbulence model is k-w SST with a turbulent viscosity ratio of 280.

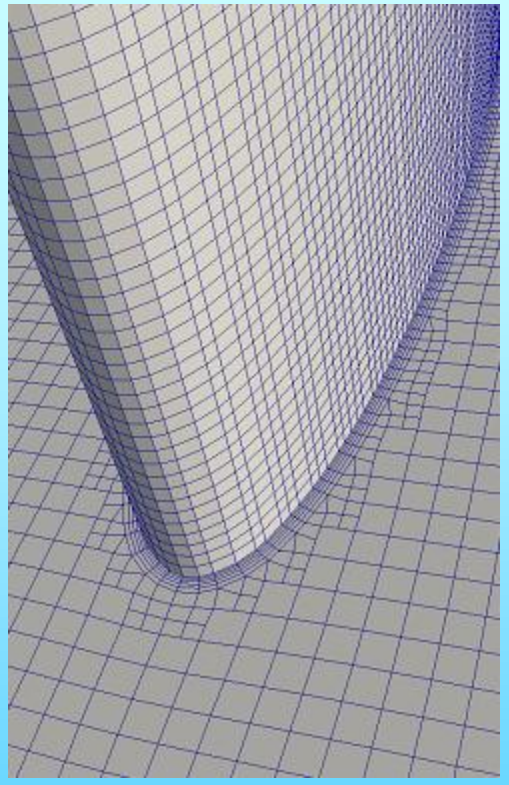


Each run (2000 it) takes approximately

10 hours using 2 processors and (linearly down) 3.5 hours using 6 processors and 1.40 hours using 12 processors at Cineca

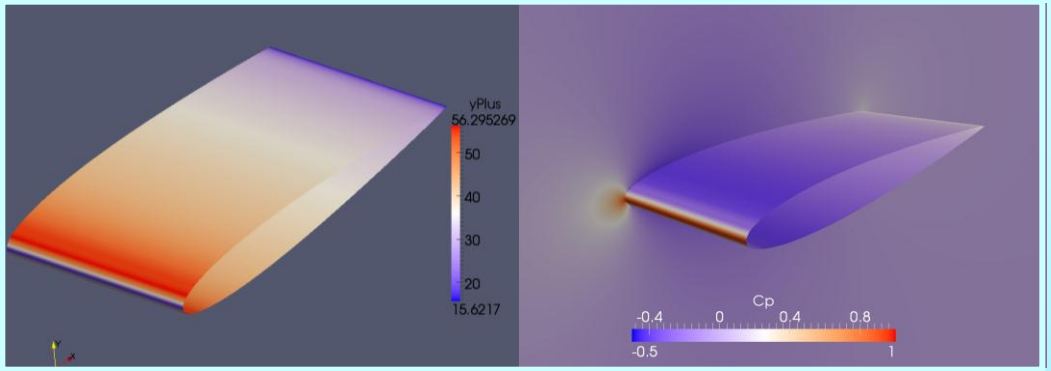


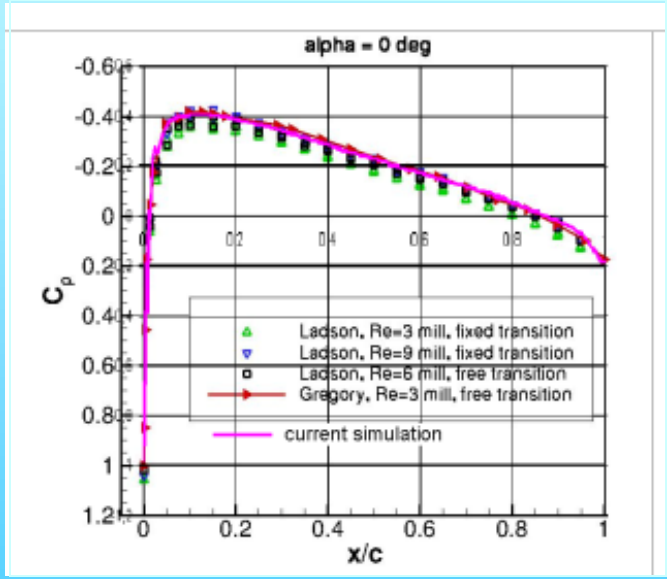


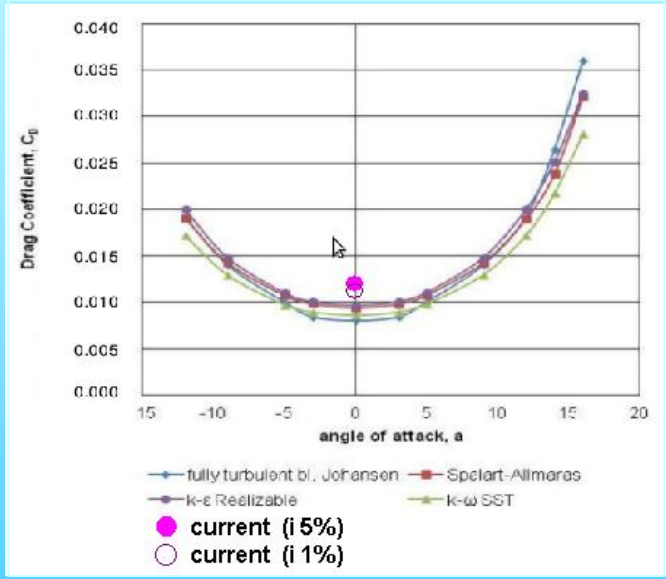


Preliminary check of the numerical model on a NACA0012 airfoil

- c = 1 m
- V = 30 m/sec
- Reynolds = 2 millions



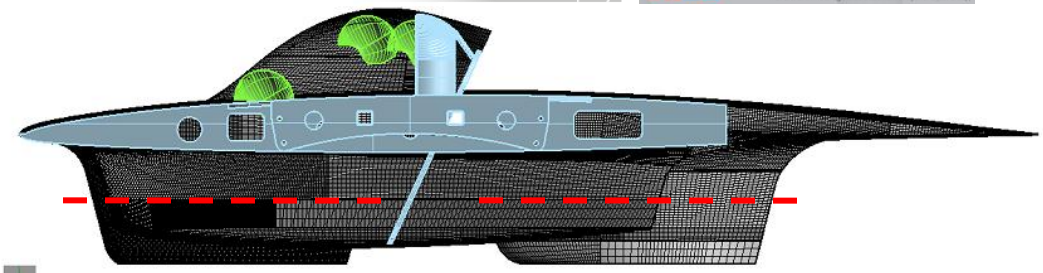


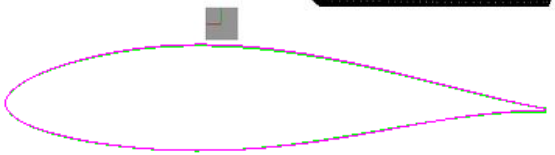


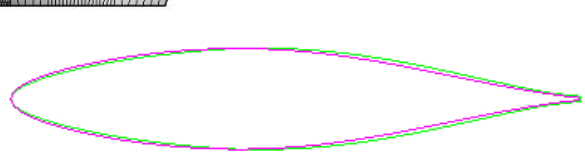
Preliminary check of the numerical model on a NACA0012 airfoil [1]

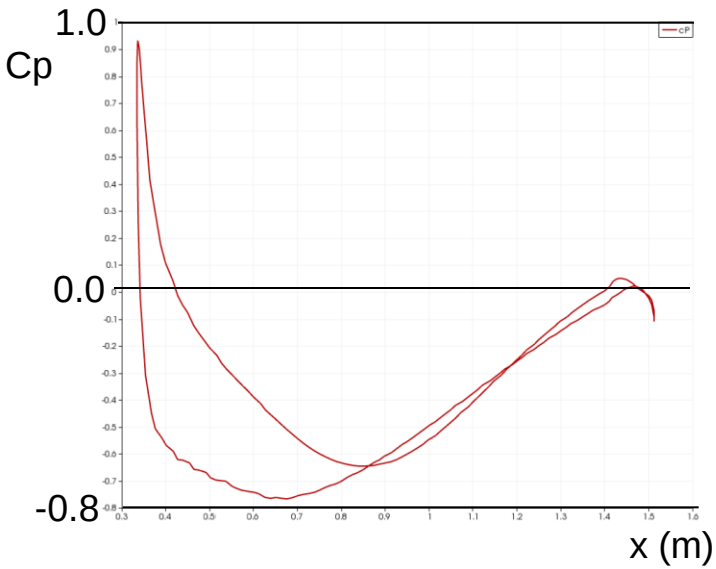
- pressure **OK**
- drag …"**it could be better**"

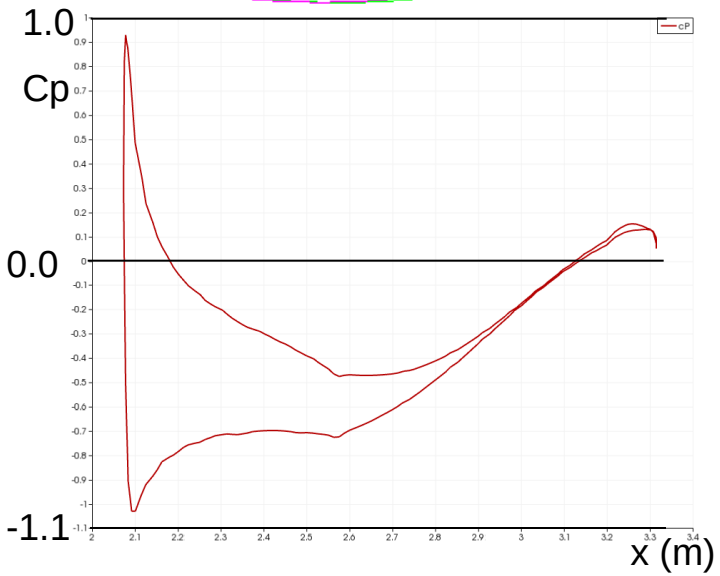
[1] turbmodels.larc.nasa.gov/naca0012_val.html





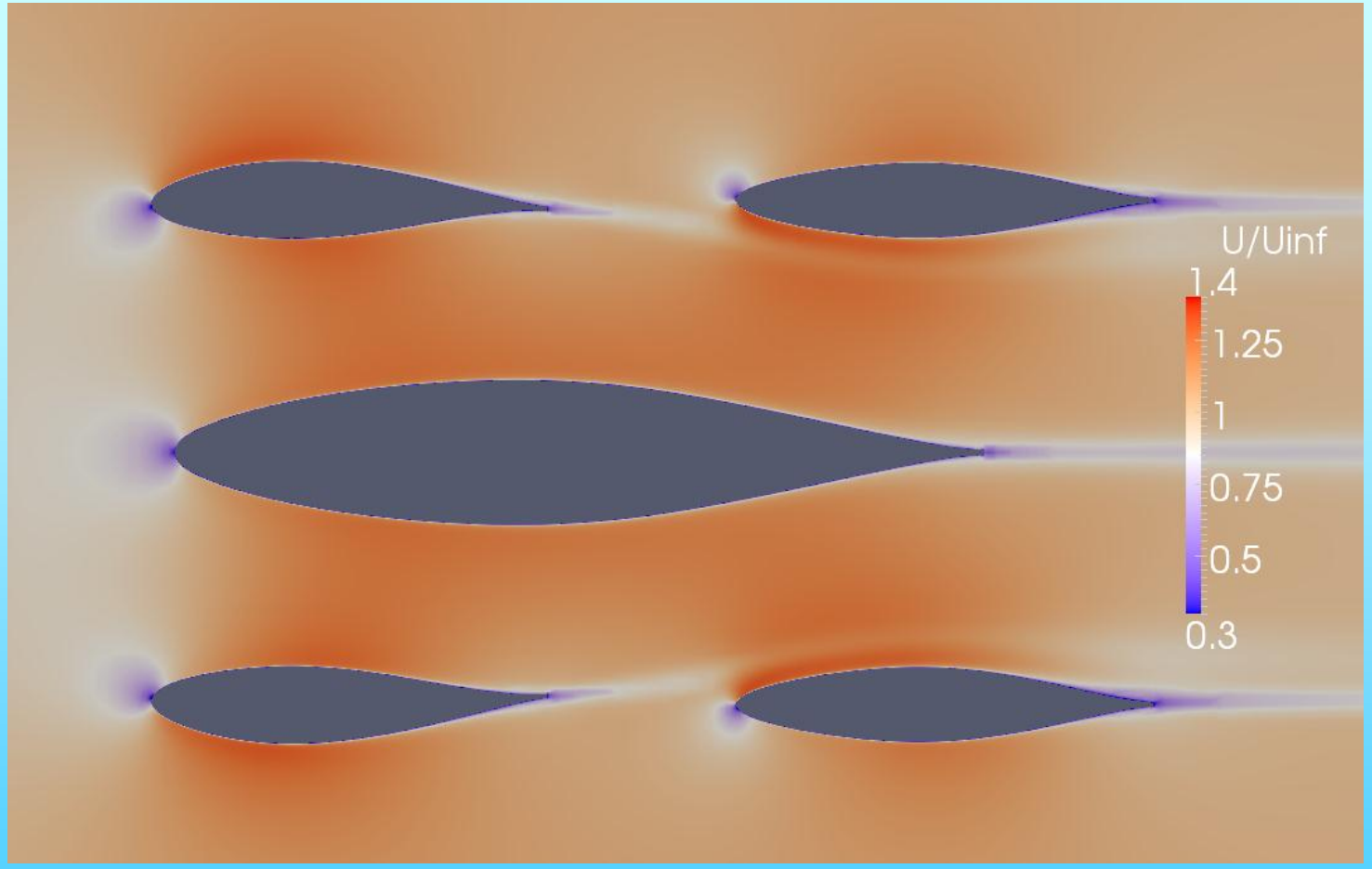






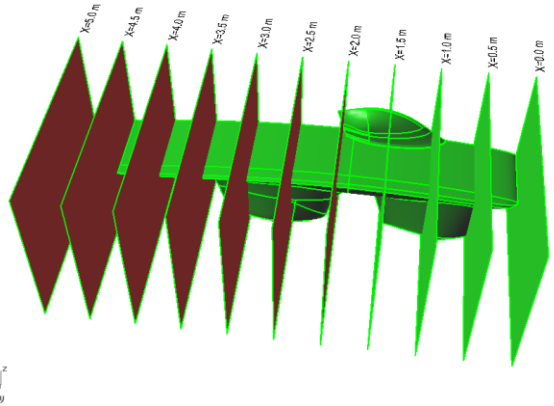
The pressure distribution must be free from peaks

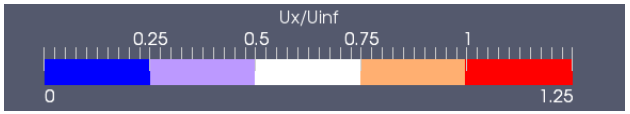
- Front wheel fairing **OK**
- Rear wheel fairing **partially achieved**



The stagnation points on the airfoils must be correctly aligned with the mean line

- Front wheel fairing **OK**
- Rear wheel fairing **partially achieved**





x=1.0 front wheel wake

x=1.5

x=2.0 cockpit wake

x=2.5

x=3.0 rear wheel wake

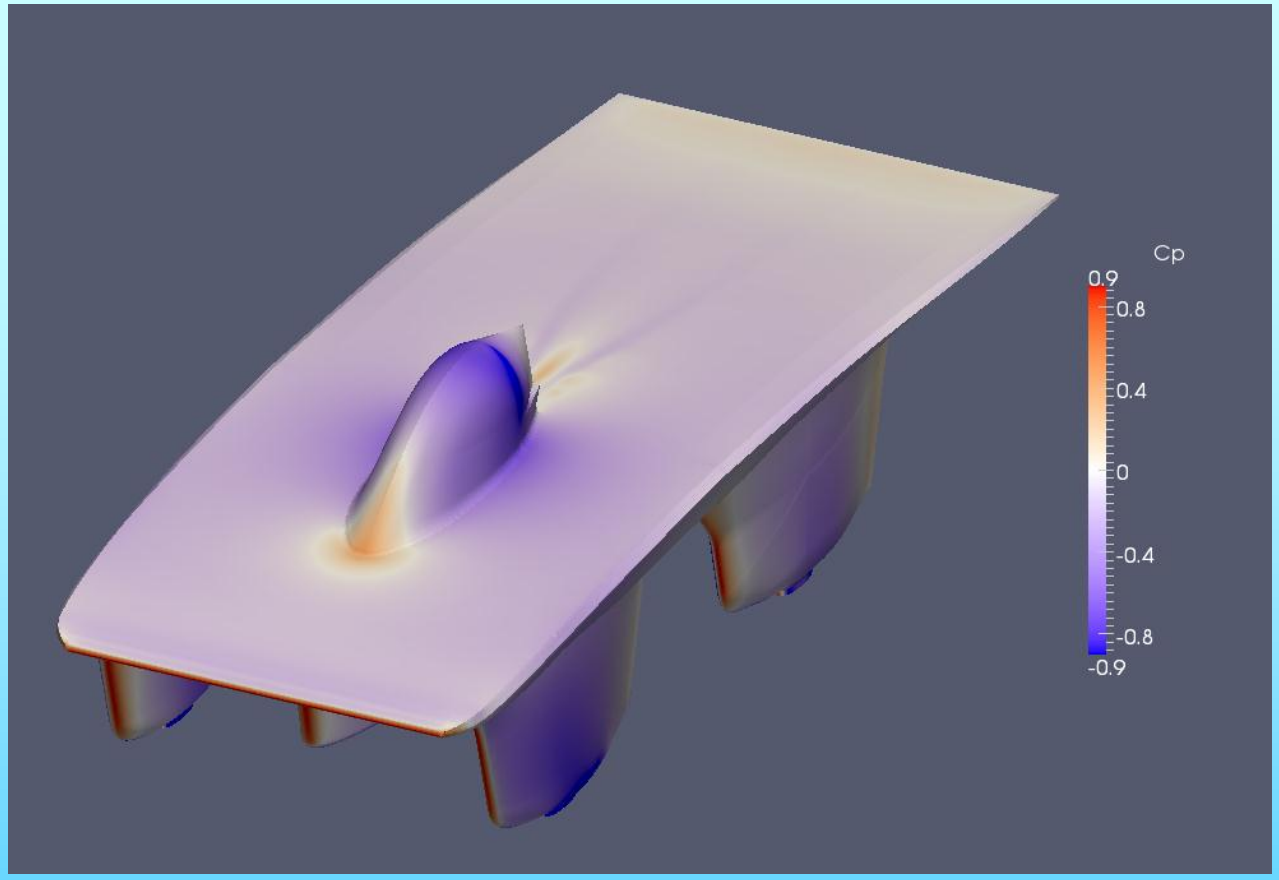
x=3.5

x=4.0

x=4.5 wing trailing edge

No reverse flow around the body (i.e. no flow separations around airfoils)

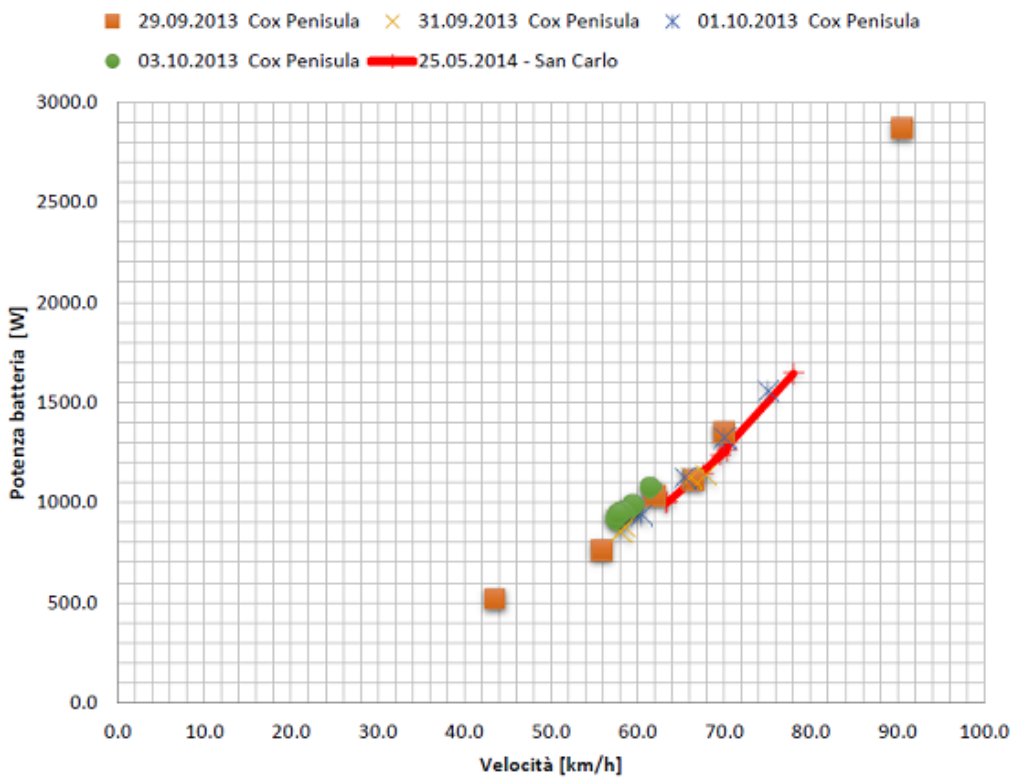
☐overall **OK**



SCx=0.161 m^2 **SCz=-0.24 m^2** S frontal surface (0.98 m^2)

The lift coefficient must be negative (for stability and safety reasons) and close to zero (to avoid tyres extra friction due to downforce)

- Cz **OK**
- Cx **?? no reference available for the 2014 configuration**



Si ha:

$$P_{mecc} = \frac{1}{2}\rho_{air} C_d A_f v^3 + C_{RR}\, g\ m_v\, v = \frac{1}{2}\rho_{air} K_{aero} v^3 + C_{RR}\, g\ m_v\, v$$

Dove:

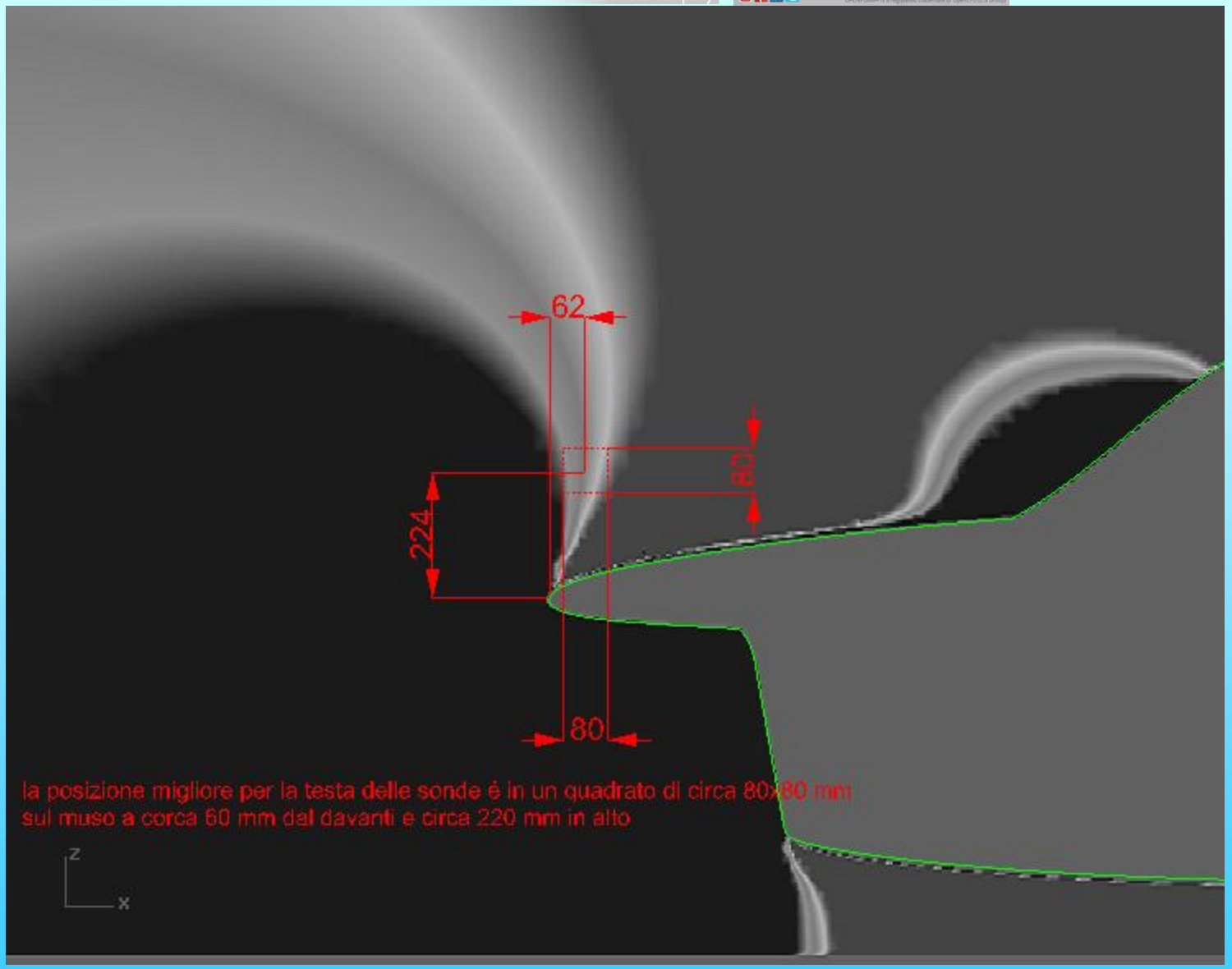
$\rho_{air} = 1.204$	Densità dell'aria
$K_{aero} = C_d A_f$	Coefficiente aerodinamico apparente
v	Velocità veicolo in m/s
C_{RR}	Coefficiente di attrito dei pneumatici
$m_v = 290\ kg$	Massa totale Emilia + Pilota
$g = 9.81\ m/s^2$	Accelerazione gravitazionale

$$K_{aero} = 0.2101$$

$$C_{RR} = 0.054$$

CxS=0.161 (CFD) vs. 0.210 (road test)

- internal flow
- wheels flow
- laminar/turbulent boundary layer



Pitot position where U/Uinf~1

CFD model improvement

- pressure distribution OK
- friction drag questionable

CFD model improvement

- sensitivity analysis to different turbulence model
- rotating wheels
- laminar/turbulent boundary layer transition

Modelling improvement

- 10° lateral wind analysis
- internal flow

Conclusions and future developments

Thank You