



Aerodynamic simulation for the general aviation

How to manage CFD in an aircraft SME

CCFR



- Created in 2002
- 8 People (Engineers and PHD)
- Wind tunnel in Magny Cours
- Wind tunnel testing
- CFD studies on OpenFOAM
- CAD with CATIA V5
- OpenFOAM trainings
- Software development: ACE of Aircraft

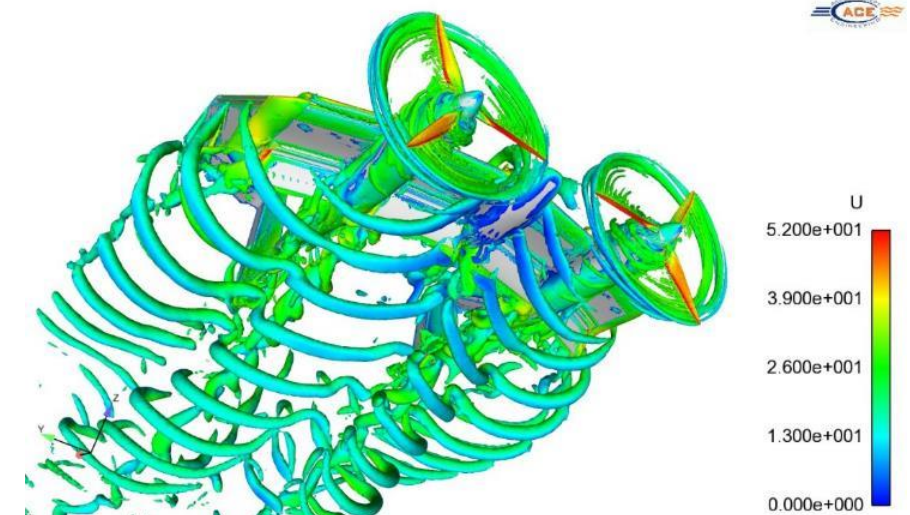
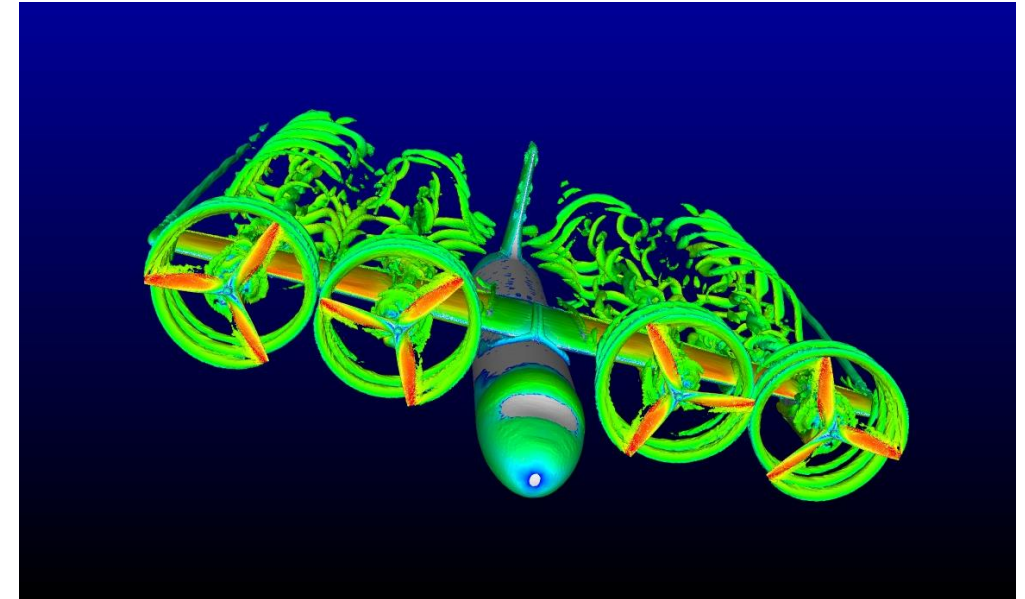


The wind tunnel

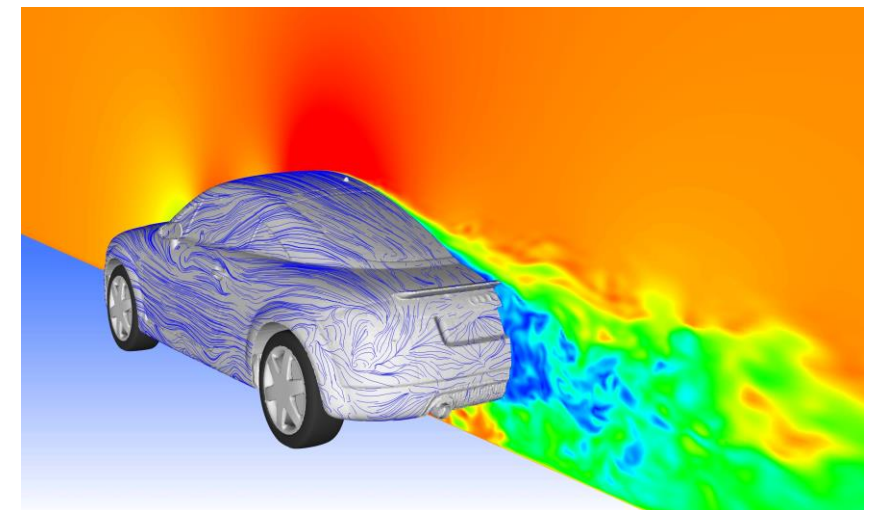
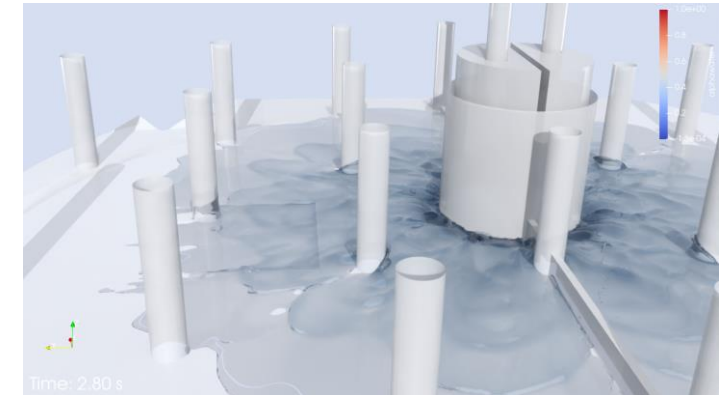
- 2,2m x 2,2 m section
- 40m/s
- Rolling Road
- Half Plane tests
 - Turn table +30 à -30°
 - Up to 1,5m half span
 - Fx, Fz, MY, Thrust and engine torque
- Full plane tests
 - Ground effect or fixed floor
 - 6 components
 - Motorized pitch
 - Manual Yaw



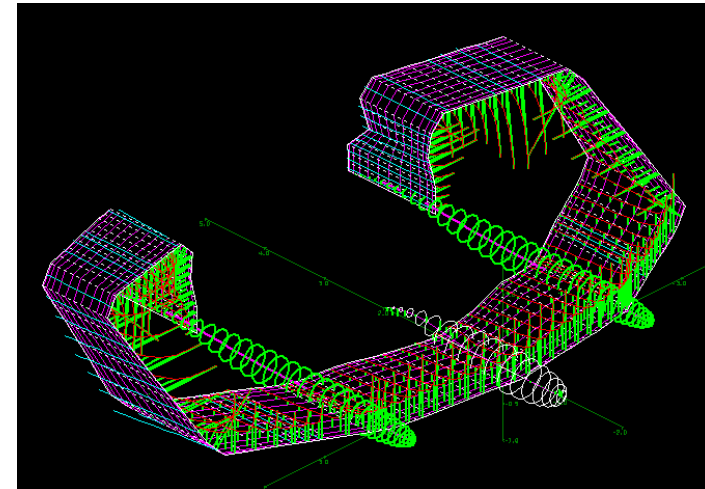
- 4 CFD engineers
- OpenFOAM (SnappyHexMesh)
- 200 cores et 2To RAM in house
- Several sectors
 - Aeronautics
 - Automotive
 - Defence
 - Sport...
- OpenFOAM Trainings
 - In customer office
 - Customized trainings



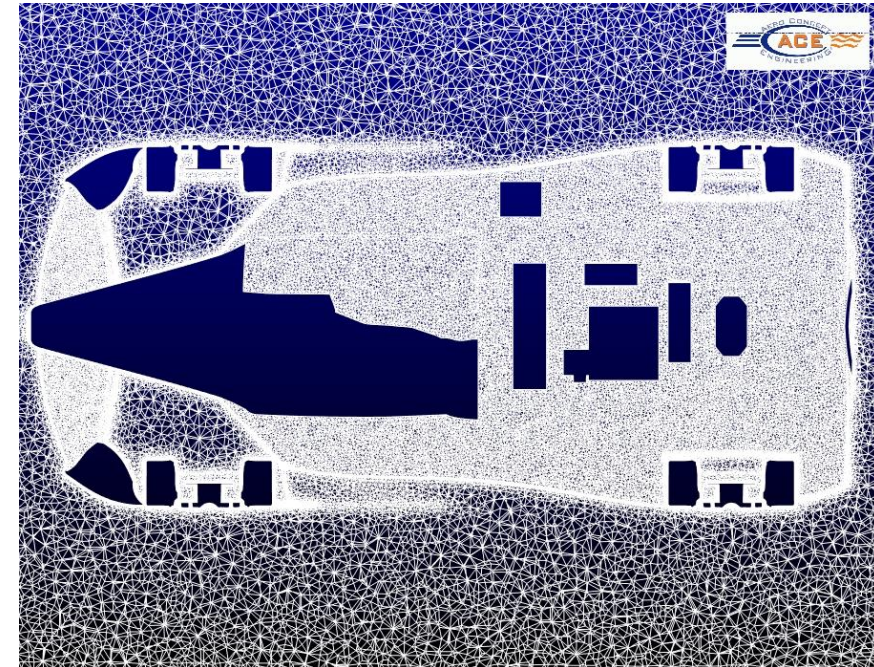
- CFD means « Computational Fluid Dynamics »
- Sometimes it means « Colors For Directors »
- Appear on the market in 1984
- Create X became Fluent then ANSYS
- Navier Stokes equations solving (RANS)
 - Air (gas)
 - Liquid
 - Multiphasic (gas + liquid)
 - Thermal
 - Species transport
 - Pollutants
 - Fire
 - Aero-acoustics
 - Particles...



- At the end of the 90's new CFD type
- Lattice Boltzmann equation solving
- RANS macroscopic flow solving
- LB: statistical particles displacements
- Other simplified flow simulation types exist in 2D or 3D
 - VLM (Vortex Lattice Method)
 - Panels method
 - ...

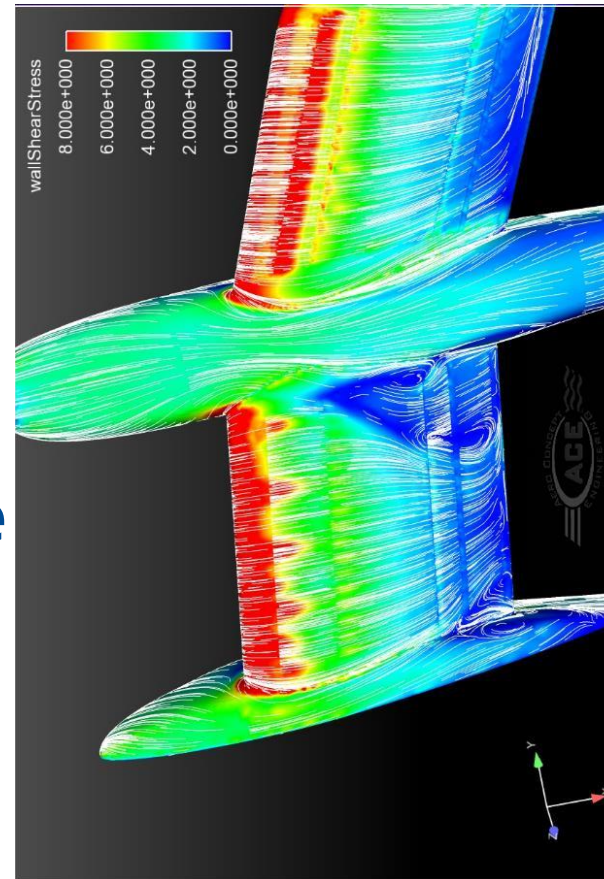


- Starting point: airtight CAD
- Computational domain
- Mesh
- Boundary Conditions set up
- Equation solving
- Post processing
- Analysis

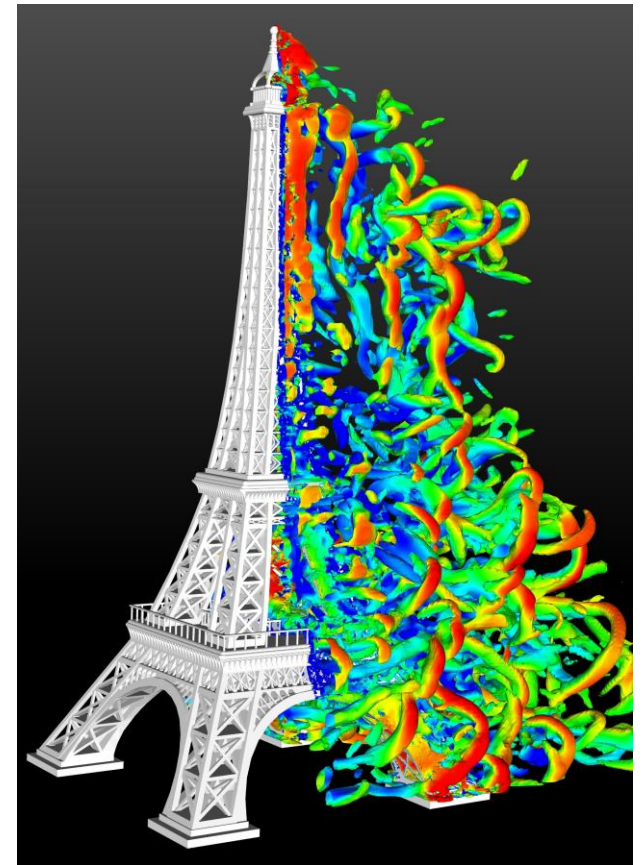


CFD vs Wind Tunnel

- No model investments
- fully virtual
- No physical limits
- Can visualize everything
- Hypothesis (simplifications)
- Big computers, calculation time
- User impact
- CFD Experts required



- **A large number of choices that impact the results:**
 - Geometrical simplifications
 - Mesh type
 - Mesh size
 - Boundary conditions choice
 - Turbulence model choice
 - Number of iterations...
- **These choices change depending on velocity, Fluid type, goal...**
- **CFD experts are needed**

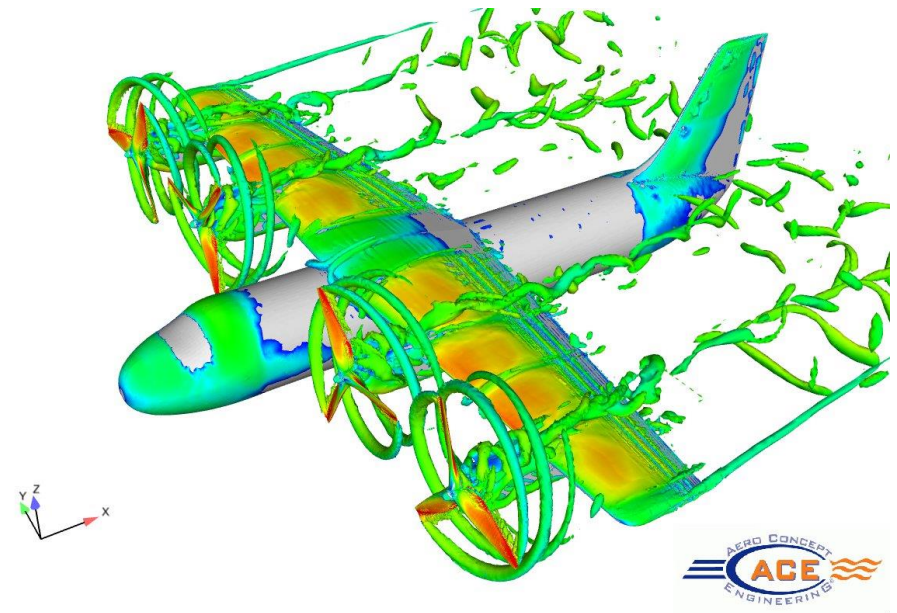


- **The majors:**

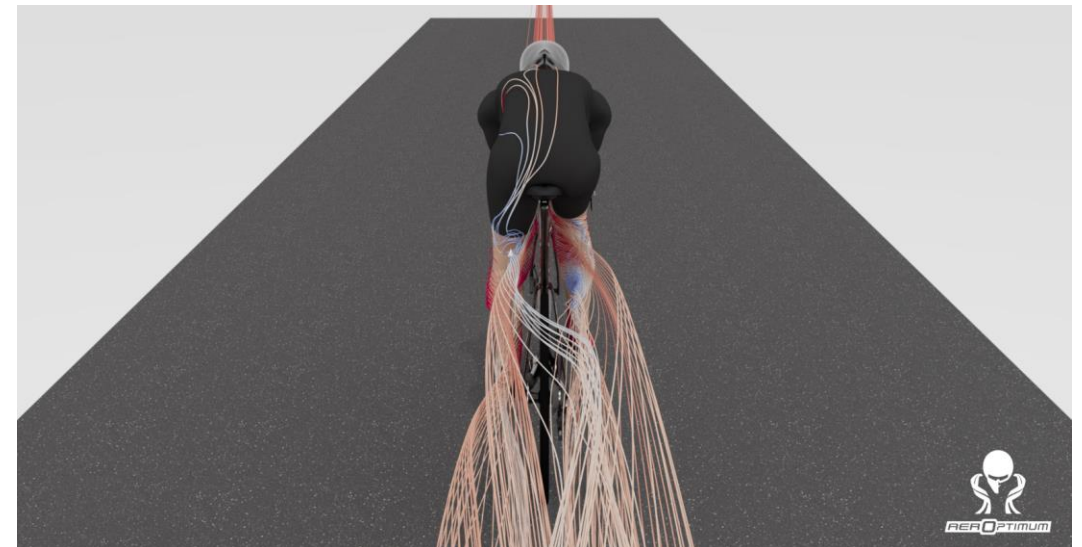
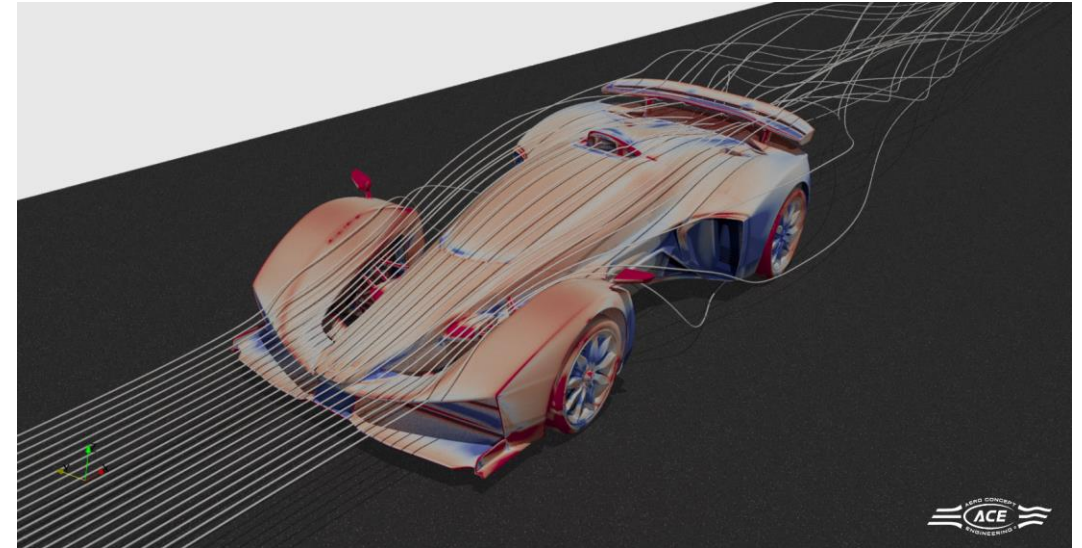
- ANSYS Fluent
- StarCCM+ (Siemens)
- OpenFOAM (open source)
- PowerFlow (Dassault Systèmes)
- CFX
- ProLB...

- **Others exist but are done for « Colors For Directors »**

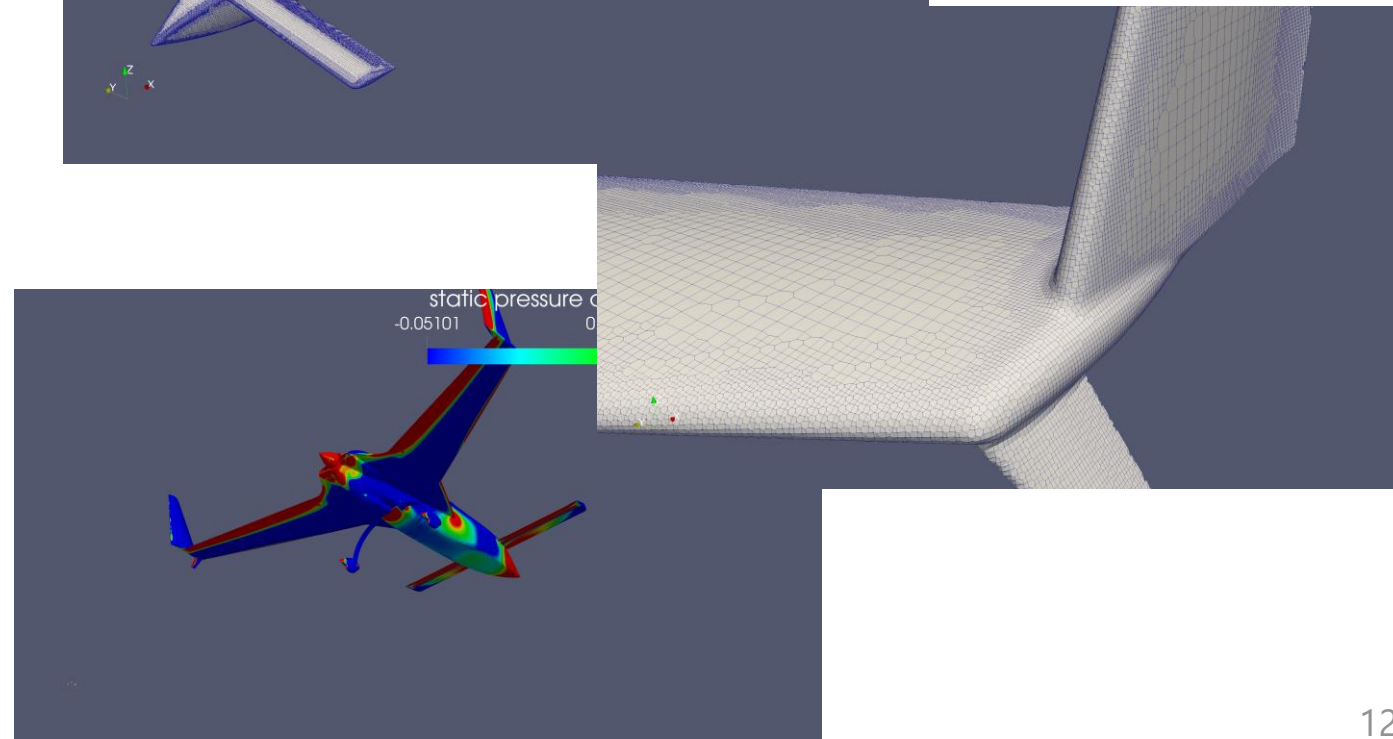
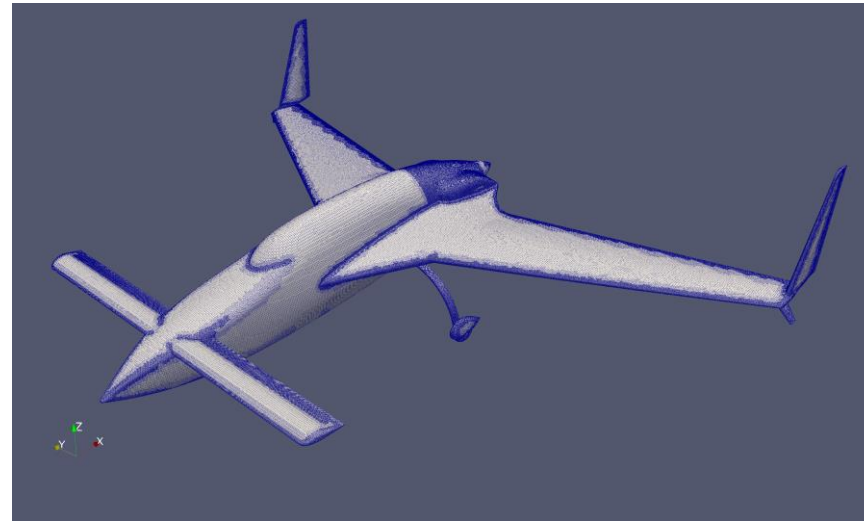
- Automated
- Cheap
- Able to calculate everything



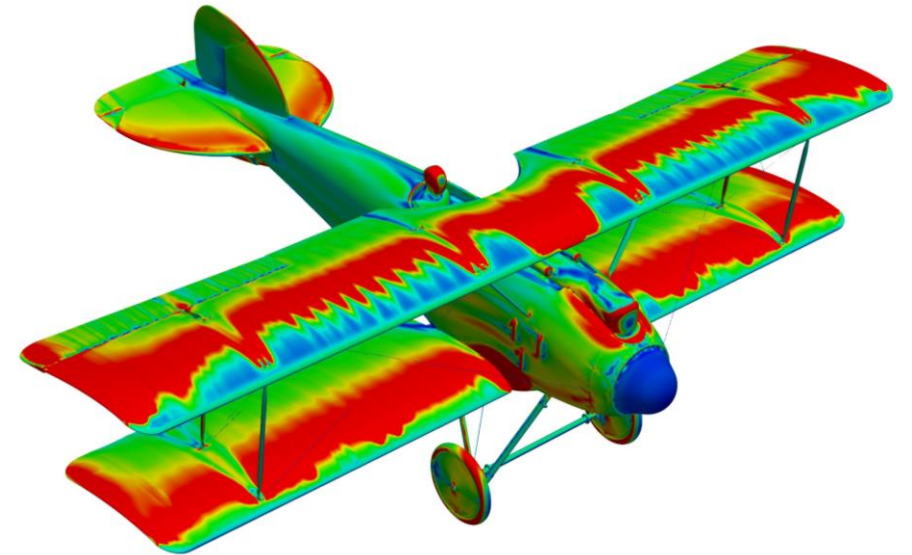
- **Big companies:**
 - Commercial Aviation
 - Defence Aviation
 - Automotive
 - Oil and gas
 - Chemical
- **Quite no SME**
 - Expert Hiring
 - Computer installation
 - Licenses costs



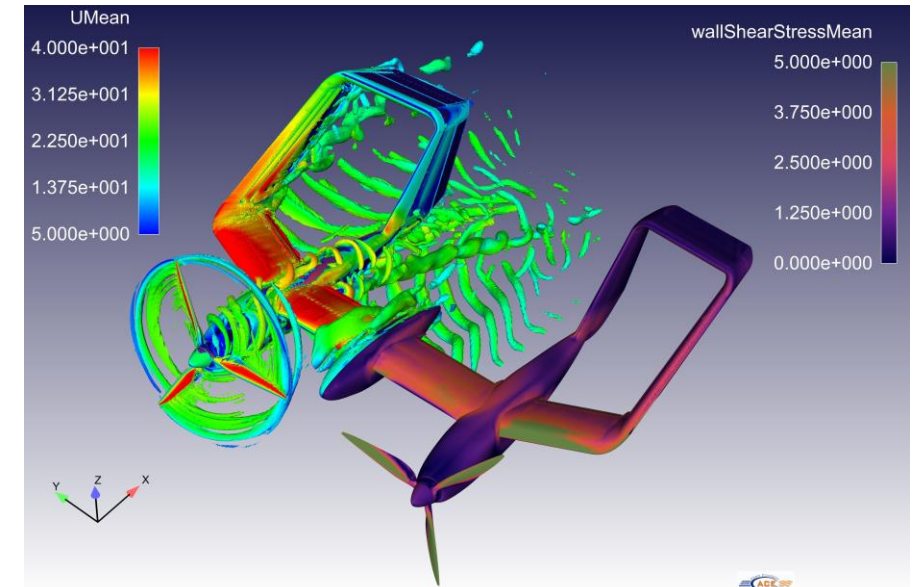
- CAD
- Mesh generation
 - Mesher (licenses)
 - Server (24 cores 128 Go RAM)
 - Mesh (40 M cells)
- Calculation
 - Solver (licenses)
 - Some thousand iterations
- Costs
 - About 12 h (1 point)
 - Licence cost (~ 50k€/year)
 - Salary (~ 50 à 80 k€/year)
 - Computer cost (~ 10 à 100 k€)



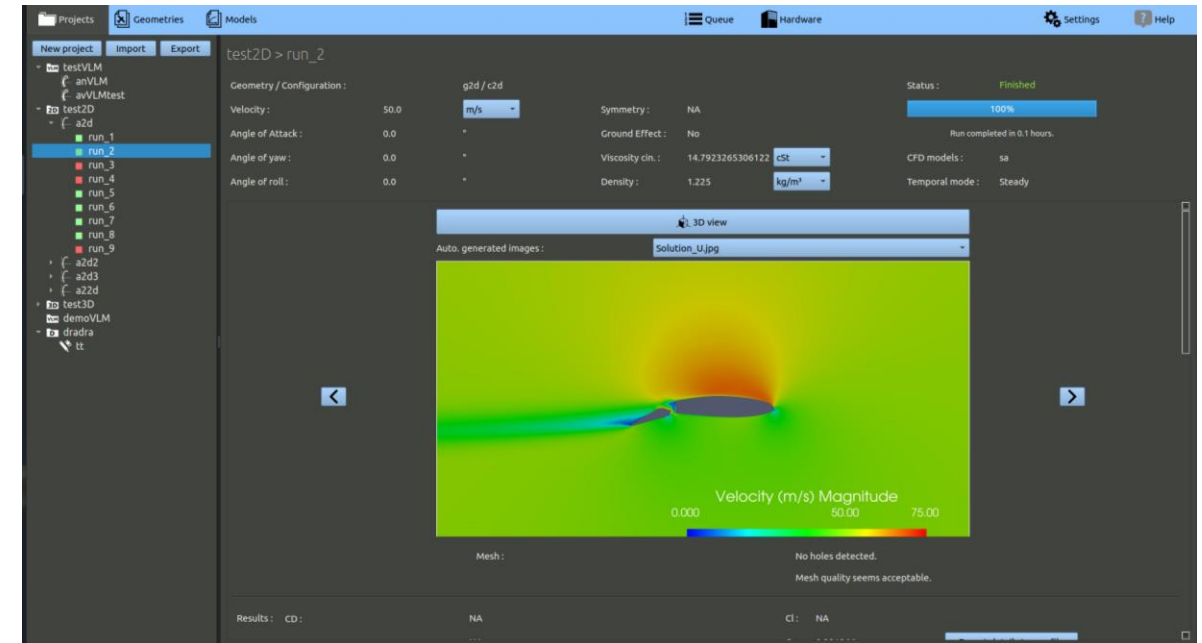
- **At the end**
 - Investment : 10 à 100 k€
 - Annual cost : 100 à 130k€
- **Impossible for a light aircraft SME**
- **Subcontracting**
 - Impossible to know the final cost at the beginning
 - Can be expensive if a lot of calculations are done
- **OpenFOAM solution**
 - Need for an expert ++
 - Computer investment
- **At the end a large part of light aircraft manufacturer doesn't use CFD**
 - This is what we conclude 4 years ago after many visit at the Aero Friedrichshafen show



- **Done with Danielson Engineering**
 - 1 ton
 - 8 m span
- **Advanced aerodynamic development**
 - 2400 full plane calculations
 - The first 800 in 3 months
 - 2 wind tunnel models
 - 5 weeks in wind tunnel testing
- **Scripted workflow**
 - CAD as an entry
 - Velocity and incidence set up
 - Mesh, set up, calculation et post processing automated
- **Software idea**
 - Graphical interface
 - Very bad customers reaction



- **Easy to use**
 - Automated
 - No need for a CFD expert
 - Choices done by ACE
- **Fast**
 - Automated data export
 - Customized for aircraft design
- **Affordable**
 - Small license cost
 - Affordable and efficient computer
 - Fixed costs (regardless number of cores or users)
- **Focused on the needs**
 - Specifications written by an aircraft designer
 - Low speed
 - Practical answers
 - All aircraft architecture



• 3 types of simulations

- Depending on project stage
- Draft (Induced drag)
- VLM (AVL)
- RANS (2D ou 3D)

• Several license types

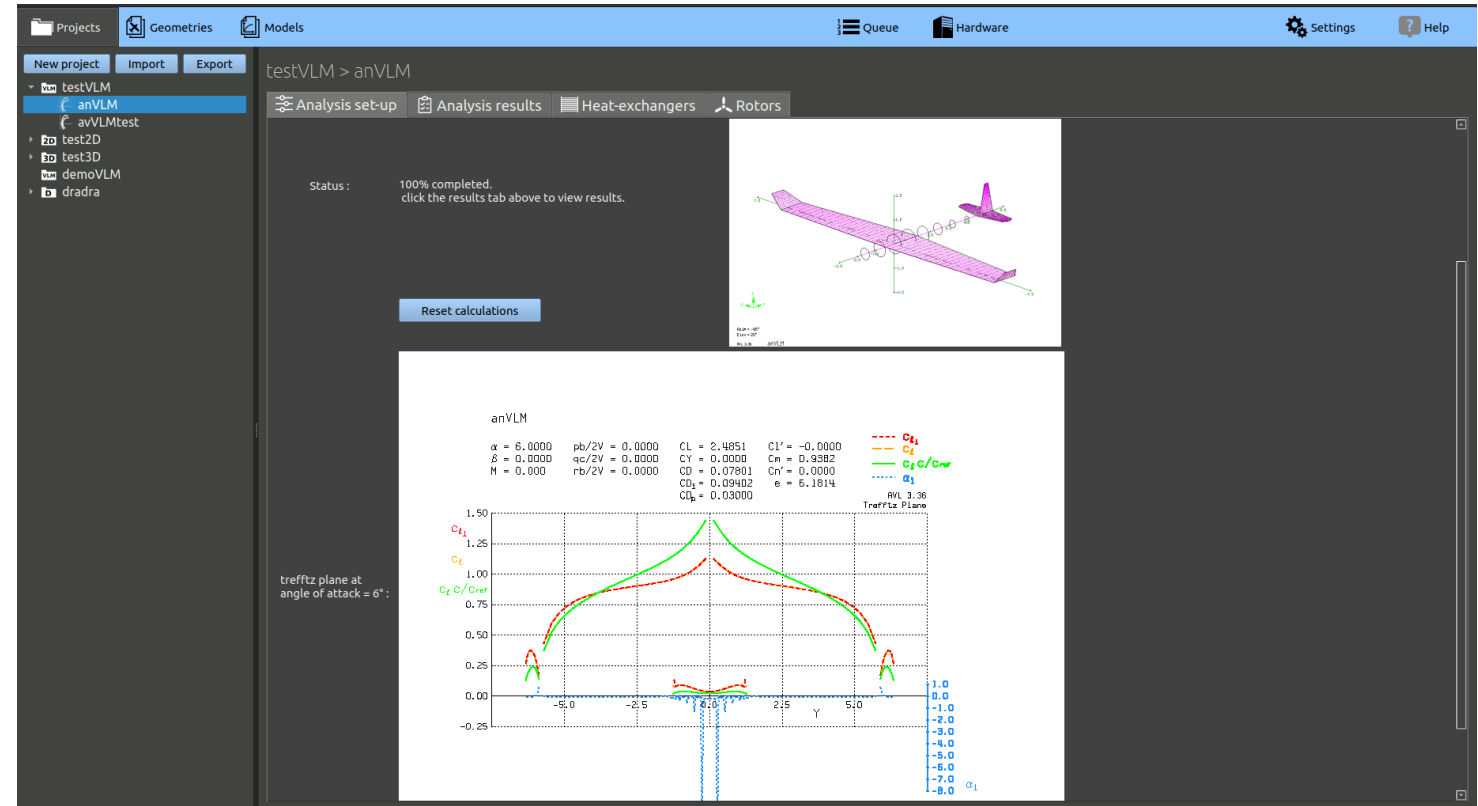
- Bronze (Induced Drag et VLM) free
- Gold (6000 €HT/year)
- Platinum (8000 €HT/year)
- Universities and engineers schools
- Demo license (free for 1 month)

• Operating systems

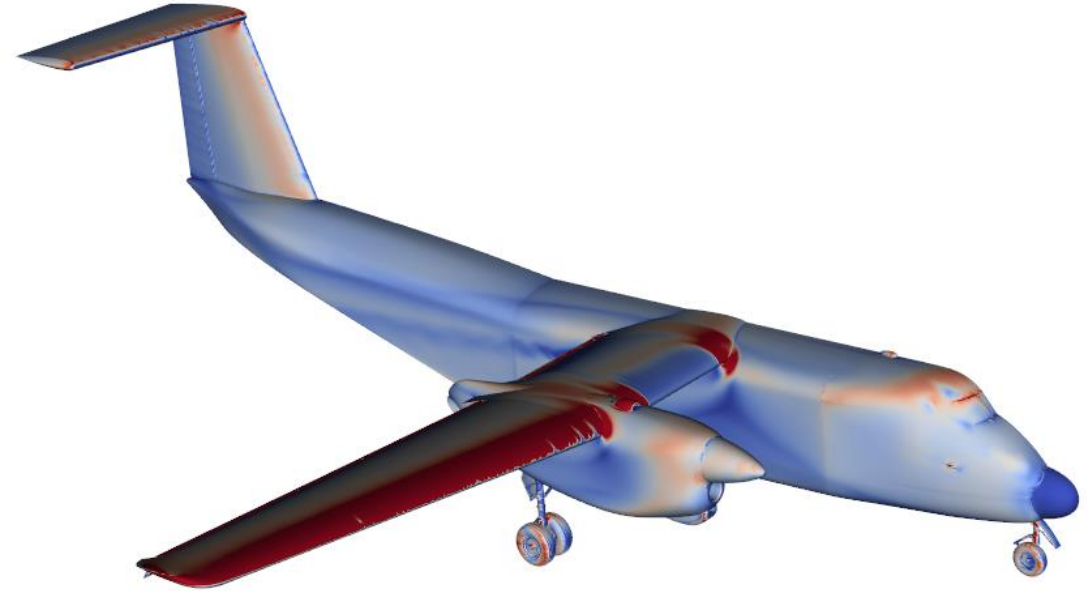
- Ubuntu et Windows for draft et VLM
- Ubuntu only for RANS

• Computer loan

- 16 cores 128Go of RAM
- Pre-installed (OS and software)
- Possible to buy it at the end of the test



- **Induced drag (Draft)**
 - Oswald coefficient
 - Allows to size the wing
 - Instant calculation
 - Doable with excel but simpler with AOA
- **VLM**
 - Some minutes calculations
 - 3D rudimentary
 - Architecture definition
 - Plane described section by section
 - No stall
 - Dynamic stability available
- **RANS**
 - Some hours (dozen) per calculation
 - Stall available
 - Cooling available
 - Details (karmans etc)
 - Complete flow visualisation
 - Hinge moments
 - Data for FEA



Buffalo

- **Polar curves**

- VLM
- RANS

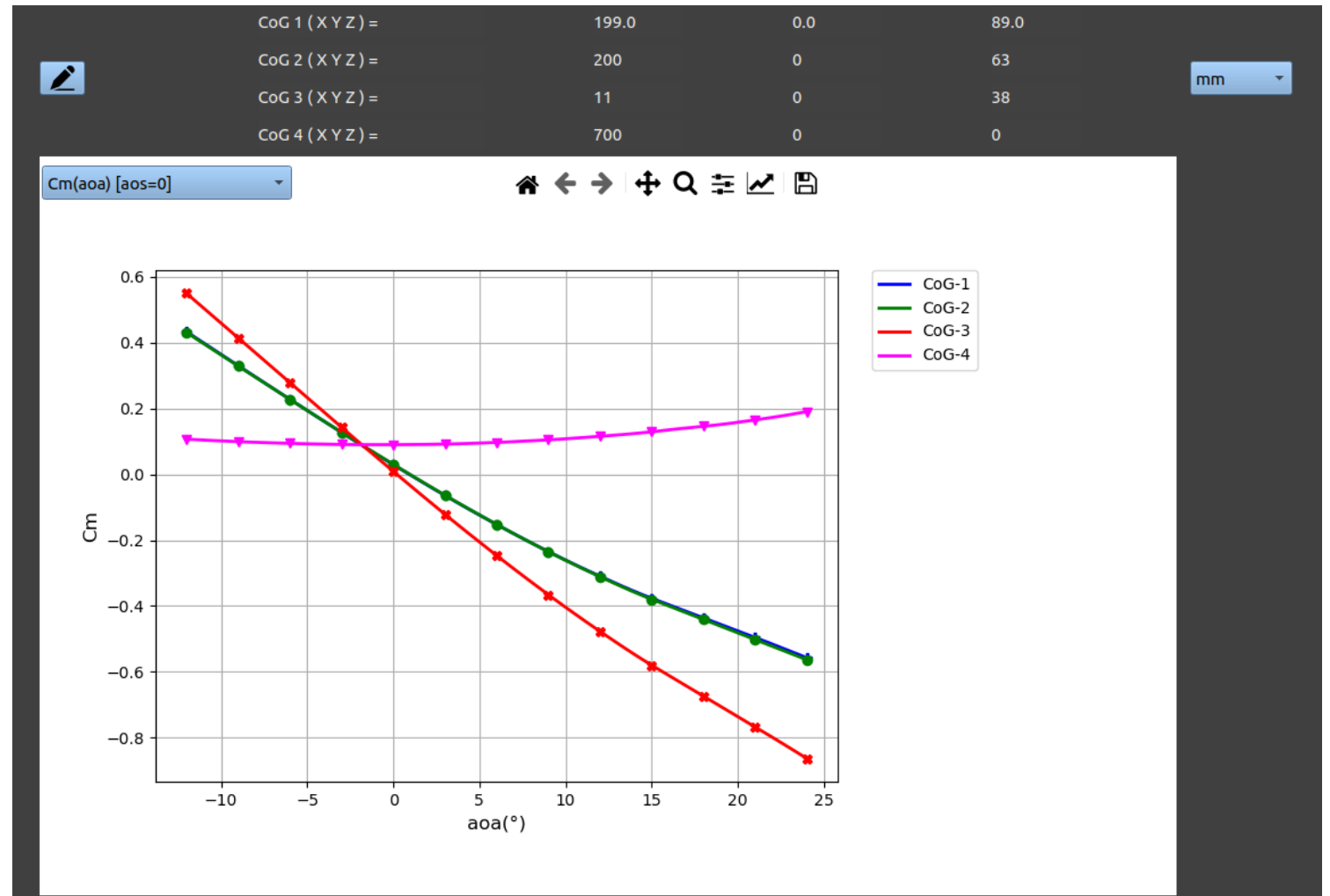
- **Static stability**

- VLM
- RANS
- Longi/side slip

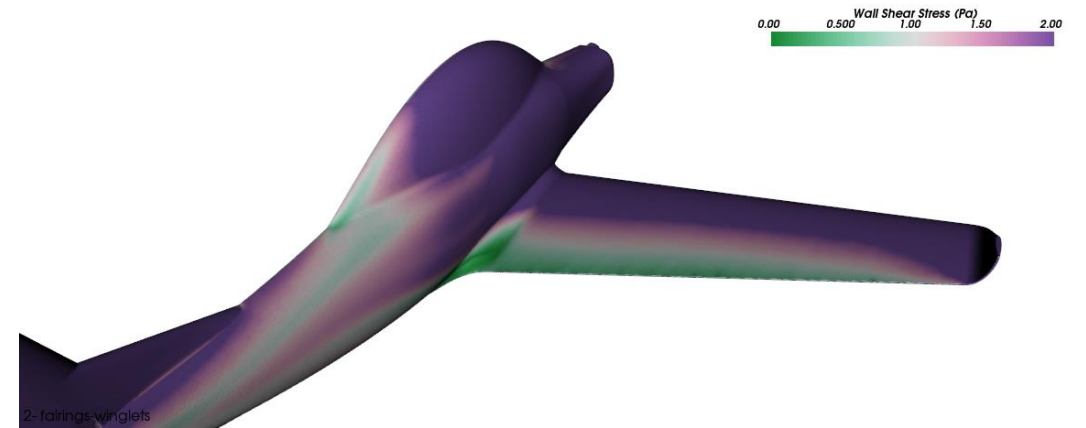
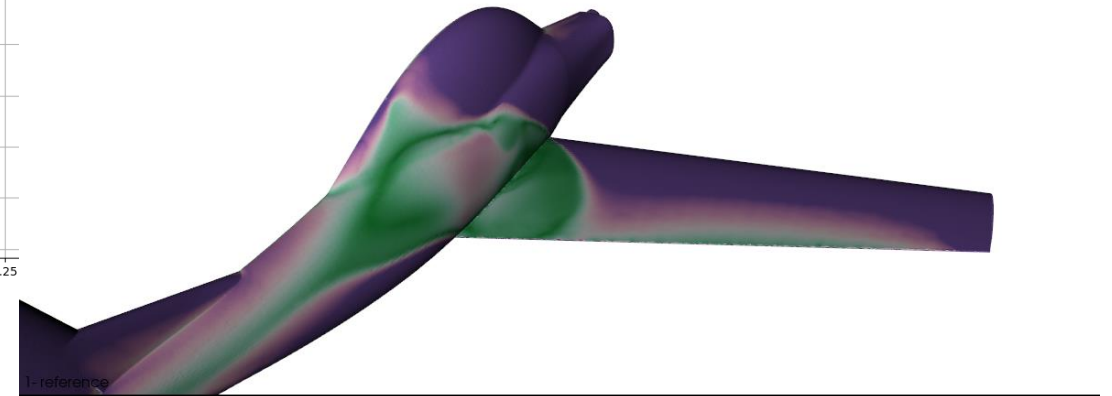
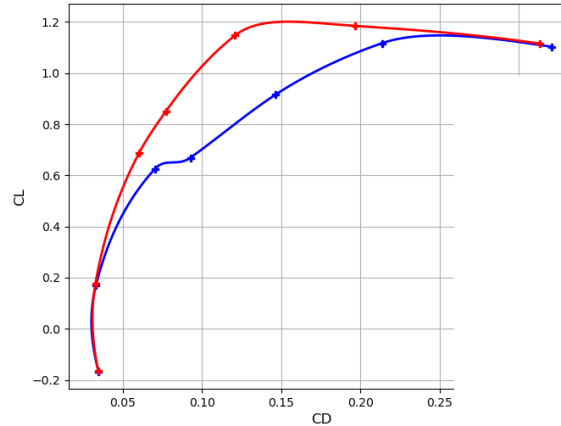
- **Dynamic stability**

- VLM

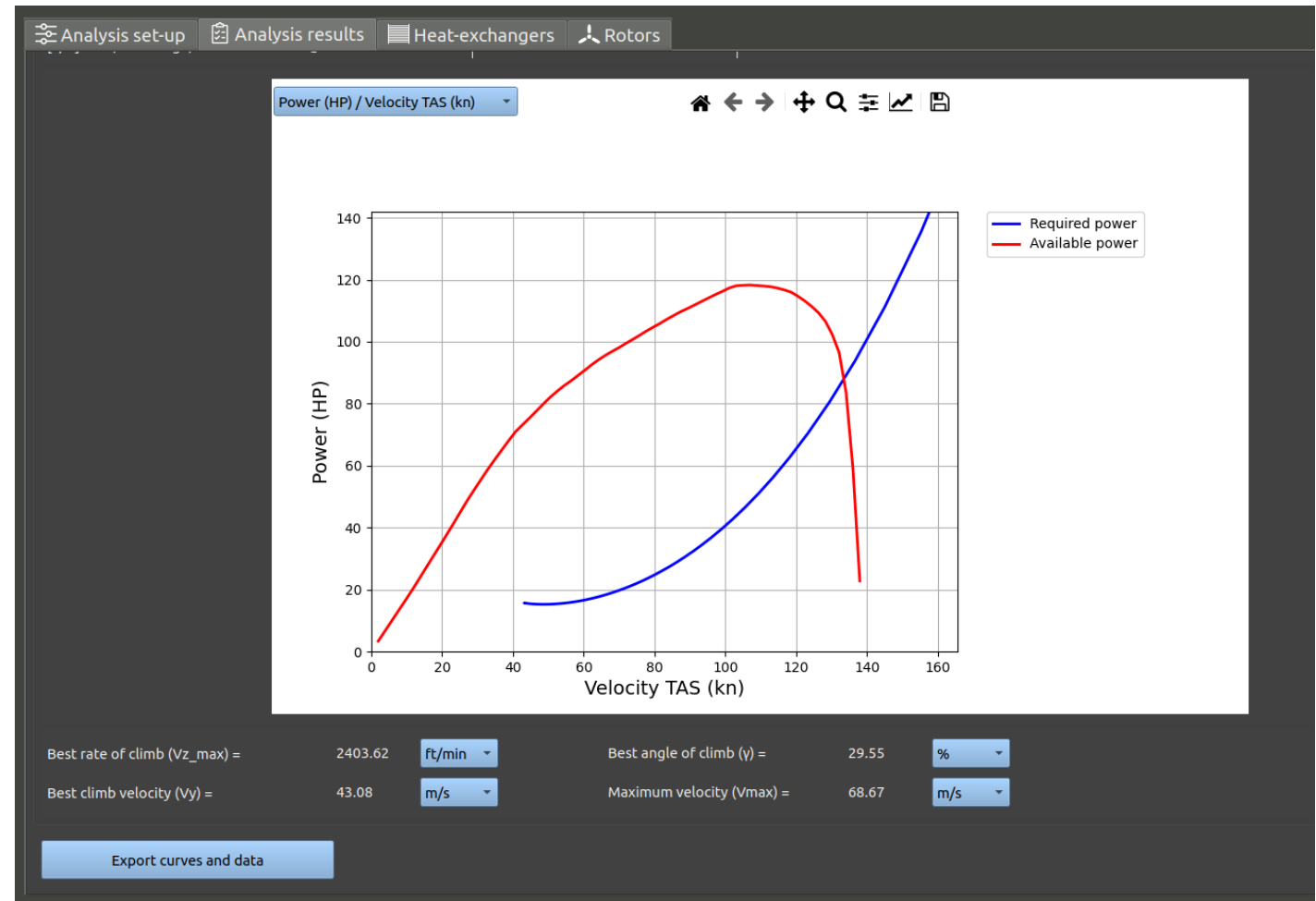
- **Stability Derivatives**



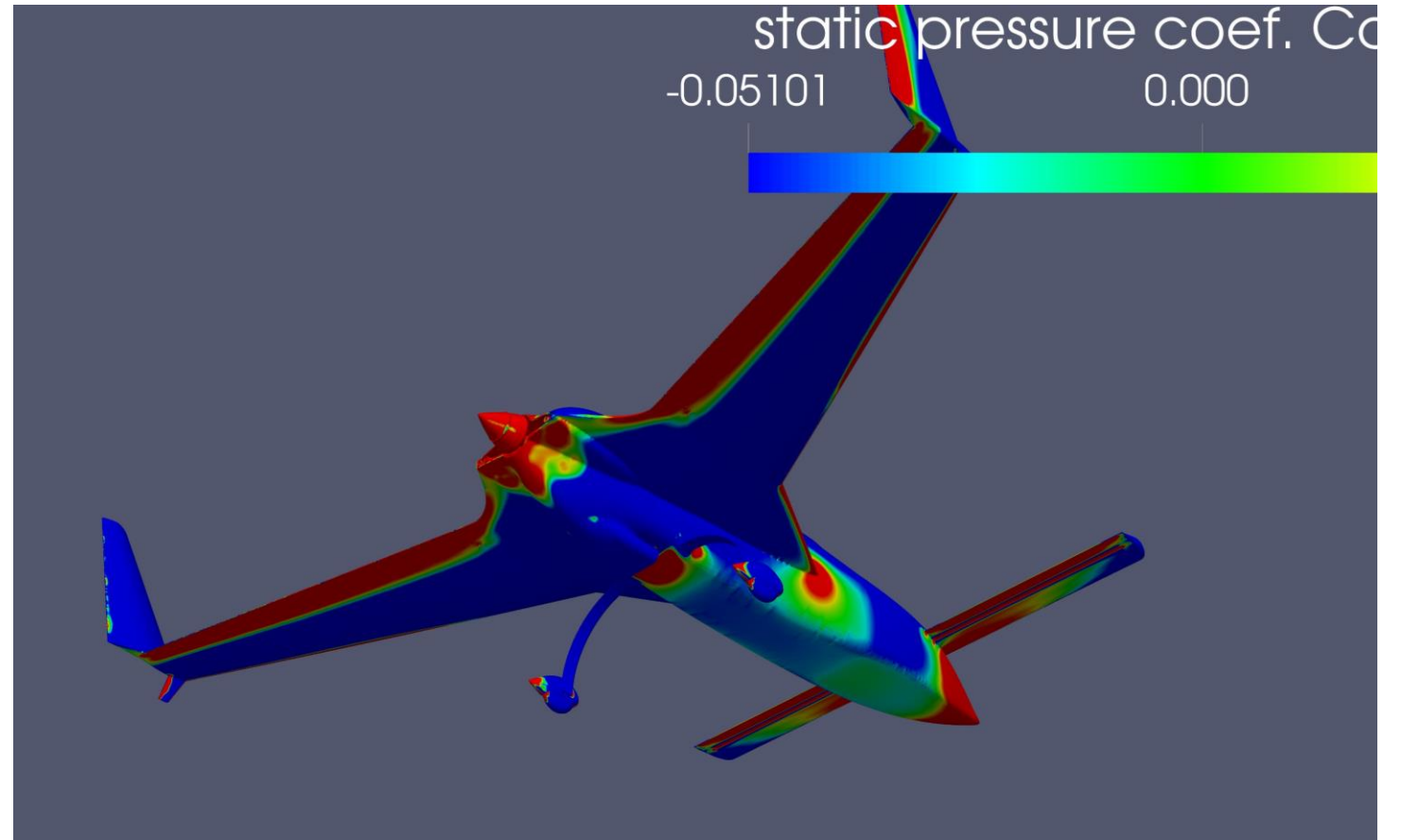
- **Copy/paste**
 - geometry
 - model
- **Design comparison**
 - 3D view linked
 - 2 à 4 screens
 - Synchronised
- **Curves plot**
 - Full plane
 - Parts
 - All physical data
- **Exports**
 - Velocity, pressure on one point
 - Hinge Moments
 - Part force
 - Spanwise Loading



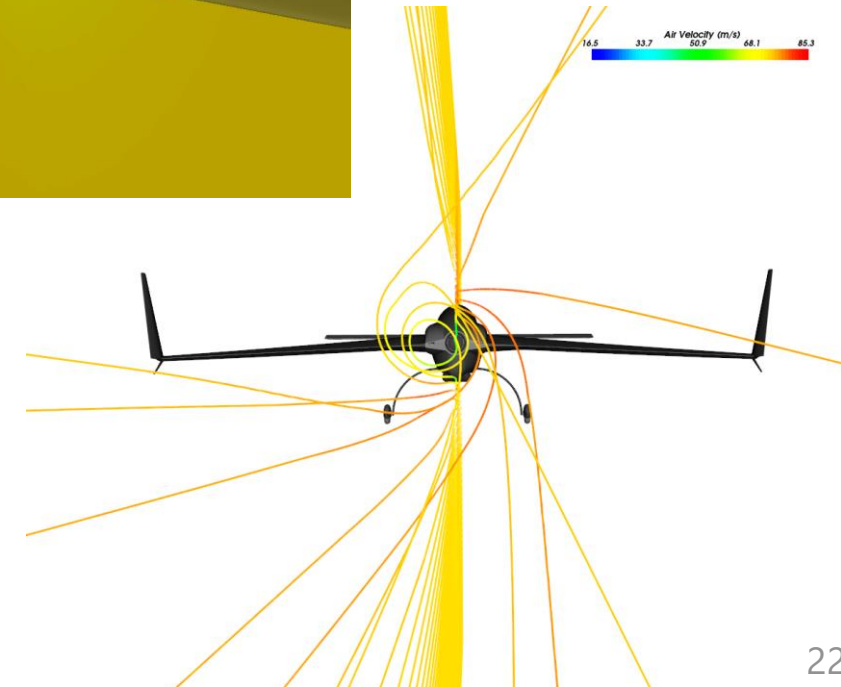
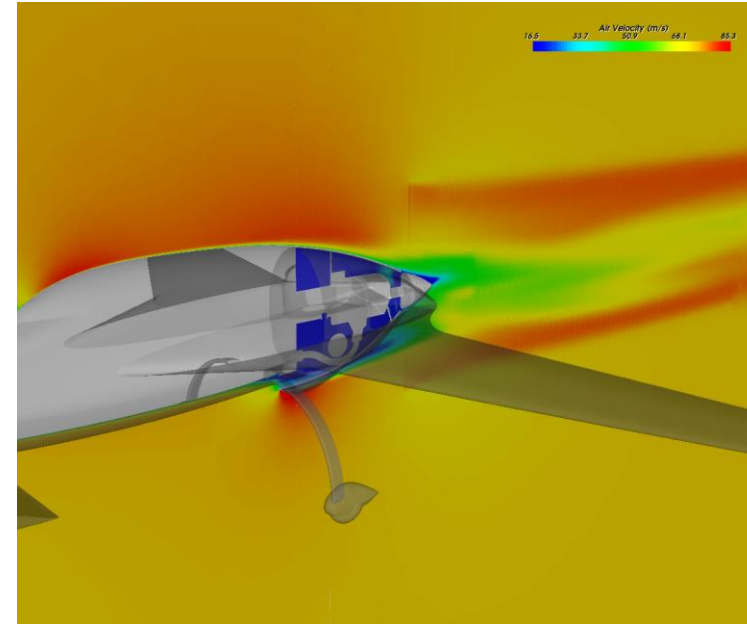
- **Automated pictures**
 - CAD
 - Mesh
 - Results
- **Configuration management**
 - Control surface angle
 - Landing gear
- **Power Analysis**
 - Vmax
 - Climb ratio
 - Climb angle
 - etc
- **Propellers**
 - Power analysis
 - RANS (rotordisk)
 - Fixed pitch, fixed velocity



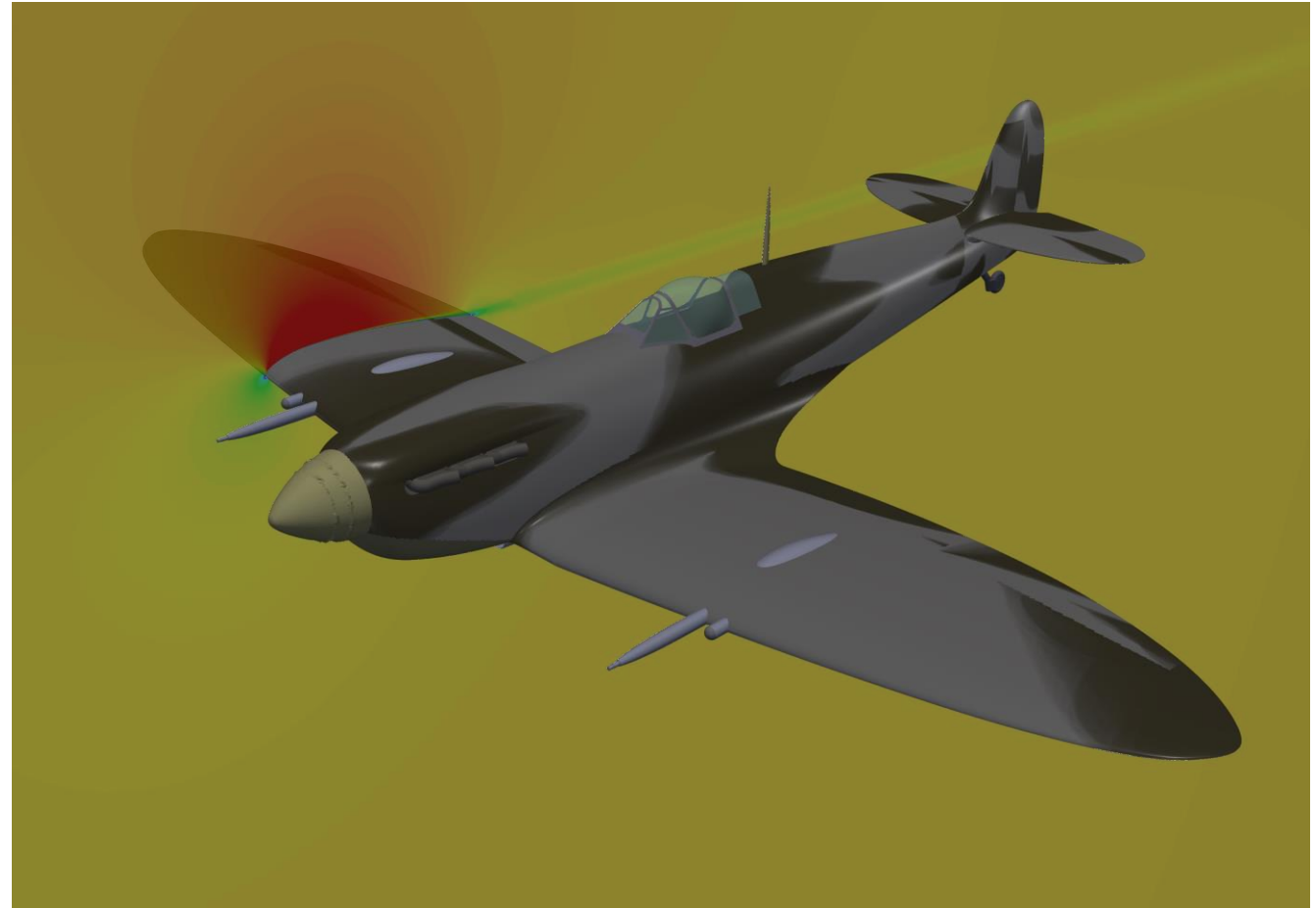
- **Custom post process**
 - Based on CS23
 - Static port position
- **Heat exchanger model**
 - Engine cooling
- **Skin friction**
- **Flow report**
 - velocity
 - pressure
 - Mass flow rate



- **Power model**
 - Engine + propeller
- **Consumption model**
 - Piston engine
 - Electric
 - hybrid
- **Mission profile**
 - Consumption Analysis
 - Capacity to realize a mission
- **Phug matrix**
 - Designs classification
 - Design selection



- **Queue**
 - Calculation management
- **Help**
 - manual
 - ?
- **Tutorials**
 - For each type of simulation
 - Auto training (no extra cost)
- **Correlation**
 - 2D Profils
 - Varieze...



Discover more about AOA



- **Ask for a demonstration**
 - Online
- **Meet us at Friedrichshafen**
 - Aero Friedrichshafen show
 - 17 au 20 april
 - Hall B2
 - Demo on the booth
- **Test the Bronze version**
 - Download and install the software
 - Ask for a free license
- **Ask for a demo license (companies)**
 - 1month (Platinum version)
 - free



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