Presentation of Edge

Peter Eliasson, Olivier Amoignon

FOI, Swedish Defence Research Agency
Computational Physics Department
SE-164 90 Stockholm, Sweden

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Presentation overview

Peter Eliasson

- Introduction
- Edge community
- Examples of Edge related research
- Work with Edge in CESAR Task 1.1

Olivier Amoignon

- Shape optimization in Edge
- Work with Edge in CESAR Task 1.2

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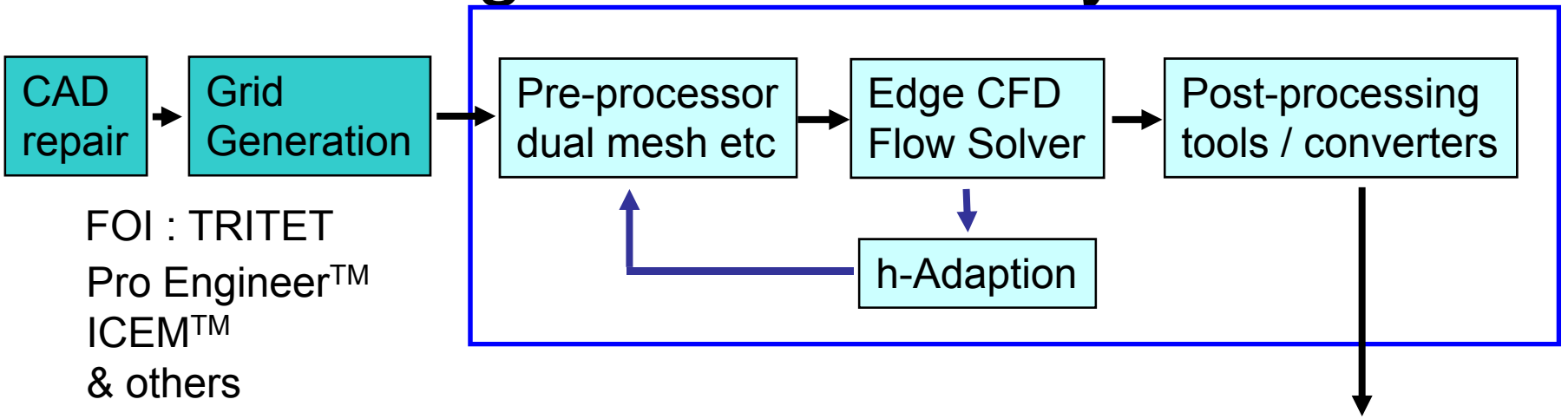
Edge Flow Solver

Edge – flow solver for unstructured grids

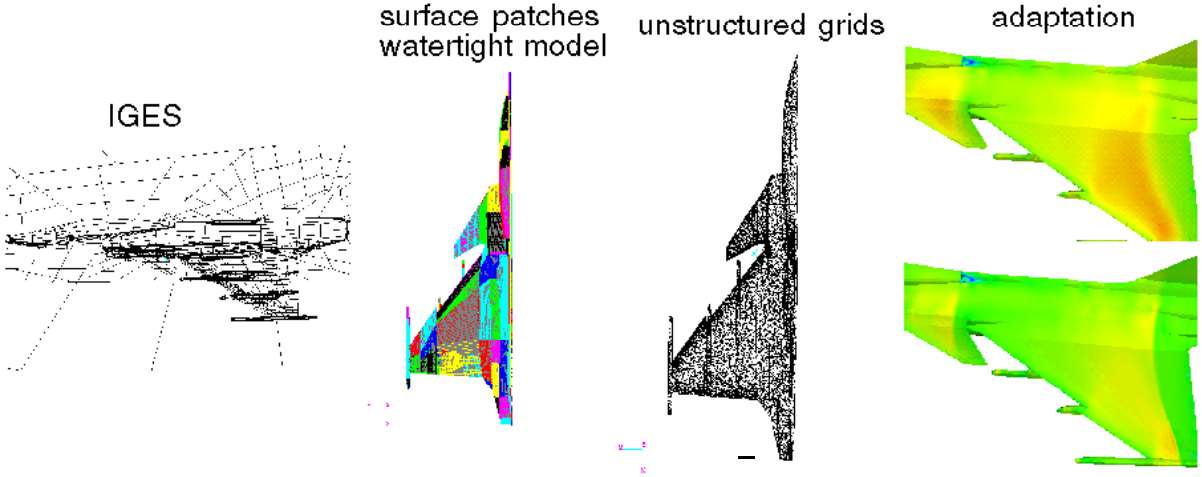
- Motivation
  - Edge developed since 1997
  - Grid generation for structured grids a bottle neck
  - Saabs need for an efficient scalable flow solver for realistic applications
  - Replaces older structured/unstructured solvers

- Flow solver details
  - Solves the compressible Euler and NS equations
  - Node-centered finite-volume solver for unstructured grids
  - Edge-based dual grid formulation
  - Explicit time-marching with multigrid acceleration
  - Steady-state and unsteady through dual time stepping

Edge : main CFD system



FOI : TRITET
Pro Engineer™
ICEM™
& others



Visualisation & Analysis

EnSight™
Fieldview™
Matlab™
ParaView.org

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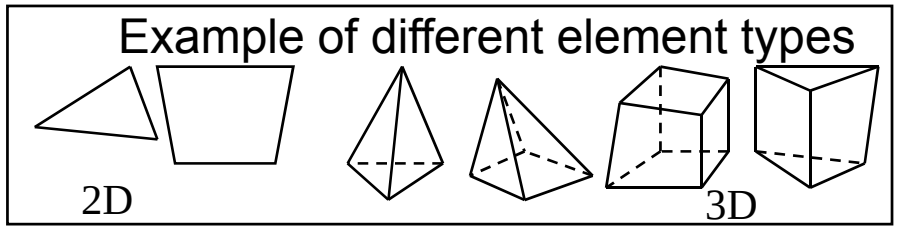
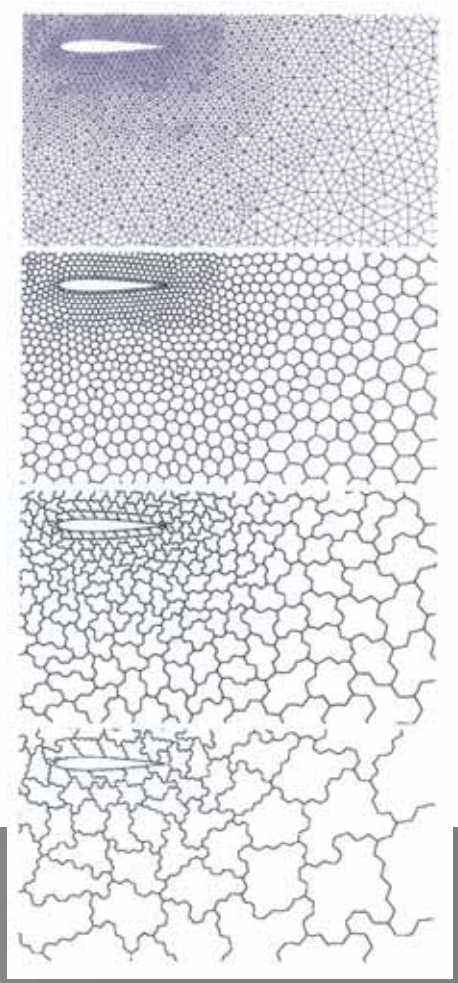
Current major Edge functionality



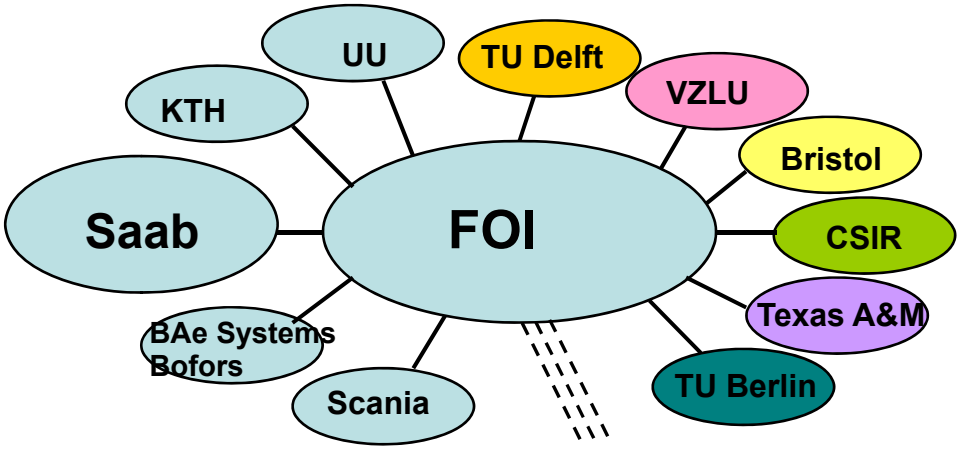
- Different element types accepted
- Ideal gas, thermally perfect gases
  - Mixing
- Many turbulence models
  - RANS, hybrid RANS/LES, LES
- Relative frame of reference
  - Multi region, Rotor-stator
- Aeroelastic capability
  - Local linear modal structural solver
- Adjoint solver part of flow solver
  - Shape optimization
- Models for flow control in solver
  - Models for VG's
- Low speed preconditioning



MULTIGRID

Edge Community

- Developed in collaboration with selected external partners
- Open source under license agreement
- Edge home page: **http://www.edge.foi.se/**



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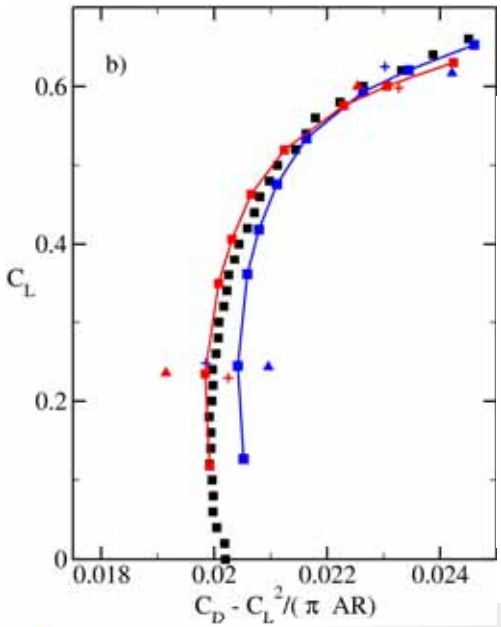
Ongoing Edge related development

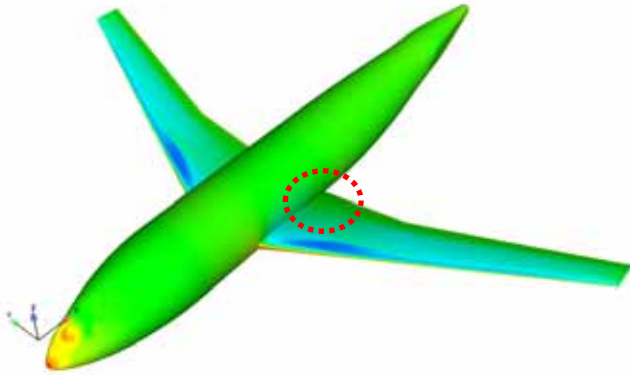
- Turbulence modeling
- Store separation
- Aeroelastic capability
  - Coupling to external structural solvers
- Transition prediction
- Models for flow control in solver
  - Models for vortex generators, jets, synthetic jets …
- Aerodynamic shape optimization
  - Extension to viscous flow
  - Coupling with aeroelastics, transition prediction …
- Enhanced efficiency
  - Improved numerical methods for implicit time integration
- Enhanced accuracy
  - Boundary conditions

Validation through drag prediction with Edge

- FOI participated in DPW2 and DPW3
- Computations on unstructured grids up to 20 M nodes
- Edge ranked as one of the better unstructured codes
- AIAA 2007-897, Journal of Aircraft 2008



DLR-F6 Wing-Body config.



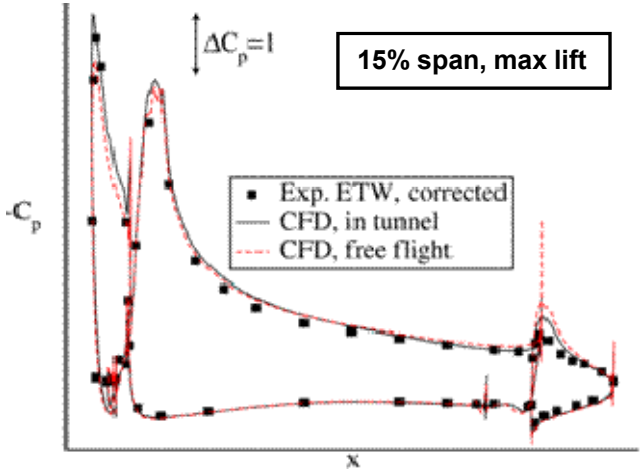
WB

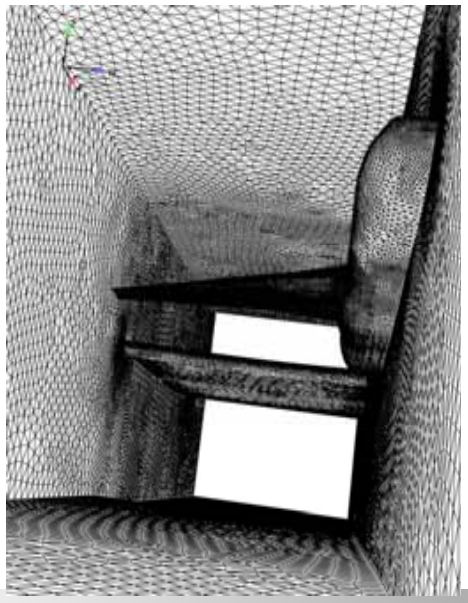
WB-FX2B

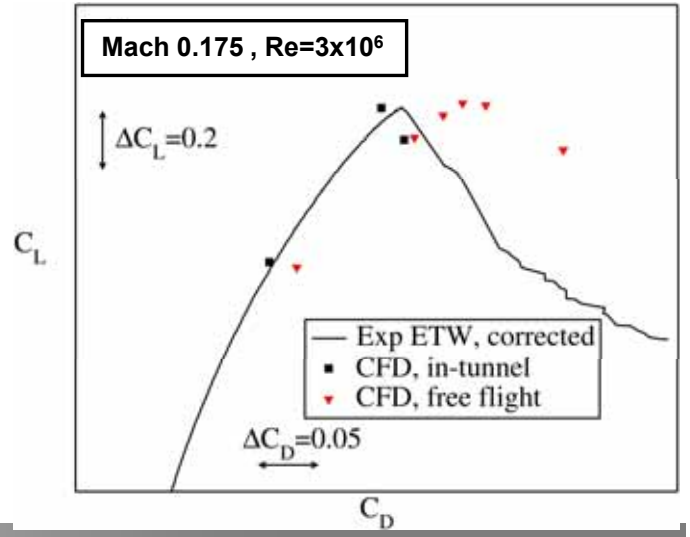
Investigation of W/T Mounting Effects

EUROLIFT II
European High Lift Program

- Free flight calculations compared to calculations inside ETW wind tunnel
  - Take-off three element configuration
- Very good experimental agreement inside wind tunnel
  - Free flight calculations over predict drag (~10%)
  - Maximum lift predicted to late
  - Similar lift break down but ~1° later in free flight
- Installation causes cross flow velocity in plane of







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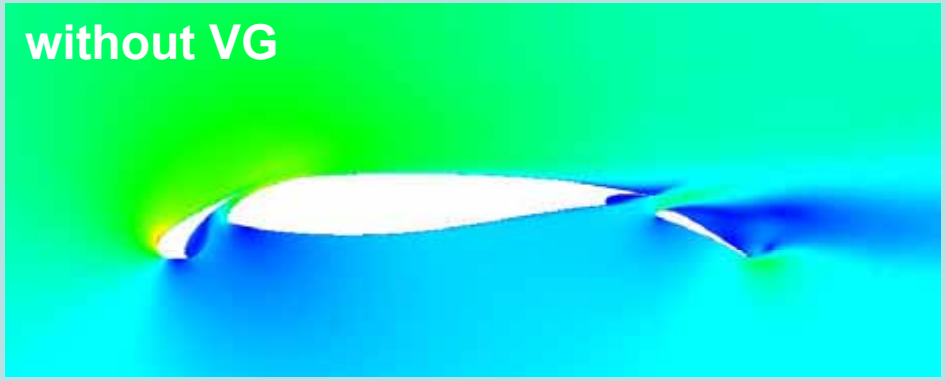
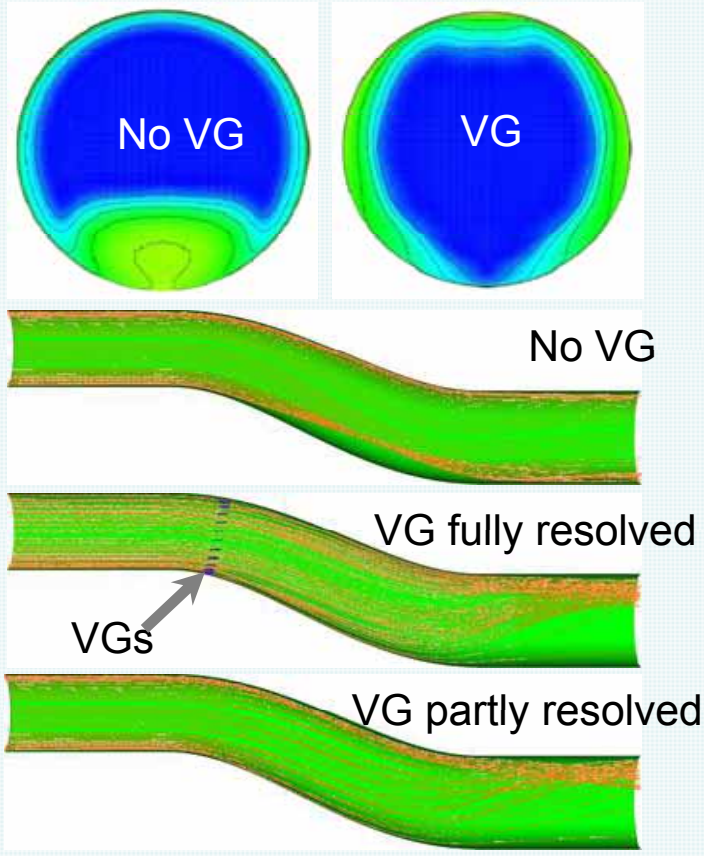
Flow Separation Control

Example: Applications of VG

- High Lift



- S-duct



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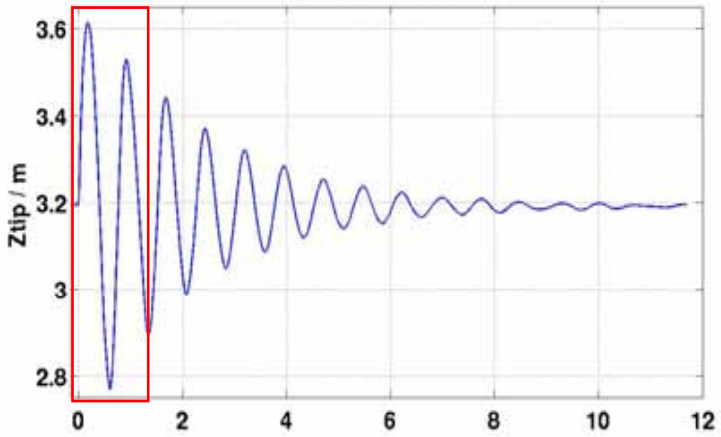
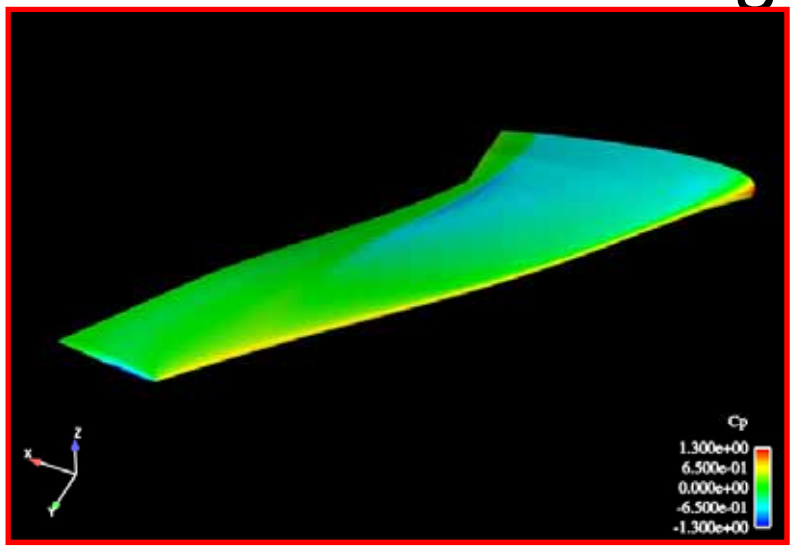
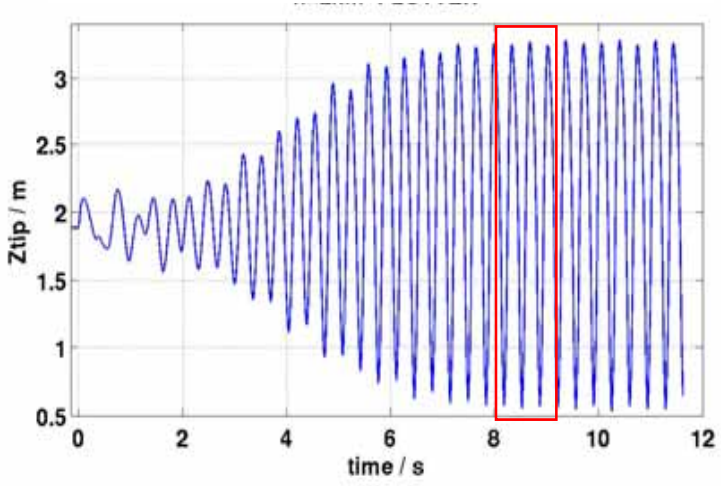
Aeroelastic Simulation : MDO-wing

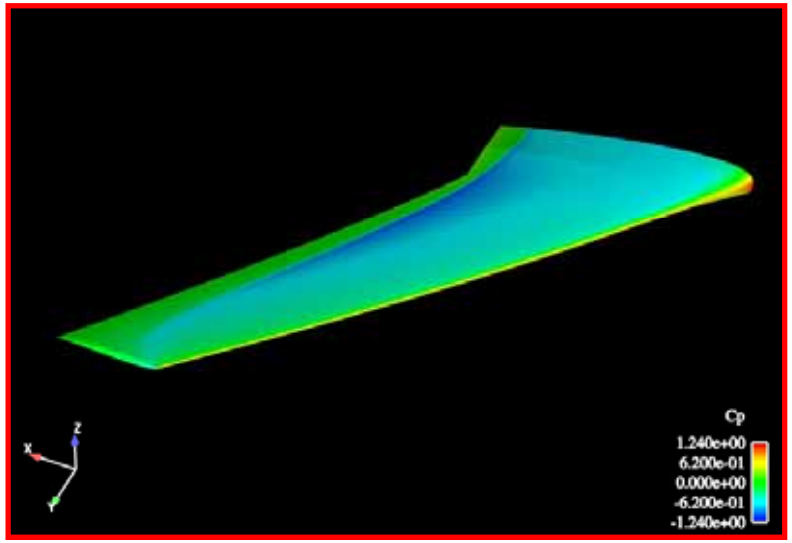
h=7km VIDEO loop 0-1.5s





h=2km VIDEO loop 8-9s





True-scale surface displacement

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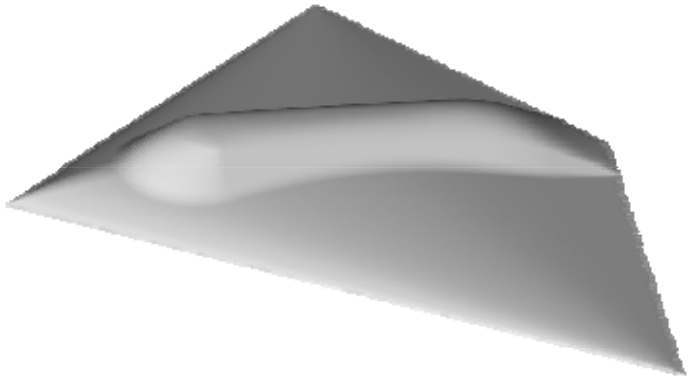
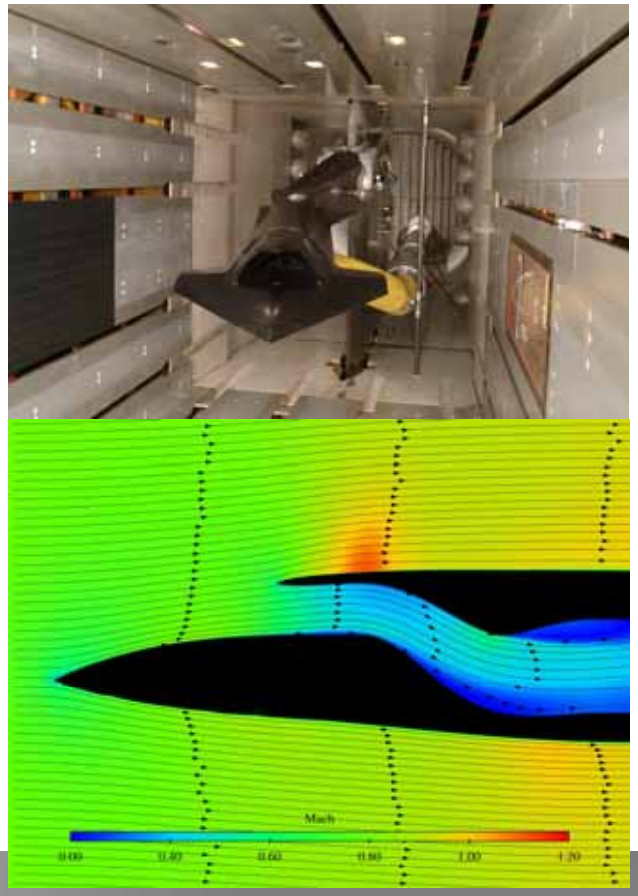
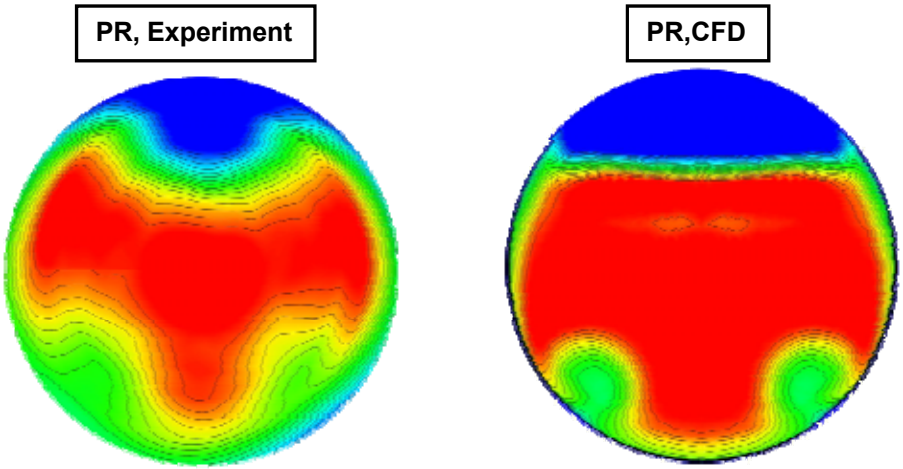
Inlet design and analysis

- Defence project on UAV inlet design and analysis
  - In collaboration with Volvo Aero
  - Engine and nozzle design by Volvo
- New inlet system designed
  - Calculations at model and full scale
  - Experimental verification at T1500
- CFD and experimental investigation
  - Mass flow target reached
  - Pressure recovery target reached
  - Good agreement between exp. and CFD







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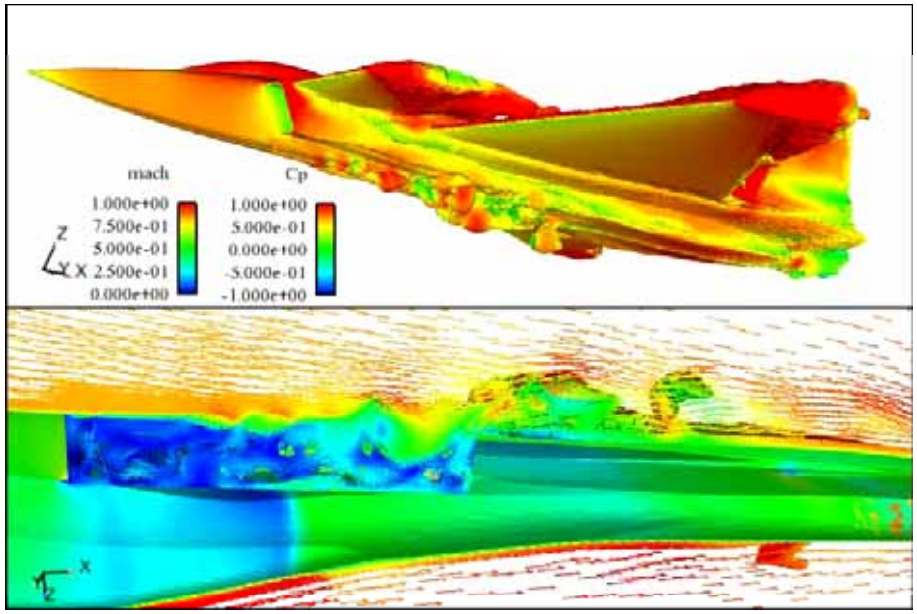
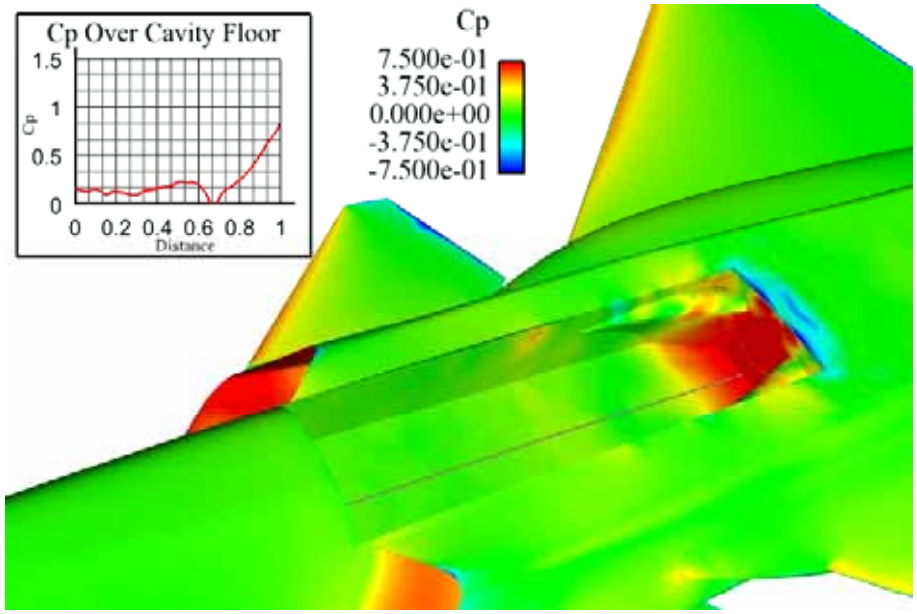
Advanced turbulence modelling, in-house model

Resolve Instantaneous vortex motions





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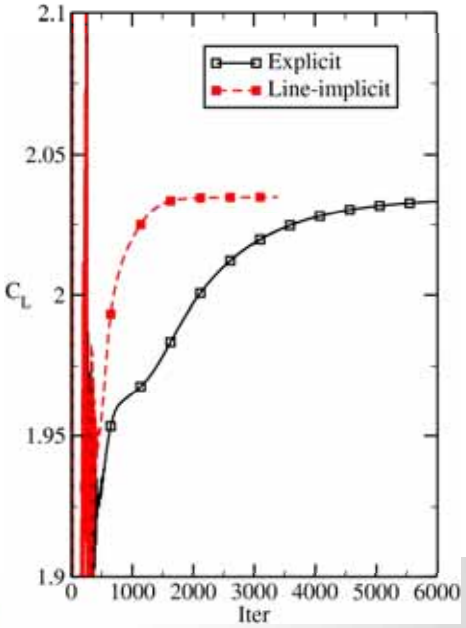
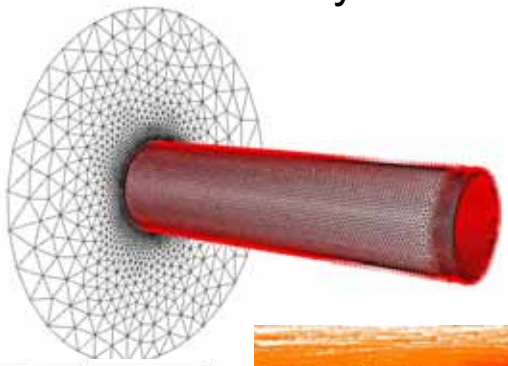
Convergence acceleration

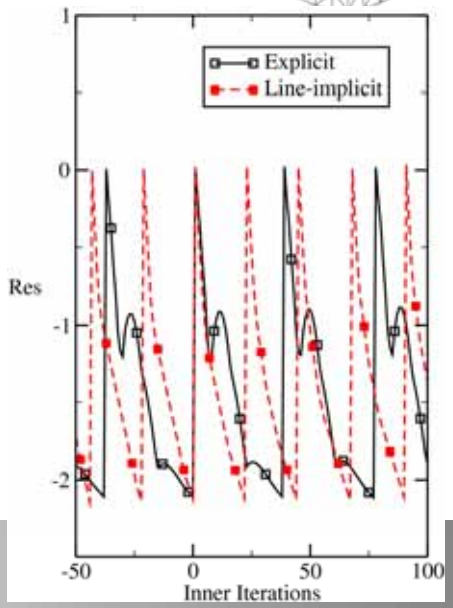
- Convergence acceleration with line-implicit time integration
  - AIAA 2009-163

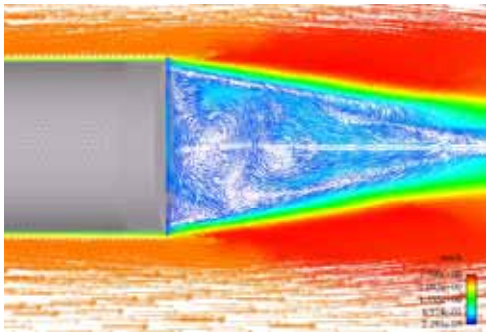
- 3D High lift case



- Supersonic unsteady base flow







CESAR

Task 1.1 FOI activities in High fidelity design tools

DoW

- ❑ Implementation of a propeller model in Edge

In addition

- ❑ Spatial accuracy investigation of Edge
- ❑ Weak boundary conditions

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Task 1.1 Propeller model

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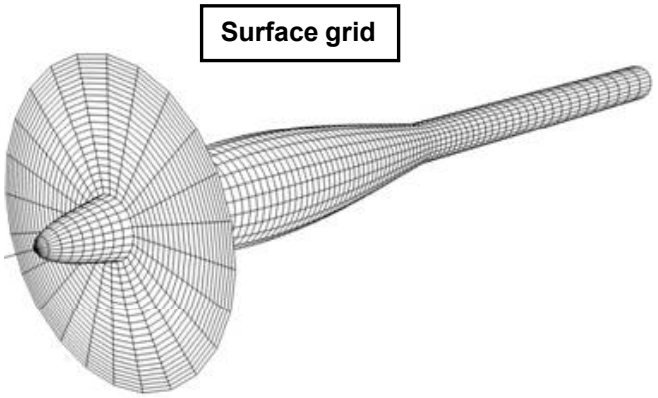
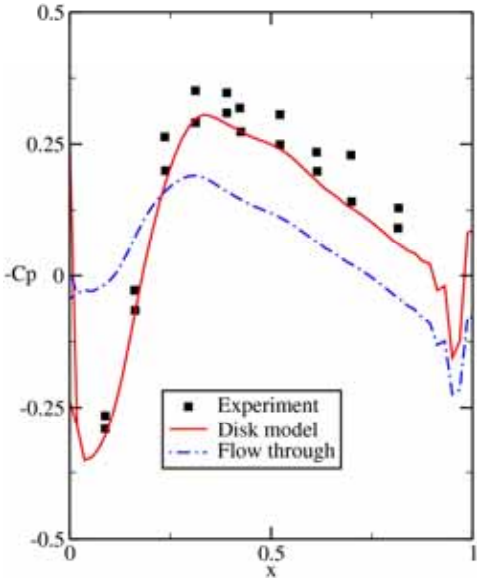
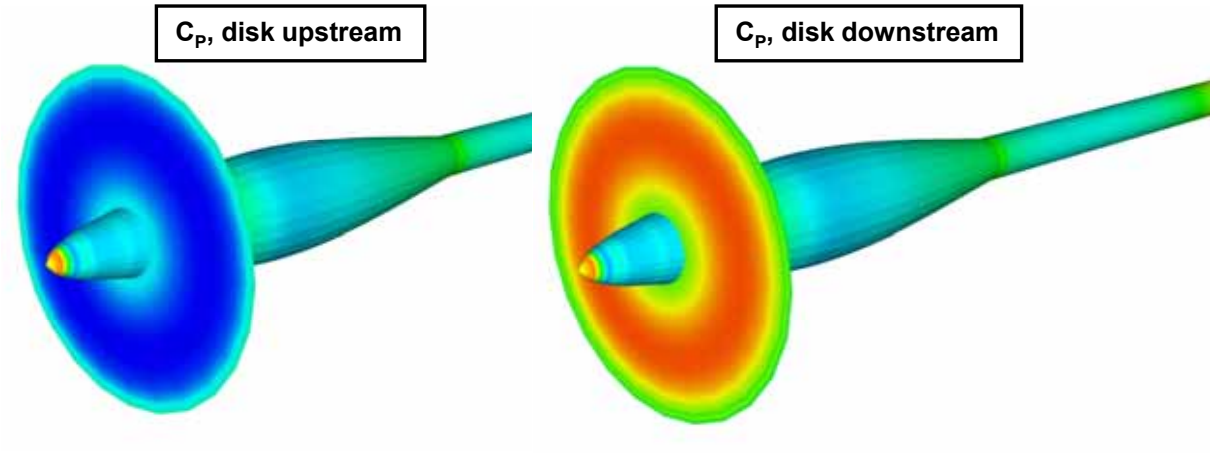
- Implementation of a propeller model in Edge
  - Actuator disk model
  - Introduces a volume force on the disk
  - Implementation using a boundary condition
- Validation on a spinner
  - M_∞=0.15
  - Comparison to experimental Cp on nacelle







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Task 1.1 Accuracy investigation

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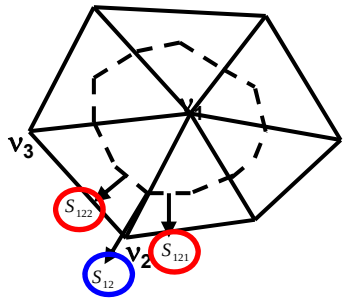
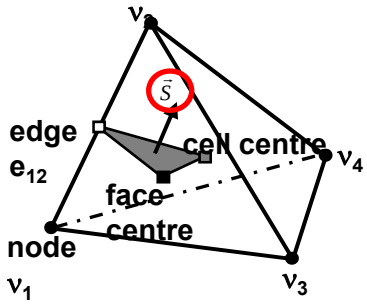
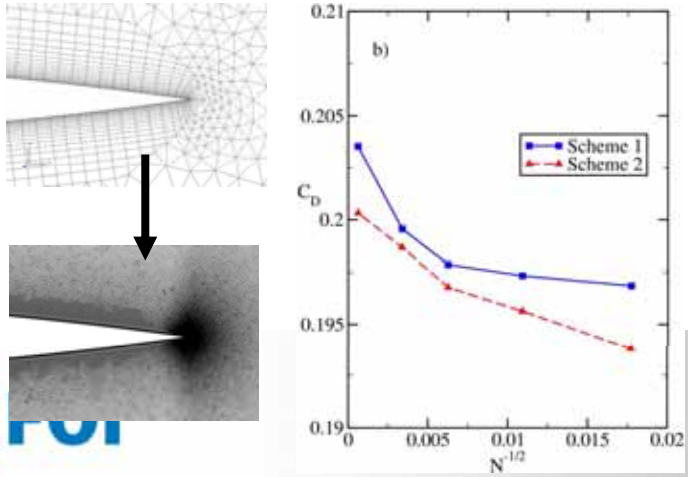
- Investigation on an alternative discretization technique in Edge
  - Flux calculations on sum of control surfaces (standard, Scheme 1)
  - Flux calculation on each sub control surface (new, Scheme 2)
  - Scheme 2 potentially more accurate
  - Scheme 2 more expensive though (~5 times)
- Investigation
  - Grid convergence studies in 2D/3D
- Conclusions
  - Small improvement in 2D, low Re
  - Accurate results in 3D with both approaches
  - Additional cost not motivated
- AIAA 2008-4153

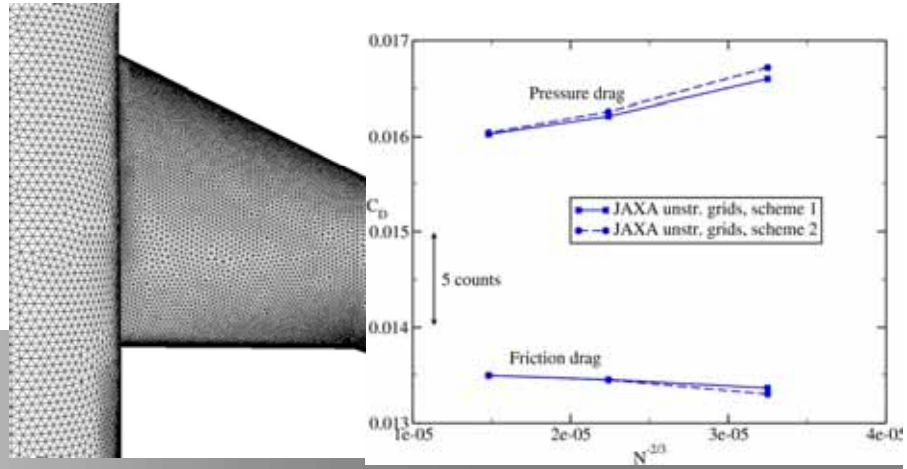




Grid convergence 2D, NACA0012



Grid convergence 3D, DPW



Task 1.1 Weak boundary conditions

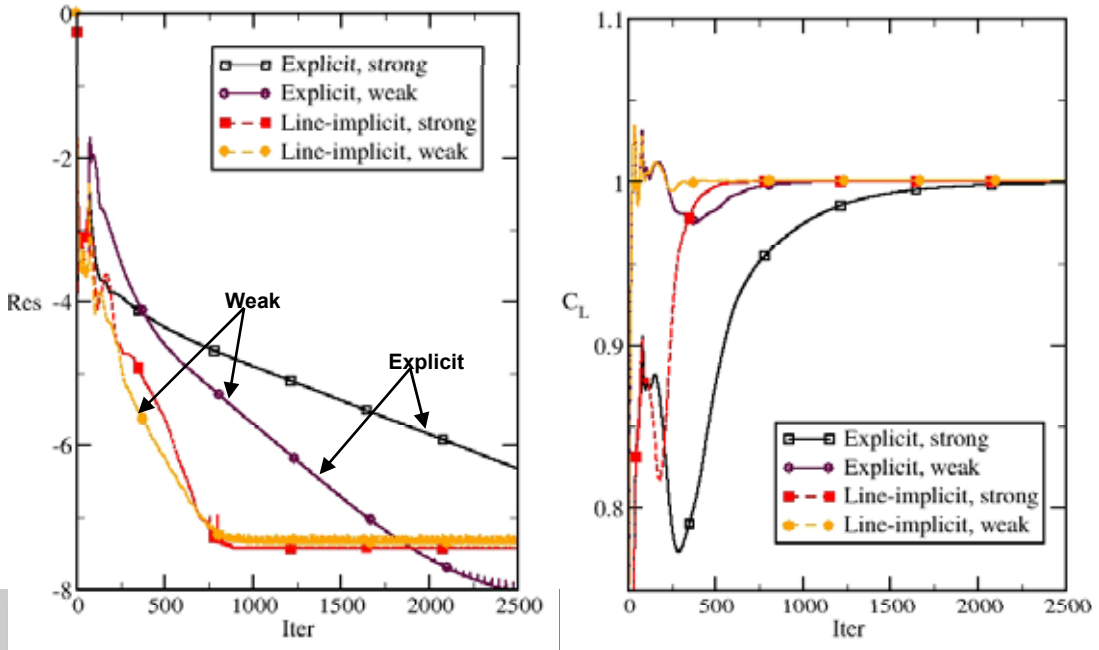
CESAR

- Boundary conditions in Edge
  - Weak bc's applied on most boundaries for all variables
  - Traditional: Strong wall boundary conditions ↔ fixed values
  - Applies to no-slip velocity, turb. wall values, isothermal temperature
- Investigation
  - Weak boundary conditions for all wall quantities
  - Analysis of spectra on model problem
  - Grid convergence studies
  - Realistic applications
- Abstract accepted for AIAA 2009

Convergence of lift for M6 wing
(ΔCL<0.1%CL)

	Explicit iter.	Line-implicit iter.
Strong bc	2600	550
Weak bc	1070	370

Convergence M6 wing



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CESAR

Wing design in CESAR

- Shape optimization with Edge
- Task 1.2 results
- FOI-CESAR-WS-Prague-2009-AESOP.ppt

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