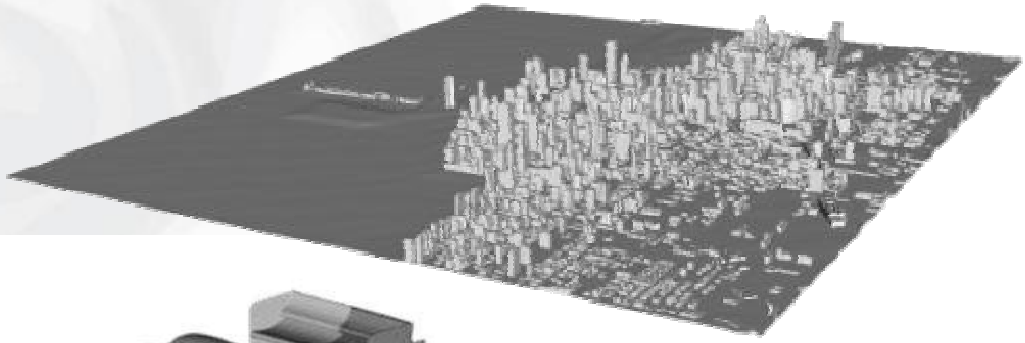
Open Source CFD in Practice

A path to industrial scale application



Prepared by: Dr E. De Villiers, ICON (UK)
Presented by: Dr K. Laakkonen, ICON (Finland)

NOTE: Some images have been removed from this presentation due to content distribution restrictions

Introduction to Icon

Technology • Process • Consulting

- Independent, Privately-owned Company Established 1992
  - Being independent, Icon can recommend the best technology from the commercial and open source community
- Principal Activity: Computational Fluids Dynamics (CFD)
  - Software/Methods development
  - Consultancy
  - Support and Training
- 45 employees - principal locations:
  UK (HQ), Germany, Greece, Spain

Introduction to Icon

Technology • Process • Consulting

- Icon has used Foam/OpenFOAM® for consultancy since 2001
- Icon support for OpenFOAM started in January 2005
  - First training provided 2006
- Icon services based on OpenFOAM
  - Consultancy
  - Software Development and Maintenance
  - Technical Support
  - Training: www.opensourcecfd.com/training
  - Icon are the organisers of the Open Source CFD International Conference: www.opensourcecfd.com/conference

Motivation

Technology • Process • Consulting

- Why Open Source?
  - Reducing total cost of ownership (TCO) of CFD process
  - Scalable, robust, long-term solutions
  - Cutting edge technology for improved accuracy
  - Customisability
- Since Icon are committed to providing the best solutions for customer requirements, this increasingly means Open Source software.

Approach

Technology • Process • Consulting

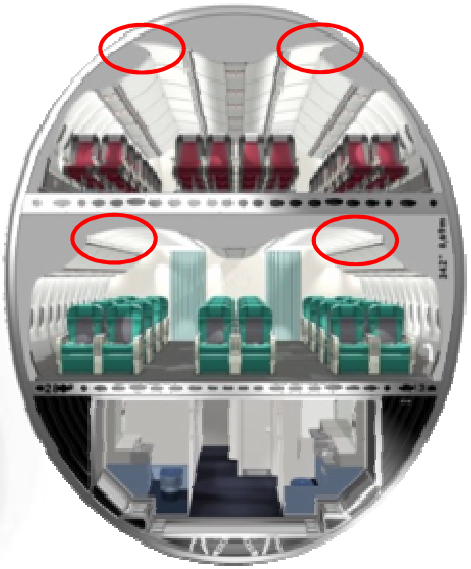
- Introducing Open Source CFD solutions in industry
  - Not only about new developments and customisation
  - Integration into efficient processes from CAD to reporting
  - Use the best tools for each component
  - Ensure robustness and reduce sources of error
  - Be receptive to the needs and culture of industry!

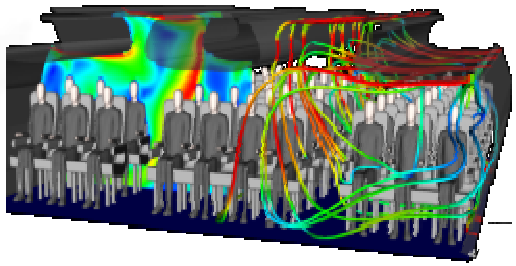
- Two examples of this approach to industrial solutions:
  - Airbus duct characterisation process
  - New developments for mesh generation

Example: Aircraft cabin air outlet duct

Technology • Process • Consulting

- October 2007 - the problem:
  - Characterise cabin air outlet duct flow
    - Pressure loss
    - Comfort factors – flow uniformity
    - Cabins - sensitive buoyancy dominated flows
    - Cabins - boundary layers





Standard cabin configuration (7 passenger rows)

Example: Aircraft cabin air outlet duct

Technology • Process • Consulting

- October 2007 - the problem:
  - Characterise cabin air outlet duct flow
  - 25 different uncleaned CAD geometries and 2D drawings
  - Strict 2.5 month time scale for delivery
    - Existing methods too slow and man-power intensive
    - Not enough licences for proprietary solvers

NOTE: Some images have been removed from this presentation due to content distribution restrictions

Example: Aircraft cabin air outlet duct

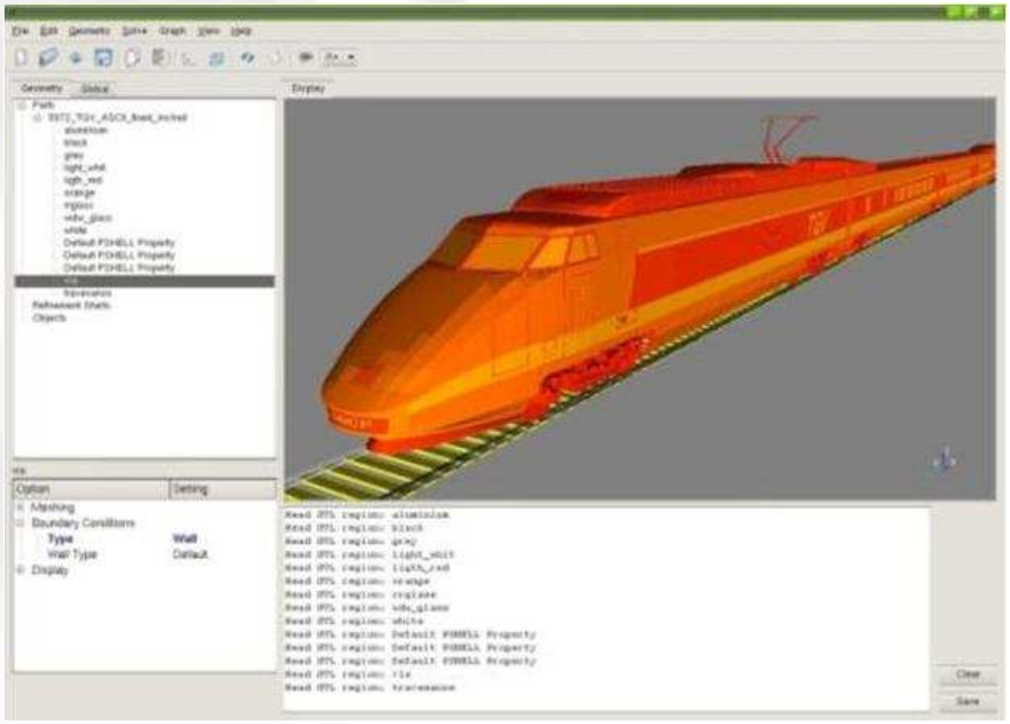
Technology • Process • Consulting

- The solution:
  - CATIA v5 for minimal CAD cleanup and preparation
    - Fast CAD creation and modification
  - FOAMpro GUI for case setup
    - Allows non-expert users intuitive access to applications
    - Reduces user input errors
  - Automated in-house mesh generator (developed by OpenCFD® and ICON)
    - Can mesh un-cleaned CAD
    - Reduced CAD cleanup time by 75%
  - OPENFOAM steady state flow solver
    - Excellent scalability
  - Standardised post-processing

Example: Aircraft cabin air outlet duct

Technology • Process • Consulting

- FOAMpro GUI:
  - GUI for setting up meshing, boundaries, initial conditions, schemes, numerical controls and other settings
  - Current focus incompressible RAS and LES simulations
  - Linux & Windows supported
  - Batch execution capability



Example: Aircraft cabin air outlet duct

Technology • Process • Consulting

- Automatic mesh generation :
  - Features:
    - Fully parallel (+ load balancing)
    - Surface layers
    - Error free – zero manual correction

NOTE: Some images have been removed from this presentation due to content distribution restrictions

Example: Aircraft cabin air outlet duct

Technology • Process • Consulting

- Results :
  - 25 meshes generated with 0 errors
  - Approx. 3M cells each

→ Less than 5 man hrs / case

NOTE: Some images have been removed from this presentation due to content distribution restrictions

Example: Aircraft cabin air outlet duct

Technology • Process • Consulting

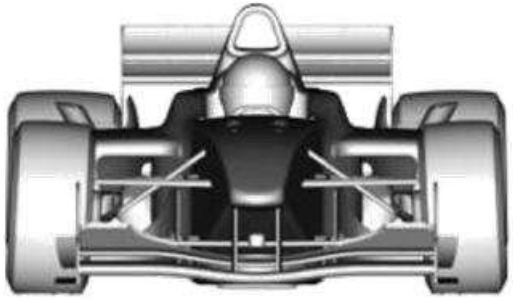
- Results :
  - 27 baseline cases + modeFRONTIER® based optimisations
  - All simulations completed inside deadline (2.5 months)
  - 64 core cluster, 1 engineer
- Comprehensive characterisation of duct design achieved

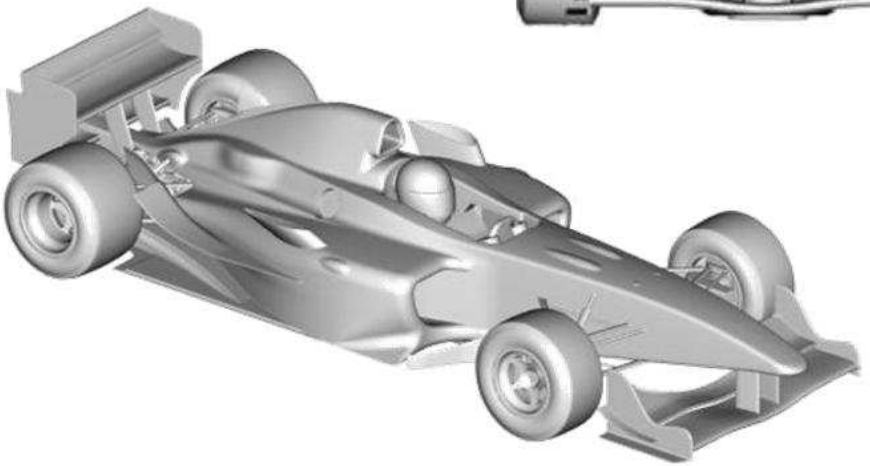
NOTE: Some images have been removed from this presentation due to content distribution restrictions

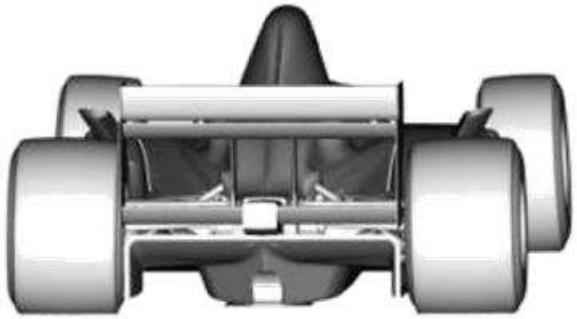
Lola 0651 Formula Nippon car

Technology • Process • Consulting

- Process development for racing vehicle aerodynamics
  - includes mesh generation
  - validate models and numerics
  - RAS steady state
- Showcase for project driven feature addition





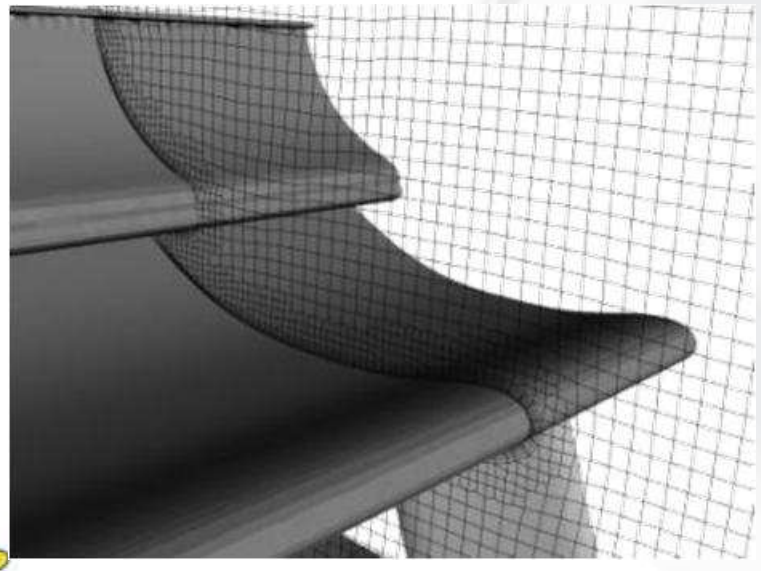


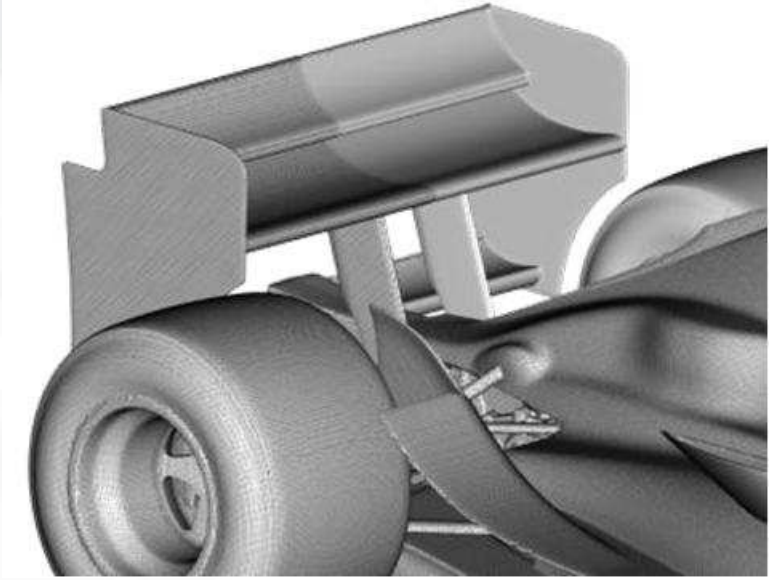
Courtesy of:

Lola 0651 Formula Nippon car

Technology • Process • Consulting

- Improved automatic mesh generator
  - Feature lines
  - Better layer coverage and quality
  - Cell quality improvement

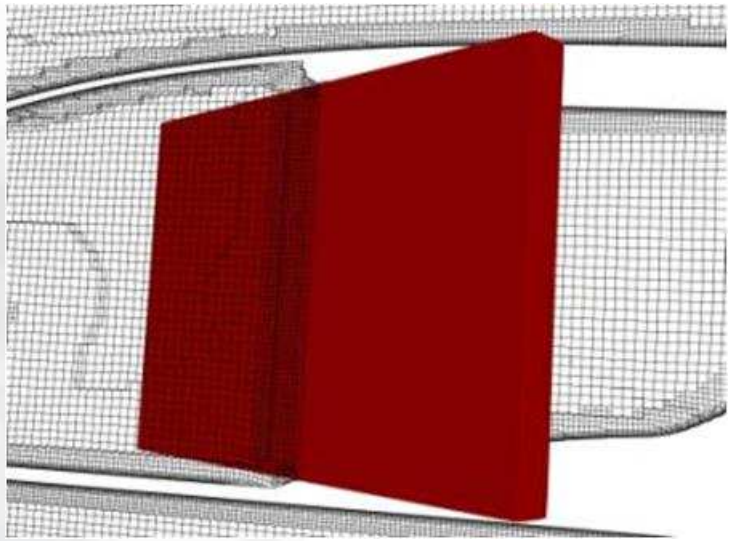


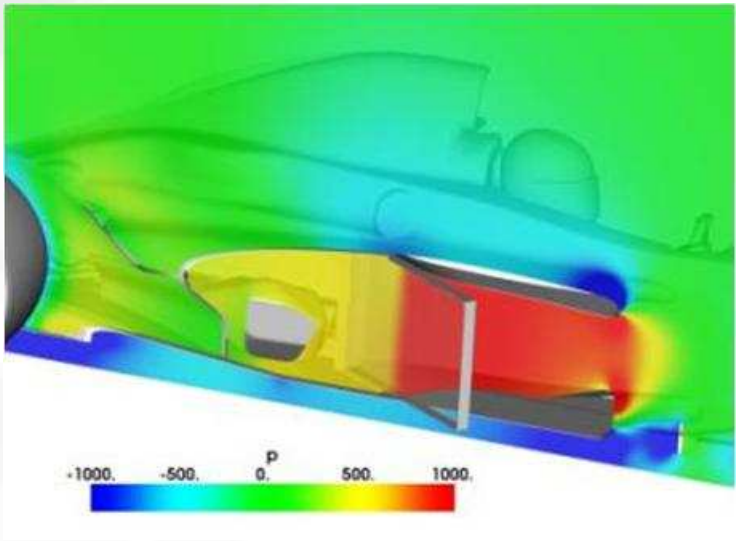


Lola 0651 Formula Nippon car

Technology • Process • Consulting

- Further additions:
  - Zonal meshing (with OpenCFD)
  - Porous media

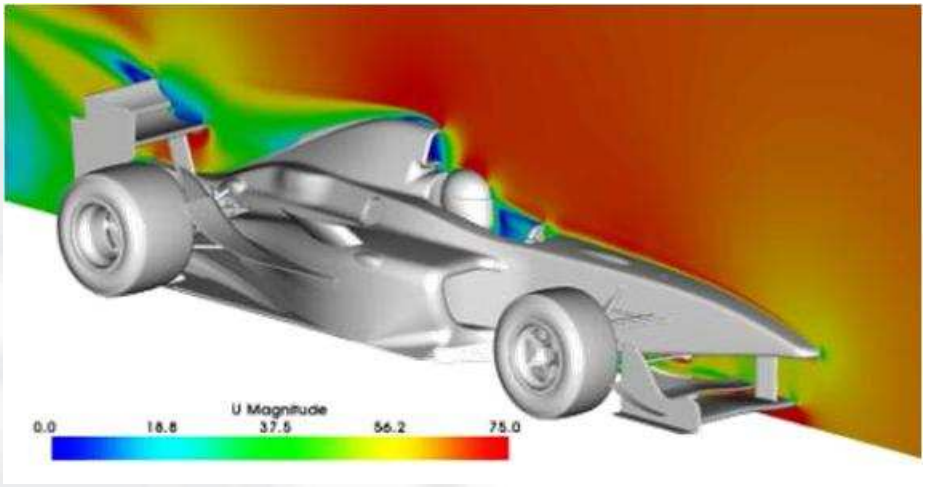


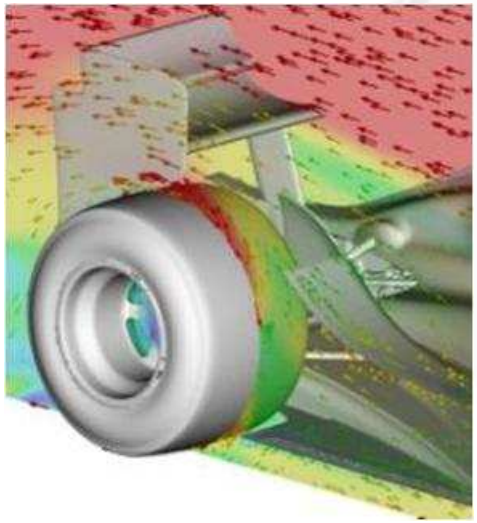


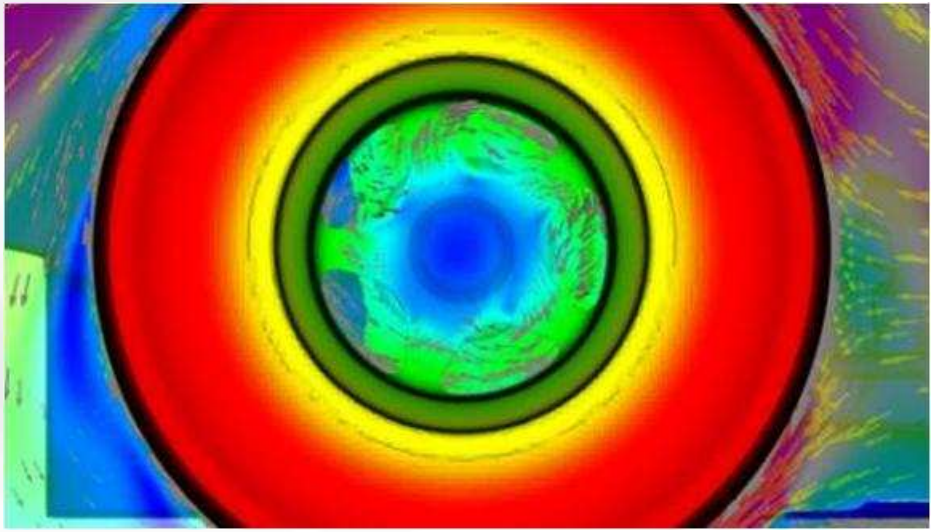
Lola 0651 Formula Nippon car

Technology • Process • Consulting

- Further additions:
  - MRF support
  - Solver integration





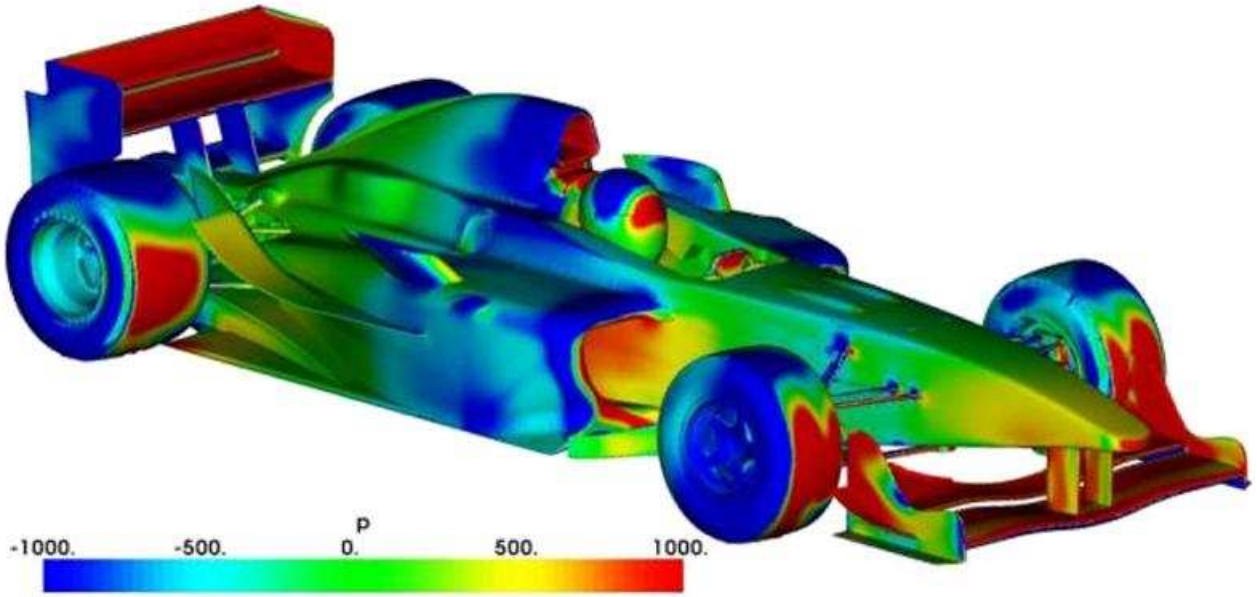


Lola 0651 Formula Nippon car

Technology • Process • Consulting

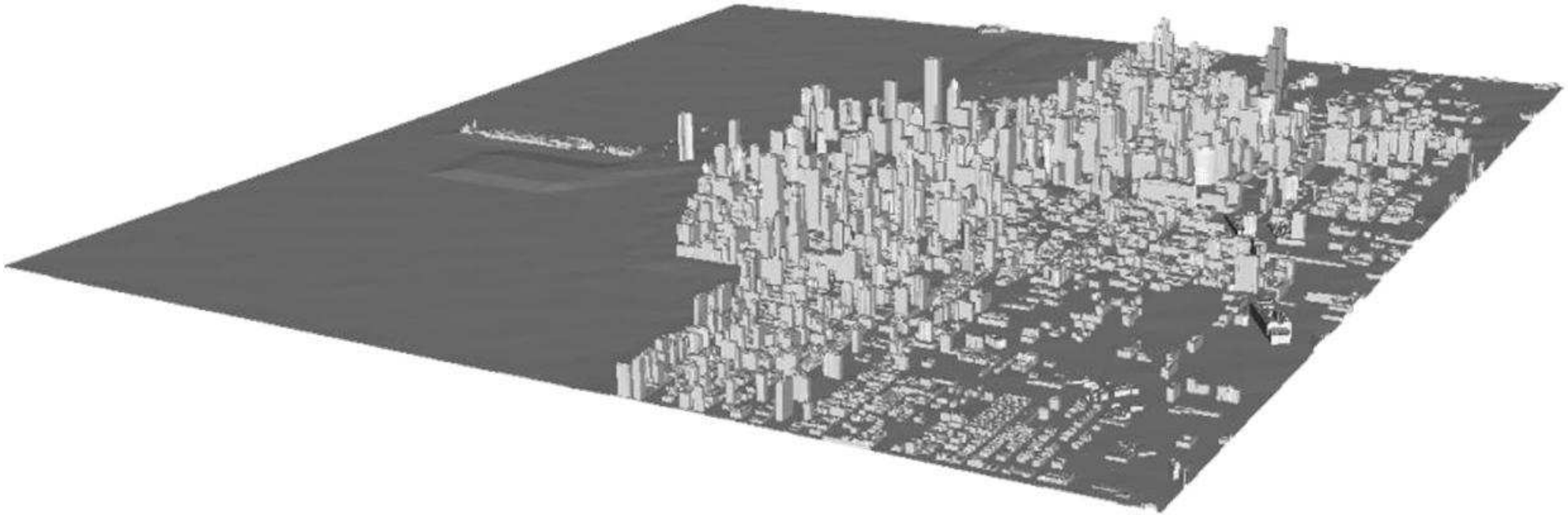
- Initial results
  - Lift 2985.34N within 10% of current best practice methods
  - Drag 1228.41N within 15%

- Mesh, models and numerical setup still work in progress



Chicago

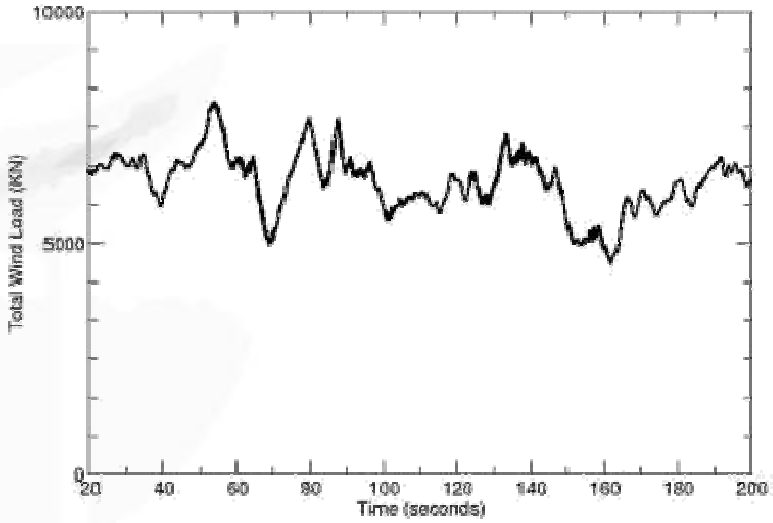
Technology • Process • Consulting



Chicago

Technology • Process • Consulting

- Proof of concept simulation for built environment
  - Unsteady wind loading on Sears Tower
  - Wind speed: NE 60 mph
- Solution:
  - Automatic mesher (~30M cells)
  - DES (oodles) 3 min 20 s simulation time



The road ahead

Technology • Process • Consulting

- ICON FOAMpro Support Service
  - User Support, User Interface, Industrial Applications
  - Publicly available in 2009
- Broadening of FOAMpro GUI feature set
  - Compressible & multiphase
  - More boundary conditions, models, etc.
  - Monitoring capabilities
- Further improvement to automatic mesh generator
  - Robustness/efficiency
  - Greater automation (less CAD work)
- Productivity tools
  - Automated post-processing

CATIA v5 is a registered trademark of Dassault Systemes S.A.
modeFRONTIER is a registered trademark of ESTECO SRL
OPENFOAM is a registered trademark of OpenCFD Ltd.
OpenCFD is a registered trademark of OpenCFD Ltd.

www.iconCFD.com