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PHOENICS

An Overview



Overview

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- This presentation is intended to be a general overview of PHOENICS, its applications, and how to use it.

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PHOENICS Overview

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- PHOENICS is a general-purpose CFD code
- The name PHOENICS is an acronym standing for:

P arabolic
H yperbolic
O r
E lliptic
N umerical
I ntegration
C ode
S eries



PHOENICS Overview

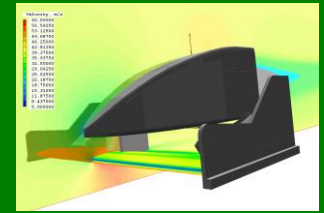
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- PHOENICS is based on the finite volume method.
- Domain is discretized into a finite set of control volumes or cells.
- General conservation (transport) equations for mass, momentum, energy, etc. – inflows and outflows in each cell must balance.
- Values of pressure, three velocity components, temperature etc in all the cells are computed by an iterative procedure.
- The distributions of these variables can then be displayed graphically.



Main Features of PHOENICS



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- Cartesian, Polar and Body-Fitted Coordinates
- Cut-cell technique for complex geometry
- Conjugate Heat Transfer
- Single or Multi-Phase Flow
- Particle Tracking
- Chemical reaction
- Radiation
- Non-Newtonian Flow
- Choice of equation solvers and differencing schemes
- “InForm” user programmability
- Automatic convergence control



Main Features of PHOENICS

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PHOENICS predicts quantitatively:-

- how fluids (air, water, steam, oil, etc) flow in and around:
 - engines,
 - process equipment,
 - buildings,
 - lakes, river and oceans,
 - and so on;
- the associated changes of chemical and physical composition



PHOENICS Structure

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PHOENICS consists of several modules:

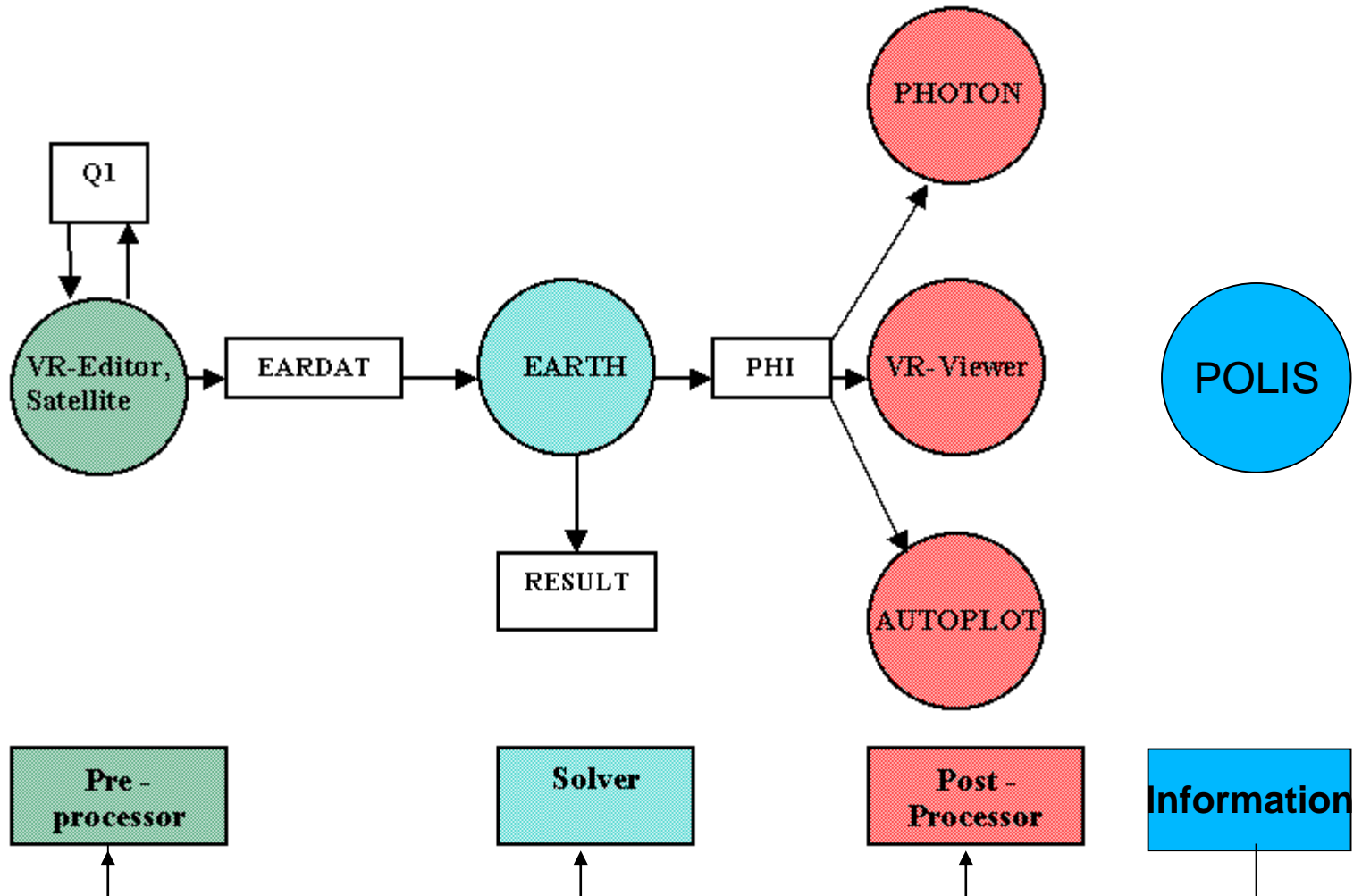
- Pre-processor for setting up problems,
- Solver for solving the problem,
- Post-processor for visualising results; and
- POLIS for providing information.



PHOENICS Structure

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How the model is defined

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Problem definition normally involves making statements about:

- **geometry**, ie shapes, sizes and positions of objects and intervening spaces;
- **grid**, ie the manner and fineness of the sub-division of space and time;
- **processes**, for example:- whether the heat transfer is to be calculated; whether materials are inert or reactive; whether turbulence is to be simulated and if so by what model



How the model is defined

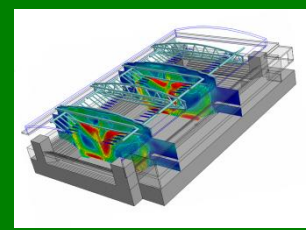
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- **materials**, i.e. thermodynamic, transport and other properties of the fluids and solids involved;
- **environmental or boundary conditions**; and
- **numerical parameters** (i.e. non-physical) affecting the speed, accuracy and economy of the simulation.

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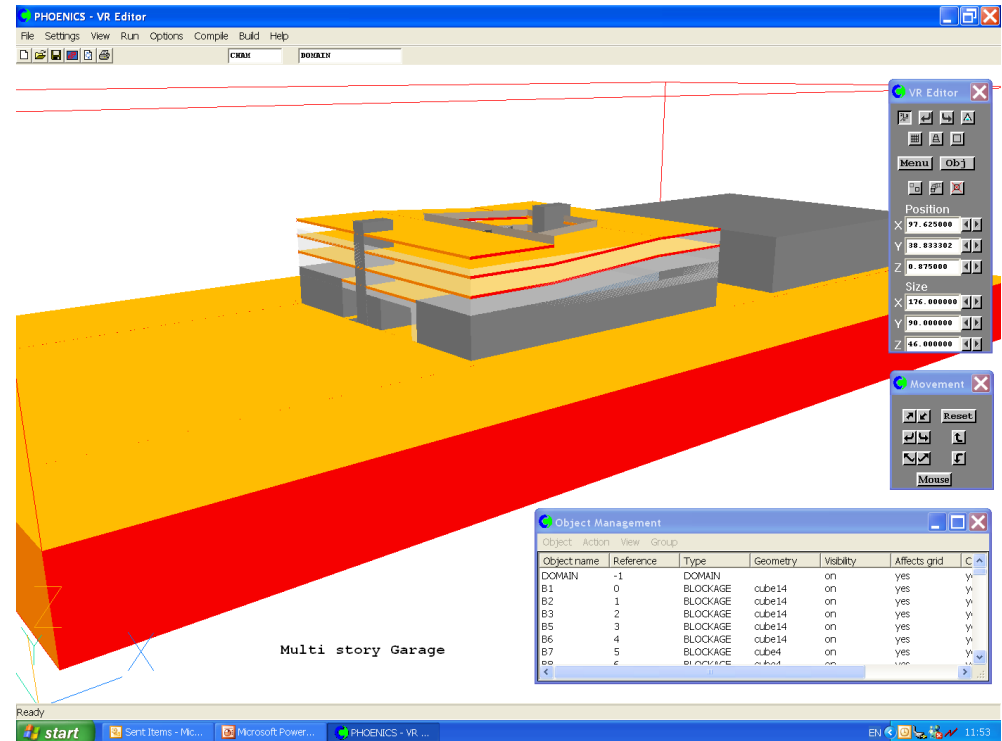
The “Virtual-Reality” Interface



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Model setup – VR Editor

- The model is defined as a set of “objects”.
- Clicking on an object brings a dialogue box onto the screen.
- This enables the information about the object to be edited.

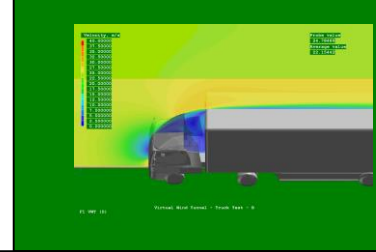


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The Virtual-Reality Interface

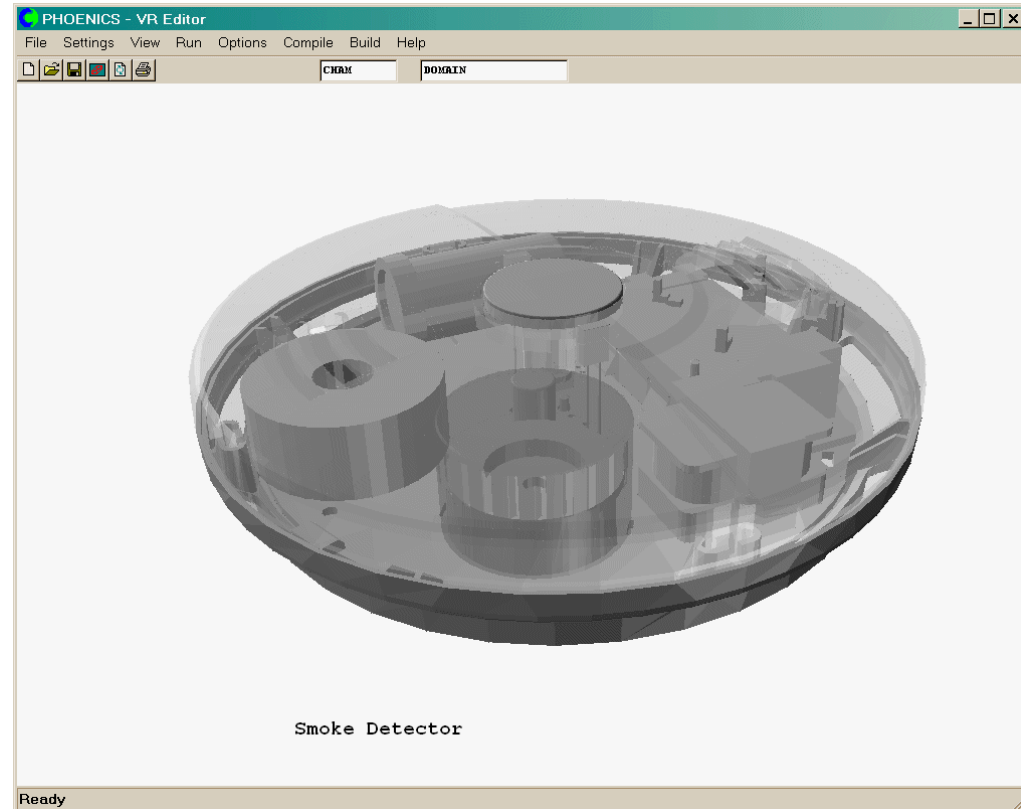
Import a CAD file



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Model setup – VR Editor

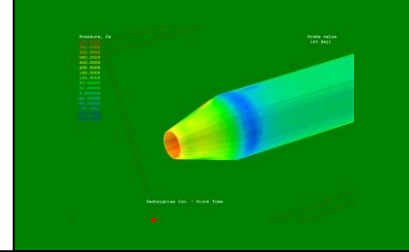
- The object geometry can be taken from a library of shapes, or loaded from a CAD file.
- CAD geometry formats include STL, DXF, 3DS and many others.



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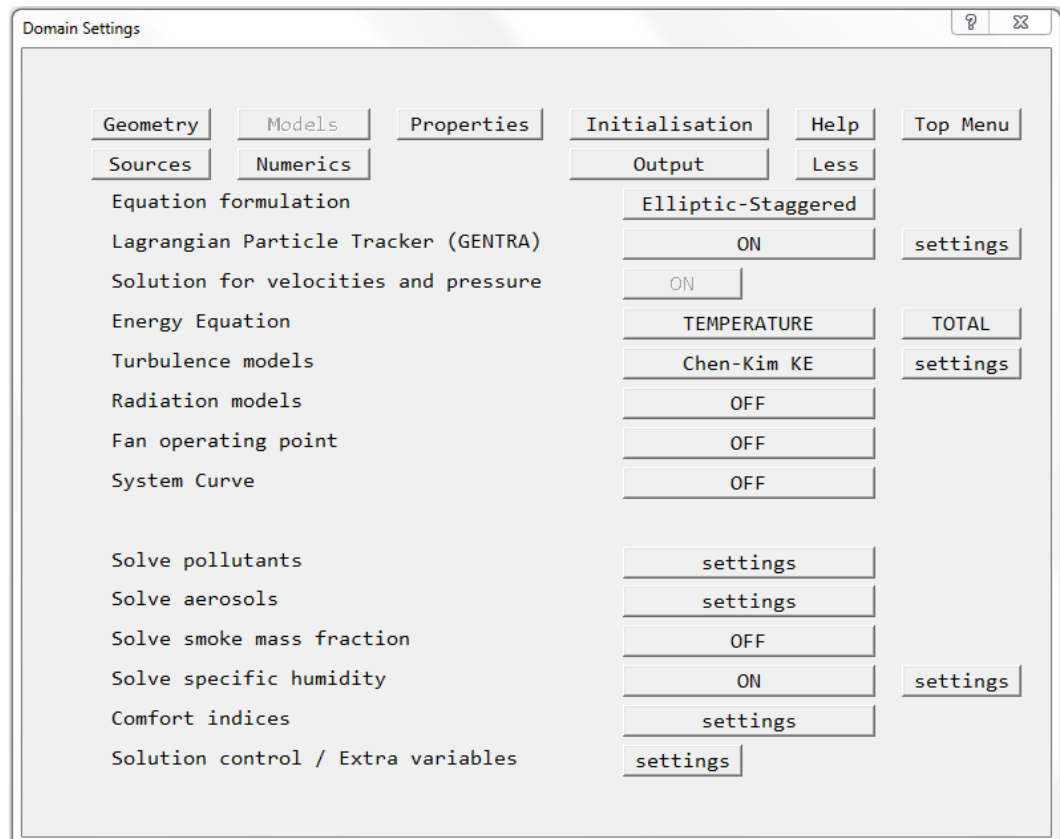
Setting Up Problems: PHOENICS-VR main menu



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The PHOENICS-VR Main menu allows you to make all the settings required for a problem, including:

- Geometry
- Variables to be solved (models)
- Fluid properties
- Initial values
- Boundary conditions
- Numerical controls
- Printout options



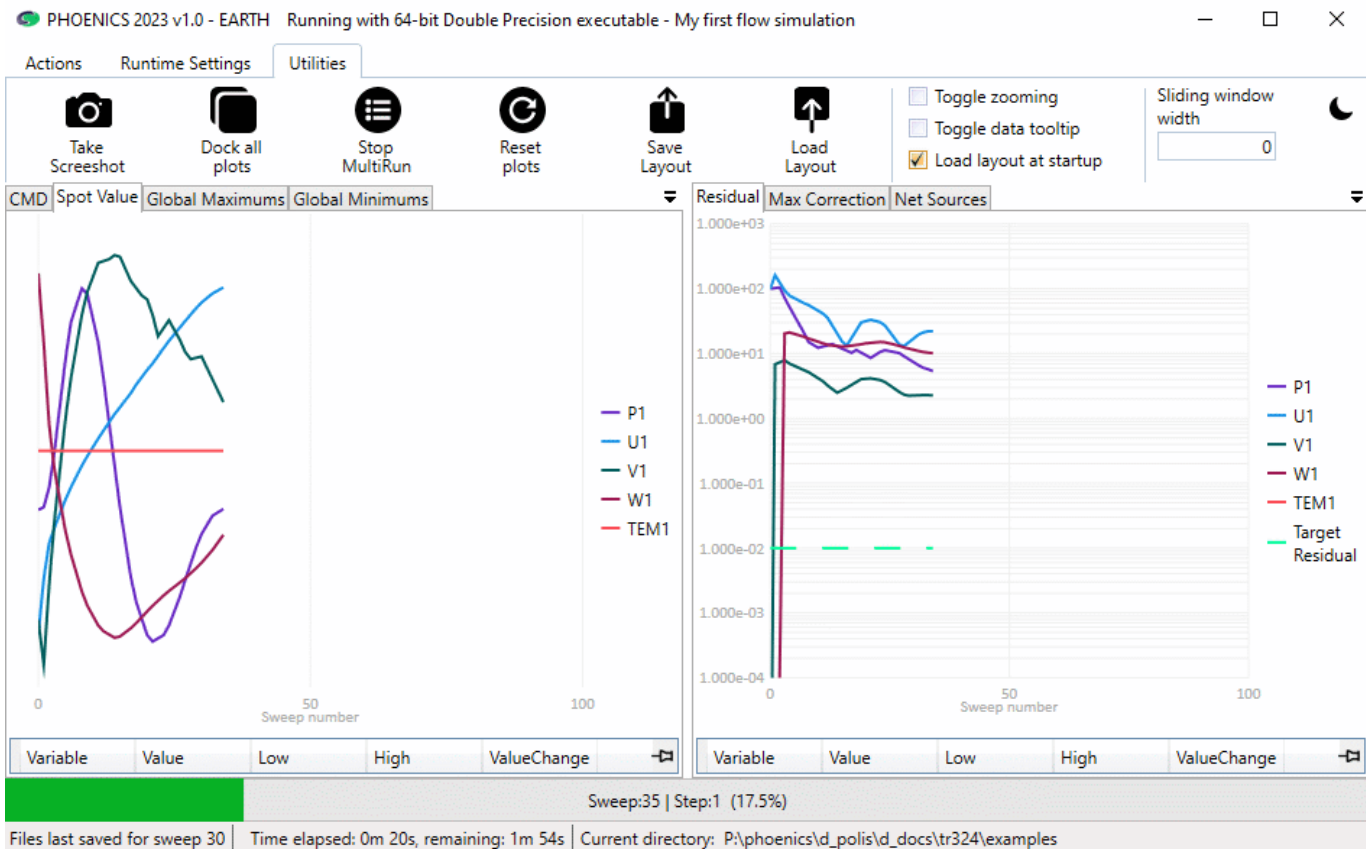
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A Typical EARTH Convergence Monitor Plot

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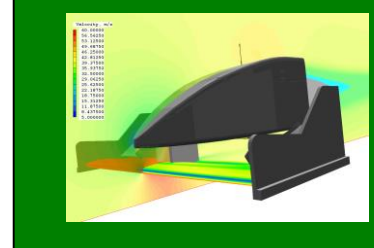
- EARTH is the program that performs the simulation.
- The graphical monitor shows the converging solution.



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Solver-Graphics Monitoring



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The EARTH run can be interrupted to change several parameters:

- Monitoring position
- Relaxation factors
- Graphical monitor settings
- Intermediate result files can also be dumped

The screenshot shows the PHOENICS 2023 v1.0 - EARTH software interface. A 'Reset' dialog box is open, displaying relaxation parameters for variable P1. The parameters are:

Variable	Type	Value
P1	Linear Relax	0.500000
LITER		200
ENDIT		0.001000
Maximum increment		1.110E20

Other parameters in the dialog include:

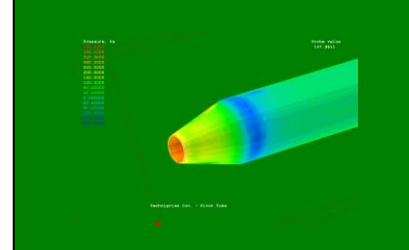
- Self-adjustment factor (SARAH): 0.000000
- Number of iterations (LSWEEP): 200
- Termination criterion (RESFAC) %: 0.010000

The background shows a graph of variables (P1, U1, V1, W1, TEM1) versus Sweep number (0 to 100). The status bar at the bottom indicates: Sweep:69 | Step:1 (34.5%) - PAUSED. Files last saved for sweep 60 | Time elapsed: 1m 50s, remaining: 2m 27s | Current directory: P:\phoenics\d_polis\d_docs\tr324\examples

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Analysis of Results - VR Viewer



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The VR Viewer allows users to see their results in a number of different ways:

PHOENICS - VR Viewer

File Settings View Run Options Compile Build Help

Velocity, m/s

- 5.512768
- 5.168365
- 4.823962
- 4.479558
- 4.135155
- 3.790751
- 3.446348
- 3.101945
- 2.757541
- 2.413138
- 2.068735
- 1.724331
- 1.379928
- 1.035524
- 0.691121
- 0.346718
- 0.002314

Probe value
0.958378
Average value
1.712301

Viewer Options

Contours Vectors Surface Plotlimits Options

Current variable: Velocity

Minimum Value, m/s: 0.002314

Maximum Value, m/s: 5.512768

Contour Appearance

- Lines
- Continuous
- Transparent
- Greyscale
- Averaged
- Boxed key
- Opacity: 100

Probe position

X: 97.625000
Y: 38.833302
Z: 0.875000

Multi story Garage

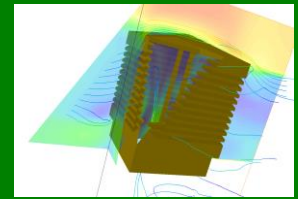
Ready

start | Inbox - Microsof... | Seminar2005.PPT | PHOENICS - VR ... | EN | 13:31

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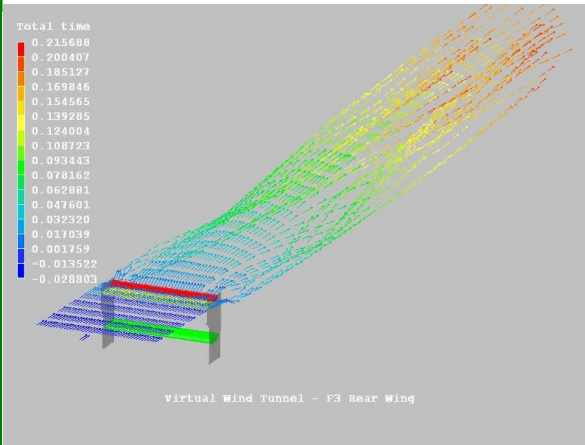


Analysis of Results - VR Viewer

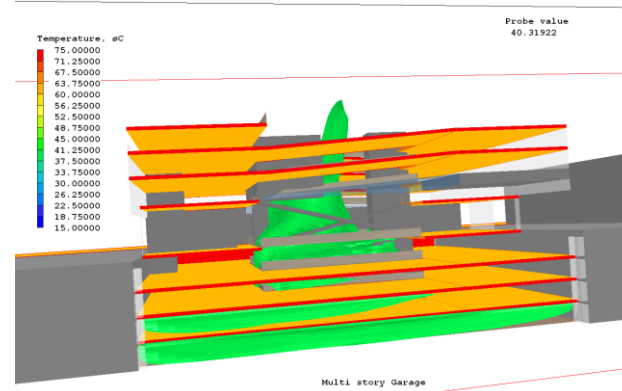


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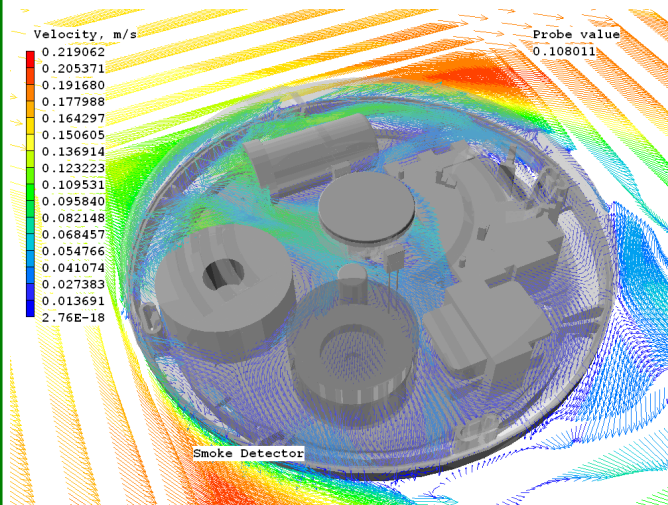
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Streamlines, static or animated



Iso-surfaces



Vectors

Contours





User Programmability

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- **In-Form** enables users of PHOENICS to greatly extend its capabilities, without any need to write FORTRAN coding.
- Users are enabled to express their requirements by way of formulae.
- These are read by the Input Module (Satellite), which transmits them to the Solver Module (EARTH); this then interprets them and performs the implied computations.
- In-Form does **not** require use of a re-compilable version of PHOENICS.



In-Form Capabilities

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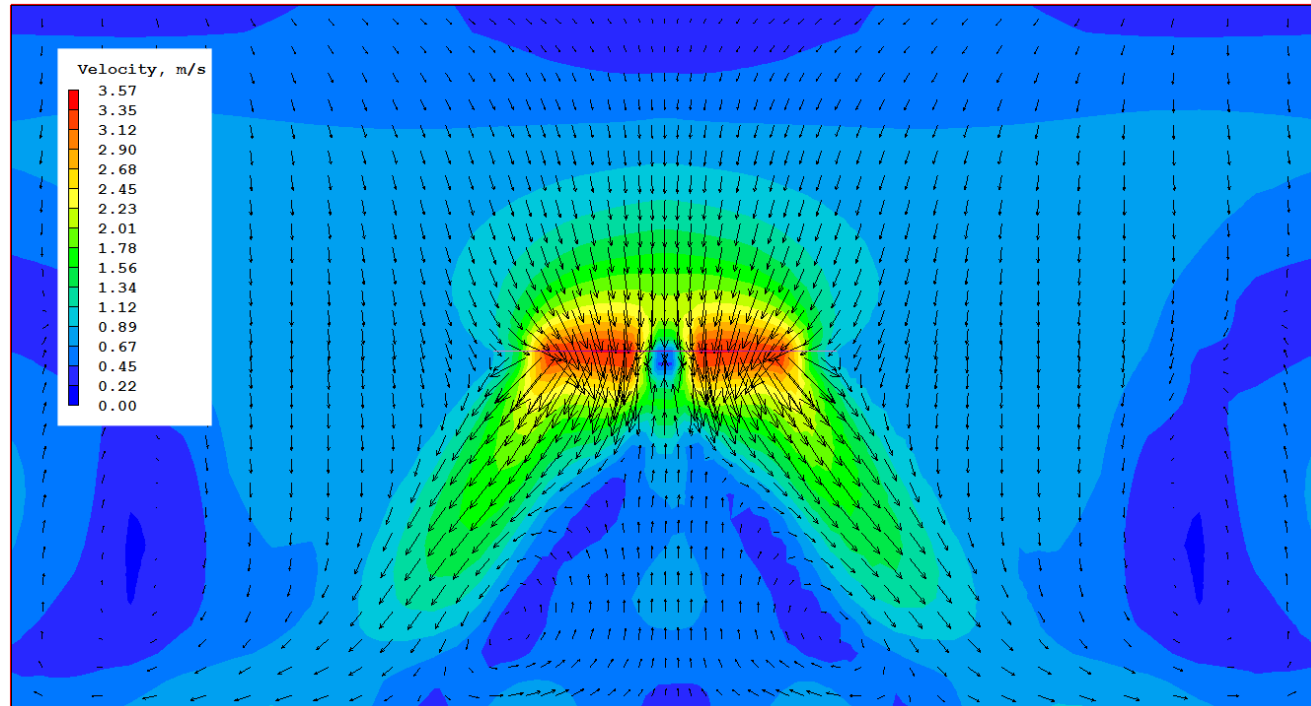
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- In-Form can be used to:
 - Set sources
 - Set initial values
 - Set physical properties
 - Define and calculate new derived quantities
 - Calculate total or average values and print them
 - Generate additional monitoring tables
 - Many others...



Big Ass Ceiling Fan

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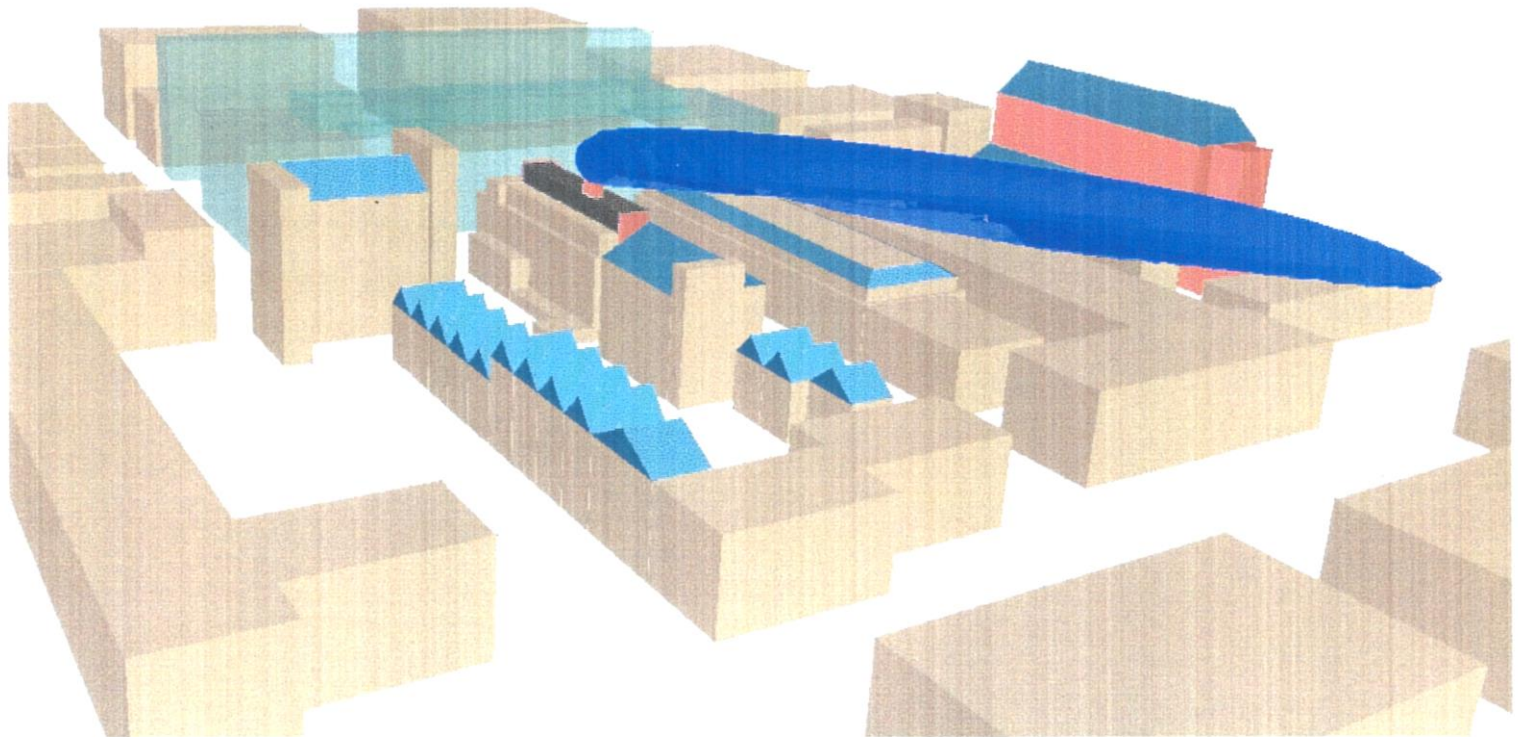
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Pollutant release

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- Animal house in an urban environment
- Isosurface of odour concentration



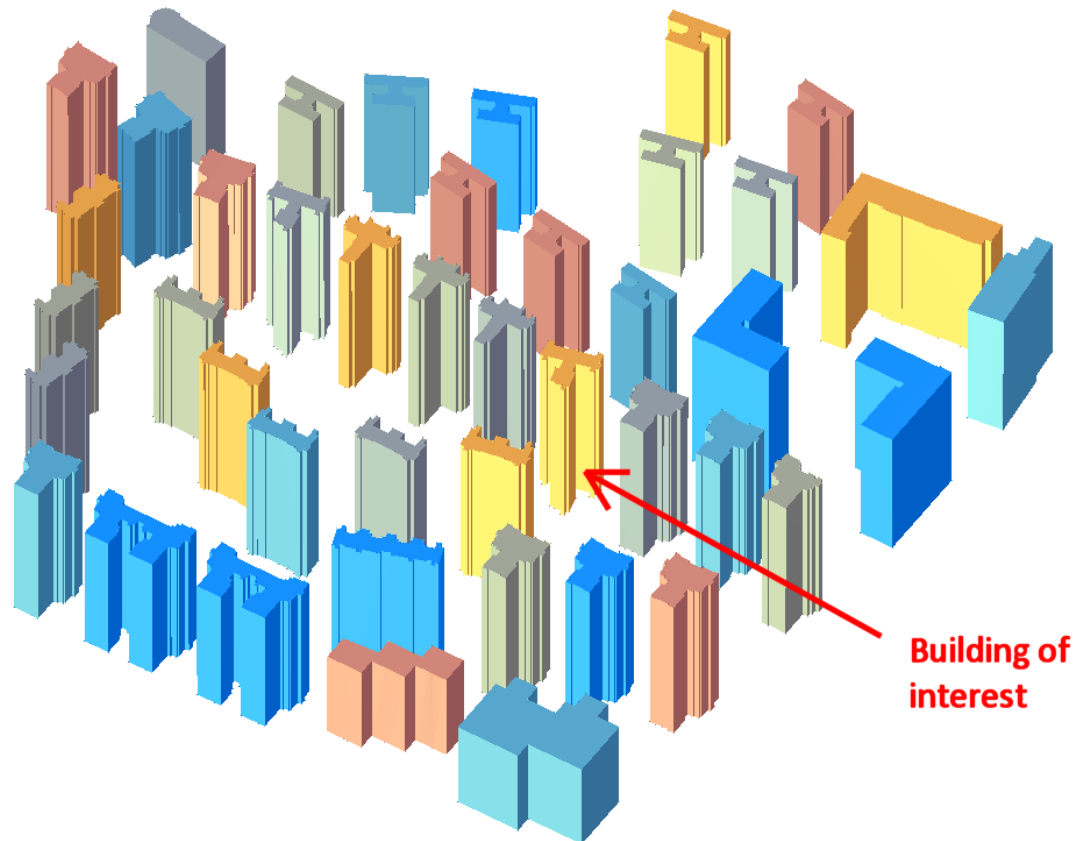
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Wind

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- Wind around a building development
- Wind 5 m/s from SW, log-law profile, roughness height 0.03m



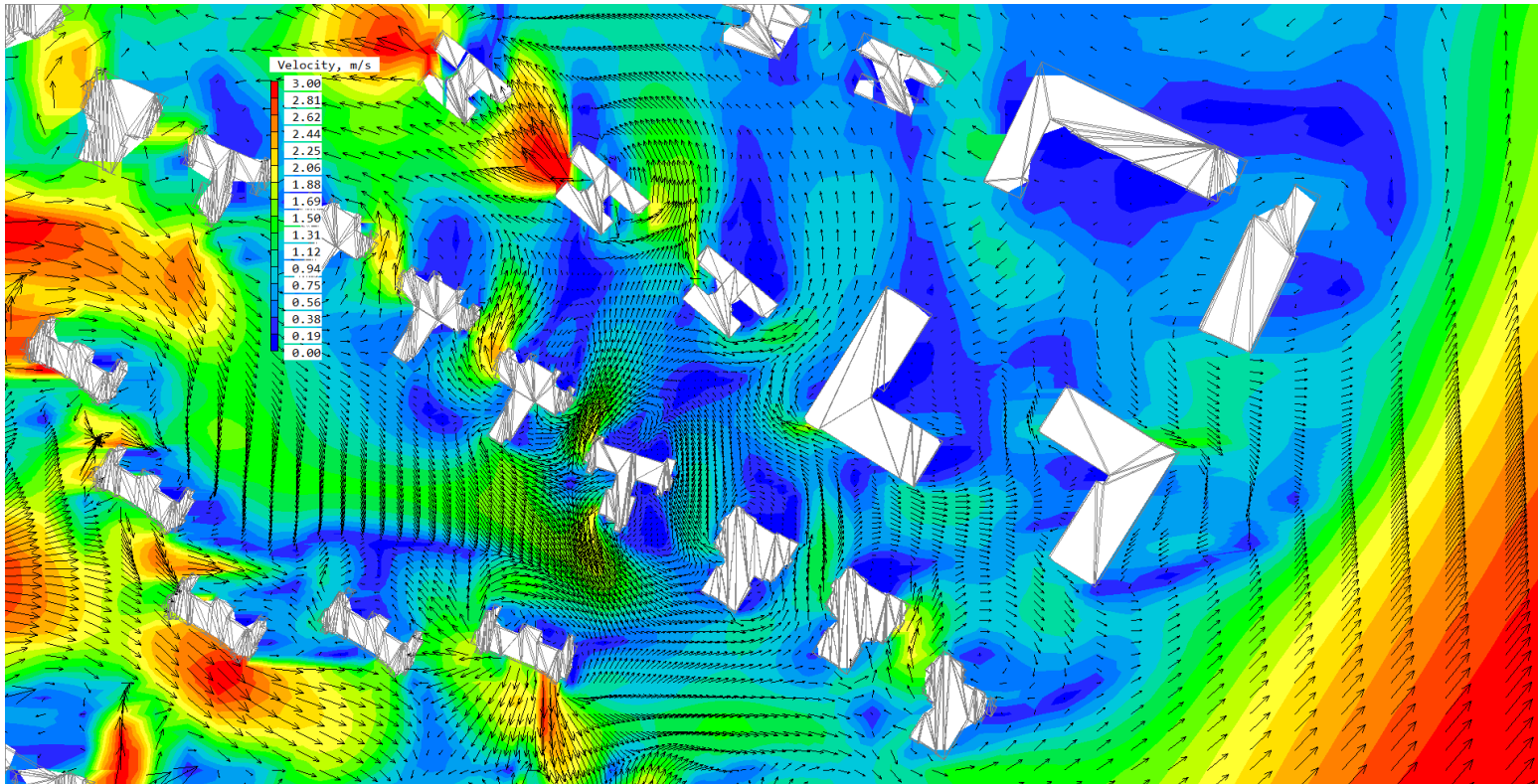
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Typical Wind Case

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- Wind 1.5m above ground, around building of interest

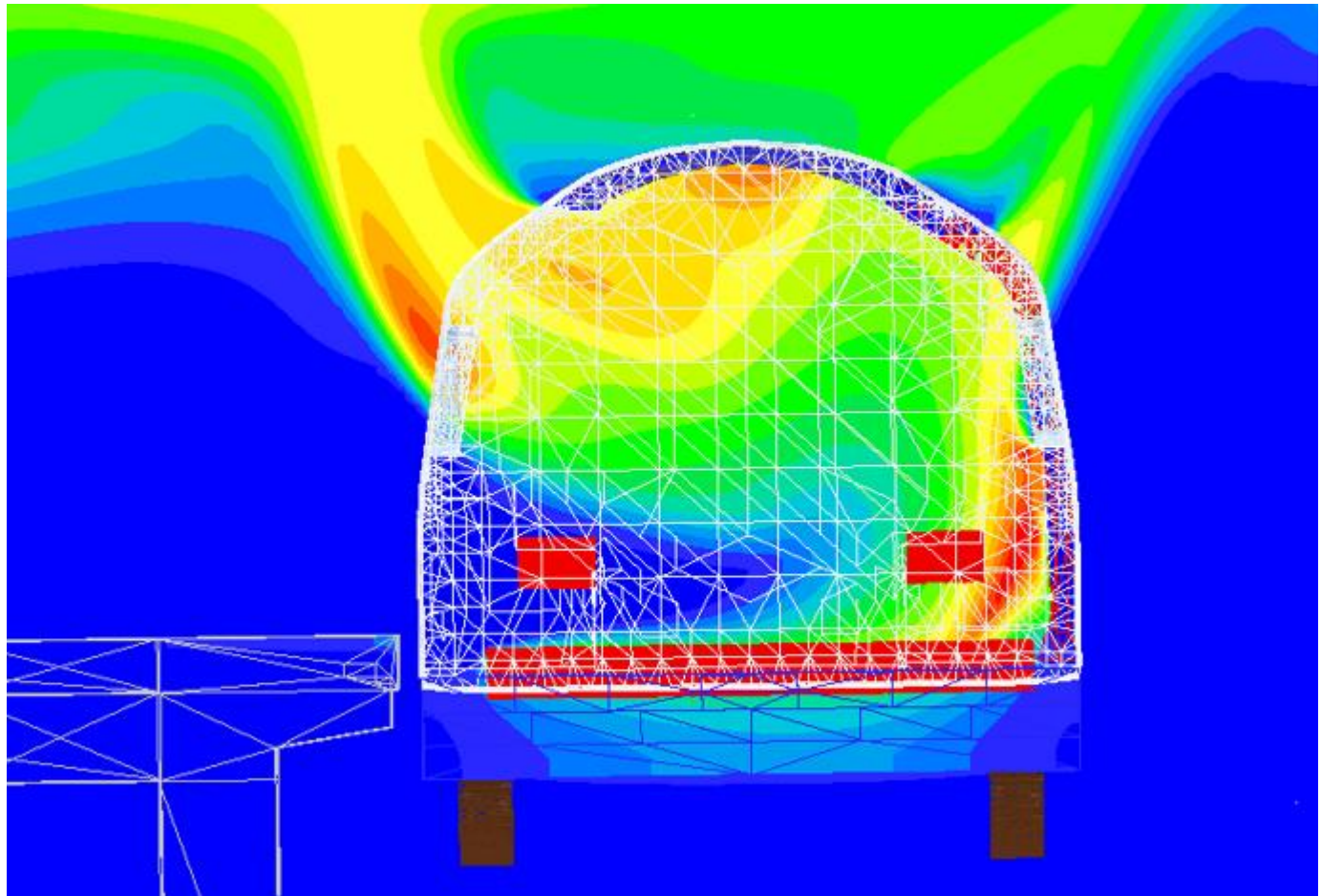


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Fire in a Train

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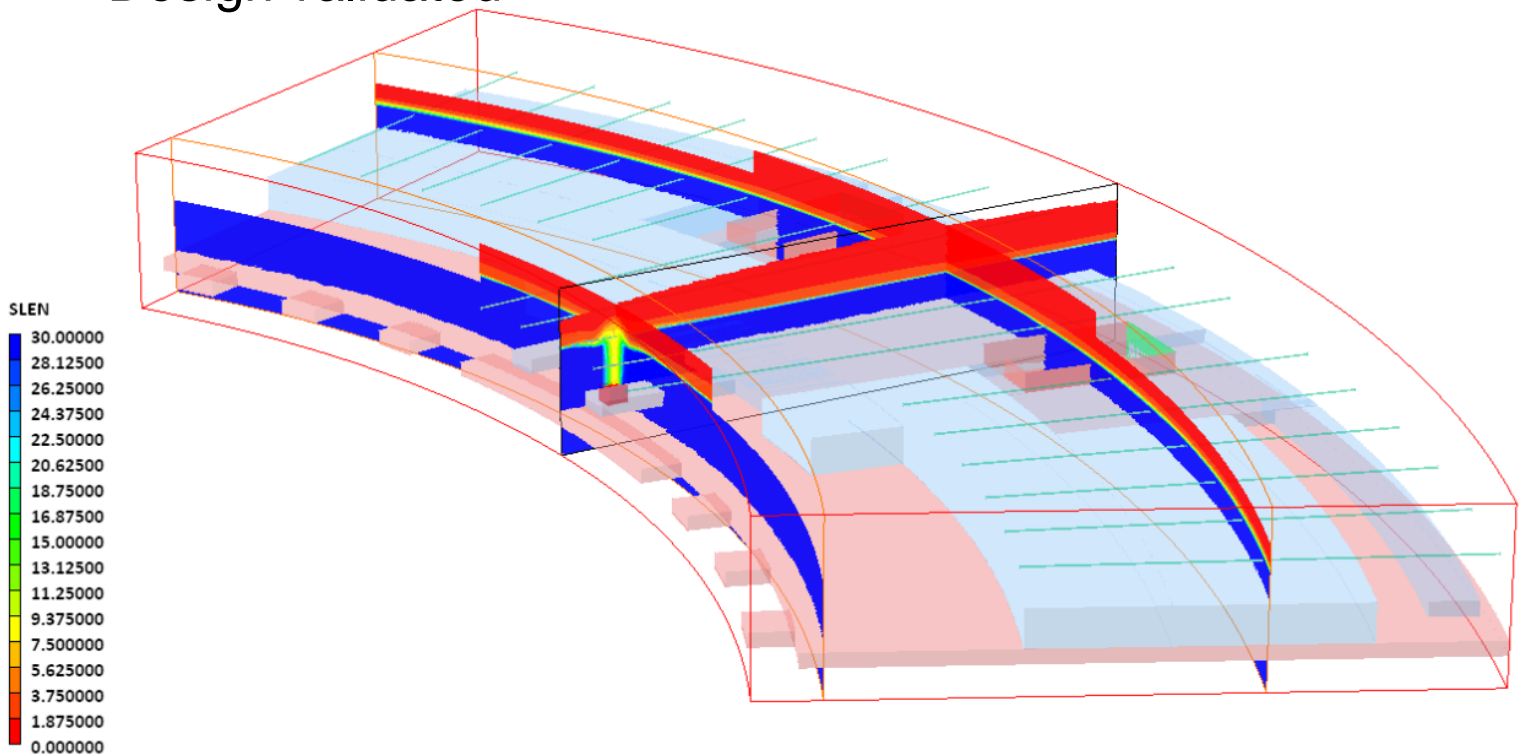
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Luggage Fire in an Air Terminal

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- Plot of visibility length – colours reversed, smoke is red
- High smoke concentrations near ceiling only
- Green lines show the smoke extracts (at bottom of smoke layer)
- Design validated



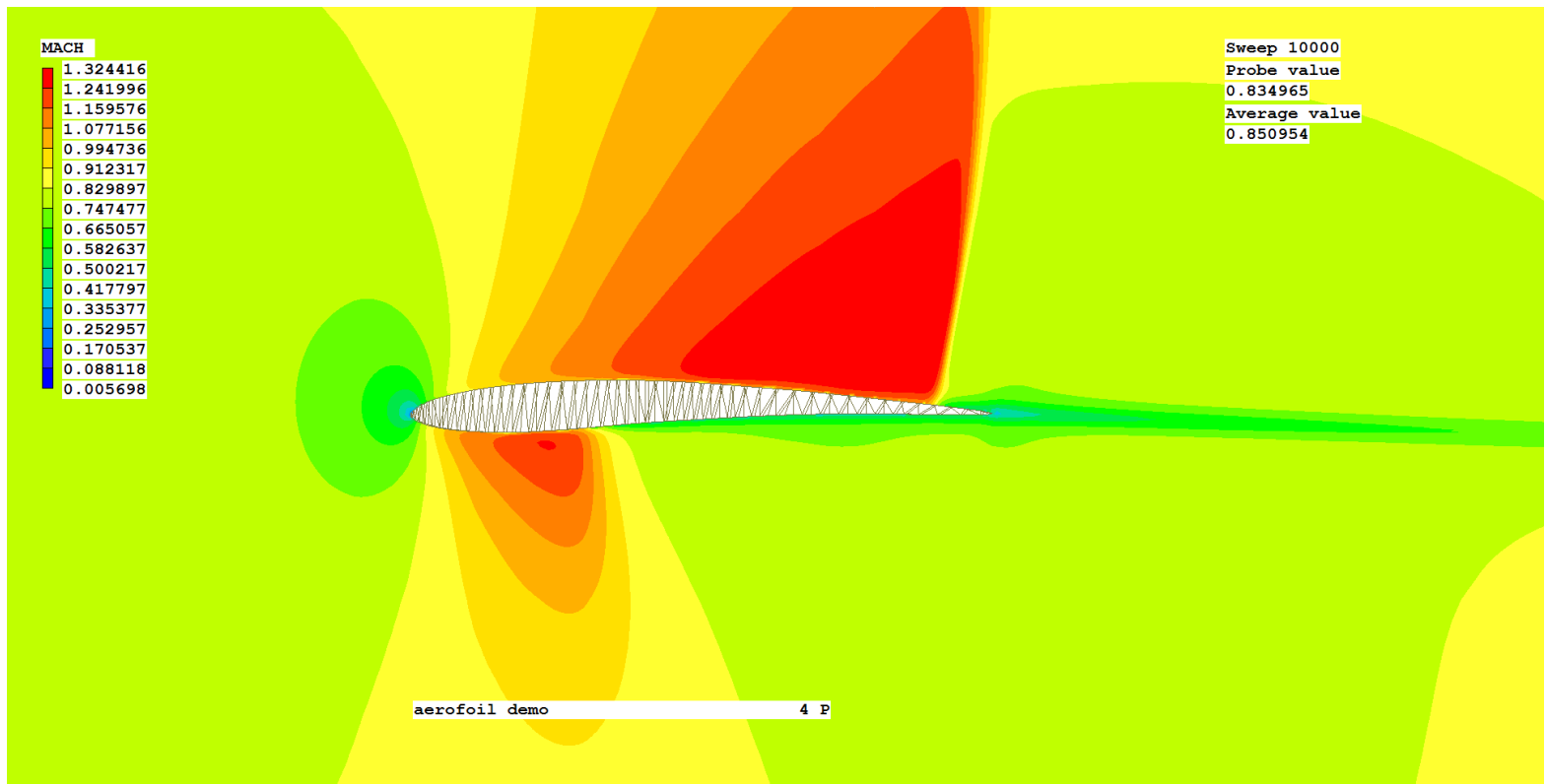
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Transonic Flow around an Aerofoil

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Features Added in Recent Years

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- “Hypre” solvers
- Improved geometry detection (Parsol / Sparsol)
- New convergence monitor
- VOF method for free surface models
- Pollutants menu and other FLAIR developments
- New comfort indices
- Wind comfort – Lawson Criteria
- Buildings treatment for UHI problems
- Extended range of non-Newtonian fluids
- New fluidised bed model
- Superior VBO graphics