BE01 Demo
Computational Fluid Dynamics and Virtual Design

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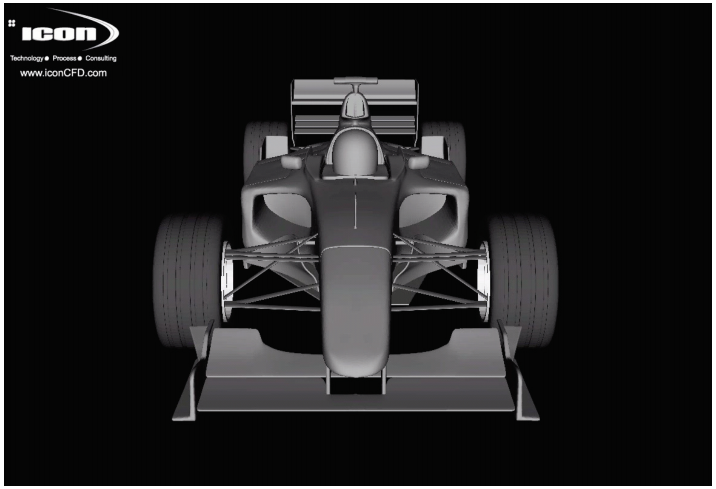
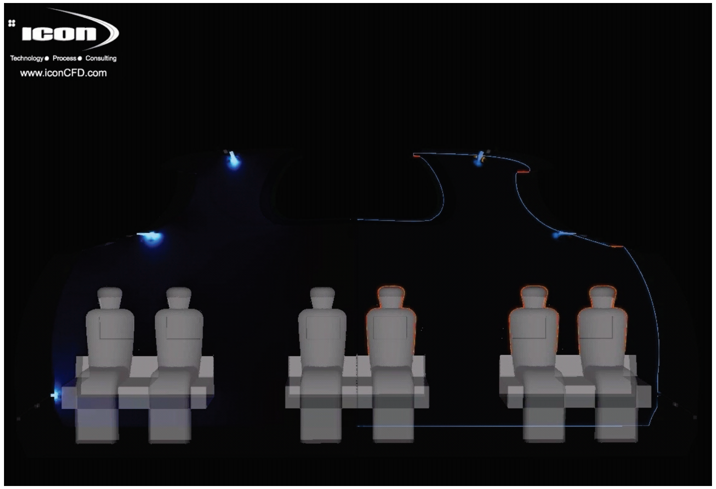
BE01 Context

- **The objective of BE01 is to provide the end user with, an effective, stable and flexible Grid-based solution for CFD execution.**
- **This solution follows the conventional CFD execution workflow, but instead of using local resources, it exploits Grid services and distributed resources.**
- **The introduction of Grid technology within the CFD process can provide a valuable resource in meeting the ever-increasing CFD-driven design demands of the automobile and aerospace industry.**
- **GRID can enable SME's to enter markets where previously, CFD infrastructure was a barrier to entry**

Computational Fluid Dynamics
CFD





A branch of fluid mechanics that uses numerical methods and algorithms to solve and analyse problems that involve fluid flows

Performs complex calculations required to simulate the interaction of fluids and gases with the complex surfaces used in engineering

Validation of CFD simulations can be performed using experimental facilities (e.g. a wind tunnel)

Sufficient Resources

- **CFD execution is a performance-oriented service with great computational demands**

- **Resource requirements vary depending on**
  - **Simulation complexity**
  - **Model size**
  - **Multiple computations**

- **An organization may suffer from having :**
  - **Too few resources**
  - **Under-utilised resources**

Why Grid?

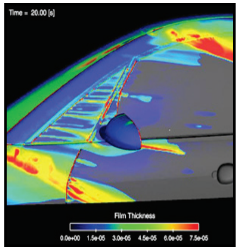
- Increased speed
  - Solutions in hours, not weeks
- Increased flexibility
  - Dynamic resource allocation
- Reduced cost
  - Lower hardware costs
  - Effective labour deployment
  - Reduced IT systems administration
- Environment friendly
  - Reduction in un-used hardware resources

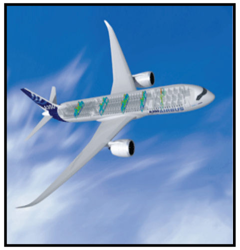
Why Grid Enabled-CFD?

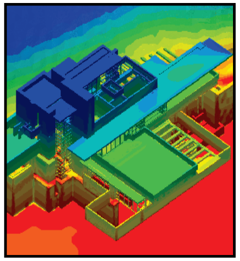
- CFD simulations call for varying hardware and software resources, depending upon:
  - the complexity and size of the model, and
  - the optimisation required

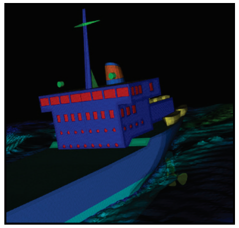
- Resource trap
  - organisations have too few resources
  - organisations have under-utilised resources

- Value network based upon Grid computing resources to:
  - provide CPU cycles when they are needed
  - reduce risk as no longer require significant hardware and software investment
  - do so in a cost-effective manner e.g. open source





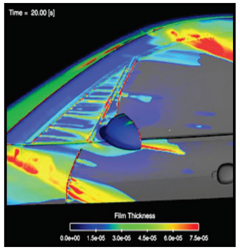


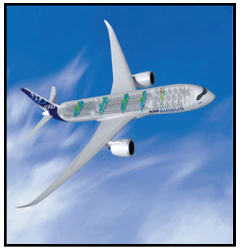


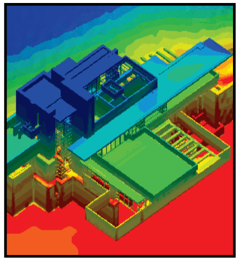
Value Proposition to Customers using GRID

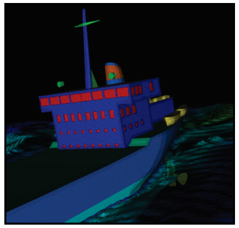
Enable Design/Business Relevant CFD Analysis for the broader market, based upon:

- Increased speed (solutions is hours)
- Increased flexibility (match costs to project budgets)
- Reduced cost (shorter programmes, lower development costs etc)
- Improved quality (higher resolution models)







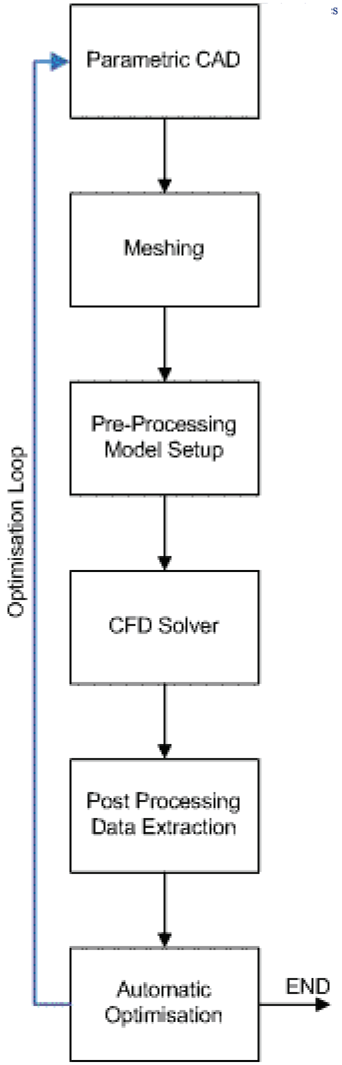


CFD Execution Scenario

- **The different steps in the process of CFD simulation include:**
  - ❑ **CAD (*Computer Aided Design*) geometry**
  - ❑ **Mesh generation**
  - ❑ **Solver setup and calculation**
  - ❑ **Post-processing**

- **This linear step-wise process in the traditional CFD methodology can be made into a fully automated sequence of events with a parametric approach.**

- **Automatic Optimisation is achieved through a loop using appropriate optimisation algorithms. (eg Genetic, Simplex)**

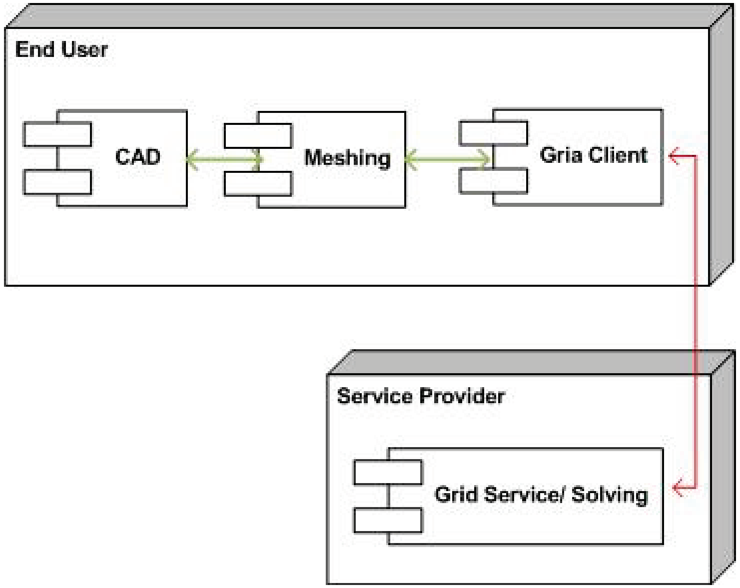


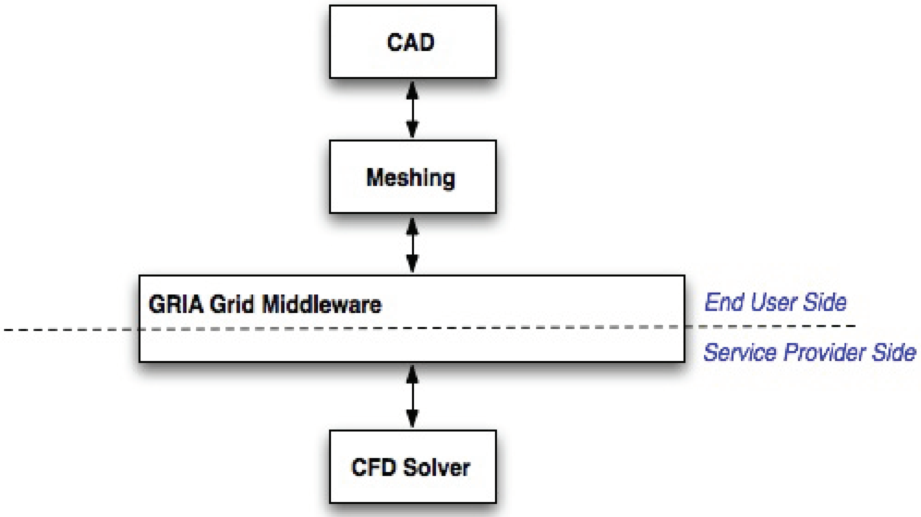
CFD in GRID

The linear step-wise process in the traditional CFD methodology can be ‘gridified’ by separating the process into two levels or roles:

- **End User**
- **Service Provider**

The interaction between levels is achieved through GRIA, the selected Grid middleware



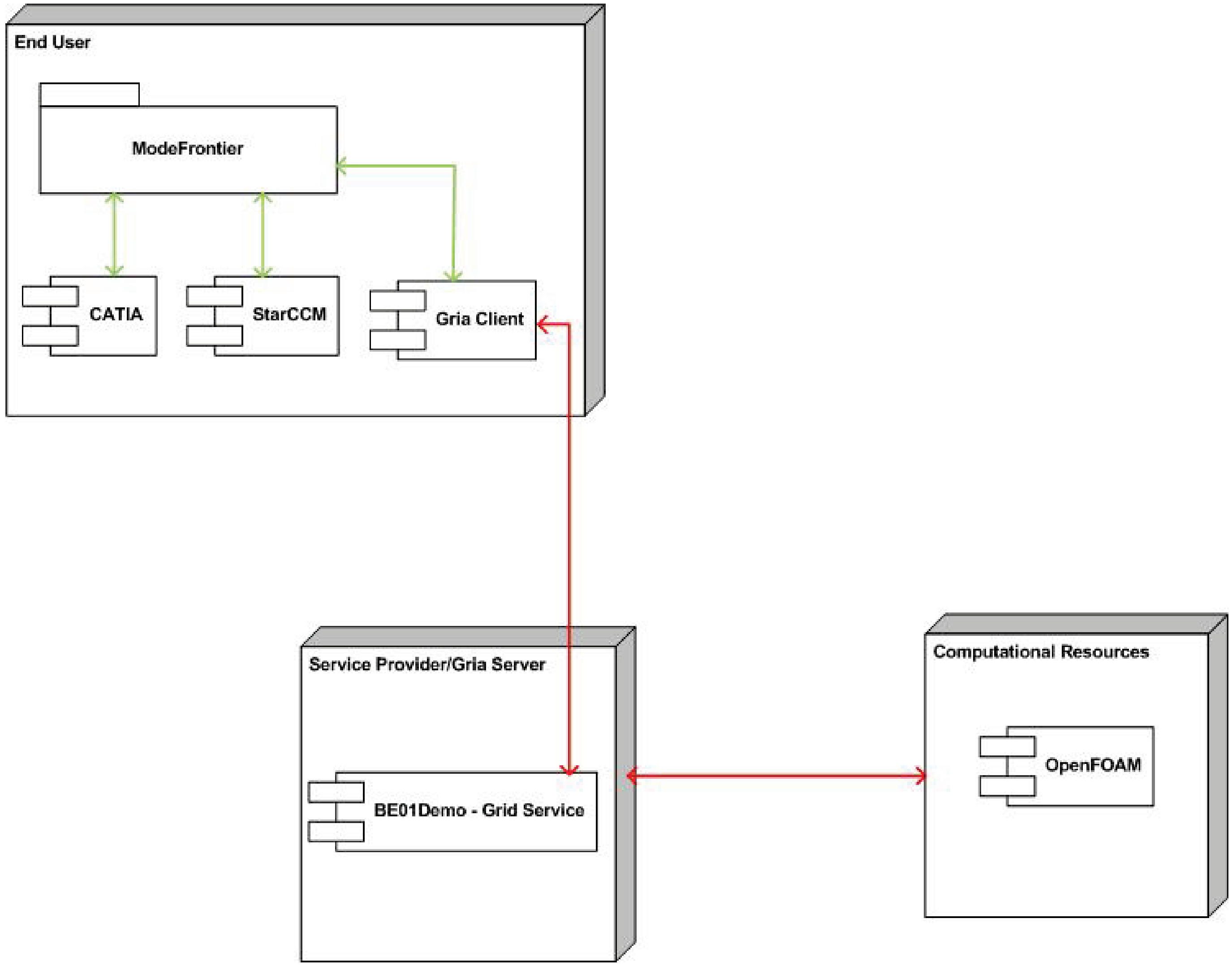


BE01 Demo - Audi case

- **The potential of GRID Computing to solve CFD optimisation problems involving industrial applications.**
- **The geometry is a cooling duct located in the under-bonnet region of a vehicle.**
  - **Air flows through the left side grill highlighted, into the cooling duct, towards the transmission.**
- **Optimisation Objectives of Duct design**
  - **Minimise Pressure Loss**
  - **Maximise Discharge Velocity**

www.audi.de

BE01 Demo - Audi case

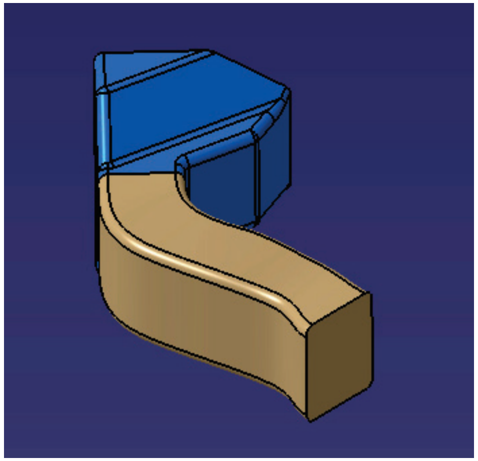


BE01 Demo - Audi case

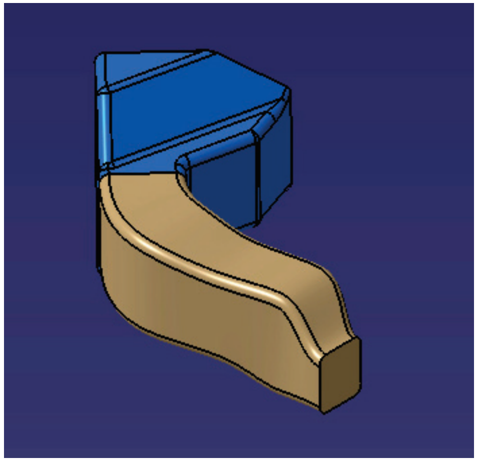
Results

- Total evaluation of 450 design variations, over 15 generations.
- 340 successful designs, while the rest were rejected due to CAD, mesh design intersections or CFD convergence problems.

- The entire execution was performed over 8 hours and 15 minutes.
- Twice as fast as the times recorded for the standard (non-Grid) execution.



Baseline Design
Discharge Velocity = 41.5 m/s
Total Pressure Drop = 661 Pa



Optimised Design (ID=397)
Discharge Velocity = 110 m/s
Total Pressure Drop = 387 Pa

Conclusions

- **Technical Benefits**
  - **Faster results**
  - **Solve larger problems in a efficient time-frame**
  - **Increase insight into the physics**
  - **Perform Automatic Optimisation**

- **Business Impact**
  - **Reduced Risk**
  - **Improved Productivity**
  - **Increased Flexibility**
  - **Reduced Cost**
  - **Improved Quality**
  - **Environmental Impact**

THANK YOU