FloVENT®

Optimizing
Airflow Design
with Simulation
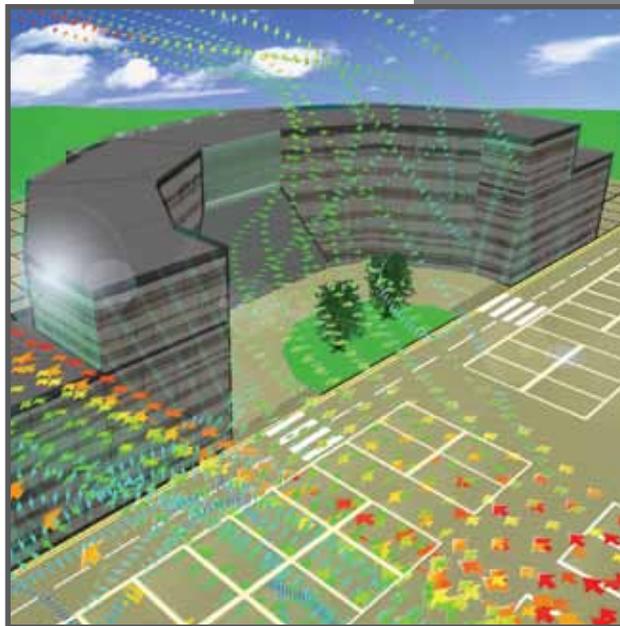
Mentor Graphics®

M E C H A N I C A L   A N A L Y S I S

OVERVIEW

Since 1988, our Mechanical Analysis Division has played a pioneering role in the simulation of airflow in and around buildings by delivering high-quality analysis software for designers. The result is powerful Computational Fluid Dynamics (CFD) software called FloVENT, which predicts 3D airflow, heat transfer and contamination dispersion in both internal and external environments.

FloVENT's fast and easy-to-use menu system is designed specifically for engineers involved in the design and optimization of heating, ventilating and air conditioning (HVAC) systems.

FloVENT can be applied to buildings of all types and sizes.

- atriums, shopping malls and office building

- theatres, airport terminals, storage facilities and warehouses

- telephone exchanges and data centers

- passenger comfort in vehicles

- air quality and contaminant control in laboratories, research facilities, hospitals and underground car parks.

Airflow modeling gives engineers the luxury to consider several design options in the minimum amount of time. As a result, the final design is not based on a tentative approach, but is a result of a professional design process considering several options and selecting the optimum solution. This can save on capital and running costs, save time on correcting mistakes further down the design route and save time on commissioning.

Whether you choose to license FloVENT for in-house use or to employ Mentor Graphic's FloVENT airflow modeling consultancy, you can meet the daily challenges of predicting airflow patterns and thermal efects, maximizing contamination control, and reducing operating costs more confidently and productively than ever before.

WHY PERFORM AIRFLOW MODELING

No matter how complex your airflow application is, modeling enables you to understand it more comprehensively through the medium of virtual reality and computer 3D animation. As a result, you can:

- Thoroughly understand the multiple, interacting factors that influence airflow.

- Optimize design calculations of air volume and set point temperatures to enable dramatic savings in capital investment and system operating costs.

- Confidently predict and eliminate airflow problems or hazards early in the design process before building or renovation begins.

- Effectively troubleshoot airflow problems or hazards in and around existing facilities to ensure fast resolution with minimum downtime.

- Dramatically reduce the time and cost while dramatically increasing the value of physical airflow testing and measurement.
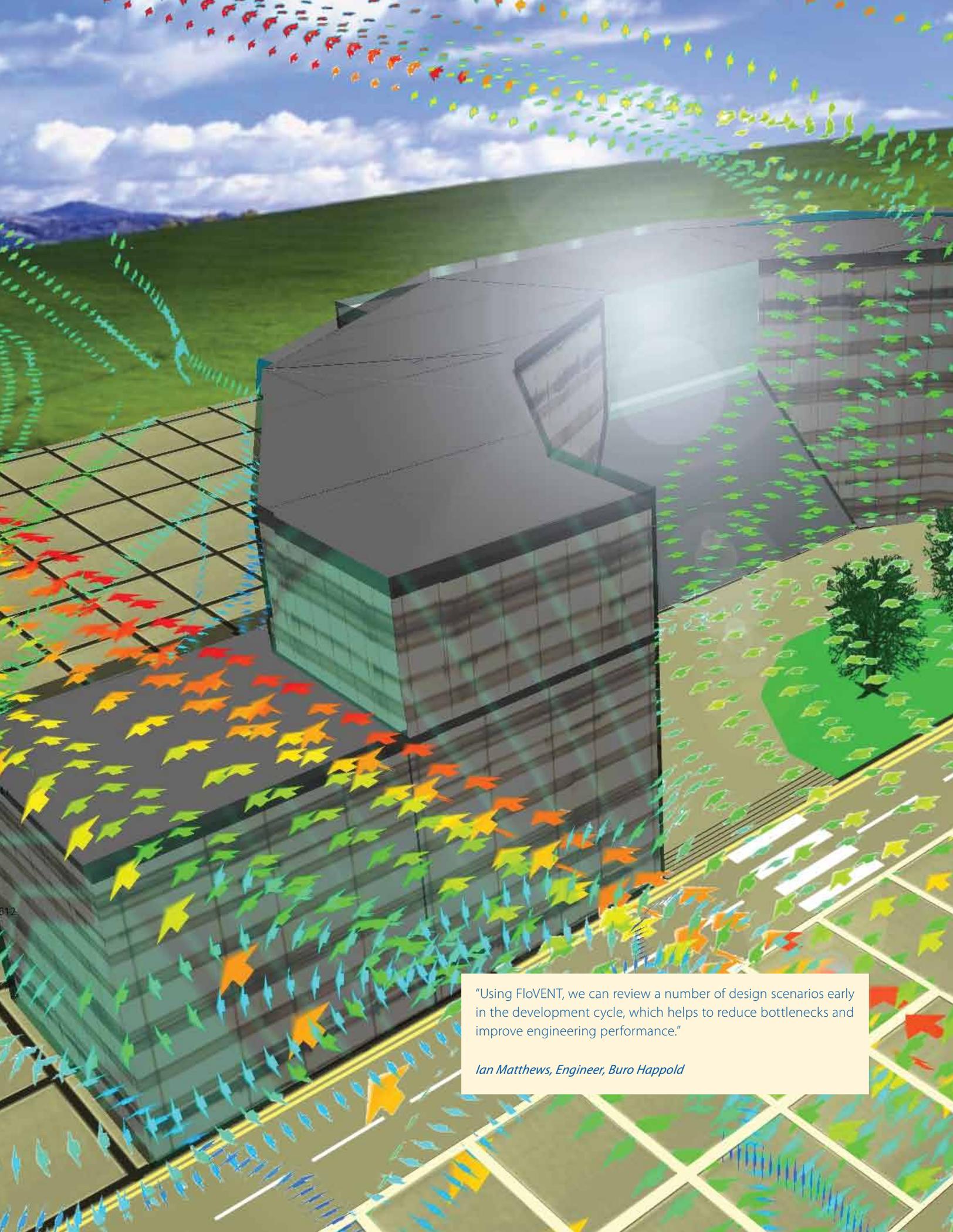
SOME KEY FEATURES

- CAD-style, mouse-driven drawing board using simple draw, drag and drop operations to create and manipulate geometry

- Explorer-style project manager with drag-and-drop functionality

- Complete set of SmartParts (intelligent model creation macros)

- Multi-level SmartParts (compact and detailed representations in a single object)

- Structured Cartesian grid that can be "localized" and nested to minimize solve times and enable multi-scale modeling

- Full control of grid constraints for fine, local and global refinement

- Object-associated grid that combines model creation and grid generation into a single step

SMARTPARTS®

FloVENT features a comprehensive set of intelligent model creation macros (SmartParts) to allow a broad range of airflow applications to be built quickly and accurately. SmartParts are available for:

- Square Diffusers
- Round Diffusers
- Swirl Diffusers
- Grilles/Vents

- Heat Exchangers
- CRAC Units
- Fans
- Rooms

All SmartParts incorporate two decades of airflow modeling experience at Mentor Graphics' Mechanical Analysis Division, and are aimed at streamlining model creation, minimizing solution times, and maximizing results accuracy.

INTEGRATION WITH CAD

FloVENT is also integrated with CAD software. Use existing native data from Creo Parametric, Autodesk Inventor, Solidworks and other CAD software, as well as the DXF file format easily.
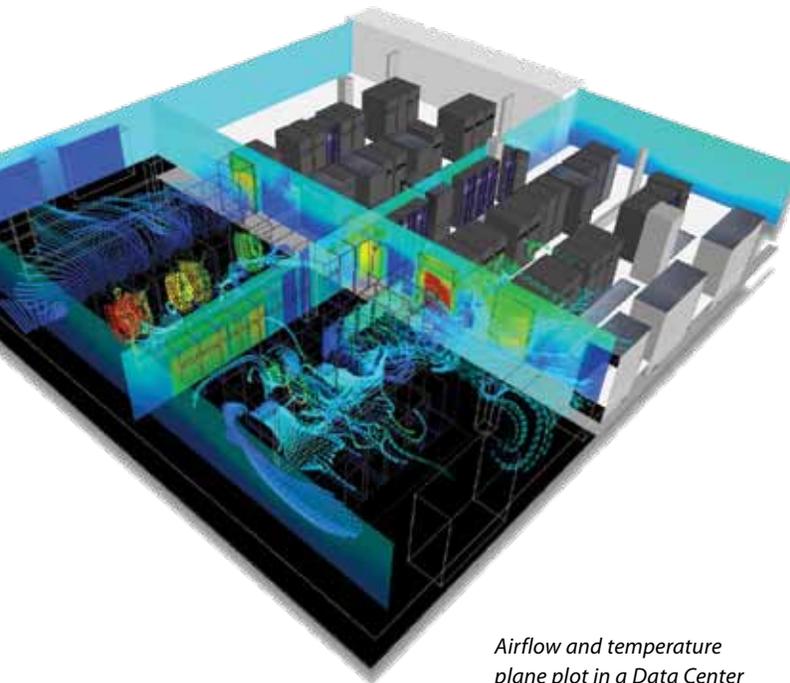
GRID

FloVENT's grid is structured Cartesian - the most stable and numerically efficient type of grid available. The ability to localize is also included for finer resolution where it is needed, minimizing solution time.

Gridding in FloVENT is associated with SmartParts and is generated as part of the model assembly process with refinement under user control. This methodology is intuitive and straightforward enabling engineers to focus on design rather than analysis. Gridding is instantaneous and reliable in FloVENT as compared to traditional tools that require significant time and expertise to master. Finally, FloVENT is the only analysis software with object associated grid that eliminates re-gridding for each model modification.
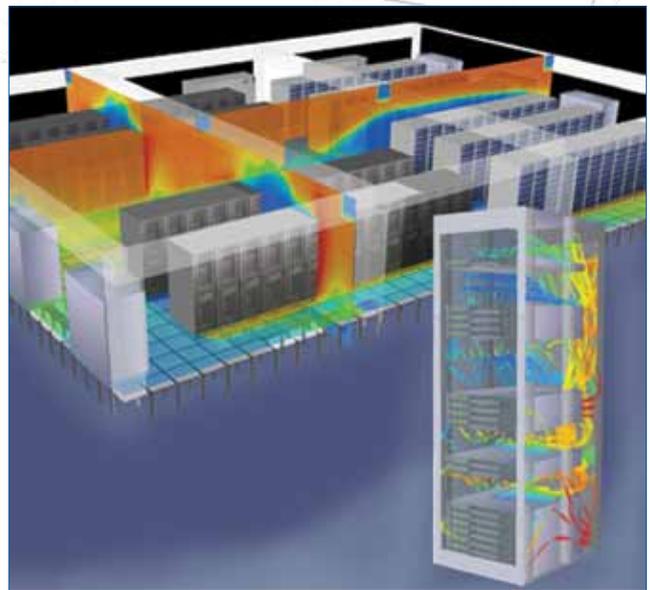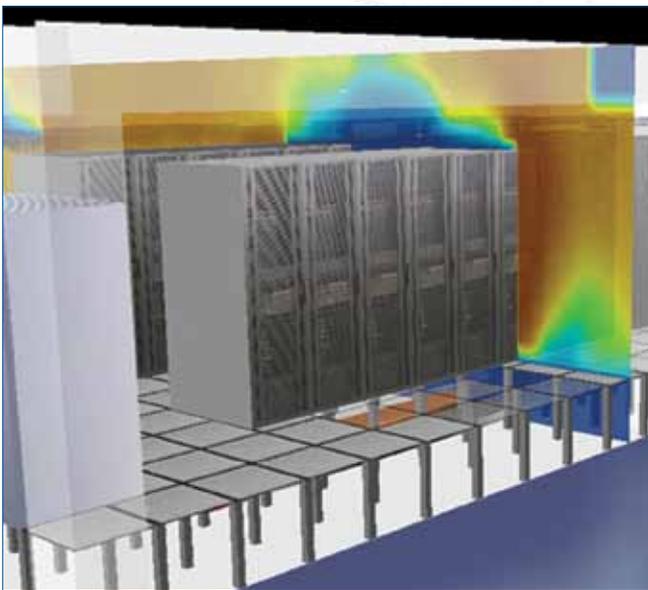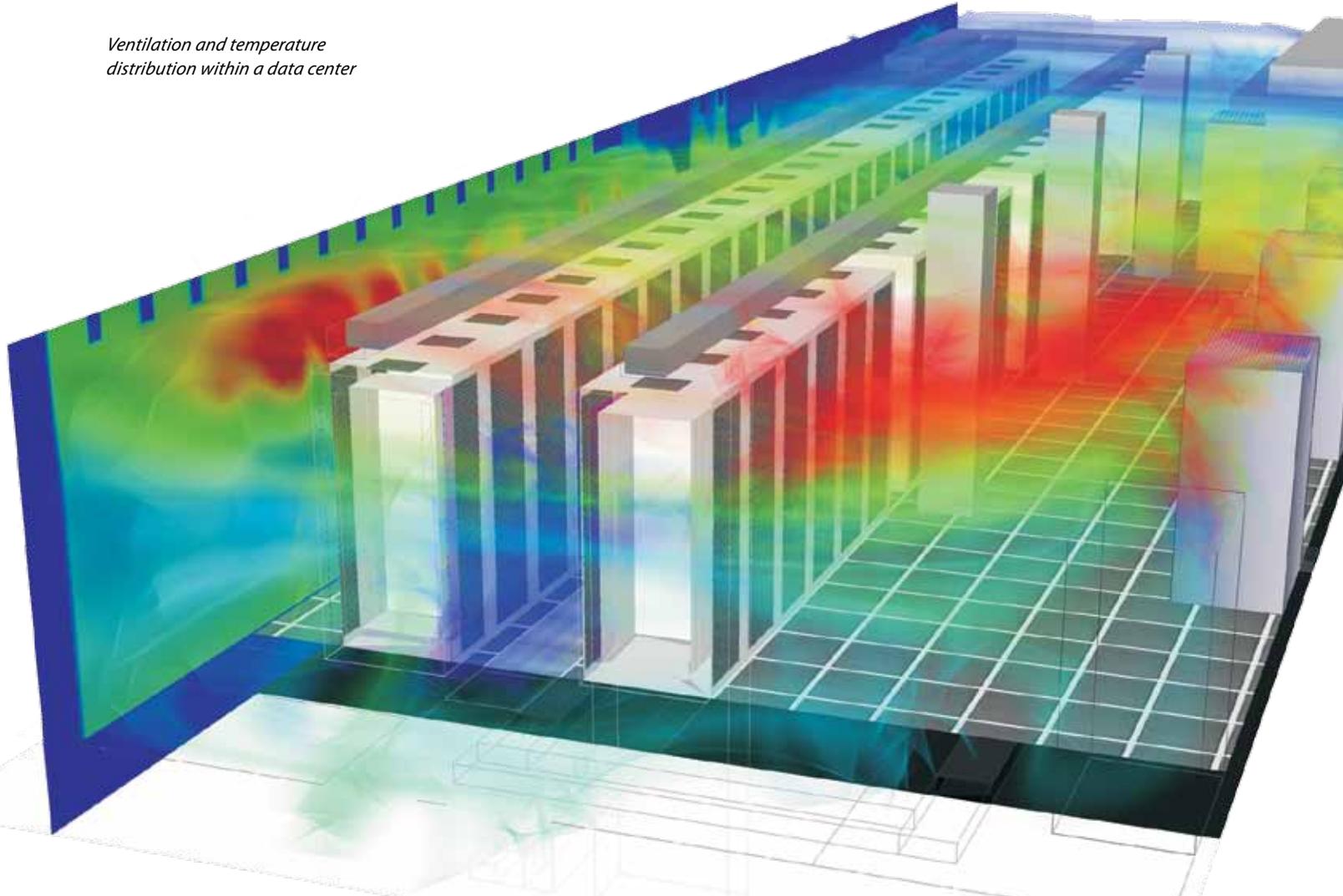
"Airflow modeling inspired confidence on projects where close control of temperature and air speed was critical."

Clinton Spiteri, Parsons Brinkerhoff

Airflow and temperature plane plot in a Data Center

Ventilation and temperature distribution within a data center

PARAMETRIC ANALYSIS AND OPTIMIZATION

SmartPart-based modeling and structured Cartesian grid enable Design of Experiments (DoE) technology to be applied to a FloVENT model. Design of Experiments is a structured method for determining the relationship between design parameters (e.g., diffuser flow rate, location of vents, etc) and results (comfort indices, contaminant removal efficiency, etc). FloVENT's Design of Experiments implementation efficiently explores the design space by building and solving variants of the initial model. This provides critical information regarding the sensitivity of the airflow results to changes in the design parameters while minimizing the number of simulations to be solved and serves as the foundation of the powerful response surface and sequential optimization design tools. To assist with the solution of the Design of Experiment cases, the user may optionally use a distributed network of computers using 'Volunteer' solution technology.

FloVENT extends this concept by computing response surfaces for all results of interest. Response Surfaces are mathematical equations derived from the DoE results that estimate the airflow solution anywhere in the design space instantaneously. The user may interact with the constructed response surfaces with real-time 2D and 3D plots that have slider bars to control the design parameter values. Mathematical optimization of a user defined cost function is fully supported with the response surfaces as well, enabling the optimal solution to be estimated without solving additional cases.
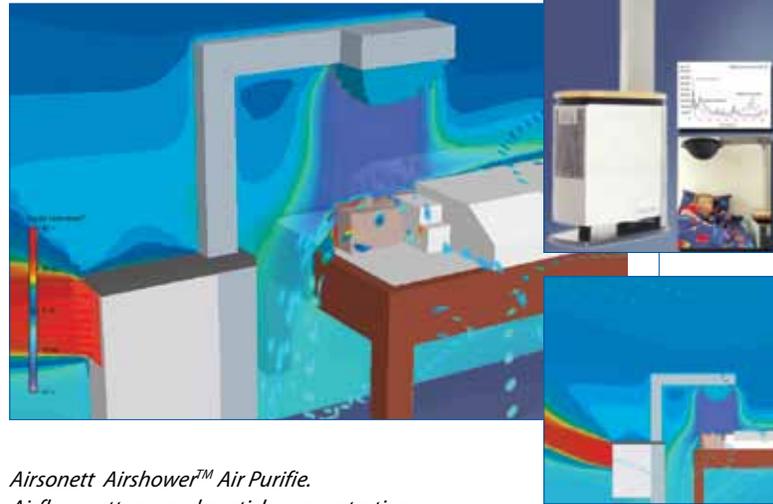
Automatic sequential optimization of the cost function can be performed as well. This gradient based approach will build and solve additional variants of the initial model to explicitly determine and confirm what the optimal solution is. Sequential optimization is able to understand design constraints (such as maximum permissible temperatures, minimum acceptable values for thermal comfort indices, etc) and incorporate them into the presented optimal configuration.
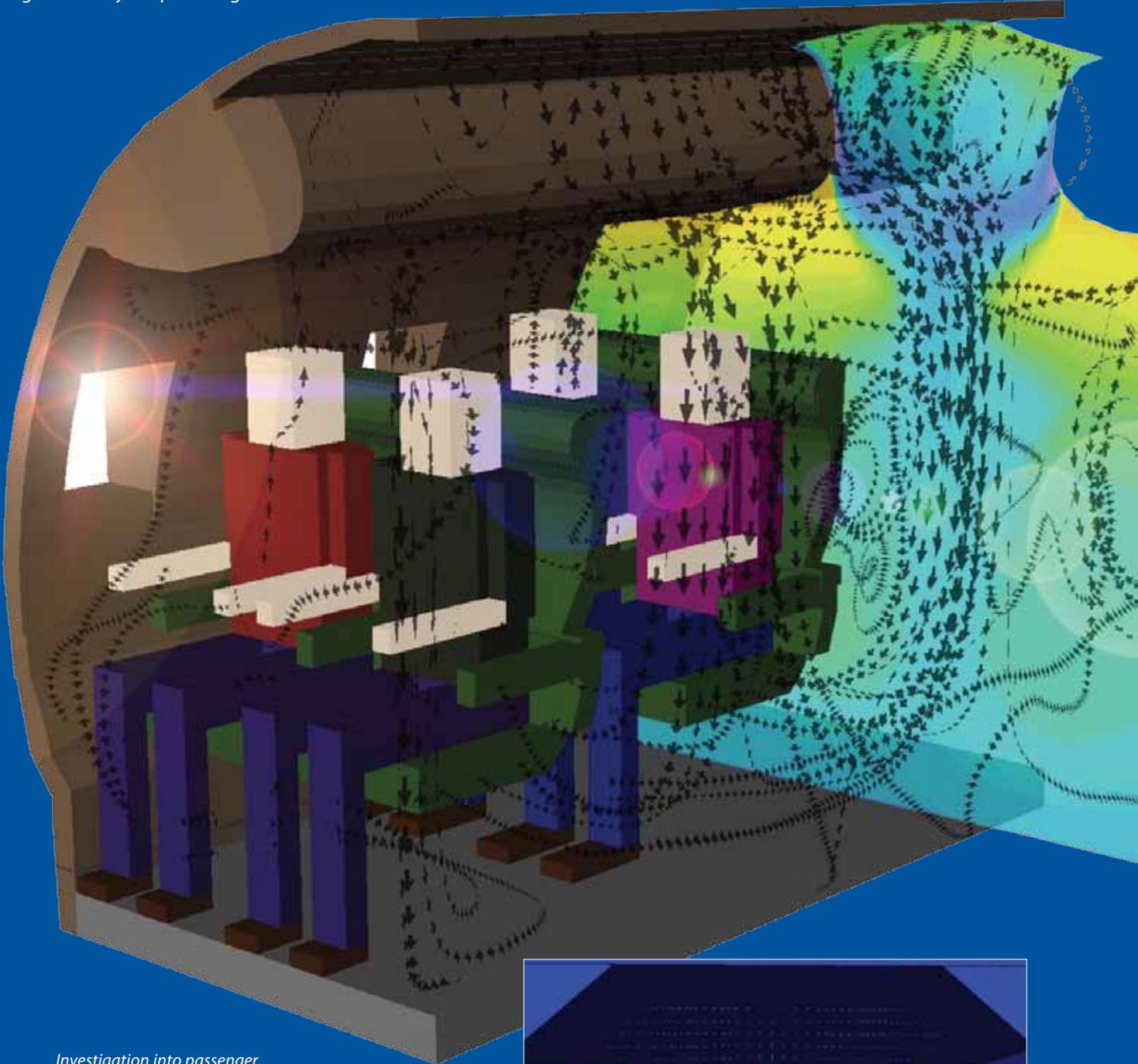
SOLVER

For over 20 years, the FloVENT solver has specifically addressed heating, ventilation and air conditioning (HVAC) applications. The solver, based on a Cartesian gridding system, delivers the most accurate results possible and the fastest solution time per grid cell. Massive disparity in geometric length scales are resolved using the unique 'localized-grid' technique which allows for integrally matched, nested, non-conformal grid interfaces between different parts of the solution domain. The conjugate nature of heat transfer is concurrently solved using a preconditioned conjugate residual solver together with a flexible cycle multi-grid solution technique. Pragmatic, unique and accurate solution termination criteria produce useful results in engineering, not academic, time scales.

TRANSIENT ANALYSIS

The powerful transient analysis capabilities in FloVENT also allow for prediction of a number of different transient behaviors. For example an accurate prediction of smoke or contaminant dispersion can be calculated both internally and externally. Various scenarios can be investigated by changing the concentration of the smoke or gas in relation to elapsed time.

SOME KEY FEATURES

- Concurrent solution for convective, conductive and radiative heat transfer

- Fully automatic radiation exchange and view factor calculation

- Automatic solar loading boundary conditions

- Automatic treatment for heat gains and losses through glazing

- Solution termination optionally based on convergence of user defined monitor points

- Multi-fluids capability

- Ability to simulate either turbulent or laminar flow

- Definition in transient variation in terms of linear ramping, power increase, exponential increase, sinusoidal, periodic or imported .csv pointwise variations

Airsonett Airshower^{TM} Air Purifie.
Airflow patterns and particle concentration

Investigation into passenger comfort within an aircraft cabin
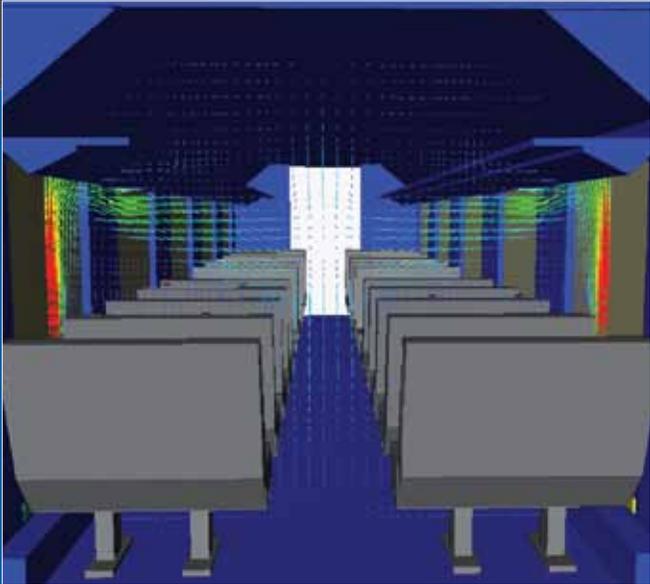

Airflow patterns in a train carriage

SOME KEY FEATURES

- Particle animation and streamlines to visualize complex, 3D airflow

- Contour animation to visualize heat transfer paths

- Isosurfaces and surface temperatures

- Airflow representation by vectors or ribbons colored by temperature or speed

- Easy output of flow animations such as video (AVI format)

- Dynamic particle tracking allowing a better understanding of complex flows

- Image texturing for photo-realistic visualization

RESULTS

The FloVENT visualization toolset is developed specifically to maximize productivity of engineers. Fully rendered models, 3D flow animation and tools for dynamic manipulation of temperature and flow results, enable engineers to pinpoint thermal and ventilation issues and visualize design improvements quickly and effectively. Texture mapping and video output enables powerful communication of design concepts with non-technical colleagues and customers.
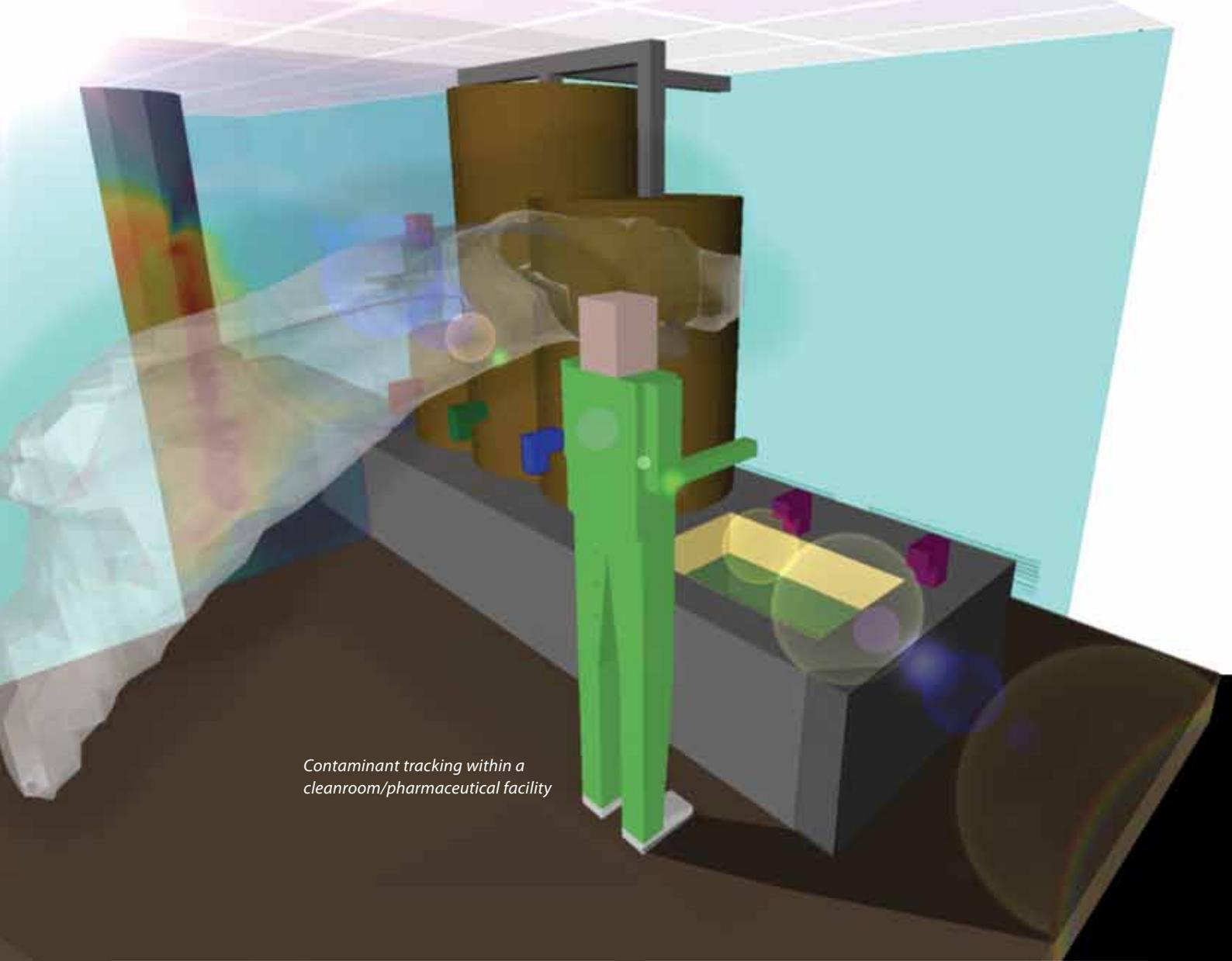
Study of cleanroom cross-contamination
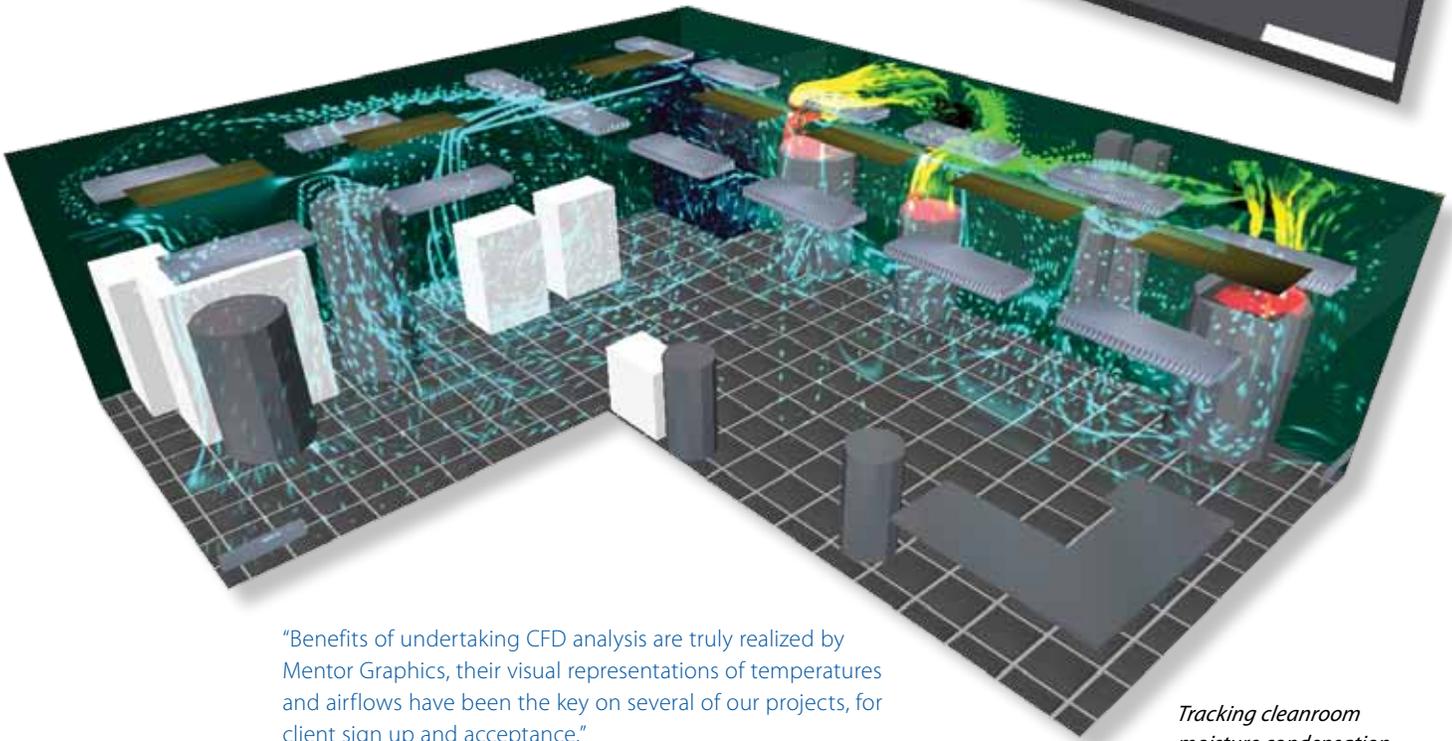
"Benefits of undertaking CFD analysis are truly realized by Mentor Graphics, their visual representations of temperatures and airflows have been the key on several of our projects, for client sign up and acceptance."

Derek Morgan, Technical Director, WSP Group Plc

Tracking cleanroom moisture condensation

Contaminant tracking within a cleanroom/pharmaceutical facility
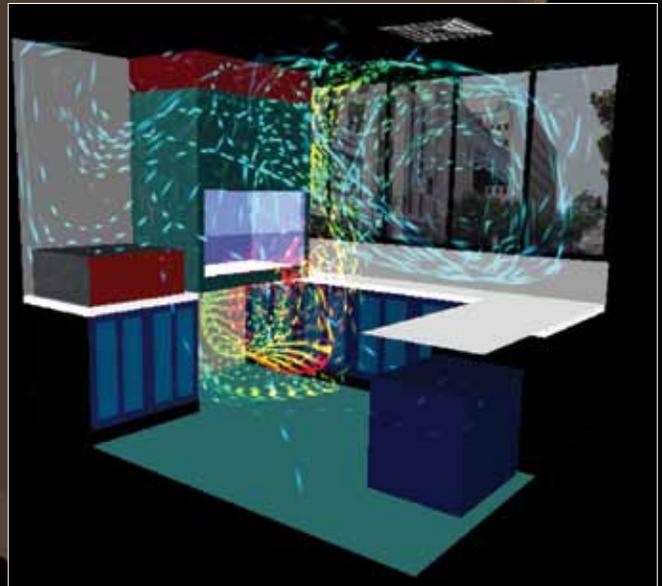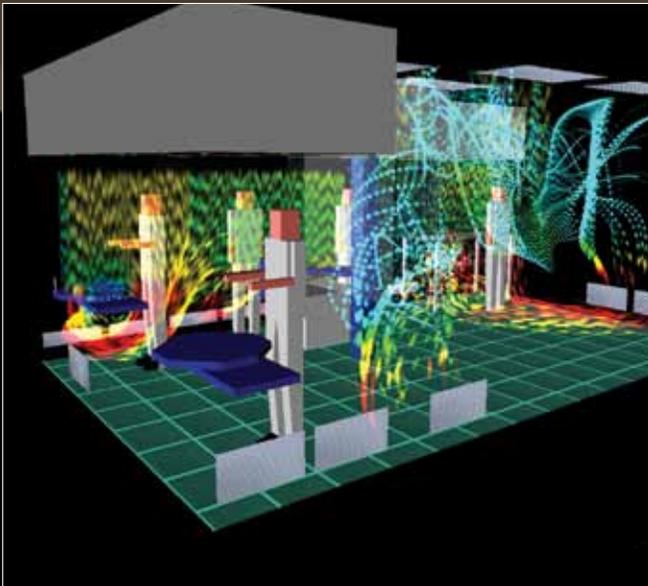
"We have found that applying airflow modeling technology in the design of our clients' cleanrooms has proved beneficial for reduction of capital costs, verification of design and optimization of operations, and has led to new design innovations, such as new concepts for 300mm manufacturing environments."

Douglas Cansdale, Cleanroom Design Specialist, CH2M Hill/DC

What we can do for you ...

Since 1988, companies worldwide have benefited from our Airflow Modeling Consultancy. Take your design and make it more efficient, eliminate the need for time-consuming and costly physical models; accurately predict thermal effect; maximize contamination control and reduce operating costs. Why not allow Mentor Graphics' Mechanical Analysis Division, the world leader in airflow modeling, to optimize your design?

DATA CENTERS

With the increasing use of electronic storage comes an increasing need for housing the necessary equipment. There is more and more need to optimize the space available to house the servers and other equipment necessary to meet the demands of the modern world. Adequate and effective ventilation in these areas is vitally important to ensure that equipment does not overheat leading to a failure and a huge financial cost. Increasingly the managers of these facilities are turning to airflow modeling during the design optimization process. Customers in this area have included IBM and Sun Microsystems.

To assess the cooling performance for a data center design FloVENT offers the ability to calculate the Cold Aisle Capture Index and Hot Aisle Capture Index. The Capture Indices measure how efficient a particular cooling strategy is, with 100% being optimal, and offer insight into which aspects of the ventilation system are underperforming from an airflow distribution perspective. These indices are in included in FloVENT under license from American Power Conversion Corporation.

OCCUPANCY COMFORT

The comfort of customers and passengers is a growing issue within the transportation industry and many service industries. Ensuring that your systems offer adequate levels of ventilation, heating or cooling can be a complicated task. Our Airflow Modeling Consultancy can run effective simulations of the inside of your atrium, office, aeroplane, train etc. and determine the comfort levels of your customers or employees. Our customers in this area have included SNCF, LIEBHERR-Aerospace and PSA Peugeot Citroen.

CONTAMINANT TRACKING

There are numerous situations where contaminant tracing is of crucial importance. Possibly the most obvious of these is in cleanroom environments and related situations where purity of the product is vital. We have been extensively involved in many such applications. Our Airflow Modeling Consultancy can build a model of your cleanroom and trace numerous contaminants through it. We can even trace the source of any contamination. Mentor Graphics' Mechanical Analysis Division have been involved in numerous projects in this area. Customers have included bioMerieux, NIH, Merck, Glaxo SmithKline and SGS Thomson.

EXTERNAL FLOW

Modeling airflow around buildings can be important for many reasons, such as pedestrian comfort or contaminant dispersal. Using airflow modeling makes it possible to check that design requirements are met without having to build expensive models for testing each time a design change is made. We have been involved in the external modeling of many buildings. Clients have included WSP and AMEC.
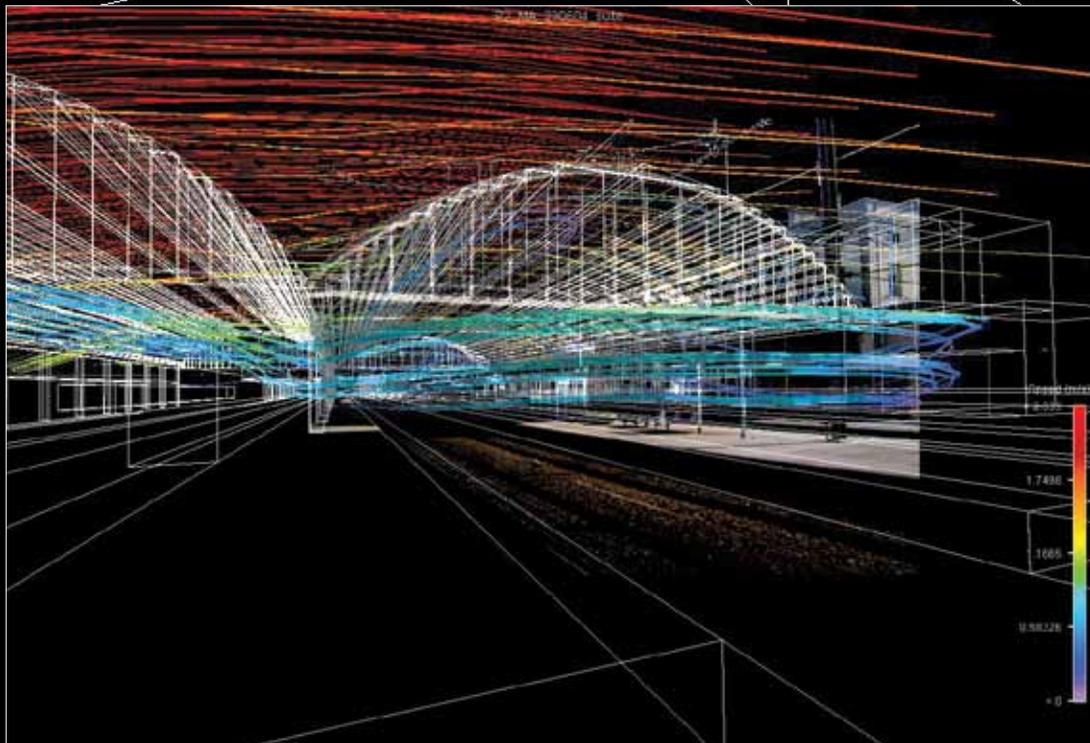
COMPREHENSIVE TRAINING AND SUPPORT

To ensure you get the most out of your investment in FloVENT, Mentor Graphics offers comprehensive telephone and e-mail technical support to licensed customers. Technical support goes far beyond answering installation questions; assistance with modeling questions, library queries and results quality confirmation are all fair game.

Whether you are a FloVENT user or a consultancy services customer, you can be confident that you are backed by the collective knowledge, practical experience and technical insight of Mentor Graphics' Mechanical Analysis Division, the world's leading authority in airflow modeling.

Pictures of a French Railway Station (Reims). This is a mix between simulation data and architectural drawing. Courtesy of Elioth - OTH.

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