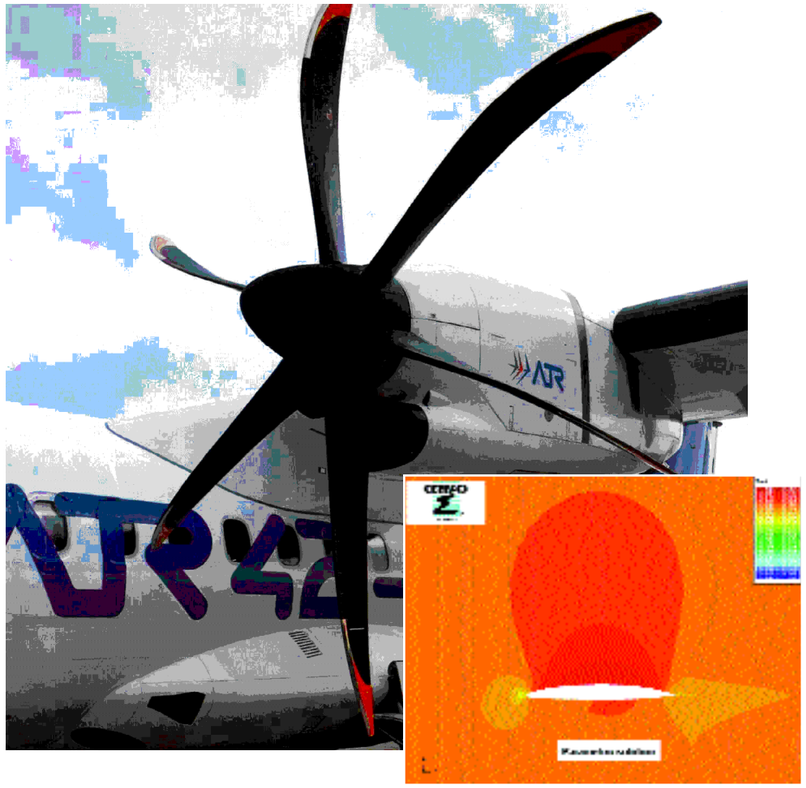
PDC Newsletter

SPECIAL ISSUE



Demands for fuel economy, speed, and serviceability translate into stringent requirements on aerodynamic performance for propellers on turboprop commuters like this ATR-42.

The design cycle of a new prop can be substantially shortened by the use of Computational Fluid Dynamics and Optimization software running on high-performance computers.

Ratier-Figeac, one of the partners in PDCTTN's OPTIBLADE project, uses the NACA16707 airfoil as a baseline design for further refinement. The pressure field around such an airfoil (white in this image) as computed by the OPTFLO software is shown in the second image.

HPCN and Industry

An Essential Tool for Development

In the same way that computers have evolved from filling a room to fitting onto the head of a pin, high-performance computing and networking (HPCN) has become more accessible to smaller organizations over time. As HPCN becomes easier to use, it is becoming an increasingly important tool for industrial development.

Computer simulation can help optimize the manufacture design of everything from steel cans to satellites. Imaging technology allows doctors to examine patients in ways that previously required surgery. Computer visualization can be used for increasingly accurate weather forecasting, which has broad implications for such industries as power and mass transit. Data mining and database management are highly relevant tools in the area of banking, retail, and mass communication.

PDC participates in a number of projects funded by industry and other nongovernmental sources. Included here is a brief overview of the umbrella organizations, with a few of the specific projects highlighted.

In This Issue

From the editor

Text

Björn Engquist
Director

E S P R I T and I S T

Information Technologies

Information technologies are critical to the competitiveness of all industries, both goods and services: IT is used in the design and manufacture of products, is incorporated into the products themselves, and underpins the way companies do business. Multinational corporations and SMEs (small- and medium-sized enterprises) alike need IT to operate effectively in the global marketplace. Europe's success depends on the timely take-up of IT by European industry, and on the ability of Europe's IT industries to provide appropriate products and services.

The European Commission created Esprit, an integrated IT programme of industrial R&D projects and technology take-up measures, to facilitate the user-supplier collaborations that stimulate innovation. Esprit forms part of the Fourth RTD (research and technological development) Framework, which ran from 1994 to 1998. It is managed by the Directorate General for Industry of the European Commission (DG III).

The Information Society Technologies Programme (IST) is a major part of the European Union's Fifth RTD Framework Programme, which will run from 1998 to 2002 and which is managed by DG XIII. IST is conceived and implemented as a single and integrated programme that reflects the convergence of information processing, communications, and media technologies.

More information:
<http://www.cordis.lu/esprit/>
<http://www.cordis.lu/ist/>

JAVA- and CORBA-Based Collaborative Environment for Coupled Simulations

JaCo3

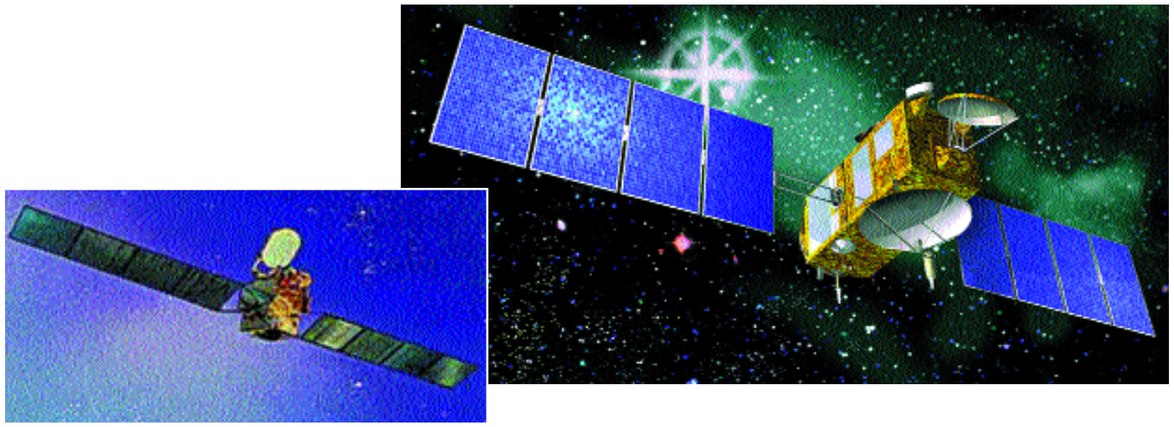
Problem

Availability of low-cost high-performance computing techniques allows many users to exploit simulation in design to reduce development cycles and costs, while optimizing the behavior of the final system. Although simulation tools are now common to solve problems in a large set of activities (e.g.,CFD, CEM,CMD),they do not easily allow a global design that couples interrelated physical phenomena. The current approach also does not easily allow different engineering departments to collaborate on the same design, sharing experience and exchanging solutions. This is even more problematic when equipment providers and subcontractors become involved.

Solution

A solution for this problem is to couple codes, exploiting available resources in a distributed way to simulate different physical behaviors, collate the results, and find a global optimized solution. Coupling codes implies the development of software components with their given interfaces to be executed on distributed resources. Analyzing the results then implies collaboration of experts from different fields.

To be successfully introduced in engineering departments, such an approach must rely on existing industrial environments, bringing added value to existing systems rather than changing everything. The solution must be adapted to the current end-user practice ä



When a satellite includes an optical system, many physical parameters must be considered. The optical system should provide consistently high-quality images under difficult conditions (e.g., temperature variation, high-frequency vibrations, aging), and it should also weigh very little and consume very little energy.

Such systems are designed under simulation based on different codes, which further complicates the process. JACO3 couples these codes in order to refine the accuracy and stability of the system's pointing performance. Coupling the codes allows global optimization, by considering the satellite's global behavior due to all of the physical parameters.

and must exploit available physically distributed computing and human resources.

Objective

The objective of the JACO3 project is to address these needs from the industry by assessing the effectiveness of using a collaborative working environment in the scientific simulation design process by coupling existing codes and visualization systems. JACO3 addresses the needs of the aerospace and automotive industries when designing complex products.

The integration of software components into a single application already occurs in other domains, thanks to the recent development in distributed object-oriented technology, the Common Object Request Broker Architecture (CORBA). On the user side, to overcome platform dependency problems, the JAVA language is another new standard supporting the communication between users and applications. Both are well connected and both are now mature enough to be well accepted.

The JACO3 project will set up a framework for running multi-site high-performance computing environments and will determine its cost benefits when applied to specific coupled engineering problems from the industry. The JACO3 environment will be an open portable CORBA architecture exploiting JAVA to access the applications. It will allow independence from hardware and software vendors and will allow the reusability of existing HPCN tools for collaborative simulations. It will draw on experiences already gained by the different partners in HPCN, in both distributed environments and distributed visualization. Special emphasis will be given to coupled simulations as well as providing small- and medium-sized companies (SMEs) with remote access to large parallel computing facilities. The JACO3 environment will support the analysis of the results of coupled simulations via a distributed visualization toolkit.

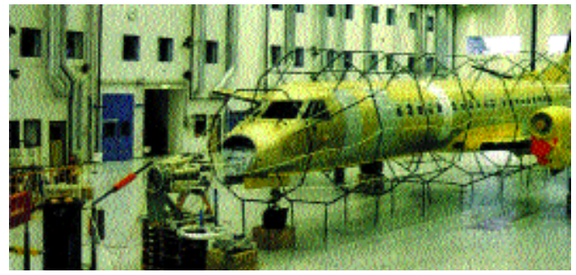
Results

The resulting infrastructure will increase the accessibility of applications based on HPCN for the European industry, not only at the research and evaluation phase but from initial design to maintenance. It will make possible the use of a combination of different simulation tools, possibly from different companies, where each tool is optimized for a certain part of a system and can be delivered as a black box by the manufacturer of the part without revealing any details. This will be translated into shorter design time, optimized system, reduction of physical prototyping and testing and, consequently, in cost savings and faster time to market.

More information:
<http://www.arttic.com/projects/jaco3>

EMC Parallel Parameterization

EMCP²



The compatibility of electromagnetic devices is currently an important issue in the automotive and aviation industries. The EMCP2 project has resulted in a method whereby the placement and interaction of electromagnetic devices can be optimized using computer simulations and then validated using measurements.

Electromagnetic compatibility (EMC) has become an important problem, particularly for the automotive, aircraft, and electronics industries. This is becoming a prominent issue for a number of reasons, including the introduction of sophisticated electronic equipment, the replacement of mechanical commands by electronic ones, the use of composite materials, and new legislation. Most EMC problems are currently solved through experimental studies, but computer simulation has recently started to be used more frequently. Simulation is still very complex, and developing an optimal solution can be very time consuming.

The EMCP2 (EMC Parallel Parameterization) project has resulted in an innovative technique and tool for parameterizing EMC design. The optimization tool, which uses simulation on MIMD computers with message-passing approach, gives interactive simulation facilities to the CAD system that was used in the initial design. It allows EMC specialists to directly solve the EMC problems and to interactively achieve an optimal design.

The technique and tool have been validated using applications from different industrial sectors (helicopters, cars, and aircraft). The validation has been established by comparing simulation results with measurements taken either in an anechoic chamber or in an open-air EMC test range.

The parameterization technique is based on the computation of a Taylor polynomial to approximate and optimize a solution. From an initial design made with a CAD system, one or a few numbers of polynomials are built and integrated back into the CAD system to allow the EMC specialist to manipulate the design and to determine the optimal solution. The automatic computation of the Taylor polynomial is based on the inversion of a complex matrix and on the high-order differentiation of the same matrix.

The differentiation and storage of the matrices and the solution of the accompanying large linear systems require computational resources only offered by parallel computers. High-performance computing is indispensable in implementing these algorithms, and large message-passing parallel architectures are particularly well adapted for the proposed solutions.

For more information, see
<http://www.arttic.com/menu.html>
then choose "Projects," then "EMCP2."

P D C T T N

Technology Transfer Nodes

In today's competitive world, success depends on making things better, quicker, and more reliable. Small- and medium-sized enterprises (SMEs) often do not have the resources necessary to investigate and deploy the latest solutions. Such solutions are however essential to satisfy customers' ever-increasing demands.

The European Commision's HPCN Programme is supporting a diverse network of Technology Transfer Nodes (TTNs) to target SMEs and to work in partnership with industry to provide novel, computer-based solutions to real business problems.

The mission of the HPCN TTN Network is:

– To make industry in Europe, particularly SMEs, more competitive through the early adoption of HPCN technology;
– To promote that early adoption through the support of demonstrators, pilot projects,and dissemination of business benefits;
– To establish a European network supporting the EU-wide deployment of HPCN technology.

The cost of computing has dropped dramatically. Today's high-end 2,000-ECU PC has the performance of a supercomputer costing 100,000-ECU at the start of the 1990s. Solutions that were unattainable for small companies just a few years ago are now both cost-effective and affordable. The TTN network provides the expertise to bring these new solutions profitably into your business.

TTNs are distributed geographically throughout Europe. They have also been organised into groups specific to certain market sectors.

For more information, see
<**http://www.pdc.kth.se/pdcttn/**>

A Better Image for Architects

Computer simulations of architectural designs, like these provided by 3DEMO, allow all the participants in a construction project to view and analyze the plans to a degree that has not been possible before.

The problem

Architects often complain that they cannot visualize and analyze plans for new buildings sufficiently well given reasonable cost constraints. Most currently available CAD systems do not perform well enough for their needs. The hardware and software are too expensive and too difficult to use. Lower-cost alternatives are available, but these are often incompatible with established CAD systems.

The Solution

3DEMO provides an integrated framework for the cost-effective visualization and analysis of buildings. 3DEMO is based on existing CAD systems and standards. It enables cost-effective design, construction, and facilities management. In 3DEMO, smart compression tools, such as polygon reduction, have been combined with powerful algorithms for 3D modeling and visualization.

Architects can take pictures of buildings, automatically generate CAD models, and then visualize them using virtual reality. 3DEMO makes it possible to render a new building, in its actual setting, with photorealistic quality. This allows architects, customers, planners, and engineers to use commonly accessible images in their discussions of building plans.

Further information on this project:
<**http://www.pdc.kth.se/pdcttn/eng/IndSol/ImpHpcn/3demo/**>

Similar activities can be found through
<**http://www.pdc.kth.se/pdcttn/**>
then choose "business improvements,"
then "Building and Construction Industry."

P D C T T N

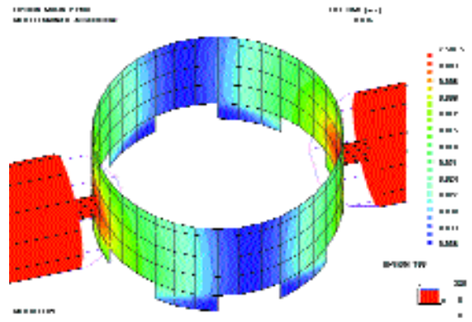
Injecting Profits into Plastic Molding

Injection molding is the predominant technique for the production of molded plastic materials. Obtaining the best choice of materials and tool design demands very close cooperation among designers,tool makers, and injection molders. Optimizing the process involves more than ten related factors with complex interrelationships.

In the practice of designing injection molding tools, intuitive decisions are made – based on the designers' experience – and the first tool offering satisfactory quality is accepted in order to save time. The result is that the majority of production processes are not optimized. This leads to significant manufacturing overheads.

Simulations and process analysis have shown savings in production time ranging from 10 to 30 percent when plastic molding machines are optimally adjusted. These savings can be achieved by identifying the right plastic to use and by making simple modifications to the cooling of equipment.

New techniques developed in the OPTIMOM project are making it feasible for even the smallest companies to take advantage of these optimizations.



Co-injection molding of a cog-wheel. The cogwheel is injection molded in two steps with different materials in each. There are three main problems with this product: thickness of the different materials, design of the tool concerning inlets, and processing parameters.

Further information on this project:
<**http://www.pdc.kth.se/pdcttn/eng/IndSol/ImpHpcn/Optimom/optimom.html**>

Similar activities can be found through
<**http://www.pdc.kth.se/pdcttn/**>
then choose "business improvements,"
then "Machinery Industry."

Old Films Restored to Former Glories

Classical manual film restoration is based on special printing machines that improve the quality of copies of old films and increase their keeping properties. Only a few commonly occurring defects can be removed with this method, which is very labor-intensive and unacceptably expensive. Semi-automatic digital film restoration software is too slow for industrial use.

FRAME is a high-speed, digitial, cost-effective film restoration system that addresses these problems. FRAME's costs for digital film restoration are close to those of analogue technologies, but it also has greater flexibility and a wider range of capabilities than its analogue counterparts.

Because a single movie frame can be as large as 45 MB, and a computer should process 1 frame per 10-20 seconds, the speed needed for restoration can only be achieved using parallel computing.

FRAME was designed in collaboration with Laboratoires NEYRAC Films (LNF), one of the main French private restorers of archived film.

Samples of restored film frames

Further information on this project:
<**http://195.89.151.88/ttn/video/frame1.html**>

Similar activities can be found through
<**http://www.pdc.kth.se/pdcttn/**>
then choose "business improvements,"
then "Film and Video Industry."

P S C I

Parallel and Scientific Computing Institute

Numerical methods and scientific computing are becoming increasingly important for modern industrial product development. The Parallel and Scientific Computing Institute (PSCI) was created to improve the interaction between academia and industry and to strengthen Swedish efforts in industrial applications of high-performance computing.

PSCI research projects are joint undertakings that include contributions from industrial partners, graduate students, and senior scientists. Projects must be motivated both by industrial needs and by theoretical development suitable for Ph.D. thesis work.

Formally, PSCI is a center of excellence funded by an industrial consortium, NUTEK, KTH, and Uppsala University. The industrial partners include large Swedish companies as well as smaller enterprises.

More information:
<http://www.psci.kth.se/>

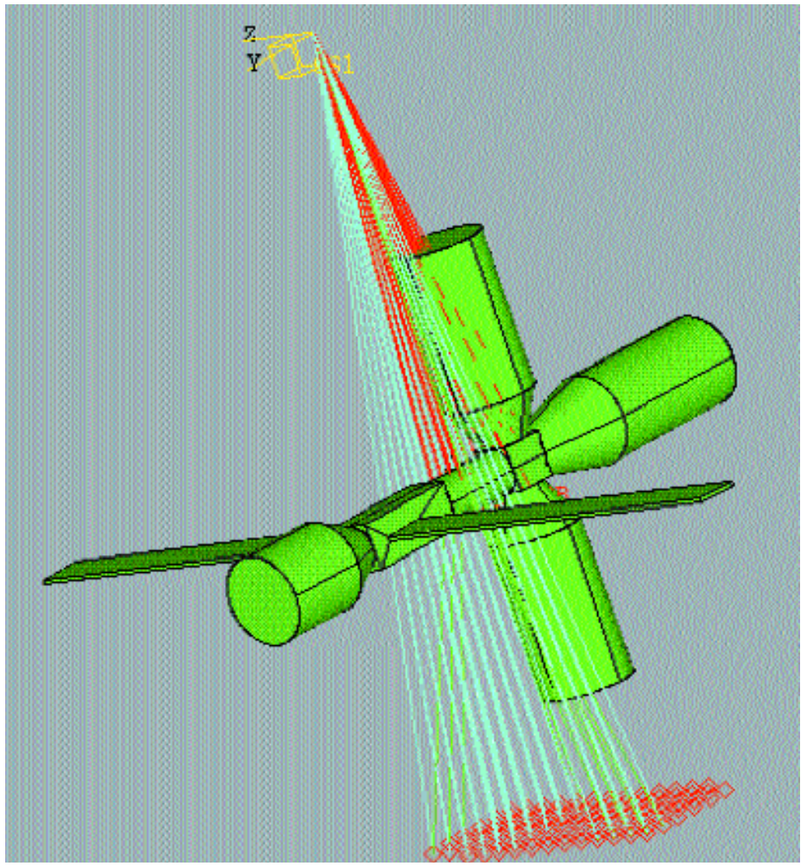


Fig. 1 *A point source is situated above a generic satellite. The shortest direct and reflected path between the source, indicated by the yellow coordinate system, and the observer points underneath the satellite are searched for in the ray tracer. The direct and the reflected GTD (Geometrical Theory of Diffraction) fields are summed up at the observer points. Green rays follow the reflected field, blue the direct, and the red rays indicate occulted direct rays.*

P S C I

GEMS: General ElectroMagnetic Solvers

The researchers in the General ElectroMagnetic Solvers project, or GEMS, are developing general-purpose time domain (TD) and frequency domain (FD) hybrid codes, as well as a waveguide mode solver. The project's objective is to develop a state-of-the-art software suite on the international level that forms a platform for future development by Swedish industry and academia.

The TD and FD hybrid codes are parallelized using Message Passing Interface (MPI), and they run on a variety of parallel computers. Although the codes are general, the primary applications are antenna analysis, scattering, and electromagnetic compatibility (EMC) computations. In addition to the code development, there is a large supporting research program running. The research is based on topics that should support the code development in the short term; should provide research in potentially interesting fields; and could increase the accuracy, performance, and functionality of the codes in the future.

The partners in the project are the Royal Institute of technology (KTH), Uppsala University (UU), The Institute for Applied Mathematics (ITM), the Defense Research Establishment (FOA), Ericsson Microwave Systems (EMW), Saab Ericsson Space (SES), and Ericsson Saab Avionics (ESB). The main code development of the solvers is done by KTH, UU, and FOA, and the industrial partners act as end users with the task of validating the software in complicated cases.

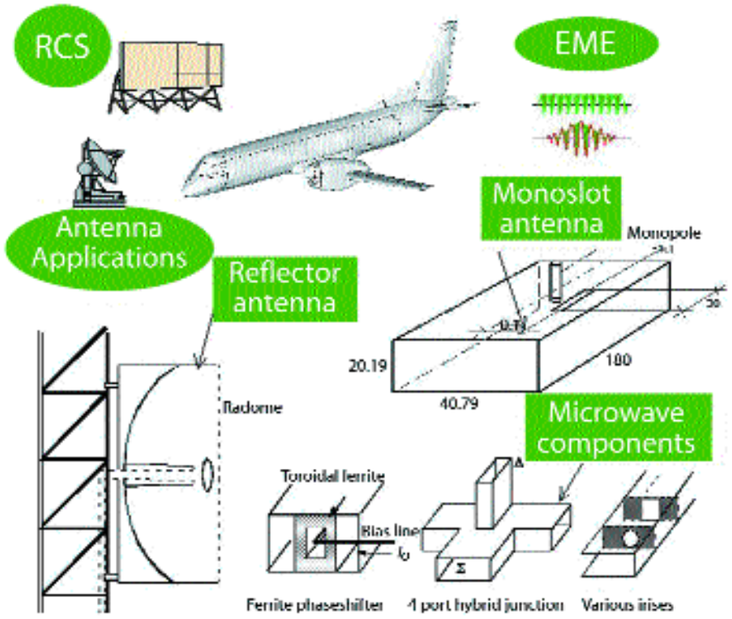
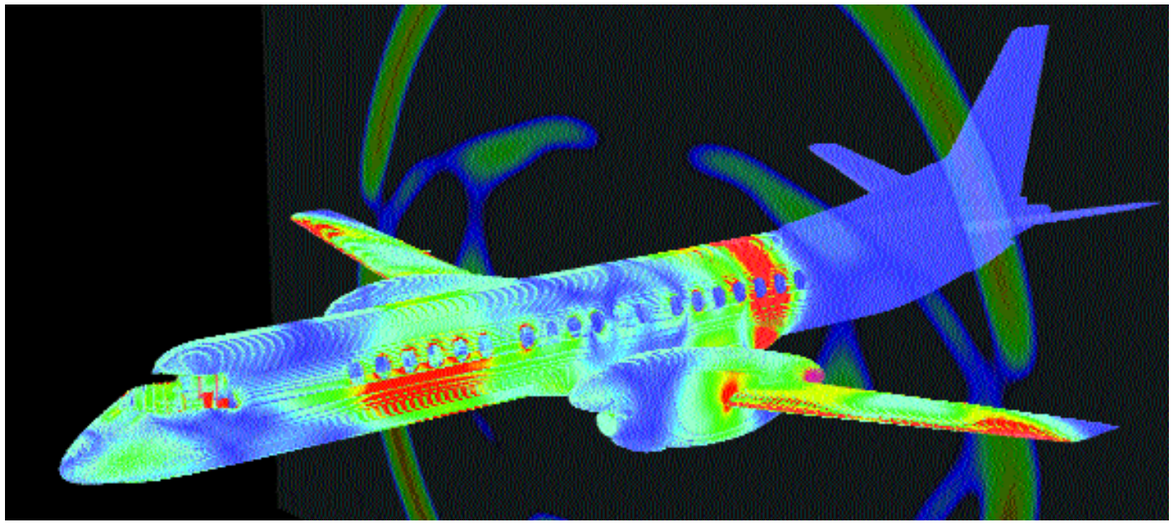


Fig. 2 *Applications in the GEMS project are aircraft and antenna analysis. The aircraft application are in the whole frequency band from low-frequency applications, such as lightning, to high-frequency applications, such as radar cross-section analysis. This is also true for the antenna applications involving design and performance analysis.*

The codes will be validated on applications defined by ESB, EMW, and SES. The applications by ESB will mainly be on aircraft analysis, such as radar cross-section analysis (RCS), and electromagnetic effects (EME), such as lightning and antenna analysis. For EMW and SES, the focus will be on antenna and microwave analysis.

More information:
<http://www.psci.kth.se/Programs/GEMS/>



Billion-Cell FD-TD Simulation of Lightning Striking an Aircraft

Fig. 1 *Surface currents after 1500 time steps on the SAAB 2000 aircraft. Also shown is the magnitude of the magnetic field on a cutting plane across the wings perpendicular to the fuselage.*

Editor's Note:

This simulation of a lightning strike to an aircraft is one of the many examples of a collaboration between industry and academia that is well suited for application in PDC's Cube, an immersive visualization environment.

Ulf Andersson and Gunnar Ledfelt, Department of Numerical Analysis and Computing Science, KTH

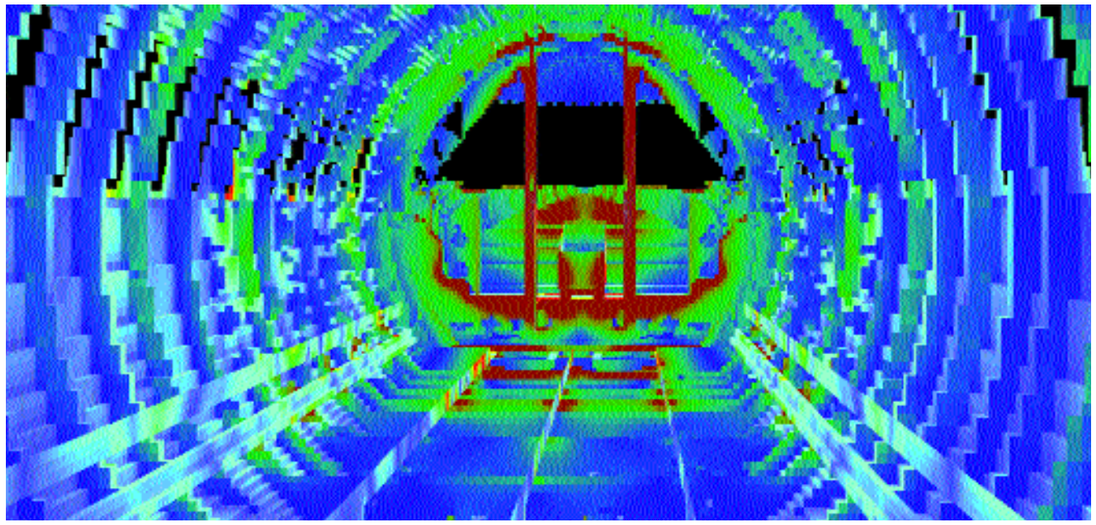
On average, every aircraft is struck once every year by lightning – whose current can be as high as 200,000 Amperes. A lightning strike results in high surface currents on the exterior of the fuselage. The currents also leak through the windows into the aircraft interior, where they can induce high currents on wires. These induced currents can damage or destroy electronic equipment, if the equipment is not designed to withstand these threats. Because modern aircraft are equipped with increasingly more electronic devices, there is a need to predict the electromagnetic environment of the aircraft. Designers are interested in finding "hot spots"– areas with high surface currents – in order to determine suitable cable placement inside the aircraft.

To solve the Maxwell equations, we use the Finite Difference – Time Domain (FD-TD) method, which is a second order leap-frog scheme using staggered grids. The object of interest (in this case, the aircraft) is embedded in a Cartesian grid, and the object is modeled by approximating the geometry in a LEGO fashion.

The total number of cells used is 1,008,126,000 (1260x1260x635), and the number of time steps is 2500. We ran the code on 125 nodes with 160MHz RS/6000 processors of the IBM SP at PDC. The parallel implementation of the code uses the Message Passing Interface (MPI) standard,and the computational domain is split into 5x5x5 blocks, where each block is put on one processor.

The performance of the code is almost 25 Gflop/s for the total time-stepping procedure. This corresponds to 1.6 seconds per time step, for a total of 66 minutes.

We have run the result of this simulation in PDC's VR-CUBE, a 3x3x2.5-m fully immersive six-surface visualization environment.



This has been very successful, and it has proved enlightening for both the academic researchers and the industrial engineers. Both groups can literally stand "inside" the computational output and experience it simultaneously, instead of simply viewing it on a two-dimensional screen. This has allowed us to share ideas and knowledge and answer each other's questions in ways that have not been possible previously.

More information:
<**http://www.nada.kth.se/~ledfelt/CEM/SC98/sc98.html**>

Fig. 2 *Interior of the SAAB 2000 aircraft. Surface currents are shown at the same time as in figure 1. The view is from the center of the aircraft towards the cockpit. High surface currents are seen on the door pillar and the threshold.*

The standing section of short tips and tricks for users

README

- **Multiprocessor nodes on StrindSubmit.** To submit jobs for execution on the SMP nodes, specify M as the type of node, e.g., **`spsubmit -p 4M -t 120 <filename>`**. You can submit SMP jobs from either log-in node (Strindberg or August).
- **Spattach.** To attach to the interactive silver nodes, enter **`spattach -p 4M -i`**. Then enter, e.g., **`poe <filename>`** at the next command line.
- **GPFS.** GPFS has replaced PIOFS as the SP-system-wide scratch file system.GPFS is a single-system-image file system. You can get further information about GPFS through the Web documentation. Choose "SP resource center," "Online books," and finally "GPFS." We currently have the physical GPFS disks attached to six nodes.

  In order to see the current setup of the GPFS disks, enter **`module add mmfs`** and then enter **`mmdf gscr`** at the next command line. With GPFS it is simple for staff members to modify the setup on the fly, e.g.,increase the number of disks, remove disks, etc.
- **SMP Submit.** In case you need to run an ordinary MPI job on the SMP nodes but you don't have a threaded application, you can submit the script found in <**/usr/local/easy/sample/smp-submit-sample.bash**> to expand the hostlist and number of processors by a factor of four.
- **BSEND/ISEND/IRECV.** Are you using non-blocking communication in MPI on Strindberg? If so, setting the environment variable **`MP_CSS_INTERRUPT`** to **`"yes"`** might give you even better performance. If the flag is set before you submit the job, it will be enforced at execution if you are using the **`-j mpi`** flag to **`spsubmit`** . E.g.,in tcsh:

  ```
  setenv MP_CSS_INTERRUPT "yes"
  spsubmit -j mpi -p 4 -t 30 mympiprog
  ```

  For more information, read the documentation on IBM Parallel Environment at <**http://www.pdc.kth.se/doc**>.

B

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VETENSKAP OCH KONST
KTH

PDC Newsletter

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