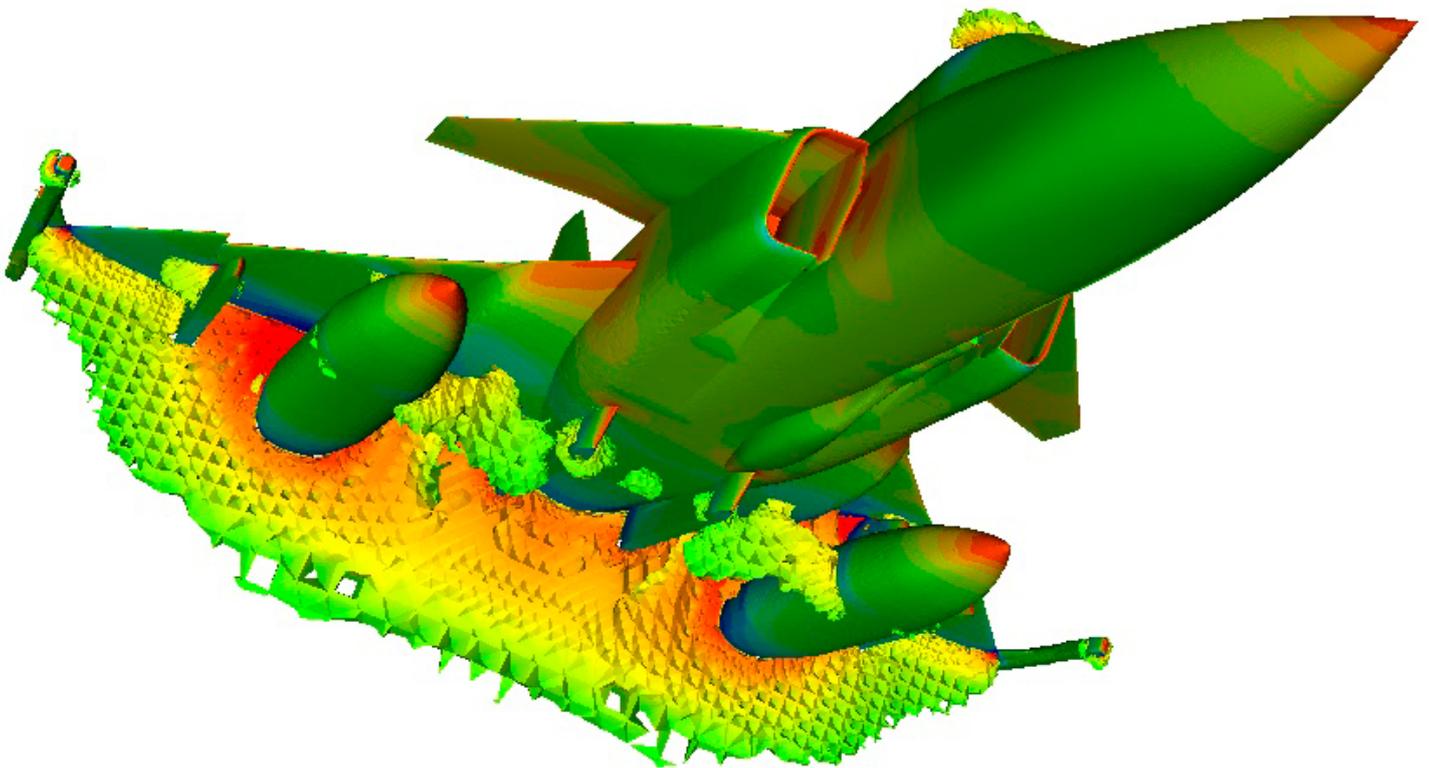


Flow at Saab



Large scale aerodynamic flow calculations at Saab

Today Computational Fluid Dynamics (CFD) plays an important role in the aerodynamic design and analysis of an aircraft says Per Weinerfelt at Saab Aeronautics.

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Porting and optimization of codes for Tier-0 PRACE systems

NSC will provide expertise to users for porting and optimizing their codes to effectively utilize the PRACE Tier-0 systems.

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Application experts in focus

Super-computing at NSC and in Sweden now increasingly is focusing on application experts. These skilled persons are able to help our users to more efficiently utilise the HPC resources. At NSC, we are currently in the process of employing two applica-

tion experts in material sciences that will be of great importance to the new MATTER cluster that will be inaugurated during autumn. Thus, NSC will by the end of 2010 have six application experts in different scientific fields, which will provide an important addition to the NSC support to our users. Furthermore, NSC together with PDC within the framework of SeRC (Swedish e-Science Research Centre) arranges the first national workshop for application experts, to be held in Linköping 2–3 December 2010. This workshop will be important for getting the application experts at the various SNIC centres to better know each other, which will pave the road for efficient and user-friendly support at a national scale. It will also be discussed how the application support should be optimally organised and how the combined knowledge is disseminated among the experts and the users.

The EU project PRACE for peta-scale computational resources in Europe has now reached its first implementation phase. During this 2-year period, selected users will get help with porting codes for the massively parallel systems. NSC will provide this support with our application experts and computational scientists. At the same time, we are now planning for the second implementation phase that will start mid-2011. This second phase will in Sweden involve all six SNIC centres, where we will coordinate and sub-specialise the support. Also in the second phase, much emphasis is on optimising of codes in order to utilise the HPC resources more efficient. More about PRACE in a separate article in this issue.

Thus, it is with great pleasure we at NSC now will be able to provide increased application support to all our users and that NSC also will help users in the future European HPC landscape.

BENGT PERSSON, NSC DIRECTOR

New production system at SMHI

During the summer, NSC has installed SMHI's new production forecast cluster Byvind on-site in Norrköping. The cluster has 140 compute nodes (HP SL2x170z G6), each with dual quad-core Intel Xeon X5550 processors at 2.66 GHz and 24 GiB of RAM. As this is an SL6000 system, two nodes make up a 1U tray, and two trays are stacked on top of each other in a z6000 chassis, sharing power supplies and fans. Eight Voltaire InfiniBand switches provide a non-blocking 4X QDR network, while a SATABeast with 42 disks at 2 TB each provide RAID-protected storage.

The Byvind cluster operates in tandem with the two years old Bore cluster located at NSC in Linköping, with the most important operational forecasts being run on both systems to provide high-level redundancy. Each Byvind core is on average about 50–100% faster than a Bore core depending on what application is run. As the system contains double the amount of cores, it is roughly three-four times as fast as Bore.

Thanks to Byvind's greater capacity, it will be possible to increase the resolution of the meteorological and oceanographic models. At the same time, a next-generation numerical weather prognosis model called HARMONIE can be phased in. This model has been developed as a European cooperation with Sweden being an active part. On the oceanographic side, SMHI is planning for ensemble runs for forecasts up to 10–15 days, which will mainly benefit winter navigation.

KENT ENGSTRÖM



Staff highlight

As Technical Director at NSC I am responsible of the daily operation and I see to that the work flows as smoothly as possible. I am also heavily involved in the procurement process of all large purchases and in keeping the activity and economy at NSC coordinated. Let me tell you, NSC always keep me more than busy.

My interest in computers started about 1980. My first computer was a Commodore 64 and I was soon excavating the possibilities of assembler programming. I started working with computers taking care of the Parsytec system. Back then, I was involved in my research at the Computer Science Department at LiU. When NSC purchased the Cray T3E and Cray T3E I was heavily involved in system administration of those systems.

Large scale aerodynamic flow calculation

Computational Fluid Dynamics (CFD) plays today an important role in the aircraft industry both in the aerodynamic design and analysis of an aircraft. At Saab Aeronautics CFD calculations are performed regularly on PC clusters which have been designed and built by NSC. The applications are mainly external inviscid/viscous flow calculations around a complete aircraft or internal flow calculation in an air intake or nozzle. The number of grid points, which are necessary for obtaining a good space resolution of the flow field, is typically 5 – 30 million and the computing time is between a few hours up to several days. We will in the following sections describe some recent applications at Saab in which CFD has been used.

Aerodynamic design in the EU project Clean Sky

The organization ACARE – Advisory Council for Aeronautics Research in Europe which is the European Technology Platform for Aeronautics & Air Transport has set up the following goals to be reached in 2020:

- 50% reduction of CO₂ emissions through drastic reduction of fuel consumption
- 80% reduction of NO_x (nitrogen oxide) emissions
- 50% reduction of external noise

As a result of these goals the Clean Sky JTI (Joint-Technology Initiative) was launched in 2008. It is one of the largest European research projects ever, with a budget estimated at €1.6 billion, equally shared between the European Commission and industry, over the period

2008 – 2013. The aim of the project is to speed up technological breakthrough developments and shorten the time to market for new solutions tested on Full Scale Demonstrators. Of particular interest is the design of new greener aircraft, by the introduction of green technology into aviation, which is essential to protect the environment. The Clean Sky JTI is made up of 6 Integrated Technology Demonstrators (ITD).

- **SMART Fixed Wing Aircraft (SFWA)** will deliver active wing technologies and new aircraft configurations.
- **Green Regional Aircraft** will deliver low-weight aircraft using smart structures, as well as low external noise configurations and the integration of technology developed in other ITDs, such as engines, energy management and new system architectures.
- **Green Rotorcraft** will deliver innovative rotor blades and engine installation for noise reduction, lower airframe drag, integration of diesel engine technology and advanced electrical systems for elimination of noxious hydraulic fluids and fuel consumption reduction.
- **Sustainable and Green Engines** will design and build five engine demonstrators to integrate technologies for low noise and lightweight low pressure systems, high efficiency, low NO_x and low weight cores and novel configurations such as open rotors and intercoolers.
- **Systems for Green Operations (SGO)** will focus on all-electrical aircraft equipment and systems architectures, thermal management, capabilities for "green" trajectories and mission and improved ground operations to give any aircraft the capability to fully exploit the benefits of Single European Sky.

- **Eco-Design** will focus on green design and production, withdrawal, and recycling of aircraft, by optimal use of raw materials and energies thus improving the environmental impact of the whole products life cycle and accelerating compliance with the REACH directive.

Saab Aeronautics is participating in Clean Sky in two ITDs SFWA and SGO. Aerodynamic design and analysis is carried out in SFWA where Saab is working on designing laminar wings, i.e. wings with low aerodynamic drag, and innovative pylon design for an aircraft with a Counter Rotating Open Rotor (CROR).

The laminar wing design is based on an optimization process in which the total drag is minimized under constraints on the aerodynamic lift and the geometry. A large number of viscous flow calculations together with boundary layer stability calculations, which are used to predict the transition where the flow switches from laminar to turbulent flow, are performed in each optimization step.

The aim of the innovative pylon design is to construct a pylon which reduces the unfavorable interference between the wake from the pylon and the CROR blades. Such a design will reduce the noise from the propeller. A way to achieve this is to introduce a trailing edge (TE) scoop inlet on the pylon according to fig. 1.

The results from the analysis of the flow over the original and innovative pylon are shown in figure 2 and 3. Observe the reduction of the wake from the pylon in fig. 3 compared to the one in fig. 2.

My first computer
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upercomputer

NSC entered a new era in 1999 when we started to design and build Beowulfs; high performance clusters out of commodity components and assembling the entire software stack using Linux as the foundation. It is only eleven years ago but it feels like a lifetime. With clusters we were able to take more responsibility of the service we delivered. Using open source software we could be in charge of solving issues and problems and not only be the middle-man between users and vendors.

I enjoy working among all highly skilled co-workers at NSC. We run a number of large, well designed and highly utilized computing and storage resources. We have a good focus on user needs, resource availability, integrity and security and we are driven by the goal of doing better, to improve. I am proud of NSC. NSC is infrastructure that works.

NICLAS ANDERSSON

tions at Saab

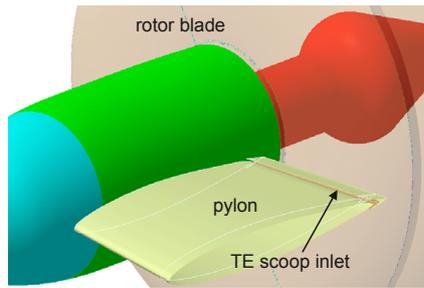


Figure 1: Innovative pylon design.

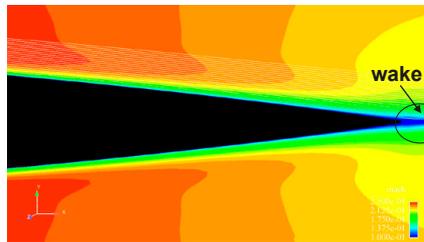


Figure 2: The 2D flow velocity over the original pylon.

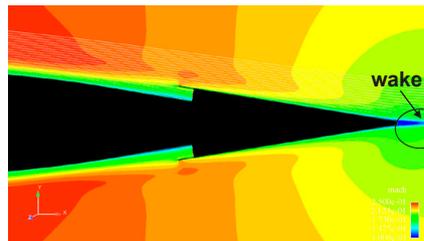


Figure 3: The 2D flow velocity over the innovative pylon.

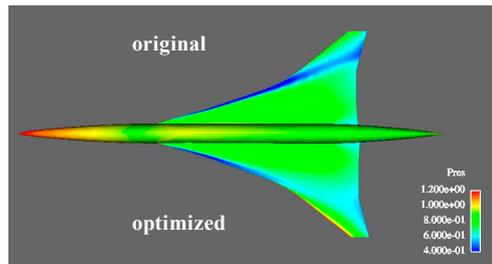


Figure 4: Pressure distribution on the upper surface of the original (top) and adjoint optimized (bottom) SCT geometry.

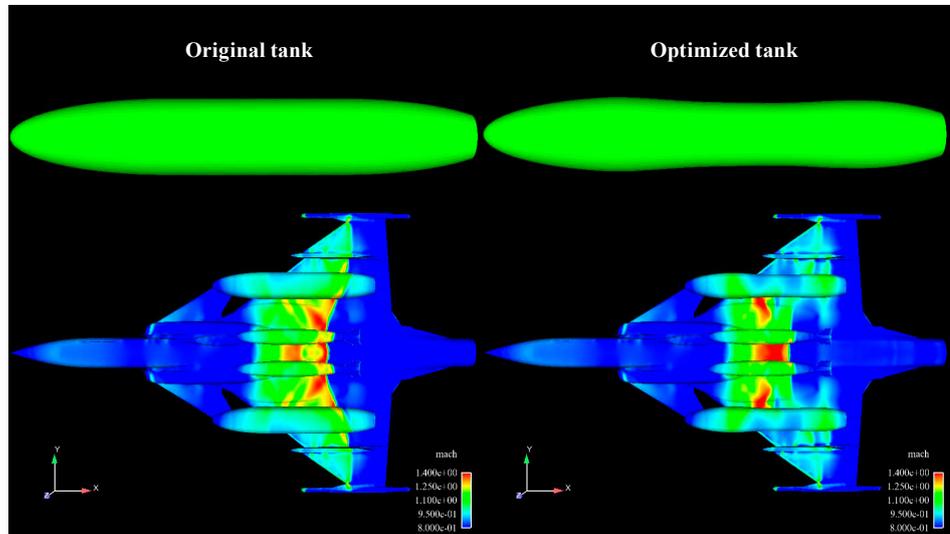


Figure 5: Original and optimized drop-tank and the Mach number distribution on the low surface of the aircraft before and after optimization.

Aerodynamic Shape Optimization

The rapid development of efficient numerical algorithms for solving inviscid and viscous flow problems, together with the improved hard-ware capacity, has led to increasing interest in optimizing aerodynamic shape coupled with inviscid or viscous flow equations. Of particular interest is the so-called adjoint technique for gradient based optimization. This technique enables

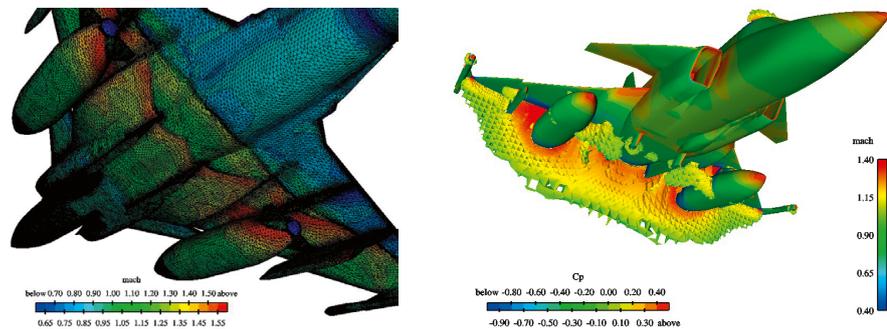


Figure 6: Simulation of transonic flow around Gripen aircraft using turbulent flow modelling.

efficient gradient computations, with a computing cost independent of the number of optimization parameters. A system for aerodynamic shape optimization, cados, has been developed at Saab, partly within the European project Aeroshape. The cados system runs efficiently on different types of computer clusters using MPI and can exploit two levels of parallelism. First,



New staff member

Hi, My name is Margareta Klang and I am a new member of the NSC staff since September 2010.

I will be working full time as an administrator. Prior to NSC I worked as a project coordinator at VTI – Swedish National Road and Transport Research Institute in Linköping. Before that I worked as a research administrator at Linköping university at ITN – The department of Science and Technology .

I am looking forward to work with all of you at NSC!

MARGARETA KLANG

each flow and adjoint flow calculation necessary for the gradient calculations are executed in parallel. On the second level, calculations associated with different physical objective functions or constraints are executed in parallel.

The cadsos system has been applied in several projects at SAAB, both internally and in cooperation with international partners, and two of these will be briefly mentioned. In the Aeroshape project, the body and wing of a supersonic commercial transport (SCT) aircraft were optimized with respect to low drag, with constraints on the lift and the geometry. Figure 4 shows the pressure over the original and optimized SCT aircraft.

In the Gripen development, aerodynamic shape optimization was recently used to design a drop-tank, creating minimum interference drag on the aircraft. The shape of the original and optimized drop-tank and correspond-

ing velocity field on the aircraft are shown in Figure 5.

Aerodynamic computations related to the development of Gripen

In the 1990's, the models increased in size when increased computer capacity and more advanced physical modeling became feasible. Unsteady aerodynamics and turbulent flow modeling was introduced into aerodynamic design during the late 1990's. CFD computations at Saab related to Jas 39 Gripen is today used for inviscid and turbulent viscous aerodynamic and aeroelastic analysis, modifications of external or internal parts of the aircraft and development of aero data which is necessary for flight mechanical simulations and structure analysis. A recent flow simulation around the Gripen using turbulent flow modeling is shown in Figure 6. The model size is 20 million grid points and a typical run time is 70 h using a PC-cluster with 32 processors.

Summary

CFD is today a powerful tool for aerodynamic analysis and design of an aircraft. Typical applications are calculations of the external flow around an aircraft, internal flow in air intakes and nozzles and analysis of aeroelastic problems. Such calculations are performed frequently at Saab Aeronautics thanks to efficient numerical algorithms and the computer resources which have been provided by NSC.

PER WEINERFELT

Per Weinerfelt is Docent in Applied Mathematics at Linköping University. He is presently working as a Technical Fellow in Numerical and Mathematical Modeling at Saab Aeronautics in Linköping.



Porting and optimization of codes for Tier-0 PRACE systems

PRACE, Partnership for Advanced Computing, is an EU project aiming at providing European scientists with extremely high performance computing systems, currently in the petaflop range. The 1st implementation phase (PRACE-1IP) started 1 July 2010 and will continue until 30 June 2012. Twenty European countries are members of the PRACE research infrastructure, which will provide access to systems at the highest performance level (Tier-0). The first PRACE system – a BlueGene/P machine at FZJ (Forschungszentrum Jülich) in Germany – is installed and available to researchers. Funding for the next three systems has been committed by France, Italy and Spain. Access to the PRACE resources will be through a single peer review process.

In Sweden, SNIC is partner in PRACE-1IP with the participating cen-

tres NSC, PDC and HPC2N. The largest contributions from NSC will be in providing expertise to users for porting and optimising their codes to effectively utilise the Tier-0 systems. This includes development of best practice guides, including optimal porting of applications, architecture-specific optimisation and petascaling techniques, optimal system environment, debuggers, performance analysis tools and programming environment. NSC will also be involved in analysis of scalable algorithms and libraries to enhance scientific applications as well as optimisation of applications on multi-core/many core systems.

Furthermore, we will evaluate novel programming languages, models and tools. Also future programming paradigms and tools for system management, performance monitoring, performance analysis and optimisation will

be studied within PRACE-1IP in order to ensure that the tools for achieving good efficiency are available on future multi-petascale and exascale systems.

Within PRACE, NSC will also contribute to investigation of future technologies, especially with respect to energy efficiency. This includes studies of highly energy efficient HPC components and systems, as well as power and cooling technologies.

In conclusion, the PRACE project will make future HPC technologies available to scientists in a number of disciplines. The 1st implementation phase will be followed by overlapping 2nd and 3rd implementation phases. PRACE-2IP is currently under planning, aiming to start mid-2011.

CHANDAN BASU
AND BENGT PERSSON



UPCOMING EVENTS

HEPiX Fall 2010 Workshop

November 1 – 5, 2010, Ithaca, NY, USA.
<http://indico.cern.ch/conferenceDisplay.py?confId=92498>

LISA'10; 24th Large Installation System Administration Conference

November 7 – 12, 2010, San Jose, CA, USA.
<http://www.usenix.org/event/lisa10>

SC10; International Conference for High Performance Computing, Networking, Storage and Analysis

November 13 – 19, 2010, New Orleans, LA, USA.
<http://sc10.supercomputing.org>

HiPC 2010; International Conference on High Performance Computing

December 19 – 22, 2010, Goa, India
<http://www.hipc.org>

Intel HPC Training

compilers, libraries, debugging, tuning, MPI

February 9 – 11, 2011, Linköping, Sweden.
<http://www.nsc.liu.se/intel-hpc-training>

PPoPP 2011; 16th ACM SIGPLAN Annual Symposium on Principles and Practice of Parallel Programming

February 12 – 16, 2011, San Antonio, TX, USA.
<http://www.ppop.org>

FAST'11; 9th USENIX Conference on File and Storage Technologies

February 15 – 18, 2011, San Jose, CA, USA.
<http://www.usenix.org/events/fast11>

IPDPS 2011; 25th IEEE International Parallel & Distributed Processing Symposium

May 16 – 20, 2011, Anchorage, Alaska, USA.
<http://www.ipdps.org>

CCGrid11; 11th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing

May 23 – 26, 2011, Newport Beach, CA, USA.
<http://www.ics.uci.edu/~ccgrid11/>

ICCS 2011; International Conference on Computational Science

June 1 – 3, 2011, Tsukuba, Japan.
<http://www.iccs-meeting.org>

The 26th NORDUnet Conference

June 7 – 9, 2011, Reykjavik, Iceland.
<http://www.nordu.net/conference/ndn2011web/welcome.html>

ParCo2011; International Conference on Parallel Computing

30 August – 2 September 2011, Ghent, Belgium
<http://parco2011.elis.ugent.be>

Euro-Par 2011; Aspects of Parallel Computing and Distributing Computing

August 29 – September 2, 2011, Bordeaux, France.
<http://europar2011.bordeaux.inria.fr>

ICPP2011; 40th International Conference on Parallel Processing

September 13 – 16, 2011, Taipei, Taiwan.
<http://icpp2011.org>

IEEE Cluster 2011

September 26 – 30, 2011, Austin, Texas, USA.
<http://www.cluster2011.org>

PACT; 20th International Conference on Parallel Architectures and Compilation Techniques

October 8 – 12, 2011, Galveston Island, Texas, USA.
<http://www.pactconf.org>



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