Enhancing efficiency

Nina Morgan

Why do commercial planes take off and land only between a certain range of angles, rather than taking off nose steep up or landing nose steep down? The answer lies in the way that air flows over airplane wings. If a plane takes off too steeply, the airflow around the wing of the plane no longer flows smoothly around the contour of the airfoil, or wing surface. As a result stall cells form on the wing surface, leading to loss of lifting capacity.

Although the effects of stall cells have been well known for decades, their origin has never been unravelled.

"One reason is because of the way that the Navier-Stokes equations, which describe fluid motion, are generally solved," says Professor Vassilis Theofilis, of the School of Aeronautics at Universidad Politécnica de Madrid (UPM), Spain.

In the GATUS project Theofilis and his graduate student, Dr Daniel Rodríguez, worked during 2009 to develop a more efficient and effective way to analyse the three-dimensional stability of flow around a two-dimensional airfoil or blade.

Predictive power

"Although industry also carries out three dimensional simulations using the Navier-Stokes equations, these draw on existing models of turbulence. They also adjust constants of the model in order to predict their application. As a result, the solutions they come up with are appropriate for one set of parameters only. In contrast, the alternative three-dimensional calculations we've developed do not rely on assumptions from the existing models of turbulence. As a result our calculations make it possible to more accurately predict the way air will flow over airfoil under different conditions," says Theofilis.
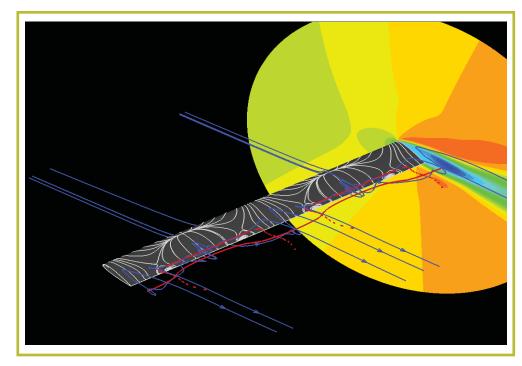

Figure 1. Stall cell structures on a wing surface, as calculated by the GATUS project.

Technical overview

Computations of the GATUS research project were performed at JUGENE in Juelich. Over 200 runs were performed, the most demanding of which used 4096 CPU cores and 24 hours each. A total of 8 million CPU hours (2.5 million CPU hours were granted initially) were invested on the computations.

An own-developed code was used for the computations. This code, written in FORTRAN, makes use of the open-source libraries ScaLAPACK and BLACS for linear algebra operations, and MPI communications.
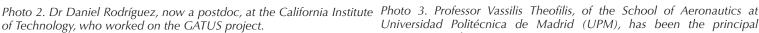
These more accurate predictions of airflow behaviour are an important key when it comes to improving efficiency in wings and blades.

"In order to design next-generation wings and blades, you need to be able to predict how air will flow over the airfoil surface under different conditions and in different situations," explains Theofilis.

"We still fly on technology developed by the Germans during World War II. And we still see planes are shaped like cigars with wings! One reason that the basic aircraft designs haven't changed very much is because the aircraft industry has become very good at optimising something whose behaviour it thoroughly understands. Up to now there hasn't been a good way of modelling airflow in three dimensions. But by making it possible to get closer to being able to solve turbulence equations for real world situations,

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Photo 2. Dr Daniel Rodríguez, now a postdoc, at the California Institute of Technology, who worked on the GATUS project.

Photo 3. Professor Vassilis Theofilis, of the School of Aeronautics at Universidad Politécnica de Madrid (UPM), has been the principal investigator at the GATUS project..

the methodology we have developed during the GATUS project will help and encourage industry to work to design better aircraft wings and blades. Reducing the noise emitted from wind-turbine blades is another problem that our methodology will help to solve."

Computing provides power

Although the new method of calculating the Navier-Stokes equations in three dimensions developed by the GATUS project is more efficient, it still involves solving coupled linear systems composed of around a million equations.

"This is where access to supercomputers is essential," Theofilis says.

"The calculations carried out in GATUS require large amounts of computing time. This is something his other research contracts did not provide. Without Deisa we wouldn't have been able to do carry out this work. But thanks to the Deisa award we've been able to produce results that have led to the publication of five papers in high impact journals over the past two and a half years, along with 10 or so conference papers. The computing time we received from Deisa, made all the difference!"

For more information:
http://www.deisa.eu/science/deci/projects2008-2009/GATUS

DEISA Training Course
Programming IBM Power6 and BlueGene/P Systems

Wednesday 9th February 2011
Garching Computing Centre of the Max Planck Society (RZG), Germany

DEISA is running a training course at the Garching Computing Centre of the Max Planck Society (RZG) on Feb 9, 2011. The course will cover IBM's supercomputer architectures, Power6 and BlueGene/P, how to program them efficiently and the use of tools for performance analysis and optimization.

The course will be based around a series of lectures with associated practical programming exercises where users can work on porting, profiling and optimizing their own parallel codes. Access to IBM systems and compilers will be provided for all attendees. However, participants will be expected to bring their own laptops to log on to these machines.

The course is free to all EU academics, but registration is mandatory.

For more details, a timetable and the registration form please see:
http://www.deisa.eu/usersupport/training/training-events/.

DEISA PRACE BOF at SC10

DEISA organized a Birds-of-a-Feather (BoF) session together with PRACE at SC10. SC10 was held in New Orleans, Louisiana in November 2010 .

The BOF session, called "PRACE – The European HPC infrastructure created", took place on Wednesday 17 November. PRACE project manager Thomas Eickermann (FZJ) presented the latest news about the PRACE Research Infrastructure covering the current status, the future plans and results to be expected during the EC funded implementation projects. Ana Bela Dias (NCF) gave an overview to PRACE services and how to access the PRACE resources. Johannes Reetz (RZG) presented the services currently provided by DEISA within the European HPC ecosystem. The session ended with Stéphane Requena's (GENCI) presentation about collaboration opportunities for academia and industry. Presentations from the session are available at: www.prace-ri.eu/documents.

DEISA and PRACE had a joint booth at the event. The DEISA PRACE booth was busy during the whole exhibition and the lucky winners in the DEISA PRACE treasure hunt were Vikas Aggarwal (Tuesday), Nils Felde (Wednesday) and Carlo Pascoe (Thursday).

Pictures from SC10 are available at: http://www.prace-project.eu/news/presentations-and-pictures-from-sc10

DEISA PRACE Symposium

The third annual DEISA-PRACE Symposium will take place in Helsinki, Finland from April 13 to April 14, 2011.

The Symposium features key note speakers from the US, Asia and Europe as well as scientific speakers from all over Europe, covering major computational science areas in HPC. The symposium will also feature speakers from different scientific communities as well as decision makers in science. The list of key-note speakers on "world-wide perspectives" includes:

-Anita Lehikonen, Finnish Ministry of Education, Culture and Science
-Kostas Glinos, European Commission
-Mitsuo Yokokawa, Riken, Japan
-Thom Dunning, UIUC & NCSA, US
-Xuebin Chi, Chinese Academy of Science, China
-David Keyes, KAUST, Saudi Arabia & Columbia University, US

The symposium is of interest to a broad audience: from scientific users, HPC technology experts and vendors, government, EC representatives and industry partners.

For more information: http://www.deisa.eu/news_press/symposium/Helsinki2011

Pictures: City of Helsinki Tourist & Convention Bureau's Material Bank/ Comma Image Oy and Paul Williams

DEISA PRACE Symposium 2011

Helsinki, Finland
13–14 April, 2011

at the National Museum of Finland

follow www.deisa.eu and www.prace-project.eu for more details