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Streamlining aerospace design

Engineers want to work on designing new aircraft, so getting software packages to talk to each other is critical, as Robert Roe reports

The design of modern day aircraft has engineering simulation embedded at its very core. Projects can be hugely expensive and the traditional methods for prototyping are too time-consuming and expensive.

Streamlining the workflow and means by which different software packages are used is critical to ensuring the design process is as efficient as possible.

Acentiss (Approved Center of Engineering Technology and In Service Support) in Germany makes use of Altair software to provide engineering services for structural design, stress and fatigue assessments for metallic and composite structures.

Acentiss has developed the all-electric technology demonstrator, Elias, an aircraft based on the one-seater UL Electra One from PC-Aero.

Engineers from Acentiss and IABG had to reengineer the structure of an existing airplane. In addition to the new development of the full electric reconnaissance system, datalinks, and the ground control station for the new aircraft, Acentiss also had to design the structure of the wings and the landing gear.

Dr Josef Mendler, CEO of Acentiss said: 'We use Altair software for pre-design development, as well as some pre-engineering structural optimisation, which means not only optimisation for weight reduction but also to minimise the cost of manufacturing for example.

'There are several limitations in the environmental conditions to address, when we are going to optimise structure for example. The issue of interaction between system failure and structure, for example, can be answered by using this software.'

Mendler concluded: 'Last but not least, verification is very important and this is also addressed by Altair software. OEMs, for example, are acknowledging and using this software in their portfolio of tools.'

Streamlining the software

A key factor governing the choice of software when designing aircraft is the interaction between the various software packages used for design analysis and optimisation. The Altair software package includes tools for modelling, visualisation, analysis, and optimisation but Mendler and his colleagues still wanted to interact with different software packages.

Mendler said: 'We are also interested in streamlining the branches to the design world, for example to Catia, so that we have a more effective linkage to the Catia platform.' One object in this is ease of feeding-back to the designer the stress patterns in different designs.

Altair has also included a number of software tools in the Altair Partner Alliance which have also been integrated to work with the HyperWorks software. This portfolio includes fatigue and stress analysis, and composite modelling.

Mendler said: 'We are in communication with Altair to constantly enhance the software. There are some open points which have to be solved, but I think that is a straightforward process.'

However this gets more complicated when dealing with different software packages from different companies. Some may use their own in-house software or other commercially available packages for CFD or FEA (finite element analysis). All these software tools must be able to interact, sending meaningful data to the next stage in the development process and sometimes backtracking for the purposes of redesign.

INTERACTION BETWEEN SYSTEM FAILURE AND STRUCTURE CAN BE ANSWERED BY SOFTWARE

These interactions are limited by data transfer but also by the format of inputs and outputs from each software package. Developing a more effective means of getting these products to talk to each other so they can be used together allows engineers to concentrate on designing new aircraft, rather than preparing data to be fed into the next set of software.

Esteco hopes to streamline this process, in fact this is their core business as Carlo Poloni, president of Esteco explains. Poloni said: 'What we do is to manage the design workflow and optimise the product performance on the basis of simulations that are orchestrated by our product.

'You cannot judge an aircraft on only one aspect; you can judge the aircraft on the basis of its mission. For a civil aircraft typically, this would be to deliver a certain range that has to be completed in a certain time and the less fuel that you use, the better the aircraft.'

Poloni continued: 'This has a lot of implications because this means that you have to reduce the weight of the aircraft, the drag of the aircraft during its flight, but you also need to be able to take off and land. These are very conflicting attributes.'

Environmentally friendly aircraft

Balancing the conflicting requirements leads to a number of possibilities for design; here Esteco uses post-processing to help customers make a strategic decision on which design variant to use.

'Our software helps you to explore the right compromise between these attributes. In fact what we always say is that if you ➤

Acentiss

Test flight of the Elias electrical plane

want to save fuel and mass on the aircraft you cannot judge that on the basis of the components you need to look at the overall mission.'

Poloni concluded: 'This is our core business, to manage key variables and to evaluate these through a chain of software.'

Alenia Aermacchi highlighted the importance of streamlining the interactions between different software platforms in a recent project where they leveraged ModeFrontier to design an environmentally friendly aircraft.

Tasked with designing an aircraft as part of 'The Clean Sky Joint Technology Initiative', this started in 2008 as a Public-Private Partnership between the European Commission and the aerospace industry.

The design automation process employed by the ModeFrontier workflow enabled 20,000 design profiles of the 2D wing shape, while incorporating aerodynamic and structural analysis using Alenia in-house codes.

Once the designs had been selected CFD computations were validated employing a proper parametric Catia 3D wing-body.

Streamlining the complex workflows in combination with the automated design process allowed the creation of 20,000 design profiles which gave Alenia valuable information about the potential performance of the product.

Poloni said: 'We go to the customer – in this case it was Alenia – they have the independent simulation; they know that for a specific activity, they will use a specific software tool.

'Some of the variables have an impact on the stresses and on the masses of the aircraft, but at the same time this has an impact on the noise.

'What we helped them with was to get the various software outputs and, critically, we help them in connecting the chain. We help them to complete actions passing the data from one simulation software tool to another one.'

WE HELP PASS DATA FROM ONE SIMULATION SOFTWARE TOOL TO ANOTHER

Poloni concluded: 'When you cannot improve one parameter without negatively affecting another, then it is just a matter of strategic decisions from the customer to decide which one best represents the compromise.'

ModeFrontier assisted Alenia with enhancing aerodynamic performance by 2.5 per cent, while reducing wing weight by four per cent. Poloni highlighted that the actual CFD or FEA analysis is done on HPC resources, but many simpler computations can be done on workstations or even excel spreadsheets in some circumstances. Managing all of these different interactions creates a complex workflow, which must be managed efficiently.

Large-scale simulations

In order to run large-scale simulations, especially in the case of optimisation where multiple design variables are often considered simultaneously, the process must be parallelised effectively. This requires the use of HPC compute resources for complex simulation.

Poloni said: 'The important thing is to be able to manage the workflow so that the sequence of codes can be run in parallel execution, while orchestrating the communications between the simple work done on a workstation together with the huge computation done on a very big server.'

Poloni concluded: 'In theory these are negligible issues but often they are the limiting factor to really execute mission analysis on a complete product.'

Mendler has experienced similar issues, with exporting designs from analysis software to design and vice versa.

Mendler said: 'Catia is also very significant, in order to have a straightforward workflow through the

complete process chain. You get delays because of the data transfer from finite element analysis to a designer tool, and that in the past was a big obstacle to working fluently through a design process.'

Mendler continued: 'If you just talk about redesign or you have to change design features during a rigid development process, then you need to have software platforms which are capable of interacting very quickly and efficiently.'

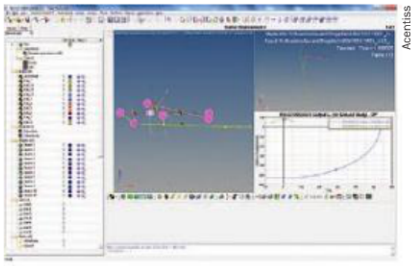
With the increasing complexity of simulation and data sets, the effective parallelisation of code used to run analysis is a primary concern.

Rate limiting steps can occur during the transfer of data from one software tool to another, but if the code is not efficiently parallelised then simulation times can increase drastically.

Mendler said: 'I think it is a constant challenge. If you just look at the models that we are working on they have significantly increased degrees of freedom for example in comparison to software models we created 15 to 20 years ago.

'There is of course more computing capacity behind this, but we have to think of smart programming architecture within the software codes which can be easily applied to more complicated programs but also larger models.'

This is a challenge for engineers working across many disciplines but is a particularly acute in aerospace simulation. Esteco's approach of managing the design workflow to optimise the product performance involves running multiple simulations which can then be critically evaluated. To do this in an effective time-scale, efficiency must be a key focus.



Acentiss

Kinematic study of the landing gear with MotionView

Poloni said: 'You need to parallelise this process so that it can be executed efficiently in parallel, and pre-define the amount of time that you are willing to spend on the case before taking a decision.'

He continued: 'Once this is completed then you have the tools to make the decision. We use decision-support systems, which are essentially data analytics for engineers, to select which one best fits the desire of the design team.'

Poloni concluded: 'The performance of a product is basically a few numbers that give you the characteristic of the design but, once you have that, you also want to dig into why these numbers are obtained and this is where our post-processing capabilities provide the ability to do that.'

While it is certain that the future of aerospace design will be one that relies heavily on simulation, no one software vendor is going to monopolise the market. Indeed, individual aerospace companies will probably want to continue using a diversity of software from different suppliers in their in-house processes. Thus both engineers and software providers must work continually to streamline software so that it runs more effectively, but also interacts with other software used at different stages in the design process.

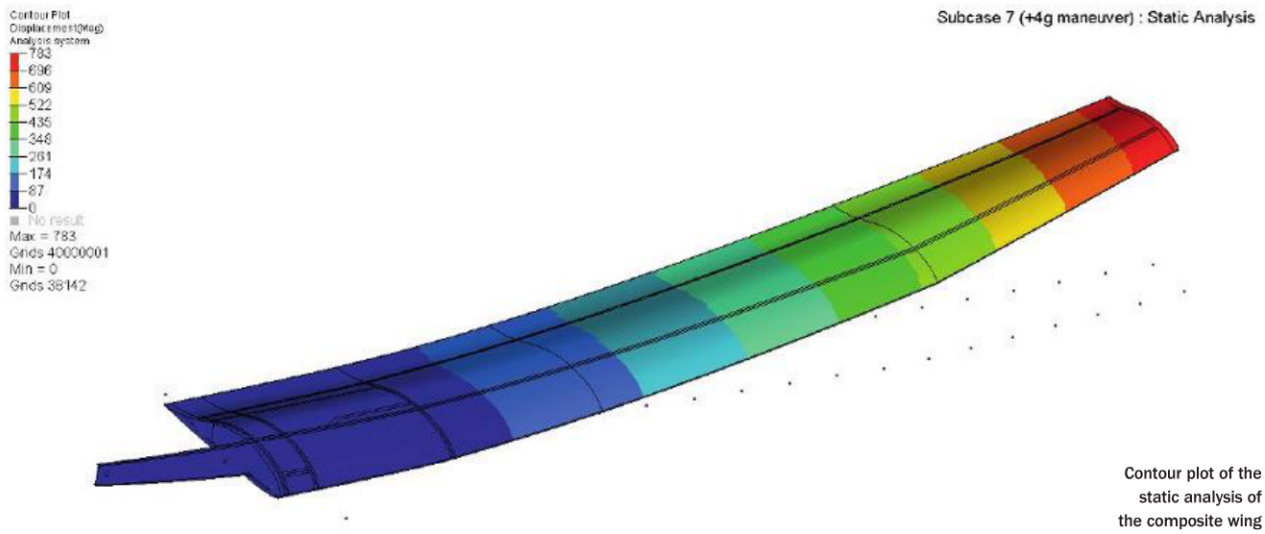
Mendler identified some areas that needed improvement at the scientific level: 'For example, looking at fatigue for composites, that in my opinion is a big issue which must definitely be supported by an adequate material database architecture in the background in order to get an adequate approach on micro mechanics and micro structure modelling.

'This requires a bilateral approach, not only to transfer this challenge to Altair, but it is also a challenge to us and to universities that we are cooperating with.'

Esteco has expanded its product line to include a web-based collaborative environment, which should help encourage further collaboration in the future. Keeping data in a shared environment allows data to be transferred easily.

Poloni said: 'All of this is moving from a desktop solution into an enterprise solution where different individuals are playing different roles. The decision maker may only look at a few numbers, while the specialist engineers would look more closely at the details of a single simulation.'

He continued: 'It is becoming a key element. We now have the opportunity of doing all this in a distributed manner, in a service orientated architecture which is the next challenge: to be able to see, execute, and monitor whatever you do from any device.'



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Contour plot of the static analysis of the composite wing structure