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# AIRCRAFT PROGRAMMES

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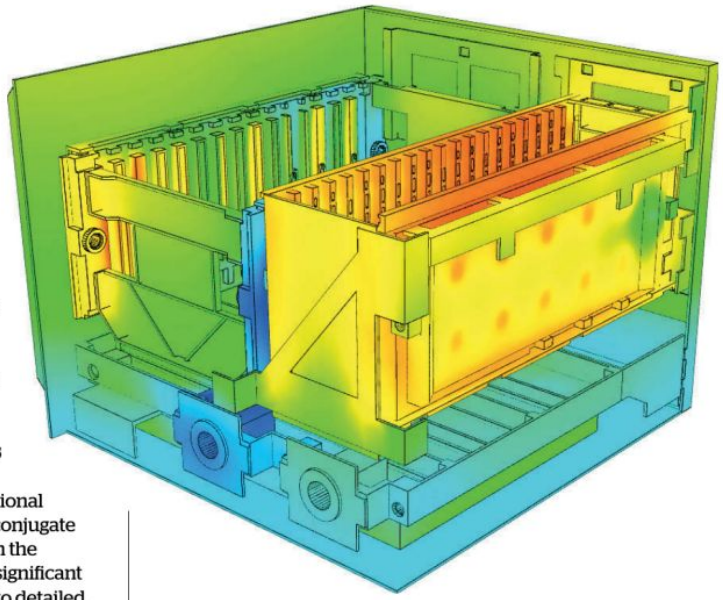
# MEETING THE THERMAL SIMULATION CHALLENGE

6SigmaET's product specialist, **Tom Gregory** examines the challenge of thermal design in aerospace electronics.



**The aerospace sector places some challenging demands on electronics designers. For a start, the environments that the electronics are exposed to are much harsher than in almost every other scenario. Moreover, the life expectancy of the products is much higher, while accepted failure rate is easily an order of magnitude lower than typical commercial products.**

The need for bulletproof reliability is absolutely critical. With defence products there are no simple recalls or Return Merchandise Authorisation (RMA) processes. Product failures always have catastrophic consequences far beyond losing market share as might be the case with a consumer electronics device.

When you combine the demand for extremely high reliability with the constant need for higher power and smaller footprints, thermal design takes on extra importance compared to other industries. Aerospace products are high-power-density, tightly packed, highly engineered products, exposed to very harsh environments. At the same time, designers must work with limited cooling resources. They must find clever ways of dissipating heat away from the critical components.

Simply put, thermal design and heat removal are the most critical aspects of aerospace electronics design, there is no way around it. The question for designers is finding the right tools to deal with these challenges in the most efficient way without sacrificing performance or size in the final products.

## Finding the right tools

There are a number of general-purpose computational fluid dynamics (CFD) and conjugate heat transfer (CHT) tools on the market – but these exhibit significant limitations when it comes to detailed thermal design and simulation work.

The key issue with these general-purpose tools is that creating suitably accurate simulation models can be extremely difficult and time-consuming – in particular because of the complex geometries often involved in aerospace products. Model and grid/mesh creation can quickly absorb significant amounts of time.

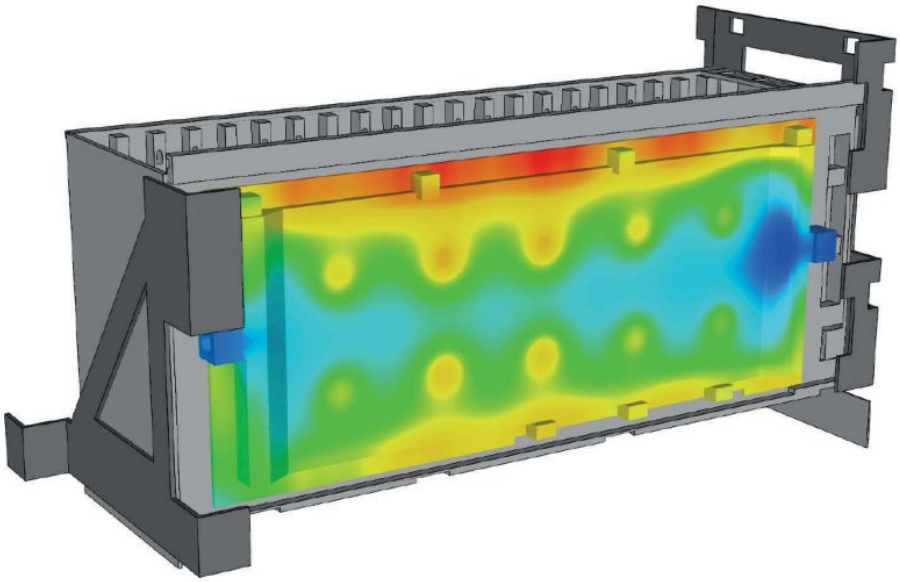
The tetrahedral or polyhedral meshing techniques typically employed by these general-purpose tools, as flexible and robust as they might be, can become a very tedious affair very rapidly. Working from conceptual design to a finished product is particularly difficult as it usually requires the creation or recreation of multiple models of different fidelity throughout the design process rather than being able to increase the level of abstraction (e.g. boards and components modelling) on the fly.

**ABOVE:** This larger chassis includes over 25 single board computers and five cold plates of various complexity

Aside from the need for more automated modelling and gridding, the ability to automatically model physics, such as altitude corrections, internal radiation and multi-fluid (e.g. liquid cooling) is another critical capability that aerospace designers need that can be challenging to models using general-purpose tools. So rather than 'make do' with general-purpose tools, aerospace designers need to take advantage of more specialised thermal design and simulation tools.

## It's a numbers game

TEN TECH was tasked to help with the design of a liquid-cooled airborne radar processing chassis. This was a very high-powered, high ambient temperature



design which had no cooling mechanism other than the liquid cooling loop. Indeed, thermal design was the main driver of the system. A little under 3kW had to be dissipated out to the (already hot) environment for the electronics to be able to reliably function. This was a significant design challenge and to solve it, TEN TECH used 6SigmaET – a dedicated thermal simulation tool – throughout the design process.

TEN TECH started with the redesign of one of the cold plates as the initial design would not have provided enough cooling. The cold plate design also had to account for pressure drop requirements. Thermal/CFD analysis using the 6SigmaET software allowed TEN TECH to better understand the flow and focus the design to maximise cooling and minimise pressure drop. TEN TECH was able to quickly create a multi-fluid model of the cold plate involving free convection and liquid cooling and optimised the cooling channels to obtain a good compromise between heat dissipation and pressure drop through the cold plate.

Once this stage was complete, TEN TECH moved on to understanding the liquid cooling of the entire system. This larger chassis included over 25 high-power single board computers (SBC) and five cold plates of various complexities. TEN TECH had to ensure that the entire chassis was properly cooled, the liquid loop would function correctly and each of the single board computers would be within its temperature requirements.

This was a big model with the added complexity of being multi-fluid with liquid cooling cavities, which in total encompassed around 40 million simulation grid cells. TEN TECH had performed some initial liquid cooling analysis on the cold plates using general purpose CFD tools. However, this required separate manual meshing of the solid parts as well as air and liquid cavities (which the team also had to create geometry for). Even for this initial analysis this involved 4-6 hours problem setup and two and a half hours of solve time. TEN TECH quickly realised that analysing the complete chassis with general purpose CFD tools would be very difficult - not only in terms of labour, but also in terms of their ability to deliver results quickly to the customer.

**ABOVE:** With 6SigmaET, TEN TECH quickly created a multi-fluid model of the cold plate

**BELOW:** The ability to automatically model physics, such as liquid cooling can be challenging to model using general-purpose tools

In comparison, it was able to conduct the cold plate analysis in just one hour with 6SigmaET. Overall TEN TECH was able to shorten solve times by 50% using 6SigmaET - both through the efficiency of the software itself, and because of the fact that the software seamlessly plugs into Rescale's high performance computing cloud clusters. Rescale is a secure, high performance cloud computing platform that allows electronics engineers to offload complex CFD simulation to cloud-based servers on demand, drastically reducing simulation times without the need for expensive on-site hardware.

This significant time-saving meant that, critically, TEN TECH was able to use 6SigmaET to easily simulate several different mission scenarios, corresponding to different altitude, ambient temperature and liquid cooling pump inlet temperature and pressure permutations. TEN TECH was also able to explore more design alternatives and improve upon the original design. This effort, which was originally estimated at six weeks was delivered in a little over three weeks, with more information provided to improve the design.

This meant a labour cost saving for the customer in excess of $25,000. There was also a significant cost saving from using thermal analysis to predict performance instead of building a prototype. Given that the initial cold plate design would have provided insufficient cooling, it would have resulted in a test failure, which would have certainly cost in excess of $50,000 in prototype building, test setup and programme delay.

Through the use of thermal simulation, TEN TECH was able to make significant savings that simply would not have been possible with general-purpose CFD tools. Indeed, this example clearly highlights both the overall importance of thermal design in the aerospace sector and the value that more specialised design and simulation tools can deliver to electronics designers.

Where the demands for reliability and performance are high there is simply no way to shortcut the design process – designers need the right tools for the job if they are to complete projects efficiently, accurately and safely.

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