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Thermal Simulation Helps Design New Telecom Platform That Delivers 40Gbps Bandwidth

The Advanced Telecom Computing Architecture (ATCA) 3.0 specification has emerged as the industry's hardware platform of choice and has already seen widespread deployment in network access layer applications. However, development of new blade sets has created the need for even higher capabilities, particularly for backplane bandwidth exceeding the 12.5 GB/sec and thermal dissipation exceeding the 200 Watts per slot ATCA 3.0 specifications. When Simclar Group set out to meet this challenge with their new TurboFabric scalable ATCA platform, the company ran into major challenges delivering the quantity and distribution of air needed to accommodate higher capacity switch fabrics. Simclar engineers used thermal simulation to evaluate a wide range of fan configurations, plenum geometries, fan specifications and air distribution methods. They succeeded in developing a platform that goes well beyond the ATCA 3.0 specification.

Expanding upon the ATCA 3.0 specification

ATCA needs to expand to cover aggregate layer and core network applications to deliver the performance improvements and cost efficiencies that service providers are demanding. By the same token, ATCA needs to seamlessly scale to accommodate new blade sets as bandwidth demands increase over time. These requirements pose a significant technical challenge. Network core and aggregation layer equipment and next-generation scalable blade-sets all require higher capacity switch fabrics than those currently offered by the ATCA 3.0 specification. While the specification accommodates a variety of data fabrics, the backplane for each fabric is based on an architecture featuring four parallel lanes of 3.125 Gbps for transmit and receive and provides limited scope either to support high end equipment or future upgrades. Furthermore the, ATCA thermal dissipation specification of 200Watts per slot is insufficient to cope with the increased power requirements that will be demanded by a truly scalable solution.

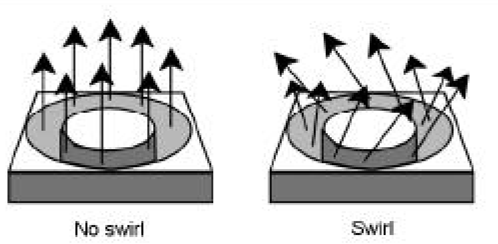
Simclar Group, a technology-based electronic manufacturing services (EMS) company, accepted the challenge and set out to design a range of high-bandwidth, highly-scalable ATCA platforms to meet these requirements. The company utilized advanced printed circuit board (PCB) materials, connectors, vias and stack design to push the performance limits of copper backplane channels up to 40 Gbps. The company's most advanced backplanes have been modeled, simulated, tested and verified for end-to-end channel performance from output of driver to input of receiver to provide up to 10 Gbps NRZ signaling capability per differential pair. But solving the signal integrity challenge fixed only one part of the problem. With higher speed blades comes the added burden of increased power consumption and heat dissipation which in turn requires increased cooling. This problem cannot simply be added by adding more powerful fans since telecom platforms have to meet strict Network Equipment-Building System (NEBS) noise requirements. Running fans at high rates to provide better cooling increases noise and also reduces fan life.

Original thermal design fall short

"The first phase thermal design for the TurboFabric platform was developed using engineering calculations and physical testing," said Dave Watson, Thermal Design Team Leader for Simclar Group. "The design was reasonable but fell short of performance requirements. Significant physical testing had been performed but provided little guidance as to the root cause of the problem since it temperature and airflow measurements were obtainable only at a few discrete points." The ATCA specifications provides for four different thermal classifications: B1 – 25 CFM per slot, B2- 30 CFM per slot, B3 – 35 CFM per slot and B4 – 40 CFM per slot. The specifications also provide that airflow must be distributed evenly over each board. The boards are divided into four zones running parallel to the direction of airflow and each zone of the board must deliver a minimum of 20% of the total volume of airflow over the board. Besides airflow and fan life, the thermal design is also constrained by the need to minimize openings in order to meet electromagnetic compatibility (EMC) requirements. The available internal space is limited by ATCA form factor requirements.

"I was brought into the project because of my thermal design experience, extending back to the early 1990s," Watson continued. "Thermal simulation is like having X-ray vision. It lets you see inside the box to look at airflow, pressures and temperatures at any point. A single thermal simulation gives you a detailed understanding of what is going on inside the box and helps you quickly identify the root causes of the problem. In the 15-plus years that I have been involved with thermal simulation I have developed a strong preference for Flomerics' FloTherm software. Its user interface is very intuitive, making it possible to rapidly create and manipulate simulations. FloTherm's visualization editor provides very powerful tools for displaying and animating results. This makes it much easier to understand problems and to explain to others why the design changes that you are recommending are necessary. In addition, many customers use FloTherm, allowing potential sharing and integration of models."

Accounting for fan swirl



A fan model with and without fan swirl

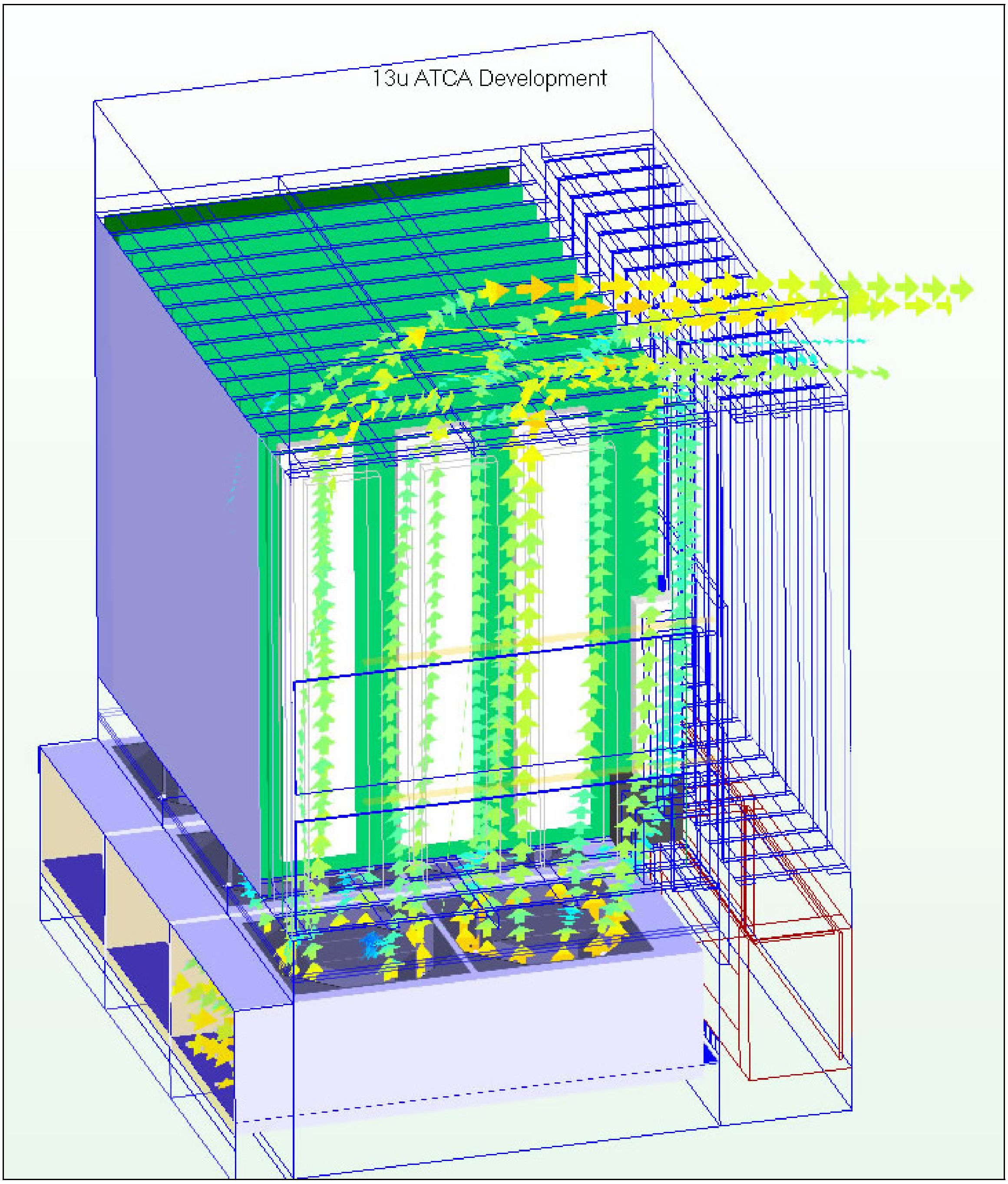


Figure 1: Original model without fan swirl

In this application, the initial FloTherm simulation of the design did not correlate with the test results. Watson had used the FloTherm Axial Fan SmartPart to model the fan. The Axial Fan SmartPart substantially reduces modeling and solution time by providing a behavioral representative of the fan that eliminates the need to model its detailed geometry and motion. In this initial simulation run, Watson had set up the Axial Fan SmartPart in the default mode which does incorporate fan swirl. Fan swirl occurs when the airflow comes off the rotating airfoils at an angle to the face of the fan. Fan swirl does not affect total airflow but changes the distribution of airflow, particularly the regions of high and low velocity. When he turned on fan swirl the simulation results then matched up closely to physical testing. The results confirmed that airflow would not meet the company's aggressive design goal of 50 CFM per slot, which is well above the ATCA 3.0 standard.

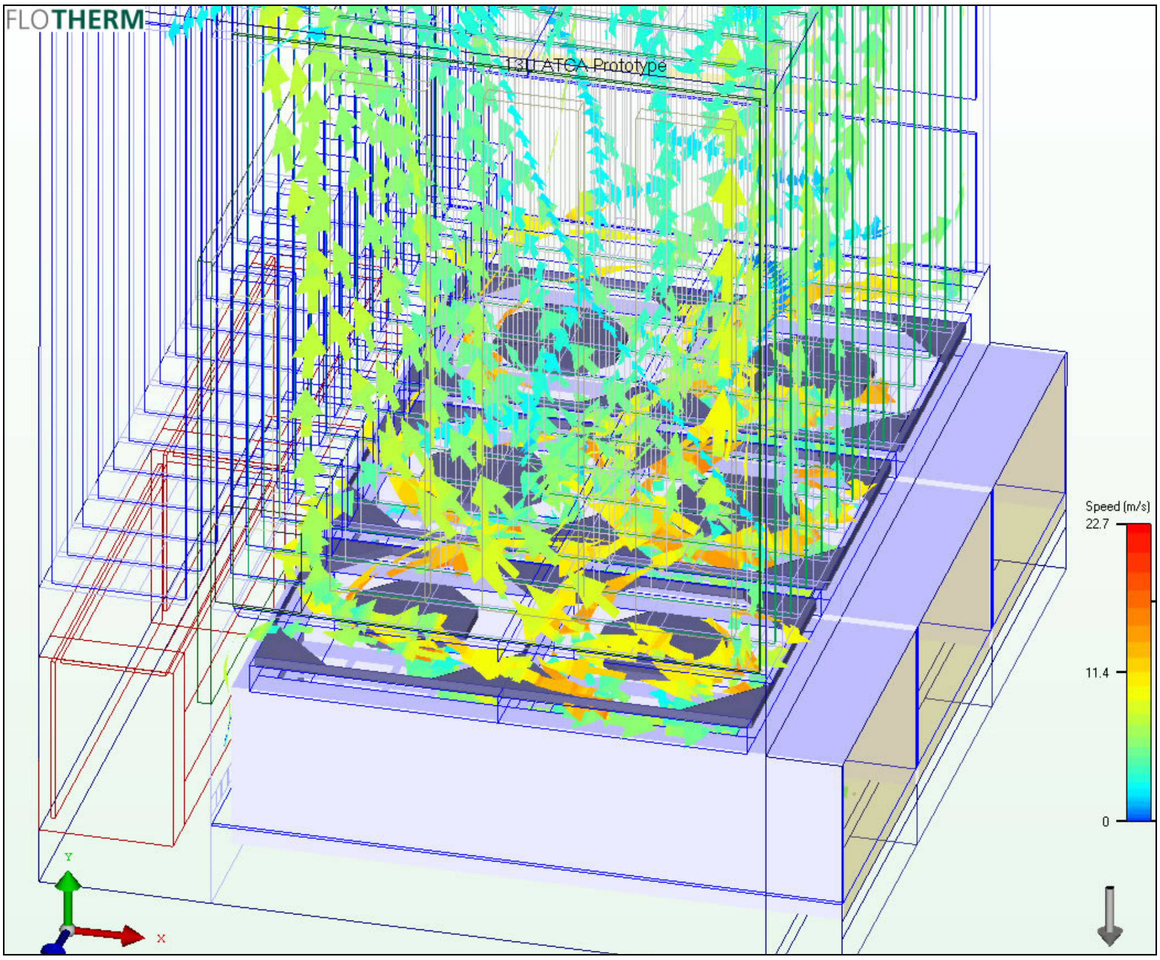


Figure 2: Adding fan swirl provides more realistic simulation

"Simulation gave me the freedom to consider a wide range of alternative designs by letting me evaluate their performance quickly and with no hardware costs," Watson said. "I simulated a "push" airflow system, with the fans located below the cards, a "pull" system, with the fans located above the cards, and a "push-pull" system, with the fans located before and after the cards. I also looked at different ways of allocating the available space to plenums at the inlets and outlets. A primary goal was to reduce pressure drop as much as possible. Lower pressure drop helps reduce fan swirl and enables the fan to run more slowly to help meet noise requirements. This meant taking a look at air filters and grilles. With pressure drops minimized we were then able to determine an optimum cooling fan design.”

Selecting the best fan

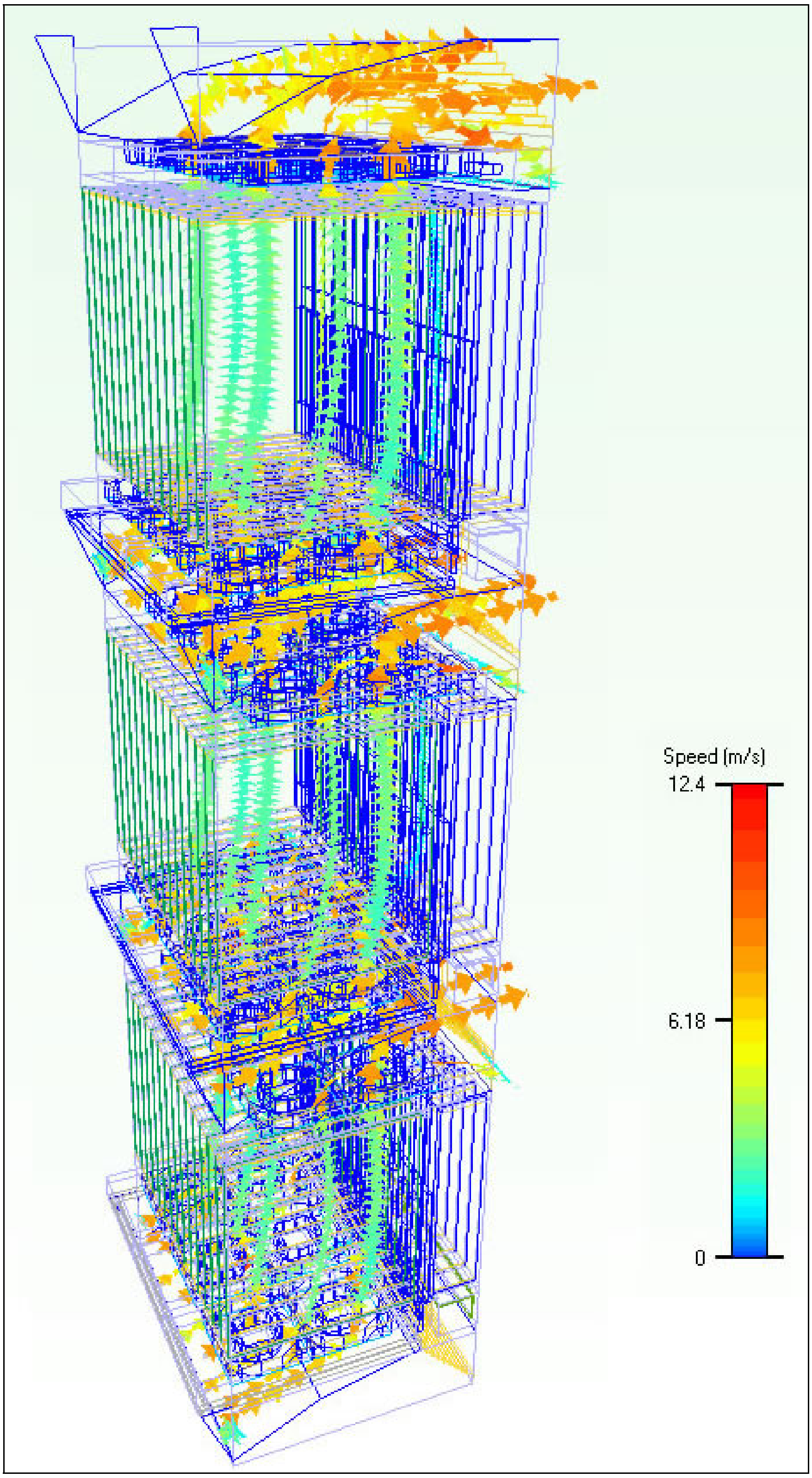


Figure 3: Simulation of final design shows air drawn in at front and exiting at rear.

The reduction in pressure drop inside the chassis changed the type of fan that would provide the best performance. The fan curve defines the output of the fan in CFM relative to the static pressure it sees. Fan curves are usually characterized by a smooth slope starting at zero static pressure with flow increasing as static pressure is reduced. At some point this curve peaks and the static pressure is reduced at the start of the surge or stall region of the curve. Except in rare special cases the fan should not be operated to the left of this peak, often called the knee of the fan curve, because this area is very unstable – small changes in static pressure may lead to large changes in flow. The ideal operating point is usually just to the right of the knee. Watson evaluated multiple fans and selected one that operated very efficiently at the static pressure generated by the optimized chassis design.

Figure 4: Simclar TurboFabric platform

"After we identified the ideal fan, I ran a new simulation that showed that we now were meeting the design specification by delivering more than 50 CFM to each slot and also meeting the 20%

air distribution requirement," Watson added. "The simulations also allowed us to evaluate a number of build variants. We made the chassis design modular so that fan configuration could be switched between push and push-pull and the size of the plenums could be adjusted. The result is that the TurboFabric not only meets the thermal requirements of the foreseeable future but can be upgraded to provide a future-proof solution for telecommunications equipment manufacturers."