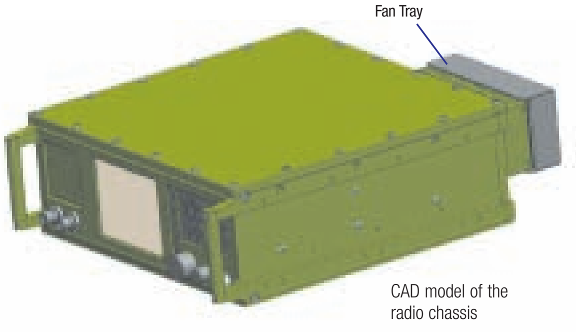
Keeping Cool in the Field



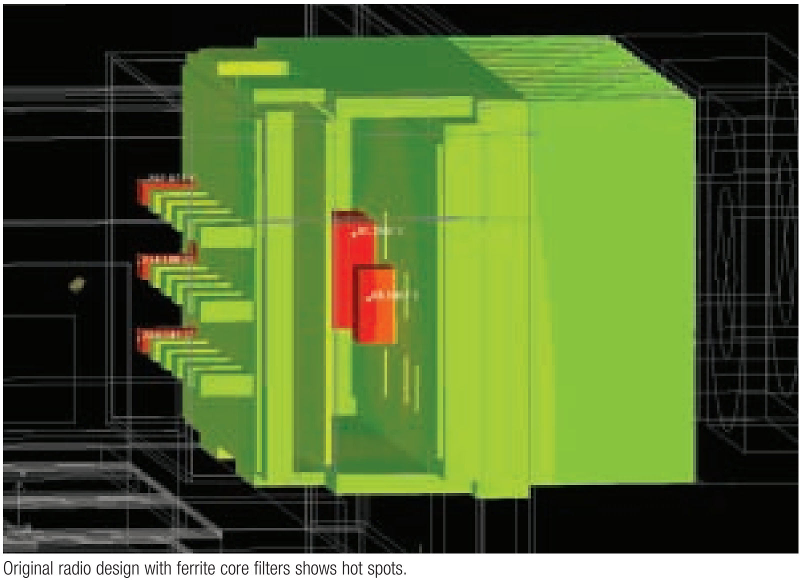
CAD model of the radio chassis

A communications systems company gains millions of dollars by using thermal simulation to bring tactical radios to market faster.

By Patrick Weber, Mechanical Engineer, Datron World Communications, Inc., California, U.S.A.

The communications systems designed and built by Datron World Communications, Inc. present major thermal design challenges. The company's radios travel with today's war fighters around the world in helicopters and Humvees® as well as on foot. The devices are designed to survive in a wide variety of environments, ranging from a sandstorm in the desert to a mountain blizzard. These systems dissipate substantial amounts of heat yet must be sealed to the outside environment to prevent damage to internal components — for example, if the radio falls into a creek, it still must work — and to prevent electromagnetic interference.

Datron mechanical engineers face the challenge of providing cooling management within a completely sealed radio cabinet in up to 60-degree Celsius (C) ambient temperatures. Communication systems are designed with heat sinks external to the cabinet that use forced-air conventional cooling. Components with the highest levels of power dissipation are mounted internally near those fins. Radios contain printed circuit boards (PCBs) for the power supply, radio frequency (RF) filter, CPU and audio functions. These PCBs generate substantial amounts of heat. In addition to keeping junction temperatures of board components within specifications, Datron engineers need to limit — for safety reasons — external temperature of the heat sink to 15 degrees C above ambient.



Original radio design with ferrite core filters shows hot spots.

Historically, thermal management design was based on engineering experience and instinct. In order to understand the cause of any thermal problems, engineers had to test a wide range of prospective solutions and corresponding prototypes. The cost of developing, building and testing prototypes was high. But the resulting delays in bringing each new product to market were even more costly. Datron engineers have improved the thermal design process by using thermal simulation.

The company now practices Simulation Driven Product Development and begins the thermal modeling early in the design process. Radios typically generate 125 watts output and dissipate approximately 220 watts inside a 15-inch wide by 15-inch deep by 5.5-inch high box. Initial models are developed based on very limited information, such as the size of the chassis, the RF output power and the expected efficiency of the radio. Engineers select primitive objects, such as cubes, as building blocks and parametrically assign dimensions and material properties. Surface properties are assigned to the outside surface of the enclosure to represent the olive paint that is typically used on the final product. In the early design stages, the internal components are approximated by a single component that dissipates the total amount of heat in the radio.

As the design progresses, more detailed information on the PCBs becomes available. Mechanical engineers model the different PCBs and components within the chassis and evaluate the thermal performance. ANSYS Icepak macros are used to quickly generate models of standard packages. Other macros are used to generate heat fins from parameters including the number of fins, fin width and fin spacing. The design team limits the model to approximately 1 million cells by meshing smaller boxes around hot spots at higher densities.

In a recent project, early models showed that junction temperatures exceeded the typical maximum of 125 to 150 degrees C. The original design specified ferrite core filters that are relatively light but have a very low thermal conductance. Simulation using the ANSYS Icepak tool showed that the devices heated up the surrounding air to the point of overheating neighboring devices. Based on this insight, engineers replaced the ferrite filters with aircoil filters that have a higher thermal conductance. This design change was the key to significantly reducing junction temperatures of high power-dissipation components. Once a working design was obtained, the engineers used parametric modeling to optimize thermal management and acoustics.

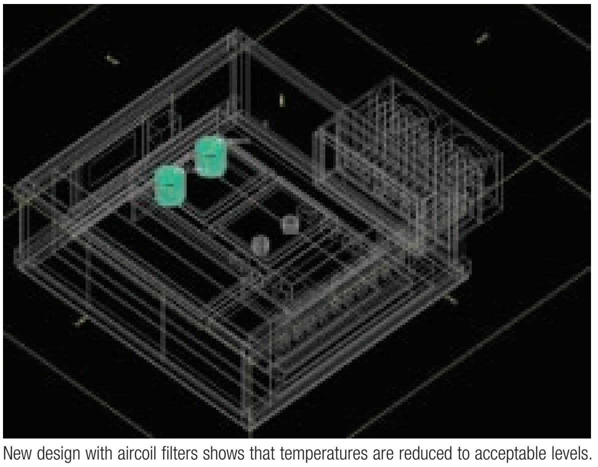
Using this approach, Datron engineers improved the performance of the software prototype until it met thermal requirements within the required margin of safety. At that point, they ordered the first thermal hardware prototype. Testing showed that the thermal prototype closely matched the simulation predictions and also met all of the thermal design specifications. As a result, no additional hardware prototypes needed to be built, and the radio was brought to market substantially earlier than if the company's original build and test method had been used.

In other recent thermal design projects at Datron, ANSYS Icepak simulations showed that several power transistors exceeded the junction temperature specification. By knowing this early in the design process, it was possible to substitute other suitable components with lower thermal resistances. If this problem had not been discovered until after the detailed design process, it would have required a considerable amount of time and work to correct. In addition, with this change, engineers discovered that they could decrease the number of fins required, which provided more room on the rear panel of the enclosure and made it possible to reduce the overall size and weight of the radio.

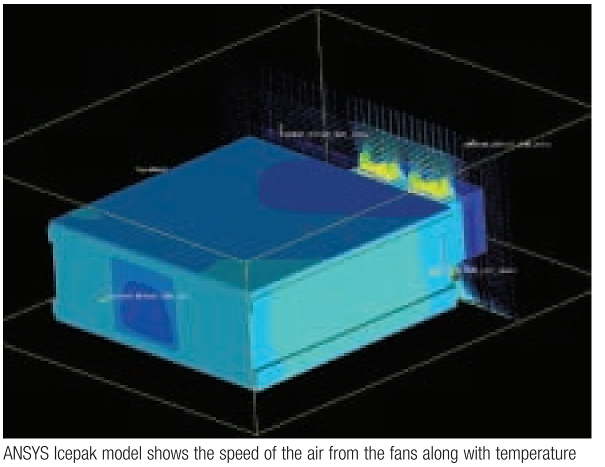
For Datron, simulation makes it possible to validate and optimize designs much earlier in the development process, saving large amounts of time and money. Engineering simulation has substantially reduced the time required to bring new, improved communications technology to the marketplace, and this can translate into millions of dollars in revenue. ■

The Natural Convection Challenge

One of the biggest challenges Datron engineers face is simulating natural convection. This is inherently difficult and expensive to simulate because the buoyancy forces are constantly changing. The Datron team developed a typical natural convection problem and compared the ability of all the leading thermal simulation tools to solve it. Several of the software packages took 24 hours or more, while ANSYS Icepak software solved the problem in only 20 minutes. Datron engineers liked the nonconformal meshing tools in the ANSYS Icepak product that make it possible to separately mesh — usually with a finer mesh than the rest of the model — critical areas within the system, such as high-dissipation components. Such a process increases the accuracy in the critical areas without unnecessarily increasing computational time requirements.



New design with aircoil filters shows that temperatures are reduced to acceptable levels. (The filter temperatures in degrees C have gone from the 200s to the 90s.)



ANSYS Icepak model shows the speed of the air from the fans along with temperature contours on the chassis. Blue indicates cooler temperature.