Case Study.

Goodyear Puts the Rubber to the Road with High Performance Computing

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In 2003 and 2004, the Goodyear Tire and Rubber Company found itself in a definite slump, suffering declining revenues and losing out to its two main competitors, Michelin and Bridgestone. In response, Goodyear leveraged its high performance computer clusters and its ongoing collaborative relationship with the Sandia National Laboratories to change the way it developed tires. Rather than designing, building and testing physical prototypes, Goodyear engineers used modeling and simulation to test virtual models and significantly cut time to market. The result was the Assurance® all-weather tire featuring TripleTred Technology®, a huge hit that helped Goodyear not only climb out of the hole it was in, but continue on to launch a flurry of new tires that resulted in record profits.

The First Law of Holes advises "when you're in one, stop digging."

Not too many years ago, the Goodyear Tire and Rubber Company was struggling at the bottom of a fairly good-sized hole. Recalls Loren Miller, the company's director for IT and physics research, "In 2003 and 2004, Goodyear was definitely in a slump, and management was looking for ways to turn the company around. We needed fresh sources of revenue and a way to move out in front of our main competitors–France's Michelin and Japan's Bridgestone."

"To make the turnaround a reality, we had to address several issues," Miller continues. "Obviously, we had to quickly introduce a new product into the marketplace. But we also had to be absolutely certain that this was the right product–that it would provide the margins we needed, and that people would be willing to buy these new tires at a higher premium compared to the typical lower cost tires currently available from our competition."

Goodyear, the only major U.S. tire company, was founded in 1898 and is headquartered in Akron, Ohio. Its primary products include the Goodyear®, Dunlop®, Kelly®, Fulda® and Sava® brands. With revenues of $19.6 billion in 2007, the company has more than 60 manufacturing operations in 26 countries and 70,000 employees worldwide. Its two major technical centers are located in Akron and Colmar-Berg, Luxembourg.

Out of the Hole, Ahead of the Competition

Goodyear decided to focus its comeback efforts on a product area where it had already established leadership–the all-season tire. The company introduced the Tempo in 1977 and it was an instant hit–the 3.5 million sold in its first year made the Tempo the most successful Goodyear tire in history. Now the company's managers felt it was time to up the ante. To not only climb out of the current revenue hole, but also take a commanding lead in the marketplace, its engineers and designers had to come up with a new, highly innovative all-season tire that provided major improvements in performance and safety. And they had to do it quickly.

In some respects, an all-season tire is like a Swiss Army knife–it has to incorporate an assortment of tools in one well-designed package that can handle a variety of situations. For example, an all-season tire has to work well on dry roads–after all, most of the time the tires are performing on dry pavement unless, as Miller notes wryly, you live in Seattle or Akron. For wet roads, another set of treads has to be built into the tire, and yet another to handle snow and ice.

"…high performance computing is more than just a very sophisticated tool…it's a strategic asset that…makes Goodyear a formidable competitive force in today's global market."

Loren Miller, Director, IT (RDE&Q), Goodyear

"The challenge we faced was how to optimize all these all-weather characteristics in a new tire," Miller says. "In addition to optimizing tire handling on dry, wet, icy or snowy surfaces, we also had to make major improvements in treadwear, noise reduction and handling. So, in a sense, we were going beyond optimization, beyond creating a tire that was quiet, rode well and handled well. We were chartered with creating something new; a tire that would perform better than any other tire in history. And we were under severe time pressures to come up with the new design."

Coping with Complexity

At first glance, an automobile tire looks quite simple—round, black, rubbery. But even passenger tires, which are far less complex than aircraft or earthmover tires,

Figure 1: This image shows the complex layering of materials that compose a Goodyear tire. All of these components are simultaneously considered during the modeling and simulation process.

have at least 18 different components blended together into a single unit. Figure 1 shows some of the components of a Goodyear tire.

Not only are the components of steel, polyester and other materials complex, but rubber itself, which, as Miller notes, sounds very low tech, is actually one of the most complicated materials found in nature. Every time the rubber meets the road, it absorbs and releases energy, and its behavior changes with every cycle—technically it is known as a non-linear viscoelastic material. As Goodyear's Joseph M. Gingo, senior vice president of technology and global products planning, once said, "Rubber is such a difficult material—the only reason we use it is that nothing else works." And in order to deliver a world-class, highly innovative tire, company researchers had to fully understand how rubber behaves under every conceivable driving condition.

HPC at Goodyear

Back in 2003, deep in the slump, the company was betting that a specific new product introduction would catapult Goodyear out of its hole and into the forefront of the market. That product, ultimately, was the Assurance tire featuring TripleTred Technology. But, there were some major hurdles to overcome before it became reality.

Given the complexity of the design of this new tire and the aggressive time-to-market schedule, the computational demands of the modeling and simulation required went far beyond anything the typical desktop workstation could handle. This was a job for high performance computing (HPC).

Fortunately, Goodyear was no stranger to supercomputers. They began using souped up minicomputers back in the 1990s, next graduated to a stand-alone HPC system, and then, like so many other companies, deployed powerful supercomputing clusters based on off-the-shelf hardware. These clusters, which use hundreds of processors, are located at Goodyear's two technical centers in Ohio and Luxembourg. But even that experience was not enough.

Goodyear researchers realized that they had to dramatically change the way they had been using HPC for modeling and simulation. "Until 2003, we had been using HPC modeling to augment our conventional procedures. Traditionally, we build physical prototypes and then subject them to extensive environmental testing. But Joe Gingo, who was primarily responsible for the design of the Assurance said, 'You know what, I don't have enough time to complete this project using the conventional design, build and test cycle. Some tests, like

treadwear, can take four to six months to get representative results. Let's flip our procedure–let's use modeling and simulation from the very beginning.'"

Symbiosis with Sandia

Even though Goodyear had been building its HPC capabilities since 1993, the Assurance project with its predictive-modeling approach was beyond the scope of their existing supercomputer systems. Fortunately, the company had a long-term relationship with Sandia National Laboratories in New Mexico. Sandia, one of the Department of Energy's three nuclear weapons

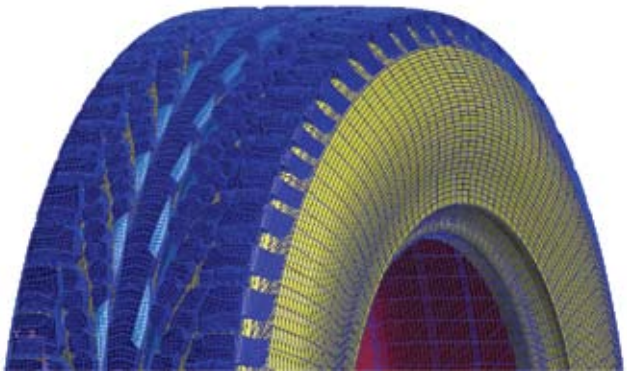

Figure 2: This computer-generated image of an all-weather tire's treaded mesh only hints at the complexity involved in creating a product that delivers outstanding performance no matter what the road conditions.

labs, had shifted its focus over time to support other national projects, such as nuclear waste management and energy alternatives, as well as using its powerful supercomputer modeling and simulation capabilities to help U.S. companies develop commercial applications. Goodyear was and is one of those companies. It does not actually run jobs on the Sandia computers–rather Goodyear engineers collaborate with Sandia's supercomputer experts in the development of intellectual property–specifically Goodyear's complex software and the detailed information required to run the software on the company's HPC clusters.

This jointly developed software, Miller says, is the real workhorse handling the upfront modeling and simulation. "It's one thing to buy the hardware; it's a whole different level to have the fundamental knowledge of physics and the advanced software required to solve the kinds of problems we were facing. Sandia, working in collaboration with our engineering mechanics–many of whom have Ph.D.s–has helped us develop and validate the software needed to simulate the tire's material properties." But it is not just a one-way street. As a result of its collaboration with Goodyear, Sandia has gained knowledge that has allowed them to solve weapons' design problems that were previously intractable.

Notes Miller, "There are other institutions in various countries that have great engineering and scientific capabilities, but in the United States, I think we are extraordinarily fortunate to have institutions like Sandia, the Department of Energy, the Department of Defense, and the various other laboratories. As a U.S. citizen, it's my hope that other companies will take the opportunity to try something that might seem counterintuitive, like working with a national lab to help solve some of their problems and improve the competitiveness of our industrial base."

HPC's Competitive Impact: Pulling Ahead of the Curve

Using the software developed in collaboration with Sandia, the Goodyear engineers working on the TripleTred Technology were able to create more complex simulations. This allowed them to realize the maximum performance from their HPC clusters and significantly speed up their initial modeling process.

One of the major factors that allowed the company to turn its revenue sheet around was that the Sandia/Goodyear association allowed Goodyear to innovate more rapidly than its competition. The introduction of the Assurance tire is a prime example of that innovation, as is the subsequent rapid-fire introductions of new additions to its Fortera® and Wrangler® light truck and SUV tires, and the new Eagle® with its ResponsEdge® and carbon fiber technology. Gingo comments, "Computational analysis tools have completely changed the way we develop tires. They have created a distinct competitive

advantage for Goodyear, as we can deliver more innovative new tires to market in a shorter time frame."

With its HPC clusters and partnership with Sandia, Goodyear has reduced key product design time from three years to less than one. Expenditures on tire building and testing dropped from 40 percent of the company's research, design, engineering and quality (RDE&Q) budget to 15 percent. The creation of this new product development engine and the launch of the Assurance tire with its TripleTred Technology resulted in Goodyear being selected for R&D magazine's "R&D 100" award in 2005, and CIO magazine's "Top 100" award the following year. There was some other significant fallout from the company's use of HPC–at the start of 2006, the company reported record sales for the fourth quarter and the full year of 2005. The full year's net income was the highest since 1998.

The design of the Assurance tire also allowed the Goodyear engineers to realize their goal of optimizing key characteristics such as treadwear, all-season performance, handling and a smooth, quiet ride. Or as Miller says, "We went beyond optimization–we created a better tire than anything our competitors could come up with. That's why for us, high performance computing is more than just a very sophisticated tool–it's a strategic asset that allows us to create new, innovative products that gain wide public acceptance. It makes Goodyear a formidable competitive force in today's global market."

In Brief

Key Challenges

- Create new high-value products to generate revenues, move the company back into a profitable position and put Goodyear out in front of its competition
- Dramatically accelerate the time-to-market for these new products

Solutions

- Change Goodyear's conventional routine of designing, building and testing physical prototypes to a more streamlined approach using modeling and simulation from the start
- Leverage long relationship with Sandia National Laboratories to jointly develop the software required to create and run these new, more complex models and simulations on the company's in-house HPC clusters

Key HPC Benefits

- Creates more complex simulations to speed up the front-end modeling process and realize maximum performance of Goodyear's HPC clusters
- Supports a significant increase in innovation among the engineering and scientific staff at both Goodyear and Sandia
- Allows the company to innovate more rapidly than its competition and quickly introduce leading-edge products
- Reduces product design time from three years to one
- Decreases building and testing from 40 percent of the company's RDE&Q budget to 15 percent
- Utilizes supercomputers to create a product design and development engine that allows the company to stay out in front of its competitors

Web Site

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