

TREADING NEW GROUND

By Nancy Forbes

AT FIRST GLANCE, IT MIGHT SEEM ODD TO FIND A NUCLEAR WEAPONS LAB AND A MAJOR TIRE COMPANY WORKING TOGETHER. HOWEVER, A COMMON INTEREST IN NONLINEAR DYNAMICS AND COMPUTATIONAL MECHANICS, TOGETHER WITH

forward-looking, supportive management, has brought engineers and scientists from Sandia National Laboratory in Albuquerque, New Mexico, together with their Goodyear counterparts to collaborate on several projects destined to improve the way tires are built and tested.

This cooperative research and development agreement (CRADA), or “strategic partnership,” as Al Romig, Sandia’s chief technologist and vice president for science and technology and partnerships prefers to call it, has been ongoing since the early ’90s. Deemed successful by both parties, they just signed a new “umbrella” CRADA that will let them extend their partnership into new areas, such as information management and chemical process technology.

Sandia has been very active in forming partnerships with the private sector, probably more so than any other US Department of Energy defense lab, and Romig is one of the primary driving forces behind that effort. Sandia has an extremely broad spectrum of research that could potentially attract many private sector companies—for example, advanced manufacturing, microelectronics, photonics, biotechnology, robotics, nanotechnology, materials science, and

highly advanced modeling and simulation capabilities—in addition to its cadre of world-class talent and resources. These resources include one of the world’s three fastest supercomputers running at teraflop speeds and highly trained computational mechanics and simulation scientists with years of experience devising advanced computational algorithms and codes.

CRADAs were developed in the early ’90s by the Department of Energy in response to the nation’s industrial competitiveness concerns, in an attempt to leverage the top-notch technology and scientific talent found in its national laboratories. According to Romig, because Sandia had a lot to offer the private sector, and its engineering culture was a good match with that found in industry, the lab was successful early on at establishing several partnerships with industry, including the one with Goodyear. “We had, and still have, a policy that these partnerships have to be a strategic coupling for Sandia, in the sense that, by working with industry, they allow us to develop or further a particular capability we have,” Romig says. “It’s not the money they bring in—which, parenthetically, was over US\$70 million last year—but rather the fact that they enhance our overall ability to fulfill our

national security mission.”

The financial arrangements behind the partnerships vary, Romig says. “One option is for the company to pay for everything, both at the lab and at its site. Another is for Sandia and the company to share costs, although this is rarer now that there are no set-aside dollars for this kind of work. Lastly, Sandia must, by law, work under full cost recovery. For example, if the industrial partner uses our computer time, they must pay for it; but if we develop a general software code that will benefit us directly, and it also happens to benefit them, then we’d cover the costs.”

In addition to giving the lab a chance to develop new abilities, CRADAs often result in the industrial partner becoming a supplier to the lab. What’s more, Romig says, “They are a wonderful vehicle for technology maturation and commercialization, helping a fledgling technology from the lab cross ‘the valley of death’ that goes from its development to the market. For more out-of-the-box technology, like MEMs, we’ll actually let some Sandians license the technology and go on leave to begin a startup company.”

The Goodyear CRADA has been one of Sandia’s longest running and most successful, in terms of the benefits both partners claim to have derived from it. John Lawrence, Goodyear’s vice president for corporate research, says, “The technology evolving from the Advanced Mechanics Tools task allows us to model the inflation, deflection under load, and rolling of tires for mechanical and thermal response. Sandia’s computational

mechanics tools have enabled us to continue our transition from design–build–test to simulations and predictions.” This process helps the company shorten production time and reduce costs. The CRADA has also resulted in other materials, process, and manufacturing technologies related to tires.

According to Hal Gordon, manager of Sandia’s solid mechanics structural dynamics department and in charge of one of the projects under the Goodyear CRADA, “The computational mechanics of modeling tires is extremely complex. Tires are highly intricate structures with many soft rubber components as well as very stiff steel cables in the bead area, steel belts in the crown of the tire, and polyester cords located radially throughout the carcass. They are composed of both soft and stiff materials, interacting together to give the tire a highly complicated response. It’s definitely a nontrivial mechanics problem.”

The advanced skill set developed at Sandia in computational mechanics, numerical methods, and software engineering over decades of modeling nuclear weapons response, has enabled the lab to find a synergy with Goodyear and apply its knowledge in a completely new arena. Sandia has traditionally used these tools for modeling and simulation purposes in the production of nuclear generators and other applications related to weapons, which has made the design process much more efficient. Neutron generators are an important element of nuclear weapons. According to Tom Bickel, director of engineering sciences at Sandia, applying these methods in the design and manufacture of tires has let them test and validate their capabilities in a completely different way.

“We’re embarking on a path where we can now capture and solve engineering physics problems in 3D at high fidelity, no matter what the object, and



solve problems with greater than 10 million finite elements. We’ve found that the software engineering skills and large, high-end massively parallel processing power used for nuclear weapons simulations at the lab is very applicable to Goodyear’s problems, and in some cases can even stimulate the development of new algorithms suited to tire modeling,” Bickel says. “Success has meant being able to use these tools to help Goodyear improve their tires, developing joint capabilities, and extending our own knowledge base to improve our ability to model nuclear weapons response.”

Goodyear’s Lawrence believes that by modifying the computational tools they have developed with Sandia, they’ll be able to apply them to areas where, up to now, it hasn’t been feasible to predict tire performance. Some of these are multiphysics problems, where a fluid dynamics problem is coupled with a heat transfer problem,

which in turn is coupled with a mechanical structural response.

The newly negotiated follow-on CRADA between Sandia and Goodyear, the seventh since 1992, will take the collaboration to new areas of commonality, such as exploring energy efficiency with Goodyear’s chemical business. Specifically, the two groups will share methods for analyzing chemical process technologies to reduce energy consumption, waste generation, and harmful emissions to the environment.

“It’s been extremely rewarding for us to interact with industry in such a productive way,” says Bickel. “It’s not every day that a weapons lab gets to collaborate with an established tire manufacturer, based on common engineering, simulation, and computational needs and common research goals.” ❏

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