2008 FLC Award for Excellence in Technology Transfer
Section 1 – Submission Cover Sheet

Laboratory Name: Sandia National Laboratories

If submitting more than one nomination in this category, please indicate how many others are being submitted: Sandia National Laboratories will submit four nominations total in the category Excellence in Technology Transfer.

Title of Nominated Technology Transfer (10 words maximum): Computational Analysis Tools for Goodyear *Assurance Tires – Featuring TripleTred Technology*

Summary:
In the space below, write a brief (450 words maximum) summary of the nomination that describes: the transferred technology, the technology transfer process used, and the benefits of the transfer effort. **Please write this paragraph in non-technical terms for a non-scientific audience.**

In partnership with Sandia National Laboratories, The Goodyear Tire & Rubber Company replaced the previous iterative methodology of "build, test, repeat" for tire development with a powerful set of simulation tools using Sandia-developed technology for design, prototype development, and performance evaluation. This allows optimization over a significantly wider range of parameters in design features and material choices, even within a tight development timeframe and budget. The result is a superior product at an attractive, competitive cost. The enabling technologies that were brought together and transferred under a Cooperative Research and Development Agreement (CRADA) include: computational modeling, high-performance computing, and surface physics.

The resulting product, *Assurance featuring TripleTred Technology,* is an Any Weather tire for a wide variety of automobiles. *Assurance featuring TripleTred Technology* is already in the replacement market and will soon be on Original Equipment Manufacturers (OEMs) vehicles. The size lineup is expanding into higher-performance speed ratings.

The *Assurance* line is one of the most successful product launches in Goodyear's history. The company has reported excellent sell-out and replenishment orders, and prices for these high-margin tires are holding at premium levels. The company is ramping up production of the line by expanding manufacturing and adding new sizes as quickly as possible to meet demand. The enhanced optimization of features and materials, as well as the shorter design-to-build schedule has helped Goodyear maintain a competitive position in the worldwide tire market.

Goodyear executives challenged the company's new product development team to create a highly differentiated and innovative new product in less than half the usual timeframe. Through the partnership/CRADA, Sandia's simulation tools were used extensively to bring this innovative new product to market in less than a year, compared to the more typical timeframe of two to three years. Goodyear's leading tire designer stated that *TripleTred* could have never been brought to market that quickly without the computational simulation capability, and that he would never design another tire without it.

The partnership also benefits the National Nuclear Security Administration (NNSA) as it allows Sandia to use its computational models over a broad set of engineering conditions, helping build confidence in their robustness and accuracy, and improving code verification and model validation metrics over a broad range of physics, including use in nuclear weapons. This saves the taxpayers money in validation and allows Sandia to evaluate different ways of achieving the next generation of computational engineering design in the industrial arena and within Sandia. Sandia's Department of Energy (DOE) defense program is using the tools to do simulations in the production of neutron generators and in other nuclear weapons applications, reducing portions of a neutron generator encapsulation schedule by a factor of two. Neutron generators are critical components of nuclear weapons.

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RECEIVED: **SUBMISSION NUMBER:**

NOMINEE INFORMATION INSTRUCTIONS:

- List the names (including Mr., Ms., Miss, Mrs., Dr., etc.) and job titles of nominees below.
- Designate one nominee as the primary contact who will be responsible for disseminating information from the FLC to the rest of the team.
- If the address is a PO Box, also include the street address.
- If the project leader is not the primary contact, please provide their information below the primary contact section and designate them as the project leader.
- If any nominee(s) has a different address than the primary contact, provide this information.

Nominee/Primary Contact: Dr. Harold Morgan
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NOMINATOR INFORMATION INSTRUCTIONS

- List the names (including Mr., Ms., Miss, Mrs., Dr., etc.) of the nominators below.
- If the nominator holds more than one of the positions listed below (e.g. FLC Representative and ORTA Representative) it is only necessary to list the name of the nominator in the entry of the second position.
- If the address is a PO Box, also include the street address.

THE FLC <u>STRONGLY RECOMMENDS</u> THAT ALL LISTED NOMINATORS HAVE AN OPPORTUNITY TO REVIEW AND APPROVE THE FINAL NOMINATION BEFORE IT IS SUBMITTED FOR JUDGING!!!

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2008 FLC Award for Excellence in Technology Transfer Section 2 – Submission Narrative

Laboratory Name: Sandia National Laboratories
Title of Nominated Technology Transfer: Computational Analysis Tools for Goodyear *Assurance Tires – Featuring TripleTred Technology*

PART A – Background and Technology Transfer Process
Address each of the following items on pages 2-1 and 2-2. See the award criteria for details on each item. If a criterion is not applicable, indicate why not and evaluators will make adjustments accordingly. **Criteria that are not addressed will not receive points.**

1. **Description of Technology (5 points)**
2. **Tech Transfer Recipient and Need for Technology (7 points)**
3. **Technology or Technical Expertise (5 points)**
4. **Initiation of Technology Transfer Partnership (10 points)**
5. **Technology Transfer Processes Used/Innovations (5 points)**
6. **Time Frame Challenges (5 points)**
7. **Patents and Publications (3 points)**

1. In partnership with Sandia National Laboratories, The Goodyear Tire & Rubber Company replaced the previous iterative methodology of "build, test, repeat" for tire development with a powerful set of simulation tools using Sandia-developed technology for design, prototype development, and performance evaluation. This allows optimization over a significantly wider range of parameters in both design features and material choices, even within a tight development timeframe and budget. The result is a superior product at an attractive, competitive cost. The enabling technologies that were brought together and transferred under a Cooperative Research and Development Agreement (CRADA) include: computational modeling, high-performance computing, and surface physics.

Assurance featuring TripleTred Technology is an Any Weather tire made for a wide variety of popular automobiles. *Assurance featuring TripleTred Technology* is already in the replacement market and will soon be on Original Equipment Manufacturers (OEMs) vehicles. The size lineup is expanding into higher-performance speed ratings.

2. The *Assurance* line is one of the most successful product launches in Goodyear's history. The company has reported excellent sell-out and replenishment orders, and prices for these high-margin tires are holding at premium levels. The company is ramping up production of the line by expanding manufacturing from one plant to four and adding new sizes as quickly as possible to meet demand. The enhanced optimization of features and materials, as well as the shorter design-to-build schedule has helped Goodyear maintain a competitive position in the worldwide tire market.

The enhanced solution algorithms that led to the original breakthrough in the CRADA also enabled many computational mechanics simulations for Sandia's nuclear weapons application that were previously intractable or less accurate than desired. In one example, the computational capabilities enabled highly accurate simulations of curing processes for polymer encapsulants used in neutron generators. These simulations were used to develop optimal curing schedules that reduced both the residual stresses in the encapsulants and the overall cure time compared to the originally planned curing process. The computational mechanics capabilities also enabled simulation of sheet metal forming processes that were used to understand the forming of screens used in neutron generators. The simulation capability was used to assess the integrity of O-ring seals as the O-rings aged over their lifetime in the nuclear stockpile.

The partnership also benefits the National Nuclear Security Administration (NNSA) as it allows Sandia to use its computational models over a broad set of engineering conditions, helping build confidence in their robustness and accuracy, and improving code verification and model validation metrics over a broad range of physics, including use in nuclear weapons. This saves the taxpayers money in validation and allows Sandia to evaluate different ways of achieving the next generation of computational engineering design in the industrial arena and within Sandia. Sandia's Department of Energy (DOE) defense program is using the tools to do simulations in the production of neutron generators and in other nuclear weapons applications, reducing portions of a neutron generator encapsulation schedule by a factor of two. Neutron generators are critical components of nuclear weapons.

3. One of Sandia's areas of expertise is virtual prototypes. Because government treaties prohibit most testing of nuclear weapons, Sandia has developed extensive modeling capabilities for virtual testing. At first glance, nuclear weapons and tires would seem to have very little in common. However, from an engineering standpoint they share several important similarities: large deformations at high speeds, multiple materials of widely varying properties in the same structure, and geometric complexity. Many of the same engineering challenges arise when a missile strikes the ground or when a tire hits a pothole. By running full-scale tire tests for validation, Goodyear confirmed the accuracy of the software for the benefit of both organizations.

Sandia provides the significant computing power needed for a useful model. As more details are included in the model, the accuracy and applicability increases but so does the cost of running the model. In the models for *Assurance*, there were millions of nodes and elements in the finite element meshes, which resulted in millions of degrees of freedom to be solved in computer runs that would typically take days or weeks on a conventional engineering computer. Running on four processors cut the turnaround time by a factor of four, so instead of waiting several days for results, the tire engineer received answers overnight.

4. Sandia technology provides a competitive advantage to companies like Goodyear, and insights gained by applying Sandia technology to difficult problems in industry improve the technology for nuclear weapons and other national security applications. The total investment over 14 years has grown to about $130M with DOE providing $17M to Sandia, Goodyear providing $42M to Sandia (funds-in), and Goodyear providing $71M of in-kind funds for its associates to work with Sandia.

The partnership began in 1993 with three CRADAs under the auspices of DOE's Technology Transfer Initiative, which funded the national laboratories to work with U.S. industry. These CRADAs focused on transfer of Sandia technology to Goodyear in the areas of computational mechanics, structural dynamics, and materials. Almost all of the DOE funding for the partnership occurred as seed money during the first three years of the relationship. A year and a half into the partnership, Goodyear began to invest directly in Sandia technology. The partnership has gone on to develop new CRADAs and, ultimately, an "umbrella" CRADA that enables even more joint efforts.

5. A common bond in computational mechanics created a teaming effort between Goodyear and Sandia to replace the tire company's traditional build-and-test design method with reliable computational mechanics simulation tools. This collaboration, accomplished under a CRADA, has provided Goodyear with modeling tools that shortened production time and reduced costs.

The partnership produced such good results that the two signed a new, five-year 'umbrella' CRADA to streamline their joint research and development work. The new CRADA, the eighth we have signed since 1992, will facilitate changes and additions to work in progress and enable them to easily establish new projects. This Umbrella CRADA concentrates on exploring new and more energy-efficient processes that could dramatically reduce U.S. petrochemical industry dependence on foreign oil. The Umbrella CRADA has eleven subordinate Project Task Statement.

6. Goodyear executives challenged the company's new product development team to create a highly differentiated and innovative new product in less than half the usual timeframe. Through the partnership/CRADA, Sandia's simulation tools were used extensively to bring this innovative new product to market in less than a year, compared to the more typical timeframe of two to three years. Goodyear's leading tire designer stated that *TripleTred* could have never been brought to market that quickly without the computational simulation capability, and that he would never design another tire without it.

7.

Patents:

D491,883. Landers, Schmalix, et al.; June 22, 2004

D501,180. Landers, Schmalix, et al., January 25, 2005

Goodyear Internal Disclosures: DN2003-087D01, DN2003-095, DN2003-096, DN2004-031L, DN2004-081, DN2004-095

PART B – Results
Address each of the following items on pages 2-3 and 2-4. See the award criteria for details on each item. If a criterion is not applicable, indicate why not and evaluators will make adjustments accordingly. **Criteria that are not addressed will not receive points.**

1. **New Relationships (5 points)**
2. **Follow-up Activities (10 points)**
3. **Outcome of Technology Transfer Effort (45 points)**

1. The success of the CRADA also inspired new collaborations between Goodyear and Sandia in other areas useful to both partners, including tire dynamics, chemical separation, pressure sensors, engineered products, manufacturing reliability focused on human factors in manufacturing processes, performance prediction focused on improved experimental diagnostics for measuring temperature, strain, and pressure, innovative use of microsystems as diagnostics, the manufacturability of innovative pressure sensors, and nanomaterials.

These collaborations with Goodyear have produced more partnering opportunities for Sandia. The value of the collaborations to both Goodyear and Sandia have drawn attention from automakers and other suppliers on the automotive industry. Energy companies have also "heard the Goodyear-Sandia story" and sought to collaborate with Sandia based on the value they see that Sandia might bring to their technology needs.

2. One example of a follow-on project that supports both Sandia's missions and the commercial requirements of Goodyear is a sensor that detects tire pressure. Current technologies that monitor individual tire pressure require individual batteries and constitute a maintenance problem for the vehicle owner. Further, these devices attach either to the inside of the rim or under the valve stem, making them vulnerable to damage during mounting and demounting operations. Sandia and Goodyear designed an inexpensive surface acoustic wave (SAW)-based pressure sensor system that consists of an active radio frequency (RF) transceiver mounted on the car as well as passive pressure sensors mounted on the tires. The sensor mounting is accomplished by producing a machined cavity formed in tire material that is sealed with a flexible conductive membrane. When an over-pressure is applied to the membrane, the membrane deflects and makes contact with several conducting ridges that are electrically connected to the conductive fingers of the SAW device. When the pressure is correct, selected fingers on the SAW device are grounded, producing patterned acoustic reflections to an impulse RF signal. The device has been demonstrated in rolling tires at speeds up to 80 miles per hour.

The Umbrella CRADA negotiated between Sandia and Goodyear's chemical business is allowing exploration of new and more energy-efficient processes that could dramatically reduce U.S. petrochemical industry dependence on foreign oil. They are sharing expertise to analyze chemical process technologies that may reduce energy consumption, waste generation, and environmental emissions. In one project, Goodyear and Sandia developed membranes for the energy-efficient production of isoprene feedstock chemicals for hydrocarbon and chemical separations. Industrial involvement from Goodyear and Burns & McDonnell provided needed direction for solving real industrial problems.

Fractional, extractive, and cryogenic distillations, which are inherently energy intensive, are the dominant separation technologies for olefin and isoprene isolation and purification. The high energy costs of these separation technologies motivated the petrochemical industry to explore alternatives, which led in the past decade to 140 patents issued worldwide. However, all these patented technologies represent incremental improvements. The work performed in this CRADA will advance current separation technology towards greater energy-efficient and waste-reducing processes that will increase productivity, product quality, and global competitiveness.

Goodyear's contribution to this research was the rapid bench-scale and pilot-plant testing of the adsorbent materials developed by Sandia, with timely feedback of these results to Sandia. Burns & McDonnell possesses the most sophisticated computer model of Goodyear's isoprene process because of their 30-year association with Goodyear's Beaumont, Texas isoprene plant. Burns & McDonnell has been an essential partner for the successful completion of this project because of their modeling, engineering design, economic analysis, construction, marketing, and licensing skills and expertise.

The improvements represented in these projects made to Sandia's computational capabilities, sensor development, and material engineering have strengthened Sandia's science and engineering base. For example, improved computational capabilities enabled improved simulations for nuclear weapons applications that were previously intractable. In addition, enhanced use of computational simulation is a critical part of Sandia's vision for a responsive nuclear weapon infrastructure. Lessons learned in helping Goodyear institutionalize computational simulation in its design culture have been useful in Sandia's transformation of its computational support of weapons activities. Goodyear has provided proprietary information on its tire distribution system that Sandia is using to develop models for the Department of Homeland Security (DHS) to assess how various parts of the U.S. economic infrastructure might be affected by terrorist disruptions. Goodyear has also allowed Sandia to use their tire test track to evaluate improvements to the tractor trailers used to transport nuclear weapons.

3. The outcome of the technology transfer between Sandia and Goodyear that is the focus of this nomination has been a breakthrough line of tires that are better and safer for the consumer, that have improved Goodyear's financial situation and helped them get the tires out quicker and less expensively, and that have given Sandia useful data to apply to their other projects. By taking advantage of the speed and parallel processing capabilities of the Sandia software, Goodyear modeled all tire sizes even within an accelerated design timetable. Goodyear has gone on to implement parallel computing on a much larger scale for new tire design, including installing clusters of 128 processors and 256 processors.

The contact patch between the tire and the road, or footprint, determines much of the tire's performance. Therefore, it is essential to capture the mechanics of contact in the footprint to have a good tire model. In the past, tire engineers had to build prototype tires and subject them to tests with specialized equipment in order to see the footprint shape, contact pressure, and frictional energy. For the *Assurance* project, virtual prototypes were used to compute these quantities. By tuning the footprint shape and contact pressure, the tire engineer can modify many of the tire's performances, including handling, hydroplaning, noise, ride comfort, and traction. By tuning the frictional energy, the engineer can control the wear performance of the tire.

Breakthroughs in technological engineering give the *Assurance* tires exceptional traction in cold, wet, or dry conditions. The tread design features an Ice Zone (helps improve traction on icy surfaces, holds onto the road, and maintains maximum flexibility in cold weather); Water Zone (long diagonal channels called Aquachutes propel water away from the tire's tread on rain-drenched roads, helping the tire hold the road); and Outer Dry Zone (grips during hard cornering or swerving without compromising durability during everyday driving).

One of the key elements in the new tire is the use of volcanic sand in the tire's winter formulated compound, which allows the tire to maintain flexibility in cold weather. Volcanic sand, added as ground pumice, is used in the tire's Ice Zone, which has a high-tech rubber compound to create a rough surface on the tread. As the tire is used, the gritty pumice creates a constantly rough and textured surface that works as tiny traction edges for better grip on slick surfaces. The volcanic sand is complemented by the use of glass fibers. These tiny fibers are designed to create a pitted surface in the tread that resembles a textured lunar surface. In addition to its innovative tread pattern and advanced in rubber compounding, the tire was the catalyst for accelerated technology in materials science, manufacturing, computer modeling, market research application, and teamwork. These process innovations are now being used throughout the company on current projects.

2008 FLC Award for Excellence in Technology Transfer
Section 3 – Submission Verification Checklist

(This page will only be accepted via fax at 856-667-8009)

Laboratory Name: Sandia National Laboratories
Title of Nominated Technology Transfer: Computational Analysis Tools for Goodyear *Assurance Tires – Featuring TripleTred Technology*

Please review each item below and determine whether your nomination meets the stated requirements. For the last two items, you must simply agree to comply with these requirements in the event that the nomination is chosen as a winner.

- ☑ The FLC Laboratory Representative and the representative's immediate supervisor are not nominated.
- ☑ The majority of the nominee(s) are employees of the FLC member laboratory listed above. In the case of a group nomination, more than 50% of the staffing or funds provided came from this laboratory.
- ☑ The technology is not solely funded by a Small Business Innovation Research (SBIR) contract or is a 100% grant funded commercial project.
- ☑ The nominee(s) has been nominated no more than three times in any year as an individual or as part of a group.
- ☑ The technology transfer achievement took place in the last five years.
- ☑ There is no proprietary information contained within this nomination.
- ☑ The technology involved is clearly described in layman's language.
- ☑ The Submission Cover Sheet (Section 1) is completed per instructions and comprises the first four pages of the nomination package.
- ☑ The nomination was reviewed and approved by all the nominators listed on the Submission Cover Sheet (Section 1).
- ☑ The Submission Narrative (Section 2) uses the page format established by the FLC, is typed in 10 point type or larger, addresses all items listed in the award criteria, and comprises pages 2-1 through 2-4 of the nomination.
- ☑ Section 1 and Section 2 of the nomination package are being submitted electronically to the FLC Management Support Office via mchambers@utrs.com by **Friday, October 19, 2007.**
- ☑ No supporting documentation is attached.
- ☑ The FLC may use this entire submission as a resource document and for media purposes.
- ☑ In the event of being chosen as a winner, at least one nominee will participate in the award ceremony at the 2008 FLC National Meeting in Portland, Oregon.
- ☑ The nominee(s) will provide a poster display for an exhibit at the 2008 FLC National Meeting in Portland, Oregon.

As the nominating official and FLC Representative from this laboratory, I understand that entries not conforming to this checklist will be returned without consideration.

Signature	Phone	Date