



U.S. DEPARTMENT OF
ENERGY

**Report on Technology
Transfer and Related
Technology Partnering
Activities at the National
Laboratories and Other
Facilities
Fiscal Years 2009-2013**

**Report to Congress
May 2015**

**United States Department of Energy
Washington, DC 20585**

Message from the Secretary

The Report on Technology Transfer and Related Partnering Activities at the National Laboratories and Other Facilities for Fiscal Year 2009-2013 is prepared in accordance with the requirements of the Technology Transfer and Commercialization Act of 2000:

It is the continuing responsibility of the Federal Government to ensure the full use of the results of the Nation's Federal investment in research and development. To this end the Federal Government shall strive where appropriate to transfer federally owned or originated technology to State and local governments and to the private sector.

Each Federal agency which operates or directs one or more Federal laboratories or which conducts activities under sections 207 and 209 of title 35 shall report annually to the Office of Management and Budget, as part of the agency's annual budget submission, on the activities performed by that agency and its Federal laboratories under the provisions of this section and of sections 207 and 209 of title 35.

Pursuant to the legislative language this report is being provided to the following Members of Congress:

- **The Honorable Joseph Biden**
President of the Senate
- **The Honorable John Boehner**
Speaker of the House
- **The Honorable Thad Cochran**
Chairman, Senate Committee on Appropriations
- **The Honorable Barbara Mikulski**
Ranking Member, Senate Committee on Appropriations
- **The Honorable Harold Rogers**
Chairman, House Committee on Appropriations
- **The Honorable Nita M. Lowey**
Ranking Member, House Committee on Appropriations
- **The Honorable Lamar Alexander**
Chairman, Subcommittee on Energy and Water Development
Senate Committee on Appropriations
- **The Honorable Dianne Feinstein**
Ranking Member, Subcommittee on Energy and Water Development
Senate Committee on Appropriations

- **The Honorable Mike Simpson**
Chairman, Subcommittee on Energy and Water Development
House Committee on Appropriations
- **The Honorable Marcy Kaptur**
Ranking Member, Subcommittee on Energy and Water Development
House Committee on Appropriations
- **The Honorable Fred Upton**
Chairman, House Committee on Energy and Commerce
- **The Honorable Frank Pallone**
Ranking Member, House Committee on Energy and Commerce
- **The Honorable Lamar Smith**
Chairman, House Committee on Science, Space, and Technology
- **The Honorable Eddie Bernice Johnson**
Ranking Member, House Committee on Science, Space, and Technology
- **The Honorable Lisa Murkowski**
Chair, Senate Committee on Energy and Natural Resources
- **The Honorable Maria Cantwell**
Ranking Member, Senate Committee on Energy and Natural Resources

Technology partnering is an active component of Department of Energy's (DOE) overall mission to promote scientific and technological innovation that advances the economic, energy, and national security interests of the United States. This *Report* describes these activities and outlines DOE's procedures for ensuring appropriate management and oversight of their conduct, in accord with prevailing policy and authorities. If you have any questions, please do not hesitate to contact Mr. Brad Crowell, Assistant Secretary for Congressional and Intergovernmental Affairs, at 202-586-5450.

Sincerely,

A handwritten signature in black ink, appearing to read 'Ernest J. Moniz', with a stylized flourish at the end.

Ernest J. Moniz

Executive Summary

During the reporting period (2009-2013), DOE has developed a sharpened focus on Technology Transfer activities, with a broader definition and commitment to continuously improving the Department's efforts, thereby enhancing the impact of the science and technology discoveries made at DOE Facilities. To support this focus, DOE has implemented a number of programmatic initiatives designed to improve the procedures for external partnering with its National Laboratories and other facilities and to provide greater visibility to the private sector of the opportunities to work with them.

DOE's National Laboratories and other facilities¹ have sustained their activities in technology commercialization and engagement with the private sector. In 2013 they participated in over 3000 contracts with the private sector, including more than 600 with small businesses, and have supported 40 start-up companies. The facilities have sustained strong rates of invention disclosures and patent awards, with over 1500 disclosures and over 700 patents issued in 2013. The high quality of the commercialization activities is recognized annually through the R&D 100 awards, with the DOE Facilities having received 185 of the 500 awards over the past five years.

DOE's technology transfer impact is also enhanced through cross cutting programs, notably the Small Business Technology Transfer (STTR) Program and through industrial engagement with DOE's Scientific User Facilities and shared R&D facilities.

¹ For simplicity, the term "DOE Facilities" in this document will be used to mean facilities at DOE and NNSA laboratories as well as DOE facilities at the non-laboratory DOE sites as defined in section II.



Report on Technology Transfer and Related Technology Partnering Activities at the National Laboratories and Other Facilities Fiscal Years 2009 - 2013

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I. Introduction

Technology transfer has been an aim of United States Federal Government (USG) policy since the passage of the Bayh-Dole (P.L. 96-517, as amended by P.L. 98-620) and the Stevenson-Wydler (P.L. 96-480) legislation during the 1980s. In 1989, the *National Competitiveness Technology Transfer Act* (P.L. 99-502) strengthened this goal by establishing technology transfer as a mission of Federal research & development (R&D) agencies, including the Department of Energy. Since then, DOE has encouraged its National Laboratories and production facilities to enter into technology partnering activities with non-Federal entities, as appropriate, using a variety of mechanisms. Pursuant to 48 CFR §970.5227-3 Technology Transfer Mission Clause (48 CFR Chapter 9, Subchapter I, Part 970, Subpart 970.52), DOE has authorized its facilities to patent and license intellectual property (IP) resulting from DOE R&D and to collect and make appropriate use of related royalties and fees for Government-funded technology transfer activities. For the purpose of this document, “technology transfer” refers to the process by which knowledge, intellectual property, or capabilities developed at the Department of Energy’s National Laboratories, single-purpose research facilities, plants, and other facilities (“Facilities”) are transferred to other entities, including private industry, academia, and state or local governments. Such transfers may take many forms, including but not limited to: Cooperative Research and Development Agreements (CRADAs), Strategic Partnership Project (SPP) Agreements (formerly Work for Others), User Agreements, and licensing of intellectual property.

As demonstrated in this report, private firms and other non-Federal entities have found that DOE’s Facilities can provide, to the benefit of their own objectives, valuable and often unique problem solving capabilities, and in some cases, they have built long-term relationships with DOE that yield greater results over time. Technology partnering is also important in furthering the vibrancy of technical competencies at DOE’s Facilities. Similarly, the DOE Facilities can benefit from engagements with others with the skills to develop, commercialize, and to distribute the benefit of knowledge from its technology into society for greater public benefit. DOE Facilities are trusted partners and commercial engagements may be kept confidential as needed to support global competitiveness.

This report satisfies reporting requirements required under Federal Statutes, in a context of DOE’s broadened focus on technology transfer as one component of DOE’s overall Technology Transitions activities, which broadly address the commercialization and economic impact of technology developments under DOE’s programmatic activities. In Section 3, we present an overview of the Secretarial Guidance for technology transfer (fully listed in Appendix A), and outline how the legislatively required activities will be supported under the new Office of Technology Transitions. A list of the Laboratory Technology Transfer offices is provided in Appendix B. The reporting metrics for Technology Transfer are presented in Section 4 (with additional information in Appendix C and D), along with the results of new metrics introduced in 2013 and a preliminary assessment of industrial engagement with DOE’s User Facilities and Shared R&D Facilities. The final section, Section 5, introduces the commercial technologies that have resulted from invention and development at DOE Facilities. Technical descriptions of a subset of these technologies are presented in Appendix E. Additionally, Section 5 includes descriptions of Programmatic Initiatives undertaken during the past 5 years to improve DOE’s Technology Transfer processes, and introduces cross cutting activities with our Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) program. In addition, the Advanced Research Projects Agency–Energy (ARPA-E), has also support technology transfer through its technology-to-market program which works directly with ARPA-E projects to help them move to the next stage of development.

II. Technology Partnering Policy and Management

In FY2011, DOE issued a new Secretarial Policy Statement on technology transfer at DOE Facilities (Appendix A). The updated policy statement builds on the earlier 2007 Policy, and emphasizes that all DOE Facilities and Programs have a responsibility to ensure robust technology transfer activities and research partnerships with industry that result in commercialization and deployment. This policy statement underscores nine principles to guide DOE's technology transfer program:

1. Commitment to continuously improving policies and procedures for effective technology transfer in support of its mission, and for the Nation's benefit.
2. Empowerment of innovators who discover and develop technologies at DOE laboratories and facilities.
3. Fairness of opportunity to promote domestic economic interests with due consideration for securing the benefits of globalization while balancing U.S. competitiveness considerations.
4. Facilitation of commercialization by involving partners that have viable business plans for expeditious technology development and deployment.
5. Assuring visibility of DOE laboratories and facilities to promote access to capabilities and intellectual property by all, including small businesses and entrepreneurs
6. Leveraging resources in partnering transactions that complement DOE's mission, goals and objectives and demonstrably benefit the United States.
7. Continuously improving impact through the use of effective incentives and metrics that are effectively indicate success and impact.
8. Predictability, streamlined processes, transparency, and appropriate flexibility in the application of policies governing technology transfer activities.
9. Cooperation throughout the DOE complex for sharing best practices and lessons learned in order to further technology transfer at the DOE, for collaborating in commercialization, maximizing flexibility, eliminating and avoiding unnecessary barriers in order to achieve positive impact.

Laboratories and facilities Engaged in Technology Transfer

Federal statutes authorize the DOE Facilities listed on the following page to conduct technology partnering activities. Most of these Laboratories and facilities have established formal technology transfer programs (Appendix B) with staff dedicated to the facilitation of the administrative and negotiating processes involved in entering into agreements with non-Federal partners.

Office of Science

- Ames Laboratory
- Argonne National Laboratory
- Brookhaven National Laboratory
- Fermi National Accelerator Laboratory
- Lawrence Berkeley National Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Princeton Plasma Physics Laboratory
- SLAC National Accelerator Laboratory
- Thomas Jefferson National Accelerator Facility

National Nuclear Security Administration

- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Sandia National Laboratories
- Savannah River Site
- Kansas City Plant
- Y-12 National Security Complex
- Pantex Plant
- Nevada National Security Site (N2S2) (formerly the Nevada Test Site (NTS))

Office of Energy Efficiency and Renewable Energy

- National Renewable Energy Laboratory

Office of Nuclear Energy

- Idaho National Laboratory

Office of Fossil Energy

- National Energy Technology Laboratory

Environmental Management

- Savannah River National Laboratory

Organization

DOE’s oversight, management, and administration of its technology partnering activities are evolving to address the broader scope of the Secretarial Policy. The evolving processes are encompassed within the establishment of the Office of Technology Transitions, and will address the functions of the Technology Transfer Coordinator (as defined in the Energy Policy Act of 2005 (EPAcT 2005), Title X, Section 1001), the Technology Transfer Working Group and the Technology Transfer Policy Board.

Technology Transfer Coordinator

EPAcT 2005, Title X, Section 1001(a-c) instructs the Secretary of Energy to appoint a Technology Transfer Coordinator to serve as the “principal advisor to the Secretary on all matters relating to technology transfer and commercialization.” In 2007, the Energy Secretary met this need by appointing the Under Secretary for Science as the Department’s Technology Transfer Coordinator. The role was subsequently filled by a full time appointment that did not occupy a dual role within DOE. To ensure DOE accomplishes mission objectives of the 2011 Secretarial Policy, the Office of the Under Secretary for Science and Energy is establishing an Office of Technology Transitions. As currently envisioned the Technology Transfer Coordinator also will serve as the head of that Office to address increasingly more complex and challenging issues DOE faces in the Technology Transfer area. In 2014, the Secretary of Energy appointed a Senior Advisor for Technology Transfer to serve as an interim leader to coordinate technology transfer activities until at such time a Technology Transfer Coordinator was appointed. The Senior Advisor was also asked to make a recommendation on how best to coordinate and leverage technology transfer related activities of the Department. Based on the Senior Advisor’s interactions with internal and external stakeholders, she recommended to the Secretary that he establish the Office of Technology Transitions for the Department. The Senior Advisor then guided the formation of the new office and

established its operations until the next Technology Transfer Coordinator could be appointed. In 2015, the Secretary appointed a TTC and Acting Director of the Office of Technology Transitions. The dual reporting lines of this position provide authority to support Department-wide coordination of technology transfer activities as directed by the Secretary and the Under Secretary to provide oversight and coordination across Departmental programs.

Technology Transfer Working Group

In accordance with EPAct 2005, DOE has a Technology Transfer Working Group (TTWG) consisting of representatives from each of the Laboratories and facilities, and members of DOE field offices. The members of the TTWG serve as the primary point of contact between the Technology Transfer Coordinator and the laboratories and facilities, and support policy development and reporting.

The Technology Transfer Working Group has produced three guides to provide information on, and provide a greater understanding of, technology transfer at DOE: TTWG Licensing Guide², TTWG Guide to Partnering with the National Laboratories³, and TTWG Reporting and Appraisal Guide.

Alternative Dispute Resolution/Ombuds

DOE's Office of Conflict Prevention and Resolution (OCPD) provides guidance on the use of Alternative Dispute Resolution (ADR) techniques to DOE laboratories and facilities for any technology transfer issues. OCPD also coordinates with the Office of the Assistant General Counsel for Technology Transfer and Intellectual Property in working with the individual ombuds at sites throughout the DOE complex to address any IP disputes at the earliest possible stage.

In FY 2009-2013, ombuds at DOE's National Laboratories and facilities were involved in 24 discussions involving CRADAs, patents, licenses, Strategic Partnership Projects, or other issues. Six of these did not proceed past the initial discussion. Of those that continued, 15 were resolved, one is still pending, and one was withdrawn.

Technology Transfer Policy Board

The Technology Transfer Policy Board (TTPB) supports the Technology Transfer Coordinator. Its members are designated from the Department's major program and staff offices engaged in technology transfer, including the National Nuclear Security Administration (NNSA), the Office of Science (SC), and the applied research programs of Energy Efficiency and Renewable Energy (EE), Nuclear Energy (NE), Fossil Energy (FE), and Electricity Delivery and Energy Reliability (OE), as well as the Offices of the General Counsel (GC), Management & Administration (MA), and Energy Policy and System Analysis (EPSA) and others at the request of the Technology Transfer Coordinator. These members serve on the Board in addition to their other full-time duties within the Department. The Board representation is intended to ensure continuity of functions that are essential to sustaining effective implementation of technology transfer policies and practices throughout the Department and across administrations.

The TTC assigns individual members of the TTPB responsibilities for the various deliverables of DOE's central technology transfer management. These include issues of technology transfer policy and

² <http://techtransfer.energy.gov/>

³ http://www2.lbl.gov/tt/industry/Doing%20Business_lr.pdf

procedures, ombuds activities, oversight and reporting. Members also serve as needed in cross agency groups such as the Federal Laboratory Consortium (FLC) for Technology Transfer and the Interagency Working Group for Technology Transfer (IAWGTT).

Interagency Working Group for Technology Transfer (IAWGTT)

DOE participates in the IAWGTT, led by the Technology Partnerships Office, National Institute of Standards and Technology (NIST), U.S. Department of Commerce. The IAWGTT serves as an interagency forum for the exchange of information and as a vehicle for raising and addressing issues and concerns related to technology transfer across the Federal government.

Federal Laboratory Consortium on Technology Transfer

The Federal Laboratory Consortium for Technology Transfer (FLC-TT) was organized in 1974 and formally chartered by the Federal Technology Transfer Act of 1986 to promote and strengthen technology transfer nationwide. Its membership draws from about 250 Federal laboratories, including DOE's 22 National Laboratories and production facilities. The FLC-TT is supported by a contract between the National Institute of Standards and Technology (NIST) and the Universal Technical Resource Services, Inc., of Cherry Hill, New Jersey.

As required by law, DOE contributes 0.008% of its R&D funding at Federally Funded Research and Development Centers to support the FLC-TT. DOE's contributions are listed in the table below:

Table 1: FLC-TT Contributions from DOE

	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
DOE Contributions	\$463,000	\$476,000	\$499,000	\$488,000	\$479,000	\$539,000

III. Summary of Fiscal Year 2009-2013 Transactions

DOE participates in the annual collection of technology transfer metrics (as required by 15 U.S.C. § 3710(f)(2)) that is coordinated by NIST in the Department of Commerce. Table I summarizes some of the metrics collected for years 2009-2013, and others are tabulated in Appendix C, along with figures showing the trends in the metrics throughout the history of the data collection. It bears noting that these metrics are used as indicators of the health of the activities, not as goals to be maximized in their own right. The 2011 Policy statement explicitly notes: “The goal is to ensure the widespread deployment of technologies developed by DOE, and as such royalties and equity interest shall not be the primary consideration in licensing transactions. Financial returns are intended as an incentive to the scientists and facility to actively participate in technology partnering and to promote a continuing substantive business commitment by the licensee.”

Table 2: Summary of FY 2009 – F7 2013 Technology Partnering Activities at DOE National Laboratories and facilities

Technology Transfer Data Element	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
<i>Transactions and Activities</i>					
CRADAs, total active in the FY	744	697	720	732	742
New inventions disclosed	1,439	1,616	1,820	1,658	1,796
▪ Patent applications filed	919	1,051	1,060	932	944
▪ Patents issued	520	657	603	676	713
Licenses, total active in the FY	5,742	6,224	5,310	5,328	5,217
▪ Invention Licenses	1,452	1,453	1,432	1,229	1,353
▪ Other IP (copyright, material transfer, other Licenses)	4,429	4,771	3,878	3,900	3,864
▪ Licenses that are income-bearing, total in FY	3,339	3,489	3,510	3,340	3,709
▪ New Licenses that are income-bearing in FY	333	357	365	341	330
Strategic Partnership Project Agreements – NFEs, total active in the FY	2,695	2,222	2,273	2,436	2,733
User Facility Agreements, total active in FY	1,417	4,391	11,981	9,119	7,396
<i>Reported Income (Thousands of Dollars)</i>					
Total Licensing Income Received	\$43,496	\$40,642	\$44,728	\$40,849	\$39,573
▪ Invention Licenses	\$40,238	\$37,066	\$40,600	\$36,103	\$36,068
▪ Other Licenses	\$3,258	\$3,576	\$4,128	\$4,746	\$3,505
Total Royalty Income Earned	\$28,901	\$25,220	\$27,107	\$28,735	\$27,670
R&D Budget Authority, Basic, Applied and Development (base, millions of dollars)	\$9,227	\$9,988	\$9,915	\$10,328	\$10,148

The results in Table 2 show that DOE’s CRADA, non-federal SPP and licensing activity has remained relatively stable over the last 5 years. This indicates continuing activity as new agreements and licenses are implemented each year at a rate sufficient to compensate for the end dates of earlier agreements.

In 2013, DOE implemented the new metrics reporting developed by the IAWGTT in response to the October 28, 2011, Presidential Memorandum -- *Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses*. Results for some of the new collection categories are listed in Table 3.

Table 3: New metrics in 2013

New CRADAs with Small Business	54
Elapsed Time for License Execution	98 days (partial reporting)
Total New License Granted to Small Businesses in FY	467
User Projects Awarded to Small Businesses	64
Total Number of Unique Small Businesses Collaborating with the Labs	764
Literature Review and Summary on Economic Impacts	1 (partial reporting)
Number of New and Active Material Transfer Agreements	1116

In addition, DOE is beginning to quantify industrial use of its Scientific User Facilities and shared R&D facilities. A preliminary analysis of the results for 2013 shows that over 700 companies made use of DOE facilities, of which 140 could be identified as small businesses.

IV. Technology Commercialization Activities 2009-2013

DOE's technology commercialization activities in 2009-2013 have involved three broad areas of focus. The primary focus has continued to be on new technologies developed at the DOE facilities. As a second focus, to support and streamline commercialization of these DOE technologies, DOE has carried out a number of new initiatives and pilot projects. Finally, DOE's department-wide commitment to using commercialization as one mechanism to support U.S. economic growth has led to new cross-cutting programs.

New technologies

The most important metric of the success of DOE's technology commercialization activities is the quality and impact of the technologies that reach the commercial sector. Often it requires many years, or even decades, after an initial discovery for the full impact to be realized. In tracking outcomes, we are best able to quantify impact at the point of handover of a specific technology to the commercial sector; we have to use indirect assessments to follow any continuing impacts thereafter.

The number of R&D 100 awards illustrates the success and visibility of the facilities' commercialization activities. The R&D 100 awards are given annually by R&D Magazine in recognition of exceptional new products or processes that were developed and introduced into the marketplace during the previous year. To be eligible for an award, the technology or process has to be in working and marketable condition – no proof of concept prototypes are allowed – and had to be first available for purchase or licensing during the year prior to the award. The awards are selected by an independent panel of judges based on the technical significance, uniqueness and usefulness from across industry, government and academia.

Department of Energy researchers won 31 of the 100 awards in 2014, 36 awards in each of 2013, 2012 and 2011, and 46 in 2010, for a total of 185 over the period of 2009-2013. A subset of these awards and other DOE developed technologies are described in Appendix E. These represent a spectrum of commercial areas including DOE mission areas of basic science, energy, efficiency, environment and security, as well as spin-off applications in the agricultural, aeronautical, medical, semiconductor and information technology industries, and broad applications in cyber security and sensing/control systems.

Programmatic initiatives

A number of programmatic initiatives have been carried out since 2009 to streamline the process of technology transfer at the National Laboratories and facilities, and to better communicate the opportunities for the private sector to engage with commercializing DOE technologies.

A. Solicitation of Best Practices and Concerns at DOE National Laboratories (2008-2009) and ACT

This solicitation (<https://www.federalregister.gov/articles/2008/11/26/E8-28187/questions-concerning-technology-transfer-practices-at-doe-laboratories>.) sought public feedback on topics including: terms and conditions in DOE technology transfer agreements; best practices in other technology transfer areas (universities, etc.); U.S. Competitiveness provisions; intellectual property rights disposition in Strategic Partnership Project (SPP) agreements; and User Agreements. The responses to the solicitation influenced the Department's decision to reduce the advance payment requirement from 90 to 60 days and to create the Agreement for Commercializing Technology (ACT) pilot.

B. Energy Innovation Portal (2010)

The Energy Innovation Portal (<http://techportal.eere.energy.gov/>) is a one-stop resource to locate energy-related technologies developed with EERE funding and available for licensing from National Laboratories and participating research institutions. Developed and managed by the National Renewable Energy Laboratory (NREL), the Portal was created to simplify access and increase private sector licensing of energy efficiency and renewable energy technologies at DOE laboratories. The Portal contains over 16,000 DOE-supported patents and patent applications, providing streamlined searching and browsing of patents, patent applications, and marketing summaries for clean energy technologies. The Portal also allows interested parties to directly contact the licensing representative from each laboratory, helps potential partners identify Laboratory researchers and facilities to engage through SPP or CRADAs, and improves opportunities for “cross-laboratory” intellectual property bundling.

C. Technology Transfer Pilot at DOE: Agreement for Commercializing Technology (ACT) (2012)

On February 23, 2012, the Department of Energy announced that eight of the Department’s National Laboratories would participate in a pilot initiative, Agreements for Commercializing Technology (ACT)⁴ which would complement the Department’s existing technology transfer mechanisms like Strategic Partnership Projects Agreements (SPPs), Cooperative Research and Development Agreements (CRADAs), and User Agreements. ACT will enable DOE facilities to engage with the private sector using terms that are more consistent with commercial practices, helping further accelerate the movement of technology from DOE facilities to the marketplace. The ACT pilot was created with the objective to strengthen new domestic industries by helping to bring innovative, job-creating technologies to the market faster by reducing some of the impediments for businesses and startups interested in working with DOE National Laboratories. Specifically, ACT addresses some of the concerns that have been raised by industry and to remove obstacles that sometimes got in the way of commercializing technology under CRADAs and SPPs. Under ACT:

- In exchange for privately assuming some of the risks and liabilities (e.g., indemnification, advanced payment and performance guarantees) normally borne by private parties sponsoring research at DOE facilities, facility contractors are authorized to negotiate and execute ACT agreements with ACT participants using terms that may be more consistent with private sector agreements.
- There is more flexibility to negotiate intellectual property rights for technologies created under an ACT transaction. While the facilities generally have limited flexibility on IP terms under CRADAs and SPP arrangements, ACT allows both parties to develop a specialized arrangement that will facilitate moving the technology into the marketplace as quickly as possible.
- DOE facility contractors are allowed to charge third parties an additional fee beyond the direct costs of the work at the facility in order to compensate for the additional risk that they are assuming.

⁴ See Official DOE Press Release at <http://energy.gov/articles/eight-national-labs-offer-streamlined-partnership-agreements-help-industry-bring-new>.

This important pilot mechanism was developed in light of a June 2009 Government Accountability Office (GAO) Report titled, *Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories*⁵ and the feedback received from a 2008 Notice of Inquiry regarding questions concerning Technology Transfer Practices at DOE Laboratories^{6,7}.

⁵ See, GAO Report No. 09-548, www.gao.gov/new.items/d09548.pdf.

⁶ See, Notice of Inquiry published on November 26, 2008 entitled “Questions Concerning Technology Transfer Practices at DOE”⁶ See, GAO Report No. 09-548, www.gao.gov/new.items/d09548.pdf.

⁶ See, Notice of Inquiry published on November 26, 2008 entitled “Questions Concerning Technology Transfer E Laboratories”, <https://www.federalregister.gov/articles/2008/11/26/E8-28187/questions-concerning-technology-transfer-practices-at-doe-laboratories>.

⁷ See responses to the Notice of Inquiry at <http://techtransfer.energy.gov/responses>.

Table 4: Comparison of the terms of different contractual forms for DOE Government-owned Contractor-operated (GOCO) laboratories. Source: Adapted from IDA Paper P-5006, “Department of Energy Agreements for Commercializing Technology,” April 2013

Attribute	Non-Federal SPP	CRADA	ACT
Parties	Laboratory and Company*	Laboratory and Company	Contractor** and Company
Approval	DOE approves each SPP agreement	DOE approves each CRADA	DOE approves statement of work, plan to mitigate organizational conflicts of interest, if applicable, and WFO-like “checklist” but does not approve ACT contract with company
Performance guarantee	None	None	Contractor can commit to negotiated schedule or performance guarantee
Advanced payment	Company provides 60-day advanced payment, with some exceptions by DOE approval***	Company provides 60-day advanced payment, with some exceptions by DOE approval***	Negotiable; contractor ensures funds are available before work is performed
Indemnification	Company indemnifies both contractor and government	Company indemnifies both contractor and government	Contractor indemnifies government; company indemnification is negotiable
Intellectual property	Company may elect title to inventions with certain restrictions	Company owns its inventions; laboratory owns its inventions Undivided rights in joint patents; company has option to license laboratory rights	Rights waived to “IP lead” designated in deal negotiation (either company or contractor); in some cases, contractor can retain title on contract termination
Government use license	Negotiable; option for government to retain a limited research license to Intellectual property	Government always retains a use license to Intellectual property	Negotiable; option for government to retain a limited research license to Intellectual property

* Company sponsors work performed by the laboratory. Also called a sponsor.

** Contractor is the organization that operates the laboratory. It is used interchangeably with laboratory operator.

*** The DOE recently reduced the 90-day-advance payment requirement to 60 days

Currently, six of the eight laboratories participating in the ACT Pilot Program have developed implementation plans. Through March of 2014, 60 ACT agreements were executed, nine of which were with small businesses. The vast majority of the agreements have been at PNNL, which already had in place administrative procedures for such agreements. In evaluating the utility of the ACT pilot, we are tracking information on what the commercial sector values in ACT, focusing on the provisions for advanced payment, indemnification, fixed price/guarantee, and non-standard terms & conditions. To date, the advanced payment provision is cited most

often (50% of agreements) as the reason a commercial partner chooses to use ACT, with the fixed price/guarantee and non-standard terms and conditions cited next most often (20% and 23%, respectively).

D. America's Next Top Energy Innovator (2011-2013)

To evaluate approaches to increase engagement with small business, the America's Next Top Energy Innovator Program was launched in May 2011. The program made it easier for start-ups to evaluate inventions and technologies developed at the DOE's National Laboratories by lowering the cost of an option agreement for up to three patents to \$1,000. An option agreement is a precursor to a license agreement and allows companies time to evaluate the technology and to assemble resources required to commercialize the technology. The option duration was set at 12 months, with the potential for a three to six month extension. Participating start-ups were invited to enter the America's Next Top Energy Innovator Competition. Each participant in the competition uploaded a short video onto the DOE website, and a public voting competition was held to select the most innovative company. The site received one-half million unique hits. Experts conducted a separate review of the companies and scored them based on their potential economic and societal contributions. The winners of the competition were featured at the 2013 ARPA-E Energy Innovation Summit and had the opportunity to meet the Secretary of Energy.

As of 2013, 21 options have resulted from this program, and five options have been converted to licenses.

E. Streamlined CRADA Order (2013) and Fast Track CRADAs (2012)

The CRADA Order establishes DOE policy, requirements, and responsibilities for the oversight, management, and administration of CRADA activities at DOE facilities. It also ensures consistent development and application of policy and procedures in planning and conducting CRADA activities at DOE facilities. The CRADA Order has recently been streamlined, deleting outdated articles and reducing the total number of articles from 30 to 12. The CRADA Order has also been updated to include a DOE Model Short-Form CRADA, which is only seven pages long for projects under \$500,000. The Short-Form CRADA is designed for further streamline and simplify the CRADA process for certain circumstances, by providing language that has been pre-approved by DOE. In order to ensure an expedited approval process, the Short-Form CRADA must be adopted in its entirety, as written, by both or all parties. The Short-Form CRADA package will be subject to the same process use for standard CRADA package review and approval at the DOE Site Offices.

Additionally, a new Fast Track CRADA program streamlines the approval process for certain CRADAs to 10 business days or less, promotes consistency across the DOE complex, and better enables DOE Facilities to move at the speed of business. Under the Fast Track program, Facility Contractors provide the cognizant DOE Site Office with a Fast Track CRADA package that includes: basic information regarding the CRADA, a certification that the Facility Contractor has undertaken all of the required reviews, and a citation to an acceptable statement of work within the Facility's DOE-approved Annual Strategic Plan or an attached Joint Work Statement as appropriate. The Fast Track program is intended to better enable DOE Facilities to operate at the speed of business while ensuring that the Department receives adequate disclosure of DOE Contractor activities to ensure prudent contract management.

Other Technology Transfer Programs

A. SBIR Technology Transfer Opportunity Pilot (2013)

The Department directly engages the private sector through its Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, which together are important components of the Department’s transfer of knowledge and technology to the private sector. The programs fund early stage R&D at U.S. small businesses in technology areas that align with the Department’s mission. The diverse set of innovations funded by these programs spans all of the participating R&D offices in the department: ARPA-E, Offices of Defense Nuclear Nonproliferation, Electricity Delivery and Energy Reliability, Energy Efficiency and Renewable Energy, Environmental Management, Fossil Energy, Nuclear Energy, and Science. Awards are made in two phases: phase I awards focus on feasibility or proof of concept with maximum awards of \$225,000 and a duration of nine months; phase II awards focus on prototype or process development with maximum awards of \$1,500,000 and a duration of two years. Allocations and awards for these programs are summarized in Table 1.

Table 5: DOE SBIR and STTR Allocations and Awards, Fiscal Years 2009-2013.

Fiscal Year	SBIR Allocation (\$)	Number of SBIR awards	Number of STTR Allocation (\$)	Number of STTR Awards	Number of Awards with DOE Lab as Partnering Research Institution
2009	\$137,869,000	529	\$16,571,000	43	16
2010	\$149,577,000	539	\$17,950,000	77	13
2011	\$145,567,000	312	\$17,469,000	48	16
2012	\$164,224,000	322	\$22,333,000	45	16
2013	\$162,437,000	380	\$21,464,000	53	13

The STTR program is specifically focused on technology transfer from the Nation’s research institutions including the Department’s National Laboratories and facilities. Shown in the last column in Table 5 is the annual number of STTR awards in which a National Laboratory acts the partnering research institution. The majority of partnering research institutions are universities; however just over 25% of the awards involve DOE National Laboratories.

DOE is now carrying out a SBIR Technology Transfer Opportunity pilot to further assist with the commercialization of technologies resulting from the Department’s funding of basic and applied research. In this pilot, the SBIR and STTR programs have included technology transfer opportunities from universities and National Laboratories in its solicitations beginning in 2013. A total of 18 technology transfer opportunities were included in the first year of this initiative and two Phase I awards were made. We anticipate expanding this initiative in future years and will be monitoring the effectiveness of this method of commercializing innovations through this technology transfer process.

B. Advanced Research Projects Agency-Energy (ARPA-E)

The Advanced Research Projects Agency-Energy (ARPA-E) catalyzes the advancement of transformational energy technologies to enhance the economic and energy security of the United States by investing in high-potential, high-impact energy projects that are too early for private

sector or other Department of Energy applied research and development investment. ARPA-E explores uncharted territories of energy technology to generate options for entirely new paths to create, store and use energy.

ARPA-E makes SBIR awards in three phases through two types of combined awards: (1) Phase I/Phase II awards funded up to \$1,725,000 with a period of performance up to 36 months; and (2) Phase I/Phase II/sequential Phase II awards funded up to \$3,225,000 with a potential period of performance of up to 48 months.

ARPA-E was established by the America COMPETES Act of 2007 following a recommendation by the National Academies in its report, *Rising above the Gathering Storm*⁸. ARPA-E focuses on energy technologies that can be meaningfully advanced with a small investment over a defined period of time. ARPA-E's rigorous program design, competitive project selection process, and hands-on engagement ensure thoughtful expenditures while empowering America's energy researchers with funding, technical assistance, and market awareness.

As of February 2014, ARPA-E has invested over \$900 million across 362 projects through 18 focused programs and two open funding solicitations. While success of these programs and projects will ultimately be measured by impact in the marketplace, ARPA-E looks at various metrics to measure progress towards eventual market adoption including several types of "hand-offs" for the next stage of the project. As of February 2014, ARPA-E has successfully facilitated numerous hand-offs including:

- At least 24 ARPA-E project teams have formed new companies to advance their technologies;
- Several ARPA-E awardees have announced strategic partnerships with established industry participants, ranging from jointly developing a demonstration site to being acquired by the larger company; and
- Over 16 ARPA-E projects have partnered with other government agencies for further development.

In addition, 22 ARPA-E projects have attracted more than \$625 million in private-sector follow-on funding after ARPA-E's investment of approximately \$95 million. ARPA-E provides annual reports to Congress which can be found at <http://arpae.energy.gov/?q=about/documentation/annual-reports>.

⁸ http://www.nap.edu/catalog.php?record_id=11463

V. Appendix A – 2011 Secretarial Policy Statement on Technology Transfer at Department of Energy Facilities (March 28, 2011)



The Secretary of Energy
Washington, DC 20585

Secretarial Policy Statement on Technology Transfer at DOE Facilities

Introduction

Through strategic investments in science and technology, the U.S. Department of Energy (DOE) helps power and secure America's future. DOE's capabilities, and the innovations it supports, help ensure the country's role as a leader in science and technology. In particular, technology transfer supports the maturation and deployment of DOE discoveries, providing ongoing economic, security and environmental benefits for all Americans.

This Policy Statement will guide, strengthen, and highlight the importance of the Department's technology transfer efforts. By ensuring the fullest use of the fruits of federal investment in research and development, technology transfer supports DOE's mission of ensuring America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.

For purposes of this document, "technology transfer" refers to the process by which knowledge, intellectual property or capabilities developed at the Department of Energy's National Laboratories, single-purpose research facilities, plants, and other facilities ("Facilities") are transferred to other entities, including private industry, academia, and state or local governments. Such transfers may take many forms, including but not limited to: Cooperative Research and Development Agreements, Work-For-Others Agreements, User Agreements, and licensing of intellectual property. This Policy Statement builds upon provisions in the Energy Policy Act of 2005 and other legislation (such as the America COMPETES Act) governing the transfer of technologies from the Facilities.

It is the responsibility of the Technology Transfer Coordinator to assist DOE in achieving its technology transfer objectives in accordance with the guiding principles listed below and to promote the Department's efforts to make technology transfer more effective, thereby enhancing the impact of the science and technology discoveries made at DOE Facilities.

Guiding Principles for Technology Transfer at DOE Facilities

The Department's technology transfer activities, and its review of associated policies and procedures, shall be guided by the following principles:

1. **COMMITMENT:** DOE Facilities and Programs have a responsibility to ensure robust technology transfer activities and research partnerships with industry that result in commercialization and deployment. DOE is committed to continuously improving its policies and procedures for effective technology transfer in support of its mission, and for the Nation's benefit.
2. **EMPOWERMENT:** Technology transfer requires direct involvement from the innovators who discover and develop technologies at DOE Facilities. Technology transfer program plans shall rely primarily on implementation by Facility directors through their Technology Transfer Offices.
3. **FAIRNESS:** DOE Facilities must ensure fairness of opportunity; promote domestic economic interests, with due consideration for securing the benefits of globalization while balancing U.S. competitiveness considerations; prevent inappropriate competition with the private sector; and protect national security in partnering transactions.
4. **FACILITATION:** Commercialization transactions shall involve partners with viable business plans for expeditious technology development and deployment.
5. **VISIBILITY:** DOE and its Facilities shall promote access to capabilities and intellectual property by all, including small businesses and entrepreneurs, and shall promote investment to accelerate the maturation and commercialization of new technologies arising at the Facilities.
6. **LEVERAGE:** DOE shall seek opportunities to leverage its resources in partnering transactions. Such transactions should complement DOE's mission, goals, and objectives, and should demonstrably benefit the United States.
7. **IMPACT:** The Technology Transfer Coordinator, supported by the Technology Transfer Policy Board and the Technology Transfer Working Group, shall identify measurable outcomes that are effective indicators of success and impact. The goal is to ensure the widespread deployment of technologies developed by DOE, and as such royalties and equity interest shall not be the primary consideration in licensing transactions. Financial returns are intended as an incentive to the scientists and facility to actively participate in technology partnering and to promote a continuing substantive business commitment by the licensee.

8. **PREDICTABILITY:** Absent overriding mission objectives, there should be predictability, streamlined processes, and appropriate flexibility in the application of policies governing technology transfer. This includes timely and transparent transaction completion in order to encourage universities, nonprofits, and the private sector to partner with the Facilities. DOE is committed to periodic review and modification of its policies to ensure it meets these objectives.
9. **COOPERATION:** The Technology Transfer Coordinator and the Technology Transfer Working Group will share best practices and lessons learned in order to further technology transfer at the Department; to collaborate in commercialization; and to maximize flexibility to achieve positive impact at the Facilities' Technology Transfer Offices, e.g., by minimizing cycle times and eliminating and avoiding unnecessary barriers.

Responsibilities

1. It is the responsibility of the Technology Transfer Coordinator with the support of the Technology Transfer Policy Board to develop the Department's Technology Transfer Framework. This Framework shall include an execution plan, performance measures, and programmatic guidance. The Technology Transfer Coordinator shall also prepare and deliver an annual progress report to the Secretary.
2. In accordance with the DOE Technology Transfer Framework, the head of each DOE organizational element that funds research and development at its Facilities shall, as appropriate, establish goals, strategies, and performance measurement criteria that provide accountability for technology transfer results.
3. Consistent with its programmatic missions, the head of each DOE organizational element responsible for a DOE Facility is responsible for supporting technology transfer efforts. This aims to promote partnering relationships among the Facilities that foster creative approaches and reduce unnecessary impediments to initiatives with non-federal partners. Each DOE organizational element responsible for a DOE Facility is responsible for overseeing and evaluating technology transfer efforts there. Technology transfer goals, objectives, and measures shall be included as appropriate in the Facilities' performance plans.
4. Facility management is responsible for implementing a technology transfer program consistent with their contract and in coordination with their funding programs. Facility management may coordinate with the DOE Program offices and the DOE Technology Transfer Coordinator to mitigate impediments to technology transfer initiatives.

5. The Technology Transfer Coordinator shall promote implementation of technology transfer in a manner that supports small business needs and the formation of new companies.
6. All research and development Programs, even those not directly targeting applied commercial applications, have a responsibility to facilitate and encourage commercialization of technologies arising from their Programs.

Review Requirement

The Technology Transfer Coordinator along with the Technology Transfer Policy Board shall continue to review, and revise as appropriate, the Department's technology transfer policies and regulations. The goal of such review and revision shall be to accelerate and simplify the process of transferring technology from DOE Facilities. The Technology Transfer Coordinator shall report to the Secretary on the results of such reviews as well as other efforts to improve the Department's technology transfer practices.

All DOE Programs will support and guide the Facilities as they work to accomplish their technology transfer goals. In addition, all DOE Programs will periodically reexamine how the Department can better integrate technology transfer in Government-wide efforts to address America's energy, environmental, and nuclear challenges.



Steven Chu
Secretary of Energy

5: 2 8 2011
Date: _____

VI. Appendix B – Technology Transfer Offices at DOE National Labs and Facilities

Ames Laboratory			
Ames Office of Sponsored Research Administration			
POC:	Debra Covey	covey@ameslab.gov	515.294.1048
Website:	www.ameslab.gov/techtransfer		

Argonne National Laboratory			
Argonne Office of Technology Development and Commercialization (TDC)			
POC:	Gregory Morin	gmorin@anl.gov	630.252.8111
Website:	http://www.anl.gov/technology		

Brookhaven National Laboratory			
Brookhaven Office of Technology Development and Commercialization (TDC)			
POC:	Connie Cleary	ccleary@bnl.gov	613.344.3035
Website:	http://www.bnl.gov/techtransfer/		

Fermi National Accelerator Laboratory			
Fermi Lab Office of Partnerships and Technology Transfer			
POC:	Cherri Schmidt	cherri@fnal.gov	630.840.5178
Website:	N/A		

Idaho National Laboratory			
Technology Deployment Office			
POC:	Mark Kaczor	mark.kaczor@inl.gov	208.526.0360
Website:	https://inlportal.inl.gov/portal/server.pt/community/technology_transfer/269		

Kansas City Plant			
N/A			
POC:	Angie Ladwig	aladwig@kcp.com	816.488.5676
Website:			

Lawrence Berkeley National Laboratory			
LBNL Innovation and Partnerships Office (IPO)			
POC:	Elsie Quait-Randall	equaiterandall@lbl.gov	515.486.7234
Website:	http://www2.lbl.gov/tt/		

Lawrence Livermore National Laboratory			
LLNL Industrial Partnerships Office (IPO) within the Office of Economic Development			
POC:	Richard Rankin	rankin8@llnl.gov	925.423.9353
Website:	http://www.ipo.llnl.gov		

Los Alamos National Laboratory			
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LANL Office of Market Transition within the Richard Feynman Center for Innovation			
POC:	John Mott	jmott@lanl.gov	505.665.0883
Website:	http://www.lanl.gov/projects/feynman-center/		

National Energy Technology Laboratory			
NETL Office of Technology Transfer			
POC:	Jessica Sosenko	jessica.sosenko@netl.doe.gov	412.386.7417
Website:	http://www.netl.doe.gov/business/tech-transfer/		

National Renewable Energy Laboratory			
NREL Office of Technology Transfer within the Office of Innovation Partnering and Outreach			
POC:	Kristin Gray	kristin.gray@nrel.gov	303.275.3050
Website:	http://www.nrel.gov/technologytransfer/		

Oak Ridge National Laboratory			
ORNL Office of Technology Transfer within the Office of Science and Technology Partnerships			
POC:	Jennifer Caldwell	caldwelljt@ornl.gov	865.574.4180
Website:	www.ornl.gov/partnerships		

Pacific Northwest National Laboratory			
PNNL Office of Technology Commercialization (OTC)			
POC:	Peter Christensen	peter.christensen@pnnl.gov	509.375.6159
Website:	http://www.pnnl.gov/business/tech_transfer.aspx		

Pantex Plant			
Pantex Technology Transfer			
POC:	Perry Kent	pkent@pantex.com	806.477.5422
Website:	N/A		

Princeton Plasma Physics Laboratory			
PPPL Office of Technology Transfer, Patents and Publications			
POC:	Lewis Meixler	lmeixler@pppl.gov	609.243.3009
Website:	http://www.pppl.gov/organization/technology-transfer		

Sandia National Laboratories			
Sandia Industry Partnerships Office			
POC:	Pete Atherton	prather@sandia.gov	505.284.3768
Website:	http://www.sandia.gov/working_with_sandia/technology_partnerships/index.htm		

Savannah River National Laboratory			
Savannah River Office of Research and Technology Partnerships			

POC:	Chuck Meyers	Chuck.Meyers@srs.gov	803.725.0490
Website:	http://www.srs.gov/general/srnl/tech_transfer/tech_transfer.htm		

SLAC National Accelerator Laboratory			
SLAC Office of Intellectual Property and Research Partnerships			
POC:	Jan Tulk	jtulk@slac.stanford.edu	650.926.5701
Website:	N/A		

Thomas Jefferson National Accelerator Facility			
Jefferson Lab Technology Transfer and Invention Review Committee			
POC:	Joseph L. Scarcello	scarcell@jlab.org	757.269.7027
Website:	http://www.jlab.org/exp_prog/techtransfer/		

Y-12 Nat'l Sec Complex			
Y-12 Office of Commercialization and Partnerships			
POC:	Tom Berg	bergta@y12.doe.gov	865.574.0907
Website:	N/A		

VII. Appendix C – Technology Transfer Data for Fiscal Years 2009-2013

The Technology Transfer Commercialization Act of 2000 (P.L. 106-404) requires each Federal agency that operates or directs Federal Laboratories or that engages in patenting or licensing of federally owned inventions to provide the Office of Management and Budget (OMB) with an annual report on its technology transfer plans and recent achievements. A copy is also provided to NIST, Department of Commerce, where that secretary prepares an overall Federal assessment of technology transfer activities for the President and Congress based on the program information in these agency reports such as DOE's. Specific data requirements to be reported each year are established by NIST.

In accordance with OMB's reporting guidelines, DOE's technology transfer data for fiscal years 2009-2013 are in section 4 with additional information shown in the tables below. Two figures illustrating historical trends are also included. A glossary of terms is provided at the end of this section.

The tables below for FY 2009-2013 quantify some additional issues regarding DOE's technology transfer metrics. Shown in Table 6, non-Federal SPPs is now a much larger component of industrial interactions than CRADAs, with more than 2000 SPP agreements active per year vs 700 or more CRADA agreements. Both non-Federal SPP and CRADA numbers have been relatively stable over the last five years.

As shown in Table 7, DOE's success rate in patents issued has increased significantly over the past five years. While the number of patent applications issued has remained relatively stable at 900-1000 per year, the issuance rate show an upward trend.

Table 8 shows a more detailed breakdown of the types of licensing activities. Patent licensing has remained relatively stable at a rate of around 1400 licenses per year. The rate of other IP licenses is much higher at around 4000 per year. However, the majority of licensing income (more than 90%) is received from patent licenses.

Table 6: CRADAs and non-Federal SPP

	FY 09	FY 10	FY 11	FY 12	FY 13
CRADAs, total active in the FY*	744	697	720	732	742
▪ Number with small businesses	261	264	264	255	237
▪ New, executed in the FY	176	176	208	181	142
▪ CRADA funds in (thousands of \$)	\$74,415	\$62,332	\$68,128	\$63,898	\$61,818
Non-Fed SPP, total active in the FY*	2695	2222	2273	2436	2733
▪ Number with small businesses					439
▪ New, executed in the FY	768	668	688	723	992
▪ Non-Federal SPP funds in (thousands of \$)	\$232,038	\$287,370	\$264,343	\$280,234	\$283,462

* "Active" = legally in force at any time during the FY.

Table 7: Invention Disclosure and Patenting

	FY 09	FY 10	FY 11	FY 12	FY 13
New inventions disclosed in the FY*	1,439	1,616	1,820	1,658	1,796
Patent applications filed in the FY	919	1,051	1,060	932	944
Patents issued in the FY	520	657	603	676	713

* Inventions arising at the DOE laboratories and facilities.

Table 8: Profile of Active Licenses

	FY 09	FY 10	FY 11	FY 12	FY 13
All licenses, total active in the FY*	5,742	6,224	5,310	5,328	5,217
▪ New, executed in the FY	755	822	656	757	567
▪ Patent licenses, total active in the FY	1,452	1,453	1,432	1,428	1,353
○ New, executed in the FY	139	166	169	192	137
▪ Other IP licenses, total active in the FY	4,429	4,771	3,878	3,900	3,864
○ New, executed in the FY	616	656	496	565	415
- Copyright licenses	2,956	3,338	3,291	3,328	3,610
○ New, executed in the FY	276	339	362	423	358
- Other	1,334	1,433	587	577	254
○ New, executed in the FY	340	317	134	142	57

* "Active" = legally in force at any time during the FY.

VIII. Appendix D – Glossary and List of User Facilities

Technology partnering encompasses several activities, and the most appropriate partnering mechanism depends on the objective of each partner. The most commonly used technology transfer mechanisms are described below.

- **Cooperative Research and Development Agreements (CRADAs).** The authority for entering into CRADAs was established under the National Competitiveness Technology Transfer Act of 1989. Such agreements typically focus on mutually beneficial collaborative research. They may involve resource commitments by each partner for its own use, or resource commitments from the non-federal partner to the Federal partner, but no funding commitments from the Federal partner to non-federal partner are permitted.
- **Strategic Partnership Projects (SPPs).** Performing work for non-DOE sponsors under DOE Order 481.1. SPP agreements permit reimbursable research and development to be carried out at DOE laboratories or facilities. This work is usually categorized into work for Federal agencies and non-Federal entities (NFE). It is the NFE work that is included as technology partnering in this report. For proprietary R&D conducted for NFEs, the Federal laboratory or facility is reimbursed by the NFE sponsor for the full cost of the activity. If the work will be published, cost may be adjusted. Intellectual property rights generally vest in the NFE, but may be negotiated.
- **Licensing.** Licensing is the negotiating and entering into license agreements and bailments that provide rights in intellectual property (IP) made, created, or acquired at or by a DOE Facility and which is controlled or owned by the contractor for that Facility. A license transfers *less* than ownership rights to intellectual property, such as a patent or software copyright, to permit its use by the licensee. Licenses may be exclusive, or limited to a specific field of use, or limited to a specific geographical area. A potential licensee must present plans for commercialization. Royalties and income are often associated with the licensing.
- **Personnel Exchanges.** These arrangements allow facility staff to work in a partner's technical facilities, or the partner's staff to work in the government laboratory, in order to enhance technical capabilities and/or support research in certain areas. Costs are typically borne by the sponsoring organization. IP arrangements may be negotiated as part of these exchanges. (Personnel Exchange activities are not included in this report.)
- **Technical Assistance.** Technical consulting usually takes the form of technical assistance to small businesses, undertaken in response to an inquiry or request for such assistance from an individual or organization seeking knowledge, understanding or solutions to a problem, or means to improve a process or product. For example, Sandia and Los Alamos lead the New Mexico Small Business Assistance (NMSBA) program with partner universities. In 2013, the program provided targeted technical support to 354 small businesses. The extent of such consulting is limited to a relatively low level of overall effort, but the relative impact to a small business may be large (Technical assistance activities have not been included in this report.).

User Facilities

DOE scientific user facilities are advanced, world-class, unique scientific facilities and equipment that are available at DOE laboratories for the technical and scientific community. These facilities are intended to serve the research needs of the Federal government, the national laboratory scientists and, at the same time, are intended to be a national resource available for research by industry and university investigators. DOE's Office of Science (SC) oversees a number of scientific user facilities; the National Nuclear Security Administration (NNSA) also oversees a number of Technology Deployment Centers and user facilities. There are four major categories of User Facilities/Other R&D Assets at DOE:

- DOE Officially Designated Proprietary User Facilities (GC-62):

Multiple Laboratories	<ul style="list-style-type: none"> ▪ ARM Climate Research Facility
Argonne National Laboratory	<ul style="list-style-type: none"> ▪ Advanced Photon Source (APS) ▪ Electron Microscopy Center for Materials Research ▪ Argonne Tandem Linac Accelerator System (ATLAS) ▪ Center for Nanoscale Materials (CNM) ▪ Argonne Leadership Computing Facility (ALCF)*
Brookhaven National Laboratory	<ul style="list-style-type: none"> ▪ National Synchrotron Light Source (NSLS) ▪ Accelerator Test Facility (ATF) ▪ Relativistic Heavy Ion Collider (RHIC) ▪ Center for Functional Nanomaterials (CFN) ▪ National Synchrotron Light Source II (NSLS-II) (under construction)
Fermi National Accelerator Laboratory	<ul style="list-style-type: none"> ▪ Fermilab Accelerator Complex
Idaho National Laboratory	<ul style="list-style-type: none"> ▪ Advanced Test Reactor** ▪ Wireless National User Facility (WNUF) ▪ Biomass Feedstock National User Facility
Lawrence Berkeley National Laboratory	<ul style="list-style-type: none"> ▪ Energy Sciences Network (ESnet)** ▪ Joint Genome Institute (JGI) – Production Genomics Facility (PGF)** (joint with LLNL, LANL, ORNL, and PNNL) ▪ Advanced Light Source (ALS) ▪ National Center for Electron Microscopy (NCEM)

	<ul style="list-style-type: none"> ▪ Molecular Foundry ▪ National Energy Research Scientific Computing Center (NERSC)* ▪ 88 inch cyclotron***
Los Alamos National Laboratory	<ul style="list-style-type: none"> ▪ Lujan at Los Alamos Neutron Science Center (LANSCE)
Oak Ridge National Laboratory	<ul style="list-style-type: none"> ▪ Center for Nanophase Materials Sciences (CNMS) ▪ High Flux Isotope Reactor (HFIR) ▪ National Center for Computational Sciences (NCCS) ▪ Shared Research Equipment Program (SHARE) ▪ Spallation Neutron Source (SNS) ▪ Oak Ridge Leadership Computing Facility (OLCF)
Pacific Northwest National Laboratory	<ul style="list-style-type: none"> ▪ Environmental Molecular Sciences Laboratory (EMSL) ▪ Molecular Science Computing at EMSL
Princeton Plasma Physics Laboratory	<ul style="list-style-type: none"> ▪ National Spherical Torus Experiment (NSTX)
Sandia National Laboratory/Los Alamos National Laboratory	<ul style="list-style-type: none"> ▪ Center for Integrated Nanotechnology (CINT)
SLAC National Accelerator Laboratory	<ul style="list-style-type: none"> ▪ Stanford Synchrotron Radiation Laboratory (SSRL) ▪ Linac Coherent Light Source (LCLS) ▪ Facility for Advanced Accelerator Experimental Test (FACET)
Thomas Jefferson National Accelerator Facility	<ul style="list-style-type: none"> ▪ Continuous Electron Beam Accelerator Facility (CEBAF)

Notes:

*In addition to offering both of the user class waivers, certain industrial users may qualify for a special user agreement available at these supercomputing facilities.

**These user facilities only offer the Non-proprietary user agreement.

*** This facility can only offer the proprietary user waiver, but is not a designated Office of Science user facility.

**** Pending finalization of Implementation Plan

- Office of Science Scientific Facilities and Other R&D Assets (see letter below);
- Other DOE Program Office R&D Assets available to researchers including the Offices of Energy Efficiency and Renewable Energy (EERE), Fossil Energy (FE), Nuclear Energy (NE), Environmental Management (EM), and Legacy Management (LM);
- R&D assets available to researchers not located at a DOE site or National Lab.

In FY 2008, DOE streamlined access for the industrial and scientific community to certain designated facilities by issuing new user agreements – one that clarifies the intellectual property and data rights that vest in non-proprietary users that agree to publish results, and another for proprietary users that are not required to publish results, but pay the cost of using the facility. In 2012, the Office of Science issued a formal definition for its user facilities (see letter below).

DOE is currently evaluating and considering alternative approaches for its management, access, and designation/nomenclature for the large number and wide variety of scientific facilities, labs, equipment, and capabilities under DOE's control and management. DOE currently lists approximately 212 user facilities and R&D assets on the data.gov website report titled "DOE User Facilities and R&D Equipment" (<http://catalog.data.gov/dataset/doe-facilities>). This dataset contains information about hundreds of designated user-facilities and R&D equipment funded by DOE and accessible to the private sector. These facilities reside at DOE's National Laboratories and sites throughout the United States and are meant to advance scientific research and accelerated technology commercialization.



Department of Energy
Office of Science
Washington, DC 20585

January 6, 2012

TO: OFFICE OF SCIENCE ASSOCIATE DIRECTORS

FROM: PATRICIA M. DEHMER *Patricia M. Dehmer*
DEPUTY DIRECTOR FOR SCIENCE PROGRAMS
OFFICE OF SCIENCE

SUBJECT: DEFINITION OF A USER FACILITY

This memorandum provides the definition of a user facility developed by the Office of Science (SC) Associate Directors through the SC User Facility Working Group. A current list of the SC user facilities is appended.

The user facilities are a defining component of the SC enterprise. More than 50% of SC's annual appropriation supports facility operations, construction, and major instrumentation. In FY 2010, 26,000 extramural researchers from universities, industries, federal laboratories, and non-profit organizations used the facilities. This number is expected to increase as new facilities are brought on line. SC user facilities enable fundamental scientific research essential to accomplish the Department of Energy's mission. A decision to establish a new facility requires that the facility address a need unfilled by existing facilities, equipment, or services within the Department or available through other government agencies, public organizations, private entities, or international bodies.

Despite substantial diversity among the SC user facilities, the following definition—which has its basis in statute, regulation, and peer-evaluated practices—applies to all and extends to facilities yet to be established.

A user facility is a federally sponsored research facility available for external use to advance scientific or technical knowledge under the following conditions:

- **The facility is open to all interested potential users without regard to nationality or institutional affiliation.**
- **Allocation of facility resources is determined by merit review of the proposed work.**
- **User fees are not charged for non-proprietary work if the user intends to publish the research results in the open literature. Full cost recovery is required for proprietary work.**



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- **The facility provides resources sufficient for users to conduct work safely and efficiently.**
 - **The facility supports a formal user organization to represent the users and facilitate sharing of information, forming collaborations, and organizing research efforts among users.**
 - **The facility capability does not compete with an available private sector capability.**
-

ATTACHMENT:

The Office of Science User Facilities List, FY 2012

**U.S. Department of Energy
Office of Science User Facilities, FY 2012**

<u>Facility</u>	<u>Host institution</u>
Advanced Scientific Research Computing (ASCR)	
National Energy Research Scientific Computing Center (NERSC)	LBL
Argonne Leadership Computing Facility (ALCF)	ANL
Oak Ridge Leadership Computing Facility (OLCF)	ORNL
Energy Sciences Network (ESnet)	LBL
Basic Energy Sciences (BES)	
<i>Light Sources</i>	
Advanced Light Source (ALS)	LBL
Advanced Photon Source (APS)	ANL
Linac Coherent Light Source (LCLS)	SLAC
National Synchrotron Light Source (NSLS)	BNL
Stanford Synchrotron Radiation Light Source (SSRL)	SLAC
<i>Neutron Sources</i>	
High Flux Isotope Reactor (HFIR)	ORNL
Spallation Neutron Source (SNS)	ORNL
Lujan at Los Alamos Neutron Science Center (LANSCE)	LANL
<i>Nanoscale Science Research Centers</i>	
Center for Functional Nanomaterials (CFN)	BNL
Center for Integrated Nanotechnologies (CINT)	Sandia/LANL
Center for Nanophase Materials Sciences (CNMS)	ORNL
Center for Nanoscale Materials (CNM)	ANL
The Molecular Foundry	LBL
<i>Electron Microscopy Centers</i>	
National Center for Electron Microscopy (NCEM)	LBL
Electron Microscopy Center for Materials Research	ANL
Shared Research Equipment Program (ShaRE)	ORNL
Biological and Environmental Research (BER)	
Environmental Molecular Sciences Laboratory (EMSL)	PNNL
Atmospheric Radiation Measurement Climate Research (ARM)	Global network
Joint Genome Institute (JGI)	LBL
Fusion Energy Sciences (FES)	
DIII-D	General Atomics
National Spherical Torus Experiment (NSTX)	PPPL
Alcator C-Mod	MIT
High Energy Physics (HEP)	
Proton Accelerator Complex	FNAL
Facility for Advanced Accelerator Experimental Tests (FACET)	SLAC
Nuclear Physics (NP)	
Continuous Electron Beam Accelerator Facility (CEBAF)	TJNAF
Holifield Radioactive Ion Beam Facility (HRIBF)	ORNL
Relativistic Heavy Ion Collider (RHIC)	BNL
Argonne Tandem Linac Accelerator System (ATLAS)	ANL

Note: This list reflects facility status as of the beginning of the fiscal year and does not reflect changes in facility status enacted in appropriations law for FY 2012.

IX. Appendix E – National Laboratory Success Stories

There are many examples of technology transfer and industry partnering activities that reflect successful programs at DOE National Laboratories and facilities. The following are brief descriptions of successes from FY 2009 through FY 2013. These examples illustrate the nature and range of technology transfer activities across the complex.

Ames Laboratory	Lead Free Solder AgSolver Efficiency in Titanium Parts Production
Argonne National Laboratory	Better Glass Furnace Designs SAS4A Fast Reactor Safety Analysis Code Program of Response Options and Technology Enhancements for Chemical/Biological Terrorism (PROTECT) ARG-US RFID Tags Multivariate State Estimation Technique
Brookhaven National Laboratory	Tin-117m Radionuclide Production and Medical Use Electrocatalyst Technology for Fuel Cells in Electric Vehicles Plant Health and Productivity Enhancement Modular Positron Emission Tomography Detector Sulfur Concrete
Idaho National Laboratory	Multiphysics Object-Oriented Simulation Environment (MOOSE) NanoSteel RELAP5-3D Portable Isotopic Neutron Spectroscopy (PINS) Sophia
Kansas City Plant	CMM Software Realizing Measurement Optimization Capability Miniature Ordnance Flight Data Recorder System New Method to Extract Heavy Oil from Oil Sands Windows Logging Service
Los Alamos National Laboratory	Acoustic Focusing Cytometer CASA Grande Muon Tomography Parallel Log-structured File System (PLFS) Safire

Lawrence Berkeley National Laboratory	EMGeo Exogen Biotechnology FLEXAB Nanosys Quest/Cholesterol SEMATECH Consortium TeselaGen
National Energy Technology Laboratory	BlackGold Nanocoating Novel Platinum/Chromium Alloy for the Manufacture of Improved Coronary Stents EnVerid Refractory Lining Material Improves Gasifier Performance Pyrochem Catalysts for Diesel Fuel Reforming
National Renewable Energy Laboratory	Gearbox Snygas Tar Removal Innovative Etching Process Solid-State Optical System Building-Integrated Supercomputer
Pacific Northwest National Laboratory	Fuel from Algae Finding Disease Biomarkers for Early Diagnosis and Treatment Ions in the Stream Ultra-low-noise Power Supply Forecasting Method and Electric Grid Operations Propylene Glycol from Plants Redox Flow Battery Technology
Princeton Plasma Physics Laboratory	Synthetic Muscles Egg Pasteurization Fusion Rocket Propulsion Zero Based Knowledge Nuclear Detection
Sandia National Laboratory	Reliable Anthrax Testing First Diesel Engine Designed Entirely Computationally Synthetic Aperture Radar Goodyear Partnership New Mexico Small Business Assistance Program Lab-on-a-Disk Radioactive Seawater Cleaned with CSTs
Savannah River National Laboratory	Hybrid Microwave Technology MicroBlower Paperless Work Package System Sound Anchor Green Chemistry Treats Contamination

Touching the Lives of Billions Worldwide: Lead Free Solder

A lead free solder, developed at **Ames Laboratory** by *Iver Anderson, John Smith, Chad Miller, and Robert Terpstra* with a co-inventor, *Frederick Yost*, at **Sandia National Laboratory**, combines tin, silver and copper in a novel alloy combination that is low melting, applies easily on typical metal joints, and has a reasonable cost, serving as a direct (no-cost) swap in the industrial setting. This revolutionary solder alloy replaces many uses of the traditional tin-lead, low-melting solder, reducing further the number of lead toxicity hazards in our everyday environment.

The use of leaded solder has a 5000-year history. There are examples of its use in Mycenae from about 1500-1300 BC, during the Roman Empire and in Denmark around 800AD. Modern electronic assembly uses solder to attach electronic chips and components to printed wiring boards to create an electronic assembly which are joined to form functional systems like cellular phones, computers or televisions. The Ames Laboratory solder alloy formula is now considered a preferred lead-free solder by the worldwide electronics assembly industry and can be found in many new consumer electronic items, including cell phones, laptops, TVs, and VCRs.

The technology's initial two patents, (5,527,628 and 6,231,691) were licensed to a small business, Johnson Manufacturing, Princeton, IA. To extend the availability of the solder, two other licensees, Multicore Solders of Richardson, Texas (now Henkel Corporation), and Nihon Superior Co. Ltd. of Osaka Japan, also obtained licenses to the technology. A Japanese industry-based consortium set up a voluntary initiative to go lead-free in consumer electronics beginning in 2000, spurring a widespread movement in this direction. Subsequent legislation enacted by the European Union to eliminate most of the lead in consumer goods sold in Europe by July of 2006 resulted in more broad licensing interest. As a result, the technology was sublicensed to over 65 companies worldwide. The initial patent expired in July 2013.



Ames Laboratory's lead free solder is the preferred solder for electronic components

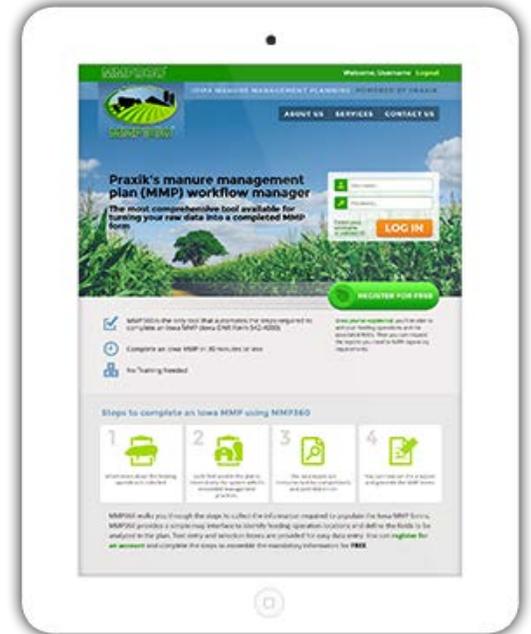
Federal funding through the Department of Energy was provided for the basic research and technology development of the solder. DOE funding developed the metal and alloy powder production capability, the eutectic tin-silver-copper composition, joint microstructure and properties studies, and alloy additions for resistance to thermal aging. The Laboratory's Contractor, Iowa State University Research Foundation, and Nihon Superior provided development funds. Ongoing product development continues to try to improve drop impact strength, thermal aging, and thermal fatigue resistance; two patent applications on improvements were filed with the US Patent and Trademark Office in 2010 and 2013.

Virtual Engineering Tools Provided the Foundation for Improved Management Decisions Tools for the Agriculture Industry

Ames Laboratory's VE-Suite's library of tools, an open-source software, provided the background and expertise needed for AgSolver, Inc., a startup company located in Ames, IA, to create and market LEAF (Landscape Environmental Assessment Framework) application tools. VE-Suite tools were developed by *K. Mark Bryden, Doug McCorkle, Aaron Bryden and other team members at Ames Laboratory and Idaho National Laboratory*. Mark Bryden's team won 3 R&D 100 awards for tools developed for VE-Suite.

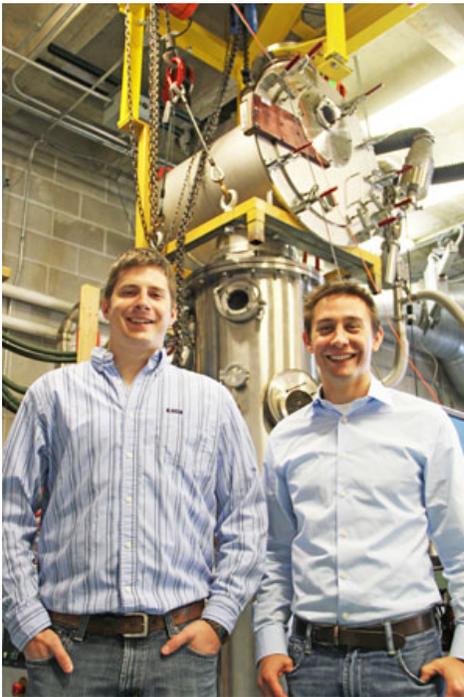
Doug McCorkle is a co-founder of AgSolver and currently holds the position of Senior Vice President of Operations. Dr. McCorkle's research at the **Ames Laboratory** focused on using diverse data streams within the engineering process to create virtualized systems that enable engineers to make well-informed decisions. At AgSolver, the open-source tools developed during that research are being deployed for training simulators, interactive design environments, and agronomic decision services products.

The AgSolver core environmental process engine determines a broad range of land performance characteristics at a high resolution that deliver market specific services to customers. AgSolver's agronomic decision service products improve land management decisions, and simplify mandatory compliance and reporting activities. Their technology uses readily available precision agriculture data including yield maps, soil sample data, and fertilizer application data, in combination with simulation tools to guide better management decisions. The technology uses these datasets with some simple inputs about the management practices for an operation to provide valuable insights at a high resolution 30 foot scale such as: profit projections for a field over 50 years of actual climate conditions, 10 – 30 year projections of key soil productivity metrics including organic matter and erosion scale, and nitrogen use efficiency. The coupled data management and simulation technology also supports high resolution conservation planning. By integrating this technology with a secure cloud computing framework AgSolver's applications can provide these improved decisions within minutes.



MMP360, a web-based tool that turns raw data into a completed Iowa manure management plan form.

Creating Efficiency in Titanium Parts Production



Joel Rieken (l) and Andy Heidloff (r), cofounders of Iowa Powder Atomization Technologies, in front of a gas atomizer.

Titanium's strength, light weight, biocompatibility and resistance to corrosion make it ideal for use in a variety of parts — from components for artificial limbs like those used by wounded veterans returning from Iraq and Afghanistan to military vehicle components, biomedical implants, and aerospace fasteners. But, working with titanium can be difficult when casting parts because molten titanium tends to react with the materials used for machine molds. Using a gas atomization process (which makes a fine, spherical powder form of titanium) manufacturers can then press the powder together at high temperatures. The process is ten times more efficient than traditional powder-making methods thereby significantly lowering the cost of the powder to manufacturers. Utilizing titanium powder has the benefits of conserving processing time and energy, and it produces less waste material.

To make titanium powder, titanium metal is melted using a standard commercial process, then it is heated and precisely guided by an **Ames Laboratory**-patented pour tube into a high-intensity atomization nozzle, also patented at **Ames Laboratory**. The metal is then sprayed out in a fine droplet mist. Each droplet quickly cools and solidifies, creating a collection of many tiny spheres, forming fine titanium powder. Inventors of the nozzle or pour tube are *Iver*

Anderson, Robert Terstra, Matt Besser, Daniel Sordelet, Joel Rieken of Ames Laboratory and Alan Hartman, Edward Argetsinger, Jeffrey Hansen, Jake Paige, Paul Turner of the Albany Research Center

The Laboratory's patents are exclusively licensed to Iowa Powder Atomization Technologies (IPAT), Ames, IA, a start-up company founded by two former Ames Laboratory employees, Joel Rieken and Andy Heidloff. Iowa Powder Atomization Technologies was one of three winners of the Department of Energy's *America's Next Top Energy Innovator Challenge* in 2012. The challenge recognizes some of the most innovative and promising startup companies that took an option to license DOE-funded technologies. IPAT also won the 2012 *John Pappajohn Iowa Business Plan Competition*, honoring top business plans of companies in business for four years or less, with an aim of stimulating business development.

Better glass furnace designs; higher quality and improved energy efficiency

When making glass, exact control of energy, mass and momentum is critical. If the glass has measurable defects or non-uniformities, it cannot be used, wasting large amounts of energy and productivity. These problems exist for any company producing glass products. However, Argonne's Glass Furnace Model (GFM) simulation code can help ensure that furnaces produce the highest quality glass possible. GFM allows glass manufacturers to create virtual furnaces on a computer to improve process design. It is a powerful cost-effective tool that can be used to analyze and optimize existing furnaces or investigate new furnace designs.



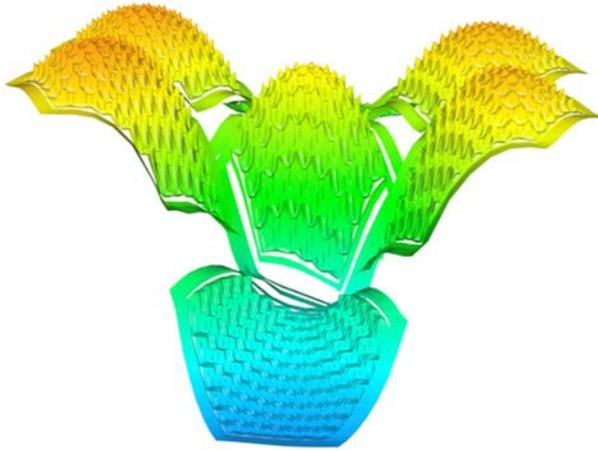
GFM consists of three major computational models:

- Combustion space model
- Radiation heat transfer model
- A multiphase glass melt model

The GFM code was extensively validated using data from three different types of operating furnaces. Data was acquired by the [Institute for Clean Energy Technology](#), which provided spatial distribution data on the gas temperature, gas velocity, gas species concentration, wall temperatures, and directional radiation heat fluxes in the combustion space and on glass melt surface temperatures and velocities.

GFM has been licensed to a wide array of users from industry to academia. The 'high touch factor' associated with GFM showcases the versatility of Argonne technology.

Improved safety analysis tool for advanced nuclear reactors



This image shows the calculated fuel, cladding, coolant, and structure temperatures for an XX09 experimental assembly and its six neighbors one minute into a full-power protected loss of flow accident.

Argonne's SAS4A/SASSYS-1 safety analysis code system is a simulation tool that can perform deterministic transient safety analyses of anticipated operational events, as well as design-basis and beyond-design-basis accidents for advanced nuclear reactors. The original code development was for sodium-cooled fast reactors, and sodium boiling can be modeled. However, basic core thermal-hydraulics and systems analysis features are applicable to other liquid-metal cooled reactor concepts.

As evidenced by the licensee list above, SAS4A/SASSYS-1 is a globally deployed national asset, encompassing decades of Argonne specific research and development.

Applications

- Safety analysis of fast reactors
- Simulations for operational, design-basis and beyond-design-basis events
- Passive heat removal and natural circulation flow predictions
- Severe accident modeling with sodium boiling, fuel melting and pin failure

Early warning crisis system to detect chemical release in interior structures

Since the 1995 sarin gas attack in a Tokyo subway, authorities have recognized that large interior structures are vulnerable to chemical (and biological) attacks. Particularly at risk are venues like subways, airports and government office buildings, where people are concentrated in small areas and quick evacuation is difficult; or enclosed buildings such as convention centers or arenas, where the threat may be high when the facility is occupied. In all cases, early detection and rapid response are essential to ensure crowd safety and the saving of lives.



Proper pre-planning, along with advanced technology, can provide facility management with an early warning to trigger emergency management tools and protocols and potentially save hundreds of lives.

Scientists at Argonne National Laboratory have created an automated hardware/software system to improve the detection of and reaction to complex terrorist attacks involving chemical agents. The system, called PROTECT (Program for Response Options and Technology Enhancements for Chemical/Biological Terrorism), integrates chemical detectors, closed-circuit TV, dispersion modeling and optimal response protocols. Alarm and response management capabilities assist infrastructure operators and first responders by pinpointing agent release areas and projected dispersion zones and recommending appropriate, predetermined response scenarios.

Safer Management Of Nuclear and Radioactive Materials

For years, radio frequency identification (RFID) technology has been used in a variety of applications, from passports to inventory tracking in retail environments. Homeland security concerns have heightened the need for sensitive, real-time tracking of thousands of radioactive and hazardous material packages to



ensure accountability, safety, security and worker and public health. Argonne scientists successfully developed ARG-US (“watchful guardian”), a remote-sensing system for monitoring and tracking nuclear and other sensitive materials based on RFID technology.

ARG-US uses battery-powered RFID tag sensors to remotely monitor the vital parameters of packages containing sensitive materials and has automatic alarm notification capabilities. The original goal in developing ARG-US RFID technology was to support the U.S. Department of Energy in modernizing the life-cycle management of nuclear materials and enhancing safety, security safeguards, and sustainability.

The form factor of the RFID tag was designed to be broadly compatible with common packaging material and has undergone radiation endurance testing. The sensor suite includes seal integrity, radiation, temperature, humidity and shock, and can be expanded to accommodate additional sensors. Sophisticated battery management and monitoring extends battery life to 10 years or more.

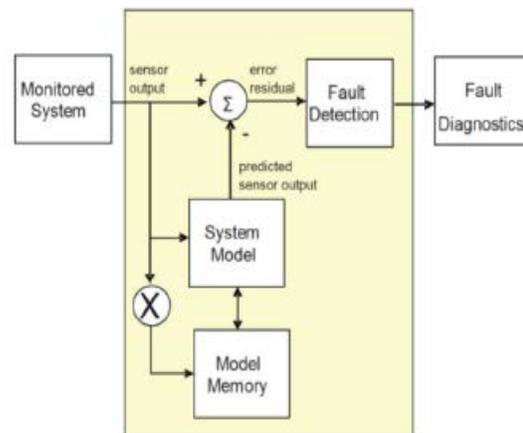
The technology was licensed exclusively to Evigia Systems, Inc. in July 2012 for commercial production of components and systems for nuclear and non-nuclear applications. This agreement highlights the value of ARG-US RFID technology and will facilitate technology transfer to the marketplace. Evigia Systems, Inc. is a leading manufacturer of ISO-18000 Par 7 RFID tags and readers and has been a steady supplier for the U.S. Department of Defense.

National Lab Sensor Technology Attracts Major Market Player

The success of modern industries – especially those that are electricity-intensive – depends on complex engineering systems to ensure safe, productive and efficient operations. System breakdowns can result in millions of dollars in lost time and productivity – and even the loss of life and property. For example, in the utilities industry, where the continuous operation of coolant pumps is essential, the breakdown of a single pump can result in a loss of as much as \$10 million in revenue.

Scientists at Argonne National Laboratory devised a unique early-warning system, called the Multivariate State Estimation Technique (MSET) that monitors the performance of sensors, equipment and plant processes in an industrial environment. A highly sensitive, highly accurate tool, MSET monitors the operations of any process that uses multiple sensors, detecting and alerting users of potential danger long before it occurs.

MSET has been used for light water reactor signal validation applications at the Florida Power Corporation Cystal River 3 nuclear power station. During the initial testing, MSET detected and identified a number of sensor problems. Other applications outside the power industry include improved manufacturing, enhanced energy use for co-generation technology, sensor validation for commercial jet engines, improved pharmaceutical quality assurance and aerospace applications.



Tin-117m Radionuclide Production and Medical Use

Brookhaven National Laboratory has a long history of working with radioisotopes for medical applications. One radionuclide in particular, Tin-117m (^{117m}Sn), has unique properties permitting its dual use for imaging and for treatment of various medical conditions. Its first application was as a palliative treatment of bone pain resulting from cancer metastases. For various reasons, this application did not come to fruition as an available treatment. However, this did not deter Dr. Suresh Srivastava's interests in continuing to develop the use of the material. Nor did it dissuade Dr. Gilbert Gonzales of Clear Vascular, Inc. from continuing his interactions with Brookhaven. The collaboration between Dr. Srivastava and Dr. Gonzales, which began over a decade ago, has now become a business arrangement in which Clear Vascular, Inc. and Brookhaven Science Associates, LLC. ("BSA"), contractor/operator of Brookhaven National Laboratory, have entered into an Exclusive Field of Use License Agreement for Cardiovascular uses of tin-117m.



Gilbert Gonzales of Clear Vascular, center, with Brookhaven's Suresh Srivastava, left, and Nigel Stevenson, Clear Vascular's Chief Operating Officer

The license agreement results from a fruitful interaction between Clear Vascular and Brookhaven National Laboratory under the Initiative for Proliferation Prevention ("IPP") CRADA program. In 2003 Clear Vascular and BSA executed the IPP CRADA that enabled the team to work in Russia to transfer the production technology for tin-117m from a nuclear reactor method to linear accelerator methods. The new methods create greater quantities and higher specific activity tin-117m than was previously practical. The work resulted in four patents for the production of high specific activity tin-117m using a linear accelerator rather than a nuclear reactor. The increased availability of the tin radionuclide is sufficient to support the production of medically useful

materials for treatments of cardiovascular conditions.

Clear Vascular has completed phase two clinical imaging trials and will be starting studies on therapeutic treatments of heart disease.

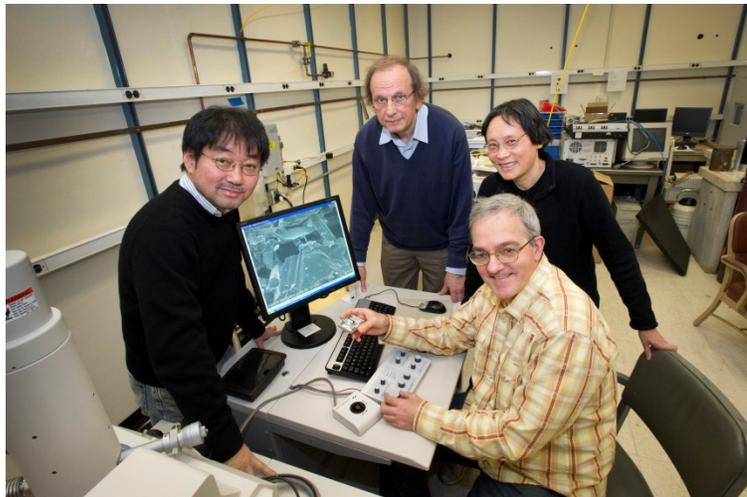
Electrocatalyst Technology for Fuel Cells in Electric Vehicles

The U.S. Department of Energy's Brookhaven National Laboratory executed a pre-commercial license with N.E. Chemcat Corporation, Japan's leading catalyst and precious metal compound manufacturer, for electrocatalysts that can reduce the use of costly platinum and increase the effectiveness of fuel cells for use in electric vehicles. The license also includes access to innovative methods for making the catalysts and an apparatus used to manufacture them. The pre-commercial license allowed market and technical development to proceed in parallel.

Platinum is the most efficient electrocatalyst for fuel cell reactions, but platinum-based catalysts are expensive, unstable, and short-lived. The newly licensed electrocatalysts have high activity, stability, and durability, while containing only about one-tenth the platinum of conventional catalysts used in fuel cells, reducing overall costs.

The electrocatalysts consist of a palladium or a palladium alloy nanoparticle core covered with a monolayer— one-atom thick—platinum shell. This palladium-platinum combination notably improves the rate of oxygen reduction at the cathode of a hydrogen/oxygen fuel cell. This type of fuel cell produces electricity using hydrogen as fuel, and forms water as the only byproduct.

Radoslav Adzic, the Brookhaven senior chemist who led the team that developed the catalysts, said, "We are delighted that N.E. Chemcat Corporation has licensed our platinum monolayer electrocatalyst technology. We hope that it will facilitate the development of affordable and reliable fuel cell electric vehicles, which would be very beneficial for the environment since they produce no harmful emissions. Also, the use of nonrenewable fossil fuels for transportation that contribute to global warming would be greatly reduced, prolonging their availability for other uses in the future."



(From left) Brookhaven National Laboratory chemists Kotaro Sasaki, Radoslav Adzic, Jia Wang, and Mimir Vukmirovic work on electrocatalysts using an electron microscope in their laboratory.

The U.S. Department of Energy's Office of Science and its Office of Energy Efficiency and Renewable Energy funded research that contributed to these technologies. In addition to Adzic, those who contributed to the research include Brookhaven chemists Jia Wang, Kotaro Sasaki, and Mimir Vukmirovic, and postdoctoral fellows Junliang Zhang and Yibo Mo.

Plant Health and Productivity Enhancement

In 2009 - 2010 Brookhaven National Laboratory scientists Daniel van der Lelie, Safiyh Taghavi and Lee Newman isolated several endophytic bacterial species from the roots of poplar trees growing on soils contaminated with heavy metals. One previously unknown Enterobacter species, identified as Enterobacter species sp. 638, was found to promote growth and development of poplar and several other plant species. Further characterization indicated that inoculating/fertilizing plants with suspensions of the bacterium increased flowering, fruit and seed production and, for some plants, increased their resistance to drought conditions. Patent protection for the use of the new bacterial species for promoting plant health and productivity is being sought.

In 2012 and 2013, Brookhaven Science Associates, LLC. (“BSA”), contractor/operator of Brookhaven National Laboratory entered into Option Agreements with Marrone Bio Innovations, Inc. (“Marrone”), a leading provider of bio-based pest management and plant health products.

The 2013 Exclusive Territory Option Agreement granted Marrone the option for an Exclusive License in the United States, Canada, New Zealand, Australia, Mexico, and member states of the European Patent Organization. During the Option Period Marrone diligently examined the utility of Enterobacter sp. 638 to enhance growth and productivity of various crop plants, including row crops and specialty vegetables. Examination of production and delivery of the endophyte was also examined.

Marrone exercised its option and is now exclusively licensed to develop and commercialize the use of Enterobacter sp. 638 for promotion of plant health and productivity in the Territories of the Exclusive Option Agreement. Marrone’s Vice President and Chief Technical Officer was quoted in a recent press release: “A product that helps reduce plants’ need for water, while maintaining or even increasing quality and yield, will be a significant contribution to overcoming future water management challenges that are a growing challenge in all areas of the world.” Marrone anticipates entering the market with a product in the 2015 to 2016 timeframe.



Plants were incubated hydroponically in the absence (cuttings on left) or presence of Enterobacter sp. 638 (cuttings on right). Root and shoot development are presented after 1 (A) and 10 (B) weeks.

Modular Positron Emission Tomography Detector

Positron Emission Tomography (PET) is a major diagnostic imaging tool used predominantly in clinical oncology for staging various cancers, assessing treatment strategies, and monitoring the effects of therapies. Emerging new diagnostic radiopharmaceutical agents that have applications in cardiology and neurology will further expand the use of PET.

A team of scientists from the medical, instrumentation and physics departments at Brookhaven National Laboratory (BNL) have developed a compact modular PET detector. The technology is covered by four United States patents. The initial invention, named RatCAP (Rat Conscious Animal PET), allows the simultaneous study of neurochemistry and conscious movement. This high-tech, wearable PET scanner that monitor brain chemistry enables correlation of the brain's chemical information with the awake animal's activity. David Schlyer, one of the scientists who led the project said "The measurement of chemical messengers in the brain is important to understanding many different diseases and conditions such as drug addiction and movement disorders like Parkinson's disease."



This small wearable preclinical scanner will advance research on conditions such as cancer, Alzheimer's, and Parkinson's disease.

The team has applied the same compact modular PET technology to produce PET scanners for various important preclinical and clinical imaging applications. The preclinical applications include PET insert for small animal research magnetic resonance imaging (MRI) systems that allows dual PET –MRI imaging. The clinical applications include the compact wrist PET scanner, a non-invasive tool to determine the arterial input function required in bringing quantitative PET to the bedside and the breast PET insert for breast MRI systems that facilitate functional evaluation of detected lesions to reduce the unnecessary biopsies of false positives.

SynchroPET, a Long Island, NY based startup company, entered into an option agreement with Brookhaven Science Associates (BSA) the contractor/operator of BNL to commercialize the technology. SynchroPET was the first BNL start-up that was formed under the DOE Startup America program. Recently, BSA has entered into a commercial license agreement with SynchroPET. The company anticipates entering the market with a product in 2016. SynchroPET's website can be found at: <http://www.synchropet.com/Home.aspx>.

The initial RatCAP technology was developed with funding from the DOE Office of Science.

Sulfur Concrete

Sulfur concrete was developed more than thirty years ago by the United States Bureau of Mines. Sulfur concrete is made by mixing sulfur, an inexpensive waste by-product of the petrochemical industry with dicyclopentadiene (DCPD), a fairly expensive organic modifier, with limited availability. This has kept the cost of sulfur concrete high and therefore, sulfur concrete has not been widely used. Dr. Paul Kalb of Brookhaven National Laboratory (BNL) together with partners from Kazakhstan, have devised an alternative concrete composition and method for making it through a process known as Stabilized Sulfur Binder using Activated Fillers (SSBAF).

The SSBAF method uses an organic component waste by-product from the petrochemical industry, mixed with and coated on filler, such as sand, before being energetically mixed with sulfur. Dr. Kalb explained that this “green” process recycles industrial byproducts and, unlike the process for making conventional concrete, does not produce carbon dioxide. This improved sulfur concrete is less expensive than conventional SPCs, requires no water, and is highly resistant to corrosive environments. This sulfur concrete can be used in a number of applications including precast concrete products such as pipes, tanks, containers, blocks and slabs.



In 2012, Brookhaven Science Associates, LLC. (“BSA”), contractor/operator of BNL entered into an Option Agreement with Green Sulcrete, a Long Island NY based company that was formed to commercialize the BNL’s sulfur concrete technology. Green Sulcrete was granted an option under the DOE Startup America program. The option was granted for the company to make, use and sell sulfur concrete made by the BNL process in certain territories. Recently the company changed its name from Green Sulcrete to Sulcrete and has entered into a license agreement with BSA. The company was awarded the Phase I SBIR NSF grant. Under sponsored research agreements, the company continues to collaborate with BNL to develop the product further. The company anticipates entering the market with a product in 2016. The website of the company can be found at: <http://www.synchropet.com/Home.aspx>.

Sulfur concrete bricks made using the SSBAF process

MOOSE – Revolutionizing Nuclear and Materials Modeling and Simulation

Winner the 2014 R&D 100 Award, Multiphysics Object-Oriented Simulation Environment (MOOSE) carries much of the programming burden for creating scientific simulation capabilities, making simulation tools more accessible to a wide array of researchers. It was developed by Idaho National Laboratory (INL) programming specialists and computational mathematicians.

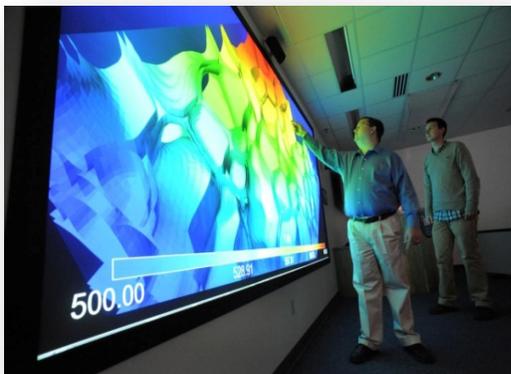
Modeling and simulation is becoming standard practice in nearly every branch of science, but building a useful simulation capability has traditionally been a daunting task -- it required a team of software developers working for years with scientists to describe a given phenomenon.

DOE's leadership in advanced computing and nuclear science converged to set the stage for development of a new simulation capability. INL built MOOSE on a foundation of computer code and numerical libraries from existing, proven numerical tools developed in the DOE complex and academia.

The MOOSE simulation platform makes advanced simulation quicker, adaptable and more accessible to a wide array of scientists because it carries much of the programming burden and doesn't require a supercomputer. It also enables simulation tools to be developed in a fraction of the time previously required.

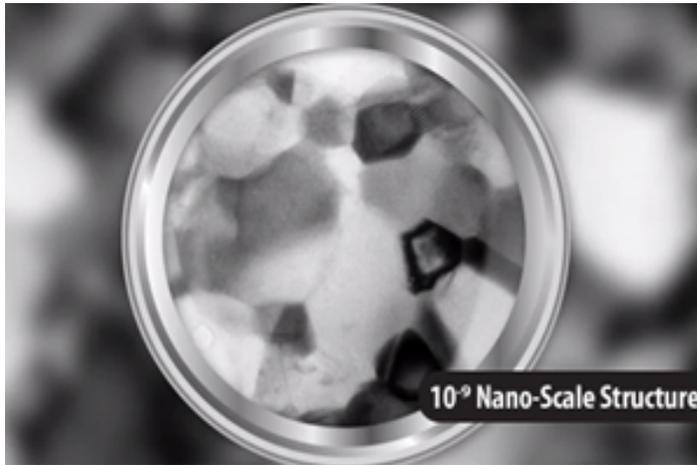
The simplicity has bred a herd of 21 different modeling applications describing phenomena in nuclear physics (BISON, MARMOT), geology (FALCON), chemistry (RAT) and engineering (RAVEN, Pronghorn). The tool has revolutionized predictive modeling, especially in the field of nuclear engineering where nuclear fuels and materials scientists have developed numerous applications to predict the behavior of fuels and materials under operating and accident conditions.

MOOSE applications are being developed in collaboration with or within INL and are in various stages of development ranging from recently obtaining preliminary results to being nationally recognized as state-of-the-art. INL is continually updating MOOSE to support its growing user community.



In July 2014, the commercialization of MOOSE was selected by the Federal Laboratory Consortium Far West to receive its Commercialization Success Award for use of Open Source Software licensing. This has produced more than 50 new licenses, representing a diverse population of users that includes domestic and foreign laboratories, universities and companies.

NanoSteel - Super-Strong Steel Materials



A successful technology transfer from the U.S. government to the private sector, NanoSteel was formed in 2002 as a spin-off company from DOE's Idaho National Laboratory with a worldwide exclusive license for a new class of nano-structured steel material. This breakthrough resulted from a U.S. government funded R&D project at INL for hard-metal surface coatings for industrial applications in extreme wear environments.

The ever-changing demands of modern technologies drive a need for metal alloys with specific novel properties. Numerous industries — including those supporting automobiles, oil and gas, mining, and steel production — are creating products that require performance capabilities beyond the known boundaries of existing materials.

INL researcher Dr. Daniel Branagan discovered a new class of nanostructured steel material, which has been used to provide solutions addressing needs in a wide range of mainstream industries. After demonstrating the technology at the lab scale, funding from the Defense Advanced Research Projects Agency (DARPA) helped scale up the process.

Since beginning, NanoSteel has created progressive generations of iron-based alloys, including foils, powder metals, and sheet steel. Surface technology has been used in extreme-wear and corrosion environments including power generation, mining and aggregates, concrete and cement, and oil and gas.

NanoSteel has quickly become a leader in nanostructured steel materials design and the company's most recent milestone is production of a third-generation Advanced High Strength Steel (AHSS) sheet design breakthrough for the automotive industry. These advances will allow automotive engineers and designers to reduce weight through the use of thinner, higher-strength gauges, while maintaining the structural integrity needed for safety.

NanoSteel has won five R&D 100 Awards, and generated more than 200 licenses, patents and patents pending. In 2011, a General Motors subsidiary invested in the company.

RELAP5-3D - Safety Modeling Helps Nuclear Reactors, Jet Engines, Fossil Plants

Developed at Idaho National Laboratory (INL), Reactor Excursion and Leak Analysis Program (RELAP5-3D) is a multidimensional thermal hydraulic transient simulation tool that allows users to model the coupled behavior of the reactor coolant system and the core for various operational transients and postulated accidents that might occur in a nuclear reactor. RELAP5-3D can be used for reactor safety analysis, reactor design, simulator training of operators, and as an educational tool by universities.

Soon after the birth of commercial nuclear energy, the Nuclear Regulatory Commission identified a need for reactor safety analysis software. In 1966, Idaho scientists began developing the Reactor Excursion and Leak Analysis Program (RELAP) to model reactor coolant and core behavior in a pressurized water reactor. The NRC and DOE have supported continued development of RELAP, incorporating increasing complexity to keep modeling realistic. RELAP upgrades also have accommodated an array of reactor designs.

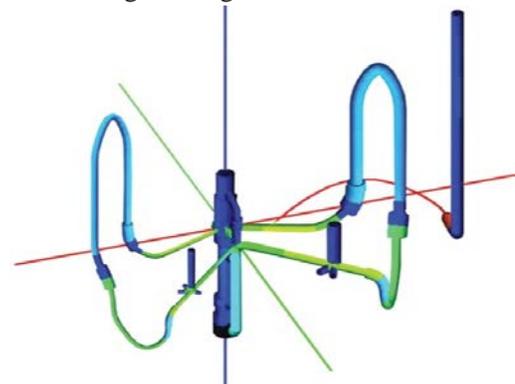
RELAP is used throughout the world to support reactor safety analysis, reactor design, operator training and university education.

In 1996, INL copyrighted the non-NRC-funded parts of the RELAP code, introducing the RELAP5-3D version in 1998. The DOE offices of Nuclear Energy (DOE-NE) and Naval Reactors (DOE-NR) have funded RELAP work since 1998. That year, the International RELAP Users Group was formed to support nongovernment users, including universities and the commercial nuclear industry.

With more than 70 active licenses today, licensing income from the international users group helps fund ongoing code development, upgrades and user support. INL develops version updates, including requested features, with beta testing from the users group.

Commercial reactor vendors use the program to support efforts to obtain NRC approval for new reactor designs. Users include AREVA NP Inc., Mitsubishi Nuclear Energy Systems Inc., Babcock and Wilcox Co., NuScale Power LLC, TerraPower LLC, and Rolls-Royce Power Engineering Ltd.

The code has been licensed for both nuclear and non-nuclear applications, including modeling of jet aircraft engines and fossil power plant components. A new version released in fall 2013 includes a variable gravity feature of interest to the aerospace industry.



PINS – Peering Inside Dangerous Containers

Portable Isotopic Neutron Spectroscopy (PINS) System is a rugged, field-deployable, non-destructive evaluation tool that identifies the contents of munitions and chemical storage containers by employing neutron radiation safely and reliably. The system non-intrusively identifies material within steel and other containers using neutron activation and gamma spectroscopy.

World War I brought the advent of chemical warfare. Decades later, problems arose as the contents of suspicious chemical and explosive munitions could not be reliably and nondestructively identified. This posed a serious risk for soldiers and munitions experts in the field.

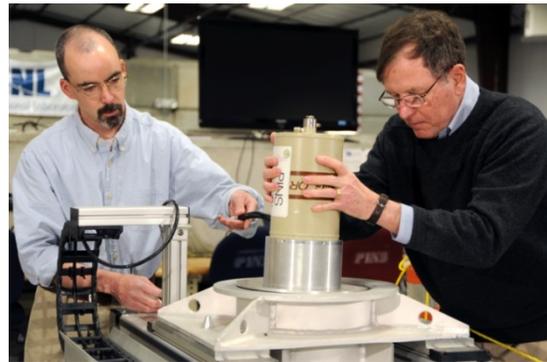
INL researchers sought to create a device that could identify the contents of these shells and containers, while minimizing risk to the people involved. The result was the Portable Isotopic Neutron Spectroscopy (PINS) System.

PINS uses gamma spectroscopy to safely identify material within steel and other containers, such as sarin drums. PINS requires a neutron generator, like californium-252, to shoot neutrons through the metal of the container, activating the elements inside and making them briefly radioactive.

As the elements within a chemical, nerve or explosive agent decay back to their stable state, they each emit signature gamma rays, which are picked up by the PINS gamma ray spectrometer. The PINS software can then analyze the gamma ray spectra and identify chemicals within the container in a matter of minutes.

In 1995, PINS was licensed to AMETEK, Inc., with license updates occurring in 1999 and 2013. PINS is regularly updated to expand its chemical library and improve its sensitivity, ruggedness, ease of use and safety. The most recent update, PINS-3, became available in 2013.

The detector is used at more than 90 sites worldwide, including over 50 in the United States. PINS is now the premier tool for identifying nerve agents, blister agents, explosives, military screening smokes, compressed gases and practice fills.



Sophia – Software Boosts Security by Passively Monitoring Networks

Sophia offers Industrial Control System (ICS) managers an effective computer network fingerprinting software tool that provides a visual representation of all connections and network traffic to and from an ICS. In the past, control systems running energy sector facilities didn't require much security because they were isolated from the outside world.

Today, control systems that run critical infrastructure such as power grids often are connected to the Internet via company computer networks. The Sophia software develops a fingerprint for a given system, then operates passively in the background to observe communications across the entire ICS network.



Administrators charged with securing these systems must maintain situational awareness of dozens or hundreds of computer systems that are constantly talking to each other. INL cyber experts have long worked with industry to assess their control systems networks to identify and help protect against vulnerabilities.

INL's vulnerability assessment experience revealed the need for a tool to map communication pathways for control system's static networks — systems whose communication patterns are fairly fixed. The Sophia software develops a fingerprint for a given system, then operates passively in the background to observe communications across the entire network.

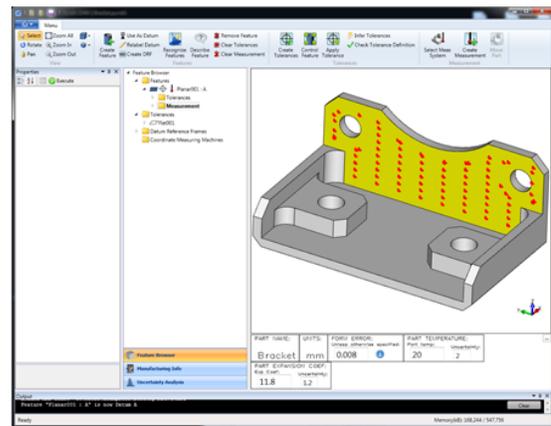
If Sophia detects something out of the ordinary, it simply alerts the operator or network administrator, who can then investigate. The software lets the human operator evaluate new activity — it doesn't attempt to decide if the novelty is threatening. Sophia flags new devices or novel communication pathways that may not be noticed by operators. Developers named the software using the Greek word for wisdom because it provides new insights and visual patterns to help network administrators watching for cybersecurity threats.

Utilities participating in initial demonstrations called Sophia “a great asset” that “adds the characteristics of a full-time employee.” Funded by DOE-OE, the alpha and beta testing of Sophia was conducted with 44 industry, academic and government entities and seven government agencies took a direct license from INL. NexDefense, Inc. of San Mateo, CA licensed the technology during 2013.

New Pundit/CMM Software Tool Realizes Measurement Optimization Capability

Earlier this year, METROSAGE LLC. commercially introduced a new model-based software tool that helps facilitate the development of coordinate measuring machine (CMM) inspection programs according to new optimization techniques. For example, it is intended that, given certain parameters of the CMM system, an inspection strategy will be generated that will result in the smallest inspection cost under constraints of time and/or required accuracy. Furthermore, users could use the tool to choose among several CMMs which one would most economically produce adequate measurements. Finally, this tool will enable the user to integrate measurement technology and sound business practice, by providing estimates of the impact of CMM metrology on product profitability.

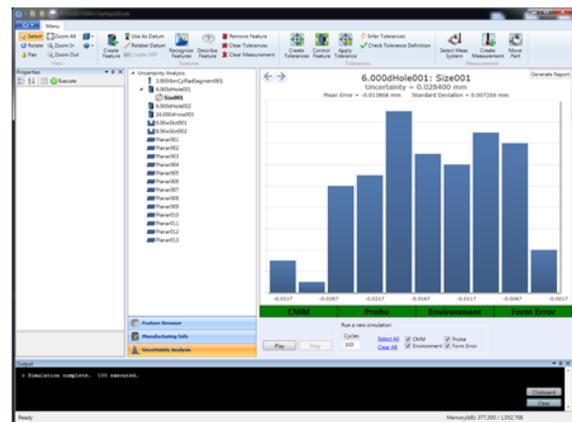
METROSAGE LLC, a small company headquartered in Volcano, CA, partnered with DOE’s Kansas City Plant (KCP) through a Cooperative Research and Development Agreement (CRADA) to undertake development of a new software product toward advancing CMM programs for product acceptance and certification. The develop results will benefit US commercial enterprises, Federal government entities, and US defense activities by providing a more efficient and cost effective tool than is currently available. The combination of model-based technology and expertise from the partnership in tolerance analysis and dimensional metrology greatly accelerate the development.



Pundit/CMM’s Optimized Sample Point Determination

METROSAGE LLC is a leading provider of inspection analysis and simulation software and services for factory applications. METROSAGE delivers automated simulation solutions focused on the improvement of quality and predictability in the manufacturing process. Improving ROI through optimized inspection planning and validation, METROSAGE applies advanced science and technology in an easy to use package to drastically improve the effectiveness and cost/benefit of quality assurance.

DOE’s Kansas City Plant (KCP) is one of the nation’s most diverse low-volume, high-reliability production facilities and is at the heart of the NNSA nuclear security organization. KCP provides high-tech production services to government agencies with high-quality requirements.



Pundit/CMM’s Measurement Uncertainty Result Histogram

Miniature Ordnance Flight Data Recorder System

An advanced miniaturized ordnance flight data recorder system was developed by the DOE/NNSA's Kansas City Plant under a Strategic Partnership Projects contract with Lockheed Martin Missiles and Fire Control, Dallas, Texas. The recorder simultaneously records four analog and four digital signals at a high resolution to characterize launch and flight conditions of Lockheed's proposed squad-level, non-line-of-sight (NLOLS) strike munition. The recorder was designed to be fully integrated into the system's Electronic Safe Arm and Firing Device (ESAD)

also being developed by the Kansas City Plant. This new technology enabled the rapid characterization of the arming conditions needed to support the final development and Air Force safety board approvals enabling rapid deployment for live-fire demonstrations. The technology has the potential to significantly reduce costs and time in the development of a wide range of new or upgraded DoD ordnance programs.



LMAMS Strike Munition (weaponized UAV)

New Method to Extract Heavy Oil from Oil Sands

Kansas City Plant inventors, in conjunction with Millennium Technologies Inc., have jointly developed a new process to recover heavy oil from oil sands. Much of the world’s oil reserves are in the form of oil sands and in the western part of the United States alone, there is an estimated heavy oil reserve of nearly 100 billion barrels. This new process not only has the potential to decrease the United States’ dependence on foreign oil but also uses an environmentally friendly, non-aqueous process well suited for water scarce western regions.



Unprocessed Oil Sand

This two phase process involves the use of a renewable, generally recognized as safe (GRAS) solvent, followed by a liquid or supercritical carbon dioxide rinse to remove the extraction solvent from the sand. Both the extraction and rinse phases are recovered using closed-loop processing to eliminate losses. The new process expands upon a previous collaboration that was awarded a FLC Technology Transfer Award in 2006.



Sand and Oil Post-Processing



Clean Sand after Processing

Windows Logging Service

In 2009, faced with the challenge of identifying the introduction of computer malware that had the potential to evade common detection mechanisms, such as antivirus software, Kansas City Plant (KCP) created the Windows Logging Service (WLS). On the surface it's a replacement for other well-known logging tools, but was created with the intent to fill the needs of an incident responder.

WLS provides the chosen cryptographic hashes of each executed process, along with many other user-defined parameters, as well as contextual data to identify related activity. The data added to the log stream initially came about as a product of indicators of compromise (IOC) contained in reports of known threats. As adoption of WLS has spread, further data has been added at the request of other US Government sites, commercial entities, and open source research.

With WLS running on each host, an organization essentially has a network of indicator generators that provide near real-time and historic data. The goal of which is to detect an initial threat vector and quickly determine the breadth of a compromise, if any. KCP utilizes this data to greatly decrease the number of hosts being reimaged by comparing network data that indicates potential compromise, with host data that confirms or refutes the previous evidence. Tracking of cryptographic hashes also allows KCP to discover new threats that bypass traditional detection mechanisms quickly and remediate before any further compromises.

The data WLS provides in near real-time and the open format in which it is provided is unique to both the host logging and host-based intrusion detection system (HIDS) markets. Utilizing the broad knowledge base of IOC types and a standard logging format allows WLS data to be directly sent to almost any commercial off-the-shelf (COTS) log analysis tool for immediate usage. The provided types of IOCs and their metadata can also be highly customized to fit the needs of the organization to meet both compliance and incident response needs.

Through contacts of previous DOE/NNSA employees and word-of-mouth, commercial interest in WLS has been building. In 2013, working with the legal and licensing personnel, KCP was able to successfully begin commercialization of WLS. Presently, a number of commercial organizations from broad market segments have purchased licenses and many more have or are pursuing evaluation and end user licenses.



Licensees of WLS are also provided with a set of queries and a pre-built app for a popular log analysis tool. The app provides everything from basic health monitoring of a WLS deployment to detailed drilldowns about a specific host.

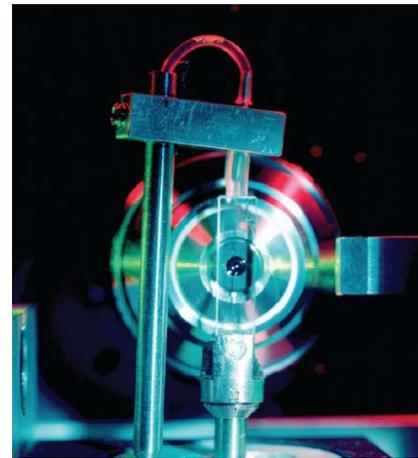
In addition, the app has a framework pre-built to allow new users to immediately begin tracking all new processes, with alerting, which can reduce detection of unknown threats to minutes.

Acoustic Focusing Cytometer

The field of flow cytometry was originally invented at Los Alamos National Laboratory (Los Alamos) as a way to allow scientists to quantitate and examine cells by passing them through a laser-based detection device.

Thousands of cells per second may be analyzed individually, allowing rapid characterization of entire populations of cells as well as the detection of rare cells. Cell biologists use flow cytometry for a wide range of applications, including the study of cellular protein expression, immunophenotyping, quantification of cellular DNA, and measurement of a variety of cellular phenotypes for the purposes of basic cell biology research and drug discovery. Advances in the development of flow cytometry instrumentation at Los Alamos have benefitted from the support of the National Center for Research Resources at the National Institutes of Health (NIH).

In 2006, Los Alamos spun out a new company, Acoustic Cytometry Systems, LLC (ACS), to commercialize a novel flow cytometer technology. The company furthered the development of a method to use sound waves to guide cells through cytometers, or cell meters, allowing researchers to closely examine tissue samples for medical diagnostics. Unlike typical flow-through cytometers—which use fluids to rapidly push thousands, if not millions, of compounds through cytometers for drug discovery—the ACS technology allows researchers to use sound waves to completely stop the flow of tissue samples and focus on individual cells up close.



DNA fragments flow through the flow channel from the bottom of the flow cell to the exit tubing at the top.

ACS was subsequently acquired in 2008 by Invitrogen Corporation, which later merged with Applied Biosystems to form Life Technologies. The company advanced the Los Alamos technology and developed the Attune® Acoustic Focusing Cytometer, a first-of-its-kind cytometer system that uses acoustic waves to precisely control the movement of cells during analysis. The system is based on a portfolio of intellectual property developed at Los Alamos for which Life Technologies (which was recently acquired by Thermo Fisher Scientific, Inc.) holds exclusive commercial license rights.

Acoustic focusing enables both longer transit times and higher throughput, which simultaneously permit better interrogation of every cell in a sample and analysis of much larger numbers of cells. By further developing Los Alamos' acoustic cytometer technology and launching it as a commercial product, Life Technologies is poised to bring researchers and scientists one step closer to precise quantitation of molecular phenotypes at the single cell level, huge advancement in today's biological and medical research capabilities.

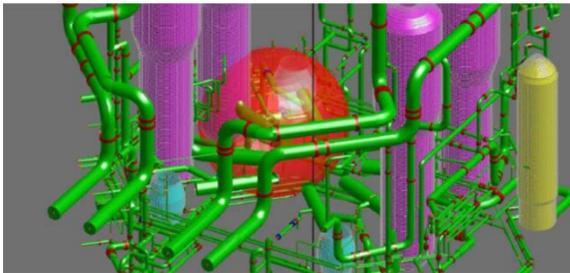
The Attune® Acoustic Focusing Cytometer offers researchers a flexible, high-performance cytometer at less than half the price of comparable instruments. It improves the sensitivity, throughput, and accuracy of flow cytometry-based assays, while also enabling a greater variety of sample types than can be evaluated on traditional hydrodynamically focused cytometer systems. The Attune Cytometer provides extremely high-quality data and the flexibility to analyze complex samples with reduced interference.

CASA Grande

There are approximately 104 nuclear power plants in the United States. These plants are some of the most sophisticated and complex energy systems ever created. Despite the painstaking engineering that has gone into such plants, no system is failure-proof. Calculating the risk of damaging the fuel by all possible failure paths is important to minimize the chance of a catastrophic event.

The Nuclear Regulatory Commission (NRC) has been striving to resolve what it calls Generic Safety Issue (GSI) 191. GSI-191 involves the following scenario: a high-energy pipe breaks, creating debris that finds its way to the plant's emergency recirculation sump strainers. Debris passing through the strainer can also accumulate in fuel channels, adversely impacting reactor cooling.

To improve and refine how best to address GSI-191, Bruce Letellier and his team at Los Alamos National Laboratory (Los Alamos) established a Cooperative Research and Development Agreement with the University of Texas to assist South Texas Project Nuclear Operating Company. The partners developed CASA (Containment Accident Stochastic Analysis) Grande, a software code that automates the evaluation of a single postulated accident so that thousands of possible scenarios can be assessed. CASA



CASA Grande is a powerful software tool that automates the calculation of performance impacts to enable statistical evaluation of thousands of postulated accident scenarios in nuclear power plants.

Grande enables generation of a spectrum of possible outcomes that range from successful performance of the plant's safety systems to various "failure" states defined by regulatory levels of concern. CASA Grande statistically samples probability distributions defined for each factor, propagating uncertainty on the input into an assessment of uncertainty on the measures of failure. Non-uniform Latin hypercube sampling (LHS) is used to sample and propagate uncertainty through a basic event scenario that includes debris generation, debris transport, and debris accumulation. Inclusion of plant-state timing in the uncertainty sampling is a novel adaptation of LHS that generates randomized event sequences that are not easily handled by traditional probabilistic risk assessment methods. A prototype of CASA Grande was exercised for the first time in December of 2011.

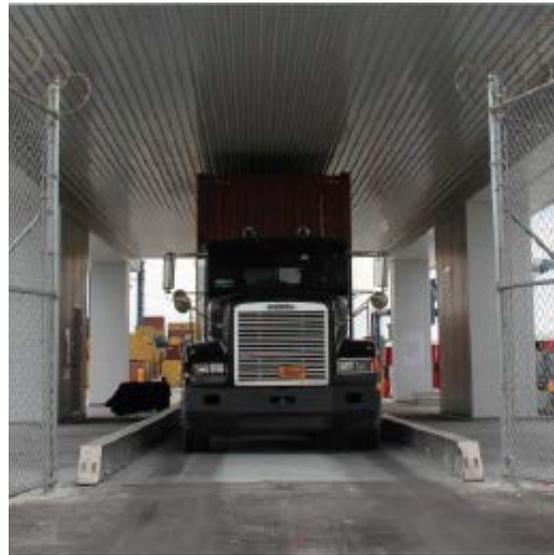
Los Alamos filed a copyright disclosure for CASA Grande and soon after established an exclusive commercial licensing agreement with Alion Science and Technology Corporation in 2013. Alion has made numerous improvements to the code to support their consulting services and is actively developing a market for users in the nuclear utility community.

Under the terms of the exclusive license, Alion can modify, market, and apply the CASA Grande code for revenue generation so long as periodic improvements to the code revert back to Los Alamos National Security, LLC for noncommercial, government use. From a corporate perspective, CASA Grande constitutes a business investment for Alion that will help the company grow its market base among commercial nuclear utilities. Alion has made substantial improvements to CASA Grande, including user-accessibility features and model-fidelity enhancements. The commercial version, now under software quality control, provides the foundation for GSI-191 resolution at the South Texas Project nuclear power plant.

Muon Tomography

In the mid-1990s, scientists at Los Alamos National Laboratory (Los Alamos) were developing proton radiography techniques for a variety of applications. During the course of their work, Los Alamos scientists contemplated the idea of using muons instead of protons. The resultant technology is known as muon scattering tomography, a breakthrough variation of muon tomography, which had been around since the 1950s. Produced from cosmic rays entering the Earth's upper atmosphere, muons naturally and harmlessly rain down on the planet's surface. Muon tomography uses these cosmic-ray muons—subatomic particles similar to electrons—to generate three-dimensional images. Muons yield deeper penetration than x-rays, making them ideal for producing images through thicker materials that x-rays cannot penetrate.

Following the terrorist attacks on September 11, 2001, Los Alamos scientists began using muon scattering tomography to detect and identify concealed nuclear threat materials inside thick containers. Unlike conventional imaging and detection techniques that use x-ray technology, muon tomography can “see” through shielded containers filled with threat materials because the dense shielding material is *itself* detected. Scientists also developed sophisticated software that images data collected from a muon-tomography scanner. The result is a three-dimensional image map that precisely locates the threat object within a shielded container. From 2003 to 2006, Los Alamos received external funding from several government agency sponsors as well as internal Laboratory Directed Research and Development (LDRD) funding to further develop this crucial technology.



What's in this truck—goods headed to market or a “dirty” bomb? In 45 seconds, the MMPDS developed by DSIC based on the technology developed by Los Alamos, can penetrate any heavy shielding and tell you precisely what is in this truck without ever having to open it up.

Additionally, Los Alamos' Muon Tomography technology can be used for a variety of imaging applications. Using muon tomography, scientists can show the distribution of the reactor core without the risk of releasing radiation. These results will be crucial for safe and timely reactor dismantlement.

Los Alamos' contribution of software to analyze the muon scattering tomography results will play a crucial role in assessing the damage at the Fukushima site. The accompanying apparatus, which has already been demonstrated on a smaller intact reactor, consists of two billboard-size detectors set up on opposite sides of the building. Each detector is like an array of pipes in a church organ, with each pipe filled with inert gases, including argon, that give an indication when a muon hits. The detectors keep track of which pipes were hit on the way in and on the way out, and at what angle. The detectors do not have to be placed inside the reactor building and would in fact be less effective inside because gamma radiation coming off the melted fuel would make it harder to spot the muons. The next phase of this project is to use mouns to image the reactor buildings in hopes to find the radiation leaks. Detectors will

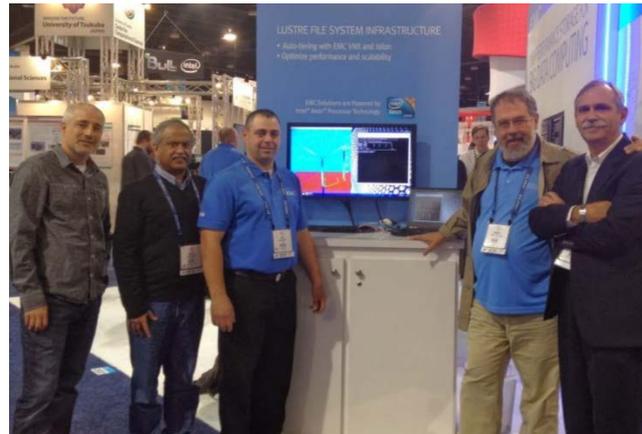
be set up a few feet away from the reactor buildings' outer walls, and will be shielded with four inches of steel, which will stop the gamma rays but makes no difference to the muons.

Parallel Log-structured File System (PLFS)

Together, Los Alamos National Laboratory (Los Alamos) and EMC, are enhancing, designing, building, testing and deploying new cutting-edge technologies in an effort to meet some of the nation's most difficult information technology challenges. Thus far, the LANL and EMC collaboration has been engaged in high-performance computing and data storage research, as well as large-scale analytics.

One of EMC's innovative products is a flash appliance, called the Active Burst Buffer Appliance, or aBBa, which helps extreme scale high-performance computing set-ups run faster and smoother. It acts like a very fast book mark: when one of the millions of parts that make up a supercomputer fails; the tightly coupled application can quickly get back to where it was.

A key software development in the operation of and other computing platforms is Parallel Log-structured File System (PLFS). PLFS, designed and developed through a Cooperative Research and Development Agreement with Los Alamos and EMC, is an open-source, extremely scalable data-management middleware library that can be used with everything from small clusters of computers to the largest supercomputers in the world. This technology is file-system agnostic and could improve computing efficiency significantly.



Los Alamos Scientist and EMC staff demonstrating aBBa and PLFS at a HPC tradeshow.

PLFS is a parallel IO abstraction layer that rearranges unstructured, concurrent writes by many clients into sequential writes to unique files (N-1 into N-N) to improve the efficiency of the underlying parallel file system. EMC is now demonstrating aBBa at High Performance Computing (HPC) trade shows. PLFS also features as a core technology in the DOE's FastForward program, targeted at eliminating barriers on the path to exascale computing.

PLFS work at Los Alamos is built on a foundation of years of storage and I/O leadership in HPC, directly impacts execution of the Laboratory's mission via a variety of computing platform as well as highlight the Laboratory's broader contribution as this key HPC technology is developed and deployed for the first time at extreme scale locally at Los Alamos.

Parallel storage infrastructure is a growing market segment in an overall multi-billion dollar industry. Los Alamos has been instrumental, first in developing parallel storage infrastructure for HPC, and now in partnering with companies who are using these concepts, including PLFS, to extend parallel storage infrastructure to a customer base spanning every possible market segment; see, for instance, <http://www.emc.com/cloud/customer-showcase.htm>.

Safire

The key to optimizing the recovery of oil from wells is straightforward: more data equals more oil. To achieve such optimization, Los Alamos National Laboratory, Chevron ETC, and GE Measurement & Control have developed Safire, the world's first cost-effective topside multiphase flow meter. The goal of Safire is simple: make the most from low-yielding wells.

A multiphase flow meter, Safire provides noninvasive, real-time, accurate estimates of oil production for every well. Safire achieves measurement rates as high as 100 readings per second (including computation time).



Safire meters perform continuous measurements in fast-changing oil flow conditions

Safire is based on SFAI, or swept frequency acoustic interferometry. SFAI uses frequency-chirp signal propagation (wideband ultrasonic frequency) through a multiphase medium to extract frequency-dependent physical properties of said medium. SFAI then uses the propagation time and the attenuation of the chirp signal as a function of frequency to extract both fluid flow and multiphase fluid composition information.

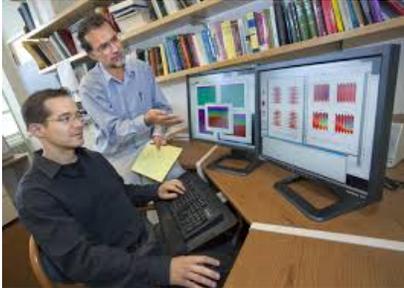
Simple to use, Safire enables continuous measurements in fast-changing flow conditions in rod-pumped wells, as well as other wells. Safire's ability to provide accurate, real-time volumetric measurements of oil flow from wells means better reservoir management, accelerated production, and huge cost savings by eliminating the need for environmentally unfriendly separation tanks.

Rather than sampling a few wells over a long period of time, Safire now makes it possible to provide real-time, accurate, and continuous measurements of volumetric oil flow from individual wells. This capability significantly speeds up the testing process, thus enabling better management of oil-well assets and improving recovery. Safire will enable faster detection and correction of well problems, thereby reducing well downtime and boosting oil production. The resultant reduction in cost—when all the various advantages are considered—will run into several billions of dollars. The bottom line is that Safire will enable more environmentally friendly oil-field development.

A few international application areas that Safire will impact in the years to come are helping meet the world's oil demands, bolstering alternative energy resources, detecting defects in solids, determining fluid density and viscosity, and monitoring waste storage containers, such as those at the Waste Isolation Pilot Plan in Carlsbad, New Mexico. As the technology has matured, more applications are being identified.

With Safire, the energy industry now has a cost-effective device that is nonintrusive, simplifies oil production monitoring, and is environmentally friendly. Safire is the only instrument available today that can operate in the presence of gas, thereby eliminating the use of gas separators or tanks. Potentially eliminating thousands of separators and tanks will enable the energy industry to dramatically reduce the footprint of facilities that produce oil and gas. Such elimination will reduce fugitive hydrocarbon emissions and the potential for oil spills. As a result, the energy industry will be in a stronger position to access environmentally sensitive areas.

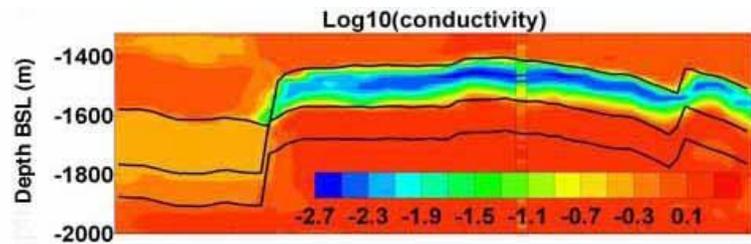
Pinpointing Energy Resources Under the Ocean Floor



Seismic imaging data can locate hydrocarbon reservoirs under the ocean floor but cannot identify specifically if oil, gas, water or brine is stored in the reservoirs. Oil and gas companies risk significant losses—up to \$100 million and six months of unrecoverable labor costs—if a drill is not successful. Locating and securing energy resources is also critical to meeting the nation’s energy independence goals.

Researchers in the Earth Sciences Division of Lawrence Berkeley National Laboratory developed a technology, Electromagnetic Geological Mapper (EMGeo), to interpret seismic images alongside extremely large data sets of electromagnetic measurements and yield high resolution, 3D maps of deep water hydrocarbon reservoirs and their surrounding features. EMGeo outperforms competitors and enables users analyze geophysical data and make critical decisions in-house, further lowering oil exploration costs. The LBNL researchers continue to add features based on user feedback.

EMGeo has been licensed to 10 companies including some of the world’s largest oil and gas companies – Chevron, ConocoPhillips, ExxonMobil –and Rock Solid Images, a geosciences consulting firm, over the last five years. As a result, EMGeo has contributed to the energy security of the United States, reduced environmental degradation caused by unnecessary drilling, and saved valuable time and millions of dollars in energy exploration costs.



Electromagnetic Geological Mapper (EMGeo) enables energy exploration companies to identify the type of fluid present (oil, gas, water, brine) in a reservoir under the ocean floor, avoiding the lost time, money, and unrecoverable labor costs of an unsuccessful drill.

DNA Damage Monitoring Made Easy

The public is gaining awareness of the effects of DNA damage on human health and the ability to repair some DNA damage through lifestyle and nutrition choices. Yet, there is no at-home blood test for assessing DNA damage and monitoring it over time. The only options for DNA damage testing are at clinical sites, and current assessment tools provide less precise information because they do not take the patient's age into account when interpreting data.



Startup Exogen Biotechnology raised over \$100,000 in crowdfunding to develop tests based on LBNL technology to measure DNA breaks, thought to be a key indicator for overall health.

Lawrence Berkeley National Laboratory scientists developed an at-home blood collection kit that requires only a few drops of blood and immediately fixes the biological activity of blood cells to enable non-toxic sample shipment or storage without changes in specific DNA markers. Samples are then assessed in an automated, high-throughput, reproducible process yielding results taking each patient's age, health status, and radiation exposure history into account. In two trials conducted in 2013, researchers correlated DNA damage with subjects' age, indicating the importance of including age in data assessment.

In 2013, startup Exogen Biotechnology recognized the potential for this technology to benefit the public and entered into an agreement with LBNL through the Startup America program. Exogen has raised over \$100,000 in an online crowdfunding campaign that offered kits to citizen scientists for their own DNA damage monitoring. Over 215 kits will be shipped to funders in late 2014.

Real World Testing for Energy Efficient Buildings

Commercial, industrial and residential buildings use nearly 40 percent of all energy, and over two-thirds of all electricity consumed, in the United States. Many energy efficient building materials, windows, lighting and HVAC choices are available for new construction and retrofits. However, the best selections, when integrated into a particular building project and location, can only be determined theoretically – not in practice.

The Facility for Low Energy Experiments in Buildings (FLEXLAB) was developed by the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory as a test-bed to research and develop cost effective, energy-saving building systems and technologies for both new construction and retrofits. Its features include a rotating test bed, for varying sun exposure, and interchangeable lighting, walls, and other architectural elements.



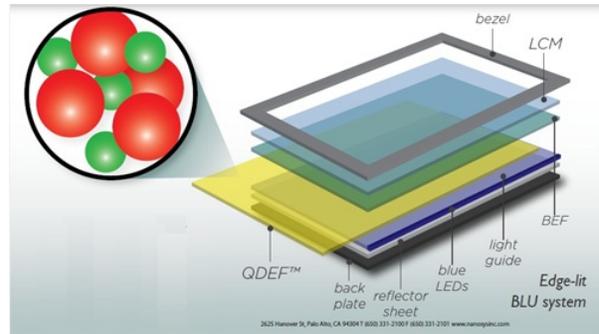
FLEXLAB was inaugurated in summer 2014. Building contract Webcor is utilizing FLEXLAB to plan a 250,000 square-foot building to serve as biotech company Genentech's new South San Francisco headquarters. Bay Area utility PG&E has signed an agreement to test whole building energy efficiency technologies to develop future incentive programs. Agreements with other industry partners – from the fields of architecture and design, utilities, regional energy and trade organizations, and energy efficient technology manufacturers – are in development.

LBL's FLEXLAB real world test-bed enables development of whole building energy saving solutions by energy services companies, building designers, utilities and product manufacturers.

Better, Brighter – and More Energy Efficient – Displays

Widespread use of devices with electronic displays – from tablets and smartphones to laptops and high definition (HD) televisions – means increased energy usage. More energy efficient displays with uncompromised color accuracy and brightness are needed.

Lawrence Berkeley National Laboratory discovered that quantum dot crystals of different sizes could be made to emit multiple colors of light. With further research, LBNL scientists learned to manipulate nanocrystals forming shapes with improved optical qualities. The technology opened new possibilities for companies developing brighter displays for HDTVs, smart phones and tablet computers while keeping a watchful eye on energy efficiency.



Quantum dot technology developed by nanoscientists at LBNL and licensed by Nanosys, Inc. yield energy efficient yet bright, vibrant displays in the growing field of smartphones, HDTVs, laptops and tablet computers.

LBNL's quantum dot technology portfolio, a breakthrough in nanoscience, was licensed by startup Nanosys Inc. for use in electronic displays. Nanosys then partnered with LG Innotek and 3M to develop a superior, energy efficient product. First announced in 2011, the company's Quantum Dot Enhancement Film™ (QDEF) technology, an engineered sheet containing quantum dots, offers 50% wider color spectrum compared with a standard liquid crystal display (LCD). Yet, its price is comparable to LCDs without requiring additional power. QDEF is being demonstrated in new HDTVs at electronic shows worldwide and is the source of the Kindle Fire HDX7's high color accuracy display. In 2014, Asus announced QDEF would be used in its new NX500 Notebook PC. Nanosys' Milpitas, Calif. plant is capable of producing enough quantum dots to build five million big-screen TVs annually. Earlier this year, the company announced LMS Co., Ltd. as the second major supplier of optical films based on QDEF. LMS will use the technology for its new Quantum Light Accumulation Sheet (QLAS) to improve brightness and vibrancy for LCDs.

A Better Test for Heart Attack Risk



LBLN researchers developed a more accurate way to test cholesterol and evaluate heart disease risk. The test is now available to the public through Quest Diagnostics.

risk patients based on lipoprotein size distribution spectra.

An estimated eighty percent of people with coronary artery disease have cholesterol levels that fall within normal ranges. This suggests that standard cholesterol tests established over fifty years ago do not adequately identify a significant number of people at risk for heart attacks -- people who, if alerted, could take lifestyle and treatment steps to reduce their risk.

Lawrence Berkeley National Laboratory scientists discovered a link between heart disease and the relative distribution of subclasses of cholesterol (HDL, LDL, IDL, and VLDL). They invented a gradient gel electrophoresis test to measure various cholesterol subclasses as well as ion mobility analysis to measure the size distribution and count of individual particles. This discovery enabled doctors to distinguish higher

A startup, Berkeley HeartLab, was founded on the LBNL technology. Berkeley HeartLab merged with Celera Corporation, which was acquired by Quest Diagnostics in 2011. Starting in 2009, Quest Diagnostics advanced widespread adoption of a specialized cholesterol test, called Cardio IQ – Lipid Subfractionation by Ion Mobility, based on the original LBNL invention.

Partners Advancing Semiconductor Technology

To stay competitive, companies in the multi-billion dollar semiconductor industry must conduct pre-competitive research years in advance to learn about the materials, process and chemistry required to continue shrinking circuit elements in computer chips.

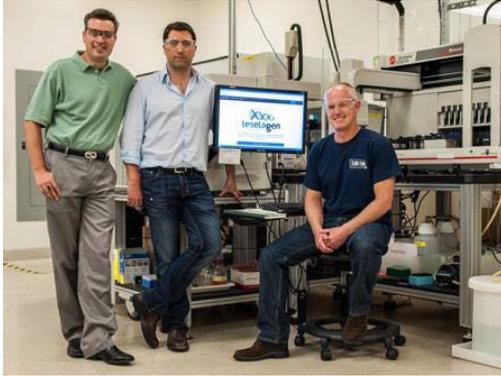


A partnership between semiconductor industry consortium SEMATECH and the Center for X-Ray Optics (CRXO) at LBNL addresses critical challenges in chip design as CRXO scientists continue to design and build more sophisticated research tools.

A collaboration between SEMATECH, a consortium of semiconductor companies and chip makers, and the Center for X-ray Optics (CXRO) at Lawrence Berkeley National Laboratory, has yielded solutions to critical questions facing the semiconductor industry such as developing extreme-ultraviolet (EUV) techniques to shrink circuit elements to the nanometer scale. Recently, additional tools have been introduced at LBNL that enable researchers from around the world to make new discoveries in resists, processing and masks. The SHARP microscope (SEMATECH High-NA Actinic Reticle review Project), designed and built by CXRO staff and brought online in 2013, will advance miniaturization and complexity in chip making. A new SEMATECH Berkeley Microfield Exposure Tool (MET) will be available in 2015 at LBNL's Advanced Light Source. Replacing the earlier MET, this new tool will enable semiconductor industry researchers to develop the next generation of photoresist materials.

Saving Time, Money in the Quest for Health and Energy Solutions

Researchers at medical, biotechnical, and bioenergy companies use decades-old, time consuming approaches to clone DNA. In 2010, constructing a combinatorial protein library with 243 constructs cost an estimated \$125,000 and took 11 months with traditional cloning. Direct DNA synthesis, while providing results in about 2 months, cost \$538,000.



j5, modular software applicable across the multi-billion dollar DNA synthesis market, is saving time and money as companies search for new medicines, feasible bioenergy solutions, and greater understanding of biotechnology challenges.

Researchers at the Joint BioEnergy Institute (JBEI), a multi-institutional research center led by Lawrence Berkeley National Laboratory, initially developed j5 software to automate the construction of biofuels pathways from DNA building blocks. Researchers then created a modular technology applicable to a wide range of biotechnical applications that improved the accuracy, scalability and cost effectiveness of DNA synthesis. With j5, a 243-construct combinatorial protein library can be built for \$30,000 in less than 2 months allowing companies to achieve their goals more rapidly, whether designing new medications, understanding the nature of disease, or developing new microorganisms for bioenergy solutions.

The j5 software was copyrighted and patent application was filed to protect the IP. The j5 was made available, at no cost, to government, nonprofit and academic research centers and today over 1,300 researchers working in 378 non-commercial institutions use the software. Recognizing the business potential for a technology that saves significant time and resources in the multibillion-dollar DNA synthesis market, startup TeselaGen licensed j5 and related software in 2011. TeselaGen has signed a multi-year deal with chemical industry leader Genomatica to speed development of organisms used in making chemicals from renewable feedstocks. The startup also teamed with Redbiotec to build a vaccine library that could lead to new or more effective vaccines against shingles, chickenpox and related illnesses.

BlackGold Nanocoating Could Save Airlines Millions

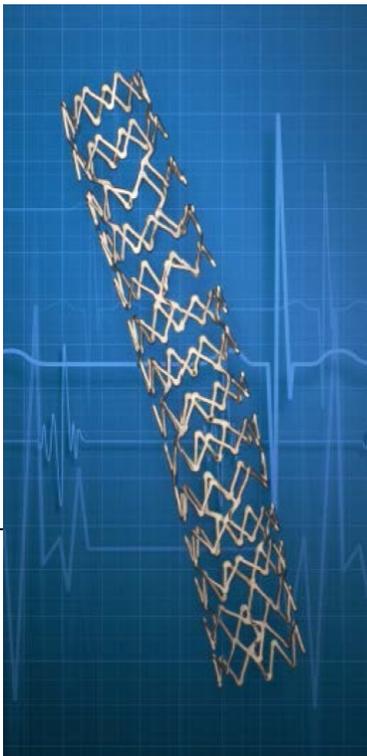
An NETL-inspired partnership that combined MDS Coating Technology Corporation's BlackGold® coating innovation with the in-the-trenches knowledge of end users like Delta Airlines, and the materials performance expertise resident at NETL, has resulted in a new nanotechnology breakthrough in the marketplace.

During aircraft operation, gas turbine engines are continuously ingesting erosive media, such as dirt, sand, rain and sea water, and corrosive agents that are suspended in the air. These particles reach very high speeds in the gas flow through the engine, damaging and eroding the parts that they strike, and in particular the fast moving blades in the compressor section. The deterioration of the blades leads to expensive repairs, reduced performance, increased fuel consumption, and unscheduled engine downtime. The engineered nanostructure of the BlackGold® coating makes it highly resistant to erosion and when applied to compressor airfoil surfaces can significantly reduce material loss. This leads to improved engine performance, resulting in significant reductions in fuel costs, spare parts costs, and reduced maintenance.

MDS Coating Technologies Corporation developed the composition of the BlackGold® coating technology. Delta Airlines evaluated this coating on high pressure compressor rotor blades in its engine fleet. Dr. Cynthia Powell and Dr. David Alman of the National Energy Technology Laboratory supported and contributed to this project by providing testing to optimize process variables and obtaining FAA certification. As a result of this collaboration, these three organizations helped bring this new nanocoating technology to market for airfoils in gas turbines.



Simulated benefit of BlackGold on leading edge erosion of turbine airfoils



The Federal Aviation Administration-approved nanocoating has the potential to save the U.S. commercial aviation industry up to 100 million gallons of fuel annually and could provide a cost savings greater than \$300 million per year at today's jet fuel prices.

Novel Platinum/Chromium Alloy for the Manufacture of Improved Coronary Stents

A coronary stent is a small, self-expanding metal mesh tube that saves thousands of lives every year by opening blocked arteries and allowing blood to flow freely again. Jointly developed by NETL and Boston Scientific Corporation, Inc., (BSCI) this novel alloy is the first austenitic stainless steel formulation to be produced for the coronary stent

industry, with a significant concentration of an element, platinum, with high radiopacity—high visibility with x-ray scanning. Better visibility means greater ease and precision in placement of the stent inside the patient’s blood vessel. In addition, the greater yield strength of the alloy allowed the stent’s designers at BSCI to make a thinner, more flexible stent that is more easily threaded through the winding path of the artery without doing damage along the way which has allowed to be deployed much smaller vessels in and around the heart.

Since introduction in 2010, the platinum/chromium coronary stent series, which includes the PROMUS® Element™, ION™, and OMEGA™ Stent Systems, has become the leading stent platform in the world. Total sales since introduction have exceeded \$4 billion. BSCI now has a 45 percent share of the market in the U.S. and a 33 percent global share of the coronary stent market using the platinum/chromium (PtCr) alloy.

A newly-developed stent that incorporates this alloy has received approval in Europe for use in treating critical limb ischemia, a severe obstruction of arteries within the extremities, which reduces blood flow and can damage tissues. Restoring and maintaining peripheral blood flow in these patients is critical for proper tissue repair and reduces the risk of amputation. This alloy will be used in making all of BSCI’s future coronary stents, both bare and drug-eluting according to BSCI personnel, making this product hugely successful.

In 2011, the new alloy captured two prestigious awards: an R&D 100 Award, given by R&D Magazine to recognize the 100 most technologically significant products entering the marketplace each year, and a technology transfer award for “Outstanding Commercialization Success” from the Federal Laboratory Consortium for Technology Transfer. On October 4, 2012, the NETL team who developed this alloy received the highest honor of all, the U.S. Secretary of Energy’s Achievement Award.

NETL Sorbents Licensed to Lower Power Draw of HVAC



NETL has licensed one of its patented CO₂-removal sorbents to Boston-based technology company enVerid Systems (www.enverid.com). enVerid has adopted the sorbent for use in their proprietary Heat Load Reduction (HLR) module, a retrofit air-recirculation system designed to increase the energy efficiency of commercial HVAC (heating, ventilation, and air conditioning) systems.

HVAC is one of the largest draws of electric power in the United States. In many cities, it consumes more than half of the load on the electric grid. When HVAC systems operate in commercial and public buildings, exhaled CO₂ quickly builds up, as do organic vapors from cooking, cleaning, and other activities. Typical air-handling systems remove contaminants by replenishing indoor air with outdoor air. Bringing fresh air to temperature, however, contributes significantly to the energy demands of HVAC; efficiently maintaining air quality at low cost is one of the industry's primary goals.

In response, enVerid developed the HLR solution to clean and recirculate indoor air, allowing the building to maintain superior indoor air quality without the need for constant inflow of large amounts of outside air. The system draws recirculating air in, cycles it through a series of purification processes, and returns it to the building at its original temperature.

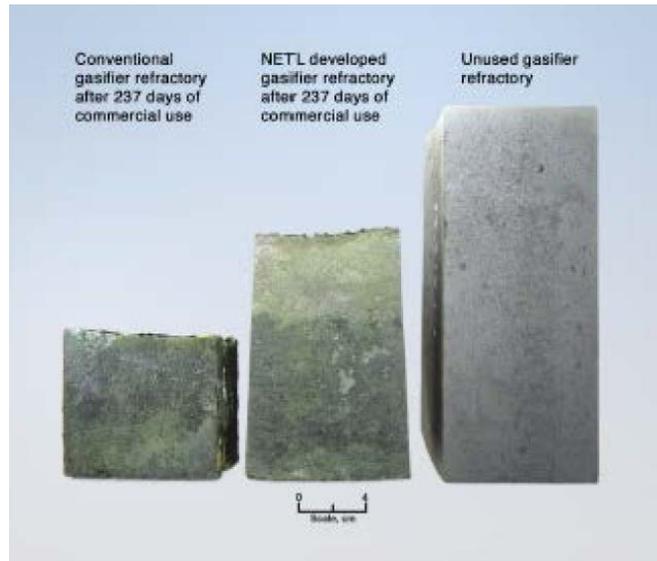
Though NETL's CO₂-removal sorbents are primarily developed to control CO₂ emissions from power plants, enVerid sees promise in using them to perform CO₂-removal as part of the HLR's overall function. The selected sorbents can be regenerated at low temperatures, saving energy and costs in comparison to currently available, high temperature products. Importantly, they are also unaffected by the moisture inherent in HVAC systems, a limitation of many commercial sorbents.

Under the patent license agreement, NETL will receive royalties as enVerid begins commercial sale of its HLR technology.

Refractory Lining Material Improves Gasifier Performance

Refractory materials are used to line the interior of slagging gasifiers, where a carbon-based feedstock such as coal, petcoke, and/or biomass, is converted at high temperatures in an oxygen-deficient environment to produce synthesis gas, which can be used in power generation.

The refractory lining is necessary to protect the steel shell of the gasification chamber from the harsh environment occurring during gasification. Refractory materials that can withstand severe operating conditions for long periods of time are needed to ensure the gasification process is continuous, efficient, and reliable. High chrome oxide refractory materials traditionally used as gasifier linings fail in 3 to 24 months, requiring a gasifier to be completely shut down for material replacement. The poor service life, replacement time, and costs associated with the gasifier shutdown have been major drawbacks, reducing on-line gasifier availability and reliability, as well as limiting commercial deployment of gasification.



To address this issue, NETL researchers developed a phosphate-modified high-chrome oxide material that increases service life up to 50 percent over traditional liner materials. Additionally, the new refractory material reduces operating costs by improving on-line availability. NETL collaborated in this effort with Pittsburgh-based Harbison-Walker Refractories to produce and evaluate the novel refractory lining. Harbison-Walker Refractories subsequently licensed the refractory for commercialization as AUREX™95P, which is marketed as a liner material for commercial gasifiers. Since introduction in 2007, Harbison-Walker has experienced steady sales growth and AUREX 95P, a material which has become the industry standard for high wear areas in slagging coal gasifiers.

NETL's accomplished materials research groups tackle the toughest of challenges daily as they investigate the theoretical and fundamental makeup of fossil energy and renewable energy systems. Addressing fundamental mechanisms and processes, the materials labs are capable of melting, casting, and fabricating up to one ton of materials; completely characterizing the physical properties of materials; and addressing the waste and by-product issues of materials processes.

The continued advancement of gasification technology requires new and improved refractory materials, such as AUREX 95P, that will increase the cycle time between maintenance shutdowns, as well as increase the gasifier's reliability and availability. The AUREX 95P represents the most significant improvement in gasifier refractories in over 30 years and will help eliminate roadblocks that limit the use of gasification technology for electric power and other product production.

Pyrochem Catalysts for Diesel Fuel Reforming

Converting heavy hydrocarbons, such as diesel and coal-based fuels, into hydrogen-rich synthesis gas is a necessary step for fuel cells and other applications. The high sulfur and aromatic content of these fuels



poses a major technical challenge since these components can deactivate reforming catalysts. Taking on this challenge, NETL researchers invented a novel fuel-reforming catalyst that overcomes limitations of current catalysts by efficiently reforming diesel fuel while maintaining thermal stability and resistance to sulfur, aromatics, and carbon formation.

This catalyst technology was exclusively licensed to start-up company Pyrochem Catalyst Corporation in 2011. Established with financial support from Pittsburgh-based Innovation Works, Pyrochem Catalyst intends to conduct its research and development activities in southwestern Pennsylvania. It is hoped that the successful commercialization of the catalyst will lead to the creation of high-technology jobs in the region. This agreement marks the first time that an NETL-licensed technology has been used as a basis for the creation of a start-up company.

Developing stable catalysts to convert diesel fuel to pure hydrogen is an important advance in the implementation of fuel cells in areas such as stationary power generation and transportation. The ability to produce hydrogen at the diesel source point will allow for more efficient and economical generation of hydrogen and lead to greater adoption of fuel cell technology.

The use of pyrochlore catalysts, in conjunction with hydrogen-based fuel cell auxiliary power systems, will reduce the economic and environmental costs of diesel engine idling. Significant monetary savings will be realized through decreased fuel consumption and extended engine life. Environmentally, reduced diesel usage will result in lower emissions of oxides and particulate matter.

This technology was the recipient of a 2011 Federal Laboratory Consortium award for “Excellence in Technology Transfer”.

More Reliable Gearboxes Help Reduce the Cost of Wind Power

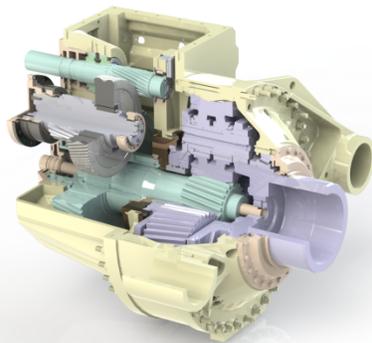
Gearbox failures have a significant impact on the cost of wind farm operations. To help minimize gearbox failures, in 2007 the National Renewable Energy Laboratory (NREL) initiated the Gearbox Reliability Collaborative (GRC), which consists of wind energy manufacturers, project owners, researchers, and consultants.

Gearbox deficiencies are the result of many factors, and the GRC team recommends efficient and cost-effective improvements in order to expand the industry knowledge base and facilitate immediate improvements in the gearbox life cycle. The GRC combines analysis, field testing, dynamometer testing, condition monitoring, and the creation of a gearbox failure database.

NREL and other GRC partners have been able to develop improved processes for the design, testing, and operation of wind turbines to increase gearbox reliability. In contrast to private investigations of these problems, the GRC quickly shares its models, data, and findings among its participants, including many wind turbine manufacturers and equipment suppliers. Ultimately, the findings are made public for use throughout the wind industry. This knowledge is resulting in increased gearbox reliability and an overall reduction in the cost of wind energy.

The GRC started with a representative gearbox design, which was then redesigned to the best industry standards as of 2007. Two heavily instrumented gearboxes were built based on this design. One was mounted in a wind turbine and tested in the field, while the other was tested on a dynamometer, which simulates the loads experienced by a typical wind turbine, but on a compressed time scale. This effort built an understanding of how selected turbine loads and operational events translate into bearing and gear responses.

Based on all the lessons learned from the past five years, the GRC has now produced a new and improved design, which is projected to yield an operating lifetime of 12 years, more than triple that of the previous redesigned gearbox. This new design, shown in the illustration below, will be built and tested in the same way as the previous iteration, and again, all results will be shared first with the GRC members and eventually made public.



To demonstrate improvements in gearbox designs, the GRC chose a representative gearbox design consisting of a low-speed planetary stage and two parallel stages. This gearbox has now been redesigned twice, and the latest version, shown here, is projected to triple the average operating lifetime.

NREL Patents a Catalyst that Removes Syngas Tar, Boosting the Economics of Biofuels

The National Renewable Energy Laboratory (NREL) has patented and licensed a catalyst that reforms tar into syngas, a breakthrough that can accelerate the process of getting biomass ready for fuel synthesis and use as a drop-in fuel. The process also can help reduce greenhouse gases because the biomass that is used in fuel gets combusted into carbon dioxide, which is food for future biomass. The result is that 90 percent of carbon emissions get recycled into new biomass.

Syngas is a mixture of hydrogen and carbon monoxide—the building blocks of fuels and chemicals—and it is generated by heating particles of biomass with steam and air in a turbulent, “fluidized” mixture to gasify it. But the making of syngas creates tars and other undesirable components. The tars can foul the



NREL developed, patented, and licensed this catalyst to Rentech, Inc.

refining process, so must be removed from the syngas before the fuel is synthesized. NREL researchers ultimately found a catalyst that could neutralize those tars.

The researchers knew they needed a fluidized material that could move around in the reactor and provide more efficient contact of the catalyst with the gaseous fluid. NREL enlisted help from a Colorado neighbor, CoorsTek, to help develop a catalyst support that would work in the fluidized bed of a gasification reactor.

The resulting catalyst support is made by taking all the raw materials and grinding them in water to form a high-solids solution. The particles in the solution are approximately one micron in diameter. The solution is spray-dried by atomizing the liquid in very hot air, forming droplets. The tiny droplets are little round pellets of ceramic; each one is formed when numerous particles from the solution adhere together. Then the material is fired, giving it strength. But the porous surface of the ceramic is not totally sealed, so the catalyst components can "soak in."

Once the support structure was identified, NREL created the catalyst by mixing the ceramic particles with a solution of nickel, magnesium, and potassium salts. When this was heated, a chemical reaction occurred and the catalytic metals stuck onto the ceramic surface, forming a catalyst that can be used in gasification reactors.

Award-Winning Etching Process Cuts Solar Cell Costs

Optimizing solar-cell technology can be a complex job, requiring expertise in material science, physics, and optics to convert as much sunlight as possible into electricity. But despite this complexity, a simple fact is key to making a high-performance solar cell: any sunlight reflected off the cell can't possibly be converted into electricity.

Manufacturers have tried to minimize the reflection of sunlight off of solar cells by first chemically etching micrometers-deep structures into the surface of solar cells and then depositing one or more thin anti-reflection layers. Unfortunately, the equipment and processes for these conventional methods add significant cost to the solar cell, and the cells still absorb only 93-97 percent of the sunlight.

To address this problem, scientists at the National Renewable Energy Laboratory (NREL) have invented the “black silicon” nanocatalytic wet-chemical etch, an inexpensive, one-step process that literally turns the solar cells black, allowing them to absorb more than 98 percent of incident sunlight. The process costs just a few cents per watt of solar-cell power-producing capacity.

To etch the silicon, a wafer is immersed in a solution that contains chloroauric acid, which is composed of hydrogen, chlorine, and gold. Tiny nanoparticles of gold instantly form and act as a catalyst for chemical reactions, producing a nanometer-scale porous surface on the cell wafer. The nanoscale pores—on the order of a billionth of a meter in diameter—are much smaller than the wavelength of the incident light, so they suppress reflection across the full spectrum of sunlight. As the tiny holes deepen, they make the metallic gray silicon appear increasingly dark until it becomes almost pure black, absorbing nearly all frequencies of sunlight. The surface becomes riddled with minute pores of varying depths with no sharp interfaces that would reflect light, creating a highly absorbent silicon wafer.



NREL Research Fellow Howard Branz examines silicon wafers with various antireflective treatments. The cells use the NREL black silicon method (top), a conventional antireflective coating with texturing (center), and the conventional texturing method only (bottom).

Using a closely-related process that employs less-expensive silver nanoparticles, NREL has made a black silicon cell with a validated 18.2 percent conversion efficiency—about the same efficiency as a typical crystalline silicon solar cell with a more costly antireflective coating.

At 100°F, NREL’s black silicon etching process takes less than a minute. In contrast, the etching process that prepares silicon wafers for conventional antireflective coatings takes 8–30 minutes, and applying the coatings adds even more processing time.

NREL Invention Speeds Solar Cell Quality Testing for Industry

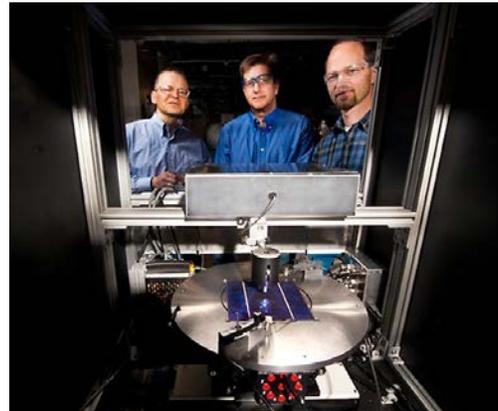
A solid-state optical system invented by the National Renewable Energy Laboratory (NREL) measures solar cell quantum efficiency (QE) in less than a second, enabling a suite of new capabilities for solar cell manufacturers.

QE is a measurement of how cells respond to light across the solar spectrum, but traditional methods for measuring QE had been too slow, limiting its application to small samples pulled from the production line and analyzed in laboratories. NREL's technique, commercialized by Tau Science as the FlashQE™ system, uses a solid-state light source, synchronized electronics, and advanced mathematical analysis to parallel-process QE data in a tiny fraction of the time required by the current method, allowing its use on every solar cell passing through a production line.

The FlashQE system uses an array of light-emitting diodes (LEDs), each emitting a different wavelength of light. The LEDs illuminate the cell simultaneously, rather than the serial approach of the conventional system. The key to the technology is that all the LEDs are flashed on and off at different frequencies, thereby encoding their particular response in the solar cell. High-speed electronics and advanced mathematics cleverly extract the encoded information to reveal a full-spectrum QE graph of the cell. A wide variety of information is gathered in less than a second—information about the ability of the front surface of the cell to absorb high-frequency light, the quality of the thin-film surface coatings, the ability of the middle region of a cell to absorb a wide range of wavelengths, how well the back surface absorbs lower-energy light, and the ability of the back surface to collect electrons.

Some of this is new information for manufacturers. Solar cell manufacturing lines test each cell to determine useful cell parameters, such as how much current and voltage is generated. But conventional tests give no information about how the cell responds to each color of light in the solar spectrum. Flash QE's ability to also test for each cell's response to color allows crucial extra information to be fed back into the production line. It does it so fast that cells of the same current and the same response to particular colors can be sorted into bins. From these sorted bins, spectrally matched modules can be made to optimize the energy produced throughout a day.

NREL's ingenious approach, in which parallel processing allows all of the QE data points to be measured simultaneously to produce a QE graph in 1 second, is more than 1,000 times faster than the industry's current state-of-the-art technique.



NREL scientists Pauls Stradins, Brian Egaas, and David Young take a look inside their instrument, the Real-Time QE, which quickly measures how a solar cell responds to different wavelengths of light.

NREL's Building-Integrated Supercomputer Provides Heating and Efficient Computing

The new Energy Systems Integration Facility (ESIF) at the National Renewable Energy Laboratory (NREL) is meant to investigate new ways to integrate energy sources so they work together efficiently, and one of the key tools to that investigation, a new supercomputer, is itself a prime example of energy systems integration. NREL teamed with Hewlett-Packard (HP) and Intel to develop the innovative warm-water, liquid-cooled Peregrine supercomputer, which not only operates efficiently but also provides hot water to the ESIF, meeting all of the building's heating needs.



The Peregrine supercomputer

Peregrine is the first installation of the new HP Apollo Liquid-Cooled Supercomputing Platform, and it provides the foundation for numerical models and simulations that are enabling NREL scientists to gain new insights into a wide range of energy systems integration issues. This innovative high-performance computer (HPC) can do more than a quadrillion calculations per second as part of the world's most energy-efficient HPC data center.

As HPC systems are scaling up by orders of magnitude, energy consumption and heat dissipation issues are starting to stress the supporting systems and the facilities in which they are housed. But unlike most other computers that are air-cooled, Peregrine is cooled directly with warm water, allowing much greater performance density, cutting energy consumption in half, and creating efficiencies with other building energy systems. Peregrine's warm-water cooling system eliminates the need for expensive data center chillers and heats the water to 103°F, allowing it to help meet building heating loads. At least 90 percent of the computer's waste heat is captured and reused as the primary heat source for the ESIF offices and laboratory space. The remaining waste heat is dissipated efficiently via evaporative cooling towers.

The ESIF is designed to address the key challenge of delivering distributed energy to the grid while maintaining reliability. It's a complex problem involving systems within systems and leveraging Big Data—and the Peregrine serves as a powerful new tool in NREL's ongoing work to find a solution. But although it's a cutting-edge facility, the ESIF is not some esoteric experimental building tucked away from the public. It was designed for partners—and since it opened for business, NREL's world-class facility has attracted many commercial partners.

Not surprisingly, the capabilities of the ultra-efficient HPC data center are placing NREL in the spotlight. It earned a 2014 R&D 100 Award and helped the ESIF earn R&D Magazine's 2014 Laboratory of the Year award and the Energy Department's 2013 Sustainability Award.

Fuel From Algae

Algae is a potentially attractive source of renewable energy, but this kind of biofuel has been challenging to bring to the marketplace. That's because producers typically must first remove the water from the algae, then extract oil from the dried algae. This is an energy-intensive and costly process, and it leaves residual material behind that is difficult to use.

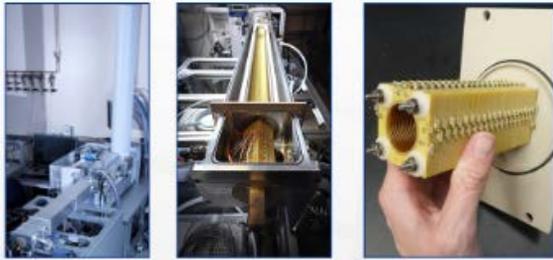
Pacific Northwest National Laboratory (PNNL) developed an efficient method to process biomass while it's still wet. The wet algae is heated and pressurized, which can convert more than 99 percent of it into oil and natural gas. This process is similar to the way fossil fuels were formed, except that it does in less than an hour what would take nature millions of years to do. Byproducts such as nitrogen and phosphorous can be treated and pumped back into the algae growth ponds to support new growth. The result is an efficient process to make clean fuel that doesn't add carbon dioxide to the atmosphere.



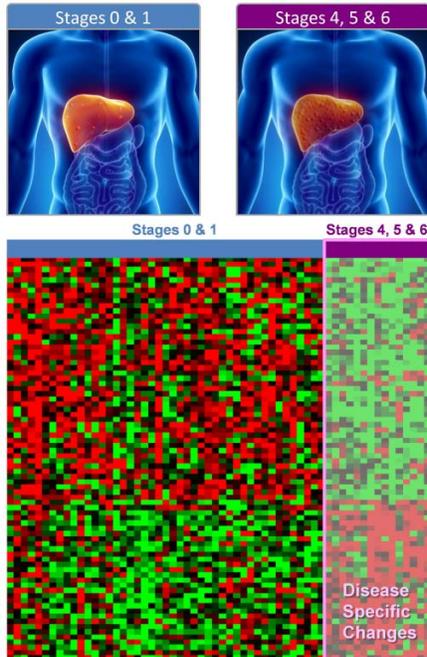
PNNL and Genifuel Corporation devised a process that transforms algae into bio-crude oil that can be further processed into gasoline, jet fuel, and diesel.

Utah-based Genifuel Corporation, which had developed growth and harvest techniques for aquatic biomass, supplied algae for early testing at PNNL. In 2009, Genifuel licensed the conversion technology from PNNL. Researchers from the two organizations collaborated to further develop and optimize the process for algae. The biofuel and business communities began highlighting the new technology, with media coverage ranging from *Biomass Magazine* to *Forbes*. Genifuel now is working with Reliance Industries, Ltd. in Colorado to build the nation's first pilot-scale plant using the technology, with operations expected to begin in 2014. If all works as planned, it will pave the way for commercial-scale deployment.

Finding Disease Biomarkers for Early Diagnosis and Treatment



Identifying molecules that indicate disease, known as biomarkers, promises to significantly improve human health through early diagnosis and customized treatment. However, improved research instruments are needed to separate and identify specific molecules that make up these biomarkers.



Pacific Northwest National Laboratory (PNNL) developed an instrument that can process these complex samples rapidly and accurately, detecting rare yet important molecules for early disease diagnosis. This instrument combines two complementary analysis techniques in one instrument. It is called CoMet, short for Combined Orthogonal Mobility and Mass Evaluation Technology. No other single instrument on the market can do what CoMet does. It won an R&D 100 award from *R&D Magazine* in 2013.

PNNL and Agilent Technologies, a California-based measurement systems company with customers in more than 100 countries, collaborated to develop, engineer, and test the technology and validate its market need and value. In 2013, Agilent licensed the CoMet technology. The company introduced the instrument to its customers at the American Society for Mass Spectrometry conference in 2013 and began taking orders on its commercial model the following year.

With the PNNL instrument called CoMet (above), medical researchers will now be better able to identify important molecules, such as biomarkers and environmental contaminants, with unprecedented speed and accuracy. The red and green pixels represent 78 proteins in blood samples from 60 patients with liver fibrosis, illustrating a sharp difference between earlier (left) and later (right) stages of the disease. Finding disease progression earlier means earlier treatment and higher patient survival rates.

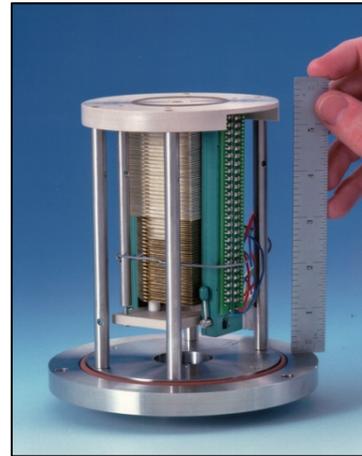
Ions in the Stream: Funnel Makes Detection Up to Ten Times Better

Complex scientific instruments called mass spectrometers measure the amount of ions, tiny portions of molecules, in a sample by pushing the ions through the instrument like a swift-flowing stream. These measurements can determine the presence of certain types of substances, such as the amount of harmful chemicals in drinking water or a specific type of protein in a person's blood that might indicate cancer. Unfortunately, measurements can be hindered, because a large portion of that free-flowing stream of ions is lost while they move from the ion source into the detector for measurement. Because of these ion losses, some substances cannot be detected at all.

Pacific Northwest National Laboratory's (PNNL's) electrodynamic ion funnel significantly improves the measurement and detection capabilities of mass spectrometers by enabling more ions in a substance to reach the detector. By focusing the ions with the funnel, scientists can get detection rates that are, on average, five to ten times better than without the funnel. This means scientists can measure smaller quantities of a substance, and even "see" substances that were previously undetectable. Most importantly, scientists are gaining new insights about the makeup of materials that are critically important in fields such as medicine and environmental science.

Four manufacturers of mass spectrometers currently hold active license agreements with PNNL: Bruker Daltonics, Billerica, Massachusetts, licensed in 2003; Thermo Fisher Scientific, Waltham, Massachusetts, 2009; Agilent Technologies, Inc., Santa Clara, California, 2010; and MassTech, Columbia, Maryland, 2011. All except MassTech are selling products that incorporate the ion funnel, with sales estimated at \$85M annually.

The ion funnel was developed through funding from the U.S. Department of Energy (DOE) Office of Science Laboratory Technology Research Program, DOE Office of Biological and Environmental Research, and National Institutes of Health. To demonstrate the technology to interested manufacturers, PNNL staff used a small amount of internal technology maturation funds obtained from the Laboratory's licensing income.



By guiding wandering ions firmly along a path into a measurement instrument, PNNL's electrodynamic ion funnel improves detection by as much as ten-fold. The result: new insights into the makeup of materials important for medicine and environmental science. Three companies are currently selling products that incorporate the technology, with sales of these products estimated at \$85M annually.

Less Noise Means Better Chemical Detection



Detecting and measuring even the smallest amounts of chemicals is important for protecting people from environmental toxins, workplace chemical exposures, and other hazards. Laser-based sensing instruments are powerful tools to detect and measure such chemical mixtures in gas form. However, the electrical current needed to drive these laser systems frequently introduces noise or jitter. Even slight fluctuations in the laser's wavelength and intensity can affect an instrument's detection ability.

When used with certain laser-based instruments, this power source made by Wavelength Electronics enables some of the most precise chemical measurements possible. That's because the PNNL-developed low-noise current controller keeps the laser "jitter" to a minimum. Wavelength's customers are using this power supply for better analyses in shale oil exploration, disease detection, and other activities.

Pacific Northwest National Laboratory (PNNL) developed an ultra-low-noise power supply for driving quantum cascade lasers, which are often used in laser-based sensing instruments. The electronic noise reduction from using this new power supply enables up to ten times the detection capability of other power sources, "the lowest current noise density of any commercially available driver," according to manufacturer Wavelength Electronics.

A PNNL researcher approached Wavelength Electronics, a woman-owned small business in Bozeman, Montana, which develops electronic components for laser systems. Wavelength wanted to see it demonstrated in one of its customer's laser sensing systems: Aerodyne Research, in Massachusetts. Impressed by the results, Wavelength licensed the technology and began selling commercial prototypes in 2009. Wavelength had never previously worked with a DOE laboratory, and initially was apprehensive about engaging with an organization that it perceived as being large and bureaucratic. But when PNNL responded rapidly to Wavelength's needs, it took only 10 months to demonstrate and commercialize the technology. Now, Wavelength is supplying low-noise current controllers to government and commercial entities for activities ranging from methane monitoring during fracking to disease detection. This product is generating several hundred thousand dollars in annual sales for Wavelength. PNNL and Wavelength won a Federal Laboratory Consortium Award for Excellence in Technology Transfer for the commercialization in 2011.

Funding to develop the laser system and the low-noise power supply came from the U.S. Department of Energy's Nuclear Nonproliferation Security Administration. In addition, the research benefited from Laboratory Directed Research and Development internal funds and the technology transfer from PNNL's Technology Assistance Program, which provided technical expertise for a limited time at no cost to Wavelength.

Forecasting Method Makes Electric Grid Operations More Stable and Efficient

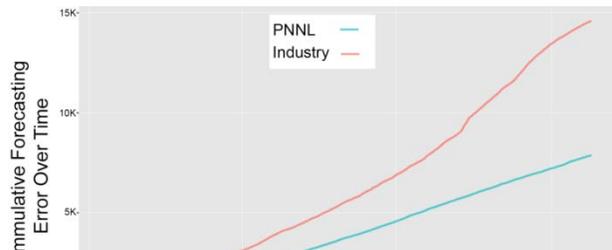
Neighboring power organizations exchange electric power to keep the electricity grid operating as efficiently and reliably as possible. Utilities rely on past trends to predict how much power they'll need to generate in the next few minutes to hours. But accurate forecasting is challenging because it can be affected by weather, renewable energy fluctuations, and the instability of neighboring power organizations. With little time for corrective action, incorrect forecasts can raise operational costs and affect stability of the regional power market. Put simply, the ability to forecast accurately is crucial for the efficiency and safety of the power grid.

Pacific Northwest National Laboratory (PNNL) developed a software tool that makes much more accurate predictions than what most utilities are using now. To address the uncertainty associated with forecasting tasks, the software combines

forecasts from multiple scenarios into one that is more reliable and accurate. This way, utilities can operate closer to the mark, improving grid reliability and efficiency, while minimizing penalties.

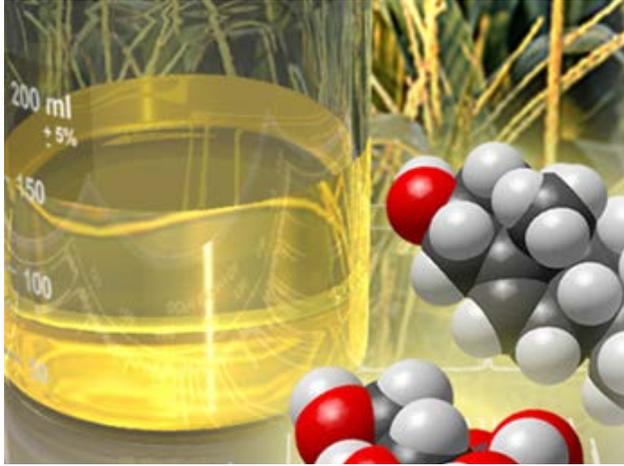
It was not long before this innovative forecasting method caught the attention of a heavy hitter in the industry. PJM Interconnection, of Valley Forge, Pennsylvania, is the largest grid operator in North America, serving over 61 million people. PJM licensed the software in 2013. When PNNL evaluated the software on PJM's data, the software reduced forecast errors by up to 48 percent, which PNNL estimated could save PJM's customers about \$75M annually. These impressive results demonstrate the tremendous potential of this forecasting method to reduce the price volatility in the nation's power market.

This work was supported by PNNL's Lab-Directed Research and Development internal funds. Under an Agreement for Commercializing Technology, PJM funded PNNL to customize the software for PJM's operating environment.



PNNL-developed software (blue line) forecasts electricity needs with 48 % fewer errors than a commonly used industry method (red line).

Kicking the Oil Habit: Making Propylene Glycol from Plants



Archer Daniels Midland Company is manufacturing propylene glycol not with petroleum, but with plants such as soybeans and canola. Using renewable sources to make this commercially important additive reduces greenhouse gases by 61%. 140 jobs were created with this facility.

Many everyday consumer products from liquid detergents to pharmaceuticals and plastics contain the additive known as propylene glycol. The downside is that propylene glycol is typically made from petroleum, a nonrenewable source. It takes more than 1 million tons of petroleum each year to meet worldwide demand.

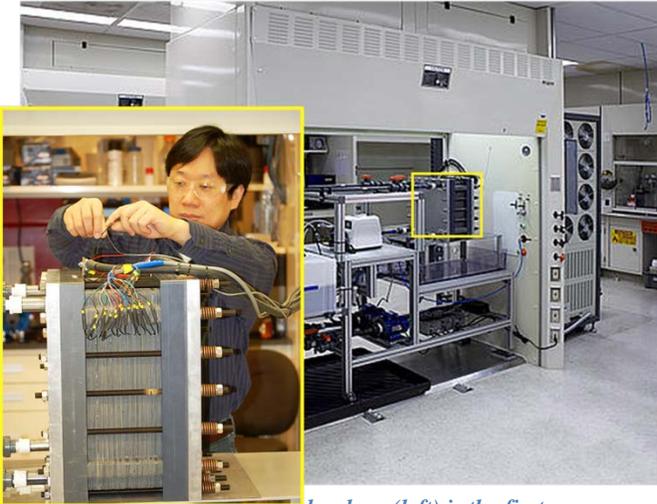
Pacific Northwest National Laboratory (PNNL) developed the first-ever catalytic process that converts plant-based raw materials to produce this valuable additive. Now, instead of relying on oil, industry has an alternative way to make propylene glycol that is environmentally friendly, cost-competitive, and commercially viable.

After seeing results from early research, Archer Daniels Midland Company (ADM) immediately realized the potential benefits of this process for its business. ADM licensed the technology from

PNNL, then used it successfully in a pilot plant in 2009. In 2011, the company constructed and began operating a full-scale, multi-million-dollar production facility in Decatur, Illinois, for the sole purpose of commercially producing propylene glycol from soybeans and canola. The plant, with a capacity of 100,000 metric tons, now is making propylene glycol entirely from renewable sources, while decreasing greenhouse gases by 61 percent when compared with oil-derived sources. In addition, 140 jobs were created with this facility. PNNL won a 2011 Federal Laboratory Consortium Award for Excellence in Technology Transfer for this process and shares with ADM a 2010 R&D 100 award from *R&D Magazine* for one of the world's most innovative new technologies.

Foundational research was initially supported through Laboratory-Directed Research and Development internal funds. That was followed by two separate Cooperative Research and Development Agreements (CRADAs) with cost-sharing from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, the National Corn Growers Association, ADM, and others.

Advanced Battery Stores Renewable Energy, Improves Grid Reliability



PNNL's redox flow battery technology (left) is the first commercially viable redox flow battery for electrical grid-scale deployment. Now licensed by five companies, the battery is already being put to work through Washington State's Clean Energy Fund (governor's press conference above).

Low-cost, large-scale energy storage is a priority not only for integrating renewable energy like wind and solar into the electrical grid but also to improve the reliability of the nation's power grid. Experts consider a type of battery called redox flow batteries the most promising option; however, operational challenges and high cost have impeded widespread adoption.

Pacific Northwest National Laboratory's (PNNL) redox flow battery technology increased the batteries' energy density by 70 percent, expanded the operational temperature range by 80 percent, and reduced the overall system cost by nearly 40 percent for an 8-hour energy storage system.

PNNL negotiated licenses with five commercial partners, an achievement that won a national Federal Laboratory Consortium Award for

Excellence in Technology Transfer in 2013 and a Deals of Distinction Award from the Licensing Executives Society the same year. One of the licensees, UniEnergy, launched its first product in 2014. At a press conference featuring UniEnergy's and utilities' roles in Washington State's Clean Energy Fund, Governor Jay Inslee called the PNNL-developed battery system "world-class technology that is going to put renewable energy to work." UniEnergy has already created 45 jobs.

DOE's Office of Electricity Delivery and Energy Reliability funded the research and development for the advanced battery. UniEnergy benefitted from PNNL's Technology Assistance Program, which provided a week of technical assistance at no cost to the company. Another licensee, Aartha USA, is collaborating directly with PNNL to customize the technology for its use.

Princeton Plasma Physics Laboratory Assists High Tech Woman Owned Small Business Develop Synthetic Muscles

Ras Lab, LLC, a high tech woman owned small business, is devoted to the development of synthetic muscle for prosthetics and robotics and has been collaborating with the Princeton Plasma Physics Laboratory (PPPL) for over five years. Ras Labs makes Synthetic Muscle™ – electroactive polymer (EAP) based materials and actuators that contract, and expand with reversed electric polarity, at low voltage with minimal heat and noise signatures. Most EAPs bend. Ras Labs' unique EAPs contract and expand and can be cycled repeatedly. Recently, Ras Lab has been invited to evaluate these shape morphing EAPs for resistance to radiation on the International Space Station (ISS) through the Center for the Advancement of Science in Space (CASIS).

The purpose of the CASIS-ISS-Ras Lab's Project is to make synthetic muscle radiation resistant, also known as radiation hardened or rad hard. Synthetic Muscle™ has already proven cold hardiness down to 4 K and preliminary studies at PPPL indicate that these EAPs are also inherently radiation resistant. Ras Labs used PPPL's facilities to evaluate Gen 3 and Gen 4 Synthetic Muscle™ with various additives and coatings and will then further evaluate these EAPs under the intense radiation environment of the ISS to demonstrate superb radiation resistance. Robust EAPs that can survive extreme temperatures and extremely radioactive conditions would provide dual use on earth and in space, including long-term space travel.



PPPL and Ras Labs personnel with summer interns

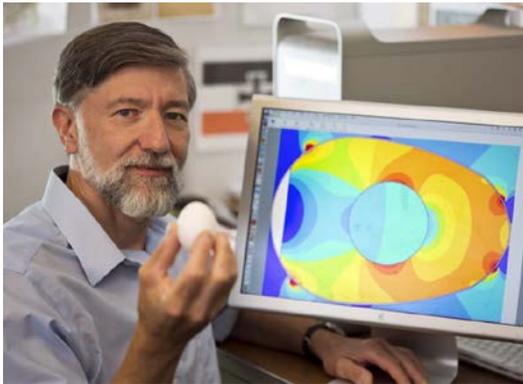
treated metal coupons are serving as mounts for the EAPs. This is how the EAPs were secured in place during the preliminary radiation experiments at PPPL and how the EAPs will be secured, in addition to a protective structure and double containment, for the payload launch to the ISS and during the ISS National Laboratory experiment in its zero gravity, high solar and cosmic radiation environment.

The Princeton Plasma Physics Laboratory has plasma capabilities and gamma and neutron radiation sources available for evaluating how Synthetic Muscle™ will function when exposed to radiation in space. For the CASIS-ISS-Ras Labs Project, the EAPs are being adhered to plasma treated titanium coupons. These shape morphing EAPs adhere well to oxygen plasma treated titanium, so the plasma

treated metal coupons are serving as mounts for the EAPs. This is how the EAPs were secured in place

Princeton Plasma Physics Laboratory teams up with the USDA to produce new egg pasteurization method

Researchers at the Princeton Plasma Physics Laboratory (PPPL) and the U.S. Department of Agriculture (USDA) have developed a novel technique and device for rapidly pasteurizing eggs in the shell without damaging the delicate egg white. The process could lead to a sharp reduction in illnesses caused by egg-borne salmonella bacteria, a widespread public health concern. The new method uses radio frequency (RF) energy to transmit heat through the shell and into the yolk while the egg rotates. Streams of cool water simultaneously flow over the egg to protect the white. Researchers then bathe the egg in hot water to pasteurize the white and finish pasteurizing the yolk. The aim is to produce a pasteurized egg that is “hardly discernible from a fresh, non-pasteurized egg,” said David Geveke, lead scientist, at the USDA Agricultural Research Service in Wyndmoor, Pennsylvania. His laboratory teamed up with PPPL engineer Christopher Brunkhorst, an expert in RF heating, to develop the device. The roughly shoebox-size prototype can pasteurize shell eggs in about one-third of the time that current methods require, Geveke said. Such methods place the eggs in heated water for about an hour and visibly change the appearance of the egg white. The RF process, by contrast, maintains the egg white's transparency. Federal regulations require pasteurization of raw liquid egg products used in commercially sold dishes such as ice cream, eggnog, sauces and dressings, but no similar rule covers eggs in the shell. Fewer than one-half of 1 percent of all shell eggs produced for retail sale in the United States are pasteurized, according to an estimate by the Food Safety and Inspection Service of the USDA.



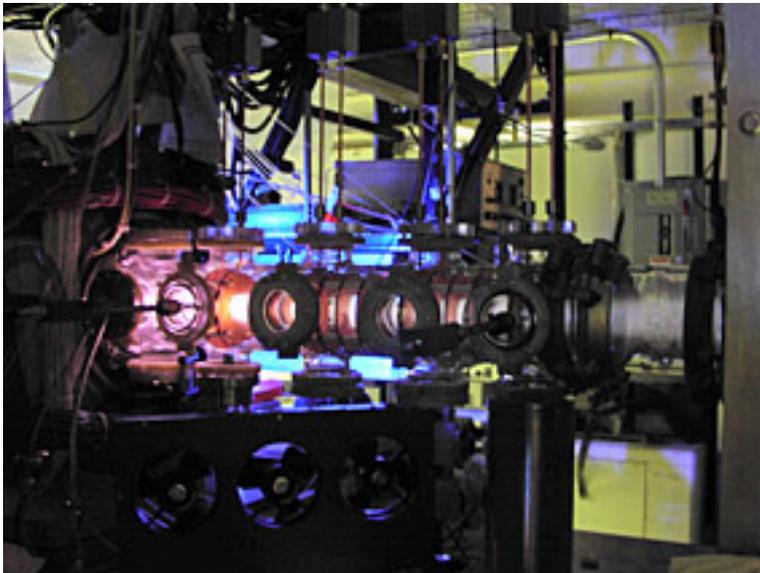
While only a small fraction of shell eggs may harbor salmonella, the public health risk posed by consumption of raw or undercooked eggs stems from the fact that millions of eggs are eaten each day. The hazard is greatest for people with weakened immune systems, including the very young, the very old and hospital patients. The USDA estimates that pasteurizing all U.S.-produced shell eggs could reduce the number of egg-borne salmonella illnesses by up to 85 percent, or more than 110,000 cases a year. “You have to raise the temperature high enough to kill bacteria, but not high enough to cook the egg,” Brunkhorst said. “You’re really threading the needle on this.” Further

complicating the process is the fact that the egg white is more sensitive to overheating than the yolk is. But the RF energy must pass through the white in order to reach the yolk, which requires a higher temperature to pasteurize. The system works through what is known as “ohmic heating,” in which the RF energy creates an electric current that produces heat inside the egg. The USDA prototype, which the agency has applied to patent, couples RF energy through the shell by placing electrodes against opposite sides of the egg. The egg rests on rollers that turn it to distribute the heat and cooling water evenly. “The goal is to reach a certain temperature for a certain time,” Brunkhorst said. Researchers then take a sample of the egg and do a bacteria count. “We’ve proven the effectiveness analytically,” Brunkhorst said. The USDA is in discussions with a licensee to commercialize the product. “We have received quite a bit of interest from industry,” Geveke said. “We expect to have a partner in the next few months.”

Princeton Plasma Physics Laboratory Licenses Fusion Technology that could Revolutionize Space Travel

Princeton Plasma Physics Laboratory has licensed the technology for Direct Fusion Drive (DFD) a fusion-powered rocket engine that could take people on a mission to orbit Mars for 30 days with total trip duration of 310 days, something that is impossible with chemical or nuclear fission engines. The mission could be launched on a single NASA Space Launch System (SLS) booster and be ready when the SLS is available for human spaceflight. This would lead to human lander missions and Mars bases. Current experiments at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) are exploring basic physics principles of the proposed engine's fuel-confinement scheme at small scale. The licenses also cover a potential new and novel magnetic fusion facility, with applications that include generating electricity for power stations and propelling space travel.

The magnetic device would create a cigar-shaped plasma—the superhot, electrically charged gas that fuels fusion reactions—inside a cylinder that is some 20 feet long and could produce up to 10 million watts of power. Propulsion would come from the stream of high-speed fusion exhaust that would blast into space through a magnetic nozzle. See PPPL Magnetic Nozzle Experiment below.



MNX — Magnetic Nozzle Experiment

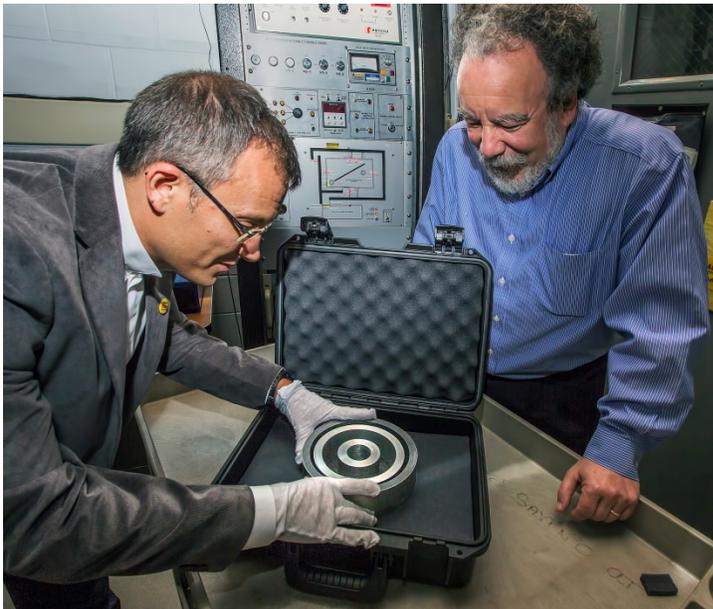
A test facility, based on a concept known as magnetic field reversed confinement, could be completed by 2022. “That’s when we’ll be in a position to build a flight version,” said Michael Paluszek, President of Princeton Satellite Systems, Inc. in Plainsboro NJ, which licensed the technology. Employing fusion to power rockets has long been a theoretical dream for space travel. PPPL and Princeton Satellite Systems are seeking funds for later versions from sources such as NASA and the U.S. Department of Defense.

Paluszek is already looking far beyond Mars. DFD would enable ambitious robotic solar system missions at far

less cost than current technology allows. For example, DFD would enable Europa robotic orbiter and landing missions or could allow resupply and refurbishment of the James Webb Space Telescope. DFD would make asteroid mining a reality and even permit deflection of asteroids that are a danger to Earth. DFD reactors could power future space station, moon bases and advanced earth observation platforms. DFD could even send robotic probes to the nearby stars, possibly for mission to orbit Earth like planets. DFD would revolutionize space exploration.

Princeton Plasma Physics Laboratory Developing a Novel Technique that could Facilitate Nuclear Disarmament

A proven system for verifying that apparent nuclear weapons slated to be dismantled contained true warheads could provide a key step toward the further reduction of nuclear arms. The system would achieve this verification while safeguarding classified information that could lead to nuclear proliferation. Scientists at Princeton University and the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) are developing the prototype for such a system, called a "zero-knowledge protocol," that would verify the presence of warheads without collecting any classified information at all. "The goal is to prove with as high confidence as required that an object is a true nuclear warhead while learning nothing about the materials and design of the warhead itself," said physicist Robert Goldston, a fusion researcher and former director of PPPL, and a professor of astrophysical sciences at Princeton. While numerous efforts have been made over the years to develop systems for verifying the actual content of warheads covered by disarmament treaties, no such methods are currently in use for treaty verification.



Physicists Alexander Glaser, left and Robert Goldston display the British Test Object.

A project to evaluate this approach is under construction at PPPL. The project calls for firing high-energy neutrons at a non-nuclear target called a British Test Object that will serve as a proxy for warheads. Researchers will compare results of the tests by noting how many neutrons pass through the target to bubble detectors that Yale University is designing for the project.

If proven successful, dedicated inspection systems based on radiation measurements could help to advance disarmament talks beyond the New Strategic Arms Reduction Treaty (New START) between the United States and Russia, which runs from 2011 to 2021.

The system would compare a warhead to be inspected with a known true warhead to see if the weapons matched. This would be done by beaming high-energy neutrons into each warhead and recording how many neutrons passed through to detectors positioned on the other side. Neutrons that passed through would be added to those already "preloaded" into the detectors by the warheads' owner and if the total number of neutrons were the same for each warhead, the weapons would be found to match. But different totals would show that the warhead being inspected was really a spoof. Prior to the test, the inspector would decide which preloaded detector would go with which warhead.

A Small Company Partnership with Global Impact: Portable, Affordable, and Reliable Anthrax Testing

Anthrax, an infectious disease caused by the bacterium *Bacillus anthracis*, poses a significant threat to U.S. national security as demonstrated by the 2001 terrorist attacks that targeted the U.S. Postal Service and Hart Senate Office Building in Washington, DC.

Sandia National Laboratories developed an anthrax detection sensor for low-resource environments called the Anthrax Detection Cartridge. The portable device, developed from a Laboratory Directed Research and Development project, is inexpensive and requires no power to run and minimal training to operate. It quickly provides highly reliable anthrax detection in controlled environments, rivaling the selectivity of rigorous laboratory analysis.

Winner of a 2014 R&D 100 Award, the Anthrax Detection Cartridge is a self-contained, credit-card sized test system that cultures a sample in a patent-pending amplification chamber using selective growth media. Once a sample is inserted, patent-pending magnetically operated valves advance it from stage to stage to complete the testing process. The device uses a lateral flow assay (LFA) to determine if the sample is dangerous anthrax, and then treats the sample with disinfectant.



At left is the BaDx (Bacillus anthracis Diagnostic) Cartridge—also known as the AnthraxDetection Cartridge

Anthrax outbreaks are common in livestock and pose significant risks to animal and public health. Diagnosis currently often requires isolation and analysis of the organism within a laboratory. These resources are often absent or difficult to obtain in rural or poorer areas. With minor modifications, simply swapping out the selective growth medium and LFA strip, the cartridges can be adapted to detect other bacteria, such as salmonella in agricultural settings, as well as bacteria of medical interest.

Aquila, a woman-owned small business based in New Mexico that specializes in the design and manufacture of technologies and services for nuclear security and international safeguards, is licensing the Anthrax Detection Cartridge technology and plans to manufacture the device. Company officials see a potential market among government and commercial customers. Company officials praised the technical support they received from Sandia as well as the smooth and rapid licensing process.

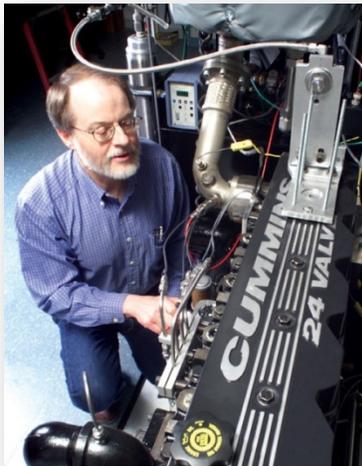
Aquila, a woman-owned small business based in New Mexico that specializes in the design and manufacture of

An Umbrella Cooperative Research and Development Agreement (CRADA) between Aquila and Sandia should result in more collaboration on this and other joint projects. Sandia is continuing to refine the technology and adapt it for other markets interested in rapid detection of biological hazards.

Combustion Research Facility - First Diesel Engine Designed Entirely Computationally

Cummins, a global manufacturer and distributor of diesel and natural gas engines, achieved a 10 percent reduction in the time and cost of designing a more robust, fuel-efficient, and clean-burning engine through the innovative work of a public-private partnership supported by the Vehicle Technologies Office (VTO) in the Office of Energy Efficiency and Renewable Energy (EERE). The improvements were achieved by using computer modeling and simulation instead of the traditional build-and-test method. The multi-institution collaboration involved industry, universities, and National Laboratories with leadership provided by Sandia National Laboratories' Combustion Research Facility (CRF) and funding largely provided by the Department of Energy.

Cummins' ISB 6.7 liter diesel engine, first introduced in 2007, was designed entirely by computer modeling and simulation. The engine now powers more than 200,000 Dodge Ram heavy-duty pickup trucks. Today, most U.S. engines are designed using computer modeling and simulation—a change that is helping U.S. industry cut years off of product development cycles and bringing the nation closer to its goal of reducing petroleum usage for transportation by 17 percent by 2020.



A Sandia researcher examines the Cummins ISB series diesel engine on a diagnostics stand at the CRF.

- Sandia's Engine Combustion Research Program provided Cummins a completely new and authoritative understanding of the complex physical and chemical processes that drive diesel combustion. This research effort rested on more than 15 years of CRF investigation into the complex and fundamental phenomena of ignition. This fundamental understanding—achieved through the application of Sandia-developed laser diagnostics in the CRF's optical engine facilities—was vital to developing the computational tools used by Cummins.
- Other key contributors to Cummins' successes include:
- Los Alamos National Laboratory provided the numerical framework for the engine combustion models
 - Lawrence Livermore National Laboratory provided chemical kinetic models for combustion and emissions
 - The University of Wisconsin and University of Michigan helped develop many of the sub-models for diesel combustion

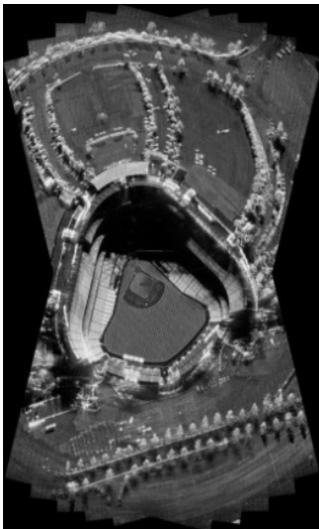
Combustion Research Facility (CRF)

As a DOE Office of Science collaborative research facility, a key aspect of the CRF's mission is to encourage the direct involvement of individuals, or "collaborators," from the scientific community. The CRF also works with industrial partners on precompetitive projects that are shared with the community and on proprietary projects that are wholly owned by the sponsor. The CRF has been working closely with U.S. engine manufacturers for more than 30 years to increase scientific understanding of internal combustion engine processes affecting efficiency and emissions.

Specialized Radar Systems Benefit Warfighters and Save Lives

Synthetic aperture radar (SAR) radar can make detailed, high resolution, photograph-like images of the ground from an aircraft, night or day, even in foggy, cloudy, or hazy conditions. The U.S. Air Force and other branches of the military use GA-ASI's Lynx® Multi-mode Radar systems. The U.S. Customs and Border Protection also operates a fleet of unmanned aerial vehicles (UAVs), most of which are equipped with Lynx systems.

Sandia National Laboratories and General Atomics Aeronautical Systems, Inc. (GA-ASI), an affiliate of privately held General Atomics, are working together to deploy SAR systems for the U.S. military and other customers. This partnership has resulted in immeasurable benefits to our warfighters, created jobs for the U.S., and spurred other technical advancements through an ongoing Cooperative Research and Development Agreement (CRADA).



This clear aerial view of Dodger Stadium at left demonstrates the high-resolution images provided

General Atomics began marketing and producing the Lynx radar in 1999, and since then numerous improvements and new features have been implemented. Today, the radars are built by the GA-ASI Reconnaissance Systems Group. Radar engineering, production, and business activities support nearly 700 employees in Rancho Bernardo, Calif., and at several other sites.

Through the CRADA, Sandia continues to support GA-ASI with development of new modes, features, and enhancements for existing radar systems. In addition, Sandia assists with development testing and validation. The technological advances resulting from the creation of enhanced features and new products at GA-ASI flow back to Sandia, benefitting other Sandia partners.

In 2012 Sandia and GA-ASI assisted with a successful demonstration of additional features of the Maritime Wide Area Search (MWAS) mode of the Lynx Radar. During Navy exercises off the coast of Southern California, the system showed the ability to support anti-piracy and counter-narcotics missions by detecting hard-to-find targets and relaying their imagery with metadata back to Navy commanders for dissemination and action.

The long-term relationship between Sandia and GA-ASI benefits both partners. Sandia's expertise and intellectual property enhances GA-ASI's position as a world leader in radar systems. Sandia gains financial support through the CRADA, which funds research and development efforts, and its engineers gain valuable real-world information and can share research discoveries through publication.

Goodyear and Sandia Have a Strong Grip on Their Long-Term Partnership



When the long-term partnership between Sandia National Laboratories and The Goodyear Tire & Rubber Company began in 1992, Goodyear was using commercial mechanics codes to model a tire's behavior. In the mid-1990s, Sandia researchers adapted one of their nonlinear finite element codes—not available commercially—to Goodyear's tire design and testing applications. This robust form of computational simulation has been used in the design of almost every new Goodyear product.

As the partnership continued, acceptance of faster, more accurate, and more complex simulation tools by the Goodyear design community grew. In some cases, new tires were accepted on first submission by automakers for their new vehicle models. Goodyear's Assurance TripleTred is an example of a major tire product that was developed with simulation tools that helped to design its innovative features for maximum performance while bringing it to market in less than a year. Goodyear and Sandia jointly won an R&D 100 Award in 2005 as a result.

The major breakthrough was the ability to run very detailed tire simulations quickly. The ability to accurately model the mechanical response of a tire as it goes into service on a vehicle—including mounting on a rim, inflation, vehicle loading, and rolling on the road with braking and cornering—enabled Goodyear to make a fundamental change in its tire design process. This allowed computational simulation to replace many prototype builds and tests.

With this technology, tire simulations with very high levels of detail could be run in a couple of days. Before the Sandia/Goodyear partnership, each tire design was followed by the manufacture of a set of prototype tires that were then tested extensively. Each test resulted in further design modifications. Since three to five design iterations were typical, three to five sets of prototype tires had to be built and tested, a process that could take two years.

State-of-the-art rubber material models have also been developed. They can represent the mechanical behavior of the various rubber compounds in a tire while including the effects of temperature, frequency, and strain level. The Sandia/Goodyear strategic partnership has recently expanded to focus on high-speed rolling, noise modeling, snow and mud traction modeling, and fully coupled thermo/mechanical rolling simulations.

Fully coupled thermo/mechanical rolling simulations are needed in order to develop a tire with minimum rolling resistance. Tires with reduced rolling resistance will have major benefits for customers, vehicle manufacturers, and the nation due to the associated savings in energy and oil consumption. The Transportation Research Board estimated that a rolling resistance reduction of 50 percent would save 10 billion gallons of fuel each year.

New Mexico Small Business Assistance (NMSBA) Program - SAVSU Technologies

NMSBA assists for-profit small businesses in New Mexico with access to experts at Sandia National Laboratories and Los Alamos National Laboratory. These experts help businesses gain knowledge and solve challenges utilizing the labs' cutting-edge technologies. The assistance is provided at no cost to the businesses.

NMSBA was created in 2000 by the New Mexico State Legislature. The law provides the labs with a Small Business Tax Credit to bring their technologies and expertise to small businesses in New Mexico. The program promotes economic development with an emphasis on rural areas. Since the inception of NMSBA, Sandia and Los Alamos National Laboratories have assisted 2,195 businesses and provided \$39 million of technical assistance to small businesses in all 33 counties of New Mexico. The program has helped create or retain 3,510 jobs. Under the program, the labs are committed to solving small businesses' critical challenges with National Laboratory expertise and resources; influencing New Mexico business development by building capacity, capabilities, and competencies; and acting as an advocate for small businesses through an entrepreneurial culture.



The NanoQ and Bruce McCormick

NMSBA has received three awards from the Federal Laboratory Consortium (FLC):

- 2014 Mid-Continent Region Award for Outstanding State and Local Government Collaboration
- 2011 National Award for State and Local Economic Development
- 2009 Mid-Continent Region Award for Outstanding Regional Partnership

NMSBA Participant Example: SAVSU Technologies Protects Vaccines in Developing Countries

The company SAVSU, which stands for “State of the Art Vaccine Storage Unit,” is clear about its mission. Inexpensive vaccines can save millions of lives, yet 14–35 percent of vaccines worldwide are exposed to freezing conditions that compromise or destroy them.

Bruce McCormick of SAVSU designed the NanoQ container to store vaccines at proper temperatures. The container uses advances in materials science, including NASA technology to overcome the freezing potential of ice while harnessing its energy storage capacity. SAVSU also began development of a solar thermal icemaker for the NanoQ, attempting to overcome the limited success of previous attempts by redesigning the technology for small volumes of ice.

Through NMSBA, McCormick teamed with Eric Coker and Brian Iverson of Sandia National Laboratories to undertake a massive review of technology relating to solar thermal ice makers, calculate optimal thermal performance criteria, and create a design basis to apply solar thermal ice making capability to the SAVSU cooler.

Sandia Scientist Ventures Out to the Public Sector: Lab-on-a-Disk

Neonatal sepsis—a bacterial infection in the blood—is one of the leading causes of death in newborns. It takes 24-48 hours to get results from current test methods, and a high volume of blood must be drawn—a challenge when dealing with an infant. Routine screening for sepsis may soon be much faster and easier with a point-of-care diagnostic tool being developed by Sandstone Diagnostics. The company is using Sandia National Laboratories’ SpinDx™ platform as the basis for an instrument that can diagnose the condition in about 15 minutes, with just a drop of blood.



Greg Sommer and SpinDx

Sandstone Diagnostics was founded by former Sandia National Laboratories employees and SpinDx inventors Greg Sommer and Ulrich Schaff, who are licensing the technology. Benefiting from two separate NIH grants totaling \$300,000, Sandstone Diagnostics is advancing the company’s long-term goal to manufacture and sell instruments and disposable test kits for different medical testing applications based on SpinDx technology. Sandstone is also developing an over-the-counter male fertility test kit that would allow for semen analysis at home. Additionally, Sommer and Schaff are working with researchers at Stanford University to look at blood-based biomarkers for earlier detection of sepsis proteins and cell markers under a National Institutes of Health (NIH) Small Business Innovation Research (SBIR) grant.

SpinDx was originally developed for biodefense, with funding from a Laboratory Directed Research and Development (LDRD) project and the NIH National Institute of Allergy and Infectious Diseases (NIAD). SpinDx is a lab-on-a-disk that uses 4-inch plastic CD-like disks with etched microfluidic channels containing beads designed for specific assays. Test samples placed on the disks are spun in a “reader” device. SpinDx combines bead-based assays with sedimentation to separate the beads, differentiating it from other centrifugal devices.

SpinDx has both medical and non-medical applications, ranging from detection of markers of infectious diseases to food and water safety testing. It can quickly complete a variety of lab screening tests and be used by people with minimal scientific training in a lab or in the field. Results are available in minutes. A new test can be run as soon as a different disk is inserted, making it highly versatile.

In addition, the technology has been licensed by several companies that are developing its use for point-of-care diagnostics testing, water pathogen testing, and other applications.

Entrepreneurial Separation to Transfer Technology (ESTT)

ESTT allows Sandia to transfer technology to the private sector by permitting Sandia employees to leave the Labs to start up new technology companies or help expand existing companies. Entrepreneurs are guaranteed reinstatement by Sandia if they choose to return to the Labs. Greg Sommer left the Labs and

co-founded Sandstone Diagnostics in 2012 to manufacture and sell instruments and disposable test kits for medical testing applications based on Sandia's SpinDx technology, which Sommer helped invent.

Radioactive Seawater in Fukushima Cleaned with CSTs

When the 2011 tsunami struck the Japanese Fukushima Daiichi Nuclear Power Plant, it contaminated seawater with radioactive cesium. It was quickly determined that Sandia National Laboratories' crystalline silico-titanates (CSTs) would be an excellent material for removing cesium from contaminated seawater that was used to cool the plant's reactors. Sandia and its corporate partner UOP, a Honeywell company, worked around the clock to license and deploy the technology in Japan, where it continues to be used to clean up cesium contaminated seawater at the Fukushima power plant.



To the left is an aerial view of Fukushima Daiichi nuclear power plant after the accident.

The technology transfer of the CST technology to Honeywell UOP has led to more collaboration with Sandia such as a work-for-others agreement with UOP to access a second Sandia material for radioactive cleanup. Honeywell UOP has also recently announced an investment of \$20 million to expand its production facility to produce adsorbents and catalysts, including CSTs.

CSTs are synthetic zeolites designed by Sandia scientists to selectively capture radioactive cesium and other group I metals. Honeywell UOP holds an exclusive license for the use of CSTs in the field of radiation waste applications. Honeywell UOP has put the CSTs in its IONSIV™ Selective Media product line and is using them in the effort to clean up the Fukushima power plant.

This technology received two awards from the Federal Laboratory Consortium (FLC):

- 2013 National Award for Excellence in Technology Transfer
- 2012 Mid-Continent Region Award for Excellence in Technology Transfer

To date, CSTs have been used to clean up more than 85 million gallons of cesium contaminated water at Japan's Fukushima Daiichi nuclear power plant.

SRNL Licenses Hybrid Microwave Technology

Hadron Technologies, Inc., a microwave technology and systems development and manufacturing company with offices in Tennessee and Colorado, has signed a license for a Hybrid Microwave and Off-Gas Treatment System developed by the Savannah River National Laboratory, the Department of Energy's applied science laboratory located at the Savannah River Site.

The agreement gives Hadron the exclusive rights to manufacture and sell the SRNL-developed system.

The microwave system is used to support gas sample analysis as part of SRS national defense mission. Laboratory experimentation has shown that the new form of hybrid microwave is capable of performing functions that traditional microwave systems could not achieve. The system achieves extremely high temperatures by enabling materials that usually do not react to microwave energy to absorb it and rapidly heat up. Metals, which normally cannot be introduced into a microwave, not only can be treated in the system, but they are actually used to help increase the temperature of the lower chamber, enabling faster degradation of waste materials.



Hybrid Microwave System

Equipment using these technologies could be used to destroy a wide variety of substances ranging from medical wastes to harmful viruses and drugs such as methamphetamine, while still allowing for DNA analysis of the destroyed material.

“This is another good example of how laboratory innovation has changed our approach to problems,” said Dr. Terry Michalske, Director of SRNL. “Public-private collaborations such as this one are important to the mission of a National Laboratory, and this one has the potential to bring a significant technology to a number of different commercial and government markets.”

“Hadron Technologies is very excited about our exclusive licensing of the Hybrid Microwave and Off-Gas Treatment System developed by the Savannah River National Laboratory. This innovative microwave technology affords solutions to a number of obstacles within the commercial and government markets. We are looking forward to commercially implementing this technology and providing solutions to these markets,” said Stan Morrow, Chief Technology Officer, of Hadron Technologies, Inc.

MicroBlower™ Soil Vapor Extraction License Agreement

Tersus Environmental, LLC, located in Wake Forest, NC, a developer and marketer of advanced, innovative technologies for the remediation of soil and groundwater, and Savannah River Nuclear Solutions, LLC recently announced the signing of an Exclusive Patent License Agreement for the MicroBlower™. This royalty-based agreement grants Tersus Environmental an exclusive worldwide license to manufacture, use, and sell the MicroBlower™, a passive soil vapor extraction technology developed at the U.S. Department of Energy's Savannah River National Laboratory, which is operated for DOE by SRNS.



MicroBlower™

“This license agreement with Savannah River Nuclear Solutions enables us to expand our strong foundation of intellectual property,” said Gary Birk, Managing Partner of Tersus Environmental. “Working with the outstanding researchers at Savannah River National Laboratory will provide our associates at Tersus Environmental and inVentures Technologies more design freedom as we develop the next generation of remediation technologies to meet the demands of this ever-expanding environmental sector. Our customers will benefit as we continue to implement an expanding array of uniquely effective remediation strategies.”

Targeting the “vadose zone” during remediation traditionally has been considered difficult and the researchers at the Savannah River National Laboratory have developed a MicroBlower™ assisted barometric valve specifically for remediation of organic compounds in the vadose zone.

MicroBlower™ uses a small, low power vacuum blower to extract or inject gases into the subsurface for characterization or remediation. While similar in design to an active soil vapor extraction (ASVE) blower, the MicroBlower™ is a low-cost alternative designed to run on renewable sources of energy such as solar and wind energy to treat volatile organic compound (VOC) contamination in the unsaturated zone. MicroBlowers offer the advantage of a reduced carbon footprint and very low operating and maintenance expenses.

A growing trend in environmental remediation is the use of natural processes. Researchers at SRNL are developing remedial approaches that take advantage of natural phenomena. These approaches are reducing the costs of cleanup and intruding less on the environment. The MicroBlower™ technology is an example of such an approach, based on natural venting cycles between the surface and subsurface. When atmospheric pressure is higher than the subsurface's pressure, air is induced to flow through wells into the subsurface. Conversely, when atmospheric pressure is lower than subsurface pressure, air flows out of wells into the atmosphere, taking with it organic contaminants such as chlorinated solvents in the gas phase.

Mobile Software Solution Eliminates Paper-Intensive Processes to Enhance Operational Efficiency

The Paperless Work Package System (PWP) is a computer program that takes information from Asset Suite, provides a platform for other electronic inputs, processes the inputs into an electronic package that can be downloaded onto an electronic work tablet or laptop computer, provides electronic inputs into the work tablet, and then transposes those inputs back into Asset Suite and to permanent records.

NextAxiom Technology, Inc. is a San Francisco-based platform innovator that has enabled the silo-free enterprise for over a decade. In 2013, NextAxiom Technology, Inc. signed an exclusive license with Savannah River Nuclear Solutions, LLC. In December of 2013, NextAxiom announced the general availability of the Mobile Work Package (MWP). The first MWP rollout at SRNS saw a \$2.7 million annual cost savings and the payback period was under one year.

This new field mobility solution, designed to support a force of 200 mission critical maintenance workers equipped with wireless tablets, automates paper-intensive work processes, while enabling cross-silo intelligent information flow between disparate systems. It was designed to assist mobile SRNS field maintenance work force and management in the following areas:



- **Streamlining the Work Process:** Eliminates the paper, while simultaneously eliminates the high costs and work inefficiency associated with the legacy paper-based process. The new PWP solution is highly scalable and manages in the range of 120,000 new work orders per year.
- **Enabling Tablet-based Field Mobility:** Enables the field workforce – 200 plus onsite mechanics and technical crew members – to leverage ruggedized, next generation mobile tablet devices and pen computing for dramatically improved work process automation in both ‘connected’ and offline modes.
- **Driving Cross-Application Integration:** Created a new bi-directional intelligent information flow. This was developed within an overall IT environment in which no legacy SOA infrastructure or middleware (e.g. enterprise service bus or ESB) was in place.
- **Manages User Access Roles:** Supports all relevant management and workforce roles within the new application, including Work Planners, First Line Managers, Mechanics and Field Work Reviewers, based on the secure user access policy.
- **Tracking Work Packages:** Includes a new Work Package Tracking System to manage the new Paperless Work Package on an ongoing basis.
- **Records Automation Module:** Once a Work Order has been completed for a specified amount of time, all work package documents are automatically grouped by task and compiled into a single PDF document. The module enables comprehensive paperless work package records creation, freeing staff to focus on work processes, not paperwork.

This paperless work system is being implemented successfully in other areas of SRNS, such as the QA Receipt Inspection and Operational Procedures.

Savannah River National Laboratory and Metallurgical Engineering Services – Helping the Anchor Hold

A vital concern for cellular, broadcast, and emergency communications is the ability to maintain a safe, dependable communications tower. The danger is from more than just strong wind, but also the corrosion of underground anchors that help support these tall structures. Anchors can become pitted and weakened, and must be monitored on a regular basis. Researchers at the Department of Energy’s Savannah River National Laboratory (SRNL), in conjunction with Metallurgical Engineering Services, Inc. (MES), have developed a way to test the integrity of these anchors without digging away the surrounding soil. SoundAnchor™ performs inspections of tower anchors by using sound waves.

“SoundAnchor™ is a technique that applies ultrasonic frequencies to assess the condition of buried anchors that support towers,” explained SRNL Meteorologist Matt Parker, who helped invent the device. “The advantage is that this technique avoids expensive and damaging excavation processes and is more thorough in assessing the condition of the rods over just a visual inspection. SoundAnchor™ can be used to monitor trends associated with degradation due to corrosion.”

Anchor rod failure due to corrosion is a problem in every environment and every geographic region. Parker said the need for a more efficient method of testing rods became evident due to the lack of robust technical and economic inspection method and an increased emphasis on worker safety. “Besides worker safety, ensuring rod integrity is vital during extreme weather events like Hurricane Sandy. The viability of the cellular network is enhanced greatly if the structures do not collapse under the duress caused by extreme wind or loads from heavy ice build-up. The Achilles Heel of most towers is the anchor rods,” added Parker.



SoundAnchor™

The industry standard is to excavate each rod every three to five years to ensure its integrity. With nine meteorological towers and 27 anchor rods, Parker said the task was unappealing.

Parker and SRNL NonDestructive Examination expert, Bill Hinz, searched for a better technical solution. “We had to conduct a lot of testing to see how much degradation could be detected and how much was ‘too much’ via tensile testing of anchors in the laboratory. The final result was a far superior technique that cost about 10% of the damaging excavations.

In order to get this technology to industries where it could be of most use, SRNL partnered with MES of Richardson, Texas. “There are literally thousands of towers in the U.S. that can benefit from this technology,” Parker said. “MES has actually improved on SoundAnchor™ to make it easier to apply and provide more detailed results. This ability for a private company to take technology invented at the lab, and take it one step further for efficiency and safety, that’s satisfying for a researcher, and satisfying for the laboratory.”

'Green' Chemistry Treats Contamination Before It Reaches The Groundwater

A technology that uses “green” chemistry to help microbes break down contaminants in soil before they reach the groundwater has earned kudos from the editors of *Environmental Protection* website as 2011 Soil & Groundwater New Product of the Year.

The technology, which was invented by the U.S. Department of Energy’s Savannah River National Laboratory, and licensed and manufactured by EOS Remediation, LLC, a subsidiary of Solutions-IES, Inc., treats chlorinated solvent contamination in the vadose zone, the area of unsaturated soils between the ground surface and the water table below. Contamination in this zone can be a continuing source of groundwater contamination.



The technology, which EOS Remediation markets under the name Vadose Organic Substrate (VOS™), is based on sustainable “green” chemistry. The thixotropic gel – a liquid consistency when stirred, but gels when left in place – uses biodegradable oil to

sequester the contaminants while providing food for the microorganisms in the soil, stimulating the microbes’ innate ability to degrade solvents. Initial results indicated that the VOS™ Technology can cost-effectively turn land once deemed unusable into productive and safe real estate.

The technology was originally developed by Brian Riha of SRNL to address solvent contamination at DOE’s Savannah River Site. EOS Remediation obtained the exclusive license to manufacture and sell the technology, as part of SRNL’s mandate to support the U.S. economy by moving technologies developed at the government laboratory into the marketplace.

Solutions-IES is an award-winning, woman-owned environmental consulting, engineering and remediation firm and is a leading developer of innovative technologies for natural and sustainable bioremediation of soil and groundwater. Its subsidiary, EOS Remediation, commercializes products developed by Solutions-IES to naturally clean-up environmental contamination. EOS® technologies are used at over 1,000 sites annually and substantially reduce the cost to restore contaminated properties throughout the world.