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Enhancing National Laboratory Partnership and Commercialization Opportunities

EXECUTIVE SUMMARY

ENHANCING NATIONAL LABORATORY PARTNERSHIP AND COMMERCIALIZATION OPPORTUNITIES: EXECUTIVE SUMMARY

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FOREWORD

National laboratories play a critical role in building the nation's innovation capacity and driving our economy. At Argonne National Laboratory (Argonne), we are working on developing a reliable, efficient and secure electrical grid, and other technologies ranging from transportation vehicles to semiconductor devices to cancer-fighting drugs that will change people's lives, nationally and globally. In order for many national laboratory innovations to be truly impactful, they must be commercialized and distributed through the marketplace, and Argonne works closely with its academic, industry and national laboratory partners to do so.

At Argonne, we strive to do a better job of working with our collaborators to transition the Laboratory's research and development (R&D) projects from lab to market, mutually benefiting all partners and always keeping the public benefit foremost. We are mindful that other national laboratories, academic and research institutions also are trying to find ways to accelerate and transition their innovations, and some are experimenting with initiatives that could be adapted by others. In order to learn more about these innovative initiatives, we commissioned Innovation Associates to explore some promising models that could be adapted for use. Several national laboratories very generously shared their knowledge with us, and by releasing portions of the Argonne report nationally, we wish to share what we have learned with others.

The U.S. Department of Energy (DOE), which funds Argonne and 16 other national laboratories, is increasingly reaching out to the laboratories to better understand impediments to technology transfer and commercialization and to identify potential remedies. Through the DOE Commission to Review the Effectiveness of the National Energy Laboratories, a number of barriers were brought to light and recommendations made. We applaud the DOE and Administration for these efforts and encourage them to continue pursuing a better understanding of public-private partnerships, experimenting with new tools, and supporting individual national laboratory efforts that test new mechanisms intended to accelerate and transition R&D. We further call on other national laboratories to join us and work together to explore new ways of collaborating and commercializing R&D that benefits all.

Peter Littlewood
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EXECUTIVE SUMMARY

INTRODUCTION

National laboratories are innovation powerhouses. They conduct wide-ranging research and development (R&D) on clean energy, national security, supercomputing, nanotechnology, materials and other scientific and engineering research, pushing technological breakthroughs and expanding new frontier boundaries. The laboratories have been responsible for research leading to the internet, integrated circuits, optical digital recording technology, maglev trains, proton accelerators, and many other technologies that make people's lives better and safer. Funded by the U.S. Department of Energy (DOE), the 17 laboratories are all, except for one, managed by nonprofit and private sector contractors such as Battelle Memorial Institute (Battelle), Lockheed Martin, University of California, and University of Chicago.[1] With an annual budget totaling more than $11 billion, and employing 55,000 researchers and staff, they are the nation's leading technology discovery and innovation force.

Partnerships with industry and the promotion of technology transfer and commercialization are increasingly important in insuring the widespread dissemination and deployment of national laboratory innovations. In order to enhance industry partnerships, technology transfer and commercialization, Argonne National Laboratory (Argonne) contracted with Innovation Associates (IA) of Reston, VA to identify exemplars from national laboratories that could serve as models for Argonne and other national laboratories. IA identified programs and practices at several national laboratories, and additional exemplars from universities and other institutions. Based on this work and previous National Science Foundation work on universities, IA provided suggestions for adapting selected exemplars; in some cases, IA suggested value-added elements.

Importance of Industry Partnerships, Technology Transfer and Commercialization

Innovation is a key component of U.S. economic prosperity, and technology transfer and commercialization are key drivers of successful innovation. Both the executive and legislative branches of the federal government set policies supporting industry partnering to promote commercialization of innovative technologies. Congress in the 1980's laid the foundation

[1] Many contractors are incorporated as separate LLCs, sometimes in collaboration with others such as Battelle and the University of Tennessee that have formed UT-Battelle LLC to manage Oak Ridge National Laboratory.

through several legislative acts,[2] and the executive branch more recently undertook numerous efforts to promote technology transfer and commercialization. In an October 2011 Presidential Memorandum, President Obama set a goal of fostering innovation "by increasing the rate of technology transfer and the economic and societal impact from federal research and development (R&D) investments."[3] The Memorandum committed each executive department and agency involved in conducting research to improve commercialization and technology transfer results, with an aim of significant improvement over five years. This call to action was echoed by DOE Secretary Ernest Moniz who, during his 2013 nomination hearing stated that the DOE could do more in the technology transfer arena, by lowering barriers and working collaboratively with universities and the private sector.[4] In early 2015, the Secretary announced the launch of the Office of Technology Transitions, enhancing a prior office to more actively promote commercialization of DOE research.

Addressing Barriers to Technology Transfer and Commercialization

In spite of the efforts to promote technology transfer and commercialization at the national laboratories, significant barriers remain. A recent report produced jointly by the Information Technology and Innovation Foundation (ITIF), Center for American Progress (CAP) and the Heritage Foundation described the persistence of "a number of policy, budgeting, cultural, and institutional barriers to interacting with industry."[5] A national expert panel at the White House Lab-to-Market Inter-Agency Summit co-chaired by IA's President, noted that commercialization of discoveries from federal agency research "has largely been an after-thought."[6] The DOE's Secretary of Energy Advisory Board (SEAB) National Laboratory Task Force found that DOE's centralized approach to promoting technology transfer at the national laboratories created barriers to policies intended to promote technology transfer,[7] and an interim report by the DOE Commission to Review the Effectiveness of the National Energy Laboratories found that support

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[2] Congressional Acts included the Stevenson-Wydler Technology Innovation Act of 1980 and Bayh-Dole Act of 1980.

[3] White House Office of the Press Secretary, *Presidential Memorandum—Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses*, U.S. Government Publishing Office, October 28, 2011, 1. http://www.gpo.gov/fdsys/pkg/DCPD-201100803/pdf/DCPD-201100803.pdf.

[4] *Hearing to Consider the Nomination of Dr. Ernest Moniz to be the Secretary of Energy, Before the Committee on Energy and Natural Resources, United States Senate*, 113th Cong. 17 (2013) (statement of Ernest Moniz). 21. http://www.gpo.gov/fdsys/pkg/CHRG-113shrg80930/pdf/CHRG-113shrg80930.pdf.

[5] Matthew Stepp, Sean Pool, Nick Loris, and Jack Spencer, *Turning the Page: Reimagining the National Labs in the 21st Century Innovation Economy*, (The Information Technology and Innovation Foundation, The Center for American Progress, The Heritage Foundation, June 2013), 42.

[6] National Expert Panel, "Lab-to-Market Inter-Agency Summit: Recommendations from the National Expert Panel," (Panel Recommendations at the White House Conference Center, Washington, DC, May 20, 2013), 2. ; http://innovationassoc.com/files/WH.L2MSummit.Recommendations.FINAL.Aug.09.2013.-2.pdf

[7] Secretary of Energy Advisory Board, *Report of the Secretary of Energy Task Force on DOE National Laboratories*, (US Department of Energy: June 17, 2015), 29. http://www.energy.gov/seab/downloads/interim-report-task-force-doe-national-laboratories.

for technology transfer was "inconsistent across the laboratories and across the DOE program offices."[8] An earlier U.S. Government Accountability Office (GAO) report found that a "lack of flexibility" in negotiating technology transfer agreements was a primary challenge to expanding commercialization of laboratory technology.[9] The Institute for Defense Analysis' Science and Technology Policy Institute (STPI) report found that laboratory researchers "may lack the knowledge, ability, and incentives necessary" to undertake the research and business activities necessary to promote technology transfer and commercialization.[10] Researchers at national laboratories are more restricted than those at universities regarding the types of activities that they can engage in, and the extent of that engagement. University researchers have more flexibility with regard to launching startups and taking equity in those startups, and they are permitted greater leeway with regard to outside consulting.[11] We can summarize the major barriers to national laboratory technology and commercialization as (a) DOE over-centralization; (b) inconsistency and mixed messages regarding the importance of technology transfer, and what is permitted; (c) aversion to risk; (d) lack of flexibility; (e) lack of researcher commercialization capacity and incentives; and (f) underfunded support for technology transfer and commercialization.

DOE, particularly the Office of Energy Efficiency and Renewable Energy (EERE), has recently worked to address some of these barriers through a series of pilots and programs. Energy Frontier Research Centers (EFRCs) are driving collaboration between university, industry, non-profit, and national laboratory researchers. Energy Innovation Hubs, such as the Joint Center for Energy Storage Research (JCESR) and the Critical Materials Institute (CMI) are investing in basic research that is linked to initial product development, and intended to bring together expertise from DOE national laboratories, universities, and industry. Agreements for Commercializing Technology (ACT) is a pilot program that provides an alternative technology transfer mechanism intended to create more flexible and expeditious private sector agreements. Lab-Corps, a pilot based on the National Science Foundation's successful I-Corps, is designed to educate researchers on commercialization and entrepreneurial practices.

Some of the most impressive attempts to improve partnerships and commercialization have come from the national laboratories themselves. These programs and practices include the

[8] *Interim Report of the Commission to Review the Effectiveness of the National Energy Laboratories*, (US Department of Energy: February 27, 2015), vi. http://energy.gov/labcommission/downloads/interim-report-commission-review-effectiveness-national-energy-laboratories.
[9] Government Accountability Office, "Technology Transfer: Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories" (2009), available at http://www.gao.gov/assets/300/290963.pdf.
[10] Mary Elizabeth Hughes, Susannah Vale Howieson, Gina Walejko, Nayanee Gupta, Seth Jonas, Ashley T. Brenner, Dawn Holmes, Edward Shyu, and Stephanie Shipp, *Technology Transfer and Commercialization Landscape of the Federal Laboratories*, Institute for Defense Analyses Science & Technology Policy Institute (IDA Paper NS P-4728: June 2011), 26.
[11] Ibid., p. 29.

National Renewable Energy Laboratory's (NREL's) Industry Innovation Showcase, Lawrence Berkeley National Laboratory's (Berkeley Lab's) Cyclotron Road, Pacific Northwest National Lab's (PNNL's) "use permit" model leading to ACT, Oak Ridge National Laboratory's (ORNL's) creative Manufacturing Demonstration Facility, Sandia National Laboratory's (SNL's) Science and Technology Park and entrepreneurial leave program, and others.

Some of the most promising recent experiments have involved the creation of external nonprofit organizations affiliated with national laboratories including Berkeley Lab's CalCharge and Los Alamos National Lab's (LANL's) New Mexico Consortium (NMC). Creating an external, nonprofit organization is one way that a national laboratory can facilitate more flexible, expedient external partnerships. Ideally, the organization not only adds value through intermediary mechanisms and services, it also ultimately enhances the laboratory's R&D and internal culture. It does so by providing the opportunities for more and broader engagement with corporate and other partners. For many years, universities have created nonprofit organizations to carry out technology transfer and certain private sector and philanthropic interactions. They have done so to create an "arm's length" distance that provides greater indemnification and flexibility in dealings with the private sector. External organizations offer one way in which national laboratories can more effectively (a) reduce risk; (b) increase flexibility and speed to market; (c) pursue and leverage broader research interests; (d) connect with the region's innovation and entrepreneurial (I&E) ecosystem; and (e) add value to the laboratory's R&D and innovation culture.

Developing Affiliated Organizations and Enhancing National Laboratory Programs

A variety of external organizations and internal programs facilitate industry R&D partnerships and successfully promote commercialization. There is no one right way to achieve greater partnership and commercialization goals. The best approach involves adapting elements from various programs and practices that address a specific laboratory's vision and environment.

National laboratory affiliated organizations are a relatively new and evolving concept. Thus, it is important to recognize that any new organization is experimental, requiring patience and flexibility to adjust to evolving demands, circumstances and goals. Whether developing a new organization or implementing enhanced practices within the laboratory, it is important to keep in mind that successful programs and practices such as those described in this report, are shaped by multiple factors that are not necessarily common across institutions. The national laboratory's leadership is one such factor. Where there is a national laboratory director who supports technology transfer, commercialization and entrepreneurship, there is likely to be

greater experimentation and innovation. National laboratories' partnership and commercialization programs are shaped, in part, by the type of R&D that they perform and their funders. DOE laboratories that are funded by EERE or have major programs funded by EERE, conduct research that is closer to market than those funded mainly by DOE Office of Science (OS), and therefore tend to be better positioned to promote technology transfer and entrepreneurship. The laboratory's management and operations (M&O) contractor also plays a potentially important role. Some laboratory contractors such as Battelle and the University of California (UC) system have emphasized commercialization and entrepreneurship more than others; in some cases, using their contractor fees and additional in-kind support to help create and sustain innovative initiatives. This support has helped underpin initiatives such as the LANL affiliated NMC, ORNL's technology transfer activities, and Berkeley Lab's Cyclotron Road and affiliated CalCharge. State government commitment to leveraging national laboratory R&D for commercialization and economic development also has played a role in underpinning the Berkeley Lab initiatives in California, and those of SNL and LANL in New Mexico. The laboratory and affiliated organization also will be affected by the regional ecosystem in which it is located. Berkeley Lab has benefitted from being located in the rich I&E ecosystem of Silicon Valley, and has leveraged the region's network to support its innovative initiatives.

These various conditions notwithstanding, there are lessons that can be gleaned from exemplars, and specific elements that can be adapted. The following national laboratory, university and other institutional exemplars provide national laboratories with some excellent models from which to draw adaptable elements.

Linking Corporate Members to National Laboratory R&D: CalCharge -- Berkeley Lab's affiliated organization, CalCharge, is an excellent example of a closely linked, nonprofit organization that facilitates laboratory-industry R&D and technology transfer. In 2012, Berkeley Lab and the California Clean Energy Fund (CalCEF) partnered to create CalCharge as a public-private partnership intended to bring together California's battery technology companies with government and academic resources to accelerate the commercialization and market adoption of energy storage technologies. CalCharge is an LLC that is a wholly owned for-profit subsidiary of CalCEF Catalyst. It is a membership organization that by late 2015 had 16 members including 12 corporations representing a mix of startups and major corporations; others were national laboratories, universities and unions. CalCharge's major feature is its Master Services Agreement (an umbrella CRADA) with Berkeley Lab that permits CalCharge members access to Berkeley Lab without negotiating individual contracts. The scope of the CRADA is broadly defined, encompassing energy storage technologies and, in order for projects to be covered under the Master Services Agreement, they must stay within that parameter. The critical difference is that Berkeley

Lab's CRADA is with CalCharge and not the individual member. In this way, CalCharge has been able to expand its reach to private sector members and expedite R&D agreements beyond that which could be done through traditional CRADAs. By late 2015 CalCharge already had executed this type of agreement with two additional laboratories, and had plans to bring in additional laboratories, universities, and private sector members.

Leveraging University-National Laboratory Collaboration: NMC -- The Consortium is a nonprofit 501(c)(3) organization fostered by and affiliated with LANL. It was established by the three New Mexico (NM) research universities - University of New Mexico, New Mexico State University and New Mexico Tech, and has academic standing for the purpose of federal and other grants. The academic, nonprofit standing allows NMC to actively seek and receive grants from a variety of federal agencies and philanthropic foundations, and gives LANL researchers who work on NMC projects access to grants that otherwise would not be available to them. Staffing agreements between NMC and LANL can be structured as an "outside activity" or a "joint appointment" which facilitate shared researcher engagement. The Consortium conducts about $10 million of research per year, about two-thirds of which is funded by (non-DOE) federal agencies and one-fourth to one-third by philanthropies. NMC interfaces with LANL and academic institutions through LANL's National Security Education Center. LANL provides a base of funding from its overhead to help support NMC administrative costs, education and program development activities, and provides additional in-kind professional support. NMC also owns a Biological Laboratory, and LANL subcontracts for access to that Laboratory.

Promoting Laboratory-Industry Partnerships: ORNL's Manufacturing Demonstration Facility (MDF) -- DOE EERE's Advanced Manufacturing Office (AMO) established the MDF at ORNL in order to develop and accelerate advanced manufacturing innovations that could be more rapidly deployed in the marketplace. It is composed of a main facility located on the ORNL campus, and two nearby offsite locations. Most of MDF's R&D involves industry collaborations, and in many cases industry representatives work alongside ORNL researchers. One industry collaboration involves exploratory technologies funded through an EERE AMO project that involves open calls and a two-phase approach: an exploratory phase and development phase, both requiring industry match. In 2015, EERE's AMO developed a unique program opportunity for teams of university professors and their students to engage in additive manufacturing research at MDF. The "Research for Additive Manufacturing Program-University Partnerships" (RAMP-UP) will select 10 university teams to engage in collaborative research projects in additive manufacturing that align with MDF's core projects. MDF received national and international acclaim for its work with Cincinnati Inc. in producing a 3-D printed automobile. It is now working with Local Motors

in Tennessee to produce a 3-D car, and working with the entire supply chain on production. The Institute for Advanced Composites Manufacturing Innovation (IACMI), the fifth designated National Manufacturing Innovation Institute (NMII), and MDF are closely tied together. IACMI's CEO is also the Director of MDF and ORNL's Advanced Manufacturing Office. IAMCI is a $250+ million public-private consortium involving 122 companies, nonprofits, universities and research laboratories, led by the University of Tennessee, Knoxville.

Accelerating National Laboratory Innovations: Cyclotron Road -- Launched by Berkeley Lab in July 2014, Cyclotron Road provides support to innovators working to develop and commercialize clean energy technologies. Cyclotron Road competitively selects a small cohort of energy related innovators from across the country and embeds them in Berkeley Lab. The program provides them with up to two years support in the form of a living stipend and access to Berkeley Lab facilities, tools, and expertise. Cyclotron Road staff provide targeted mentorship on technology and manufacturing challenges, and networking connections to internal and external experts who can serve as advisors, collaborators, and potential commercial partners and investors. During their time as innovators at the Laboratory, they are expected to identify financing partners for next stage development and commercialization. The Cyclotron Road competition is open to any U.S. citizen, and projects must have the potential for long-term impact in enabling materials and manufacturing-based products and processes that advance DOE's mission. Cyclotron Road's pilot phase (2014-16) involves eight innovators conducting research in six projects spanning various "hard" energy technologies. The pilot program initially was structured to support the innovators by hiring them as Berkeley Lab temporary employees. This structure was problematic because any new intellectual property developed by the innovators would by default be owned by the Laboratory. In late 2015, Berkeley Lab formulated a proposed new organizational structure in which the innovators would partner with the Laboratory under an umbrella CRADA. At the writing of this report, Cyclotron Road's structure still was evolving. Cyclotron Road's value is that it provides a resource base to support researchers in developing products and processes that generally are too applied for typical academic or national laboratory research, and yet too early stage to be supported by traditional venture capital. It is an innovative way to combine external entrepreneurial ideas and innovations with national laboratory resources.

Facilitating Philanthropic Funding: Berkeley Lab Foundation -- In 2013, Berkeley Lab's M&O contractor, UC, established the Berkeley Lab Foundation as a separate nonprofit organization to provide a way for philanthropic and other contributions to fund Berkeley Lab research. A donor has committed a $10 million donor endowment to establish the

Foundation, and while the payout from that endowment builds, UC provides funding from its laboratory fee to cover the operating costs of the Foundation. Berkeley Lab Foundation is an official "support group" within the UC system, giving the University responsibility for oversight and management of the Foundation's funding. By the end of 2015, there were three major gifts to the Foundation, with a fourth gift forthcoming. The separate foundation structure offers certain advantages over Berkeley Lab or UC receiving philanthropic funding. For example, the funding associated with two of the philanthropic contributions/loans was made through the Berkeley Lab Foundation rather than given directly to Berkeley Lab or UC because they were considered somewhat risky, and additionally could be construed as potential "augmentation" which is not allowable under DOE funding. Moreover, the Laboratory has higher overhead costs and while UC has the power to waive overhead costs for philanthropy, the Berkeley Lab cannot. Philanthropic funding thus far has been used mainly for major laboratory equipment that will help establish the Laboratory's prominence in specific technological areas.

Promoting Public-Private Partnerships: NREL Innovation Incubator (IN2) -- IN2 is a joint program conducted by NREL with Wells Fargo. It combines external entrepreneurial talent with the Laboratory's R&D to develop, test and apply innovations to commercial buildings. Wells Fargo funded NREL with $10 million over five years to launch the joint program which identifies and funds entrepreneurs to work with experts from national laboratories, universities and regional accelerators. NREL intends to employ this public-private partnership to bridge the gap between national laboratory R&D and the marketplace. NREL used an ACT agreement to facilitate this partnership.

Showcasing National Laboratory Innovations: NREL's Industry Growth Forum -- The Forum is a well-known, 28 year annual event featuring presentations from emerging clean energy companies, as well as organized networking opportunities and panels. Private, one-on-one meetings are organized between startup companies and potential investors. Presenters can win commercialization services from NREL in addition to potential investment capital from private investors. The Forum receives funding from a variety of public and private sponsors, including Wells Fargo and the State of Colorado's Energy Office. Since 2003, companies presenting at the Forum have raised financing worth more than $4 billion.

Showcasing New Mexico's Innovations: Technology Ventures Corporation (TVC) -- TVC was founded as a 501(c)(3) nonprofit charitable foundation by Lockheed Martin in 1993, as part of Lockheed's M&O contract for SNL. TVC was created to commercialize federally funded technologies, and does not charge fees or take equity compensation for its services.

The organization's operational costs are funded by a Lockheed Martin grant, and TVC receives additional grants from federal agencies for related work. TVC accepts seed and early-stage companies competitively, and mentors and showcases them at its annual Deal Stream Summit. One-third of all companies who present at TVC's Summit have received funding. Lockheed reports that TVC's efforts have helped create more than 117 companies and created 13,500 jobs; its work has been key to the production of more than $1.2 billion in venture capital investments.

Facilitating Access to University Research: Massachusetts Institute of Technology (MIT) Industrial Liaison Program (ILP) -- The ILP is a portal to MIT's researchers, providing access and value-added services for corporate clients. Established in 1948, it was developed to strengthen relationships between MIT and corporations. Operating as part of MIT's Office of Corporate Relations, it is a branded membership program that now involves 230 companies. These member companies account for about 40 percent of all corporate gifts and single-sponsored research expenditures at MIT. At any given time, about one-third of ILP members are actively sponsoring research at MIT. Core activities for members involve Industrial Liaison Officers developing an action plan, providing help with coordinating research management, and sometimes help in assembling multi-disciplinary teams. ILP activities additionally provide access to MIT's entrepreneurial community through various events and through MIT's database of startups. Other membership benefits include information and events in technology areas, discussing management strategies and facilitating recruitment of MIT students. ILP's most important services are that it serves as a single point of contact for corporations and provides individualized plans of engagement.

Commercializing University R&D: Arizona Technology Enterprises (*AzTE*) -- Arizona State University (ASU) created AzTE in 2003 to increase the flexibility and speed of ASU's technology tranfer operations. AzTE was established as an Arizona LLC with the ASU Foundation as its sole member; AzTE additionally has a wholly owned for-profit LLC. The organization has evolved through several iterations, starting out as a unit within the University, reorganized as a separate legal entity to perform technology transfer using a venture capital structure, and now restructured to provide a more "balanced" technology transfer approach focused on generating longer-term industrial partnerships and research engagements. In addition to traditional technology transfer services involving invention disclosures, patenting and licensing, AzTE provides services for startups including introductions to mentors, entrepreneurs-in-residence and potential investors. Other resources linked to AzTE's efforts include the University's Entrepreneurship and Innovation program, in which faculty inventors are matched with one of about 100 mentors. Another program, the Furnace Accelerator provides incubation, acceleration funding and mentoring

to entrepreneurs who participate in a nine-month accelerator experience culminating in a Demo Day where teams pitch business plans to investors. AzTE has developed a marketing strategy that includes a team review of University innovations and detailed market assessments mainly targeting small- and mid-sized enterprises. Since AzTE's founding in 2003, the ASU's faculty has formed more than 84 startups and has been issued over 600 patents. After the formation of AzTE, energy-related invention disclosures increased ten-fold.

Accelerating University Innovations: MIT Deshpande Center -- Established in 2002 through a gift from philanthropists Gururaj "Desh" and Jaishree Deshpande, the Center gives MIT researchers the funding and tools to bring innovative technologies from lab to market in the form of breakthrough products and startup companies. MIT faculty, student and other researchers with principal investigator status are eligible for a grants and services. The program's staff carries out several core activities: educating grant recipients about the innovation process; coaching grantees on how to commercialize their inventions and launch startup companies; providing research teams with mentoring and guidance from investors, startup specialists and entrepreneurs; and nurturing MIT's I&E ecosystem. The Deshpande Center grant program is conducted in two phases: Ignition Grants provide $50,000 for an invention which is at an early stage; Innovation Grants provide $50,000 to $150,000 for an invention which is within two years of moving out of MIT into a commercial entity. Grants are for one year and can be renewed over multiple years, for a cumulative maximum of $250,000. The Center's Catalyst Program involves volunteer mentors from the external I&E community, who provide mentoring to grantees. Since its inception, the Center has supported the work of 300 faculty, graduate students and post-doctoral researchers, and funded more than 125 projects with grants totaling more than $15 million. Thirty-two companies have spun out of the Center and have collectively raised over $600 million in capital. Nearly 30 percent of funded projects spin out a new enterprise.

Addressing Industry Problems through Entrepreneurial-Laboratory Partnerships: Fraunhofer's TechBridge -- A U.S.-based international example - the Fraunhofer Center for Sustainable Energy Systems (CSE) - in 2010 created TechBridge, a commercialization arm for CSE. TechBridge performs as an applied R&D contract research organization. It actively seeks to identify problems in major industries that can be solved through CSE, and by identifying and working with startups that can bring their expertise to add R&D value that of CSE. It identifies startups to address specific technological problems through its extensive network with local universities and Boston's active I&E community. If the work generates IP specific to the project, then CSE will own the IP. Depending upon the project,

they will sometimes provide a non-exclusive, royalty-free option to the startup. TechBridge does not invest funding in the startups that it works with and does not normally take an equity position, but does assist them in linking to potential investors and corporate partners. Since 2008, Fraunhofer CSE has filed and licensed several patents in photovoltaic and building energy technologies and has supported over 30 early-stage cleantech companies that have raised more than $67 million in follow-on funding.

Recommendations and Next Steps

In this executive summary, we briefly reviewed some barriers to national laboratory partnerships and described exemplary programs that employ creative solutions to advance private sector partnerships and commercialization. Some of the highlighted programs are new and evolving, and we encourage other national laboratories to use these programs as a base, building on them and taking them to the next level as well as experimenting with their own unique programs.

Two of the models highlighted here are particularly promising: Berkeley Lab's Cyclotron Road and CalCharge. Cyclotron Road combines the strengths of external innovators and the resources and expertise of national laboratories. Managing the program through a national laboratory-affiliated organization or other organization(s) rather than directly through the laboratory as it is now managed, might enhance the program by making it more attractive to external innovators. Such an arrangement could potentially offer more flexible and favorable terms. In addition, the Cyclotron Road program could be enhanced further by adding a second phase - Cyclotron Road "Plus-up" - that would provide follow-on matching funding for those innovators successful in attracting investment capital for commercialization. The program also would benefit from the laboratory or affiliated organization(s) proactively connecting innovators to the Lab-Corps program, showcasing related innovations, and proactively connecting them with investors and potential customers. It is our understanding that, in the near future, Cyclotron Road will enhance their program with external connections in this way. CalCharge, another promising model, leverages its nonprofit organizational status by employing a Master Services Agreement or umbrella CRADA to facilitate private sector and other partnerships with Berkeley Lab. This model could be expanded in several ways. The potential value-adds could include (a) creating inter-disciplinary R&D teams involving multiple corporations, academic institutions and national laboratories to address specific industry problems; (b) adding a highly focused laboratory that is designed to accelerate specific types of technologies spinning out of Berkeley Laboratory; (c) providing industry portal services for the full range of national laboratory R&D; and (d) creating an evergreen fund that would invest in potential spinouts.

NMC also provides a good base upon which laboratories can build. Small, specialized laboratories that operate outside of the national laboratory's fence, such as NMC's Biological Laboratory, allow the national laboratory to explore related R&D that may be of interest to the private sector and philanthropic institutions but are too risky, tangential or for security reasons cannot be performed at the national laboratory. In addition, by creatively applying an academic standing status for national laboratory researchers working on specific NMC projects, the Consortium has expanded LANL's R&D reach. ORNL's MDF provides another good model for laboratories to replicate. MDF has implemented some promising pilots involving university and private sector researchers, and has shown impressive results from its industry collaborations. MDF and similar user facilities might consider adding further value through processes similar to those used by Germany's Fraunhofer centers and its U.S.-based programs such as TechBridge. These programs proactively identify industry problems and address them by applying the combined resources and expertise of universities, national laboratories and entrepreneurs.

National laboratories could replicate some university acceleration models covered in this report, such as MIT's Deshpande Center, by applying maturation funding and external mentoring to commercialize promising innovations. Other state and local technology and acceleration programs not covered here, such as those found in Pittsburgh, New York and Kentucky, and private sector models also should be further explored for potential adaptation to national laboratories. Where possible, linkages between national laboratories and these programs should be made.

There are additional activities not covered here that might enhance national laboratories' private sector partnering and R&D commercialization efforts. Under recent reauthorizations, national laboratories are allowed to participate in the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. By proactively identifying potential R&D and SBIR/STTR partners, laboratories can participate in a no-cost (to the laboratories) avenue for development and commercialization, combining their R&D with that of external businesses and universities. Participation of national laboratories in NMIIs, exemplified by MDF's leadership in IACMI and participation in America Makes, also benefits the laboratories through increased private sector and university collaborations. The NMII collaborations potentially provide a vehicle for acceleration and diffusion of national laboratory innovations. In addition, engaging national laboratories with the Manufacturing Extension Partnership (MEP) could provide a mechanism for linking evolving national laboratory technologies to small- and medium-sized manufacturers. At the writing of this report, it is our understanding that greater MEP and national laboratory connections are being explored.

Organizing industry advisory boards is one of the most valuable and least costly activities that a national laboratory can do. These advisory boards provide the laboratory with insights on and connections to private sector R&D, and the potential for collaboration and technology transfer. The boards should involve a wide range of private sector representatives including investors, entrepreneurs and manufacturers as well as major corporations. National laboratories should organize these boards at the director's level and at each key center/division. Additionally, mapping of R&D in specific fields could help identify strategic R&D direction for national laboratories and potential partnership opportunities.

Perhaps the most important aspect to improving private sector partnerships, technology transfer and commercialization are the cultural changes in national laboratories that need to take place. To this end, national laboratory and DOE leadership should review researchers' incentives and rewards regarding private sector partnering and commercializing R&D. Universities provide some good examples including allowing faculty to devote a portion of their time to perform external consulting, giving credit toward promotion, providing awards, using hiring practices that favor some corporate experience, providing entrepreneurial education, and facilitating opportunities for external networking. In terms of commercialization and entrepreneurial training, Lab-Corps is a good start, and more could be done in this area. A Lab-Corps "Phase II" might competitively select particularly promising Lab-Corps "graduates" for follow-on acceleration and commercialization funding and external mentoring.

In order for national laboratories to truly enhance their partnerships and potential for technology transfer and commercialization, DOE policies and practices must be addressed. In this report, we cite numerous issues that range from excessive centralization to presumption of unacceptable risk in determining licensing agreements. As we have noted, EERE has attempted to address some of the barriers by implementing several pilots. However, many barriers remain. Greater flexibility by DOE, allowing individual laboratories to experiment with their own programs and practices is critical to finding ways to advance private sector partnerships and technology transfer. Additionally, a small increase in the percentage of laboratory funding dedicated to industry partnering, technology transfer and commercialization would go a long way in advancing partnering and commercialization goals. Ongoing evaluation and dialogue with the private sector aimed at making real change, and Congressional attention to addressing barriers is needed to fulfill intended Congressional mandates and Presidential Executive Orders.

Given the current DOE leadership and some dynamic national laboratory directors, there is a window of opportunity for DOE national laboratories to enhance partnerships, collaboration and commercialization. At the writing of this summary, Bill Gates and other philanthropists

have announced major commitments in renewable energy. There has never been a more propitious time to experiment with new paradigms that leverage the nation's enormous national laboratory resources to create partnerships resulting in energy breakthroughs benefitting people nationally and globally, now and for generations to come.