U.S. Manufacturing Competitiveness Initiative

Ignite 2.0

Voices of American University Presidents and National Lab Directors on Manufacturing Competitiveness

Full Report
August 2011

Ignite 2.0: Voices of American University Presidents and National Lab Directors on Manufacturing Competitiveness

Full Report

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The **U.S. MANUFACTURING COMPETITIVENESS INITIATIVE (USMCI)** is led by a CEO-level leadership council and steering committee, comprised of chief executives from industry, academia, organized labor and national laboratories.

An equally diverse and expert advisory committee is helping to shape the substantive aspects of the initiative, as well as providing ongoing counsel and support to the steering committee and Council staff.

Together, these individuals will frame the critical questions, provide the strategic direction, and develop a comprehensive set of actions to ensure a vibrant manufacturing base for America's future.

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From Our Leadership

The Council on Competitiveness launched its U.S. Manufacturing Competitiveness Initiative (USMCI) in June 2010 to tackle the challenges facing domestic manufacturers and drive the dialogue, policies and programs necessary to ensure the long-term health of American manufacturing. Our vision is a reinvigorated, vibrant, diversified and technologically advanced manufacturing sector that produces American jobs, economic growth, prosperity, energy sustainability and an improved ability to meet national security needs.

To inform our efforts, the Council began the *Ignite* report series: a multi-part, interview-driven project capturing insights from diverse leadership groups across the American manufacturing landscape. The first report, *Ignite 1.0: Voice of American CEOs on Manufacturing Competitiveness*, was released in February 2011 and recorded the input of nearly 40 CEOs on the measures necessary to advance U.S. manufacturing.

We are now pleased to share with you *Ignite 2.0: Voices of American University Presidents and National Lab Directors on Manufacturing Competitiveness*. The insights that follow are compiled from a series of interviews with more than 30 leaders in higher education and advanced research. In the coming months, we also look forward to releasing *Ignite 3.0*, which will highlight the perspectives of U.S. labor leaders.

The outcomes from the *Ignite* reports, in conjunction with the ongoing work of the USMCI Steering Committee and Executive Advisory Committee, will form the foundation of the Council's 3rd Millennium National Manufacturing Strategy. This strategy will explore the entire manufacturing ecosystem and the full life cycle of product development to provide a truly comprehensive path forward for U.S. manufacturing. We will present this strategy to private sector leaders, the administration, Congress, governors and other key stakeholders at a national manufacturing summit on December 8, 2011, in Washington, DC.

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Deere & Company

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Chairman, President and CEO
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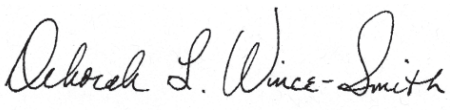

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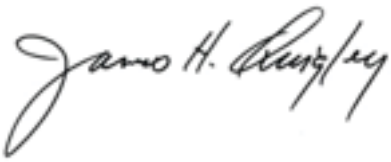


James H. Quigley
Former CEO
Deloitte Touche Tohmatsu

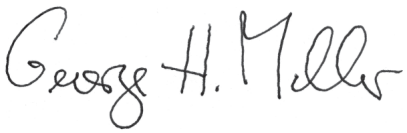
***From left**: Dr. Edward Moses, Principal Associate Director of NIF & Photon Science, Lawrence Livermore National Laboratory; Ron Bloom, Assistant to the President for Manufacturing Policy; Deborah L. Wince-Smith, President & CEO, Council on Competitiveness; Dr. Tomás Díaz de la Rubia, Deputy Director for Science and Technology, Lawrence Livermore National Laboratory before a tour of the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory.*

The NIF boasts the world's largest and most energetic laser, which has the goal of achieving nuclear fusion and energy gain in the laboratory for the first time—in essence, creating a miniature star on Earth.

The Council strongly believes that modern manufacturing is both complex and rapidly evolving. To remain competitive in the global marketplace, sustained cooperation and ongoing collaboration between government, industry, academia and labor leaders is required to effect real change. We feel that the recommendations contained in the *Ignite* report series and the broader efforts of the USMCI represent the highest levels of cross-sector collaboration, and we look forward to advancing our work on manufacturing competitiveness in the coming months.

We would like to extend our sincere thanks to the education leaders and national laboratory directors who have shared their valuable thoughts and insights with the Council. We also want to thank our colleagues at Deloitte for their tremendous support in conducting the interviews and preparing this report. Without their efforts, this project would not be possible.

Susan Hockfield
President
Massachusetts Institute of Technology



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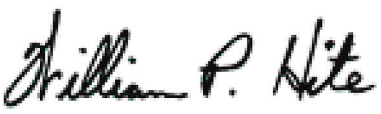

William P. Hite
General President
United Association of Plumbers and Pipefitters

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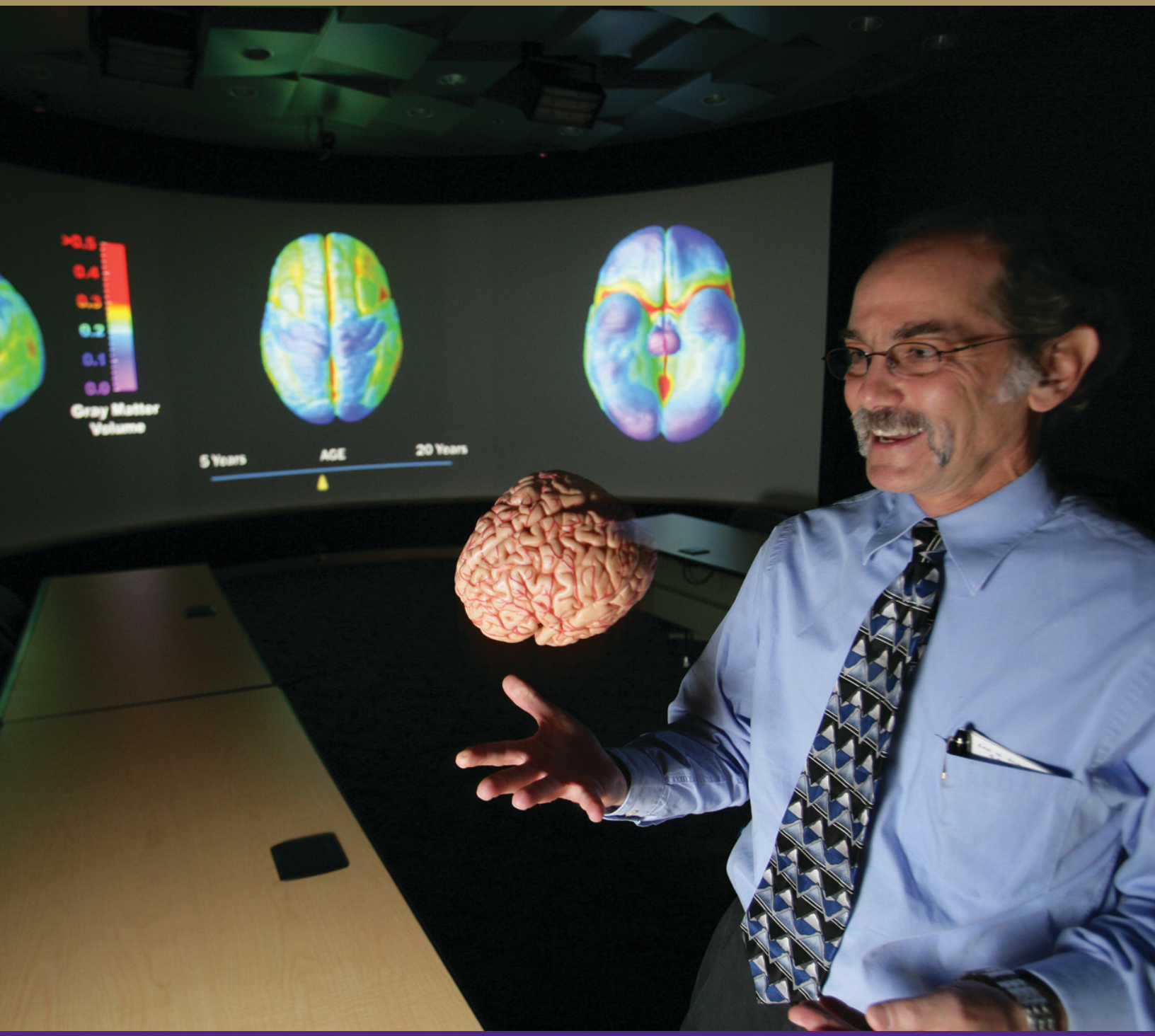


Neurology professor Arthur Toga directs computer science, biostatistics and neuroscience researchers in brain mapping.
Photo by Stephanie Diani, courtesy of the University of California, Los Angeles.

Key Messages

Manufacturing Is Essential for America

A robust American manufacturing sector advances national security and defense readiness, increases exports and catalyzes economic growth across many sectors of the U.S. economy. Moreover, a strong U.S. manufacturing base plays a critical role in America's energy security by creating opportunities to lead the development of alternative energy sources and thereby reducing the United States' reliance on foreign oil. The manufacturing base also creates high-value jobs for middle-class America, and its multiplier effect cultivates a network of supporting service sector jobs. Most importantly, however, manufacturing is vital to America's innovation ecosystem. The United States must articulate a globally competitive, long-term innovation and manufacturing strategy that identifies inspirational goals and achievable steps to keep America in the business of innovating and "making things."

A welder modifies newly designed jets that spray steam into the condensers at The Geysers geothermal power plant. With a 750-megawatt output from 14 units, The Geysers is the largest producer of geothermal power in the world.

Photo courtesy of the National Renewable Energy Laboratory (NREL).

Translational Pathways for Innovation Must Be Bolstered

The closed-loop product development cycle, spanning from idea to process and product generation, flourishes when an intimate and co-located research and manufacturing connection is encouraged. Co-location enables continuous product and process improvement through the symbiotic relationship which exists between the manufacturing and innovation processes. A manufacturing innovation ecosystem that promotes the maturation of basic research to applied research, and encourages the transition of pilot projects into the full commercialization of new ideas, is needed to enhance the quality, impact and return on investment of breakthrough discoveries. The United States must create the right incentives and allocate enough resources to generate new ideas, develop these ideas through focused research, and in turn, start new businesses that produce well-paying jobs.

Superior Talent Is the Key to America's Competitiveness

In today's borderless economy, the United States must be the global leader in attracting, developing and retaining top science and engineering talent to drive world class innovation and R&D. This demands an education system that arms students with advanced science, technology, engineering and math (STEM) skills, creative problem solving skills, entrepreneurial training and leadership skills. America's 'secret sauce' for success lies in a workforce equipped with the science and math backgrounds to compete with the best, and the

creativity and leadership to be pace setters for the world. Educational institutions should establish programs to engage top talent with manufacturing firms to advance the U.S. manufacturing innovation ecosystem.

America's K-12 Education System Needs to Be Improved to Create the World's Most Desired Talent Pool

Primary and secondary level students need teachers who are subject matter experts in STEM disciplines. These experts are better equipped to educate and inspire students to pursue the advanced STEM education and career opportunities that will drive growth of the U.S. economy for years to come. Educators must move away from the persistent focus on pedagogy and return classroom focus to superior content and student performance. Flexible pathways for advanced degree acquisition and certifications must also be established through collaboration across K-12 schools, universities and, in particular, community colleges—which are instrumental in ensuring students are armed with requisite university-level skills perhaps not attained at the secondary level and/or offering flexible pathways to advanced vocational certifications. These programs will spawn creative, multi-disciplinary leaders who will enable the next generation of innovations to flourish.

National Laboratories and Higher Learning Institutions Are Gems that Must Be Protected

America has developed an unparalleled network of national laboratories and higher learning institutions, including universities and community colleges. These valuable assets set the United States apart from other nations and are a critical component of America's competitive advantage that must be protected and kept strong through thoughtful policy setting and stable funding models. This will ensure that these institutions continue to achieve the insights and advances that have become a hallmark of U.S. innovation. Policymakers should ensure that they "do no harm" to our most valuable resources when addressing the urgent deficit and budget challenges facing the federal and state governments.

Collaboration Enhances America's Ability to Compete

Colleges, universities, national laboratories and the public and private sectors must collaborate, devising new ways to incentivize innovation and commercialization. Successful innovation hubs generate breakthroughs and develop mutually beneficial, long-lasting partnerships. These partnerships are the heart of many regional economies and self-perpetuate by engaging and inspiring students to become America's next generation of innovators.

Government Policies Need to Address Uncertainty and Encourage Business

Several public policies should change to foster a competitive business environment and encourage the world's leading researchers to pursue careers in state-of-the-art facilities in the United States. Such policies include the tax code, patent processing, intellectual property protection, immigration, export controls and funding for research and facilities.

Summary of Recommendations

Recommendations denoted in italics were also outlined as recommendations in *Ignite 1.0*.

Developing Talent and Skills for the 21st Century

1. Ensure that our "current gems", such as our universities and national laboratories, remain the greatest in the world by "doing no harm," i.e. continue to contribute to U.S. competitiveness by maintaining long-term, predictable and steady support for these institutions.
2. Adopt more stringent and consistent standards for STEM disciplines throughout the entire educational system in the United States. These standards should be tied to metrics in other leading manufacturing economies.
3. Improve and incentivize primary and secondary teacher programs in the STEM disciplines to develop educators who are subject matter experts and better able to prepare students for advanced degrees or certifications programs. Offer incentives, such as continuing education opportunities, for current STEM educators while simultaneously focusing on the next generation with college scholarship programs that attract top high school talent to post-secondary STEM education. Like college and university professors, develop discipline-linked salary tiers in the K-12 systems to entice teachers to become subject matter experts and reward them for doing so.
4. *Benchmark best practices from other countries and reform immigration policies to better attract the world's most advanced workforce, and retain foreign talent educated in American universities upon graduation.*
5. *Advance performance-based legislation and incentives like the America COMPETES Act, the Elementary and Secondary Education Act, Investing in Innovation, Race to the Top and Teacher Incentive funds.*
6. Develop long-term programs that inspire and glorify careers in research, engineering, and other areas of science, technology and mathematics. Begin aggressively marketing to the next generation with focused, creative, and impactful programs targeted at today's and tomorrow's students…and parents.
7. *Develop federal and state programs that promote and market manufacturing as a high-value, vital industry with rewarding long-term career opportunities for high school and college students in the United States.*
8. Build government-industry partnerships that incentivize workers to pursue careers in science, engineering and manufacturing.
9. Ensure adequate support for the "manufacturing innovation ecosystem" and research and science infrastructure.
10. Replicate best practices from disciplines like health care to make work experience mandatory at the secondary and post-secondary education levels.

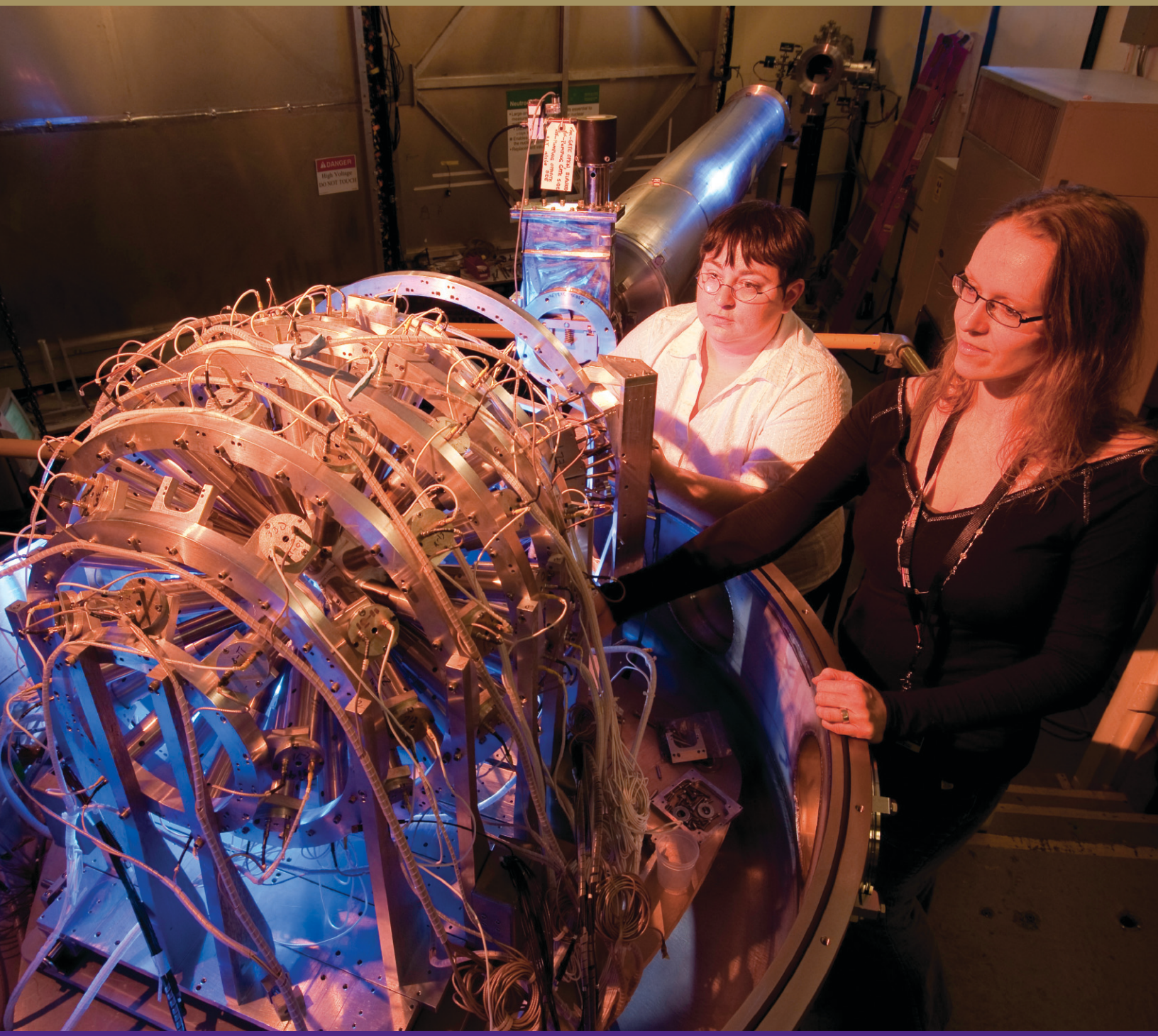
Fueling Science, Technology and Innovation

1. *Establish a consortium of business, university, labor and public sector leaders to develop daring strategic long-term goals with a 15 to 20 year development horizon around science, technology and manufacturing.*

2. Develop a U.S. innovation strategy that establishes programs to feed an innovation pipeline through full life-cycle commercialization and supports both basic and applied research. The strategy should also break down barriers to collaboration between universities, laboratories and the private and public sectors.
3. Create long-term mechanisms that insulate funding programs from election cycles and changing administrations.
4. Create a system that seeds innovation and helps avoid multiple "valleys of death" by establishing translational pathways that are supported by the private and public sectors and include enabling mechanisms to drive innovative ideas and technologies through to commercialization.
5. Fuel private investment by ensuring globally competitive corporate tax rates and strengthening and making permanent research and development tax credits, especially for U.S.-based innovation.
6. *Tax credits should address both human capital, and include support for continuing education for scientists and engineers, as well as R&D equipment and infrastructure to ensure the United States remains an attractive destination for long-term investment in innovation and manufacturing.*
7. *Increase the number of public-private initiated industry clusters that convene research institutions, industry and the best talent to focus on advancing research and full life-cycle commercialization. Ensure there is a process in place to identify and revise the essential components required for the clusters to continually meet changing market demands.*
8. Focus on sectors of strategic importance to the United States, including national security, defense and energy, as well as emerging sectors that serve as hot beds for rapid, concurrent research and innovation.

The Role of Colleges, Universities and National Laboratories in Improving U.S. Competitiveness

1. Continue to support community colleges and universities as catalysts for innovation and competitiveness through long-term government funding programs like the America COMPETES Act, the Carl D. Perkins Career and Technical Education Act and various research grants.
2. Continue expanding the role of American universities to serve as economic development engines. Create conduits that connect talent and ideas at the university with the private sector and the local community in regional clusters.
3. Implement university programs that promote student interest in math, science and manufacturing.
4. Utilize community colleges more effectively to develop a skilled workforce with the requisite vocational skills to support technology commercialization and manufacturing.
5. Ensure that national laboratories develop mission-driven innovations that are crucial to national interests, while broadening the definition of national interest to include impactful economic development. Continue to leverage America's national laboratories' ability to drive applied research on the journey to commercialization, but establish succinct and concise goals that focus on areas important to the United States both for economic development as well as national security, defense, energy, etc. Support their role in community outreach programs, such as educational outreach for local primary and secondary schools, nearby corporations, and the community.



Micha Kilburn, graduate student (left), and Daniela Henzlova, research associate (right), of the Michigan State University National Superconducting Laboratory. Photo courtesy of Michigan State University.

Education, Research and U.S. Manufacturing Competitiveness

For much of the 20th century, the United States was recognized as the world's greatest innovator and leading manufacturing economy. Driven by scientific and technological challenges important to the nation and the world, the United States has been responsible for innovations like supersonic flight, space exploration, chemotherapy, lasers, integrated circuits, mobile phones, GPS and personal computers. America's strong industrial base and skilled workforce enabled many of these innovations to be commercialized, generating prosperity for America and laying an economic foundation that continues to drive the U.S. and global economies.

Today, the United States is still recognized as the world leader in research and post-secondary education. However, a number of global and domestic factors have contributed to a steady decline of U.S. manufacturing, which represented approximately 26 percent of nominal GDP in 1947 and today makes up less than 11 percent.[1] This decline in U.S. manufacturing has negatively impacted American competitiveness and the country's ability to produce and scale leading innovations. According to the *2010 Global Manufacturing Index*,[2] the United States ranks fourth in global manufacturing competitiveness behind China, India and South Korea. Moreover, the *Index* suggests the United States will fall to fifth by 2015 as these countries and others continue to develop manufacturing-based economies supported by strong infrastructures, robust education programs and pro-business public policies. The multiplier effect of these efforts has created strong domestic economies that attract additional direct investment and create middle-class workforces that grow more prosperous and competitive.

To advance the work begun in the *2010 Global Manufacturing Index*, and to better understand the steps the United States must take to improve its manufacturing competitiveness, the Council and Deloitte[3] conducted a series of interviews in the fall of 2010 with approximately three dozen CEOs and other senior executives. These executives' companies range in size from small start-ups to some of the world's largest manufacturing companies. The findings of those interviews were released in January 2011 in *Ignite 1.0: Voice of American CEOs on Manufacturing Competitiveness*.

In an effort to build on the insights identified in *Ignite 1.0*, the Council and Deloitte once again collaborated to conduct a series of interviews with leaders of America's top colleges, universities and national laboratories for *Ignite 2.0: Voices of American University Presidents and National Lab Directors on Manufacturing Competitiveness*. The university presidents and national laboratory leaders who contributed to this report broadly agree with the recommendations outlined by *Ignite 1.0* executive participants. In particular, the *Ignite 2.0* respondents emphasized that manufacturing is important for the United States, and noted the following three reasons why a strong manufacturing sector is critical to America's competitiveness in the 21st century:

1. Manufactured goods account for nearly 60 percent of all U.S. exports, which is an essential component of the national economy.
2. America's unparalleled ability to innovate, apply new ideas and manufacture critical products and systems is inextricably linked to national defense and energy security.

3. Manufacturing jobs require a highly skilled workforce which traditionally fuels the growth of a prosperous middle-class and has a positive impact on the U.S. economy.

University presidents and national laboratory leaders felt that a highly skilled workforce was the number one factor positively impacting U.S. competitiveness. Like their CEO counterparts who participated in *Ignite 1.0*, they identified talent-driven innovation as the lynchpin to U.S. competitiveness.

Respondents also noted a number of primary, secondary and post-secondary education system challenges, and numerous public policy issues—including taxes, trade and immigration—that were consistent with *Ignite 1.0* findings. Finally, *Ignite 2.0* participants pointed to issues impacting the ability of the United States to research and commercialize ideas and new technologies.

To address these challenges, participants outlined a set of recommendations which they felt were most critical to developing a skilled workforce and improving America's global competitiveness in the 21st century.

Approach & Methodology

In May 2011, Deloitte interviewed approximately 30 leaders of American colleges, universities and national laboratories. Participants were asked to provide their perspectives on the U.S. economy for the next two to four years and the U.S. economy through year 2025. They were also asked to address the importance of America's ability to "make things," both in the context of the domestic economy and America's prosperity in the 21st century.

Finally, respondents were asked to provide their perspectives and recommendations on the following areas.

- **Developing Talent and Skills for the 21st Century:** What should be done to ensure the United States is the most attractive, most capable and most successful nation in the world for workforce talent and skills development?
- **Fueling Science, Technology and Innovation:** What is necessary to ensure that U.S. science, technology and innovation capabilities provide an ongoing global competitive advantage to America's manufacturing sector?
- **Defining the Role of Colleges, Universities and National Laboratories in Improving U.S. Competitiveness:** What is the ideal role for America's community colleges, universities and national laboratories to play in improving U.S. global competitive capabilities in the future? Will that role evolve?

Perspectives Regarding America's Economic Future

Overwhelmingly, the university presidents and national laboratory leaders participating in this report expressed a sense of pride in America's ability to innovate and conduct research addressing complex scientific, technological and social challenges. America's accomplishments and contributions to the global community in these fields are considered to be unrivaled by the interviewees.

Respondents were cautiously optimistic about the future of the U.S. economy and America's long-term prosperity, though the optimism expressed by many came with a number of caveats. In the short-term, participants felt that the U.S. economy was recovering, yet tempered expectations by suggesting that growth and job creation would remain very slow during the next two to four years. Respondents cited a number of reasons for this slow growth, including ongoing corporate uncertainty over economic and policy issues, significant federal and state deficits and budget concerns, continued volatility in the housing markets, sovereign-debt concerns in Europe and the sense that little progress would be made by policymakers over the next several years because of upcoming elections and repeated failures by lawmakers to engage in constructive dialogues.

Some participants felt the United States is now at a point of inflection, with an increasingly divided economy becoming a real possibility if action is not taken to address the challenges outlined above. Specifically, participants indicated that the economy would likely divide into skilled and unskilled workforce factions. One side of this divide would be represented by a minority of the workforce that will continue to excel professionally and financially by leveraging strong, STEM based education and maximizing professional ability through ongoing skills cultivation and training. By contrast, the balance of the workforce would be comprised of workers deficient in quality education, STEM literacy, training and skills. These underdeveloped workers would be relegated to performing low paying, low value jobs and would likely be dependent on some type of government safety net to support themselves and their families financially.

Despite those concerns, interviewees were optimistic that the United States could have a bright, long-term economic future. There was a feeling that a stronger economic system would emerge in the United States in the next five to 10 years as a result of actions taken by federal and state policymakers during the downturn, a process described by one university president as a "fundamental resetting of our financial system."

There was universal agreement that the U.S. economy has tremendous potential to fuel growth domestically and abroad. To reach a bright economic future, however, respondents pointed to the need for the United States to reduce the federal deficit and meaningfully address the deficiencies in the U.S. primary and secondary education systems.

In particular, participants felt that primary, secondary and post-secondary education in the United States needs to place a significant and renewed emphasis on the importance of science and technology research—both basic and applied—and manufacturing. They also highlighted the need for the United States to rededicate itself to being a nation that "both innovates and makes things," thereby fostering the success of entrepreneurs and institutions. Most felt the United States has the will, the talent and the resources to be extremely successful, but only if there is a clear understanding that America's position of leadership in the global economy is not assured, and past accomplishments and successes, however significant, are not sufficient to keep America on top in the fiercely competitive international arena.

Photographs at right courtesy of the California Institute of Technology.

The Manufacturing Innovation Ecosystem

Understanding the way in which the university presidents and national laboratory leaders characterize manufacturing, and the role the manufacturing sector plays in the broader economy, is essential to properly position the recommendations outlined in this report. All participants noted the importance of manufacturing to the U.S. economy in the 21st century, and cited the following items:

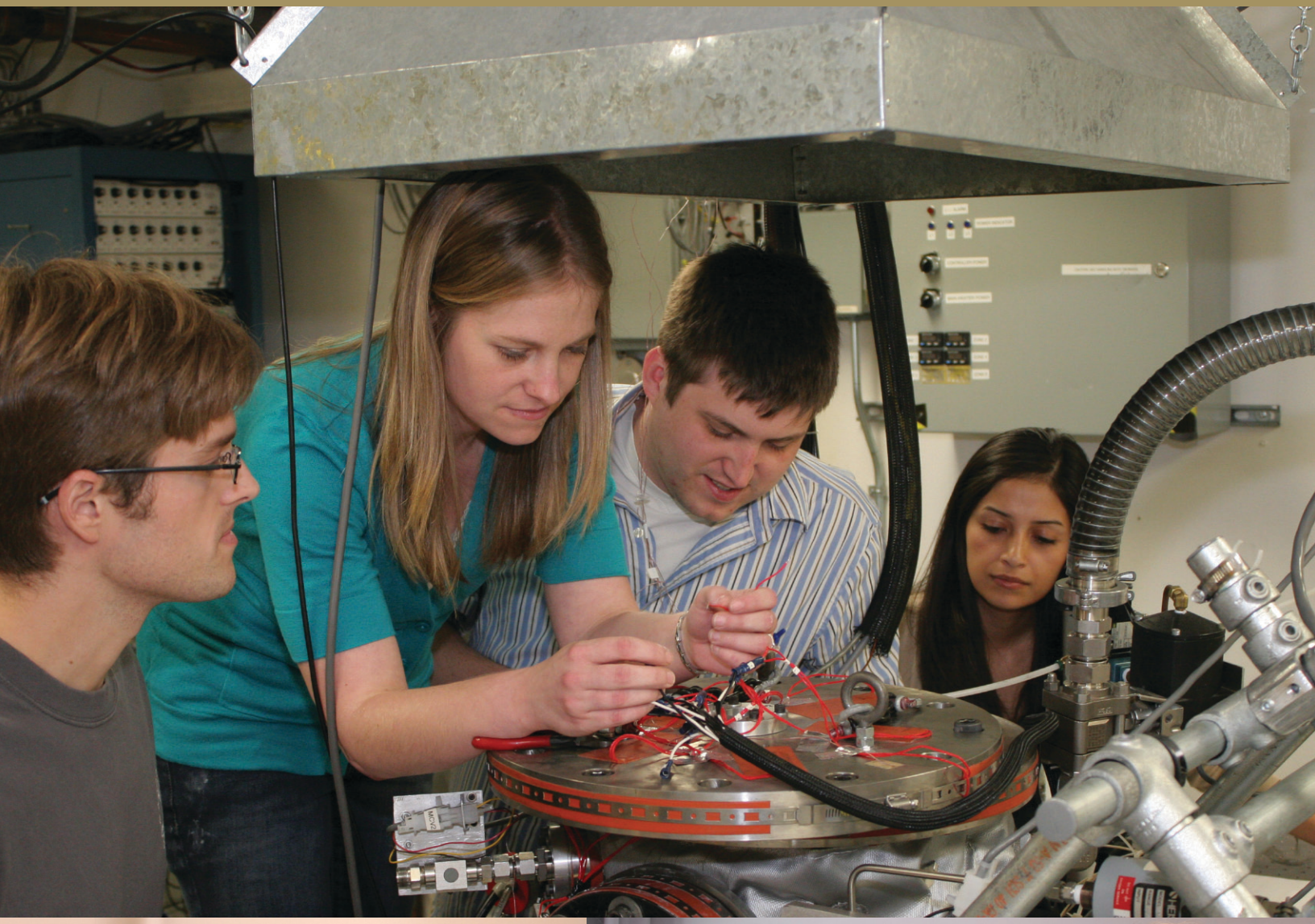
1. The practical and real connections to U.S. defense and national security.
2. The positive impact of high paying manufacturing jobs.
3. The multiplier effect of the manufacturing sector, which typically generates 2.5 jobs in related industries for each job created in the chain of manufacturing activity,[4] including the creation of service-related jobs for the middle-class.

Participants indicated that the term "manufacturing" is a misnomer, as it no longer accurately captures the interplay between the manufacturing and innovation processes. They also suggested that "manufacturing" fails to address the role the sector plays in the development and growth of a robust and prosperous economy. As a result, many felt that manufacturing is misunderstood, and suggested that America's youth and many others, including policymakers, fail to grasp the need to bolster the manufacturing base. This leads to an undervaluation of the manufacturing sector in the eyes of the general public and in federal and state policies.

Participants emphatically described the symbiotic relationship between manufacturing and innovation in an ecosystem that extends to include colleges, universities, national laboratories and the private and public sectors. They also touched on the tremendous contribution of the manufacturing sector to both the past and future economic success of the United States.

Interestingly, each interviewee independently refuted the idea that America can maintain its competitive advantage in research and scientific discovery without also maintaining its superiority in manufacturing. During many interviews, participants dedicated significant portions of time to provide detailed explanations of how basic research is leveraged and applied through pilot projects and scaling new ideas and inventions. One university president drew an analogy between America's manufacturing and agriculture sectors, suggesting that the United States would not be the world's leader in agriculture science[5] and global leader in food production had it failed to retain a critical understanding of the business processes required to produce crops and livestock.

While no participant felt that low-skilled, commoditized manufacturing would return to the United States, or considered it necessary to advance America's global competitiveness, nearly all respondents believed that superior innovation is dependent on experimenting and learning from a closed-loop manufacturing-innovation ecosystem. In commenting on the closed-loop process, participants described innovation as the creation of all elements of the closed-loop product development cycle, from initial idea creation to process and product generation. Critical to the process was the development of translational pathways that help build ideas into innovations, and innovations into products. And while not required in all cases, co-location and intimate and sustained collaboration between basic researchers, applied researchers, engineers and manufacturers was identified as an essential ingredient, leading to greater innovation of both product and process.




Avant

Further, participants felt that innovation of product and processes peaks when synergies created through closed-loop, co-located manufacturing and research are maximized. They felt that if the United States closed its doors to manufacturing, the overall long-term ability to develop breakthrough ideas would be compromised because critical feedback loops would not exist to propel the innovation cycle forward. As other economies continue to invest in manufacturing—setting their sights upstream toward advanced basic and applied research and advanced manufacturing capabilities—participants expressed concern that the role of the United States would become increasingly limited, and that America's workforce would become even more vulnerable to competitive challenges from emerging manufacturing economies.

Some participants also described the unintended, long-term consequences of allowing lower skilled, commoditized industry sectors and manufacturing jobs to leave the United States for lower cost locations around the world. Televisions, invented and at one time manufactured in the United States, were one notable example of the unintended consequences of such moves. As a result of moving television production to Asia, some argued the United States missed the opportunity to develop next generation flat panel televisions, a competency that years later proved instrumental in the design and manufacture of solar panels.

Similarly, many shared perspectives on the critical missing link of sufficiently funded and prioritized applied research in today's manufacturing innovation ecosystem. Participants noted the void left when monopoly protected Bell Labs and other important basic and applied research centers vanished. Many felt organizations like Bell Labs were critical in moving ideas and inventions through what they called the "valley of death" to commercialization. By contrast, many of today's advanced research universities and national laboratories cannot navigate through the "valley of death" because of prohibitive funding, scale and mission directive issues with which they must contend.

Beyond facilitating the commercialization process, entities like Bell Labs also provided a destination for top graduates of advanced science and engineering programs, and were magnets for attracting, developing and retaining superior science talent. Respondents consistently indicated that policymakers and those directing research grants often misunderstand the role and importance of applied research to the innovation process, and fail to grasp the negative consequences of not allowing for that process to occur.

Interviewees frequently suggested that too often, good ideas and basic research become commercialized products in competing countries in which applied research, pilot manufacturing and plant development projects are more easily and patiently funded. Participants were also clear that funding is not meant to supplant the role industry must play in the product development lifecycle. Similarly, they indicated that government or grant-funded basic research is not meant to simply drive the creation of new businesses. Rather, it is meant to enhance and encourage the complete innovation process while capturing the full benefit of exceptional, publicly funded basic research, including new, technologically advanced products, processes and critical high-paying jobs.

Participants described the complex nature of research policy and addressed the key differences in how the United States funds and directs particular types of research. They noted that, for example, research in areas deemed of strategic importance to the United States—such as national security, nuclear weapons and energy—are funded much further through the "valley of death," essentially toward full-scale manufacturing and commercialization.

Conversely, funding and missions are curtailed for all but basic research in areas not clearly tied to select national strategic initiatives, though the unknown, long-term benefits of this research may be of equal or greater strategic and economic value.

The question of inconsistencies in funding and policy for the U.S. innovation system was also addressed by participants. Some stated that the system is functional, and pointed to examples to reinforce their claims. One often used example was Silicon Valley and the new technologies and consumer electronics products that have successfully traveled through the "valley of death" on the journey to commercialization.

It should be noted, however, that many felt that the innovation-to-commercialization process was different in Silicon Valley, suggesting that the Silicon Valley system operates with smaller capital requirements and risk scales than the systems needed to push large, complex manufactured goods through the "valley of death."

In addition, some participants noted concern with what they described as short-sighted, Wall Street, quarterly earnings driven perspectives that reward business executives based on short-term performance and profits. The result, in the absence of entities like Bell Labs, is a void in private sector funding for long-term R&D. This is further exacerbated by the lack of permanent government incentives that reward investment in and funding of R&D throughout a long development process from basic research to full commercialization.

This is not a new insight and has been recently acknowledged by a number of policymakers. As an example, in his remarks to the President's Council of Advisors on Science and Technology (PCAST) in 2010, former United States Commerce Secretary Gary Locke said, "America has a broken innovation ecosystem that does not efficiently create the right incentives or allocate enough resources to generate new ideas, develop those ideas with focused research and turn them into businesses that can create good jobs. America simply does not have an efficient system to take new ideas from government, academic and private sector research labs and translate them into commercially viable products and businesses." Many of the *Ignite 2.0* participants echoed these sentiments and referenced Secretary Locke's "broken innovation ecosystem" during the interview process.

Many participants felt the United States should assume greater responsibility for moving outstanding, government-funded basic research farther through the "valley of death." They shared that greater emphasis should be placed on areas where innovations can flourish and result in societal benefits and U.S. job creation. Respondents were clear that this idea should not be confused with an industrial policy that picks winners and losers. Instead, they suggested that the world has changed and that funding new ideas and basic research only has serious unintended consequences for the nation's manufacturing innovation ecosystem and prosperity.

Finally, it is important to note that respondents were realistic about the budget deficit and implications, and were clear that their recommendations were not attempts to gain additional funding for their respective institutions. Instead, participants indicated an eagerness for policymakers to do no harm, and broaden the understanding, tolerance and importance for the basic-to-applied research connection and the manufacturing innovation ecosystem. Many felt that doing so would effectively raise the expectations and the standards for the "return on investment" to the United States for funded research, and raise the prospects for America's economy in the 21st century.

Talent as the Catalyst for Competitiveness

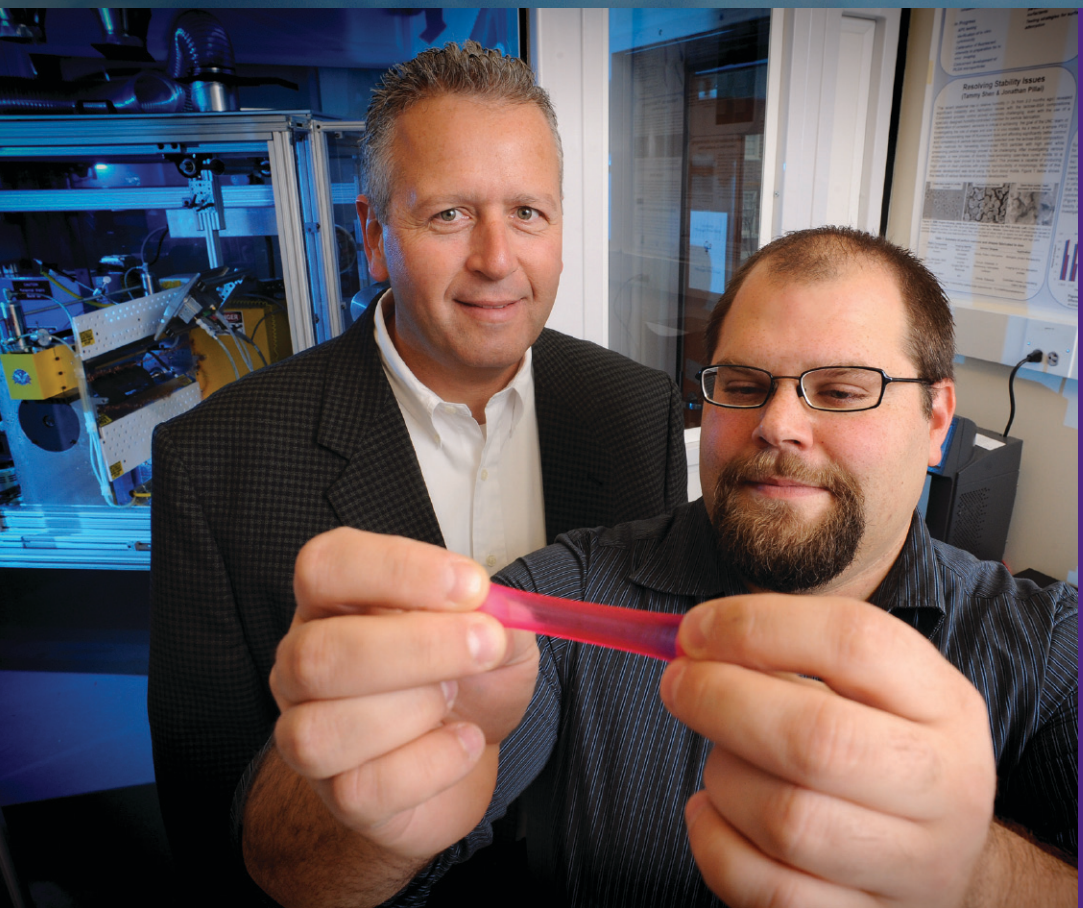
Both university presidents and national laboratory leaders described America's manufacturing innovation ecosystem as an integrated chain—one which is only as strong as its weakest link. To be globally competitive, America's entire system needs to be strong, streamlined and responsive for people and ideas to thrive. By extension, talent was identified as the most critical element of U.S. competitiveness by all interviewees. In fact, talent was described as both the key differentiator of America's competitive edge in the 20th century and the most critical determinant of success in the 21st century. Participants were emphatic, stating that talent is the catalyst for innovation, competitiveness and prosperity.

During all the interviews, however, it became clear that participants felt America's talent edge was under attack on several fronts, and that the long-term negative consequences of these challenges could be profound. Specifically, participants spoke often and energetically about:

1. A K-12 "feeder system" failing to produce the quantity of qualified STEM-educated students necessary to drive an advanced manufacturing innovation ecosystem in the 21st century.
2. Budget cuts and cost pressures jeopardizing programs and capabilities of colleges and universities to maintain America's dominance in post-secondary education quality, and additional incidental damage to an already broken K-12 system. Further, more budget pressures at national laboratories jeopardize the ability for labs to conduct breakthrough research and to attract and retain the world's best researchers and scientists.
3. Restrictive immigration policies that make it difficult to encourage the long-term immigration of superior talent to the United States.
4. More aggressive recruiting of U.S. educated talent in science, math and engineering by other developing nations, both those born outside and inside the United States.

Many participants felt that education and talent were becoming the weakest links in the manufacturing ecosystem, suggesting that over the last several decades, the United States has begun stepping away from its commitment to education and is putting its tremendous advances at risk. And, as a result, is putting the "social contract" that got America to where it is today at risk. Many participants recalled that prior to the 1970s and 1980s, the United States maintained an unwavering commitment to provide its citizens with a strong education and a foundation of critical skills on which to build careers and livelihoods—regardless of race or economic or socioeconomic status. As a result, students educated in America became the envy of the world. These students were able to work smarter, contribute to extraordinary productivity, innovate and translate new ideas and inventions into advanced products better than their global peers.

Some participants also felt that America's commitment to education was truly the embodiment of the American Dream, sharing that the United States is the only place in the world where people know anything is possible with a good education and hard work. Consequently, the United States has consistently attracted the world's most motivated, inspired and talented individuals.



Top: *Dr. Rachel Noble of the UNC-Chapel Hill Institute of Marine Sciences examines water samples in her lab taken from a beach near Morehead City.*

Bottom: *Graduate student Timothy Merkel and Professor Joseph DeSimone stretch out a sample of the squishy hydrogel polymer they used to make synthetic red blood cells.*

In the background is a reel-to-reel system which enables the researchers to manufacture large quantities of such particles. Dr. DeSimone is a member of the U.S. Manufacturing Competitiveness Initiative (USMCI) Executive Advisory Committee

Photographs courtesy of The University of North Carolina at Chapel Hill.

Discussing the four challenges in greater detail, many felt that teaching practices at the K-12 level, and post-secondary educator training programs, have moved away from a model in which teachers possess strong subject matter content and toward the pedagogy of teaching, resulting in critical deficiencies, most notably in the STEM disciplines. Participants described innovation and talent as two sides of the same issue, sharing that ideas and innovation begin with talented human capital. Scientists begin as students, whose potential is often limited by the quality of their teachers and the programs in which their skills are nurtured and developed. Many participants also detailed the interplay between education and research, suggesting that exciting, breakthrough research has as much upstream opportunity to positively impact the U.S. economy through commercialization of new technologies and inventions as it has downstream potential to develop tomorrow's generation of scientists and engineers.

To remain global leaders in talent cultivation, education systems in the United States must begin with a robust K-12 curriculum and bright, capable teachers. Respondents identified a critical need to ensure that America's K-12 system approaches STEM disciplines with the rigor necessary to prepare students for post-secondary education. They also indicated that the nation's community colleges share responsibility for imparting the requisite skills for students to excel in post-secondary education environments. Elaborating, many stated that community colleges are uniquely positioned to re-educate and certify students and teachers in STEM disciplines, to provide additional STEM education for under-prepared students before they move on to four-year universities and to promote manufacturing careers through vocational training programs.

Respondents unanimously said that, while the process of teaching was important, quality content should remain the central focus of K-12 education, and that the pendulum had swung too far and for too long toward process and methodology at the expense of students developing STEM proficiency.

Many participants also felt that a balance of STEM and arts education is necessary to ensure the United States is developing creative problem solvers capable of leading the world in innovation and manufacturing. Several suggested this might also give rise to more executive-level leaders with strong STEM backgrounds, citing that at present, only 20 percent of Fortune 500 CEOs have an engineering degree, and that fewer than 50 members of Congress have a STEM background.

Second, many felt the United States has lost sight of the importance of providing a "strong education for all," as evidenced by consistent budget cuts to education programs at the federal, state and local government levels, and declining achievement metrics for American students when compared to their peers worldwide. All interviewees felt the United States must maintain its position of leadership in post-secondary education if it hopes to continue attracting top domestic and foreign talent. Respondents again pointed to the need for lawmakers to adopt a "do no harm" approach to ensure this competitive advantage is not lost.

Recognizing that the prevailing economic environment in the United States makes increased funding for education unlikely, respondents emphatically stated that continued reductions in education spending would have a pervasive and negative long-term impact on the United States' ability to educate a world class workforce. They also stated that continuing cuts would adversely affect America's research and development cycles, fundamentally compromising the ability to develop high-value added goods and services moving forward. While many acknowledged that these sentiments may seem self-serving, and all agreed that the amount of money spent on

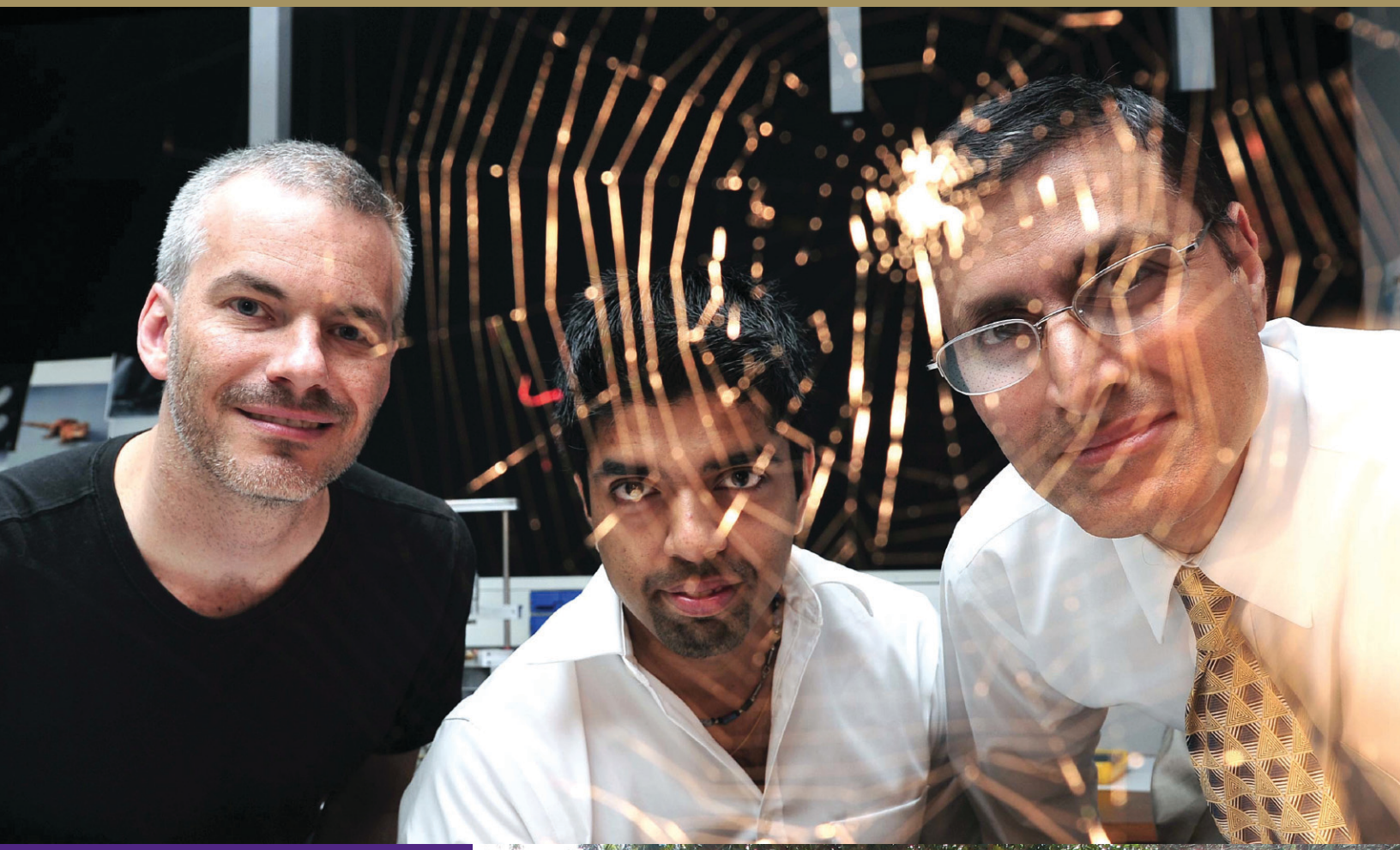
education was not a predictor of success, strong consensus remained for the need to maintain funding at present levels at the risk of causing irreparable harm to America's talent and R&D pipelines.

Third, *Ignite 2.0* participants echoed the sentiments expressed in *Ignite 1.0*, stating that to compete effectively in today's global market, the United States needs access to top science and engineering talent from around the world to drive cutting-edge innovation and R&D. To ensure access to this talent, America requires policies that will improve and streamline the ability to attract and retain top tier students, experienced scientists, engineers and researchers from around the world.

Many indicated that the immigration policies needed to facilitate the flow of outstanding talent into the United States were being held hostage by pressing border control and national security concerns. They felt that policymakers must proactively seek solutions that ensure national security and allow talented students and professionals to live and work in the United States. Failure to enact these necessary changes will compromise America's innovation economy, as top talent will flow to the countries that are better able to manage immigration and security concerns.

Fourth, and again consistent with the CEO respondents, university presidents and national laboratory leaders stressed that developing and retaining the best talent is a key area where countries and companies will increasingly compete in the 21st century. Many interviewees indicated that America's historic position of leadership has been taken for granted, and that emerging competition will challenge this role without swift and timely action. Though once considered the most attractive site for R&D, the United States is slowly losing ground to countries like China, where significant investments are being made in research, and top talent is being actively recruited with a clear and deliberate strategy. The United States needs to recognize that competition for talent is global in scale, and respond accordingly. Participants stated that America must provide attractive environments in which to conduct research, and that these environments must be supported with consistent, adequate funding and a committed strategy. In particular, respondents pointed to the need for significant investments in both top-notch infrastructure and talent compensation. Unanimously, participants believed that a compromised ability to both attract and retain highly-skilled scientists, researchers, engineers, teachers and students will cripple American competitiveness as other countries develop the supporting systems and strategies to encourage talent to immigrate to their shores.

Finally, participants noted the need to ensure that the U.S. manufacturing innovation ecosystem provides attractive and plentiful career options in the public and private sectors. They consistently highlighted the need for career paths in education, research and engineering to be strengthened and supported in an effort to mitigate the loss of talent to foreign economies at all levels of the manufacturing ecosystem. They also reiterated support for the business environment and policy recommendations articulated in *Ignite 1.0*, suggesting that these items are critical to revitalizing and sustaining the U.S. industrial base. Students, workers, entrepreneurs and investors all need to see that the process of realizing innovation from concept to commercialization is robust, efficient and rewarding in the United States.



Top: *Todd Blackledge, Leuchtag Professor of Biology; Vasav Sahni, Ph.D. candidate; and Ali Dhinojwala, chair of the Department of Polymer Science and Morton Professor of Polymer Science reveal the secret behind the stickiness of spider web silk.*

Bottom: *During a trip to Madagascar, Dr. Teena Jennings, associate professor of family and consumer science, traded moth silk harvesting techniques with women she met there.*

Photographs courtesy of The University of Akron.

Consequences of Uncertainty

Building on the perspectives captured in *Ignite 1.0*, university presidents and national laboratories leaders expressed an overarching concern for the consequences of legislative, policy and strategic uncertainty. Typically, these concerns were tied to the implications of funding instability and inconsistency. However, some participants also commented on current R&D tax credits and, like CEO respondents participating in *Ignite 1.0*, felt that permanent R&D tax incentives for basic and applied research would help mitigate uncertainty. Repeatedly, participants shared that uncertainty inhibits productivity in a host of ways, and in doing so impedes innovation. Although an increase in funding would be welcomed, most respondents indicated they would prefer a consistent, long-term funding stream instead of the peaks and valleys that characterize today's political climate and funding models.

Participants argued emphatically that universities and national laboratories engaged in important research need insulation in the short-term and stability in the long-term to allow researchers the flexibility to take unconfined risk and to allow ideas to flourish. Participants consistently noted that scientific discovery often has a much longer time horizon than U.S. political election cycles, a reality which creates significant budgetary uncertainty as research funding often changes with elections. Furthermore, persistent strains on federal and state budgets are creating a sense of uneasiness that the current, reduced funding levels will be cut even further.

While all participants were clear that America's budget deficits at the federal and state levels must be addressed, they agreed that a stable and consistent funding stream remains essential to drive the groundbreaking innovations which have come to define the American economic landscape.

Funding inconsistency, coupled with wavering strategic goals and unexpected alternations in missions, not only interrupts research efforts and curtails innovation, but also adversely impacts America's ability to retain top talent. Stability is essential to enable long-term research, commit to the development of world class infrastructure, encourage unconstrained curiosity and attract and retain the best and brightest researchers.

Policy uncertainty also directly and negatively impacts the way in which institutions pursue competitive research grants, and by extension, U.S. innovation potential. An operating environment characterized by pervasive funding uncertainty leads scientists, researchers and research centers who are dependent on fluctuating funding to frequently submit proposals that are a "sure thing," rather than riskier, loftier, potentially game-changing project proposals. In addition, the short-term nature of present funding and grant models does not encourage the best ideas to reach the commercialization stage in which the U.S. economy can reap the benefits of its investment in R&D. In articulating these challenges, participants drew a line of distinction between innovation and innovation realized. As one university president noted, "an idea is not an invention, an invention is not a product and a product is not a business."

Finally, many argued that funding uncertainty now overshadows the overall process of innovation in America. Respondents stated that the U.S. manufacturing sector and broader economy would be better served by clear and committed long-term innovation strategies, pursued in conjunction with stable funding and policies.

Recommendations in Detail

To address the global competitiveness of the United States, those participating in *Ignite 2.0* felt the following recommendations must be adopted for U.S.-based manufacturing to drive America's prosperity in the 21st century. They felt that both the federal and state governments should play a strong role in investing in critical drivers of the economy, such as innovation and manufacturing. In addition, the participants shared the belief that nations which have well-executed innovation and manufacturing strategies attract talent, investment and business, thereby moving their countries and economies forward.

Developing Talent and Skills for the 21st Century

Most participants cited talent as the primary driver of a healthy U.S. manufacturing sector. In order to reinvigorate manufacturing and the overall economy, several challenges must be addressed, including increasing appeal for careers in the fields of science and engineering, better preparation in the K-12 education system and more effective immigration policies.

Almost all of those interviewed believe the majority of America's students and workforce do not view a career in science, technology, mathematics, engineering or manufacturing as either appealing or inspirational. Many noted this perception creates long-term competitiveness implications, primarily as a result of a continued decline in the population of scientists and engineers in the United States. Two specific challenges were frequently cited.

First, the United States needs to better encourage those graduating with advanced degrees in the STEM disciplines to pursue careers in their field of study. According to a recent study conducted by Georgetown University's Center on Education and the Workforce, more than 30 percent of engineering, computer science and mathematics majors choose careers in business or professional services over careers in science and engineering.[6] Many participants felt that this challenge is exacerbated in the manufacturing sector because the best and brightest graduates are opting out of an industry they perceive as "dirty and dangerous," with few rewarding and stable jobs to offer. There is a need to change the public vocabulary surrounding manufacturing to be more attractive to students and the future talent pool. Those same participants felt the United States

was not in a position to lose these talented professionals to other industries or countries. Interviewees felt that programs like simulated work environments developed in collaboration with learning institutions and the business community, along with government incentives, would be helpful in elevating the popularity of science and engineering as a profession.

Second, America must begin promoting science, technology and mathematics as inspiring areas of study at the primary and secondary levels. Participants consistently felt that programs at the K-12 levels that inspire and glorify careers in engineering, computer science, mathematics and other areas are critical to building America's next generation of scientists and engineers. That said, as much as participants felt educators need to inspire, they also felt school-age children need to be pushed to make sure they have the correct attitude about rigorous study and academics. Some noted an increasing trend where students today are driven to work very hard at sports and but not math and science.

All participants felt developing and implementing programs to elevate STEM disciplines was the responsibility of all stakeholders in the manufacturing innovation ecosystem, but placed special attention on more stringent certifications for educators at the K-12 levels. Many felt more experience in the STEM disciplines for primary and secondary teachers would not only result in better prepared advanced degree and certification candidates, but would also create educators who were subject matter experts and STEM champions at all levels of the K-12 system. According to the National Center for Education Statistics, 93 percent of fifth through eighth graders in U.S. public schools today are taught the physical sciences by teachers without degrees or certificates in these subjects.[7]

All felt that the success of American manufacturing and innovation begins at the K-12 level, and a lack of properly qualified STEM educators creates a poor foundation for the system. Many felt that the United States has placed more focus on knowing how to teach, making this more important than knowing the subject matter. This has been the case for at least the last four decades and it has become particularly damaging in the areas of science and math.

While participants made it clear that America needs teachers that have meaningful subject matter expertise, they also highlighted the need to encourage individuals with meaningful STEM knowledge and skills to pursue teaching careers through competitive compensation and rewards by developing salary tiers in the K-12 system that are similar to college and university compensation models and link salaries to educators' expertise in the STEM disciplines. Currently qualified individuals are opting out of the teaching profession, partly because it is not competitive with offers from the private sector.

To improve the skills of current teachers, some participants shared that paid continuing education summer programs affiliated with local universities and/or national laboratories would upgrade current teacher proficiency. These programs would also create stronger bonds between primary and secondary teachers and leading-edge scientists and academia. Programs could be modeled on initiatives like the Laboratory Science Teacher Professional Development program that was created by the Department of Energy (DOE). Participants also felt K-12 edu-

cators could earn STEM degrees or certifications through graduate programs that met during summer breaks and on weekends throughout the academic year. Opportunities like these would enable teachers to increase their skill set, as well as qualify them for pay increases.[8]

Respondents also felt that high-performing high school students could be offered full-ride scholarships toward four-year STEM education programs to increase the overall number and caliber of new STEM teachers. These scholarships would be tied to a five-year education service period that would initiate upon graduation, with the hopes that the graduates then choose a life-long career in education.[8] The Robert Noyce Teacher Scholarship Program at the National Science Foundation (NSF) and Teachers for a Competitive Tomorrow programs were cited as leading examples of programs currently addressing this opportunity.

As important as a rigorous STEM foundation is for success, participants also noted a need for students to learn creative problem solving and how to approach issues using multi-disciplinary and/or team-based methods. Numerous respondents pointed out that other nations can develop students with strong STEM skills, but it is critical that the "secret sauce" of creativity is also developed and nurtured in U.S. students through well-rounded curricula and challenging, engaging, and motivating problem solving embedded in our human capital development process and programs. Math and science alone will not lead to success, but strong skills in those areas combined with knowing how to approach and solve complex problems with creative application of rigorous STEM based solutions will differentiate America's leadership, as one participant explained. Supplementing strong math and science skills with complex problem solving abilities will differentiate America's leadership.

Turning to research, many shared that talent flows to countries where the best environments exist to pursue research. Participants pointed to advanced facilities, a consistent pipeline of available jobs and rewarding compensation packages as magnets for research talent. They strongly suggested the United States needs to fix its education system to develop and attract the best talent, and needs to ensure employment opportunities are attractive enough to retain research talent educated in U.S. colleges and universities. Again, the loss of beacons such as Bell Labs—a starting point and home for many outstanding scientists—left a void in the prospective U.S. research job market. Today, the instability and inconsistency of programs and funding, combined with a more cautious approach taken by industry, have made it harder to present compelling employment opportunities in the United States for the best and the brightest.

Finally, participants felt the United States must do a better job of retaining foreign workers educated in America's world class universities. Many cited today's U.S. immigration policies as ineffective and a significant contributor to the competitiveness of other economies (which often have easier pathways to commercializing new ideas) as these workers return to their countries of origin and begin their careers. The majority felt that the ability to attract foreign talent to the United States through the university system was world class; however, many also felt that changes to immigration policies need to be enacted in order to improve America's ability to retain that talent upon graduation. Lifting the cap on H-1B visas and providing automatic visa extensions for doctorates in STEM-related fields that are offered employment with a U.S.-based company were routinely cited as ways to increase the ability to retain top global talent.

Developing Talent and Skills for the 21st Century

To address these challenges, participants recommended the following activities be considered. Recommendations denoted in italics were also outlined as recommendations in *Ignite 1.0*.

1. Ensure that our "current gems", such as our universities and national laboratories, remain the greatest in the world by "doing no harm"—i.e. continue to contribute to U.S. competitiveness by maintaining long-term, predictable and steady support for these institutions.
2. Adopt more stringent and consistent standards for STEM disciplines throughout the entire educational system in the United States. These standards should be tied to metrics in other leading manufacturing economies.
3. Improve and incentivize primary and secondary teacher programs in the STEM disciplines to develop educators who are subject matter experts and better able to prepare students for advanced degrees or certifications programs. Offer incentives, such as continuing education opportunities, for current STEM educators while simultaneously focusing on the next generation with college scholarship programs that attract top high school talent to post-secondary STEM education. Like college and university professors, develop discipline-linked salary tiers in the K-12 systems to entice teachers to become subject matter experts and reward them for doing so.
4. *Benchmark best practices from other countries and reform immigration policies to better attract the world's most advanced workforce, and retain foreign talent educated in American universities upon graduation.*
5. *Advance performance-based legislation and incentives like the America COMPETES Act, the Elementary and Secondary Education Act, Investing in Innovation, Race to the Top and Teacher Incentive funds.*
6. Develop long-term programs that inspire and glorify careers in research, engineering, and other areas of science, technology and mathematics. Begin aggressively marketing to the next generation with focused, creative, and impactful programs targeted at today's and tomorrow's students…and parents.
7. *Develop federal and state programs that promote and market manufacturing as a high-value, vital industry with rewarding long-term career opportunities for high school and college students in the United States.*
8. Build government-industry partnerships that incentivize workers to pursue careers in science, engineering and manufacturing.
9. Ensure adequate support for the "manufacturing innovation ecosystem" and research and science infrastructure.
10. Replicate best practices from disciplines like health care to make work experience mandatory at the secondary and post-secondary education levels.

Fueling Science, Technology and Innovation

In providing their recommendations for spurring science, technology and innovation in America, almost all participants agreed that the ability to efficiently commercialize intellectual property into new products and services was critical to the United States' long-term, global competitiveness.

Many participants felt that countries like China and Germany do a much better job in communicating national innovation strategies. These countries also outperform the U.S. at the early stages of innovation by connecting ideas and products with established translational pathways that are supported by the private and public sectors. For example, one participant noted China's public disclosure of its 10-year strategy, which includes a focus on clean energy technologies, as a national commitment. It should be noted that the NSF released its five-year strategic plan in April 2011, which includes clearly articulated strategies for emphasizing the seamless integration of research and education; developing performance-based goals that make investments in emerging new fields of science and engineering; preparing and engaging a STEM workforce to participate in emerging fields; increasing international partnerships and collaborations to fuel U.S. competitiveness; and making investments that are useful to society and address societal changes through science and engineering.[9] Strategies like these, despite their potential flaws, serve as catalysts for new technologies and propel innovation across both products and manufacturing processes. Participants also felt strongly that national innovation strategies positively impact the ability to commercialize ideas and inventions.

It was noted that other countries with strong manufacturing innovation ecosystems have identified the critical issue of providing a broader translational pathway between basic and applied research and commercialization, and have developed solutions that could serve as models in the United States to help fill the void. The Fraunhofer Institute in Germany was endorsed as a leading example of a public-private collaboration. Fraunhofer is Europe's largest application-oriented research organization and aims to transform scientific findings and basic research into useful innovations to further economic growth and job creation.[10] Founded in 1949, Fraunhofer receives funding from the public sector (approximately 40 percent) and contract research earnings (roughly 60 percent).[10] The Fraunhofer Institute operates between application-oriented fundamental research and innovative applied research and early stage commercialization development projects.[10]

Also mentioned by participants was the Industrial Technology Research Institute in Taiwan (ITRI), developed with a similar mission and model as the Fraunhofer Institute. ITRI describes itself as a national research organization, with a mission of conducting technological research, promoting industrial development, creating economic value and improving social welfare for Taiwan.[11] Today, ITRI is Taiwan's largest applied technology R&D institution.[11] ITRI has continued to evolve since its inception in 1973 and is now spearheading original and innovative industrial research, transfer of technology and product developments, thereby proliferating domestic and international industries.[11] ITRI states they have three core objectives: "Industrial Technology Research, Method and Knowledge

Transfer, and Derived Value-Added Methods."[11] In the United States, organizations like the National Center for Manufacturing Sciences (NCMS) and the Edison Welding Institute (EWI), both mentioned by participants, play similar important roles, but either on a smaller scale and/or with more select industry sector focus and more limited federal support. Scaling up the role, the mission and the associated funding of these types of organizations, driven by strong federal government leadership and financial support, was offered as one solution to this issue.

As part of its national innovation strategy, participants felt the United States needs a system that seeds innovation and advances new ideas and innovations through the product development "valley of death." The system should provide support throughout all phases of development (prototype to pilot and pilot to commercialization) while also relying on researchers, not private sector investors that may be focused on time horizons too short for many innovations, to ensure and demonstrate their ideas have commercial viability. Participants also felt the system must defray upfront costs for capital intensive areas and support funding through "no man's land"—when inventions become too big and capital intensive for venture capitalists or are too small, too early or too risky for IPOs.

To further speed commercialization in America, some participants felt the United States needed more sector-specific industrial clusters that place universities and/or national laboratories and companies in close proximity. Clusters optimize the process of commercializing new ideas and innovations while creating economic value and growth as they compete in the United States and around the world. The biomedical clusters in Ohio, Massachusetts and Switzerland were noted as good examples. Participants also advocated adopting a model similar to the translational medicine process—where discoveries in biology result in the creation of drugs and medical devices—in the manufacturing sector to reduce time to market.

Participants cited a number of other areas where federal and state governments play a vital role in improving U.S. competitiveness. Respondents believe the current research and development infrastructure in the United States is world class, just like its university system. As a result, educators and scientists should feel assured they will have a steady supply of financial support and technology goals to drive research and maintain the current leadership status. However, concerns persisted over U.S. funding policies that require regular approval for key projects. Many felt that these policies create a sense of uncertainty amongst both researchers and potential investors interested in advancing ideas beyond basic research. One participant highlighted the National Institutes of Health (NIH) funding model as a leading example in the United States, noting that funding through the NIH is stable, committed for five years and, as a result, allows scientists to focus on more intensive research activities rather than on completing paperwork to renew funding.

In addition, all felt that policymakers could do more in the areas of tax incentives, intellectual property protection and patent policies, which have an immediate and positive impact on U.S. competitiveness. The "New Top Energy Innovator" program recently launched by the DOE was cited as an example, and allows companies to license up to three national laboratory patents for $1,000 each, rather than the normal fee of $10,000-$50,000.[12]

In terms of tax incentives, multiple respondents indicated ensuring competitive corporate tax rates and encouraging private investments through policy changes like making R&D tax credits permanent are essential to put in place. Two specific R&D credits that would have a positive impact on university/industry partnerships are improved tax incentives for basic research and increased flexibility regarding time frame for calculating the credit. As an example, participants referenced the findings of the Organization for Economic Co-operation and Development (OECD), which shows the United States has not kept pace with other countries that offer tax subsidies. The United States provided the most generous tax treatment of R&D in the late 1980s among OECD nations, but by 2004 it had fallen to 17th place.[13] CEOs in *Ignite 1.0* also cited this as a key recommendation.

Many respondents emphasized that there is an imbalance in the ability and speed to commercialize innovations within sectors deemed of national importance versus areas that fall outside that parameter. Innovations of national importance were noted as attractive opportunities for universities, national laboratories and businesses because the federal government's continuous demand for the world's best technology in the areas of aerospace, defense, robotics and energy enables more support for the complete innovation process. Participants pointed to past examples where the needs of the government resulted in the commercialization of products and services to the long-term benefit of consumers and the U.S. economy that would have otherwise not made it through the "valley of death." Examples included the national highway system to support America's supply chain demands and the Department of Defense's need for technologies like GPS.

Participants noting this area of opportunity felt more could be done by policymakers to better communicate long-term goals and technology requirements. They also shared that more could be done to connect universities, national laboratories and businesses of all sizes to accelerate the development of technologies and products that support government requirements. Respondents stated that policymakers must recognize that a "one size fits all" approach cannot be used to determine how far ideas should be supported with applied research. Policymakers should recognize the unique challenges with commercializing innovations outside the scope of those deemed of national importance and incent industry to overcome the "valley of death."

Fueling Science, Technology and Innovation

To address these challenges, participants recommended the following activities be considered. Recommendations denoted in italics were also outlined as recommendations in *Ignite 1.0*.

1. *Establish a consortium of business, university, labor and public sector leaders to develop daring strategic long-term goals with a 15 to 20 year development horizon around science, technology and manufacturing.*
2. Develop a U.S. innovation strategy that establishes programs to feed an innovation pipeline through full life-cycle commercialization and supports both basic and applied research. The strategy should also break down barriers to collaboration between universities, laboratories and the private and public sectors.
3. Create long-term mechanisms that insulate funding programs from election cycles and changing administrations.
4. Create a system that seeds innovation and helps avoid multiple "valleys of death" by establishing translational pathways that are supported by the private and public sectors and include enabling mechanisms to drive innovative ideas and technologies through to commercialization.
5. Fuel private investment by ensuring globally competitive corporate tax rates and strengthening and making permanent research and development tax credits, especially for U.S.-based innovation.
6. *Tax credits should address both human capital, and include support for continuing education for scientists and engineers, as well as R&D equipment and infrastructure to ensure the U.S. remains an attractive destination for long-term investment in innovation and manufacturing.*
7. *Increase the number of public-private initiated industry clusters that convene research institutions, industry and the best talent to focus on advancing research and full life-cycle commercialization. Ensure there is a process in place to identify and revise the essential components required for the clusters to continually meet changing market demands.*
8. Focus on sectors of strategic importance to the United States, including national security, defense and energy, as well as emerging sectors that serve as hot beds for rapid, concurrent research and innovation.

The Role of Colleges, Universities and National Laboratories in Improving U.S. Competitiveness

All participants felt America's colleges, universities and national laboratories play a critical role in improving U.S. competitiveness beyond the areas previously discussed—developing tomorrow's talent and fueling the nation's innovation engine.

At the same time, most participants, whether university presidents or national laboratory leaders, felt they could and should be doing more. They cited the need for more collaboration with each other and with industry, more focus on applied research that results in economic development and more leadership in collaboration with policymakers and business leaders to address these critical competitiveness issues. Many of the university presidents participating in this report felt K-12 schools, colleges—community and/or vocational—and universities could collaborate more effectively to deliver the requisite education and "real world" work environments capable of providing learning opportunities beyond the classroom. Many national laboratory leaders felt they could do more to both directly help educate students and engage them in careers in math, science and research, but also help develop current and future teachers with STEM requisites.

In addition, many suggested that universities should collaborate more with national laboratories and industry to push innovation to commercialization. While the primary role for universities and community colleges is to educate the next generation of talent, interviewees agreed that the current economic constraints require universities to make a concerted effort to become more creative and entrepreneurial in their operating approach with partnering and collaboration.

To do so, participants defined the following key roles for national laboratories and learning institutions at the primary, secondary and post-secondary (community colleges and universities) levels:

The Role of Primary and Secondary Schools

Participants felt K-12 schools were primarily responsible for prepping students for higher levels of education, with particular emphasis on developing a sufficient pipeline of STEM-literate students, irrespective of race, gender or economic status. This includes the soft side of STEM, or the creative problem-solving skills necessary to be equally embedded in students at an early age and promoted throughout their K-12 journey. As noted previously, participants also felt secondary educators were responsible for inspiring interest, communicating career opportunities, and having subject matter expertise in the fields of science, technology, engineering and mathematics.

The Role of Community Colleges

Participants felt America's community colleges were crucial to help lessen the ever-increasing economic divide between low- and high-skilled workers and play a bigger role in local economic development by creating a system that is flexible and responsive to the changing needs of industry. The role of the community college should be to serve as a translational pathway by developing a skilled workforce focused on application and armed with the vocational skills frequently required when supporting commercialized new products and technologies. Many participants also noted the important role community colleges play in helping students define and plan career decisions, as well as the role they play in re-educating America's workforce in response to ever increasing changes in technology and global marketplaces. Another area of opportunity is to educate and train veterans in the areas of greatest need. In addition, community colleges should be leveraged more ex-

tensively by industry as a tool for continuing education of current employees. Finally, all participants agreed that America's community colleges must continue to serve as a bridge between K-12 and university if high school did not provide a sufficient learning foundation.

The Role of Universities

Participants felt universities were primarily responsible for delivering broad educational opportunities, with research consistently noted as a secondary area of focus. Most participants also felt that the global leadership position America's universities enjoy today allows the schools to attract the best and brightest global talent. However, those same participants noted that increased competition from foreign universities is impacting the ability of U.S. schools to continue attracting the best talent worldwide. With respect to U.S. competitiveness, some participants felt it was also the responsibility of universities to keep students interested in math and science as well as manufacturing, and play a role in supporting workforce education and educational outreach for local primary and secondary schools, nearby corporations, and the community. Finally, numerous examples were cited of universities doing a good job and the need to do more in terms of economic development. For many, this was seen as both an opportunity and a practical need to keep universities economically viable in the future. As one university president noted, the model for universities is rapidly evolving from "publish or perish" to "partner or perish" in the 21st century.

The Role of National Laboratories

With respect to the role of America's national laboratories, many participants felt these institutions were primarily responsible for driving innovations that are deemed crucial for national well-being and security. With clearly defined core missions, laboratories are uniquely positioned to create environments that are fundamentally different than those at the university level. These environments enable broad science capabilities in areas important to the nation and in areas that the private sector would not or could not do on its own. Participants described national laboratories as catalysts for advancing basic research to applied research for ideas and innovations that were important to take to the next phase of development but not yet ready for mass commercialization.

Beyond the excellent work being done today, participants suggested that if properly directed, empowered and funded, national laboratories could contribute in additional ways that bridge the "valley of death." In order to maximize the investment in national funding of the United States' laboratories, participants felt more needs to be done to ensure that expectations for America's national laboratories are inclusive of missions vital to the nation, and where applicable, every effort should be made to translate these innovations into new technologies and pilot products that have impactful market opportunities. Given the reduced level of R&D at private corporations and short-term nature of industry, there is an increasing role for national laboratories to play in the areas of both basic and applied research. In many cases, ideas fall short of commercialization because it is still too early for the private sector to invest and laboratories cannot get funding and/or support to take ideas to the next level. This not only stifles innovation, but also dissuades talented scientists as they are not be able see their ideas through to fruition. As an example, participants regularly pointed to vertically integrated companies and private research entities like Bell Labs that, despite their past regulatory and monopolistic protection, had served their purpose by attracting and developing talent, and overcoming the "valley of death" for ideas taking significant time and investment.

Finally, several leaders of the national laboratories felt their organizations could also play a more significant role in outreach; tutoring students and teachers; and inspiring interest, communicating career opportunities and helping mentor subject matter experts in the fields of science, technology, engineering and mathematics. In this regard, participants also cited the importance of policymakers supporting the national laboratories' role in community outreach programs, such as educational outreach for local primary and secondary schools, nearby corporations and the community.

The Role of Colleges, Universities and National Laboratories in Improving U.S. Competitiveness

To address these challenges, participants recommended the following activities be considered.

1. Continue to support community colleges and universities as catalysts for innovation and competitiveness through long-term government funding programs like the America COMPETES Act, the Carl D. Perkins Career and Technical Education Act and various research grants.
2. Continue expanding the role of American universities to serve as economic development engines. Create conduits that connect talent and ideas at the university with the private sector and the local community in regional clusters.
3. Implement university programs that promote student interest in math, science and manufacturing.
4. Utilize community colleges more effectively to develop a skilled workforce with the requisite vocational skills to support technology commercialization and manufacturing.
5. Ensure that national laboratories develop mission-driven innovations that are crucial to national interests, while broadening the definition of national interest to include impactful economic development. Continue to leverage America's national laboratories' ability to drive applied research on the journey to commercialization, but establish succinct and concise goals that focus on areas important to the United States both for economic development as well as national security, defense, energy, etc. Support their role in community outreach programs, such as educational outreach for local primary and secondary schools, nearby corporations, and the community.

Closing Comments

All of the leaders interviewed for this report expressed optimism and excitement about the long-term opportunities for the U.S. manufacturing sector. They believe that it is important to raise awareness of how "making things" is crucial to the U.S. economy and citizens' prosperity. Manufacturing competitiveness should be among the nation's top priorities.

In the long term, participants envision a U.S. manufacturing sector that is once again a global leader in innovation and driven by a world class ecosystem of education, research, public sector and industry partnerships. Participants described technologically advanced industries where all the stakeholders in the ecosystem identify, prioritize, test, develop and commercialize new products in a globally superior model able to attract investment and talent from around the world.

Central to this vision are federal and state policies that remove uncertainty and support competitiveness in areas such as research and development, the patent system, intellectual property protection, tax rules and immigration. By developing and adopting pro-competitiveness policies across these areas, all businesses would have increased incentive to make long-term investments in the U.S. manufacturing industry.

End Notes

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The Council's mission is to set an action agenda to drive U.S. competitiveness, productivity and leadership in world markets to raise the standard of living of all Americans.

The Council on Competitiveness is the only group of corporate CEOs, university presidents and labor leaders committed to ensuring the future prosperity of all Americans and enhanced U.S. competitiveness in the global economy through the creation of high-value economic activity in the United States.

Council on Competitiveness

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HOW WE OPERATE

The key to U.S. prosperity in a global economy is to develop the most innovative workforce, educational system and businesses that will maintain the United States' position as the global economic leader.

The Council achieves its mission by:

- Identifying and understanding emerging challenges to competitiveness
- Generating new policy ideas and concepts to shape the competitiveness debate
- Forging public and private partnerships to drive consensus
- Galvanizing stakeholders to translate policy into action and change

Special Acknowledgements

On the eve of his retirement as Director of Lawrence Livermore National Laboratory, the Council on Competitiveness would like to recognize Dr. George H. Miller for his tremendous contribution to U.S. competitiveness and national security. As a member of the Council, Dr. Miller has been an integral contributor to the U.S. Manufacturing Competitiveness Initiative (USMCI), the Energy Security, Innovation and Sustainability (ESIS) Initiative and other key program areas.

Dr. Miller, we thank you for your leadership and insightful perspectives, and wish you the best in your future endeavors.

With his recent retirement, the Council would like to thank Dr. Michael R. Anastasio for his many years of service to America and his extraordinary leadership as director of Los Alamos National Laboratory. Dr. Anastasio has been an active and engaged member of the Council and has participated in the Technology Leadership and Strategy Initiative (TLSI) and the U.S. Manufacturing Competitiveness Initiative (USMCI).

Dr. Anastasio, thank you for your invaluable contributions to our country, and we extend warm wishes for future success.

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