The Accelerating Engineering Innovation Summit

Prepared by
Sandia National Laboratoriess

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

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Sandia National Laboratories

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Participant List

The "Accelerating Engineering Innovation" Summit was held at Sandia National Laboratories, May 31-June 2, 2006. Representatives from industry, academia, national laboratories, and government convened to examine issues in engineering innovation and recommend approaches to increase U.S. competitiveness in the global marketplace. Institutions and organizations that participated in the summit are listed below.

Industrial Participation	Universities and Colleges	Government and National Laboratories
Intel	Massachusetts Institute of Technology	Department of Energy
Goodyear Tire & Rubber	University of New Mexico	National Nuclear Security Administration
Microsoft	Rensselaer Polytechnic Institute	Los Alamos National Laboratory
Hewlett Packard	Yale University	Sandia National Laboratories
IBM	Harvard University	Oak Ridge National Laboratory
Proctor and Gamble	University of Florida	Staff from US Senate
Lockheed Martin	Harvey Mudd College	Council on Competitiveness
Monsanto	University of Wisconsin	
ExxonMobil	University of Illinois	
	University of California at Davis	
	University of Texas	
	University of California at Santa Barbara	
	Rose-Hulman Institute of Technology	
	University of Michigan	

Executive Summary

Sandia National Laboratories hosted a Summit on Accelerating Engineering Innovation in Albuquerque, NM (May 31st - June 2nd, 2006) to explore the opportunities for jump starting a national response to the President's American Competitiveness Initiative. The Summit brought together leaders from industry, academia, government, and the national laboratories to examine today's innovation dilemma and consider new approaches for the future.

In the Summit discussions, industry leaders emphasized that partnerships are critical to their success and that partnering among U.S. institutions must become easier to facilitate interactions. Academic leaders also highlighted the need for greater multidisciplinary research and education, the problem of too much to teach in a limited time, and difficulties of effectively rewarding multidisciplinary endeavors in some universities. Government and laboratory leaders focused on the opportunity to leverage investments in research staff and state-of-the-art tools to help train the next-generation of engineers. These investments in talent and capital will accelerate the discovery of breakthrough technologies that can impact industrial product development.

Concerns raised at the summit were consistent with those raised in previous studies on education, innovation, and economic competitiveness. The challenges in maintaining a strong national base to provide technical innovation are significant and diverse - ranging from the quality of K-12 math and science education and student performance; to declines in research investment and enrollment in engineering and science programs; to formidable increases in barriers to partnering across institutional sectors. And yet *partnerships,* participants agreed, *will be the essential element of successful solutions.* Participants discussed a plan to create a system of Discovery Institutes that would be located at national laboratories. These centers would bring together academia and industry at innovation hotspots that build off the expertise resident at the host national laboratory. Summit members also agreed that actions – not more talk – must be undertaken boldly, and quickly.

In response to these concerns, Sandia advanced the National Institute for Nano-Engineering (NINE) as a prototype Discovery Science and Engineering Innovation Institute (DSEII) to accelerate innovation in this emerging field. NINE will bring together the R&D community to focus on critical mission problems such as energy and national security and will work with universities to establish a new, multidisciplinary engineering curriculum by providing unique facilities and multidisciplinary approaches. As a pilot of the DSEII approach, NINE would leverage DOE investments from NNSA and the Office of Science in microsystem technologies (MESA facilities), nano-sciences (Center for Integrated Nanotechnology - CINT), and high-performance computing (Red Storm and others).

Recommendations: Consistent with the American Competitiveness Initiative and the Protecting America's Competitive Edge (PACE) legislation, DOE should use its

tremendous assets to establish an important leadership role for national innovation and engineering education by:

1) Creating a system of Discovery Science and Engineering Innovation Institutes (DSEII) as innovation incubators and educational hot spots resident at a host National Laboratory.
2) Founding the first of these centers, the National Institute for Nano-Engineering (NINE), at Sandia National Laboratories in FY07. NINE will be a distributed enterprise, with its hub at Sandia and with spokes at major universities and with key industrial participants. Additional Innovation Institutes would be established over time through the DOE complex to address national priorities.
3) Developing partnership approaches, including legislation, to optimize the flexibility and effectiveness of the DSEIIs to manage Intellectual Property (IP) and facilitate partnering.

Summit Motivation

The Augustine Committee's report in 2005 for the National Academies, *Rising Above The Gathering Storm*[1], articulated the key challenge to our nation's prosperity and competitive position globally: maintaining the innovation engine that enables our global leadership for defense and economic security. To stay ahead in the global engineering race, the Augustine report recommended actions needed in four priority areas: increasing the talent pool through improved K-12 education, sow the seeds through a strengthened commitment to long-term research, foster the best and the brightest (make the U.S. the best setting for research to attract and retain the top students, scientists and engineers), and ensure the U.S. is the premier place to innovate. Other recent reports from the National Academies – notably *Engineering Research and America's Future*[2] and *Educating the Engineer of 2020*[3]- called for similar actions in funding R&D for physical and engineering sciences, upgrading the quality of the technical workforce to meet the future, and strengthening the link between fundamental research and its impact on the U.S. innovation engine.

Taken together, and in combination with recent reports from other organizations and agencies, the national imperative is clear. The American Competitiveness Initiative acknowledges the need to take actions on these fronts:

- Improve the pipeline for technical talent by creating additional opportunities to engage youth and teachers in the excitement of science and engineering, improving educational curriculum at all levels, and preparing future engineers – ***a notably more diverse population*** – with a greater range of technical and non-technical experiences.
- Enhance our ability to capitalize on opportunities created by scientific discoveries to meet important national challenges and generate new industries, jobs and wealth by improving the environment for innovation including incentives, intellectual property reforms, improved infrastructure and strengthening academic-government-industry collaboration.

A successful national response to the Engineering Innovation imperative must have as its central focus a bold plan to re-engineer engineering, for it is the Nation's engineers that translate scientific knowledge and new discoveries into innovative, high-value products that are the basis for our continued prosperity. By leveraging the considerable existing intellectual capabilities and facilities in the physical and engineering sciences at U.S. universities and national laboratories, the DOE can jump-start a national response to the call to action.

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[1] Rising Above the Gathering Storm; Energizing and Employing America for a Brighter Economic Future. Washington, DC: National Academies Press, 2006.

[2] Engineering Research and America's Future: Meeting the Challenges of a Global Economy. Washington, DC: National Academies Press, 2005.

[3] The Engineer of 2020: Visions of Engineering in the New Century. Washington, DC: National Academies Press, 2004.

Summit Panel Summaries

Summit participants split into three working groups to articulate challenges and opportunities from the perspective of industry, academia, and government. The key themes presented here capture the findings from these working groups.

Industry Trends

Summit participants from industry emphasized that the current business environment is characterized by intense competitive pressures driven by increased globalization and heightened fiduciary responsibility to stockholders. Time is always of the essence, and learning curves have been shortened drastically – the imperative is to take the best people you can find, and put them into the most productive environment as quickly as possible.

Theme #1: Engineer employees need to know how to quickly build successful partnerships. In an increasingly globalized and fragmented world, companies rarely have direct command over all the elements required to invent, develop, and introduce products. Successful companies quickly establish networks of partners with the necessary complementary skills and produce the required results, then move on to the next challenge. These partnering / collaboration skills are not taught as part of a university curriculum, but are considered essential and cannot be instantly transferred to new employees who have previously been unexposed to them.

Theme #2: Partnering among U.S. institutions must be made simpler. Just as businesses must be able to quickly locate and tap resources in other companies, they must also be able to do the same with their academic and government partners. Industry representatives voiced concern that it is cumbersome to set up R&D partnerships with universities and government labs; *the process must be greatly streamlined*. The issue that seems to create the greatest friction is ownership of Intellectual Property (IP) generated by such collaborative efforts; universities in particular seem to be driven by IP concerns in recent years – perhaps because of the revenues that can result when IP is successfully managed. Participants noted that foreign universities do not seem to be distracted by IP issues, and that the simplicity of working with them has made it increasingly attractive to do so rather than attempting to partner with U.S. institutions.

Theme #3: Engineers need to be more broadly educated. While recognizing that depth in traditional skills are essential (and, indeed must be better addressed), the demands described above illustrate the need for competencies beyond the traditional engineering disciplines. These include:

- An understanding of how business operates, along with the communication and people skills that underlie business success.
- The ability to use advanced tools such as high-performance computing and sophisticated software simulations
- An openness to lifelong learning and a desire to pursue new knowledge as part of a strategy to continuously adapt to new challenges

These skills illustrate the challenge implicit in educating the “Engineer of the Future” to the degree of depth and breadth required in the current competitive environment.

University Trends

University representatives acknowledged many of the same themes expressed by their industry counterparts, but offered their own perspective on the institutional challenges faced in educating the Engineer of the Future.

Theme #4: The advantages and needs for a multi-disciplinary approach to education are recognized, but the challenges to implementing this approach are great and must be recognized as well. The traditional university organization is discipline-based, and this will not change quickly. While departments and students have shown great flexibility in working together across organizational lines, a discipline-based structure will prevail in matters of fundamental importance, such as who will be hired or retained; what subjects will be offered (and by whom); and how outstanding performance will be recognized and rewarded. Furthermore, the funding that supports university research is discipline-based as well – reflecting the same infrastructure that underpins funding sources, such as government agencies. (NIH funds biology, DOE funds physics, etc.)

In addition, university participants noted that traditional approaches to education have not been directly connected to the solution of "real world" problems – on the contrary, the emphasis has been on fundamentals and the pursuit of knowledge. It is perceived that interdisciplinary approaches work best when they are coupled to compelling problems. It is important that students have a good balance between learning the necessary fundamentals and getting an opportunity to expand their experience by working on real problems with multidisciplinary teams.

Theme #5: There is already too much to teach in four years. Reflecting on the "broader and deeper" theme articulated in #3 above, there is concern that only so much can be taught in a finite amount of time. Today's engineering bachelor's degrees already provide fewer hours of formal training than those granted twenty five years ago. If graduates are to receive more training in business or communications skills, what should be eliminated in order to make room for new topics?

Theme #6: There must be a concerted effort to attract, inspire, and retain qualified U.S. students – a "pipeline" of talent essential to future competitive success. Undergraduate programs are especially aware of the "pipeline" challenges, as they are critically dependent on the quality, quantity, and motivation level of students produced by the national K-12 education system. It is difficult to first reverse the decline, and then raise the performance of math and science education. Graduate institutions have decades of experience with foreign-born engineering students, many of whom return home on completion of their studies. In recent years, however, opportunities for employment in foreign countries have proliferated due to globalization, and the quality of foreign education has improved – making it more difficult to recruit and retain top talent.

A focus on real-world problems is seen as central to solving the "pipeline" problem, in addition to its role in organizing multidisciplinary efforts as discussed above. Engaging the public and teachers in the excitement of science and engineering is also important for attracting students into the field.

Government and National Laboratory Trends

Following the discussions led by industry and university representatives, government and national laboratory leaders highlighted several related issues.

Theme #7: Students are attracted to engineering when they are given the opportunity to solve challenging problems of national importance, and provided access to state-of-the-art facilities. Bright minds love big challenges, and will gravitate toward opportunities to solve them using the most advanced tools available. National Labs invest heavily in these kinds of facilities, but awareness of what exists and opportunities for access to these capabilities have been limited.

In a related point, national labs have discovered that there needs to be a greater appetite for risk if innovative breakthroughs – not just incremental progress – are the goal. Government labs do not experience the same relentless competitive pressures as industry, so maintaining an appetite for high-risk, high-reward efforts can be challenging.

Theme #8: There needs to be a realistic awareness of time horizons associated with engineering and research. National labs occupy an intermediate position in the research continuum, ranging from "pure" fundamental research (as typically practiced at academic institutions) to applied, product-focused development more common in the commercial sector. Fundamental research is typically practiced on a time-scale of 5 years or much longer, while applied research is more focused on immediate results. Novel approaches to engineering innovation will need to successfully span these opposing tendencies – allowing basic research into fundamental questions, while supporting rapid development of more mature concepts, as appropriate in each case.

Theme #9: Industry, universities, and national laboratories all are subject to many of the same challenges when it comes to engineering innovation. The challenges listed by industry and universities are all familiar, in somewhat different forms, to the national laboratories. The pace of invention has quickened, and the complexity of new problems demands interdisciplinary solutions. Ownership of IP has been a tricky problem that can impede partnerships. Broader, life-long education is demanded of those who aspire to keep pace of innovation. Funding has become increasingly tied to a need for immediate results rather than careful study and understanding of problems. (One exception is the Laboratory-Directed Research & Development program, which is the sole source of discretionary research within national laboratories.) Demand is critical for highly-talented U.S. citizens to who can perform challenging work in the national interest.

The fact that these themes are common among all three institutions, however, suggests that there is much to be gained through a trilateral approach to the problem of engineering innovation that will benefit and strengthen all three R&D sectors.

Partnering to Succeed – A Call to Action

The Summit discussions confirmed that the country needs to take bold and immediate action to maintain its technical leadership position in today's competitive, global economy. The tremendous intellectual resources and facilities at the Department of Energy's National Laboratories, puts **the DOE in position to have a strong leadership role in addressing this national imperative**. Already DOE funds more R&D in physical sciences and engineering than any other federal agency and its laboratories represent a largely untapped resource to power engineering education and technical innovation at the interface between R&D & product realization. The DOE missions in science and engineering, energy security, and national security are well-aligned with the key challenges identified by the Augustine Committee: '*creating high-quality jobs for Americans and responding to the nation's need for clean, affordable, and reliable energy*.' Throughout Europe and Asia, attention to key national priorities brings together powerful partnerships between universities, national laboratories & institutes and industry to collaborate on complex, multidisciplinary problems. While collaborations between different sectors in the U.S. continue to improve, re-invigorating and accelerating engineering innovation requires concerted national action to jump-start the effort.

Based on these findings, representatives at the Summit make the following recommendations:

#1 The DOE should establish Discovery Science and Engineering Innovation Institutes at national laboratories to drive new partnerships with universities and industry and provide enhanced opportunities for engineering education (graduate and undergraduate). This recommendation is consistent with the NAE recommendations and the PACE legislation currently before Congress and should commence quickly.

#2 Sandia should stand up the National Institute for Nano-Engineering (NINE) in early FY07 with university and industry partners. Additional Innovation Centers would be established over time through the DOE complex. These Engineering Discovery Institutes should be established to focus on technology challenges to inspire the education, research, and innovation agendas. Example compelling national challenges recognized at the Summit include, but are not limited to:

- Creating clean, abundant, and affordable energy (Breaking U.S. dependence on foreign oil)
- Tackling global climate change
- Ensuring U.S. economic competitiveness by stimulating engineering innovation
- Taking the terror out of terrorism
- Revolutionizing health care and its delivery

#3 New approaches, to accelerate and enhance partnerships amongst institutes, are required to facilitate partnering and truly accelerate innovation for the nation. Example of important collaborations and partnerships recommended by the Summit participants include:

- provide partnering opportunities for industrial engineers to access state-of-the-art facilities and technologies to stimulate innovation;
- establish active partnerships with business, communication, and technology policy programs at leading educational institutions; and
- foster increased public awareness of the importance of engineering in solving global problems and in creating prosperity.
- Support innovative approaches to improving science, mathematics, and engineering K-12 education

In closing, much has been done by the National Academies of Engineers and other organizations to define the challenges that threaten our nation's prosperity and security and to create national momentum. Now is the time to address these concerns with bold action and a new approach. The national Discovery Science and Engineering Innovation Institutes could be a key step to creating a better future.