Nanotechnology & Homeland Security

Leveraging New Technology to Counter New Threats

Prepared by
NOVA Workforce Board

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Introduction

On December 15, 2003, NASA Ames Research Center (ARC), in collaboration with the offices of three distinguished Congressional representatives and a variety of municipal governments and relevant organizations, sponsored the second of what NASA ARC hopes will be an ongoing series of forums dedicated to developing the nanotechnology industry within Silicon Valley.

The Nanotechnology & Homeland Security forum focused on opportunities and challenges of nanotechnology within the domain of homeland security and was a targeted follow-up to the introductory forum four months earlier. This document summarizes the content of this second conference and serves as a companion piece to a white paper published by the NOVA Workforce Board following the initial August gathering entitled, "Nanotechnology: The Next Great Wave of Innovation." For more detailed information relating to nanotechnology as an enabling technology and Silicon Valley's readiness to serve as an incubator for this "wave of innovation," please refer to this earlier publication *(See reference on page 2).*

Nanotechnology, according to Steve Jurvetson, managing director of Draper Fischer Jurvetson, a leading venture capital firm, will revolutionize every industry a mere 50 years from now. There is little doubt that nanotechnology provides great potential for transforming every aspect of our lives, but it will require sincere dedication from investors, both public and private, to support this promising science and reap the

"It's a great time to do business in Northern California: We have one of the world's most productive workforces, obviously great venture capital funding, and an entrepreneurial spirit."

Chris Piercy
President & Chairman
Northern California Nanotechnology Initiative

Chris Piercy is an experienced investor, entrepreneur, and manager who has founded and managed a number of biotechnology, nanotechnology, high-tech, and consulting companies worldwide. He is currently with Knowledge Market, LLC, and SVIC, both Silicon Valley-based venture capital firms focused on early-stage nanotechnology and biotechnology companies.

Mr. Piercy has served as a founding board member of the National Nanotechnology Initiative Regional Nanotechnology Coordination Committee, Northern California Nanotechnology Initiative, NanoSIG, and the Nanotechnology Industry Organization, Bay Area Nanobiotechnology Group, and various companies. He also assists a number of government agencies and companies on business and technology issues regarding nanotechnology and biotechnology.

rewards. Attention must be paid not only to the current fiscal focus of research and development at a foundational level, but also to the later stages of funding the equally important development of practical applications and commercialization of the resulting innovations. “Homeland security is not the end-all be-all,” stated Dr. Shankar Sastry of U.C. Berkeley, “but perhaps it is a leading indicator of a broader commercial need.” Although national defense is not seen as an ideal market opportunity for private investors, there is definitely a need for nanoscale developments within the realm of national security, and with these needs, opportunities. As J. Leighton Read, general partner at Alloy Ventures, put it: “It’s always been the case that the best defense is a good offense.” The reality is that nanotechnology is changing the world and if the United States is not at the forefront of understanding both the positive and negative implications of this technology, then we will remain unprepared to deal with threats from hostile countries, organizations, and individuals.

To obtain copies of NOVA’s initial publication, “Nanotechnology: The Next Great Wave of Innovation,” please visit our website at www.novaworks.org/lmi or call NOVA at 408-730-7232.

Homeland Security

On October 8, 2001, less than one month after the terrorist attacks on the United States, President Bush ordered the establishment of the Office of Homeland Security. This department was tasked with coordinating the reorganization of 22 domestic agencies into one department to protect the United States against terrorist threats and improve the quality and timeliness of response to future emergencies.

The responsibility of this department to protect the United States and its people is an enormously difficult task for a variety of reasons. First, the threat to the United States is asymmetrical. That is, a small number of individuals rather than a large country are the primary threat to our nation. How do you identify, monitor, and capture individuals and small groups in this large world?

Second, the nature of these attacks has changed. Locations or structures consisting of a large number of civilians rather than military installations are the new targets of choice. Large structures, such as the World Trade Center, are especially vulnerable to catastrophic attack, given that it is difficult or impossible to completely protect large or extensive structures and networks. For example, according to Martin Lagod, managing director of Firelake Capital Management, there are 700,000 miles of water delivery pipes running throughout the United States. The size of our water system makes it currently impossible to detect and prevent terrorists from introducing harmful substances into the water.

Third, it is unclear whether or not emergency personnel are adequately prepared to respond effectively to an attack, should it occur again. For

"Our challenge is to develop new tools of detection, intelligence gathering, and countermeasures, yet still be mindful of the constraints of a free society."

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Dr. G. Scott Hubbard
Director
NASA Ames Research Center

Prior to his appointment as director of NASA Ames Research Center, Dr. Hubbard served as deputy director for research, and prior to that, as the first Mars program director at NASA headquarters. He is acknowledged as the originator of the Mars Pathfinder mission and was the project manager for Ames' portion of that mission that successfully landed on Mars in 1997. Previously, Hubbard served as staff scientist at Lawrence Berkeley Laboratory, was founder, vice president, and general manager for Canberra Semiconductor, and held the position of senior research physicist at SRI International.

Hubbard received his undergraduate degree in physics and astronomy at Vanderbilt University and graduate education in solid state and semiconductor physics at University of California, Berkeley. He is the author of more than 40 papers on radiation detection and space missions.

example, the communication problems experienced during the September 11 attacks in New York City and Washington, D.C. demonstrated the need for an integrated communication system. Additionally, there have been few studies about disasters and what is needed to effectively respond to them.

Therefore, to successfully protect the United States from future terrorist attacks, the Department of Homeland Security will need a variety of tools in its arsenal to detect and defend against terrorism. What role can nanotechnology play in providing solutions to the new requirements of homeland security?

Nanotechnology Solutions

The Department of Homeland Security requires practical applications of evolving technologies in order to stay ahead of terrorists in order to protect the United States from terrorist incursion. Here are several examples of how nanotechnology can assist with homeland security:

1. Sensors

Given that the nation's infrastructure is vast and difficult to fully protect, that it is possible for an individual to launch a full-scale attack, and that biological, chemical, and nuclear substances may play an increasing role in terrorist activities, it is vitally important that sensors are created to detect, respond, and control these substances. Nanotech sensors such as carbon-based nanotubes may be a solution to this problem. Sensors can be designed to be reliable, robust, extremely high in sensitivity and selectivity while low in power consumption and cost, and have a platform that meets the most needs. It is expected that the market for sensors will develop within the next two to three years with large-scale deployment in five to seven years.

2. Computers

As Dr. Shankar Sastry, Chairman of the University of California, Berkeley Department of Electrical Engineering and Computer Sciences, stated at the forum, "Tomorrow's weapon will be the PC." Computers are now used for practically every purpose, including tracking terrorists, relaying emergency information, and determining threats. Therefore, computers must not only be able to quickly and accurately process information, they must also be able to operate during and after an attack. However, there is a low level of diversity in computer architecture and operating systems—PCs running Windows platforms are the

predominant model. This means that if a computer-based attack is launched, a majority of computers will be impacted. Nanotechnology can therefore be applied to computer technology, by creating system architecture that uses all-optical, bio-electronic, DNA, quantum, or molecular electronics computing. Also, nanoteched computers have the ability to process data and information at a much faster rate. For example, quantum computers are able to run through all possible solutions to a problem at the same time, rather than one by one as with current computers. This means that computers will be able to come up with the correct answer in a much faster time. This capability is especially important in terms of encryption. For example, if the FBI attempts to decrypt information about possible terrorist activities, use of a quantum computer will allow the FBI to "crack" open secret information more quickly, and ideally in enough time to act upon the information.

3. Emergency Responder Devices

There is a vital and greatly underserved need for emergency responder technology that helps rescuers find and retrieve victims while keeping rescuers safe. Nanotechnology can assist with this problem, by creating communication systems that are lighter and require less power while having greater transmission reach, and are able to work with other responder technology. Other devices such as nanoteched robots and sensors can be used to locate trapped victims, decreasing risk to emergency responders.

4. Devices for the Military

All the applications mentioned above can be used by the military to identify, track, and respond to terrorist threats. However, nanotechnology can further be used to create explosive devices that can more precisely control the effects of explosion, and lightweight devices and equipment that can be easily transported and maneuvered in and out of position (such as lightweight yet structurally strong tanks). There has also been discussion of incorporating nanoteched sensors into uniforms, so that servicewomen and men are more quickly alerted to nearby toxic substances.

Although there are many ways nanotechnology can serve the needs of the homeland security industry, there are several issues that may hinder the development of these (and other) applications. To begin with, although domestic counter-terrorism and emergency response is a large market—$80 to $160 billion per year, according to Dr. Tom Costello, Technical Staff of IBM—the market is fragmented. For example, local public safety departments still have latitude as to what devices they purchase and from which vendor—there is no mandate that all emergency response departments buy and use the same equipment.

Additionally, the perception that nanotechnology can be used for indiscriminate purposes as well as good may hinder public and government willingness to support nanotechnology applications. It is therefore important that systems are in place to address and respond to these and other concerns and perceptions in a timely, informative manner so that the benefits of nanotechnology will not be lost.

Funding

Currently, the federal government is the primary funding source within the United States for nanotechnology research and development. According to the National Nanotechnology Initiative [www.nano.gov], federal funding for nanotechnology R&D has increased from $116 million in 1997 to $849 million in 2004, an increase of more than 630 percent in only seven years. This funding trend should continue for at least the foreseeable future with the recent passage of the "21st Century Nanotechnology and Research Act," which provides a total of $3.7 billion over the next five years for nanotechnology research and development. While these funds will go a long way toward establishing the science of nanotechnology, this alone will not be enough to take nanoscale innovations to the commercial level. Participation of private investors will be a necessity.

Due to the technical risks involved, the federal government has historically served as the primary funding source in early stage development of new technologies. This has also proven to be the case for nanotechnology—an industry that is still in the very early stages of development—but the government recognizes the need to spur private investment to prepare for seeing the results of the research through to commercialization. In fact, a substantial portion of government funds are dedicated to promoting partnerships between researchers and private enterprise for this very purpose, and more than 100 nanoscience and technology centers are funded by federal monies for the sake of encouraging public/private collaboration.

"Forecasting is futile. The very nature of innovation is that you can't predict it."

Vinod Khosla
General Partner

Kleiner Perkins Caufield & Byers

Vinod Khosla is a general partner of Kleiner Perkins Caufield & Byers. He was a cofounder of Daisy Systems and founding Chief Executive Officer of Sun Microsystems, where he pioneered open systems and commercial RISC processors. Mr. Khosla serves on the boards of Centrata, Indian School of Business, Infinera, Juniper Networks, Kovio, OnFiber Communications, SEEC, QWEST Communications, Zambeel, and Zaplet.

Mr. Khosla holds a Bachelor of Technology in electrical engineering from the Indian Institute of Technology, a master's in biomedical engineering from Carnegie Mellon University, and an MBA from the Stanford Graduate School of Business.

Of the government's 2004 provision for nanotechnology, 29 percent has been allocated to the National Science Foundation (an independent agency of the U.S. government commissioned to promote the progress of science and secure the national defense), and 26 percent and 23 percent to the Departments of Defense and Energy respectively. The remaining 22 percent was split unevenly among seven other federal agencies, with the Department of Homeland Security receiving less than one-quarter of one percent.

While much of the focus of NASA's recent forum was on the specific needs and applications relative to U.S. national defense and homeland security, discussion did touch on the challenges of funding. Vinod Khosla, general partner at Kleiner Perkins Caufield & Byers, one of the region's foremost venture capital firms, gave a keynote address emphasizing the role of venture capitalists and their support of technological innovation. The three panelists, representing other VC firms and academia, agreed that there has been an inherent disconnect between the R&D stage and commercialization.

J. Leighton Read of Alloy Ventures used the economic term "discount rate" to describe the extent to which we are more likely not to take action because a hypothetical event is viewed as being irrelevant in the present. The events of 9/11 reduced the discount rate for most Americans relative to the idea of terrorism within the safety of our borders. However, many investors remain hesitant to appreciate the cost benefits of investing in nanotechnology given the length of time before commercial products will be readily available and market opportunities abound. "If your market is only the U.S. government," says Martin Lagod of Firelake Capital Management, "it might be a good business, but it's not a particularly good one for venture capital."

Until the time of widespread commercialization, the federal government must rely on nanoproducts developed for homeland security's particular needs of detection, assessment, and response. These products include such things as nanosensors; more efficient portable power sources; lighter, sturdier materials; greater computing capabilities in terms of both memory storage and computations per second; and nanoscale solutions to biological and chemical threats.

Technology Needs

Given that the U.S. Department of Homeland Security (DHS) is little more than two years old, and nanotechnology as an applied science is not much older, there has been little time to compare the needs of the one with the potential solutions of the other. As the DHS continues to assess the country's infrastructure and the range of possible threats, and as progress continues in determining the breadth of opportunities available through practical application of nanotechnology, the links between the two—and resulting business opportunities for commercial applications—will no doubt become readily apparent.

At NASA's recent forum, Congressman Mike Honda (D-CA) spoke of the need for nanotechnological advances to assist with the prevention, deterrence, detection, mitigation, and identification of materials used in weapons of mass destruction, while several other panelists focused their introductory talks on particular areas of interest—from protecting the nation's infrastructure to detecting biological, chemical, and nuclear threats to making the task of urban search and rescue more safe and efficient.

Martin Lagod of Firelake Capital Management and Rick Rowe, CEO of Safeview, both spoke of the magnitude of the nation's challenge to protect its infrastructure. Lagod told of the hundreds of thousands of miles of high-voltage transmission lines and water delivery pipelines that cross the country virtually unprotected. Nanosensors could be deployed throughout these systems to monitor the systems and provide real-time

"We need to integrate nano-, micro-, and macro-[technologies] in order to get the right kind of usable product."

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Dr. Meyya Meyyappan

Director, Center for Nanotechnology

NASA Ames Research Center

Dr. Meyya Meyyappan is director of the Center for Nanotechnology and senior scientist with NASA ARC. He is a founding member of the Interagency Working Group on Nanotechnology (IWGN). The IWGN was established by the U.S. Office of Science and Technology Policy and is responsible for developing the National Nanotechnology Initiative.

Dr. Meyyappan is a fellow of the IEEE and he is the IEEE and ASME's Distinguished Lecturer on Nanotechnology. He has been awarded NASA's Outstanding Leadership medal for his work on nanotechnology. Dr. Meyyappan is the author or coauthor of more than 100 publications in refereed journals and has given over 200 presentations at national and international conferences.

data to better safeguard these essential systems. Rowe focused on the physical structures that might attract terrorist threats in the form of explosives, weapons, or chemical, biological, or nuclear attacks. According to Rowe, "The use of the 'unthinkable' is now common. Suicide bombers, for example—it's not a question of if, but when." The task of protecting the countless government buildings and innumerable public areas in which large numbers of civilians might gather is daunting. Again, nanosensors and nano-enhanced scanning technologies (X-rays or pulsed neurons) have the capacity to provide a level of security many times more powerful than anything currently available.

The issue that was raised most often, however, does not arise from the homeland security side of this equation, but rather from the practical but essential element of education. Similar to arguments made by experts in other high-tech, high-skilled industries, if steps are not taken to ensure that mathematics and the hard sciences are better emphasized in our schools and developed in today's youth, the next generation of workers will be ill-prepared to drive this technology forward in the not-too-distant future and momentum will be lost. Steve Jurvetson, of Draper Fischer Jurvetson, wholeheartedly agrees. "We must increase focus on science and math in schools in order to remain a competitive force; otherwise this technology will shift to Asia." With nanotechnology expected to become a $1 trillion industry within the decade, it is in the nation's best interest to ensure that we maintain our established lead in the field—not simply for the sake of economics, but also for the sake of national security.

Similarly, it is essential that those within the industry continue to provide a rational voice to the moral debate smoldering in regard to this young but burgeoning technology. The scientific community learned painfully from the ongoing stem-cell debate that ignorant or misguided voices can carry great distances, particularly when they spout the language of fear. While there are aspects of nanotechnology that have the potential to be destructive or offensive, the benefits of the technology greatly outweigh the concerns. "Are there dangers?" asked Vinod Khosla at NASA's recent forum. "Absolutely." Progress, however, should not be halted in the face of raised concerns. Supporters of the technology must instead take the opportunity to redirect the conversation to one of educating the public and the policymakers of the objective truth—both the positive benefits and the less-than-appealing realities of science gone astray—in order to ensure that this debate remains one of facts and not solely one of feelings.

Research & Development

As U.S. Representative Anna Eshoo aptly described it, Silicon Valley is the "cradle of science and innovation for the world." Silicon Valley has the infrastructure, resources, and talent to take the lead in nanotechnology. Several businesses and research institutions in Silicon Valley are involved in nanotechnology R&D, using a diverse, interdisciplinary approach which, at times, involves a fusion of information technology, bioscience, and nanotechnology. Although there is currently no "hot new area" within nanotechnology, and it is difficult to truly predict where exactly nanotechnology innovation will lead to, there are a few nanotechnology R&D pursuits that may impact future applications for homeland security.

1. Single-Walled Carbon Nanotubes

Single-walled carbon nanotubes are rolled sheets of graphite at the nanoscale level that can be manipulated to offer very little resistance, conduct extremely well, and have a high level of sensitivity and surface-to-volume ratio. For homeland security purposes, nanotubes and molecular nanomechanics can be used to create highly sensitive sensors to detect chemical, biological, and nuclear pathogens.

2. Semiconductor Quantum Dot Nanostructures

Semiconductor quantum dot nanostructures are unique 3-D nanostructures that can be used for several applications, including high performance optoelectronic and photonic devices. For

"Research on nanotechnology will give rise to a host of novel social, ethical, philosophical, and legal issues. To appropriately address these issues will require guidance that is responsive to the realities of science…."

Hon. Mike Honda
Congressman
U.S. Congress

Representative Honda represents the 15th Congressional District of California, the center of Silicon Valley and globally recognized as the breeding ground of technology and innovation. Elected to the U.S. House of Representatives in 2000, he serves on the House Committee on Science and the Transportation & Infrastructure Committee.

As evidenced at both Bay Area Nanotechnology Forums, Representative Honda is recognized as taking a leading role in informing and bringing Democrats and Republicans together to increase their understanding of the role of technology and its potential societal returns. He was also honored as the "High-Tech Legislator of the Year" by the American Electronics Association for his advocacy of the high-tech economy.

example, quantum dot nanostructures increase the sensitivity of photonic devices like night vision imaging systems, allowing for a greater level of visibility, which the military and public safety responders can use to see more clearly in low visibility situations.

3. Bionanoscience

Bionanoscience is the application of physical sciences at the nanometer scale to biological measurement and manipulation. Homeland security may benefit from this research, as devices such as the bioaerosol mass spectrometry system can be used to quickly detect any biohazardous substances and alert monitors to the situation.

4. Quantum Communications & Computers

Quantum-level communications and computers are potentially powerful tools in the homeland security arsenal. For example, quantum communication devices are highly secure communication systems, as they make eavesdropping on data communications impossible. Additionally, quantum computers will have the ability to store and process a much larger amount of information than the most powerful computers presently in existence.

These are just a few examples of the current nanotechnology research and development activities in Silicon Valley. The success and applicability of this work will be dependent upon several things. First, according to Vinod Khosla, the basis of innovation is unpredictability—we cannot enforce linear programs to pursue nanotechnology, as innovation does not work in a linear fashion. This non-linear, unpredictable aspect of research and development may be a challenge especially to investors, as there is a decided lack of control over how the technology develops and an uncertainty of what marketable applications result from this work. Also, although the recent passage of the "21st Century Nanotechnology Research and Development Act" authorizes $3.7 billion over the next five years for nanotechnology research and development efforts, appropriations are needed to secure actual monies to cover this $3.7 billion goal. However, there is a strong impetus to get nanotechnology applications and devices realized for homeland security purposes—the overarching concern right now is to "meet the mission" rather than determining the scalability of nanotechnology and applications for the larger consumer market.

Business & Market

Nanotechnology as an emerging market has the potential to transform every industry that will be involved with developing and manufacturing homeland security-related products. Business leaders in attendance at the forum commented on the market prospects of nanotechnology in homeland security in light of the existing downturn of the region. Evidence proves that Silicon Valley is still expected to be the premiere hotspot for innovation, and thus the commercial prospect for nanotechnology to reinvent homeland security is expected to materialize in only a matter of time. Experts at the forum agreed that the ability to understand and to adapt to the advantages and setbacks of innovation is necessary if development in the nanotechnology-homeland security area is to continue to grow.

Silicon Valley and Market Opportunity with Innovation

Silicon Valley is still seen as a model of innovation for the world despite the economic downturn which has lead to the largest percentage of jobs lost in an urban region since World War II. In fact, as noted at the forum, venture capitalists vote with their funds—and in 2003, one-third of all the venture capital funds in the U.S. were invested in the Valley. Even with the competition from other regions within the U.S., venture capital funds into the Valley have increased. According to business leaders, this is where the beginning of the future for nanotechnology rests.

"It is essential that we bring leading thinkers and innovators together to understand the tremendous potential of nanotechnology and what needs to be done to further encourage its development."

Hon. Zoe Lofgren
Congresswoman
U.S. Congress

Zoe Lofgren was first elected to the U.S. House of Representatives in 1994 and was appointed to the position of At-Large Whip for the 106th Congress. She is a member of the Judiciary Committee and two of its subcommittees, one of which has jurisdiction over patent, trademark, and copyright issues, which are critical to the computer and Internet industries, the other of which has jurisdiction over H-1B-related bills. She is also a member of the Science Committee.

Rep. Lofgren was rated one of the top ten members of the House in support for high tech by the Tech Law Journal in 1998 and she is best known in high tech policy circles for her cosponsorship of the Safety and Freedom through Encryption Act. California's 16th district, where Rep. Lofgren serves, covers a great deal of Silicon Valley.

Market Demand for Nanotechnology

Energy use was identified as one of the most pressing needs of homeland security, and nanotechnology was identified as a potential solution to the issue of energy efficiency. The need for efficient and environmentally sound methods of energy use has been with us for generations, amplified in recent years. Companies and research institutions within the Valley are partnering together to find solutions that are not only scientifically possible, but also financially feasible and will be commercially marketable in both the short and long term.

The demand for energy resources is certain to outrun supply. According to experts at the forum, nanotechnology can help to alleviate the issues relative to resource supply. One example is platinum. Platinum is used to supply energy both regionally and nationally, but also has attached risks and disadvantages with its use. The supply of platinum is becoming increasingly diminished and roughly 70 percent of platinum today comes from such politically unstable areas as South Africa and the Middle East.

The opportunity for nanotechnology to revolutionize the platinum market is within reach. Current nanotechnology developments involving quantum simulation techniques suggest that a material requiring less or virtually no platinum can be produced on an engineering scale and can function as the energy resource of the future. While recent nanotechnology advances include the creation of photovoltaic materials, and the creation of catalysts to process energy for energy plants, the most competitive technology that poses the potential to revolutionize the energy market is still the catalytic converter, an antipollution device in automotive exhaust systems.

Catalytic converters account for 31 percent of platinum ever used, resulting in shortages of the precious metal. According to forum experts, quantum simulation has the potential to create new materials that will reduce and potentially phase out the use of platinum. This technology is anticipated to appear in the market as a bridge between earlier quantum simulation techniques that transform a small number of atoms to an engineering scale development. The change toward the production of materials on an engineering scale is a prerequisite to developing real practical materials for energy use and equalizing supply and demand.

Short-term target markets for replacing platinum with nanoteched materials include auto catalytic converters and fuel cells. Long-range markets include optimizing chemical plants so that the environmental impact of substances in these plants is reduced while increasing plant efficiency and processes. As expressed during

the panel discussion at the forum, the ultimate market goal for this field of industry is to produce a prototype material using less or virtually no platinum. Because of partnerships in nanotechnology innovation, this prototype material is anticipated to be ready for market launch within the next 12 months. Within the next several years, it is anticipated that such materials as fuel cells will be developed that will become competitive alternatives within the automotive industry.

Characteristics of Innovation

Nanotechnology, as an enabling technology, is innovation at its finest. As an enabling technology, discoveries in this field when applied to specific sectors of the market have the potential to revitalize segments of industry as well as the economy as a whole. Atypical of the historical trends regarding start-up success in the Valley, however, because of the significant upfront capital costs involved, innovations integrating nanotechnology require the partnership of a major research institution.

Innovation is both helpful and disruptive as it opens the opportunity for competitive advantages. If advantages related to nanotechnology such as auto catalytic converters are to be realized, the characteristics of innovation must both be understood and facilitated. The materialization of innovation creates new businesses, new industries, and new jobs. However, these advances are not without their disruptions. The disruptive side of innovation in the market, as noted by business leaders, is that while there are new jobs, the labor force needs to be adequately prepared. Oftentimes innovation outruns the skills set of the general labor force and the lag time involved in uptraining the labor force results in greater short-term disruption of the economic cycle. In an area such as nanotechnology it is key that continued growth of this market is accompanied by workforce development strategies that not only train for the current industry market but also for the future.

Beyond Homeland Security

As an enabling technology, nanotechnology has the potential to revolutionize a variety of industries, most notably manufacturing, which has been suffering a significant downturn in Silicon Valley and throughout the United States. The research targeting nanotechnology invites a spectrum of possibility for discoveries, some of which are already happening. Some of the most intriguing developments include the application of nanotechnology to medicine, space, drug delivery, and multimedia.

Medicine

Nanotechnology, also considered "the manufacturing technology of the 21st century" in medicine, has enabled scientists and engineers collaboratively to build upon the development of computer controlled molecular tools that are much smaller than the human cell and built with the accuracy and precision of drug molecules. Because of the characteristics of the nanoscale, it is anticipated that instruments built for medicine based upon the nanoscale will allow tissue to be examined in unprecedented detail. With the development of sensors smaller than a cell, there is the ability to obtain an exquisitely precise look at the ongoing function of cellular, subcellular and molecular activities.

Given such molecular tools, a device designed to this scale could be applied to the identification and eradication of cancer cells possibly replacing the existing method of chemotherapy. The current idea behind

"Nanotechnology is the new frontier … and we Americans love to explore the new frontier."

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Phillip J. Bond
Under Secretary of Commerce for Technology
U.S. Department of Commerce

Phillip J. Bond was sworn in as Under Secretary of Commerce for Technology in October 2001. Under Secretary Bond serves as the principal advisor to Secretary Evans on science and technology policy to maximize technology's contribution to America's economic growth. In this context, his primary responsibilities are to supervise policy development and direction among the Office of Technology Policy, the National Institute of Standards and Technology, and the National Technical Information Service.

Mr. Bond also serves on four committees of the President's National Science and Technology Council, a Cabinet-level council established by the President to coordinate science, space, and technology policy within the federal research and development enterprise.

this is that a nanotechnology device would be able to identify the cancer cells, and because it would have binding sites to determine the concentration of specific molecules, a supply of some poison could be selectively released and able to kill a cell identified as cancerous.

Another idea for the application of nanotechnology to the field of medicine would be to develop a technology that could provide oxygen and metabolic support in the event of impaired circulation. Improving the levels of available oxygen despite reduced blood flow would provide an "artificial red blood cell."

Space

The application of nanotechnology to space spans the scientific as well as the commercial range. It is anticipated that nanotechnology will have impact particularly within the fields of structure materials, energy generation and storage, data processing and storage, data communication (optical/EHF), sensor technology/instruments, life support systems, biomedical applications and thermal protection and control. Developments anticipated include the creation of satellites based on nanotechnology which would significantly decrease the weight of current satellites and improve efficiency. However, although space-related technology research and development may accelerate if President Bush finds support for his "Moon and Mars" goals, these innovations are not expected to become actual products for another 10 to 15 years.

Drug Delivery

The fact that most drugs, in addition to their positive pharmacological effects, also exhibit negative side effects makes the concept of merging nanotechnology in the drug delivery sector commercially attractive. Nanoparticles exhibit attractive properties like high stability and the ability to modify their surface characteristics easily. Additionally, because nanoparticles are small enough to gain access to target tissues and cells, it is hoped that nanotechnology applied to drug delivery and targeting can eliminate some of the side effects associated with drugs in today's market.

Multimedia

While fairly new in its research phases, there is current investigation into the applicability of nanotechnology to the multimedia industry. It is anticipated that digital media such as sounds and images can be manipulated

at the nanoscale level, through the use of “nano-kernel” computer programs. Nanocomputers, given their size, run faster than regular computers, and the programs they run would similarly be very small and specialized, creating optimal throughput with little waste. Nanocomputers would also be able perform tasks that are required to decode and display multimedia content at the same time, which is called parallel processing. Parallel processing is quicker and more efficient then standard computer processing, as current computers can only perform one task at a time.

Summary & Recommendations

While there were a number of developments in homeland security discussed at the Nanotechnology and Homeland Security Forum, the three overriding themes of the conference were focused on the need to invest in education, formalize organizational communication, and appropriately address concerns about how to balance privacy concerns with protection needs.

Toward that end, there was unanimous agreement among the speakers regarding the need to improve math and science education. As the number of individuals graduating with math and science degrees continues to dwindle, the future of nanotechnology lies not only in the hands of funders and legislators, but also inventors. When products associated with nanotechnology make a significant entrance into the market, there will be a similar upswing in the demand for workers into this industry. Without an adequately prepared workforce, the potential to capitalize on the economic growth stimulated by the nanotechnology will be greatly diminished.

In addition to education, several speakers, including U.S. Representative Anna Eshoo, spoke to the importance of formalizing communication lines amongst government, education systems, public organizations, and businesses. As a new technology, there is an underlying fear that nanotechnology could be used for indiscriminate purposes, or bear a negative impact on the environment or the well-being of people in our nation. To safeguard against such potential possibilities, the formalization

"Direct applications for defense, intelligence, and homeland security for nanotechnology are boundless and only limited by our imagination and … I might say … our appropriations."

Hon. Anna Eshoo
Congresswoman
U.S. Congress

First elected to the United States House of Representatives in 1992, Anna G. Eshoo was elected by her colleagues as an At-Large Democratic Whip in the 108th Congress. Rep. Eshoo serves the 14th Congressional District, which is home to high technology and biotechnology companies, to farms and fishing enterprises, and to wonderful communities all thriving side by side. The district is also the home of the world-renowned center of learning, Stanford University, with its research and teaching facilities respected around the world.

Anna Eshoo has spent a decade defending consumers, assuring access to health care for families and children, promoting American competitiveness, and protecting the environment.

of communication structure will help to keep the public and the government informed. Additionally, these open communication lines will allow interested groups to learn more about the applications and objectives of nanotechnology developments and provide opportunities for the appropriate checks and balances to occur.

A third concern that may impact nanotechnology research and development for homeland security was raised by Martin Lagod at the forum: "How much privacy are we willing to give up in order to be safe?" Nanotechnology is a non-visible technology that could conceivably be used by the homeland security industry to develop devices that can collect, analyze, and disseminate information about an individual without that person's knowledge. For example, nanotech-enabled computers could collect and track such data as a person's political views or religious affiliations for "security purposes" without the person ever knowing or even consenting to the release of that information. Ensuring secure protection of privacy and civil liberty will be a challenging tightrope to walk when balanced with the need to protect the United States and its populace from further terrorist attack.

As an enabling technology, the growth of nanotechnology has the potential to reinvent Silicon Valley's economy and workforce as well as provide support towards critical infrastructures such as Homeland Security. The possibilities of this technology are seemingly endless, and with a concerted and collaborative effort towards its growth, Silicon Valley can leverage and develop upon its existing resources and help to reinvent our nation's economy.

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About NOVA

NOVA (North Valley Job Training Consortium) is a non-profit, federally funded employment and training agency dedicated to providing innovative, high-quality, customer-focused workforce development services. To accomplish this goal, NOVA works closely with local businesses, educators, and job seekers to ensure that our programs provide opportunitites that build knowledge, skills, and attitudes necessary to address the workforce needs of Silicon Valley. NOVA is a seven-city consortium consisting of the cities of Cupertino, Los Altos, Milpitas, Mountain View, Palo Alto, Santa Clara, and Sunnyvale. Its policies are set by the NOVA Workforce Board and the consortium cities' councils, and it is administered by the City of Sunnyvale. For more information about NOVA, please visit www.novaworks.org.