Minutes
NIST Technology Innovation Program (TIP)
Advisory Board Meeting
May 11, 2010

Executive Summary (Full Minutes Follow)

Technology Innovation Program's (TIP) Deputy Director, Dr. Lorel Wisniewski, was the first speaker. She summarized TIP's purpose and key features. TIP supports, promotes and accelerates U.S. innovation through high-risk, high-reward research in areas of critical national need (CNN). Single companies (small or medium for-profits) can receive up to $3 million in Federal funds for up to three years, and joint ventures (which must contain at least one small- or medium-sized for-profit company) can receive up to $9 million in Federal funds for up to five years. TIP funds direct costs only and no more than fifty percent of the total project cost.

Proposals are due on July 15, 2010, for the third TIP competition for which approximately $25 million in new awards is available. The topical area is "Manufacturing and Biomanufacturing: Materials Advances and Critical Processes."

TIP receives input from a variety of sources, including the Advisory Board, other Federal and state technology agencies, industry, non-profits, NIST technical experts, and others. TIP's "White Paper" process invites anyone with opinions regarding critical national needs appropriate for TIP support to submit ideas and rationales. Civil infrastructure and manufacturing have already been shown to meet TIP's criteria for critical national needs appropriate for TIP support. At this meeting, two other areas currently under consideration as possible critical national needs were discussed:

- Advanced automation
- Water

The Board reinforced the importance of TIP continuing to be involved in interagency discussions of technical areas that are candidates for critical national needs. It endorsed the idea of TIP running competitions for other Federal agencies.

Several speakers addressed Advanced automation as a potential critical national need, including Dr. Richard Bartholomew of TIP, Dr. Howard Harary and Ms. Elena Messina of NIST's Manufacturing Engineering Laboratory, and Dr. Sridhar Kota of OSTP (the White House Office of Science and Technology Policy).

Advanced automation can be viewed as a platform for the delivery of innovative technologies into new markets and applications. Advanced automation, which includes technologies such as sensing, signal processing, artificial intelligence, modeling and control systems, are important enablers for the adoption of new products and technologies in markets ranging from manufacturing to care for the elderly. Advanced automation technology can improve the safety, effectiveness and therefore the commercial viability of a wide range of new products. Thus,

advanced automation is seen as a potential lever point for broadly accelerating new businesses and products.

The Administration (through OSTP) and the Congress both have a keen interest in advanced automation. Guest speaker Dr. Sridhar Kota of OSTP summarized OSTP's interest in advanced automation and manufacturing. Dr. Kota encouraged Board members to contact him directly with additional input these topics.

TIP's Dr. Donald Archer spoke about water as a potential critical national need. Like advanced automation, water is also being explored by TIP to determine whether it reaches the threshold of being a critical national need appropriate for TIP funding. TIP has received a number of white papers describing the need for better technology to ensure an adequate supply of clean water for the nation.

Demand for water grows proportionally with population growth. Already there are water shortages in sections of the United States, and as population grows, such shortages are likely to become more commonplace. Thirty-six states anticipate water shortages in the next ten years. The economic impact of droughts is significant.

Technical challenges include desalination, removing contaminants, and transporting water long distances at a cost that is economically viable. As an example, perhaps new technologies such as carbon nanotubes pose a new solution for this sector.

Full Minutes

Attendees:

Board Members
Jeffrey Andrews, Advanced Electron Beams
Vinton Cerf, Google, Inc.
Charles Cooney, Massachusetts Institute of Technology
Martin Izzard, Texas Instruments, Inc.
Radia Perlman,
James E. Reeb, Caterpillar
William Peter Teagan, Consultant

NIST
Lorel Wisniewski, TIP
Don Archer, TIP
Richard Bartholomew, TIP
Brian Belanger, Advisory Board Liaison
Herbert Bennett
Bill Boettinger
Steve Campbell, TIP
Mrunal Chapekar, TIP
Jeffrey Fong, TIP
Edward Garboczi
Howard Harary
Purabi Mazumdar, TIP
Elena Messina
Mike Moldover
Linda Beth Schilling, TIP
Michael Schen, TIP
Emil Simiu
Marc Stanley
David Swanson, TIP
Marlon Walker, TIP
Tom Wiggins, TIP

OUTSIDE
Sridhar Kota, OSTP

(In the discussion sections, "**Q**" refers to a question from the Board, "**A**" is the answer, and "**C**" is a comment.

Welcome and Introduction – Mr. Jeffrey Andrews, Board Chair

Mr. Andrews called the third meeting of the Advisory Board to order at 8:48 a.m. The Board's first annual report was published following the previous meeting. Mr. Andrews noted that former TIP Director, Marc Stanley, had retired since the last meeting, and he wished him well in his retirement. Mr. Andrews expressed admiration for Mr. Stanley's leadership in establishing

TIP and the Advisory Board, and he thanked Dr. Wisniewski for arranging this meeting and for continuing to maintain the high standards that have been set for TIP operations.

Key Aspects of the Technology Innovation Program – Dr. Lorel Wisniewski, Deputy Director, TIP

Dr. Wisniewski thanked the Board members for their advice and guidance to date.
Dr. Wisniewski began by noting that five "NIST Fellows" had been invited to attend this meeting:

- Dr, Herbert Bennett
- Dr. William Boettinger
- Dr. Edward Garboczi
- Mr. Michael Moldover
- Mr. Emil Simiu

(NIST Fellows are distinguished scientists or engineers recognized by the Institute for their accomplishments. TIP welcomes their expertise and advice.)

Dr. Wisniewski summarized TIP's purpose and the program's key features. TIP supports, promotes and accelerates U.S. innovation through high-risk, high-reward research in areas of critical national need (CNN). Single companies (small or medium for-profits) can receive up to $3 million in Federal funds for up to three years, and joint ventures (which must contain at least one small- or medium-sized for-profit company) can receive up to $9 million in Federal funds for up to five years. TIP funds direct costs only and no more than fifty percent of the total project cost.

Proposals are due on July 15, 2010, for the third TIP competition for which approximately $25 million in new awards is available. The topical area is "Manufacturing and Biomanufacturing: Materials Advances and Critical Processes."

TIP's appropriation for this fiscal year is $69.9 million. The President's budget request for 2011 is $79.9 million, but it is too early to predict what the final appropriation might be. Dr. Wisniewski noted that funds to complete ongoing projects from NIST's former Advanced Technology Program were included in recent year TIP appropriations, but most ATP projects will end this year.

Q: Does TIP fund projects year by year? If so, there is no guarantee that TIP will have future year funding available to complete ongoing projects.

A: Yes, that means that for multi-year projects, there are "mortgages" that must be budgeted for. TIP awards specify that future year funding is contingent on Congressional appropriations. However, history has shown that Congress is usually willing to ensure the completion of ongoing projects. Of course, TIP reviews the progress of each ongoing project on a regular basis, and will not continue to fund a project that is not making progress or fails to continue to be consistent with TIP's funding criteria.

A bill to re-authorize both NIST and TIP, the America COMPETES Act, is moving through Congress now. This version of the bill would stabilize TIP funding at about $40 million in new awards per year. While that is encouraging, it is the annual *appropriation* bill that determines the actual amount of funding, and it is too early to predict what that number will be for FY 2011.

In 2009, TIP received 138 proposals, of which 20 were funded (8 in civil infrastructure and 12 in manufacturing). Most awardees were small businesses. Civil infrastructure project awards were made in technical areas such as highways and bridges, pavement, water and wastewater, and dams and levees. Manufacturing project awards were in areas such as nanomaterials, composites, alloys, and smart materials. Funded projects are listed on the TIP Website.

Dr. Wisniewski reminded the attendees of the meaning of the terms “Critical National Need” and “Societal Challenges.” A diagram in her presentation illustrated how projects suitable for TIP funding represent a subset of the total spectrum of critical national needs. For example, if a critical national need is being addressed adequately by another Federal agency or by industry, TIP will not support R&D in that area. If a critical national need does not lend itself to being addressed through high-risk, high-reward R&D, TIP will not support that area.

TIP receives input from a variety of sources, including the Advisory Board, other Federal and state technology agencies, industry, non-profits, NIST technical experts, and others. Through its white paper process TIP invites anyone with opinions regarding critical national needs appropriate for TIP support to submit ideas and rationales. Areas such as civil infrastructure and manufacturing have been shown to meet TIP’s criteria for critical national needs appropriate for TIP support. At this meeting, two other areas currently under scrutiny as possible critical national needs were discussed: advanced automation and water.

Q: Does TIP jointly fund R&D with other Federal agencies?

A: TIP coordinates with other agencies to ensure that it is not duplicating R&D funded by others. TIP can leverage R&D funded or conducted by other agencies. The TIP statute permits TIP to run competitions for other agencies using TIP’s selection process, but there are no examples of that to date.

C: I would encourage that. Perhaps OSTP could look for opportunities.

C: There are fuzzy boundaries between manufacturing and materials. TIP should encourage the development of advanced materials and better ways to manufacture them. That kind of R&D is too long-term for most companies. TIP’s definition of manufacturing should, therefore, be broad.

A: Developing manufacturing processes for advanced materials is an appropriate area for TIP.

C: The White House is encouraging collaboration among agencies, and NIST is reaching out to other Federal S&T agencies even more than before. NIST’s new Director, Dr. Pat Gallagher, is giving a high priority to inter-agency collaboration.

Q: The Department of Energy is the lead agency in energy. In the area of civil infrastructure, is NIST the lead?

A: There are about a dozen Federal agencies involved in civil infrastructure, for example, the Federal Highway Administration and the Army Corps of Engineers to name just two. So, while NIST makes important contributions, we are one of many agencies involved in civil infrastructure.

C: NIST must have a seat at the table to be a player. One could characterize the Department of Commerce's role as being a conduit between government and small businesses. It is appropriate that NIST is located in Commerce.

A: Commerce does have an important role. NIST is currently involved in a number of intergovernmental working groups.

C: It is essential that TIP continue to be involved in such groups. TIP can and should leverage R&D by other agencies.

Advanced automation as a Potential Critical National Need – Dr. Richard Bartholomew, TIP

Mr. Stanley and Dr. Bartholomew were invited to attend a meeting of the Massachusetts Technology Leadership Council. At the meeting they asked the other attendees to comment on their perceptions regarding critical national needs. Advanced automation proved to be an area of considerable interest.

It appears that Japanese auto companies (e.g., Toyota) make better use of robots for auto assembly than U.S. manufacturers.

In 2007 Congress formed a Congressional Caucus on Advanced automation. OSTP has also formed a Advanced automation Working Group, confirming the current Administration's interest in this topic. A number of groups such as the Robotic Technology Council of the National Center for Manufacturing Sciences have devoted attention to identifying challenges and opportunities. Several NIST laboratories have programs related to advanced automation. Many government agencies (e.g., DOD, NASA, NSF, DARPA, and NIST) fund advanced automation R&D programs, and the National Science Foundation has issued a particularly helpful roadmap called *From Internet to Advanced automation*. TIP has received twelve white papers on this topic, indicating a high level of interest, and three advanced automation related projects have already been funded as part of the manufacturing critical national need area.

There are numerous technical challenges, such as developing mobile robots not bolted to the floor and robots that can assess their environment and make decisions. Safety issues are key if robots and human workers are to share space on the factory floor.

As our population ages, robots that can help with elder care could be important, so advanced automation and healthcare have a connection.

Q: Why is the U.S. behind some other countries in the adoption of advanced automation?

A: It is expensive to install robots and their support systems as a retrofit in old plants. Many of our factories are older plants. Current robots may be too expensive and insufficiently flexible for small companies not involved in mass production.

C: There are accounting and return-on-investment problems, too. When the capitalization associated with installing new robots is compared with outsourcing, robots may not win. High volume manufacturing may benefit from robots, but low volume manufacturing may not. More flexible robots that can adapt to small lot production are needed.

C: In Europe labor regulations regarding hiring and firing are rigid, and companies are reluctant to make long-term commitments to hire new people. For that reason, the use of robots may appear more attractive to them than hiring workers for whom a long term need is unclear. In Japan there is an aging population, and using robots may be more cost effective than hiring and training assembly line people in a tight labor market.

C: My company makes high-tech products with highly automated assembly lines, and the cost of manufacturing in the U.S. vs. offshore differs very little because labor costs represent only a small portion of the total product cost.

C: Robots can replace low-skill people. But instead of thinking in terms of retrofitting robots to existing production lines to reduce assembly labor costs, companies need to rethink the whole process, integrating people and robots into the production in the most efficient way.

Dr. Howard Harary of NIST's Manufacturing Engineering Laboratory told of a Maryland company (Marlin Wire) that converted production to robots. It increased sales and increased its workforce substantially, suggesting that the perception that the adoption of robots inevitably reduces jobs may not be the case. Because this company now uses flexible automation, they can undercut Chinese producers and shorten turn-around time.

C: Customization is important, and companies that can produce small lot sizes economically will prosper.

C: Typically people write programs off-line, then try to train the robot on the shop floor, and there is often considerable tweaking required to get the desired performance. Being able to shift to a new program quickly and easily and having it work properly the first time it is tried is important.

Dr. Bartholomew showed a video of a robot picking towels out of a pile and folding them. While one cannot justify buying an expensive robot to fold towels, this was a good illustration of how modern robots can carry out complex tasks involving vision and perceiving their surroundings.

Q: Why is power and energy in the list of challenges for advanced automation?

A: That is important for robots that are not bolted to the floor, but can move around the factory. They must be able to recharge their batteries when needed and communicate with control points.

Q: What about advanced automation in agriculture?

A: That is another promising application for future smarter robots. Designing a robot to pick apples, for example, is a challenge—being able to handle fruit without damaging it and being able to distinguish a ripe apple from one that is not ready to be picked requires a sophisticated robot.

High precision robots can be essential for manufacturing tiny assemblies where human fingers are too clumsy to handle the small parts.

Administration Priorities in Manufacturing and Advanced automation – Dr. Sridhar Kota, Asst. Director for Advanced Manufacturing, OSTP

The Administration, through OSTP, has a keen interest in manufacturing and advanced automation. The President's Council of Advisors on Science and Technology (PCAST) has a special committee on advanced manufacturing that will soon issue a report. OSTP is examining issues of how to create new industries and how to improve existing industries. Areas such as flexible electronics are receiving attention, as well as advanced automation, modeling and simulation, and cloud computing.

Efforts are underway to study the roadmaps developed by industry and the plans of the many Federal agencies that are dealing with these technical issues. Reducing costs is certainly a key issue.

Safety issues with robots must be addressed.

Q: Is the main role of OSTP that of a convener?

A: Yes, OSTP seeks to identify gaps and opportunities and to foster interagency cooperation.

Q: Does OSTP get involved in joint solicitations?

A: OSTP has no funding of its own, but it works with OMB to develop science and technology budgets that make sense, and to get agencies to buy into coordinated plans. OSTP can provide guidance to agencies, given its overview of all that is happening.

C: Opportunities abound for improvements in the construction industry.

C: New technology is not the only factor. There is technology on the shelf today to increase productivity, but there are tax issues, capital availability issues, and other issues that affect productivity improvements. However, I do believe that it is important to continue R&D for the development of new technology.

A: Today manufacturing can be done anywhere in the world, but smaller companies often cannot afford to move offshore, and they may not be able to afford robots either.

C: The situation is quite different in different industries. For example, very high-tech, high production volume manufacturing (e.g., microprocessors) is very different from low volume low tech metal bending. Where should the U.S. try to be competitive? Labor costs may be minor in some high-tech, high production volume operations where automation is essential and already in widespread use.

C: There is a need for ongoing assessment of national priorities. Is healthcare more important than, say, wind turbines? If the U.S. wants to be a world leader in wind turbines, that requires certain manufacturing capabilities. But if the nation wants to be world class in healthcare, that requires rather different technical capabilities.

Dr. Kota encouraged Board members to email him with their thoughts on these topics.

Next Generation Advanced automation – Dr. Howard Harary, Acting Director, NIST Manufacturing Engineering Laboratory-MEL, and Ms. Elena Messina, Acting Chief, Intelligent Systems Division

Dr. Harary's laboratory has done much pathbreaking work in the area of advanced automation for manufacturing. The Automated Manufacturing Research Facility (AMRF), completed almost thirty years ago, was, at the time, considered a world-class demonstration facility for the adoption of robots in manufacturing. Thousands of visitors came to see the AMRF. While MEL's research topics have evolved since then, MEL continues to carry out important research in advanced automation.

Dr. Harary's talk focused on robots that can share the factory floor with humans. Creating such robots is a huge challenge, particularly with regard to safety issues, but if successful, the applications could be numerous. Operating a robot in an unstructured environment implies that the robot must be capable of sophisticated decision making. Simple and instantaneous communication is a necessity. Human-like manipulation of objects, autonomous navigation, and 3-D vision are examples of desirable characteristics. Quantifying the performance of such robots presents challenges, too.

With adaptable robots, flexible manufacturing can be achieved, and the potential economic impact is great. Interoperability standards are needed so that robots from different manufacturers can be operated seamlessly together in a plug and play fashion in factories without the problems of incompatible proprietary operating systems. NIST is addressing a number of these challenges and making progress.

Q: How do standards get set in this field?

A: Organizations such as ASTM, RIA, and the IEC convene experts to develop standards. NIST gets involved in international standardization efforts. The United States is currently behind countries such as Japan and Korea. We can learn from their work.

C: The general public tends to be enthusiastic about humanoid robots, but it is important to consider the job to be done and devise the best approach. Humanoid-type robots are often *not* the best approach. For example, rather than design a robot that washes dishes by handling each dish separately as humans do, it makes more sense to use the familiar batch dishwater mode.

Q: The use of robots differs radically from one application to the next. A robot for eldercare will be very different from a robot for coal mining. To what extent are advanced automation R&D needs generic vs. specific to the application?

A: There definitely are generic problems for which R&D is needed. For example, artificial intelligence and vision are common to any type of sophisticated robot. A robot may not always act as predicted by the sum of its components, hence there are challenges in modeling the behavior of complex systems.

Q: Are there intellectual property issues in this field that limit progress?

A: That does not seem to be a major impediment to progress.

C: In fields like food processing, patents are valuable and practitioners guard trade secrets aggressively.

Q: How does NIST define advanced automation? Traditionally, robots are used in repetitive assembly line processes, but there are remote operations that share some of the characteristics of robots. Also, what about software "bots?"

A: Tele-operation would be included in what we consider advanced automation. Advanced automation implies more than just software.

Future robots will need to be able to decide what action is called for and modify their programs based on sensory input. Image processing is computation intensive and so it is difficult for a robot to be as fully aware of its environment as a human might be.

C: My university has a manufacturing R&D program focusing on continuous processing of materials. One might not think of a closed process involving sensing and activating as "advanced automation" but it has the same aspects.

A: Yes, sensing and actuating is a part of the field of advanced automation even when the process is a continuous process rather than one dealing with discrete parts.

C: In industries such as auto assembly, robots typically are programmed to do repetitive tasks, but don't really think. In some applications that is sufficient, but there are other applications for which thinking is important.

A: As noted before, future robots will need to be able to decide what action is called for and modify their programs depending on what is being sensed. There is a spectrum of needs, ranging from cases where just being able to perform a repetitive task is all that is needed, to other cases where adaptability would be extremely valuable.

C: But such robots are likely to be expensive, and a real need is to lower the cost of all advanced automation, even unsophisticated advanced automation. There are companies that could benefit from using simple robots but cannot afford the up-front cost. It may be more cost-effective for them to hire minimum-wage people to do simple jobs than to employ robots.

C: Costs are likely to come down. Consider the case of computers. Originally computers were big and expensive, and only companies having massive data processing needs and deep pockets could afford a computer. Today we have sophisticated computers in throw-away cell phones. Perhaps the same might happen with advanced automation in the coming years.

The meeting broke for lunch at 11:45 a.m. and reconvened at 1:30 p.m.

Water – A Potential Critical National Need – Dr. Donald Archer, TIP

A number of white papers have been received describing the need for better technology to ensure an adequate supply of clean water for the nation. Like advanced automation, water is also is currently being explored to determine whether it reaches the threshold of being a critical national need appropriate for TIP funding.

Demand for water grows proportionally with population growth. Already there are water shortages in sections of the United States, and as population grows, such shortages are likely to become more commonplace. Thirty-six states anticipate water shortages in the next ten years. The economic impact of droughts is significant.

Agricultural use accounts for about 65 percent of water consumption. Domestic use is about 20 percent, and industrial use, about 10 percent. As water is increasingly taken from less desirable sources (e.g., brackish or polluted water), subject to more intensive treatment, and transported over increasingly greater distances, the cost to the consumer increases. That will have an adverse impact on the economy. In California, which moves vast quantities of water over great distances, 19 percent of the state's energy generation is used for water supply and treatment—a surprisingly large number.

New technologies could address these problems, for example, decontamination employing nanomaterials, but a technical issue is whether carbon nanotubes could be made in the large quantities needed at an affordable price. Inexpensive robust sensors, to detect harmful substances in water, is another area for exploration, as is affordable technology to remove harmful trace elements. Still another area for exploration is how to reduce the energy required to process water. The private sector has traditionally not invested much R&D funding in water processing. Federal agencies have some efforts underway, e.g., NOAA and NASA, as well as DOE's efforts on climate modeling and hydrosphere prediction. EPA has worked on assessing water quality. NSF has funded predictive science. The Bureau of Reclamation has funded desalination plants. There has not been much R&D work devoted just to lowering the cost of future water supplies and ensuring their purity.

TIP has been consulting with other Federal agencies, state and local government bodies, and industry regarding these issues and has developed a working draft making the case for designating this area as a critical national need.

Q: Tell us more about the use of carbon nanotubes for water processing.

A: The tubes must be oriented vertically in the membranes. Large quantities of such materials would need to be manufactured cheaply for this to be a viable solution.

Q: Would the present increased interest in nuclear power help the water problem, by making waste heat available to reduce desalinization costs?

A: It might not have a big impact, but anything we can do to reduce the importing of foreign oil is a plus.

Q: There are techniques to extract oil and gas from shale—hydrofracturing approaches. Don't those approaches produce large quantities of contaminated water that might need to be cleaned up?

A: Yes, and it is expensive to clean up that kind of contaminated water.

Q: What about the issue of drinking water being contaminated with pharmaceuticals?

A: There has been increased awareness of that issue in recent years. Fish with gender anomalies has been attributed by some to that. Today we can detect contaminants at very low concentrations. Nicotine in water is another contaminant that has come to our attention recently.

Q: Are there other technologies that look promising besides carbon nanotubes? Can we reduce the energy required for desalinization?

A: There are thermodynamic limits for separating salt from water. Traditional desalinization methods work on bulk thermodynamics whereas membrane approaches work on surface thermodynamics and that can be an advantage. One area of current interest is Toricelli columns, where one puts water in a long vertical column and allows gravity to assist with the separation. One issue that arises often is how *much* of the salt must be removed. Obviously the smaller the acceptable concentration of residual salt in the processed water, the higher the processing cost. If waste energy can be used in desalinization, that tends to lower costs.

Q: What about solar desalinization?

A: There has not been much R&D in that area. In sunny desert areas solar desalinization might have some applicability.

Q: Is customer conservation being pushed? Are there demonstration projects?

A: Some cities are giving up their municipal water plants and turning operations over to private companies. Companies like American Water are looking for ways to cut costs, and sometimes innovation comes from the private sector. Years ago cows in the Chicago Stockyards were dying from contaminated water. The management began using chlorine to purify the water, and for a time, the cows had better water than the people in Chicago.

Q: If TIP funds water projects, how will we ensure that the benefits stay in the U.S.?

A: For TIP projects, the intellectual property must vest with U.S. firms. TIP can fund foreign firms under certain conditions, but that does not happen very often, and when it does, there must be clear evidence that the principal benefits of the R&D accrue to the U.S. If innovative new technology is developed in a TIP project, chances are that eventually the technology will be adopted worldwide, but that can benefit U.S. exports.

Q: Has anyone considered an approach where not all water to consumers is purified to potable water standards? Much water consumption goes to toilets, taking showers, washing clothes and dishes, watering lawns—applications that do not require potable water.

A: Yes, that point comes up frequently. The problem is that the cost of installing a second set of water mains and piping to homes and businesses to supply non-potable water would be prohibitively expensive. People are exploring options for reusing "grey water" for lawn watering, etc. In parts of the country like Southern California, some people are replacing grass with native wildflowers or other approaches that do not require watering.

C: One might consider providing consumers with non-potable water and using bottled water for drinking. Reverse osmosis filters are available for sinks to ensure water quality.

A: If non-potable water were delivered to homes for other than drinking and cooking, fluoride would need to be provided somehow for the drinking water.

Q: What other new techniques are there for water purification besides carbon nanotubes?

A: There are innovative ideas around, and that is why we need TIP—to encourage people to think out of the box. There are biometric approaches to selectively removing particular contaminants. Microorganisms can do cleanup. After Chernobyl, sunflowers were planted because they take up uranium from the soil.

C: Scale up may be a challenge.

A: Yes, small scale recovery from waste streams is much easier than large scale plants where economic issues are critical.

Q: What is the biggest problem? Cleaning the water, knowing when it is potable, or the cost of transporting to where it is needed?

A: None of these is easy and they are related. As Los Angeles needs more water, it must go farther away to find sources, and those sources may be salty or contaminated. Another problem is, after you have separated the brine, what do you do with it? In a desalination plant, if you dump the brine back into the ocean, the ocean in that area becomes saltier, which makes the desalination more costly and also has adverse impact on ecosystems. Arizona has problems with arsenic in water. After you successfully extract the arsenic, where do you dump it? Which problem is the most challenging depends on where you are in the country.

Chairman Andrews thanked Dr. Archer and opened the floor for discussion of any of the topics.

C: People worry that adoption of advanced automation might eliminate jobs, but if the U.S. could be a world leader in advanced automation and export the technology, it could create lots of new high paying jobs.

C: The use of next-generation advanced automation can allow companies to be more agile and allow them to make higher quality products, thereby increasing sales. As transportation costs increase, making more goods in the U.S. vs. offshore can be attractive.

C: The U.S. should be more aggressive in the international standards arena. Participation of experts from other countries is often paid for by their governments, which ensures that those countries are well represented. U.S. industry is not always adequately represented at these meetings and so the U.S. is at a disadvantage.

C: Vision systems, image recognition for robots, and artificial intelligence are key generic R&D areas that TIP might support. Humans should be able to shout commands to robots that could react accordingly based on voice recognition.

C: If TIP were to focus on advanced automation, areas such as advanced automation for healthcare might be easier to justify than, say, advanced automation for automobile assembly.

Micro-robots can be used to find breaks in water mains.

C: Water treatment is a good example of a societal problem in which the private sector is unlikely to invest sufficient R&D effort.

C: When comparing alternatives for water treatment, the cost of energy must be taken into account.

C: It is too early to tell whether using nanotubes for water treatment is feasible. There are issues of scale-up to be able to manufacture nanotubes in large arrays of the kind needed for water treatment. Actual desalination plants have proved to be more expensive than anticipated, and the same might be true of treatment with nanotubes.

Before adjourning the meeting, both Mr. Andrews and Dr. Wisniewski thanked the attendees for their input. TIP's Rene Cesaro was thanked for her excellent work on meeting arrangements.

The meeting was adjourned at 3 p.m.