NIST Technology Innovation Program (TIP)
Advisory Board Meeting
May 18, 2011

EXECUTIVE SUMMARY
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TIP Advisory Board Chair Mr. Jeffrey Andrews called the meeting to order, reviewed the agenda and then turned the meeting over to TIP Deputy Director Dr. Lorel Wisniewski.

Dr. Lorel Wisniewski reviewed the meeting logistics and reminded the attendees that the meeting was open to the public. Dr. Wisniewski introduced Dr. Phillip Singerman, NIST's new Associate Director for Innovation and Industry Services. Under the NIST reorganization that took place in October 2010 NIST no longer has a Deputy Director, but instead, three Associate Directors. Dr. Singerman is responsible for NIST's extramural programs—the Technology Innovation Program, the Hollings Manufacturing Extension Partnership, and the Baldrige Performance Excellence Program. Dr. Singerman also has responsibility for the NIST Grants Management Office, the Economic Analysis Office, and the Office of Technology Partnerships.

Dr. Wisniewski reviewed the new NIST organization chart, and noted that NIST Director Dr. Patrick Gallagher now also serves as Commerce Undersecretary for Standards and Technology thus giving NIST higher visibility within the Administration. While the reorganization has not changed TIP's internal management structure it has tended to increase collaboration among the various parts of NIST.

Dr. Wisniewski gave a budget update. Her charts cited data on projects in the two areas currently funded: Civil Infrastructure and Manufacturing. The 38 ongoing projects involve $135.7 million in federal funding as well as awardee cost sharing, for a total investment of $279.7 million. One hundred and thirty-two organizations participate in these projects. None has reached completion as yet.

Several presentations were given by expert TIP staff on the status and progress of awards. These included:

Civil Infrastructure projects, presented by Mr. David Swanson and Dr. Felix Wu

Manufacturing projects, presented by Dr. Michael Schen, Jean-Louis Staudenmann, and Donald Archer

TIP invited two awardees to address the Board and share their experiences carrying out TIP-sponsored research. Dr. Mohammed Ettouney of Weidlinger Associates gave a presentation, as did Professor Daniel Inman of Virginia Tech (via remote teleconference).

Ms. Margaret Phillips then addressed TIP's response to recommendations from the Advisory Board's annual reports.

Minutes

Attendees:

Board Members
Jeffrey Andrews, Advanced Electron Beams
Radia Perlman, Intel Lab.
Jim Reeb, Caterpillar
Peter Teagan, Consultant

NIST

Donald Archer	Michael Schen
Brian Belanger	Linda Beth Schilling
Douglas Bischoff	Robert Sienkiewicz
Steve Campbell	Phillip Singerman
Michael Gaitan	Marc Stanley
Prasad Gupte	Jean-Louis Staudenmann
Eric Letvin	David Swanson
Jeffrey Mazer	Michael Walsh
Cindy McKneely	Lorel Wisniewski
Margaret Phillips	Felix Wu

Invited Speakers
Mohammed Ettouney, Weidlinger
Daniel Inman, VA Polytechnic Institute and State University [via webinar]

Public
Christopher Golon, AEIS LLC
Frank Golon, David Wayne Development
Ghouse Ismail, AEIS LLC
Brittany Westlake, American Chemical Society

Mr. Jeffrey Andrews, Advisory Board Chair – ***Call to Order and Welcome***

[***Note:*** *In the discussion sections, "Q" refers to a question, "A" is the answer from the speaker or Dr. Wisniewski, and "C" refers to a comment from the panel. Because the charts used in the presentations will be posted on the TIP website, these minutes summarize the key elements of the presentations rather than document their details*.]

Board Chair Mr. Jeffrey Andrews called the meeting to order at 8:30 a.m. TIP Deputy Director Dr. Lorel Wisniewski reviewed the meeting logistics and reminded the attendees that the meeting was open to the public.

Dr. Wisniewski introduced Dr. Phillip Singerman, NIST's new Associate Director for Innovation and Industry Services. Under the NIST reorganization that took place in October 2010, NIST no longer has a Deputy Director, but instead, three Associate Directors. Dr. Singerman is responsible for NIST's extramural programs—the Technology Innovation Program, the Hollings Manufacturing Extension Partnership, and the Baldrige Performance Excellence Program, as well as the NIST Grants Management Office, the Economic Analysis Office, and the Office of Technology Partnerships. Dr. Singerman began this new responsibility in January. During his distinguished career he has held a number of high-level positions, e.g., he headed the Ben Franklin Program in Pennsylvania and served as Commerce Department Assistant Secretary for Economic Development.

Dr. Singerman thanked the Board members for their service and their good advice, and also thanked the highly dedicated TIP staff. He holds TIP in high regard, calling it "the gold standard for federal technology programs" because of its rigorous and thorough reviews of proposals and its value-added project management.

Dr. Lorel Wisniewski - TIP Program and Budget Update

Dr. Wisniewski reviewed the new NIST organization chart and noted that NIST Director Dr. Patrick Gallagher now also serves as Commerce Undersecretary for Standards and Technology, thus giving NIST higher visibility within the Administration. While the reorganization has not changed TIP's internal management structure, it has tended to increase collaboration among the various parts of NIST.

Nine new TIP awards were announced in December 2010. Dr. Wisniewski reported that no funds were appropriated in FY 2011 for a new TIP competition, so staff effort has been focused on managing the 38 ongoing TIP projects, as well as the remaining ATP projects.

During the first years of TIP, competitions were announced only when funding actually became available. This meant that proposals were typically due 90 days after the announcement of the competition. That put time pressure on applicants preparing proposals. Accordingly, the Board recommended that TIP publicize topical areas under consideration (with appropriate caveats that future competitions are subject to the appropriation of funding) so that potential proposers would have more lead time to plan proposals. Responding to this recommendation, TIP published a Program Plan in January. It indicated that if and when funding becomes available, TIP would run competitions in areas of critical national need such as manufacturing, energy, healthcare, and water. The plan will be updated in the near future and re-posted.

Dr. Wisniewski's charts cited data on the projects in the two areas currently funded: Civil Infrastructure and Manufacturing. The 38 ongoing projects involve $135.7 million in federal funding as well as awardee cost sharing, for a total investment of $279.7 million. One hundred thirty-two organizations participate in these projects. None has reached completion as yet.

The President said that he is committed to fostering innovation, and his budget for FY 2012 includes $75 million for TIP. However, the budget debates currently underway in the Congress suggest that budget austerity is likely to characterize the climate for the foreseeable future.

The Board urged TIP to define topical areas as broadly as possible. In response, the scope of the manufacturing topic was broadened to include biomanufacturing.

C: Adding biomanufacturing to the manufacturing topic makes sense. Another important issue is energy independence. That relates to manufacturing, too, because many industrial processes are energy intensive. Some have said that roughly 50 percent of the nation's energy is used for manufacturing.

A: Yes, energy consumption is an important consideration in manufacturing, and there is overlap between the manufacturing topic and the energy topic. TIP identifies challenges via the white paper process but it is up to industry to propose solutions.

C: Product development and manufacturing process development go hand in hand. Often you cannot separate product development from the process used to make the product. Making the process more energy efficient frequently *is* a manufacturing issue.

Civil Infrastructure: A Critical National Need

Mr. David Swanson of TIP presented an overview of the civil infrastructure topical area, and Dr. Felix Wu described representative examples of ongoing projects.

The two major aspects of civil infrastructure technology addressed by this topic are:

- Sensing and monitoring the degree of deterioration of existing infrastructure, in order to improve strategic maintenance decision making.
- Developing repair and retrofit technologies for existing infrastructure.

In 2008 and 2009 TIP made 17 awards in civil infrastructure, involving 69 different organizations. TIP will provide $72.6 million, and the total investment is $149.9 million.

TIP organized five special sessions at the 2011 meeting of the Society of Photo-Optical Instrumentation Engineers. At this event, 47 papers were presented by TIP awardees. Attendees agreed that there is value in sharing findings in this type of forum.

Three examples of ongoing civil infrastructure projects were described in some detail at this Advisory Board meeting:

Project 1: This joint venture project goes by the acronym "VOTERS" ("Versatile Onboard Traffic Embedded Roaming Sensors"). The project involves three universities plus instrumentation firms. By instrumenting a vehicle with a family of suitably designed instrumentation systems (including ground penetrating radar, acoustic and vibration sensors, optical profilometry, and millimeter wave radar), the vehicle can travel a roadway at traffic speeds while collecting data on the condition of the roadway without an interruption of roadway construction.

Project 2: "Cyber-enabled Wireless Monitoring Systems for the Protection of Deteriorating National Infrastructure Systems." This is a large joint venture involving the University of Michigan plus several instrumentation and modeling firms. For quite some time structural engineers have envisioned equipping bridges or other critical structures with sensors to provide ongoing data on structural integrity. While this can be done in principle, and experiments have been carried out with existing technology, it has not proven practical for widespread application. A major problem is that on a large structure, this approach requires a large number of sensors, and if the sensors are battery powered, the batteries must be replaced much too frequently for the approach to be cost effective. Connecting a large number of sensors with wires is also expensive. Ideally one would like to be able to utilize a large number of low-cost easy to attach sensors to existing structures, each of which could be interrogated wirelessly.

In this project, the researchers are investigating self-sensing cement-based materials and sensors powered by "harvested" power, that is, power from renewable sources such as tiny wind turbines. The other innovation is to employ a wireless network involving sensor nodes operating at two orders of magnitude lower power than existing technology.

Project 3: This project investigates non-invasive monitoring technology for failures in drinking water and waste water collection systems. The project involves the University of California at Irvine, and also involves private sector participation and several municipal water and sanitation districts. The idea is to instrument a piping network with a sufficient number of sensors and monitor them so that should a leak or rupture occur the infrastructural manager can determine immediately how serious the problem is and where it has occurred. Field testing is underway.

Q: What parameters are typically measured in systems to monitor structural integrity?

A: A variety of measurements— such as acceleration, vibration, load stresses and strains.

Q: Do civil engineers have models to correlate such measurements with estimated lifetimes?

A: To some extent, although more work is needed to quantify how such data predict lifetime for the many different types of structures of interest.

Establishing baseline data is important. If you know the "signature" of a bridge when it is new, and have a model of how that bridge is expected to behave under stress, then changes to that baseline over time can be important. The challenge is to understand what particular vibration signature correlates with impending bridge failure.

Q: In the projects described, was the emphasis on sensing technology or on data interpretation?

A: Both were studied.

Mr. Reeb noted that a research project several years ago at Caterpillar, funded by the Advanced Technology Program (ATP), involved installing sensors on heavy equipment booms to predict remaining lifetime. The feasibility of the approach was demonstrated.

C: The challenge in any of these kinds of projects is to establish whether the data collected are sufficiently meaningful to be actionable.

Q: Aren't wired systems currently used for some of this kind of sensing?

A: Yes, but wireless technology has many advantages over wired systems. The proliferation of wire cables and multiple channels can be costly. For example, the new bridge in Minneapolis has a network of 323 embedded wired sensors, but current technology for performing this task is cumbersome and expensive.

TIP invited two TIP awardees to address the Board to share their experiences carrying out TIP-sponsored research. Dr. Mohammed Ettouney of Weidlinger Associates spoke first about his work.

Dr. Mohammed Ettouney

Dr. Ettouney noted that within the next 15 years, 50 percent of the nation's more than 600,000 bridges will be more than 50 years old. Thus the urgency of the kind of research described at this meeting should be obvious. Federal, state, and local governments are all in a period of unprecedented austerity; hence aging bridges cannot be replaced unless the need is acute. Pre-stressed concrete bridges are a particular challenge because the internal deterioration is not visible. Better data for decision making is needed. Structural health monitoring has been around for a long time, but the nature of this project is more innovative than any he had been involved in previously.

Structural health monitoring systems are not widely used today for a variety of reasons: today's sensors do not measure damage directly; point sensors detect conditions at one particular point rather than over a wider area; wired sensors are expensive and difficult to install on large structures; managing and interpreting large volumes of data is a challenge. All of this is of no use unless it helps the structure operator make tough decisions. (Does this bridge need to be shut down?)

Dr. Ettouney considers this project to be a potentially paradigm-shifting effort with major impact. He applauds TIP for funding projects of this kind. Dr. Ettouney feels that the interdisciplinary teaming of university civil and electrical engineers, and material and computer scientists, plus industry experts from equipment manufacturers and also state transportation departments is unique and valuable. For project success, all of the elements must be compatible and developed in parallel, and TIP enables that.

Q: In this project are you trying to discern what to measure, or just how best to measure those quantities?

A: Measurements include stress, strain, acceleration, etc. The challenge is to weave all those data into a degradation model capable of meaningful prediction.

Rebar degradation in pre-stressed concrete bridges cannot be observed visually. People have used X-rays to assess damage, but that does not lend itself to *continuous* monitoring. Some of the work revolves around establishing a baseline and then seeing how things shift with time as the bridge ages. Modeling behavior is important. Deflections should be within a certain range, and if they exceed the design range, that can be a warning that something is wrong. Users want simple unambiguous answers such as “Is this bridge about to fail or not?” Giving a simple “yes” or “no” to such questions is difficult.

Professor Daniel Inman

Professor Daniel Inman of Virginia Tech was the second presenter. (Dr. Inman was out of the country but participated remotely via the Internet.) The goal of this project is to lower the power requirements of sensing systems and raise the power output of power harvesting devices so that structural monitoring systems can eliminate batteries.

Dr. Inman's expertise is in tiny highly efficient wind turbines. At present he can create mini wind turbines (for wind speeds down to 1-2 mph) capable of generating about 50 milliwatts or more, but the hope is that future progress might raise that number to something near a watt.

He emphasized the unique nature of TIP funding. National Science Foundation (NSF) funding is different. NSF supports open ended basic research, whereas TIP projects strive to produce actual hardware to demonstrate the feasibility of new technology. TIP projects have milestones and quantified objectives to be met. The fact that TIP can fund projects for up to five years is important for university participation since that is the time that a PhD grad student typically requires. TIP encourages teaming between universities and industry, which means that grad students get a taste of what life in industry is like. He also considers it appropriate that TIP asks participants to agree on intellectual property rights before beginning work.

Q: Is the focus of this project sensing or electrical generation?

A: It is both. I emphasized the turbine aspects because that is the work I am doing.

Q: Please comment on turbine generation vs. piezoelectric generation.

A: There are physical limits for initiating the rotation of a wind turbine generator. This project is looking at both turbines and piezoelectric generation. (Piezoelectric devices generate electricity when subjected to vibration.) A bridge that has more traffic will have more vibration and that will help increase the amount of vibrational energy available to tap into. Actual systems may involve a combination of wind turbine-generated energy and energy generated by vibration.

Q: Is the project on schedule?

A: Fifty milliwatts of output [from a wind turbine] has been achieved. We are now aiming at 100 mW—our goal for 2011. We had a successful demonstration in February, and I feel that we have shown the basic feasibility of harvested energy for this application.

Q: Is there a lifetime target?

A: Batteries for this application tend to wear out. Reliability in this kind of application is certainly important. Lifetimes need to be many years in under difficult ambient conditions.

Manufacturing—a Critical National Need

TIP staff members Dr. Michael Schen, Dr. Jean-Louis Staudenmann, and Dr. Donald Archer were the presenters for this agenda item.

Dr. Schen began by pointing out that when NIST's predecessor, the National Bureau of Standards, was created by Congress in 1901; aid to U.S. manufacturers was an explicit part of the charter, so TIP's current efforts to improve manufacturing are fully consistent with a long-standing NIST/NBS mission element. The NIST laboratories have many scientists and engineers with expertise in various aspect of manufacturing, and TIP is able to draw upon their knowledge to supplement TIP expertise.

While a significant amount of U.S. manufacturing has moved offshore in the past few decades, the United States is still the world's largest manufacturing economy (followed by China and Japan). To reap the benefits of new technological breakthroughs, those breakthroughs must be transitioned into products that can be manufactured. Thus innovation and manufacturing are closely linked. Economic growth is stimulated by new technology and the ability to manufacture innovative products incorporating that new technology. Industry and universities see numerous opportunities for improving U.S. manufacturing prowess. That led to the justification for naming manufacturing a critical national need.

In 2009 and 2010 TIP encouraged applicants interested in manufacturing research to submit proposals dealing with accelerating the availability of advanced materials and their incorporation into new products. In 2010 the scope was broadened considerably to include critical process advances. Biomanufacturing has also been added to the scope. The 21 manufacturing research projects funded to date total $129.8 million, of which $63.1 million is the federal share.

Examples of ongoing projects were described by the speakers, e.g.,

- Silicon nano wires for lithium-ion batteries
- Scale-up for manufacturing nano composites with sub-10 nm particles
- Magnesium diboride superconductors
- Nano graphene
- Semiconducting single-walled carbon nano tube inks
- Sensors for recycling high-value aerospace materials

Today, lighter and stronger structures such as bridges can be built with high strength steels and other advanced materials. Nano technology is important because materials with smaller grain size generally are stronger. A variety of new techniques for creating nano structured materials are being explored. Much promising work has been done with nano particles in laboratory settings, but scaling up to industrial scale processes presents many new challenges. Conventional molding techniques may not work for these advanced materials, and that is another area where research is needed.

In addition to pursuing opportunities for creating improved metal alloys, TIP is funding a project involving engineered cementatious composites. If that project is successful, it might lead to high strength concrete that could be bent like a metal without breaking.

In describing the TIP-funded recycling project, it was noted that in the future, as exotic materials become increasingly rare, it could be necessary to "mine" landfills. Even for common materials, the time may come when that could be necessary. It has been estimated that one third of the world's copper is in use, one third is still in mines, and the remaining third is in landfills. When the cost of obtaining copper from mines becomes sufficiently high, recycling from landfills could be become a viable option. Many exotic alloys must be exceedingly pure to preserve their properties, hence the ability to detect traces of unwanted contaminants in a recycle process stream will become increasingly important, and TIP-funded researchers are exploring that area. In one application cited, it is necessary to achieve 99.9999 percent sorting accuracy, and do it at an affordable cost.

Biomanufacturing is another important field in which TIP funding is leading to new manufacturing technology. TIP consulted with and solicited input from the National Institute of Biomedical Imaging and Bioengineering within the National Institutes of Health in developing this program area.

The cost of manufacturing biopharamaceuticals is a driver of increasing medical costs. While there is intense debate among politicians about the government's role in dealing with rising healthcare costs, there is no disagreement that new lower cost manufacturing methods for biopharmaceutical products would be beneficial to the nation. Given the complexity of the processes typically used to make biopharmaceuticals, high-risk research is needed if there is any hope of achieving significant cost reductions, and TIP funded research is providing encouraging results. One TIP project has the potential for reducing by 80 percent the cost of producing therapeutic proteins.

Examples of biomanufacturing projects include:

- Genetic engineering for real time process monitoring of therapeutic proteins
- New tools to improve the therapeutic action of manufactured proteins
- Freeze dry processes for powder forms for biomolecules
- Gene transfer vehicles for vaccination, gene therapy, and tissue transplantation
- Hollow drug-filled fibers for drug delivery and tissue engineering

Q: Could these new techniques be used for bio weapons as well as for beneficial applications?

A: In principle, they might, but the beneficial applications are many and worth pursuing. Some of these TIP projects could lead to ways of making stockpiles of antidotes and vaccines at more affordable costs, and that is clearly an important aspect of defense. TIP focuses on high volume production and quality control issues, not small batches.

TIP's Response to Board Recommendations

TIP's Margaret Phillips then addressed TIP's response to recommendations from the Advisory Board. TIP has taken action to address all the Board's recommendations noted in previous Board minutes and reports.

With regard to communicating with the public:

- A five-year TIP plan has been developed and publicized
- Outreach has been stepped up, including webinars
- Project showcases are being planned
- TIP and public white papers are on the web, with electronic comments solicited
- TIP and NIST's Manufacturing Extension Partnership (MEP) are collaborating

With regard to operational improvements:

- The five-year plan has been developed and publicized
- The scope of the manufacturing area was broadened
- An analysis was made of where proposers had the most difficulty so that more assistance and advice can be provided in the future
- Terminated projects from the Advanced Technology Program were studied to see how lessons learned there might help avoid failures in TIP projects.
- TIP and MEP are collaborating in joint data collection efforts for manufacturing
- TIP is participating in a working group of the Office of Science and Technology Policy to help ensure that TIP complements other federal science and technology programs

TIP continues to build its network of collaboration with other federal and state technology agencies.

Q: The Board continues to be concerned about the potentially onerous requirement that proposers must show that they “have left no stone unturned” in seeking funding elsewhere. If rigorously enforced, that can be a deterrent to apply, even for projects that are clearly important to the nation and deserving of support. Has TIP studied that issue?

A: We have thought about it a lot. It is common for proposals to fail to address that criterion adequately. It does seem appropriate to expect applicants to provide evidence that Federal funding is really needed for a particular project to go forward.

Q: Will there be any changes in instructions for applicants in the next competition?

A: We are working on a revision of the application kit language.

Q: Have any TIP projects been terminated?

A: TIP has suspended projects until specific issues were resolved, but no projects have been terminated as yet. We reserve the right to do so if the project gets off track. Historically, about ten percent of projects were terminated under the former Advanced Technology Program (ATP). A variety of circumstances led to the terminations, such as, the company was purchased by a new owner that had other business or research priorities, or the technology development turned out to be much more difficult than envisioned. Many of the terminations were at the request of the recipient and not necessarily for non-compliance issues.

TIP Future Directions and Open Discussion

Dr. Wisniewski summarized the status of TIP and invited comments and feedback from the Board. One of the challenges will be to maintain momentum for TIP without holding a competition this year.

Comments from Board members:

TIP should focus on the ongoing projects, seek opportunities to make the new technologies as enabling as possible, and disseminate results widely to enable the solving of multiple problems.

While it is reasonable to ask TIP applicants to explain why the private sector is unlikely to provide all the funding for a project, it is too demanding to expect them to *prove* that no private funding is available. In the time that it would take to prove that no private funding is available (by diligently going to many potential sources and being turned down repeatedly), the window of opportunity for the new technology could be lost to foreign competition.

If an applicant's project has potential for high profits, and the time frame is short, the venture capital community will probably fund it, but there are many projects that are of great potential value to society, where the time frame is longer, and where the potential for high profits is less. Those are the kinds of projects where TIP funding makes sense.

Q: To what extent do NIST technology experts from outside TIP play a role in topic selection?

A: NIST technical expertise is used extensively in scoping topic areas. Suggestions from industry and others are gathered by TIP, and NIST experts are invited to critique the input. TIP also makes effective use of expertise available at other federal agencies. For example, NIH experts are consulted regarding program ideas involving health related biological and medical topics.

Q: If awardees have to show that they cannot get private funding for the project, but typically there is 50 percent cost sharing, where does the cost share typically come from?

A: Proposers contribute their indirect costs as cost share and may be able to get a contribution to cost sharing funds from other sources. Sometimes a state technology agency will agree that if TIP funds are awarded, the state agency will provide a grant to cover some of the cost share. Of course, universities are in a different situation than, say, small start-up companies. Companies are willing to risk substantial blocks of their own resources because they hope to create a new technology that will pay dividends down the road. Indirect costs as cost share typically make up the majority of the TIP cost share requirement.

Q: Does a proposal that offers a higher cost share percentage score higher than one with a lower cost share?

A: No. (The selection criteria are documented in the application kit.)

Q: In selecting proposals, it might be helpful to have experienced business professionals with current knowledge of the industry or perhaps venture capitalists involved in the selection. Is that possible?

A: In the ATP, where business plans were considered along with technical plans, retired business executives and people with prior venture capital experience *were* recruited to review the business plans. TIP requires information regarding the potential for impacts from the project, but does not require submission of business plans; instead the emphasis is on the technical plans. If current private sector people were involved in the TIP selection process, reviewing proposals in their areas of expertise, there would be the potential for conflict of interest issues and issues related to protection of company proprietary information. TIP must ensure that proprietary information is protected and does not inadvertently fall into the hands of competitors.

C: Regional technology development organizations can play a role in TIP. Nortech is a regional technology development organization in Ohio that has helped mentor companies to compete effectively in programs like TIP. Nano technology has been an area that Nortech has encouraged. Wisconsin also has a similar technology development organization.

C: TIP needs to capture the attention of the Congress. There are so many good ideas for new technology that could help solve national problems and stimulate the economy.

Q: TIP awards tend to be larger than many other federal R&D awards. Why is that?

A: SBIR (small business innovative research) awards are limited in size by the SBIR legislation. A start-up company might begin with an SBIR award and “graduate” to a TIP award. The kind of long-range high-risk R&D that TIP supports typically takes several years to complete, and many projects are joint venture projects involving teaming by several organizations, so it is understandable that TIP awards would be larger. Applicants can decide what size project makes sense (up to the legislatively mandated limits).

The meeting was adjourned at 2:30 p.m. In his closing remarks, Board Chair Jeffrey Andrews thanked the Board members for attending and participating. He also thanked TIP staff for arranging the meeting and commented that TIP is a well-executed federal R&D program staffed by highly dedicated personnel.