ATP FY2007 Competition: Crosscutting Areas of National Interest
Introduction and Discussion

The Department of Commerce's National Institute of Standards and Technology (NIST) is a Federal research agency that promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

The mission of the Advanced Technology Program is to accelerate the development of innovative technologies for broad national benefit through partnerships with the private sector. This broad mandate, to promote U.S. innovation and industrial competitiveness, challenges U.S. industry to propose ideas for innovative, high technical risk R&D across any business sector, or industry application.

In 2007, the ATP is soliciting proposals from U.S. industry - including teams involving industry, academia, and when appropriate federal laboratories - in all areas of technology, but also in four Crosscutting Areas of National Interest that have clearly recognizable broad societal and economic benefits, but where significant technical challenges hinder full market impact. These interest areas aim to spur innovation in foundational technologies and accelerate the utilization of the technology in path-breaking, new to the world products, goods, or services that have broad-based societal and economic benefits. R&D in these areas is expected to stimulate advancements in a number of distinct but interdependent scientific and technological disciplines and to enable advancements across a multitude of businesses and sectors. Societal and economic benefits from funded ATP awards are expected to be cross-cutting, not only sector-specific.

ATP seeks to fund the development of high risk technologies that benefit society broadly – far beyond the innovators that receive ATP funding. The goal of the ATP is to compensate for areas the market does not fund because the technology is too high risk and too far from market. Awards to cross-cutting areas are one way to address national priorities and generate synergies among companies, laboratories, and universities in areas of current technological promise, while also funding technology gaps more broadly.

Enabling technologies that ATP funds must aim at technical breakthroughs with potential to solve major industry problems, spawn new industries, or address critical national needs. Such technologies will positively affect our quality of life, national security, manufacturing processes, and society at large. Technology developed for one purpose can potentially have an even larger impact in other areas. Examples are technologies that will enable low-cost energy production with minimal impact on the environment, while achieving greater efficiency in energy use; platform technologies that enable healthcare efficiencies in disease prevention, management, diagnostics and therapies; strengthen the nation's security while reducing incidences of terrorist activity; reduce manufacturing costs, and improve efficiency of processes, and increase quality of outputs; and change the behavior of firms to undertake high risk and collaborative research, even after ATP funding ends.

The NIST study of the U.S. Measurement System (USMS) provides a foundation for the development of Crosscutting Areas of National Interest for the ATP competition.[1] Using measurement science needs as an innovation indicator, the industry roadmap analysis from the NIST USMS report highlights trends for considerable innovative potential in a wide variety of business aligned sectors and in technology areas that cross industry sectors. These innovation areas have clear societal and economic benefits for the nation, align with statements of national need, and are inclusive of the widest possible array of innovation potential without specifying a narrow technical scope for each area.

[1] An Assessment of the United States Measurement System: Addressing Measurement Barriers to Accelerate Innovation, NIST Special Publication 1048, February 2007, http://usms.nist.gov/usms07/index.html

Crosscutting Areas of Interest

Four broad Crosscutting Areas of National Interest for the 2007 Competition provide a framework that links a diversity of technical areas to broad-based economic and societal benefits that are important for technological competitiveness and are well-known priorities for the nation. The areas of interest are each multi-disciplinary technological areas that impact a multitude of industry sectors and applications, and represent technology frontiers with many high-technical risk challenges. They also represent areas where teaming among industry, universities, government labs, and regional centers of excellence is likely to be highly competitive due to the nature of the technical challenges and the potential for economic benefits. The four areas are:

- Technologies for Advanced and Complex Systems,
- Challenges in Advanced Materials and Devices,
- 21st Century Manufacturing, and
- Nanotechnology.

Industry roadmaps, reports by the National Academy of Sciences and other respected bodies – for example *Rising Above the Gathering Storm* (National Academy of Sciences) **,** *An Ocean Blueprint* (U.S. Commission on Ocean Policy)*, or The Global Competitiveness Report* (World Economic Forum) - and federal government science and technology plans - for example, The President's *American Competitveness Initiative*, *The National Nanotechnology Initiative*, or The White House National Economic Council's *Advanced Energy Initiative* - all contribute to the formulation of the four ATP Crosscutting Areas of National Interest for the 2007 Competition, and point to the spectrum of future benefits.

Non-exclusive examples of what can be considered to be within each area are provided within the discussion that follows. Proposers are expected to identify and briefly explain within the proposal's Executive Summary the rationale for why the proposal best fits one of the Crosscutting Areas of National Interest, and the primary societal and economic benefits the team expects to accomplish if the technical and business plans are successful. It is expected that the national need framework of the crosscutting areas will guide proposers to more specifically target in their proposal all the potential for broad-based economic benefits that a successful project could enable.

If a proposal has a primary impact in one of the four areas to solve a challenging problem that would result in broad societal and economic benefits to the nation, consider proposing under that area interest. If the primary impact of the proposal better fits one area over another, but has significant secondary benefits to another area(s), propose under the area of primary impact and include descriptions of the benefits to the other areas, as applicable.

AREA 1: Technologies for Advanced and Complex Systems

"Systems science is capable of networking specialized sciences and fields of knowledge, and integrate concrete knowledge about specific situations into complex problem solving processes."

Eberhard Umbach, International Society for the Systems Sciences

The frontiers of science and technology often occur where fields of knowledge intersect to meet an unprecedented problem within a complex or new to the world system. The field of complex systems is highly interdisciplinary and seeks to deliver solutions to complex phenomena or objectives. New to the world advanced systems frequently includes or must deliver technical functionality that pulls from divergent fields of science and technology. Thus high technical risk can occur when new technologies and the integration of new technologies with existing approaches is needed to reach market objectives, including those that have clear societal and economic benefits to the nation.

New advanced and complex systems of national interest will benefit from accelerating the incorporation of advanced concepts and critical platform approaches from basic research and engineering into technologies for the marketplace.

Examples of benefit areas include (not exclusive list):

- **Life Science System Discovery Tools & Methods** (i.e., for health, agriculture, aquaculture, or bioprocessing systems)
- **Ocean and Lake System Management, Monitoring and Cultivation Technologies** (i.e., fish and aquatic plant systems for food or energy, etc.)
- **Information Systems** (i.e., for networks, security, managing complex data sets, or healthcare systems)
- **Energy System Technologies** (i.e., adaptable distributed energy systems, alternative energy systems, energy efficiency, etc.)
- **Environmental System Technologies** (i.e., green process technologies, pollution prevention, slowing climate change, monitoring systems, etc.)

AREA 2: Challenges in Advanced Materials and Devices

"Materials with tailored functionality (such as high strength, electronic, or optical properties) are critical to modern technologies."

Materials Science and Technology: Challenges for the Chemical Sciences in the 21st Century
Board on Chemical Sciences and Technology, The National Academies, 2003

Materials are the physical substances used in production or manufacturing, and are used across industry. They are the physical building blocks of the world and commerce. Materials typically include polymers, metals, ceramics, biomaterials, building materials, nanomaterials, and various types of composites. Advanced materials have strategic importance due to their tailored and unique characteristics, and their wide range of potential applications.

Materials science and engineering R&D has the goal of bringing new materials with superior properties and advanced processing techniques to the market for industry and consumers. Materials science and engineering R&D is inherently interdisciplinary, with strong connections to physics, chemistry, biology and the engineering fields.

Advancements in new functional materials enable altogether new types of devices and structures. These new devices and structures frequently demand superior material properties and processing not currently available. The information age, for example, has been spurred by innovations in electrical, optical, magnetic devices, and would not have been possible without innovations in advanced materials. Thus advanced materials and devices contribute to the advancement of a number of applications, including medicine and health, information and communication, national security and space, transportation, structural materials, textiles, agriculture and food science, and the environment.

This area of national interest includes proposals in which the primary R&D focus features innovations in advanced materials, materials processing, and/or functional devices that have application within any of a number of uses important to U.S. industry.

Examples of benefit areas include (not exclusive list):

- **Energy and Power Technologies** (i.e. membranes for fuel cells, fuel cell stacks, high power electronics, etc.)
- **Electronics and Photonics** (i.e. novel nanoelectronic or optical materials and functional devices, magnetics, etc.)
- **Microsystem Devices** (i.e. MEMS, etc.)
- **Broadband Networks and Communications** (i.e. integrated optical devices, switches, etc.)

- **Healthcare Diagnostics and Assays** (i.e., for the environment, agriculture, aquaculture, food processing and safety, healthcare platform technologies, etc.
- **Composite materials** (i.e. or industry, transportation, buildings, etc.)
- **Recycling materials** (e.g. for industrial or consumer use)

AREA 3: 21st Century Manufacturing

"Manufacturing is an essential part of our economy. Not only are manufactured goods the currency of world trade, but manufacturing is what creates wealth."

Dr. G. Wayne Clough, in Congressional testimony, 2005
President, Georgia Institute of Technology

Manufacturing creates items of greater value through the application of physical, chemical and biological processes that alter the geometry, properties, composition and/or appearance of a given starting material to make parts or products. These parts or products are both intermediate and finished goods for sale to others. The effort includes all intermediate processes required for the production and integration of a product's components. Some industries, such as semiconductor and steel manufacturers, use the term fabrication. Others, including the chemical or food industry, use the term processing. In 2005, the U.S. manufacturing sector, in terms of GDP, represented close to $1.5 trillion.[2]

Today, U.S. manufacturers are challenged as never before. They are on the front lines of the most intense global competition in history. The Manufacturing Institute states "*A strong and vibrant domestic manufacturing base promotes workforce and R&D investments and keeps the innovation process functioning, fostering productivity, competitiveness and economic growth.*" To succeed globally, manufacturing must be sufficiently linked up to the new sciences and technologies - emerging fields like nanotechnology, biotechnology, multifunctional materials, process design, broadband communications, and others. For small- and medium-sized manufacturers, innovation, flexibility, speed to market and closeness to the customer are characteristics to be successful.

This crosscutting area of interest includes proposals in which the primary R&D focus is on developments that will be commercialized in manufacturing applications, or where the results can enable or can be adapted to advanced manufacturing processes and/or systems. The primary technical innovation should be in the field of manufacturing, and the R&D should address technical issues that enhance manufacturing.

Examples of benefit areas include (not exclusive list):

- **Computer and Electronic or Photonic Products** (i.e. for networks, information systems, etc.)
- **Motor Vehicles and Mechanical Products** (i.e. for automotive, aerospace, discrete piece-parts, machinery, etc.)
- **Biomanufacturing/Bioprocessing** (i.e., for pharmaceuticals, fuels, chemicals etc.)
- **Bulk Materials** (i.e., metal, composites, paper, polymers etc.)
- **Chemical or Material Processing** (i.e., for chemicals, plastics, raw materials, etc.)
- **Manufacturing Systems and Controls** (i.e. communications, simulations, systems integration, etc.)
- **Energy** (i.e. for power generation, storage, conservation, management, etc.)
- **Food Processing** (i.e. for food, beverages, etc.)

[2] The Facts About Modern Manufacturing, National Association of Manufacturers, 2006, http://www.nam.org/s_nam/bin.asp?CID=201507&DID=230620&DOC=FILE.PDF

AREA 4: Nanotechnology

"'Nanotechnology' touches upon a broad array of disciplines, including chemistry, biology, physics, computational science, and engineering. Like information technology, nanotechnology has the potential to impact virtually every industry, from aerospace and energy to healthcare and agriculture."

The National Nanotechnology Initiative at Five Years:
Assessment and Recommendations of the National Nanotechnolgy Advisory Panel
May 2005

The federal government first acted on the potential of nanotechnology in Fiscal Year (FY) 2001 through the establishment of the National Nanotechnology Initiative (NNI).[3] The NNI identifies seven essential investment areas in nanotechnology innovation, referred to as Program Component Areas (PCAs).[4] Four NNI innovation PCAs that are applicable to cost-shared projects funded by ATP include the following.

- Cutting edge ***instrumentation research, metrology and standards:*** R&D pertaining to the tools needed to advance nanotechnology research and commercialization, including next-generation instrumentation for characterization, measurement, synthesis, and design of materials, structures, devices, and systems.
- Precise ***nanomanufacturing:*** R&D aimed at enabling scaled-up, reliable, cost-effective manufacturing of nanoscale materials, structures, devices and systems. This also includes R&D and integration of ultra-miniaturized top-down processes and increasingly complex bottom-up or self-assembly processes.
- New ***nanomaterials:*** Research aimed at discovery of novel nanoscale and nanostructured materials and at a comprehensive understanding of the properties of nanomaterials – ranging across length scales, and including interface interactions. It also includes R&D leading to the ability to design and synthesize, in a controlled manner, nanostructured materials with targeted properties.
- ***Nanoscale devices and systems:*** R&D that applies the principles of nanoscale science and engineering to create novel, or to improve existing, devices and systems. This includes the incorporation of nanoscale or nanostructured materials to achieve improved performance or new functionality. The enabling science and technology must be at the nanoscale, but the systems and devices themselves are not restricted to that size.

This Crosscutting Area of Interest includes proposals in which the primary R&D focus is in nanotechnology. Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers (10^{-9} m). Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale. At this level, the physical, chemical, and biological properties of materials differ in fundamental and valuable ways from the properties of individual atoms and molecules or bulk matter. Nanotechnology R&D is directed toward understanding and creating improved materials, devices, and systems that exploit these new properties.

Examples of benefit areas include (not exclusive list):

- **Life Sciences, Biotechnology, Healthcare** (i.e., nano-particles to detect and treat diseases)
- **Electronics and Photonics** (i.e. hardware that incorporates nanotechnology innovation, etc.)
- **Information Technology** (i.e. systems, networks, software, etc.)
- **Energy Systems** (i.e. alternative fuels, power sources, conservation, etc.)
- **Advanced Materials** (i.e., polymers, catalysts, metals, composites, etc.)

[3] http://www.nano.gov/
[4] The National Nanotechnology Initiative – Supplement to the President's 2006 Budget, National Science, Engineering, and Technology Subcommittee, Committee on Technology, National Science and Technology Council, March 2005.

REFERENCES

1. An Assessment of the United States Measurement System: Addressing Measurement Barriers to Accelerate Innovation (NIST Special Publication 1048) http://usms.nist.gov/usms07/index.html

2. Rising Above the Gathering Storm
http://www.nap.edu/catalog.php?record_id=11463#description

3. A New Generation of American Innovation 2004
http://www.whitehouse.gov/infocus/technology/economic_policy200404/toc.html

4. American Competitiveness Initiative http://www.whitehouse.gov/stateoftheunion/2006/aci/

5. Advanced Energy Initiative: http://www.whitehouse.gov/stateoftheunion/2006/energy/index.html
http://www.whitehouse.gov/stateoftheunion/2006/energy/energy_booklet.pdf

6. Ocean Commission Report
http://www.oceancommission.gov/documents/full_color_rpt/welcome.html

7. The Global Competitiveness Report 2006-2007
http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm

8. Innovate America http://innovateamerica.org/index.asp