Statement of
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Before the
U.S. Senate Committee on Commerce, Science, and Transportation
Concerning
Developments in Nanotechnology

February 15, 2006

Chairman Stevens, Senator Inouye, Members of the Committee, I want to thank you for inviting me to testify on developments in nanotechnology, a subject near and dear to my heart. I have spent my entire career working to transition nanotechnologies from the research laboratory to products. Trained as an applied physicist, my career includes work for large and small technology companies working variously in the fields of semiconductors, magnetic storage, sensing, equipment, and defense. I am currently employed by Science Applications International Corporation in McLean, Virginia where I manage a group of scientists and engineers providing nanotechnology development and transition services to government and commercial clients.

Nanotechnology is not an isolated technical innovation; rather, nanotechnology is a convergence of emerging capabilities from the physical, chemical and biological sciences dealing with the manipulation and design of matter at the nanometer scale. I believe that the term *nanotechnology* ultimately will be recognized as an era of innovation lasting throughout most of this century that transformed human existence with profundity and scope never before seen.

In the past two decades I have observed a seemingly inexorable displacement of the technology industries in this country. For example, most of the newest semiconductor and display manufacturing facilities are being located offshore. In large part this transformation is a consequence of global competition, technology access, and a general leveling of the quality of life across the world. From a global humanitarian perspective this transformation is long overdue, and I believe it will continue unabated. From a national perspective, however, we must maintain leadership in the commercialization of new technologies, as this leadership will be the material basis of our economic prosperity and our global leadership. My testimony today focuses on the challenges of transitioning nanotechnologies from the research laboratories to commercialization. Because of the inherent complexities associated with nanotechnologies, many of the most valuable of these transitions will be extremely difficult. In addition to its basic research investment, I propose that the country consider investment in a new means to effectively commercialize nanotechnologies.

Referring now to Chart 1, I illustrate a typical technology transition process in the United States today. Basic research at universities and research laboratories results in the creation of novel technical capabilities whose applicability is generally poorly understood. A very small fraction of these capabilities are absorbed by a small company, which invests in the transition of that capability into a commercially viable concept. A larger company then enters to provide late-stage product development and market access. The critical portion of the transition process is borne by the small company and its investors. Prior to the emergence of the current model, the prevalent model involved very large, very profitable companies transitioning internally funded basic research into new products. This older model became obsolete with the advent of increased domestic competition and the emergence of similarly powerful foreign competitors. By virtue of evolving global competition and investor sentiments, the current model featuring small companies and venture capital investors is now under stress.

The current technology transition model poses three major challenges for nanotechnology commercialization. The first challenge is that the technology transition process is very long, often exceeding 10 years, because of the technical breadth and complexity inherent in most nanotechnologies. Research institutions and large companies typically cannot support a technology transition effort exceeding 2 years; venture capitalists are typically uninterested in investments exceeding 5 years; and very, very few small companies can sustain a decade-long transition. The second challenge is access to intellectual property, which initially may be distributed among various research institutions and which freedom to employ is required for successful commercialization. The third challenge is access to (or existence of) supporting hardware infrastructure, for example prototype manufacturing to demonstrate product scalabity and cost.

Referring now to Chart 2, I illustrate an alternative technology transition model intended to address these challenges. The critical piece is the creation of public-private organizations dedicated to technology transition in a specific industry segment that coordinate and serve a large array of research institutions, a consortium of large and small technology companies, and public economic development organizations nationwide. At the interface with the research institutions, the new organization provides a conduit for intellectual property to the business consortium. At the interface with the established industry (mostly large companies), the new organization provides well-developed technologies and new product opportunities and receives financial support, product development resources, and market guidance. At the interface with small technology companies, the new organization provides business, technical and infrastructure-related services and receives product development resources. At the interface with the public sector, the organization provides economic development opportunities and receives assistance for participating businesses. Public funding for the new organization is used to establish and maintain core staff and facilities, while participating businesses and research institutions contribute technical staff. The many challenges of establishing such an organization notwithstanding, the advantages of such an approach include

- sufficient longevity to address the length of the technology transition process;
- a comprehensive approach to access and employ the intellectual property assets of the nation and, thereby, to maximize the value of the national investment in basic research in nanotechnology;
- a means to effectively share expensive infrastructure such as prototype manufacturing capabilities;
- a means to target markets through the market leaders;
- a large reduction in risk for private investors and entrepreneurs, thereby generating greater private investment and more new company starts;
- a coordination of regional economic development resources nationwide; and
- a competitive posture that does not attempt to select winners in the marketplace.

I propose that the country consider the creation of a network of these technology transition organizations, each with an industry focus such as, for example, energy conversion (*e.g.* solar, thermal), energy storage (*e.g.* batteries, hydrogen), agriculture, medical diagnostics and devices, medical therapeutics, high speed electronics, flexible electronics, and high strength materials. This network would closely parallel the research activities sponsored by the National Nanotechnology Initiative and would seek to capitalize on the research that it supports.

Lastly, I would like to comment on the often heard statement that we need to educate more scientists and engineers in the United States. The unstated assumption behind this statement is that by educating more scientists and engineers we will be able maintain our leadership in technical innovation and technology based economic development. I would like to point out that the career of the technical professional generally parallels the transition of new technologies. In response to our recent difficulties in transitioning new technology and the corresponding dearth of career opportunities, the best and brightest students in the US increasingly (and correctly) select other professions. When the opportunities return, the US students will return, as well

Summary of Testimony before the U.S. Senate Committee on Commerce, Science and Transportation

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I have spent my entire career working to transition nanotechnologies from the research laboratory to products. I am currently employed by Science Applications International Corporation in McLean, Virginia where I manage a group of scientists and engineers providing technology development and transition services to government and commercial clients. My testimony today focuses on the challenges of transitioning nanotechnologies from research laboratories to the commercial sector. Because of the inherent complexities associated with nanotechnologies, many of the most valuable of these transitions will be extremely difficult.

Nanotechnology is not an isolated technical innovation; rather it is a convergence of emerging capabilities from the physical, chemical and biological sciences dealing with the manipulation and design of matter at the nanometer scale. Control of matter at this scale is potentially the ultimate step in mankind's attempt to manipulate materials to improve the quality of life. As such, it is of vital national interest not only to continue basic research in nanotechnology, but also to transition these technologies into commerce.

The primary model for technology transition in the United States today is as follows: (1) basic research from universities and other research institutions results in the creation of new (nano)technology; (2) a small company absorbs that technology and makes the transition to a viable product concept; and (3) a larger company enters to provide late-stage product development and market access. The current technology transition model poses three major challenges for nanotechnology commercialization: (1) because of broad technical content and complexity the technology transition process is very long (>10 years); (2) intellectual property is broadly distributed and difficult to access; and (3) supporting hardware infrastructure is difficult to access or does not exist (*e.g.* prototype manufacturing).

I propose an alternative technology transition model to address these challenges. The critical piece is the creation of public-private organizations dedicated to technology transition in a specific industry segment that coordinate and serve a large array of research institutions, a consortium of large and small technology companies, and public economic development organizations nationwide. Public funding is used to establish and maintain core staff and facilities. Businesses provide financial support, while businesses and research institutions contribute technical staff for pre-production technology development. The advantages of such an approach include (1) sufficient longevity to address the inherent length of the transition process; (2) a comprehensive approach to employ the intellectual property assets of the nation; (3) a means to effectively share expensive infrastructure; (4) access to market leaders; (5) a large reduction in risk; (6) coordination of economic development resources; and (7) an aggressively competitive posture that does not attempt to select or subsidize winners in the marketplace. Potential nanotechnology-enabled industry segments for such public-private organizations include energy conversion (*e.g.* solar, thermal), energy storage (*e.g.* batteries, hydrogen), agriculture, medical diagnostics and devices, medical therapeutics, high speed electronics, flexible electronics, high strength materials, and others.

I propose that the country consider the creation of a network of these technology transition organizations, each with an industry focus such as, for example, energy conversion (*e.g.* solar, thermal), energy storage (*e.g.* batteries, hydrogen), agriculture, medical diagnostics and devices, medical therapeutics, high speed electronics, flexible electronics, and high strength materials. This network would closely parallel the research activities sponsored by the National Nanotechnology Initiative and would seek to capitalize on the research that it supports.

Chart 1

Model Technology Transition Process in the United States Today

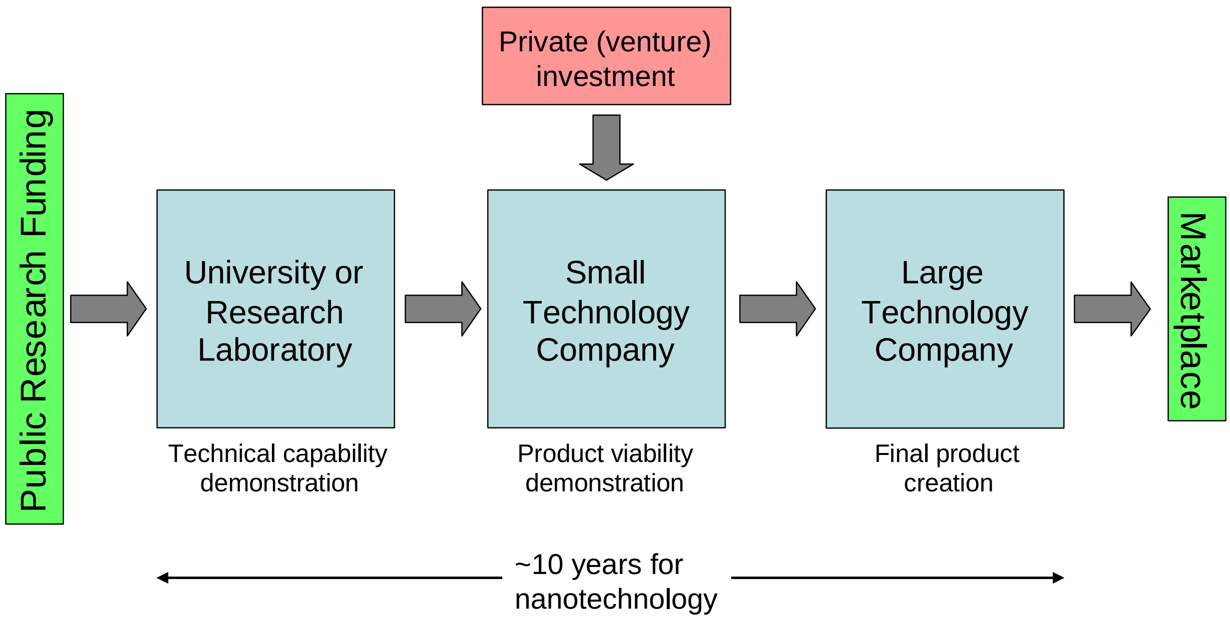

Chart 2

Modified Technology Transition Process

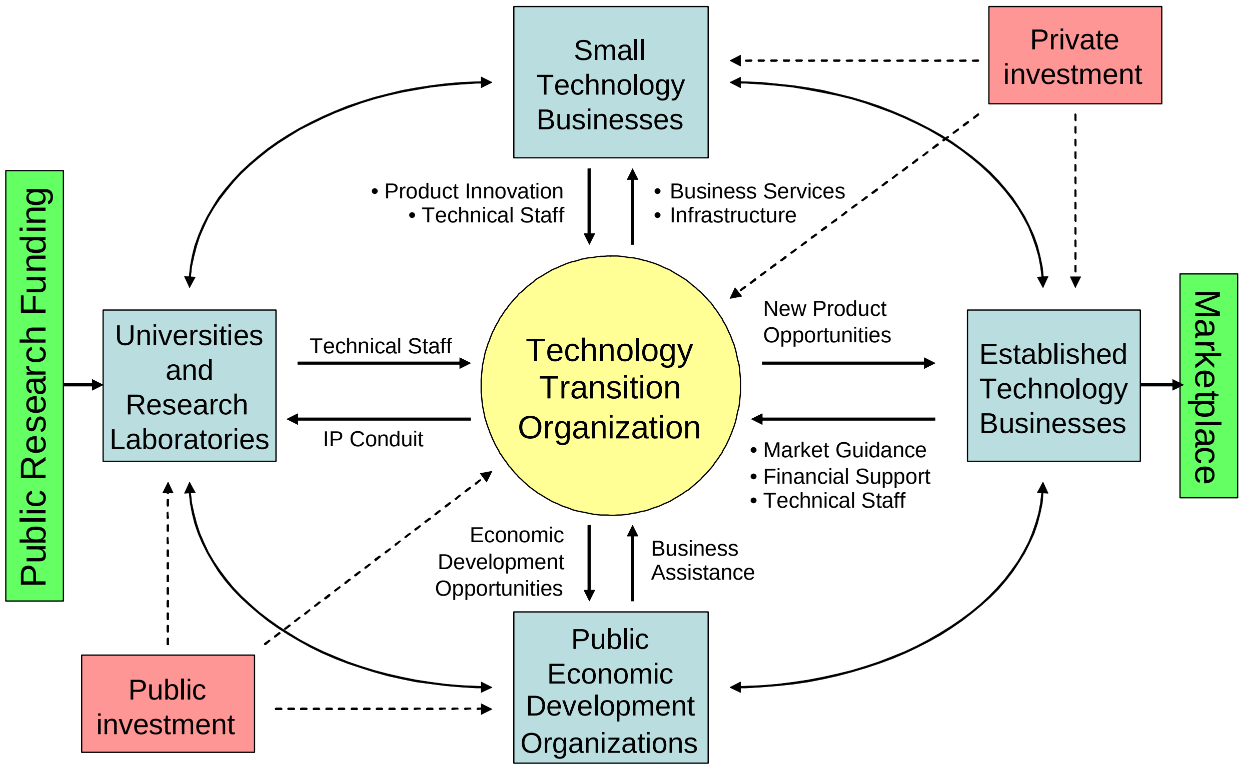

Chart 3

Functions of the Technology Transition Organization

- Intellectual Property Coordination
- Product Development Infrastructure
- Small Business Services
- Participant Relationship Management
- Technical Development Coordination
- Economic Development Coordination
- Market Strategy Coordination and Roadmapping

Chart 4

Potential Industry Focused Technology Transition Organizations

- Energy conversion (*e.g.* solar, thermal)
- Energy storage (*e.g.* batteries, hydrogen)
- Agriculture
- Medical diagnostics and devices
- Medical therapeutics
- High speed electronics
- Flexible electronics
- High strength materials

- *The Focuses of the Technology Transition Organizations should parallel the investments of the National Nanotechnology Initiative*