INNOVATION IN TRANSPORTATION

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> *"Science and technology have clearly been among the principal determinants of change and agents of progress. Not surprisingly, therefore, participation in the front ranks of research and innovation has been and will continue to be essential for our national capacity to capture the gains of scientific and technological advances."*[1]

Importance of Innovation

The importance of harnessing the best and most promising scientific and technological advances to improve the national economy, security, and quality of life has been understood for years, especially since they played such key roles in winning both World War II and the 'Cold War' that followed. This ability will be of even greater importance in the next century. As a recent study by the Council on Competitiveness found: "[E]very company ranks the capacity to innovate--the transformation of knowledge and ideas into new products, processes, and services--as a top priority. Innovative capacity plays a dominant, and probably decisive, role in determining who will prosper in the global arena."[2]

The U.S. lead in both economic output and key technologies is no longer as dominating as it was in the 1950s and 1960s. Both allied and the defeated nations have recovered from the effects of war and are rapidly gaining on the U.S. in a number of economic and scientific fields, at the same time as newly emerging nations are joining the ranks of the 'developed world'. We now have many more competitors in many more fields than ever before. Companies have become international, and then even trans-national, as modern communications and transportation networks have created a global market for the first time in history.

Secretary of Transportation Slater acknowledges the profound impact of technology on our transportation system. In his recent remarks to the President's Committee of Advisors on Science and Technology,[3] he referred to several key elements in this technological revolution in transportation:

> "Transportation is going digital, with microchips regulating engines, new technologies controlling car and truck braking, and electronic tuning ensuring a cleaner burning engine.

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[1] "Science and Technology: Shaping the Twenty-First Century" U.S. Office of Science and Technology Policy, April 1997, p. 1.

[2] "Going Global: The New Shape of American Innovation", Council on Competitiveness, September 1998, p. 9.

[3] At the White House Conference Center, May 24, 1999. See http://www.dot.gov/affairs/52499sp1.htm.

> Advances in materials technology are also beginning to have an impact. Vehicle components, materials and systems are far safer than a decade ago . . . . Highway and airport pavements are more durable, cheaper, and easier to maintain.
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> Transportation technology is also getting smarter. Communications and information and navigation systems integrated into passenger cars are enabling smarter and safer personal driving. Aircraft continue to become quieter, more efficient, and environmentally friendly. Electronic applications and tracking systems have revolutionized the freight industry."[4]

Other countries have also elevated science and technology as a national priority.[5] These nations, along with many others, have devoted considerable time and resources to formulating national strategies for successfully applying the results of scientific and technological breakthroughs to benefit their societies. And as is the case in other policy areas, each nation's approach has taken into account its own unique historical, political, economic and scientific environments. At issue here is how the U.S. should tailor its science and technology strategy in the field of transportation to maximize its contribution to our own prosperity, security, and quality of life.

Necessary Conditions for Successful Innovation

A considerable literature has arisen examining the necessary factors and pre-conditions for successfully identifying and applying innovations. For example, the Council on Competitiveness report Going Global: The New Shape of American Innovation, studied innovations in five key economic sectors, four of which have direct relevance to transportation. These are: Information Technology, Advanced Materials, Express Package Transportation and Logistics, Automotive, and Health Care. From these case studies, the report concluded that the following are essential enablers of innovation:

- A well-educated population with trained and talented scientists and engineers;
- Sufficient investment in both fundamental and cutting-edge research to generate new ideas and knowledge;
- Strong partnerships between government agencies, universities, and private companies which can accelerate the development, diffusion and implementation of these new ideas and knowledge;

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[4] Ibid.

[5] For example, In 1997, the Critical Technologies Institute at the RAND Corporation released a White Paper entitled *Critical Technologies in a Global Context: A Review of National Reports*. This report reviews recent national 'key' or 'critical' technology reports from the U.S., Japan, Germany, France, and Britain, including the following: *National Critical Technologies Report* (U.S.); *Future Technology in Japan Toward the Year 2020 (Japan), Delphi-Bericht 1995 zur Entwicklung von Wissenschaft und Technik* (Germany); *Les Technologies Cles pour l'Industries Francaise a l'Horizon 2000* (France); and *Winning Through Foresight: A Strategy Taking the Foresight Programme to the Millennium* (Britain).

- Maintenance of a strong base of high value-added manufacturing to encourage the applications of new technologies;
- A legal and regulatory framework that encourages innovations; and
- Sufficient investment capital to finance these activities before profits become apparent.

In the case of the automotive industry, for example, technological leadership is critical to success in the highly competitive global vehicle market. In recent decades, the U.S. edge in technology has been eroding as other nations have focused their policies on enhancing their technology resources. Thus, in order to remain competitive in this and other key industrial areas, the U.S. should take such steps as increasing public funding for medium- to longer-term research, expanding R&D tax credits, increasing the number of U.S. engineers, promoting government-university-industry research partnerships, and adopting incentives for consumers to purchase vehicles with new technologies (such as alternate fuels or improved mileage) embedded in them.[6]

A one-day National Innovation Summit hosted by the Council on Competitiveness and the Massachusetts Institute of Technology was held at MIT in 1998. This event brought together 150 key leaders in education, labor, business and government to discuss the future of innovation in the United States. They discussed a very similar list of factors that drove innovation:

- The talent pool (well-educated population);
- The national research base (fundamental and cutting-edge research);
- Capital availability (sufficient investment capital);
- National market vitality; and
- International market access.

The consensus of the participants was that the strength of our national talent pool compared to our international competitors stood out as the most worrisome aspect for the future, followed by the condition of our national research base. In contrast, the U.S. stands in a much stronger position in terms of the capital and market factors.[7] Among the steps recommended to maintain the nation's ability to innovate were: increasing the number of science and engineering graduates, attracting talented scientists and engineers from overseas, increasing federal funding for research, additional tax credits for private R&D, and expanded university-industry-government collaborations aimed at commercializing innovations.

At the National Innovation Summit, Professor Michael Porter of the Harvard Business School presented the results of research into factors that correlated with successful innovations. Among the strongest correlates were such factors as: "level of R&D expenditures, number of R&D

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[6] Ibid., pp. 136-140.

[7] "Competing Through Innovation: A Report of the National Innovation Summit", Council on Competitiveness and the Massachusetts Institute of Technology, March 12-13, 1998, p. 3. These factors are explored in greater detail in Michael E. Porter and Scott Stern, "The New Challenge to America's Prosperity: Findings from the Innovation Index", Council on Competitiveness, March 1999.

personnel, share of GDP spent on secondary and tertiary education, protection of intellectual property, international openness, and GDP per capita."[8]

Robert Atkinson, an economist who writes for the Progressive Policy Institute, is developing a *New Economy Index* to measure how well states are fostering economic growth. Atkinson has identified four pillars of "a progressive innovation-oriented state policy framework." They are:

- "Co-investment in an infrastructure for innovation;
- Fostering the growth of the digital economy;
- Co-investment in the skills of the workforce; and
- Re-invention--and digitalization--of state governments themselves, to make them as fast, responsive, and flexible as the economy and society they interact with."[9]

Atkinson particularly stresses the impact of the growing 'digital economy'--e.g., the application of state-of-the-art information and communications technologies to the workplace--and the increase in productivity associated with it as keys to economic growth. As he stated to the National Governors' Association, "[I]nnovation drives growth in the New Economy. At least two-thirds of per capita economic growth stems from technological innovation."[10] Among the tactics to spur innovation Atkinson identifies are: increasing the number of scientists and engineers; expanded R&D tax credits; encouraging the growth of electronic commerce, broadband telecommunications, and the Internet; and creating regional alliances to promote concentrations of skilled workers in particular fields.[11]

Role of Government *vis à vis* Private Sector and Academia

One area in which the government can play a fruitful role is to establish national science and technology policies and priorities. In the U.S., this has occurred most recently in the publication of the National Science and Technology Council's *Transportation Science and Technology Strategy* (September 1997) and the expanded *National Transportation Science and Technology Strategy* (April 1999). These documents describe a four-tiered approach: (1) an ongoing and structured strategic planning and assessment process; (2) a series of thirteen private-public technology partnerships in specific transportation-related areas; (3) seven enabling research areas that can contribute to transportation goals; and (4) education and training initiatives covering math and science topics at all levels of formal education and job-related training. *(See Figure 1)* The entire approach has been developed to solicit and encourage participation by the transportation community in its broadest context -- federal, state, regional, local and tribal agencies; educational, academic and research institutions; and private sector companies involved directly in, or supporting, transportation and logistics activities. This conference will explore in

[8] Ibid., p. 13.

[9] Robert Atkinson, "How Can States Meet the Challenge of the New Economy?" presented at the National Governors' Association Winter Meeting, February 21, 1999. At http://www.dlcppi.org/texts/tech/speech_nga.htm.

[10] Ibid.

[11] Ibid. See also Robert Atkinson and Randolph Court, "The New Economy Index: Understanding America's Economic Transformation", Progressive Policy Institute, November 1998.

depth four technology-related issues that run through these initiatives and enabling research areas. These topics are: information systems and communications, also known collectively as *cybertechnology*; the future of *fuels and propulsion systems* for automobiles, light-duty and heavy-duty vehicles; potential applications of *nanotechnology* to transportation; and the *education and training* needs of the 21st Century.

Figure 1. Private-Public Strategic Partnerships and Enabling Research Areas

Strategic Partnerships:	Enabling Research:
Aviation Safety Research Alliance	Human Performance and Behavior
Next Generation Global Air Transportation	Advanced Materials
Next Generation Transportation Vehicles	Computer, Information, and Communications Systems
National Intelligent Transportation Initiative	Energy, Propulsion, and Environmental Engineering
Intelligent Vehicle Initiative	Sensing and Measurement
Transportation and Sustainable Communities	Tools for Transportation Modeling, Design, and Construction
Transportation Infrastructure Assurance	Social and Economic Policy Issues
Enhanced Goods and Freight Movement at Domestic and International Gateways	
Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure	
Maritime Safety Research Alliance	
Space Transportation Technologies	
Accessibility for Aging and Transportation-Disadvantaged Populations	
Enhanced Transportation Weather Services	

Source: *National Transportation Science and Technology Strategy*, April 1998.

The concept of collaborative partnerships to identify and develop promising technologies has received particular emphasis in recent years. The Council on Competitiveness issued an influential report in 1996 titled *Endless Frontier, Limited Resources: U.S. R&D Policy for Competitiveness*. This document resulted from the deliberations of an advisory group of experts, as well as detailed assessments of R&D in six key industries: aircraft, automotive, chemical, electronics, information technologies, and pharmaceuticals.

In order to maintain U.S. competitiveness and adapt to changes in the economic, institutional and technological environment, the report calls for government, industry and universities to share their knowledge and resources in large-scale collaborative efforts. For this to happen, each of these three communities must be willing to make some changes. Industry must assume a greater

share of funding for R&D, and must reduce the barriers to R&D partnerships among different firms. The government should also ease the existing financial, legal and regulatory barriers to research partnerships, while becoming an active member in them. It should make the considerable resources of the national laboratories more available to these partnerships, and it must maintain its support for research at the nation's universities. The academic community, in turn, must focus more attention on graduate-level education that is more directly responsive to the needs of the industries that will hire these students, while keeping and attracting students to science and engineering fields.

Topics for Discussion

- What are the best means for creating a greater general awareness for what innovation is and its importance to economic growth and quality of life?

- What are the most accurate measures or indices for determining how successful we are at innovating?

- What is the appropriate role of government in identifying and/or creating technological innovations for transportation? Of industry? Of academia

- What is the appropriate role of government in implementing technological innovations within transportation? Of industry? Of academia?

- How can successful partnerships between these sectors be best created and sustained?