INTERNATIONAL COOPERATION
IN TRANSPORTATION RESEARCH

European–United States Transportation Research Collaboration

Challenges and Opportunities

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A Report of the TRB–ECTRI Working Group
on EU–U.S. Transportation Research Collaboration

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Foreword

The world is becoming more and more interdependent and interconnected through the information superhighway. National borders are increasingly becoming intellectually porous; and economic, social, and behavioral issues are gradually converging. Cross-national collaboration on resolving mutual challenges becomes a natural outcome of such interdependency and interconnectedness. Yet, successful collaboration across national borders is not yet an easy task. It must traverse cultural, linguistic, and political divides in order to yield productive outcomes. And it has to deal with the historical baggage of inequalities among and within nations as it strives to create genuine equitable partnerships that bridge the inequality gap.

By its nature, transportation research dictates thinking "outside the box" in new and creative ways, seeking fresh perspectives and continuously tapping new innovations for cost-effective and environmentally friendly movement of people and goods. For transportation research, collaboration across borders is perhaps more imperative than it is in other disciplines, going hand-in-hand with the advent of globalized economies, commerce, and societal trends and values. International collaboration in transportation research will create fertile conditions for research innovations, understanding, and common solutions to common problems.

This report is a clear and concerted attempt to foster such international collaboration in transportation research. It was created by a working group set up under the terms of the Memorandum of Understanding (MOU) signed on January 2006 between the European Conference of Transport Research Institutes (ECTRI) and the Transportation Research Board of the U.S. National Academy of Sciences (TRB). TRB's involvement was organized by its standing Committee on International Activities.

The TRB–ECTRI MOU (shown in Appendix A), was complemented by a 10-point, 2-year action plan, in which the two organizations agreed on a number of joint activities, including: a European scanning tour by U.S. research managers, active participation in the activities of each other's organizations (some of which could be held jointly), joint investigation of international (EU–U.S.) transportation research collaboration issues, etc. The 10-point action plan is shown in Appendix B. As part of Activity 10 of that action plan, a joint working group on EU–U.S. collaboration in transportation research was formed and became known as WG 10. The scope of its work is defined in the following:

1. Discuss and establish existing priorities, strengths, and weaknesses, as well as gaps and diversions in transportation research on both sides of the Atlantic;
2. Discuss and determine common characteristics and needs for transportation and transportation-related research on the basis of the transportation and transportation-related policies, emphases, and priorities that exist today in both regions (EU and the United States), as well as their expected future needs and priorities;
3. Consider and discuss issues of research management, including research governance in both regions;
4. Assess the benefits, or added values, and prospective synergies from closer collaboration; and
5. Investigate ways and procedures for effecting such closer collaboration.

WORKING GROUP 10

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ORGANIZATION OF REPORT

This report consists of six chapters as follows:
The first two chapters examine issues related to the governance, management, and financing of surface transportation–related research both in Europe and in the United States. Explored are the evolution of the systems and the current know-how of governance, management, and financing. The chapters also explore the factors that drive transportation research and the instruments and methods for coordination, the policies, the range of funding, and for Europe especially the vision of the European Research Area in relation to transportation.

The third chapter provides a comparative analysis between transportation research in the United States and the European Union and discusses the status and trends of current transportation research in the two areas. It also examines priorities on both sides of the Atlantic and identifies gaps in transportation research.

The fourth chapter presents a comparative assessment of innovation systems and the role of markets in the United States and Europe. Six ideal types of innovation systems are examined along with their connection to the marketplace.

The fifth chapter examines successful models of transatlantic transportation research collaboration such as that between TRB and ECTRI and explores the main barriers to collaboration. This chapter also highlights the lessons learned from these models, and identifies the factors that led to their success and how the factors can be enhanced and mobilized in other contexts to create conditions conducive to transatlantic research collaborations. Barriers and opportunities are examined as well as the framework for optimizing opportunities and overcoming challenges resulting from the globalization of economic activities. Also examined is transatlantic collaboration in a globalized world.

The sixth chapter draws final conclusions and presents recommendations.

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- Robert E. Skinner, Jr., TRB Executive Director
- D. Wurzel, ECTRI Secretary General

Preface

The need for international collaboration in transportation research has never been greater. Both the European Community and the United States are buffeted by the forces of climatic change, escalating energy prices, and economic decline. While innovation in the transportation sector is only part of the solution, it is an important element in any strategy designed to respond to a world that, in Thomas L. Friedman's words, is increasingly "hot, flat, and crowded" (Friedman, 2008).

This report is an important first step in establishing a structure for pooling finite resources to discover new solutions. However, it differs from many other recent studies in that it places transportation research in its proper historical, institutional, economic, social, and policy context. A critical lesson of this report is that while there are notable economic and political differences between Europe and the United States, these differences pale in comparison with the similarities in the barriers faced by both entities in forging sustainable collaborative research ventures. Furthermore, the current unprecedented economic crisis and its transformation of the global environment of cooperation bring new urgency to the need for international collaboration.

The authors believe that understanding this context is critical to creating a realistic process that will ultimately lead to a significant increase in collaborative transportation research. However, they did not stop at defining the current research environment; they pushed beyond the current research "envelope" to identify models of collaboration that could succeed between countries separated by the depths of the Atlantic Ocean, yet bound together by the principles of democracy, the scientific method, and a fundamental commitment to creating a better life for all.

This report owes its existence to a Memorandum of Understanding (MOU) signed in January 2006 between the European Conference of Transport Research Institutes (ECTRI) and the Transportation Research Board of the National Academies (U.S.–TRB). The MOU was translated into practice through a 10-point, 2-year action plan. As part of this action plan, a joint working group on EU–U.S. collaboration was established and known informally as Working Group 10 (WG 10) The group was cochaired by George A. Giannopoulos, Head, Hellenic Institute of Transport, Greece; and Michael Meyer, Georgia Institute of Technology. These chairs recruited an international team of experts from various academic, governmental, and financial institutions to contribute to this report. This report represents an important example of the benefits of intellectual and organizational diversity and true international collaboration.

Europe and the United States (and the entire world) face physical, social, and economic challenges that are coming to the fore with increasing vigor and at an ever-quickening pace. Efficient and safe surface transportation can make an important contribution to mitigating many of these challenges. Nevertheless, even the world's largest economies are ill-equipped to face these problems independently.

The realities of globalism require cooperation and a pooling of intellectual and financial resources. It is truly a time to choose: Do nations continue to work independently as primarily competitive units, or can they come together to solve problems that appear at first glance intractable? The answer formulated in this report is that true international collaboration is both necessary and fully possible.[1] The fates of Europe and the United States have been inextricably linked for more than 500 years—it is time to reaffirm this reality and move forward collaboratively to solve critical 21st-century transportation challenges.

This report and its recommendations come at a particularly timely moment. In Europe, it is time for implementation of the ERA Vision 2020 plan and for updating the current FP7 program for research, while preparing the next one—the FP8. On the American side, the new Obama administration will form its research and development policies and prepare the reauthorization acts for energy and surface transportation.

[1] The authors point out that, although this report is about European–U.S. collaboration, most of its points and recommendations have a wider application and could be equally applicable to international collaboration in general.

Summary

The report's first two chapters provide information about the historical background and current trends in governance, management, and financing of surface transportation–related research in both Europe and the United States. This is done on the premise that historical backgrounds influence to a large extent (or at least help explain) the current situation.

SURFACE TRANSPORTATION RESEARCH IN EUROPE

For Europe the period from 1944 to 1955 was marked by the rebuilding of transportation infrastructure, and national efforts focused on the following:

- Establishment of road research laboratories;
- Integration of rail research to rail operators; and
- Creation of national waterways and harbor technical centers.

From the 1960s to the 1970s, strong intergovernmental collaboration accompanied the rebuilding of nations and the new challenges faced at each side of the Iron Curtain. The period witnessed the establishment of the first surface transportation–related research program, which inspired many countries to start creating national research programs.

The period from 1982 to 1992 saw the beginning of national transportation–related research programs, often supporting multilateral and intergovernmental initiative programs such as EUREKA (an initiative for industrial research) or bilateral or regional programs such as DEUFRAKO (DEUtsch-FRAnzösische KOoperation) between Germany and France, and the Nordic Road Research Council. Programs included new stakeholders such as industrialists and operators. Some universities also entered the field of surface transportation research and education.

The Maastricht Treaty, signed February 1992, and the beginning of the creation of the European "single space" unification process within the European Union continued to place surface transportation on the priority agenda of its Framework Programme and emphasized the involvement of all Europe in all transportation-related research priorities.

In 2000, new stimuli were created for transportation-related research in Europe. The *Lisbon Agenda* of March 2000 had the vision of transforming Europe to a knowledge society by creating the European Research and Innovation Area. Two years later, the *Barcelona Agenda* set a target for Europe of 3% GDP expenses for research and development (R&D) activities, including roughly two-thirds from private funding and one-third from public funding. These two agendas established the European Research Area (ERA).

Today, the European Commission[1] uses an array of coordinating mechanisms:

[1] The European Commission is the administrative and executive body of the European Union, corresponding to a federal government. Other institutions of the European Union's structure include: the European Parliament, the Council of Ministers, and the European Court of Justice**.** The role and scope of each of these bodies is self-explanatory except perhaps for the Council of Ministers, which is the body of National Ministers (secretaries responsible for specific areas (e.g., Council of Ministers of Transport).

- The ERA-NET and ERA-NET+ networks coordinate national research programs through coordination of public funders and creation of joint calls for proposals (ERA-NET Transportation and ERA-NET Road are two examples).
- The European Union's Networks of Excellence2 are transnational networks of collaboration–competition that coordinate and integrate the supply side of research in interaction with stakeholders. They also
  - Test new governance and management concepts with institutions, scientists, and young scientists;
  - Evaluate efficiency and productivity of knowledge products; and
  - Prepare the next generation of scientists.
- The European Technology Platforms (ETPs)[3] consist of a mechanism aimed to promote the interaction between industrial and all other research stakeholders around a strategic research agenda in a specific field. Stakeholder research actors include the European Commission, the member states, industry (industrialists, suppliers, and operators), academia (universities and research and technology RTOs), transportation societies or organizations, and ad hoc authorities. For surface transportation, there are several related platforms; namely, European Road Transport Research Advisory Council (ERTRAC), http://www.ertrac.org/; European Rail Research Advisory Council (ERRAC), http://www.errac.org/; European Waterborne Research Advisory Council (WATERBORNE), http://www.waterborne-tp.org/; European Embedded Systems Advisory Council (ARTEMIS), http://www.artemis-office.org/dotnetnuke/; European Nanoelectronics Initiative Advisory Council (ENIAC); European Hydrogen and Fuel Cells Advisory Council (H2FC); Biofuels Technology; Future Manufacturing Technologies; and eSafety Intelligent Car Initiatives.[4] At the national level, platforms mirror the European Technology Platforms or groups of them.
- The Joint Technological Initiatives (JTIs) are more ambitious research-funding mechanisms using articles 169–171 of the EU treaties in the transportation-related domain. These treaty articles have also been used as the legal basis for program Galileo or SESAR, the new European Air Traffic Management, etc. In the transportation field, JTIs are currently under creation.
- The creation of *clusters* (e.g., in eastern and central European countries and in smaller European countries) aims at promoting a better interaction within academia or between industry and academia among specific groups of countries or disciplines. In particular, clusters aim at reinforcing the triangular linkages among research, innovation, and education; and among regional and local anchorage, national and European integration, and international relevance and excellence.

On the level of coordination between national and European research, the "subsidiarity" principle implies that EU-funded research shall have a complementary character to what is done on the national level.

The current structure and funding of EU research in the 7th Framework Programme are shown in Figures 1 and 2 of the main text.

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[2] See the definitions at the Europa-Cordis website for FP6 and FP7; these Networks of Excellence are transnational networks of cooperation–competition aimed at the international excellence of European scientists and the creation of critical masse.

[3] See also http://cordis.europa.eu/pub/technology-platforms/docs/etp3rdreport_en.pdf.

[4] They are assimilated into ETPs.

SURFACE TRANSPORTATION RESEARCH IN THE UNITED STATES

The United States, in order to build, maintain, and expand its vast, multimodal system, has long relied on research innovations in planning, materials, construction methods, system operations, infrastructure maintenance, and many other methods. While expenditures for research in the transportation sector have been generally lower than those for other sectors, federal government support and funding for transportation research have been strong, dating back to the 1893 formation of the Office of Road Inquiry in the U.S. Department of Agriculture.

Federally sponsored research involves many programs and many public and private stakeholders, internally within Congress and the U.S. Department of Transportation; and externally with state departments of transportation (DOTs), local and regional governments and planning agencies, universities, private firms, and users of the system. Stakeholder input is recognized in the current *Safe, Accountable, Flexible, and Efficient Transportation Act: A Legacy for Users (*SAFETEA-LU*),* which was signed into law in 2005. Title V of SAFETEA-LU spells out the commitment of the United States to transportation research as well as the need to augment applied research with fundamental or basic research.

There are a number of factors that influence the character of highway research in the United States. First, the federal character of government requires a sharing of powers between the national government and state governments; second, formal transportation policy making is not located in one institution, but shared among three branches of government: executive, congressional (Senate and House of Representatives), and judicial; third, there is a strong tradition of relying on private research entities such as the National Academies' Transportation Research Board and major national associations such as the American Association of Highway and Transportation Officials (AASHTO) to develop strategic directions for transportation research and technology development and deployment; fourth, universities and colleges, big and small, public and private, have long been relied upon to develop solutions that require "outside the box" thinking; and, finally, underlying U.S. government institutions and policy making is a strong ideological commitment to private sector participation in the research process.

The current structure of U.S. transportation research administration is shown in Figure 3 of the main text.

EUROPE AND THE UNITED STATES—COMPARISON AND CONTRAST

The third chapter examines the differences and similarities between Europe and the United States in the performance of surface transportation research and technology deployment. The United States is a single country; Europe establishes integrating mechanisms to facilitate cross-country collaboration. Obvious economies of scale would be expected as the natural result from a research system that flows from one national entity rather than from multiple national entities with different state–society relationships, cultures, and languages.

The driving forces for public research programming and funding in transportation are quite different in the United States and the European Union. In the United States, initiatives for transportation research programming and funding are basically organized in a bottom-up approach, while in Europe they respond more to top-down procedures.

The organizing principle in the United States is responsiveness to the requests and needs of transportation stakeholders, with a focus on subjects of interest to state DOTs and on problems of immediate national concern that can be solved through applied research in a relatively short time frame. In this context, agencies and universities are encouraged to initiate research proposals for funding at local, state, and federal levels. Public research proposals compete for funding, while local groups and business groups seek to influence decisions for content and the use of earmarked funds according to their vast array of competing and diverging interests. Nonmarket-based coordination is relatively lacking, with no centralized process by which a research agenda is defined.

In the EU, by contrast, public research programming and funding for transportation tends to be defined by reference to national and EU strategic plans and priorities—agendas, platforms, or research areas—which serve as a framework for research institutions' work programs development. Public research proposals seek to respond competitively to the strategic priorities with relevance, innovation, synergy, and significance. The emerging intermediate level of transnational networks of institutions opening cross-national funding options enhances the complexity of the system without changing its features. In fact, organizations such as the European Conference of Transport Research Institutes (ECTRI) reinforce the top-down process by seeking to review the coherence of the strategic research agenda and initiatives and filling the research gaps.

The differences between both systems are therefore considerable, and yet both present similar core features: both are highly complex, involve large numbers of stakeholders, and present a truly multilevel system of governance among local, state, national, and federal governments. Both systems lack a proactive instrument to enhance effective synergy between research activities. Both systems may yield opportunities for incoherence among the various levels of research and development agenda setting. In today's real-time electronic knowledge sharing, the research communities of both the European Union and the United States are informed by the same global information system, have access to the same technical publications, are motivated by similarly competing demands between local and regional technical transportation issues, and share global integration, competitiveness, and sustainability challenges.

Interestingly, both systems display forces that tend to reduce their differences over time. The research governance and management styles and mechanisms in the European Union and the United States are converging more and more. Common characteristics include the following:

- Emphasis on overall program management;
- Performance of programs through calls for proposals (with few exceptions) for dedicated projects;
- Existence of several common themes (i.e., similar research topics), including technological issues, congestion related issues, human factors, and safety–security issues (an exception is represented by the institutional and organizational issues that are not as evident among the U.S. themes);
- Emphasis on researcher mobility; and
- Emphasis on preparation, education, and training of a new generation of transportation scientists.

There seems to be a need to

- Benchmark the research governance evolution on both sides of the Atlantic (this by itself would allow for greater possibilities of collaboration);

- Comply with intellectual property rights that are important on both sides but not necessarily manageable in the same way nor following the same type of laws;
- Address the accessibility issues of the "soft" research infrastructures and data.

TRANSPORTATION RESEARCH AND TRANSPORTATION MARKETS

The fourth chapter examines the relationship between transportation research and innovation and the function of the transportation markets. It explores how markets in association with government involvement have contributed to the improvement of transportation research by producing innovations ranging from automated signals to composite materials. The following issues concerning the interrelation between markets and transportation research are considered:

- Innovation as a public good, market failure, and the role of government;
- Characteristics of the U.S highway research and technological development (RTD) markets;
- Introduction of a typology for characterizing government–market relationships;
- Characterization of the U.S. innovation system using a typology for defining national innovation systems; and
- Comparisons between U.S. and European national innovation systems using the typology.

TRANSPORTATION RESEARCH COLLABORATION

The fifth chapter examines the various models for transportation research collaboration and tries to initiate a dialogue on the issue of globalized transportation research and development. It also explores the key premises and elements of globalization.

The following seven models of international research collaboration are examined:

1. Organized, centralized, and institutionally driven RTD collaborative research;
2. Foreign RTD investment (public or private funds being made available to researchers on a global basis);
3. Scientist-to-scientist, research-initiated RTD collaborative activities occurring at the national or subnational level (bottom up);
4. Distributed collaboration that involves several government entities and shared management structure;
5. Information exchanges on technologies and best practices (international technology scanning programs);
6. Information exchange through technology assistance programs; and
7. Creation of a unified environment for RTD involving many countries and research agencies; that is, creating a Global Research and Innovation Area (GRIA). [5]

There are several conditions that are identified as forming crucial prerequisites for international research collaboration:

[5] This last ultimate scale is drawing on the European paradigm in its creation of the European Research Area (ERA). Transportation research within such a GRIA would focus on regional issues and challenges, how to achieve better coordination and collaboration between advanced and less-advanced areas, and address (through the strength of a unified and more global research demand and supply) global challenges such as congestion, energy consumption, environmental impacts, climate change, and formulation of truly regional transportation policies, and so forth.

1. Strategic convergence of individual and collective interests among partners focused on the particular scientific or technical issue in question;
2. Clearly defined and articulated goals and objectives;
3. Ground rules in the form of a formal agreement or memorandum of understanding for interaction among partners;
4. Inclusion of all key stakeholders. All key stakeholders should be involved during program or project specification and through the research life cycle; leaving a key "actor" out of the partnership may create problems. All elements of the program, including funding and exploitation, should be understood by all interested stakeholders (public, private, and academia—including research and technical organizations, consultants, operators, and commerce);
5. Existence of champions or advocates, who are critical in ensuring that the partnership is successfully launched and that barriers to effective functioning are eliminated;
6. An inclusive participatory decision-making process must be in place to ensure that all partners feel they are owners of the process and have a stake in the success of the partnership;
7. Agreement on the initial sources of funds as well as on how the partnership will be sustained over time is critical to sustainable collaborations;
8. Distribution of benefits among partners is also a critical element to keeping the partnership intact and viable;
9. An organizational structure or procedures must be in place for management and operation of the partnership as well as for the overall evaluation of success;
10. A seamless vertical as well as horizontal communication and coordination linkage is the driving engine of partnerships and ensures that the benefits can be accomplished; and
11. Transnational networks that serve as enablers of international research collaboration are important to build vital connections and create communities of practice. They facilitate the strategic convergence of individual and collective interests.

RECOMMENDATIONS

The sixth chapter contains the group's final recommendations.

There is need for a joint long-term vision of a wide range of transportation research content and processes as well as infrastructures and governance that would encompass both sides of the Atlantic. This vision would need to

- Benchmark the evolution of joint research on both sides of the Atlantic, as well as its evolution in other important existing and emerging scientific areas (India, China, other OECD, etc.);
- Be aware of the different approaches to intellectual property rights (first-to-file and first-to-invent);
- Look for convergence in governance;
- Understand the discrepancies in research infrastructures (hard; soft, i.e., libraries, the basis for freely accessible data and knowledge);
- Ensure the creation of the next generation of surface transportation scientists and ultimately take care of the differences between the American and the Bologna PhDs; and
- Create, develop, and enhance evaluation methods and criteria.

To work toward creating such a vision, the report makes a number of specific recommendations summarized as the following:

1. Create Enabling Policies

To create successful collaboration, there is a need for national and subnational policies to alleviate concerns over intellectual property rights, create standards and common frameworks for the performance of research, and take into consideration the role of the market in fostering innovations. Policies may also target the provision of incentives to stimulate funding networks for collaboration. A top-down approach is needed to dismantle barriers to collaboration, especially those that involve prohibitive costs and conflicting intellectual property rights. Enabling policies must also take into consideration the mobility of scientists across borders.

2. Mobilize Human Capital

In the area of human capital, there is a need to focus on generating new scientists and strengthening the collaborative capacity of existing scientists. Training and education should target governance and management as well as thematic issues of global concern, such as climate change and sustainability. Communication across cultures is an area of utmost importance because collaboration ultimately involves human behavior and positive human interaction. Cultural competency and sensitivity can lead to successful cross-cultural collaboration.

3. Build Collaboration Mechanisms and Joint Programs

At the top level, it is important to have clearly defined goals and processes that lower the effects of barriers and enhance synergy. Fair partnerships using credible champions and institutions may encourage a joint programming process of calls for proposals and work programs. The Next Generation SIMulation (NGSIM) framework could be a reference model.

At the bottom level, professional networks have brought researchers in contact with each other across national borders. Strengthening the capacity of these networks and creating mechanisms that would cultivate new productive collaboration is recommended.

4. Systematically Address the Main Barriers

To develop and foster collaboration policies and mechanisms, addressing the following issues that correspond to today's major barriers is recommended:

- Discussion and dissemination of new ideas and paradigms;
- Avoidance of "blind alleys";
- Optimization of resources by creating "common pools" and other means;
- Promotion of common global policies for international transportation;
- Promotion of global standardization and harmonization of research knowledge; and
- Establishment of common agendas for transportation research by addressing global problems and issues (e.g., public health, global warming, energy, and travel behavior).

5. Improve Data Management and Sharing

Improved data management is essential for successful international collaboration. Developing the infrastructure for data management and sharing is also an imperative. To create enabling policies, it is critical to address the issue of free access to soft research infrastructures such as libraries, data, and knowledge. Creating common standards for technical documentation would facilitate collaboration, as also would establishing agreed-upon practices.

6. Facilitate Common Education and Training

Education and training are critical, as noted in recommendation 2. The following three measures are recommended to facilitate common education and training:

- Exchanges at the PhD and postdoctorate levels to train and educate the new generation of scientists, ensuring that Europe and the United States remain at the forefront of transportation research;
- Development of well-trained research administrators or research managers, ultimately in a training academy for strategic and operational research governance; and
- Development of a professional certification process for international research work.

7. Establish the Foundation for Future Joint Programming and Funding

Joint programming and funding of common research projects would go a long way toward the long-term vision of the suggested transportation *GRIA*. Such a development would require the following:

- Facilitating the issuing of international research calls for tenders and bids, and facilitating their evaluation through proper agreements between the funding bodies and organizations on both sides of the collaboration;
- Finding ways of merging international sources of finance to create funding for specific, common international research programs;
- Establishing common rules for the allocation and commitment of research funding;
- Finding common administration and monitoring procedures for international research projects;
- Setting commonly acceptable evaluation procedures for research results; and
- Establishing common rules relating to intellectual property rights (IPR) and exploitation–implementation of research outcomes.

The frame of a common vision for transportation research that is outlined in this report could be a useful input for the renewals of the formal bilateral science and technology agreement between the European Union and United States, or for other formal bilateral agreements between the United States and EU member states.

A number of next steps would be necessary and useful:

1. Release and disseminate this report to any concerned stakeholder on both sides of the Atlantic and beyond;
2. Give priority and bring into force—to the maximum extent possible—Recommendations 2, 5, and 6;
3. Amass further study in the details and work necessary to formulate common proposals and policies around Recommendations 1 and 4;
4. Start implementing collaboration mechanisms with top-level encouragement (see Recommendation 3); and
5. Start experimenting with initial joint programming in well-defined and mutually interesting themes by working on the steps outlined in Recommendation 7.

List of Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ACRP	Airport Cooperative Research Program
ARTEMIS	European Embedded Systems Advisory Council
ATM	Asynchronous Transfer Mode
BTS	Bureau of Transportation Statistics
COMECOM	Common Economic Organisation of the Warsaw Pact
COST	European Cooperation in Science and Technology
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DEUFRAKO	DEUtsch-FRAnzösische KOoperation (German–French technical and research cooperation in the area of terrestrial transport)
DG RTD	Directorate General for Research and Technological Development
DG TREN	Directorate General for Transport and Energy
DOT	department of transportation
EAR	Exploratory Advanced Research program (U.S. Federal Highway Administration)
EC	European Commission (executive body of government of the EU—equivalent to the Federal U.S. government)
ECMT	European Conference of the Ministers of Transport (now International Transport Forum or ITF)
ECTRI	European Conference of Transport Research Institutes
EGNOS	European Geostationary Navigation Overlay Service
EIIT	European Institute of Innovation and Technology
ENIAC	European Nanoelectronics Initiative Advisory Council
ENPC	Ecole Nationale des Ponts et Chaussées
ERA	European Research Area
ERA NET/ ERA NET+	European Research Area research coordination networks
ERC	European Research Council
ERRAC	European Rail Research Advisory Council
ERTRAC	European Road Transport Research Advisory Council
ETP	European Technology Platform
EU	European Union
EUREKA	Initiative for Applied Transnational Research and Development in Europe
FAA	Federal Aviation Administration
FHG	Fraunhofer Gesellschaft (German research organization)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FP	Framework Programme for Research
FRA	Federal Railroad Administration
F-SHRP	Future Strategic Highway Research Program (now SHRP2)
FTA	Federal Transit Administration

FY	fiscal year
GALILEO	Global navigation satellite system built by the European Union (EU) and the European Space Agency (ESA)
GIS	geographic information system(s)
H2FC	European Hydrogen and Fuel Cells Advisory Council
HMCRP	Hazardous Materials Cooperative Research Program
IDEA	Innovations Deserving Exploratory Analysis
INRETS	French National Institute for Transport and Safety Research
IPR	intellectual property rights
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITF	International Transport Forum (intergovernmental organization in the OECD family)
ITS	intelligent transport system(s)
ITS JPO	FHWA's ITS Joint Program Office
ITSP	International Technology Scanning Program
JTI	Joint Technology Initiative(s)
LCPC	Laboratoire Central des Ponts et Chaussées
LTAP	Local Technical Assistance Program
LTPP	Long-Term Pavement Performance
MS	EU member state(s)
MNC	multinational corporations
NANIAC	(see ENANIAC)
NATO	North Atlantic Treaty Organization
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NGSIM	Next Generation SIMulation
NGTR	nongovernmental transportation research
NHI	National Highway Institute
NHTSA	National Highway Traffic Safety Administration
NOE	Network of Excellence: European transnational networks of cooperation–competition
NTI	National Transit Institute
NTL	National Transportation Library
NTPEP	National Transportation Product Evaluation Program
OECD	Organisation for Economic Cooperation and Development
OECD Frascati Manual	Internationally recognized methodology for collecting and using R&D statistics, published in 2002
OMC	Open Method of Coordination (new means of governance in the EU)
PHMSA	Pipeline and Hazardous Materials Safety Administration
R&D	research and development
R&T	research and technology
RAC	Research Advisory Committee to the AASHTO Standing Committee on Research
RD&T	research, development, and technology
RITA	Research and Innovative Technology Administration

RTD	research and technological development
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SCOR	AASHTO Standing Committee on Research
SESAR	Single European Sky ATM Research
SHRP	Strategic Highway Research Program
SINTEF	Norwegian Technical Research Centre
SMB	small and medium businesses
SME	small and medium enterprises
SPR	state planning and research
SRA	strategic research agenda
STEP	Surface Transportation Environment and Planning Cooperative Research Program
STERA	Surface Transport European Research Area
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century
TFHRC	Turner-Fairbank Highway Research Center
TIG	Technology Implementation Group (established by AASHTO)
TNO	Netherlands Organization for applied Scientific Research
TPF	Transportation Pooled Fund
TRB	Transportation Research Board
TRIS	Transportation Research Information Services
TTAP	Tribal Technical Assistance Program
U.S. DOT	U.S. Department of Transportation
UITP	International Association of Public Transport
UNECE	United Nations Economic Commission for Europe
USACE	U.S. Army Corps of Engineers
UTC	University Transportation Center(s) (managed by RITA)
VTT	Technical Research Centre in Finland
WATERBORNE	European Waterborne Research Advisory Council

Surface Transportation Research Governance and Financing in Europe

Historical Background and Current Trends

This chapter provides historical background and current trends in governance, management, and financing issues of surface transportation–related research in Europe.

HISTORICAL OVERVIEW, 1950–2000

The period from 1944 to 1955 in Europe was marked by the rebuilding of transportation infrastructure and the presence of the Iron Curtain; in this context, national efforts focused on

- Establishing road-research laboratories;
- Integrating rail research to rail operators; and
- Creating national waterways and harbor technical centers.

In the 1960s through the 1970s, various strong intergovernmental collaborations accompanied the rebuilding of nations and the new challenges faced at each side of the Iron Curtain. The period witnessed the establishment of the first surface transportation–related research program, which inspired many countries to start creating national research programs. Western Europe developed the roads and road-transportation research program of the Organisation for Economic Cooperation and Development (OECD) in 1967, and the Enhanced Safety of Vehicles program of the North Atlantic Treaty Organization (NATO) in 1967; Eastern Europe established the road–vehicle technical research requirements and the road research of the Common Economic Organisation of the Warsaw Pact (COMECOM) programs, used also as a source of scientific knowledge by the United Nations Economic Commission for Europe (UNECE).

Across the eastern and western parties in 1961, the European Cooperation in Science and Technology (COST) retained transportation as one of its priorities, and the European Conference of the Ministers of Transport (ECMT), currently known as the International Forum for Transport (ITF), created its Transport Economics Research Centre in 1964. Also, the two international commissions for protecting the Rhine and the Danube played a critical role in the waterways.

These developments led to the establishment of research institutes with focus on the economics of transportation that opened the way to dedicated transportation economic research and the formation of centers with corresponding research capacity to complement the more common engineering type of research (infrastructure construction, etc.).

The European treaties established the initial bodies that evolved into what is now the European Union[1] (EU) and had considerable impact on the development of EU transportation policy and research in the 1980s and 1990s.

[1] The European Union consists of four pillars of government and decision making: 1) the European Commission or executive body (equivalent to the U.S. federal government); 2) the European Council, a council of the ministers representing various fields in the national governments (e.g., Council of Ministers of Transport); 3) the European Parliament, consisting of elected representatives from all member countries of the European Union; and 4) the European Court of Justice.

The European Union's First Framework Program (FP1) was dedicated to research focused on basic information and communication technologies, but the appearance of transportation-related research at the European Commission[2] (EC) level began in earnest in 1985 during its Second Framework Programme (FP2), focusing on transportation telematics (computers and telecommunications). In 1988, FP3 broadened the focus, covering all areas of surface transportation and aeronautics.

At the same time, national transportation–related research programs began to be created (1982–1992), often in the perspective of supporting multilateral and intergovernmental initiative programs such as EUREKA (an initiative for industrial research) or bilateral or regional programs such as DEUtsch-FRAnzösische KOoperation (DEUFRAKO) between Germany and France, and the Nordic Road Research Council. Programs included new stakeholders such as industrialists and operators. Some universities also entered the field of surface transportation research and education.

The Maastricht Treaty, signed in February 1992, saw the beginning of the creation of the European "single space" unification process, continued to place surface transportation on the priority agenda of the EU's Framework Programme, and emphasized the involvement of all Europe in all transportation-related research priorities.

By that time, almost all EU member countries had developed national transportation research programs, and there were incentives for the creation of national academic clusters between universities and higher education institutes and research and technological organizations.

EUROPEAN RESEARCH GOVERNANCE, MANAGEMENT, AND FINANCING IN THE 21ST CENTURY

New Stimuli

Starting in 2000, new stimuli were created for European transportation-related research. The Lisbon Agenda of March 2000 had the vision of transforming Europe to a knowledge society through the creation of a European Research Area (ERA). Two years later, the Barcelona Agenda set a spending target for Europe of 3% of its GDP expenses for research and development activities, including roughly two-thirds from private funding and one-third from public funding.

These two agendas established the ERA as the research segment of the European triangle between research, education, and innovation, with a package of increased research investment in education and environmental research, the reduction of fragmentation and duplication, research excellence and relevance on an international level, and development of the human resources dedicated to research and its excellence. The ERA emphasized the strong need for nationally coordinated, or at least harmonized, strategies with the European Commission at three levels: policy, programs, and operations. Industry and private funding were encouraged.

The ERA and the Surface Transport European Research Area (STERA) sought to raise the bar, strengthen and reorient research, and open new perspectives using three concepts:

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[2] The European Commission is the administrative and executive body of the European Union, corresponding to a federal government.

- Creation of an "internal market" in research (free movement of knowledge, researchers, and technology);
- Restructuring the European research fabric (coordination of policies and activities); and
- Development of a European research policy (taking into account other EU and national policies).

Governance and Funding Networks

With a new mission and project-oriented public budget process, new governance and funding networks were created.

The Open Method of Coordination (OMC) is one of the key instruments changing governance, with a focus on coordination (for the OMC definition on the type of use, refer to the OECD and European Council of Ministers websites). While created by OECD, the open method is used by the EU Council of Ministers through the Directorate for Science Technology and Industry.

Also created was the National and European Research and Innovation System's auditing network, which relates to the European triangle of research, innovation, and education. The goals of this network were to

- Create national funding agencies (all domains or dedicated by big domains);
- Stimulate funding by private foundations;
- Stimulate private funding by industry, banking, and venture capital industry;
- Capture the excellence and the relevance for every type of stakeholder, setting economy and sustainability as key drivers;
- Stimulate the interaction between research stakeholders;
- Stimulate the excellence and relevance of the supply side for education, research, and also industry capabilities; and
- Develop new concepts of science adapted to today's knowledge society: focused research, aiming at solving specific problems and answering questions; and frontier research, aiming at opening new scientific knowledge[3] focusing on regional and local anchorage, national and European integration, international relevance and excellence, and on making the link between research, innovation, and regional policies.

Building on the Frascati Manual (officially known as the Proposed Standard Practice for Surveys of Research and Experimental Development and published by the OECD Directorate for Science, Technology, and Industry), the field of transportation is recognized as the formal domain of its three classifications, and transportation-related research and innovation are considered an integral part of science and technology.

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[3] The traditional split of research between basic and applied is linked to the linear innovation network (basic research, invention, applied research, development, and implementation of innovation), with the appearance of a nonlinear network of innovation where frontier research opens new scientific knowledge and where focused research is aimed at solving problems to answer questions. In Europe, the objective of the new European Research Council is to promote frontier research and collaboration through the FRDP, and development through the Comon Innovation Programme (CIP) for focused research. In the transportation research domain, the first document noting focused research is the proceedings of the 12 Annecy Principles of the OECD–RTR–RP6 workshop published by INRETS.

Coordinating Mechanisms

Today, the European Commission uses an array of coordinating mechanisms:

- The ERA-NET and ERA-NET+ networks, which coordinate national research programs through coordination of public funders and creation of joint calls for proposals (ERA-NET Transport and ERA-NET Road are two examples);
- The Networks of Excellence[4] are transnational networks of cooperation–competition that coordinate–integrate the supply side of research in interaction with stakeholders. They also
  - Test new governance and management concepts to institutions, scientists, and young scientists;
  - Evaluate efficiency and productivity of knowledge products; and
  - Prepare the next generation of scientists.
- The European Technology Platforms (ETP) consist of a mechanism aimed to promote the interaction between industrial and all other research stakeholders around a strategic research agenda in a specific field (see also http://cordis.europa.eu/pub/technology-platforms/docs/etp3rdreport_en.pdf). Stakeholder research actors include the European Commission, the member states, industry (industrialists, suppliers, and operators), academia (universities and research and technology organizations [RTOs]), transportation societies or organizations, and ad hoc authorities.
- For surface transportation, there are several such platforms; namely, European Road Transport Research Advisory Council (ERTRAC), http://www.ertrac.org/; European Rail Research Advisory Council (ERRAC), http://www.errac.org/; European Waterborne Research Advisory Council (WATERBORNE), http://www.waterborne-tp.org/; European Embedded Systems Advisory Council (ARTEMIS), http://www.artemis-office.org/dotnetnuke/; European Nanoelectronics Initiative Advisory Council (ENIAC); European Hydrogen and Fuel Cells Advisory Council (H2FC); Biofuels Technology; Future Manufacturing Technologies; and eSafety Intelligent Car Initiatives (assimilated into ETPs).
- At the national level, national platforms mirror the European Technology Platforms or groups of European Technology Platforms.
- Joint Technological Initiatives (JTIs). These are more ambitious research funding mechanisms using articles 169–171 of the EU treaties in the transportation-related domain. These treaty articles have also been used as the legal basis for program Galileo or SESAR, the new European Air Traffic Management (ATM), etc. In the transportation field, JTIs are currently under creation.
- The creation of clusters (e.g., in eastern and central European countries and in smaller European countries) aims at promoting a better interaction within academia or between industry and academia among specific groups of countries or disciplines. In particular, clusters aim at reinforcing the triangular linkages among research, innovation, and education; and among regional and local anchorage, national and European integration, and international relevance and excellence.
- A scientific cluster seeks to develop excellence and relevance through new governance, the supply side of education and research poles of excellence, advanced thematic research

[4] See the definitions in the Europa-Cordis website for FP6 and FP7; these Networks of Excellence (NOEs) are transnational networks of cooperation–competition aimed at the international excellence of European scientists and the creation of critical mass.

networks or networks of excellence, engineering research national network, elite universities, or the European Institute of Innovation and Technology (EIIT) project.
- Competitiveness clusters are aimed at promoting interaction between academia and industry, including spinoffs and small and medium businesses.
- The scientific and technical parks developed in the United Kingdom, Sweden, Spain, Germany, and France have similar objectives as the clusters.

Research Funding Approaches

The governance management and funding for transportation-related research in Europe is moving forward with new approaches and funding agencies, some of which were already mentioned in the previous section as "coordination mechanisms."

The most notable new approaches to research funding are

- Establishing ETPs, which are now becoming self-supporting and funded;
- Creating Joint Technology Initiatives, which are vehicles for research funding in their specific field or area of research, endowed with the appropriate financial resources from public funds (EU or national governments) and private funds (the first such JTI in the transport sector, called ARTEMIS, has already raised more than 200 million Euros);
- Forming clusters (scientific or competitive);
- Strengthening the supply side of research more generally (i.e., strengthening the institutions providing research); and
- Providing incentives to attract world or European RTD organizations in European countries.

New approaches to research management are also taking into account new challenges such as energy and climate-change concerns.

Research Supply

The structure of the research supply in Europe is developed in five different ways:

- Scientific clusters aimed at excellence.
- Incentives for focused research and creation of new concepts of research and technological organizations. Examples of such RTOs include the German Fraunhofer Institute Fraunhofer-Gesellschaft concept (http://www.fraunhofer.de), which syndicates a transportation alliance of 18 institutes; the Technical Research Centre of Finland (http://www.vtt.fi); Dutch Technical Research Centre (http://www.tno.nl) in the Netherlands, which also coordinates many transportation activities; the Technical Research Centre (http://www.sintef.no) in Norway; or the Institutes Carnot, (http://www.instituts-carnot.eu/) in France [with an alliance of four transportation institutes, including the French National Institute for Transport and Safety Research (http://www.inrets.fr/) and LCPC-ENPC (http://www.lcpc.fr and http://www.enpc.fr) respectively].
- Incentives for frontier research such as the European Research Council, the Nordic Research Council, or ad hoc networks from national research agencies.
- Incentives for creating research-intensive small- and medium-sized companies (SMEs) and spin-offs.
- Change of governance for academia (universities and RTOs).

State members as well as regional and local authorities are eager to attract or keep world RTD headquarters of industry (at least European ones) in the frame of their responsibilities and that of the EU state aid network (see www.ec.europa.eu/competition) and are using directly or indirectly many of the vehicles described above.

Universities and RTOs have an incentive to change their former governance model in order to better respond to the demand for thematic and process-oriented activities, international scientific products of excellence, and tools and instruments to support scientists within projects.

DRIVERS AND CONTENTS OF RECENT EUROPEAN RESEARCH PROGRAMS

Background to the Current EU Research Program FP7

EU-funded transportation research is largely driven by the research demand that is expressed by the big stakeholders in the transportation field; namely, transportation-related industries

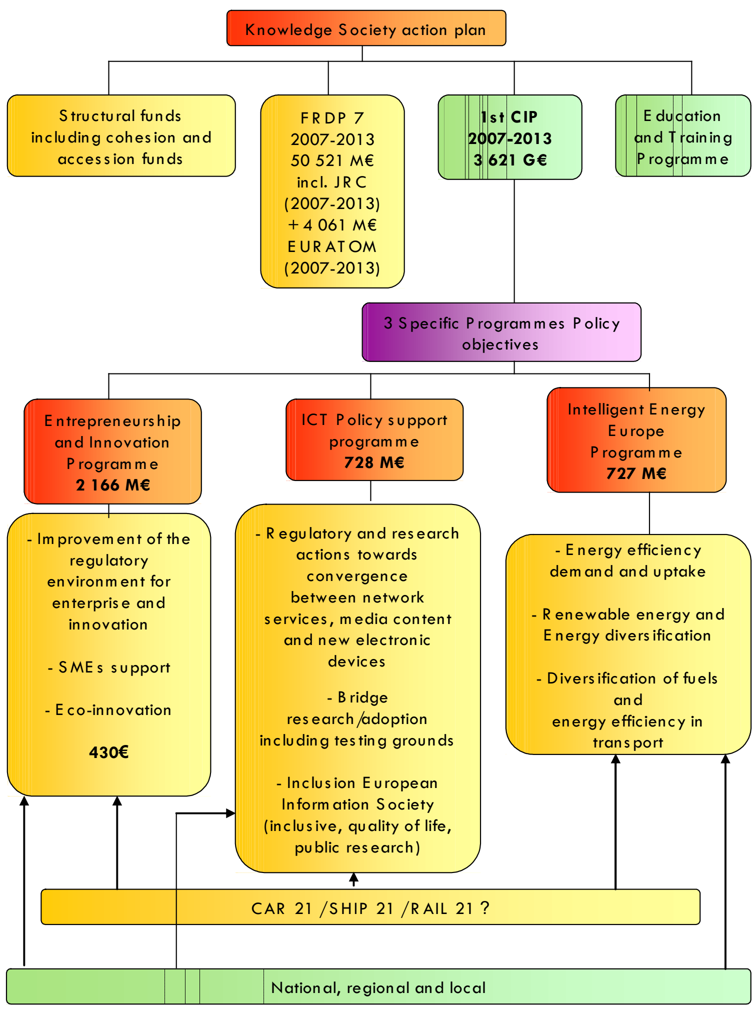

FIGURE 1 Research and innovation governance and funding network of the European Conference of Transport Research Institutes.

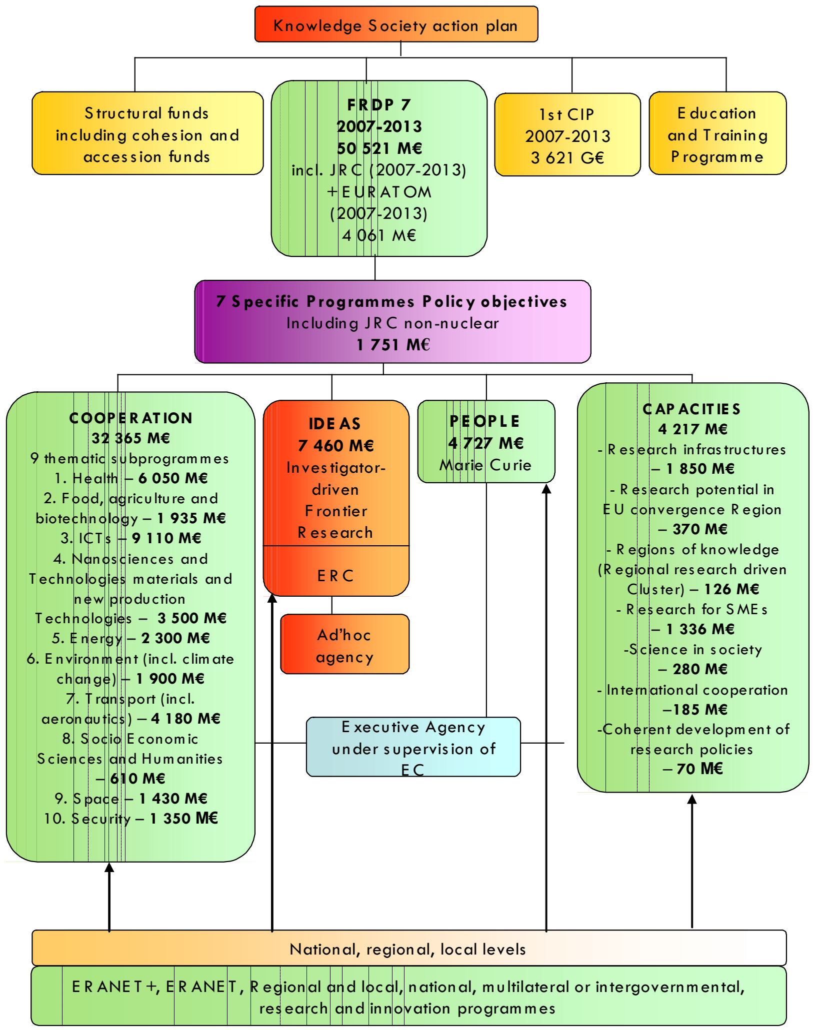

FIGURE 2 Programs and funding provisions of the current 7th Framework research and development program.

[automotive, communication, intelligent transport system (ITS), rail, aviation] and, although to a smaller degree, transportation operators. While the stakeholders accept and support competitiveness and sustainability as main targets for European transportation research on a general level, they try to put forward their particular interests at the same time. This is reflected in the research agendas that have been developed in the last few years by Europe-wide technological platforms such as ERTRAC and ERRAC for road and rail transportation, but also by the European Conference of Transport Research Institutes (ECTRI) and the International Association of Public Transport (UITP) for urban mobility.

As a consequence the FP7 is widely reflecting the recommendations given by the strategic research agendas (SRAs) developed through the European Technology Platforms or within various other European transportation-related associations. The decision of the European Council (of Research Ministers)[5] on the FP7 explicitly points out, on page 6 of the FP7 official text, that "particularly relevant for industrial research are the European Technology Platforms (ETPs) and the Joint Technology Initiatives (JTIs). ETPs can evolve to represent a general tool for fostering European competitiveness." This text demonstrates that transportation research in Europe is still largely sectorial and very much driven by the European industry—a view also reflected in the decision of the European Parliament.

The Transport Advisory Group[6] of the European Commission commented to the FP7 that even the consideration of broader societal and economic issues and transportation policy objectives is left almost entirely to the industry instead of being driven by the relevant General Directorates of Transport and Energy (DG TREN) and the General Directorates of Research and Technological Development (DG RTD). (See page 4: http://ec.europa.eu/research/fp7/pdf/advisory-groups/transport-wp2008.pdf.)

For the transportation research area, the FP7 starts with the general objective to "develop integrated, safer, 'greener' and 'smarter' pan-European transport systems for the benefit of all citizens and society, respecting the environment and natural resources; and securing and further developing the competitiveness attained by the European industries in the global market." (FP7, p. 35).

The envisaged content of FP7 research in the field of transportation combines the topics raised by the SRAs and associations such as ECTRI. For the case of surface transportation (rail, road, and water), FP7 focuses on sustainability objectives by the following topics:

- Greening of surface transportation by reduction of environmental and noise pollution through technological and socioeconomic means (e.g., clean and efficient engines and power trains, use of alternative fuels, increased cost- and energy-efficiency);
- Encouraging and increasing modal shift and decongesting transportation corridors (e.g., intermodal and interoperable regional and national transportation and logistics networks, cost internalization, optimization of infrastructure capacity, and modal-shift strategies);
- Ensuring sustainable and accessible urban mobility for all citizens (e.g., innovative organization networks, means of transportation with lower levels of pollution, integrated town planning and transportation);
- Improving safety and security (e.g., design and operation of vehicles, vessels, and infrastructures);
- Strengthening competitiveness (e.g., improvement of design processes, development of advanced power train and vehicle and vessel technologies, and innovative and cost-effective production systems); and
- Support to the European Galileo and EGNOS global satellite navigation systems.

The most direct impact of SRAs is to be found in the calls that are forwarded in the framework of FP7.

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[5] The member states, represented by their Research Ministers in the *European Council*, as well as the European Parliament gave a formal consent to the 7th Framework Programme legislative document by their respective votes. The execution of the 7th Framework Programme via its work programs is guided or controlled by the representatives of the member states on the respective program committee. On the basis of this role, member states are involved in balancing the European Research Program with their national programs to ensure subsidiary.

[6] The Transport Advisory Group consists of some 30 experts from all member countries, covering all aspects and modes of transportation research. Together with the ETPs and other advisory bodies it was created to advise the European Commission about the contents and scope of its transportation research program and also to advise on strategy, procedures, and even the specific contents of the various calls.

With a total funding of more than 4 billion Euros the transportation program is the third most important topic within FP7 after "Information and Communication Technologies" (9.05 Billion) and "Health" (6.1 Billion).

Research Implementation in Europe

It is evident, and by no means surprising, that EU-funded transportation research has to be understood as the result of a broad "negotiation process" in which a broad range of stakeholders try to position their particular interests. The need to understand and get the different stakeholders' specific approaches has been "channeled" by the Commission through the support of a number of instruments such as the technology platforms (primarily), the Transport Advisory Group, and the various consultation processes.

Currently, a lively discussion is going on about the highly technology-oriented direction that European transportation research has taken since then. While societal needs are present in both the general program description and its specific calls, funding is largely dominated by technological issues; research on mobility issues that have a societal focus is restricted to an "accessory" position in the technology-oriented research. In fundamental papers such as the Transport White Paper Review of 2006, the transport user appears basically only in the case of safety. With this very technology-oriented approach, EU-funded research reflects an approach that underlies also national transportation research funding in most European countries. Possibly, the opening of the discussion for urban transport topics will attract more attention to nontechnological issues. This has already become true for the field of economic research focusing on financing and efficiency issues.

The process of deepening the European Commission's dialogue with the stakeholders in the field of transportation and transportation research was applied in the form of public consultation to prepare the Green Paper on Urban Transport. The objective of the public consultation—open to the general public via the Internet during a six-month period—was to support the preparation of the Green Paper by collecting views from interested parties on how the European Union may best contribute to improving transportation and mobility in urban areas. In parallel, an extensive expert consultation was organized to initiate a discussion process and some first consensus findings. The Green Paper itself identifies potential European added value to actions taken at local levels, with the aim to become a guideline for future transportation research supported and funded by the European Commission.

On the level of coordination between national and European research, the *subsidiarity* principle implies that EU-funded research shall have a complementary character to what is done on the national level. This aim has been translated into a process where the main steps are

- Advice to the European Commission services from advisory groups set up by high-level national experts about research priorities (in the transportation-research area, advisory groups show a noticeable overlap with technology platforms);
- Development of thematic research programs that are discussed and evaluated by the relevant program committee (representatives of the national research ministries are members of these committees); and
- Acceptance of EU Framework Programs by the national ministers (secretaries of state for research and innovation).

There is currently some criticism, however, in Europe that the *subsidiarity* principle does not really work in European research. So far, as the process of coordination between national and European funding has just started to develop, double-funding by national and European programs is quite common. How difficult this can be may be illustrated by a figure from the Intelligent Transport Systems (ITS) research area (http://www.portal.cistrana.org), revealing that in 2008 there were about 100 national programs running in parallel with EU-funded ones (similar figures do not exist for the transport sector).

To overcome these coordination deficits, the ERA-Net was created (http://cordis.europa.eu/coordination/era-net.htm), which is also active in the transportation sector. Through its 2005 communication, "Building the ERA of Knowledge for Growth," the Commission acknowledges (at least implicitly) this coordination challenge as it points out the need to reinforce links with national and private efforts (European Commission, 2005a, p. 8). The intended improvements will also help overcome the barrier to more innovation, because currently resources are not distributed efficiently and therefore cannot sufficiently support innovative ideas.

CONCLUSION

Today the European Research Area concept and the follow-up of the Green Paper of the Future of the European Research Area create the framework for all research activities and surface transportation–related research in Europe. This is true not only from a content perspective, involving the needs of various stakeholders (operators and industrialists), but also at the process level (mobility, young researchers' training and education, research infrastructures) and through coordination of efforts made by the stakeholders, including the public bodies and their agencies. A European Research Area 2020 Vision document was recently approved by the European Council of Research and Science Ministers.

At the same time, the European Commission maintains the consultative approach to set up its new programs. Therefore, the preparation of initial ideas on FP8 is already under way, although FP7 projects have just been started at the beginning of 2008. In 2009, a new European Parliament was elected and a new Commission nominated. As one of his first tasks, the new Commissioner for Research will have to perform the FP7 mid-term review in 2010. In parallel, the European Commission will prepare the financial perspectives for 2014–2020 (to be officially proposed in 2011), which will include also first guidelines for research. In 2012, a first general proposal on FP8 is expected. Within this time frame there is at least one year's time (in 2009) to prepare concepts and ideas on future European research.

According to the European Commission's Directorate-General for Research, there is basic agreement on continuation of the Ideas (European Research Council) and People (Marie-Curie) Program. With some adjustments toward European research infrastructures, the Capacities Program will also basically continue. With respect to the core of the framework program (cooperation), EC is not certain about how to organize it. Possible options are the continuation of the thematic approach by setting up major programs according to challenges such as the environment, mobility, energy, a mixture of these subject areas, or a completely new concept. Therefore EC will be open to ideas and concepts prepared by the stakeholders, in particular those organized in ETPs.

One major topic in this discussion will be the opening of the European Research Area to the international world, which will have to take into account the various competitive and cooperative aspects. A discussion on the international level, and in particular with the United States, about transportation research cooperation–collaboration seems to be timely.

Surface Transportation–Related Research Governance and Financing in the United States

Historical Background and Current Trends

This chapter provides historical background and current trends in governance, management, and financing issues of surface transportation–related research in the United States.[1]

EVOLUTION OF TRANSPORTATION RESEARCH IN THE UNITED STATES: A HISTORICAL OVERVIEW

The 19th and 20th centuries witnessed the American building of a nation and the creation of a new frontier around the transcontinental railroad, road trail, and wagons. Surface transportation research began with the appearance of civil engineering research at West Point, the U.S. Army Corps of Engineers, and some universities providing education training and research (in response to demand from the states, local authorities, and industry). The story of surface transportation–related research includes the following historical steps:

- Creation of the Office of Road Inquiry (ORI) in 1893;
- Creation of a highway bureau in the Department of Agriculture in 1904 and creation of other highway bureaus at the state level;
- Change of the federal highway bureau's name in 1905 to the Office of Public Roads (OPR) as it became a division of the U.S. Department of Agriculture;
- Change of OPR's name to Bureau of Public Roads (BPR) in 1915;
- Creation of the National Academies' Highway Research Board in 1920 (currently the Transportation Research Board) following the U.S. Army's transcontinental motor convoy of 1919, which was commanded by then–Lieutenant Colonel Dwight D. Eisenhower;
- Change of BPR's name in 1939 to Public Roads Administration (PRA) as it was moved under the Federal Works Agency (FWA);
- Change of PRA's name back to BPR and its move to the U.S. Department of Commerce with the abolition of the FWA in 1949;
- Transfer of BPR in 1967 to the newly created FHWA, where it joined two other original bureaus: the Bureau of Motor Carrier Safety and the National Highway Safety Bureau.

Evolution Toward Evidence-Based Transportation Research

The United States has gradually evolved from a surface transportation research policy based on experience and nonsystematic field observation to a policy based on systematic, empirically

[1] The authors are grateful to AASHTO's Standing Committee on Research (and CTC & Associates LLC), who provided much of the information for this and following sections in its document, *Transportation Research: Value to the Nation—Value to the States* (NCHRP 20-80 [1]).

based research. For instance, prior to World War I, engineers from the OPR generally were not concerned with developing theories of material behavior through experimentation, nor were they concerned with expressing results in quantitative terms. Instead, they relied on road construction techniques based on the century-old efforts of European engineers such as Macadam, Telford, and Tresaquet.

By the start of World War I, the OPR claimed that the significant challenges in road building had been conquered and that "significant problems remained only in the realms of finance and administration, not in technique." Unfortunately, this confidence in existing convention and experience was soon dashed during the winter of 1917–1918 when railroad cars carrying water materials for France were held up in midwest freight yards and government officials recommended that manufacturers of trucks drive them to ports on the eastern seaboard.

Highway routes to New York, Philadelphia, and Baltimore were laid out by federal and state planners using existing conventions. Unfortunately, and much to the consternation of OPR, the convoys of trucks almost immediately caused a massive series of road failures. Hundreds of miles of roads failed under heavy motor truck traffic within a few weeks or months. These failures were not only sudden, they were catastrophic.

These failures fundamentally altered the way the Bureau of Public Roads (BPR) approached road construction. Rather than continue to rely solely on field observation studies and European tenants of road construction, the BPR began to use controlled experimentation. By attempting to isolate each factor or variable in a controlled setting, federal researchers (in marked contrast to most of their state counterparts) sought replicable quantitative data.

The approach of rigorous experimentation and the quantitative results of this process were generally ignored by state researchers well into the 1950s, and observational approaches continued to produce adequate results in many cases. Indeed, while the BPR set the stage for rigorous, experimentally based research that could produce worthwhile results, less rigorous field studies employed by many states apparently produced useful evidence that could be translated into usable policy and practice at the state and local levels (Seely, 1991, pp. 798–831).

Despite the contest between field observations and controlled experimentation, the paradigm of rigorous or controlled experimentation has become a primary tenet of the way both the federal government and the states conduct research. Indeed, there are many examples of how federal and state governments use controlled experimentation to support highway policy decisions and practice at all levels of government. Even more striking, as sensor and computer technology have rapidly progressed and become less expensive, the distinct line between field observation–based research and controlled experimentation within a laboratory setting has receded in many areas of surface transportation research.

Key Structural Characteristics of the U.S. Highway Innovation System

The consumer of highway transit in the United States wants safer roads that reduce fatalities and injuries from crashes. The consumer also wants to be able to get to work unstressed by hours of congestion. As a taxpayer, the American consumer would also like smoother, longer-lasting pavements and bridges that are far less costly to maintain through taxes as well as more in tune with established communities and the natural environment.

Meeting these needs requires a strong and sustained national highway research and technology development (RTD) effort that moves innovations quickly into the marketplace.[2]

[2] See, for example, *Special Report 261: The Federal Role in Highway Research and Technology*, TRB, National Research Council, 2001.

Therein lies the dilemma: Sustaining a directed, responsive RTD program is complicated by the structural characteristics of the U.S. highway RTD marketplace.

The U.S. national system of innovation has several characteristics; among them are a highly decentralized and fragmented marketplace and a heterogeneous research and technology development system.

Highly Decentralized and Fragmented Marketplace

The U.S. highway marketplace is not a homogenous unit. It comprises 35,000 government units linked together by various roads and highways that are under the control of private entities, local, and state governments, all loosely integrated under the federal government. Services from RTD to highway maintenance are conducted by tens of thousands of contractors, material and equipment suppliers, and other organizations providing various services.

The consequences of a decentralized and fragmented marketplace are significant. Performance requirements for a particular technology may differ from one jurisdiction to another, causing problems in taking advantage of natural economies of scale that occur in the production of automobiles or computers. The more tailor-made a technology must be, the less incentive (or more risk) there is for a particular firm or individual to invest in a particular technology's development and transfer to the market. When markets are too small or fragmented to support private involvement, the onus for development falls on government to provide selective incentives to attract participation.

The highway marketplace stands in distinct contrast to sectors such as bio-pharmaceuticals, where there are huge potential markets for a particular innovative drug or procedure. In this industry, the growth and development of patents and licenses has propelled research and technology development and deployment forward. The same cannot be said for the highway marketplace, where the development of intellectual property (IP) and the subsequent commercialization of new products through exclusive licenses remains, for the most part, an untapped strategy.

Heterogeneous Research and Technology Development System

For more than 60 years, the federal government, primarily through the Federal Highway Administration and its predecessor agency, the Bureau of Public Roads, has played a direct and positive role relative to the marketplace. It has provided substantial funding for highway research, helped transform highway research into a rigorous scientific discipline, supported program staff and technology transfer activities in every state, organized international scans to collect information on new technologies and innovative ways of managing surface transit, and facilitated collaborations between highway engineers and scientists across the globe. Finally, it has gathered and disseminated information about research activities and promising results to literally thousands of state and local transportation agencies and other technology consumers through traveling exhibits that have crisscrossed the United States.

Sources of highway innovation extend well beyond those funded directly by the federal government. This heterogeneous environment ranges from universities and university transportation centers to state and local departments of transportation that are required by statute to dedicate a percentage of their federal aid highway funds to invest in research and technology deployment.

A large portion of state-initiated transportation research is supported cooperatively by the individual states and the federal government through the *State Planning and Research Program* (SPR). The program was initiated in 1994 as the *Highway Planning and Research Program* (HPR) and throughout its history has provided one of the most effective tools for encouraging state-controlled transportation research.

The research and technology development environment also includes the national laboratories operated by the U.S. Department of Energy. Many small businesses are involved in the development of highway technologies that range from advanced traffic simulation models to new materials for highways and bridges.

The Transportation Research Board of the National Academies also oversees a myriad of research and technology programs and projects along with the American Association of State Transportation Officials. This diversity has increased over the years in tandem with the significant growth in funding designations and earmarks included with highway reauthorization legislation.

There are more than 50 programs sponsoring highway research and technology development and deployment in the United States, and literally thousands of separate entities (ranging from universities to private firms to the 50 state departments of transportation) conducting research. The central advantage is that there are multiple perspectives for addressing complicated research issues. On the other hand, there is a greater likelihood that there will be cases of duplicative research or research that is not precisely in line with national highway RTD goals as stated in the U.S. Department of Transportation's or the Federal Highway Administration's strategic plans. The National Cooperative Highway Research Program (NCHRP) depends on federally budgeted state planning and research (SPR) funding. It was established in 1962 as a program of applied research on issues of interest to state DOTs. Table 1 shows some characteristic features of this program.

TABLE 1 Information on Aspects of the U.S. National Cooperative Highway Research Program RTD

Aspect	Approach Used
Program management	Managed by TRB
Agenda setting	Set by state highway agencies and by AASHTO's Standing Committee on Research (SCOR)
Researchers	Universities, private firms, research institutes, and individual contractors
Scope	Projects that promise immediate applications (applied research)
Research selection mechanism	Open competition
Expert peer review	Project panels of subject matter experts, research peers, and federal, state, and local government representatives

Adapted from Table 3-5 in *Special Report 261: The Federal Role in Highway Research and Technology,* Transportation Research Board, National Research Council, 2001.

TABLE 2 TPF Program Studies

Item Description	State-Led Studies	FHWA-Led Studies
Total obligated funds	$85,859,123	$60,772,440
Total number of participants	792	607
Total number of studies	131	74
Average state contribution	$108,408	$100,119
Average cost	$655,413	$821,249
Average number of partners	6	8.2

Source: Federal Highway Administration.
NOTE: As of December 10, 2007, there were 205 active pooled-fund studies, valued at $146,631,563, listed on the TPF website.

Individual states voluntarily pool 5.5 percent of their SPR set-aside funds each year to finance the program. The research projects are selected by the AASHTO Standing Committee on Research from a list of problem statements submitted by AASHTO-member departments, AASHTO committees, and FHWA.

The Transportation Research Board (TRB) is responsible for administering the contract research program under an agreement among the National Research Council, AASHTO, and FHWA. NCHRP research focuses on problems of immediate national concern that can be solved through applied research in a relatively short time frame.

The states also voluntarily obligate funding for research projects administered by FHWA's Transportation Pooled Fund (TPF) Program (see Table 2). The TPF allows state departments of transportation (DOTs) and FHWA to create synergy by leveraging resources, avoiding duplication of effort, and joining forces on planning and research projects of mutual interest.

MANAGEMENT AND FINANCING FOR TRANSPORTATION RESEARCH IN THE UNITED STATES AT THE BEGINNING OF THE 21ST CENTURY

U.S. Transportation Research and Its Institutional Context

To build, maintain, and expand its vast, multimodal system, the United States has long relied on research innovations in planning, materials, construction methods, system operations, infrastructure maintenance, and many other methods. While expenditures for research in the transportation sector have been generally lower than for other sectors, federal government support and funding for transportation research have been strong, dating back to the 1893 formation of the Office of Road Inquiry in the U.S. Department of Agriculture.

Federally sponsored research involves many programs and many public and private stakeholders, internally within Congress and the U.S. Department of Transportation; and externally with state departments of transportation, local and regional governments, planning agencies, universities, private firms, and users of the system. Stakeholder involvement is recognized in the current Safe, Accountable, Flexible, and Efficient Transportation Act: A Legacy for Users (SAFETEA-LU), which was signed into law in 2005. Title V of SAFETEA-LU spells out the commitment of the nation to transportation research as well as the need to augment applied with fundamental research. While the performance of research is decentralized, the vast major of research dollars are provided by the federal government to organizations ranging from the National Academy of Sciences, to University Transportation Research Centers (UTCs), to state DOTs, and to the private sector (primarily although not solely) through the use of contracts.

Despite the advantages of the federal government overseeing and providing the bulk of transportation research funds, the implementation of transportation research and technology development and deployment initiatives is decentralized. The decentralized nature of transportation research helps keep research close to those that implement the results: the states. On the positive side, this decentralized structure provides multiple sources of potential innovation. However, decentralization can also have significant drawbacks, including a greater likelihood for duplication of efforts, results that are not or cannot be transferred to practice beyond the local or statewide level, and significant research gaps—especially in addressing the needs of smaller states that lack the organizational and financial means to develop innovations tailored to their particular geographical, socioeconomic, and climatic conditions.

Research in a Market Economy

A number of factors influence the character of highway research in the United States. First, the federal character of government requires a sharing of powers between the national government and the states; second, formal transportation policy making is not located in one institution, but shared among three branches of government (the executive branch, Congress, and the judiciary); third, there is a strong tradition of relying on private, nonprofit research entities such as the Transportation Research Board of the National Academies and major national associations such as AASHTO to develop strategic directions for transportation research and technology development and deployment; fourth, universities and colleges, big and small, public and private, have long been relied upon to develop solutions that require “out of the box” thinking; and, finally, underlying U.S. government institutions and policy making is a strong ideological commitment to private sector participation in the research process.

Organizing from the Bottom Up

State Planning and Research Program The sharing of powers between the federal government and the states in the United States—and the organization of its transportation research and development—is exemplified by its first federal legislation to allow aid for transportation research: the State Planning and Research (SPR) program, which was created by the Highway Planning and Research program in the Federal-Aid Highway Act of 1944. Currently, SPR funding to each state equals 2% of its federal funds in six core highway programs, with at least 25% of this total required spending on research (SPR, III). Total dollars available to the states for SPR, Part II, are approximately $150 million per year, although the amount for an individual state varies dramatically, from a low of $575,000 to a high of $13 million.

State Pooled Fund Program While funding is distributed to individual states through the SPR program, there are mechanisms in place that are established to promote collaboration and coordination. The Transportation Pooled Fund Program is a critical mechanism for state DOTs to collaborate on common transportation programs, where they may use 100% federal funds. More than 187 pooled-fund projects are currently active, valued at more than $130 million in total investment. Joining a pooled fund is totally a volunteer effort; states must see a value coming from their investment to join.

State-Originated Funding

Not all research funding comes directly or indirectly from the federal government. Sixteen states spend $500,000 to $1,000,000 of their own funds annually, and 10 states spend $1 to $5 million. One state typically spends $27 million of its own funds on transportation research each year. Typically, research at the state level is done through universities or private firms.

National Research Programs

National research programs are federally funded but state- or university-administered or managed by a private, nonprofit institution, such as the Transportation Research Board of the National Academies. Major transportation research programs of long standing funded through SAFETEA-LU and operated on a national basis include the National Cooperative Research Program; the Long-Term Pavement Performance Program; University Transportation Centers; the Transit Cooperative Research Program, and the National Product Evaluation Program.

- The National Cooperative Highway Research Program (NCHRP), founded in 1962, is a unique contract research effort that responds directly to the needs of the states. NCHRP is voluntarily funded by the states, usually using SPR funds, and project selection is carried out by AASHTO and its member departments to meet common state needs. NCHRP is funded at approximately $35 million per year and the results may have a significant impact on practice, sometimes resulting in an AASHTO publication or standard.
- Established in 1999, the purpose of the AASHTO Technology Implementation Group (TIG) is to identify and champion the implementation or deployment of a select few ready-to-use technologies, products, or innovative processes. The TIG executive committee annually solicits AASHTO member agencies and others for recommendations of new technologies that have recently been adopted by one or more AASHTO member states and found to be highly beneficial.
- The Long-Term Pavement Performance program (LTPP), initiated in 1987 as part of the Strategic Highway Research Program, collects and analyzes information on pavement performance and the elements that may influence pavement performance. The program is funded at about $7 million per year. LTPP's value extends beyond the state level to helping improve engineering practices at all levels of government as well as for private road owners.
- The University Transportation Center (UTC) program, initiated in 1987, provides federal grant funding to establish and operate programs of transportation education, research, and technology transfer. SAFETEA-LU expanded to 60 the 33 UTCs previously authorized, and funding has reached approximately $77 million per year.

- The Transit Cooperative Research Program, established in 1992, is the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it. Funding for the program is approximately $9 million per year.
- The National Transportation Product Evaluation Program, established in 1994, provides testing and evaluation of products, materials, and devices that are commonly used by AASHTO-member departments.

Direct Federal Research and Technology Development and Deployment

While almost all highway research in the United States receives some federal funding, and many are under the same level of federal review, there are a number of research initiatives directly operated by various agencies of the U.S. DOT, including the FHWA.

- The Research and Innovative Technology Administration (RITA) coordinates the U.S. DOT's research programs and is charged with advancing the deployment of cross-cutting, intermodal technologies to improve the U.S. transportation system. RITA was established in 2004 as one of 13 U.S. DOT agencies. One of RITA's initiatives is the Intelligent Transportation Systems (ITS) program, which launched a generation of initiatives aimed at improving transportation safety, relieving congestion, and enhancing productivity through the use of advanced communications technologies. Established in 1991 and funded annually at $110 million, ITS technologies have the potential to significantly enhance the operation of America's transportation systems. The ITS Joint Program Office is very beneficial as an ITS resource for state DOTs and also provides excellent training opportunities, including both classroom and teleconference–Internet training sessions.
- Through the development of its document, "Transportation Vision for 2030: Ensuring Personal Freedom and Economic Vitality for a Nation on the Move," (January 2008) RITA is seen as a primary agenda setter for future transportation research and technology development in the United States.
- The Turner-Fairbank Highway Research Center (TFHRC) provides FHWA and the national highway community with advanced research and development related to new highway technologies. TFHRC plays an essential role in transportation research at the national level and is particularly suited to carry out research affecting a majority of states.
- The FHWA's Local and Tribal Technical Assistance Programs (LTAP–TTAP) provide information and technology training to local governments and agencies. There are 58 LTAP and TTAP centers nationwide, funded at about $11 million a year.
- The National Highway Institute (NHI) is the training and education arm of the Federal Highway Administration. Established in 1970 and funded at $9.6 million per year, NHI provides critical information in a wide variety of areas of importance to state DOTs.
- The U.S. DOT's Intelligent Transportation System (ITS) program launched a generation of initiatives aimed at improving transportation safety, relieving congestion, and enhancing productivity through the use of advanced communications technologies. Established in 1991 and funded at $110 million, ITS technologies have the potential to significantly enhance the operation of America's transportation systems.

- The U.S. DOT's Federal Transit Administration engages in research to provide the transit industry and policy makers with the information to make good business decisions about transit technology and operational and capital investments, as well as to share research results that identify best practices and to show a range of outcomes that help chart the course of future investments.
- The Federal Motor Carrier Safety Administration (FMCSA) was established in 2000 with the primary mission of reducing crashes, injuries, and fatalities involving large trucks and buses. FMCSA's work has yielded significant results in improved highway safety.
- FHWA's International Highway Technology Scanning Program serves as a means for access to innovative technologies and practices in other countries that could significantly improve highways and highway transportation services in the United States. Seventy scans have been conducted since 1990.

New National Research Programs

While many surface transportation research and technology programs have been in existence for a decade or more, there are a number of new programs (most authorized under SAFETEA-LU) that have begun more recently. The programs administered by TRB include:

- The second Strategic Highway Research Program (SHRP 2), with $170 million in funding to be spent over 7 years, is the most well known of new federally financed research programs. The four focus areas of the SHRP 2 program (safety, renewal, reliability, and capacity) are all of vital concern for the national transportation system.

- The National Cooperative Freight Research Program (NCFRP) is designed to carry out applied research on problems facing the freight industry that are not adequately addressed through current research programs. Authorized at approximately $3.75 million per year, NCFRP will produce a series of research reports and other products to the intended end-users of the research: freight shippers and carriers, service providers, suppliers, and other public sector officials.
- The Hazardous Materials Cooperative Research Program (HMCRP) is structured to carry out applied research projects to improve the information used in managing risk associated with the transportation of hazardous materials. Authorized at approximately $1.25 million per year, HMCRP research will help advance critical knowledge and practice related to hazardous materials transportation.
- The Commercial Truck and Bus Safety Synthesis Program (CTBSSP) initiates synthesis studies annually that extend the research for commercial truck and bus safety, synthesizing new information from existing work, uncovering trends and commonalities, and helping define direction for future research and implementation needs.

FHWA's Exploratory Advanced Research (EAR) program is intended to redress the historical imbalance between applied research with immediate payoffs and research that is higher risk but more likely to produce fundamental scientific breakthroughs, with some notable failures.

The Surface Transportation Environment and Planning Cooperative Research Program (STEP), administered by FHWA, is a program for improving understanding of the complex relationship between surface transportation, planning, and the environment. FHWA conducts a needs-driven research program within STEP that builds on past and future outreach to the research and user communities as well as on documented research needs assessments. STEP is funded at approximately $16 million per year.

Political Entrepreneurship

Along with the formal research and technology programs of the federal government, states, and major transportation associations, there is a growing tradition of political entrepreneurship in which private and public research centers and universities directly lobby Congress for designated funds or earmarks. The movement toward dedicating federal funding to the research agendas of institutions located in particular states and congressional districts has accelerated in recent years. At the level of research, political entrepreneurship can lead to multiple institutions pursuing similar research topics, with other key transportation research problems remaining ignored.

Private-Sector Involvement

The private sector is integral to transportation research as well as innovation development and deployment in a market-based economic system. Much of the research done at the federal and state levels is done by contractors, both large and small. In addition, there are a number of programs designed to capture the ideas of the private sector, such as the Innovations Deserving Exploratory Analysis (IDEA) program sponsored by AASHTO through the National Cooperative Highway Research Program (NCHRP). Other sponsors include the Federal Motor Carrier Safety Administration (FMCSA), the Federal Railroad Administration (FRA), and the Federal Transit Administration (FTA). The program differs from traditional research programs in two ways: IDEA projects are initiated by researchers rather than by a request for proposals, and funding can support initial testing of unproven concepts. The investments made in IDEA by the noted organizations are meant to "capture the unexpected concept that challenges conventional thinking," according to TRB's 2008 announcement of the program.

Another critical program for promoting private-sector involvement in transportation research and technology development and deployment is the Small Business Innovative Research Program (SBIR). This program is funded out of the extramural research budgets of the major U.S. Department of Transportation modes. Its projects are funded in two phases and range from the development of new bridge sensors to mechanisms for controlling the invasion of nonnative plant species via road construction.

While the private sector is viewed as the fountainhead of traditional innovation throughout the economy, the role of the private sector in transportation research and technology development is somewhat different than it is in other sectors because of the enduring problem of collective goods and its impact on private investment in surface transportation, in general, and highway research and technology development, in particular.

U.S. Research Priorities and Research Gaps

The United States is at a critical juncture in the development of its research technology and deployment agenda, with new transportation authorization legislation on the horizon. U.S. transportation reauthorization legislation, in many ways, plays the equivalent functional role as

European transportation research policy codified through the "Transport White Paper" of 2001, the 2000 "Lisbon Agenda," and the revision of the EU transportation white paper on European transportation policy, published in September 2006, "Keep Europe Moving: a Transport Policy for Sustainable Mobility." Such policy is essentially lacking in the United States.

The formation of political consensus regarding a new surface transportation research agenda will be the product of testimony and studies provided by the U.S. executive branch and Congress, federal and state transportation agencies, the major industry and research associations, universities, and private sector interests. For instance, the recently published "Report of the National Surface Transportation Policy and Revenue Study (NSTPRS) Commission, Transportation for Tomorrow" (December 2007), which was required under Section 1909 of SAFETEA-LU, provides the outline for a continuing dialogue that will eventually influence the development of a new consensus on the direction and scope of highway research and technology development.

The report received extensive input from many of the major transportation stakeholders and sectors. While there was a definite split in the commission on the content of the report, the document is important in that it initiates "a call to action" on the future of the surface transportation system in the United States. Indeed the report argues that the "*future of our Nation's well-being, vitality, and global economic leadership is at stake. We must take significant, decisive action now to create and sustain the preeminent surface transportation system in the world.*"

The development of a consensus-based national surface transportation agenda will require agreement on several key areas, including funding. Specifically, the future role of the federal fuel tax is in question. The NSTPRS Commission report is only one of several sources of an evolving dialogue that will eventually be codified into new transportation authorization legislation. The direction in which the United States ultimately goes regarding the financing of highways will have both direct and indirect consequences for the development and implementation of future research and technology "platforms."

Currently, the major research and technology issue, from a macro-institutional perspective, is primarily one where the nation's research needs and appetite are larger than what can be legislatively appropriated. Year after year, actual appropriation levels do not reach what is approved in prior authorizing legislation. Consequently, research areas such as transportation policy or security research lacking specific budget lines may be zeroed out so that research areas with specific lines can be funded, albeit at reduced funding levels. Indeed, just because a transportation technology or policy area is on the national research agenda does not mean that it will necessarily receive the funding to conduct the research.

The issue in the United States is not only recognizing the need to conduct highway research on an intermodal basis or on the development of new technologies to reduce congestion, enhance mobility, protect the environment, or increase safety; it is also finding mechanisms to fund the development of new technologies and innovations at sustainable levels and translating consensus-based research commitments into practice.

Research Implementation in the United States

In the United States, research and technology innovation implementation is left primarily to the states and localities. The Federal Highway Administration has had a long history of advocating and demonstrating the value of new highway technologies on a national basis. Federal and state agencies are helped immeasurably by organizations such as the Transportation Research Board and AASHTO, which play critical roles in bringing transportation officials and researchers together in common forums that enable the rapid diffusion of innovations and scientific knowledge.

Organizations such as AASHTO also have critical standard-setting responsibilities. And, as most economists recognize, new standards lead to new markets for technologies and innovations. For instance, in January 1996 AASHTO entered into a 5-year cooperative agreement to "foster the development of ITS Standards." Four other standards development organizations (SDOs) were similarly chosen to participate, including the Institute of Transportation Engineers (ITE), the Society of Automotive Engineers (SAE), the Institute of Electrical and Electronics Engineers (IEEE), and the American Society for Testing and Materials (ASTM).

Impediments to rapid technology implementation in the United States differ in accordance with the technology sector involved. For instance, the primary impediments to the use of a new traffic simulation model may relate to the costs of adopting new technology and the continuing reluctance of traffic engineering departments to adopt innovations. New technologies pertaining to pavements and bridges and other infrastructure facilities may be delayed by the requirement to fully test the efficacy of the new technology under different geographical and climatic conditions and the concomitant need to approve and implement standards—sometimes on a state-by-state basis.

Another factor is the nature of geography in the United States, along with patterns of transportation that have evolved over the last hundred years. Unlike Europe, where large segments of the population are located in relatively constrained spatial settings, there are vast areas of the United States that are so sparsely populated that a number of intermodal technologies and integrated transportation systems—easily applicable to Europe—are simply not cost-effective on a national scale. In those situations, cars and trucks are likely to remain the primary form of transportation for the foreseeable future.

Finally, there is an ongoing philosophical debate in transportation research and development circles pertaining to the appropriate role of government in promoting science and technology. On one side, there are those who believe that the federal government's role should be limited to basic research, while on the other side there are those who believe that government's involvement can be justified all the way through commercialization. An example of this is reflected in the FHWA's role in traffic model development. At one point in time, the major impetus was to fully develop and maintain particular traffic models such as CORSIM[3] from "cradle to grave."

Now the tide has shifted to supporting the development of behavioral algorithms for models, but leaving it to the private sector organizations to incorporate the algorithms into their proprietary models as they see fit. The Next Generation SIMulation (NGSIM) program funded by the Federal Highway Administration is an example of this research management paradigm. NGSIM is a unique public–private partnership between FHWA and commercial micro-simulation software developers, the academic research community, and the traffic micro-simulation

[3] TSIS-CORSIM is a microscopic traffic simulation software package for signal systems, freeway systems, or combined signal and freeway systems. TSIS-CORSIM requires Microsoft Windows and Microsoft Internet Explorer. Not only did FHWA develop this software; for many years, it was solely responsible for maintaining and updating the package.

community. In undertaking this partnership, FHWA has acted as a market facilitator by sponsoring algorithm development. The objective of the NGSIM collaborative research program of FHWA is to develop a core of open behavioral algorithms in support of traffic simulation, with a primary focus on microscopic modeling, including supporting documentation and validation data sets that describe the interactions of multimodal travelers, vehicles, and highway systems—interactions presented to them from traffic-control devices, delineation, congestion, and other features of the environment. These products will be openly distributed and made freely available to the broad transportation community. Determining the usefulness of the algorithms is left to private entrepreneurs.

CONCLUSION

Today, the American equivalent of the European Research Area is structured around the role of various stakeholders such as the National Academies' Transportation Research Board, AASHTO, and others; and it functions within the frame of the authorization or reauthorization acts. Such acts are SAFETEA-LU, the energy or commerce acts, or the Washington State Ferries acts that are impacting surface transportation research.

Comparisons of Current Trends in Surface Transportation–Related Research in the European Union and the United States

This chapter provides a comparative analysis between the United States and the European Union on transportation research and discusses the trends and status of current transportation research in the two regions. Table 3 summarizes the major findings. This chapter also examines priorities on both sides and identifies gaps that are not given much attention in transportation research.

Transportation is an intermediary good that concerns all activities. Transportation research is also a heterogeneous field of research activities ranging from problems of how to build the optimal road, develop low-emission engines, or optimize supply chains. It includes topics of ensuring mobility and accessibility or the interrelation of land use and transportation. The annual TRB conference, for instance, reflects this broad range of interests. This diversity renders more difficult the development of a coherent transportation-sector policy and the consensus building around it by stakeholders. Transportation policy is, all in one, infrastructure policy, economic policy, environmental policy, urban policy, and even social policy.

Although there have been repeated demands for a better integration of research areas into a coherent whole, covering in a homogeneous way all major areas and aspects of the transportation field and serving strategic transportation policy objectives, the current status of transportation research on both sides of the Atlantic is still a very fragmented one. In addition, the areas and topics of transportation research have been continuously extended to include, as models become more complex, traditional domains of research such as land use topics, or to include new topics such as the relationship between transportation and telecommunications, as new technologies are mainstreamed into the economy. This broadening of the transportation research scope also hampers integration.

Research trends in the last ten years are increasingly driven by the confluence of technological, economic, and social factors. Environmental and congestion concerns (mainly carbon dioxide emissions from automobile transportation), transportation infrastructure, and service financing increasingly influence the policy debate. An increasingly prominent issue in the future will be how to address user behavior in transportation research. On both sides of the Atlantic, there is a perception that a new transportation paradigm is in the making, and that the corresponding transportation policy choices will have deep socioeconomic implications. This places transportation research in a spotlight to provide the analytical platform that will inform and stimulate the policy-making debates.

SIMILARITIES AND DIFFERENCES BETWEEN SURFACE TRANSPORTATION RESEARCH IN THE UNITED STATES AND EUROPE

The United States is a single country with the natural economy of scale of a system organized within one national entity, while Europe establishes integrating mechanisms that facilitate cross-country collaboration, with the substantial complexity of varying state–society relationships, and different cultures and languages. Accordingly, the driving forces for public research programming and funding and for technology deployment in transportation are quite different in the United States and the European Union. Basically, in the United States, initiatives for transportation research programming and funding are organized in a bottom-up approach, while in Europe they respond to more top-down procedures.

In the United States, the organizing principle is the responsiveness to the requests and needs of transportation stakeholders, with a focus on subjects of interest to state DOTs and on addressing problems of immediate national or state concern that can be solved through applied research in a relatively short time frame. In this context, agencies and universities are encouraged to initiate research proposals for funding at local, state, and federal levels. Public research proposals compete for funding while local and business groups seek to influence decisions for content and earmarked funds according to their vast array of competing and diverging interests. Nonmarket-based coordination is relatively lacking, with no centralized process by which a research agenda is defined.

In the European Union, by contrast, public research programming and funding for transportation are defined by reference to the Lisbon Agenda and the Barcelona Agendas, which set a long-term vision for a "Knowledge Europe" and established the principles of coordination and harmonization. The triangle of research, education, and innovation is the organizing principle of that vision. EU strategic plans and priorities—agendas, platforms, or research areas—are defined in that long-term perspective to serve as a framework for research institutions' work-program development. Public research proposals seek to respond competitively to the strategic priorities, with relevance, innovation, synergy, and significance. The emerging intermediate level of transnational networks of institutions opening cross-national funding options enhances the complexity of the system without changing its features. In fact, organizations such as ECTRI reinforce the top-down process by seeking to review the coherence of the strategic research agenda and initiatives and to fill the research gaps.

The differences between both systems are therefore considerable, and yet both present similar core features: they are highly complex, involve large numbers of stakeholders, and present a truly multilevel system of governance between the local, state, national, and federal levels. Both systems lack a proactive instrument to enhance effective synergy among research activities. Both systems may yield opportunities for incoherence among the various levels of research and development (R&D) agenda setting. Obviously, yet importantly, in today's real-time electronic knowledge sharing, the research communities of both the European Union and the United States are informed by the same global information system, have access to the same technical publications, and are motivated by similarly competing demands between local and regional technical transportation issues, as well as global integration, competitiveness, and sustainability challenges.

The contrast between the systems may be expected to yield different areas of strengths and weaknesses. The U.S. R&D system is likely to be stronger on resolving issues with visible impact in the short term, yet the EU system may better favor technical innovation and change. The EU top-down system may ensure greater attention to societal needs, yet the U.S. market response may be more focused on technological issues. The U.S. system may be more favorable to ensure traction between R&D and state and local decision making and change, yet the European Union may have an advantage by setting community goals and aligning sector activities to that development or societal agenda. This difference may be particularly visible for matters related to global issues and the linkage between the transportation sector and environmental sustainability.

Interestingly, both systems display forces that tend to reduce their differences over time:

- In the European Union, the top-down approach is counter-balanced by a keen and growing competition between member states, regions, and local governments to attract competitiveness clusters and R&D activities, while a broad range of stakeholders seek to position their interests in the Commission. Transportation research is also, as a whole, more funded at the "state" level (i.e., national government level) rather than at the EU level; and
- In the United States, transportation research is also, overall, more funded at the federal level through funds dedicated for research: the market response is effectively complemented by transportation pooled fund programs that effectively allow synergy and leveraging, while FHWA gradually develops more strategic approaches to planning technologies for joint uses by federal and state decision makers, program planners, and researchers.

Table 3 summarizes the similarities and differences.

TABLE 3 Characteristic Similarities and Differences in EU and U.S. Transportation Research: Organization and Execution

Similarities	Major features of the contemporary framework for transportation research management were set during the 1960s with the creation of 1. The European Conference of Ministers of Transport (1964), now the International Transport Forum (ITF), the transport research program of OECD Experimental Safety vehicle program of NATO in Europe (1967); and 2. The FHWA, Bureau of Motor Carrier Safety and National Highway Safety Bureau in the United States (1967).
	The overall system of transportation research is complex, involves large numbers of stakeholders, and presents a multilevel system of governance between the local, state, national, and federal levels.
	Transportation research is fragmented, despite repeated efforts to focus and organize by themes. It lacks a proactive instrument to enhance effective synergy between research activities and yields opportunities for incoherence among the various levels of R&D agenda setting. There are as many separate markets for transportation research and technology as there are countries in the European Union and states in the United States.
	Research is increasingly more driven by the confluence of technological, economic, and social factors: environmental and congestion concerns, transportation financing, and user behavior. A most notable example is the way both sides consider climate change as a big challenge and priority.

(continued on next page)

TABLE 3 *(continued)* **Characteristic Similarities and Differences in EU and U.S. Transportation Research: Organization and Execution**

	Competition for access to transportation research funding is strong: - In the European Union an array of coordinating promotional and funding mechanisms for stakeholders collaboration—platforms, networks, clusters, initiatives—provides choices for competing research outfits. - In the United States strong private sector and public university research communities aggressively seek R&D funding from a large number of state and federal programs and contract from research programs and institutes.	
	The need for fundamental research is recognized: the U.S. Transportation Act of 2005 (SAFETEA-LU) seeks to complement "applied research with fundamental research," while in the European Union attention is given to complement short-term "focused" research with "frontier" research built on the reinforcing triangle of research innovation and education activities.	
	There is a perception that a new transportation paradigm is in the making, and that the corresponding transportation policy choices will have deep socioeconomic implications. This places transportation research in a spotlight.	
	There is universal access to technologies that facilitate collaboration between geographically remote facilities.	
	There is universal recognition that the complexities of transportation research require global collaboration.	
	The research governance and management styles and mechanisms are converging. Common characteristics include the following: - Emphasis on overall program management; - Performance of programs through calls for proposals (with few exceptions) for dedicated projects; - Existence of several common themes (i.e., similar research topics) including: technological issues, congestion-related issues, human factors, and safety–security (exception is the institutional and organizational issues, which are not as evident in the U.S. themes); - Emphasis on researcher mobility; and - Emphasis on preparation, education, and training of a new generation of transportation scientists.	
	European Union	*United States*
Differences	The European Union establishes mechanisms to facilitate cross-country collaboration, stimulate research funding, and promote excellence among national entities with different state–society contracts, cultures, and languages.	The U.S. constitutionally defined federal structure facilitates horizontal and vertical R&D coordination across political jurisdictions.
	The European Union is subsidiary to the states and, in theory though not in practice, complements state transportation research initiatives and programs.	Power sharing between the federal government and states as well as among the three branches of government (executive, legislative, and judiciary) applies to transportation research.
	The European Union's multiyear Framework Program of Research (FPI) sets the research effort. Started in 1982, it includes transportation as a self-standing sector since 1985.	The U.S. 5-year Transportation Act, currently SAFETEA-LU (2005), spells out the commitment of the nation with respect to transportation research.

(continued on next page)

TABLE 3 *(continued)* **Characteristic Similarities and Differences in EU and U.S. Transportation Research: Organization and Execution**

	European Union	*United States*
	Transportation research is structured top down through the European Framework program (now EFP7) on the basis of the 2000 Lisbon Agenda and 2003 Barcelona agenda, which set a mission for research, education, and innovation.	Transportation research is organized from the bottom up, with state research programs receiving strong incentives to work in pooled fund programs. Many programs, some financed by states and managed by AASHTO, are accessed by stakeholders on a competitive basis.
	The Barcelona Agenda provides the long-term perspective of a "Knowledge Europe" based on the triangle of research, education, and innovation, within which research programs are defined. The European Research Area 2020 Vision will be sent for approval at the end of 2008.	The organizing principle is the responsiveness to the requests and needs of transportation stakeholders, with a focus on subjects of interests to state DOTs and on addressing problems of immediate national or state concern that can be solved through applied research in a relatively short time frame.
	Technology platforms, research associations such as ECTRI, and the consultation process favor large organized-sector stakeholders and technology-based industry interests in promoting a research agenda in front of EU decision makers.	Strong reliance on quasi-private entities such as the National Academies' Transportation Research Board provides an open platform for multi-sector stakeholders to promote research agendas and priorities to federal decision makers.
	Strengthening competitiveness is a core priority, yet the system is substantially supply driven.	Innovative technology is a recurrent concept, yet most programs focus on applied research, with little funding opportunities for fundamental research.
	Transportation research is structured substantially from a supply side with scientific clusters and focused or frontier research, and efforts are made to strengthen the supply.	Transportation research is strongly motivated from a demand side, yet the vibrant bottom-up initiatives also reflect supply and research outfit preferences.
Strengths	May better favor technical innovation and change. May ensure greater attention to societal needs. May have an advantage by setting community goals and aligning sector activities to set a social agenda.	Likely to be stronger on resolving issues with visible impact in the short term. May be more focused on technological issues. May be more favorable to ensure traction between R&D and state or local decision making and change.
Challenges	While societal needs are articulated in the overall vision and are present in all research programs and specific calls, funding continues to be largely dominated by technological issues that have restricted the societal focus of mobility to a specialized item of technology-oriented research, instead of organizing its core focus. Urban transportation topics offer opportunities to mainstream in research the less technological dimension of transportation.	There is a need to better recognize, fund, and mainstream highway research on an intermodal basis or on the development of new technologies to reduce congestion, enhance mobility, protect the environment, and increase safety. Developing the mechanisms to fund the development of new technologies and innovation at sustainable levels is a major challenge. Translating consensus-based research commitments into practice is critical.

MOVING TOWARD COLLABORATION

Very few research programs are currently open to both sides of the Atlantic, even on a reciprocal basis (i.e., each side can participate in the other side's calls but has to pay its own funding). To arrange the details of all this, there is a trend to have more scientific and technical agreements between the two sides (i.e., the EU and European governments and the U.S. federal government and its individual states). There is a need to

- Find the proper funding vehicles to implement collaboration; and
- Deepen the thematic cooperation on modal and co-modal transportation research issues, as well as for energy and environmental issues.

The reciprocal opening of research tasks in the various calls for proposals or projects should be used and nurtured as a step toward joint programming and full collaboration.

On the preparation, education, and training of the next generation of scientists, there is also a need to deepen understanding and collaboration between the European and American sides. The focus should be on the educational systems, especially the PhD research aims and format, and to promote the development and collaboration between "soft" research infrastructures (basically access to scientific information or databases, the rules and working environment for data exchanges, library exchanges, etc.).

Furthermore there appears to be a need to

- Benchmark the research governance evolution on both sides of the Atlantic. This, by itself, would allow for greater possibilities of collaboration;
- Introduce and apply ex post facto project and program evaluation with regard to their impact and effectiveness; this is a basic task of any managerial control and should be adopted also for research projects and programs; there is clearly also room for practical cooperation in developing evaluation practices and tools;
- Comply with intellectual property rights that are important on both sides but not necessarily manageable in the same way nor following the same type of laws; and
- Address the accessibility issues of the "soft" research infrastructures and data.

Transportation Innovation and the Role of Markets

An Assessment of U.S. and European Systems of Innovation

This chapter examines the relationship between transportation research and innovation and the function of the transportation markets.

DEFINING THE MARKETPLACE FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT AND INNOVATION

For the purposes of this report, markets are defined as social structures developed to facilitate the exchange of rights, services, or products, including innovations and technologies. Markets enable peoples' services, firms, and products to be evaluated and priced. There are two roles in markets, buyers and sellers. A market allows buyers and sellers to discover information and carry out a voluntary exchange of goods or services. This is commonly done through trade. These trades may be handled a variety of ways, but in small market environments, buyers and sellers typically deal in currency, and goods. In this chapter, government is viewed as the buyer of scientific and technological goods and services (through the use of tax dollars or Euros) from a variety of organizations and institutions. Government, especially in the case of surface transit, takes these scientific and technological products and integrates them through various means into the transportation system.

On one side of the continuum, complex economic systems in which goods and services are generally exchanged through markets by larger groups of people, organizations, and businesses are called market economies. At the other extreme, government mandates determine investments and prices and are called planned economies or command economies. The attempt to combine socialist ideals with the incentive system of a market is known as market socialism. In practice, very few countries can be properly located at either extreme of this continuum.

Underlying the discussion of transportation innovation and the role of markets is the primary assumption that knowledge is the most important resource in modern economies and, furthermore, the purchase, production, accumulation, and sharing of knowledge is critical to the development and operation of safer and more efficient surface transit systems. New technologies and innovations are simply forms of applied knowledge as well as market products. All are part of what is known in the common parlance of globalism as "knowledge economies." Yet, the critical question remains whether markets and market signals—even in knowledge economies—will stimulate highway innovation at the level necessary to achieve international mobility objectives.

Research and technological development (RTD) is present in multiple marketplaces. The first marketplace exists for the RTD itself, in the sense that there are those who demand RTD services and those who supply them. In transportation, the demand for RTD comes from the public sector at U.S. federal and EU levels, or from EU member states and U.S. states, or even at supra-state levels. In the supply side of RTD services we find the various research organizations, universities, etc. The RTD market follows any other division or segmentation of the traditional markets and can be segmented in as many ways.

Within the transportation sector, we can identify multiple other market segments, namely (using the transportation system components) infrastructure, operations, and equipment. The first one is hosted mostly by the public sector, whereas the other two—operations and equipment market—increasingly fall to the mandate of the private sector and private companies. There is also the supply of RTD, which comprises those businesses' own internal RTD efforts (Table 4).

In the following, the RTD market is treated as a large single entity, which is not the reality but is accepted for pragmatic reasons. The adopted view is simply a panorama snapshot on the mobility market as a whole.

There is a considerable difference between the U.S. and EU approaches when it comes to the RTD market segments, even if there are obvious similarities, especially regarding the infrastructure-related RTD.

TABLE 4 Current RTD Demand and Supply in Major Transportation System Segments

Segment of Transportation System	RTD Demand	RTD Supply	Main Focus for Demand–Supply
Infrastructure	Infrastructure managers and operators (e.g., road authorities, agencies, ministries, states, cities, construction contractors, and maintenance contractors)	Research institutes, academia, consultancies, infrastructure operators' and contractors' internal RTD, and national–federal research organizations	Mixed demand: both public and private Supply: public with some investments by entrepreneurs interested in the privatization of highways
Operations	Regulators, infrastructure managers, transportation operators, cities, towns, regional authorities, states	Research institutes, academia, consultancies, and transportation operators' internal RTD, private entrepreneurs	Mixed Demand: both public and private Supply: mixed; both public and private
Transportation equipment	Transportation operators, equipment manufacturers, and infrastructure managers and operators (e.g., road authorities, state and federal agencies, ministries, cities, construction contractors, and maintenance contractors)	Equipment manufacturers' and transportation operators' internal RTD, research institutes, academia, and consultancies	Demand: private Supply: private

THE MECHANISMS, PROCESSES, AND MARKETPLACE RELATIONSHIPS OF U.S. RESEARCH AND INNOVATION

Introduction

No matter where one lives, there is a commonality of interest for safer roads that reduce injuries and fatalities, new and reconstructed highways that can expedite commerce while protecting communities and the natural environment, and the deployment of technologies and innovations that will reduce the endemic congestion associated with traffic. Clearly, the pursuit of enhanced mobility is the phrase that characterizes common transit pursuits around the globe in the 21st century.

Despite a commonality of concern, global highway technology development and innovation have often not kept pace with the growth in traffic and its attendant challenges. Any city—whether it be Paris, London, New York, Moscow, Bangkok, Athens, or Beijing—experiences (on a daily basis) the psychologically frustrating, physiologically threatening, and economically costly impacts of congestion. Moreover, with certain notable exceptions roads and highways are not as safe or as environmentally benign as might be expected given the remarkable scientific and technological advances of the 20th and 21st centuries. The relationship between government and markets in promoting or impeding the identification and diffusion of solutions to these problems remains a conundrum with many conflicting answers.

If we use history (but characteristically even current events) as our guide, the answer is that markets will require assistance. Indeed, the record is clear. Every modern economy—whether in the northern or southern hemispheres, socialist or capitalist, developed or developing—has relied, at least in part, on government to support and to stimulate highway innovation. The root cause for government intervention in the highway sector is that highway research and technological development and highway transportation in general are what economists call collective goods.

The Collective Goods Issues

Collective goods often fall prey to free riders (i.e., entities that receive the benefits of an investment without incurring any of the costs or risks). The special nature of collective goods requires government interventions, which can vary depending on whether the nation is characterized as a market economy or whether it leans in the direction of democratic socialism. When it comes to highways and other forms of surface transportation, the differences in the nature of governmental intervention that can be attributed to the overall structure of the government in place are not as significant as one might assume.

This chapter explores how markets in association with government involvement have contributed to the betterment of highway transportation by producing innovations ranging from automated signals to composite materials. The investigation begins with a picture of how highway research and technology markets operate in the United States and concludes with a discussion of the extent to which market successes and failures have been mirrored in other countries. The goal is to encourage collaboration by illustrating a commonality of experience and needs-accelerated levels of global highway RTD. This chapter is organized into the following major sections:

- Innovation as a public good, market failure, and the role of government;
- Characteristics of the U.S highway RTD markets;
- Introduction of a typology for characterizing government–market relationships;
- Characterization of the U.S. innovation system using a typology for defining national innovation systems; and
- Comparisons between U.S. and European national innovation systems using the typology.

U. S. Highway Innovation as a Public Good and the Consequence of Market Failure

Clearly, the solution to many of our most significant surface transportation problems will depend on the accelerated development and deployment of innovations and technologies on a global scale. One hope will be a fully functioning marketplace in which innovations result from evolving needs. Unfortunately, transportation markets and their ability to identify and produce innovations suffer from that persistent, intractable problem facing all markets when they are expected to create critically needed public goods such as highways, national defense, and so forth.

These are products and services that all citizens and consumers benefit from in one way or another. It is typically impossible to exclude anyone from using a public good, thereby creating a consequent lack of incentives necessary for the private sector to support broad deployment and commercialization. Indeed, a product that can be bought and sold without excluding nonpayers is typically a product that does not exist.

In market-based economies, a public good is a good that is non-excludable. This means that consumption of the good by one individual does not reduce the amount of the good available for consumption by others; and no one can be effectively excluded from using that good. Thus it is impossible to limit the benefit of the good to those who are willing to pay for the good (innovation). For instance, it is difficult to limit access to highways that are built solely with public tax dollars. Every citizen has an equal right to access that highway and the innovations incorporated in its construction and operation—even if they did not pay taxes or tolls to drive on it. Sometimes economists refer to those who receive a benefit without paying for it as free riders. If the free-rider problem is too massive, privately financed innovation will be curtailed. Hence, the justification (or even necessity) for government investment in RTD and infrastructure.
In contrast to public goods, private goods are those products where a firm can produce a particular technology, innovation, or service and charge a particular price for it. Access is limited to those who are willing and able to pay the price charged. Non-excludable goods are considered public goods and excludable goods are considered private goods. While in the real world there may be no such thing as an absolutely non-excludable good, most traditional economists think that some goods in the real world approximate closely enough these concepts to be meaningful in explaining why markets produce certain types of solutions and not others.

Even when goods are excludable, markets (left to their own devices) sometimes fail to respond to a particular need. The size of the potential customer base may be simply too small for an entrepreneur to take the financial risk to bring to market a particular safety device, a new algorithm, or a new long-lasting pavement material. When the costs of development are added to those associated with obtaining regulatory approval, the costs of the innovation may simply outweigh the potential financial benefits that the entrepreneur could receive by investing intellect, time, and money in an alternative technological endeavor with a significantly higher rate of return.

The Role for Government

When the free-rider problem is too great, government and the private sector must form partnerships that allow financial benefits resulting from a technological breakthrough or innovation to reach the inventor, while at the same time enabling the innovation to be widely distributed across the public domain; this rule applies whether the innovation is bridges that require less maintenance, highway signs and pavement markings with enhanced retroreflectivity, or new algorithms that better predict traveler behavior.

One role of government is to reduce the risks associated with research and technology development by providing direct or indirect financial incentives. A direct incentive would be the government financing contractors to conduct work to produce a technological breakthrough. An indirect incentive would be the removal of a particular regulatory barrier that adds tangible costs to product development or the provision of tax incentives for engaging in basic or advanced research activities.

When government mitigates the risk of a particular research activity, it may seek to secure a return on the investment of public tax dollars through royalties that are associated with licensing a particular technology. These dollars flow back to the treasury, to individual researchers, or to laboratory directors to purchase the latest research equipment. Even when government assists in reducing the risks associated with private research markets, the private sector still plays powerful roles in the development and deployment of innovations.

The U.S. Highway Innovation System and Its Relation to the Market

In systems engineering, signal-to-noise ratio is a term for the ratio between a signal (meaningful information) and the background noise. Similarly, markets operate more effectively if market signals are relatively strong relative to the noise produced by competing producers and consumers of goods and services.

Strong and clear market signals must be present if government entities are to develop priority technologies and innovations in a timely and effective manner. Unfortunately, the complexity of the marketplace—where literally there are thousands of engineering firms, contractors, and equipment manufacturers—complicates the process of focusing on the greatest needs at any particular point in time. Under these conditions, market signals are obscured by the sheer number of stakeholders and divergent needs. With so many agencies and companies involved, the pace of innovation development and deployment is slowed. And the concern that is backed by the loudest and most persistent interest may cause research agendas to be skewed in a manner that is inconsistent with the most significant need. Hence, the effective management of the highway RTD marketplace requires the use of tools that can efficiently mobilize a representative number of stakeholders to reach a consensus on where and at what level finite public resources should be invested.

Over the last several years, FHWA has put in place a number of planning tools that are able to overcome the "noise" associated with highway market demands. One of these tools is the development of stakeholder-based roadmaps. Through an iterative process that involves the federal government and a broad group of stakeholders, consensus is reached on what should be the scope and timing of research activities. Recently, FHWA engaged concrete-pavement stakeholders in a road mapping process that led to the successful identification of research priorities for concrete research.

Commitment to Predicting System and Component Performance

Difficulties in characterizing the complex interactions among the fundamental properties of many highway-system components hinders the development and implementation of new technologies and innovations. Under conditions of uncertainty, the U.S. highway marketplace is highly reticent to approve the application of new innovations in construction projects without extensive field testing and validation.

Lack of Support for Innovation in Highway Construction Projects

Highway construction projects are organized and managed in a manner that does not always promote innovation. Several factors associated with the way highway construction and maintenance activities are organized and undertaken constrain innovation. Highways and bridges, for example, are usually built by a temporary alliance of contractors and subcontractors under a system of contracts and subcontracts. Although contractors many contemplate new ways to accomplish specific tasks, their central goal is task completion and profit maximization. Procurement in the public sector is driven largely by a low-bid process based on detailed specifications and procedures established to satisfy the need for open competition; accountability; and the safety, health, and well-being of the population. Such a process often can discourage contractors who have developed new products or methods, because existing specifications determine how facilities must be built. Reforms and innovative practices are gradually making their way into the highway marketplace but it is a slow process.

Market Risk Aversion

Innovation involves higher levels of risk and uncertainty. Many public facilities are large, with high fixed costs and long performance lives. As a consequence, construction innovation must be assessed not only within the context of the original installation but also over a very long time period. Public officials are often deterred from innovation by the risks associated with unintended and unexpected performance consequences that may happen long after the facility is constructed.

Conservative Attitudes Toward Innovation and Deployment

Long-standing engineering practices and training have created a workforce that is reluctant to deploy and use modern traffic models and simulation tools. While this barrier is slowly eroding as new generations of engineers and scientists enter the work force, proven engineering practices have sustained a level of professional conservatism that continues to slow the development and deployment of some innovations (Halkias and Munro, 2002).

In addition, many state transportation officials have approached technology deployment in a conservative fashion as evidenced by their lack of awareness of the importance of marketing technologies to various groups of potential users. Only recently has the importance of technology marketing grown in visibility and importance. For instance, states like California have taken a leadership role by integrating marketing into the roles of highway technology development managers.

Redistribution of Decision-Making Authority

While historically FHWA has played a key role in highway research, several factors, "including greater congressional designation of research projects and research performers and increased state R&T activity in response to growth in SP&R funding have reduced this role." Nevertheless, FHWA continues to be responsible for addressing highway issues of national interest and managing the nation's largest single RTD program (TRB *Special Report 261: The Federal Role in Highway Research and Technology*, p. 71).

Lack of Comprehensive Approach to Evaluation

Despite multiple sources of funding for research and technology development, the ability to estimate the relative benefits of various investments in highway research and technology development is often lacking. In addition, there are very few systems that would allow assessments of market penetration by particular highway technologies. Hence, the outcomes of research and technology development often are not used to determine future investment priorities.

Market Events and Their Unpredictable Effect on Collaborative Research

The U.S. highway transportation innovation system is always susceptible to external events such as a turn down in the economy or an escalation in energy prices. When both interact synergistically, they can seriously affect revenues received through the highway trust fund passed on to the states. High energy prices can depress revenues, as do stagnant economic conditions. However, when both occur in close proximity, they may coconspire to depress the amount of funding available for research, especially research that involves collaboration with international research constituencies. International constituencies do not typically vote in U.S. elections; thus funding for international research may be one of the first items to be cut.

In addition, in the United States, the apparent working hypothesis on stimulus packages is that the money must enter the economy quickly to produce lots of jobs and concomitant spending increases. Unfortunately, funds allocated to research may be seen as not necessarily having the same rapid impact as money invested in fixing pot holes or repairing bridges. Moreover, many times stimulus funding is used to make up for cuts at the state level; and that often does not increase a transportation budget. At best, it is funding that reduces the impact of funding cuts already planned.

In the short run, economic slowdowns and escalating energy prices can work together to sidetrack research and even deepen a recession or depression. Nevertheless, over the long run, and with sufficient creative thinking on the part of scientists and policy makers, investment in green transportation technologies (on a collaborative basis) could be viewed as a primary strategy for revolutionizing the economy. Under this paradigm, high energy prices and economic recession or depression may trigger major investments in technologies that support greater efficiency and export sales.

Government–Market Interrelationships and Contrasting National Innovation Systems

The key components of national highway innovation systems can be characterized by the types of private companies that are involved, the distribution of public and private research organizations, education and training support systems, providers of capital for research such as venture capitalists, state governments, and federal agencies, as well as the various formal and informal rules governing interactions. Variations in central characteristics, such as governance structures and organizational capabilities, and in how their activities are coordinated, produce the following three distinctive systems of innovation that exist in parallel and are evolutionary in nature.

State-Led Innovation

In state-led systems of innovation, authority sharing within and between organizations tends to be limited by the high level of dependence of many firms on government agencies, but central coordination encourages considerable integration of projects in the public research system with private sector innovation development. The risks involved in developing major system technological change are shared between government and private companies.

Market-Based Innovation

In market-based innovation systems, there are relatively stable networks of commitments and collaborations. Technology–capital exchanges within and across sectoral boundaries contribute to shared knowledge and opportunities within distinct groups of public, private, and quasi-public transportation organizations. Innovations build on continuous group learning in and between group members, and tend to follow particular technological trajectories that reinforce current organizational capabilities. In this respect, immediate usefulness always trumps the promise and uncertainty of long-term payoffs that could result from basic or advanced research.

Mixed or Hybrid Systems

As both U.S. and European transportation research institutions mature, it is increasingly difficult to classify research as purely state- or market-directed. These highly collaborative innovation systems combine considerable authority sharing with and between organizations, with active involvement from the public and private sectors, especially those segments focused on the development of specific technologies. Innovations are based on learning within the organization, between industry and trade associations, and within research associations and similar public–private collaborative institutions, connecting formal knowledge production with technical development. National, state, and local bodies are often directly involved in encouraging these linkages through the joint funding of projects and the establishment of government research programs dedicated to technological innovation (Table 5).

U. S. System of Highway Innovation and Corresponding EU Characteristics

Assessing the U. S. national system of highways reveals qualities that illustrate the hybrid nature of U.S. research (see Table 2). Given the pluralistic nature and multi-level nature of the U.S. system of governance—with significant numbers of groups and organizations competing for research and technology development resources at the federal, state, and local levels of government—the U.S. innovation system is best viewed as the shared offspring of government

TABLE 5 Characteristics of Three Ideal Types of Innovation Systems

Characteristic	Government-Led	Market-Based	Government–Market Collaboration
Authority sharing	limited	considerable	considerable
Involvement with public science systems	high by definition	passive	active
Market coordination	considerable	considerable	considerable
Discontinuity of innovations	high	limited	limited
Systematic nature of innovations	considerable	considerable	considerable

Adapted from Richard Whitley's "Characteristics of six ideal types of innovation systems," page 350, in *How Europe's Economies Learn* (2006).

direction and market demand, which in turn is influenced by the availability of public and private resources and the nuances of geography. The U.S. highway innovation system has been and continues to be a leader in the development of innovations in highway infrastructure, traffic operations, and safety.

Nevertheless, the United States suffers the discontinuity of innovations characteristic of all pluralistic research regimes where it is difficult to take an integrated systems approach. Economies of scale resulting from collaboration are often sacrificed in favor of organizational and individualistic competition. Despite these hurdles, one can also argue that the U.S. system of innovation has some of the features of a systematic approach, as reflected in its Pooled Fund Program and NCHRP projects. Private, nonprofit institutions such as the National Academies' Transportation Research Board are examples of efforts to bring about a more integrated approach to transportation research.

Not surprisingly, non-market-based coordination mechanisms are relatively lacking in the U.S. innovation system. However, as Table 6 illustrates, the U.S. innovation system reflects significant authority sharing between the different levels of government, while the EU system shows a more independent structure.

The U.S. highway innovation system is accurately viewed as a system in transition. While the U.S. will probably remain relatively hands off (laissez-faire) in comparison to some European countries, especially when it comes to using nonmarket methods of coordination, it appears to be evolving incrementally toward a system that supports a more strategic approach as new planning technologies such as roadmaps are jointly used by senior federal and state decision makers, program planners, researchers, and technologists. The ultimate result could be a national RTD system that is more systematic and collaborative in nature.

EUROPEAN SYSTEM OF TRANSPORTATION RESEARCH AND INNOVATION: MECHANISMS, PROCESSES, AND RELATIONSHIP TO THE MARKET

Transportation research in Europe is driven by broad EU-based policies that cut across national borders and, at the same time, at the national level—by national governments or authorized organizations—where research agendas are generally established to reflect national priorities.

TABLE 6 The U.S. National System of Highway Innovation and Corresponding Characteristics of EU System

Characteristic	The U.S. Surface Transportation Innovation System	Notes (on United States)	The EU Transportation Innovation System	Notes (on European Union)
Authority sharing between federal and state governments	Considerable and increasing	FHWA shares authority with 50 states and Congress.	Independence between the Commission and member states	National priorities are independent or projected via political process (e.g., within European Parliament).
Involvement with public sector	High	Federal system of innovation interacts with other subnational public research programs through initiatives such as the Pooled Fund Research Program.	High	EU research is financed through budgets ultimately received from national governments.
Nonmarket coordination	Limited to absent	Government is relatively passive and disjointed.	Mixed	The Commission is active in facilitation and coordination, but also in involving industry through the technological platforms.
Specificity of innovations	Considerable	Federal government has particular emphasis on applied technology.	Limited, usually a holistic approach	EU research programs and projects are mostly policy driven.
Discontinuity of innovations	Varies, but typically is significant.	Some innovation streams are integrated; others are not. Use of roadmaps is intended to increase continuity of research.	Varies, but the proceeding towards practical applications has been limited.	Because of top-down nature, the applications are usually done by industry–companies using the project results.
Systemic nature of innovations	Very often quasi-public institutions such as TRB stimulate integrated research.	Historically the nature of innovation development was reductionist—roadmaps and strategic planning leading to more systemic view of innovations.	High, because of the involvement of many stakeholders	Top-down emphasis in program design and project selection
Extent of intermodal research	Varies, but has been historically low.	Recent efforts have been made at the highest levels of the Department of Transportation to promote inter-model research.	High	Intermodal aspects are visibly present in both passenger and freight transportation RTD.

Research agendas often flow from the top down, through a strategic process that is closely tied to national policy goals and objectives. There is significant integration between the strategic research agendas developed at the EU level and the national transportation research agendas. "Extra-national" (i.e., EU-based) policy making has a steadily increasing influence on national transportation policy making in Europe.

European Transportation Research: The Diffusion of Centrally Driven Policy

The European Commission, mandated by the European Parliament, issues its political visions and objectives in so-called white papers, the latest for transportation being the white paper of 2001 (COM2001 370 Final, Brussels 12.9.2001), "European Transport Policy for 2010: Time to Decide." The white papers are supplemented by a number of strategies and key documents (e.g., on alternative fuels, infrastructure pricing, investment finance, seamless cross-border transportation, etc.). In the midterm review report (COM2006 314 Final, Brussels 22.06.2006) of the 2001 transportation white paper entitled "Keep Europe moving: Sustainable Mobility for our Continent," some of the earlier stated policy objectives have been maintained (and are further divided into more specific targets):

- Mobility of people and businesses;
- Protection of the environment and sustainable energy consumption; and
- Innovation to support mobility and sustainable development.

Creation of the European Research Area (ERA), which supports uniform and coordinated European research in all areas, is another goal pursued in order to create a research and innovation foundation that would be competitive and resourceful enough to produce results actually meeting the policy goals of the European Union. EU-funded research is pursued via the Framework Programmes (FP) for Research, which are the main financial and operational tools to facilitate and realize the goals of the ERA. Through the mechanisms of the FPs, the proposed research projects are ultimately selected and financed.

To involve European industry in the research and innovation process of the Union, a number of mechanisms exist besides the requirement of "industrial" participation in research consortia. The most prominent feature is the European Technology Platforms (ETP), which are bodies (committees) consisting of a large number of representatives from the industry, collective organizations or bodies, and academia in a specific scientific area or field. Platforms are created in order to focus and identify the strategic issues that call for future research and innovation in this field, to assess the current status of research work, and so on. Through a dialogue with the ETPs, the Commission manages FPs so that they answer the needs of both European citizens and industry.

In the field of transportation, the ETPs that have been created so far are

- **ACARE**, the *Advisory Council for Aeronautics Research in Europe*, which includes 39 members from the aeronautics industry, air transportation operators, EU member states, EUROCONTROL, and the Commission (http://www.acare4europe.org);
- **ERRAC**, the *European Rail Research Advisory Council*, which comprises 45 representatives from each of the major European rail research stakeholders: manufacturers, operators,

infrastructure managers, the European Commission, EU member states, academics, and users' groups (www.errac.org);

- **ERTRAC**, the *European Road Transport Advisory Council*, which includes representatives of consumers, vehicle manufacturers, component suppliers, road infrastructure operators and developers, service providers, energy suppliers, research organizations, and cities and regions as well as public authorities at both European Union and national levels (www.ertrac.org); and
- **WATERBORNE**, the *Waterborne Research Advisory Council*, which brings together the maritime industry as represented by trade associations, the shipping industry, ports, the ship building industry, etc., and representatives of the EU member states along with a number of nonmembers, including Norway (http://www.waterborne-tp.org).

The ETPs (*European Technology Platforms*) are mainly responsible for generating mode-specific *Strategic Research Agendas* (SRAs), which are used as one key input to planning and carrying out the European Commission's FPs.

Hence the European approach tries to accomplish two, or perhaps even three, goals with one stroke:

1. It attempts to facilitate RTD that takes into account the needs of its transportation industry facing global competition, including the segments of transportation system actors in infrastructure, operations, and equipment manufacturing;
2. It seeks to answer the political goal-setting of the European Union and its member states in an effort to create a single market, sustainable transportation, safety, security, and employment; and
3. It fosters the European innovation architecture by trying to bring together the best forces in RTD over the member-state forces. In many ways, the European Union is clearly looking for a single market of RTD, too. ECTRI, the European Conference of Transport Research Institutes, is a clear manifestation of that effort.

European Transportation Research Systems: Emphasis on Partnerships and Joint Research Efforts[1]

European nations vary greatly in the amount of resources that can be allocated to transportation research. The general goal of creating a single research area for Europe (through the European Union) is a critical catalyst in fostering joint transportation research efforts and partnerships. Independent organizations representing transportation research interests in Europe such as ECTRI or the Forum of European National Highway Research Laboratories (FEHRL), etc., are actively promoting the attractiveness and effectiveness of leveraging research resources that cover all aspects of the research cycle—from agenda setting to implementation and deployment. The challenge to the European RTD and innovation system is not the lack of structures, but rather the efficient integration of the existing structures so that they meaningfully contribute to the most important research problems and to the needs of European industry and citizens. This will not only require skillful and efficient management and policy implementation, but RTD and

[1] The author of this section drew liberally from the International Technology Scanning Program Summary Report, authored by Barbara T. Harder for distribution to the U.S. Department of Transportation, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the National Cooperative Highway Research Program (June 9, 2008).

innovation management, and policy implementation—and innovation management is where the ultimate challenge lies.

The European RTD architecture has created a bundle of institutional actors in surface transportation whose members share common interests within the architecture. They are enumerated in the following list (see also the ECTRI website, www.ectri.org.):

ACEA	European Automobile Manufacturers' Association
CEDR	Conference of European Directors of Roads
CER	Community of European Railways
CLEPA	European Association of Automotive Suppliers
EARPA	European Automotive Research Partners' Association
ECTRI	European Conference of Transport Research Institutes
ELTIS	European Local Transport Information Service
EMTA	European Metropolitan Transport Authorities
ERF-IRF	European Union Road Federation–International Road Federation
ERSO	European Road Safety Observatory
ERTICO	Intelligent Transport Systems and Services – Europe
EUCAR	European Council for Automotive R&D
FEHRL	Forum of European Highways Research Laboratories
FERSI	Forum of European Road Safety Research Institutes
ITF	International Transport Forum
OECD	Organization of Economic Cooperation and Development
POLIS	European Cities and Regions Networking for Innovative Transport Solutions

Some of these organizations have explicitly emerged because of a new European context. For example, CER came out of the International Union of Railways (UIC) as soon as European railways foresaw that taking part in European activities—including RTD but also many other activities—and being a credible member of the "European club" would require institutional arrangements from their side.

The "National" Aspect of European Transportation Research

Despite the role of the European Union, about 80% of European research and innovation activities take place on a national basis, meaning that the national efforts are still the major source of innovation. Companies create jobs and generate national income, hence the national research and innovation activities are almost without an exception driven by the industry policy goals. Nations want to succeed, and in a global marketplace this is not possible without successful companies.

For example, in Finland the Funding Agency for Technology and Innovation (TEKES) explicitly states that the commercial sector must participate in any research and innovation project that TEKES will be funding. With this assured industrial base, the research and innovation will be more or less directed according to it. Finland may represent a somewhat extreme case, but there is little doubt that in other European countries the same drivers are present.

TEKES runs 20 national technology programs that involve about 2,000 companies and 500 research units, some of which may belong to one university (TEKES website, www.tekes.fi). Currently none of the TEKES programs is strictly transportation oriented. The Finnish transportation RTD is mainly resting on the shoulders of the Ministry of Transport and Communications, Road Administration, Rail Administration, Maritime Administration, and Civil Aviation Authority. From this group, the overwhelming majority of activities are initiated by the Ministry and Road Administration.

The Finnish innovation system is thus strongly industry-driven and even at the operational level the companies have a say in which projects are to be launched. The trend is, however, in the direction of program-level participation. With hundreds or thousands of projects, the innovation process is considered very hard to manage. In other words, the Finnish practice is changing to what we see in European research with the participation of technology platforms.
The universities of Finland have been changing from budget-economy entities to active prospectors of research and innovation projects, and they have been penetrating to TEKES-funded programs. To succeed, they have been compelled to build contacts with industry and change from academic free thinkers to "business consultants," and they have become more radical than what appears from the surface.

European ministries and subordinate research institutes are very important mechanisms of stimulating and directing transportation research partnerships and collaboration with the private sector and universities. An example is the French National Institute for Transport and Safety Research (INRETS), a French, state-owned institute under the authority for the Ministry for Ecology, Energy, Sustainable Development, and Spatial Planning and the Ministry for Research. INRETS facilitates partnerships with the French National Research Agency, universities, and industry for pre-competitive research for research calls by the EU Framework Program, with ECTRI, and other European technology platforms such as ERTRAC (International Technology Scanning Program, Summary Report, p.11).

In Germany, the responsible ministries for transportation research funding are the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Transport, Building and Housing (BMVBW), the Federal Ministry of Economics and Technology (BMWi), and the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU).
The German Academic Exchange Service (DAAD) is an organization jointly run by German universities and largely financed by the federal government. The role of the DAAD is to promote relations with higher education sites abroad, primarily by exchanging students and researchers. The German Federation of Industrial Cooperative Research Associations (AIF) coordinates cooperative industrial research that is financed from funds of the Federal Ministry of Economics and Technology (BMWi) and also supports the industry's own efforts in the field of research and technology development. For this reason, approximately 50,000 businesses—most of them small and medium-sized enterprises (SME)—have established a total of 104 industry- or technology-related research associations as well as the umbrella organization AIF.

Notably, in Germany private foundations complement public research funding. The Association for the Promotion of Science and the Humanities (Stifterverband für die Deutsche Wissenschaft) is an example of a concerted action of industry to promote German science and research.

At the end of 2002, the association administered a total of 347 private foundations and endowment funds under its umbrella, with total assets of 1.4 billion Euros. Other large German foundations—such as the Volkswagen Foundation, the Thyssen Foundation, the Robert Bosch Foundation, the German Foundation for the Environment, and the Bertelsmann Foundation—sponsor projects or organizations from a wide variety of different fields of research.[2]

Differences in Funding Levels for the European National Transportation Research Systems

Substantial differences can be found in the national transportation research programs. These programs are not on the same financial footing, just as many states in the United States vary widely in the amount of transportation research they can support. For example, Italian research occurs in a very fragmented environment in which several small excellence groups in specific technological domains of the transportation sector are not in a position to constitute a strong national system and often find it necessary to look directly for partnerships with peers outside Italian national boundaries.[3] An overall appraisal of the European system of surface transportation research and innovation is shown in Table 7.

TABLE 7 Characteristics of the European System of Surface Transportation Research and Innovation

Characteristic	The European Surface Transportation System	Notes
Authority sharing among levels of government	Considerable	Greater degree of centralized innovation management due to the preponderance of national research institutes
Involvement with public sector	High	Public sector is the driver of transportation research.
Nonmarket coordination	High	EU-level policy is centrally directed, but with industrial input.
Specificity of innovations	Low	Greater integration of innovations due to the extra-national role of the European Union and the growth of venues for cross-national collaboration
Discontinuity of innovations	Varies, but is declining	Declining, primarily through agreed-upon research platforms that cut across national boundaries
Systemic nature of innovations	High	Emphasis on strategic research agenda setting and highly effective communication of this agenda across Europe and within European nations
Extent of intermodal research	High	European countries tend to approach national transportation priorities in a manner that is inter-disciplinary and cross-ministerial.

[2] Information on Germany was obtained directly from ERTRAC's *Mapping of National Road Research Activities in Europe,* based on information supplied by ERA-NET Transport, EXTR@WEB and ERTRAC Members.

[3] Marco Diana and Cristina Pronello, Transport Research in Italy: Basic Statistical Data, Organizational and Financial Issues Related to Demand and Supply Sides of Research (ECTRI Benchmarking Report, April 2005), pg. 5.

The Role of Research Markets in Centrally Driven European System

Markets are prominent in the European research and innovation process. At the national level, the supply side of the markets is driving the innovation activities, even at project level. In the European context, the structures built to help the research supply market interact with the research and innovation process are rather extensive. There is a certain trend that the technology platforms become self-sufficient organizations with the wide participation they today include. On the other hand, the Finnish example shows that project-by-project management of the innovation process is extremely challenging.

From the demand side of the market, consumers or end-customers are rarely present in the research and innovation process. Their lack of presence is striking. Whether they have a role beyond consumers, customers, and voters is an interesting question; and the internal processes of the supply side of the market (i.e., the industrial relations and the workers' position) should not be forgotten.

The supply side of the market is well represented in the European research and innovation process, at both national and European levels. Nevertheless, the European process should perhaps be built to be more explicit, more informal, and yet transparent.

The government role is apparent in both sides of the market (demand–supply). It is the governments' role to protect the safety and well-being of its citizens, regardless of whether referring to nationalities or European citizens. Consumer rights have been addressed by the European legislation. The number of sectors and examples covered by these legislative actions is so vast that even a very superficial browsing of them is pointless. We can simply state that these matters are more or less taken care of. The closer to the supply-side entities (i.e., the companies we approach), the more meaning and impact this legislation has. Thus, it is also affecting the research and innovation process, perhaps not restricting it but rather setting certain boundaries.

One good, non-transportation example of this is gene technology where the human rights are in conflict with the technological possibilities and serious moral issues are raised—which do have a market impact and do affect research and innovation. In transportation, such examples can be found. Identification of persons and vehicles is one such issue. The market for the applications exists, there are business opportunities, and there are new technological possibilities, but moral and ethical issues have to be considered as well. In the end, some boundaries must be set, and this will have implications for research and innovation. The moral and ethical boundary-setting is a political process; thus, we have entered the policy level again, but this time from the demand side of the market!

From this discussion, we may clearly conclude that the market has a role, a very strong role, in the European research and innovation process. On one side, the industry policy and economic goals are driving transportation research and innovation in order to enhance employment and growth; industry participates in the research and innovation process through structured organizational mechanisms. On the other side, the demand side of the market, consumers, customers, and voters are mainly participating through political processes and certainly through some civil organizations, but formal participation is far weaker and seems to be weakening further. If this is a trend that is preferred to change, and this is a political choice, new mechanisms are probably needed. It would certainly require an institutional innovation of some sort.

The Case of Venture Capital

One of the key issues is whether an innovation has "cash potential." If it does, investors will be interested and innovators will have a chance to benefit financially. The role of the venture capitalist is therefore crucial. Larger companies have access to financial resources to finance the innovation process from idea to product, but medium and small companies may have a different situation, as may individual innovators.

The potential for financial rewards from an innovation is certainly a strong driver, and one could generalize that the larger the company, the stronger is the drive of financial reward because of the nature of the management of such companies. Even those innovations that have an environmental or social aspect are expected to give financial rewards because of the company's more competitive position in the market.

European capital funding is essentially done by traditional financing institutions. SMEs and entrepreneurs as well as spin-offs have to rely mainly upon on-the-spot market financiers. Some structural funds of the European Union can be used for spin-offs or by SMEs. These financing tools are available also on-the-spot through national bodies such as local and regional governments, ministries, and agencies.

A look at venture capital investments in Europe as a whole shows that during 2002 and 2003, less than 0.001% of the GDP was invested in spin-off or start-up companies (European Innovation Scoreboard 2004). And yet in EU27 about 2% of the GDP was invested in research and innovation (Eurostat). There is a huge gap between what is invested in the process and what is invested in actual realization of innovations or research results. Not all research is meant to lead into commercial or other applications, but it seems too large a difference and a poor utilization ratio where for every 2,000 € spent, 1 € is invested in a spin-off or start-up company. The most eager investors in early stage spin-offs and start-ups come from Sweden, the United States, Finland, and Denmark. The EU average is quite far behind these countries (European Innovation Scoreboard 2004). Not surprising, the same countries are also the most eager investors in the research and innovation process: Sweden, about 3.8% of GDP; Finland, 3.5%; Denmark and Germany, about 2.5% each in 2006 (Eurostat).

The most recent Innovation Survey (Eurostat) showed that more than 40% of EU27 firms are active in innovation, the highest ratios coming from Germany (65%), Austria (53%), Denmark, Ireland, and Luxembourg (52% each). Interestingly, whereas Germany, a highly industrialized society, is a self-evident case, some of the other countries (such as Ireland and Luxembourg) are surprises. Belgium and Sweden exceed the 50% threshold, but the new accession countries are clearly in the rear group. The definition of "innovation" in the survey was "a new or significantly improved product, service or process in producing them."

It seems that the institutional arrangements to facilitate the research and innovation process have also resulted in a good financing situation for the process. What is then the factual pay-back ratio is a more difficult question. At least the capital finance market seems to be selective in determining how much is viable for it to invest in from the outputs of the process.

The use of European research results is a question for future examination. Are there tools and measures in place that can pick the gold nuggets from the great bulk of research and innovation reports, deliverables, outputs, and results? One of the key motives for European research has been economic growth and competitiveness. This is difficult to achieve without the creation of new businesses and a restructuring of the old. Hence the post-RTD market should be considered as important as the pre-RTD market, remembering the old wisdom about dusty research reports on dusty bookshelves. The European RTD is, however, increasingly recognizing this by putting lots of effort in demonstration projects and activities, making RTD projects show tangible applications.

Where Does Innovation Ultimately Originate?

Can innovation be achieved or created through a deterministic process? When looking at the European research and innovation field, or even the U.S. transportation innovation system, with its mechanisms and organization, it seems evident that research and innovation policy makers believe it can.

Innovation requires risk-taking and entrepreneurship. The challenge of large-scale research programs is to maintain the entrepreneurial spirit and willingness to accept risk. This being the case, the RTD architectures should be designed so that these aspects of the innovation process are served also. This would probably mean accepting the "wild ideas" and very loose "management control" of the innovation process itself. Innovation is a delicate process, leading in the best case to new insights and business opportunities. Platforms, projects, programs and funds are simply facilitators for this process.

A climate of innovation may be achieved when the right kind of freedom is granted within RTD projects. It should also be recognized that the power of entrepreneur-like thinking will gain ground when the benefits of innovations can be, at least partially, shared by those making them. This calls for skillful innovation process management and transparent and motivating intellectual property management practices. Currently, intellectual property rights issues are required to be dealt with, as a rule, in all EU RTD projects. However, these are mostly handled on a project-by-project basis.

Given the nature of collective goods and the tendency for firms and even governments to be free riders, it is highly unlikely that the most creative invention will see widespread use unless there is an activist government or private-sector organization (national or trans-national) that is willing and able to push that transportation technology or innovation into the marketplace or, alternatively, ensure that the innovation is transformed into valuable intellectual property that can tap the powerful, ubiquitously motivating force of profit.

A NOTE ON INTELLECTUAL PROPERTY AND OPEN-SOURCE DEPLOYMENT STRATEGIES

Within the surface transportation community (in both Europe and the United States), there has been an underemphasis on the use of intellectual property (IP) and open-source methods to stimulate the deployment of highway innovations and technologies. In this regard, it is a relatively simple task to tally the numbers of patents and licenses generated by the transportation sector to see that the numbers pale in comparison to those generated by other industries such as biotechnology.

One of the barriers to the use of IP to spur the generation and commercialization of new innovations is the surface transport sector's (at the federal and state levels of government) tendency to view transportation innovations as a public good that should be freely available. This attitude is changing (at least in the academic community) as universities look at intellectual property and licenses as an important sources of additional revenue and as incentives to retain intellectual talent.

Somewhat paradoxically, the use of open-source strategies to promote the broad development and use of innovative technologies also was not optimized until relatively recently. In the United States, for instance, some modeling and simulation technologies have often been developed and maintained solely by the federal government. This "cradle to grave" approach has left little room for entrepreneurs interested in refining and selling traffic management tools.

Recently this approach has begun to change, with the federal government gradually moving toward the position that it should focus on basic research where funding is typically scarce. The private sector would then exploit this research to develop specific applications that could be commercialized to generate profits. Rather than the government restricting access to a particular entrepreneur, as could happen under an IP commercialization regime, all qualified private parties would have equal access to the research findings.

CONCLUSION

In surface-transportation research, looking at the "market" is of critical importance in the following areas:

- It is critical for all transportation stakeholders;
- It provides basic knowledge for industrialists and operators to develop new business opportunities or competencies;
- It provides good scientific knowledge for creative and innovative business, even in times of crisis; and
- It creates the frame and articulation for various types of fair partnerships for the benefit of all parties involved, while taking into account intellectual property and other commercial confidentiality rules.

It is also critically important to achieve a public-interest approach in the formation of transportation systems and services that positively impact our economy and society, while taking into account the transportation customer issue, the fair partnering between public and private entities, the environmental impacts, and other social or political issues. Transportation research with the involvement of industry makes a crucial difference and is fundamental for government and policy making.

Models of Collaboration and Issues of Concern

The Role of Globalization in International Collaborations

The purpose of this chapter is to examine alternative models of research collaboration and initiate a dialogue on the issue of globalized transportation research and development. It explores the key premises and elements of globalization, covers the idealized dimensions of globalization when applied to transportation research, and addresses some key barriers and enablers to achieving globalization in surface transportation research, development, and technology transfer.

Some of the benefits resulting from investment in transportation research and technology development and deployment include a vibrant economy, a transportation system that is less costly to maintain and operate, fewer highway-related deaths and significant injuries, enhanced mobility and accessibility (economic and physical) within and between cities and nations, and social and environmental improvements. While research and technological innovations will continue to be generated domestically in fields ranging from intelligent information systems to bridge design, international collaborations, which can operate in association or independently of national governments, will continue to make significant contributions to the solution of seemingly intractable problems such as congestion.

The traditional logic of competition at the international level for scientific excellence should not be incompatible with the logic of global research cooperation and the many benefits that could emerge from the globalization of transportation research, development, and deployment activities. It would likely mean that significantly greater financial resources and human intellectual talent would be concentrated on transnational problems of congestion, inefficiencies in the transportation of goods, the heretofore illusive pursuit of enhanced mobility and accessibility, and a significant reduction in greenhouse gases and other forms of environmental pollution and social inequity associated with the operation of automobiles and trucks. In addition, one would expect an increase in the timely application of practices and approaches that would reduce injuries and fatalities by significant numbers worldwide.

There are many examples of international facilities supported through EU–U.S. collaboration that have successfully fostered international collaboration for decades. Some may be found in the U.S. president's report, "President's Council of Advisors on Science and Technology," on ideas for enhancing European–American cooperation (PCAST, 2004).

The principles that have been used successfully to guide the formation of these partnerships, include the following:

- A fundamental commitment to peer-reviewed, high quality interactions of mutual benefit;
- The integration of research and education;
- The provision of open and reciprocal access to all researchers; and
- The sharing of discoveries and developments from joint investments.

Also highlighted in the report is the importance of considering cost models, governance, accountability, and evaluations when participating in large international infrastructure partnerships. It is important that each project be developed through iterative dialogues and long-term planning with all stakeholders in the research community.

Beyond the PCAST document, this group notes their belief that currently a legal framework already exists for collaboration between the European Union and the United States, namely, the EU–U.S. Science and Technology Agreement. Although a recent impact assessment of the agreement found tangible benefits, it also noted that substantial progress is still needed to realize the full potential of the agreement.

Nevertheless, enacting a truly globalized transportation research regime faces significant hurdles. First, the fluidity of political support for research, and variable access to capital and human scientific and technical talent worldwide, are enduring barriers to implementing the globalist perspective. Second, it is likely that the globalization of transportation research and development would threaten existing domestic research and product-development networks, thereby limiting government and commercial support for this venture. Third, research collaboration on an international scale is usually limited to those types of problems or questions that are of a scale (e.g., high energy physics) that no one nation has sufficient resources necessary to investigate the phenomenon. Transportation research issues are often divisible and can be approached on a smaller scale.

This chapter examines the platforms of collaboration and the overall mechanisms (models) that point toward new systematic approaches to stimulating transatlantic cooperation and joint research. These models go beyond the traditional government-centerd ones, and will involve private funding of transportation research aiming to exploit the synergies and common interests that exist in the private sector on both sides of the Atlantic.

THE BENEFITS OF GLOBALIZED TRANSPORTATION RTD AND CURRENT MODELS

Collaborating across vast geographic distances brings diverse and rich perspectives and experiences to the table and is ideal for research and explorations. There is no doubt that "linkages enhance creative thinking" (Wagner et al., 2002). There are a number of important benefits that can result from international research collaborations in the transportation sector:

1. Partnerships provide access to additional research capital, advanced equipment, and technical skills;
2. Participation in international collaboration allows partners to become immediately aware of advances in technology and practices. Both public and private entities are thus able to deploy state of the art and state of the practice technologies and methods of operation more quickly. In some cases, quick deployment can lead to a significant savings in lives;
3. Enduring relationships among professionals representing both the public and private sectors

are built among various countries. This serves as an effective conduit for information exchange and the deployment of technologies and innovations with a relatively small investment of resources;

4. Participation in the working groups of international organizations allows participants to understand the issues faced in other countries, how solutions have been developed, and lessons learned;
5. Research collaboration can allow participating organizations or nations to avoid costly duplicative research;
6. International partnerships in research contribute generally to the building of positive multilateral and unilateral relationships between and among countries; and
7. Partnerships can also benefit individual researchers by providing international exposure (reputation building) and additional funding resources for research.

There is significant evidence that a primary determinant for domestic and internal collaboration is the potential benefits that come from a more junior scientist teaming with a more visible or renowned scientist. Indeed, research shows that the growth of international collaboration can be attributed primarily to a self-organizing phenomena based on preferential attachment (search for recognition and reward) within networks of researchers and coauthors (Wagner et al., 2004).

These benefits have already formed the incentive for a number of innovative models of transportation research cooperation, which can now be cited as useful existing examples. These benefits have already formed the incentive for a number of innovative models of transportation research collaboration that can be offered as useful examples:

1. Centralized, institutionally driven collaborative research;
2. Bilateral research initiated scientist-to-scientist—no governmental intervention;
3. Distributed collaborative research involving several entities at governmental or industrial levels[1];
4. Information exchanges (technology scanning tours); and
5. Focused research collaboration through technology assistance programs established by bilateral MOUs or agreements. Typical examples are:
   - The French DOT Caltrans model and others either already existing or in discussion between Caltrans and other European countries (the Netherlands, Finland, etc.) involving industry, operators, and academia and research institutions. Such agreements establish and define collaborative relationships for research activities between Caltrans and the European partners;
   - The collaboration between FHWA and the Czech Republic, whose aim is to improve access to road transportation technology, including institutional and program building activities to facilitate technology transfer and the flow of information and goods;
   - The traditional academic MOU between research groups collaborating on research and development of specific products or issues; and
   - The MOU between European regional clusters and their counterparts in the United States (industry funding is at stake).

[1] Includes private funders stimulating research internationally, including the use of transatlantic collaboration. For example, the Volvo Research Foundations has established a number of Centers of Excellence in various countries, including the United States and Europe.

Institutional structures for collaboration may be classified into the following types, of which only the first two are currently commonly found in practice:

1. Ad hoc and informal collaborations between individuals;
2. Partnerships on a case-by-case basis, basically exploiting special relationships or situations between the cooperating research organizations;
3. Formal organizational partnerships between umbrella organizations representing many members;
4. Creation of new leading organizations for joint research, with funding coming from both public and private sources; and
5. Specific mechanisms that encourage cooperation of research in support of particular topic areas and policies.

Collaborative research and technological innovation on an international scale, and indeed between the U.S. and EU transportation research communities, require new and innovative enabling frameworks. Such frameworks may not always depend on governments or the public sector but must include private funding and market-approved processes. Several drivers that were expected to increase international research collaboration include the Internet, national interests, geographical proximity, and historical relations.

Two recent examples of international transportation research collaboration that will serve as model examples in subsequent sections are the following:

1. The 2006 **MOU** between the Transportation Research Board of the National Academies in the United States and the European Conference Transport Research Institutes (ECTRI), an example of the type 5 institutional structure, consisted of a simple MOU outlining ways and methods of collaboration and was followed by a 10-point, two-year action plan that referenced specific actions. Part of this MOU and its related two-year action plan was the formation of the working group issuing this report.
2. The Next Generation Simulation Model **(NGSIM)** development and exploitation structure is a collaborative research program of the FHWA, designed to develop a core of open behavioral algorithms in support of traffic simulation with a primary focus on microscopic modeling. It includes supporting documentation and validation data sets that describe the interactions of multimodal travelers, vehicles, highway systems, and interactions presented to them from traffic-control devices, delineation, congestion, and other features of the environment. These products will be openly distributed and made freely available to the broad transportation community.

ELEMENTS FOR SUCCESSFUL INTERNATIONAL COLLABORATION

While governments and other institutions may set the policies that drive the need for research, ideally the organizational structure in which the actual scientific research occurs has no direct influence on the research. In practice, however, administrative divisions within the organization can create artificial barriers to collaboration. This was underlined in the PCAST report,[2] which discusses two sets of issues with regard to organizational and regulatory frameworks:

- Best mechanisms and practices for forming and sustaining international collaborations; and
- Regulatory, legal, and policy issues with regard to intellectual property, standards, and trade.

There are usually four main prerequisites for enhancing research collaboration:

- Clearly defined goals and principles for collaboration;
- Mutual benefit to be derived;
- Appropriate institutional structures and processes in place; and
- Credible champions (i.e., individuals or institutions) who will take the lead.

The first two may be assumed to exist or may be proven to exist with relative ease, and there are credible champions on both sides of the Atlantic.

The key ingredients or characteristics for the establishment of successful international partnerships are the following:

1. Strategic convergence of individual and collective interests among partners who are focused on the particular scientific or technical issue in question;
2. Clearly articulated goals and objectives;
3. Ground rules for interaction among partners in the form of a formal agreement or MOU;
4. Inclusion of key stakeholders during program or project specification through research life cycle; leaving a key actor out of the partnership may create problems. All elements of the program, including funding and exploitation, should be understood by all interested stakeholders (public, private, and academia—including research and technical organizations, consultants, operators, and commerce);
5. Existence of champions or advocates, who are critical in ensuring that the partnership is successfully launched and that those barriers to effective functioning are eliminated;
6. An inclusive participatory decision-making process, which must be in place to ensure that all partners feel they are owners of the process and have a stake in the success of the partnership;
7. Agreement on the initial sources of funds as well as on how the partnership will be sustained over time is critical to sustainable collaborations;
8. Distribution of benefits among partners is also a critical element to keeping the partnership intact and viable;

[2] In considering organizational models that have successfully supported international collaboration PCAST (2004) also discusses concerns over certain organizational barriers to collaboration. Many of these barriers appear to be the result of the different structures, requirements, restrictions, and rules in place in the United States and the European Union for sponsoring scientific research. Collaboration can be easily improved simply by communicating more effectively about the structure of the respective systems. For example, U.S. companies and organizations can misunderstand their eligibility to participate in EU activities. The PCAST report also discusses the effect of long-term planning documents on the identification of national and international research priority areas. U.S. government agencies (such as the Department of Energy and the National Institutes of Health) have created roadmaps to guide long-term strategic planning and funding. In addition, as PCAST (2004) notes, given the complexity of today's scientific problems and the high cost of research necessary to solve them, the advantages of combining resources, ideas, and economic efforts among nations—the establishment, in other words, of large-scale international science projects—are self-evident.

9. An organizational structure or procedures for management and operation of the partnership as well as for the overall evaluation of success must be in place;
10. A seamless, vertical as well as horizontal, communication and coordination linkage is the driving engine of partnerships and ensures that the benefits can be accomplished;
11. Transnational networks serve as enablers of international research collaboration, building vital connections, creating communities of practice, and facilitating the strategic convergence of individual and collective interests.

Table 8 shows the application of these characteristic elements in two examples of international transportation research collaborations, illustrating the MOU and NGSIM.

TABLE 8 Elements of Effective International Collaborations in Two Example Approaches

Necessary Elements of Effective Collaborations	TRB-ECTRI Approach	NGSIM Approach
A seamless, vertical as well as horizontal, communication and coordination linkage is the driving engine of partnerships and ensures the potential for accomplishment.	MOU facilitates seamless communications; extensive stakeholder involvement insures seamless communications.	Program built on extensive stakeholder involvement which has in turn established a seamless organizational structure and seamless communication.
Strategic convergence of individual and collective interests among partners that are focused on the particular scientific or technical issue in question	MOU represented convergence of diverse interests.	Marketing assessment led to development of research program that represented convergence of interests.
Clearly articulated goals and objectives	MOU spells out goals and objectives based on stakeholder input.	Program plans laid out goals and objectives based on stakeholder input.
Ground rules for interaction among partners in the form of a formal agreement or a MOU	MOU in place	Program plans spelled out interaction process.
Inclusion of key stakeholders; leaving a key actor out of the partnership can create problems.	Process designed to be inclusive	Process designed to be inclusive
Existence of champions or advocates, who are critical in ensuring that the partnership is launched and that barriers to effective functioning are eliminated.	Champions will naturally evolve as organizations find mutual interests for entering into partnerships.	Champions will naturally evolve as organizations find mutual interests for entering into partnerships.
An inclusive participatory decision-making process must be in place to ensure that all partners feel they are owners of the process and have a stake in the success of the partnership.	Process is inclusive.	Process is inclusive.

(continued on next page)

Necessary Elements of Effective Collaborations	TRB-ECTRI Approach	NGSIM Approach
Agreement on initial sources of funds as well as on how the partnership will be sustained over time.		Initial funding provided by federal government; subsequent development activity will be funded by model developers.
Distribution of benefits among partners; a critical element to keeping the partnership intact and viable.	Benefits will be negotiated by individual collaborators.	Benefits will be determined by marketplace.
An organizational structure or procedures must be in place for management and operation of the partnership as well as for the overall evaluation of success.	Implementation structure under development	Specific implementation plans developed and in place

BARRIERS TO GLOBALIZED TRANSPORTATION RTD

Just as there are powerful forces leading to international collaboration, there are also a number of barriers to the development of effective collaborations on an international scale. These are listed below, while in Table 9 these barriers are presented in a more detailed way for the two examples of international collaboration that were also used in Table 8.

High Information Costs

Very often the formation of collaborative activities is stymied by a lack of information on collaborative opportunities and converging interests. Searching for potential collaborations at the international level may require levels of time and effort that are simply not available to researchers or organizations, especially when domestic partners and collaborators are readily available.

Transactional Hurdles

Establishment of collaborations involves multiple organizations and parties. What may appear as simple to establish from afar may turn out to be very complicated from the standpoint of gaining the necessary approvals from the respective partners' governments to enter into a collaborative relationship. The problem of administrative red tape can be a powerful deterrent to international collaboration.

Differences in Intellectual Property Rules

The sharing of intellectual property, publication rights, and credits can be a serious sticking point in partnerships. For instance, the United States operates under a first-to-file system, whereas European countries operate under a first-to-invent system. This difference may lead to a difference in the length of protection under a patent. Up-front agreements on intellectual property issues among partners can avoid numerous problems down the road (PCAST, 2004).

Cultural Differences

As with any interactions that involve crossing cultural boundaries, partners should also recognize the cultural differences in communication protocols and patterns. They may affect the success of scientific collaboration (Wagner et al., 2002). In an age of terror and intercultural suspicion, cultural differences may constitute a powerful barrier to collaborative activity.

Capacity to "Go It Alone"

Governments, especially the U.S. government, with a large scientific research community need powerful reasons to collaborate outside their borders, since international collaboration is usually a more complex undertaking than national partnerships. Besides mining fresh new resources and ways of thinking, internationalization of RTD has to provide the promise of conceiving solutions to complex transportation problems through partnerships with countries that have scientific capacity and an expanding pool of researchers and technologies. As Wagner et al. (2002) pointed out, the collaboration has to help governments do what they otherwise could not do alone.

Institutional Inertia

Each collaborative activity that a government or organization enters into involves what economists call "opportunity costs." Because resources are always finite, when governments enter into one or more partnerships, the amount of time and capital that can be used in other collaborations is limited. If the investment of time and money proves to be productive, then the opportunity cost is usually outweighed by the benefits produced in terms of new technologies or productivity; however, it is also possible that the legal and institutional entanglements associated with the collaboration will prevent the government or organization from dissolving the current relationship in favor of a more productive one. Consequently, the institutional inertia associated with many positive collaborations may act as a barrier to the formation of new partnerships when needed.

Labor Issues

The lack of common criteria for governance administration, management, and assessment and performance measurement complicates international research collaboration and hinders intellectual mobility.

Differences in Institutional Cultures

Partnerships between institutions that possess different organizational cultures, missions and goals may be a challenge. For example, academic researchers are motivated by a desire to advance theoretical concepts and achieve standing among peers in academia and less by finding practical solutions to problems that preoccupy a practitioner or government official. Such differences in orientation make partnering difficult because interests do not necessarily converge.

TABLE 9 Potential Barriers to Collaboration in Two Example Approaches

Barriers to Effective Collaborations	TRB-ECTRI Approach	NGSIM Approach
Information Costs. Searching for potential collaborations at the international level may require levels of time and effort that are simply not available to researchers or organizations, especially when domestic partners and collaborators are readily available.	The framework reduces information costs by providing a centralized forum or clearinghouse for identifying partners.	NGSIM involves the relatively small network of traffic model developers so that information costs are less than they would be in larger research areas.
Transactional Hurdles. The problem of administrative red tape can be a powerful deterrent to international collaboration.	Working through the MOU structure should lower transaction costs.	Since algorithms are open source, transaction costs associated with licensing are reduced.
Differences in Intellectual Property Regimes. Sharing of intellectual property, publication rights, and credits can be a serious sticking point in partnerships.	Intellectual property issues will remain a potential issue or barrier.	Since algorithms are open source, transaction costs associated are not a barrier.
Cultural Differences. In an age of terror and intercultural suspicion, cultural differences can constitute a powerful barrier to collaborative activity.	Cultural differences may still constitute a significant barrier to collaboration.	Cultural differences are lessened because development efforts are left to the individual efforts of model developers and vendors.
Capacity to "Go It Alone." Besides mining fresh new resources and ways of thinking, internationalization of RTD has to provide the promise of conceiving solutions to complex transportation problems through partnerships with countries that have scientific capacity and an expanding pool of researchers and technologies.	Since governments are not necessarily the primary decision makers in these collaborations, the advantages of collaboration will be determined by potential collaborators.	NGSIM is established on the premise that government cannot do it all and that the power of the marketplace must be unleashed.
Institutional Inertia. The institutional inertia associated with many positive collaborations may act as a barrier to the formation of new partnerships when needed.	With individuals or nongovernmental institutions entering into agreements, the inertia problem should be lessened.	Marketplace inertia is overcome by natural competition between model developers.

GLOBALIZATION MODELS OF RTD

In spite of the barriers, there is a need to find ways to enhance and increase EU–U.S. collaboration (and indeed international collaboration) in transportation research. The scope and justification for such collaboration is based on the need to share critical data:

- Expose new ideas and paradigms to a broader audience;
- Avoid blind alleys that lead nowhere;
- Optimize resources;
- Promote global policies for international transportation;
- Enhance global standards; and
- Address global problems and issues (e.g., issues relating to public health, accidents, global warming, and travel behavior).

Wagner (2002) offers a model of collaborative forms of RTD. The model describes a spectrum of possible collaborations. At one end of the spectrum lies dynamic informal collaborative arrangements where learning and sharing of tasks and information among geographically dispersed researchers occurs in loosely structured networks. At the other end of the spectrum are collaborative arrangements that are highly centralized, organized efforts with well-defined outcomes. The same study suggests that there are several forms of collaborations that have historically taken place. Both transportation and nontransportation examples are used to illustrate these models.

In this report, the possible models of collaboration have been distinguished in the seven categories described below. Given the high level of government involvement in transportation research (in the United States and the European Union, most transportation research funding comes from the departments of transportation, irrespective of their particular form or status in each case), it is no surprise that currently most international collaborations are largely restricted to the model described in the following section. However, there are examples in practice for most of the models below.

Organized, Centralized, and Institutionally Driven RTD Collaborative Research

In this model, governmental entities come together to identify the objectives of the partnership, set strategic goals, identify a research agenda, and create the means for accomplishing the agenda.

The Joint OECD–ITF Transport Research Centre (JTRC) is an example of an organized, centralized, and institutionally (government) driven RTD collaborative research program. The JTRC was established January 1, 2004, by merging the OECD Road Transport and Intermodal Linkages Research Programme with the ITF Economic Research activities. The mandate of the center is to promote economic development and contribute to structural improvements of OECD and ITF economies through cooperative transportation research programs addressing all modes of inland transportation and their intermodal linkages in a wider economic, social, environmental, and institutional context. The work of the center is shared broadly with OECD member countries, and also directly supports meetings of the European Ministers of Transport and ITF members.

The International Transport Forum originated from the European Conference of Ministers of Transport (ECMT) in May 2006 and includes a much wider group of countries in its membership. The founding members of the forum consist of the 51 ITF members and associate members. The yearly forum provides Ministers of Transport with an opportunity to discuss topics of global strategic importance relating to all modes of transportation and includes the participation of leading nongovernment actors.

The Joint Transport Research Center (JTRC) of the OECD–ITF was established in 2004 and all 50 members of the OECD and ITF are full members. The United States participates in program activities of the center and its participation in JTRC on a variety of working groups has been important in providing independent sources of information and scientific evidence on essential transportation issues. For example, the recent draft final report, "Managing Traffic Congestion in Large Urban Areas," has been useful in discussions relating to the development of U.S. congestion management programs, policies, and practices. The report was produced by the ITF Working Group on Tackling Traffic Congestion in Large Urban Areas. These collaborative relationships at the working-group level are by no means one-sided. The working groups also provide a mechanism through which U.S. researchers may update their international colleagues on similar research conducted in the United States

Another example is the 2004 OECD report, "Keeping Children Safe in Traffic," which highlights successful programs and strategies that can be adopted by OECD countries to improve children's safety on the roads. Many of these strategies are now being promoted in the United States through the Safe Routes to School program established in 2005 under Section 1404 of the SAFETEA-LU transportation act (http://safety.fhwa.dot.gov/saferoutes/overview.htm).
A final example is the bilateral sharing of know-how through the institutionalized hosting of scientists: the ITS Joint Research Program of the United States and Japan.

The FHWA has maintained formal technical collaboration with Japan's highway transportation authority since 1992. Cooperative activities have encompassed joint research, annual workshops, exchange of experts, and information-gathering field studies. These activities have helped engineers in the United States and Japan gain better insight into engineering principles covering many areas of interest to both countries, including pavements, bridge design and maintenance, wind engineering, tunnel safety, earthquake and geotechnical engineering, intelligent transportation systems, traffic safety, and the environment. Since 2000, the FHWA Office of Operations RTD has sponsored one research fellow from Japan. The research fellow supports the U.S.–Japan Intelligent Transportation Systems (ITS) Joint Research Program, which was initiated in November 2000 at a meeting held in conjunction with the ITS World Congress in Turin, Italy.

An innovative way of implementing this model of international collaboration is through the so-called joint programming approach. In joint programming, several institutions from all sides get together to formulate a common program for research activities, priorities, and themes; the program is then put forward for implementation through the participating agencies.

Investing in Foreign RTD

Another potentially interesting and relatively novel model of international RTD collaboration is the model in which public or private research funding is made available to researchers from abroad (i.e., outside the geographical area of jurisdiction or reference of a specific national program). Such investment in foreign RTD is justified on several grounds:

- Optimization of operational and scientific efficiency, because the best of the best researchers may be employed on a global basis;
- Economic efficiency through the sometime use of less expensive researcher rates;
- The tackling of international problems through international research teams; and
- Extension of the human-resource capital for cutting-edge research, and so on.

We already see this type of research organization in several national RTD programs in which an increasing number of foreign researchers is employed or where others are sent to foreign research centers to carry out a particular research assignment. This is also seen in terms of the private research funds that are given to research centers outside the country of origin of the funds, (e.g., the research funding dedicated to research firms in the United States' Silicon Valley). The internationalization of R&D through private foreign direct investment (FDI) by multinational corporations (MNCs) is one indicator of increasing globalization of innovation activities (Carlsson 2006; OECD 2006). International R&D links are particularly strong between U.S. and European companies, especially in pharmaceutical, computer, and transportation equipment manufacturing

Majority-owned affiliates of foreign companies located in the United States performed $29.9 billion in U.S. R&D expenditures in 2004, with little change from 2003. However, between 1999 and 2004, R&D by these affiliates increased faster than overall industrial R&D in the United States (2.1% on an annual average rate basis after adjusting for inflation, compared with 0.2%). In 2004, manufacturing accounted for 70% of U.S. affiliates' R&D, including 34% in chemicals (of which 86% were in pharmaceuticals), 13% in transportation equipment, and 11% in computer and electronic products. U.S. affiliates owned by European parent companies accounted for three-fourths ($22.6 of $29.9 billion) of U.S. affiliates' R&D compared with their 66% share in value-added by U.S. affiliates (NSF, 2008).

Affiliates from some investing countries are particularly notable in some industries. German-owned affiliates classified in transportation equipment performed $2.6 billion of R&D, or 68% of all U.S. affiliates' R&D in this industry and 43% of total R&D performed by Germany.
Parent companies of U.S. MNCs performed $139.9 billion in R&D in 2003, or just under 70% of total U.S. industrial R&D; foreign affiliates of U.S. MNCs invested $22.8 billion in R&D overseas in the same year.

Spontaneous, Dynamic, Researcher-to-Researcher, Research-Initiated RTD Collaborative Activities Occurring at the National or Subnational Levels

In this model, an international team of researchers takes the lead in developing and providing a specific technology or jointly managing a research project under the expressed consent of national or subnational governments. Apart from large-scale international research partnerships that are sponsored by multiple national entities—which are more the grand exception than the rule—there are multiple examples of partnerships that occur at the subnational levels involving science and research on a much smaller scale. Knigge (2004) analyzed case studies of several international environmental collaborations between Europe and the United States that were organized at the subnational level. These partnerships included city-to-city, state–country, and regional partnerships.

The partnerships involved a number of activities, including the exchange of ideas, sharing best practices, and the identification and adoption of innovative policy approaches. While the study points to the fact that problems are often experienced at the local level, partnerships in general ignited better collaboration among different stakeholders, enhancing working atmospheres and promoting self-reflection in work. The relationships Knigge identified did not involve formal collaboration on research initiatives of mutual interest. The value of these exchanges is that they can be regarded as initial phases of full-fledged RTD partnerships. These relationships served as seeds that could grow into full international partnerships.

Examples of subnational partnerships include collaboration on a single issue such as protection of Winnipesaukee Lake in New Hampshire and the Sea of Galilee in Israel (the Sister Lakes Program) and saving salmon in Oregon and the Netherlands. The partnerships may also form around multi-issues such as the partnership between the State of New Jersey and the Netherlands on climate change, smart growth, and emissions trading. The impetus for subnational partnerships seems to be the similarity in conditions, circumstances, and problems faced as well as the particular interests of the scientists responsible for championing the collaboration (Knigge, 2004). The partnerships, however, generated more than the mere exchange of ideas; the benefit of cross-fertilization is evident in those exchanges (Knigge, 2004).

These case studies suggest that collaboration on subnational or local problems may provide sharpened focus and strengthened convergence of strategic scientific interest. In the age of globalization, where information is instantly shared across national boundaries and across disciplines, distance partnering—enabled by advances in computing and networking technologies—in scientific and technical knowledge creation and exchange will likely become the norm as researchers look for ways to leverage funding and access resources that are not available to them domestically.

A central advantage of smaller scale, international collaborations—especially those occurring at the subnational level—is that they can form to meet a particular research need and then readily dissolve when the need no longer exists. On the other hand, larger collaborations involving national governments, once formed, often take on a life of their own that lasts long after the original mission has been met.

Distributed Collaboration Involving Several Governmental Entities and a Shared Management Structure

This model combines the top-down approach of institutionally driven research collaborative and the bottom-up approach to creating collaborations. Needs are usually identified from the bottom upward through an interactive collaborative process at the individual investigator level. This process is coupled with an institutional-level identification of strategic direction.
In terms of governance, collaborating partners may rely on bodies (steering committee, consortium, working groups, committee, etc.) composed of representatives of the different stakeholders, with varying degrees of complexity to ensure coordination and a participatory inclusive decision-making structure. A critical point is that training and professional certification of administrators and managers is crucial to supplement expertise that may not include thematic or governance knowledge.

An interesting example in the transportation sector of this type of combined approach is the *STELLA-STAR–ATLANTIC Thematic Network.*[3] This initiative emerged from a call for proposals

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[3] A more detailed outline of the two international collaboration examples (the STELLA and ATLANTIC) as well as references and contact details may be found in Appendix C.

issued by the European Commission in the 5th Framework Programme of Research and Development (5FP); two strands of international cooperation in the field of transportation were established: One—called STELLA—had its European base in the Energy and Transportation Directorate General, and the second—called ATLANTIC—began in the Information Society Directorate General. Both drew their membership from the United States, Canada, and Europe. The STELLA Thematic Network's outward face was STELLA-STAR, recognizing the interweaving of European and North American identities.

The STELLA-STAR research agenda covered a wide scope of transportation issues, and ATLANTIC established a targeted network of research in the area of intelligent transport systems.

The STELLA project established both working and focus groups on globalization, e-economy, and trade; information and communication technologies (ICT), innovation, and the transportation system; society, behavior, and private–public transportation; environment, safety, health, land use, and congestion; and institutions, regulations, and markets in transportation. These groups met on both sides of the Atlantic advancing research cooperative agendas for common research indicatives. The concluding deliverable was "Research Directions" for forthcoming research in transportation. Full results are covered in deliverables. Cooperation continued beyond the conclusion of the Thematic Network through the NECTAR & STAR networks.

A legacy of the ATLANTIC project is the International Benefits, Evaluation and Costs (IBEC) Working Group, which in 2009 has a worldwide membership of more than 400 individuals and is active in promoting the outcomes and good practice in ITS research and deployment mainly through interventions at major conferences such as the ITS World Congresses.

A significant outcome of the STELLA-STAR–ATLANTIC Thematic Network (which was also its key to success) was the format of their funding and management. Timing, funding regimes, and procurement practices on each side of the Atlantic are different. In establishing the projects, it was clear that these facts impaired the establishment of fully united projects funded from a central source. A modus operandi was conceived where participants from each funding regime were remunerated under their own systems, the procurement following practices of each funding regime. Evaluation in Europe for STELLA involved experts from North America participating in European evaluations. Management was achieved jointly through the principals from each side of the Atlantic agreeing on joint deliverables, workshops, and other meetings.

The European Organization for Nuclear Research (CERN) is another more-institutionalized and farther-reaching example of this research model. CERN is an intergovernmental organization with 20 member states, located in Geneva, Switzerland, but straddling the French–Swiss border. As the world's largest laboratory for fundamental research on particle physics, with a support staff of approximately 2,500, the CERN facility provides the very large scientific tools and infrastructure needed to carry out experiments in high energy physics. CERN itself employs only a very small number of researchers, and most of them for a limited duration. Research is initiated and executed by user members. Funding is provided by national agencies, in general directly to the individual participating groups. Collaborations are administratively and scientifically self-governing; CERN is considered a success almost beyond the most optimistic expectations. In large-scale research, it is considered one of the most successful and effective collaborations and has served as a model for other research organizations across the globe (Schukraft, 2004).

The difficulties with this model of international collaboration lie in their long-term viability. Notably, it is often argued that weak ties and shifting networks of collaborations are preferable to strong ties and stable networks when practitioners are seeking the creation of knowledge.

Close collaboration and stable or institutionalized networks may not prove to be very productive over the longer term, since partners may start to think alike after a while (i.e., organizational "group think"). Diversity of partners, the arms-length involvement of governments, and geographic distribution lend themselves to fresh new ideas and ways of thinking (Wagner, 2004; Granovetter, 1974; Haythornthwaite, 2001; and Cowan and Jonard, 2003). Bala and Goyal (2000) suggest that stable and close networks may not be efficient.

One- or Two-Way Information Exchanges on Technologies and Best Practices Involving One or More Host Countries and an Information-Seeking Technical Delegation

An example of this type of model is the International Technology Scanning Program. The International Technology Scanning Program, sponsored by FHWA, AASHTO, and NCHRP, accesses and evaluates innovative foreign technologies and practices that could significantly benefit U.S. highway transportation systems. This approach allows for advanced technology to be adapted and put into practice much more efficiently without spending scarce research funds to recreate advances already developed by other countries.

FHWA, AASHTO, and NCHRP determine priority topics for teams of U.S. experts to study. Teams in the specific areas being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, or financing. Scan teams usually include representatives from FHWA, state departments of transportation, local governments, transportation trade and research groups, the private sector, and academia.

After a scan is completed, team members evaluate findings and develop comprehensive reports, which may include recommendations for further research and pilot projects to verify the value of adapting innovations for U.S. use. Scan reports, as well as the results of pilot programs and research, are circulated throughout the country to state and local transportation officials and the private sector. Since 1990, approximately 80 international scans have been organized on topics such as pavements, bridge construction and maintenance, contracting, intermodal transportation, urban management, winter road maintenance, safety, intelligent transportation systems, planning, and policy. Recent scans include the following:

- Improving Safety and Mobility for Older Road Users (2008);
- Public-Private Partnerships for Highway Infrastructure (2008);
- Transportation Research Program Administration (2008); and
- Integrating Right of Way and Utility Processes with Project Planning, Environment, Design and Construction (2008).

International Information Exchange Through Technology Exchange Programs

This type of model involves RTD cooperation between countries on the basis of technology exchange programs involving various activities and relationship models, one example of which is known as "twinning." In this type of arrangement, because of the important role that state DOTs play in owning and managing roads in the United States, FHWA often encourages them to meet with representatives of road agencies from abroad. From these introductions, twinning relationships have been established between state DOTs and such road departments.

This particular category of cooperative relationships has been found to be an effective means of assisting and cooperating with developing countries and countries in transition. In simple terms, twinning is the establishment of a sister-state type of relationship between agencies and organizations with similar responsibilities. This has been effective because counterparts communicate directly with each other on common issues. Examples of twinning relationships include the Kentucky DOT with the Oblast (state) of Perm in Russia and between the Maine DOT and the Oblast (state) of Arkhangelsk in Russia.

The Local Technical Assistance Program (LTAP) of the FHWA is another mechanism that has provided training, technical assistance, and technology exchange products to local transportation agencies for more than 20 years. The program is sponsored by FHWA, in partnership with state DOTs and, in some states, with local governments and universities. LTAP is the network of programs whose mission is to provide dissemination of information regionally through linking resources nationally and even internationally.

Rather than a one-way dissemination of knowledge, twinning relationships encourage two-way information dissemination and technology transfer. The role of FHWA in developing twinning relationships is to facilitate introductions between subnational entities. It is then up to these organizations to form a lasting partnership.

CREATING A UNIFIED ENVIRONMENT FOR RTD INVOLVING MANY COUNTRIES AND RESEARCH AGENCIES

The long-term aspiration for a research collaborative environment is one whose ultimate scale and extent involves many countries and research agencies. Drawing on the European paradigm used to create the European Research Area (ERA), this model would entail working toward the creation of a Global Research and Innovation Area (GRIA), with transportation research substantially represented. The GRIA could be formed to refer geographically to major global regions and entail a joint long-term vision of a wide range of transportation research content and processes as well as research infrastructures and governance.

The main objective of such research collaboration using the GRIA model would be to focus on regional issues and challenges, achieve better coordination and collaboration between advanced and less-advanced areas, avoid research fragmentation, etc. It should also address the following issues:

- The research demand in each area;
- The (usually very fragmented) research supply;
- The emergence of real or virtual transportation research;
- Global transportation challenges such as congestion, energy consumption, environmental impacts, and climate change, etc.;
- Formulation of regional transportation policies; and
- Realization of a single labor market for researchers.

To enable this vision, it would be necessary to

- Benchmark the evolution of transportation research on both sides of the Atlantic as well as in other important existing and emerging scientific areas (India, China, other OECD, etc.);

- Be aware of the different approaches to intellectual property rights (e.g., first-to-file and first-to-invent);
- Look for convergence in governance;
- Understand the discrepancies in the research infrastructures (hard, soft), and create the basis for freely accessible data and knowledge;
- Ensure the creation of the next generation of surface transportation scientists, taking care of the differences in the educational systems (e.g., differences between the American PhD and the Bologna PhD); and
- Create, develop, and enhance common research evaluation methods and criteria.

Looking further into the future, globalization may very well induce a more closely intertwined research collaboration of the transportation research community on a larger regional scale. Such collaboration may fully reap the benefits of globalization.

GLOBALIZATION AND RESEARCH GOVERNANCE AND MANAGEMENT ISSUES

The more globalized transportation research becomes, the more importance must be attached to the interaction between research governing or managing bodies, with a view to achieving compatibilities and ironing out barriers. The issues are very important because the existing differences in the systems of research governance, financing, and monitoring can become real barriers to international research collaboration. The most eminent issues involved are

1. Research management;
2. Research evaluation (criteria, methods); and
3. Research governance and financing.

Research Management

These issues relate to how the research effort is managed at the research provision level. There are many levels and layers of such research management from the very simple one project manager–one project, to the more complex structures involving a whole project management team, typically involving administrative, technical, and quality assurance project managers, with management groups such as a project assembly or a steering committee, etc.

There is an increasing practice and need to compile and follow detailed project management manuals that specify the form, hierarchy, and method of decision making in research projects so that specific management and productivity objectives are met. The manuals also specify the all-too-important issues of research products ownership and exploitation after the research is concluded, factors that cause many serious problems and hindrances in research execution within a specific national entity, but especially so at an international level.

Specifying and following harmonized management rules for research projects and practices across the Atlantic or even on a more global scale may therefore be of immense importance for transatlantic or global research collaboration. Such harmonization must obviously include one or more of the following issues:

- Project quality control and quality assurance;
- Research results exploitation–implementation issues;

- Intellectual property rights (IPR); and
- Project management and control methods.

Research Evaluation

Research evaluation is concerned with the types and methodologies involved in evaluating project results and outcomes. Harmonization of these methodologies can have an impact on the compatibility of the results of international collaboration projects where parts of the same project are developed in different states (continents) or between different research projects in the same subject area. Guidelines for research project evaluation methodologies and evaluation results formulation have been specified by the European Union during the course of the 5th and the 6th Framework Programmes of Research as part of a number of initiatives. Currently the evaluation methodology specified as part of, for example, the EU project may perhaps be considered as the norm in EU-funded transportation research.

Research Governance and Financing

This is the area where most of the convergence has to be sought in order to achieve better international collaboration results. It has to do with the way transportation research is governed at the central or regional administration level, and the procedures and prerequisites that are necessary in order to be financed. PCAST (2004) cites concern from the academic community and from scientific professional societies about the funding of collaborative scientific research, especially with regard to additional incentives for European participation in U.S.-led research. The lack of financial incentives is stated as a primary reason that European researchers do not collaborate to a greater extent with their colleagues in the United States. Because many European countries have national funding systems, and because European policies are making more funding available within the European Union, these sources are more attractive than what the United States has to offer.

Finding common ground for compatibility in research governance and financing at the international level can help foster international transportation research efforts through breakthroughs in a number of fronts where today most of the barriers exist. These fronts relate to

- Facilitating the issuance of international research bids and their evaluation;
- Finding ways of merging international sources of finance to create funding for specific common international research programs;
- Setting common rules for research funds allocation and commitment;
- Finding common administration and monitoring procedures for international research projects;
- Setting commonly acceptable evaluation procedures of research results; and
- Setting common rules relating to IPR and exploitation–implementation of research results.

For collaboration that is privately funded, there must be clear market advantages to all parties as a result of the work—that is, there must be exploitable opportunities available to all (although those opportunities in some instances may arise solely as a result of services provided during the course of the research). Parties should consider joint ventures, partnerships, and marketing agreements.

TRAINING AND HUMAN-RESOURCE MANAGEMENT ISSUES

Perhaps the most profound obstacle to overcome in international transportation research collaboration is the lack of appropriately trained and certified scientific personnel for this type of international research cooperative work. Currently there are no specific initiatives in human-resource development for this type of international cooperative research project. The scientific labor market has to manage and overcome the frictions of geographical or intellectual mobility through its own spontaneous responses to each specific case. The crucial questions relate to training and certification issues regarding the following:

- Scientific discipline;
- Thematic and cultural changes;
- International research project governance; and
- Assessment of results and outcomes.

The main (and perhaps only) current exposure (and thus training experience) that research personnel has to international research is through the so-called transnational research networks, which are loosely connected networks of scientific excellence in a specific area that provide grounds for brainstorming sessions and exchange of research results, etc. These are the frontrunners in international collaboration and globalization today.

However, in order to promote substantially international transportation research cooperative efforts, one needs to approach the human development issue in a more systematic and profound way. Common rules and approaches have to be laid out in terms of

- Research administration and management;
- Researcher training; and
- Professional certification (for international research work).

Characteristic of this issue is the suggestion by a number of research administrators from some ECTRI Institutes for the creation of a European training Academy for strategic research governance to enhance the ability of the European research system (as compared with the world systems) toward the research globalization challenge. The rationale behind this suggestion was that these research administration professionals would have to be trained for a whole new area of activity that has nothing to do with the simple administrative or research activities that are found in national research programs.

At a more immediate and practical level a basic initial training effort can be undertaken with initiatives from organizations such as TRB in the United States, or the EU's DG RTD as well as nongovernmental research supply organizations such as ECTRI, FEHRL, FERSI, etc., in Europe. The Young Researchers Seminar series, organized jointly by these three organizations every 2 years in a different European transportation research institute, is a good example of such an initiative.

The training for international transportation research project execution is an area where specific initiatives could start by way of priority. The thematic of such training courses could start from the research administration and governing aspects that are the most complicated ones when it comes to international cooperative research and funding. Initiatives could also extend to issues of information and dissemination of material on the different research environments in each country or region and the ways of reconciling cultures and attitudes.

The role of organizations such as TRB and ECTRI in promoting and even sponsoring training actions aimed at the researchers and research administrators in different countries and regions could be very important. However, actions must be taken at the governmental level primarily through bilateral or multilateral conventions for research collaboration.

CONCLUSION

The signing of the TRB-ECTRI MOU in January 2006 (see Appendix A) and the NGSIM program both represent continuing steps in a flexible, distributed model of international RTD collaboration that is consistent with review of the literature and an examination of current international RTD partnerships (Wagner et al. 2002). The major difference between the two frameworks is that the NGSIM model clearly uses a hands-off market-based approach to encourage innovation and technology development, and deployment partnerships use the best features of the top-down and a bottom-up approach presented in this report. It is useful to identify the elements of successful collaborations (Table 8) that these two frameworks embody as well as the potential barriers to international collaboration (Table 9) that they avoid.

Cooperative research across borders has the potential to leverage resources and increase the growth of creative solutions to transportation problems. Communication technologies have made these collaborations more feasible and dissolved barriers of distances. The creation of enabling institutional frameworks to provide structure for these collaborations is critical. The transitory and agile nature of these frameworks is deemed necessary to preserve creativity and productivity.

Although positive efforts have been made toward organizational frameworks that facilitate international research collaboration (including transportation), new and more innovative organizational–institutional frameworks that will enable increased EU–U.S. transportation research collaboration are needed. These must go beyond the traditional interpersonal (i.e., scientist to scientist) models or governmental bilateral agreements.

The TRB-ECTRI and the NGSIM frameworks satisfy many of the criteria necessary for effective collaborations to evolve, while avoiding potential barriers that can work to sidetrack scientific and technical partnerships. The NGSIM framework's central advantage is that it allows market forces to carry model development work to fruition. Indeed, government involvement becomes negligible after the initial algorithm research work is completed.

However, the extent to which the NGSIM framework is applicable to other areas of potential transportation research collaboration remains an interesting and open question. Both frameworks move collaborations away from highly centralized, nationally organized efforts and toward a collaborative paradigm that is decentralized and based upon relatively loosely structured (and sometimes autonomous) networks of researchers and entrepreneurs. The personal and collective interests of the entrepreneurs will ensure that the collaborations are successful or alternatively that they quickly and quietly disintegrate if there is no sustaining mutual interest involved.

In summary, although there are some successful examples of EU–U.S. international collaboration, there are still many barriers to its becoming commonplace. New innovative institutional frameworks that will enable increased EU–U.S. transportation research collaboration, and that do more than merely extend existing collaborative approaches, are required.

General Recommendations

Competition for scientific excellence at the international level does not necessarily contradict the logic of global research collaboration and the many benefits that could emerge from the globalization of transportation research development and deployment activities. The current and ongoing global economic crisis brings new urgency to the need for international collaboration and makes the issues concerning its facilitation of even more relevance and priority.

For the European Union and the United States, further collaboration in transportation research would mean greater financial resources and human intellectual talent that could be concentrated on solving common problems such as congestion, inefficiencies in freight transportation, sustainable pursuit of enhanced mobility and accessibility, reduction in greenhouse gases and other forms of environmental pollution from transportation, and more social equity associated with the operation of passenger and freight transportation systems. In addition, one would expect an increase in the timely application of practices and approaches that would reduce injuries and fatalities in road traffic accidents and other accidents associated with the operation of the transportation system.

Enacting a truly international (in the context of U.S.–EU or beyond) or globalized transportation research regime faces, however, significant hurdles today. Of prime significance is the fluidity of political support for such globalized transportation research and development that is often perceived as a potential threat to the existing domestic research and product-development networks, thereby limiting government and commercial support for such ventures.

Against such a background, this report examines[1] the platforms of collaboration and the overall mechanisms or models that would enable new systematic approaches to stimulating transatlantic cooperation and joint research. These models go beyond the traditional government-centered ones and may involve private funding of transportation research aimed at exploiting the synergies and common interests in the private sector on both sides of the Atlantic. They must be regarded as the common elements necessary to foster transatlantic surface transportation research collaboration and be understood by all interested stakeholders: public, private, academia (including research and technical organizations), consultants, operators, and commerce.

PREREQUISITES FOR INTERNATIONAL RESEARCH COLLABORATION

There are several conditions that may form crucial prerequisites for international research collaboration.

[1] This was the result of a long process of inquiry and discussions between American and European colleagues involved in this TRB–ECTRI working group endeavor, the results of which are presented in this report. The members of this group also examined various research innovation models, such as those proposed by Whitley et al. 2002, PCAST 2004, Lundin 2004, and Wagner 2004. They have also taken in the views and proposals made during a special workshop organized by the group during the 11th World Conference on Transport Research, held in June 2007 at the University of California, Berkeley. The subject of this workshop, chaired by George Giannopoulos, was European–American transportation research cooperation. Participants and contributors included Sam Elrahman, Jean-Pierre Médevielle, Barbara Lenz, Cristina Pronello, Neil Paulley, Martine Micozzi, John Munro, Wes Lum, Debra Elston, Alex Skabardonis, and Michael Meyer.

1. Strategic convergence of individual and collective interests among partners focused on the particular scientific or technical issue in question;
2. Clearly defined and articulated goals and objectives;
3. Ground rules for interaction among partners in the form of a formal agreement or a memorandum of understanding;
4. Inclusion of all key stakeholders. All key stakeholders should be involved during program or project specification and through the research life cycle; leaving a key actor out of the partnership may create problems. All elements of the program, including funding and exploitation, should be understood by all interested stakeholders (public, private, and academia—including research and technical organizations, consultants, operators, and commerce);
5. Existence of champions or advocates who are critical in ensuring that the partnership is successfully launched and that those barriers to effective functioning are eliminated;
6. An inclusive participatory decision-making process must be in place to ensure that all partners feel they are owners of the process and have a stake in the success of the partnership;
7. Agreement on the initial sources of funds as well as on how the partnership will be sustained over time is critical to sustainable collaborations;
8. Distribution of benefits among partners is also a critical element to keeping the partnership intact and viable;
9. An organizational structure or procedures for management and operation of the partnership as well as for the overall evaluation of success must be in place;
10. A seamless, vertical as well as horizontal, communication and coordination linkage is the driving engine of partnerships and ensures that the benefits may be accomplished; and
11. Transnational networks that may serve as enablers of international research collaboration, building vital connections, creating communities of practice, and facilitating the strategic convergence of individual and collective interests.

Collaborative research and technological innovation on an international scale, and indeed between the U.S. and EU transportation research communities, requires new and innovative enabling frameworks. Such frameworks may not always depend on governments or the public sector but must include private funding and market-approved processes. Although positive efforts and steps have been made toward organizational frameworks that facilitate international research collaboration (including transportation), new and more innovative organizational–institutional frameworks that will enable increased EU–U.S. transportation research cooperation are needed.

MODELS OF INTERNATIONAL COLLABORATION

As a result of the work carried out for this report, seven types (models) of existing or potential international (EU–U.S.) collaboration were defined and discussed:

1. Organized, centralized, and institutionally driven RTD collaborative research (programs top-down);
2. Investing in foreign RTD, with public or private funds made available to researchers on a global basis;

3. Scientist-to-scientist research-initiated RTD collaborative activities occurring at the national or subnational level (bottom-up);
4. Distributed collaboration that involves several governmental entities and a shared management structure;
5. Information exchanges on technologies and best practices, including the International Technology Scanning Programs;
6. Information exchange through technology exchange programs; and
7. Creation of a unified environment for RTD involving many countries and research agencies (i.e., creating a Global Research and Innovation Area).

Employing the European paradigm used to create the European Research Area (ERA), the ultimate long-term vision of a Global Research and Innovation Area, with transportation research substantially represented, could focus on regional issues and challenges; achieve better coordination–collaboration between advanced and less-advanced areas; avoid research fragmentation; through the strength of a unified and more global research demand and supply, address global challenges such as congestion, energy consumption, environmental impacts, and climate change; and help formulate regional transportation policies, and so forth.

To enable this vision, it would be necessary to

- Benchmark the evolution of transportation research on both sides of the Atlantic as well as in other important existing and emerging scientific areas (India, China, other OECD, etc.);
- Be aware of the different approaches to intellectual property rights and harmonize them as much as possible;
- Look for convergence in research governance;
- Understand the discrepancies in the research infrastructures (hard, soft), and create the basis for freely accessible data and knowledge;
- Ensure the creation of the next generation of surface transportation scientists, taking care of the differences in the educational systems (e.g., differences between the American PhD and the Bologna PhD); and
- Create, develop, and enhance common research evaluation methods and criteria.

RECOMMENDATIONS FOR INTERNATIONAL COLLABORATION

The following specific recommendations are based on the discussed principles.

1. Create Enabling Policies

In order to create successful collaboration, national and subnational policies need to alleviate concerns over intellectual property rights, create standards and common frameworks for the performance of research, and take into consideration the role of the market in fostering innovations. Policies may also target the provision of incentives to stimulate funding networks for collaboration. A top-down approach is needed to dismantle barriers to collaboration, especially those that involve prohibitive costs and conflicting intellectual property rights. Enabling policies must also take into consideration the mobility of scientists across borders.

2. Mobilize Human Capital

In the area of human capital, there is a need to focus on generating new scientists and strengthening the collaborative capacity of existing scientists. Training and education should target governance and management as well as thematic issues of global concern, such as climate change and sustainability. Communication across cultures is an area of utmost importance because collaboration ultimately involves human behavior and positive human interaction. Cultural competency and sensitivity can lead to successful cross-cultural collaboration.

3. Build Collaboration Mechanisms and Joint Programs

At the top level, it is important to have clearly defined goals and processes that lower the effects of barriers and enhance synergy. Fair partnerships that use credible champions and institutions may lead to a joint programming process of calls of proposals and work programs. The NGSIM framework could be a reference model.

At the bottom level, professional networks have brought researchers in contact with each other across national borders. Strengthening the capacity of these networks and creating mechanisms that would cultivate new productive collaboration is recommended.

4. Systematically Address the Main Barriers

To develop and foster these collaborative policies and mechanisms, this group recommends addressing the seven following issues that correspond to today's major barriers:

- Discussion and dissemination of new ideas and paradigms;
- Avoidance of "blind alleys";
- Optimization of resources by creating "common pools" and other means;
- Promotion of common global policies for international transportation;
- Promotion of global standardization and harmonization of research knowledge; and
- Establishment of common agendas for transportation research by addressing global problems and issues (e.g., public health, global warming, energy, and travel behavior).

5. Improve Data Management and Sharing

Improved data management is essential for successful international collaboration. Developing the infrastructure for data management and sharing is an imperative. To create enabling policies, it is critical to address the issue of free-access soft research infrastructures such as libraries, data, and knowledge. Creating common standards for technical documentation would facilitate collaboration, as would also establishing agreed-upon practices.

6. Facilitate Common Education and Training

Education and training are critical, as noted in Recommendation 2. The three following measures are recommended:

- Exchanges at the PhD and postdoctorate phases to train and educate the new generation of scientists to ensure that Europe and the United States remain at the forefront of transportation research;

- Development of well-trained research administrators or research managers—ultimately in a training academy for strategic and operational research governance; and
- Development, ultimately, of a professional certification process for international research work.

7. Establish the Foundation for Future Joint Programming and Funding

Joint programming and funding of common research projects would go a long way toward the long-term vision of forming a transportation GRIA. Such a development would require

- Facilitating the issuing of international research calls for tenders, bids, and their evaluation through proper agreements between the funding bodies and organizations on both sides of the collaboration;
- Finding ways of merging international sources of finance to create funding for specific common international research programs;
- Establishing common rules for the allocation and commitment of research funding;
- Finding common administration and monitoring procedures for the international research projects;
- Setting commonly acceptable evaluation procedures for research results; and
- Establishing common rules relating to IPR and exploitation–implementation of research outcomes.

As a first step the working group recommends facilitation and more extensive use of existing instruments of collaboration (usually set up through bilateral agreements at all levels), to be followed by a second short-term step of funded participation in the research programs on both sides of the Atlantic, and a more institutionally protected use of each other's research infrastructures.

The above concrete recommendations will establish the foundation for much-needed closer and more institutionalized transport research collaboration on both sides of the Atlantic. There are no magic solutions or immediate results to be effected. The responsible administrations must work closely and consistently toward the goals in order to realize—in the not too distant future—a totally different and much more productive research collaboration environment, which is sure to result in substantial benefits for both sides.

CONCLUSION

The framework of a common vision for transportation research outlined in this report could be a useful input for the renewal of the science and technology EU–U.S. agreement—as well as for other science and technology agreements between the EU (or its members states) and the U.S. government.

A number of steps would be necessary and useful:

1. Release and disseminate this report to any concerned stakeholder on both sides of the Atlantic and beyond;
2. Give priority and bring into force—to the maximum extent possible—Recommendations 2, 5, and 6;

3. Foster further detailed study and work toward formulating common proposals and policies around Recommendations 1 and 4;
4. Begin implementing collaboration mechanisms with top level encouragement (see Recommendation 3); and
5. Begin experimenting with initial joint programming in well-defined and mutually interesting themes by working on the steps outlined in Recommendation 7.

APPENDIX A

The ECTRI–TRB Memorandum of Understanding

Signed January 2006

This Memorandum of Understanding (MOU) provides a conceptual framework for strengthening cooperation between the two organizations, the **European Conference of Transport Research Institutes (ECTRI)** and the **Transportation Research Board (TRB)** and their respective members, henceforth referred to as "the Parties."

CONSIDERING that the Parties share mutual objectives to promote and conduct transport research activities and disseminate their findings;

ACKNOWLEDGING

- their desire to foster and facilitate greater synergies for information-sharing and cooperation; and
- their position of being representatives of a substantial part of the transport research community in their respective regions;

RECOGNIZING the benefits of

- Establishing an institutional arrangement with respect to coordinating exchanges on research and development projects;
- Facilitating regular contacts between European and American researchers in the field of transport;
- Cooperation in the preparation of the next generation of transport researchers in the United States and Europe; and finally
- Exchanging experiences concerning the management of transport research.

HEREBY, the Parties agree as follows:

1) Cooperation in Mutual Activities

The Parties may provide opportunities for representatives from ECTRI and TRB to participate in each other's meetings, conferences, and working groups. Each party, through its own initiative or after a request from the other, may include in its working groups, select committees, or task forces representatives of the other.

2) Dissemination of Information and Research Results

The Parties will try to accommodate submissions of information on research reports and other activities of each other for inclusion in their newsletters and other appropriate publications (e.g., the TRB's bimonthly *TR News* or ECTRI's quarterly newsletter).

3) Organization of, or Participation in, Joint, Select Activities

The Parties may jointly organize activities of common interest, or may invite each other to participate in their activities when such participation would be beneficial or appropriate in the context of this MOU. Examples of such activities are: participation of TRB-selected participants in the Young Researchers Seminars organized by ECTRI in cooperation with other European Organizations, creation of a joint committee or working group on future transportation research needs, more visible participation of ECTRI in the annual TRB Conference through a booth or participation in sessions, naming of keynote speakers in dissemination events or conferences, etc. These activities could be formalized through a two-year common action plan approved on an annual basis by e-mail exchange between the TRB Executive Director and ECTRI President. The persons responsible for the achievement of the activities should be nominated in this action plan.

4) Effective Date

This MOU shall be effective upon complete execution by the cooperating organizations.

5) Revision or Termination of this Memorandum of Understanding

This MOU is subject to mutually acceptable written revision or written modification at the request of any subscriber hereto. Participation by any signatory party may be terminated on three month's notice to the other signatories, provided such termination shall not impair any obligations or commitments already validly incurred.

______________________________	______________________________
Georgios Giannopoulos President, ECTRI	Robert E. Skinner, Jr. Executive Director, TRB
Date: ____________________	Date: ____________________

APPENDIX B

Two-Year Action Plan of ECTRI–TRB Memorandum of Understanding (2006–2009)

ECTRI–TRB Action plan 2006–2007

General moderator for the Action Plan: Josef Mikulik—CDV
Co-moderator for the Action Plan: Jean-Pierre Médevielle—INRETS

Subject	ECTRI Moderator and Co-Moderator	Other ECTRI Members Involvement	TRB Liaison
1. Arrangement of a scanning tour of U.S. research managers to European leading research institutes and vice versa	**Christian Piehler—DLR** Hans Jeekel—AVV	CDV, INRETS, VTI, TØI, UPM, CEDEX, POLITO	Mike Meyer Martine Micozzi (working with Henry Nevares, FHWA)
2. Participation of TRB selected researchers in Young Researchers Seminar organized by ECTRI together with FEHRL and FERSI in Brno, Czech Republic, in May 2007	**Pra. Cristina Pronello—POLITO (from 1 of June)** Dr. Josef Mikulik—CDV (until end of May)	DLR, INRETS, VTI, TØI	Genevieve Giuliano—University of Southern California
3. Publishing of an informative article on ECTRI in *Transportation News* and an article on TRB activities in ECTRI Newsletter	**Guy Bourgeois—INRETS** Jean-Pierre Médevielle – INRETS	CDV	Mike Meyer Martine Micozzi
4. Active participation of ECTRI members in TRB committees	**Lasse Fridstrøm—TØI** Claire Plantié-Niclause – INRETS	CDV, DLR, DTF, POLITO, TNO, VTI, VTT, UPM, AVV, CEDEX	Martine Micozzi
5. Active participation of ECTRI in TRB Annual Conferences (expert presentations in sessions, an exhibition booth)	**Neil Paulley—TRL** Claire Plantié-Niclause – INRETS	DLR, POLITO, VTI, TØI, UPM	Martine Micozzi

6. Regular exchange of information on the elaboration of transport and research strategic documents and key research events on both U.S. and European sides	**Caroline Alméras—ECTRI** Jean-Pierre Médevielle—INRETS		Alejandra Medina—Virginia Tech
7. Strengthening of U.S. participation in the COST projects through a permanent exchange of information on the COST activities	**Pra. Cristina Pronello—POLITO** Willy Diddens—AVV	INRETS	Pr. Jorgé Prozzi—Austin University of Texas
8. Building up research collaboration possibilities between U.S. and European research bodies by exploring the means of EU Framework programs and of the corresponding U.S. research programs (e.g., NSF programs, TCRP, NCHRP, etc.)	**Josef Mikulik—CDV** Pra. Cristina Pronello—POLITO	VTI	Dr. Ossama 'Sam' Elrahman—NY DOT Dr. Dennis Judiycki—FHWA Derek Sweet
9. Proposing a European flavor to future TRB Annual Meetings (special Europe session or keynote European speaker to another session)	**Jean-Pierre Médevielle—INRETS**	AVV, TNO, TRL, TØI	Mike Meyer Martine Micozzi
10. Creating a joint committee or working group on future transportation research needs	**Pr. Georgios Giannopoulos—HIT** Jean-Pierre Médevielle—INRETS	VTI, DLR, CNTK, FhG, CEDEX, POLITO, TRL	Debra Elston, John Munro, J. Halkias, FHWA, Dr. Franck François, AASHTO, Pr. Mike Meyers, Pr. Roja Amjadi, OHIO DOT, O. A. Elrahman, NYDOT, Pr. Jorgé Prozzi, University of Texas, Austin; Wes Lum, CALTRANS; A. Skabardonis, UC Berkeley; Susan Zielinski, Umich; Maryvonne Plessis-Fraissard, World Bank

APPENDIX C

An Example of Transatlantic Transportation Research

The STELLA-STAR–ATLANTIC Thematic Networks

STELLA NETWORK

STELLA brought together two preexisting networks of researchers: The Network on European Communications and Transport Activity Research (NECTAR), which was initiated by and linked to the European Science Foundation in Strasbourg, France; and the Sustainable Transportation Analysis and Research Network (STAR), linked to the National Science Foundation (NSF) in Washington, D.C.

The new network, STELLA, was a thematic network that centered on common issues in transatlantic transportation research. Its aim was to generate value-added information from knowledge exchange and to support a common research approach from both sides of the Atlantic, a goal that was believed not only to benefit the research community but also to be of interest to policy-making bodies and industrial organizations. The STELLA network addressed five major focus areas:

- Globalization, e-economy, and trade;
- Information and communication technologies (ICT), innovation, and the transportation system;
- Society, behavior, and private–public transportation;
- Environment, safety, health, land use, and congestion; and
- Institutions, regulations, and markets in transportation.

The overriding goal of STELLA was to generate a clear added value from knowledge exchange and a common research perspective that is applicable on both sides of the Atlantic. By bringing together research institutions, universities, industry, and public authorities in the transportation field, STELLA addressed the following three objectives:

- Creating an institutionalized platform for exchange of scientific information (particularly research-in-progress) for pooling of experience (partly common, partly contrasting) and for facilitating research cooperation among European and North American transportation researchers and experts;
- Fostering a better understanding of the causes (common and different) and backgrounds of mobility behavior in both Europe and North America, particularly with a view to the impacts of policy (transportation, land use, environmental, and economic); and
- Fostering and creating conditions for applied comparative research in both Europe and North America on behavioral motives, innovative strategies, and policy assessment in the transportation sector, with a view to sustainable transportation.

The STELLA network has not been maintained. The 3-year STELLA-STAR Thematic Network concluded with a workshop during the 2005 TRB Annual Meeting in Washington, D.C.

ATLANTIC NETWORK

The ATLANTIC network grew out of the excellent transatlantic collaboration on ITS research topics that developed under the umbrella of the PIARC (World Road Association) Committee C.16 on Intelligent Transportation. The PIARC committee undertook a program of work over the period from 1995 to 1999 involving an exercise to review and consolidate the results of research and field trials on ITS around the world. This led to the publication of the ITS Handbook,[1] coedited by Kan Chen of the University of Michigan and John Miles of Ankerbold International, who were both key actors in ATLANTIC. Objectives of the ATLANTIC Thematic Network were to

- Stimulate an active debate among a key group of experts on the research taking place on transportation telematics (computers and telecommunications) and intelligent transportation systems (ITS) for surface transportation;
- Distill the lessons of experience of ITS research on both sides of the Atlantic to inform decision making among policy makers, practitioners, and other concerned stakeholders;
- Identify barriers to progress with ITS research and make recommendations on the level at which it is most appropriate to address them;
- Identify subjects where transatlantic cooperation on ITS research would bring added value;
- Carry out case studies and formulate recommendations on suitable business models and good practice for telematics-based traffic and travel information (TTI) services;
- Facilitate discussion and analysis of issues emerging from the TTI using focus groups of key stakeholders; and
- Make available to principal actors and stakeholders the results of these discussions.

Specifically, the European ATLANTIC project had three components. Although the activities described here are formally part of the second component listed below, there is also close integration with components 1 and 3:

1. Operation of an ITS forum based on e-mail groups, including key individuals involved in transportation telematics and ITS. The Forum subgroups will be benchmarking the coverage, content, and results from the European ITS programs against similar activities in the United States and Canada.
2. Convening of international meetings with American and Canadian partners in the project. The current report concerns a roundtable discussion of a series of meetings arranged in the margins of the TRB 2002 Annual Meeting. ATLANTIC is also providing the secretariat for two international workshops on ITS cost-benefit, which was held at the ITS World Congress in 2001 and 2002.

[1] PIARC Committee on Intelligent Transport, K. Chen and J.C. Miles (eds.) ITS Handbook 2000. Artech House, London and Boston, 1999.

3. Development of good practices and policy on telematics-based traffic and travel information services for cities and regions. ATLANTIC will work with key stakeholders and the POLIS network of European Cities and Regions for Transport, thereby supporting the e-Europe Transport 2002 initiative.

   The ATLANTIC Thematic Network reached its conclusion in mid-2003.

Contacts

STELLA-STAR

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STAR—North America—Bill Black (now retired), Indiana University; or Ken Button, kbutton@gmu.edu, George Mason University.
STELLA STAR (Sustainable Transport in Europe, and Links and Liaisons with America) was supported by the European Commission, the National Science Foundation (NSF) in the United States, and Transport Canada.

ATLANTIC

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ATLANTIC (A Thematic Long-Term Approach to Networking for the Telematics and ITS Community) was supported by the European Commission, the U.S. DOT, and Transport Canada. Maintained web address: http://www.atlan-tic.net/index.cfm.

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