

## State of the Art and Future Trends in Transportation Engineering

Radu Andrei

*Department of Transport & Infrastructure Engineering  
Technical University "Gh. Asachi" Iasi  
43, Professor D. Mangeron Str., 700050 Romania*

### Summary

*This paper intends to present a synthesis and a comprehensive view of transportation as it exists today and can expect to evolve with the beginning of this new century, based on a various published papers by internationally recognized experts fully engaged in the progress of transportation engineering.*

**KEYWORDS:** transportation, education, environment, intelligent transportation systems

### 1. TRANSPORTATION CHALLENGES FOR OUR GENERATION

To mark the beginning of this new millennium, the various transportation bodies and committees from the world (TRB,<sup>1</sup> ERC<sup>2</sup>, AARB<sup>3</sup>, etc.) mounted a special effort to capture the current state of the art and practice and their perspectives on future directions in their respective areas of focus. The results of that effort was a thoughtful and perceptive review], prepared by experts fully engaged in advancing the way the traveling public is served, providing a comprehensive view of transportation as it exists today and can be expected to evolve in this new century. Various published papers [1],[2],[3] present very useful information in gaining a better understanding of the current technologies, practices, and issues of interest to transportation professionals today, encouraging their readers to become major players as the new challenges are addressed by the transportation community. In this context all over the world, the quality of education in general and transportation education in particular, continue to be a major factor in a nation's ability to succeed and excel.

<sup>1</sup> TRB-Transport Research Board (USA)

<sup>2</sup> ERC-European Road Conference

<sup>3</sup> ARRB- Australian Road Research Board



R. Andrei

## 2. TRANSPORTATION AND EDUCATION

Undertaking a short insight into the current status of transportation education as an academic discipline and examining some significant areas that may challenge educators and administrators into the near future it was found out [1], that several recommendations to support future development in this academic area are necessary to be made. Formal education programs and academic research efforts have not always been a determining factor in the development of transportation innovations. Nineteenth century innovations, such as steamboats and railroads, initially came from entrepreneurs' talents. In the 20th century, transportation issues became more complex. In the 1950s and 1960s, education endeavors in transportation were focused on the practical matters of building and maintaining road and rail networks. In the latter part of the 20th century, transportation education became a discipline in its own right. Development in the field now comes about because of continuing demands and commitments at several levels. For the particular case of our country, from legislative point of view, it is necessary, at this stage to issue at the level of the Ministry of Education and Research (MEC) a document, through which government could support and encourage the development of all transportation organizations ( government, private, etc.) and to mandate the existing university transportation centers, Bucharest, Timisoara Cluj and Iasi, to provide leadership in transportation education teaching and research. In this respect the government has to provide appropriate research programs and the necessary funding to achieve the commitment for teaching and research, as well as a technology transfer network to link transportation education needs. The outcome benefits of such undertaking will be not only for academics, but also for practitioners at various levels who wish to learn new skills or enhance their current knowledge base. In the new economical environment, it is also expected that beside the government sector, the private sector will provide also some education commitment, based on a research component capable to meet the specific needs of a developing product/service or to transform an existing transportation enterprise. As the transportation education system grows, the focus is changing in several ways. From an academic standpoint, additional policy areas—as opposed to technical areas—become apparent. For example, students and professors will have to broaden their scope to examine communication between public and private interests, strategic management of human and capital resources, environmental impacts, as well as the impacts of computerization and technology. In this respect, more efficient management of existing infrastructure systems are envisaged now and this can be accomplished only through the use of enhanced management systems and intelligent transportation systems. At the same time, there is a growing realization that transportation education needs to broaden its focus beyond academic offerings. To create future leaders in transportation careers, in the frame of the actual



## *State of the Art and Future Trends in Transportation Engineering*

restructuring process, academic, elementary and secondary curricula have to be developed accordingly and revised. Some technology and transportation futures programs, capable to support lifelong learning endeavors and innovation at the elementary, secondary, college, and graduate levels have to be initiated. At the other end of the learning spectrum, existing professionals, they themselves have to be engaging, in a lifelong learning process. Learning might also involve those who are informally interested in transportation issues. This perspective highlights the changing and evolving focus of the “transportation professional.”, because in order to meet the society’s demands it is no longer sufficient to have only a technical background or to view transportation education not just as a series of college courses but as a multidisciplinary and lifelong endeavor. According this perception and in accordance with other specialist views, in this new century, some factors such as globalization, the progress of technology, changing demographics, and curriculum development will have a great impact on the educational process. In the frame of the actual globalization, defined as “seeing the whole world as nation less or borderless”, in the private-sector transportation organizations provide products, services, and research capabilities to a diverse world community that is becoming more competitive. In public-sector transportation endeavors, governments at various levels are responsible for the development, implementation, and maintenance of existing and evolving transportation infrastructures. In this context, transportation education may act as the catalyst to bind these forces together by supporting innovation. Globalization and the future entrance of our country into the European Community will significantly affect the changing academic environment. In a direct sense, it will have to face and to support the internationalization of resources, not only in the individual classroom, but also in the research facility that then extends out to the workplace environment. As global transportation education efforts support industrialization, the movement of goods and people, enhanced resources, better communication, and improvements in the quality of life for all countries, outcome shares learning innovations and the latest research and development endeavors that go beyond the academic setting. These globalization forces are also enhancing a very strong competition— thus providing a wonderful opportunity for education stakeholders to show leadership through innovative research projects, as well as by utilizing technology and communication to share resources and knowledge. Transportation innovations are expected to act as an “engine of growth” among the economic and environment drivers of the actual technology revolution involving major effects on transportation education. Within the teaching environment, the use of computers as a learning tool is revolutionizing how students study existing theoretical and practical problems. Within the learning environment, research methodologies and outcomes are bringing about continuing change, not only in tabulating and evaluating complex quantitative problems, but also in how information is shared through web-site addresses and communication links. This revolution will extend beyond the formal classroom since it opens up



R. Andrei

distance learning opportunities to the academic and to the practitioner, even in remote locations. Technology will be used as information and learning tool to interest young students and those who wish to know more about the field. By combining technology and education endeavors, an opportunity is provided to build new technology, improve existing infrastructure, develop world-class facilities, enhance capital investments, create alternative energy sources, improve the environment, and make better communication alternatives. At the same time, it can be used to create, test, implement, and monitor potential innovations before a financial, environmental, political, or research commitment is made. For transportation education to be relevant to society's needs, it must take into account the changing demographics in the workplace. For example, the traditional scope of jobs and careers is broadening to include women in key managerial and leadership positions, education being a key component in preparing and sustaining all individuals throughout their careers within the transportation hierarchy. To ensure broader interest and understanding for everyone, advantage should be taken of opportunities to extend the transportation learning process to the secondary and elementary levels. At the other end of the spectrum, the older, established practitioners in the field will need to maintain and upgrade their existing knowledge and skills in the face of the massive technological and policy changes going on around them. As leaders in transportation they will have to prepare their students in such a way, that finally these students to be able to compete and demonstrate (a) leadership, to have (b) technical knowledge and skills, (c) analytical ability, (d) communication and intercultural skills, (e) technology/computerization skills, and (f) a variety of policy skills. At the same time, they need nontraditional skills, such as (g) ability to communicate between public and private interests, (h) talent to manage human and capital resources, and (i) ability to discern effects on the environment. All these objectives could be accomplished only if educators and administrators will succeed to meet changing demands through the courses of study that they offer and the research opportunities that their institutions provide. There must be a continuing commitment to broaden the focus beyond "traditional learning" to "students" of all ages. Also, there must be a commitment by numerous stakeholders to supply the tangible resources needed (e.g., funding, scholarships, grants, research opportunities, internships). Finally, educators must bridge the gap between the academic, the public, and the private sectors (e.g., by building public-private partnerships) and in a world of highly competitive resources, they need to market their success to academics and non-academics to build interest and support for their programs. This complex approach is expected to have many benefits, by developing the next generation of transportation leadership and at the same time, building the field of transportation education and creates the necessary innovation to meet known and unforeseen challenges. Finally, it will contribute significantly to the developing of a safe,



## *State of the Art and Future Trends in Transportation Engineering*

efficient transportation system capable to meet not only Romania's but also the Europe Community's—needs, in the actual highly competitive environment.

### 4. TRANSPORTATION RESEARCH. CURRENT PRACTICE AND TRENDS

There has long been widespread recognition that transportation is the foundation of our society's economy and quality of life. The last century has brought major changes in the way we plan, coordinate, and conduct transportation research, primarily as a result of numerous trends in the transportation sector and in society as a whole. More recently, however, transportation agencies have begun to see their role as much more than simply providing infrastructure, their actual mission statements typically include enabling the movement of people and goods in an efficient, convenient, safe, and environmentally sustainable manner. In their new roles, transportation providers must interact and compete with other government departments and agencies, becoming more focused on making sound investments in transportation solutions that address strategic issues and needs. This change requires an increased emphasis on the careful allocation of funds to achieve the maximum benefits and outcomes of the research programs, transportation research being expanded beyond traditional infrastructure concerns by including new areas such as policy, economics, sustainability, and the environment. Consequently, transportation engineers have to broaden their knowledge bases so that they will become prepared to deal with these new areas of concern and as program and project managers, to be effective at planning and delivering their products and meeting their customers' needs. Thus, in the field of road transportation, responding to an aging highway network the agencies is shifting their emphasis from building new roads to maintaining existing systems and optimizing their capacity. In addition, the construction, maintenance, and operation of transportation facilities, which traditionally was provided by government entities, are increasingly being delivered by private-sector firms and public-private partnerships. The world's trading patterns and economies also have changed, and as communication networks continue to expand, additional change is inevitable. As economies expand from national systems to continental and global systems, new transportation issues and problems evolve in response and thus new research issues are emerging, challenging our professional ability to look beyond traditional borders for information, best practices, and potential partnerships. In this new environment, we must continue to imagine and to operate intermodal transportation systems that are efficient, safe, and environmentally sustainable. In this respect the envisaged research programs must demonstrate how they will support these goals while remaining responsive to the transportation profession's current and future needs. It is this balance between supporting current programs and trends and



R. Andrei

anticipating the future that allows research programs to best serve their customers, even in times of shrinking budgets. The recent advances in the fields of communication and information technology have had major impacts on research methods. Today, we have fast and convenient access to vast quantities of information. Electronic communication technologies have made the information available to transportation researchers, making the global knowledge more readily accessible. Improved communication tools and information resources, together with stronger partnerships with marketing and communications professionals, have contributed greatly to our ability to disseminate and implement the results of our research, these factors contributing to significant and benefic trends and changes in the conduct of transportation research such as financing and administration of transportation, information management, and implementation of research results.

Thus, to secure adequate research funding, transportation research organizations must closely reflect and support the strategic goals of society, most government transportation agencies now moving away from their old mission of solely providing and maintaining infrastructure, toward facilitating and enabling a broad range of integrated services, their research departments playing an important role in helping to achieve these new institutional objectives. Research programs with a strong policy and economic component will more likely be supported by their parent organizations, because they offer the resources and expertise that senior management needs to make wise strategic investment decisions, the research managers in transportation agencies being very often regarded as part of the strategic management process. It is envisaged that, in the context of global changes and increased demand for better use of limited resources, the research organizations that excel in the future will be those that pool their resources to work on common issues and problems. Transportation organizations must find new and innovative ways to finance their research. Cooperative partnerships are an important strategy for both maximizing the value of the research investment and reducing the duplication of effort. Cooperative research programs in the United States, in Europe and around the world are strongly supported, and all partners have a solid understanding of the value and benefits that result from sharing resources. Research collaboration, in various forms, has achieved a high level of prominence and partnerships between public, private, and academic institutions are common and are being used more frequently to leverage available funding for best results. The recently concluded Strategic Highway Research Program (SHRP) in US and the ongoing SHRP and RO-LTPP implementation programs are excellent examples of successful partnerships among governments, industry, and academia. In Europe, by pooling funds and expertise, through various COST<sup>4</sup> and SERP<sup>5</sup>

<sup>4</sup> COST-Cooperation Scientifique et Technique

<sup>5</sup> SERP-Strategic European Research Program





## *State of the Art and Future Trends in Transportation Engineering*

programs, and through various research bodies such as FEHRL<sup>6</sup>, ECREDI<sup>7</sup>, etc, the EC states are able to leverage their resources to study and develop solutions for a targeted list of problems over short (5-year) timeframes. In the foreseeable future, these arrangements will become even more common and will more often include multinational public and private sector partners. At the international level, the OCDE<sup>8</sup> administers research programs using pooled voluntary resources contributed by the member countries.

To justify their programs, today's research managers must be able to measure and discuss the performance, quality, and value of their programs in terms that support the strategic goals of senior management. A significant example in this respect is the ongoing COST Action 345 "Performance Based Indicators for Road Pavements", in which Romanian specialists are involved together with highway specialists from other ten European countries. Performance measures for research and development programs are currently a high priority among highway agencies. It is not enough to simply evaluate a program's performance, quality, and value. To develop and sustain support for a strong research program, researchers must proactively promote the value of research both within and outside the agency, by developing and perfecting their skills in marketing their programs and services. Today, transportation researchers also have better tools and training to carry out their work than their predecessors did. As the primary role of transportation agencies shifts from delivery of infrastructure to management of transportation services, research administrators need a broader set of management skills. Sustaining and improving the skills of the current research community and laying the groundwork for the next generation of highly trained and competent transportation researchers is a critical issue. Much work has been done to develop manuals, and courses that provide guidance and assistance in conducting research. The conduct of research will be treated in an even more systematic fashion in the future, and the emphasis on the application of superior research practices, scientific methods, networking, partnering, and marketing will likely increase.

Because organizations with sound fiscal management practices do not spend time or money duplicating research that has already been conducted and verified, comprehensive information on the state of the art and practice must be readily available. Information based on published reports and journals, research in progress, and human expertise can be found and retrieved by using a wide variety of manuals and electronic sources, which include bibliographic and statistical databases, library catalogs, and web sites. The value of information and information services is gaining recognition among transportation researchers. A

---

<sup>6</sup> FEHRL -Forum of European Highway Research Laboratories

<sup>7</sup> ECREDI-European .....

<sup>8</sup> OECD- Organization for Economic Cooperation and Development



R. Andrei

recent study by FHWA<sup>9</sup> found that the money spent on information services can yield benefit-to-cost ratios in excess of 10:1. The value of information can be measured in terms of reduced costs of agency research, technology development, and operations, quicker implementation of innovations, time savings, and more effective decision making at all levels of the agency. Transportation professionals from all over the world are becoming more aware of major transportation research resources such as the Transportation Research Information Service (TRIS) and the International Road Research Documentation (IRRDP) database, as well as less focused sources. These resources provide access to the global network of research information and hence improve the quality of research and make more efficient use of resources. As the amount of information proliferates, the importance of the role of the information professional has become better understood and more prominent. Research librarians and information specialists—trained and skilled in the integration, analysis, and management of information—now are recognized as important members of the research team. Information professionals will play an important role in the organization and retrieval of web-based information systems in the future. Other information management initiatives have sprung up in recent years. For example, information clearinghouses are being developed that compile, organize, and disseminate information on high-priority topics such as those of intelligent transportation systems, work zone safety, and transportation demand management. Concern for the timely reporting of current research is of growing interest. Information databases are only as useful as the information they contain, and research organizations are increasingly motivated to report new projects as they begin. New technologies are being developed and used to facilitate information gathering, making it easier for researchers to contribute information about their work to major international databases. So, information technology will continue to advance rapidly and significantly affect the way we exchange information, acquire new knowledge, and conduct transportation research. Issues involving the organization, storage, and retrieval of information present some of the greatest challenges that need to be addressed in the coming years. The preservation and archiving of printed transportation research documents (to ensure that documents are not lost as a result of age or deterioration) is another important concern. Finally, serious efforts must be taken to analyze and organize the volume of information being made available through web-based Internet sites, through either better design or integration of the sites as they are developed, or improved sophistication of tools that enable users to search for information across multiple web-sites.

The benefits of applied research will be realized only after the research products are implemented in the field. The information and communication tools described

---

<sup>9</sup> FHWA- Federal Highway Administration, USA





## *State of the Art and Future Trends in Transportation Engineering*

earlier can be used to help market innovative technologies and strategies for improving our transportation system. However, having the ability to quickly and efficiently access information about the latest research will not guarantee that the research products will be put into practice. Many barriers to the implementation of research results—resistance to change; the complexity of effective communications; and the cost and inconvenience of personal contact, which often is the most effective way to disseminate information about and learn to adopt new technologies—remain to be demolished. The concepts behind technology transfer and its practice have received considerable attention from the transportation community during the past decade. Technology transfer generally refers to a strategy or process for bringing appropriate practices or technologies to the attention of the transportation practitioners who can benefit from them. Technology transfer has been described as a process that links research and implementation; however, it is more accurately described as an effective communication process that links information with the people who can benefit from it. Technology transfer involves packaging and communicating information in a manner most appropriate for its target audience. Technology transfer has a tremendous potential to optimize the operation of transportation systems cost-effectively, by reducing or eliminating duplicated effort and by facilitating the implementation of best practices and relevant technologies. Technology transfer in transportation will continue to expand, and the most effective practices for technology transfer will become more widely disseminated. Transportation agencies, seeking ways to hasten the implementation of research results, are increasingly encouraging or requiring researchers to develop implementation plans as part of the research process. In the future, we probably will see even stronger ties between the research and implementation phases of innovation processes.

### References:

1. TRB Transportation in the New Millennium State of the Art and Future Directions
2. Manning P., Transportation Education. TRB/ A1A04: Committee on Transportation Education and Training
3. Hedges C, Harrington-Hughes C., Carr P, W., Current Practice and a Look Forward TRB/ A5001: Committee on the Conduct of Transportation Research

