BUILDING PROFESSIONAL CAPACITY IN ITS:

GUIDELINES FOR DEVELOPING THE FUTURE PROFESSIONAL

US Department of Transportation
ITS Joint Program Office
ITS PCB Program

April 1999

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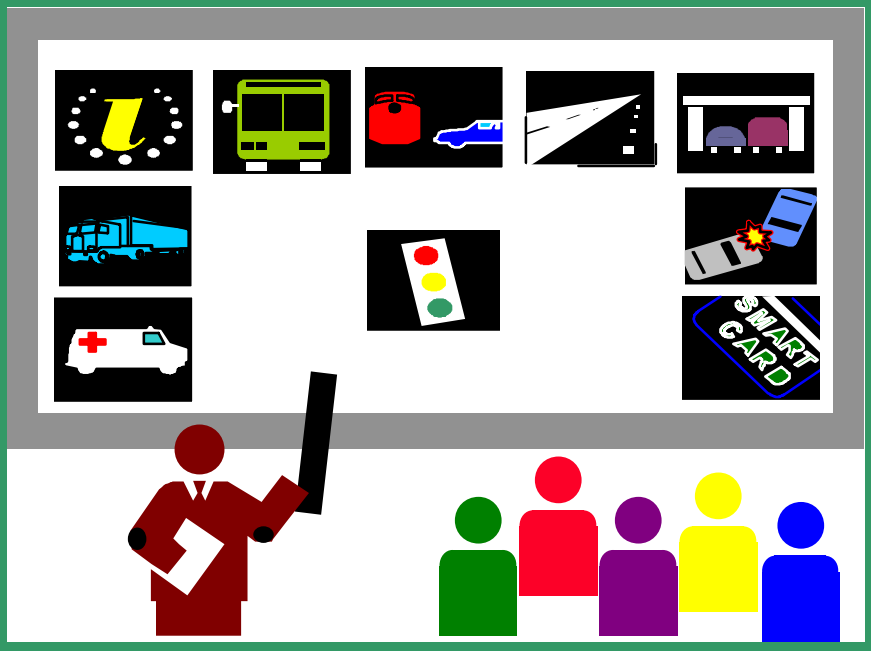
Guidelines for Developing the Future Professional



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Foreword

This report summarizes a comprehensive effort conducted in the summer of 1998 to more systematically investigate the intelligent transportation systems (ITS) training and education needs of transportation professionals. A team of analysts conducted a series of nearly 200 interviews in an effort to obtain a more detailed understanding of the underlying fundamental knowledge and skills required in support of ITS applications and services. The interviewees spanned a range of ITS involvement from those actively engaged for several years, to those just beginning the process. Thus, the reported needs reflect an important "grass-roots" perspective obtained from the public-sector, private-sector, and the academic community.

This report documents the wide-ranging ITS training and education needs of transportation professionals. An analysis of those needs resulted in the development of a PCB Program strategy to meet those needs both now and in the future. Although the focus of this work is ITS, the analysis also revealed that the fundamental knowledge and skills are applicable to a wider audience of transportation professionals engaged in the operation and management of multimodal surface transportation systems.

The ITS PCB Program is comprised of a partnership or organizations which work cooperatively to provide ITS professional capacity building. That partnership encompasses the public sector, the private sector, and the academic community. It is hope that this report will be used as a foundation for ongoing dialogue with the multiple partners, stakeholders and transportation professionals everywhere about:

- The process of building professional capacity for ITS;
- The design and delivery of training and education programs that achieve the level of competency required for meeting the challenges of 21st century transportation systems; and
- The most effective and cooperative programmatic ways to meet training and education needs in ITS.

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- The Volpe National Transportation Systems Center (VNTSC)
- The Federal Transit Administration's ITS Program
- The Federal Highway's National Highway Institute (NHI) and Office of Personnel and Training.

The VNTSC project director was Suzanne M. Sloan, assisted by Mary Susan Sparlin of NHI. Key staff support from the Volpe Center was provided by Robert Brodesky, Joseph LoVecchio, Maureen Luna-Long, John O'Donnell, Douglas Rickenback, and Margaret Zirker.

The authors wish to thank the many individuals, located across the country, who took the time and made the substantial effort to arrange for the staff interviews that were so critical to this effort. Also, thanks is gratefully extended to the nearly 200 interviewees and the training and education experts who were willing to be interviewed and whose excellent contributions of information and guidance have greatly benefited our work.

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INTRODUCTION

This report presents a set of guidelines and recommendations for developing the "future transportation professional." The introduction of intelligent transportation systems (ITS) technologies to transportation broadens the focus from the building and expansion of physical infrastructure, to include the operation and management of existing infrastructure with newly developed high-technology tools and applications. This expansion changes the skill set required of transportation professionals.

A series of nearly 200 interviews with current transportation professionals, conducted in the summer of 1998, helped identify a set of competencies recommended for the next generation of transportation professionals. In particular, ITS requires skills that venture beyond the borders of traditional civil engineering to include a technical breadth and depth in information, sensing, and computer technologies; systems, telecommunications, and electrical engineering; and in the design and installation of new ITS applications. It also requires a broader understanding of institutional issues such as interagency cooperation, coalition building, and public and private sector partnerships, necessitating new skills in partnering, contracting and negotiations, applying new business and organizational skills, and enhanced verbal and written communications skills. In addition to increased technical and institutional breadth and depth, future transportation professionals will need to operate and manage from a systems perspective.

These new competencies tend to be in addition to the ones already required in formal degree programs; thus, academic institutions face the challenge of how to provide the required foundation with an additional high-technology focus to prepare students to be 21st century transportation professionals.

The intended audiences for this report are faculty, students, and others who are developing future professionals for the 21st century. Guidelines and recommendations are presented in three parts:

- The first section presents the essential characteristics of future professionals who will be engaged in ITS and the operation and management of transportation systems.

- The second section recommends actions to a range of educational institutions and audiences — from K-12 to technical and vocational schools to universities and colleges.

- The third section recommends actions for the U.S. DOT PCB Program and its partners to assist in developing future professionals.

Appendix A presents a series of brief summaries of the reports and articles included in the literature review. Readers who are interested in a more academic treatment should review these.

Appendix B provides the bibliography.

Supporting Documentation

This report is one in a series of reports presenting ITS training and education needs of transportation professionals. The primary report, for which the needs assessment was conducted, is titled, *Building Professional Capacity in ITS: Documentation and Analysis of Training and Education Needs in Support of ITS Deployment.* This report on future professionals is included as an appendix to this broader report, in addition to being issued as a stand alone document.

In addition, there are two companion guideline reports that emerged from this broader effort (and are also appendices to the primary report). They are:

- *Building Professional Capacity in ITS: Guidelines for Designing an Individualized Training and Education Plan,* is a guide for transportation professionals who are interested in building their own professional capacity in ITS.

- *Building Professional Capacity in ITS: Guidelines for Staffing, Hiring, and Designing Ideal ITS Project Teams,* is a guide for decision makers who are responsible for staffing, hiring, and designing project teams for ITS. These decision makers must consider not only the competencies of current staff, but also anticipate the qualifications of future staff and/or of team members from other agencies. This guide presents strategies and programs for building and maintaining organizational professional capacity.

In addition, a set of transit specific findings and recommendations are highlighted in a separate report titled:

Building Professional Capacity in ITS: An Assessment of ITS Training and Education Needs — The Transit Perspective.

All of these reports are posted to the ITS PCB Program web site (www.its.dot.gov/pcb/pcb.htm) and the ITS Electronic Document Library (http://www.its.dot.gov/welcome.htm).

Section I – Characteristics of Future Transportation Professionals: Interview Findings

The transportation professional of the future will be required to have both breadth in several disciplines, and depth in a number of specific areas. A series of ITS site interviews, focus groups, and telephone interviews revealed a need for a new cadre of professionals. Current transportation professionals indicated that their priority when hiring is to seek candidates who are electrical engineers with knowledge of telecommunications and transportation. Managers look for civil engineers with some depth in electrical engineering and computer science. Managers also look for candidates with management and business skills and excellent interpersonal and communications skills. Interviewees also noted that often the most valuable skills are adaptability and creativity, coupled with the ability to apply them to practical, real-world needs. Many agencies said they would rather hire someone with a broad education and practical experience, than a person with an advanced degree with little real-world experience. However, such individuals are not only difficult to find but also difficult to retain if hired, given the competition from the private sector.

As part of the interviews, participants were given a survey and asked to indicate which knowledge and skills they deemed most important for ITS. The following is a summary of specific topics that were proposed, by current professionals, as critical to the transportation professional of the future:

Systems Integration — This essential competency requires the recognition that a comprehensive regional transportation system is made up from a number of individual projects carried out by a variety of transportation organizations. The "system" encompasses all of the individual projects, even though each is complete and functional in its own right. On a more detailed level, systems integration refers to the specific components or devices required by the individual projects and how they are related. Each device's internal performance, its communication links to other devices, data input/output or manipulation, and control mechanisms are part of a complex chain with many potential "weak links." The devices must work properly and communicate accurate and timely information to be of practical use. Specific knowledge of the various technologies and their application is necessary for this purpose.

Managing Contractors — ITS deployments require management skills not found in traditional government-contract relationships. Since managing outside contractors is such an important part of most ITS deployments, it is especially important to understand both the contractor and the public sector agency point of view. The ability to manage contractors requires continual support throughout the deployment process. It starts with the writing of good functional specifications for the "request for proposals," and continues to the development of detailed contract documents that are clearly stated and understood. A sound knowledge of scheduling using Gantt charts and budget management is also important.

Contracting Options — Contracts outline a schedule of deliverables defined for a specific project. Given the intricacies of advanced technology procurements, it is important that transportation officials know alternative types of deployment contracts such as design/build, low-bid, fixed price as

well as special clauses to be included in contracts. Examples of the latter include clauses specifying responsibility and liability of involved partners, clarification of software and hardware sharing issues between States and other jurisdictions, source code ownership, acceptance testing and operability, warranties, and inclusion of training and performance standards.

Software/Hardware Specifications — Software is a critical component of virtually all ITS projects. Interviewees noted that they would like to know the basics of writing code and how computers talk to each other using local area networks and wide area networks. They would also like a more detailed understanding of software programs and relational databases. Since hardware must be carefully selected to be an efficient platform for the desired software, knowledge of hardware device options is important.

Project Management — Project management requires the ability to take a project from its early conception stages to completion. It includes creating "requests for proposals" that adequately reflect end-user needs, scheduling and financially managing both staff and contractors, particularly individuals with strong ITS-related technology based expertise. A sound knowledge of data management and its usage in data sharing arrangements with other transportation agencies is also important. Excellent communication and facilitation skills are crucial.

Data Management — The proliferation of data collection devices, the need for public agencies to continually deliver "more for less", and the advances in database technology create a situation where so much information is available that it can often be overwhelming. The essence of many ITS devices is the data they produce; and the value of the system is closely related to how that data is used. Effective data management involves many issues such as data consistency and accuracy, data sharing with other agencies, compatibility and conversion to other systems, data archiving and storage, analysis and interpretation of data, and privacy. Knowledge of database design, manipulation, and data import/export is needed.

Data Evaluation — Data evaluation requires determining the effectiveness of a program and identifying where improvements can be made. For example, traffic speed and volume data evaluation is particularly needed on the highway side. Schedule planning and fleet data evaluation is needed on the transit side. Strong statistical and analytical skills are needed to undertake these activities.

Section II – Recommendations: Suggestions and Activities for Implementing Change

Ideally, recent college or university graduates would come to the job with fundamental education skills, ready to hit-the-ground-running. In practice, this would be too much to hope for and impossible to achieve. Interviewees made numerous suggestions that included curriculum changes in undergraduate and graduate civil engineering programs (the predominant source of transportation professionals) to incorporate concepts in electrical engineering, telecommunications technologies, systems

engineering, software development and basic electronics. Several interviewees recommended that a course on project management be included with emphasis in economics, business, public agency organization, and the political process. Also, in an ideal world, electrical engineering and computer science majors interested in transportation would take a "Transportation 101" course that included fundamentals in traffic engineering and transportation systems analysis, so that these professionals could see how their skills apply to transportation problems.

Based upon the current field interviews and previous studies the following recommendations for actions are offered. They are divided into the following seven categories:

1. Pre-college programs
2. Community and junior college programs, and technical schools
3. Undergraduate programs
4. Graduate programs
5. Continuing education programs
6. Educating the educators
7. Innovative delivery media

1. PRE-COLLEGE PROGRAMS

Although not necessarily included in a substantive or explicit way in previously referenced work, there is continuing concern that the industry must appeal to the interests of young people at an early stage in the education process in order to attract them to the transportation profession. A recent study sponsored by the American Society of Civil Engineers (see Appendix B) found that the average American feels uninformed about the engineering enterprise, and has very little understanding of the significance and importance of the engineering discipline. Further, there is a limited understanding of the role of science and technology and its impact on society. The transportation profession, being just one of the individual engineering disciplines, is just as likely to be misunderstood or overlooked by young people who are thinking about a career.

Current Activities

There are several national programs available to help fill that void, which should be expanded upon and nurtured by the profession. Two of note are the:

- Garrett A. Morgan program, sponsored by U.S. DOT
- the Transportation Civil Engineering Research Activities Centers (TRAC) program, sponsored by U.S. DOT and the American Association of State Highway and Transportation Officials.

Another example is the Texas Transportation Institute (TTI) program for cultivating new professionals early. In conjunction with the Southwest University Transportation Center, TTI has launched a pilot program to develop educational and outreach materials designed to target age groups from kindergarten to high school seniors. In addition to materials and internet access, the program includes classroom visits as well as tours of local transportation facilities and traffic management centers.

2. COMMUNITY AND JUNIOR COLLEGES AND TECHNICAL SCHOOLS

These institutions play an essential role in developing future professionals for ITS. First, there is and will continue to be a demand for many categories of highly skilled technicians such as electronic maintenance technicians or system operators. Education programs must be established to expand that pool of talent. Second, these institutions could instill an interest in transportation among students who might not otherwise recognize the opportunities provided by the transportation profession. This could lead to increased enrollments in four-year undergraduate transportation programs.

Finally, these institutions provide an excellent venue for continuous education for professionals in specific technical areas. However, such events will not take place without a concerted effort to facilitate and encourage such actions by the public sector, the private sector, and the academic community.

Current Activities

A number of community and junior colleges offer transportation or related programs for future professionals. However, our research did not explore this important topic further.

3. UNDERGRADUATE PROGRAMS

The findings of the interviews and literature review reveal that undergraduate transportation programs need to be carefully re-evaluated to consider the new challenges being faced by transportation professionals. Each university will no doubt continue to debate these issues for some period of time; a number of experimental programs will no doubt be carried out. The previous insights on competencies viewed as essential by current practitioners, together with several recommendations made by noted academicians lead to the following suggested curriculum guidelines to consider at the undergraduate level:

Fundamentals

- Basic mathematics and science
- Systems engineering concepts
- Advanced materials
- Advanced sensors
- Modeling
- Computer software
- Computer hardware
- Information technologies
- The interrelationship between technology and society
- Economics and business analysis.

Electives – Essential Non-Technical Skills

- Oral and written communications
- Project management
- Social, environmental impacts, public-private relationships
- Political science
- Planning
- Interpersonal relations.

- **Other bachelor-degree level programs.** Traditionally, a majority of transportation professionals have come from the civil engineering profession. However, in recent years, and particularly in those instances where ITS deployment is moving ahead rapidly, other disciplines have become essential. They include electrical engineering, computer sciences, systems engineering, mechanical engineering, and information technology. In addition, it has become apparent that many non-technical disciplines are required as well. They included human factors, planning, environmental analysis, economics, political science, and legal expertise.

  There is no doubt that it would be difficult to incorporate "transportation" courses into those non-engineering disciplines, unless an individual were particularly interested in the topic. However, in these cases, training in basic transportation systems would be desirable in order to groom individuals to the tasks to be undertaken. To accomplish this objective, cooperative inter-departmental programs would be required within the university environment.

  It is recognized that to address all these areas in a period of four years represents a challenge for the educational community. Many will argue that the time is too short and that five or more years are needed. As seen from the field interviews of ITS professionals, graduates from universities, after spending several years in the field may discover that there are subject areas for which they lack specific training. They may reflect on their undergraduate education and conclude that additional courses should have been offered to meet specific work related requirements they now face. However, the undergraduate experience should be viewed as preparation to begin a professional career (where more in-depth training will be required) or to pursue graduate study as a way of developing more depth in particular areas. Thus, an appropriate balance must be found.

- Finally, opportunities must be established to undergraduate students to help provide practical on-the-job training as part of internships, cooperative education programs, summer jobs, applied research projects and mentoring programs. Closer partnerships with government agencies and the private sector will assist undergraduates in relating fundamental knowledge to real-world issues. This could be established through work-study programs and applied research projects.

Current Activities

Some universities have already embarked upon the kinds of modifications suggested above with a focus in three areas:

- Incorporation of ITS knowledge and skills into existing coursework.
- Development of full semester ITS education modules/courses.
- Restructuring of undergraduate degree curricula.

Virginia Tech's Center for Transportation Research, in cooperation with U.S. DOT's ITS PCB Program, recently published a catalog of university ITS offerings titled, *Intelligent Transportation Systems Education and Training Efforts at U.S. Universities: Course Catalog.* In three parts, it lists **Full Semester ITS Courses; Short Courses, Workshops, and Other ITS Offerings**; and **Courses Modified to Include ITS Concepts**. IT can be accessed on the Virginia Tech's Center for Transportation Research web site at: www.ctr.vt.edu/catalog/toc.shtml.

4. GRADUATE LEVEL PROGRAMS

A number of universities have already begun the process of modifying existing graduate courses in transportation, and developing new degree programs. The following section provides some examples of these programs. There are other significant developments in graduate level programs, either in place or being considered. This is being addressed by the Council of University Transportation Centers

Another view on this topic was presented recently by the American Society of Civil Engineers (ASCE). In a recently published article, the ASCE Board of Directors approved a new policy statement supporting the concept of the Master's degree as the first professional degree for the practice of Civil Engineering. That body stated, "The Civil Engineering Profession is undergoing significant, rapid and revolutionary changes, demanding a much higher level of knowledge and experience of new engineers than of previous generations…..Today's engineers must have skills in computer applications, information technology, management, communications and foreign languages, as well as fundamental engineering skills. They must also grasp the political, economic and social implications of projects." The above recommendations from the ASCE Board of Directors were not focused on Intelligent Transportation Systems. Rather, they applied to the entire Civil Engineering profession, which traditionally has included transportation as a major discipline.

The significant connection here is that the findings from the field interviews support the recommendations for both under graduate and graduate level programs discussed above. It is hoped that the identification of the competencies required for ITS provide the more detailed guidance needed by universities to develop programs best suited for their specialty areas. These competencies are found in more detail in the report, *Building Professional Capacity in ITS: Documentation and Analysis of Training and Education Needs in Support of ITS Deployment.*

Current Activities

A number of universities are pursuing changes as the ones described above. One example is the University of Michigan which is in the process of establishing a new two-year "Masters of Engineering in Transportation." It is an interdisciplinary degree program in the College of Engineering having five focus areas and four requirements:

Five Focus Areas	
(1) Vehicles	• Mechanical Engineering • Aerospace Engineering
(2) Physical infrastructure	• Civil Engineering
(3) Information technology	• Electrical Engineering
(4) Human factors	• Industrial and Operations Engineering • Ergonomics
(5) Systems	• Industrial and Operations Engineering • Electrical and Systems Engineering • Civil Engineering

Four Requirements	
Depth	Course requirement satisfied by courses taken in the major focus area or sub-area;
Breadth across engineering	Course requirement satisfied by introductory course and engineering courses taken outside of the major focus area;
Breadth beyond engineering	Course requirement satisfied by Mathematics, Statistics, Urban and Regional Planning and other courses
Team project experience	Industrially relevant team project requirement.

Other universities are pursuing similar activities to establish new degree programs or restructure established programs to reflect the inter-disciplinary nature of the job market.

5. CONTINUING EDUCATION PROGRAMS

It is very clear that continuing education programs at the college and university level are an essential part of ITS professional capacity building. There are several compelling reasons for this need:

- As stated earlier, the bachelors degree in any professional discipline must be viewed as only the first stage of a continuous learning process for all professionals. The same is true for the masters level, even though this is in a specialty area. Technological change, environmental and social change, and all the elements of current society are rapidly evolving. Thus, every professional needs to take advantage of continuing education programs to stay current in all professional disciplines.
- Continuing education programs can be designed to eventually lead to graduate programs in many areas. This provides motivation for individuals, and opportunities for universities.
- Colleges and universities have much more flexibility in designing new programs for busy professionals and are thus well-equipped to address many of the new demands for education suggested in this chapter.
- Building upon the competencies required for ITS deployment, universities can offer training for current professionals in critically needed areas. This provides just-in-time delivery to meet current needs.
- Potential students need tailored courses of study to meet their own individual needs. Continuing education programs can be designed to be flexible enough to deal with changing demand and immediate needs.
- Certificate programs can be established to provide students with specific skills needed to plan and deploy surface transportation projects.

Current Activities

Numerous universities are now engaged in these activities. For instance, Penn State University has worked closely with Penn DOT to offer continuing education courses for a number of years. A number of other universities around the nation offer similar programs in conjunction with their state DOTs. Also, FHWA sponsors the Local Technical Assistance Programs (LTAP). The LTAP serves as the primary channel through which innovative transportation technology is prepared and delivered to urban and rural communities throughout the United States. There are 57 centers (one in each state, one in Puerto Rico and six for American Indian tribal goverments) that provide training and technical assistance to local government. Each center is a partnership of federal ,state, and local agency resources as well as universities and the private sector. More information can be found at the web site: www.ota.fhwa.dot.gov/about/ltapover.html.

6. EDUCATING THE EDUCATORS

College and university faculty engaged in directly related research programs are in an ideal position to bring up-to-date research results into the classroom. This is one of the best ways to remain current and to transfer technology to the classroom.

However, not all universities are research-oriented. Thus, it may be difficult for faculty members to keep up-to-date on the latest technological and related developments. This leads to the conclusion that targeted education programs need to be designed specifically for faculty during summer or sabbatical leaves. This is a new challenge that can be addressed by the U.S. DOT Professional Capacity Building program. But, it can also be addressed by encouraging the private sector to work closely with universities through cooperative application of transportation programs.

Current Activities

This happens now through conferences and workshops. This is a topic worthy of more discussion.

7. INNOVATIVE DELIVERY MEDIA

There is clearly a need for education to be delivered by a combination of available media, including:

- Traditional classroom
- Distance learning via satellite or teleconference
- Web-based
- CD ROM-based

Individuals need “just-in-time” delivery of training, education, technical assistance and information required to do their jobs. Distance learning media provide the tools necessary to deliver and meet those needs.

Current Activities

Many universities are now actively developing distance learning in order to deliver courses, certificate programs, continuing education programs, and degree-granting programs. This is a growing trend throughout the Nation. More information on distance learning for ITS education can be found in the report, *Building Professional Capacity in ITS: Documentation and Analysis of Training and Education Needs in Support of ITS Deployment.*

Summary and Conclusions

Recommendations on how to prepare transportation professionals for the 21st century are not new or startling; it is important to note that those made by practitioners in the field are very consistent with the recommendations made by several prominent academicians whose work is summarized in Appendix A. However, the results of the field interviews do highlight several important directions to consider:

- *Education must be a continuous, lifelong endeavor.*
- *Attracting bright young people to transportation* and educating the transportation professionals of the future should begin well in advance of the college years.
- *Education programs must be viewed in a comprehensive way*, that consider community and junior colleges, technical schools, undergraduate and graduate programs, continuing education programs and new delivery media.
- Given the rapid advances in transportation technology, *programs must be established for transportation faculty and working transportation professionals* to assist them in keeping up-to-date.
- *The need for more comprehensive courses and programs at the college and university level* is a growing concern for both the "operations" segment and the "infrastructure" segment for undergraduate transportation programs. Those programs are already burdened with increasing demands for more information to be incorporated in existing courses or in new courses. This is a significant constraint that must be addressed. However, it appears that there are common needs in technology requirements that are applicable to both transportation infrastructure and operations purposes. The challenge is to identify these common needs.

Section III – Role of the ITS PCB Program: Recommendations and Actions for Supporting Change

The ITS PCB Program has an important role in helping to meet these goals. The ITS PCB Program is comprised of a collaboration of many organizations which bring different strengths and expertise to bear on building ITS professional capacity. The PCB partners are drawn from the private sector, the public sector, and the nation's universities to develop and deliver the comprehensive, national transportation training and education initiatives required to create the transportation professional of the 21st century.

ITS PCB Program Partners

Public Sector Organizations	Academic Institutions	Private Sector Organizations
• The ITS Joint Program Office • The U.S. DOT ITS PCB Program • FHWA and NHI • OMC and NTC • FTA and NTI • ITS America (ITSA) • Non-profit professional associations • State and local programs	• Undergraduate degrees at universities and colleges • Graduate degrees at universities and colleges • Continuing education • Community colleges • Technical and vocational schools • Pre-college programs	• Private sector training organizations • Vendors of ITS equipment • Consultants and corporations in the deployment, systems integration, and operations business • Professional associations with private sector membership

Role of the U.S. DOT PCB Program

The role of the U.S. DOT's program has been to establish partnerships among other organizations, and to define critical topics in ITS professional capacity building, namely:

- The full range of competencies needed for ITS deployment;
- The initial course and seminar offerings for ITS professional capacity building; and
- The preliminary definition of the role of PCB partner organizations.

The U.S. DOT's ITS PCB Program has also accomplished the following to address the needs of future transportation professionals:

- Helped to organize and support the organization of two forums to discuss the role of universities in ITS professional capacity building, one at ITS America in February 1997 and one at the Transportation Research Board's (TRB) Annual Meeting in January 1999.
- Provided matching funding to a university to develop the university catalog.
- Leveraged funding to cost-share on the development of future ITS distance learning initiatives.

It is important that this and the other PCB guideline reports be used as the foundation for ongoing dialogue with the PCB partners. We will continue to work with the universities to help achieve our mutual goals.

Role of Academic Institutions

Academic institutions — Universities and Colleges, Continuing Education Programs, Community/ Junior Colleges and Technical/Vocational Schools — are partner's that bring research strengths and teaching expertise to building ITS professional capacity in future professionals. They have and will continue to play a critical role in a wide variety of program activities such as:

- Develop and/or update professional capacity building materials and programs for current professionals; Integrate PCB materials into courses and degree programs for future professionals.
- Deliver ITS professional capacity building to target audiences (working professionals and future professionals) using the ITS "model" curricula.
- Monitor the demands and motivations of their membership and continually assess their ITS training and education needs (for a needs assessment framework, refer to *Building Professional Capacity in ITS: Documentation and Analysis of Training and Education in Support of ITS Deployment)*.
- Build awareness of the ITS Professional Capacity Building program.
- Help their members gain access to PCB information and materials.
- Share presentation materials with other groups, allowing them to adapt materials to audiences as needed.

Based on these roles, the following actions can be taken by the PCB academic partners to assist in the overall PCB efforts:

Immediate Actions

- Access the course and seminar materials of the U.S. DOT ITS PCB Program. Review them, modify them to meet audience needs and incorporate them into degree programs and curricula.
- Develop and deliver new ITS courses to future transportation professionals, as part of degree programs, and to current professionals as part of continuing education programs.
- For those with existing ITS courses and workshops that are delivered through traditional classroom teaching, consider using innovative media to reach a wider audience.

Near-Term Actions

- Work with the U.S. DOT ITS PCB Program to develop new courses that meet the top ten most critical learning needs of current professionals. Again, review and incorporate these courses into degree programs and curricula.
- Work with the U.S. DOT ITS PCB Program to develop hands-on workshops that teach skills.
- Work with the U.S. DOT ITS PCB Program to develop "model" curricula through a series of workshops and forums.
- Assist the U.S. DOT's PCB Program in training-the-trainers.
- Conduct needs assessments to target PCB course and seminar materials to local audiences.
- Assist in developing distance learning initiatives.

Appendix A: Brief Summaries of Previous Studies on Education Needs

It is recognized that there are no definitive or clear-cut answers to the question, "How should we educate the transportation professional of the future?" Universities are already in the process of attempting to answer that question by carefully evaluating their own transportation education programs. It is expected that the results of this project will assist those efforts.

Earlier studies and thoughtful papers prepared by academicians provide an excellent base to work from, as the report moves toward identifying the fundamental competencies that need to be taught at the university level. Following is a summary of the results from some of those studies, conferences and papers. They are:

(1.) "Intermodal Transportation Education and Training," TRB Conference Proceedings

(2) "Developing a Market Sensitive ITS Education Program," by Boile, Spasovic and Pignataro

(3) "Professional Education in Transportation: A Prototype Masters in Transportation" by K. J. Steffel, Texas Transportation Institute

(4) "Educating the 'New Transportation Professional'," by Joseph M. Sussman, MIT.

(5) "Transportation Education for the 21st Century," Lester A. Hoel, University of Virginia.

(6) "Ideas for ITS Education and Training: Coordination Among Institutions," Kan Chen.

(1.) "Intermodal Transportation Education and Training," TRB Conference Proceedings

Core competencies should be defined by academia and stakeholders for all levels of entry into the workforce. The concept of core competencies was viewed by many (at the conference) as a key point of departure for education and training programs. These core competencies should be developed jointly by all major stakeholders and constituencies and should provide input for program development.

Conference participants identified a set of competencies or skills that could apply to any level or position as well as to any field in transportation. These "core competencies" included the following:

- **Technical competence:** No matter what the task, individuals must be technically competent to perform it successfully.
- **Teamwork*:*** Being able to work effectively as a team is becoming one of the most critical characteristics of today's workforce.
- **Role of measurement**: Implied by measurement is any level of mathematical reasoning, from basic mathematical skills to the development of mathematical models.
- **Communications*:*** One of the important needs, and a real challenge to educators, is developing student skills in technical communications.
- **Critical thinking:** Referred to by some as "problem solving," in essence this skill involves the ability to figure out the logical path from an existing status to a desired one.

These core competencies are generic in the sense that they could be applied to any type of position. Conference participants also identified higher-level skills and knowledge that were appropriate for those involved with intermodal transportation:

- **Customer orientation:** Given the market context for intermodal transportation, the transportation workforce must understand customer desires and needs.
- **Systems perspective:** Intermodal transportation requires a systems perspective in the planning, operations, and management of services and facilities.
- **Economics and forecasting:** A basic understanding of how economies operate and how transportation fits into this economic context is needed.
- **Data, modeling, and information systems:** In a complex world, transportation officials need to understand how to use data in a decision support context, which could include developing models and information systems.
- **Basic research understanding:** These skills include developing research designs, conducting experiments, and drawing conclusions.

As an example of how different levels of competency can relate to different levels of education, one conference group developed illustrative programs at different levels of entry for those interested in ITS. For example, two-year programs should include computer-assisted drafting and design (CADD), computer programming, electronics, quality control, and traffic control systems. Undergraduate programs should include a broad understanding of other engineering disciplines, crosscutting skills such as those in communications and business, and problem solution. Graduate programs should include broad knowledge of a major field and a subspeciality, computer tools, ITS and management information systems, and related multi-disciplinary courses.

(2) "Developing a Market Sensitive ITS Education Program," by Boile, Spasovic and Pignataro

Relevant excerpts from that paper include the following:

- There is a consensus between public and private sectors on the one hand, and academia on the other, on the importance of an "ITS education." An ITS education on both the graduate and undergraduate level is essential.

- It seems that the academic programs are aware of the educational needs of the private and public sectors in ITS and have been reacting to those needs. Academic institutions are improving their existing curricula to reflect the role of ITS by either introducing new courses, or revising existing courses to include course-related ITS aspects.

ITS is an interdisciplinary area. The nature of the interdisciplinary aspects of ITS is reflected in the existence of ITS groups consisting of professionals from various backgrounds and educational levels. This is especially true in the private sector. A traditional civil engineering curriculum needs to be revised to better educate engineers in ITS, thus the ITS educational program must be inter (or cross) disciplinary. The interdisciplinary element should facilitate team work in "ITS Groups" of the private-public sector organizations which, according to the survey, consist of engineers, non-engineers, and technicians from many different disciplines.

- Students should be educated in areas that are not traditionally part of civil engineering education. These include communications, traffic surveillance, systems analysis, social and institutional issues.

- A dedicated degree in ITS is not considered to be essential, since, as some respondents are concerned, it could confine ITS education to several narrow courses. However, a core ITS program open to various disciplines such as civil, systems, electrical, computer, industrial and mechanical engineering; and computer, information, planning, management, and social sciences will help students from various disciplines to acquire a proper ITS education, and relate their careers to ITS needs.

- ITS projects are accomplished by groups; thus team work is essential. To prepare students for this, it is important that their ITS educational experience incorporate teamwork with students from various disciplines working together. It seems that the academic programs have recognized this and are emphasizing teamwork through student involvement on real-world ITS projects.

(3) "Professional Education in Transportation: A Prototype Masters in Transportation" by K. J. Steffel, Texas Transportation Institute

This report states:

> *"Current transportation education, as seen from the survey results and supported by Shen and Sheridan, 1991, occurs mainly through civil engineering curricula. The transportation environment is rapidly changing, and transportation policy-makers face challenges beyond the design and construction of the transportation system. The next generation of transportation policy-makers must have not only technical skills and an understanding of systems and their operations, but also sufficient management and "people" skills. These skills will help them to meet the challenge of comprehending and fulfilling the demands of society (ITE, 1990; Khisty, 1988). In addition, they must do so in a politically influenced climate and make decisions with a decreasing allocation of already limited resources (Khisty, 1988). Therefore, to account for the evolution of the transportation environment, the transportation education curriculum must be reformulated."*

Based on this insight, TTI recommended a new graduate level program to create a multi-disciplinary graduate transportation degree that would shift the focus from a single discipline to multiple academic areas. The new degree would go beyond current inter-disciplinary programs, giving relatively equal weight in three main areas: Systems Analysis & Design, Transportation Planning, and Management and Economics, supplemented by other electives.

- **Systems Analysis & Design —** The engineering college will coordinate this subject area. Course requirements would include:
  - *A Newly Designed Composite Core Class;*
  - ITS;
  - Traffic Flow/Modeling/Engineering;
  - Highway Engineering and Design;
  - Materials;
  - Transportation Systems Engineering and Operations;
  - Infrastructure Engineering;
  - Environmental Engineering.

- **Transportation Planning —** The urban/city/regional planning colleges will coordinate this subject area. Course requirements would include:
  - *A Newly Designed Composite Core Class;*
  - Transportation Planning and Analysis;
  - Community and Regional Planning;
  - GIS and Computer Graphics;
  - Planning Theory and Methods;
  - Environmental Impact Assessment.

- **Management and Economics —** The business and economic colleges will coordinate this subject area. The course requirements would include:

  - *A Newly Designed Composite Core Class;*
  - Management;
  - Budgeting and General Accounting;
  - Transportation Economics;
  - Financial Management;
  - Logistics;
  - Public Finance;
  - Economic Development;
  - Public Policy;
  - Human Factors and Resources.

- **Other Electives**
  - Public Speaking;
  - Technical Writing;
  - Speech Communications.

Specifically addressing the topic of undergraduate curriculum are several thoughtful papers, all of which provide themes that are consistent with the findings from this study's interviews. Following is a summary of several selected papers and relevant recommendations from those papers.

(4) "Educating the 'New Transportation Professional'," by Joseph M. Sussman, MIT.

In addressing undergraduate education needs, Sussman suggests that academic programs focus on education in the broadest sense rather than training students in a narrow way. He proposes that university education focus on transportation fundamentals that include an understanding of:

- Technological advances, to include:
  - an understanding of the role of changes in technology
  - the pressure on transportation to integrate new technologies with the environment
  - how advanced technologies will fundamentally change the transportation profession.
- The systems methodologies fundamental to the analysis or design of transportation systems, to include:
  - probability and statistics;
  - optimization theory;
  - macroeconomics;
  - network analysis tools;
  - transportation modeling.
- The broader context of where transportation fits in a societal/political/institutional framework.

But he also suggests that additional "breadth" is required to include:

- modern communication systems and telecommunication policies;
- sensor and control technologies;
- advanced engineered materials and their uses;
- human factors;
- information networks;
- systems methodology; and
- institutional issues.

(5) "Transportation Education for the 21st Century," Lester A. Hoel, University of Virginia.

Hoel suggests that in training the transportation professional of the future, the first step is to begin with determining how the bachelor of science or bachelor of arts degree can be used as the essential step in a system of lifelong learning. He suggests seven elements:

- Basic knowledge of mathematics and science and its application to transportation problems;
- Language and communications skills including writing, public speaking, and the ability to interpret technical and non-technical literature;
- Basic knowledge of applied sciences that are relevant to transportation;
- Understanding and familiarity with computers, including programming, applications software in word processing, spreadsheets, data management, telecommunications skills and transportation applications;
- Understanding the interrelationships between technology and society, both nationally and globally and the context within which the transportation professional works;
- Familiarity and experience with the elements of transportation systems including planning, operations, design, maintenance and management in an intermodal context; and
- Awareness of the impacts of transportation on society including social, economic and environmental concerns as well as the importance of ethics in modern professional practice.

In addition to the above, he suggests that the 21st century professional should also be prepared to meet the new challenges of working in a global environment. Thus, universities must also prepare students to meet the new challenges of global and managerial competition.

Consequently, he suggests that several additional themes should be included in the curriculum:

- Study of at least one foreign language with follow-up travel and experience in a country where that language is used;
- Study abroad opportunities and international exchange programs for faculty and students;
- Placing greater emphasis on practice and industry concerns; and
- Introduction to economic, business and trade aspects of international engineering with emphasis on those elements that differ from U.S. experience.

(6) "Ideas for ITS Education and Training: Coordination Among Institutions," Kan Chen.

In another paper, Chen suggests that curricula for education programs are mainly intended to educate professionals to meet long term unpredictable future needs. Thus, university curricula materials need to be developed to provide students with basic principles before leading them step-by-step to a more thorough grasp of advanced knowledge.

The findings from these reports are representative of other reports. Additionally, they confirm the findings of the interviews.

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