DEVELOPING A MARKET SENSITIVE ITS EDUCATIONAL PROGRAM

by

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ABSTRACT

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The paper presents results of research that was undertaken to evaluate the educational needs of the emerging field of Intelligent Transportation Systems (ITS), and to ascertain how these needs are met by course offerings in academic programs. A survey was conducted to: (1) determine needs for ITS education among the public and private sector entities, and (2) assess the perception of the academic sector on the type and level of ITS education to be offered. The results indicated 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. A traditional civil engineering curriculum is inadequate to educate engineers in ITS, thus the ITS educational program must be inter (or cross) disciplinary. Focus should be on the areas that are not traditionally part of civil engineering education such as communications, traffic surveillance, systems analysis, and social and institutional issues. The results are primarily intended to provide a guideline to universities to develop the content of an ITS program by identifying the type of program structure as well as the topics to be covered in the courses. A case study of how such a program was implemented at the graduate level at New Jersey Institute of Technology (NJIT) is presented.

Key words: Intelligent Transportation Systems, Engineering Education, Transportation Education, Survey of Educational Needs.

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INTRODUCTION

On January 10, 1996, during his keynote speech at the 75th Annual Meeting of the Transportation Research Board (TRB), the Secretary of the US Department of Transportation Federico Peña set a national goal: To build an Intelligent Transportation Infrastructure across the United States. The Secretary said that we ought to ask the same question President Eisenhower asked: how do we prepare for the next decade? Many public and private organizations and academic institutions share this concern as they are responding to these new challenges by training and hiring the workforce with skills in the development and application of Intelligent Transportation Systems (ITS) technology.

The purpose of this paper is to present results of research that was undertaken to evaluate the educational needs of the emerging field of Intelligent Transportation Systems, and to ascertain how these needs are met by course offerings in academic programs. Intelligent Transportation Systems encompass advanced surveillance, communication, control and computing systems and engineering management methods and are envisioned to be able to increase safety, reduce congestion and improve productivity of our transportation systems.

The results are primarily intended to provide a guideline to universities to develop the content of an ITS program by identifying the type of program structure that is desired as well as the topics to be covered in the courses. They also suggest ways to do this by either redesigning the existing programs or developing an entirely new program. A case study of how such a program was implemented at the graduate level at New Jersey Institute of Technology (NJIT) is presented.
BACKGROUND

Reacting to the need to assess the impact of technological changes the development of ITS may bring to the engineering profession, NJIT applied for and received a grant from the AT&T Foundation to carry-out a planning study dealing with the enhancement of the ITS content in the Transportation Program, which is the main educational component of the Institute for Transportation (IT). An extensive literature review and a comprehensive survey were conducted to determine the needs for ITS education and to assist the IT in modifying its curriculum to reflect the increasing role of ITS in the national economy.

The literature review surveyed papers written mostly by academics that either described the existing ITS related academic curricula or a vision of such curricula. The results of the literature review were used in designing the survey. The survey, consisting of two questionnaires, was designed to: (1) determine needs for ITS education among the public and private sector entities, and (2) assess the perception of the academic sector on the type and level of ITS education to be offered.

The first questionnaire surveyed the needs of private and public sector organizations for ITS educated employees, thus addressing their perceived demand for ITS educated personnel. To accomplish this, the questionnaire gathered information on the ITS-related background of each company/organization. These included information on the type and status of ITS projects, representation of various occupations within internal "ITS Groups, Teams and Task Forces", types of academic degrees of employees involved in the ITS activities, and distribution of these degrees (i.e., graduate, undergraduate, both).
The second questionnaire gathered information on the perception of the academic sector on the type and level of ITS education that should be offered. To accomplish this, information on the structure of existing transportation and/or ITS programs in various academic programs at US universities recognized for their transportation education was collected.

The organization of this paper is as follows. First, the existing literature in the area of ITS education and training was reviewed. Second, an analysis of survey results and conclusions drawn from the analysis are presented. Third, a redesigned ITS curriculum which reflects the findings of the survey and the literature review is presented. This curriculum has been implemented within the Transportation Program at NJIT, although it may be applicable and transferable to any institution with a graduate program in transportation.

LITERATURE REVIEW

The responsibility of academia in educating ITS professionals is addressed in the ITS America strategic plan (1). The document states that: "Universities must develop new academic programs that will educate a new type of transportation professional, one schooled in the disciplines and concepts fundamental to ITS." Research that has been undertaken to assist universities in developing such new programs is presented in several papers and reports some of which are referenced here.

A paper by Smith and Hoel (2) examines the changing role of the transportation profession and the educational needs of students who want to become transportation engineers working in ITS. The transportation engineers of the nineties are facing new technologies such as communications, complex software, and sophisticated electronics,
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and serve as technical, legal, and political experts. To educate these professionals, colleges and universities should provide them with the necessary skills in transportation fundamentals, information technology, systems engineering, and engineering management, and educate them to integrate complex systems and provide the best possible solutions to the real transportation challenges. The paper proposes a masters degree program which differs from traditional transportation curricula in that it includes courses in systems engineering and electives in electrical engineering, mechanical engineering and computer science, and two interdisciplinary project courses.

Realizing the challenges that ITS present to the transportation community and that continuing education and training of new engineers is essential, Caltrans and the Institute of Transportation Studies at University of California at Davis conducted a study to address advanced technology opportunities and challenges. A paper by Jovanis (3) presents the findings of this study which resulted in the development of a core education material that can be used as an introduction to ITS with the perspective that ITS is developed from technology building blocks such as communications, computer systems, sensors/detectors, vehicle technology, human factors, policy issues.

A paper by Hyman (4) examines employment projections for ITS, assesses implications of these projections and sets skill requirements for technical specialists in the national labor market. The author analyzes two competing views, one that believes that there will be an adequate supply of technical personnel for ITS, and the opposing which predicts that there will be a shortage of such personnel. He concludes that there will be an adequate supply of ITS specialists due to the shrinking of the size of defense contracts and the attraction of engineers and other technical specialists previously
employed by the defense industry into the high-tech ITS area. Similarly, the author considers two opposing views on the educational needs of ITS. He also concludes that there is a need for substantially broader, more integrated college and university curricula to meet ITS needs. Civil engineering programs need to address the acquisition of management, organizational, cooperative, and broader technical knowledge. Engineers of other disciplines need to acquire transportation skills and knowledge, including some basic civil and traffic engineering if they want to effectively address transportation programs in ITS. The private sector is likely to provide the training for installation and maintenance of equipment it manufactures and to respond to essential ITS training needs that the public sector is too slow to respond to. Conclusions on the above issues are also presented in a comprehensive report by Hyman et. al. (5). This study looks at various sources of supply including defense conversion, the educational pipeline, and foreign born engineers and examines key issues affecting supply such as growth in the labor force and the labor force participation rate.

Chen et al. (6) present the University of Michigan response to the needs for ITS education. They state that their ITS Certificate Program is designed to provide ITS education to both university students and practicing professionals, and to revive the interest of bright young people in transportation studies. The program has been structured as a cross-disciplinary effort and is open to anyone pursuing relevant graduate degrees.

Beaubien (7) recognizes the fact that traffic engineers who had early training as civil engineers might not have the knowledge of the computer and communication technologies available in ITS, however, they have a unique understanding of traffic operations needed to ensure that new technologies address current operational problems.
Because of these problems, traffic engineers should be trained and get involved in ITS since their experience is an ultimate key in the continuing success of ITS.

In an effort to develop a Strategic Plan for ITS education and training, ITS America convened a national invitational workshop in Reston, Virginia on June 12-14, 1995. The workshop was sponsored by the ITS America subcommittee on education and training in cooperation with U.S. Department of Transportation Federal Highway Administration. Workshop groups, representing formal education (precollege through associate degrees, and baccalaureate and graduate programs), informal and non-degree education and training, public agencies, manufacturers and service providers, transportation companies, and students, addressed several demand and supply issues in the area of ITS education and training (8). The demand side findings identify those who need ITS education and training and categorizes them into groups such as ITS providers, decision makers, educators, students, and ITS users. It is determined that nearly all groups need in-depth information on the benefits and costs of ITS. In addition, there is a need to increase the understanding of ITS economics and the awareness of what ITS is and what it can do to improve societal mobility. Findings from the supply side suggest types of education and training programs that can potentially fill the needs of educators and students, public agencies, private sector companies, and ITS America. Recommendations are made on specific programs that address the needs of each of these groups.

In a paper presented during the ITS Education and Training Strategic Planning Workshop, Sussman (9) determines that the “New Transportation Professional” must have a good understanding of the issues that impact the world of transportation, the components of a transportation system, and how they fit together. A broad based
knowledge in transportation fundamentals as well as in-depth knowledge within a transportation specialty are essential in order to be able to address the increasingly complex transportation environment.

In summary, several conclusions can be reached. The traditional civil engineering curriculum is unable to provide the transportation engineers with the skills required for ITS. They need to be exposed to a variety of courses from several engineering and social science disciplines. The educational effort in ITS should thus be inter (or cross) disciplinary.

SURVEY RESULTS

Survey of Private/Public Sector Organizations

The first questionnaire was distributed through the September 1994 issue of the ITS America newsletter to individuals representing public and private sector companies or organizations. These companies are members of ITS America, an umbrella organization that coordinates and fosters private/public/academic partnerships in ITS that will increase the productivity and safety of the US. transportation system while preserving the environment. Approximately 2,000 surveys were sent out. Sixty three (63) responses, or 3.15% of the total questionnaires, were received; 37 from private sector, 15 from public sector, and 11 that could not have been identified as either private or public sector. The ITS America list contains multiple recipients of the newsletter within a member organization (e.g., a state DOT or a professional consulting engineering firm), with only one member of the organization authorized to answer a kind of policy making questions asked in the survey. Under the conservative assumption that there were on average 2 mailings per organization, the survey covered 1,000 organizations. The response rate is then doubled. Selected questions and responses to the survey are shown in Table 1. A detailed list of survey participants can be found in Boile et. al. (10).
The analysis of the First Questionnaire is presented in two parts. The first part entitled “General Background Information” provides the summary on the type of projects and functional areas the companies in public and private sectors are engaged in as well as the types of resources they either utilize or plan to utilize in their ITS activities. The second part entitled “Perceived Demand for ITS Education” identifies the needs and desires of these sectors in receiving the ITS-related education.

**General Background Information**

- Among the six functional ITS areas, namely Advanced Vehicle Control Systems (AVCS), Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Public Transportation Systems (APTS), and Advanced Rural Transportation Systems (ARTS), ATMS and ATIS are the most frequently cited areas of engagement in both private and public sectors. Seventy six percent (76%) of the private and 100% of the public sector respondents are engaged in ATMS projects, while 62% of the private and 80% of the public sector respondents are engaged in ATIS projects.

- The overwhelming majority of the private and public sector organizations’ projects (78% and 87%, respectively) is characterized as engineering.

- In both private and public sectors, the current status of the majority of projects is research and development, and deployment (51% of private and 60% of public).

- Most of the respondents (84% of private and 73% of public) have "ITS Groups", meaning that several employees are working in teams exclusively on ITS projects. For private sector, the most frequent size of these groups is medium (6-20 people) (52%).

- In the last two years, among the private organizations, 63% hired people with either graduate or undergraduate degrees to work on ITS projects, while 19% hired only people with graduate degrees, and 19% hired only people with
undergraduate degrees, to work on ITS projects. In the public sector, 55% of the organizations hired candidates with either graduate or undergraduate degrees, 27% hired only candidates with undergraduate degrees, and 18% hired only candidates with graduate degrees.

- The employees within the "ITS Groups", were categorized as engineers, non-engineers, and technicians. Table 1 shows that public and private sectors seem to have different composition of these employees.

- It should be noted that among the engineers, in private sector 43% of all respondents have electrical and electronic engineers, followed by civil (38%), mechanical (24%) computer (19%), industrial (5%) and aeronautical engineers (3%). In public sector the situation is quite different. The majority of engineers is civil (80%), followed by electrical and electronic (27%), mechanical (7%) and computer engineers (7%).

**Perceived Demand for ITS Education**

- Universities should offer a specialization in ITS, according to 62% of the private sector respondents, and 87% of the public sector respondents. However, 38% of the private sector respondents think that this is unnecessary. This is interesting and one can speculate that private sector views ITS as a system integration field rather than a specific field in itself.

- There is a consensus on the type of ITS education to be offered by the universities. They should produce: graduates with a broad ITS background (according to 62% of the private, and 60% of the public sector respondents), specialists in certain ITS areas (21% of the private and 13% of the public), or both (16% of the private and 27% of the public).

- A new hiree in the ITS area should have undergraduate degrees (according to 33% of the private and 47% of the public respondents); graduate degrees (36% of the private and 33% of the public); either one (17% of the private and 13% of the
public). In addition, 14% of the private and 7% of the public respondents stated that the level of education depends on the job.

- When it comes to job experience and qualifications, 79% of the private sector, and 60% of the public sector respondents preferred to hire people with several years of work experience in transportation. However, only 7% of the private sector preferred to hire people with an ITS educational background compared to 40% of the public sector. 14% of the private sector would hire either one.

- The preferred external continuing education vehicle in both private and public sectors, is seminars and conferences (86% and 93%, respectively). For the private sector, this is followed by short courses (73%), and professional society meetings (73%). In public sector, this is followed by professional society meetings (87%) and short courses (47%). Graduate school ranked last with 46% of the private and 47% of the public sector. The primary areas of interest for external continuing education, common to both public and private organizations, are ITS applications, systems architecture, funding opportunities, public and private partnerships, national ITS needs. There are also some areas that are very specific and reflect the needs of each organization, for example sensors, transaction processing, navigable databases, focused technical/engineering/ management topics.

- The first ranked of the internal mechanisms for continuing education in both private and public sectors is: meetings and activities (86% and 93%, respectively). In the private sector, this is followed by in-house training (76%) and on-the-job training (68%). In the public sector, this is followed by on-the-job training (93%) and in-house training (80%).

**Survey of Academic Programs**

The second questionnaire was distributed to transportation programs at fifty nine (59) academic institutions around the country. The rationale for selecting these programs
was that they were members of the: (1) ITS America, and as such had indicated that they have been pursuing an interests in an ITS related educational program, (2) University Transportation Centers Program (UTCP) of the US DOT, and (3) Council of Urban Transportation Centers (CUTC).

Twenty (20) responses were received. Selected questions and responses are shown in Table 2. The survey results are divided into two parts. The first part, entitled "General Academic Program Information", relates the background information on the type of programs surveyed, their administrative structure, their plans for developing an ITS program, possible constraints on implementing such programs within the existing structure of an accredited academic program, to name a few. The second part, entitled "Perceived Supply of ITS Education" reflects the attitude and efforts of academic programs in developing educational tools for serving the needs of ITS.

**General Academic Program Information**

The analysis reveals the following:

- Four (20%) of the transportation programs responded are independent, while the remaining 80% are administered by either the civil engineering (94%) or the systems engineering (6%) departments.
- Nine academic programs (45%) have an ITS program, focus, or specialization area.
- Fifteen programs (75%) consider development of new courses in ITS.
- Three quarters (75%) of the respondents feel that the elements required for an ITS program already exist in the courses that are offered within their graduate programs.
There is enough flexibility in course requirements in 95% of the institutions, to allow students to follow an interdisciplinary program. This could enable students to specialize in ITS.

All twenty institutions that responded, are engaged in ITS projects. Also, all but one, have students either working on or being supported from these projects. The work on these projects involves the students working in groups in 89% of the institutions. There are small groups in 10% of the institutions, in medium groups in 55%, in large groups in 5%, and it varies in 30% of the institutions. The background of these students varies, and it is mostly civil, electrical, industrial, computer, transportation and systems engineering, as well as operations research, computer and information science.

Seminars and/or short courses on ITS are offered by 45% of the institutions and will be offered by another 30% of the institutions in the near future. However, in 22% of these institutions, seminars and short courses are open only to students. The remaining 78% of the institutions have them opened to both students and professionals.

Perceived Supply of ITS Education

The overwhelming majority of respondents (75%) feels that an introduction to ITS at the undergraduate level is essential. This introduction should be given in the departments of civil, electrical, computer, mechanical, industrial and systems engineering, and computer, information and social sciences. It should emphasize basic definitions and concepts, and reflect the role of each department in the ITS applications.

Five (25%) of the respondents indicated that there should be a program/certificate in ITS at the graduate level.
Universities should produce specialists in certain ITS areas according to 10% of the respondents, people with a broad ITS background according to 60%, and both according to 30% of the respondents.

- The background of a student who wishes to get involved in ITS should be technical, from most of the engineering disciplines.

- A traditional civil engineering curriculum is deemed inadequate to educate engineers that will get involved in ITS according to 75% of the respondents. The additional requirements in the program for those students who wish to pursue a focus on ITS are communications, operations research and computer science courses, in addition to some advanced transportation courses, to mention a few.

CONCLUSIONS

Based on the literature review and surveys, the following conclusions are reached:

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

2. It seems that the academic programs are aware of the educational needs of 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.

3. 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 is inadequate to 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. These findings are
consistent with the views expressed in some of the papers reviewed in the literature section [(1), (9)].

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

5. A dedicated degree in ITS is not considered to be essential, since as some respondents fear, 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.

6. Although this may not be apparent, there might be a potentially different opinion on how to offer the needed education to the ITS community. While the universities feel that their graduate programs are sufficient either as a complete degree or a set of courses taken by a student in a matriculated status to meet the needs for ITS careers, 20.6% of the private sector feels that a narrow focus of the courses in required. This may mean that the universities may reevaluate their position not to offer a specialization in the ITS field. A set of courses under a “Certificate Program” might suit the needs especially of the private sector and be clearly more attractive. This issue needs to be clarified. This is best left to individual programs to do market research in their respective area and see what the demand for a Certificate Program would be.

7. ITS projects are done in groups, thus team work is essential. To prepare for team work, it is important that during their ITS educational experience students from various disciplines work together in teams, and get exposed to real world ITS projects. It seems that the academic programs have recognized this need and are emphasizing the team work through student involvement on ITS projects.
8. There are various mechanisms for internal continuing education, including meetings and activities, on-the-job training, and in-house training, in most of the private and public organizations. In addition to the internal mechanisms, there is significant interest in external mechanisms, such as seminars, conferences, short courses, graduate school in most of the private and public organizations. The primary areas of interest in continuing education include systems architecture, funding opportunities, public and private partnerships, national ITS needs. It seems that academic institutions have recognized the major role they can play in educating ITS professionals, through short courses and seminars, and ultimately through their graduate programs.

9. The different compositions of engineering disciplines in the public and private sectors may explain the difference in their desires when it comes to hiring new employees. Forty percent (40%) of the public sector respondents preferred to hire people with ITS education compared to the 7% in the private sector. The public sector employs civil engineers (80% of respondents have civil engineers) and might feel that they need to know more about ITS, as if it were a distinctive engineering discipline. Private sector organizations might be more willing to train their employees. The private sector might be perceiving ITS as nothing more than a new "APOLLO program" for the US economy, and thus another large activity in the systems integration area.

**RECOMMENDATIONS AND FUTURE DIRECTIONS**

Based on the survey results, it was decided that NJIT should develop the key elements of an ITS education in its undergraduate and graduate programs. It was felt that these elements should be developed and tailored to suit the following five distinctive markets of students seeking an ITS education:

1. individuals with superb technical and analytical skills with interests in technology development, engineering design, hardware and software design and prototyping, systems engineering, and systems integration;
2. individuals with solid technical background with interests in application of the well developed (almost off-the-shelf) technologies, hardware and software, to solving particular ITS engineering and design problems;

3. individuals with technology (and/or engineering) and management background with interests in business venture aspects of technology, product development, marketing, costing and economic analysis, financing, and entrepreneurship;

4. individuals with solid analytical background with interests in applications of commercially available technology, hardware and software, to solving particular problems in planning for ITS systems and services including behavioral issues related to the user acceptability of such advanced technology and services;

5. individuals with some analytical and limited technical background with interests in public policy issues, institutional barriers and limitations to development and applications of advanced technology in general, and ITS in particular, legal implications of ITS systems applications, and regulatory issues.

It was decided that an ITS educational program should be developed to consist of the following four components:

1. a concentration in the Interdisciplinary Graduate Program in Transportation with a set of courses emphasizing the systems and technology of ITS. The Graduate Program at NJIT is a free standing academic program offering MS and Ph.D. degrees in Transportation.

2. ITS elements in other graduate programs such as Electrical and Computer Engineering, Computer and Information Science, Social Science and Policy Studies, and Industrial Management.

3. undergraduate technology oriented course(s) in ITS offered to engineering majors,

4. an ITS certificate program opened to both graduate students already enrolled in graduate programs at NJIT, and professionals desiring to improve their ITS skills.
Program Development Stages

It was envisioned that an approach for developing the ITS educational components would be executed in four stages:

1. An urgent development of the initial ITS curriculum of interdisciplinary nature that is based on disciplines that are integral part of ITS. Initially, this curriculum would rely on the existing courses offered across NJIT. A sample curriculum with emphasis on technology and engineering, is given in Table 3.

2. Supporting the faculty in various departments across NJIT to develop ITS elements in their courses, namely to redesign the existing courses to reflect the ITS components. For example, the redesigning of the current EE 642 Communication Systems I would focus on current and future communications protocols for ITS.

3. Develop a set of courses to support an ITS option in undergraduate education.

4. Develop an ITS laboratory that will have both technology and public policy elements.

ITS in the Graduate Program

To date, within the Graduate Program in Transportation a concentration in Advanced Transportation Systems and Technology was developed. This concentration is designed for graduate students who were described above as the first market. The majority of courses is already offered across NJIT, and ITS concepts have been introduced within these courses. For example, the course in Public Transportation Operations and Technology (TRAN 625) now includes the latest technological improvements in APTS such as Automatic Vehicle Location (AVL) and Automatic Vehicle Identification (AVI), smart card technologies for payment of fares, and transit ATIS, to name a few. Students deal with case studies such as development of ATIS using GIS platform, route planning algorithms, development of ride-on-demand transit services, design of dynamic bus routes in the presence of AVL/AVI systems. Similarly, the
Transportation Economics (TRAN 610) course considers the economic impacts of ITS. It involves case studies with cost-benefit analyses of different alternative systems and technologies (e.g., different traffic surveillance and communication technologies). Transportation Finance (TRAN 643) deals with case studies on public/private partnership for financing new intelligent transportation systems and toll roads. Within Geographic Information Systems (TRAN 602), students are expected to participate in a development of a generic ATIS system using the ARC/INFO software. They are asked to enhance the Multi-modal Advanced Traveler Information System (MATIS) which was developed at IT. The enhancements include: the interface of traffic simulation software such as TRAFNETSIM and representation of traffic conditions on the links of the network in different colors; representation of different types of roadway services using special symbols, such as gas stations, hospitals, restaurants and other yellow page type of information. In traffic management applications, the students are asked to design different functions to the GIS such as: identify faulty detectors or traffic controllers and display them using special symbols, display incidents, communication links of the facility, truck routes, roadway signs and variable message signs, develop a function to monitor the position in real time of different emergency services.

In addition, a new course TRAN 755 Intelligent Transportation Systems dedicated exclusively to new systems, technology and operations has been introduced. It deals with case studies on developing real time route planning algorithms, evaluating different real time route planning algorithms, developing regional multi-modal traveler information systems, decision support systems for regional incident management, incident detection algorithms for freeway facilities and urban signalized networks, travel time estimation and prediction algorithms, and evaluating different traffic surveillance and communication technologies as well as the use of centralized communication systems vs. distributed communication systems.
Students with the educational desires and background specified in the second market area, are encouraged to take the Transportation Engineering area of study. Students in Civil Engineering and Industrial and Manufacturing Engineering are also encouraged to take the ITS related transportation courses. Students with the needs described in areas 3 - 5 are recommended to take courses in Industrial Management and Social Studies and Policy Studies.

Undergraduate Course

On the undergraduate level, we are developing an analytical course that will serve as an introduction to the ITS transportation area. In order to secure the approval of the undergraduate advisors in the Departments of Electrical and Computer Engineering, and Computer and Information Science, the course had to be of a technical nature and challenge the students’ analytical skills. This course will offer the opportunity to the students to learn about the necessary systems approaches, procedures, tools, algorithms and technologies required for the planning, design and operation of intelligent transportation systems. This will prepare them for studies at the graduate level, or concentrate their studies to specific fields at the undergraduate level. The students will be required to design computer programs for the algorithms to be presented in class, to develop statistical models for travel time estimation and prediction, understand the traffic flow models presented in class, and be able to make inferences on the models developed. The course provides an opportunity for students from different disciplines (civil, electrical and computer engineering, industrial engineering, computer science, industrial management) to work in groups on real-world ITS applications (e.g., work on TRANSMIT project, an evaluation of the ETTM-based incident detection algorithm). The proposed course outline is given in Table 4. The table shows the course’s emphasis on case studies each dealing with an important ITS application.

Certificate Degree Program in ITS
The Certificate Program is in the planning stage. A sample program is shown in Table 5. The program utilizes existing courses that will be enhanced with ITS technological developments and case studies. The program may be offered to either full time students, part-time students or non-matriculate students. The students who wish to enroll in the certificate program will have the option to continue to complete a Master's degree in Transportation or in another discipline if they fulfill degree requirements of each individual department. The certificate program will require the completion of 15 credit hours and a paper on an ITS topic or case study.

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REFERENCES

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TABLE 1. Selected Questions andResponses of the First Questionnaire

A. General Information

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<td>6 (40)</td>
</tr>
<tr>
<td>Status of ITS projects</td>
<td>Research &amp; Development</td>
<td>19 (51.4)</td>
<td>9 (60)</td>
</tr>
<tr>
<td></td>
<td>Design &amp; Testing</td>
<td>19 (51.4)</td>
<td>8 (53.3)</td>
</tr>
<tr>
<td></td>
<td>Systems Architecture</td>
<td>13 (35.1)</td>
<td>4 (26.7)</td>
</tr>
<tr>
<td></td>
<td>Deployment</td>
<td>19 (51.4)</td>
<td>9 (60)</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>2 (5.4)</td>
<td>4 (26.7)</td>
</tr>
<tr>
<td></td>
<td>Evaluation</td>
<td>13 (35.1)</td>
<td>5 (33.3)</td>
</tr>
<tr>
<td>Is there an ITS Group within your organization?</td>
<td>YES</td>
<td>31 (84)</td>
<td>11 (73)</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>6 (16)</td>
<td>4 (27)</td>
</tr>
<tr>
<td>ITS Group Size</td>
<td>Single Person</td>
<td>1 (3)</td>
<td>1 (9)</td>
</tr>
<tr>
<td></td>
<td>Small (2-5 people)</td>
<td>10 (26)</td>
<td>7 (46)</td>
</tr>
<tr>
<td></td>
<td>Medium (6-20 people)</td>
<td>19 (52)</td>
<td>6 (36)</td>
</tr>
<tr>
<td></td>
<td>Large (more than 20 people)</td>
<td>7 (19)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Distribution of degrees within ITS Groups</td>
<td>only undergraduate</td>
<td>4 (11.5)</td>
<td>4 (25)</td>
</tr>
<tr>
<td></td>
<td>only graduate</td>
<td>3 (7.7)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>both graduate &amp; undergraduate</td>
<td>30 (80.8)</td>
<td>11 (75)</td>
</tr>
<tr>
<td>Distribution of degrees of the last two year hirees</td>
<td>only undergraduate</td>
<td>7 (18.5)</td>
<td>4 (27)</td>
</tr>
<tr>
<td></td>
<td>only graduate</td>
<td>7 (18.5)</td>
<td>3 (18)</td>
</tr>
<tr>
<td></td>
<td>both graduate &amp; undergraduate</td>
<td>23 (63)</td>
<td>8 (55)</td>
</tr>
<tr>
<td>Representation of Engineers in ITS Groups</td>
<td>Aeronaughtal/Astronautical</td>
<td>1 (3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>Civil (including Traffic)</td>
<td>14 (38)</td>
<td>12 (80)</td>
</tr>
<tr>
<td></td>
<td>Electrical/Electronic</td>
<td>16 (43)</td>
<td>4 (27)</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>2 (5.4)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>9 (24)</td>
<td>1 (6.7)</td>
</tr>
<tr>
<td></td>
<td>Computer</td>
<td>7 (19)</td>
<td>1 (6.7)</td>
</tr>
</tbody>
</table>

⁴ The respondents are not engaged exclusively on the projects in one functional area. Consequently, the percentage distribution does not add up to 100%. The same is true for the answers to questions 2, 3, 8, 9 and 10 in Table 1.
Boilé et al.

TABLE 1. Selected Questions and Responses of the First Questionnaire (continued)

A. General Information

<table>
<thead>
<tr>
<th>Representation of Non-Engineers in ITS Groups</th>
<th>Geologists</th>
<th>Mathematicians</th>
<th>Computer Scientists</th>
<th>Economists</th>
<th>Urban &amp; Regional Planners</th>
<th>Lawyers</th>
<th>Operations Res. Analysts</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geologists</td>
<td>0 (0)</td>
<td>4 (10.8)</td>
<td>7 (18.9)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>2 (5.4)</td>
<td>11 (29.7)</td>
</tr>
<tr>
<td>Mathematicians</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>1 (6.7)</td>
<td>0 (0)</td>
<td>2 (13.3)</td>
<td>1 (6.7)</td>
<td>0 (0)</td>
<td>5 (33.3)</td>
</tr>
<tr>
<td>Computer Scientists</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>3 (27.3)</td>
<td>2 (18.2)</td>
<td>1 (9.1)</td>
<td>1 (9.1)</td>
<td>2 (18.2)</td>
<td>4 (36.4)</td>
</tr>
<tr>
<td>Economists</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>3 (27.3)</td>
<td>2 (18.2)</td>
<td>1 (9.1)</td>
<td>1 (9.1)</td>
<td>2 (18.2)</td>
<td>4 (36.4)</td>
</tr>
<tr>
<td>Urban &amp; Regional Planners</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>3 (27.3)</td>
<td>2 (18.2)</td>
<td>1 (9.1)</td>
<td>1 (9.1)</td>
<td>2 (18.2)</td>
<td>4 (36.4)</td>
</tr>
<tr>
<td>Lawyers</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>3 (27.3)</td>
<td>2 (18.2)</td>
<td>1 (9.1)</td>
<td>1 (9.1)</td>
<td>2 (18.2)</td>
<td>4 (36.4)</td>
</tr>
<tr>
<td>Operations Res. Analysts</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>3 (27.3)</td>
<td>2 (18.2)</td>
<td>1 (9.1)</td>
<td>1 (9.1)</td>
<td>2 (18.2)</td>
<td>4 (36.4)</td>
</tr>
<tr>
<td>Management</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>3 (27.3)</td>
<td>2 (18.2)</td>
<td>1 (9.1)</td>
<td>1 (9.1)</td>
<td>2 (18.2)</td>
<td>4 (36.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Representation of Technicians in ITS Groups</th>
<th>Electrical/Electronic</th>
<th>Engineering Science</th>
<th>Communications</th>
<th>Computer Programmers</th>
<th>Computer Operators</th>
<th>Mechanical</th>
<th>Civil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical/Electronic</td>
<td>11 (29.7)</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>3 (8.1)</td>
<td>2</td>
</tr>
<tr>
<td>Engineering Science</td>
<td>11 (29.7)</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>3 (8.1)</td>
<td>2</td>
</tr>
<tr>
<td>Communications</td>
<td>11 (29.7)</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>3 (8.1)</td>
<td>2</td>
</tr>
<tr>
<td>Computer Programmers</td>
<td>11 (29.7)</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>3 (8.1)</td>
<td>2</td>
</tr>
<tr>
<td>Computer Operators</td>
<td>11 (29.7)</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>3 (8.1)</td>
<td>2</td>
</tr>
<tr>
<td>Mechanical</td>
<td>11 (29.7)</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>3 (8.1)</td>
<td>2</td>
</tr>
<tr>
<td>Civil</td>
<td>11 (29.7)</td>
<td>2 (5.4)</td>
<td>2 (5.4)</td>
<td>6 (16.2)</td>
<td>3 (8.1)</td>
<td>3 (8.1)</td>
<td>2</td>
</tr>
</tbody>
</table>

B. Perceived Demand for ITS

<table>
<thead>
<tr>
<th>Sector</th>
<th>Private [responses (%)]</th>
<th>Public [responses (%)]</th>
<th>Not Identified [resp. (%)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should universities offer specialization in ITS?</td>
<td>YES</td>
<td>23 (61.8)</td>
<td>13 (86.7)</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>14 (38.2)</td>
<td>2 (13.3)</td>
</tr>
<tr>
<td>Should universities produce people with:</td>
<td>broad ITS background specialization in an ITS area both of the above</td>
<td>23 (61.8)</td>
<td>9 (60)</td>
</tr>
<tr>
<td></td>
<td>8 (21.6)</td>
<td>2 (13.3)</td>
<td>1 (9.1)</td>
</tr>
<tr>
<td>What level of education should a new ITS hiree have?</td>
<td>Undergraduate graduate either grad. or undergrad.</td>
<td>12 (33)</td>
<td>7 (47)</td>
</tr>
<tr>
<td></td>
<td>14 (36)</td>
<td>5 (33)</td>
<td>5 (45.4)</td>
</tr>
<tr>
<td>Do you prefer to hire people with:</td>
<td>ITS educational background work experience in transp. Either of the above</td>
<td>3 (7)</td>
<td>6 (40)</td>
</tr>
<tr>
<td></td>
<td>29 (79)</td>
<td>9 (60)</td>
<td>7 (63.6)</td>
</tr>
<tr>
<td>What are your external mechanisms of continuing education?</td>
<td>Short courses graduate school seminars &amp; conferences professional soc. Meetings</td>
<td>27 (73)</td>
<td>7 (47)</td>
</tr>
<tr>
<td></td>
<td>17 (46)</td>
<td>7 (47)</td>
<td>3 (27)</td>
</tr>
<tr>
<td>What are your internal mechanisms of continuing education?</td>
<td>In-house-training on-the-job training meetings &amp; activities</td>
<td>28 (76)</td>
<td>12 (80)</td>
</tr>
<tr>
<td></td>
<td>25 (68)</td>
<td>14 (93)</td>
<td>7 (64)</td>
</tr>
<tr>
<td></td>
<td>32 (86)</td>
<td>14 (93)</td>
<td>10 (91)</td>
</tr>
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</table>
### TABLE 2. Selected Questions and Responses of the Second Questionnaire

#### A. General Academic Program Information

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is your transportation program:</td>
<td>independent administered by a department</td>
<td>4 (20%)</td>
<td>16 (80%)</td>
</tr>
<tr>
<td>Do you have an ITS program/focus/specialization area?</td>
<td>YES</td>
<td>9 (45%)</td>
<td>11 (55%)</td>
</tr>
<tr>
<td>Do you consider the development of new ITS courses?</td>
<td>YES</td>
<td>15 (75%)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td>Do the elements required for an ITS education exist in your graduate program?</td>
<td>YES</td>
<td>15 (75%)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td>Is there enough flexibility in course requirements for a student to follow an interdisciplinary program?</td>
<td>YES</td>
<td>19 (95%)</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Is your school engaged in ITS projects?</td>
<td>YES</td>
<td>20 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Do you have students working or being supported from these projects?</td>
<td>YES</td>
<td>19 (95%)</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Are these students working in groups?</td>
<td>YES</td>
<td>18 (89%)</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>What is the size of these groups?</td>
<td>small (2-3)</td>
<td>2 (10%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>medium (4-5)</td>
<td>11 (55%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>large (more than 5)</td>
<td>1 (5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>depends on the project</td>
<td>6 (30%)</td>
<td></td>
</tr>
<tr>
<td>Does your institute offer seminars or short courses in ITS?</td>
<td>YES</td>
<td>9 (45%)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td></td>
<td>NO will offer in the near future</td>
<td>6 (30%)</td>
<td></td>
</tr>
<tr>
<td>To whom are these seminars/short courses open?</td>
<td>Students</td>
<td>5 (25%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>students and professionals</td>
<td>15 (75%)</td>
<td></td>
</tr>
</tbody>
</table>

#### B. Perceived Supply of ITS Education

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should an introduction to ITS be given at an undergraduate level?</td>
<td>YES</td>
<td>15 (75%)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td>Should there be a program/certificate in ITS at the graduate level?</td>
<td>YES</td>
<td>5 (25%)</td>
<td>15 (75%)</td>
</tr>
<tr>
<td>Should universities produce people with:</td>
<td>specialty in certain ITS areas broad ITS background both the above</td>
<td>2 (10%)</td>
<td>12 (60%)</td>
</tr>
<tr>
<td>Is a traditional civil engineering curriculum adequate to educate engineers in ITS?</td>
<td>YES</td>
<td>5 (25%)</td>
<td>15 (75%)</td>
</tr>
</tbody>
</table>
TABLE 3. The ITS Graduate Program on Advanced Transportation Systems and Technologies

**Core Courses -- 9 credits**
- Tran 603 Introduction to Urban Transportation Planning (CE 603)
- Tran 610 Transportation Economics (IE 610)
- Tran 650 Urban systems Engineering (CE 650)

**Required Courses -- 9 credits**
- Tran 615 Traffic Studies and Capacity (CE 660)
- Tran 755 Intelligent Transportation Systems
- Tran 765 Multi-Modal Freight Transportation Systems Analysis (CE/EM 765)

3-6 credits from:
- Tran 700 Master's Project
- Tran 701 Master's Thesis

**Elective Courses -- 6 - 9 credits from:**
- Tran 602 Geographic Information Systems (CE 602)
- Tran 608 Behavioral Issues in Transportation Studies (HRM 608)
- Tran 625 Public Transportation Operations and Technology (CE/IE 625)
- Tran 653 Transportation Demand Management (STS 653)
- Tran 752 Traffic Control (CE 752)
- Tran 760 Urban Transportation Networks
- EM 714 Multicriteria Decision Making
- EnE 671 Environmental Impact Analysis
- ME 635 Computer-Aided Design
- CIS 610 Data Structures and Algorithms
- CIS 651 Data Communication
- CIS 661 System Simulation
- EE 642 Communication Systems I
- EE 609 Artificial Neural Networks
- IE 624 Heuristic Methods
- IE 642 Network Flows and Applications
- IE 644 Application of Stochastic Modeling in Systems Control
- IE 651 Industrial Simulation
- IE 705 Mathematical Programming in Management Science
- IE 706 A Queuing Approach to Performance Evaluation
- HRM 601 Organizational Behavior
- MIS 648 Decision Support Systems
- MGMT 692 Business Strategy
- MKTG 632 Strategic Marketing Management
- MKTG 636 Product Strategy and Management
- MKTG 640 Industrial Marketing Management
TABLE 4. A Course Outline for the ITS Course “Analytical techniques in ITS (TRAN 555)”

1. Introduction to Intelligent Transportation Systems: Principal Components of the Transportation System; ITS in the US, Europe and Japan.
2. An ITS Planning Process
3. ITS System Architecture
4. Overview of traffic flow theory.
5. Route Planning Algorithms: Static; Time Dependent. CASE STUDY 1
6. Incident Detection Algorithms. CASE STUDY 2
8. Regression Analysis: Ordinary Least Squares, Multiple regression analysis.
9. Travel Time Estimation and Prediction Models. CASE STUDY 3
10. Traffic Assignment: Static; Dynamic.
11. Mid-term.
12. Introduction to communications.
13. Communications in ITS: Infrastructure to Infrastructure; Infrastructure to vehicle; Vehicle to Vehicle.
15. FINAL. Student Presentations on Case Studies; Submit case study Report.

Textbook

References:
1. "IVHS Strategic Plan", USDA, 1992
5. Transportation Research Record papers on ITS.
9. IEEE papers on ITS.
10. Other Journal Publications on ITS.
TABLE 5. A Sample Certificate Program with TRAN 755 as a Core

1. **Data Processing in ITS**
   - TRAN 555: Analytical Techniques for ITS
   - TRAN/CE 615: Traffic Studies and Capacity
   - TRAN/CE 752: Traffic Control
   - CIS 610: Data Structures and Algorithms
   - MATH 669: Statistics for Engineers

2. **Travel Demand**
   - TRAN/CE 602: Introduction to Urban Transportation Planning
   - TRAN/STS 670: Transportation Demand Management
   - TRAN/STS 720: Discrete Choice Modeling for Travel Demand Forecasting
   - TRAN/HRM 608: Behavioral Issues in Transportation Studies

3. **Telecommunications**
   - CIS 651: Data Communication
   - EE 642: Communication Systems I
   - TRAN/CE 752: Traffic Control

4. **Multi-modal Transportation**
   - TRAN/CE 602: Introduction to Urban Transportation Planning
   - TRAN/CE 765: Multi-modal Freight Transportation Systems Analysis
   - TRAN/CE/EM 740: Management of Transportation Carriers
   - TRAN/CE 654: Mass Transportation Systems

5. **Advanced Transportation Management Systems**
   - EE 642: Communication Systems I
   - CIS 610: Data Structures and Algorithms
   - TRAN/CE 752: Traffic Control
   - CE 611: Project Planning and Control