White Paper

University Programs in Intelligent Transportation Systems (ITS): The Evolving Transportation Engineering Discipline

November 2015

Purpose

The purpose of this paper is to emphasize the growing demand for university degree and certificate programs to meet the emerging needs of Connected Vehicle (CV) and related technologies for transportation. This paper examines Intelligent Transportation Systems (ITS), CV, the changing workforce demographics, the education and training efforts of the ITS Professional Capacity Building (PCB) Program. The paper then describes the need for changes in the University engineering discipline to incorporate evolving transportation topics. It includes a series of recommendations to address these needs.

Background

Just as transportation innovation within all modes acted as an "engine of change" in the 19th century during the Industrial Revolution, it is also one of the major economic and environmental drivers of the technology revolution in this century. This current technology revolution going on inside and beyond the classroom continues to be a major influential factor on transportation education. Curricula development and reform manifest themselves in the changing focus of the traditional engineering curricula. This curricula will need to be supplemented with details regarding new and emerging technologies, including policy, planning and environmental concerns, just to point out a few new items of focus.

Transportation today is a global business, with companies providing products and services to diverse markets world-wide. In this ever shrinking world, transportation workers must have the skills to communicate and to work with people anywhere on the globe – requiring new work roles and entirely new ways of interacting.

ITS today

The major factors in this transportation revolution are applications and technologies from established ITS, near-term Connected Vehicle (CV), and over a decade away Automated Vehicles (AV). As defined by the U.S. Department of Transportation's ITS Strategic Plan, 2015-2019 ITS is a set of tools that facilitates a connected, integrated, and automated transportation system that is information-intensive to better serve the interests of users and be responsive to

the needs of travelers and system operators. ITS technologies improve transportation safety and mobility, reduce environmental impacts, and enhance productivity through the integration of advanced communications-based information and electronic technologies into the transportation infrastructure and vehicles. [1] ITS products and services can include road weather information, traveler information, adaptive signal, and services such as freeway and highway incident management. These are just a few of the technologies involved in the world of ITS.[2]

ITS is a 25-year-old national program that uses modern computers and communications to make travel smarter, reliable, safer and more convenient. ITS applies high technology (sensors) and computer power to our current highway, traffic, and transit systems. These systems have the potential to solve future problems of increases in population, traffic congestion, and less land for new roads. Listed below are some of the major ways in which ITS enhances transportation:

- Intelligent traffic control systems help by reducing the time we spend stopped at traffic signals or waiting on freeways when an accident occurs.
- Automatic toll collection moves vehicles more quickly through toll booths, reducing congestion and pollution.
- Traveler information systems provide current, multi-modal information on travel conditions allowing travelers to make smarter choices about how, when and where to travel.
- In-vehicle systems help by providing in-vehicle maps and improving safety by automatically notifying emergency services when a serious accident occurs and exactly where the accident is located.
- Advanced transit systems help transit agencies operate more efficiently and provide travelers with real time information that makes using transit easier and more attractive.
- Intelligent commercial vehicle systems help commercial vehicle operators process the paperwork associated with moving goods. These systems also help public agencies improve safety by inspecting the vehicles that need it the most.

Connected Vehicles and Autonomous Vehicles

Connected Vehicles (CV) represent the development and deployment of a fully connected transportation system that makes the most of multi-modal, transformational applications that require a robust, underlying technological platform. The platform is a combination of well-defined devices, interfaces, and processes that, when combined, ensure safe, stable,

[1] USDOT. **ITS Strategic Plan, 2015-2019.** December 2014, FHWA-JPO-14-145.
[2] USDOT. Intelligent Transportation Systems (ITS) Standards Program Strategic Plan for 2011-2014. April 2011, FHWA-JPO-11-052.

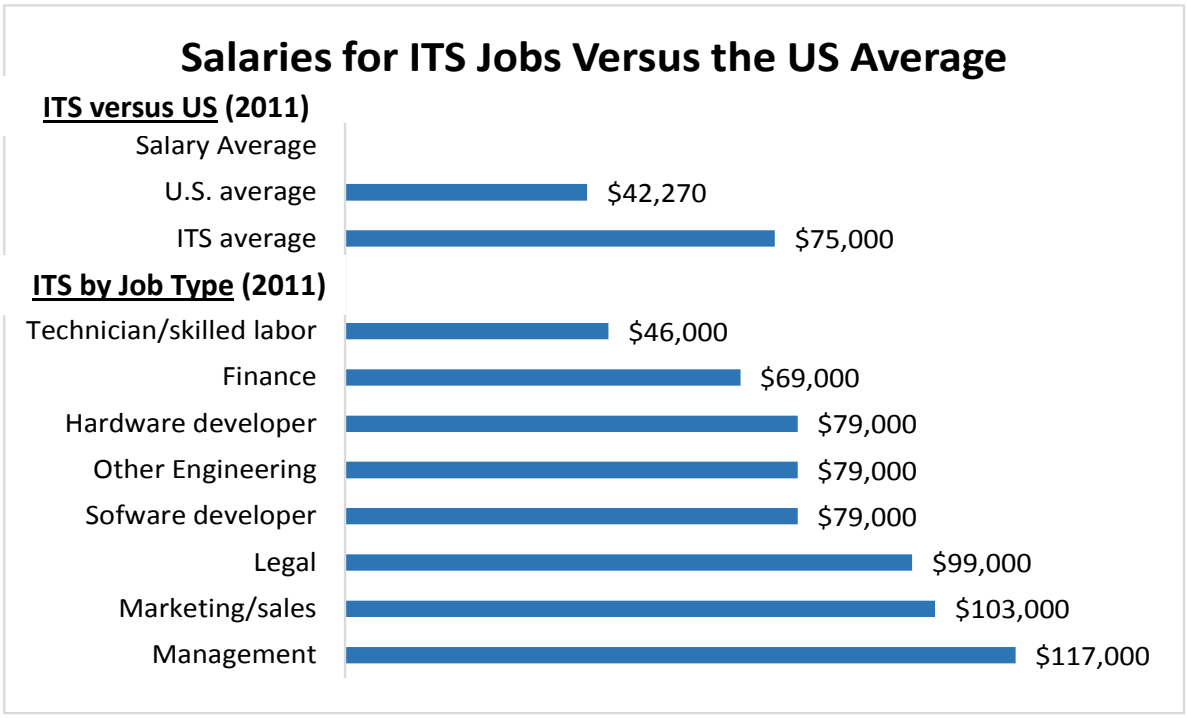
interoperable, reliable system operations that minimize risk and maximize opportunities. The Connected Vehicle program is a large set of research activities centered around vehicles or mobile devices equipped with sensors, communications and processing allowing location and situational status to be communicated among the vehicles and with the surrounding infrastructure. The CV platform currently under development allows for growth, expandability, and incorporation of newly evolving technologies. In knowing the architectural configuration and definition of interfaces, creative private-sector firms will be able to develop new applications that are not yet envisioned but remain in the future. And finally, the platform will be based on the complexity and range of human behaviors that will interact with and impact upon the system. Much work and research is needed to make the full potential of CV a reality. Research is needed in the creation of standards for interoperability; security of the system; strategies that address the complexity of human behavior and risks associated with the driver's workload; and processes that define how travelers and equipment become a certified part of the system.

Such innovation also requires an educated and motivated workforce. Developing, deploying, and diffusing technology requires the active collaboration of all sectors of the economy: government at all levels, industry, labor, education, and the research community. These sectors must pool their resources to ensure that a capable well-trained workforce is readily available – one with the skills to create, embrace, and use rapidly evolving ITS technologies. Today's transportation professionals must adapt to a continuous infusion of new and emerging vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and automation technologies. It is no longer sufficient to have a technical background or to view transportation education as just a series of college courses. Ensuring that the job force is technically-savvy on CV and AV systems will be an ongoing life-long, multi-disciplinary endeavor.

The Changing Workforce

Meeting these educational and workforce challenges is a prerequisite for innovation in this century. In large part, the success of the transportation workforce depends on how well transportation organizations and educational institutions understand and adapt to change. Today's transportation educators have a different set of rules than their predecessors. To prepare the next-generation transportation workforce, educators and organizations must bring together the public, private, and academic sectors. Next, they must supplement the traditional focus on technical issues with training in transportation management and policy (as well as on environmental, energy, and cost factors). They also must embrace a systems engineering

approach to transportation.[3] Workforce demographic changes, the competitive labor market, and the new expectations in the transportation industry combine to make attracting and retaining a capable workforce difficult for state and local transportation entities, both public and private. A study by the Intelligent Transportation Society of America provides statistics showing that the average salary for ITS-related jobs are higher than US averages. This salary differential is the result of the more complex skills needed in the ITS arena.



Note: 2011 salary data. Source: Sizing the U.S. and North American Intelligent Transportation Systems Market: Market Data Analysis of ITS Revenues and Employment. The Intelligent Transportation Society of America (ITSA). August 2011.

Impact of ITS/CV on University Programs

A Preliminary Report from the "Goals" Committee of the American Society for Engineering Education, and the resulting impact its recommendations have had in drawing out its proponents and opponents, clearly indicate that engineering education is approaching a crossroad. The ASEE paper suggests that the essential issue to be decided is the role that an engineering education should, or perhaps could, play in a college or university. The issue is examined by first developing a rationale for a college education and then discussing the

[3] Systems engineering is an interdisciplinary approach aimed at enabling the realization of successful systems. It focuses on defining client needs and required functionality to address those needs early in planning, and then carries out design and operations while considering the complete problem from both technical and business perspectives. GAO-12-308 Intelligent Transportation Systems.

implications of this proposed rationale. It is proposed that, at this crossroad, engineering education should develop into a pre-engineering baccalaureate program taught by engineering scientists (who will also offer graduate programs in engineering science) followed by a post-baccalaureate professional engineering program taught by professional engineers.[4]

In addition, a 2011 National Cooperative Highway Research Program Study showed that US universities produce far too few skilled applicants for state and local DOTs. Recent studies by the US Department of Labor and others predict that the worldwide market for intelligent transportation technologies will grow to $24.75 billion in 2017 (MarketsandMarkets, 2012). With this rapid growth comes the demand for a transportation workforce with the competencies and skills needed to plan, design, deploy, operate, and maintain ITS networks that transportation agencies rely upon for operating their roadways and transportation services – including transit. The ITS value chain is projected to contribute over 564,000 jobs in North America – an increase of 14 percent over 2009 levels (Keeling, 2011). Meanwhile, research on connected vehicles is moving into deployment stage of wireless V2V communications and other CV technologies. A high demand for technicians and engineers to fill ITS jobs will only increase in the coming years. Experts note that intelligent transportation technologies require people from a wide range of fields, including civil engineering, electrical engineering, communications, systems engineering, software, and even non-technology fields such as psychology.

The ITS Professional Capacity Building Programs is a leader in addressing these workforce knowledge, skills, and abilities (KSAs) needs.

The ITS PCB Program

The ITS PCB Program provides the ITS workforce with flexible, accessible ITS learning through a variety of training opportunities, technical assistance services, and educational resources. The program assists transportation professionals in developing their KSAs to build technical proficiency while furthering their career paths. Through its outreach, coordination, and instructional products, the ITS PCB Program is integral in aiding universities to develop new tools and concepts in education and training to deploy the advanced technologies inherent in Connected and Automated Vehicles (CV/AV).

The PCB Program currently provides ITS Case Studies and a Connected Vehicle (CV101) course, all of which are available to be applied to existing university course curriculum. New Case Studies and an eLearning (on-line) version of the CV101: *Intro to Connected Vehicles* course will be available in 2015. A second CV workshop - CV102: *Applications and Planning for Implementation* was demonstrated at the ITSA Annual Meeting in May 2015. Development of

[4] IEEE Transactions on Education, 1996. Vol. 9 Issue 3.

CV201: *Enabling Technologies & Infrastructure Deployment* is also in development. The PCB Program is benefiting from the Small Business Innovation Research (SBIR) program through the innovative development of the ITS-CV STEM (Science, Technology, Engineering, and Math) curriculum development for secondary students and the ITS-CV curriculum development for Community Colleges.

The ITS PCB Program continues to increase collaboration with modal and industry partners such as ITE, ITSA, CITE, NHI, APTA, and the National Operations Center of Excellence (NOCoE) to offer expanded online learning to practicing ITS professionals and the future ITS workforce. In addition, the PCB Program is conducting a study that will provide additional focus for the ITS PCB Program on Connected Vehicle outreach and training. Universities and other academic institutions are seen as key partners in expanding knowledge, skills, and abilities in ITS and CV/AV.

Key resources of the ITS PCB Program include:

- **Web-based Training**. Web-based courses covering a wide range of topics are available anytime. Certificate programs in ITS Project Management, ITS Systems, Traffic Engineering and Operations, and Road Weather Management are also available.
- **Classroom Learning**. A variety of courses are available allowing for direct interaction between instructors and participating students.
- **Blended Learning**. Courses combine the flexibility of web-based instruction with the structure of periodic interaction with an instructor and other students.
- **Tailored/Event-Specific Training**. Customized training for conferences, workshops, meetings focusing on cross-cutting topics.
- **Talking Technology and Transportation (T3) Webinars** **and** **T3 Webinar Archives**. T3 webinars are 90-minute interactive web conferences that provide discussions on select and timely ITS-related topics of interest. An extensive online archive of previous webinars is available.
- **ePrimer.** The ITS ePrimer provides transportation professionals with fundamental concepts and practices related to ITS technologies. The ITS ePrimer is both a stand-alone reference document as well as a textbook in many universities and training courses.
- **ITS Standards Training Modules**. Free online training is provided in a series of 1-2 hour class modules aimed at practitioners in state and local highway and transit agencies.
- **ITS Peer-to-Peer (P2P) Program**. Short-term technical assistance from subject matter experts is available to be used for transferring ITS knowledge, resources, and experiences.

- **The Consortium for ITS Education and Training (CITE).** CITE is a consortium of university and industry partners. CITE develops interactive on-line courses. Courses for continuing educational units (CEUs) are available through CITE as well as college level for-credit courses. CITE University partners have full access to all course materials at no cost.

The ITS PCB Program is successfully transitioning into the learning environment of this century and is building the foundation for coordinated and strategic Connected Vehicle training.

The ITS PCB University Partners Workshops

In January 2012, the ITS PCB Program conducted its first university partner's workshop at which 12 experienced professors discussed model education programs and activities, documented educational materials needed to support ITS professors, and identified types of ITS knowledge and skills required by university students. At the second workshop in September, 2013, university professors with varying degrees in teaching ITS topics – from new professors to those with many years in the field – discussed their experiences and identified gaps and obstacles to preparing the transportation professionals needed in the world of ITS. During the third workshop in September of 2014, the ITS PCB Program brought together 10 university professors, 2 state/county DOT ITS professionals and 2 students to continue the discussion on how to get ITS into the university curriculum. It also focused on understanding the education need for entry-level ITS engineering positions in the workforce and specifically addressed the skills and competencies needed for CV technologies.

Photo: 3rd ITS PCB University Partners Workshop Participants, September, 2014

As a result of discussions from these workshops, the ITS PCB Program identified specific items that must be addressed in order to provide for a workforce possessing the skills needed in the ITS/CV world.

- The identification of core competencies and skills needed for ITS including CV technologies and an associated gap analysis of core competencies. The ITS PCB Program is currently partnering with the BAH consulting firm to conduct such an analysis.

- Limitations in current university engineering programs. At the college level, there is a strong need for a transportation curriculum that transcends the formal technical requirements of science and engineering to encompass transportation management and policy issues. Adding additional course requirements could result in additional semesters and additional cost for students. The institutions will likewise need to determine how to add courses and new or expanded topics within an already taxed undergraduate engineering course schedule.

Recommendations to Address University ITS/CV Education Needs

1. **Conduct a Core Competency Study.** A core competency study is necessary to map competencies needed for ITS/CV. The Five-Year Connected Vehicle Training and Education Implementation Plan, to be completed in 2015, will provide additional focus for the ITS PCB Program on Connected Vehicle outreach and training. Part of this study includes a mapping of relevant core competencies to core functions. The study will then provide a gap analysis with specific recommendations for how the ITS PCB Program can best address these gaps identifying the most effective way to deliver the training.
2. **Expand University Engineering Programs from 4-years to 5-years.** More and more courses are needed for a transportation engineer to become a truly qualified professional. Five-year programs will permit students to complete the needed general and specialized courses for a truly qualified ITS professional engineer. Courses specific to ITS and CV, courses related policy, the environment, etc. are now demanded by corporations and government entities. The greatest incentive to implement this is the difference in prospective salaries for those professionals. Some universities such as the North Carolina State University, Bucknell University, the University of Massachusetts, and Vanderbilt University offer such ITS/CV programs as an integral part of a 5-year transportation engineering degree.
3. **Develop Certificate Programs in ITS/CV.** Certificate programs are recognized as a way to expand a student's background without undue financial burden and too much additional time to complete such programs. In fact, many working professionals are able to achieve completion of certificate programs via on-line programs offered by both colleges and professional organizations. Such programs are beginning to grow in number. The ITS PCB Program through its partner, CITE, offers credits and certificates in the ITS field. Another such program offered by the Society of Automotive Engineers is The Connected Vehicle Professional™ Credentialing Program. This program is designed to build a skill set and increase professional credibility in the ITS community. It represents a comprehensive curriculum and shows upon completion that an individual possesses the complete knowledge and comprehension needed to perform tasks

involving vehicle and ITS best practices. Numerous colleges and universities are also offering certificate programs such as Villanova University, the University of Kansas, and the University of California-Berkeley, just to name a few.

4. **Increase course offerings and professional improvement courses in ITS/CV on-line**. The ITS PCB Program is continuously reviewing its offerings on its website. With its partners, such as CITE, the National Highway Institute (NHI) and others, the program revises and initiates new offerings as they are identified utilizing innovative educational delivery methods including webinars, on-line traditional courses, case studies and blended courses. The PCB Program is working with NHI, Transportation Safety Institute, and private firms to produce a wide range of ITS Case Studies available in 2015 and 2016.
5. **Utilize Community Colleges and Technical Schools to address training and education for those not requiring a university degree and to encourage/excite students to pursue university degrees in transportation.** Community colleges and technical schools are a largely untapped resource that can be used to fill-in gaps in technical training for those in professions not requiring a 4-year college degree such as maintenance technician, transportation communications specialists, etc. Community colleges can also act as a pipeline to attract and interest students to pursue degrees in transportation. In addition, they can provide individuals already in transportation and related professions to expand their knowledge as new technologies are implemented. The ITS PCB Program is currently working with community colleges through a 2015 SBIR award to develop ITS and CV lesson plans and programs at the community college level.

Lastly, technology innovation requires an educated and motivated workforce. We must develop a transportation workforce with the skills to create, embrace, and use the transportation innovations of the 21st century. Transportation organizations must institutionalize education and training in their day-to-day operations. Learning should be life-long and available to all – to technicians and operators as well as to engineers and professionals. Education and training must be tailored, targeted and accessible; it must attract 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 considered in an integrated manner that includes secondary school STEM programs, community and junior colleges, technical schools, undergraduate and graduate programs, and continuing education programs. The ITS/CV program must also utilize new training delivery methods to reach these varied audiences.

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