



Strategic Highway Research
Program

SHRP 2 L17 Academic White Paper

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ACKNOWLEDGEMENTS

In preparing this white paper the L17 Team identified a number of research reports and resources developed by the transportation industry relevant to this topic, including:

- **University of Maryland Operations Academy¹**

Sponsored by the I-95 Corridor Coalition, this “two-week, total immersion transportation management and operations program” for TSM&O mid-level and senior managers represents industry efforts to provide support for current TSM&O practitioners. The preliminary self-study curriculum for the Operations Academy was used as the foundation for the TSM&O knowledge framework, which summarizes the industry’s perspective on the technical knowledge TSM&O practitioners should have.

- **Federal Highway Administration’s (FHWA) National Transportation Training Resource (NTTR) database²**

This database is the repository for the results of the NCHRP 20-77 project which created and populated a transportation operations training framework.³ This project focused both on professional development and academic courses offered by “industry associations, federal government, universities, state departments of transportation, and private industry.” The resulting list of courses captures many, but certainly not all, TSM&O-related topics. The NTTR database was used to validate the TSM&O knowledge framework and is a source of information on current TSM&O-related courses.

- **The Institute of Transportation Engineers (ITE) Education Council, Curriculum Subcommittee knowledge tables and learning outcomes⁵**

ITE is developing “knowledge tables” as well as course learning outcomes to help guide educators in the selection of specific course material for transportation engineering students.⁴ The knowledge tables identify concepts, processes, and tools students should learn as well as how to apply the knowledge. Knowledge tables have been completed for Traffic Operations and Highway Capacity, Geometric Design, Transportation Planning and Land Development, and Finance and Economics. Tables for Traffic Safety, and Transit and Non-Motorized are partially complete. Additional knowledge tables identified but not yet started include Systems, Asset Management, Pavement, and User Behavior/Human Factors. The relevant knowledge tables were used to validate technical knowledge information summarized from the Operations Academy curricula and the NTTR database.

¹ I-95 Corridor Coalition, “Operations Academy.” Available at: <http://www.i95coalition.org/i95/Training/OperationsAcademy/tabid/90/Default.aspx>. Also see the Operations Academy website: <http://www.operationsacademy.org/>.

² Federal Highway Administration, “National Transportation Training Resource.” Available at: <http://www.nttr.dot.gov>.

³ Results of the NCHRP 20-77 research can be found at: <http://www.catt.umd.edu/research/nchrp-framework.html>.

⁴ The materials developed by the subcommittee can be found on the Curriculum Subcommittee to the ITE Education Council webpage: <http://www.ite.org/councils/Education/curriculum/default.asp>.

- **Value Added Employee Framework⁵**

The resources listed above were developed by the transportation industry and focus on the technical knowledge TSM&O practitioners need. To help identify required technical skills, abilities, and non-technical competencies, the L17 Team used a framework developed by Edward J. Cripe and Richard S. Mansfield in their 2002 book [The Value Added Employee: 31 Competencies to Make You Irresistible to Any Company](#). The Value-Added framework includes thirty-one core competencies grouped into three categories: People, Business and Self-Management. The appendix includes the definitions of the 31 competencies. This information was used to identify the full spectrum of core competencies – technical and non-technical – that shape a well-rounded TSM&O practitioner.

- **The Consortium for ITS Training and Education (CITE)⁶**

CITE is comprised of university and industry associations to provide online advanced transportation training and education. CITE offers a combination of individual-study, instructor-led, and certificate programs focused on traffic engineering and ITS courses. The courses identified were captured in the NTTR database and are therefore included in this research.

The resources listed above were used to identify both TSM&O core competencies and the courses and trainings that are available to develop those competencies.

⁵ The website <http://www.workforce.com/article/20020903/NEWS01/309039977> provides the definitions included in the appendix as well as the observable behaviors that may indicate the existence of a competency in a person.

⁶ Consortium for ITS Training and Education (CITE), “Training Online: Web-based Transportation Courses.” Available at: <http://www.citeconsortium.org/>.

PURPOSE

In a time when funding is shrinking and travel demand is growing, increasing congestion on our transportation system must be addressed with all available resources and strategies. Travel interruptions and delays resulting from unanticipated events contribute significantly to congestion and represent an area in which transportation agencies can make significant gains. The benefits of reducing non-recurring congestion – fewer crashes, reduced vehicle emissions and fuel consumption, and others – can be realized through better understanding of strategies, new technology and practices, as well as reducing institutional barriers. The main goal of the Transportation Research Board’s Strategic Highway Research Program (SHRP 2) Reliability focus area is to reduce non-recurring congestion and improve travel time reliability through incident reduction, management, response, and mitigation. As the capstone project for the Reliability program, L17 will play a critical role in integrating the findings, methods, and recommendations of all other Reliability research, in addition to providing a bridge to key elements of the SHRP2 Capacity program. The objective of L17 is to advance the integration of transportation systems operation and management (TSM&O) into mainstream transportation agency practice. The most important product of the L17 research, and the Reliability program overall, is a Knowledge Transfer System (KTS) that will serve as an effective means for moving research findings and products into everyday practice.⁷

An important facet of advancing TSM&O into mainstream agency practice is ensuring that there are professionals available to staff and support TSM&O activities. While there is a strong need for TSM&O practitioners to fill vacancies in transportation agencies, as well as in the consulting firms that support them, the number of qualified candidates is limited. As transportation agencies shift from construction to a more “operate and maintain” focus, the need for entry and mid-level TSM&O practitioners is anticipated to grow. This need will be exacerbated as practitioners in the Baby Boomer generation continue to retire. The resulting workforce gaps can be partly addressed through training for current transportation professionals, but it is also necessary to ensure that there are academic supports for developing future TSM&O professionals. Undergraduate and graduate programs provide the entry-level workforce necessary to support the TSM&O field in the long term.

There has been significant interest in academic support for TSM&O over the past several years. Research studies and working groups have addressed this issue either directly or indirectly. This paper compiles lessons learned and foundational support from prior National Cooperative Highway Research Program (NCHRP) studies and industry-led efforts identified through the L17 research to present the current status of undergraduate and graduate level curricula to address the need for entry level TSM&O practitioners. First, the paper presents a framework of core competencies – the skills and knowledge (technical and non-technical) – generally required for entry-level positions within TSM&O. This framework is then used to analyze current TSM&O curriculum offerings with a focus on courses for undergraduate and graduate students. This analysis offers lessons learned that highlight gaps within the transportation engineering curriculum that need to be addressed to ensure that more students are exposed to and prepared for careers in TSM&O.

⁷ For more information on this project, please visit the SHRP 2 Reliability program website: http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/Public/Pages/Reliability_159.aspx.

WHAT THE BEGINNING PRACTITIONER NEEDS

A recent study, *Attracting, Recruiting, and Retaining Skilled Staff for Transportation System Operations and Management* (NCHRP 20-86), identifies some of the barriers to introducing future transportation professionals to the TSM&O field. The report states:

SOM interfaces with many disciplines and transportation modes, both internal and external to the organization, as well as with functions such as emergency management and public safety, and the concerns of the general public.... As the emphasis on transportation management and operations increases, the demand for personnel with skills in these areas is also increasing. Transportation agencies are experiencing a shortage of SOM professionals with the suitable skills and knowledge to move beyond more traditional civil engineering functions to the broader and more diverse SOM activities.⁸

The NCHRP 20-86 project found that leaders in the field recognize the challenge in finding candidates with the necessary broad background among current graduates. Many have also observed that students rarely become aware of TSM&O as a unique transportation discipline prior to graduation, and therefore are unprepared for this career path. One of the recommendations included in the NCHRP 20-86 report is to develop TSM&O curriculum content for higher education courses and training programs.

These recommendations address the fundamental and interrelated issues of course availability and student interest in the subject area. In order for transportation agencies to recruit individuals for entry-level positions within TSM&O, colleges and universities must provide an introduction to this area of transportation practice and equip students with the basic skills required for TSM&O work. Students primarily select courses to meet graduation requirements, and then to obtain the necessary background for an entry level position. Currently, these two objectives may not align for TSM&O careers. The unique skills required of TSM&O professionals draw upon a combination of engineering, planning, communications, technology, and systems management that requires a multi-disciplinary education. Although this mix of topic areas may be very attractive to students considering the field, their knowledge of TSM&O career opportunities needs to be increased. The challenge, therefore, is to both provide relevant coursework and to raise awareness of the field and the skills needed for TSM&O practitioners, so that students will be able to pursue the proper coursework. Any successful effort to close the gap in supplying entry level TSM&O professionals must deal with both the knowledge and skills needed and the lack of awareness of TSM&O as a potential career path.

One of the most significant challenges in preparing this white paper has been to identify the core competencies, both technical and non-technical, that an entry level TSM&O professional should have. Core competencies are the essential skills, knowledge, abilities and qualities that are required to successfully perform a specific position. Research for this project did not uncover any information that identified specific TSM&O core competencies. Therefore, the approach was to “back into” core competencies from other studies and initiatives underway to address gaps in TSM&O academic

⁸ Transportation Research Board, “Attracting, Recruiting, and Retaining Skilled Staff for Transportation System Operations and Management (NCHRP Report 693)” 2012. Available at: <http://www.trb.org/Publications/Blurbs/166342.aspx>.

coursework and professional training. A framework was necessary to make the connection between academic and training courses and core competencies.

The best foundation for this framework is the Operations Academy preparatory reading material. As a training course for practitioners, the Operations Academy curriculum does not repeat academic course work, but rather builds from that foundation. However, recognizing that participants enter the Academy at different stages in their career, pre-program self-study materials specific enough to help identify entry-level skills and competencies are provided as background to the training. While there are many TSM&O related courses and training classes available, the Operations Academy is the only TSM&O “curriculum” specifically designed for existing TSM&O practitioners and, therefore, this represents the industry’s best thinking on what is needed to create a well-rounded TSM&O practitioner. For the purpose of this paper, the Operations Academy material is used as a starting point to identify technical knowledge expected of undergraduate or graduate students as they enter the TSM&O field as practitioners.

In order to categorize the type of knowledge needed for entry into the TSM&O field, the pre-study materials in the Operations Academy were divided into focus areas to serve as the basis for examination of the current state of the practice for TSM&O academic curricula. The focus areas are:

- Traffic Operations Analysis
- Traffic Safety
- Social and Institutional Issues
- Transportation Planning
- ITS Awareness/Devices/National Architecture
- Data, Networks, and Telecommunications
- Project Management
- Emergency Management

This framework for technical knowledge was validated in two ways. First the courses and training included in the NTTR database represent a subset of the knowledge that the NCHRP 20-77 research team identified as relevant for TSM&O practitioners. These offerings were mapped to this framework to identify inconsistencies and gaps. The two sets of categories are strongly related, and this provides validation that the Operations Academy categories developed from the pre-study materials are a useful surrogate for the entry-level technical knowledge needed for a career in TSM&O. As a final cross-check, we compared the results of Operations Academy and NTTR comparison to the currently available and relevant ITE knowledge tables. There were no inconsistencies.

These three sources provide an excellent picture of the industry’s assessment of the technical knowledge TSM&O practitioners need. Core competencies, however, go beyond knowledge and identify the underlying skills and abilities that are required to perform the job. For example analytical thinking is a core competency for the rigorous analytical skills that support an engineering curriculum. To broaden our understanding of TSM&O core competencies beyond this initial assessment, we used the Value-Added framework developed by Cripe and Mansfield to identify the core competencies – both technical and non-technical – that are needed in an effective TSM&O practitioner. The framework includes 31

core competencies grouped into three categories: People, Business and Self-Management (see Appendix 1).

CURRENT STATUS OF ACADEMIC TSM&O CURRICULA

The NTTR database includes 642 TSM&O-related courses, of which 378 are offered by academic institutions. There are 68 academic institutions with courses in the database. The NTTR database courses are focused on training for transportation engineers; the database contains a limited number of courses relevant to TSM&O outside of the traditional transportation (or civil) engineering field. Courses are classified by subject matter, using the framework developed for the project. The primary subject matter headings are: Real-time Operations, Systems Development and Information Technology, Project Management, Policy and Strategic Considerations, and Program Planning. We mapped the subject matter areas to the Operations Academy topic areas described above in order to identify available academic training in each area.

The resulting focus areas were then used to consider the adequacy of courses that are currently available. Table 1 summarizes and compares the information from each source. The Operations Academy detailed course outline, as the most recent and continually updated resource, provides the foundation for our analysis. The NTTR database illustrates the breadth of support that exists currently in each area while providing the detail of which schools provide which courses.⁹ Course offerings are also summarized by AASHTO region to give an overview of the extent to which the topics are available. Non-academic courses in the NTTR database address knowledge gaps for current practitioners by highlighting the need for training in these areas. From the breadth of information, core competencies were identified for each skill category from the NCHRP 20-77 report and the Value-Added framework.

Table 1 includes no distinction between undergraduate and graduate courses. It is expected that some of these topics would only be covered in a graduate program. The identification of “academic” courses was based on the institution offering the course, not on the audience for the course. Several universities offer professional development courses in addition to their undergraduate or graduate education and some of these offerings are likely included in the analysis as academic courses.

⁹ Note that courses listed in the NTTR database can be categorized under multiple subject matter headings, so the “Current course availability” column should not be summed to get a total number of courses.

Table 1. Matrix of Current Academic Support for TSM&O

Operations Academy focus areas	Related topic areas from NCHRP 20-77	Core competencies	Current course availability (NTTR database)	Universities/ colleges that currently provide	Courses by AASHTO region	Training offered to practitioners (NTTR database)
<p>Traffic Operations Analysis:</p> <ul style="list-style-type: none"> ▪ Traffic flow concepts, ▪ Road user characteristics, ▪ Freeway operations, ▪ Intersections, ▪ Transportation system management techniques, ▪ Access management tools, ▪ Travel demand management, ▪ Incident management 	<ul style="list-style-type: none"> ▪ Systems engineering process/methods, ▪ Operations strategies 	<p>Analytical thought and skills with focus on traffic engineering concepts, basic communication skills</p> <p>People Skills</p> <ul style="list-style-type: none"> ▪ Attention to communication ▪ Written communication ▪ Customer orientation <p>Business Skills</p> <ul style="list-style-type: none"> ▪ Diagnostic information gathering ▪ Conceptual thinking ▪ Technical expertise ▪ Results orientation ▪ Thoroughness <p>Self-management skills</p> <ul style="list-style-type: none"> ▪ Flexibility 	<p>165 courses</p>	<p>46 universities</p>	<p>Region 1 (30) Region 2 (29) Region 3 (39) Region 4 (66) Online (1)</p>	<p>116 non-academic courses</p>
<p>Traffic Safety:</p> <ul style="list-style-type: none"> ▪ Safety improvement program, ▪ Crash records (rate, frequency, type) and understanding crash patterns, ▪ Road safety audits, ▪ Liability and negligence, ▪ Traffic safety program 	<ul style="list-style-type: none"> ▪ Safety management 	<p>Analytical thought and skills with focus on traffic engineering concepts, basic communication skills</p> <p>People Skills</p> <ul style="list-style-type: none"> ▪ Attention to communication ▪ Written communication ▪ Customer orientation <p>Business Skills</p> <ul style="list-style-type: none"> ▪ Diagnostic information gathering ▪ Forward thinking ▪ Conceptual thinking ▪ Technical expertise ▪ Results orientation ▪ Thoroughness <p>Self-management skills</p> <ul style="list-style-type: none"> ▪ Flexibility 	<p>3 courses</p>	<p>3 universities</p>	<p>Region 1 (1) Region 2 (1) Region 3 (1)</p>	<p>10 non-academic courses</p>

Operations Academy focus areas	Related topic areas from NCHRP 20-77	Core competencies	Current course availability (NTTR database)	Universities/colleges that currently provide	Courses by AASHTO region	Training offered to practitioners (NTTR database)
<p>Social and Institutional Issues:</p> <ul style="list-style-type: none"> ▪ Types of federal, state and local regulations that affect transportation decision making, ▪ Public interaction and involvement, ▪ Stakeholders and partners 	<ul style="list-style-type: none"> ▪ Management of real-time operations systems, ▪ Organizational change management, ▪ Policy development, ▪ Program definition/concepts of operation (Conops) 	<p>General knowledge of social and economic issues related to transportation; strong communication and collaboration skills</p> <p>People Skills</p> <ul style="list-style-type: none"> ▪ Problem solving ▪ Attention to communication ▪ Oral communication ▪ Written communication ▪ Persuasive communication ▪ Interpersonal awareness ▪ Influencing others ▪ Building collaborative relationships ▪ Customer orientation <p>Business Skills</p> <ul style="list-style-type: none"> ▪ Diagnostic information gathering ▪ Analytical thinking ▪ Forward thinking ▪ Conceptual thinking ▪ Fostering innovation ▪ Results orientation ▪ Thoroughness ▪ Decisiveness <p>Self-management skills</p> <ul style="list-style-type: none"> ▪ Self-confidence ▪ Flexibility 	<p>87 courses</p>	<p>39 universities</p>	<p>Region 1 (31) Region 2 (13) Region 3 (14) Region 4 (27) Online (2)</p>	<p>35 non-academic courses</p>
<p>Transportation Planning:</p> <ul style="list-style-type: none"> ▪ Integration of various transportation modes, ▪ Growth management (policies, funding, environmental, vehicle), ▪ Transportation planning and modeling, ▪ Performance measurement, 	<ul style="list-style-type: none"> ▪ Performance measurement/dashboards/reports, ▪ Link between operations & planning 	<p>Analytical thought and skills with focus on urban and transportation planning concepts; basic communication and collaboration skills</p> <p>People Skills</p> <ul style="list-style-type: none"> ▪ Attention to communication ▪ Oral communication 	<p>127 courses</p>	<p>42 universities</p>	<p>Region 1 (33) Region 2 (17) Region 3 (25) Region 4 (51) Online (1)</p>	<p>45 non-academic courses</p>

Operations Academy focus areas	Related topic areas from NCHRP 20-77	Core competencies	Current course availability (NTTR database)	Universities/colleges that currently provide	Courses by AASHTO region	Training offered to practitioners (NTTR database)
<ul style="list-style-type: none"> ▪ NEPA 		<ul style="list-style-type: none"> ▪ Written communication ▪ Interpersonal awareness ▪ Building collaborative relationships ▪ Customer orientation Business Skills ▪ Diagnostic information gathering ▪ Analytical thinking ▪ Forward thinking ▪ Conceptual thinking ▪ Technical expertise ▪ Results orientation ▪ Thoroughness Self-Management ▪ Flexibility 				
<p>ITS Awareness/Devices/National Architecture:</p> <ul style="list-style-type: none"> ▪ Describing ITS, ▪ Integrating systems, ▪ Surveillance technologies, ▪ Dynamic message signs and other information displays, ▪ Traffic controller, ▪ Radio and camera, ▪ DMS applications, ▪ Introduction to the national architecture, ▪ Basic concepts of systems engineering, ▪ Regional applications, ▪ Standards and user service requirements 	<ul style="list-style-type: none"> ▪ Systems architecture, ▪ Systems and technology 	<p>Analytical thought and skills with focus on IT systems and applications related to ITS; basic communication skills</p> <p>People Skills</p> <ul style="list-style-type: none"> ▪ Attention to communication ▪ Building collaborative relationships ▪ Customer orientation <p>Business Skills</p> <ul style="list-style-type: none"> ▪ Diagnostic information gathering ▪ Analytical thinking ▪ Conceptual thinking ▪ Technical expertise ▪ Fostering innovation ▪ Results orientation ▪ Thoroughness 	59 courses	29 universities	Region 1 (17) Region 2 (12) Region 3 (7) Region 4 (23)	51 non-academic courses

Operations Academy focus areas	Related topic areas from NCHRP 20-77	Core competencies	Current course availability (NTRR database)	Universities/ colleges that currently provide	Courses by AASHTO region	Training offered to practitioners (NTRR database)
<p>Data, Networks, and Telecommunications:</p> <ul style="list-style-type: none"> ▪ Telecommunications fundamentals (signals, frequencies, voice and data, wire line and wireless), ▪ Networks (local area, wide area), ▪ Data communications (standards and applications), ▪ Architecture and communications 	<ul style="list-style-type: none"> ▪ Program languages and technology, ▪ Visualization, ▪ Network security, ▪ Database management for operations, ▪ Data management and evaluation 	<p>Analytical thought and skills with focus on data management and systems applications related to traffic management and operations; basic communication skills</p> <p>People Skills</p> <ul style="list-style-type: none"> ▪ Attention to communication ▪ Building collaborative relationships ▪ Customer orientation <p>Business Skills</p> <ul style="list-style-type: none"> ▪ Diagnostic information gathering ▪ Analytical thinking ▪ Conceptual thinking ▪ Technical expertise ▪ Fostering innovation ▪ Results orientation ▪ Thoroughness 	<p>110 courses</p>	<p>50 universities</p>	<p>Region 1 (25) Region 2 (22) Region 3 (24) Region 4 (38) Online (1)</p>	<p>31 non-academic courses</p>
<p>Project Management:</p> <ul style="list-style-type: none"> ▪ Project management (including ITS, financial aspects, procurement), ▪ Asset management 	<ul style="list-style-type: none"> ▪ Organization and staffing, ▪ Project management, ▪ Partnership development, ▪ Performance management/ accountability, ▪ Partnerships 	<p>Strong overall management, team building, communication and collaboration skills</p> <p>People Skills</p> <ul style="list-style-type: none"> ▪ Establishing focus ▪ Providing motivational support ▪ Fostering teamwork ▪ Empowering others ▪ Managing change ▪ Managing performance ▪ Attention to communication ▪ Oral communication ▪ Written communication ▪ Persuasive communication ▪ Interpersonal awareness ▪ Influencing others ▪ Building collaborative 	<p>33 courses</p>	<p>21 universities</p>	<p>Region 1 (12) Region 2 (3) Region 3 (3) Region 4 (12) Online (3)</p>	<p>65 non-academic courses</p>

Operations Academy focus areas	Related topic areas from NCHRP 20-77	Core competencies	Current course availability (NTTR database)	Universities/colleges that currently provide	Courses by AASHTO region	Training offered to practitioners (NTTR database)
		<ul style="list-style-type: none"> relationships ▪ Customer orientation Business Skills ▪ Diagnostic information gathering ▪ Analytical thinking ▪ Forward thinking ▪ Conceptual thinking ▪ Initiative ▪ Results orientation ▪ Thoroughness ▪ Decisiveness Self-Management Skills ▪ Self-confidence ▪ Personal credibility ▪ Flexibility 				
<p>Emergency Management:</p> <ul style="list-style-type: none"> ▪ Emergency response planning 	<ul style="list-style-type: none"> ▪ Security management 	<p>Analytical thought and skills with focus on risk assessment and contingency planning; strong communication skills and the ability to be decisive under pressure</p> <p>People skills</p> <ul style="list-style-type: none"> ▪ Problem solving ▪ Fostering teamwork ▪ Attention to communication ▪ Oral communication ▪ Written communication ▪ Influencing others ▪ Building collaborative relationships <p>Business skills</p> <ul style="list-style-type: none"> ▪ Diagnostic information gathering ▪ Analytical thinking ▪ Forward thinking ▪ Technical expertise ▪ Results orientation 	19 courses	3 universities	Region 3 (1) Region 4 (1) Online (17)	34 non-academic courses

Operations Academy focus areas	Related topic areas from NCHRP 20-77	Core competencies	Current course availability (NTRR database)	Universities/colleges that currently provide	Courses by AASHTO region	Training offered to practitioners (NTRR database)
		<ul style="list-style-type: none"> ▪ Decisiveness ▪ Self-Management Skills ▪ Stress management ▪ Flexibility 				

ISSUES AND LESSONS LEARNED

Analysis of the NTTR database points to a number of issues within current transportation academic course offerings relative to TSM&O careers. While there are courses offered in all identified focus areas, several have limited offerings or fewer offerings than would be expected. The gaps in technical competencies highlight areas that may need additional attention in the transportation engineering curriculum via course material or connections to other programs covering that subject area.

- Traffic safety does not have many courses in the database, even when counting the professional development courses, and is offered at relatively few institutions. This gap is notable given that the ITE Curriculum Subcommittee includes safety as one of its knowledge tables. The information is either being covered as part of courses that largely focus on other topics (and so were not classified as relating to this topic in the NTTR database) or not covered at all.
- Emergency management courses are also limited and are only being taught at a handful of universities. This topic may be covered in other fields that relate to TSM&O.
- Project management course offerings are limited, especially compared to the number of professional development courses on this topic. We expect that there may be more project management courses offered in the construction management track of civil engineering programs that are not being captured here. We note that of the 68 universities listed in the database, 37 offer a construction management track or program within their civil engineering department. It is not clear if courses from those tracks were included in the NTTR database.
- ITS Awareness/Devices/National Architecture courses are not as widely available as anticipated considering the significant focus on technology and funding support for this area that has been available in the past. It is possible that some ITS information is included in the telecommunications area, which is more robust.

In addition, it is unclear how well the People and Self-Management competencies are represented within the technical courses offered. Many of these skills could be addressed by integrating these skills as a part of an engineering course. For example, oral and written communication could be incorporated as a learning objective, including evaluation and grading, in selected engineering courses. Likewise, collaboration skills could be integrated into an engineering course by incorporating course material on collaboration theory and techniques and evaluated through team assignments or joint projects. It is unlikely that this approach would address all of the required core competencies; however, it represents a relatively basic approach to beginning to fill the gap.

None of the analysis performed using the Operations Academy and the NTTR database evaluates the extent of the barriers to student awareness of TSM&O as a career path discipline for entry level engineers. However, looking at the ITE Curriculum Subcommittee knowledge tables, the proposed topic areas for an undergraduate introductory transportation engineering course currently do not include references to ITS, telecommunications, or emergency management issues.¹⁰ While there is limited time to discuss material in these courses, more mention of the full range of TSM&O topics could help to build awareness and interest in TSM&O careers. Courses related to these topics are likely offered in other (non-transportation engineering) degrees where TSM&O may be supported. This perspective is

¹⁰ Project management is not included in the knowledge tables, but is a topic area that may be covered in the broader civil engineering curriculum rather than in transportation-specific courses.

validated by the NCHRP 20-86 research which suggests that there are several other degree programs (electrical engineering, computer science) where potential candidates for TSM&O careers may be found.

Though not incorporated into our summary table, the NTTR database information can also be supplemented by a recent report by Karen Gitman (2010)¹¹ describing the state of the practice in transportation training at community colleges. This report finds that community college programs specifically related to transportation are mostly focused on the areas of automotive technologies, commercial driving, or supply chain/logistics. However, community colleges do offer both general studies and technical courses that can feed into transportation careers: for example, computer information systems and electronics courses. Community colleges can serve a role in advancing TSM&O academic offerings through opportunities for positions in ITS-related industries such as maintaining equipment and staffing traffic management centers. It is unclear from this research how much direct connection is made between relevant transportation programs and courses and TSM&O careers. Nonetheless, this would provide another arena in which to develop TSM&O career interest.

The breadth and depth of TSM&O related competencies drives home the challenges of preparing undergraduates to enter the TSM&O field right out of college. First, the multi-disciplinary background that is needed to help students succeed in the field is a significant challenge in and of itself. Creating cross-disciplinary degrees is difficult at many academic institutions and requires the student, and the student's advisor, to know early in an academic career that this is desired career path. Since TSM&O is not a well-known or fully established discipline within the transportation engineering field, students and college advisors are often not aware of this as a career option early enough in their course of study. Second, even if the lack of student awareness of TSM&O can be overcome, the current civil engineering curriculum is demanding, requiring many students five years to receive their undergraduate degree. In general, undergraduate civil engineering students only receive about 40 hours of instruction on all topics specifically related to transportation engineering. This significantly limits the time available to address non-engineering related TSM&O competencies.

¹¹ Gitman, Karen, "Transportation Workforce Development at Community Colleges (Report #10-002)," University of Vermont Transportation Research Center, March 2010. Available at: www.uvm.edu/~transctr/trc_reports/UVM-TRC-10-002.pdf.

Appendix 1: Core Competencies

Edward J. Cripe and Richard S. Mansfield identified 31 core competencies grouped into three overall categories, People, Business and Self-Management, in their 2002 book The Value Added Employee: 31 Competencies to Make You Irresistible to Any Company. The 31 competencies are:

People

1. Establishing focus: the ability to develop and communicate goals in support of the business' mission.
2. Providing motivational support: the ability to enhance others' commitment to their work.
3. Fostering teamwork: as a team member, the ability and desire to work cooperatively with others on a team; as a team leader, the ability to demonstrate interest, skill, and success in getting groups to learn to work together.
4. Empowering others: the ability to convey confidence in employees' ability to be successful, especially at challenging new tasks; delegating significant responsibility and authority; allowing employees freedom to decide how they will accomplish their goals and resolve issues.
5. Managing change: the ability to demonstrate support for innovation and for organizational changes needed to improve the organization's effectiveness; initiating, sponsoring, and implementing organizational change; helping others to successfully manage organizational change.
6. Developing others: the ability to delegate responsibility and to work with others and coach them to develop their capabilities.
7. Managing performance: the ability to take responsibility for one's own or one's employees' performance, by setting clear goals and expectations, tracking progress against the goals, ensuring feedback, and addressing performance problems and issues promptly.
8. Attention to communication: the ability to ensure that information is passed on to others who should be kept informed.
9. Oral communication: the ability to express oneself clearly in conversations and interactions with others.
10. Written communication: the ability to express oneself clearly in business writing.
11. Persuasive communication: the ability to plan and deliver oral and written communications that make an impact and persuade their intended audiences.
12. Interpersonal awareness: the ability to notice, interpret, and anticipate others' concerns and feelings, and to communicate this awareness empathetically to others.
13. Influencing others: the ability to gain others' support for ideas, proposals, projects, and solutions.

14. Building collaborative relationships: the ability to develop, maintain, and strengthen partnerships with others inside or outside the organization who can provide information, assistance, and support.
15. Customer orientation: the ability to demonstrate concern for satisfying one's external and/or internal customers.

Business

16. Diagnostic information gathering: the ability to identify the information needed to clarify a situation, seek that information from appropriate sources, and use skillful questioning to draw out the information, when others are reluctant to disclose it.
17. Analytical thinking: the ability to tackle a problem by using a logical, systematic, sequential approach.
18. Forward thinking: the ability to anticipate the implications and consequences of situations and take appropriate action to be prepared for possible contingencies.
19. Conceptual thinking: the ability to find effective solutions by taking a holistic, abstract, or theoretical perspective.
20. Strategic thinking: the ability to analyze the organization's competitive position by considering market and industry trends, existing and potential customers (internal and external), and strengths and weaknesses as compared to competitors.
21. Technical expertise: the ability to demonstrate depth of knowledge and skill in a technical area.
22. Initiative: identifying what needs to be done and doing it before being asked or before the situation requires it.
23. Entrepreneurial orientation: the ability to look for and seize profitable business opportunities; willingness to take calculated risks to achieve business goals.
24. Fostering innovation: the ability to develop, sponsor, or support the introduction of new and improved method, products, procedures, or technologies.
25. Results orientation: the ability to focus on the desired result of one's own or one's unit's work, setting challenging goals, focusing effort on the goals, and meeting or exceeding them.
26. Thoroughness: ensuring that one's own and others' work and information are complete and accurate; carefully preparing for meetings and presentations; following up with others to ensure that agreements and commitments have been fulfilled.
27. Decisiveness: the ability to make difficult decisions in a timely manner

Self-management

28. Self-confidence: faith in one's own ideas and capability to be successful; willingness to take an independent position in the face of opposition.

29. Stress management: the ability to keep functioning effectively when under pressure and maintain self-control in the face of hostility or provocation.
30. Personal credibility: demonstrated concern that one be perceived as responsible, reliable, and trustworthy.
31. Flexibility: openness to different and new ways of doing things; willingness to modify one's preferred way of doing things.