Transportation System Management & Operations (TSM&O) Workforce Development 
White Paper 2: Competencies, Education and Training

Introduction

This is the second of three White Papers prepared for the NOCoE Workforce Development Summit on June 22-23, 2016. The first paper provides general background and context regarding TSM&O as a program activity and TSM&O staffing within transportation agencies and the private sector. This paper addresses the needed staff competencies and related education and training. The third White Paper will focus on strategies and actions for TSM&O Workforce development – providing an agenda for Summit activities.

1. TSM&O Workforce Characteristics

General: The workforce knowledge, skills and abilities (KSAs) needed for effective TSM&O programs in public agencies have been developed in previous research – on a function by position basis – whether supplied by a public agency employee or private sector consultant or vendor. Exhibit 1 presents a simplified version indicating the “competencies” as related to staffing for current typical TSM&O programs and activities – and provides a point of departure for the discussion below. The table includes not only TSM&O-specific competencies in terms of knowledge for each function/position combination, but also notes the needed “complementary skills” – both technical and general – as well as an assessment of the importance of on-the-job –experience in acquiring the competencies and skills. Obviously the workforce needs will vary by agency type, size and urban/rural context – and current state of TSM&O, but the template captures the broadest framework.

1. Top Managers (HQ & Regions) -- These leaders are not TSM&O specialists. But they must supply the leadership and vision without which TSM&O programs remain informal, ad hoc, under-resourced activities. These positions are filled for a variety of reasons - of which TSM&O-specific background is a minor component. They are likely to come from senior positions within the agency or similar agencies with the skills and abilities related to agency management as well a specific knowledge of agency context and history. Principal challenge is identifying individuals with appropriate leadership KSAs, combined with an agency mission/policy/program understanding that appreciates the business case and includes a commitment to formalizing TSM&O so that program managers can develop an effective program. On-

1 This White Paper has been prepared by Steve Lockwood and Gary Euler on behalf of the National Operations Center of Excellence

2 These competencies are a modified versions of those developed in NCHRP 20-77 (2008) that defined in considerable detail the competencies required by personnel at various levels in a transportation operations organization -- technicians, engineers, and managers - and determined the –gaps between what training is needed vs. what is available, appropriate training packages and a review of training methods (http://att.umd.edu/research/transportation-operations-framework). NCHRP SR 693 (2012) built on the previous work, state-of-the-art initiatives, and best industry practices including other disciplines and non-transportation industry practices -- to develop guidance to help transportation agencies recruit and retain qualified TSM&O staff with special focus on a set of series of eight workforce action plans for various staff positions (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_693.pdf)
the-job leadership experience in similar leadership settings is key. In addition, a key role of senior leadership is to detect changes in the external environment and implications for organizational development (e.g., connected vehicles, road pricing, demographic changes, performance management).

2 and 3. Senior and Mid-level TSM&O Program Managers and Planners (HQ and Region) - provide the critical “core” program development and project management competencies. This group is essential to program development -- and program management needed for operational excellence -- and to developing performance management and contracting procedures -- and appears to be the level most needed by current agencies. They require a special combination of KSAs including: (1) in-depth knowledge of TSMO strategies, applications and performance; (2) management skills and agency-type experience related to needed business and technical processes and/or project management as related to TSM&O systems and technologies (3) systems engineering and (4) complementary abilities such as interpersonal communications, writing skills and personnel management. Given the rapid changes in technology and service applications, program managers must have a high degree of technical knowledge in the field.

4. Program Planners (HQ and Regional) -- are specialists for a new function that does not yet exist in most state and local governments and is rare in MPOs -- but is a recognized need with the basic knowledge still under development. It requires a broad background in TSM&O plus knowledge related to general transportation planning, data management and analysis, performance measures and institutional development related to improving the full range of capabilities.

5. Systems Engineering and Related Specialists, (Mid-Level) -- includes electrical engineering, information technology, data management and software specialists. These are key specialties outside the mainstream of most transportation agencies that are critical as they move into more technologically advanced applications.

6. Mid-level Project Managers - play key roles in day-to-day operational management with a project-specific focus. They require the same range of KSAs as No 3 above with a focus more limited to project management and specific applications and technologies.

7. Non-Professional Staff - TMC and Field - require specific functional skills related to TMC staffing, external incident management and ITS infrastructure and device maintenance.

2. Size of the Workforce Development Problem

The workforce development challenge is a combination of competency needs, the source of recruits and their backgrounds, and the size and location of the demand. Expansion of TSM&O staff has been modest in light of overall agency constraints and TSM&O lack of program status within most transportation entities (public and private) - as described in White Paper No 1. In general, there has been limited experience with a systematic approach to recruitment and to addressing competency gaps of either existing staff or potential recruits. Very few agencies have been granted additional slots -- most staffing has been in response to retirement and made from internal transfers.

To examine implications of the level of demand, general assumptions were made of order of magnitude future demand by function at a 20-year build out at “ideal” staffing levels. The assumptions were built on the Exhibit 1 function/position matrix, assuming that state DOTs, MPOs and larger local governments expand their TSM&O staff (and program) up to the level of current TSM&O “best practice” staffing level.
For state DOTs, the assumptions about staffing level by function/position (including headquarters and districts for state DOTs) assumed an average agency size – recognizing the large disparity in size and TSM&O relevance across all states. Based on these assumptions, the presumed 20-year future ideal “build out” TSM&O staffing level for best practice would total up to about 5 percent of total state DOT workforce today (200K)¹ – and to even a smaller percentage of all highway owner-operator entities combined (perhaps a not unreasonable level given that today’s TSM&O share of most state DOT budget is in the 2-3% range). Obviously the demand will vary considerably depending on the rate of update from agency to agency. Nevertheless, this exercise establishes reasonable benchmark ranges against which to consider the implication of level of demand for education and training of new employees.

3. Competency Needs vs Available Education and Training Resource

The competencies matrix by function (Exhibit 1) and the training resources table (Exhibit 2) provide a general accounting for resources available by function. Applicable TSM&O-related education and training is available from a variety of sources – most supported by USDOT (FHWA, ITSJPO, NHI, CITE). This material is designed for working professionals who already have substantial knowledge of institutional and program context – primarily in state DOTs -- and is at three levels:

- **Introductory** -- familiarization for staff who are not directly involved in TSM&O applications but need a general knowledge
- **Intermediate** – focused on the state of practice
- **Advanced** – primarily systems engineering technical knowledge and skill development

The relevance and availability of needed material for each function is described briefly below –based on Exhibits 1 and 2:

- **Sr. Policy, Strategic Management** (Function 1): the annual demand range (20-40) is modest, and, based on the KSAs needed, the source is likely to be internal recruits who are already equipped with the required leadership and management skills and abilities. There is no formal TSM&O training material specifically related to agency policy and program development designed for senior program level managers -- beyond online courses that introduce ITS. Those not previously involved in TSM&O can be exposed thru short general familiarization courses, through briefings by staff or at AASHTO, NOCoE or other professional meetings. There are several reports on TSM&O and on state-of-the practice and material from the Operations Academy (OA) and Regional Operations Forums (ROF) from which high level business case, program and processes development familiarization material could be developed. The key educational challenge is building recognition in leadership of the need for an appropriately aggressive and robust TSM&O program.
- **Sr. Program Management** (Function 2): the annual demand range (30-60) appears to be modest, and, based on the KSAs needed, the source is likely to be internal recruits or transfers from similar agencies that are already equipped with the required general management skills and abilities and an understanding of agency culture and organization. They already have the management background but need intermediate level TSM&O knowledge covering the full range

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³ Obviously this estimate is based on limited insight and assumptions including: (1) the current total TSM&O workforce; (2) a judgment call regarding best practice staffing configuration (3) assumptions of the “average” size of agencies and presumption that all would develop an aggressive TSM&O program. It should be noted that the general conclusions regarding workforce development require only an order of magnitude estimate

⁴ AASHTO Salary Survey, 2015
of applications as well as an understanding of the current state of practice – which can be largely satisfied by existing resources.

General engineering project management education is widely available pre-employment and post-employment within both agencies and the private sector. There is a wide range of TSM&O material available – from introductory to advanced. Systems engineering is well covered by ITS-JPO courses and there is considerable emphasis on most (but not all) specific applications available through FHWA, courses available through the Consortium for ITS Training and Education (CITE) courses and the Operations Academy/ROF modules –although much of the applications material is on state-of-the practice – rather than “how to” for managers. Coverage of technical and business processes is uneven: performance measurement and management is increasingly covered; there is little current material on TSM&O planning (although new material is emerging); organization and staffing are typically not addressed in training forums; project development, procurement and risk management – as specific to TSM&O – are dealt with only at an introductory level.

Experienced senior agency managers often comment that 50-75 percent of these KSAs for TSM&O are acquired on-the-job -- and therefore developing needed competencies is not a simple matter of formal pre-or post-employment education or training. Therefore, the mix of formal education and on-the-job training to develop the KSAs for these position/function combinations is a special challenge that needs to be "managed" either by individual agencies, peer groups, or industry-wide and the level of demand suggests the potential of a pre-employment custom-tailored course.

- **Mid-level Program Management** (Function 3): The annual demand range (80-160) is significant and these positions require a mix of general management related skills combined together with domain-specific and application specific knowledge at a moderate to advanced level. Staff assuming these positions are likely to come from two sources (1) transfers from other programs (with management experience) that need to be re-trained in TSM&O or (2) new junior hires that require both management and TSM&O-specific training – in addition to experience gained on the job. The same general comments regarding KSA needs, resources and their acquisition as discussed for Sr. Program Management (Function 2) above apply – together with more in-depth knowledge of systems engineering and applications. As the potential senior leaders of the future, continued training to improve management skills and to keep abreast of the TSM&O state of the practice is vital.

- **Program Planners** (Function 4): The annual demand range (60-120) is significant (substantially in MPOs and local governments) suggesting the potential of specifically developed pre-employment course materials that could be added into university transportation engineering and planning programs and used in post –employment training industry wide. TSM&O “program planning”, developing TSM&O-specific business process development and designing and managing a TSM&O performance program are special competencies for which training is currently minimally available - either to public agency or private sector staff, although new material is currently under development by NCHRP, FHWA and CITE.

- **System Engineering and Related Technical Specialties** (Function 5): the annual demand range is modest (30-60) and covers a range of specialized expertise in systems engineering, IT, EE, etc. The basic knowledge in these disciplines is widely available in pre-employment professional education. New hires may already have much of the essential technical background. The level of TSM&O-specific knowledge needed by various specialties varies from modest to detailed, and
would have to be accommodated with post-employment training (and is partially available at intermediate and some advanced training -- focused on architecture and standards). A wide variety of courses and training material in key technical specialty areas is available outside the TSM&O-specific context. The ITS JPO has produced guidance in the ITS architecture process, communications, and standards development, but no formal training appears to be available in IT, GIS and database management as applied in the TSM&O context. Given the rapid change in – and complexity of – new technologies and more complex applications (such as Active Traffic Management, Integrated Corridor Management and advanced traffic operations) continuing training is important to stay abreast of the state of the practice. These may also be areas of expertise that depend on both specific university-based research entity support – and the private sector.

- **Mid-level Project Management** (Function 6): the annual demand is large – (demand range of 60-120) suggesting the potential of a specifically developed post-employment training program to be used industry wide. The competency needs and availability of materials are noted above for functions 2 and 3 –but also include a need for more in-depth treatment of individual applications to be managed. The needed education and training can be mapped into a sequence of formal transportation and TSM&O knowledge at the university level, and continuing through post-employment TSM&O application-specific training offered by professional transportation organizations. Generic training materials for project management KSAs are widely available and can be developed post-employment anywhere within entities and adapted to TSM&O -- for both internal and external hires – in both the public and private sector.

- **Field Staff (TMC, field)** (Function 7): the annual demand for these non-professional, technical positions demand range is large (570-1070) but can be supplied by post-employment training – a mix of on-the-job and vendor training. While some community colleges offer general engineering technician courses and certificate programs that address key STEM areas – and a few train for other transportation domains – none appear to address TSM&O needs in particular. Most of the required background knowledge and specific skills are ordinarily developed with special post-employment internal training - including that regularly supplied by agencies and vendors. There are special federal initiatives for some areas with significant field operations, e.g., incident management, emergency management and special events. Especially for field technicians responsible for the maintenance of rapidly evolving electronic equipment, there is a need for training to remain current that is often available from technical schools or training institutes.

4. **Education and Training Gap vs Resources (This section is based on a review of available material.)**

TSM&O requires a broad range of competencies related both to the legacy context and to the dynamic system and technology features of TSM&O – as well as the complexities of real-world applications. The KSAs needed include:

- Understanding of the transportation enterprise (public, private) and context (mission, roles, organization, etc.)
- Broad understanding of TSM&O in general
- Systems engineering background (or other technical specialties as appropriate)
- Program and/or project management expertise (general and special)
- Complementary general skills - communications, personnel management, etc.
- TSM&O KSA maintenance in the changing contexts
This suggests that the needed workforce requires a combination of KSAs that are not efficiently supplied by one method or institution – and that a “hybrid” curriculum is needed that portrays the synergism among areas of knowledge. Needed workforce education and training includes both formal pre- and post-employment education and training – as well systematic on-the-job training.

Pre-employment Education/Training resources -- TSM&O is a new small specialty area in both practice and education. TSM&O focus in universities and training entities is minimal – a reflection of the small scale of student demand (foreign and domestic), crowded curricula -- and of faculty interest and general faculty competence –both substantially impacted by both student employment opportunities and the low level of federally supported university TSM&O research. While there are many university civil engineering bachelors and master’s programs with a transportation specialization – TSM&O is largely absent from the curricula – except as a special initiated sub-option, or as part of a “certificate of proficiency” program that would be based on a mix of elective courses outside the core concentration area of study. Similar certificate programs already exist for engineering specialties in several universities. The existing technical training material provides resources from which material could be drawn to develop introductory course material for graduate engineering and planning curricula –that could be tailored by educators (perhaps by a University Transportation Center) to their context as either a full course or course module. For graduate students with greater interest, there is a wide range of material available to pursue further interests.

For the TSMO-related functional specialties (systems engineering, electrical engineering, IT, data management), there is widespread availability of graduate curricula. In addition, there are courses and curricula in general engineering management – all of which provide useful background for the TSM&O arena.

At the technician level, while there are some community college curricula for certain transportation specialties, there is nothing yet with a TSM&O-related focus.

Post-employment education and training resources – Many states have transportation education professional development (TEPD) programs -- focused primarily on new civil engineers- in-training and limited to accredited graduate civil engineers. The programs are a mix of internally developed courses, courses made available thru supporting universities and access to “national” industry sources (NHI, FHWA, etc.). States have varying guidelines regarding training required to meet credentialing requirements and maintenance – and these vary with technical disciplines. A variety of learning formats are used including classroom, remote and peer-to-peer – and most of the programs have a tracking system. Florida DOT’s recruiting page offers one example:

“The P.E. Training Program facilitates the recruitment and hiring of graduate civil engineers by offering an initial career path providing broad, practical experience in the field of transportation engineering, leading to licensure as a Professional Engineer in Florida. The program is also a resource providing a succession of Professional Engineers who develop into future leaders and managers within the Department. The P.E. Training Program is a four-year program divided into two components. The first component is the Engineer in Training (EIT): a 24-month rotational assignment encompassing most phases of the Department's work. The second component is the Senior Engineer in Training (SET): a 24-month internship combining on-the-job training in both the technical and managerial functions of a specific work area in the Department.” (FDOT)

There does not appear to be parallel opportunities within the TSM&O arena, although on a more modest scale, the University of Maryland’s CITE program provides a web- based ITS curriculum jointly with the ITS JPO.
As per Exhibit 2, post-employment education and training resources currently available – Introductory, Intermediate and advanced – is designed for working professionals who already have substantial knowledge of institutional and program context. As suggested by the exhibit, coverage of existing material is not complete – and is substantially concentrated on:

- introductory and middle level courses to a wide range of TSM&O applications (state of practice)
- advanced courses on selected specific applications (ex: incident management)
- full range of courses on systems engineering, architecture and standards
- a few introductory courses on performance measurement and management combining both knowledge and skill components
- high level discussion of issue areas of process and institutional capabilities (not training)

The above discussion suggests the need for special custom-tailored approaches, focused on specific training programs developed and maintained by the employer agencies –and their related professional associations – with strong support from US DOT. A few states have an organized, centrally administered, multidisciplinary training program – with specific curricula designed to cover the full range of program areas (what CDOT calls its “CDOT University” and “colleges”) –and which include both general awareness courses for staff outside program areas – as well as specialized courses.

Post-employment training programs – As noted above, both pre- and post-employment education (courses) may represent less than 50 per cent of the knowledge and skills required in the diverse and dynamic TSM&O context. On-the-job training is key – including rotational assignments, exposure to best practice standards and skills development.

Given the reputation of the millennial workforce, the long-term approach, requiring pre-certification and significant employee time commitment, may not be appropriate, suggesting a shorter program with a more concentrated focus. For example, outside of the state DOT arena, the Transportation Professional Certification Board Inc. (TPCB), an autonomous certification body affiliated with the Institute of Transportation Engineers, offers online training, exams and certification for Professional Traffic Operations Engineer® (PTOE) to licensed professional engineers as well as certification for non-professional “Traffic Operations Specialists.”

5. Workforce Development Implications

Based on the discussion above – notwithstanding the lack of hard data in some cases – several key issues can be identified for further consideration.

Size of demand – As indicated in Sections 2 and 3 the staffing-up demand is modest. The numbers have implications for both pre-employment professional education (economies of scale in course development and delivery) and practicalities of developing material developed for a wide range of function/position combinations – for staff dispersed among a large number of entities – large and small.

Needed Position/Function competencies – The analysis of competency requirements – and related position descriptions used in organization and recruitment – are over a decade old and may not sufficiently reflect where TSM&O is headed in terms of new applications, technologies, and sector roles (such as connected vehicles).

Pre-employment education – There is clearly a hole in transportation education related to TSM&O – arguably a significant part of the profession’s future. While traffic engineering and operations is widely...
available in graduate civil engineering programs, a recent survey indicates that there are about 40 courses with and “ITS” or “TSM&O” focus nationwide – two at the undergraduate level.  

**Gaps in post-employment formal training** – Extensive training resources are available – Introductory, Intermediate, and Advanced (as per exhibit 2) designed for working professionals who already have substantial knowledge of institutional and program context. There is a core curriculum in theory with various components existing in the form of webinars, guides, (FHWA, ITS JPO, NIH) and self-administered web courses (CITE, ITE) and forum presentations (Operations Academy and ROFs). However, not all pieces are developed to the same level of detail and in the same learning medium – and there are some significant substantive gaps. In addition, standard sequences of training – familiarization, intermediate, advanced –have not been defined to determine the priorities in gap filling.  

**Budget commitments** – TSM&O staff involvement in training, mentoring, conferences and other support activities are very modest—and have been reliant on federal support – especially during the SHRP2 program. In general, agencies engineering training budgets are vulnerable when budgets are constrained – and TSM&O – as a small program – is not high on the totem pole.  

**Capitalizing on full range of knowledge transfer/training/education modes** – There is currently a broad mix of formal education modes that use materials ranging from classroom learning, web-based training, peer-to-peer, and blended approaches, etc. On-the-job training (mentorship, work-shadowing) is employed on an informal basis – and many of the newer IT-based knowledge transfer systems (content management, groupware, etc.) have not been used. The appropriate mode of knowledge transfer for specific knowledge transfer and skills development has not been systematically related to audience sizes and characteristics or the need to tailor combined learning modes to substance.  

**Combining education, training and on-the-job experience** – It is increasingly recognized that Workforce “Development” is more than formal knowledge transfer -- for both core knowledge areas themselves and for developing important complementary skills. Anecdotal evidence and the experience at TSM&O workshops and forums have highlighted that point. This reality has long been recognized via long-standing civil engineer-in-training programs that combine formal training materials with carefully considered program of rotational assignments, mentoring and deliberate exposure to national state of the practice material and discussions – most of which is managed by individual agencies. Key issues for TSM&O include the resource commitment in staff and funds – and in trainee time. Pilot programs could be developed, possibly on a peer state basis.  

**Performance management** – New regulations pursuant to MAP-21 legislation establish performance management as a new federal aid objective to which state and local transportation agencies must respond, including performance measurement, targeting and performance reporting requirements for congestion, freight movement and on-road mobile source pollution. Meeting these requirements will require public agency investments in—and staffing for -- TSM&O activities both in measurement and management.  

**Certification** – As noted above, in section 4, certification is offered in traffic operations and planning for licensed engineers that provide a measure of professional credibility – and can be developed both for pre- and post-employment contexts. As noted in a previous study: “A program of this nature is ideally suited to the needs of the M&O field, in that it permits students that may be pursuing an engineering degree to address their interests in other skills required for M&O........... These types of programs are also very

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5 Informal web survey conducted by CalPoly, CE423 Intelligent Transportation Systems course under the direction of Professor Robert Bertini
popular with companies and government agencies seeking ongoing educational opportunities for their employees. “

Public/Private sector cooperation – Private sector consultant and vendors are playing increasingly important roles in TSM&O applications development and service delivery. This is likely to increase in a world of automated and connected vehicle-related data and operations. Outsourcing responds to a variety of factors including the ability to recruit/retain certain skills, staffing and budget constraints and the cost of sustaining them in-house on a continuing basis, and the use of contracting to provide technical training. A key issue is the importance for public agencies to retain “core competencies” -- needed both for essential program development as well as for intelligent approaches to outsourcing and other forms of partnership. In the future the “revolving door” of staff moving between the public and private sector may have valuable payoffs in terms of effective partnerships and knowledge transfer.

Increased Support for the National Operations Center of Excellence – The NOCoE offers a convenient forum for consideration of matters related to Workforce Development –as well as a potential sponsor/manager of funded follow-up activities.

7. Connections to Recruitment, Retention and Career Development

It is clear from the above, that the workforce development challenge is closely related to those of career development, recruitment and retention. The key connections include identifying competencies to be recruited, realistic position descriptions, potential of credentialing, developing awareness among potential recruits in educational institutions, development of career tracks in the function/position matrix, and development and maintenance of professional capabilities.

These issues and others will be addressed in White Paper No. 3

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<table>
<thead>
<tr>
<th>Role</th>
<th>Function/Position Combinations (20-77)</th>
<th>Criticality</th>
<th>Associated TSM&amp;O Competencies (Knowledge) (20-77)</th>
<th>Complementary skills</th>
<th>% OJT vs Technical</th>
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<tr>
<td></td>
<td></td>
<td>Leadership: progress dependent on visionary leadership</td>
<td>Mission/Policy Development • Public Outreach • Objectives/Strategy Development • Organizational Change Management</td>
<td>Leadership, vision communications</td>
<td>90% (in similar role)</td>
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<tr>
<td>1. Policy and Strategic: Top TSM&amp;O Manager --HQ &amp; Region</td>
<td>Critical management capacity that integrates deep agency background, managerial capacity with program-specific knowledge that provides program directions, momentums</td>
<td>TSM&amp;O Strategies, Systems &amp; Tech. • Safety, Security • Performance Management</td>
<td>Program/Project Management • Finance • communications</td>
<td>75%</td>
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<tr>
<td>2. Real-time Operations: Sr. Program Management --HQ &amp; Region</td>
<td>Core technical/specialist capacities needed to get the job done on a day-to-day basis and maintain state of the practice</td>
<td>Business Process Management • Organization &amp; Staffing • Performance Measurement • Link Between TSM&amp;O &amp; Planning</td>
<td>Transportation Planning and OD development background (education)</td>
<td>50%</td>
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<td>3. Real-time Operations: Mid-level, program Managers, specialists</td>
<td>TSM&amp;O Strategies, Systems &amp; Tech. • Safety, Security • Performance Management</td>
<td>General Systems engineering • Contract Management • Outsourcing Contract Management • Procurement • In-House PM Risk Management • Communications</td>
<td>50%</td>
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<td>4. Program Planning: Senior and Mid-level</td>
<td>TSM&amp;O Strategies, Systems &amp; Tech. • Safety, Security • Performance Management</td>
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| Techical Support | 6. Project Management: Mid-level and project | - Contract Management  
- Outsourcing Contract Management  
- Procurement  
- In-House PM Risk Management | General project management | 50% |
|------------------|---------------------------------------------|--------------------------------------------------------------------------------|-------------------|-----|
|                  | Real-time Operations: Administration/Technician/Field (inside and outside) | - TSM&O Operations Strategies, Systems & Tech.  
- Safety Security  
- Management TSM&O Systems | Communications Data analysis | 80% |

This table is a modified version of material developed in NCHRP 20-77 (2008) [http://att.umd.edu/research/transportation-operations-framework](http://att.umd.edu/research/transportation-operations-framework).
## Exhibit 2 -- Workforce Development Long-term Annual Demand Assumptions for Order of Magnitude

Based on current “best practice” staffing applied to “average” entities by type (in-house or outsourced)

- 20 year staffing “build out”, straight line growth/minimal retirement
- Needs expressed in range of +/- 30 percent and rounded

### Function/Position Combinations (20-77)

<table>
<thead>
<tr>
<th>Function/Position Combinations</th>
<th>State DOTs</th>
<th>MPOs</th>
<th>City/County</th>
<th>Sub Total</th>
<th>Need per year (straight line) based on growth from 20% of target build-out today for 10 years with minimal retirement</th>
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<tr>
<td></td>
<td>HQ (50)</td>
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<tr>
<td></td>
<td>Districts (av. 7 per state X 50 = 350)</td>
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<td><strong>1. Policy and Strategic:</strong></td>
<td>Sr. Manager</td>
<td>50 (1)</td>
<td>200 (1)</td>
<td>150 (1)</td>
<td><del>400</del>20-40</td>
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<td><strong>2. Real-time Operations:</strong></td>
<td>Sr. Program Management</td>
<td>100 (2)</td>
<td>350 (1)</td>
<td>150 (1)</td>
<td><del>600</del>30-60</td>
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<td><strong>3. Real-time Operations:</strong></td>
<td>Mid-level planners, program Managers, specialists</td>
<td>200 (4)</td>
<td>1050 (3)</td>
<td>300 (2)</td>
<td><del>1,500</del>80-160</td>
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<td><strong>4. Program Planning:</strong></td>
<td>Senior and Mid-level</td>
<td>150 (3)</td>
<td>350 (1)</td>
<td>400 (2)</td>
<td><del>1,200</del>60-120</td>
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<td><strong>5. Systems Engineering/Development:</strong></td>
<td>Mid-level -- project managers, specialists, operators</td>
<td>250 (5)</td>
<td>350 (1)</td>
<td>300 (2)</td>
<td><del>550</del>30-60</td>
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<td><strong>6. Project Management:</strong></td>
<td>Mid-level and project</td>
<td>1050 (3)</td>
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<td>450 (3)</td>
<td><del>1,200</del>60-120</td>
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<td><strong>7. Real-time Operations:</strong></td>
<td>Administration/Technician/Field (inside and outside)</td>
<td>8,750 (25)</td>
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<td>1,500 (10)</td>
<td><del>10,250</del>570-1070</td>
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<td>Core Functions</td>
<td>National Highway Institute</td>
<td>Consortium on ITS Training and Education (CITE) – Web-based</td>
<td>ITS PCB Program – T3 Webinar Archive - Webinars</td>
<td>Agencies &amp; Associations</td>
<td>Education Institutions</td>
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<td>Policy and Strategic Consideration</td>
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<td>• Introduction to the National ITS Architecture</td>
<td>• Roles of TMC in IM on Managed Lanes</td>
<td>• ITS ePrimer (ITE)</td>
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<td></td>
<td></td>
<td>• Performance Measures</td>
<td>• Educating Students for ITS Careers</td>
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<td>• Transportation Management</td>
<td>• CV Basics</td>
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<td>Program Planning</td>
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<td>• Connected Vehicles 101</td>
<td>• Road Transport Automation &amp; Transportation Planning</td>
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<td>• Deploying ITS: Strategic Planning and Implementation</td>
<td>• Fundamental Issues for Road Transportation Automation</td>
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<td>• Principles and Tools for Road Weather Management</td>
<td>• Demonstrating the Benefits &amp; Costs of ITS</td>
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<td>• WRTM</td>
<td>• National CV Field Infrastructure Footprint Analysis</td>
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<td>• Interoperability: ITS Systems Architecture &amp; Standards</td>
<td>• Guidance Tool for Implementation of TIM PM</td>
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<td>• Connected Vehicle Workforce</td>
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<td>• How to Maintain an ITS Architecture</td>
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<td>Systems Development</td>
<td>• Turbo Architecture (WB)</td>
<td>• Advanced Systems Engr for Advanced Transportation Projects</td>
<td>• How to Use an ITS Architecture to Plan ITS Projects</td>
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<td>• ITS Deployment Analysis System (WB)</td>
<td>• Fundamentals of Database Management Systems</td>
<td>• Guidelines on Virtual Transportation Management Center Development</td>
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<td>• ITS ePrimer (ITE)</td>
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<td>• ITS Architecture Use &amp; Maintenance</td>
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<td>Project Management</td>
<td>Real-Time Operations</td>
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<td>• Systems Engineering for Signal Systems Including Adaptive Control (C)</td>
<td>• Careers in ITS</td>
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<td>• Introduction to Systems Engr</td>
<td>• Improving Highway Safety with ITS</td>
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<td>• Telecommunications and Networking Fundamentals</td>
<td>• ITS Apps in Transit Management Operations</td>
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<td>• Tools of ATMS</td>
<td>• RWIS Equipment and Operations</td>
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<td>• Traffic Flow Theory as Applied to ITS</td>
<td>• Traffic Incident Management</td>
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<td>• Network Design &amp; Deployment Considerations for ITS Managers &amp; Professionals</td>
<td>• Traffic Signal Timing</td>
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<td>• Advanced Sys Engr for Advanced Transportation Projects</td>
<td>• Traffic Signal Systems Fundamentals</td>
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<tr>
<td>• CV Reference Implementation Architecture Webinar #3 and #4</td>
<td>• Managing Travel for Planned Special Events (C)</td>
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<td>• Next Generation Traveler Information System</td>
<td>• Corridor Management</td>
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<td>• Performance Measures and Benefit-Cost Analysis for WRTM</td>
<td>• Crash Investigation &amp; Reconstruction Technologies &amp; Best Practices</td>
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<td>• Innovative Approaches to Real-Time System Management</td>
<td>• Securing Transportation Systems Webcast</td>
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<td>• Introduction to the Connected Vehicle Reference Implementation Architecture (CVRIA)</td>
<td>• Using Mobile Data for WRTM Management</td>
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<td>• ITS Standards Training Modules (introductory, Application, Understanding)</td>
<td>• Using Crowdsourced Data from Social Media to Enhance TMC Operations</td>
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<td>• ITS ePrimer (ITE) - modules</td>
<td>• Transit Safety &amp; Mobility Apps in a CV World</td>
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<td>• WSDOT problem/strategy web site (TRAC)</td>
<td>• Open Data Policy Guidelines for Transit</td>
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Effectiveness of Disseminating Traffic Messages  
Traffic Incident Management Performance Measures  
CV Reference Implementation Architecture Webinar #7,6,5,2,1  
Using ITS to Increase the Effectiveness of Your TIM  
Managing Traffic During Flood Events ITS Applications for Bicycles and Pedestrians  
Introduction to ITS Architecture Use and Maintenance |
Exhibit 4 -- Operations Academy Modules

- Making Managers Into Leaders
- The Future of TSM&O
- Operations Capability Maturity Model
- Traffic Incident Management
- Ride with Maryland State Highway Association Service Patrol
- Maryland Statewide Operations Center
- SE/ConOps/Benefit Cost
- Workforce Development Session
- Data Visualization and Performance Measures
- Integrating Planning and Operations
- Communicating with Your Customer
- Customer Service
- Transit: Improved Collaboration and Cooperation
- Performance Measurement
- Safety and Operations
- Connected Vehicles
- Facilitating Goods Movement Through Operations
- Connected Vehicles and Drivers and its Impact on Transportation Management
- VDOT Northern Virginia Express Lanes: P3’s
- Application of Operations Concepts
- Implementing Change in Your Organization
- Mainstreaming TSM&O in a State Program: A CEO Perspective

Regional Operations Forum Modules:
- Review of Capability Self Evaluations
- Operations Program Planning
- Performance Measurement
- Facilitating Goods Movement
- Systems Engineering
- Traffic Incident Management, Emergency Operations, and Planned Events
- Road Weather
- Traveler Information and Operations
- Work Zones
- Managing a Corridor (includes ICM, ATM, Managed Lanes)
- How to Organize for Operations
- Communicating the Value of Operations
- Applying What You Learned
- Agency Meetings – Development of Implementation Plans
- Connected Vehicles & Future of Transportation
Additional Resources (SHRP2 and AASHTO Reports):

- Business Process Frameworks for TSM&O
- E-tool for Business Processes to Improve Travel Time Reliability
- Organizing for Reliability – CMM Assessment and Implementations Plans Executive Summary
- Improving Transportation Systems Management and Operations - CMM Workshop White Papers
  - Business Processes
  - Systems and Technology
  - Performance Measurement
  - Culture
  - Organization and Staffing
  - Collaboration
- AASHTO Transportation Systems Management and Operations Guidance
- SHRP 2 Report S2-L06-RR-1: Institutional Architectures to Improve Systems Operations and Management
- SHRP 2 Report S2-L01-RR-1: Integrating Business Processes to Improve Travel Time Reliability
- SHRP 2 Report S2-L01-RR-2: Guide to Integrating Business Processes to Improve Travel Time Reliability
- SHRP2 Solutions Regional Operations in the 21st Century – A Vital Role for MPOs
- SHRP2 Operations in the 21st Century DOT – Meeting Customers’ Needs and Expectations