NNTW
National Network for the Transportation Workforce

National Transportation Career Pathways Initiative

YEAR ONE REPORT

FEB 2018

California State University, Long Beach, Research Foundation

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THE INITIATIVE

The Initiative

On October 24, 2016, the California State University, Long Beach, Research Foundation (CSULB) was awarded FHWA Grant #DTHF6116H00030, the Transportation Workforce Strategic Initiative, on behalf of the National Network for the Transportation Workforce (NNTW)—a university-based collaborative of five regional transportation workforce centers that provide research and strategic partnerships for FHWA's Office of Innovative Program Delivery. This initiative seeks to establish a set of five discipline-focused career pathways for deployment at post-secondary education/training institutions nationwide, in order to begin development of forward-looking, technology-infused workforce pipelines that lead to critical occupations within the highway transportation sector.

Each NNTW Center is assigned one of the five disciplinary focuses specified by the initiative (see below). CSULB houses one of these centers, the Southwest Transportation Workforce Center (SWTWC) and acts as programmatic lead. On Jan 12, 2016, the strategic initiative was renamed the National Transportation Career Pathway Initiative (NTCPI) to better represent its primary objective. The content of this report provides a summary of the research progress achieved by NNTW and its partners during the preceding quarter.

National Network for the Transportation Workforce

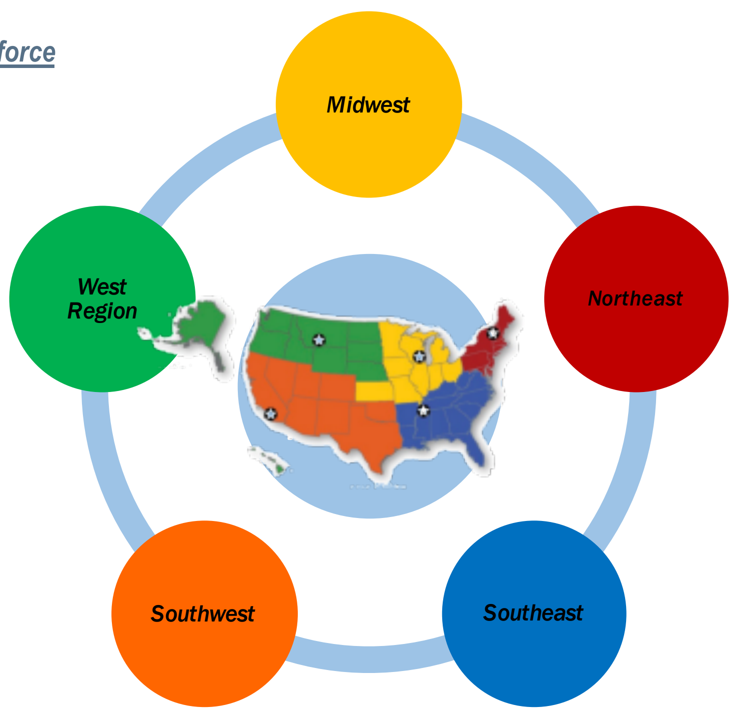
Southwest Transportation Workforce Center
California State University, Long Beach
Planning Discipline (SWTWC)

Southeast Transportation Workforce Center
University of Memphis, Tennessee,
Operations Discipline (SETWC)

Northeast Transportation Workforce Center
University of Vermont, Burlington
Environment Discipline (NETWC)

Midwest Transportation Workforce Center
University of Wisconsin, Madison
Engineering Discipline (MTWC)

West Region Transportation Workforce Center
Montana State University, Bozeman
Safety Discipline (WRTWC)



EXECUTIVE SUMMARY

Executive Summary

INTRODUCTION

In accordance with Tasks 4.3 through 4.7 of the FHWA Cooperative Agreement referenced above, this comprehensive Project Report is presented as an interim, year-one summary of the research, discoveries, outcomes, and deliverables achieved during the execution of the National Transportation Career Pathway Initiative. The five sections that follow this summary present this first year effort in alignment with the requirements of Task 4.3, where each specifically represents one of the initiative's five key disciplines.

In the performance of this work, an abiding goal for the five NNTW Regional Centers has been to develop a multidisciplinary roster of transportation career pathways and related implementation plans that best support FHWA's strategic goal of "*keeping the nation's highway system safe, reliable, effective, and sustainably mobile for all users.*"

The NNTW Regional Centers have worked collaboratively with leaders from transportation, education, and workforce development, to establish a body of research that challenges traditional approaches to job classification, occupational forecasting, and career pathway development. Each of the five centers contributed strongly to the development of methodologies and solutions that present a better understanding of how the transportation sector is evolving, what skillsets its future workforce will require, and how to prepare that workforce for employment. Collectively, these research efforts have informed the development of career pathways that lead to priority occupational clusters within each of the five transportation disciplines—Planning, Operations, Environment, Engineering, and Safety, as presented in more detail within the report that follows.

Shared here as part of this Executive Summary are the important cross-disciplinary highlights, observations, and recommendations regarding the state of the transportation industry, the characterization of its workforce, and the directives of this pathway initiative.

STAKEHOLDER ENGAGEMENT

The NNTW had the opportunity to convene with disciplinary working group (DWG) advisories on at least four formal occasions over the last year, both to inform members of initiative progress and to elicit critical industry and academic feedback on issues still under

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review. These issues included the identification of occupational priorities, the validation of job competency models, and the advisement of experiential learning programs and innovative learning strategies. While these meetings were clearly vital to keeping members and their stakeholder networks well informed, separate one-on-one interviews were found to be the most effective way to broaden staff understanding of occupational details.

The idea of maintaining a broader, external network of stakeholders represents a significant resource in terms of recommendations and validation of initiative processes and outcomes. NNTW continues to expand its stakeholder network through DWG associations, industry presentations, and social-media, with the goal of establishing a robust base of national survey respondents and subject matter expertise. The Operations Team alone conducted several stakeholder discussions at recent professional meetings, including the Tennessee Section Institute of Transportation Engineers, the Traffic Club of Memphis, the World Trade Club, the Greater Memphis IT Council InnovateIT Conference, the Journal of Commerce Inland Distribution Conference, and the DBi Services Annual Symposium.

Similarly, the Safety Team recently partnered with the National Center for Rural Road Safety to survey impacts of transformational technologies on the safety workforce, and with the Montana DOT Traffic Safety Division to address formal funding mechanisms that would support Montana State University Civil Engineering programs to work on priority safety projects. In preparation of a major survey launch, the Engineering Team contacted over 1000 external stakeholders to capture workplace characterizations for its highway maintenance workforce.

Research efforts alone—much of which can be performed in a vacuum of well-connected tools, databases, and literature posts across the internet—allow for a detailed and data-rich analysis of workforce competencies and the workplace environment. But accessing real experiential understanding of these factors from committed project advisors who represent both the employment and preparation sides of workforce development, as well as validating research through a network of relevant stakeholders, brings meaningful breadth and depth to project outcomes not just in terms of perspective over the issues at hand, but also in the occasional realignment of thinking and methodologies so that both offer a better match for the operation and performance of the transportation sector.

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TECHNOLOGY & WORKFORCE

Much like employees in other industries, the transportation workforce is susceptible to the influences of emerging transformational technologies. And though the promise of such technologies may be substantial in terms of increasing a system's operational economy, efficiency, and user safety and convenience, the future of workers within that system can sometimes be uncertain. These technologies have the potential to eliminate current occupations, create new ones, and dramatically affect which skills are most in-demand from industry employers, particularly 10 years into the future. To anticipate these affects in an effort to adapt workers—through updates to workforce pipelines and professional development programs—so that they stay competitive in a dynamically changing workplace, requires the continuous analysis of relevant sector data (i.e., industry technology and sector employment forecasts) and input from professional advisories, to identify which technologies may become disruptive and how that might impact an industry as a whole, while also its employment opportunities and workplace competencies more specifically.

For instance, research suggests that the continued evolution of connected and automated vehicles will present a considerable influence over the transportation industry as a whole, while most directly impacting the highway maintenance and operations professions specifically. With an increased presence of automation and connectivity, the human involvement in traditional operations occupations, such as commercial drivers, will likely see a decrease over time. And the maintenance of such new systems, particular roadways confounded by extreme weather conditions, will likely require workers to have new competencies to operate more intelligent vehicles—possibly remotely—and manage more complex decision-making scenarios in what is becoming a highly data-centric workplace.

In a similar example, the more frequent usage of robotics and unarmed aircraft systems can greatly reduce the direct labor required for highway maintenance activities, while also providing a notable increase in workplace safety, as highway workers perform roadway or bridge inspections and repairs without actually being present at the worksite. This transition would naturally result in a competency-demand shift from "able to perform hands-on maintenance tasks to "able to deploy and operate remote craft". Such implications suggest that, for this workforce, competencies of the future will be more geared towards machine interfacing and maintenance than actual on-site roadway maintenance, though naturally "experience in roadway maintenance" would remain a requirement either way.

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This overall increase in the reliance and incorporation of technology into transportation systems also contributes to the "Internet of Things" (IoT) phenomenon, which is an ever-increasing connectivity and communication ubiquity between devices. The growth of IoT provides ever greater opportunities for data gathering and the necessary implications of associated advancements in the management of "Big Data". For the workplace, this suggests that both data collection and data management will become key skillsets to staying relevant/competitive, along with an ability to read, interpret, and use this available data.

Finally, to precisely identify transformational technologies and their consequence on the workforce is a somewhat unachievable pursuit, particularly in a rapidly changing industry like transportation. There are no guarantees that forces impacting industry development today will still prevail or assert the same pressures tomorrow, making vigilance and diligence the best strategies to forecasting the workforce effects of such influences. And regardless of which technology becomes most impactful, research suggests two general conclusions: (1) technological deployment will require a corresponding skills adoption, and (2) the requirement for improved data handling and analysis will continue to grow.

A full summary of transformational technologies and their anticipated effects on the five disciplinary workforces is presented at the end of this report as Attachment A.

LABOR MARKET ANALYSIS

Validating occupational priorities using strong, evidence-based labor market information (LMI) is a fundamental approach to investing in workforce development solutions. "*Leveraging labor market data, employer input, and engaging educational and workforce stakeholders are explicit strategies being utilized to create a skilled, diverse, and aligned workforce and should serve as an important guide to stakeholders engaged in training and development.*" (NevadaWorks, Jan 2017). And yet the capture and analysis of reliable LMI using currently available online resources, job-posting databases, and query tools, has proven challenging throughout this project, when trying to surface employment data that best characterizes the occupations within the five disciplines of this transportation workforce.

Conventional LMI resources, such as employment data and forecasting from the Bureau of Labor Statistics (BLS) or Burning Glass Technologies, and the index of industry and occu-

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pational identities maintained through the SOC, O*Net, and NAICS systems, together provide a complex look into a traditional job market with title-centric occupations, but are less helpful at characterizing emerging industries and their occupations and workforce competencies. Some well-known limitations of these systems include:

- BLS employment projections are based on historic data that doesn't take into account any recent changes in the job market or impending influences from transformative technologies.
- BLS only provides labor market Information for occupations identified with a 6-digit SOC top code. Interest in data for emerging jobs (not represented by an SOC) will not find relevant information.
- The O*Net job classification system adds 2-digits of resolution to the 6-digit SOC system, however BLS does not recognize these distinctions, so all underlying job titles share the same labor market data.
- BLS projections are for a 10-year period, but are published with a 12-24 month time lag.

In most modern organizations, fewer professionals are employed to assume a broader range of responsibilities, mostly due to technology making greater levels of capability accessible to a broader audience. This same technological accessibility is also responsible for the reduction of what would now be considered incidental staff positions. At one time, a "Manager" was responsible for the coordination of efforts of subordinate staffers, collectively working within a common department. Today, a "Manager" is often also responsible for project scheduling and budgeting, contracted services, asset management, resource deployment, stakeholder presentations and report generation, etc. While the title itself was once sufficient to represent its occupational responsibilities, today it is the list of underlying competencies that better define the occupation.

This realization allowed the NNTW to approach each transportation disciplines as a cluster of jobs that share fundamentally critical employment competencies, as a more definitive way of identifying occupations within this sector. This approach not only supports the characterization of new and emerging occupations, but also helps to more clearly document the pathways that lead to these job clusters in terms of their competency lattice.

Further, by focusing on which competencies are in high demand from industry employers, versus which job titles are most often listed, a more exact representation of disciplinary priorities emerges, particularly when addressing new competencies that are expected to

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result from the impacts of transformational technologies. To adequately forecast the future workforce needs of an industry sector undergoing disruptive and transformational change, the research must first start with a foundational understanding of what those transformative forces are, how they will impact the workforce, and when those effects will take place. A draft of such an effort is presented at the end of this report as Attachment A.

Another complication of LMI-driven analyses is the lag-time present when top-down policies or practices are put into place versus when the competencies needed to implement those policies are defined and appear within job postings. Some skills projected to be increasingly in demand have yet to show-up in job descriptions, either because employers do not expect applicants to have access to such knowledge/expertise or because employers are not yet emphasizing those skills in their performance metrics. This is a particular challenge for career pathway implementation within a field like transportation safety, where practices are not yet being cultivated by agencies in terms of recognizing, actively seeking, and promoting staff with known safety competencies.

As NNTW pursues the characterization of the transportation industry—its occupational job clusters and disciplinary priorities—by cataloging and analyzing its common and critical competency sets, the validation of each research outcome and observational assumption is strictly tied to industry accepted data models, employer demand, and broad stakeholder surveys. Providing traceable and repeatable data-driven workforce solutions—via best LMI practices and employment forecasts—is a critical component of engaging subsequent partnerships for the implementation of these career pathway solutions.

STATE OF PRACTICE

A significant wealth of research and discovery has advanced the understanding of each discipline's occupational state of practice, curricular pathways of study, and experiential learning programs. Key investigatory tools used by NNTW researchers included the Burning Glass Technologies Labor Insight analytics tool to mine their captive database of job employment postings. This is done not just to yield labor market validation of targeted occupations, but to develop a broader picture of disciplinary components that occupy these workforce areas, in terms of industry specific employment requirements for workforce. Factors captured, cataloged, and analyzed included job titles; education, training, and competency requirements; previous work experience; certifications; and salary ranges.

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The compilation of multiple national listings reveal the occupational state of practice for these careers, and promote those competencies that represent a core set of expectations employers desire from their workforce. The alignment of these competencies will support the development of a comprehensive cross-disciplinary map that lays out the multiple pathway options available to students pursuing a transportation career, both in-discipline and across, as a function of the attainment of common skills and competencies.

A second and equally important effort has been to ascertain the curricular state of practice (academic pathways of study) that represent the educational backbone of these career ladders. Essentially documenting the state of education and training for pathway travelers within each discipline, these efforts provide a basis for highlighting the gaps in training and certification that existing programs present, falling short in terms of adequately preparing new entrants to each respective workforce.

EMPLOYMENT TRAINING

Transportation employers, particularly those in the public sector, rely on on-the-job training (OJT) to prepare hew-hires for their workplace responsibilities. Few 4-year academic programs incorporate experiential learning or job training programs into their career-oriented programs of study. With the rapid pace of technological advances and demand of employers for more interdisciplinary skillsets from employees, it is more important than ever to create opportunities for students to be immersed in “real world” projects and content in order to extend their learning experiences (Hart Research Associates, 2015). And, with evolving areas such as transportation operations or environment where there is not a single, specific disciplinary program of study that prepares students for these career pathways, industry-driven projects, innovative and alternative apprenticeship models, internships, and other industry-academic partnerships are necessary to help students develop essential knowledge, skills, and abilities within the pre-employment realm (Cronin, et al., 2012).

And while research into transportation construction-related academic programs revealed that some experiential learning and job training was incorporated into their programs of study, this is an outlier. Industry can and should utilize these training opportunities when present—and create them where missing, to integrate more current and in-demand content into these degree programs. Civil Engineering programs and ABET accreditation requirements for these degree programs provide a good case study, as accreditation criteria

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emphasize breadth of knowledge over specialization. As a rule, employers cannot expect that Civil Engineering Under Graduates will emerge with transportation-specific specialized skillsets or knowledge. Industry involvement in shaping experiential learning opportunities can act as an important driver to enabling the integration of more specialized content areas into degree programs. This is seen as a seriously underutilized resource.

Further, the lack of job training can also compound issues with attracting students to particular transportation careers, such as transportation operations, where students may encounter little relevant content related to the discipline in their course of study (Cronin, et al., 2012). This results in students having poor understanding of career opportunities and limited contextual training relevant to the discipline. Underrepresented students may be disproportionately affected by this lack of pre-employment training, as many of these students leave academic programs or career paths because of lack of confidence or identity with the particular career field. Apprenticeships, internships, and other experiential learning models are demonstrated to be effective for addressing these issues (Quaye, Griffin, & Museus, 2015). Because many transportation occupations have significant gender imbalance and low numbers of workers from ethnic minorities, there is a need to consider an approach at this stage in the pipeline to combat diversity issues (Quaye, Griffin, & Museus, 2015).

With academic programs already stressed to cover required content, particularly to meet accreditation requirements, a different approach is needed to address pre-employment training challenges. There is a need for much greater collaboration across academia and industry than ever before in order to address transportation workforce challenges and to adequately prepare students for careers of the future. Thus, adopting a comprehensive strategy for integrating experiential learning into 4-year academic programs may lead to greater preparedness of students for the workplace and workforce, increased awareness and interest in specific transportation occupations, and improved diversity outcomes.

BARRIERS & RECOMMENTATIONS

One key barrier to implementing new programmatic material, whether curricular changes in response to skills gaps or career pathways in response to industry demand, is that in most postsecondary institutions, programs of study are contained within traditional academic silos. Further, academic programs for many priority occupations are constrained by

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program hour limitations and accreditation demands. As the need for more interdisciplinary education and cross-cutting skills increases, institutions will need to transform the way postsecondary education takes place in order to appropriately prepare students for the workforce of the future.

Better development of career pathways and connections between two and four-year institutions are also needed. For instance, if a student wants to pursue an engineering degree, accreditation challenges currently limit opportunities to create two-year engineering programs—resulting in relevant certifications—that can transfer to four-year institutions.

Another barrier is that of misperceptions about careers in a discipline like transportation operations, and perceptions of technical careers in general, can limit the pipeline for some priority occupations (i.e., diesel mechanics, ITS technicians, traffic signal technicians, commercial drivers). This reflects a larger crisis in our country of undervaluing technical occupations and workers. It is essential to change the conversation around technical occupations so that more students consider these options.

A final insight is that better coordination and communication across the transportation industry is needed so that students are aware of the breadth of opportunities in the industry as a whole, rather than just within a particular transportation mode. This will also provide broader recruitment options for employers with recognition of non-traditional pathways that may provide appropriate background for particular occupations. Addressing these challenges will require concerted effort, significant time, and investment to ensure appropriate interventions and programs are developed through collaborative approaches.

Interdisciplinary certificates, at both the undergraduate and graduate level, may be one approach to addressing the challenge of academic silos in the short term. Non-traditional approaches to education must also be explored, including the role of apprenticeships and technical certifications/degrees as experience of value in four-year programs.

An important recommendation for success in addressing any of these barriers is that the focus cannot be limited to postsecondary institutions. By the time students reach postsecondary training and education, it is often too late; students may find themselves without the academic preparation to enter STEM fields requiring four-year degrees.

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Additionally, attracting students to a particular profession needs to begin in K-12, as students begin developing perceptions of careers, identifying with gender stereotypes, and closing doors as early as elementary school. Further, parents are a key influencer in a student's choice of postsecondary path. Practitioners must also change the conversation with parents about "success" and the numerous paths for pursuing it, if we are to make any significant progress in raising the profile of, and respect for, technical careers.

Most importantly, effective strategies for transportation workforce development must be collaborative. The right agencies, people, modes, and industries must be at the table to ensure that varied and wide-ranging perspectives are included and comprehensive solutions are developed.

THE YEAR AHEAD

Who Do Career Pathways Serve: While a staple of Career & Technical Education (CTE) at community colleges, where employment is often a significantly more tangible outcome of attendance than transfer into a university program, how can career pathways work to establish and promote better connections between these two and four-year academic institutions, given that so many professional occupations require a formal college degree? How should universities be expected to connect to career pathways in a useful way, and what value proposition can be identified to promote their participation, particularly in regions like Southern California, where applications to UC and CSU institutions far outweigh available enrollment? As the NNTW works to develop implementation plans and establish implementation partnerships for these pathways, it will become essential to understand "who" the audience is for this type of work and that how these career pathways are designed will differ based on that audience.

A Larger Role for NNTW: Clearly, the scope of this career pathways initiative and its definitive methodological and disciplinary-specific outcomes establish the NNTW Regional Centers as logical conduits for the promotion, partnership, and implementation of transportation career pathways into K-16 institutions, technical trade colleges, and those public/private agencies seeking to remediate workforce shortage and turnover. Yet more formidably, this two-year research effort has the potential of positioning the university-based NNTW as ideal advisory partners who are called upon to collaborate with other high-level

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stakeholders, during the development and implementation of complex infrastructure projects that can affect multiple communities across state and local borders.

As an example, estimates for the California High Speed Rail Authority's high-speed rail system—the first of its kind in the US, peak at a deployment of over 256,000 direct workforce personnel over the life of the project, 79% of which are during the construction phase alone. The logistics of developing entrant pipelines to satisfy a workforce of this capacity, that span the 800 miles of communities impacted by this project, require apolitical innovations and strategic partnerships that are beyond the scope of most state and municipal agencies and regional academic/training institutions.

As the investment in transportation infrastructure development and repair gains momentum in this country, having NNTW at the forefront of these new projects would result in substantial influence over attracting new entrants to this workforce and a comparable investment into new and innovative programs at CTE institutions who are interested in servicing these new workforce opportunities.

Deployment Options: As NNTW moves past the work of career pathway design and development and towards practical applications and implementation strategies, discussions surrounding the delivery of these pathway efforts into the education/training continuum have surfaced, with an acknowledgement that presenting research in a traditionally flat, static format, belies the potential and forward-looking nature of this project and its discoveries. Instead, the possibility of piloting a modern, interactive career path website is under consideration. Such a site would visually attract students to professional career opportunities in the transportation sector, while articulating the education, training, and certification pathways that lead to those opportunities.

This site would act to connect students and career counselors seeking local employment opportunities with regional post-secondary programs that are tailored to prepare workers for entry into transportation professions, to industry employer partners interested in advertising open positions and sponsoring internship/apprenticeship programs. By presenting initiative outcomes using an online, web-based platform, issues of national access, pathway deployment, and periodic research updates become greatly simplified.

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Demonstration Programs: The Planning Team continues to work with its two and four-year academic partners to develop and deploy curriculum for a credit-bearing pilot course that introduces Geographical Information Systems (GIS) to transportation pathway students. This Career Pathway Demonstration Program has now launched as part of the Los Angeles Community College District's Spring 2018 academic session, which opened Feb 5th, 2018, and is actively encouraging a diverse population of bridge and CTE students to consider transportation planning careers at multiple entry points along this pathway.

To bring experiential learning into the classroom, students will be introduced to a variety of industry-partnered events and presentations, including the practical application of GIS technology using work-based challenge projects regularly faced by planners. The Planning Team will also introduce their Transportation Planning Career Pathways, which offer a directed plan of continuous education that includes transfer options into accredited graduate planning programs offered at a number of local universities.

For the Operations Team, Career Pathway Demonstration Programs oriented around real-world projects, industry engagement, and strategies that "put a face" on operations careers, are likely to be the most effective at increasing student awareness of and interest in this discipline. Development of projects that provide students with an opportunity to better understand the importance of and practice key skills within the context of a transportation operations challenge, while providing industry mentors, is one approach that will be investigated further for developing a model for postsecondary institutions.

TRANSPORTATION PLANNING

Transportation Planning

INTRODUCTION

According to the American Planning Association (APA), the goal of planning is to "*maximize the health, safety, and economic well-being for all residents [involving] thinking about how we can move around our community, the businesses and attractions in our community, where we want to live, and opportunities for recreation*". Planners work closely with the citizens and elected officials to look at how the pieces of a community fit together and make recommendations based on their findings. Together with engineers, architects, or developers, planners design future communities, anticipating challenges and accounting for growth and change in resources and demand.

Transportation planning is a crucial specialization within the planning profession, characterized as *"the discipline that examines and evaluates the potential of future actions to improve movement of people and goods by motor vehicle, public transportation, walking and cycling in accordance with a set of objectives"* (TPCB.org). Much like other planners, transportation planners provide cooperative interaction between different community stakeholders, such as transportation professionals, decision makers, and the public. In addition to mobility, transportation planning also takes into account safety, environmental, and social equity concerns. Throughout this project, the Southwest Transportation Workforce Center (SWTWC) has worked to clarify the role of the transportation planner—as found in both public and private-sector employment—and the workplace competencies that are considered critical to the effective execution of the transportation planning function.

This effort includes identifying key occupations within this workforce that represent top priorities in terms of unmet demand and projected job growth, such that career pathway portfolios can be developed to encourage new participation in the field of transportation planning. These career pathways will provide post-secondary institutions with a roadmap to the effective and comprehensive preparation of students for work in this field; preparation in terms of the both academic and experiential learning that will yield the knowledge, skills, and abilities (KSAs) that employers demand today, plus new and emerging competencies that will keep workers competitive for years to come, as the impacts of economic and technological disruption continue to transform the transportation workplace.

TRANSPORTATION PLANNING

TRANSFORMATIONAL TECHNOLOGIES

Research efforts to identify priority occupations in transportation planning began with the SWTWC 2016 Job Needs and Priorities Report, a regional labor market analysis designed to "*… identify priority jobs and set the stage for meaningful regional workforce discussions and initiatives.*" The recommendations of this report have since been evaluated against more recent Bureau of Labor Statistics (BLS) employment data and an occupational competencies analysis captured by Burning Glass Technologies analytics software. This initial analysis was subsequently presented to and reviewed by the Planning Discipline Working Group (DWG); a key panel of regional transportation and workforce stakeholders representing both industry need and education and training solutions.

These earlier results allowed researchers to appreciate the importance that workplace competencies play in identifying priority occupations, as competencies/KSAs better reflect the search that employers undertake when seeking talent within the transportation sector. Competencies also offer a keener insight into the effects of new technology on the workplace, as the pure elimination or creation of jobs is less a result of technological advancement than is the need to continually update the skillsets of workers to be more effective and competitive in a technically dynamic workplace. This realization led researchers to assemble a database of projected workforce impacts that are expected over time and that will result from disruptive or transformative technologies and their effects on transportation. As a starting point, researchers used and reviewed the following literature:

Beyond Traffic: 2045 Final Report (2017)
U.S. Department of Transportation

2015 OST-R Transportation Technology Scan: A Look Ahead (2015)
Elizabeth Machek, Joseph Stanford, Stephanie Fischer, Kara Canty, Brian Dechambeau, and Gary Ritter
U.S. Department of Transportation – John A Volpe National Transportation Systems Center

20 Game-Changing Technology Trends That Will Create Both Disruption and Opportunity on a Global Level (2012)
Daniel Burrus

These Next Generation Government Agencies Are Using Mobile Technology to Save Taxpayers Billions (2016)
Mark Fidelman

I-NUF Presentation: Connected and Automated Trucks: What and When (2017)
Steven Shladover

I-NUF Presentation: Heavy duty CAV – fast or slow? (2017)
Peter Sweatman

The Future of the Transport Industry - IoT, Big Data, AI And Autonomous Vehicles (2017)
Bernard Marr

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Based on this literature, researchers explored each technology for its potential impact on the transportation sector, by characterizing their application in context with this industry. A summary of this scan, presented as Attachment A, identifies technologies, trends, and potential impacts on the transportation industry as a whole, as well as any specific impacts (new or emerging skill sets) forecast for each of the five disciplinary workforces of this pathway initiative (Planning, Operations, Environment, Engineering, and Safety). This latter content was captured in collaboration with all five NNTW regional centers and their respective DWG advisors.

Further, researchers presented their findings out to a broader network of professional stakeholders during an interactive workshop at the 2018 Transportation Research Board (TRB) Annual Conference, entitled "*Addressing the Impact of Disruptive/Transformational Technologies on the Transportation Workforce*". This 3-hour workshop addressed the main challenges faced by the transportation workforce faces from new and emerging technologies, noting that pressures from technological advancements within the freight and personal mobility spaces are pushing employers and workforce development practitioners to collaborate on career pathways that better support future transportation professionals.

In this workshop, SWTWC and its panel of transportation technology experts discussed how new career pathway designs will better target the attainment of key workplace competencies that are necessary to be effective in a transportation planning agency, and how to achieve this through collaboration among academic institutions, employers, and government agencies. Effective transportation pathways must address the new and essential competencies that are sought after by industry employers, including the application and analysis of "Big Data", working with Intelligent Transportation Systems (ITS), understanding autonomous vehicle technologies, and adapting to 21st century soft-skills.

PRIORITY OCCUPATIONS

Initially, researchers conducted a labor market analysis to identify critical occupations and related competencies for transportation planners. To focus this effort, a draft list was first established by narrowing the field of occupations to just those represented by the "Transportation & Warehousing" North American Industry Classification System (NAICS) code. Under this heading, occupations related to planning were targeted using BLS Standard Oc-

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cupational Classification (SOC) codes. These SOCs were then cross-referenced against labor market databases warehoused at online facilities O*Net Online and Burning Glass, to establish a report with current and projected employment statistics, related job competencies, and a list of typical job titles. This draft report is shown in Table P1 below:

Table P1. Transportation Planning Occupations – National BLS Projections (draft)

O*NET SOC CODE	OCCUPATION	CURRENT # EMPLOYEES, 2014	PROJECTED # EMPLOYEES, 2024	PRECENT CHANGE	2016 MEDIAN PAY PER HR
17-1021.00	Cartographers & Photogrammetrists	12,300	15,900	29%	$30.17
15-2031.00	Data Analysts / Ops Research Analysts	91,300	118,900	14%	$38.08
15-1132.00	~~Software Developers, Applications~~	718,000	956,000	14%	$48.12
19-2041.02	Environmental Planners	95,000	134,300	9%-13%	$33.13
19-2041.00	Environmental Scientists & Specialists	95,000	134,300	9%-13%	$33.13
15-1141.00	~~Database Administrators~~	120,000	159,200	9%-13%	$40.84
15-1111.00	~~Computer & Information Research Scientists~~	26,000	32,000	9%-13%	$53.77
17-2081.00	Environmental Engineers	55,000	77,400	9%-13%	$40.81
17-2051.00	Civil Engineers	281,400	305,000	8%	$40.16
53-6041.00	Traffic Technicians	7,000	10,900	5%-8%	$21.71
13-1199.04	~~Business Continuity Planners~~	998,00	1,164,900	5%-8%	$33.19
19-4061.01	City & Regional Planning Aides	32,000	47,200	5%-8%	$20.76
17-2051.01	Transportation Engineers	281,000	387,700	5%-8%	$40.16
17-3022.00	Civil Engineer Technicians	74,000	95,600	5%-8%	$24.03
19-3051.00	Urban & Regional Planners	38,000	40,400	6%	$33.66
15-1199.04	Geospatial Information Scientists & Techs	233,000	270,700	2%-4%	$41.59
15-1199.05	Geographic Information Systems Techs	233,000	270,700	2%-4%	$41.59
13-1081.02	Logistics Analysts	130,000	150,600	2%-4%	$35.66
11-3071.01	~~Transportation Managers~~	112,000	139,100	2%-4%	$42.88
11-3071.02	~~Storage & Distribution Managers~~	112,000	139,100	2%-4%	$42.88
11-9199.04	~~Supply Chain Managers~~	986,000	1,241,400	2%-4%	$50.47
11-3071.03	~~Logistics Managers~~	112,000	139,100	2%-4%	$42.88
15-1199.08	Business Intelligence Analysts	233,000	270,700	2%-4%	$41.59
15-1199.02	~~Computer Systems Engineers/Architects~~	233,000	270,700	2%-4%	$41.59
11-9041.00	~~Architectural & Engineering Managers~~	182,100	185,800	2%	$64.78
19-2099.01	~~Remote Sensing Scientists & Technologists~~	29,000	32,000	-1%-1%	$46.19
19-3094.00	Policy Analysts/Political Scientists	6,200	6,100	-2%	$54.95
19-3099.01	Transportation Planners	36,000	40,200	-2%	$37.03
17-3031.00	Surveying & Mapping Technicians	57,300	53,000	-8%	$20.41

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To begin narrowing this field of occupations down to 10-20 priorities, the Planning DWG provided valuable industry perspective that included striking those occupations with only a tenuous connection to the planning function. This initial culling is represented in Table P1 with red strikeout text. Planning DWG advisors also recommended taking into account which competencies industry and public agency employers seek-out when building a successful planning team. This realization helped researchers to redirect focus away from the traditional silos of static, title-driven job classifications, to a broader understanding that in today's workforce, critical functions within an organization are accomplished by a team of tightly collaborating professionals.

To validate this new approach, an review was performed on all planning-related job opportunities posted by the Southern California Association of Governments (SCAG), which contained occupational specifications that were rich with in-demand job competencies. This effort led to the development of a labor market database that captured all relevant SCAG job data, including job titles, minimum qualifications (skills, competencies, education, certifications, and prior work experience), and salary range. An analysis of this data, representing 32 active job listings, helped establish a clear state of practice for planners working within a significant public agency employer like SCAG.

To validate these results on a national level, a second scan was conducted using the same methodology, this time mining job listings posted by the APA, which maintains the largest membership of professional planners from both public and private sectors. In this scan, 51 job opportunities were documented, evaluated, and then compared against the results summarized by the SCAG report. This comparison, presented as Figure P1 below, demonstrates a significant overlap between regional and national employers and provides an excellent summary analysis of employer workforce demand for transportation planners in a way that visually highlights the most sought-after competencies.

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COMPARISON OF COMPETENCIES IN JOB LISTINGS/DESCRIPTIONS - APA AND SCAG

Top Five Sought-After Competencies American Planning Association	Total Observations or Average Amount	Percentage n = 51
Written and Oral Communication	31	61%
Collect, Compile, and Analyze Data	24	47%
Principles of Planning and Development	24	47%
Presentations (Public Speaking)	22	43%
Professional Relationships/Interpersonal Skills	21	41%

	Competencies/Requirements	Total Observations or Average Amount	Percentage n = 51
Knowledge	Analysis/Research/Report Methods	10	20%
	Principles of Planning and Development	24	47%
	ORG/MGMT/HR Practices	7	14%
	Transportation Modeling	1	2%
	Project Management Practices	6	12%
	Market Research	1	2%
	Funding/Grant Writing	2	4%
	Regulation/Legislation Related to Area	16	31%
	Business language, Document Drafting	7	14%
	Gov./City Structure (Boards, Councils, Commissions)	9	18%
	Budgeting/Financial Analysis	4	8%
	Foreign Language	2	4%
Technology	GIS	19	37%
	Standard Microsoft Appliations	12	24%
	Adobe Tools (Creative, Illustator)	6	12%
	CAD	2	4%
Skills/Abilities	Prepare Reports	15	29%
	Presentations (Public Speaking)	22	43%
	Public Interaction	20	39%
	Customer Service	2	4%
	Collect, Compile, and Analyze Data	24	47%
	Negotiation	2	4%
	Plan and Coordinate Projects	17	33%
	Teamwork	12	24%
	Work Independently	10	20%
	Professional Relationships/Interpersonal Skills	21	41%
	Written and Oral Communication	31	61%
	Leadership	11	22%
	Management/Supervision	12	24%
	Prepare/Administer Budgets	4	8%
	Multitasking	13	25%
	Strategic Mindset	2	4%
	Time Management/Organizational	3	6%
	Logical Thinking/Problem Solving	6	12%
Education	Bachelor's Degree	39	76%
	Master's Degree	3	6%
Certification	AICP	24	47%
	PE	3	6%
Work Experience	Work Experience (Average Years)	3.45	N/A
Salary	Salary (Average Lower Limit)	$ 46,653.86	N/A
	Salary (Average Upper Limit)	$ 61,757.87	N/A

Top Five Sought-After Competencies Southern California Association of Governments	Total Observations or Average Amount	Percentage n = 32
Regulation/Legislation	23	72%
Principles of Urb./Reg./Trans. Planning	22	69%
Prepare Reports/Presentations	22	69%
Collect, Compile, Analyze Data	21	66%
Complex Problem Solving	19	59%

	Competencies/Requirements	Total Observations or Average Amount	Percentage n = 32
Knowledge	Analysis/Research/Report Methods	18	56%
	Statistical Theory/Methods	13	41%
	Principles of Urb./Reg./Trans. Planning	22	69%
	PR Techniques	4	13%
	Air Quality Planning	5	16%
	ORG/MGMT/HR Practices	9	28%
	Transportation Modeling	10	31%
	Project Management Practices	18	56%
	Regulation/Legislation	23	72%
	Economic Forecasting	4	13%
	Env./Sust. Practices	4	13%
	Gov./City Structure (Boards, Councils, Commissions)	3	9%
	Transportation Development Act	2	6%
	Budgeting	11	34%
	Principles in Transportation Demand Mgmt.	3	9%
Technology	GIS	8	25%
	SAS	3	9%
	Standard Office Appliations	3	9%
	Other Software Requirements	4	13%
Skills/Abilities	Prepare Reports/Presentations	22	69%
	Public Interaction	13	41%
	Collect, Compile, Analyze Data	21	66%
	Plan/Coordinate Projects	10	31%
	Teamwork	8	25%
	Work Independently	14	44%
	Gain Coop./Consesus thr. Disc. and Persuasion	9	28%
	Written and Oral Communication	8	25%
	Leadership	11	34%
	Management	10	31%
	Prepare/Administer Budgets	8	25%
	Complex Problem Solving	19	59%
Education	Bachelor's Degree	30	94%
	Master's Degree	2	6%
Work Experience	Work Experience (Average Years)	4.45	N/A
Salary	Salary (Average Lower Limit)	$ 99,018.40	N/A
	Salary (Average Upper Limit)	$ 137,865.37	N/A

Legend
Green cells represent the top five most commonly found knowledges and skills/abilities, and the top two technology competencies mentioned.
Yellow cells represent the overall top five competencies for the respective scans (presented on top of the page).

Data sources
APA: Nationwide job listings posted at www.planning.org using the key word 'Transportation' as selection criteria
SCAG: Regional (CA) job descriptions found at www.scag.ca.gov using transportation/planning education requirements as selection criteria

Figure P1. Planner Job Competency Comparison: APA vs SCAG

A result of these analyses, along with recommendations from the Planning DWG (Planning DWG, Sep 2017), was a refinement of the initial occupational list into a version that represented competency-driven assignments for planning function priorities within an organization where proficiencies in “Geographic Information Systems” (GIS), “Statistical Modeling”, “Data Capture & Analysis”, and “Data Visualization & Presentation” pushed the definition of a traditional planner into occupational areas where occasionally, no standardized titles exist or no LMI is cataloged.

This revised list of occupational priorities for the planning discipline is shown in Table P2, where gaps in LMI denote an absence of appropriate SOC tagging and targeting. A pending industry survey is expected to gather broader input on these refined titles.

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Table P2. Transportation Planning Occupations – Competency Driven Refinement

O*NET SOC CODE	OCCUPATION	CURRENT # EMPLOYEES, 2016	PROJECTED # EMPLOYEES, 2026	PRECENT CHANGE	2016 MEDIAN ANNUAL WAGE
19-4061.01	City and Regional (Planning) Aide	34,000	35,500	4.3%	$43,190
19-3099.01	Transportation Analyst	42,100	44,900	2.7%	$77,020
19-3099.01	Transportation Planner	42,100	44,900	2.7%	$77,020
19-3051.00	Urban & Regional Planner	36,000	40,600	12.8%	$70,020
19-1031.01	Land Use Planner	22,300	23,700	6.3%	$61,810
19-2041.02	Environmental Planner	89,500	99,400	9.9%	$68,910
17-1021.00	Cartographers & Photogrammetrists	12,600	15,000	19.4%	$62,750
17-3031.00	Surveying and Mapping Technician	60,200	66,600	10.6%	$42,450
19-3051.00	Regional Planner, Data/GIS	36,000	40,600	12.8%	$70,020
19-3051.00	Regional Planner, Modeling & Forecasting	36,000	40,600	12.8%	$70,020
19-3051.00	Regional Planner, Environment & Assessment	36,000	40,600	12.8%	$70,020
17-2081.00	Environmental Engineer	53,800	58,300	8.3%	$84,890
17-2051.01	Transportation Engineer	303,500	335,700	10.6%	$83,540
17-2051.00	Civil Engineer	303,500	335,700	10.6%	$83,540

*Note 1: Occupations listed in brown do not correspond to a traditional SOC O*Net designation. Instead, each has been assigned a related code that best matches the competency set of the O*Net designated occupation.*

*Note 2: LMI limitations in this data set are endemic to the BLS SOC coding system. Employment data captured by BLS is only presented at the 6-digit SOC top-code level and is not representative of the more granular 8-digit occupational resolution provided by O*Net. Thus, "Transportation Planner", an occupation that can only be found within O*Net's 8-digit classification system (19-3099.01), is not distinguished by BLS from its 6-digit SOC top-code 19-3099, designated as "Social Scientists and Related Works, all other categories". As a result, labor market projections presented above at the 8-digit O*Net level actually share the same workforce data as every occupation indentured under the respective 6-digit SOC top-code.*

STATE OF PRACTICE: EDUCATION

To better understand the current educational environment for planners, researchers conducted a scan of transportation engineering and planning programs offered at 53 universities across the United States, as cataloged initially by the Volpe National Transportation Systems Center. This included 27 academic programs offered at 11 of the 53 universities, which culminate in a bachelor's degree, master's degree, and/or graduate certificate.

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These particular 11 institutions were selected due to their curricular focus aligning well with the needs of transportation planners, as identified by the Planning DWG. The remaining 42 universities offered engineering degrees, but did not present the curriculum components related to transportation or transportation planning, as noted by Volpe. The curriculum components that were analyzed had focus areas in “Land-Use Planning”, “Transportation Planning”, “GIS Applications”, “Urban Design”, “Transit Systems”, and “Sustainable Urban Development”. Overall, this research identified commonalities across engineering and planning academic programs that could attract college students into pursuing a transportation planning career. The 11 universities included in this scan were:

Michigan Technological University	*BS & MS Civil Engineering & Transportation Engineering*
Virginia Tech	*BA Public & Urban Affairs, BS Environmental Policy & Planning*
	Master of Urban Planning, Transportation Planning & Policy
	MS Transportation / Infrastructure / Systems Engineering
University of California, Berkeley	*BS Civil Engineering, MS Transportation Engineering*
	MS Energy, Civil Infrastructure & Climate
	Master of City Planning: Transportation Policy & Planning
Cal Poly Pomona	*Master of Urban & Regional Planning*
Mass. Institute of Technology	*Master of City Planning: Transportation Systems Planning*
Georgia Tech	*BS & MS Civil & Environmental Engineering: Transportation Systems*
	Master of City & Regional Planning: Transportation & Land Use
	MS Geography Information Science & Technology
	Minor in Sustainable Cities, Certificate in Geographic Systems
Missouri Univ. of Science & Tech.	*BS & MS Civil Engineering: Transportation Engineering*
Illinois Institute of Technology	*Master of Engineering, Transportation Engineering*
	Graduate Certificate, Transportation Systems Planning
Purdue University	*MS Civil Engineering: Transportation & Infrastructure Systems*
New York University	*MS Transportation Planning & Engineering*
Ohio State University	*Master of City & Regional Planning*

The second phase of this curricular scan assessed transportation planning programs that are offered at colleges around Southern California. This sample-set originated from an extensive list of institutions accredited by the Association of Collegiate Schools of Planning (ACSP)—a “*consortium of more than 100 university departments and programs offering planning degrees as well as programs that offer degrees affiliated with planning*”—and APA. This list that was ultimately narrowed to include network partners from CSULB’s Center for International Trade and Transportation (CITT).

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This localized approach allowed researchers to uncover linkages between CITT's partners and stakeholders, and ultimately to discover curriculum best practices. Existing relationships with these university partners make them ideal candidates for participation in subsequent pathway implementations, where issues like approving community college course articulation and providing a program point-of-contact will become key factors in deploying successful pathways. These regional institutions include:

CA Polytechnic State Univ, Pomona (Cal Poly)	*Master of Urban & Regional Planning* *BS Urban & Regional Planning; Infrastructure & Transportation Professional Education (collaboration with APA)*
CA State University, Northridge (CSUN)	*BA Urban Studies & Planning* *Minor in Urban Studies, Master of Urban Planning*
San Diego State University	*Master of City Planning*
University of California, Irvine (UCI)	*BA Urban Studies, Minor in Urban Studies* *Master of Urban & Regional Planning*
University of California, Los Angeles (UCLA)	*Master of Urban & Regional Planning* *Minor in Urban & Regional Studies* *Certificate in Global Public Affairs*
University of Southern California (USC)	*BS Urban Studies & Planning, Minor in Urban Sustainable Planning* *Master of Planning, w/ Concentration in Transportation Planning* *Certificate in Transportation Systems*

These universities offer a variety of undergraduate, graduate, and professional graduate programs that include comprehensive transportation planning elements required by public and private-sector planning organizations (Planning DWG, Sep 2017). For example, Dr. Kimberly Clark explained that many SCAG new-hires graduated from urban planning programs at local APA-accredited universities, including Cal Poly, CSUN, and USC. Accordingly, these institutions' transportation planning programs were analyzed throughout this. Overall, this curricular scan captured the core competencies and learning objectives from 17 transportation planning degree programs, providing an essential cross-validation of the critical planning competencies identified earlier by the APA/SCAG occupational analysis.

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Undergraduate Programs

In Southern California, there are eight undergraduate programs accredited by ACSP that pertain to Urban & Regional Planning, Urban & Regional Studies, and Urban & Sustainable Planning. These programs provide students with the option of choosing a transportation planning track, which then dictates they take a series of general education and prerequisite courses designed to prepare them for upper-division planning coursework. In general, the 4-year programs of study accredited by ACSP and APA are pure "planning" programs; some institutions provide the option of declaring an emphasis in transportation planning.

For institutions offering planning programs without a transportation emphasis, students are encouraged to design their own class schedule in a way that includes such specializations early in their academic program. Focusing studies in this way can provide students with a broader base of foundational transportation knowledge than would normally be attained through a static degree program, better preparing them for employment.

General Education Prerequisites

Students pursuing these planning programs are able to integrate lower and upper-division specialty courses into their schedule once they have successfully passed general education (GE) requirements. CSUN and Cal Poly provide basic fundamental skills of "Analytical Reading" and "Expository Writing," "Critical Thinking," "Mathematics," and "Oral Communication"; invaluable skills for pursuing upper-division courses or seeking employment in a professional environment. In some cases, students may be eligible to take lower-division, planning-contextualized courses to fulfill their GE requirements, as long as those courses provide the same learning outcomes. Each university offers a unique course outline for its transportation planning undergraduate programs; outlines researchers used to identify overlapping course prerequisites. These prerequisites offer a broad understanding of the technical and theoretical knowledge required to successfully complete a major's curriculum. Common course titles for these pre-requisite courses include:

An Introduction to Graphic Communication Tools used by Urban Studies & Planning Professionals

Quantitative/Qualitative Urban Research Methods

Planning Theory

General Plan & Zoning

GIS & Planning Applications

Economics

Urban Policy & Planning

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By completing these courses within their first two years, students are eligible to pursue a planning pathway that focuses on urban and regional planning, where program offerings more directly relate to transportation. These courses provide critical technical skills in 3D Modeling, GIS, Statistical Analysis, and Regulatory Compliance.

Internships

As part of an accredited university planning program, students may be required to construct a fieldwork research project and/or complete an approved internship, both of which earn them college credit. Pathway students are encouraged to seek-out these opportunities to better challenge the development of real workplace competencies. For example, internships prepare students for careers in urban planning by providing them with theoretical and practical skillsets, along with broad-based educational experiences that support a greater exploration of career options. Students with prior work experience who seek employment are more favored by industry employers over recent graduates who lack such experience (Planning DWG, Sep 2017). Further, internships and other co-curricular involvement demonstrate to employers a commitment and work ethic that is otherwise not directly apparent (ibid). Many of these academic programs require or recommend that students intern at a transportation planning organization and engage in professional collaboration in order to develop critical communications skills and a network of potential employers.

As discussed earlier, the Volpe university scan focused primarily on transportation planning engineering programs; programs with a focus in advance mathematics (calculus) and imaging technology software used by engineers. A subsequent analysis concluded that these programs also met the basic knowledge requirements asked for by transportation planning organizations, as their curricula required students to take theoretical and technical courses that address transportation and planning related topics. Even though these programs honor students with engineering degrees, they maintain a strong transportation knowledge base. In addition, an APA/ACSP program scan produced an array of curriculum that has been accredited by these national associations. These programs foster students with a more intensive degree, addressing urban planning with an emphasis in transportation. This reflects how academic institutions prepare the future workforce through theoretical and technical approaches, indicating a fundamental lack of prescriptive experiential learning. Internship programs fill this gap by providing pathway students with extracurricular industry work experience, preferably at a public or private planning agency.

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STATE OF PRACTICE: EMPLOYMENT

SWTWC researchers followed up on an earlier occupational analysis of 32 public sector job listings for transportation planners, posted by SCAG (the nation's largest metropolitan planning organization), to identify trends in employment, occupational competencies, salary ranges, and critical pre-hire expectations. Although requirements naturally differed across job listings, there were a few noteworthy, recurring observations: the most commonly sought-after competencies included the “Preparation & Presentation of Reports”, “Collection, Compilation, and Analysis of Data”, and “Ability to Problem Solve in a Work Environment”. Further, a number of jobs required knowledge of applicable legislation and regulation within their respective service area, but also principles of urban, regional, and transportation planning. Additional, seemingly fundamental requirements included project management practices and research and analysis methods.

More recently, this occupational analysis was augmented by a second scan conducted across a national set of employment opportunities for transportation planners, as posted by APA. Here, an additional 51 listings were characterized for their employment specifications and competency-demand frequency, which identified “Written & Oral Communication” as the most frequently specified competency, followed by “Collection, Compilation & Analysis of Data”, and “Principles of Planning & Applicable Legislation”. Table P3 below presents the top five competencies identified in both the APA and SCAG scans.

Table P3. Top Planner Job Competencies, Regional vs National

TOP 5 PLANNER COMPETENCIES, SCAG	TOP 5 PLANNER COMPETENCIES, APA
1. Regulation/Legislation	1. Written & Oral Communication
2. Principles of Planning & Regulations	2. Collect, Compile, Analyze Data
3. Report Prep & Presentation	3. Principles of Planning & Regulations
4. Collect, Compile, Analyze Data	4. Presentations (public speaking)
5. Complex Problem Solving	5. Pro Relationships / Interpersonal

Clearly, overlap and agreement exist between these two sets of listings and their starkly different sources. Unsurprisingly, “Principles of Planning & Regulations” are valued highly by a majority of employers, as is “Collecting, Compiling, & Analyzing Data”. Competencies like “Report Preparation,” “Presentation & Public Speaking,” and “Written & Oral Communication Skills” are also competencies that appear frequently in both lists. Generally, pos-

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sessing interpersonal skills and maintaining professional relationships are considered desired traits by employers of transportation planners and their related occupations.

Similarly, researchers analyzed a salary survey conducted by the Urban & Regional Information Systems Association (URISA), to identify the high-demand skills required by employers of GIS professionals. The Planning DWG identified GIS as a core technical competency for future planners and SCAG identifies planners with a specialty in GIS as a critical workforce component. Not surprisingly, many of the technical skills documented by the URISA survey align with previous research, demonstrating that data analysis, data manipulation, and data acquisition/creation are critical skills for these areas.

Similarly, project management, research, report writing, public speaking, personnel management, and budgeting are also competencies that frequently appear in all three sets of job data (SCAG, APA, URISA). However, somewhat unique to GIS occupations are cartography, database maintenance, and data visualization and reporting, though the latter has been identified by the Planning DWG as an emerging expectation by planning agencies.

Other differences include training, strategic planning, and cost benefit analysis, though here again stakeholder feedback identifies these competencies (more generally, project management skills) as requirements for private-sector planners, who are normally consulting on projects within outside public agencies.

PLANNING COMPETENCY MODEL

To begin the work of documenting the competencies required for a career in transportation planning, researchers engaged the CareerOneStop online Competency Model Clearinghouse, sponsored by DOL, to build and register a standardized model for the occupational cluster that makes up transportation planning careers. This effort conforms with a primary objective of this pathway initiative: to establish a basis for new competencies in transportation planning anticipated over the next 15 years.

The CareerOneStop 6-step competency building process provides both rigor and structure for establishing, validating, and representing occupational competencies in a uniform and sharable way that also builds upon occupational standards already established by DOL, including competency standards for occupational clusters within Transportation, Distri-

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bution & Logistics, and Geospatial Technology. These existing models, along with competency data captured through SCAG and APA occupational scans, were used to build the draft Transportation Planning model presented below.

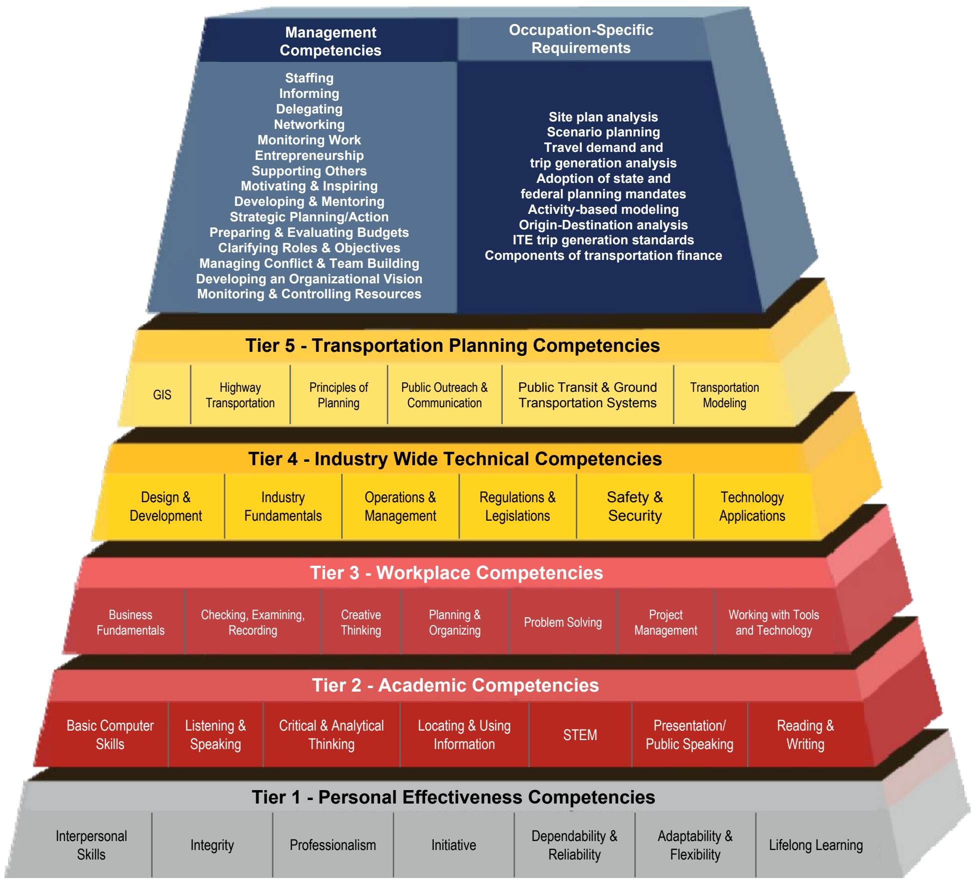

Figure P2. DOL Competency Model for Transportation Planning

The CareerOneStop model consists of six competency tiers. The first three tiers represent foundational competencies that are applicable to a large number of industries and occupations. These are categorized as Personal Effectiveness Competencies—soft skills usually attained in a home or community environment, Academic Competencies—cognitive functions and thinking styles usually attained in an academic setting, and Workplace Competencies—qualities that help individuals function in an organizational setting that are applicable to many industries and occupations. An enumeration of these first three tiers for Transportation Planning is shown in Table P4 below:

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Table P4. DOL Competency Model for Transportation Planning (Tiers 1-3)

TIER 1: PERSONAL EFFECTIVENESS	TIER 2: ACADEMIC COMPETENCIES	TIER 3: WORKPLACE COMPETENCIES
Interpersonal Skills	Basic Computer & Software Skills	Business Fundamentals
Integrity	Communication (Listening/Speaking)	Planning & Organizing
Professionalism	Critical & Analytical Thinking	Checking, Examining, Recording
Dependability & Reliability	Locating & Using Information	Problem Solving, Decision Making
Adaptability & Flexibility	Mathematics	Teamwork
Initiative	Reading	Working w/ Tools & Technology
Lifelong Learning	Writing Reports	Time Management
	Presentation / Public Speaking	Multitasking
		Project Management

This table identifies specific competencies suggested by existing models in the clearing-house in black text, while those competencies that also appear in SWTWC occupational scans are listed in brown. Competencies that appear in these scans, but are missing from the DOL base model are highlighted in yellow. Observationally, there are few soft skills in common between the DOL model and SCAG/APA job scans, while many common competencies are apparent in the academic and workforce areas. It is possible that these soft skill qualities presented by the DOL clearinghouse models are too rudimentary to appear in modern job descriptions, or are simply perceived as common-sense traits.

Tiers 4 and 5 of the competency model represent skills sought after in the transportation industry and the transportation-planning sector, respectively. Using the same entry legend as described for Tiers 1-3, these two competency sets are illustrated in Table P5:

Table P5. DOL Competency Model for Transportation Planning (Tiers 4-5)

Tier 4: Transportation Industry-Wide Technical Competencies	Tier 5: Transportation Planning Competencies
Research, Design, Development of Transportation Systems	Highway Transportation
Industry Fundamentals: Transportation, Distributions, Logistics	Public Transit & Ground Transportation Systems
Operations & Management	Principles of Transportation, Urban, & Regional Planning
Regulations	Transportation Modeling
Safety & Security	GIS
Technology Applications	Public Outreach

Tier 6 of this model is used to identify Management Competencies and Occupation-Specific Requirements, the latter of which are pending broader stakeholder input.

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CAREER PATHWAYS

By combining research efforts from the SCAG/APA occupational scans, the transportation planning academic curricular scan, and this DOL competency model, SWTWC researchers have been able to draft a framework of a planning career pathway map, as represented by the current state of practice. This pathway map (Figure P3 below) will be evolve as additional information surfaces pertaining to target occupational priorities, and as NNTW works to formalize the structure and content for these pathway graphics.

Transportation Planning Pathway

	KSAs	ACADEMIC PROGRAM OF STUDY & WORK EXPERIENCE	RECOMMENDED CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	- Considerable knowledge of the theory, principles and techniques of the planning profession and development process - Federal, state and local laws, codes and regulations and recent changes - Principles and practices of supervision, training, performance evaluation, and personnel management - Budgeting and finance - Recent developments, current literature and sources of information related to municipal planning and administration. - Knowledge of local government procedures and practices - Citizen involvement techniques and processes	Master's Degree in in urban planning, transportation planning, or related field At least three years supervisory experience required Five or more years planning experience	AICP	**Advanced Level** - Planning Director - Executive Director - Director/Owner - CEO/President - Planner IV - Principal Planner - Planning Manager **Annual Salary:** $51,848 - 224,307
INTERMEDIATE LEVEL	- Advanced knowledge of the philosophies, principles, practices and techniques of planning - Advanced knowledge of one or more relevant specializations - Excellent oral and written communication skills for preparing and presenting planning reports and projects to diverse audiences - Knowledge and experience in construction processes - Knowledge of or experience in community remediation and redevelopment, and knowledge of relevant Federal programs - Project management skills - Ability to provide effective supervision and staff management - Knowledge of a relevant specialization (such as transportation) desired - Ability to create graphic designs, development strategies, and render site plans via sketches and/or computer graphics is highly desirable	Earn AICP Certification Bachelor's Degree in urban planning, transportation planning, or related field Some supervisory experience preferred for Planner III/Senior Planner positions Up to six years planning experience required	AICP	**Intermediate Level** - Planner III - Senior Planner - Planner II - Associate Planner - Junior Planner - Planner I - Assistant Planner **Annual Salary:** $43,234 - 107,952
ENTRY LEVEL	- Planning principles and practices - Principles and practices of research and data collection - Statistics, algebra, geometry - ArcMAP/GIS, MS Office/Access, Adobe Suite, AutoCAD - Regulation and legislation - Written/oral communication skills - Problem solving and multitasking skills - Teamwork and independent work skills - Public outreach and interpersonal skills	Associate's Degree/two-year transfer degree/two to three years college experience with major coursework in urban studies, urban planning, transportation planning, or related field Up to two years work experience desired	N/A	**Entry Level** - Planning Technician - GIS Technician - GIS Analyst - Other Specialized Technician - Graduate Planner - Planning Intern **Annual salary:** $24,960 - 74,776

Figure P3. Transportation Planning Career Pathway

Brief descriptions of the different Planner occupational levels are presented below, as designated by APA for public sector career advancement:

- *Planning Director: The top management level specializing in planning issues. Within a private sector planning firm or a nonprofit, the Executive Director directs all operations of the organization and reports to a Board of Directors. The Planning Director of a local, county or state government directs planning initiatives and typically reports to a Town/City Manager.*

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- *Principal Planner: Supervises and participates in advanced, highly-complex professional planning activities. Often manages and supervises sections or divisions within the larger planning department of an organization. May function as deputy director. In other cases, Principal Planner may possess a limited supervisory role and function as the most senior planner with expertise in a particular specialization.*
- *Planner III: Requires advanced professional planning experience of high complexity and variety. Often leads or is significantly involved with larger, more complex planning assignments. Planners at this level exercise greater independence and judgment, receiving general supervision from senior management. The Planner III may supervise the Planning Technician, Planner I or II.*
- *Planner II: Requires professional planning work of moderate difficulty. Characterized by increasingly specialized knowledge of the planning field and a more elevated level of required duties and responsibilities compared with the Planner I. The Planner II is expected to possess in-depth knowledge within one or more planning specialties. planners at this level receive somewhat less immediate supervision when compared to the Planning Technician or Planner I.*
- *Planner I: Entry-level position within professional planning. It is distinguished from the Planning Technician position because it involves professional-level duties and judgment, and fewer routine administrative tasks. Expected to possess knowledge within one planning specialty.*
- *Planning Technician: Entry-level paraprofessional work. The Planning Technician devotes a significant amount of time on routine administrative tasks. A Planning Technician often works closely with the public on a regular basis to provide customer service on planning issues. Successful Planning Technicians may be asked to perform professional-level (Planner I) duties of limited complexity as a trainee.*
- *Planning Intern: The internship level in the planning profession often represents the first practical contact a prospective planner makes with the profession. Successful internships yield valuable insight and practical knowledge for students as they refine their educational and career paths.*

When designing career pathways for transportation planning, researchers discovered the planning industry follows a narrow, highly vertical hierarchal structure. This hierarchy applies to planning occupations within multiple industries, given slight alterations for specificity. These variant planning tracks are considered “specializations” within the broader planner occupational cluster; SWTWC research naturally focuses on highlighting pathway distinctions that are unique to the transportation industry, as categorized by the APA job listing database. In addition to transportation, these other specializations include land use planning, community development, urban and regional planning, comprehensive or long-range planning, and environmental planning.

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Regardless of specialization, the career path and program of study depicted in Figure P3 (above) remains roughly the same. As an individual proceeds up this career ladder, one's knowledge gain becomes collateral to the occupational specialization, and access to other specializations becomes easier the higher one progresses. This observation is supported by the fact that competencies identified for each successively more senior position overlaps with more occupational requirement from other planner specialties. Each of the six planning specializations are described in more detail below:

- *Transportation Planning: A transportation planner is someone who works alongside government agencies to select and develop plans to organize mass transit. Transit routes may be developed for walking, bicycling, bussing, rail, or air. Transportation planners normally communicate through the media in oral, written or visual forms.*
- *Land Use Planning: In urban planning, land-use planning seeks to order and regulate land use in an efficient and ethical way, thus preventing land-use conflicts. Governments use land-use planning to manage the development of land within their jurisdictions.*
- *Urban & Regional Planning: Urban and regional planners develop land use plans and programs that help create communities, accommodate population growth, and revitalize physical facilities in towns, cities, counties, and metropolitan areas.*
- *Environmental Planning: Environmental planning is urban and regional planning with a focus on sustainability. It aims to analyze and minimize the environmental impacts of proposed construction projects and make sure they meet all environmental regulations.*
- *Comprehensive / Long-Range Planning: Comprehensive planning is a process that determines community goals and aspirations in terms of community development. The outcome of comprehensive planning is the Comprehensive Plan which dictates public policy in terms of transportation, utilities, land use, recreation, and housing. Comprehensive plans typically encompass large geographical areas, a broad range of topics, and cover a long-term time horizon.*
- *Community Development: Community development is a complex business involving a multidisciplinary approach to achieving goals. The role of the city community development planner is to determine how best to use land, usually through construction of new housing or business developments. In some cases, building grass-roots support for a project can be key. In others, environmental protection and integration is vital.*

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INNOVATIVE LEARNING STRATEGIES

To successfully incorporate sought-after competencies into an otherwise academic career path, researchers initiated a literature review on the state of practice of innovative and experiential learning practices being deployed by workforce development and career technical education (CTE) professionals today, as well as strategies under development for the future. This revealed several practices that would benefit a transportation planning program of study, though it must be noted that, while these creative and innovative practices are known to increase student learning effectiveness, their implementation is subject to an often bureaucratic, slow-moving, and conservative academic environment. Applicable learning practices that apply to and are recommend for planning pathways include:

- *Competency-Based Curriculum: Curriculum that meets academic and quality standards is designed and organized by competencies required for jobs and is cross-walked with industry skill standards and certifications where applicable. Job profiling and the use of "subject matter experts" should be strongly considered to strengthen curriculum and meet the competency needs of business.*
- *Modularized Curriculum: Structure and sequence curriculum in modules tied to jobs with multiple entry and exit points, with multiple levels of industry recognized credentials built into the sequenced pathway.*
- *Asynchronous Learning: Provide education and training for students and incumbent workers at times and locations convenient to students and employers, rather than instructors or institutions. This can include evenings or weekends, blended or "hybrid" delivery models, and delivery at off-campus locations.*
- *Problem-Based Learning: Problem-based learning helps students who seek hands-on learning and want to be media-makers foster team-building and solve real life problems.*
- *Experiential Learning: Incorporate opportunities for "learning by doing", including internships, co-op work experience, simulations, and team class projects that are assignments from local employers.*
- *Context-Based Learning: By interpreting new information in the context or place of where and when it occurs and relating it to what we already know, we come to understand its relevance and meaning. To design effective strategies for learning requires an understanding of how context shapes the process of learning.*
- *Individual Learning: Learners are different and innovative learning environments reflect the various experiences and prior knowledge that each student brings to class. It's important that practices and processes help teachers engage each student where they are.*

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- *Career Planning: Provide career planning courses, workshops, and web-based resources that include tools such as assessments, career portfolios, and individual education/career plan development, thereby increasing understanding about demand occupations and career clusters of interest.*

- *Assessment: Assessments should be for learning, not of learning. Assessments are important, but only to gauge how to structure the next lesson for maximum effectiveness. It should be meaningful, substantial, and shape the learning environment itself.*

Researchers also began investigating what experiential learning programs are currently available for students and incumbents that would benefit their progress along a transportation planning career pathway. Still a work in progress, some examples of academic and employer-favored internships, co-curricular activities, and work-based learning programs are presented below and pending validation by the Planning DWG advisory:

- *Sierra Club Angeles Chapter Transportation Committee: The local Sierra Club chapter in Los Angeles is home to the Angeles Chapter Transportation Committee, a grassroots network linking volunteers and staff activist who are interested in having an impact on conservation issues. This committee's efforts seek more sustainable transportation in LA and Orange Counties, which support Sierra Club's national Beyond Oil campaign – "especially expanding public transit; planning for livable, walkable, bikeable communities; and promoting clean plug-in vehicles." This chapter is a volunteer-driven grassroots initiative that engage new members to work together and discuss issues and solutions to transportation topics in the regions. Students have the opportunity to engage with other members, leaders of the organization, and community members to network and develop impactful campaigns and initiatives.*

- *Association for Public Policy Analysis and Management: The APPAM gives master and PhD student members the opportunity to attend various regional student conferences and participate in their mentor matching program, where students and a policy expert are matched and able to connect one-on-one during the organization's premiere conference hosted during the fall, APPAM Fall Research Conference.*

- *American Planning Association: Attending an APA-accredited university or obtaining membership gives planning students the opportunity to network with other planners and industry professionals. APA boasts 47 national chapters where students can connect and network with their local planning community. As members, students are eligible to obtain an American Institute of Certified Planners (AICP) certification; the only national, independent verification of planner qualifications.*

- *Global Planners Network: Similar to APA, the Global Planners Network (GPN) connects planning professionals to planning organizations across the globe. This network is recognized worldwide and offers international resources related to the state of planning. GPN provides research and conference resources that*

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address various planning topics and their global outcomes. Students who are also members of APA have the opportunity to connect with GPN members through APA's regional conference here in the U.S.

- *The Urban Land Institute: This is organization promotes responsible land use and creating sustainable communities worldwide. The Urban Land Institute provides its members with various workshops and research competition opportunities across the country. The organization's develops its members understanding current urban planning challenges and how to address the industries latest trends.*

DISCIPLINARY SUMMARY

SWTWC's curricular and occupational scans were efforts necessary to better understand the state of practice for transportation planners and to begin the work of designing efficient, industry-driven career pathways. These efforts revealed the breadth of available programs of study offered through a network of accredited universities, a general lack of feeder programs that lead students to these planning schools from the technical school and community college level, and the range and importance of workplace competencies that employers expect from their workforce.

These scans also established a basis for the identification of gaps between the learning outcomes promised by current academic programs and the skills in high demand from industry employers. And while a program's theoretical content and degree attainment do align with employer job requirements, there is a clear lack of hands-on experiential learning opportunities.

Also noteworthy, and worth additional evaluation, is the notion that job listings are somewhat more of a marketing tool than a job specification, used by employers to both "thin the herd" and to encourage qualified talent to apply and interview. As explained by the Planning DWG, being "qualified" in terms of checking-off the competency boxes of a job posting may have little to do with your likelihood of being hired, as interpersonal dynamics, on-the-spot thinking, and quantifiable work experience may be far greater influencers.

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TRANSPORTATION OPERATIONS

Transportation Operations

INTRODUCTION

The Southeast Transportation Workforce Center (SETWC) leads the operations focus for the National Transportation Career Pathways Initiative (NTCPI). With a goal of identifying priority occupations, relevant KSAs, education and training practices, and related gaps, SETWC staff first embarked on a process of defining the term "transportation operations".

Varied definitions exist depending on the industry sector of interest. For example, the USDOT refers to this discipline as Transportation Systems Operation and Management (TSMO) and defines it as incorporating, "*... a broad set of strategies that aim to optimize the safe, efficient, and reliable use of existing and planned transportation infrastructure for all modes.*", and reflects the greatest emphasis on traffic operations *(USDOT Federal Highway Administration, 2015)*. Similar definitions exist with transportation operations being a clearly defined discipline in the freight and logistics realm, where it may extend to manufacturing and distribution operations in the case of supply chain *(Council of Supply Chain Managment Professionals, 2018)*, and it is defined by the FHWA Office of Operations as encompassing "*... the practical work of moving goods from a shipper to a receiver, a subset of activities that constitute logistics management.*" *(USDOT Federal Highway Administration, 2017)*.

Regardless of the setting, an overarching theme in transportation operations is the necessity of a systems approach and ever-changing impacts of technological advances *(Manyika, Chui, Bughin, Dobbs, Bisson, & Marrs, 2013)*. In the public sector, the rise of Intelligent Transportation Systems (ITS) began rapidly changing the knowledge, skills, and abilities (KSAs) required of its workforce *(USDOT Federal Highway Administration, 2013) (Cronin, et al., 2012)*. Transformative technologies also dominate all other areas of the transportation industry and occupy a key focus for companies, whether from the standpoint of impact on efficiencies and the way business is conducted or the challenges in attracting and retaining an appropriately skilled workforce *(Materials Handeling Institute, 2017) (Intelligent Transportation Systems Joint Program Office) (National Academies of Science, Engineering and Medicine, 2017)*. Given this broad perspective, SETWC developed a comprehensive process for the identification of operations-focused occupational priorities that includes literature reviews, national labor market data analysis, disciplinary expert insight, broad stakeholder engagement, and real-time job data. This process is discussed in more detail below.

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IDENTIFYING PRIORITY OCCUPATIONS

Previous research related to the SETWC Job Needs and Priorities Report *(Southeast Transportation Workforce Center, 2015)* uncovered the importance of considering a broader definition of transportation rather than one narrowly focused on traffic, particularly due to the high demand for workers across industry sectors, occupational overlap, and the tendency of the workforce to remain siloed. For example, discussions with critical stakeholders revealed that very similar roles are reflected in traffic, transit, and freight (regardless of mode), but industry stakeholders do not necessarily recognize these similarities and associated opportunities for attracting workers. Discussions with discipline experts at the FHWA-hosted kickoff meeting for the NTCPI project (NTCPI, Nov 2016) further underscored the need to consider an expanded scope of transportation operations over the more narrow definition of TSMO. Thus, the focus for the transportation operations discipline specifically addresses occupations within three realms: Traffic, Transit, and Freight.

The process for identifying priority operations occupations involved a collection of research strategies, including conducting literature review, national labor market analysis, employer job data analysis, integrating expert advisory insight, and incorporating a broad stakeholder engagement and feedback loop, as explained in the sections to follow.

Literature Review

Literature and online resources were reviewed to determine existing occupational inventories and to acquire insight on technologies that might impact workforce demands on occupations within the transportation operations discipline. The primary resources considered in this phase of the project are shown below.

- *NCHRP Report 693, Attracting, Recruiting, and Retaining Skilled Staff for Transportation System Operations and Management (Cronin, et. al, 2012)*
- *ITS Joint Program Office Technology Scan and Assessment and other relevant research fact sheets (https://www.its.dot.gov/communications/its_factsheets.htm)*
- *Publications and resources available through the National Operations Center of Excellence (including white papers developed for the NOCoE TSMO summit)*
- *Project documentation for the Innovative Public Transportation Workforce Development Program - FTA Report 0094, Innovative Transit Workforce Development Projects of 2011 (FTA, 2016)*
- *FTA Report 0096, Proceedings of the 2016 Workforce Development Summit: Implementing, Disseminating, and Modeling Ladders of Opportunity (FTA, 2016)*
- *Materials Handling & Logistics Roadmap 2.0 (MHI, 2017)*

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- *Transportation industry research, trends, and projection reports developed by Raymond James, the American Trucking Association, Transport Topics, Inbound Logistics, and other relevant media*
- *Numerous state and local agency reports on workforce challenges and focus areas (such as Chicago's Freight Cluster Drill-Down workforce analysis reports, CMAP, 2011-13)*
- *NCHRP 221, Protection of Transportation Infrastructure from Cyber Attacks: A Primer (TRB, 2016)*
- *NCRRP 2, Guide to Building & Retaining Workforce Capacity for the Railroad Industry (TRB, 2015)*
- *FHWA, Impacts of Technology Advancements on Transportation Management Center Operations (USDOT, 2013)*
- *National Academies Press, Envisioning the Data Science Discipline: The Undergraduate Perspective (NAP, 2017)*
- *McKinsey Global Institute, Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy (McKinsey Global Institute, 2013)*
- *NCHRP 768, Guide to Accelerating New Tech. Adoption thru Directed Technology Transfer (Hood, et. al, 2014)*
- *NCHRP Synthesis 508, Data Management & Governance Practices (Gharaibeh, et. al, 2017)*
- *TCRP 178, A National Training and Certification Program for Transit Vehicle Maintenance Instructors (TRB, 2015)*
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- *NCHRP 503, Leveraging Technology for Transportation Agency Workforce Development & Training (Laffey, 2017)*
- *Airports Council International Business of Airports Conference, Strategic Workforce Planning Working Group Update (Beckett, 2017)*
- *DOL Career Pathways Toolkit: Enhanced Guide/Workbook for System Devel. (Manhattan Strategy Grp, 2016)*
- *National Academies Press, Information Technology and the U. S. Workforce: Where are We and Where Do We Go from Here? (NAP, 2017)*
- *Advance CTE, Putting Labor Market Information in the Right Hands: A Guide (Advance CTE, 2017)*
- *SHRP 2 Project L17, Gap Filling Project 6: Business Case Primer- Communicating the Value of Transportation Systems Management and Operations (ICF International, 2014)*
- *National Academies Press, Knowledge Management Resource to Support Strategic Workforce Development for Transit Agencies (Cronin, et. al, 2017)*

Review of Labor Market Data

A review of BLS data, including labor projections for operations-related occupations, was conducted to develop a draft list of occupational priorities. Considering insight garnered from the on-going literature review and the Job Needs and Priority Report *(Southeast Transportation Workforce Center, 2015)*, operations-related occupations were identified within the BLS database, then that data was reviewed at both the national and regional level using the BLS tools and search engine. This served as a starting point for further conversations with project stakeholders, including the Operations DWG, which together yielded the list of occupations identified in Tables O1 and O2 below.

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Table O1. Transportation Operations Occupations – National BLS Projections

SOC CODE	OCCUPATION TITLE	CURRENT # EMPLOYEES, 2012	PROJECTED # EMPLOYEES, 2022	PERCENT CHANGE
11-1021	General & Operations Managers	1972700	2216800	12.4%
11-3021	Computer and Information Systems Managers	332700	383600	15.3%
13-1081	Logisticians	125900	153600	22.0%
15-1142	Network and Computer Systems Administrators	366400	409400	11.7%
15-2031	Operations Research Analysts	73200	92700	26.6%
17-2051	Civil Engineers	272900	326600	19.7%
17-2112	Industrial Engineers	223300	233400	4.5%
47-2073	Operating Eng. & Other Construction Equip Operators	351200	417600	18.9%
47-4061	Rail-Track Laying & Maintenance Equipment Operators	17300	18200	5.2%
49-3031	Bus & Truck Mechanics & Diesel Engine Specialists	250800	272500	8.7%
53-1031	First-Line Supervisors of Transportation & Material-Moving Machine & Vehicle Operators	201000	218300	8.6%
53-3032	Heavy & Tractor-Trailer Truck Drivers	1701500	1894100	11.3%
53-4011	Locomotive Engineers	38000	36500	-3.9%
53-4021	Railroad Brake, Signal, & Switch Operators	25000	24400	-2.4%
53-4041	Subway & Streetcar Operators	9000	9600	6.7%
53-6041	Traffic Technicians	6600	7300	10.6%

Table O2. Transportation Operations Occupations – BLS Projections for SE Region

SOC CODE	OCCUPATION TITLE	CURRENT # EMPLOYEES, 2012	PROJECTED # EMPLOYEES, 2022	PERCENT CHANGE
11-1021	General & Operations Managers	456517	61581	13.49%
11-3021	Computer & Information Systems Managers	67705	12803	18.91%
13-1081	Logisticians	29572	7820	26.44%
15-1142	Network & Computer Systems Administrators	80082	14957	18.68%
15-2031	Operations Research Analysts	19365	4764	24.60%
17-2051	Civil Engineers	65076	13901	21.36%
17-2112	Industrial Engineers	52550	4651	8.85%
47-2073	Operating Eng. & Const. Equipment Operators	91062	15395	16.91%
47-4061	Rail-Track Laying & Maint. Equipment Operators	3224	166	5.15%
49-3031	Bus & Truck Mechanics & Diesel Engine Specialists	61129	6203	10.15%
53-1031	First-Line Supervisors of Transportation & Material-Moving Machine & Vehicle Operators	62531	6790	10.86%
53-3032	Heavy & Tractor-Trailer Truck Drivers	460000	60291	13.11%

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SOC CODE	OCCUPATION TITLE	CURRENT # EMPLOYEES, 2012	PROJECTED # EMPLOYEES, 2022	PERCENT CHANGE
53-4011	Locomotive Engineers	6380	80	1.25%
53-4021	Railroad Brake, Signal, and Switch Operators	4220	140	3.32%
53-4041	Subway and Streetcar Operators	210	30	14.29%
53-6041	Traffic Technicians	1130	61	5.40%

Operations DWG Engagement

A national group of disciplinary experts with representation from both public and private sectors was assembled and engaged in discussions regarding occupational priorities in traffic, transit, and freight operations over the next 5-15 years. The DWG members included representatives from the following organizations:

National Operations Center of Excellence
FHWA Office of Freight Management and Operations
TDOT Operations Division
Tennessee College of Applied Technology
National Academy of Railroad Sciences
Memphis Area Transit Authority
Monte Vista Associates/TRB
DBi/TRB
North Jersey TPA
Gannett Flemming / ITE
TeamOne Logistics
HNTB Companies
FedEx Freight

These conversations enabled a refinement of the preliminary occupations list as a direct result of industry input. Table O3 lists these refined occupational priorities:

Table O3. Priority Operations Occupations, as Informed by DWG

TRAFFIC	TRANSIT	FREIGHT
Program Managers	Operations & Environmental Planners	Commercial Drivers
Program Planners	Project Managers	Data Science Analyst / Logisticians
Traffic Signal / Maint. Technicians	Commercial Drivers	Diesel Mechanics / Shop Technicians
Incident Managers	Diesel Mechanics	Industrial Engineers
Field Safety / Service Operators	Industrial Trainer	Ops. Research / Modeling Analysts
ITS Technicians	Civil Engineers	Project & Program Managers
Civil Engineers		Transportation Planners
		Service Assurance Advisors

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Broader Stakeholder Engagement

An expanded list of transportation operations stakeholders was engaged to provide project feedback and validation from a national perspective, including critical input from professional organizations that serve stakeholders in traffic, transit, and freight realms; key corporate representatives; and academic and workforce agencies. A disciplinary workforce survey was distributed to these stakeholders via interfaces established with professional organizations. These national stakeholders, professional organizations, and academic agencies include:

TN Dept. Economic & Community Development
FedEx Freight Headquarters
Titan Transfer, Inc.
FHWA, Arkansas Division
FHWA, Tennessee Division
Northwest Mississippi Community College
Vaco Logistics
Louisiana LTAP
MS Consultants, Inc.
University of Kentucky
TRB Standing Committee, Maint. & Ops. Personnel
TRB Standing Committee, Maint. & Ops. Management
American Public Transportation Association
Memphis Area Transit Authority
ITS America
Schneider
IMC Companies
Arizona DOT
California DOT
Ohio DOT
Michigan DOT
Nevada DOT
North Carolina DOT
Tennessee DOT
Washington State DOT
Wisconsin DOT
Virginia DOT
TransDev
ITE TSMO Council

To date, 34 responses were collected from this workforce survey. These respondents were asked to rank operations occupations from the refined list (Table O3) according to their critical functionality within the organization, to project the number of workers needed at their organizations, and to relate any difficulties in attracting and retaining employees. Respondents were also asked to describe occupational education, training, and skillset requirements; their organization's most significant operations workforce challenges; and to recommend any additional occupations that should be considered as a priority for this discipline (Southeast Transportation Workforce Center, 2017).

Researchers also conducted several stakeholder discussions at professional meetings to expand participation in this phase of the discussion, including meetings of the Tennessee

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Section Institute of Transportation Engineers, the Traffic Club of Memphis, the World Trade Club, the Greater Memphis Information Technology Council InnovateIT Conference, the Journal of Commerce Inland Distribution Conference, and the DBi Services Annual Symposium. These broader stakeholder discussions further refined the transportation operations priority occupations list.

Key findings from this phase of the research include the following:

- *Analytical skills, and converting data to "information", are key requirements for operations professionals, regardless of setting, and*
- *In traffic operations, civil engineering has traditionally been the primary source for professionals. With the rise of ITS and the complexity associated with integrating relevant technology, a broader pool of professionals (i.e., computer systems, industrial engineering, and IT professionals) is necessary.*

Review of Real-Time Job Data

To validate the broader stakeholder input, researchers collected job data to validate the refined occupational priority list and to formulate a profile of job requirements desired by industry employers. A number of transportation operations employment opportunities were reviewed using a variety of online job sites, including Jobs.com, Indeed.com, Monster.com, USAjobs.gov, as well as individual corporate sites like FedEx and IMC Companies. A minimum of 30 postings per priority occupation were evaluated from a range of states and agencies, with the goal of uncovering any appreciable regional or sector differences.

Data from these postings was recorded into spreadsheets and separated by general job details (job title, posting agency, state, etc.), education and training requirements, desired skillsets, job functions, salary, and any other relevant details. An analysis was conducted to develop a list of job-specific KSAs and their respective frequency of appearance. Examples of this analysis are shown in Figures O1-O3 below for a single occupational cluster within each of the operations realms considered in this research.

For each of these figures, the Y-axis presents a comprehensive list of the most relevant KSAs appearing within the total job posting dataset as scanned, while the X-axis presents their frequency of appearance as a percentage of the whole dataset, where "50", as an example, would represent a KSA appearing in half of all job postings reviewed.

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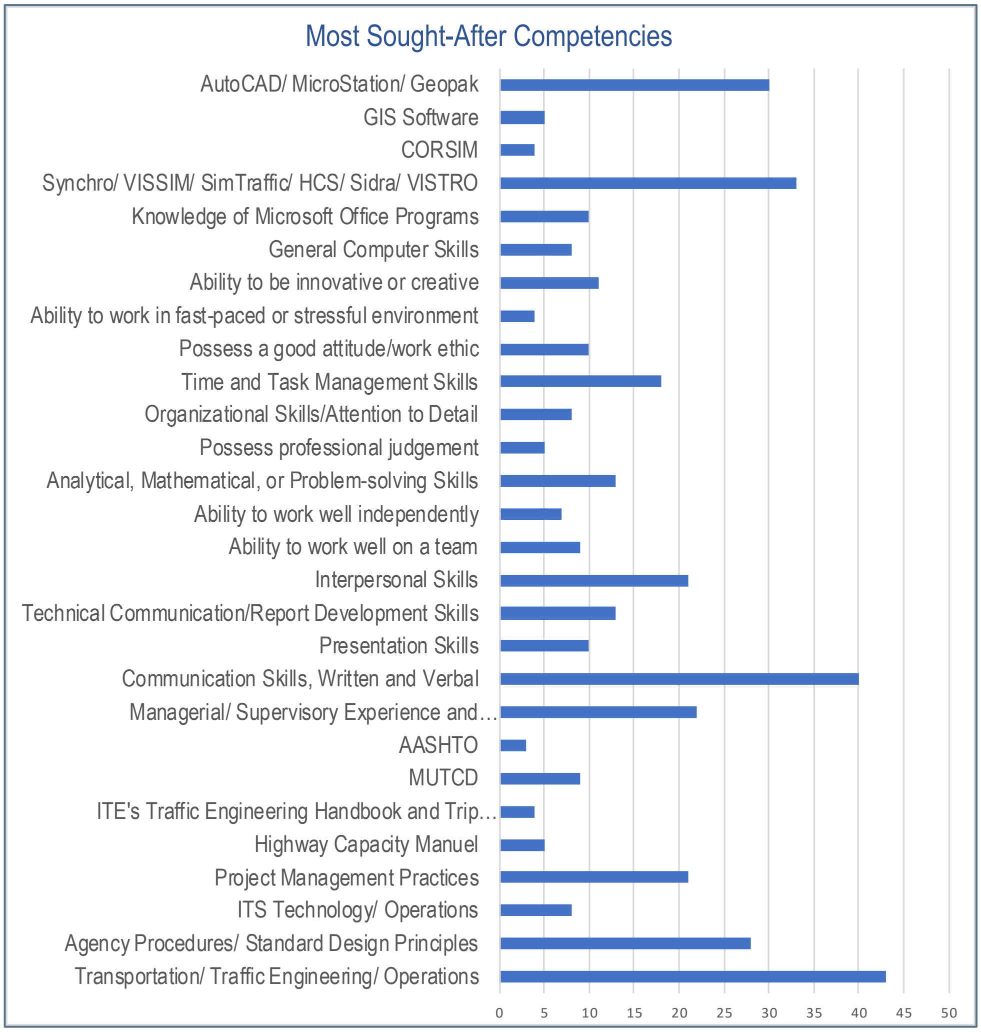

Figure O1. High Frequency Competencies, Traffic Engineer or Project Manager

So, for the occupational cluster “Traffic Engineers or Project Managers”, the top competencies specified by employers are “knowledge of transportation/traffic operations”, “communication skills”, “local agency procedures”, and “specialized software proficiency (Synchro, VISSIM, SimTraffic, AutoCad, MicroStation)”.

For the occupational cluster “Transit Engineers or Project Managers”, Figure O2 (below) shows the top in-demand competencies to be “knowledge of civil engineering/transit operations”, “communication skills”, “local agency procedures”, “interpersonal skills”, and “specialized software proficiency (AutoCad, Civil 3D, MicroStation)”.

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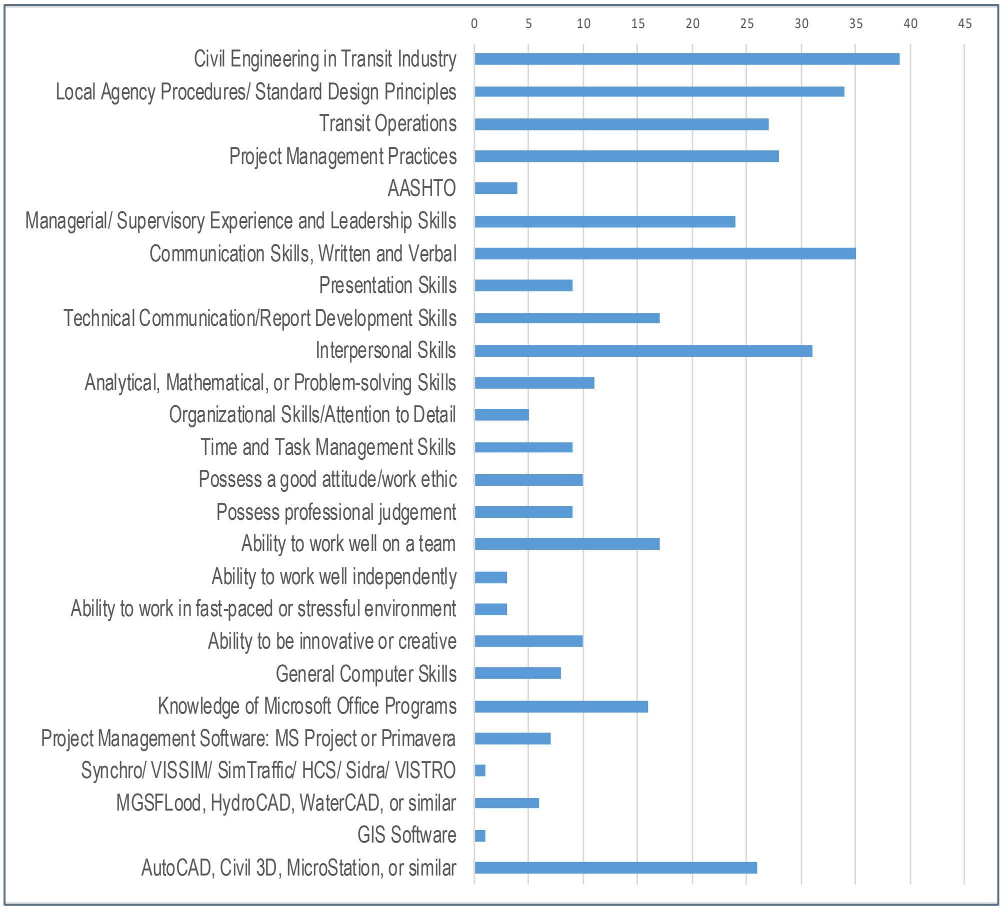

Figure O2. High Frequency Competencies, Transit Engineer or Project Manager

For the occupational cluster “Data Science/Logisticians or Project Managers” within the Freight realm (Figure O3 below), top in-demand competencies include “communication skills”, “knowledge of transportation/warehousing operations”, “analytical/mathematical or problem-solving skills”, and “software proficiency (MS Office)”.

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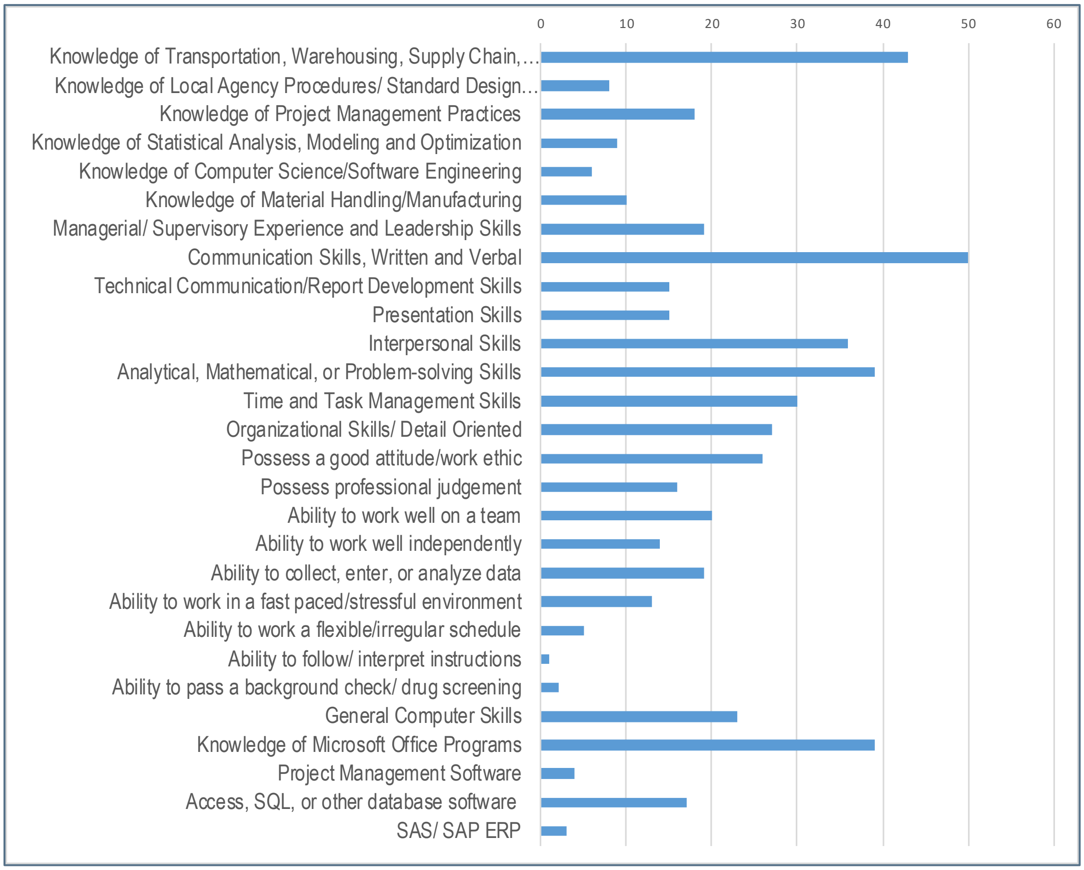

Figure O3. High Frequency Competencies, Data Scientist/Logistician or Project Manager

The Burning Glass Technologies occupational database was also mined to uncover any additional information on these priority occupations, including the number of real-time job postings over the last 12 months, the required education and skillsets, and a frequency analysis of national data scatter. However, this database provide little additional value over traditional BLS projections, as it was difficult to isolate occupations of interest that were specifically relevant to operations.

Finalizing Priority Occupations

All input gathered through prior analysis was used to establish a final set of occupations and a consistent set of occupational titles within each disciplinary realm (Traffic, Transit, and Freight). After the job postings analysis, it was determined that several occupations listed under multiple realms appeared similar enough in their occupational characterizations that their job titles could be standardized.

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For instance, each realm included similar “Project Management” or “Program Management” occupations, so they were standardized into “Project & Program Managers”. Similarly, the occupations “Industrial Engineers” and “Operations Research Analysts” were grouped within the freight realm, as a review of relevant data indicated these titles were frequently interchangeable within transportation settings.

Several occupations were also removed from the final list. “Industrial Trainers” was removed, as the analysis revealed this occupation to be spread too widely across a range of non-specific job titles and applications, making it difficult to isolate online job postings that were specific to the operations discipline. “Field Safety / Service Operators” was removed from the Traffic realm because this occupation ranked lowest in priority by the broader stakeholder group (Southeast Transportation Workforce Center, 2017), plus its disciplinary assignment may more accurately be defined by this initiative’s Safety and/or Engineering efforts.

“Environmental Planners” (Transit) and “Transportation Planners” (Freight) were similarly removed as these occupations are assigned to this initiative’s Planning discipline. By contrast, the occupation “Operations Planner”, also potentially aligning with the Planning discipline, was promoted as a priority within all three operations realms, due to the observed critical need for planners within transportation operations. Table O4 below presents the final list of priority occupations.

Table O4. Final List of Priority Occupations within Transportation Operations

TRAFFIC	TRANSIT	FREIGHT
Project & Program Mangers	Project & Program Managers	Project & Program Managers
Computer & Information Systems Managers / Cyber Security	Computer & Information Systems Managers / Cyber Security	Computer & Information Systems Managers / Cyber Security
Operations Planners	Operations Planners	Operations Planners
Traffic Signal / Maint. Technicians	Commercial Drivers	Commercial Drivers
Traffic Incident / Ops Center Mgrs	Diesel Mechanics	Diesel Mechanics
Civil / Traffic Engineers	Civil / Transportation Engineers	Data Science Analyst / Logisticians
ITS Technicians		Ind. Eng. / Ops Research Analysts

It became clear upon reviewing job postings and relevant literature (Lockwood & Euler, 2016) that many of the occupations identified as priorities for operations actually pulled professionals from multiple disciplines. Thus, a mapping of priority occupations to potential candi-

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date pools from standardized BLS SOCs was developed from a review of the job descriptions. This mapping is shown in Table O5 below:

Table O5. SOC Mapping for Priority Occupations within Transportation Operations

SETWC PRIORITY OCCUPATION TITLE	SOC	BLS OCCUPATION TITLE
Project & Program Managers (freight)	11-1021	General & Operations Managers
	13-1081	Logisticians
	15-1111	Computer & Information Research Scientist
	15-2041	Statisticians
	15-2031	Operations Research Analyst
	17-2112	Industrial Engineers
Project & Program Managers (Traffic/Transit)	17-2051	Civil Engineers
Computer & Info Systems Mgrs / Cyber Security	11-3021	Computer & Information Systems Managers
	15-1122	Information Security Analyst
Operations Planners (freight)	11-1021	General and Operations Managers
	13-1081	Logisticians
	15-1111	Computer & Information Research Scientists
	15-2041	Statisticians
	15-2031	Operations Research Analysts
	17-2112	Industrial Engineers
Operations Planners (Traffic or Transit)	17-2051	Civil Engineers
	19-3051	Urban & Regional Planner
Traffic Signal / ITS Technicians	53-6041	Traffic Technicians
	17-2071	Electrical Engineers
	17-3023	Electrical & Electronic Engineering Technician
	49-2093	Electrical & Electronics Installers & Repairers
Traffic Incident /Ops Center Managers	11-9161	Emergency Management Directors
	17-2051	Civil Engineers
	53-6041	Traffic Technicians
Civil/Traffic/Transportation Engineers	17-2051	Civil Engineers
Commercial Drivers	53-3032	Heavy & Tractor-Trailer Truck Drivers
	53-3021	Bus Drivers, Transit & Intercity
Diesel Mechanic/Diesel Shop Technician	49-3031	Bus & Truck Mechanics & Diesel Specialists
Data Science Analyst/Logistician	13-1081	Logisticians
	15-1111	Computer & Information Research Scientists
	15-2041	Statisticians
Industrial Engineers / Ops Research Analysts	15-2031	Operations Research Analysts
	17-2112	Industrial Engineers

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Once this mapping was complete, a final review of BLS data and employment projections for these occupations was conducted, which is presented in Table O6:

Table O6. BLS Projections for Priority Occupations within Transportation Operations

SOC CODE	OCCUPATION TITLE	CURRENT # EMPLOYEES, 2016	PROJECTED # EMPLOYEES, 2026	PERCENT CHANGE
53-6041	Traffic Technicians	6,600	7,200	9.10%
17-2071	Electrical Engineers	188,300	204,500	9.00%
17-3023	Electrical & Electronic Engineering Technician	137,000	139,800	2.00%
17-2051	Civil Engineers	303,500	335,700	10.60%
49-3031	Bus and Truck Mechanics & Diesel Engine Specialists	278,800	305,300	9.50%
15-2031	Operations Research Analysts	114,000	145,300	27.40%
17-2112	Industrial Engineers	257,900	283,000	9.70%
53-3032	Heavy and Tractor-Trailer Truck Drivers	1,871,700	1,985,500	6.10%
53-3021	Bus Drivers, Transit & Intercity	179,300	195,100	8.80%
13-1081	Logisticians	148,700	159,000	6.90%
15-1111	Computer & Information Research Scientists	27,900	33,200	19.20%
15-2041	Statisticians	37,200	49,600	33.40%
11-3021	Computer & Information Systems Managers	367,600	411,400	11.90%
15-1122	Information Security Analyst	100,000	128,500	28.40%
11-9161	Emergency Management Directors	10,100	10,900	7.70%
11-1021	General and Operations Managers	2,263,100	2,469,000	9.10%
19-3051	Urban & Regional Planner	36,000	40,600	12.80%
49-2093	Electrical & Electronics Installers & Repairers	13,900	14,300	2.90%
47-2111	Electricians	666,900	727,000	9.00%

This new data revealed that the occupations with the greatest projected change over the next 10 years were those in the computer and information security disciplines. This is important to note given that these professionals will be in high demand from numerous industry sectors outside of transportation.

STATE OF PRACTICE: EDUCATION

The state of practice in education and training for operations largely depends on specific job titles and occupation classes. At the technical level, numerous programs exist for training commercial vehicle drivers and for training diesel mechanics. For traffic and ITS technicians, International Motor Sports Association (IMSA) certifications are key requirements for entry to these occupations. The reason for these occupations being deemed priorities is not due to a lack of training options, but due to a lack of program participants.

There are also numerous universities offering programs in Civil Engineering, Industrial Engineering, Operations Research, Planning, and other relevant disciplines for operations occupations that require four-year degrees. However, the key challenge with these programs is that there is limited content specific to transportation operations (USDOT Federal Highway Administration, 2015). Transportation operations is not in and of itself a discipline with a distinct career pathway, but rather an evolving discipline that requires significant professional development and experience in order to master the required KSAs that cross over traditional discipline boundaries (Lockwood & Euler, Transportation System Management & Operations (TSM&O) Workforce Development White Paper 1: Background and StateofPlay, 2016). For example, while civil engineers are traditionally fulfilling TSMO roles, in most civil engineering programs there is only one required transportation course at the undergraduate level with limited content relevant to TSMO (Turochy, et al., 2014). Additionally, the accrediting body for civil engineering (ABET) eliminated the requirement that civil curricula include basic courses in electrical engineering, further limiting the exposure of students to content relevant to TSMO (ABET Engineering Commission, 2018).

A variety of professional development courses and modules designed for integration in undergraduate programs have been developed to try to improve educational opportunities related to TSMO. Notable examples include online courses available through the Consortium for Innovative Transportation Education (CITE), which are offered free-of-charge through a partnership with the ITS Professional Capacity Building (PCB) Joint Program Office (Intelligent Transportation Systems Joint Program Office, 2018) and case studies developed and hosted by ITS PCB for traffic operations (Office, 2018); courses offered by the National Transit Institute for transit operations (Rutgers University, 2018); and the Council of Supply Chain Management Professionals (CSCMP) for freight/logistics operations online courses and academic case studies (Council of Supply Chain Managment Professionals, 2018).

CAREER PATHWAYS

National conversations regarding transportation operations are often considered from the standpoint of DOT-driven Transportation Systems Operation & Maintenance (TSMO), though professionals in this field can be found in both public and private sectors (Cronin, et al.,

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2012) (USDOT Federal Highway Administration, 2013) (ICF International, 2014) (Chicago Metropolitan Agency for Planning, 2012). And when regarded in a vacuum, the demand for traffic operations professionals can appear significantly underrated, which diminishes the opportunity to capitalize on the more progressive areas of this industry in terms of defining workforce models. The jobs and skillsets in-demand within TSMO also cross over into transit and freight operations—along with numerous other industry sectors, which promoted researchers to focus on a broader definition of transportation operations for this NTCPI project (Operations DWG, 2016).

Transportation operations is arguably the most significantly impacted discipline area in terms of technological disruptions, as professionals within this workforce are at the forefront of integrating a broad set of technologies that include the "Internet of Things" (IoT), autonomous and connected vehicles and infrastructure, robotics, ITS, and similar new technologies to make systems work (USDOT Federal Highway Administration, 2013) (National Academies of Science, Engineering and Medicine, 2017) (Manyika, Chui, Bughin, Dobbs, Bisson, & Marrs, 2013) (Lockwood & Euler, 2016). Regardless of the realm (Traffic, Transit, or Freight) in which a future operations professional may be engaged, a key aspect has emerged as essential for competency across all priority occupations: data management, data manipulation, and data analysis (Operations DWG, 2016).

Currently, traffic operations positions requiring education at a four-year level and beyond are traditionally based within civil engineering (Lockwood & Euler, 2016) (Operations DWG, 2016) (Operations DWG, 2016). Similarly, in transit operations, these roles are largely held by civil engineers and transportation planners. However, this is not the case within the freight realm, where the private sector dominates employment (Southeast Transportation Workforce Center, 2017) (Operations DWG, 2016). Freight operations roles have traditionally been staffed by professionals with a much wider range of backgrounds, in particular those with an expertise in data management and interpretation. The need to diversify the educational requirements for operations professionals is recognized by traffic and transit professionals, as has been reflected in survey responses, stakeholder discussions, and recent reports (Southeast Transportation Workforce Center, 2017) (Operations DWG, 2016) (Lockwood & Euler, Transportation System Management & Operations (TSM&O) Workforce Development White Paper No 3: Recruitment, Retention and Career Development, 2016).

Operations professionals of the future, regardless of the specific mode or sector in which they work, must possess a wide range of skills and be able to evaluate systems and processes from a broad perspective. They must be able to communicate effectively with a

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wide range of audiences, work in teams, think critically, solve problems, analyze and interpret data, and analyze a problem from multiple contexts and perspectives (Southeast Transportation Workforce Center, 2017) (Operations DWG, 2016).

Another area needing attention is that of the trade and technical occupations associated with transportation operations. As in most industries, this is where the greatest number of jobs are available, yet these are also the most challenging occupations in terms of attracting and retaining skilled workers (Operations DWG, 2016). Innovative approaches, particularly those spanning into K-12 programs for occupations such as diesel technology and traffic technicians, are necessary to increase awareness of and interest in these professions. A very important aspect to addressing this challenge is changing the traditional message that students must obtain a four-year degree in order to be successful in their career, and creating new messaging that promotes fulfilling occupations with career growth potential that are available in these technical areas. This is such a significant conversation across public and private sector agencies that SETWC will be coordinating a working group meeting focused on this topic as part of its 2018 Choosing Transportation Summit.

The transportation operations career pathway and competency models presented below were developed in accordance with common NNTW templating and demonstrate the competency requirements and pathway entry/exit points across this discipline's priority occupations. Individual occupational descriptions that demonstrate education and training requirements, KSAs, and career progression opportunities that will also "spotlight" actual professionals in each priority occupation are currently being developed. The competency model for each sub-discipline (Traffic, Transit, and Freight), along with an example career pathway model for each are displayed in Figures O5-O10. A full set of pathway models developed for this project are provided as Attachment B.

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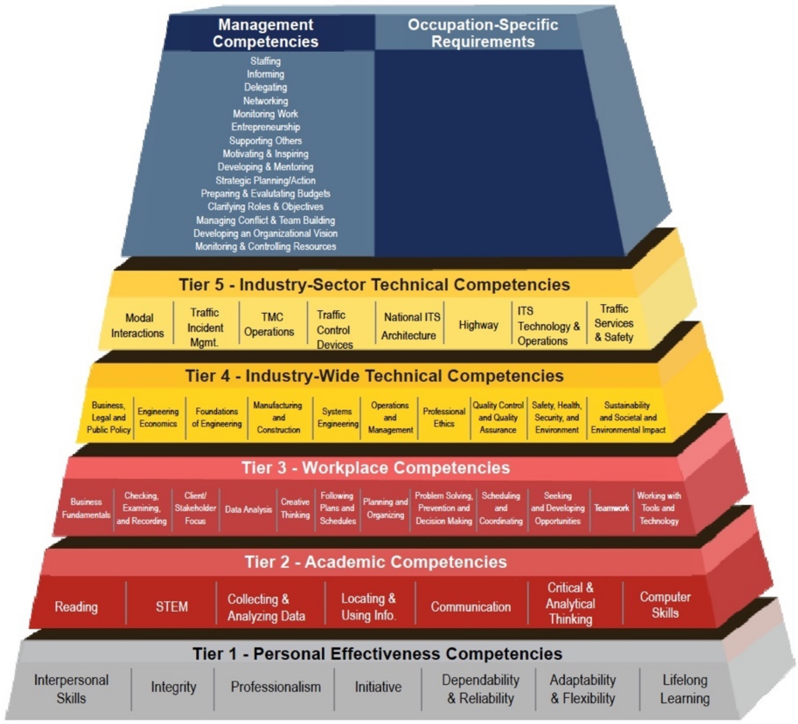

Figure O5. Traffic Operations Competency Model

Traffic Operations Pathway: Traffic Engineers or Project Managers

	KSAs	ACADEMIC PROGRAM OF STUDY		INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of Transportation and Traffic Engineering/Operations Knowledge of Project Management Practices Managerial/ Supervisory Experience and Leadership Skills Communication Skills, Written and Verbal Experience with Synchro, VISSIM, SimTraffic, HCS, Sidra, or VISTRO software	Master's degree preferred *Major Coursework in Civil Engineering or related field strongly preferred*	Supervisory experience required 6-10 years experience in management of traffic engineering projects	❑ Envision Sustainability Professional (ENV SP) ❑ AICP	**Advanced Level** **Advanced Traffic Operations Project Manager** **Advanced Traffic Operations Engineer** $55.67 (mean hourly rate from job descriptions)
MID LEVEL	Knowledge of Transportation and Traffic Engineering/Operations Knowledge of Agency Procedures/ Standard Design Principles Communication Skills, Written and Verbal Experience with AutoCAD, MicroStation, or Geopak Experience with Synchro, VISSIM, SimTraffic, HCS, Sidra, or VISTRO software	Bachelor's Degree Required or In Progress Master's Degree sometimes preferred *Major Coursework in Civil Engineering*	5-9 years experience in transportation or traffic engineering	❑ Professional Engineering License ❑ Professional Traffic Operations Engineer ❑ IMSA Traffic Signals Level II or III	**Intermediate Level** **Traffic Operations Engineer** $32.28 (mean hourly rate from job descriptions) • Associate Traffic Engineer • Traffic Operations Design Engineer • Traffic Project Engineer **Traffic Operations Program/Project Manager** $39.36 (mean hourly rate from job descriptions) • Transportation Project Manager **Traffic Engineer/Program Manager** $43.14 (BLS mean hourly wage 2016)
ENTRY LEVEL	Communication Skills, Written and Verbal Analytical, Mathematical, or Problem-solving Skills Interpersonal Skills Ability to work well on a team Experience with AutoCAD, MicroStation, or Geopak	Bachelor's Degree Required or In Progress Master's Degree sometimes preferred *Major Coursework in Civil Engineering*	0-3 years experience in traffic engineering	❑ Engineer-in-Training (EIT) certification ❑ Driver's License	**Entry Level** **Entry Level Engineer** • Operations and Maintenance Engineer Intern • Civil Engineering Intern • Assistant Traffic Engineer $35.47 (mean hourly rate from job descriptions)

Figure O6. Traffic Operations Example Career Pathway Model

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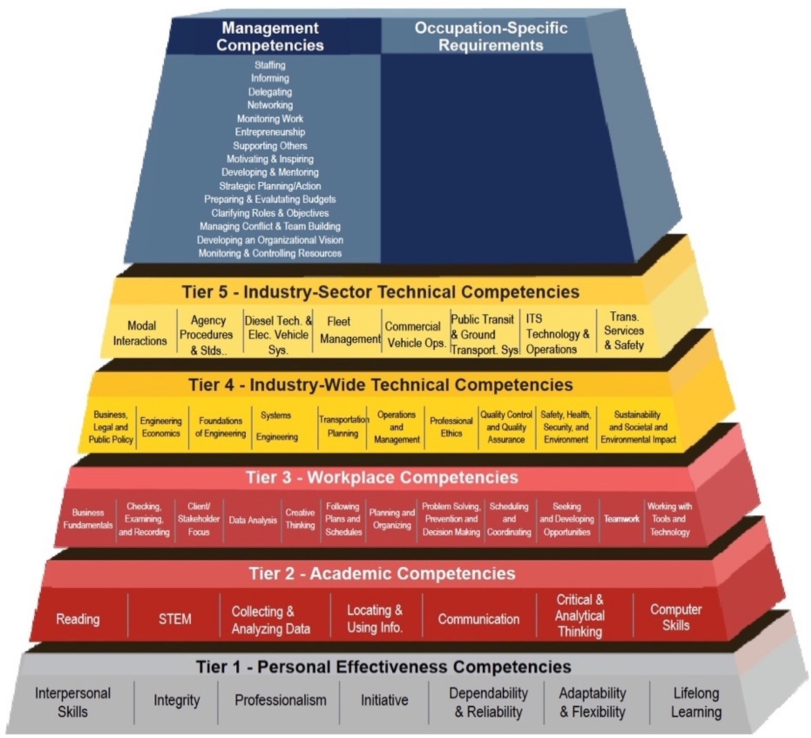

Figure O7. Transit Operations Competency Model

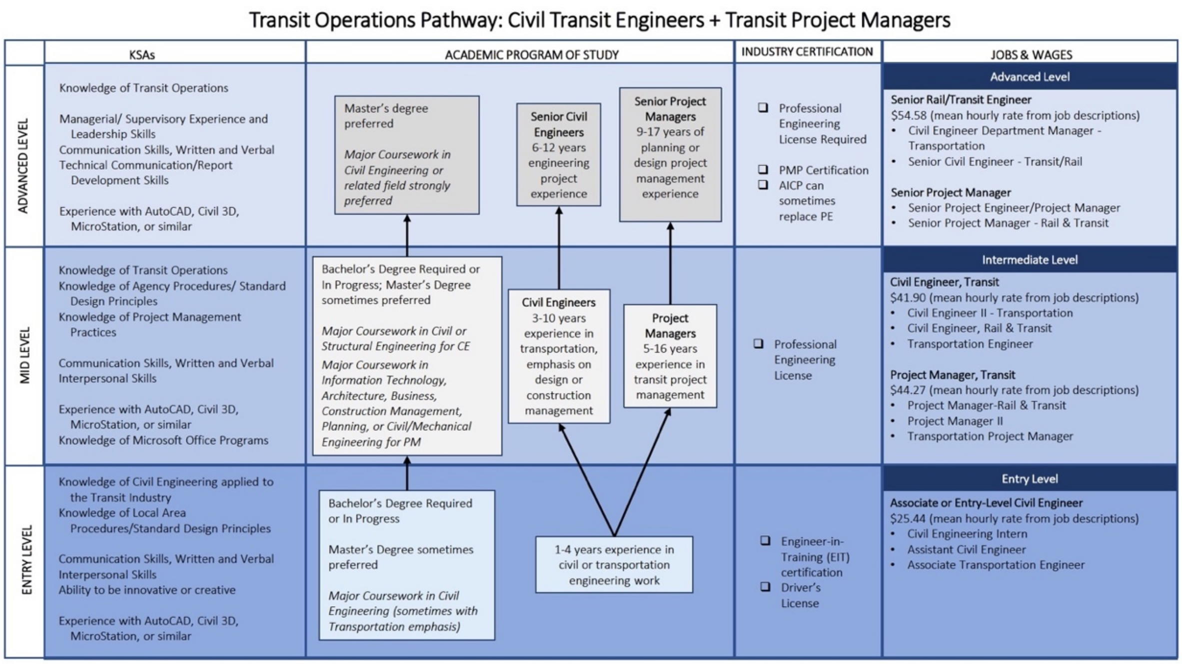

Figure O8. Transit Operations Example Career Pathway Model

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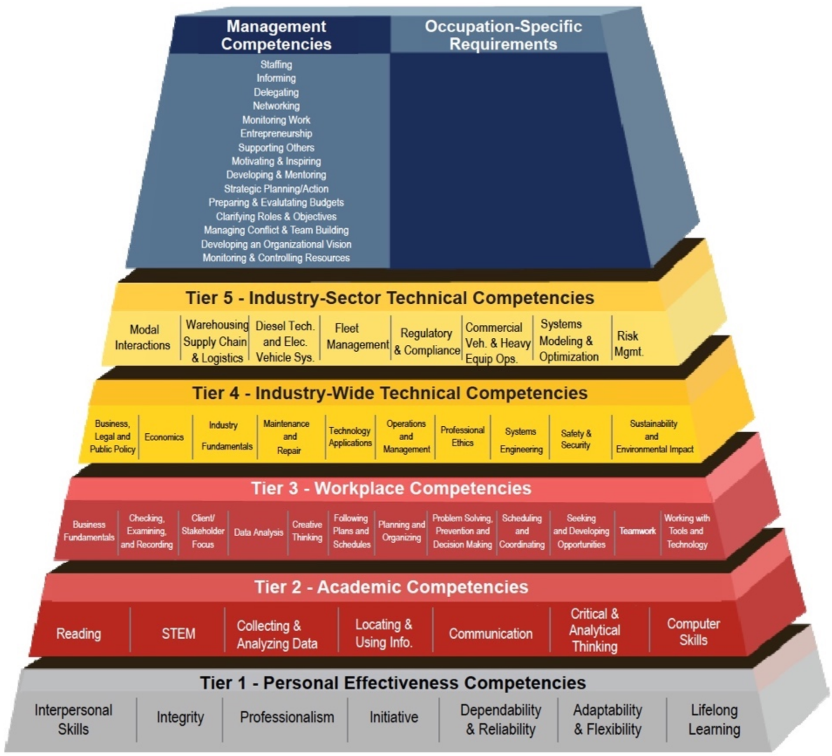

Figure O9. Freight Operations Competency Model

Freight Operations Pathway: Data Science Analyst / Logisticians + Project and Program Managers

	KSAs	ACADEMIC PROGRAM OF STUDY	INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Analytical, Mathematical, or Problem-solving Skills Communication Skills, Written and Verbal Interpersonal Skills Managerial/ Supervisory Experience and Leadership Skills Knowledge of Microsoft Office Programs General Computer Skills Access, SQL, or other database software	Bachelor's degree required *Major coursework in Business, Computer Science, Economics, Engineering, Finance, Logistics, Management Info Systems, Mathematics, Operations, Statistics, or Supply Chain Management* 4-12 years in project management in a global supply chain environment	❑ PMP (Project Management Professional) Certification ❑ Driver's License	**Advanced Level** **Senior Analyst, Logistician, or Project Manager** • Senior Manager Global Logistics & Fulfillment • Senior Supply Chain Program Manager • Vice President / Director of Supply Chain • Logistics Analyst Senior $35.22 (mean hourly rate from job descriptions)
MID LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Communication Skills, Written and Verbal Analytical, Mathematical, or Problem-solving Skills Time and Task Management Skills Interpersonal Skills Organizational Skills/ Detail Oriented Knowledge of Microsoft Office Programs General Computer Skills	Bachelor's degree required (or Associate's degree for some Logistics Analyst positions) *Major coursework in Logistics, Business Analytics, Mathematics, Transportation, Logistics, Supply Chain, Business Administration, Engineering or other technical field* 3-10 years in years in Operations, Program Management, Project Management, Procurement and/or Logistics Management	❑ PMP ❑ CPM (Certified Project Manager) ❑ MPM (Master Project Manager) ❑ CPIM (Certified Production and Inventory Management)	**Intermediate Level** **Program/Project Manager or Level III** • Supply Chain Manager • Transportation Analyst III • Logistics Program Administrator • Transportation Operations Manager $32.45 (mean hourly rate from job descriptions)
ENTRY LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Knowledge of Project Management Practices Communication Skills, Written and Verbal Analytical, Mathematical, or Problem-solving Skills Possess a good attitude/work ethic Interpersonal Skills Presentation Skills Time and Task Management Skills Knowledge of Microsoft Office Programs	Bachelor's degree required (or Associate's degree for some Logistics Analyst positions) Master's degree or MBA sometimes preferred *Major coursework in Engineering (Industrial, Mechanical, Manufacturing, or Software), Computer Science, Mathematics, Logistics, Supply Chain Management, Operations, Statistics, or Business (Economics, Finance, or Accounting)* 1-5 years Project Management, Supply Chain Procurement or Inventory Planning in a manufacturing company (background in statistical/ data analysis a plus)	❑ Certified Professional Logistician (CPL) preferred ❑ PMP Certification a plus ❑ Customs Broker's License ❑ Certified Lean Manager ❑ Forklift Certified ❑ Driver's License	**Entry Level** **Analyst or Logistician** • Logistics Analyst • Logistician • Supply Chain Management Specialist • Data Scientist • Operations Systems Analyst • Application Engineer $17.00 (mean hourly rate from job descriptions)

Figure O10. Freight Operations Example Career Pathway Model

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These career competency and pathway models will be reviewed by the Operations DWG and SETWC's network of external stakeholders to finalize and validate each model prior to this project's final report. These draft competency models do reflect DWG and stakeholder findings regarding the KSAs that professionals in each realm should possess, while the career pathway models represent current employment practices as extracted from job posting data. Recommendations will be made regarding amendments to these current pathways and their implications for education and training as part of the final NTCPI report.

INNOVATIVE EXPERIENTIAL LEARNING

Researchers have been reviewing available training and education programs for operations, along with scanning literature and engaging stakeholders in conversations around innovative experiential learning strategies and approaches. Several such approaches have been identified through this process, as described below:

1. **Online "Micro-Learning":** This approach provides short, content-rich exploration of career opportunities and training modules that lead to a new form of stackable credentialing through badges and other forms of recognition, typically subject to the agency hosting the content. Two examples of effective online micro-learning can be found at Transportation Tech and MemphisWorks.

   a. *Transportation Tech provides cutting-edge online training for Intelligent Transportation Systems and Connected Vehicles Professionals.*

   b. *MemphisWorks connects job seekers to jobs in advanced manufacturing, information technology, health sciences, and transportation. It provides career exploration and engaging sector overviews tailored to the local market, profiles professionals in a wide range of jobs within these industry sectors, helps users develop tailored resumes and apply directly to specific job postings, and provides online modules that allow users to build skills and collect badges.*

2. **Industry Challenges:** This approach engages industry in defining challenge projects and competitions to deploy in classrooms from K-12 through college. This type of experiential learning is particularly important for demonstrating connections to course content and real-world applications. It also provides an opportunity to highlight new technologies and to help students start to "build a picture" of what a par-

ticular career field entails. This becomes particularly impactful for students when industry professionals engage in a mentoring or advisory role. Examples of industry challenges include the National Operations Center of Excellence (NOCoE) developed TRB Student Competition, where students develop and submit TSMO ePortfolios and the Transportation Technology Tournament jointly sponsored by NOCoE and USDOT's ITS Joint Program Office for Professional Capacity Building.

3. **Industry Academies:** Perhaps one of the most interesting models is that of industry-driven post-secondary education and training, where employers develop their own internal programs that are offered to candidates immediately following high school graduation. No formal post-secondary education or training is required for these students to enter a job, and candidates who successfully complete these employer-based programs are immediately hired. Examples of industry academies largely come from private corporations, such as a large transportation operations company in need of candidates with computer programming and data analysis skills. In this example, the employer is piloting their own internal program that will allow interested high school graduates to go directly into relatively high-paying programming jobs upon academy completion.

The most critical and common element to all of these programs is that they are industry-engaged. Academic and industry silos cannot exist if successful workforce development strategies and programs are to be developed and deployed.

CROSS-DISCIPLINARY PATHS

The process of analyzing priority occupations has led to the formation of the disciplinary model presented in Figure O4 (below), which defines transportation operations as a discipline, as a set of relevant career pathways, and as cross-disciplinary paths.

Currently a work-in-progress, this Transportation Operations Discipline Description will provide a broad overview of the discipline, backgrounds for entry, and relevant skillsets, as well as graphically depict the relationships between Traffic, Transit, and Freight realms. This product is will eventually lead to the deployment of an interactive online resource that allows students to explore the occupations and training requirements of operations careers, while also showcasing a variety of professionals employed in each occupation.

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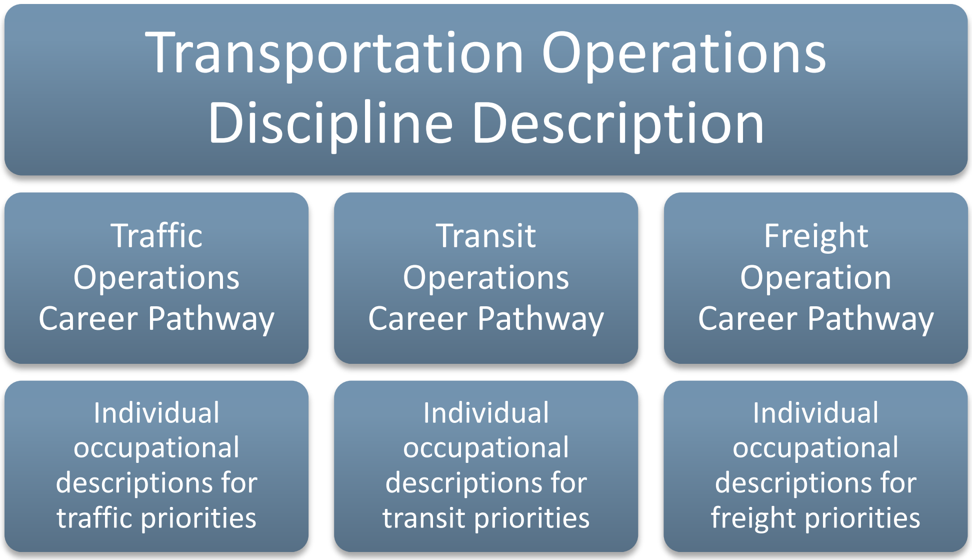

Figure O4. Transportation Operations Discipline Model

DISCIPLINE SUMMARY

Transportation operations requires workers who are:

- *Tech-savvy;*
- *Flexible, responsive, and adaptive to an ever-changing set of technological tools and innovations;*
- *Effective communicators, particularly with a wide range of stakeholders;*
- *Knowledgeable of system infrastructure design and connectivity; and*
- *Equipped with skillsets related to data acquisition, management, analysis, modeling, and decision-making.*

There are a variety of entry points into this workforce, from technician-level occupations that require technical training or 2-year degrees, to engineering, data science, and management positions that require 4-year degrees and beyond. But for workers to be fully prepared to handle the challenges of the next 10-15 years, they must possess more interdisciplinary skills that cross over traditional boundaries of academic preparation.

Also, though the specific challenges to attracting and retaining workers in these occupations may differ across realms, they also share some broader issues. For technician-level occupations, perceptions of the industry or its work environment (i.e., driving positions are unfulfilling or diesel mechanic jobs are “dirty”) limit the attraction of new workers. In

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higher-level positions, its competition between public, private, and other industry sectors that vie for a limited pool of qualified applicants.

However, a general lack of awareness of the transportation industry as a whole, and the transportation operations realm in particular, offers a more significant barrier to preparing an adequately trained and sized workforce. This includes the challenge of attracting more diversity to these positions. It is important to tell the story of transportation operations so that potential candidates understand the value of these workers in our society and to put a "face" on the occupations so that they can "see" themselves in these roles.

Further, beyond the more entry-level positions, there is no common pathway for entering into a transportation operations career. As the complexity and interdisciplinary nature of these jobs continues to increase, this further complicates this career path model and the mechanisms needed to introduce students to these careers within a traditional academic environment. Innovative interdisciplinary partnerships for integrating experiential learning into academic programs and demonstrating to students the opportunities available within transportation operations are key to developing career awareness and relevant competencies for the workforce of the future.

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TRANSPORTATION ENVIRONMENT

Transportation Environment

INTRODUCTION

The U.S. transportation system is a significant contributor to environmental degradation across all media—Air (e.g., particulates), Water (e.g., run-off), Land (e.g., consumption of farmland), Aesthetics (e.g., landscape), Health (e.g., noise); significantly adds to waste generation (construction & hazardous) and the diminishment of wildlife and wildlife habitat and cultural resources, and is a major generator of greenhouse gases that are driving climate change. Further these impacts, as well as the benefits of transportation, are not evenly distributed across society. USDOT outlines their mission, along with strategies for addressing environmental justice, as a core area of DOT's environmental work.

The work needed to mitigate the environmental impacts of building and operating the nation's transportation systems is carried out across multiple disciplines and sectors, embedded in the job responsibilities of a broad workforce. Environment as a "discipline" can be found in academia directly—schools and departments of Environmental Studies, Environmental Sciences, and now in a wide range of "sustainability programs." It also includes departments and programs in the natural and physical sciences, such as Biology, Chemistry, Geology, Earth Sciences, and Physics, and crosses over into disciplines such as Environmental Engineering, Urban Planning, Architecture, Environmental Law, Community Health, Public Policy, and Historic Preservation. There is no singular definition or set of credentials defining the "environment" as a discipline for study or work. What is emerging is an understanding of the depth and breadth of the field through extensive multi-year surveys of academic programs by the National Council for Science and the Environment.[1]

In the survey of the field, 1859 academic programs were identified at 838 colleges offering 4-year and graduate degrees. At Community Colleges, 939 related degree programs were identified. In the survey reports, "transportation" as a modifier did not surface.

In the online tool EnvironmentalScience.org, which self-reports its mission to be "*the most reliable and expansive advocate for environmental science education and careers"*, a career

[1] *Interdisciplinary Environmental & Sustainability Education & Research: Institutes & Centers at Research Universities (2014); Interdisciplinary Environmental & Sustainability Education & Research: Results from the Census of Community Colleges (2014); Sustainability Education: Results from the Census of 4-Year U.S. Colleges & Universities (2013); Interdisciplinary Environmental & Sustainability Education: Results of U.S. 4-Year Colleges & Universities (2012).*

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search drills down to three transportation specific environmental jobs (Planner, Engineer, and Modeling Specialist) that can emerge from pursuing an environmental degree. These occupations do address environmental issues in the transportation field, however they offer no specificity to understand how these fields will grow specific to transportation environmental occupations.

USDOT and state DOT transportation planning and project development is guided by the National Environmental Policy Act (NEPA) process. It provides the framework to evaluate impacts associated with each individual project, working to align it to reflect the desires of communities and take into account the impacts on both the natural and human environment across the disciplines and areas noted above. In addition, because of the embedded nature of social equity in the environment field, as defined by FHWA, there are important crossover into fields where these issues are addressed, such as Community Development, Communications, Sociology, Anthropology, and a focus on Environmental Justice, which has become a distinctive field in the last twenty-five years. FHWA's focus on the environment is very deliberate in its trans-disciplinary nature.

Bringing a scientific understanding of project impacts and options to align with best practices and to comply with existing laws is however, just one part of the environmental work related to transportation systems. USDOT's report Beyond Traffic 2045**,** summarizes an emerging future view of transportation systems, indicating that a major transformation is emerging "akin to the introduction of the steam engine or the automobile", promising to dramatically improve the "safety, efficiency, competitiveness, accessibility, and sustainability of our transportation system." The transformation is not about building more and bigger infrastructure, but "smarter" infrastructure; advancing Intelligent Transportation Systems (ITS), connected and autonomous vehicles (CV/AV), shared-use mobility options, and an electric-powered fleet. All of these transformations promote systems development that reduce the environmental impacts associated with mobility of people and things.

This vision of environmentally sound transportation systems underlay USDOT's "Smart City Challenge" initiative launched in 2015. The initiative stimulated the development of 78 partnership networks around the country to "develop ideas for an integrated, first-of-its-kind, smart transportation system that would use data, applications, and technology to help people and goods move more quickly, cheaply, and efficiently."

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This transformative approach has been paralleled in academic research and education to prepare a new generation of transportation workers. The 3 Revolutions Future Mobility Program at UC Davis' Institute of Transportation Studies, posits the "rapid adoption of shared mobility services and electric vehicles, coupled with the prospect of driverless vehicles, has the potential to radically transform how people and goods move." Its interdisciplinary team is working on technology and policy platforms to support systems change in the state of California and beyond. At Carnegie Mellon University (CMU), researchers in the Metro21: Smart Cities Initiative take a forward-looking, creative approach to bringing people, technology, and policy together to create and test smart city solutions. Working in collaboration with the City of Pittsburgh, Allegheny County, and other government agencies, CMU produced successful outcomes that are already being implemented in additional metro areas. Further, CMU is a member of the MetroLab Network, "working closely with 35 other city-university partnerships to scale effective solutions, accelerate best practices, and advance the understanding of urban science."

In the private sector, environmental work is expressed as an integrated, holistic approach carried out by an interdisciplinary team, as evidenced by the private sector members of the Environment Discipline Working Group (DWG), including Nelson Nygaard, JMT, and VHB. JMT advances environmental sustainability in their work to address solutions "available if we innovatively plan and engineer communities, transportation networks, infrastructure, and technologies that reconcile the environmental, social, and economic demands of human society." To do this, JMT *engages multi-disciplined teams to look at projects from all perspectives*. Similarly VHB describes themselves as *Engineers, Scientists, Planners, and Designers—1,350 passionate professionals* "working together to deliver value to our clients and help shape our communities in a meaningful way. A project can't move forward without addressing its surrounding environment. Balancing development and infrastructure needs with stewardship of the environment is what we do."

Environment Discipline Background

> *"Transportation planning and project development must reflect the desires of communities and take into account the impacts on both the natural and human environments. Transportation projects are closely looked at to see how they might impact the community, the natural environment, and our health and welfare. Before any project can move forward to construction, the FHWA must address and comply with laws related to the environment. These laws cover social, economic, and environmental concerns ranging from community cohesion to threatened and endangered species."*

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> *"The offices of Natural Environment and Human Environment primarily focus on environmental programs associated with air quality, climate change, sustainability, noise, and on programs associated with the built environment, including transportation enhancements, and bicycle and pedestrian facilities. The Office of Project Development and Environmental Review focuses on NEPA project development process as a balanced and streamlined approach to transportation decision-making that takes into account the potential impacts on both human and natural resources and the public's need for safe and efficient transportation improvements."* (FHWA)

FHWA approaches the Environment discipline as an area that is extremely broad and operates more as a lens, informing work across multiple fields and occupations in the transportation sector (competencies, knowledge, and skills), than as a specific occupational category or guide.

Initial Investigation

The Northeast Transportation Workforce Center (NETWC) efforts to establish a comprehensive understanding of, and to identify relevant occupational clusters around, the transportation environment discipline, was informed by consultation with industry professionals, significant literature review, and analyses of trending initiatives and research. Utilization of LMI data warehouses like the Bureau of Labor Statistics (BLS) or real time occupational employment review tools like Burning Glass Technologies, has added depth to this research, but LMI analysis has not proven as useful as hoped. In part, this reflects the nature of environmental jobs in transportation, being more interdisciplinary in nature and tending not conform to clean Standard Occupational Classification (SOC) categories.

The US Department of Labor (DOL) O*Net tool offers a more direct opportunity to search-out clusters of occupations. An exploration within O*Net reveals 229 transportation occupations. When further filtered by "Green Jobs", 26 occupations surface. As shown in Table E1 below, most of these occupations fall into the fields of manufacturing or technology design; another significant group into operations, distribution, and logistics. Some occupations appear within rail and transit, as their modes are considered comparatively green, while classifications like Transportation Managers, Planners, and Engineers are generic enough that without context, may or may not represent an environmental field.

Utilizing these codes and classifications did not provide a concrete data set that would support an investment in career pathway development in the Environment discipline.

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Table E1. O*NET Green Economy Sector – Transportation

CODE	OCCUPATION
17-2011.00	Aerospace Engineers
17-3027.01	Automotive Engineering Technicians
17-2141.02	Automotive Engineers
49-3023.02	Automotive Specialty Technicians
49-3031.00	Bus and Truck Mechanics & Diesel Engine Specialists
53-3021.00	Bus Drivers, Transit & Intercity
43-5032.00	Dispatchers, Except Police, Fire, and Ambulance
17-2072.00	Electronics Engineers, Except Computer
43-5011.01	Freight Forwarders
17-2141.01	Fuel Cell Engineers
17-3029.10	Fuel Cell Technicians
53-3032.00	Heavy and Tractor-Trailer Truck Drivers
53-7051.00	Industrial Truck and Tractor Operators
53-4011.00	Locomotive Engineers
13-1081.02	Logistics Analysts
13-1081.01	Logistics Engineers
11-3071.03	Logistics Managers
17-2141.00	Mechanical Engineers
47-4061.00	Rail-Track Laying & Maintenance Equipment Operators
53-4031.00	Railroad Conductors & Yardmasters
43-5071.00	Shipping, Receiving, & Traffic Clerks
11-9199.04	Supply Chain Managers
17-2051.01	Transportation Engineers
11-3071.01	Transportation Managers
19-3099.01	Transportation Planner
53-6051.07	Transportation Vehicle, Equipment & Systems Inspectors

SOURCE: https://www.onetonline.org/find/green?n=12

FHWA's Office of Environment presents the wide range of fields and needed competencies in their divisional breakdown of transportation planning and project development and implementation tasks to meet environmental requirements and advance environmental goals. These are inherently interdisciplinary fields, some of which are listed below:

Operations – Environmental Regulatory Compliance in Projects (NEPA) & Public Process
Compliance Focused Environmental Management
Waste Management and Remediation
Sustainability Systems
Hydrological Studies
Hazardous Materials
Noise Abatement

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Cultural (Historical & Archaeological) Resources
Surface Water Quality (Storm Water Management, Wetlands & Waterways)
Fish, Wildlife, Plants & Rare Species (including invasive plant species)
Bicycle & Pedestrian initiatives
Transit & TDM
Air Quality & Health
Community Impact Assessment
Landscape Stewardship
Farmland Soils and Agriculture
Parks & Recreation Areas
Planning & Modeling

FHWA's Competency Building Program in Environment provides further background, but no further definition of specific occupations. Within DOTs in the Northeast, environmental specialists might serve in one of the 18 divisions listed above. An examination of the organization of state DOTs and their Environment sections nationally, revealed common sets of occupations, including Hydraulics Engineer, Air Quality Coordinator, HazMat Program Coordinator, Wildlife Biologist, and Historic Preservation Program Manager, but not occupations that could be traced back to labor market data specific to transportation.

The American Association of State Highway and Transportation Officials (AASHTO) Center for Environmental Excellence lists 20 key topic areas (similar to FHWA above) and five disciplines specific to environment: Planning, Design, Construction, Maintenance, Operations, and Project Delivery—along with four communities of practice (Air Quality, Environmental Justice, Historic Bridges, and Stormwater Management), emphasizing the interdisciplinarity of the field, but again, provide no specificity regarding occupations.

Since 2002, the National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP) reports have repeatedly documented concern, as expressed at FHWA and state DOTs, that they would be facing significant retirement pressures and a need to replace large numbers of key personnel. This was highlighted across all transportation disciplines in the 2012 National Summit on the Transportation Workforce and then documented regionally in the NETWC 2016 Jobs, Needs & Priorities Report. Concern for this phenomenon and it impacts specifically on environmental workers in state and federal agencies has been noted, and though they are considered critical staff, they tend to be in small numbers, especially in any identifiable sub-discipline.

The issue of replacement of retiring environmental positions in federal and state agencies does not reflect an overall growth in sector jobs with significant increases in occupational opportunities that would lead to the development or expansion of current education and

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training programs across the post-secondary spectrum. This does however, call for a better branding of environmental jobs in the transportation sector from all disciplines, with a profiling of people and positions in planning, design, construction, maintenance, and operations that highlight opportunities in transportation from the many disciplines needed in the field. An effort to address this need was identified in the 2016 NETWC Action Plan and has been built into that ongoing effort.

The 2016 Jobs, Needs & Priorities Report did not specifically surface environmental occupations as priority occupations. Many of the occupational categories have small environmental sub-divisions, but efforts to utilize LMI data sets did not surface specific data for the transportation environmental fields specifically, only for more general fields within which transportation professionals would be represented (e.g., Environmental Engineers, Urban & Regional Planners, Environmental Planners, Geospatial Information Scientists & Technologists, Data Analysts, and Policy Analysts). While there is evidence of growth in all of these sub-fields that represent occupations in the transportation sector, there is no data as to what growth, if any, is represented in the transportation field itself.

Early in this project, NETWC and its Environment DWG advisory reviewed the broad and interdisciplinary range of environmental competencies and occupations employed in surface transportation systems design, construction, maintenance, and operations. LMI data sources were limited and did not offer good clarification or readily available strategies to surface clear data related specifically to occupations within the transportation field, or data that would help differentiate Environment from the other disciplines.

Using initial project methodologies, no group of specific critical occupations directly arose in the Environment disciplines aligned with the transportation field, being significantly influenced by transformative technologies, and could be substantiated as growing in significant numbers. This reality presented an unexpected impediment to immediately moving into the process established across the five disciplines: *(1) get data from existing labor market analyses to identify a draft list of Environment occupations, (2) facilitate and advise DWG meetings to narrow that list to the top 10-20 disciplinary priorities, and (3) develop related skills gap assessments, competency models, and career pathway definitions.*

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Changing the Paradigm

NETWC, working closely with its DWG advisory, shifted tactics to identify a field where the change in transportation technologies was driving work to achieve environmental outcomes, while (a) enhancing the transportation system, (b) attracting significant new investment and attention, and (c) contributing to the growth of redefined or completely new occupations. Researchers first broadly identified the converging fields of work and investment in Smart City, ITS, Shared-Use Mobility, and Transit. These strategies work to move people and goods more efficiently, limit the environmental impacts of CO^2 emissions and wasted fuel from idling, congestion and poorly timed traffic lights, and work to establish multimodal active transportation options for citizens that minimize the need and desire for single occupancy vehicle use. While it was determined that many environmental fields continue to be important in transportation environmental systems planning and implementation, a hypothesis that the Environment DWG advanced stated that "*… the rapidly changing fields related to Smart Cities, Shared Mobility, and Climate Adaptation are emerging as key drivers for investments, particularly at the state and local level, and growth in these fields is driving a need for identifying new competencies, occupations, and career pathways for entrants (and incumbents) to this new mobility field.*" (Environment DWG, Jun 2017)

Subsequently, identifying occupations that can be inserted into new career pathways has been a process of reverse engineering, performed by first examining the scale of investments in each field and the demand in various sections of the industry. With uncertainty facing the future of federal investments, the Environment DWG examined areas that exhibited an intersection between investments (private, state, and local) and a deployment of innovative technologies that would have the greatest impact on future environmental impacts in the transportation sector. What quickly surfaced were investments in Smart City and ITS that also encompassed the Transit and Shared Mobility fields.

This four-part convergence rapidly became a focus, as the implementation of these programs, technologies, and new infrastructure will potentially have a significant positive impact across the spectrum of environmental fields identified under transportation (e.g., air quality, land use, climate change) and would potentially open up new jobs and define new occupations in high demand throughout communities across the country.

Using the USDOT Smart Cities site as a departure point, emerging technologies being utilized by Smart City applicants were identified and common trends and fundable projects

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in the proposals were noted. While there were several major themes (autonomous vehicles, dynamic parking management, and shared mobility), an initial focus on traffic signal management and more broadly, vehicle-to-infrastructure (V2I) technology, was selected as a starting point, to address mitigating pollution and the more efficient movement of people and commerce through a city. As a transportation technology, ITS improves safety and mobility and reduces environmental impacts for its users. ITS emerged as a critical field for investigation, within and beyond the Smart Cities effort. The application of ITS, particularly Transit Signal Priority (TSP), has been around since the 1970s. As a vehicle to infrastructure (V2I) tool, TSP improved mobility and reduces environmental impacts by "altering signal timing to extend the duration of green signals for public transportation vehicles when necessary." TSP systems use sensors to detect approaching transit vehicles and alter signal timings to improve transit performance. An initial review of actual and proposed investment plans found that many cities and municipalities are investing in updates to their ITS infrastructure as well as new infrastructure projects.

No career pathway is viable unless there is evidence of growth and investment in the sector. In the case of ITS, Denver, Pittsburgh, and San Francisco—all Smart City Challenge finalists—received grants to implement smart traffic management technologies like TSP and connected vehicle systems. Evidence suggests investment in this type of infrastructure technology dates back to the 1984 Olympic Games in Los Angeles, when the Los Angeles DOT deployed the Automated Traffic Surveillance & Control System (ATSAC) around the LA Coliseum to improve efficiency of the city's road network during the 1984 Olympics. This system has since grown to also monitor traffic conditions, set signal timing, and provide equipment diagnostics and alerts. In 2015, the Tampa Hillsborough Express Authority (THEA) was awarded $17 million by USDOT for a connected vehicle pilot project. USDOT's ITS site also identified three pilot projects for connected vehicle deployment worth more than $45 million: the New York City Pilot, Tampa-Hillsborough Expressway Authority (THEA) Pilot, and the Wyoming DOT Pilot.

Miami-Dade County is also investing in a multimillion-dollar modernization program to improve traffic signal coordination and move the county toward intelligent traffic signals (Chardy, Alfonso, Apr 2016). In Chicago, the Regional Transportation Authority (RTA) and Chicago Transit Authority (CTA) are implementing TSP on bus corridors in the region, using a $36 million grant from the Federal Congestion Mitigation & Air Quality Improvement program

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(CMAQ) and $4 million in local match (Regional TSP Implementation Program, 2017). In March 2017, the Maryland Transit Administration (MTA) announced it would invest $11 million to install TSP sensors on local buses and city traffic signals to increase the flow of buses throughout city streets. As part of the project, MTA will also create bus-only lanes and remove underutilized bus stops. (Campbell, Colin. March 29, 2017)

This short list of infrastructure investments documents a growing trend at the state and municipal level to invest in and implement ITS systems, transforming traffic management. The work being initiated by Smart Cities finalists (Austin, Columbus, Denver, Kansas City, Pittsburgh, Portland, San Francisco) as well as the 71 other applicants, has initiated numerous public-private implementation programs. The growth of shared-use mobility systems (e.g., bike share programs being built out in hundreds of communities), and the integration of those systems into transit, represents another set of important investments that are building out new infrastructure and building demand for workers with new competencies and qualifications at the leadership, design, and operations levels.

Yet, there remains a question of whether there are a sufficient number of qualified workers to support these system roll-outs and improvements, along with the necessary maintenance and operations tasks they will require for decades to come. Will new or updated training/education for ITS, Smart City, Shared Use Mobility, and Transit employees at all levels (e.g., Big Data, Traffic Operation Technicians, Transit Engineers), be adequate to upskill workers to meet the demands of these challenging technologies in the near-term?

A key takeaway here is that future program identification and the building blocks for new program development are best aligned with a cluster of possible in-demand occupations, as opposed to a single occupation, as communities and businesses expand and upgrade their ITS, Shared Mobility, and Smart City systems. While some educational degree or certificate programs can be focused on a single occupational outcome, such as Welder or X-Ray Technician, given the growth and fluidity of these transportation fields, successful programs are likely to be built around competencies and skill-building in ways that lead to multiple occupational opportunities along a career pathway.

NETWC's contention is that the future environmental narrative leading to growth in employment in transportation is embedded in the work of new mobility systems. They define a growing number of jobs working to improve environmental quality and mitigate the

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negative environmental impacts of operating the system; jobs that are emerging from a convergence of Smart-City, ITS, Shared Mobility, and Transit. The most articulate narrative, outside USDOT's Smart City Competition applications and action plans, is the "*Three Revolutions*" report from the UC Davis Institute of Transportation Studies, which states that public-sector employer participants are looking toward implementation and hiring, particularly in ITS and data analysis, while private sector employer participants are hiring across planning and design fields, as well as data and technology specialists. These are part of a growing new trend in attracting qualified workers to build out significantly different mobility systems parallel to the existing system it will eventually replace.

Table E2 below presents the current priority occupation classifications for the Environment discipline. Occupational titles are drawn from aggregated employer job announcements and do not easily align with traditional occupational codes.

Table E2. Environment Priority Occupations (working draft)

SUSTAINABLE TRANSPORTATION PLANNER / MANAGER	SMART CITY / EV INFRASTRUCTURE	SHARED MOBILITY / BIKE SHARE OPERATIONS	SMART CITY / ITS TECHS / ENGINEERS
Dir Transit & Shared Mobility	Smart City Network Architect	Bike Share Ops Coord.	ITS Technician
Mobility Strategic Advisor	Infrastructure Architect, Information Systems Specialist	Bike Share Ops Manager	ITS Engineer
Transportation Supervisor & Mobility Coordinator	Regional Mgr, Smart Cities & Connected Vehicles	Bike Share Ops Specialist	Traffic/ITS Engineer
Transportation Demand Mgmt & Program Specialist	Project Mgr, EV Infrastructure & Clean Transportation	Bike Share Ops Supervisor	Senior ITS Engineer
Trans. & Mobility Coord.	Project Mgr, Electric Vehicle Charging & Infrastructure	Asst. Field Ops Manager	Smart Mobility ITS Eng
Urban Planning Assistant	Ops Engineer Associate	Community Coordinator	Sr Traffic Engineer, ITS
Sr Mgr, Trans. Planning	Project Engineer, Charging Infrastructure	Project Manager	Transportation Engineer
Transportation Specialist			Connected & Autonomous Systems Engineer
Special Projects Manager Sustainable Trans. Mgr			ITS Manager, Public Transportation
Bicycle/Ped Mobility Coord.			ITS Traffic Engineer
Trans. Planner, Entry Level			
Resource Conservation			

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CAREER PATHWAYS & STATE OF PRACTICE

Four clustered pathways representing three emerging fields (Smart Cities, Shared Mobility, and ITS) have been designed with a level of distinction and integrity and reflect how hiring and job development is proceeding in these emerging fields. These fields are bound together with an emerging set of foundational skills that employers are increasingly expecting new job entrants to have mastered, evidenced in review of hundreds of job postings for these positions and discussions with the Environment DWG (October 2017).

Observationally, certain occupations overlap across these three clusters, due to their interrelated transformative nature, while at the same time overlapping into other initiative disciplines like Planning and Operations. Examples of the competency models and career pathway maps for the Environment discipline's four emerging fields are presented and characterized below, in Figures E1 through E8. Each has been developed and refined in conjunction with advisory input from the Environment DWG, and have been presented to a broader stakeholder audience at the Northeast Association of State Transportation Officials (NASTO) Summer Meetings, the USDOT ITS Professional Capacity Building (PCB) workshops for universities and community colleges, and the international meetings of the National Council for Science and the Environment.

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Career Path 1: Sustainable Transportation Planner/Manager

Compatible Job Titles:

- Director of Transit and Shared Mobility
- Transportation Supervisor and Mobility Coordinator
- Transportation Demand Management and Program Specialist
- Urban Planning Assistant
- Special Projects Manager - Sustainable Transportation Manager
- Transportation Planner: Entry Level
- Specialist I/II
- New Mobility Strategic Advisor
- Transportation Specialist
- Transportation and Mobility Coordinator
- Senior Manager: Transportation Planning
- Bicycle and Pedestrian Mobility Coordinator
- Resource Conservation

O*Net Job Titles:

- Transportation Planner/Chief Sustainability Officer
- Transportation Planners/Transportation Managers
- Urban and Regional Planners
- Transportation Planner

Competency Model & Pathway Characterization:

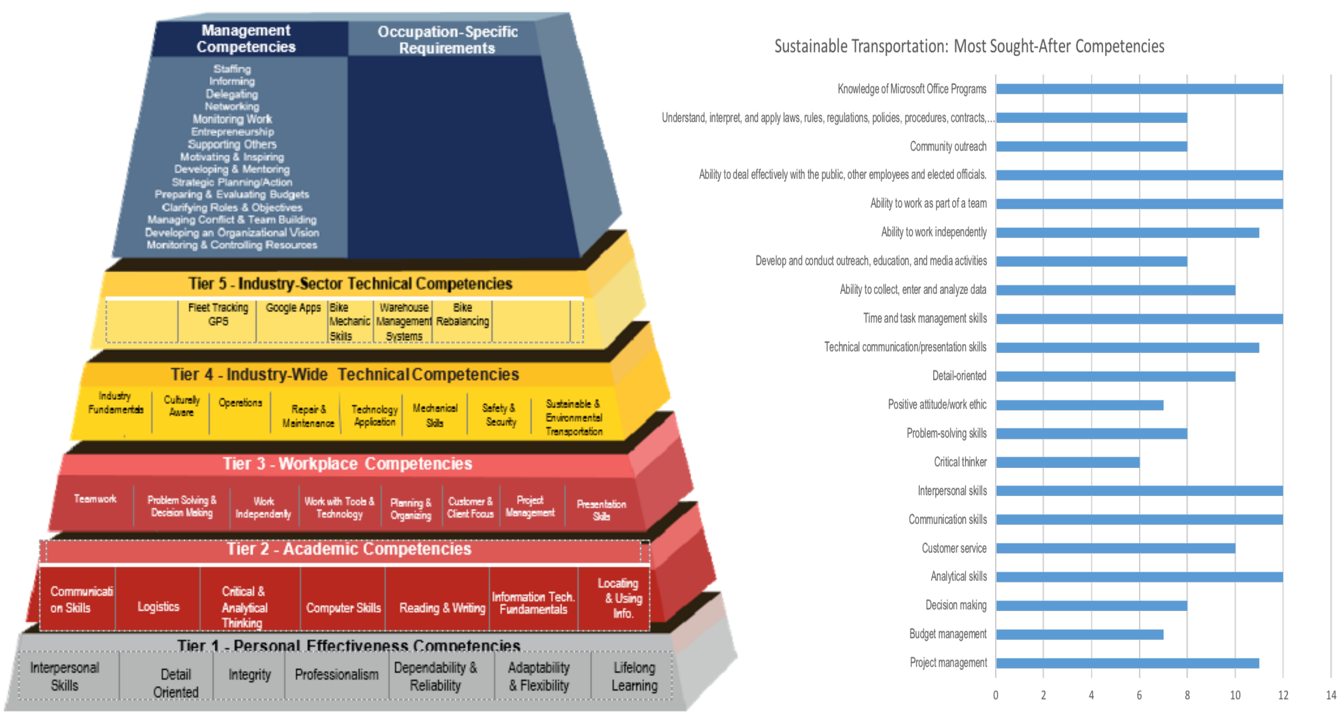

Figure E1a. Competencies: Sustainable Transportation Managers/Planners

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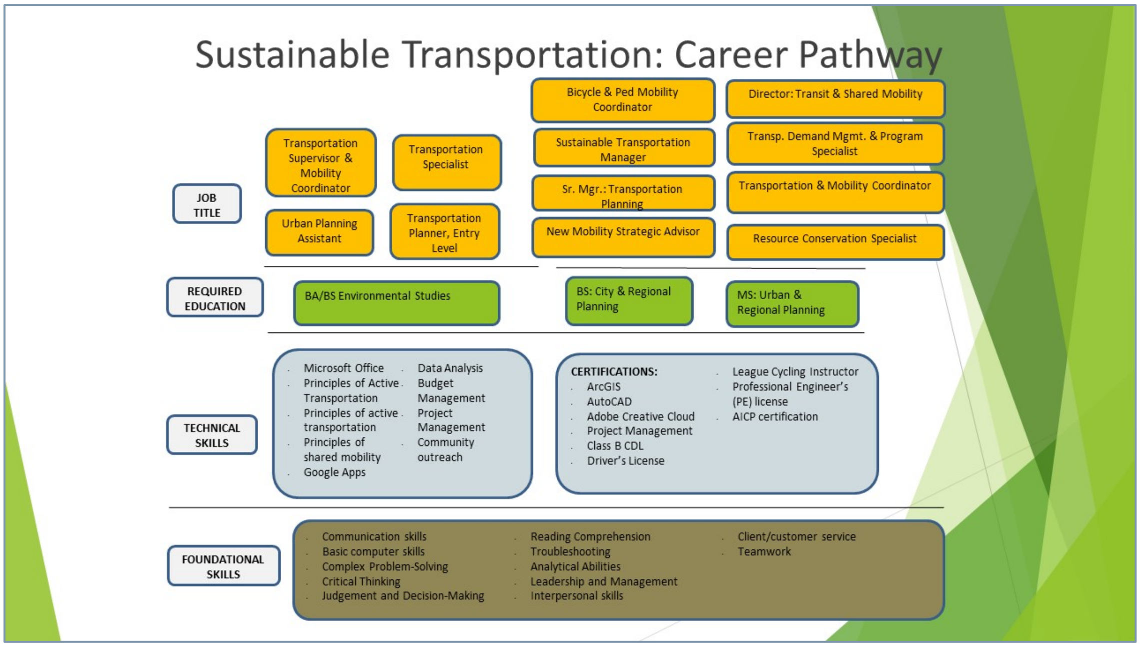

Figure E1b. Career Pathway: Sustainable Transportation Managers/Planners

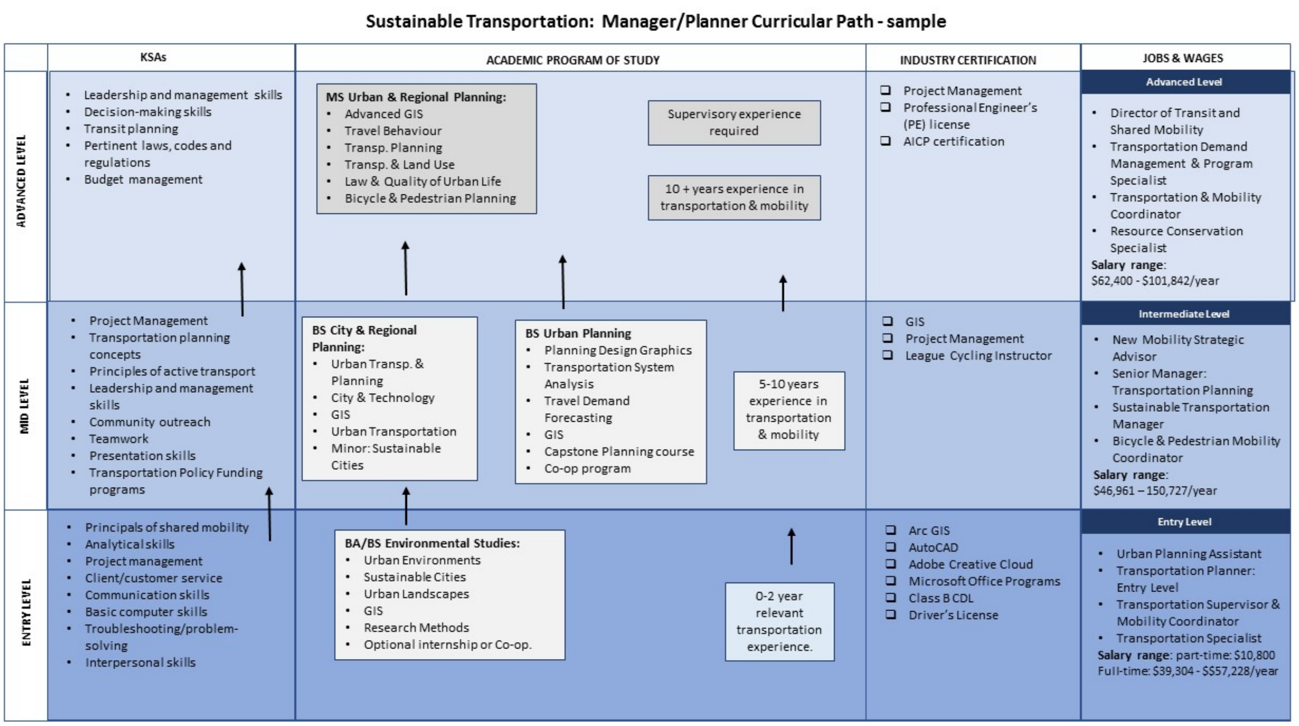

Figure E1c. Career Pathway: Sustainable Transportation Managers/Planners

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Career Path 2: Shared Mobility/Bike Share Operations

Compatible Job Titles:

- Bike Share Operations Coordinator
- Bike Share Operations Specialist
- Bike Share Operations Supervisor
- Community Coordinator
- Bike Share Operations Manager
- Bike Share Operations Supervisor
- Assistant Field Operations Manager
- Project Manager

O*Net Job Titles:

- Bicycle Repairers/General and Operations Managers
- Bicycle Repairers/Social and Community Service Managers
- Chief Sustainability Officers/Social and Community Service Managers

Competency Model & Pathway Characterization:

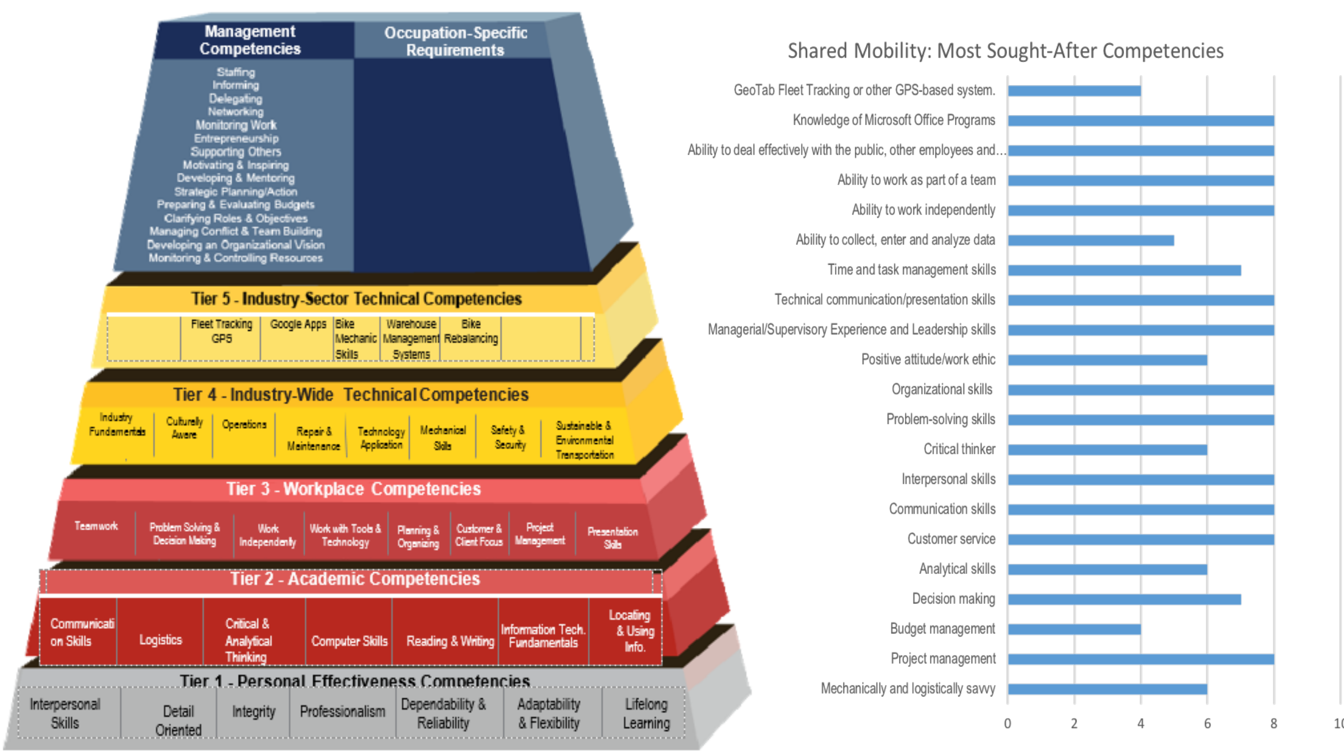

Figure E2. Competencies: Shared Mobility/Bike Share Operations

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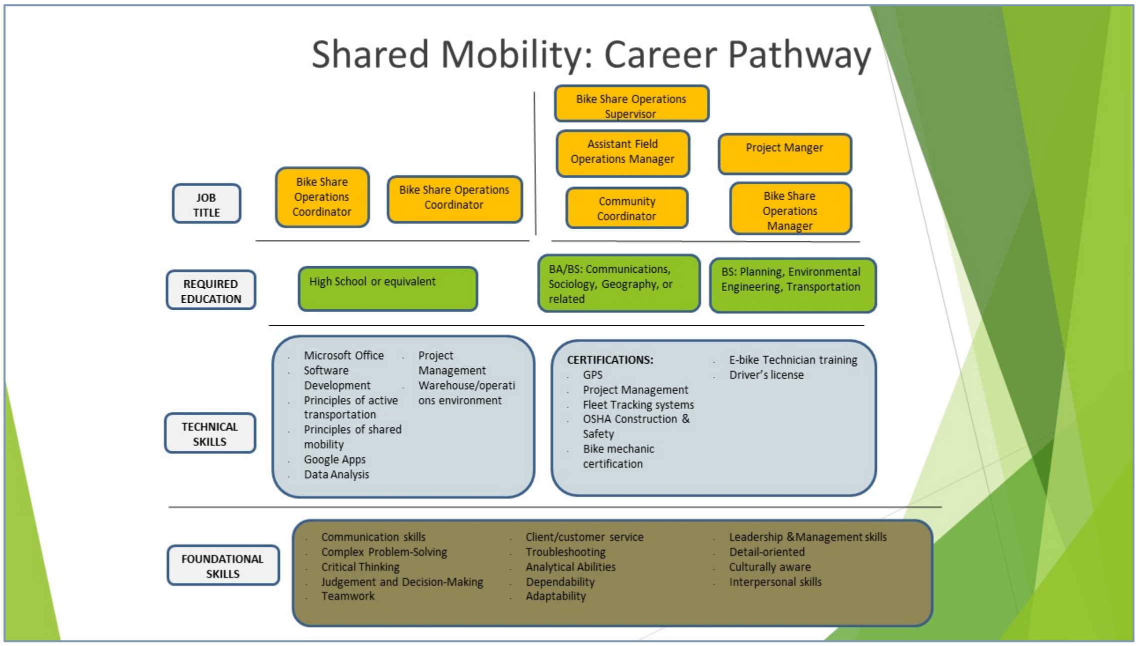

Figure E2a. Career Pathway: Shared Mobility/Bike Share Operations

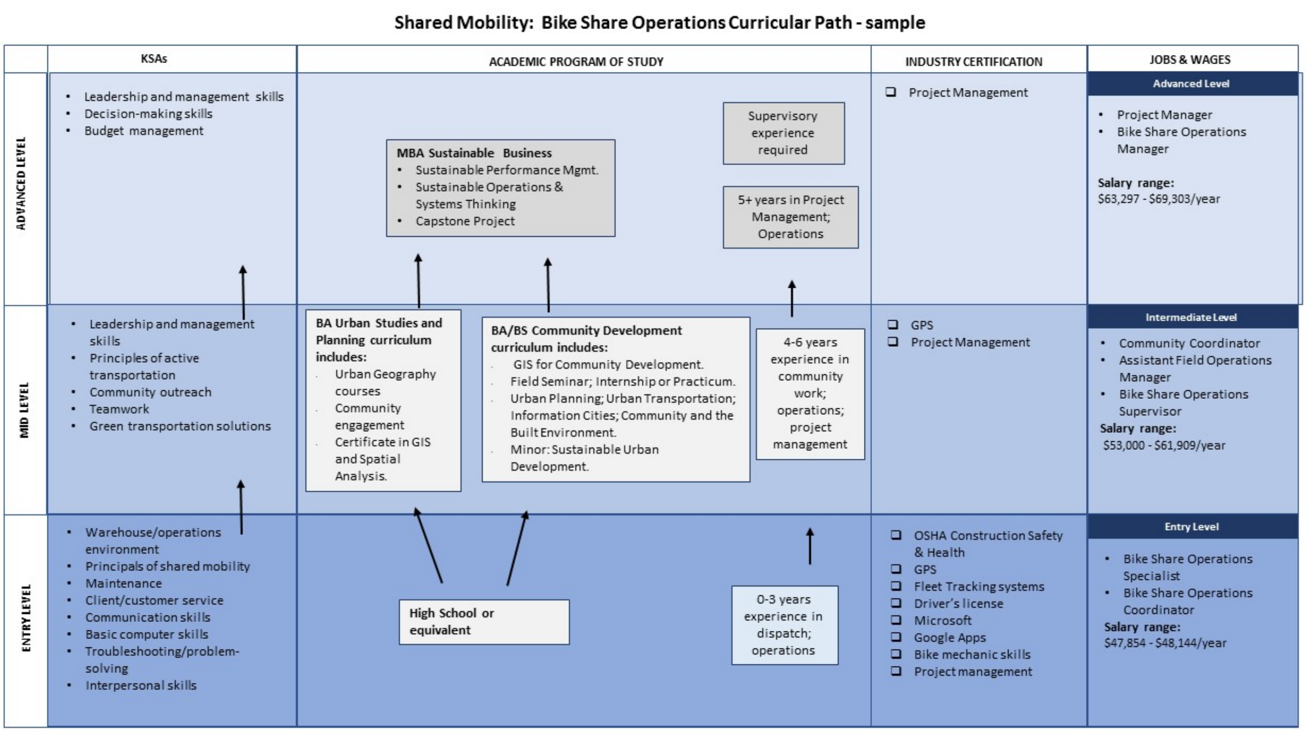

Figure E2b. Career Pathway: Shared Mobility/Bike Share Operations

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Career Path 3: Smart City / EV / Infrastructure

Compatible Job Titles:

- Infrastructure Architect - Information Systems Specialist
- Regional Manager for Smart Cities and Connected Vehicles
- Project Manager, EV Infrastructure Clean Transportation
- Project Manager, Electric Vehicle Charging & Infrastructure
- Operations Engineer Associate
- Project Engineer - Charging Infrastructure

O*Net Job Titles:

- Computer Network Architects
- Civil Engineers/Sustainability Specialists
- Computer Network Architects/Electrical Engineers
- Civil Engineers/Transportation Managers
- Civil/Electrical Engineers

Competency Model & Pathway Characterization:

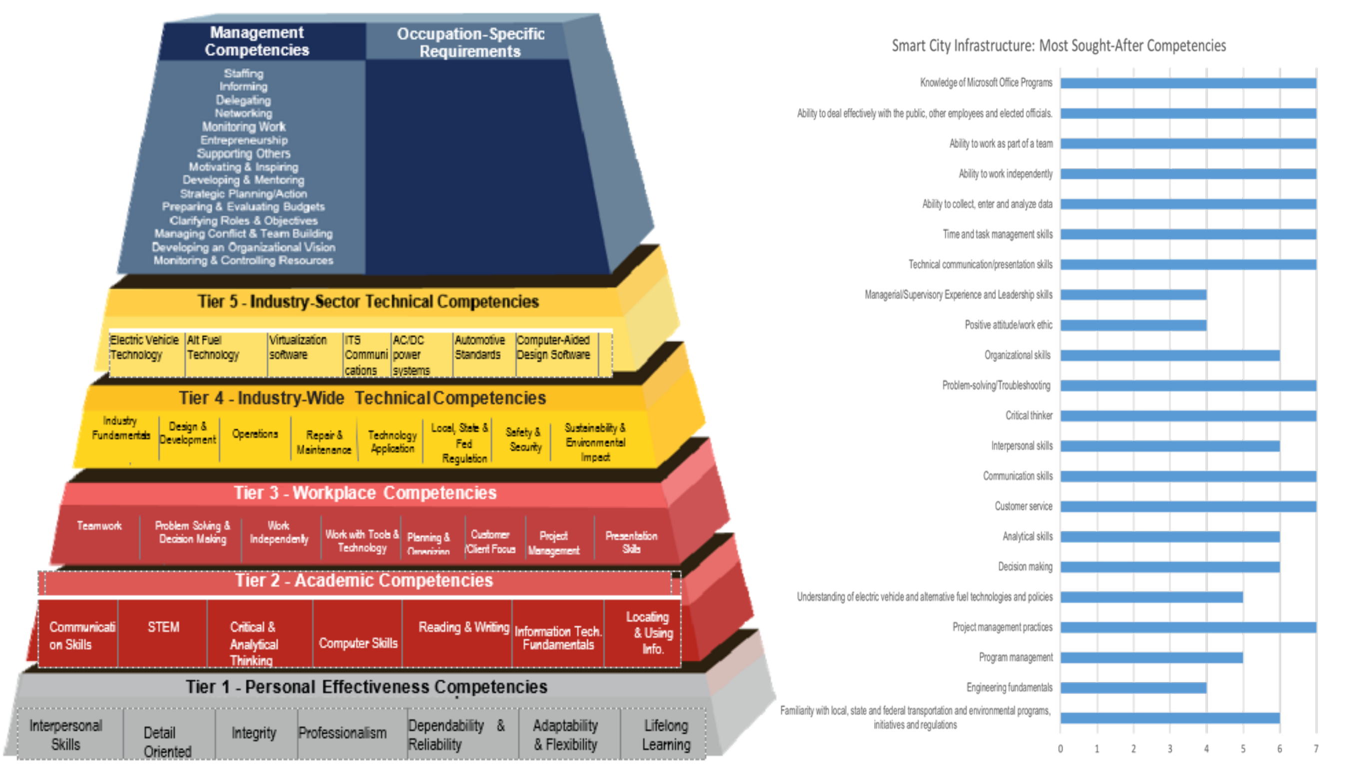

Figure E3. Competencies: Smart City / EV / Infrastructure

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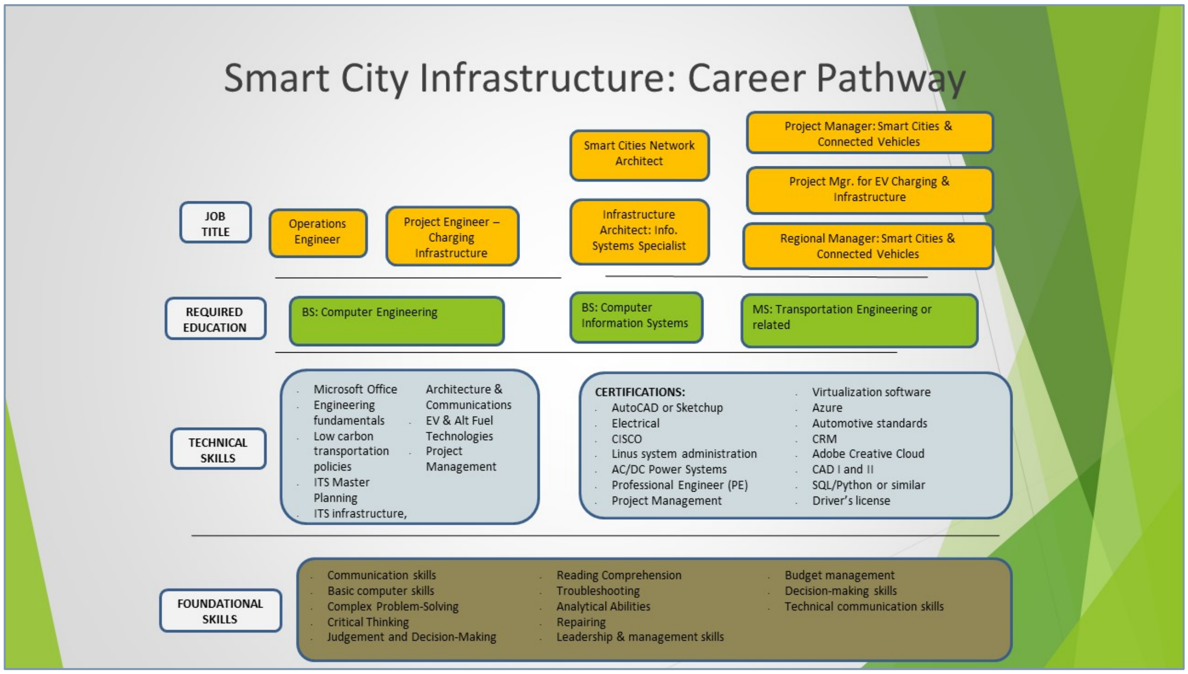

Figure E3a. Career Pathway: Smart City / EV / Infrastructure

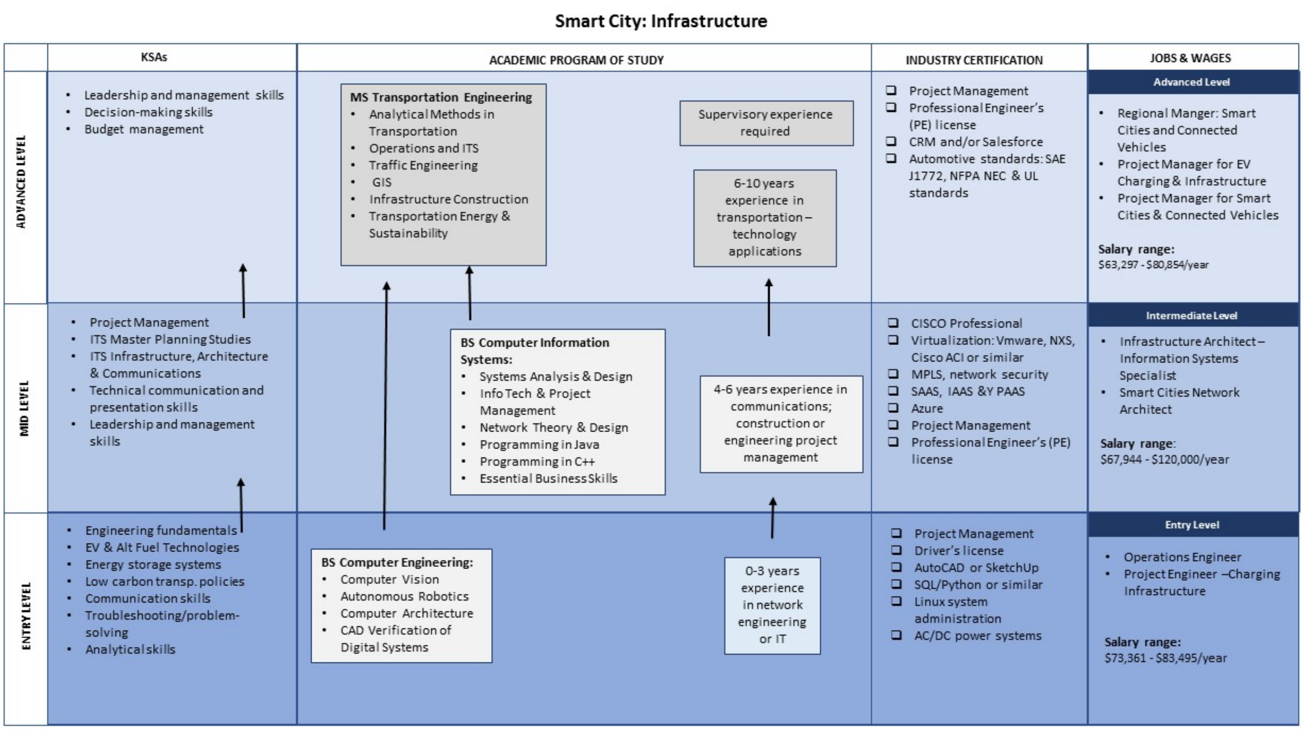

Figure E3b. Career Pathway: Smart City / EV / Infrastructure

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Career Path 4: Smart City / ITS Technicians/ Engineers

Compatible Job Titles:

- ITS Technician
- Traffic/ITS Engineer
- Smart Mobility ITS Engineer
- Senior Traffic Engineer: Intelligent Traffic Solutions
- Connected and Autonomous Systems Engineer
- ITS Engineer
- Senior ITS Engineer
- Transportation Engineer
- ITS Manager: Public Transportation
- ITS/Traffic Engineer

O*Net Job Titles:

- Traffic Technician
- Transportation Engineer

Competency Model & Pathway Characterization:

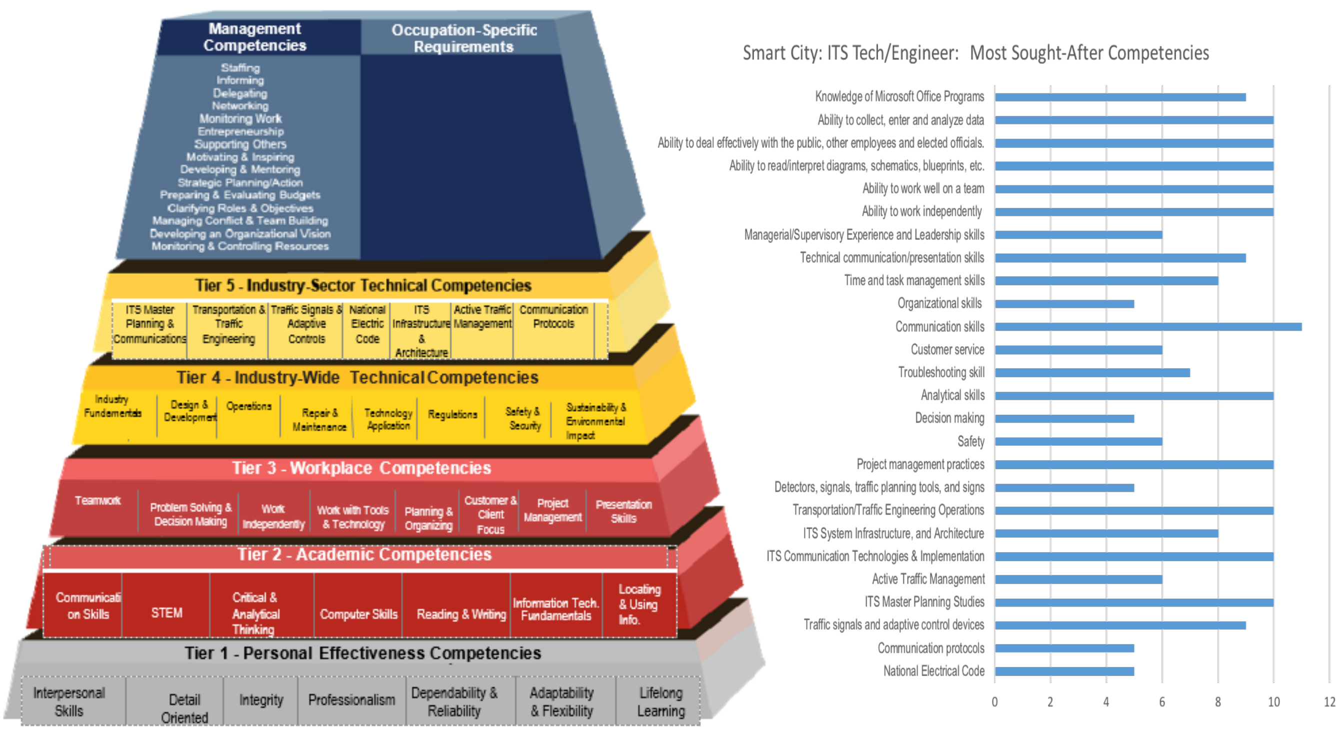

Figure E4. Competencies: Smart City / ITS Technicians/ Engineers

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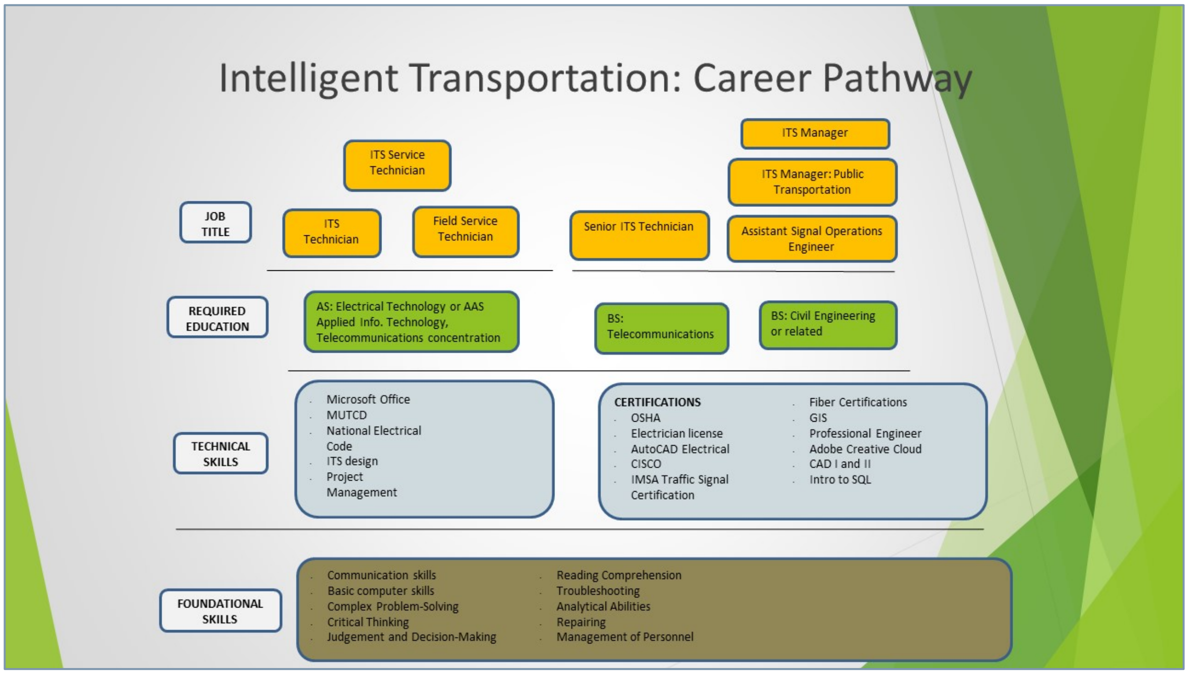

Figure E4a. Career Pathway: Smart City / ITS Technicians/ Engineers

Smart City/ITS Engineers Curricular Path - sample

	KSAs	ACADEMIC PROGRAM OF STUDY		INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	• Leadership and management skills • Decision-making skills	**MS Civil Engineering with Transportation concentration** • Traffic Engineering • Transportation Planning & Engineering • Graduate Co-op	Supervisory experience required 6-10 years experience in management of traffic engineering projects	❑ Project Management ❑ Professional Engineer's (PE) license ❑ Professional Traffic Operations Engineer (PTOE) certification	**Advanced Level** • Senior ITS Engineer • Transportation Engineer • Connected & Autonomous Systems Engineer • ITS Director **Salary range**: $106,000 - $134,000/year
MID LEVEL	• Project Management • ITS Master Planning Studies • Traffic Planning tools • Technical communication and presentation skills • Active Traffic Management	**BS Civil Engineering, Transportation Engineering:** • Traffic Operations and Design • Transportation System Analysis • Travel Demand Forecasting • GPS & GIS • Sustainability • Project Management • Optional Civil Engineering internship or Co-op.	5-9 years experience in transportation or traffic engineering	❑ GIS ❑ Project Management ❑ Professional Engineer's (PE) license ❑ Professional Traffic Operations Engineer (PTOE) certification	**Intermediate Level** • Traffic Engineer • Assistant Signal Operations Engineer • Smart Mobility ITS Engineer • Senior Traffic Engineer **Salary range:** $75,000 - $96,000/year
ENTRY LEVEL	• National Electrical Code • MUTCD • ASHTO • Communications protocols • Fiber optics • Communication skills • Basic computer skills • Troubleshooting/problem-solving	**BS Civil Engineering, Transportation Engineering:** • Traffic Operations and Design • Transportation System Analysis • Travel Demand Forecasting • GPA & GIS • Sustainability • Project Management • Optional Civil Engineering internship or Co-op.	0-3 years experience in traffic engineering	❑ OSHA Construction Safety & Health ❑ AutoCAD Electrical ❑ Microstation ❑ Engineer-in-Training (EIT)	**Entry Level** • ITS Engineer • ITS Technician Supervisor **Salary range:** $59,000 - $78,000/year

Figure E4b. Career Pathway: Smart City / ITS Engineers

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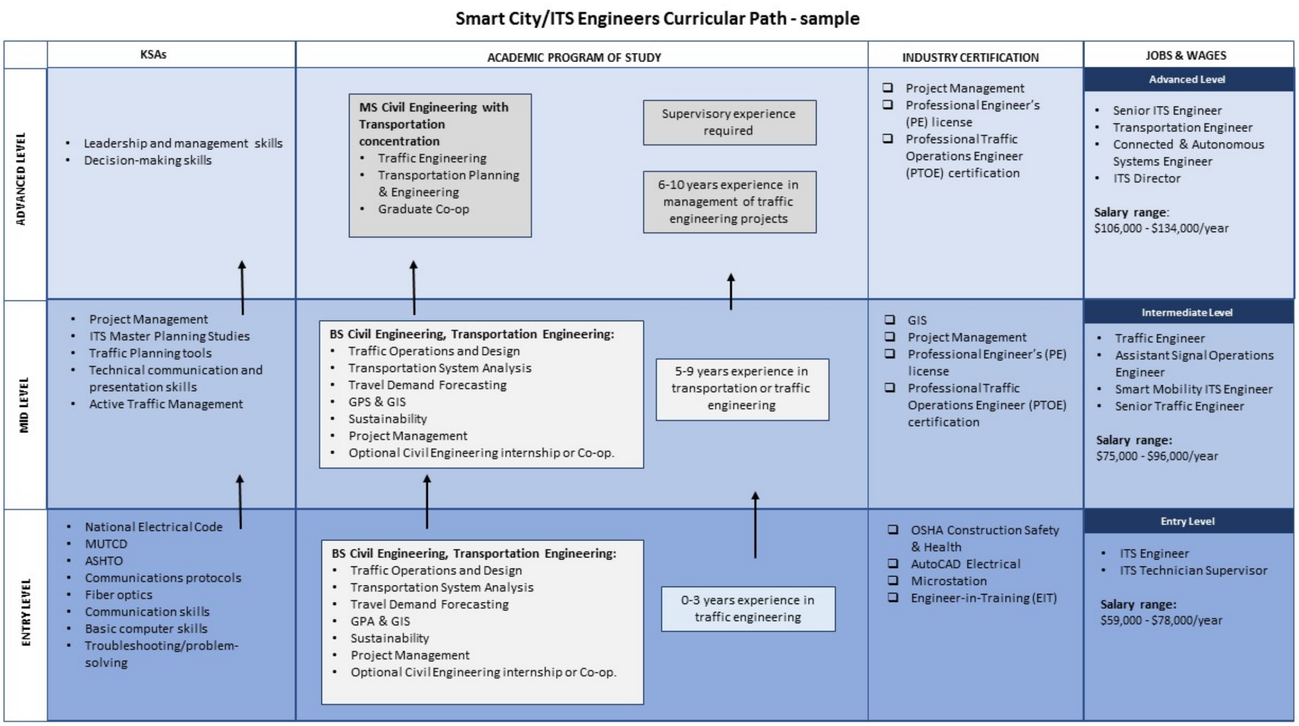

Figure E4c. Career Pathway: Smart City / ITS Technicians

These pathways and their occupational categories will be further refined from an upcoming focused qualitative review, as NETWC follows the premise that these emerging technologies, innovations, and investments are happening at municipal and regional levels throughout the country. Researchers plan to work directly with Smart City coalitions—both public and private and partners, the Shared-Use Mobility community, and city/regional governments accessible through their organizations, with the goal of documenting the emerging workforce need. This investigation will also examine how current positions are being transformed, with new skills and competencies being required.

As these fields are emergent, researchers also seek to track the real-time development of new departments, new positions, and new groupings of employees, trainees, and job positions, in order to present a coherent picture. One case study under examination is the new Department of Mobility & Infrastructure in Pittsburg, which will include hiring a new set of staff and building-out a city-wide agenda, all as part of Pittsburgh's Smart City application. And while survey tools will be deployed to gather additional data and spur reflections that will inform this examination, a parallel effort of case studies, direct interviews, and document review of job postings and classifications will continue in this sector.

In moving toward the idea of piloting programs that showcase employer/educator partnerships and establish pathways that develop a workforce capable of supporting these fields, researchers will explore how these clusters are emerging in other cities, including Columbus, Cambridge, Pittsburgh, Austin, Philadelphia, and the greater District of Columbia area, documenting not only those job opportunities being posted, but how municipal and regional entities and their private-sector partners are organizing themselves and their workforce—both current and future, to build out new environmentally sensitive infrastructure and systems. NETWC will also take a deeper dive into the programs of partnering universities, colleges, and training organizations that are being responsive to local employers as they identify in-demand competencies, credentials, and knowledge sets.

EXPERIENTIAL LEARNING

The experience level of a candidate has become a key attribute in discussions about hiring new employees in these fields. Employers have identified co-ops and internship programs that partner with post-secondary institutions, as being a critical pipeline for new hires; one most often cited is the Northeastern University Cooperative Education Program. This program is considered a valued industry partnership by employers, providing them with a pipeline of potential future full-time workers. It has been cited as a cost-effective way to meet human resource needs, and its six-month co-op cycles allow students to spend more time on long-term projects and less on training or shadowing others; a significant downside to summer and other shorter-term programs. The Northeastern program in Engineering was specifically cited as an excellent feeder to employment with Massachusetts DOT (MassDOT University & HR officials, Aug 2017) and with private sector transportation project and engineering firms (DWG Members VHB; NASTO Summer Meetings, July 2017; ITS PCB Community College Workshop Sep 2017).

In some cases, employers have set up their own internal programs to hire recent graduates for a one-year term, providing students with specific work-based training while also evaluating them for continued employment. DWG member Nelson Nygaard noted this practice as particularly effective for on-boarding new employees, given that their introduction to future workers is often through short-term internships.

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DISCIPLINE SUMMARY

The continued refinement of priority occupations in the Environment discipline has been driven by competent advisory input and diligent review of public and private-sector jobs. And while mining LMI from BLS and Burning Glass have added to this effort, these traditional data sources have proven less useful, due in part to the nature of environmental jobs in transportation that, as previously explained, are interdisciplinary and do not conform to standard occupational codes or categories. Further, a trend analysis conducted at the start of this project found that the largest growth in investment and action within this sector—focusing on the design, planning, construction, operation, and maintenance of the transportation system—was in new and emerging fields that are not well represented in current LMI databases.

One future environmental narrative for transportation that may most significantly impact workforce needs, growth, and preparedness, is the growth in "new mobility" initiatives that is occurring at the convergence of ITS, Smart Cities, Shared Use Mobility, and Transit. In this convergence, new occupations are emerging and being encompassed in transportation and mobility planning and implementation in communities throughout the country. There are many outcomes that are expected of these initiatives and the work beyond them. As pointed out in USDOT's Beyond Traffic 2045, the goals of a system that dramatically improves safety, efficiency, competitiveness, accessibility, and sustainability are now integrated into how we think about them and how we plan, invest, and implement. Jobs that will greatly contribute to improving environmental quality and mitigating the negative environmental impacts from operating transportation systems, are to be found in these rapidly growing and dynamic fields.

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TRANSPORTATION ENGINEERING

Transportation Engineering

INTRODUCTION

Historically, for over two decades starting in the 1960s, transportation agencies focused on the building and expansion of the nation's Interstate Highway System. This led to a shift in priorities in the mid 1980s toward the preservation and operation of regional investments in highways and bridges (Asset Management Primer, 1999). Today, as 2020 approaches, these agencies are faced with a critical need for skilled workers to address the challenges of maintaining a system that is experiencing ongoing deterioration (USDOT, 2016).

To address this need, the Midwest Transportation Workforce Center (MTWC) is focused on building an engineering workforce that can maintain transportation infrastructure by developing career pathways that combine the skills, competencies, and training of highway construction workers with the education and training required for the engineering, operation, and asset management of transportation infrastructure. These Highway Maintenance Engineering (HME) career pathways will satisfy a critical need for workers who are qualified to interact with rapidly advancing data systems that collect, analyze, and display valuable information that, in turn, will support their daily, on-the-job decision making. Workers in these critical occupations will have information technology skills and be capable of operating advanced automated equipment and systems (USDOT, 2016).

The HME pathway builds upon the commonalities in KSAs that are needed by workers in both construction and maintenance disciplines, then adds those KSAs that are unique to the maintenance mission. In highway transportation, maintenance is an on-going workforce effort that strives to achieve reliable and acceptable service within its budget. Construction, on the other hand, is project based, with a well-defined budget and completion schedule. Highway construction efforts strive to meet established standards and performance metrics on time and on budget. The skillful practice of HME is based on concepts like level of service, service life, performance targets, life-cycle cost analysis, cost-benefit analysis, and customer service. The HME workforce maintains, not only the highway, bicycle, and other modal corridors, but also their rights of way. HME workers are the custodians and stewards of facilities and property in the public right of way.

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At the outset of the project, researchers met with the Director of Apprenticeship for Wisconsin's Department of Labor—the Department of Workforce Development (DWD)—to understand the possibility and process of initiating apprenticeships and to discuss career pathway development for highway maintenance engineering workers. DWD made it clear that apprenticeship development and approval would be based on demand for the occupation and would require a sponsor. This promoted a realignment of project tasks to satisfy the intent of the pathway initiative and to start implementation of a workforce/training solution, should demand for highway maintenance workers be proven.

From the start, MTWC advanced the idea of a career pathway in highway maintenance, because sustainability would be engaging to new entrants to the field.

PRIORITY OCCUPATIONS

Table H1 identifies eleven priority occupations within the HME focus area, including their SOC code, occupational title, 2016 employment statistics, 2026 employment projections, and their extrapolated labor market growth.

Table H1. Highway Maintenance Engineering Priority Occupations

SOC CODE	OCCUPATION TITLE	CURRENT # EMPLOYEES, 2016	PROJECTED # EMPLOYEES, 2026	PERCENT CHANGE
11-1021	General & Operations Managers	2,263,100	2,468,300	9.1%
11-9021	Construction Managers	403,800	448,600	11.1%
17-2051	Civil Engineers	303,500	335,700	10.6%
17-3022	Civil Engineering Technicians	74,500	81,100	8.8%
47-1011	1st-Line Supervisors, Const. Trades & Extraction	602,500	678,300	12.6%
47-2061	Construction Laborers	1,216,700	1,367,100	12.4%
47-2071	Paving, Surfacing, & Tamping Equip. Operators	51,900	58,200	12.1%
47-2073	Operating Eng. & Other Const. Equip. Operators	371,100	416,900	12.3%
47-4011	Construction & Building Inspectors	105,100	115,700	10.0%
47-4051	Highway Maintenance Workers	149,900	160,200	6.9%
53-1031	1st-Line Supervisors, Transp. & Material Moving Machine & Vehicle Operators	204,200	217,700	6.6%

Source: BLS https://www.bls.gov/emp/ep_table_108.htm -Table 1.7

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The process used to identify occupations in the highway maintenance space consisted of four steps involving data-driven approaches. Burning Glass Technologies real-time job database was used to provide a data-driven approach to identifying critical occupations. Some occupations were reviewed as a group. For example, construction laborers and construction and building inspectors were grouped separately from highway maintenance workers. This was also necessary as literature treats, for example, the construction workforce differently from the highway maintenance workforce.

The four steps taken to develop this list of priority occupations include:

1. *Understand the extent of occupations in the highway maintenance engineering discipline.*
2. *Conduct a literature review.*
3. *Determine methodology to uncover information needed from LMI data sources, like Burning Glass.*
4. *Refine occupations based on trends and employment projections.*

Each step is explained and the resulting findings or actions are described below.

Step 1. Understand HME Occupations

At the outset of the project, researchers met with Wisconsin Department of Transportation (WisDOT) maintenance leadership to understand the extent of occupations involved with the highway maintenance engineering function within a state DOT.

Workers in this discipline must have a knowledgeable interpretation of, but not limited to, the following administrative rules: vegetative rules, private right-of-way usage, use of state highway facilities, regulation of signs, utility installation, building moving permits, temporary closing and special use of state roads, drainage connections, and state highway system connections access management. The highway maintenance function is part of an agency's asset management strategy and engineers and planners must often acquire general management skills in budgeting, finance, and performance measurement. Landscape architects, surveyors, biologists and environmentalists are part of the highway maintenance team along with engineers and planners.

Other workers, such as front-line workers, learn equipment operations skills for road maintenance and snow-plowing. Wisconsin (the target for the HME pathway template) is the only state in the country to not employ highway maintenance workers, that is entry-level workers (Laffey & Zimmerman, 2015). WisDOT contracts this function out to counties overseen by a County Highway Commissioner. There is no career pathway from the county to the WisDOT. The highway maintenance function in Wisconsin is provided by contractors and public works staff at various levels of government: county, city, and village.

With the focus of career pathways in highway maintenance being sustainability, the promotion of a "sustainability framework" would have an agency of the future focusing on a "multidisciplinary workforce—acceptance of flexible standards, a commitment to sustainability education, training, and internal incentives to be sustainable, and to a culture of sustainability and stewardship" (NCHRP 750). With this in mind, researchers conducted a keyword search in O*NET to identify over thirty occupations with Standard Occupational Classification (SOC)/O*NET codes and commonly used job titles that represent the breadth of occupations within a state DOT's highway maintenance practitioner point of view. These thirty plus occupations included outlier titles that could present a pathway into highway maintenance, as might happen if a student of landscape architecture takes a course exposing them to careers in highway maintenance or takes a job with a DOT.

In some cases, a DOT may only employ one or two workers in an occupational category, such as landscape architect. However, the number of employees within an occupation in an agency was not a consideration, at this point. Rather, the KSAs needed within an organization to complete the maintenance function were considered.

Table H2 lists these 33 occupations by SOC and, where applicable, O&Net code.

Table H2. Highway Maintenance Engineering Occupations by SOC / O*NET Code

SOC -CODE	O*NET CODE	OCCUPATION TITLE
11-1011		Chief Executives
11-1021		General and Operations Managers
11-9021		Construction Managers
11-9041		Architectural and Engineering Managers
15-1199		Computer Occupations, All Other
15-1199	15-1199.05	Geographic Information Systems Technicians
17-1012		Landscape Architects
17-1022		Surveyors
17-2051		Civil Engineers
17-2051	17-2051.01	Transportation Engineers
17-3011		Architectural and Civil Drafters

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17-3011	17-3011.02	Civil Drafters
17-3019		Drafters, All Others
17-3022		Civil Engineering Technicians
17-3029		Engineering Technicians, Except Drafters, All Other
17-3031	17-3031	Surveying and Mapping Technicians
17-3031	17-3031.01	Surveying Technicians
17-3031	17-3031.02	Mapping Technicians
19-1023		Zoologists and Wildlife Biologists
19-3051		Urban and Regional Planners
19-4099		Life, Physical, and Social Science Technicians, All Other
19-4099	19-4099.03	Remote Sensing Technicians
37-1012		1st Line Spvrs Landscaping, Lawn Service, Groundskeeping Workers
37-3011		Landscaping and Groundskeeping Workers
47-1011		1st Line Spvrs of Construction Trades & Extraction Workers
47-2061		Construction Laborers
47-2071		Paving, Surfacing, and Tamping Equipment Operators
47-2073		Operating Engineers and Other Construction Equipment Operators
47-4011		Construction and Building Inspectors
47-4051		Highway Maintenance Workers
51-9061		Inspectors, Testers, Sorters, Samplers, & Weighers
53-6099		Transportation Workers, All Other
NA		Engineering Technologist

Step 2. Literature Review

The following sources were reviewed as a starting point and focused on the highway maintenance worker, as this was the occupation deemed critical by the HME Discipline Working Group (DWG). (HME DWG, Apr 2017)

- *Advances in Developing a Cross Trained Workforce* (Holland, et.al 2016)
- *Attracting, Recruiting, Retaining Skilled Staff for Transportation System Operations & Mgmt* (Cronin, et. al 2012)
- *Training and Certification of Highway Maintenance Workers* (Laffey & Zimmerman, 2015)
- *Engineering Workforce Development in Transportation Agencies: A Survey of Practice* (CTC Associates, 2015)
- *2016 AASHTO Salary Survey* (AASHTO, 2017)

Some general findings that are relevant to the identification of priority occupations and career pathways include:

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- *Engineering support positions are more often called and classified into the job "Technician" where highway maintenance is not an exclusive duty* (AASHTO, 2017). *The technician functions in the areas of bridge design, highway construction, highway maintenance, traffic engineering, chemical engineering, highway design, highway materials, or transportation planning.*
- *Career paths exist between construction and highway maintenance. Highway workers move within the organization to positions within construction, such as quality assurance/bridge inspector etc.* (MinnDOT, 2017)
- *There are many agencies that have classifications for workers that exclusively perform highway maintenance tasks. However, the job titles are inconsistent from one agency to the other.* (AASHTO, 2017)
- *Cross training employees is an emerging practice as agencies improve efficiency in light of smaller transportation budgets.* (Holland, 2016)

In following up on the literature review and exploring other state DOT websites, some like the Virginia DOT document the SOC codes of their job classifications. Table H3 shows the SOC codes associated with occupations in highway maintenance. In some cases, multiple codes appear as a result of agency consolidation, where legacy positions have yet to be fully removed from their database. This implies that not all workers in highway maintenance are classified under one code, and to determine labor market demand in Virginia, all of the SOC's in Table H3 would be pertinent. But since BLS labor data cannot be parsed by industry—and some occupations listed here are found in other industries, it becomes a challenge to extrapolate labor market demand for just the public transportation sector.

Table H3. Highway Maintenance Occupations & SOC Codes: Virginia DOT

VIRGINIA DOT JOB CLASSIFICATION	SOC CODE	OCCUPATION NAME
Transportation Operator I	47-4051	Highway Maintenance Workers
	53-3033	Light Truck or Delivery Services Drivers
	53-3041	Taxi Drivers and Chauffeurs
Transportation Operator II	47-2070	Construction Equipment Operators (Occupation Group)
	53-3032	Heavy and Tractor-Trailer Truck Drivers
Transportation Operator III	47-2071	Paving, Surfacing, and Tamping Equipment Operators
Transportation Operators Manager I	53-1031	First-Line Supervisors of Construction Trades and Extraction Workers
Transportation Operators Manager II	53-1031	First-Line Supervisors of Construction Trades and Extraction Workers
Transportation Operators Manager III	53-1031	First-Line Supervisors of Construction Trades and Extraction Workers

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Virginia DOT documents an Occupational Family, in this case Trades and Operations, and the roles that can be found within this family which includes practitioner and manager. According to Virginia DOT, "*The roles define the typical career paths for employees who pursue careers in this field. Since a role represents different levels of work, or career progression, career paths may exist within a single role, extend to other roles in this Career Group, or to roles in other occupationally related Career Groups.*"

The classification series also shows the pathway within the organization and the additional skills can be inferred by the SOC code—that is equipment operation skills, followed by construction equipment skills and then supervisory skills.

Attachment C summarizes the highway maintenance frontline workforce at State DOTs, presenting both its size and training partners and training requirements for career progression.

In some DOTs, workers in highway construction and highway maintenance are cross-trained. The question that arises from a data analysis standpoint is how are cross-trained employees' occupational data being reported to BLS? That is, how is work reported for employees who are construction workers during warm weather and snow plow operators (working in maintenance) during the winter months. To answer this, researchers interviewed the Human Resources (HR) staff at Minnesota DOT (MinnDOT), who confirmed the practice of cross-training and the challenge in determining demand for highway maintenance workers alone, by using employment projections based on SOC codes reserved for highway maintenance workers (SOC 47-4051).

Iowa DOT also shared the SOC's they use to report their technicians and other occupations that cross-train. Table H4 lists the SOC for each Iowa DOT classification (Iowa DOT, 2017). While there are some "Highway Maintenance Workers," the function of highway maintenance—mainly snowplowing—is also performed by "Materials and Construction Technicians". In essence, the function of highway maintenance could be measured as a percentage of the full-time equivalent (FTE) hours of most of occupations listed below.

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Table H4. Highway Maintenance Occupations & SOC Codes: Iowa DOT

IOWA DOT JOB CLASSIFICATION	SOC CODE	SOC OCCUPATION
Materials Fabrication Inspector 1	51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
Materials Fabrication Inspector 2	51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
Materials Technician 3	51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
Materials Technician 4	51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
Materials Technician 5	51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
Bridge Inspector 1	47-4011	Construction and Building Inspectors
Bridge Inspector 2	47-4011	Construction and Building Inspectors
Construction Technician Assistant	47-2061	Construction Laborers
Construction Technician	47-2061	Construction Laborers
Construction Technician Senior	47-1011	First-Line Supervisors of Construction Trades & Extraction Workers
Garage Operations Assistant	47-1011	First-Line Supervisors of Construction Trades & Extraction Workers
Equipment Operator Senior	47-4051	Highway Maintenance Workers
Highway Technician	47-4051	Highway Maintenance Workers
Highway Technician Associate	47-4051	Highway Maintenance Workers
Highway Technician Senior	47-4051	Highway Maintenance Workers
Highway Maintenance Supervisor	47-1011	First-Line Supervisors of Construction Trades & Extraction Workers

This practice of cross-training also impacts other occupations. At the Human Resources Community of Practice meeting that MTWC sponsored in December 2015, Missouri DOT shared that engineers in the districts are expected to snowplow.

Step 3. Labor Market Analysis

MTWC used the Burning Glass Technologies [Labor Insight] product, which provides both snapshot and in-depth information regarding a single occupation. Reports for multiple occupations can be generated using keywords, SOC codes, or O*NET codes, which are then filtered by industry type, employer, skill, job title, and other elements.

Top Jobs in Transportation: An initial query into this labor market focused on determining the top job needs across the country at State DOTs. That query, spanning Nov 2016 thru Oct 2017, returned the O*NET job postings shown below in Figure H1.

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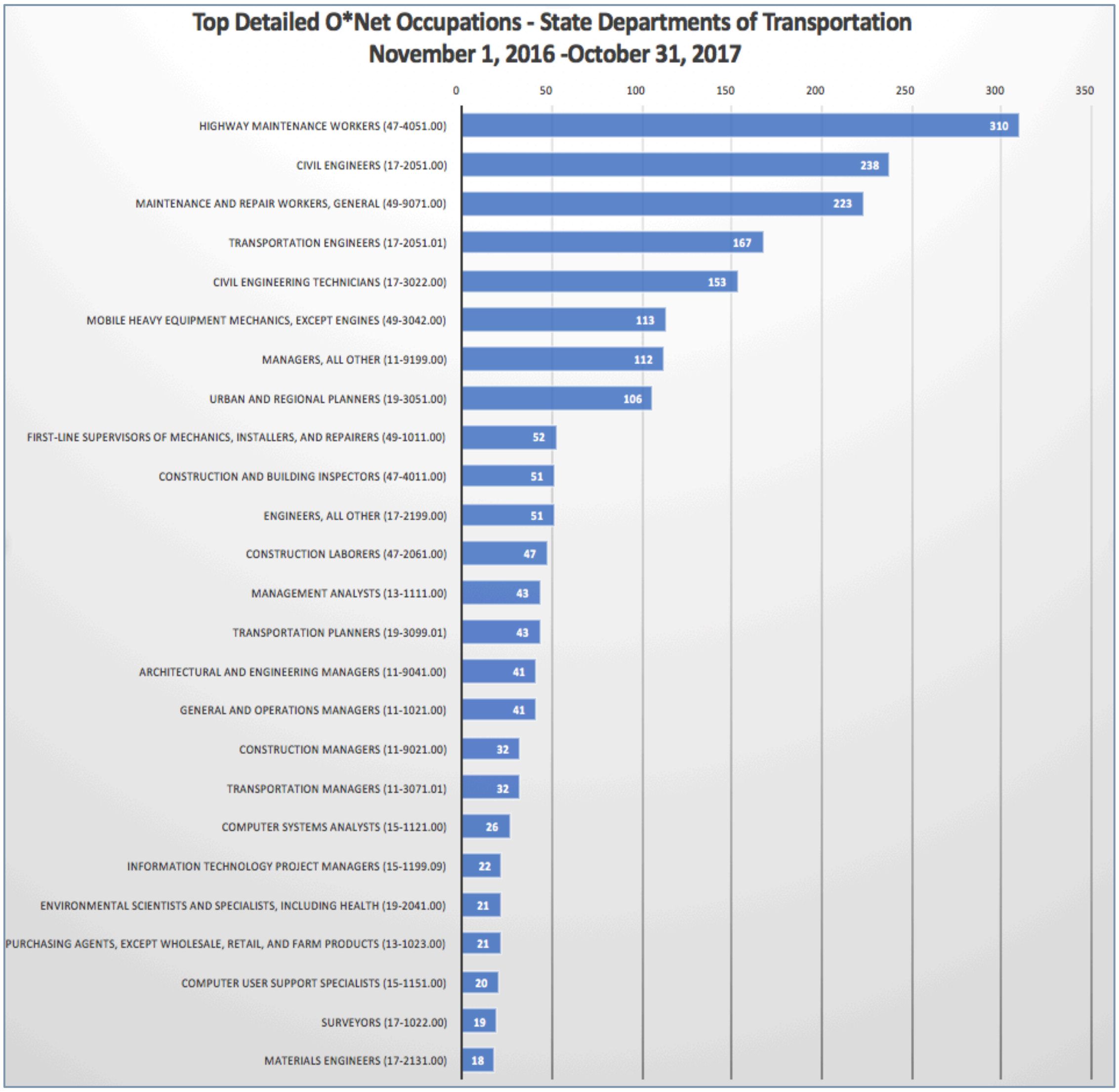

Figure H1. Burning Glass Query – Demand for Jobs in State DOTs

The highest number of job postings during the query period was for "Highway Maintenance Workers", followed by "Civil Engineers" and "Maintenance and Repair Worker, General". O*NET describes this latter occupational category as:

> *"Performs work involving the skills of two or more maintenance or craft occupations to keep machines, mechanical equipment, or the structure of an establishment in repair. Duties may involve pipe fitting; boiler making; insulating; welding; machining; carpentry; repairing electrical or mechanical equipment; installing, aligning, and balancing new equipment; and repairing buildings, floors, or stairs."*

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Sample of Reported job titles: *Building Maintenance Mechanic, Building Mechanic, Equipment Engineering Technician, Facilities Manager, Maintenance Engineer, Maintenance Man, Maintenance Mechanic, Maintenance Supervisor, Maintenance Technician, Maintenance Worker.*

While it is unclear whether the occupation "Maintenance Technician" differs from "Highway Maintenance Worker", a second search was conducted using Burning Glass Occupation Codes (BGTOCC); a proprietary LMI taxonomy. Again, a similar distribution of job postings (223 vs 217) appear for the Maintenance Technician occupation (Figure H2).

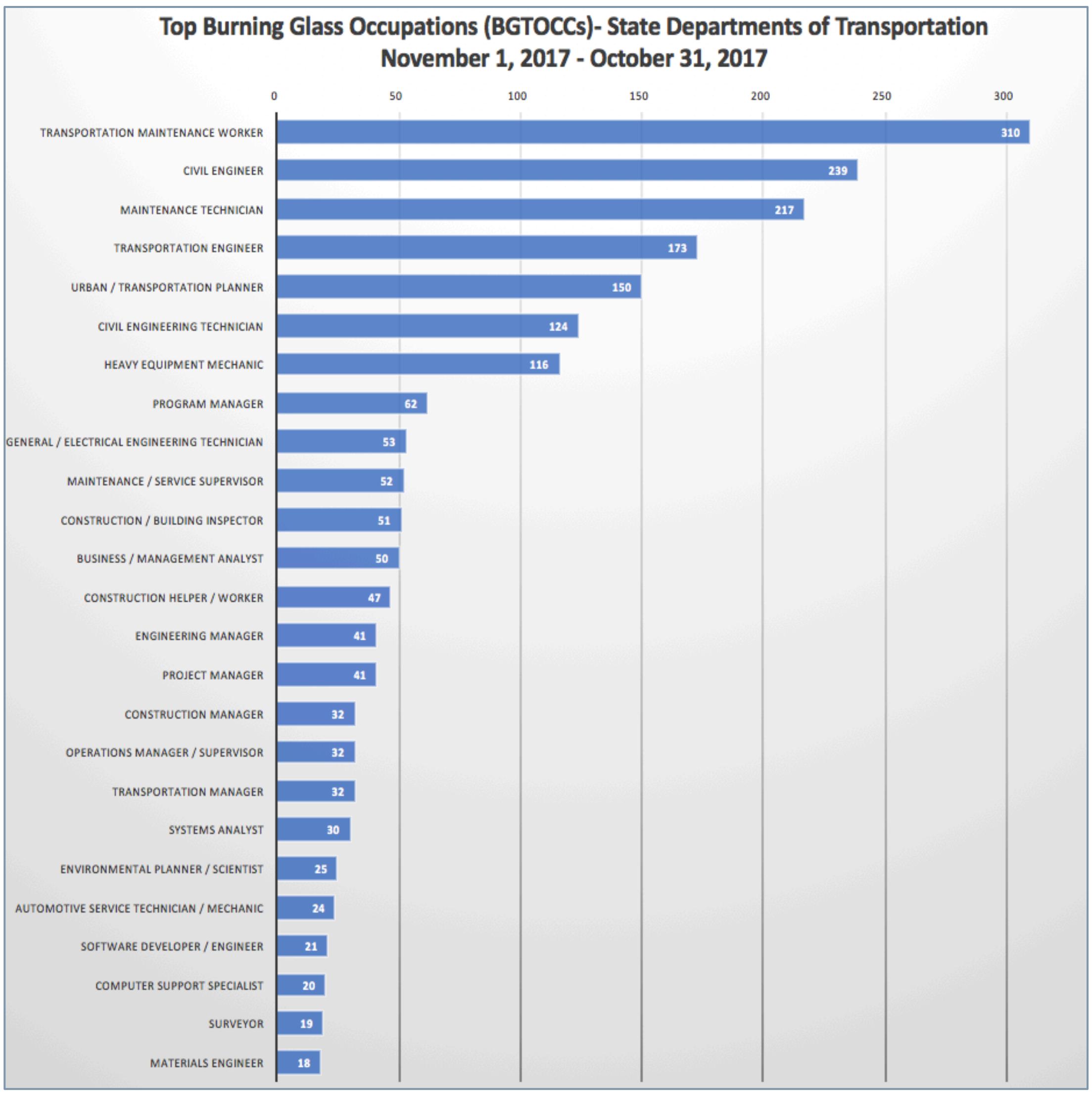

Figure H2. Top Burning Glass Occupations in State DOTs

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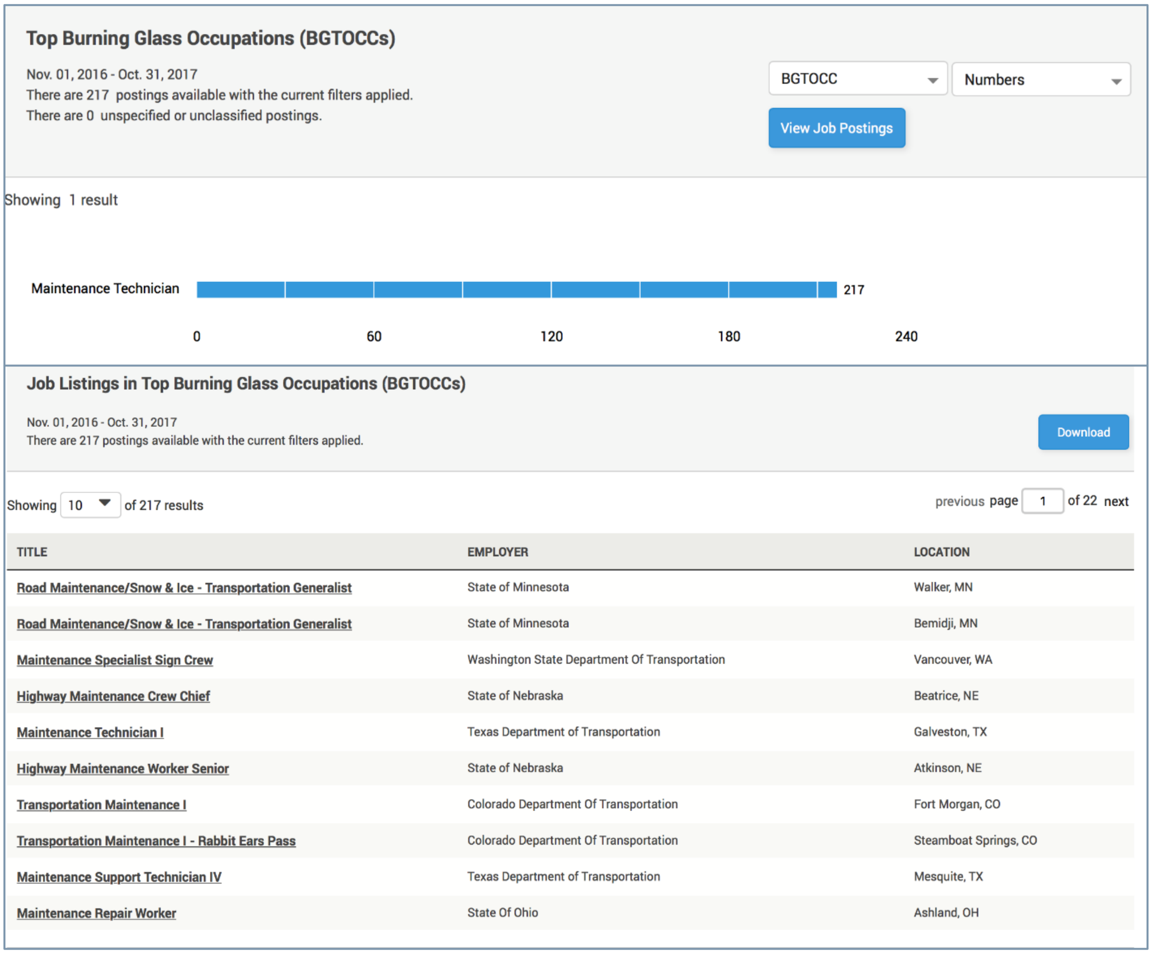
Burning Glass allows the isolation of "Maintenance Technician" to see the job postings behind this classification. Figure H3 shows this analysis:



TITLE	EMPLOYER	LOCATION
Road Maintenance/Snow & Ice - Transportation Generalist	State of Minnesota	Walker, MN
Road Maintenance/Snow & Ice - Transportation Generalist	State of Minnesota	Bemidji, MN
Maintenance Specialist Sign Crew	Washington State Department Of Transportation	Vancouver, WA
Highway Maintenance Crew Chief	State of Nebraska	Beatrice, NE
Maintenance Technician I	Texas Department of Transportation	Galveston, TX
Highway Maintenance Worker Senior	State of Nebraska	Atkinson, NE
Transportation Maintenance I	Colorado Department Of Transportation	Fort Morgan, CO
Transportation Maintenance I - Rabbit Ears Pass	Colorado Department Of Transportation	Steamboat Springs, CO
Maintenance Support Technician IV	Texas Department of Transportation	Mesquite, TX
Maintenance Repair Worker	State Of Ohio	Ashland, OH

Figure H3. Burning Glass Occupation: Maintenance Technician

From this report, these job postings are clearly Highway Maintenance occupations that have been coded as "Maintenance and Repair Worker, General" (SOC 17-2051), confirming that Highway Maintenance Workers are in great demand at State DOTs, given the over 500 listings—the sum of these two occupations—found over the query period.

As job listings are captured by Burning Glass Database only once per posting, it is difficult to know from this dataset just how many positions are being filled. An interview with the Ohio DOT revealed they hire 600 seasonal workers to perform highway maintenance.

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Civil Engineers: Additional labor market queries isolated the skills needed for maintenance engineers by way of "Civil Engineers" and "Transportation Engineer" O*NET codes. According to Alabama DOT, job titles within their Maintenance Division include:

Assistant Maintenance Engineer for Roadways
Assistant Maintenance Engineer for Bridges
Assistant Manager Engineer for Permits & Operations
Assistant Manager for Management and Training
Assistant Manager for Traffic Operations
State Maintenance Engineer
Division Maintenance Engineer
Maintenance Engineer
District Engineer

Queries using these job titles produced no results for the study period, Nov 2016 to Oct 2017. Stepping back and only looking at civil or transportation engineers with "maintenance" or "maintenance management systems" as keywords, produced a listing of generic job titles. The job descriptions are generic in nature with titles such as "Civil Engineer".

Accordingly, queries with "maintenance management systems" excluded private sector engineers, as they may not have that responsibility. An alternate, data-driven approach would be to survey agencies and employers.

Public Works: Highway maintenance workers are also employed by counties and municipalities and private-sector contractors throughout the country. To determine the demand of the maintenance workers in the counties, Burning Glass was searched to determine which SOCs contain the job title "Public Works Director"; the highest position in the career ladder for county maintenance workers. Currently, a search for "Public Works Director" does not return any code matches in O*NET or BLS classification systems.

A "Deep-Dive" occupational report in Burning Glass returned two SOCs for the title "Public Works Directors" under "General & Operations Manager" and "Chief Executives". While "Chief Executives" is clearly too broad to for this pathway, the SOC for "General & Operations Manager" was added to the search criteria. Table H5 lists the job titles that fall under these two classifications, when queried nationally within the "Public Works" sector.

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Table H5. SOC codes for Job Titles Containing "Public Works"

Occupation	Job Postings
General and Operations Managers	660

Job Titles	Job Postings
Public Works Director	232
Director Of Public Works	121
Assistant Public Works Director	36
Assistant Director Of Public Works	32
Public Works Operations Manager	22
City Engineer	19
Deputy Director Of Public Works	15
Director of Engineering	14
Director, Public Works	12
Deputy Public Works Director	10

Occupation	Job Postings
Chief Executives	208

Job Titles	Job Postings
Public Works Supervisor	38
Public Works	25
Public Works Employee	23
Public Works Department	9
Public Works Foreman	9
Public Works Supervisor II	5
Commissioner Of Public Works	3
Public Works Coordinator	3
Public Works Crew	3
Public Works Crew Member	3

Burning Glass provides a real-time snap shot of the labor market, yet it remains difficult to mine for civil engineering jobs by their skills alone (i.e., "Asset Management" or "Highway Maintenance"), possibly due to employers not using descriptive terms in their job listings. Burning Glass did provide validation of the direction/focus of the highway maintenance worker, and MTWC will continue to use tool to refine its career pathways.

Step 4. Refining the List of Priority Occupations

As a starting point, the USDOT Volpe Center's Beyond Traffic 2045 was reviewed for a long-term vision of the transportation sector. Key points made by this report that will impact the highway maintenance workforce include:

- *Automation and robotics will affect all modes of transportation, improving infrastructure maintenance and travel safety, and enabling the mainstream use of autonomous vehicles.*
- *Public transportation revenues are not keeping up with the rising costs of maintenance and expansion.*

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- *Two-thirds of all roads are in “less than good” condition; a quarter of all bridges need significant repair.*
- *Higher average temperatures will raise maintenance costs across all modes. High temperatures accelerate the deterioration of pavement on roads and runways, and cause failures of railroad tracks.*
- *The advent of automated ground vehicles can change the way transportation agencies perform operations and maintenance and deploy fleets and utility vehicles. Many tasks associated with construction and road operations/maintenance can be performed by either automated vehicles or remotely operated vehicles.*
- *Increased volumes of traffic could also increase the maintenance needs of infrastructure and offset efficiency gains, leading to increased emissions.*
- *Managing and maintaining automated ports and fleets will require advanced mechanical and data analysis jobs, which demand higher skills and higher pay than traditional freight work.*
- *Fleet managers of freight companies, public transit systems, and school buses are able to track vehicles in real time, maximize vehicle utilization, and select efficient, reliable routes.*

Researchers then identified technologies—currently in use or in development—that may also impact the way highways are maintained. Some technologies were identified by the Engineering DWG, others from literature and blogs. A survey was distributed among practitioners to capture the perceived timeline of adoption for these technologies, the results of which are presented in Figure H4 in the section to follow. Among the newer technologies reviewed were: Autonomous Vehicle (AV), Connected Vehicle (CV), Augmented Reality (AR), Virtual Reality (VR), and Unmanned Aerial Systems (Drones). Older technologies include Geographic Information. Systems (GIS), Road Weather Information Systems (RWIS), and Automated Vehicle Location (AVL).

With these technologies in mind, researchers selected “Fleet Manager” as a potential priority occupation, as it falls under an agency’s “maintenance”. Fleets are generally the second highest expenditure for DOTs after labor, and Fleet Managers are often first adopters of new technology as the return on investment is typically very high. However, “Fleet Manager” is not represented by an O*NET or SOC code, so Burning Glass was queried to find which classifications were most often used for the Fleet Manager position, revealing that “First-Line Supervisors” and “Transportation & Material Moving Machine & Vehicle Operators” contained the most job openings.

The occupations “First-Line Supervisors of Landscaping”, “Lawn Service”, “Groundskeeping Workers”, and “Landscaping & Groundskeeping Workers” were initially added to the

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list of priority occupations in recognition that some of their knowledge, skills and abilities (KSAs) are shared with Highway Maintenance. While ultimately eliminated from this list, they are recognized as potential feeder occupations to this workforce.

"Civil Engineering Technologist" is being considered for certification by the American Society of Civil Engineers, but since this role is still emerging and cannot be tied to a given occupation at this time, its consideration as a workforce priority was eliminated. Similarly, "Engineering Technicians, Except Drafters, All Other" was identified through an analysis of Classification of Instructional Program (CIP) codes in use at Bridgewater Community College of West Virginia, which offers a "Highway Technology: Department of Highways" associates degree. They use this code as an alternative to Civil Engineering Technician. Labor market demand for this occupation was found to be low.

BLS employment forecasts were analyzed to help finalize the list of priority occupations. Those occupations projected to decline were eliminated, as were occupations that belong to separate disciplines such as "Urban Planner", "Geographic Information Systems", "Landscape Architect", and "Biologist". It is possible that occupations like "Remote Sensing" have skillsets, or use tools that have now matured enough that they are now being required in other occupations. For example, a civil engineer may need to now know how to process satellite images, thus eliminating a remote sensing technician. Or a GIS Technician might fulfill the requirements for both GIS and remote sensing. Table H6 shows the occupations that were eliminated to arrive at the final list published in Table H1.

Table H6. Prioritizing HME Occupations

SOC -CODE	O*NET CODE	OCCUPATION TITLE
11-9021		Construction Managers
~~11-9041~~		~~Architectural and Engineering Managers~~
~~11-1011~~		~~Chief Executives~~
11-1021		General and Operations Managers
~~15-1199~~		~~Computer Occupations, All Other~~
~~15-1199~~	~~15-1199.05~~	~~Geographic Information Systems Technicians~~
~~17-1012~~		~~Landscape Architects~~
~~17-1022~~		~~Surveyors~~
17-2051		Civil Engineers
17-2051	17-2051.01	Transportation Engineers
~~17-3011~~		~~Architectural and Civil Drafters~~
~~17-3011~~	~~17-3011.02~~	~~Civil Drafters~~
~~17-3019~~		~~Drafters, All Others~~
17-3022		Civil Engineering Technicians

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SOC -CODE	O*NET CODE	OCCUPATION TITLE
~~17-3029~~		~~Engineering Technicians, Except Drafters, All Other~~
~~17-3031~~	~~17-3031.01~~	~~Surveying Technicians~~
~~17-3031~~		~~Surveying and Mapping Technicians~~
~~17-3031~~	~~17-3031.02~~	~~Mapping Technicians~~
~~19-1023~~		~~Zoologists and Wildlife Biologists~~
~~19-3051~~		~~Urban and Regional Planners~~
~~19-4099~~		~~Life, Physical, and Social Science Technicians, All Other~~
~~19-4099~~	~~19-4099.03~~	~~Remote Sensing Technicians~~
~~37-1012~~		~~First-Line Supervisors of Landscaping, Lawn Service, and Groundskeeping Workers~~
~~37-3011~~		~~Landscaping and Groundskeeping Workers~~
47-1011		First-Line Supervisors of Construction Trades and Extraction Workers
47-2061		Construction Laborers
47-2071		Paving, Surfacing, and Tamping Equipment Operators
47-2073		Operating Engineers and Other Construction Equipment Operators
47-4011		Construction and Building Inspectors
47-4051		Highway Maintenance Workers
51-9061		Inspectors, Testers, Sorters, Samplers, and Weighers
~~53-6099~~		~~Transportation Workers, All Other~~
~~NA~~		~~Engineering Technologist~~

Conclusions and Recommendations

One way to develop a data-driven approach for the identification of priority occupations is to determine what SOC codes transportation organizations submit to BLS.

The American Association of State Highway and Transportation Officials (AASHTO) conducts a salary survey every year. One recommendation is to include the SOC codes that State DOTs use for each classification. This would help tie DOT jobs to career pathways on Career Information System websites, facilitate job demand analysis interactions with outside agencies like workforce boards or community colleges that focus their curriculum on occupations. Also, any improvement in the SOC system would help with LMI reseaarach.

STATE OF PRACTICE

During this first project year, three surveys were launched to inform the process of developing career pathways: a “Your Career Pathway” questionnaire was designed to capture the career paths of public works managers employed in Wisconsin, a “Transformative Technologies in Highway Maintenance” survey was used to identify technologies being deployed within the HME workspace, and a “Wisconsin Highway Maintenance Workforce” survey was used to determine the state's demand for HME workers, uncover challenges in recruitment and retention, and to understand how this workforce is typically trained.

Career Pathways in Wisconsin Questionnaire

To better understand how Wisconsin workers advance in their careers, a questionnaire was administered to various public works staff attending the Wisconsin American Public Works Association Fall Conference and the Wisconsin County Highway Association Leadership Conference. In total, 42 responses were collected—representing about 20% of event attendees—revealing a number of career path characteristics presented below.

Table H7. Formal Education of HME Workers

JOB TITLE	ASSOCIATE'S	BACHELOR'S	AA & BS	MASTER'S	TOTAL
Highway Commissioner	5	10	3	2	13
Deputy Commissioner	0	3	0	0	3
Director of Public Works	1	4	1	0	4
Assistant Director of Public Works	1	0	0	0	1
Engineer	1	7	1	0	7
Engineering Technician	1	1	0	0	2
Operations Mgr / Superintendents	8	4	1	2	12

Table H7 presents the formal education level of Wisconsin HME workers who participated in the survey. Of the 42 respondents, the most common educational achievement was a bachelor's degree. Column 5 indicates the number of respondents for each job title.

Of the 13 Highway Commissioners surveyed, ten hold bachelor's degrees: seven in Civil Engineering, two in Construction (usually a specialization of Civil Engineering), one in GIS and Cartography, and one in Public Administration. Two Highway Commissioners also had master's degrees, one in Structural Engineering and the other in Business Administration. All three Deputy Commissioners surveyed held Civil Engineering degrees. Similarly, three of the four Public Works Directors held bachelor's degrees in Civil Engineering; the fourth had a degree in another engineering field. The Assistant Director of Public Works had acquired an associate's degree in Engineering Technology.

This small sampling suggests that an educational pathway is viable from the technical to four-year degree in Engineering, and may be more common than anticipated. Six of the 42 survey participants entered the HME workforce with associate or technical degrees, then

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went on to earn a bachelor's degree. Among these were three Highway Commissioners and one Public Works Director, who started their careers with two-year degrees in Engineering Technology, then went on to earn Civil Engineering degrees. One Operations Manager/Superintendent started with an associate's degree in Materials Management, then earned a bachelor's degree in Business Management. These results are encouraging for engineering pathway initiatives that build on technical degrees. Survey respondents also include two Engineering Technicians, one with a four-year degree in Civil Engineering. For this respondent, Engineering positions are rare at his location.

Operations Managers/Superintendents presented the most diverse formal education. Among the twelve respondents in this occupation, four held bachelor's degrees—two in Civil Engineering and two in Business. Their technical degrees included Materials Management, Welding & Fabrication, Supervisory Management, Diesel Mechanics, Hydraulics, and Police Science—all competencies relevant to HME career pathways.

Also from this survey are Table H8 and H9 (below), which list "career regrets" and "career roadblocks", respectively. This anecdotal information is considered useful for the design of curricula that crosses barriers and supports career advancement.

Table H8. Career Regrets by Current Occupation

OCCUPATION	REGRETS
Highway Commissioner	Not taking steps to improve public speaking skills. Not taking more transportation courses in college. Not getting more management and ethics and leadership training. Wish I completed advanced degree sooner; gotten a P.E.
Deputy Commissioner	Electrical Engineering relates to traffic signal, street lighting, facility management. Had I planned for a career in street design, a master's in Civil Engineering would be appropriate.
Director of Public Works	Wish I had pursued public works/city engineer positions earlier in my career. Wish I would have worked under a Director or Supervisor for a longer period.
Asst. Public Works Dir.	Not getting a 4-year degree right out of high school
Engineer	Not completing master's degree immediately after bachelor's degree Not getting a Master's Degree instead of two undergrad degrees No regrets. I am doing what I planned and have the degree I wanted. Not getting an MBA or taking an engineering sales job for a few years.
Engineering Technician	Wish I had learned about GIS B.S. degree sooner in college career.

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Operations Manager / Superintendent	No regrets; worked 10yrs before getting associate's degree in management. Without the prior experience, I do not feel the education I received would have made sense. More training in leadership skills and planning. Not getting 4-year degree. Not much. I really like being a mechanic and fixing stuff. I like being a manager; I have the knowledge to train and help our department. Not finishing my Bachelor's degree in Public Service Administration. Wish I would have gone to school earlier in my career Wish I would have gotten more construction experience. Would have liked to have completed my post-high school education.

Table H9. Career Roadblocks by Current Occupation

OCCUPATION	CAREER ROADBLOCKS NOW
Highway Commissioner	CAD, computer drafting, and design skills. Desire (not looking for another position). Managerial and financial; could learn more.
Deputy Commissioner	Skills to go to Commissioner of Public Works position. Need skills for working with Alderpersons and residents related to complaints and questions.
Director of Public Works	Lack of fleet management; financial Management; leadership; time/project management; managing projects at a director level means loss of technical skills.
Asst. Public Works Director	(Blank)
Engineer	Better CAD efficiency; developing political network; lack of computer skills; managing people and budgets; years of experience necessary to know industry.
Engineering Technician	Management courses to gain experience and receive a certification(s); lack of Professional Engineering degree and licensure.
Operations Manager / Superintendent	A degree and probably formal training in Engineering; financial and time management; leadership and budgeting skills; skills to deal with elected officials; more education; master's degree; opportunity to find right position.

Transformational Technologies Survey

A second survey was deployed on the use of technology in public/private sectors for highway maintenance. Table H10 breaks down 39 survey respondents, including Public Works Directors and County Highway Commissioners attending the Wisconsin American Public Works Association Fall Conference and the Wisconsin County Highway Association Leadership Training (the local perspective), and representatives of state transportation agencies and other major employers who participate in TRB (the national perspective).

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Table H10. Participants in the Highway Maintenance Technology Survey

PERSPECTIVE	AUDIENCE	RESPONSES
Wisconsin Public Works Directors and County Highway Commissioners	Wisconsin meetings of Wisconsin County Highway Association and American Public Works Association	13
State/Federal Maintenance Engineers	Related TRB committee members	20
	Total	33

Figure H4 (below) reflects participant responses to "*What Technology Does Your Highway Maintenance Agency Use?*", with results tabulated as a percentage of all responses. Almost 40% of respondents indicated their agency uses drones, while 100% use some form of GIS.

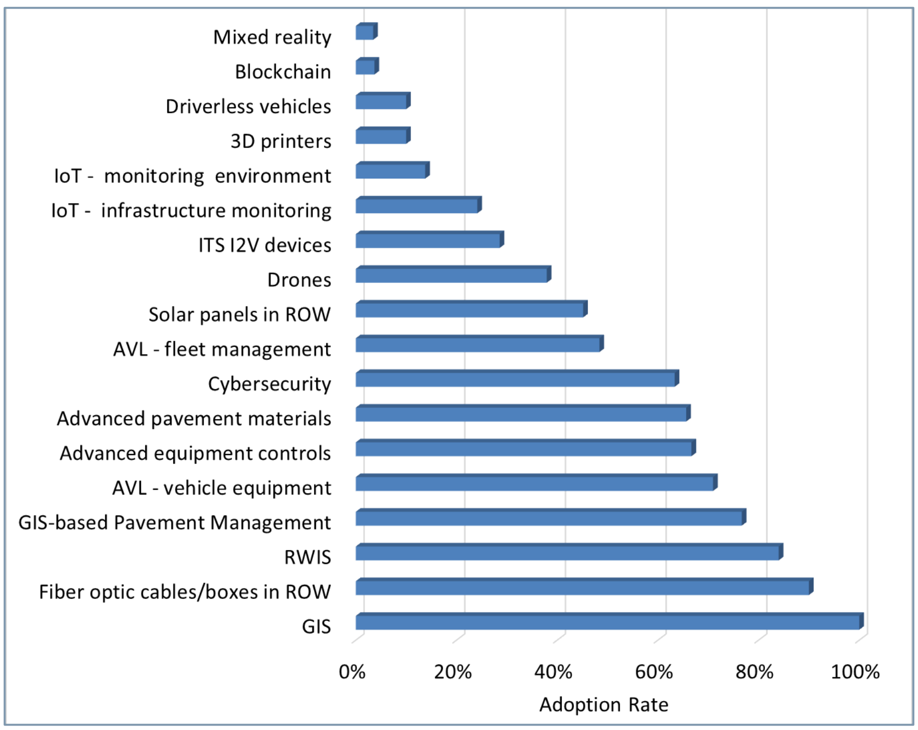

Figure H4. Technology Adoption Rates at Highway Maintenance Agencies

Researchers conducted a [student-paired t-test] to assess the difference between the local and state/federal perspectives. The t-test estimated a less than five percent probability

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that the variances are not different, suggesting that technology adoption is different at local highway agencies compared to state/federal agencies. Figure H5 compares the adoption rate for various technologies having significant differences in adoption rates.

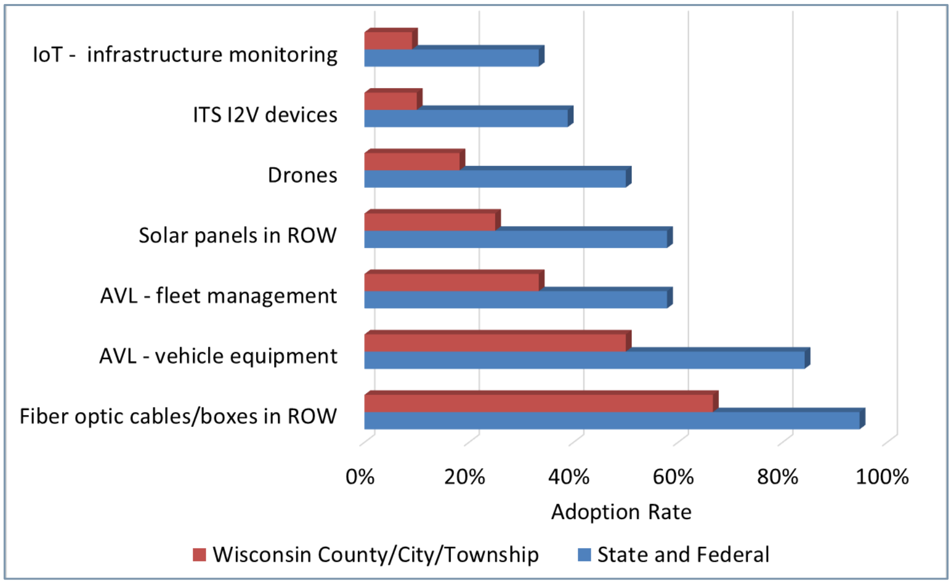

Figure H5. Technology adoption rates depend on agency jurisdiction

If a survey respondent indicated their agency had not yet adopted a technology, they were asked to estimate when that technology might be brought onboard. The response choices were "less than 5 years," "5 to 10 years," and "more than 10 years." Figure H6 (below) illustrates these responses on a radar graph. The axis from center-to-outside measures the percentage of responses for each choice. The outer most point for each technology indicate the most frequent timeframe estimate. For example, "Blockchain" and "Mixed reality" are not expected for at least 10 years. Drones are expected in less than five years.

The survey participants were asked to assess whether various factors contribute to slow technology adoption. The responses choices were "no," "a little," "somewhat," "quite a bit," and "a great deal." These five responses were grouped into three. Figure H7 also illustrates these responses on a radar graph. The outer-most point for each factor shows the most common opinion on how much the factor contributes to slow adoption of technology. Lack of qualified workers is an important factor; lack of training is not.

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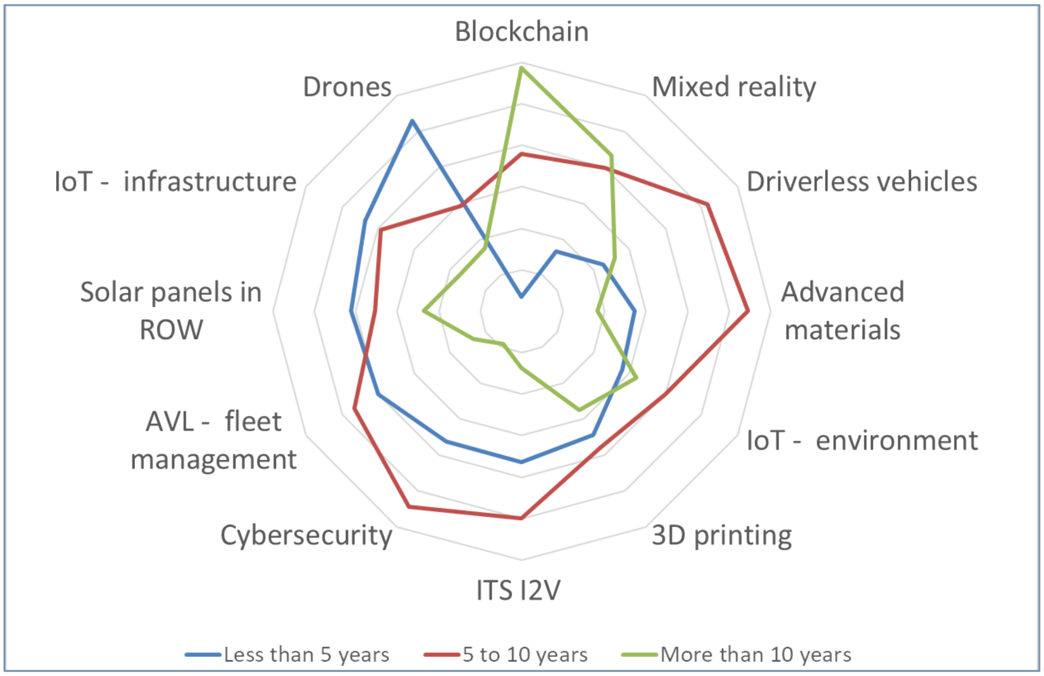

Figure H6. If technology has not been adopted, the estimated time until technology does gets adopted

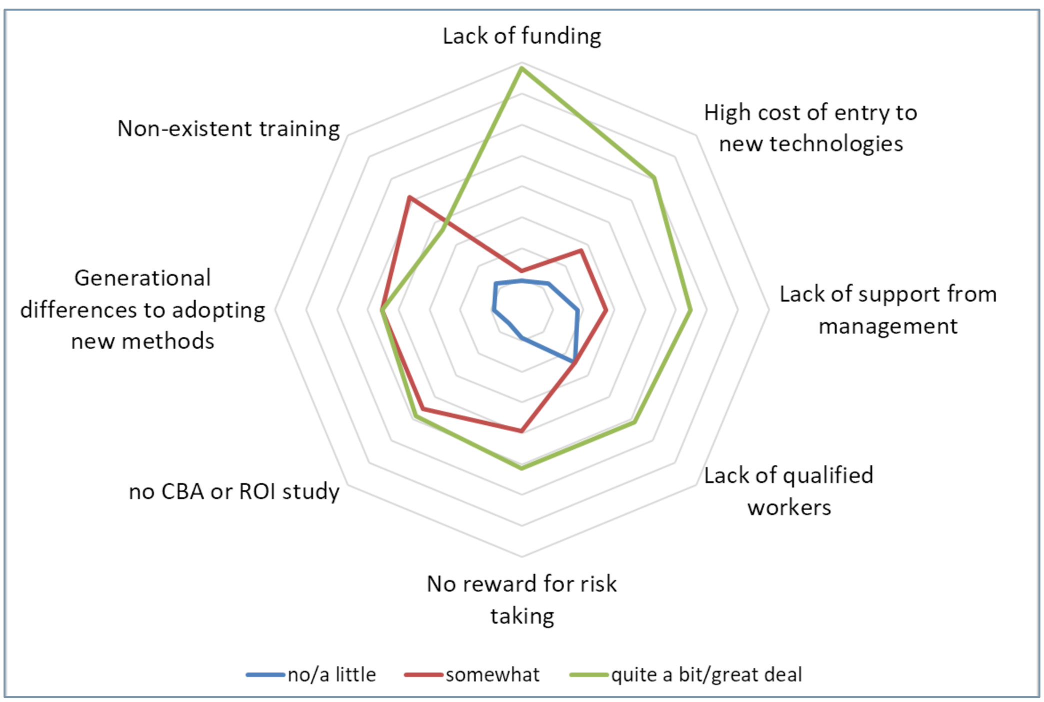

Figure H7. How various factors contribute to slow technology adoption

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Technology and Automation in Highway Maintenance

Automation occurs when we use mechanical muscles to replace human muscles and/or "mechanical brains" to replace human brains. Automation is inevitable. Automation does not need to be perfect, just better than humans; i.e., faster, cheaper, more accurate.

Automation today is possible because of faster, cheaper technology of the last decades, such as vision sensing. Automation is expected to grow rapidly through the deployment of general purpose computers and robots for special-purpose activities. General purpose robots are smart, can learn, and can be trained. An example in HME: Colorado DOT has implemented a driverless crash truck to follow maintenance vehicles in operation.

In highway maintenance, the motivations for automation are:

- *Lack of workers – some jobs are undesirable*
- *Safety risks – some jobs are dangerous*
- *Minimize disruption to motorists*

Automation in highway maintenance may be challenging for developers, due to many elements of the roadway environment being unknown or uncontrollable. Roadway traffic is constantly changing and weather is uncontrollable. These factors will only limit the range of possibilities in the short term. As self-driving vehicles become popular, the roadway environment will become more controllable. As agencies continue to develop roadway inventories, the roadway environment will becomes more known.

2017 Wisconsin Highway Maintenance Workforce Survey

The target audience for the Wisconsin Highway Maintenance Workforce survey are the 72 County Highway Commissioners that contract with WisDOT to maintain the state trunk highway system, with the goal of better understanding demand for workers in Wisconsin, issues of recruitment and retention, and how these workers are trained. This survey will close March 2, 2018, thus a full response analysis remains pending. Data from this survey is expected to inform development of a career pathway implementation plan and to evaluate interest in competency model validation and apprenticeship development.

Survey Validation: Bonnie Wohlberg, HR at MinnDOT and Jim Hessling, President of Wisconsin APWA, provided significant guidance with survey content. The University of Wisconsin, Madison, Survey Office helped with question structure, the AASHTO HR Director provided salary survey guidelines (allowing responses to be checked against their own survey results), and WisDOT reviewed the final survey. The process of survey validation has engaged several partners who are willing to work on the implementation plan.

Survey Distribution: Researchers emailed this survey to County Highway Commissioners, Highway Maintenance Engineers for the State DOT and its five regional offices, the Public Works Director or City Engineer of each city/village/town over 2,000 in population, and to private contractors that perform highway maintenance within Wisconsin. All told, over 500 survey requests were emailed from the UW-Madison Qualtrics survey platform, which were followed by mailed and phone reminders.

Marketing: MTWC engaged with multiple partners to develop a marketing campaign that included a series of follow-up emails, blog articles, and postcards. These partnering Wisconsin organizations included the APWA, Transportation Development Association, League of Municipalities, County Highway Commissioners Association, Transportation Road Builders Association, Towns Association, and Dane County Highway Commissioner.

APPRENTICESHIPS

MTWC sees the use of apprenticeships as an innovative experiential learning practice within the transportation sector. There are two apprenticeship programs in Highway Maintenance at State DOTs in the Midwest. Ohio DOT (ODOT) has an apprenticeship program for highway workers, where participants are hired as DOT employees. While not an unusual practice for apprenticeship sponsors, ODOT has gone a step further to allow its apprentices to use an agency truck when taking their CDL exam. Some training venues do not offer a truck so individuals must cover this expense.

ODOT uses its apprenticeship program to bolster agency diversity and inclusion, and focuses on returning citizens. While a career path exists for these apprentices, ODOT still has to hire 600 seasonal workers annually (no pathway exists for seasonal workers).

Idaho DOT offers a similar, though cohort-hired, highway maintenance apprenticeship. In this model, cohort performance is measured against agency goals, which if met, advances the entire apprentice group up to the next job and pay level. This strategy does a better job of connecting worker performance to agency goals, which in turn benefits all workers and encourages tighter teamwork. Both the Ohio and Idaho programs are not officially "Registered Apprenticeships" through the US Department of Labor (DOL), meaning they are unable to provide participants with any formal or accredited credential.

The Department of Labor's Office of Apprenticeship (OA) maintains a list of officially recognized apprenticeable occupations and an online database of Registered Apprenticeship program sponsors. Various searches were conducted to identify training opportunities in the highway maintenance / public works sector and to discover any precedence for public-sector organizations sponsoring RAs. If an HME-serving RA were found to exist, the standards (curriculum) could be used as a starting point for building a similar apprenticeship program in Wisconsin, using local workforce partners. For the most part, these RA sponsors tend to be private-sector organizations.

Current searches, shown below, reveal public-sector RA sponsors in the transportation sector. Those asterisked (*)are directly related to the HME pathway.

- USDOT Federal Railroad Administration sponsors one RA in Rail Safety Inspector
- Mass Transportation Authority (Transit) of Flint Michigan sponsors RAs in 3 occupations:

  Diesel Mechanic (Alternate Title: Power Generation Equipment Repairer)
  Electrician Automotive
  Automobile Body Repairer

Three state DOTs sponsor a Registered Apprenticeship.

- Arizona DOT – Operating Engineer (Alternate Title: Heavy Construction Equipment Mechanic) *
- West Virginia Division of Highways – Maintenance Tech Municipal *
- Kentucky Transportation Cabinet – Automotive Technician Specialist

There is also precedence for Public Works sponsors, which is the type of organization that would likely sponsor an entry-level Highway Maintenance apprenticeship. The Department of Public Works in Tamuning, Guam, sponsors 17 such apprenticeships. Two are related to Highway Maintenance: "Truck Driver, Heavy" and "Operating Engineer" (aka "Heavy Construction Equipment Mechanic"). The City of Edmond, Oklahoma Public Works department also sponsors a "Maintenance Tech Municipal" apprenticeship. Five other municipalities sponsor RAs in a number of trade occupations.

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In fact, there are over 150 RAs that could offer standards applicable to an entry point in an HME career pathway. These include "Landscape Technician", "Landscape Management Technician", "Landscape Gardener", and "Arborist/Urban Arborist". While many of these sponsors are private companies, some are unions, school districts, parks departments, private associations, universities, and even low-security federal correctional institutions.

Many of the "Landscape Technician" apprenticeships exist at correctional facilities, suggesting that a pipeline of workers with some skills related to Highway Maintenance may be available for frontline highway workers. In the Midwest, apprenticeships exist at correctional facilities in Iowa, Illinois, Indiana, Minnesota, Missouri, and Ohio, where apprenticeships are also available within juvenile correctional facilities.

Table H11 shows private-sector sponsors of HME-related apprenticeships.

Table H11. Private-Sector HME Registered Apprenticeships

PRIVATE-SECTOR SPONSOR	APPRENTICEHSIP
Midstate Asphalt Repair Inc., – Illinois	Asphalt Paving Machine Operator *(Alt. Title: Concrete and Asphalt Equip Op)* Truck Driver, Heavy
King Asphalt Inc. – South Carolina	Field Tech Soil/Asphalt Inspector
American Asphalt Company, INC. – New Jersey	Asphalt Paving Machine Operator (Alt. Title: Concrete and Asphalt Equip Op)
Elgin Precision Pavement Markings, Inc. – Illinois	Pavement Striper*
AC Pavement Striping Company – Illinois	Pavement Striper*

Apprenticeships at Technical Colleges: Pinellas Technical College, Florida, offers a 2-year, 4,000 on-the-job (OJT) and 312 hours of related classroom instruction for its "Roadway Technician Apprenticeship". Here, apprentices are employed by apprenticeship partners, work during the regular work week to earn on-the-job (OJT) hours, and attend school for 5 hours, one day a week, during the regular school year. These apprentices earn the Florida Department of Transportation Intermediate Maintenance of Traffic certification.

STACKABLE CREDENTIALS

Colorado DOT (CDOT) is currently working with Front Range Community College to develop a curriculum (DACUM) for an Associate of Applied Science in Highway Maintenance

Management. CDOT evaluated National Highway Institute (NHI) course offerings in maintenance to develop this curriculum. In the process, CDOT identified a number of courses that would need to be developed. Course and certifications are listed below.

- *HWY 100: Introduction to Highway Maintenance and Operations – 3 credits (to be developed)*
- *HWY 105: Traffic Control – 3 credits (CCA or ATSSA Traffic Control Technician, Traffic Control Supervisor Certification)*
- *HWY 110: Highway Asset Management – 1 credit (NHI course)*
- *HWY 115: Highway Preventive Measures and Preservation Treatments – 3 credits (NHI courses)*
- *HWY 205: Highway Drainage – credits tbd (industry training source tbd)*
- *HWY 210: Unimproved/Gravel Roads – credits tbd (industry training source tbd)*
- *HWY 220: Asphalt Pavement Technician/Inspector Certifications – 3 credits (CAPA)*
- *HWY 223: Concrete Pavement Inspector Certification – 3 credits (ACPA, American Concrete Institute)*
- *HWY 226: Transportation Technician Certification – credits tbd (WAQTC)*
- *HWY 230: Commercial Driver's License Class B – 2 credits (Colorado Division of Motor Vehicles)*
- *HWY 233: Commercial Driver's License Class A – 2 credits (Colorado Division of Motor Vehicles)*
- *HWY 240: Erosion and Storm Water Certification – 3 credits (Envirocert or Inspector of Sediment & Erosion Control)*
- *HWY 243: Bridge Maintenance – 2 credits (NHI course)*
- *HWY 246: Winter Storm Operations – 2 credits (Clear Roads Consortium training)*
- *HWY 250: Highway Maintenance and Operations Field Practicum – 3 credits (to be developed)*
- *HWY 255: National Highway Institute Maintenance Leadership Academy (or substitute) – 6 credits? (tbd)*
- *HWY 260: Independent Study/Special Topics – 1-3 credits*

Several state DOTs offer Maintenance Leadership training for highway maintenance workers. NHI's Maintenance Leadership Academy is open to county and state DOT workers.

COMPETENCY MODEL

A draft competency model for the highway maintenance workforce was developed to represent HME disciplinary competencies found within an organization's maintenance division. This model is not intended to represent one occupation, but all the occupations in an organization. The value of such a competency model is to:

- *Understand the current competencies of the highway maintenance discipline.*
- *Assist in the development of a career pathway(s) in the highway maintenance discipline.*
- *Serve as a basis for new job competencies needed in 10 -15 years.*
- *Document competencies for the development of an apprenticeship in highway maintenance.*

Designed using DOL's CareerOneStop competency model builder, this Highway Maintenance Competency Model will be formerly registered in the online clearinghouse. MTWC

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has already engaged stakeholders interested in serving as champion or partner; a DOL requirement for inclusion in the clearinghouse database, and NHI has expressed interest in partnering on this model. In the Wisconsin Highway Maintenance Workforce Survey, respondents are also asked about their interest in validating the model.

Four industry sources were tapped to develop the draft HME Competency Model.

1. *DOL Clearinghouse models Engineering and Heavy Highway Civil competency models*
2. *AASHTO TC3 (Transportation Curriculum Coordination Council) Competency Matrix for Maintenance*
3. *Iowa DOT's Job Classification Descriptions*
4. *CDOT Division of Highway Maintenance (Highway Maintenance Management Degree Competencies)*

Designed using CareerOneStop's 5-step construction process:

> *Step 1. Populate a draft highway maintenance competency model,*
>
> *Step 2: Draft industry-sector technical competencies,*
>
> *Step 3: Test the draft highway maintenance competency model,*
>
> *Step 4: Gather feedback from subject matter experts,*
>
> *Step 5. Refine the competency model framework,*

the resulting competency model is represented by a 6-tier pyramid (Figure H8 below), where tiers 1–3 present foundational skills (personal effectiveness, academic and workplace competencies); tier 4 the general competencies needed for Civil Infrastructure Construction, Asset Management, and Highway Maintenance disciplines; and tier 5 presents competencies specific to HME. This approach also follows the grouping that AASHTO (TC3) used in developing their curriculum competencies, which include:

> *Roadway & Shoulder, Drainage, Winter Operations, Roadside Maintenance, Bridge & Culvert Maintenance, Fleet Management, Work Zone Traffic Control, and Traffic Services & Safety.*

Tier 6 lists management competencies sourced from DOL's Generic Competency Model for Management. Occupation-Specific Requirements are not required as part of the submission process to DOL, as these competencies are organization specific.

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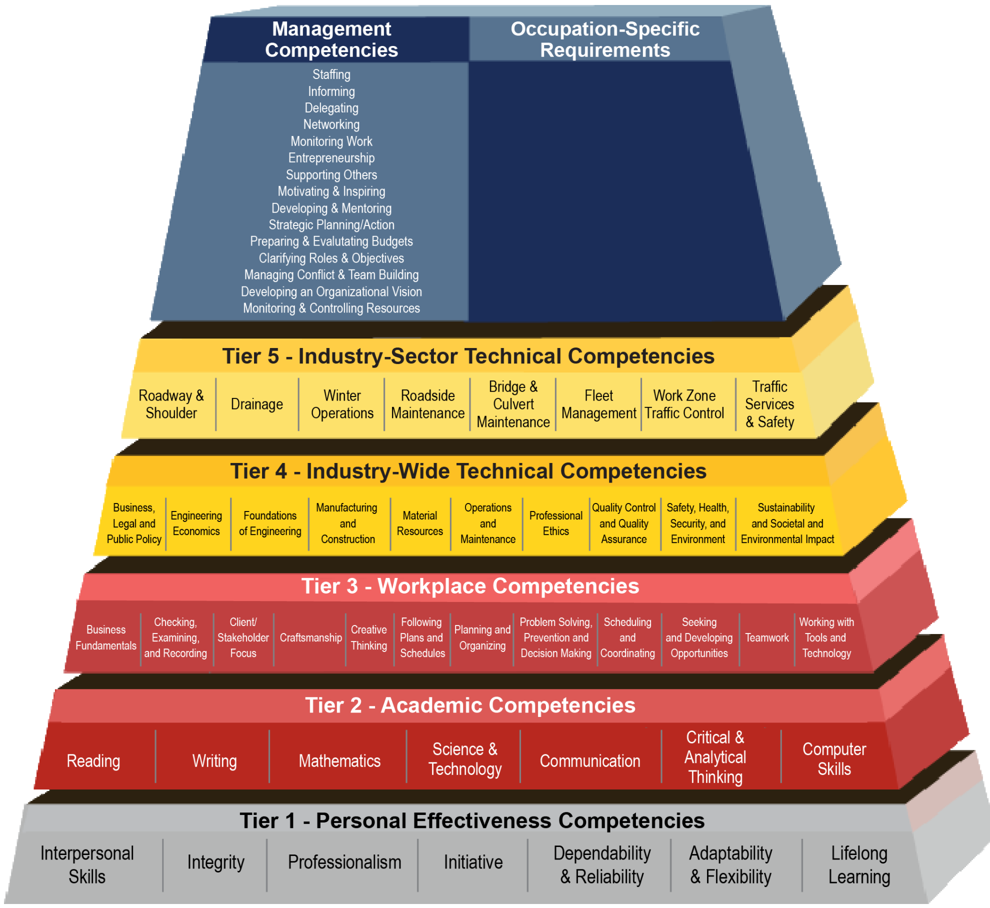

Figure H8. HME Proposed Competency Model (draft 06302017)

Note: The BLS SOC code for the Highway Maintenance occupation is 47-4051.
Under DOL, Highway Maintenance is listed under the Construction Industry (NAICS 23).
Highway Maintenance falls under the Architecture & Construction Career Cluster and Maintenance/Operations Pathway.

CAREER PATHWAYS

MTWC researchers developed five conceptual, forward-looking career pathways within HME, a brief description of each pathway and its related priority occupations follows.

1. *Maintenance Operations*
2. *Asset Management & Policy*
3. *Infrastructure Renewal, Resilience & Repair*
4. *Equipment, Automation & Fleet Management*
5. *Regenerative Highway Eco-System Management*

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While the underlying occupations for these pathways show employment demand in the future (Table H1), researchers took into account trends in job hybridization (the merging of KSAs into a single occupation), technology advances, rate of adoption/implementation, trends in sustainability, and the forces of nature, to flesh out details on these pathways.

In the HME discipline, there are two sets of workers: those with a high school education and those with a college degree. From a career pathway standpoint, two questions arose:

1. *Is it possible for a laborer or highway maintenance worker to become a maintenance engineer?*
2. *What other careers within a DOT or Public Works agency can a worker advance to within HME?*

A focus of a HME DWG meeting in Oct 2017, was to determine whether a laborer or highway maintenance worker could become a maintenance engineer. The advisory confirmed it is possible, but rare. Minnesota and Idaho DOT similarly confirmed this vertical career ladder exists, but more common is the practice of developing horizontal pathways, which provide lateral opportunities for workers who may not have an interest in responsibilities like staff and/or project management.

From a retention standpoint, horizontal pathways are an excellent workforce strategy, and both Minnesota and Idaho DOTs acknowledged the importance of maintaining in-house technical expertise. CDOT reported recruiting from outside its agency for supervisory positions, due to a lack of qualified candidates in its current workforce. This accounts for CDOT's interest and investment in the Highway Maintenance Management program at Fort Range Community College, which is expected to launch in January, 2019.

Finally, a NHI survey of State Maintenance Directors revealed future topics of interest:

- *Automated vehicle location for maintenance equipment*
- *Equip fleet management systems*
- *Interoperability of maintenance management systems w/ emergency response and other maintenance systems.* (Gay Dugan, Maintenance Training Program Manager, NHI)

Career Path: Maintenance Operations

Common titles in this pathway include Highway Maintenance Worker 1, Equipment Operator, Transportation Maintenance Worker, Transportation Generalist Senior, Crew Leader, Foreman, Superintendent, and Roadway Operations Manager; occupations found in both

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public and private sectors. This workforce will be impacted by autonomous vehicle technology, advancements in pavement, and trends in environmental stewardship. This pathway is designed to develop a hybrid worker capable of accessing jobs across multiple transportation areas, like Public Safety/Public Assistance, Roadway Inventory, Utility Management, and Transportation Systems Management Operations. These entry-level positions often only require a high school diploma and offer excellent career opportunities.

Highway Maintenance Career Pathway: Maintenance Operations

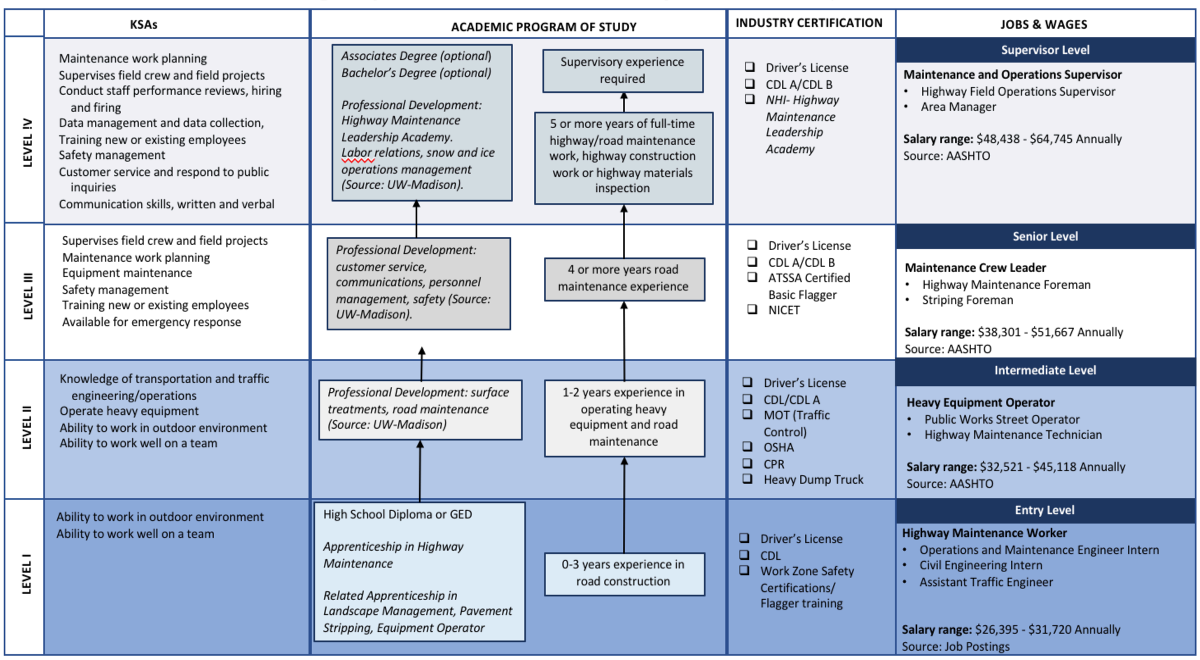

Figure H9. Maintenance Operations Career Pathway

Career Path: Asset Management & Policy

Common job titles for this pathway include State Maintenance Engineer, Maintenance Engineer, Civil Engineer, and Transportation Engineer. Occupations that are normally found within State DOTs include titles such as:

Assistant Maintenance Engineer for Roadways
Assistant Maintenance Engineer for Bridges
Assistant Manager Engineer for Permits and Operations
Assistant Manager for Management and Training
Assistant Manager for Traffic Operations
State Maintenance Engineer
Division Maintenance Engineer
District Engineer
Maintenance Engineer

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While county titles include Public Works Director and Assistant Public Works Director.

Within the US, there are few academic programs or university courses that allow Civil Engineering students to experience or specialize in the fields of Transportation Maintenance or Asset Management. This exposure typically happens at the continuing education level, where engineers seek professional development in project budgeting and risk management, so they are better able to contribute to the asset management efforts of an agency.

This concept of "Asset Management" is described by FHWA as:

> *"Asset management is a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair (SOGR) over the lifecycle of the assets at minimum practicable cost (23 U.S.C. 101(a)(2))."*

A review of educational opportunities for maintenance engineers was conducted, exploring programs of study such as "Masters in Management of Infrastructure Systems", however a more comprehensive query of the Integrated Postsecondary Education Data System (IPEDS) database is pending identification of CIP codes that best represent this pathway.

A dated report by the Midwest Regional University Transportation Center lists all the Asset Management Training, revealing the myriad of training within this discipline, some of which were identified as asset management candidates at NHI. Both NHI and the Wisconsin Local Technical Assistance Program (LTAP) have been approached for course information. Courses through NHI do not offer a certificate or credential. The offerings are:

FHWA-NHI-130109A --------------- Bridge Management Fundamentals
FHWA-NHI-130109B --------------- Performance-Based Management of Highway Bridges
FHWA-NHI-134001 ----------------- Principles and Applications of Highway Construction Specifications
FHWA-NHI-134064 ----------------- Transportation Construction Quality Assurance (1.5-Day)
FHWA-NHI-134064A --------------- Transportation Construction Quality Assurance (3-Day)
FHWA-NHI-134112 ----------------- Principles and Practices for Enhanced Maintenance Management Systems
FHWA-NHI-136002A --------------- Introduction to Financial Planning for Transportation Asset Management
FHWA-NHI-136065 ----------------- Risk Management
FHWA-NHI-136106A --------------- Introduction to Transportation Asset Management with Workshop
FHWA-NHI-136106B --------------- Developing a Transportation Asset Management Plan
FHWA-NHI-136106C --------------- Introduction to a Transportation Asset Management Plan
FHWA-NHI-136113 ----------------- Transportation Asset Management Overview

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Professional associations, such as AASHTO TC3, Clear Roads, APWA, and the various LTAP Road Scholar Programs, also offer training options, though it is not yet clear who is actually benefiting from this training. If counties around the country are using NHI training, then it presents a good precedent for use in Wisconsin.

Highway Maintenance Career Pathway: Asset Management & Policy

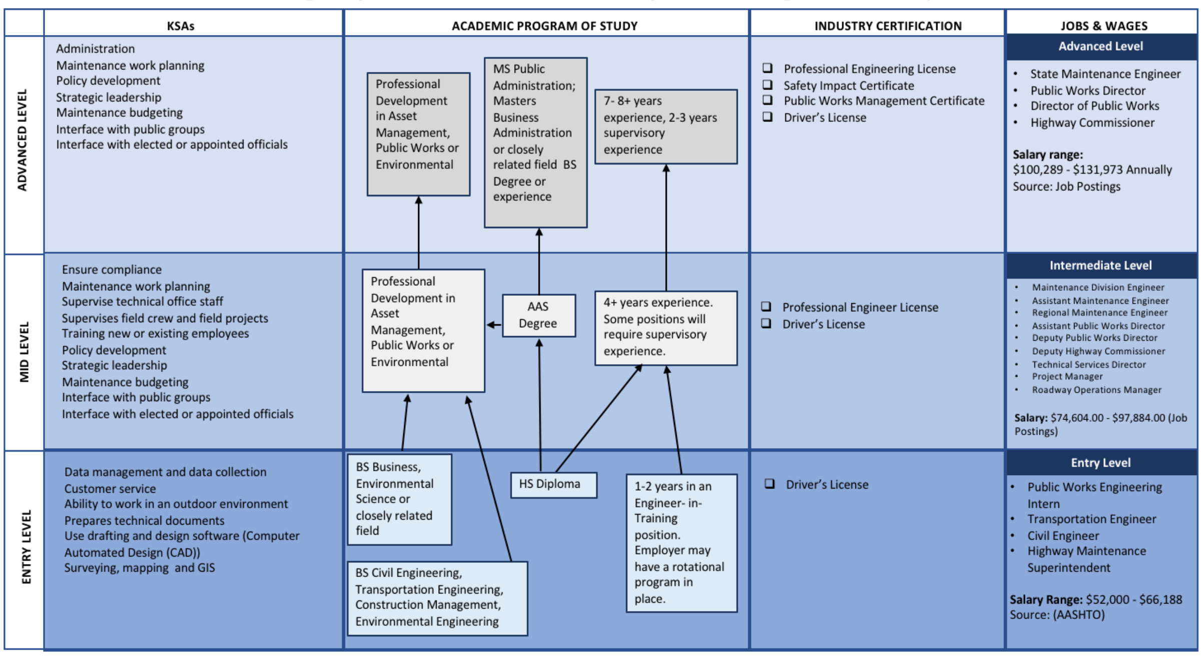

Figure H10. Asset Management & Policy Career Pathway

Career Path: Infrastructure Renewal, Resilience, & Repair

Common job titles include Construction Manager, Construction Inspection, Bridge Inspector, Bridge Supervisor, First-Line Supervisors of Construction Trades & Extraction Workers, and Civil Engineering Technician. With transportation systems continuing to fail due to extreme climate impacts, this pathway looks to increase workforce participation within a framework of "resilience," where technological changes in pavement and other infrastructure materials are being deployed to withstand climate-induced deterioration.

In addition to infrastructure resilience to changing weather patterns, this Infrastructure Renewal pathway (Figure H11) prepares workers to address infrastructure adaptation for new conveyance systems and uses as driverless and connected vehicles get deployed.

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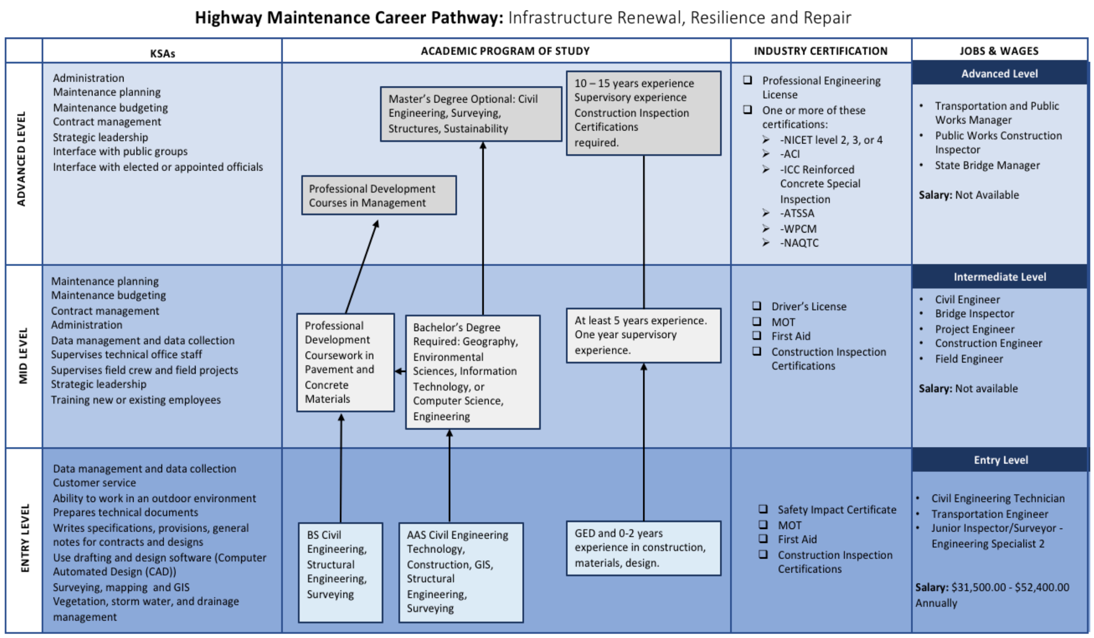

Figure H11. Infrastructure Renewal, Resilience, & Repair Career Pathway

Career Path: Equipment, Automation & Fleet Management

Both a public and private sector pathway, common job titles include Facilities Manager and Fleet Manager, which are found under SOC classifications "Operations & General Manager" and "First-Line Supervisors, Transportation & Material Moving Machine & Vehicle Operators". Entry points in the public sector may be from Engineering or Operations.

Over the past years, many agencies switched their fleet vehicle fuels (e.g., from gas or diesel to CNG or hybrid electric) to improve their organizational goals on sustainability, to improve vehicle fuel economy, and to improve budget performance. Yet vehicles slated for deployment over the next 5-15 years are likely to require fleet changes again, given the advent of all-electric autonomous/assisted vehicle technologies. (http://www.vtpi.org/avip.pdf)

However, with autonomous technology, entire fleets will be put in place to replace cars, shuttles, and buses. With service starting in 2018, companies like Waymo have already partnered with other companies to handle insurance costs and maintenance.

This transition will include a demand for new vehicle maintenance and repair training that typically takes place at the technical school and community college level. This vehicu-

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lar evolution is pushing a workforce evolution for traditional "auto mechanics" to now require competencies in computer diagnostics, maintenance of LIDAR systems, mapping equipment, and similar features of autonomous cars, buses, and trucks. (Navya, WI, Dec 2017)

The American Transportation Research Institute (ATRI) reports that "*Autonomous system hardware and software will have to be properly maintained to ensure safety. While OEMs may provide this service or may partner with third parties for this service, education and training also needs to be available for drivers, equipment managers, and mechanics employed by the carrier*". In 2017, the AASHTO Subcommittee on Maintenance developed a research statement on "Determining Maintenance Implications of Autonomous Vehicles".

Transportation Tech is also developing competencies and curriculum for Connected Vehicle Technicians, an occupation that may fit into HME. These techs repair and maintain connected vehicles, which transmit information between vehicles and infrastructure.

There are few options for education in Fleet Management. Ferris State University offers a minor in Fleet Management, while institutions like Ranken Technical College offer academic credit for NAFA's Certified Automotive Fleet Manager program. APWA recently developed a certification for Public Fleet Professionals, and CDOT has identified the following competencies for "Equipment & Fleet Management," which are now incorporated into MTWC's HME Competency Model. This Pathway to be further developed during Year 2.

- *Explain how to use the principles of fleet management to practice preventive maintenance.*
- *Explain how to maintain high readiness of highway maintenance equipment.*
- *Explain how to make sound economic decisions on the replacement of vehicles and equipment.*

Career Path: Regenerative Highway Eco-System Management

Common job titles include General & Operations Manager and Civil Engineer. This pathway is based on The Ray, an 18-mile stretch of I-85 in Georgia that serves as a proving-ground for a regenerative highway ecosystem. This vision embeds technologies such as solar-powered vehicle charging, tire safety check stations, solar-paved highways, pollinator gardens, and bioswale systems into this highway infrastructure. This career path will require a strong background in environmental impact, conservation, and technologies, and is expected to be consistent with the Green & Blue Highways Initiative of New York

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DOT, which encourages problem solving from a perspective of stewardship, operations, and maintenance. This Pathway to be further developed during Year 2.

Apprenticeships in the US have traditionally been used to train the construction workforce. However, there are a growing number of new technologies slated for field deployment—including drones, augmented reality, and robotic paving systems—that signal a need for a future-looking pathway models in this area. This can be seen at the Wisconsin Operating Engineers Union, which offers drone training to its members.

DISCIPLINARY SUMMARY

Interactions with Wisconsin's highway maintenance officials indicate a demand for both an entry-level highway/public works workforce and a need for training, which is currently performed at the employer's expense "on-the-job" (WI CHAL Conference, Dec 2017) . These stakeholders would like to see an apprenticeship program serve this purpose, and while professional associations do a fairly good job of training incumbent workers who already have work experience, there is no comparable solution for new workers. Also, supervisors without a formal college education would like to see a credit for prior learning program. There are many excellent practices at the State DOTs that need to be scaled or could be applied to the Wisconsin template. Examples include offering credit for prior learning at local community colleges, transparency about the career paths available within an agency.

There is evidence workers move from skilled trades to engineering positions. To encourage this, additional resources should be deployed to improve "Grow Your Own" strategies.

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TRANSPORTATION SAFETY

Transportation Safety

INTRODUCTION

During the start-up phase of this initiative, researchers from the West Region Transportation Workforce Center (WRTWC), working in conjunction with the Safety Discipline Working Group (DWG) advisory, use of networking and presentation opportunities at several safety and workforce development-related events (Session 862: Leveraging Technology for Transportation Agency Workforce Development and Training, ANB23 Highway Safety Workforce Development Committee) and scanned relevant literature to identify what research has already been conducted in the areas, including:

- *Workforce supply and demand estimations for transportation safety professionals,*
- *Occupations directly tied to transportation safety,*
- *State of the practice for training and education of safety specialists,*
- *Certificate programs and training or education opportunities in safety, and*
- *Core competencies for transportation safety specialists.*

These relevant literature contributions included the following foundational reviews:

- *Committee for a Study of Supply & Demand for Highway Safety Professionals in the Public Sector.* (2007)
- *Building the Road Safety Profession in the Public Sector: Special Report 289 (Vol. 289).* TRB

In particular, the 2007 Public Sector report estimated that over 10,000 public sector employees have responsibilities directly related to road safety and an additional 100,000 professionals from various sectors have responsibilities that impact road safety. The report authors predicted an increase in these numbers as focus on data-driven safety outcomes increases at the local, state, and federal levels. This led researchers to compile an up-to-date assessment of the qualifications expected of today's transportation safety professionals, conducted through interviews with key safety stakeholders that included university faculty, private sector industry, state transportation safety and maintenance departments, and local road supervisors.

This outreach effort provided a clearer understanding of the recruitment and training challenges faced by employers within this discipline, as well as the state-of-practice in education and training pathways available for today's road safety managers, the common themes of which will be discussed in more detail in the sections to follow.

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This occupational data collected was supplemented by outreach to professional organizations that recently established (e.g., the American Road & Transportation Builders Association, or ARBTA) or are currently establishing (e.g., the Institute for Transportation Engineers, or ITE) professional certification programs in transportation safety. The goal of these discussions was to understand the process these associations utilize to develop certification programs, the rationale behind the occupations they target, industry demand for these certifications, existing training and education sources, and the core competencies these certification programs address.

IDENTIFYING PRIORITY OCCUPATIONS

The data gathered through this effort was combined with O*Net occupation descriptions and presented as a list of leading/key occupations in the safety discipline for review by the Safety DWG (Safety DWG, May 2017). In working to identify an initial list of priority occupations for safety, titles and Standard Occupational Classification (SOC) codes developed by the Bureau of Labor Statistics were used to facilitate subsequent labor market analyses. Safety DWG members then ranked priority occupations through an anonymous feedback process, which resulted in the identification of eight candidate titles that the advisory considered critical to transportation safety from a systems perspective (Safety DWG, May 2017). These titles (presented in Table S1 below) no longer included five occupational clusters that were originally targeted for evaluation, due to their divergence from the "system of safety" disciplinary approach. These dropped SOC clusters included "Occupational Health & Safety Technicians" (SOC 29-9012), "Occupational Health & Safety Specialists" (SOC 29-9011), "Construction & Building Inspectors" (SOC 47-4011), "Operating Engineers & Other Construction Equipment Operators" (SOC 47-4061), and "First-Line Supervisors of Transportation & Material-Moving Machine & Vehicle Operators" (SOC 53-1031).

The eight priority occupations that remain include staff responsible for infrastructure construction and maintenance decision-making as well as for engineering design, operations, and analysis. In recognition of the fact there are different education and training paths for construction and maintenance personnel as compared to staff specializing in engineering design, operations, and analysis, the Safety DWG identified two separate, but overlapping, disciplinary realms for priority transportation safety occupations: "Infrastructure Construction & Maintenance" and "Road Safety", as represented conceptually in Figure S1. In this regard, the Safety DWG expressed consensus that the approach to career

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pathway development should be interdisciplinary and cross-occupational, and supported a conceptual framework in which a systems approach to safety provided the interconnection between different subject matters and occupational perspectives (Safety DWG, Sep 2017).

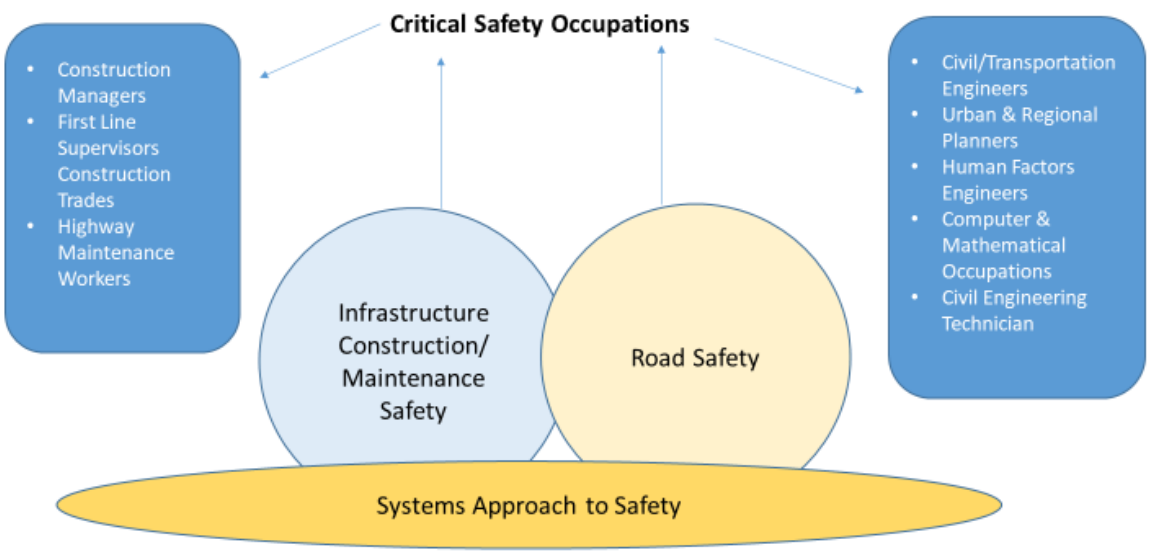

Figure S1. Career Clusters for Critical Transportation Safety Occupations

In addition to critical Safety DWG input, industry demand for safety professionals in these two career cluster areas is supported by professional credentialing efforts currently being undertaken, or recently completed, by professional associations (e.g., ARTBA's Safety Certification for Transportation Project Professionals (SCTPP) and ITE's Road Safety Professional Certification (RSP)). Both certification efforts are based upon extensive outreach to industry representatives, as the significant development and administration costs for such certifications make it critical to establish substantial industry interest and demand to warrant moving forward with the development process.

According to an interview with ITE CEO and Safety DWG member Jeff Paniati, ITE's RSP certification development process was predicated upon a survey of some 4,000 industry representatives, to gauge demand. Ultimately, this certification will be applicable throughout North American, due to its joint development with the Transportation Association of Canada, which also undertook extensive national outreach to determine demand. The Transportation Professional Certification Board (TPCB), the formal certifying body for this

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effort, is working with a steering committee that represents multiple organizations (including TRB, AASHTO, ITE, GHSA, and various universities) to identify specific competency needs. According to Paniati, TPCB is currently pursuing a two-level, three-part RSP certification. Level 1 will target a broad set of professionals who, in the course of their occupational responsibilities, make decisions that impact the safety of the traveling public. This Level 1 certification will ensure that these professionals have a foundational level of knowledge on road safety. A Level 2 certification will target professionals with more primary responsibilities related to road safety, including the planning, design, and operation of highway infrastructure. This Level 2 certification will have two specialty areas, infrastructure and behavior. Both certifications are expected to be available by mid-2019.

For highway construction, ARTBA similarly used an outside certification body to develop a nationally recognized credential for transportation project safety. From an interview with Brad Sant and Una Connolly of ARTBA, this process began by establishing a group of some twenty-five subject matter experts (SMEs) representing a variety of industries from both public and private sectors. Initially, ARTBA intended for their safety certification to focus on occupations like “Safety Director” or similar professionals that handle both occupational safety and temporary traffic control at job sites. However, feedback ARTBA received from SMEs involved in the development process redirected their certification efforts, as industry’s true focus is to increase the safety skills of non-safety professionals, like foremen, supervisors, managers, etc., who are responsible for ensuring safety on the job site.

ARTBA’s revised approach was therefore based on input they received from two sources. The first was state DOTs (the road owners) who expressed a concern that, as more innovative contracting processes were utilized (like public-private partnerships), increased demand was likewise placed on private employers to handle all aspects of a project, including safety. These DOTs had an understandable concern that there was no guarantee that private entities were properly equipped to take on the responsibilities of project safety.

The second source came in the form of industry feedback highlighting concerns over a lack of safety knowledge on the part of project engineers and supervisors, as well as an observed lack of standards for basic project safety competencies. ARTBA’s SME advisory also recommended changing the state of the practice and actually re-labeling occupations like “Foreman” into more safety conscience titles; a change that should include redefining job performance beyond productivity to include safety. According to Sant and Connolly,

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transportation project safety competencies included in ARTBA's SCTPP final exam blueprint were validated by approximately 750 industry representatives.

Once a final list of priority safety occupations was identified, researchers focused on analyzing labor market data to support the priority workforce status. BLS employment data and national growth projections for these occupations are shown in Table S1 below.

Table 1. BLS Growth Projections for Priority Safety Occupations

SOC CODE	OCCUPATION TITLE	CURRENT # EMPLOYEES, 2016	PROJECTED # EMPLOYEES, 2026	PERCENT CHANGE	MEDIAN WAGE
11-9021	Construction Managers	403,800	448,600	11.1%	$89,300
15-0000	Computer & Mathematical Occupations	4,419,000	5,026,500	13.7%	$82,830
17-2051	Civil/Transportation Engineers	303,500	335,700	10.6%	$83,540
17-2112	Human Factors Engineers	257,900	283,000	9.7%	$84,310
17-3022	Civil Engineering Technicians	74,500	81,100	8.8%	$49,980
19-3051	Urban and Regional Planners	36,000	40,600	12.8%	$70,020
47-1011	First-Line Supervisors of Construction Trades	602,500	678,300	12.6%	$62,980
47-4051	Highway Maintenance Workers	149,900	160,200	6.9%	$38,130

A challenge to the Transportation Safety discipline overall, and to this career pathways initiative in particular, is the difficulty of identifying relevant labor market data to validate priority occupations and in-demand knowledge, skills, and abilities (KSAs), due to general lack of explicit references to "safety" in job titles and employer-posted job requirements.

An in-depth analysis of real-time online job postings (using Burning Glass Technologies' query tool) was conducted for four priority occupations identified by the safety initiative:

1. *Civil/Transportation Engineers,*
2. *Human Factors Engineers, and*
3. *Construction Managers and First-line Construction Supervisors (combined)*

Overall, fifty postings were reviewed for construction supervisors and managers to identify in-demand KSAs, where common job titles included "Foreman", "Project Inspector", "Project Manager", "Project Superintendent", and "Senior Project Manager". While these

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titles do not include the classification "safety" specifically, several safety-related competencies were evident within their job descriptions. Most frequently cited were: "Safety Compliance" (56%), "Ability to Promote Safety (50%), Knowledge of Health, Safety, and Environmental Policies (e.g., OSHA) (18%), and "Job Hazard Analysis" (4%).

Postings for "Human Factors Engineers" likewise did not emphasize safety in job titles. Here again, an analysis of fifty online postings identified common job titles to be "Ergonomist", "Human Factors Engineer", and "Human Factors Researcher". The most frequently cited safety-related competencies listed in these posts included: "Ability to Recommend Appropriate Changes in Policies, Procedures, & Equipment to Prevent Incidents (12%); "Risk & Hazard Analysis (10%); and "Knowledge of OSHA Policies" (4%). Many of the in-demand KSAs listed in "Human Factors" job postings directly correlated with future-oriented safety competencies identified by respondents of the WRTWC Survey on Expected Impacts of Transformational Technologies on the Safety Workforce, described later. Such forward-looking competencies include "Human-Computer Interactions", "Machine Learning", "User Risk Analysis", and "Statistical Data Analysis".

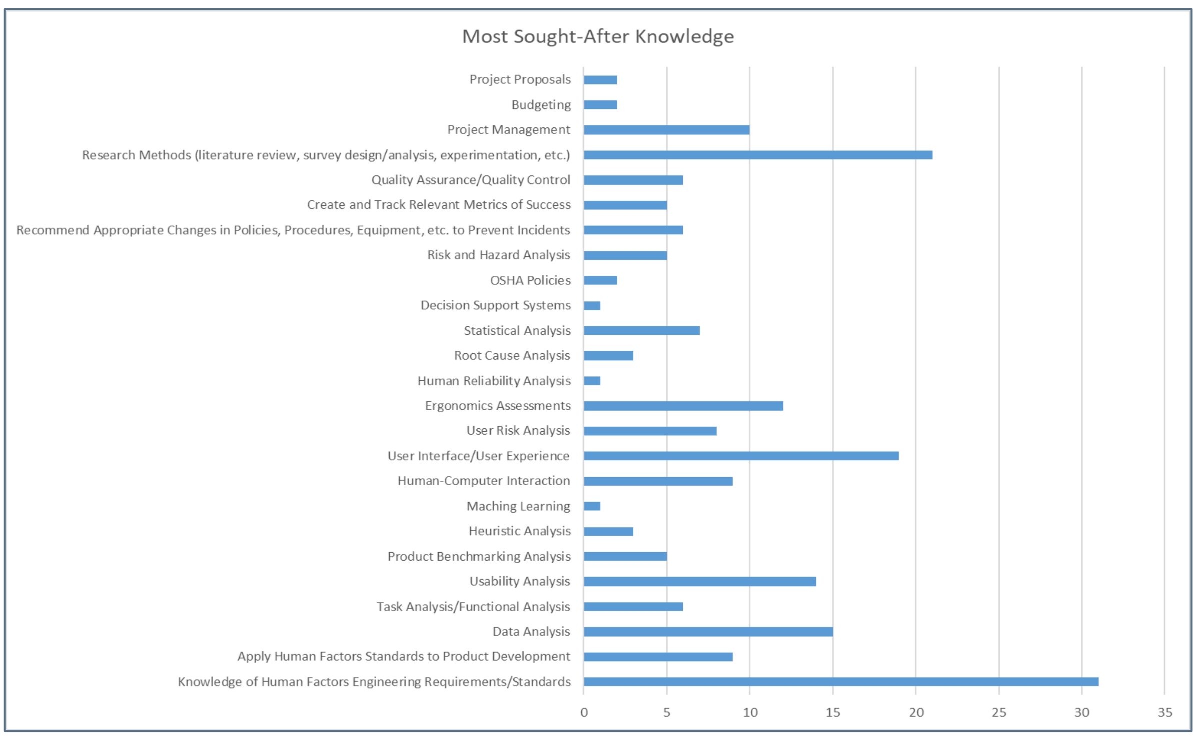

Figure S2: In-demand Competencies for Human Factors Job Applicants

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An analysis of thirty Transportation Engineer job postings produced even less evidence of demand for specific safety competencies. The most in-demand skills on job postings related to “Highway Design Tools” (e.g. MicroStation, GeoPak, InRoads), whereas AASHTO’s Highway Safety Manual (HSM) was never mentioned. While responsibility areas listed in postings for Transportation Engineers carry direct safety impacts (i.e., bike/pedestrian design, intersection layouts, roadway alignments, pavement markings, sight distance, traffic control, etc.), the posted job descriptions failed to list any specific safety knowledge or tool requirements for (or preferred by) job applicants.

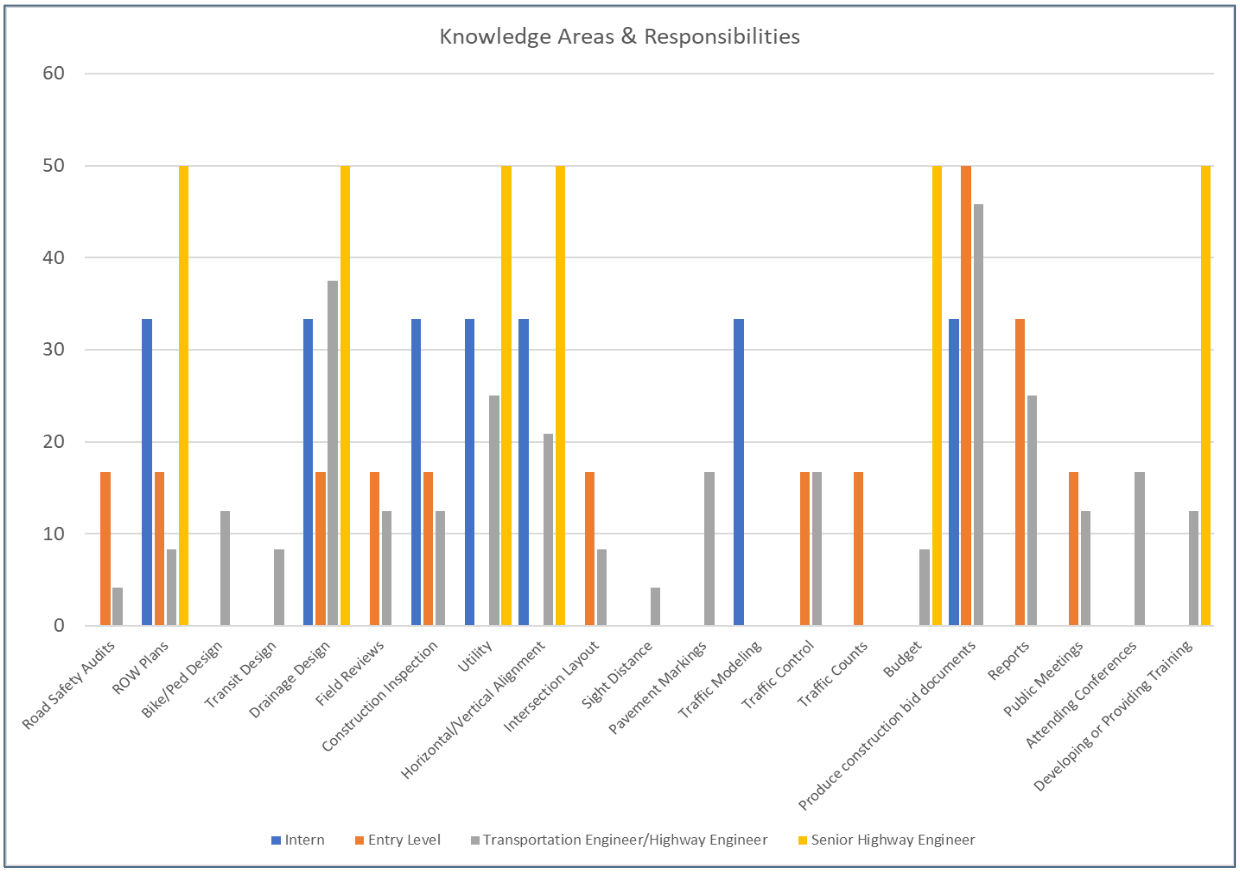

Figure S3: Knowledge Areas & Responsibilities for Transportation Engineers

Despite implementing a variety of LMI searches to pinpoint road safety engineering occupations, none were successful in obtaining adequate coverage of safety-focused jobs or KSA requirements for the type of Road Safety Professional envisioned by the Safety DWG; an occupational category seen as critical to the future highway transportation system.

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CAREER PATHWAYS

The general lack of safety emphasis in job titles and required or preferred job qualifications in online job postings is not unexpected. Interviews with safety professionals and input from the Safety DWG advisors highlight some of the challenges for employers. The hiring process in many state DOTs, for example, relies on broader job classifications. This can block career paths within specialty areas like safety, because supervisors do not have the flexibility to train and groom subordinates for promotion into a leadership position within the department. Those with seniority in a given DOT job classification (as a whole) are given priority regardless of their area of expertise.

By contrast, private sector employers have more flexibility in establishing job descriptions and qualifications. However, a reluctance is noted on the part of employers in both sectors to write specific safety KSAs into job qualification requirements, because of the assumption these skills are too difficult to find in typical applicant pools and would therefore impede the hiring process (Safety DWG, Dec 2017). Safety engineers at state and local agencies have noted they expect to train new staff on safety-related knowledge and skills, because it is rare to find applicants who already have these skills (Chief Safety Engineer, NV DOT; County Engineering Services Manager, Thurston WA, May 2017). Even for staff in management positions, many describe "stumbling into" safety leadership positions without past experience, foundational knowledge, or specialized skills in safety. An initial training period is therefore required to get new-hires "up to speed" with the skills needed in their position (Chief Safety Engineer, NV DOT; Highway Safety Manager, Idaho Transportation Department). A more clearly defined road safety career pathway with clearly defined curriculum for safety would benefit road safety managers and divisions.

Over the past few years, an increasing level of activity toward defining, developing, and supporting safety professional development is evident. In addition to the development of safety certifications (described previously), training providers, professional associations, and state DOTs are working to develop safety recognition or comprehensive safety training programs for their staff. These efforts include a collaborative research and development program to operationalize safety competencies for state DOT employees (Barnett, T., Herbel, S., Hull, R., Beer, P., 2017), a guidance paper for developing a safety recognition program for local roads maintenance personnel (National Center for Rural Road Safety, 2017), and an in-progress effort to develop a safety training and recognition program for local roads engineers (NACE). As an example, for highway maintenance occupations the National Center for Rural Road Safety

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(RCRRS) produced a scan of existing safety trainings that are relevant to maintenance staff. This led to the recommendation of maintenance safety competencies and guidelines for agencies seeking to develop a safety culture and to recognize and reward local maintenance personnel who obtain the requisite knowledge and skills to contribute to road safety goals. This effort was undertaken in recognition of the important role local maintenance personnel play in road safety, as well as the lack of a structured process or program for staff to obtain road safety skills. The report identified eight key learning objectives for local roadway maintenance staff to assist them in understanding different approaches for diagnosing safety issues "at the systematic, systemic, and individual candidate site levels", and to identify appropriate courses of action to address safety issues focused on maintenance activities that have safety impacts, such as vegetation/ROW management, lighting and signage, and temporary traffic control (RCRRS, 2017). This report highlights gaps in existing safety curricula for maintenance staff and underlines the importance of local agency leadership undertaking concrete steps to foster a safety culture and to develop a more safety-knowledgeable maintenance workforce.

Efforts like these indicate an increasing demand for safety workforce competencies and are important in furthering efforts to adequately train transportation personnel. Increasing demand for competent transportation safety professionals is tied to international, national, state, and local initiatives/efforts to prioritize safety outcomes. For example, Vision Zero has helped to push safety as a policy, planning, and budgetary priority down to local levels (County Engineer, Thurston WA, May 2017). Legislative efforts at national and state levels have also mandated improved integration of safety measures and outcomes into transportation planning, design, and operations. MAP-21 established a performance and outcomes-based highway investment program to include reductions in traffic fatalities and injuries on public roads. The Highway Safety Improvement Program (HSIP) likewise focuses on a data-driven strategic approach to highway safety. And national initiatives like Toward Zero Deaths, FHWA's Every Day Counts and the National Safety Council's Road to Zero Coalition help facilitate implementation of safety innovations and best practices at the local level.

However, sole reliance on professional development and on-the-job training to meet worker skillset needs has its limitations. A study on safety training utilization by four state departments of transportation (Otto, J., Finley K., Ward, N., 2016) found that "… most states are not integrating safety workforce development into their DOT workforce development training program. Instead, training is being addressed on an ad-hoc basis depending on availability

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and staff needs." Safety training utilization for transportation staff was uneven across different state DOTs and the study found a significant relationship between agency prioritization of safety, DOT support for safety workforce development, and DOT staff access to safety workforce development (Otto, J., Finley K., Ward, N., 2016).

Safety career pathways that begin at a pre-career level and build needed safety competencies at the academic degree level, through coursework and experiential learning obtained while students are still in school, have the potential to overcome the barriers noted above in terms of professional development, to meet an increasing demand for safety skillsets. In addition to providing a skilled pool of potential safety professionals, integration of road safety competency development at the degree-level provides opportunities to target multiple disciplines and to ensure that emerging workers in a variety of entry-level fields (i.e., roadway design, traffic operations, planning, etc.) have foundational safety knowledge and skills. Feedback collected from safety professionals underline a desire for safety to be embedded throughout an agency's multiple divisions and personnel levels.

As observed by one Safety Engineer, the safety skills gained late in his career would have been helpful earlier-on while he was a Road Design Engineer (Chief Safety Engineer, NV DOT, May 2017). This interviewee expressed a desire for current DOT road designers to be more aware of safety issues and their mitigations, as safety offices lack sufficient staff to review every project. A private sector engineer similarly advised that safety should not be siloed into a few "safety" professions or occupations (Senior Engineer, Kittelson & Associates, May 2017), observing that silos foster an unfortunate tendency for staff to leave safety-related decisions up to a "Safety Engineer," rather than incorporating safety features into every level of decision-making.

To further support of this type of stakeholder feedback on the state of practice in educating, training, and employment of safety professionals, as well as in-demand safety competencies, a significant collection of current research was evaluated, including:

- *Gambatese, J. A., Hurwitz, D., & Barlow, Z. (2017). Highway Worker Safety (No. Project 20-05, Topic 47-16). NCHRP Synthesis 509, National Cooperative Highway Research Program, Transportation Research Board.*
- *ARTBA Transportation Development Foundation (2016). Safety Certification for Transportation Project Professionals Candidate Handbook. Available online: https://www.artba.org/wp-content/uploads/SCTPP/SCTPP_Candidate_Handbook.pdf*
- *Sun, X. (2013). Development of a Highway Safety Fundamental Course (Project number FHWA/LA.14/524. National Center for Intermodal Transportation for Economic Competitiveness (NCITEC).*

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- *Bahar, G. (2011). Highway Safety Training Synthesis/Roadmap (NCHRP Project 20-07, Task 290), National Cooperative Highway Research Program, Transportation Research Board.*
- *Cambridge Systematics. (2010). Model Curriculum for Highway Safety Core Competencies NCHRP Report 667, National Cooperative Highway Research Program, Transportation Research Board, Washington, DC.*
- *Hauer, E. (2007). A case for evidence-based road-safety delivery. Improving Traffic Safety Culture in the United States, 329. AAA Foundation for Traffic Safety.*
- *Batelle and Midwest Research Institute (2012). Human Factors Guidelines for Road Systems, NCHRP Report 600. National Cooperative Highway Research Program, Transportation Research Board, Washington, DC.*
- *Cambridge Systematics, Inc. (2015). Applying Safety Data and Analysis to Performance-Based Transportation Planning. FHWA Report: FHWA-SA-15-089.*
- *U.S. Department of Transportation, Federal Highway Administration (2017). Road Safety Fundamentals: Concepts, Strategies, and Practices that Reduce Fatalities and Injuries on the Road. FHWA Report No. FHWA-SA-18-003.*

To better understand the current state of practice in educating this workforce within colleges and universities, an analysis of degree-level safety course content was conducted.

For the Road Safety career cluster, the seminal work continues to be Gross and Jovanis' 2008 review of safety course offerings in engineering and public health (Gross, F., & Jovanis, P. P., 2008). At the time of their report, only 25 out of the 117 engineering programs surveyed offered a safety course. The Safety DWG agreed these findings are still relevant today, as the amount of engineering course content specific to road safety remains limited or non-existent within most university programs. Road safety is considered a subset of transportation engineering—itself a subset of civil engineering—and there is little academic time available in a civil engineering undergraduate program to devote to specialized content. As a result, degree-level road safety curriculum is sparse and often dependent on faculty interest (Safety DWG, Sep/Dec 2017).

A similar survey was reviewed (Gambatese, J. A., 2003) on safety content in construction-related programs, which queried course content in three areas: OSHA Standards, Safety Management, and Safety in Design. Here OSHA regulations was found to receive the bulk of course time, an also highlighted a significant difference between civil engineering and construction programs: 90% of construction programs offered a separate safety course, while no engineering programs were found to offer a separate course on construction safety. This 2003 Gambatese study also included a review of various accreditation requirements and found accreditation standards to be influential in driving curricular content.

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A separate data collection effort was also undertaken to determine to what extent two and four-year degree programs in construction technology, civil and construction engineering, and construction management cover safety topics through coursework and work-based or experiential learning. An online survey instrument was created using Qualtrics, that queried university and community college representatives regarding what construction specialization areas were covered a their institutions, and at what level and how much time was devoted to specific safety topics. Participants were asked what competencies students would be expected to master by graduation, as well as what (if any) institutional expectations were in place regarding work-based and experiential learning opportunities for students during their program enrollment. This survey was distributed to degree program contacts at 401 universities and colleges across all 50 states and Puerto Rico. Of the 110 complete survey responses from civil engineering and construction programs, 29% (32 institutions) represented two-year degree programs and 71% (78 institutions) represented four-year universities. Results show a mixed picture on safety topic coverage in construction curricula (Figure S4).

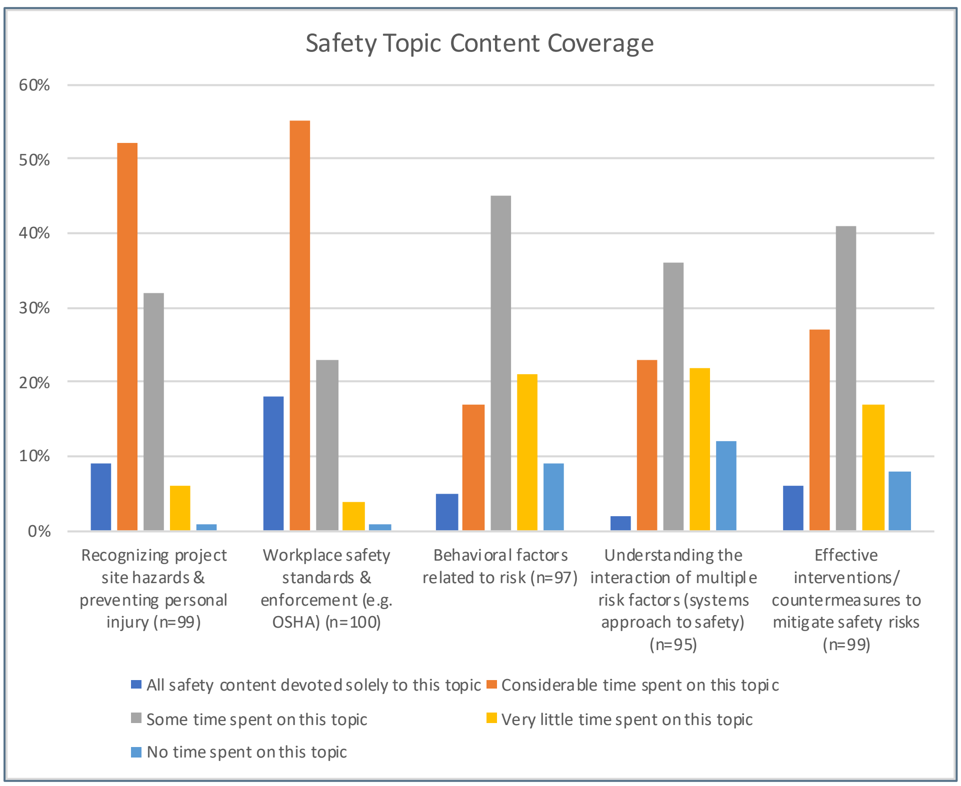

Figure S4: Course Content Coverage by Safety Topic

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Safety topics receiving the most content coverage were related to safety standards and enforcement (e.g., OSHA), followed by recognition of project site hazards and personal injury prevention. On the other hand, behavioral factors, systems safety, and risk mitigation topics presented a more mixed picture. Respondents also listed their expectations for graduating students in a variety of competency areas; these results depicted in Figure S5:

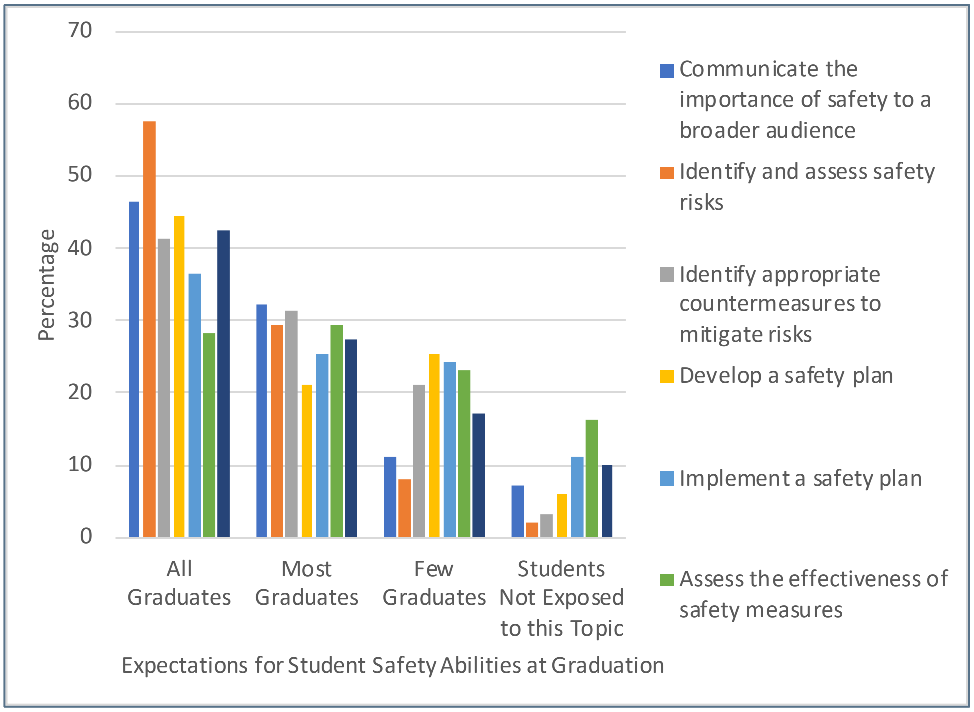

Figure S5: Abilities Expected of Construction Program Graduates

An analysis of survey responses from two and four-year institutions indicates that most construction programs offer a separate safety course and all programs integrate some aspect of safety into their course content. Most construction programs expose students to topics related to personal and job site safety; only 4% of respondents reported spending no time covering topics related to OSHA.

Institutional expectations of program graduates are correspondingly high in these areas, with respondents expecting most or all graduates to be able to identify and assess safety risks (88%), communicate the importance of safety to a broader audience (80%), and identify and implement regulatory safety requirements (71%). Survey respondents re-

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ported devoting less class time to risk mitigation measures and systems safety, and expectations regarding abilities of program graduates were correspondingly lower in these areas. Over a third of respondents expected few or no program graduates to be able to develop or implement a safety plan, while 39% expected few or no graduates to be able to assess the effectiveness of safety measures.

Research results also underscore opportunities for industry to foster experiential learning opportunities for students to implement classroom knowledge in real-world scenarios and to develop in-demand safety competencies. Construction programs express broad support for work-based and experiential learning as evidenced by survey responses on these two topics. Thirty-seven respondents (38% of sample) require work-based learning experiences for their enrollees, while an additional 45% encourage and support such experiences. Only 9% of respondents indicated that no experiential learning opportunities were offered to students at their institutions. A full write-up of survey analysis results has been submitted for review to the ASEE 2018 National Conference.

A second survey was distributed among transportation safety professionals on the expected impact that emerging technologies will have on the safety workforce, to better understand how the current state of education and training will need to change to meet the needs of this future workforce. This survey was distributed to safety-focused TRB committees and stakeholder networks of the NCRRS, which include local road supervisors and maintenance personnel. Ninety-five responses were received; the majority of respondents represented engineering (44%) and research/education (43%), with 11% from the planning sector. Only 1% of respondents were from the construction sector and no responses were received from maintenance.

Survey participants were asked “What transformational technologies will most shape the future skillsets and/or competencies required of transportation safety professionals?” Top responses included “V2I & V2V”, “Autonomous Vehicles”, “In-Vehicle & Roadside Technologies”, “Automated Data Collection Systems”, “Data Security”, and “Machine Learning”. In response to “What types of additional knowledge and/or skillsets will be needed by safety professionals to work with the emerging technologies that are impacting or are expected to impact transportation safety and safety-related decision-making?” the top three ranked KSAs were 1) “Analysis Techniques for Large Datasets”, 2) “Predictive Analytics”, and 3) “Human-Machine & Human-Computer Interactions”.

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Additional skills manually added by respondents included: “Creativity”, “Psychology”, “Human Factors”, “Systems Engineering”, “Change Management”, and “Communication Skills”. These survey responses provide insight into emerging skillsets for transportation safety professionals, particularly in relation to the increasing importance of data analytics and computer science competencies (e.g., programming, algorithm development, AI, machine learning). A complete summary of survey results is included as Attachment D.

Figure S6 below highlights how these emerging technologies are perceived to be changing needed skillsets within transportation safety. A key issue facing critical safety occupations will be finding education and training programs that successfully integrate the multidisciplinary and cross-occupational expertise that will be required in this new world.

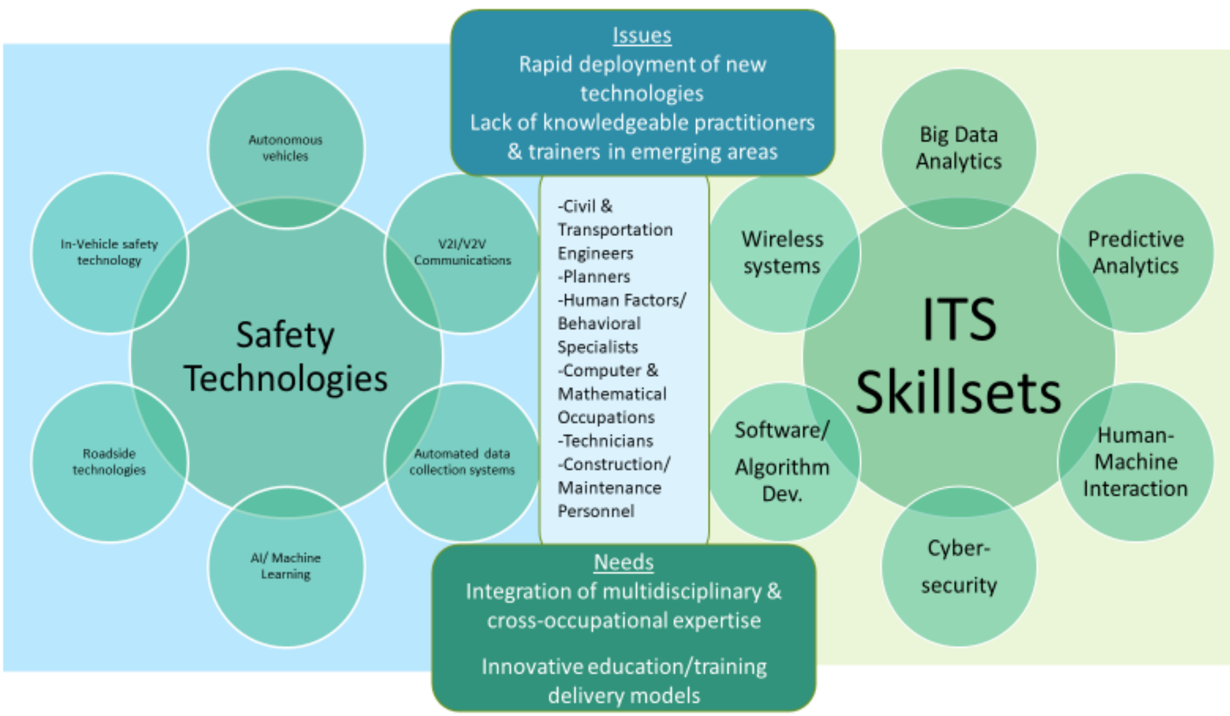

Figure S6: Expected Impact of Transformational Technologies on Required Skillsets of Safety Professionals

Figure S7 through S10 below present draft career pathways for both safety disciplinary realms, Road Safety and Infrastructure Construction & Maintenance, including competency models designed in compliance with DOL CareerOneStop specifications.

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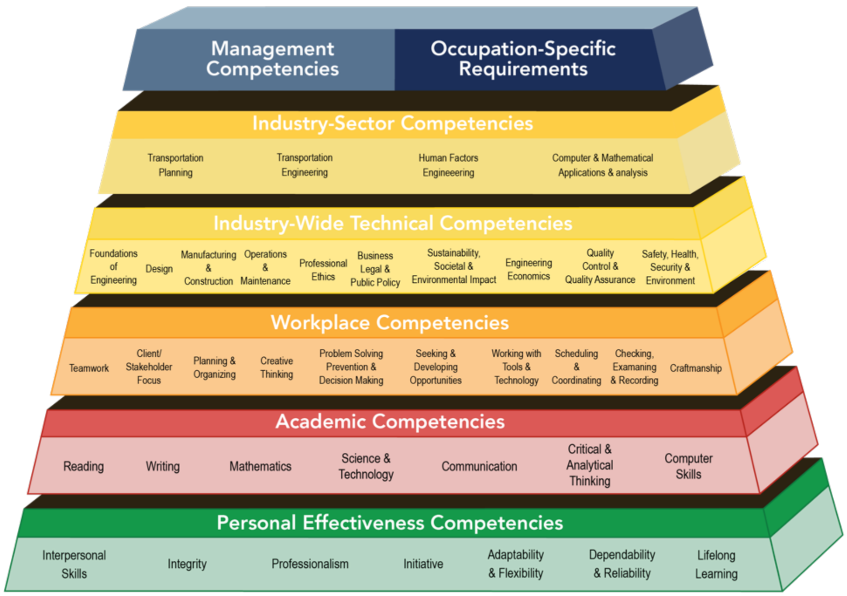

Figure S7: DOL Competency Model for Road Safety

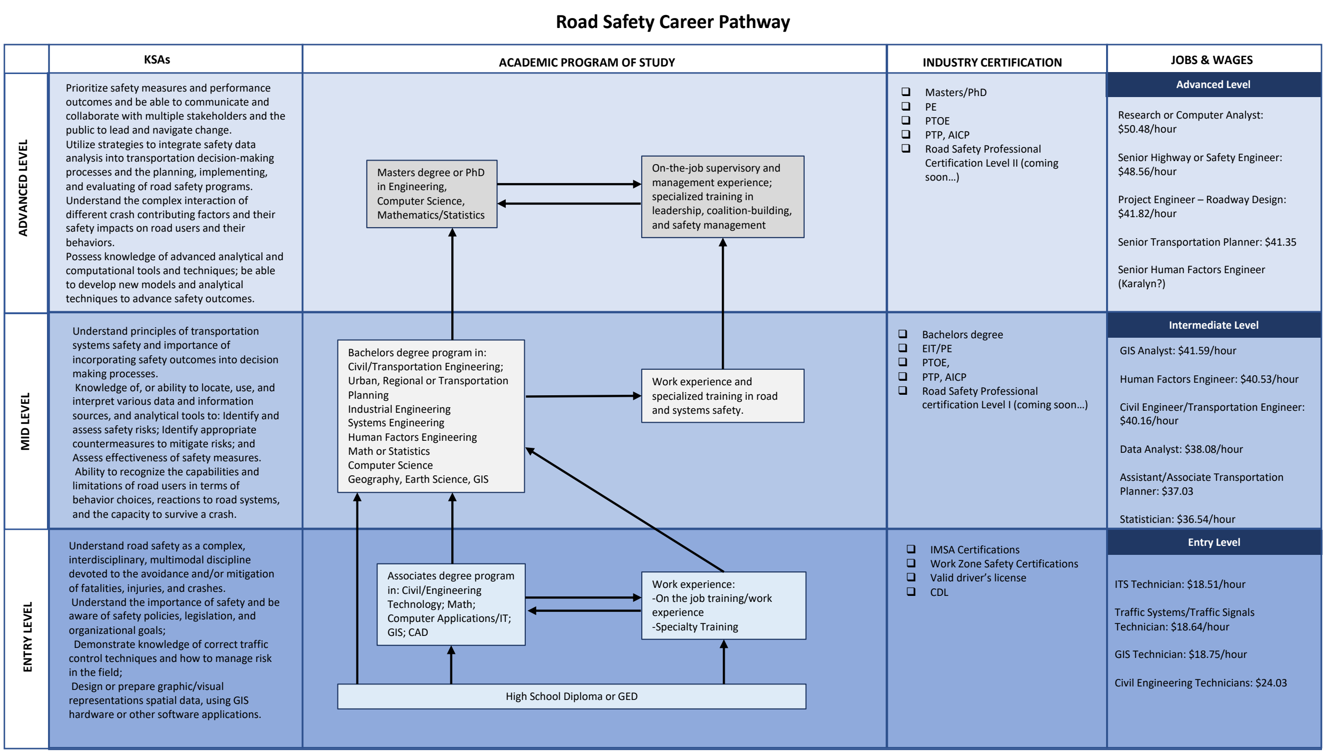

Figure S8: Career Pathway Template for Road Safety

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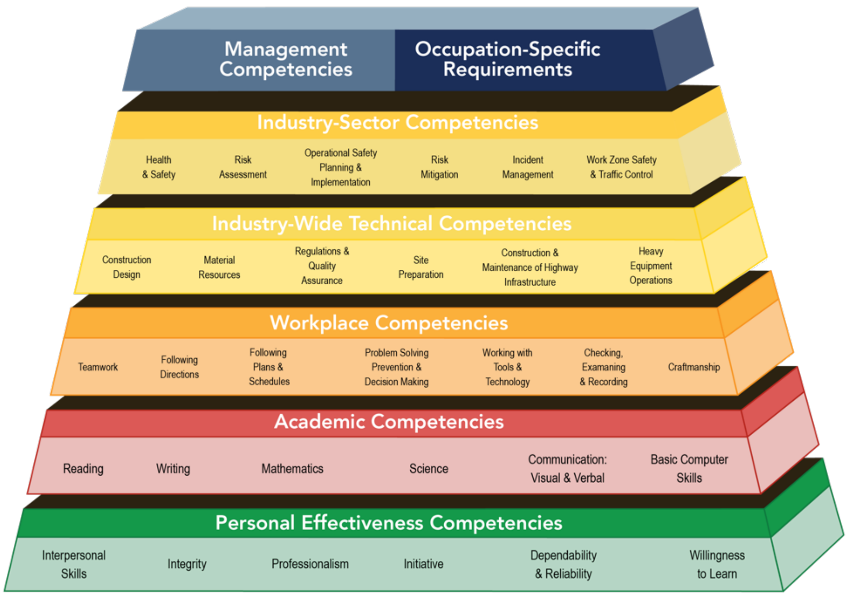

Figure S9: DOL Competency Model for Road Maintenance & Construction

Road Construction & Maintenance Safety Career Pathway

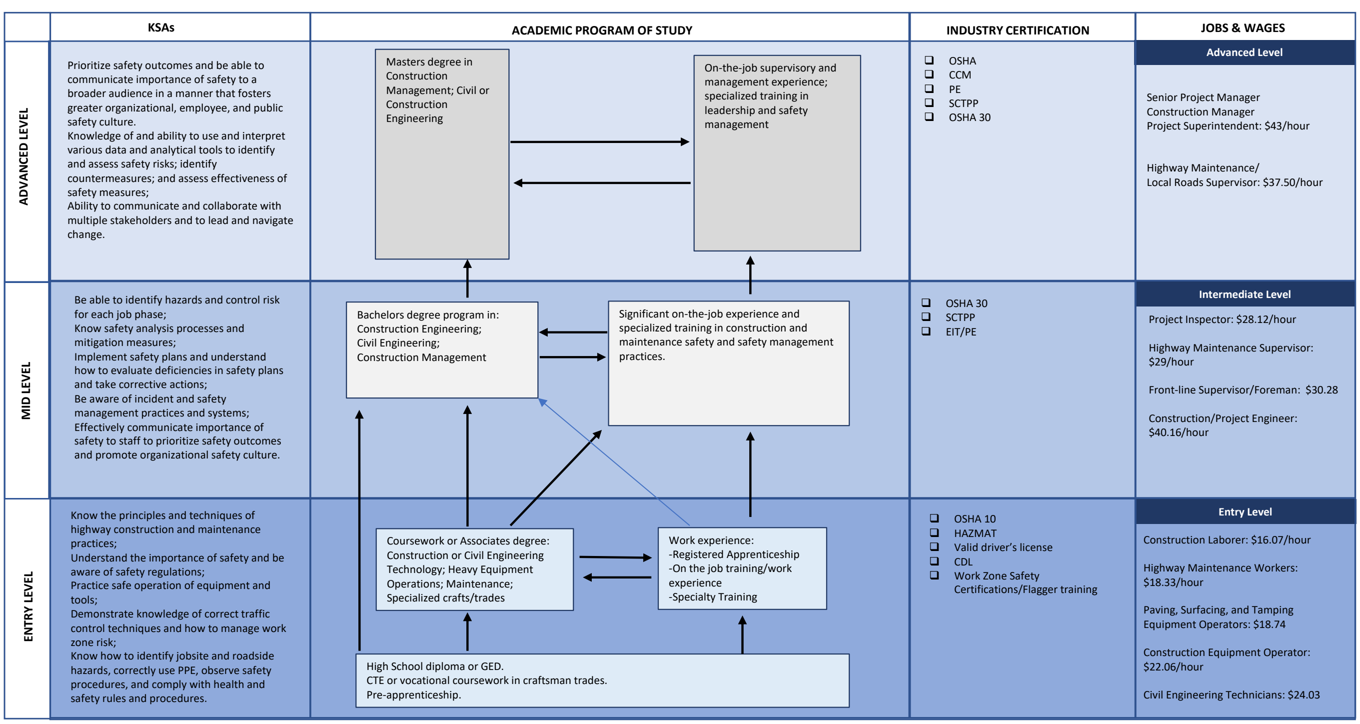

Figure S10: Career Pathway Template for Road Maintenance & Construction

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INNOVATIVE EXPERIENTIAL LEARNING

Given the institutional barriers evident in trying to create new coursework in engineering degree programs, or even new course content, as well as the challenges of implementing multidisciplinary curricula, researchers have focused on identifying models that provide experiential learning to students while still in school. These models are predicated upon the engagement of transportation agencies/organizations with institutions of higher education, to offer enrichment opportunities in the area of transportation safety.

WRTWC conducted outreach to a variety of transportation agencies and universities to better understand effective industry-education experiential models for transportation safety. To be effective and broadly replicable, these models must offer a win-win opportunity for both industry and educators. Figure S7 represents this general concept:

Figure S7: General Experiential Learning Model

Examples of University/State DOT Safety Analysis Collaborations

1. *Utah DOT (UDOT) contracts with Brigham Young University (BYU) to develop safety countermeasure improvements, develop and improve safety models (crash prediction, crash severity, and intersection crash prediction models), analyze up-to-date safety data, and identify countermeasures. Project development is a collaborative effort between, allowing for progressive improvements as partners jointly identify next steps. Since the collaboration began, more than 25 students (primarily from Civil Engineering and Statistics programs) have been involved. Many of these alumni have since entered safety-focused careers, either at the DOT or with private consulting firms.* (Grant Schultz of BYU, Robert Hull formerly UDOT, Oct 2017)

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2. *Alabama DOT (ALDOT) contracts with five Alabama state universities to implement safety-focused project work. These relationships allow for universities to serve as one-stop sources for data and analysis across agencies (i.e., courts, revenue, law enforcement, etc.) and to provide ALDOT with access to multidisciplinary expertise that would be difficult to obtain in-house (e.g. Computer Science). They also facilitate quicker project implementation, collaborative project scoping and development over time, while also building student interest and expertise in transportation safety.* (Tim Barnett & Waymon Benifield, ALDOT, Feb 2018)

3. *Iowa DOT and Iowa State University (ISU) partner to develop safety data analysis and visualization tools that facilitate collection, sharing, and integration of crash data across the state. These projects utilize undergraduate and graduate students, many who pursue safety consulting work after graduation. University of Kentucky and Kentucky DOT are currently developing a similar traffic safety data service partnership.* (Zach Hans, ISU Center for Transportation Research & Education, Dec 2017)

4. *California Office of Traffic Safety and California state universities work together to implement outreach, education, research, and data and information sharing for safety initiatives in California, through grant funding from the National Highway Traffic Safety Administration (NHTSA). The University of California at Berkeley has contributed to a variety of projects, including an injury mapping system, safe streets assessments, and motorcycle collision studies, conducts a safety course (cross-listed between Public Health and Civil Engineering), and hosts informational websites with grant support. Currently, approximately 75 university alumni have been involved in safety projects through this collaboration; alumni that now carry forward a safety mindset and toolkit into their planning or engineering careers.* (Jill Cooper, UC Berkeley, Nov 2017)

Examples of University – Public Agency Partnerships for Engaged Learning

Other models for education/industry collaborations include those that provide formal structures or mechanisms for integrating experiential learning into multidisciplinary coursework using real-world problems or projects from industry, agency, or community partners. Specific examples of this model include:

1. *The Educational Partnerships for Innovation in Communities (EPIC) model provides mechanisms to systematically match local priority projects with university capacity. This model is based on existing agency priorities and existing university courses and structures, making it easily adaptable to local contexts. This model provides a formalized structure to addressing critical issues facing local government agencies, while also training the next generation workforce in high impact, multidisciplinary practices on a larger scale. EPIC could be used to advance innovation in transportation safety goals.*

2. *Many universities support community-engaged scholarship by supporting staff or activities that help facilitate the integration of community-based projects into coursework. Examples include the Office of Community-University Partnerships & Service Learning (CUPS) at the University of Vermont, which trains faculty*

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on the practice of service-learning and ensures students have access to a variety of service-learning courses each year in partnership with community organizations. Universities with offices or other formal mechanisms like CUPS could be utilized by transportation organizations to collaborate with faculty on safety-focused community projects, to expose students to transportation safety issues, and to involve students from multiple disciplines in safety-related systemic problem-solving.

CROSS-DISCIPLINARY PATHS

In recognition that safety is at its essence both cross-disciplinary and cross-cutting across a variety of key occupations, the Safety DWG identified core safety competencies for transportation professionals (Safety DWG, Sep 2017). "Core competency" is used to distinguish organizational or industry-wide competencies versus individual, occupation-specific ones. Core competencies represent KSAs that are widespread and shared across sub-units or disciplines. WRTWC and its DWG advisory recognized that identification of cross-occupational skillsets will help new career entrants build a portfolio of safety skills and experience that facilitates the greatest career flexibility and allows for multiple career paths into safety-related careers. These cross-occupational safety competencies are listed below:

Table S2: Cross-Occupational Safety Competencies

CORE COMPETENCIES FOR TRANSPORTATION SAFETY PROFESSIONALS
Awareness of the importance of safety and ability to communicate importance to a broader audience in a manner that fosters greater organizational, employee, and/or public safety culture.
Understanding of safety management principles and the safety planning process.
Ability to identify and apply regulatory requirements.
Knowledge of, or ability to locate, use, and interpret various data and information sources and analytical tools to: 1. Identify and assess safety risks. 2. Identify appropriate countermeasures to mitigate risks (including prioritization of multiple options using a data-based decision-making process). 3. Assess effectiveness of safety measures.
Ability to effectively develop and/or implement a safety plan.
Ability to communicate and collaborate with multiple stakeholders and to lead and navigate change.
Ability to recognize the capabilities and limitations of road users in terms of behavior choices, reactions to transportation systems, and the capacity to survive a crash.

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DISCIPLINARY SUMMARY

The development of career paths for transportation safety professionals is confounded by both evidence of demand for safety professionals and a quantitative lack of it. In Hauer's 2007 "A Case for Evidence-Based Road Safety Delivery", he makes a point that is both simple and profoundly challenging for the purposes of the Safety Career Pathways Initiative.

> *"The question is how to bring into existence a healthy layer of professionals to be the carriers and suppliers of factual road-safety knowledge. Three conditions must exist: there has to be sufficient factual knowledge; there have to be textbooks, teachers, and courses of study by which the factual knowledge is imparted onto trainees; and there have to be jobs in which the graduates make use of the knowledge they mastered. … I believe that factual knowledge is sparse and training for professionals is sporadic because there is virtually no demand for the services of persons trained in road-safety."* (Hauer, 2007, pg. 335)

While there has recently been significant progress related to the development of textbooks, courses, and even full degree programs dedicated to transportation safety, there remains a major challenge. Because there are so few official "safety" occupations, there is a notable lack of an obvious career ladder offering progressive career advancement. As Hauer notes, *"Without demand there is no supply* (ibid., 335)*"*. The success of a safety career pathway implementation plan is underpinned by industry demand for safety professionals possessing safety competencies.

To demonstrate that demand, transportation employers must:

1. *Value transportation safety skills within their organization.*
2. *Seek to advance and measure safety outcomes in all aspects of their operations*
3. *Reward and recognize workers for developing safety competencies.*

In recognition of this fact, WRTWC's development of a Transportation Safety Career Pathways implementation plan will integrate industry-involved experiential and work-based learning as a key component to activating defined pathways into safety careers.

REFERENCED CITATIONS

Safety Discipline Working Group meeting 1, May 31, 2017

Safety Discipline Working Group meeting 1, May 31, 2017

Safety Discipline Working Group meeting 2, September 21, 2017

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Phone interviews (May 12, 2017) with Chief Safety Engineer, Nevada DOT; and County Engineering Services Manager, Thurston, Washington

Phone interviews (May 12, 2017) with Chief Safety Engineer, Nevada DOT; and Highway Safety Manager, Idaho Transportation Department

Barnett, T., Herbel, S., Hull, R., Beer, P. (2017). Road Safety Workforce Development in the United States. Presented at the 27th CARSP Conference, Toronto, ON, June 18-21, 2017.

National Center for Rural Road Safety (2017). Development Materials for a Local Maintenance Personnel Rural Road Safety Recognition Program. Prepared for the U.S. Department of Transportation Federal Highway Administration and available online: https://ruralsafetycenter.org/resources/list/development-materials-for-a-local-maintenance-personnel-rural-road-safety-recognition-program/

NACE is currently developing the program based on personal communication with the National Center for Rural Road Safety project manager.

National Center for Rural Road Safety (2017). Development Materials for a Local Maintenance Personnel Rural Road Safety Recognition Program. Prepared for FHWA, online: https://ruralsafetycenter.org/resources/list/development-materials-for-a-local-maintenance-personnel-rural-road-safety-recognition-program/

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Based on phone interview with Tim Barnett and Waymon Benifield, Alabama DOT, February 2018

Based on phone interview with Zach Hans from Iowa State University, Center for Transportation Research and Education, December 2017

Based on phone interview with Jill Cooper, UC-Berkeley, November 2017

Safety Discipline Working Group meeting 2, September 21, 2017

APPENDIX A: ACRONYMS

Appendix A: Acronyms

The following acronyms are in use within this report:

AASHTO = American Association of State Highway & Transportation Officials
APA = American Planning Association
APTA = American Public Transportation Association
APWA = American Public Works Association
ARTBA = American Road & Transportation Builders Association
BLS = Bureau of Labor Statistics
CSULB = California State University, Long Beach
CTE = Career and Technical Education
DOL = Department of Labor
DOT = Department of Transportation
DWG = Discipline Working Group
FHWA = Federal Highway Administration
GIS = Geographic Information Systems
HME = Highway Maintenance Engineering
ITE = Institute of Transportation Engineers
ITS = Intelligent Transportation Systems
KSA = Knowledge, Skills, and Abilities
LATTC = Los Angeles Trade Technical College
MAASTO = Mid America Association of State Transportation Officials
MTWC = Midwest Transportation Workforce Center
NAICS = North American Industry Classification System
NASTO = Northeast Association of State Transportation Officials
NCHRP = National Cooperative Highway Research Program
NETWC = Northwest Transportation Workforce Center
NNTW = National Network for the Transportation Workforce
NTCPI = National Transportation Career Pathways Initiative
PCB = Professional Career Building
SCAG = Southern California Association of Governments
SCTTP = Safety Certification for Transportation Project Professionals
SETWC = Southeast Transportation Workforce Center
SOC = Standard Occupational Classification
SWTWC = Southwest Transportation Workforce Center
TC3 = Transportation Curriculum Coordination Council

APPENDIX A: ACRONYMS

TRB = Transportation Research Board
TWSI = Transportation Workforce Strategic Initiative
WRTWC = West Region Transportation Workforce Center

ATTACHMENT A: TRANSFORMATIONAL TECHNOLOGIES

TRANSFORMATIVE TECHNOLOGY	DESCRIPTION	POTENTIAL WORKFORCE IMPATCT
Connected/Automated Vehicles - In-vehicle crash avoidance systems - V2V/V2I/I2V - Self-driving vehicles. - Remote train control (PTC, CBTC) - Truck platooning	Connected vehicles are those communicating with other vehicles or with the infrastructure. Automated vehicles are those in which at least some aspect of a safety-critical control function (e.g., steering, throttle, or braking) occurs without direct driver input. Includes “autonomous vehicles”.	Human-machine/computer interaction skills, analysis techniques for large datasets, predictive analytics. The operations discipline will become increasingly dependent on expertise in the area of computer technology, IS and data management and analysis, and cyber security. Reduced need and changed skillsets for commercial drivers. Planners will need knowledge and understanding of the specific construction needs of AV/CV infrastructure.
Robotics, Unmanned Aircraft Systems (UAS) - Inspection/maintenance robots - Automation - Drones - Machine-to-machine communication (M2M)	Robotic inspection technologies use tools such as aerial and surface robots, sensors, and 3D imaging to advance inspection methods of aging infrastructure. Most UAS that allowed to operate today are used for security, research, and environmental monitoring purposes. In recent years, private sector interest in UAS has increased rapidly – from crop dusting and land surveying, to package delivery and filmmaking.	Safety professionals will require knowledge of an expanded range of engineering disciplines, such as mechanical, electrical, and telecommunications. If UAS become state of practice, operators who manage these systems will require advanced analytical skills and understanding of complex robotics as well as the routing and logistics of these new networks. Pilots must have a FAA license. In the consultant world, engineers have the pilot license and need a co-pilot to help them maneuver. Will require a knowledge of UAS capabilities and risks. Transportation planners will also be expected to process data about UAS usage and impact on systems. Need to develop metrics for AUS use that impact the environment including noise and congestion impacts.
Big Data/Data Analytics - Big Data - Advanced Analytics - Data Collection - Machine Learning - Cloud Services	Big Data is a term used to describe the technologies and techniques used to capture and utilize the exponentially increasing streams of data with the goal of bringing enterprise-wide visibility and insights to make rapid critical decisions. Advanced analytics are using the growing capability of today’s computers to identify patterns, which can then be used to make well-informed predictions.	Ability to manage and analyze the data and leverage the information to improve efficiency and maximize performance. Within 15 years, certifications in data science will be required. HR Directors and Maintenance Training Directors will begin recruiting talent other than engineers. The expectation on the part of elected officials, commissioners and the general public that more data means better data will likely translate into greater pressures for the use of quantifiable performance metrics in project review. This could result in greater numbers of transportation planners within both public agencies and in private firms. The ability to "read" good vs bad data will become more challenging and also open up opportunities for data scientists with an expertise in transportation.
Intelligent Transportation Systems (ITS)	An intelligent transportation system (ITS) is an advanced application which aims to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.	Strong understanding of telecommunications, electrical engineering, and mechanical engineering impacts of advanced vehicle technologies like ITS will be necessary. There is a critical need for adaptive learning and continuing education. The application of cross-discipline approaches will continue and the need for the knowledge and skills to understand and apply information and knowledge from other areas and to think across disciplines is critical. Evaluation of apps and integration of third party or cloud solutions with agency ITS monitoring. ITS creates incentives to plan along transportation corridors. This means planning at the regional level or across jurisdictional boundaries. This may require skill sets in eliminating institutional barriers to data sharing.
Intelligent Tracking & Navigation Systems - GPS - GIS	Geo-Spatial Visualization combines geographic information systems (GIS) with location-aware data, RFID (radio frequency identification), and other location-aware sensors (including the current location of users from the use of their mobile devices) to create new insights and competitive advantage.	Safety professionals identified GIS certification, training in spatial visualization, and experience with programs like TransCAD as "in demand credentials." Part of day-to-day operations and requires professionals to be adept with technology and to be able to analyze and interpret data to understand how operational efficiencies can be impacted. New requirements for Electronic On Board Readers (EOBR) in trucking will make new kinds of data available but also require additional background knowledge of freight systems. Understanding data security and demonstrating compliance with restrictions on data use.

ATTACHMENT A: TRANSFORMATIONAL TECHNOLOGIES

TRANSFORMATIVE TECHNOLOGY	DESCRIPTION	POTENTIAL WORKFORCE IMPATCT
Virtual & Augmented Reality (VR/AR)	Virtual reality (VR) is a computer technology that uses headsets or multi-projected environments to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual or imaginary environment.	The use of VR/AR technologies in safety training may facilitate the development of key safety competencies within the workforce. However, to incorporate VR/AR trainings into safety curriculums, educators will also need to develop VR/AR skills and have access to equipment and facilities. From a training standpoint, VR/AR can allow workers and students to participate in interactive, hands-on training in much more authentic settings that can deepen understanding and improve skillset acquisition. These technologies have the potential to decentralize the workforce as one does not need to be at the site. AR and VR also create a demand for the data mined and assessed by travel behavior/human factors researchers.
Artificial Intelligence (AI)	Artificial intelligence (AI), also machine intelligence (MI), is intelligence displayed by machines, in contrast with the natural intelligence (NI) displayed by humans and other animals.	Will need time to understand and trust the automatic "decision-making" conducted by AI systems. DOTs will begin hiring technians for AI applications. Understanding and usage of predictive analytics
Shared Mobility - Smartphones - On-demand services (HaaS, Saas) - E-construction	A growing smartphone presence (64 percent of all Americans, and 85 percent of Americans ages 18-29 now own a smartphone). E-construction refers to the practice of having construction management and documents digitized and quickly distributed to stakeholders through mobile devices	To promote use of new shared mobility services, practitioners will need to increase their understanding of psychological/cultural factors that impact transportation mode choice. E-construction will further increase the need for professionals with strong data analysis and IT skills. Management of shared mobility system operations, particularly as this becomes an increasing share of vehicles on the road, requires workers that can analyze data, troubleshoot systems, develop and improve apps
Energy - Alternative Fuel Vehicles - Charging/Refueling Infrastructure - Energy Efficient Mobility Systems (EEMS) - Sustainable Transportation - Wireless Power Transfer (WPT)	Different sources of and approaches to more effective and efficient management of fuel usage and infrastructure.	Mechanics will need to be trained on how to maintain the engines powered by these new sources. The location and distribution of available energy sources may impact supply chain decisions and also could affect traffic operations. The future highway worker may be adept at managing all the facilities in the right of way. This may require certifications in the maintenance of new equipment. Transport planners designing and managing infrastructure for different kinds of vehicles will need to develop a better understanding of fuel technologies and their operating characteristics.
3D Printing (Additive Manufacturing)	3D printing allows three‐dimensional objects to be created with great precision, using a laser or an extruder to build an object layer by layer.	In freight/logistics, there will be a need for workers with understanding of additive manufacturing processes, merging transportation and manufacturing workforces. The changing patterns of trade inc. truck movements/drayage, imports, and domestic transport resulting from additive manufacturing will require freight transport planners to gather and assess new kinds of data.
Miscellaneous Tech - Material Science (nanotechnology) - Hyperloop - Internet of Things (IoT) - Innovative Concepts for Vulnerable Road Users		The hyperloop would not only open a new field of needs for engineers and maintenance people, but it would also require a new level of data analysis and implementation, cyber security protection, and project management. Workers will need to develop tools that can quickly evaluate technologies so adoption is not delayed. Bridge technologies like HSR create a need for expertise in construction design and management that differ from more traditional transport system design. The development of CA's system has identified a vacuum in training programs that prepare the workforce to build the system.

ATTACHMENT B: OPERATIONS PATHWAYS

Traffic Operations Pathway: Traffic Engineers or Project Managers

	KSAs	ACADEMIC PROGRAM OF STUDY		INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of Transportation and Traffic Engineering/Operations Knowledge of Project Management Practices Managerial/ Supervisory Experience and Leadership Skills Communication Skills, Written and Verbal Experience with Synchro, VISSIM, SimTraffic, HCS, Sidra, or VISTRO software	Master's degree preferred *Major Coursework in Civil Engineering or related field strongly preferred*	Supervisory experience required 6-10 years experience in management of traffic engineering projects	❑ Envision Sustainability Professional (ENV SP) ❑ AICP	**Advanced Level** **Advanced Traffic Operations Project Manager** **Advanced Traffic Operations Engineer** $55.67 (mean hourly rate from job descriptions)
MID LEVEL	Knowledge of Transportation and Traffic Engineering/Operations Knowledge of Agency Procedures/ Standard Design Principles Communication Skills, Written and Verbal Experience with AutoCAD, MicroStation, or Geopak Experience with Synchro, VISSIM, SimTraffic, HCS, Sidra, or VISTRO software	Bachelor's Degree Required or In Progress Master's Degree sometimes preferred *Major Coursework in Civil Engineering*	5-9 years experience in transportation or traffic engineering	❑ Professional Engineering License ❑ Professional Traffic Operations Engineer ❑ IMSA Traffic Signals Level II or III	**Intermediate Level** **Traffic Operations Engineer** $32.28 (mean hourly rate from job descriptions) • Associate Traffic Engineer • Traffic Operations Design Engineer • Traffic Project Engineer **Traffic Operations Program/Project Manager** $39.36 (mean hourly rate from job descriptions) • Transportation Project Manager **Traffic Engineer/Program Manager** $43.14 (BLS mean hourly wage 2016)
ENTRY LEVEL	Communication Skills, Written and Verbal Analytical, Mathematical, or Problem-solving Skills Interpersonal Skills Ability to work well on a team Experience with AutoCAD, MicroStation, or Geopak	Bachelor's Degree Required or In Progress Master's Degree sometimes preferred *Major Coursework in Civil Engineering*	0-3 years experience in traffic engineering	❑ Engineer-in-Training (EIT) certification ❑ Driver's License	**Entry Level** **Entry Level Engineer** • Operations and Maintenance Engineer Intern • Civil Engineering Intern • Assistant Traffic Engineer $35.47 (mean hourly rate from job descriptions)

Traffic Operations Pathway: Traffic Signal/ITS Technicians

	KSAs	ACADEMIC PROGRAM OF STUDY		INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of Transportation and Traffic Engineering/Operations Knowledge of ITS Technology and Operations Knowledge of Local Agency Procedures/ Standard Design Principles Knowledge of Traffic Control Devices Communication Skills, Written and Verbal Interpersonal Skills Managerial or Supervisory Experience and Leadership Skills Knowledge of Microsoft Office Programs	Bachelor's degree required *Major coursework in Civil or Electrical Engineering with experience in ITS planning, design, or implementation*	3-9 years experience in ITS supervisory/ management position (education may count toward experience)	❑ Professional Engineering License ❑ Safety Impact Certificate	**Advanced Level** **Traffic System Supervisor** • Traffic Devices Certification • Traffic Systems Supervisor • Traffic Signal/ITS Engineer $23.44 (mean hourly rate from job descriptions)
MID LEVEL	Knowledge of ITS Technology and Operations Knowledge of the Electrical Trade Knowledge of Traffic Control Devices Management of Labor, Tools, or Materials Ability to read and interpret diagrams, schematics, blueprints, etc. Analytical, Mathematical, or Problem-solving Skills Communication Skills, Written and Verbal General Computer Skills	Some additional training required (technical, vocational, or college level) Associate's degree sometimes required *Major coursework in Electronics, Electrical Engineering, Engineering Technology, Computer Technology*	5-8 years experience as electrician or traffic signal technician (construction experience is also sometimes applicable)	❑ IMSA Traffic Signal Level II ❑ Networking Certifications ❑ BICSI Certifications ❑ Fiber Certifications ❑ Wireless Certifications ❑ Comtrain Tower Climbing Certification	**Intermediate Level** **ITS Technician** $18.51 • ITS Field Technician • ITS Locator • Traffic Signal/ ITS Technician **Traffic Systems/ Signal Technician II** $19.85 (mean hourly rate from job descriptions)
ENTRY LEVEL	Knowledge of Traffic Control Devices Knowledge of the Electrical Trade Operation of relevant equipment/machinery Communication, Written and Verbal Ability to follow/interpret instructions Interpersonal Skills Ability to read and interpret diagrams, schematics, blueprints, etc. General Computer skills	High School Diploma or GED required Some additional training required (vocational, technical, or college level coursework) *Major coursework in Electronics or related field*	1-5 years experience with installation, maintenance, and repair of traffic signals or related system (education may count as experience)	❑ Driver's License with a good driving record ❑ Commercial Driver's License (Class A, B, or C with airbrake endorsements) ❑ IMSA Traffic Signal Level I, II, or III ❑ Work Zone Traffic Control ❑ Electrician Certification	**Entry Level** **Traffic Systems Signal Technician I** • Traffic Signal Installer $18.64 (mean hourly rate from job descriptions)

ATTACHMENT B: OPERATIONS PATHWAYS

Traffic Operations Pathway: Traffic Incident Managers

	KSAs	ACADEMIC PROGRAM OF STUDY		INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of TMC Operations Communication Skills, Written and Verbal Interpersonal Skills Managerial/ Supervisory Experience and Leadership Skills Time and Task Management Skills Technical Communication/Report Development Skills General Computer Skills Knowledge of Microsoft Office Programs	Associate's or Bachelor's Degree required ↑ Bachelor's Degree or at least some college preferred *Major Coursework in Safety Management, Civil Engineering, or related field*	Supervisory experience required ↑ 3-5 years experience in traffic operations (preferably in a TMC) with emphasis on safety or emergency response work	❑ Commercial Driver's License (Class A, B, or C) ❑ Professional Engineering License ❑ International Municipal Signal (Level I & II) ❑ Basic Electronics and Fiber Optics ❑ Driver's License	**Advanced Level** **TMC Supervisor or Senior Operator** • TMC Shift Supervisor • Field Operations Supervisor **TMC Manager or Coordinator** • Incident Management Coordinator • Senior TMC Operator $80,521 Salary (Indeed.com)
MID LEVEL	Knowledge of Transportation and Traffic Engineering/Operations Knowledge of ITS Technology and Operations Possess professional judgement Communication Skills, Written and Verbal Technical Communication/Report Development Skills General Computer Skills	Bachelor's Degree Required ↑ High School Diploma or GED Required	At least 2 years experience in emergency highway response or related field	❑ Driver's License ❑ Class A Commercial Driver's License	**Intermediate Level** **TMC Engineer** • Incident Management Engineer **TMC Technician** $16.37/hour (Indeed.com) • Emergency Operations Technician • Emergency Response Technician
ENTRY LEVEL	Knowledge of TMC Operations Knowledge of Regional Highway Systems Communication Skills, Written and Verbal Interpersonal Skills Ability to work in fast-paced or stressful environment General Computer Skills Knowledge of Microsoft Office Programs	High School Diploma or GED Required	0-2 years experience in technical operations		**Entry Level** **TMC Operator or Dispatcher** • Dispatch Clerk • Operator • Operator I • Traffic Management Operator • Traffic Management Dispatcher $16.50 (mean hourly rate from job descriptions)

Transit Operations Pathway: Civil Transit Engineers + Transit Project Managers

	KSAs	ACADEMIC PROGRAM OF STUDY			INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of Transit Operations Managerial/ Supervisory Experience and Leadership Skills Communication Skills, Written and Verbal Technical Communication/Report Development Skills Experience with AutoCAD, Civil 3D, MicroStation, or similar	Master's degree preferred *Major Coursework in Civil Engineering or related field strongly preferred*	**Senior Civil Engineers** 6-12 years engineering project experience	**Senior Project Managers** 9-17 years of planning or design project management experience	❑ Professional Engineering License Required ❑ PMP Certification ❑ AICP can sometimes replace PE	**Advanced Level** **Senior Rail/Transit Engineer** $54.58 (mean hourly rate from job descriptions) • Civil Engineer Department Manager - Transportation • Senior Civil Engineer - Transit/Rail **Senior Project Manager** • Senior Project Engineer/Project Manager • Senior Project Manager - Rail & Transit
MID LEVEL	Knowledge of Transit Operations Knowledge of Agency Procedures/ Standard Design Principles Knowledge of Project Management Practices Communication Skills, Written and Verbal Interpersonal Skills Experience with AutoCAD, Civil 3D, MicroStation, or similar Knowledge of Microsoft Office Programs	Bachelor's Degree Required or In Progress; Master's Degree sometimes preferred *Major Coursework in Civil or Structural Engineering for CE* *Major Coursework in Information Technology, Architecture, Business, Construction Management, Planning, or Civil/Mechanical Engineering for PM*	**Civil Engineers** 3-10 years experience in transportation, emphasis on design or construction management	**Project Managers** 5-16 years experience in transit project management	❑ Professional Engineering License	**Intermediate Level** **Civil Engineer, Transit** $41.90 (mean hourly rate from job descriptions) • Civil Engineer II - Transportation • Civil Engineer, Rail & Transit • Transportation Engineer **Project Manager, Transit** $44.27 (mean hourly rate from job descriptions) • Project Manager-Rail & Transit • Project Manager II • Transportation Project Manager
ENTRY LEVEL	Knowledge of Civil Engineering applied to the Transit Industry Knowledge of Local Area Procedures/Standard Design Principles Communication Skills, Written and Verbal Interpersonal Skills Ability to be innovative or creative Experience with AutoCAD, Civil 3D, MicroStation, or similar	Bachelor's Degree Required or In Progress Master's Degree sometimes preferred *Major Coursework in Civil Engineering (sometimes with Transportation emphasis)*	1-4 years experience in civil or transportation engineering work		❑ Engineer-in-Training (EIT) certification ❑ Driver's License	**Entry Level** **Associate or Entry-Level Civil Engineer** $25.44 (mean hourly rate from job descriptions) • Civil Engineering Intern • Assistant Civil Engineer • Associate Transportation Engineer

ATTACHMENT B: OPERATIONS PATHWAYS

Transit and Freight Operations Pathway: Commercial Drivers

	KSAs	ACADEMIC PROGRAM OF STUDY	INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Communication Skills, Written and Verbal Interpersonal Skills Ability to work a flexible/irregular schedule Ability to perform manual labor/ meet physical requirements General Computer Skills Knowledge of Microsoft Office Programs Ability to operate relevant equipment or software	High School Diploma or GED Required Bachelor's Degree preferred *Major Coursework in business, transportation, safety or other relevant area* Past experience in similar business required, supervision of bus operators preferred.	❑ Commercial Driver's License (CDL) Required ❑ Class A or B CDL with Airbrake and Passenger Endorsements ❑ Good driving record required	**Advanced Level** **Transit Operator Supervisor** • Supervisor, Transit Service Delivery $29.72 (mean hourly rate from job descriptions)
FREIGHT	Knowledge of Local Agency Procedures Interpersonal Skills Ability to perform manual labor/ meet physical requirements **Communication Skills, Written and Verbal** **Possess a good attitude/work ethic**	Must be at least 21-24 years old in many cases 0-2 years driving experience, commercial driving experience preferred	❑ CDL Required- Class A (or sometimes Class B) with the following endorsements: ❑ **Hazardous Materials** ❑ **Tank Vehicle** ❑ **Double or Triple Trailer** ❑ **Airbrake** ❑ Good driving record required	**Freight Driver/Operator** • **Commercial Driver** • **Equipment Operator** • **Route Delivery Driver** • **Truck Driver Class A** **$26.29** (mean hourly rate from job descriptions)
TRANSIT	Knowledge of Local Agency Procedures Knowledge of Local Geography Communication Skills, Written and Verbal Interpersonal Skills Possess professional judgement Ability to work a flexible/irregular schedule Ability to pass a background check/ drug screening Ability to perform manual labor/ meet physical requirements **Ability to work well independently** Ability to operate relevant equipment or software	Must be at least 21 in some cases High School Diploma or GED required 1-5 years driving experience, commercial driving experience preferred (training can sometimes count experience)	❑ CDL Required- Class A, B, C or D with the following endorsements: ❑ Airbrake ❑ Passenger ❑ Good driving record required ❑ **Driver's License with a good driving record required** ❑ **Class A, B, or C CDL with Airbrake and Passenger Endorsements** **(On the job training toward obtaining a CDL is sometimes available)**	**Paratransit Driver/ Operator** • **Paratransit Bus Driver** • **Paratransit Driver** • **Van Driver - Paratransit** **$13.46** (mean hourly rate from job descriptions) **Bus or Shuttle Driver/Operator** • Airport Shuttle Bus Driver • Bus Driver • Bus Operator / Motor Coach Driver • Chariot Driver – Commuter $16.11 (mean hourly rate from job descriptions)

Transit and Freight Operations Pathway: Diesel Mechanics/ Diesel Shop Technicians

	KSAs	ACADEMIC PROGRAM OF STUDY	INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of Vehicle Systems/ Mechanical Aptitude Knowledge of Electrical and Hydraulic Systems Knowledge of Local Agency Procedures/ Standard Design Principles **Time and Task Management Skills** **Ability to work a flexible/irregular schedule** Ability to operate relevant equipment or software General Computer Skills	High School Diploma or GED Required Vocational/ Technical Training Required • Trade School Certification or Diploma in Diesel Technology • Associate's degree 3-7 years experience fleet maintenance or diesel equipment maintenance and repair (education can count toward experience in most cases)	**In addition to the certifications listed below:** ❑ Automotive or Medium/ Heavy Duty National Institute for Automotive Service Excellence (ASE) Certification ❑ Annual Inspector Certification ❑ Brake Inspector Certification ❑ 608 and 609 HVAC – Refrigeration Certification	**Advanced Level** **Senior Diesel Technician/ Mechanic** • Diesel Fleet Mechanic Technician II • Diesel Mechanic III • Senior Diesel Technician/Mechanic • Head Diesel Mechanic $31.50 **in Transit and** $26.44 **in Freight** (mean hourly rate from job descriptions)
MID LEVEL	Knowledge of Vehicle Systems/ Mechanical Aptitude Knowledge of Equipment Management Communication Skills, Written and Verbal Ability to work well on a team Interpersonal Skills Possess a good attitude/work ethic General Computer Skills Ability to operate relevant equipment or software	Additional Vocational/ Technical Training Preferred in Diesel/Automotive Mechanics High School Diploma or GED Required 1-4 years experience heavy duty diesel or automotive equipment repair and maintenance (education can count toward experience in some cases)	**Relevant Industry Certifications for Technicians and Mechanics:** ❑ Driver's License ❑ Class A or B CDL with Passenger and Airbrake Endorsements ❑ National Institute for Automotive Service Excellence (ASE) Certification ❑ Journeyman's Card ❑ Diesel Mechanic Certification	**Diesel Technician** • Diesel Technician • Heavy Duty Diesel Technician • Fleet Services Technician • Truck & Trailer Diesel Tech. $35.97 **in Transit and** $29.13 **in Freight** (mean hourly rate from job descriptions)
ENTRY LEVEL	Knowledge of Vehicle Systems/ Mechanical Aptitude Knowledge of Diesel Technology Knowledge of Equipment Management Practices Communication Skills, Written and Verbal Time and Task Management Skills Ability to follow/ interpret instructions Ability to operate relevant equipment or software	Additional Vocational/ Technical Training Preferred • Trade School Certification • Associate's degree High School Diploma or GED Required 1-5 years experience in heavy equipment mechanics (education can count toward experience in some cases)	Some additional relevant certifications: ❑ Transportation Workers Identification Card ❑ HVAC Certification ❑ Forklift Certification ❑ Welding Certification ❑ **Valid DOT Medical Card**	**Diesel Mechanic** • Diesel & Heavy Equipment Mechanic • Diesel Mechanic • Diesel Truck Mechanic $26.67 in Transit and $29.10 in Freight (mean hourly rate from job descriptions)

ATTACHMENT B: OPERATIONS PATHWAYS

Freight Operations Pathway: Industrial Engineers + Operations Research/Modeling Analysts

	KSAs	ACADEMIC PROGRAM OF STUDY	INDUSTRY CERTIFICATION*	JOBS & WAGES*
ADVANCED LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Knowledge of Project Management Practices Problem solving, mathematical, or critical thinking skills Communication Skills, Written and Verbal Possess a good attitude/work ethic AutoCAD/ MicroStation/ Geopak SAS/ SAP ERP	Bachelor's Degree Required *Major Coursework in Transportation, Supply Chain Management, Operations Research, Mathematics, Logistics Management, Industrial Engineering, Business Administration, or other quantitative field* 5-10 years of supply chain leadership/management and engineering experience in logistics/ transportation		**Advanced Level** Supply Chain Manager or Senior Analyst • Director of Supply Chain Engineering • Senior Analyst, Operations Analysis • Supply/Demand Planning Program Manager
MID LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Knowledge of Material Handling/ Manufacturing Communication Skills, Written and Verbal Problem solving, mathematical, or critical thinking skills Interpersonal Skills AutoCAD/ MicroStation/ Geopak SAS/ SAP ERP	Bachelor's Degree Required or In Progress; Master's Degree sometimes preferred *Major Coursework in Computer Science, Data Analytics, Engineering (Industrial, Electrical, Systems or Mechanical), Logistics Management, Operations Research, Statistics, Supply Chain Management, or Transportation, or other related field* 2-5 years experience transportation and/or production industry 1-3 years experience logistics planning or process engineering		**Intermediate Level** Logistics/Supply Chain Engineer • Industrial Engineer • Logistics Engineer I • Manufacturing Engineer • Logistic Engineer/Distribution Analyst Logistics Coordinator/Analyst • Logistics Coordinator • Logistics Operation Analyst • Materials Analyst II
ENTRY LEVEL	Knowledge of Project Management Practices Communication Skills, Written and Verbal Time or task management skills Organizational Skills/ Detail Oriented Interpersonal Skills Problem solving, mathematical, or critical thinking skills AutoCAD/ MicroStation/ Geopak	Bachelor's Degree Required or In Progress Master's Degree sometimes preferred *Major Coursework in Industrial Engineering, Logistics/Transportation Management, Operations Research/Management, Supply Chain, Finance, or other related business field*		**Entry Level** Logistics Intern • Intern - Global Logistics • Intern - Industrial Engineering • Logistics Analyst Intern

**Dataset did not include Certification or Salary Information*

Freight Operations Pathway: Data Science Analyst / Logisticians + Project and Program Managers

	KSAs	ACADEMIC PROGRAM OF STUDY	INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Analytical, Mathematical, or Problem-solving Skills Communication Skills, Written and Verbal Interpersonal Skills Managerial/ Supervisory Experience and Leadership Skills Knowledge of Microsoft Office Programs General Computer Skills Access, SQL, or other database software	Bachelor's degree required *Major coursework in Business, Computer Science, Economics, Engineering, Finance, Logistics, Management Info Systems, Mathematics, Operations, Statistics, or Supply Chain Management* 4-12 years in project management in a global supply chain environment	❑ PMP (Project Management Professional) Certification ❑ Driver's License	**Advanced Level** **Senior Analyst, Logistician, or Project Manager** • Senior Manager Global Logistics & Fulfillment • Senior Supply Chain Program Manager • Vice President / Director of Supply Chain • Logistics Analyst Senior $35.22 (mean hourly rate from job descriptions)
MID LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Communication Skills, Written and Verbal Analytical, Mathematical, or Problem-solving Skills Time and Task Management Skills Interpersonal Skills Organizational Skills/ Detail Oriented Knowledge of Microsoft Office Programs General Computer Skills	Bachelor's degree required (or Associate's degree for some Logistics Analyst positions) *Major coursework in Logistics, Business Analytics, Mathematics, Transportation, Logistics, Supply Chain, Business Administration, Engineering or other technical field* 3-10 years in years in Operations, Program Management, Project Management, Procurement and/or Logistics Management	❑ PMP ❑ CPM (Certified Project Manager) ❑ MPM (Master Project Manager) ❑ CPIM (Certified Production and Inventory Management)	**Intermediate Level** **Program/Project Manager or Level III** • Supply Chain Manager • Transportation Analyst III • Logistics Program Administrator • Transportation Operations Manager $32.45 (mean hourly rate from job descriptions)
ENTRY LEVEL	Knowledge of Transportation, Warehousing, Supply Chain, and Logistics Knowledge of Project Management Practices Communication Skills, Written and Verbal Analytical, Mathematical, or Problem-solving Skills Possess a good attitude/work ethic Interpersonal Skills Presentation Skills Time and Task Management Skills Knowledge of Microsoft Office Programs	Bachelor's degree required (or Associate's degree for some Logistics Analyst positions) Master's degree or MBA sometimes preferred *Major coursework in Engineering (Industrial, Mechanical, Manufacturing, or Software), Computer Science, Mathematics, Logistics, Supply Chain Management, Operations, Statistics, or Business (Economics, Finance, or Accounting)* 1-5 years Project Management, Supply Chain Procurement or Inventory Planning in a manufacturing company (background in statistical/ data analysis a plus)	❑ Certified Professional Logistician (CPL) preferred ❑ PMP Certification a plus ❑ Customs Broker's License ❑ Certified Lean Manager ❑ Forklift Certified ❑ Driver's License	**Entry Level** **Analyst or Logistician** • Logistics Analyst • Logistician • Supply Chain Management Specialist • Data Scientist • Operations Systems Analyst • Application Engineer $17.00 (mean hourly rate from job descriptions)

ATTACHMENT B: OPERATIONS PATHWAYS

Transportation Operations Pathway: Operations Planners

	KSAs	ACADEMIC PROGRAM OF STUDY		INDUSTRY CERTIFICATION*	JOBS & WAGES*
ADVANCED LEVEL	Knowledge Transportation Planning or Engineering Communication Skills, Written and Verbal Interpersonal Skills Managerial/ Supervisory Experience and Leadership Skills Ability to work well on a team Technical Communication/Report Development Skills Possess professional judgement	Bachelor's Degree Required *Master's Degree, MBA, or PhD preferred* *Major Coursework in Industrial, Civil, or Transportation Engineers, Urban/regional or Transportation Planning, Business, Public Administration, or Supply Chain/Logistics*	6-12 years of management experience in a transportation division or manufacturing operations environment	❑ Driver's License Required ❑ AICP Certification ❑ PE License ❑ PTOE	**Advanced Level** **Operations Planner III/ Planning Manager** • Manager, Global Strategic Planning & Analysis • Operations Director • Regional Operations Director • Senior Manager, Logistics Planning • Sr. Planning Manager • VP of Transportation $42.53 (mean hourly rate from job descriptions)
MID LEVEL	Knowledge Transportation Planning or Engineering Technical Communication/Report Development Skills Interpersonal Skills Communication Skills, Written and Verbal Ability to work well on a team General Computer Skills Knowledge of Microsoft Office Programs	Bachelor's Degree Required or In Progress Master's Degree or PhD preferred *Major Coursework in Civil or Transportation Engineering, Urban/regional or Transportation Planning, Operations, Logistics, Public Administration, Economics, Architecture or other related field*	2-6 years experience in transportation planning including scheduling, budgeting, zoning analysis, or business analysis	❑ Driver's License Required ❑ AICP Certification ❑ PE License ❑ IMSA Traffic Signal Level	**Intermediate Level** **Operations Planner/ Engineer** • Transit Planner • Transportation/Traffic Engineer • Operations Planner • Transportation Planner • Load Planner • Practice Leader, Transportation Planning • Transportation Planning Manager $25.82 (mean hourly rate from job descriptions)
ENTRY LEVEL	Knowledge Transportation Planning or Engineering Communication Skills, Written and Verbal **Interpersonal Skills** Ability to work well on a team Technical Communication/Report Development Skills Time and Task Management Skills Organizational Skills/Attention to Detail GIS Software	Bachelor's Degree Required or In Progress *Major Coursework in Engineering, Public Administration, Supply Chain Management, Transportation Planning, or other related field*	1-3 years experience in transportation planning or analysis	❑ EIT Certification	**Entry Level** **Operations Planning Intern** • Entry level Transportation Planner • Planner I • Traffic EIT • Transportation EIT $17.78 (mean hourly rate from job descriptions)

Transportation Operations Pathway : Computer and Information Systems Manager

	KSAs	ACADEMIC PROGRAM OF STUDY		INDUSTRY CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	Knowledge of IT Practices/Computer Science Principles Knowledge of Project Management practices (budgeting, scheduling, etc.) **Knowledge of Transportation Operations** **Managerial/ Supervisory Experience and Leadership Skills** **General Computer Skills**	Bachelor's Degree Required Master's degree or MBA sometimes preferred *Major Coursework in Civil Engineering or related field strongly preferred*	4-10 years of experience in computer technical development, program management, and/or system administration with technical management experience	❑ GIAC Certifications (GCIA, GCIH, GMON, GPPA or GCED) ❑ EC-Council (CEH, ECSA, CHFI) ❑ Cisco CCIE	**Advanced Level** **Senior Level Computer Information Systems Manager** • Engineering Manager • IT Leadership Development Program • IT Manager – Transportation • Analyst / Sr. Specialist Mechanical Systems • Lead IT Analyst • Senior Systems Product Manager $51.99 (mean hourly rate from job descriptions)
MID LEVEL	**Knowledge of IT Practices/Computer Science Principles** **Knowledge of Data Analytics** **Knowledge of Transportation Operations** **Technical Communication/Report Development Skills** **Communication Skills, Written and Verbal** **Analytical, Mathematical, or Problem-solving Skills** **General Computer Skills** **Knowledge of Microsoft Office Programs**	Bachelor's Degree Required *Major Coursework in Engineering, Mathematics, Physics, Computer Science, Information Technology, Business Administration*	2-8 years experience with **computers, systems or technical experience with Logistics / Transportation experience preferred**	❑ Professional Engineering License	**Intermediate Level** **Engineer/ Technologist/ Programmer** • Systems Engineer • Information Systems Programmer • Information Technology Security Engineer • ISSO-Security Engineering and Architecture • Information Technology Technician
ENTRY LEVEL	**Knowledge of IT Practices/Computer Science Principles** **Knowledge of Data Analytics** **Knowledge of Transportation Operations** **Communication Skills, Written and Verbal** **Technical Communication/Report Development Skills** **Possess a good attitude/work ethic** **General Computer Skills** **Knowledge of Microsoft Office Programs**	Bachelor's Degree Required or In Progress *Major Coursework Computer Science, Management Information Systems, Engineering, Supply Chain/Logistics, or Mathematics*	1-5 experience in IT systems design and development	❑ Driver's License Required ❑ Microsoft Certifications ❑ Comp TIA IT Certifications	**Entry Level** **IT Specialist/ Analyst** • IT Support Specialist • IT Analyst - Supply Chain Systems • Cyber Security Specialist • Paratransit Technical Support Data Analyst (Administrative Officer III)

ATTACHMENT C: HME STATE TRAINING SCAN

Scan of Training Offered at State DOTS by Classification and Salary (Sources: Laffey & AASHTO)

State	Highway Maintenance Level	Match Title	# Incumbents	Minimum Annual Pay Range	Midpoint Annual Pay Range	Maximum Annual Pay Range	Actual Low, Annual Salary	Actual Average, Annual Salary	Actual High, Annual Salary	State	%	Region	Percentage maintenance work performed by contract?	General Maintenance training provided by Community Colleges?	Is certification in general maintenance skills offered?	Does your organization align its training programs offerings with maintenance worker performance requirements?	Is the promotion of a frontline maintenance worker dependent on the completion of certain training requirements?	Notes
AK	1	Equipment Operator Sub-Journey II	7	38,610	42,237	45,864	42,081	47,547	53,157	AK	152%	4	Less than 50%		No	No	Yes	
AK	2	Equipment Operator Journey II	238	46,020	50,359	54,698	46,020	59,841	74,022	AK	152%	4	Less than 50%		No	No	Yes	
AK	3	Equipment Operator Lead	113	49,277	53,908	58,539	51,909	66,134	78,663	AK	152%	4	Less than 50%		No	No	Yes	
AK	4	Equipment Operator Foreman II	6	54,873	60,012	65,150	71,234	76,297	80,145	AK	140%	4	Less than 50%		No	No	Yes	
AL	1	Transportation Maintenance Technician I	224	22,272	28,931	35,590	22,272	24,035	35,590	AL	77%	2	No response		No	No response	No response	
AL	2	Transportation Maintenance Technician II	514	23,993	31,642	39,290	24,595	30,401	39,290	AL	77%	2	No response		No	No response	No response	
AL	3	Transportation Maintenance Technician III	201	26,465	35,441	44,417	27,806	36,606	44,417	AL	84%	2	No response		No	No response	No response	
AL	4	Transportation Maintenance Superintendent	70	33,902	45,294	56,686	33,902	47,765	56,686	AL	88%	2	No response		No	No response	No response	
AR	1	Maintenance Aide I	381	24,258	33,787	43,316	24,258	25,416	36,842	AR	81%	2	Less than 50%		No	No response	No response	
AR	2	Maintenance Aide II	715	29,328	40,417	51,506	29,328	30,545	42,900	AR	78%	2	Less than 50%		No	No response	No response	
AR	3	Crew Leader	134	42,094	56,173	70,252	46,722	48,319	57,798	AR	111%	2	Less than 50%		No	No response	No response	
AR	4	Area Maintenance Supervisor	85	53,950	70,018	86,086	59,904	61,746	69,472	AR	113%	2	Less than 50%		No	No response	No response	
AZ	1	Hwy Ops Tech 1	53	29,008	40,524	52,040	31,782	31,842	33,372	AZ	102%	4	Less than 50%		No	No	Yes	
AZ	2	Hwy Ops Tech 2	53	31,110	43,437	55,763	34,936	35,042	39,168	AZ	89%	4	Less than 50%		No	No	Yes	
AZ	3	Hwy Ops Tech 4	78	36,814	51,321	65,828	41,744	43,675	47,189	AZ	100%	4	Less than 50%		No	No	Yes	
AZ	4	Hwy Ops Tech Supervisor	60	43,240	60,355	77,469	58,827	58,827	58,827	AZ	108%	4	Less than 50%		No	No	Yes	
CA	1	Caltrans Highway Maintenance Worker; Caltrans Highway Landscaped Maintenance Worker	683	35,508	37,998	40,488	35,508	39,242	40,488	CA	125%	4	Less than 50%		Yes	Yes	Yes	
CA	2	Caltrans Equipment Operator II	1790	42,264	46,626	50,988	42,264	49,290	50,988	CA	125%	4	Less than 50%		Yes	Yes	Yes	
CA	3	Caltrans Highway Maintenance Leadworker; Caltrans Landscaped Maintenance Leadworker	515	44,316	50,022	55,728	44,316	54,801	55,728	CA	126%	4	Less than 50%		Yes	Yes	Yes	
CA	4	Caltrans Maintenance Area Superintendent; Caltrans Bridge Maintenance Supervisor	230	50,724	63,282	75,840	53,532	69,505	75,840	CA	128%	4	Less than 50%		Yes	Yes	Yes	
CO	1	N/A								CO		4	Less than 50%		No	Yes	Yes	
CO	2	Transportation Maintenance Worker I	799	33,624	40,716	47,808	33,696	42,079	47,400	CO	107%	4	Less than 50%		No	Yes	Yes	
CO	3	Transportation Maintenance Worker II	251	44,892	54,360	63,828	46,200	51,494	58,512	CO	118%	4	Less than 50%		No	Yes	Yes	
CO	4	Trans Maintenance Worker III	100	48,264	58,440	68,616	57,924	62,045	66,264	CO	114%	4	Less than 50%		No	Yes	Yes	
CT	1	Transportation Maintainer 1	104	39,933	46,105	52,276				CT		1	Less than 50%		No	No	Yes	
CT	2	Transportation Maintainer 2	569	41,756	48,144	54,531				CT		1	Less than 50%		No	No	Yes	
CT	3	Transportation Maintenance Crew Leader (Hwy)	94	55,361	63,127	70,892				CT		1	Less than 50%		No	No	Yes	
CT	4	Transportation Gen Supv (Maint)	47	65,288	75,268	85,247				CT		1	Less than 50%		No	No	Yes	
DE	1	Equip Operator I	58	22,943	30,591	38,238	24,716			DE	79%	1	No response		No respon	No response	No response	
DE	2	Equip Operator II	50	26,271	35,028	43,785	28,483			DE	72%	1	No response		No respon	No response	No response	
DE	3	Equip Operator III	189	30,074	40,099	50,124	33,281			DE	76%	1	No response		No respon	No response	No response	
DE	4	Maint Area Supervisor	17	39,422	52,563	65,704	42,339			DE	78%	1	No response		No respon	No response	No response	
FL	1	Missing	0	0	0	0	0	0	0	FL	0	0	Greater than 50%		Yes	Yes	Yes	
FL	2	Highway Maintenance Technician II	0	23,141	0	29,947	0	0	0	FL	0	0	Greater than 50%		Yes	Yes	Yes	Salary- Indeed.com
FL	3	Highway Maintenance Tech Coordinator	0	29,189	0	37,774	0	0	0	FL	0	0	Greater than 50%		Yes	Yes	Yes	Salary- Indeed.com
FL	4	Missing	0	0	0	0	0	0	0	FL	0	0	Greater than 50%		Yes	Yes	Yes	
GA	1	Equipment Operator 1	296	16,929	22,423	27,917	20,782	21,094	21,406	GA	67%	2	Less than 50%		No	Yes	Yes	
GA	2	Equipment Operator 2	81	18,611	25,125	31,639	20,782	24,891	28,999	GA	63%	2	Less than 50%		No	Yes	Yes	
GA	3	Highway Maintenance Foreman 2	117	29,974	41,214	52,454	38,428	43,456	48,484	GA	100%	2	Less than 50%		No	Yes	Yes	
GA	4	Highway Maint. Superintendent	12	32,971	45,335	57,699	43,538	47,583	51,629	GA	87%	2	Less than 50%		No	Yes	Yes	
HI		Missing	0	0	0	0	0	0	0	HI		0	No response		No respon	No response	No response	
HI		Missing	0	0	0	0	0	0	0	HI		0	No response		No respon	No response	No response	
HI		Missing	0	0	0	0	0	0	0	HI		0	No response		No respon	No response	No response	
HI		Missing	0	0	0	0	0	0	0	HI		0	No response		No respon	No response	No response	
IA	1	Highway Technician Associate	576	34,486	42,494	50,502	34,486	47,874	50,502	IA	153%	3	Less than 50%		No	No	Yes	
IA	2	N/A								IA		3	Less than 50%		No	No	Yes	
IA	3	Equipment Operator Senior	123	37,627	46,582	55,536	39,333	54,066	55,536	IA	124%	3	Less than 50%		No	No	Yes	
IA	4	Highway Maintenance Supervisor	50	53,394	68,037	82,680	56,056	74,061	82,680	IA	136%	3	Less than 50%		No	No	Yes	
ID	1	Transp Tech Apprentice	56	24,149	30,940	37,731	27,602	27,741	28,642	ID	89%	4	Less than 50%		No	Yes	Yes	
ID	2	Transp Tech	296	27,810	35,631	43,451	29,806	34,710	43,451	ID	88%	4	Less than 50%		No	Yes	Yes	
ID	3	Senior Transportation Tech	80	36,629	46,925	57,221	38,938	43,462	53,685	ID	100%	4	Less than 50%		No	Yes	Yes	
ID	4	Transportation Tech, Principal (MTC)	50	41,018	52,552	64,085	41,018	49,072	62,046	ID	90%	4	Less than 50%		No	Yes	Yes	
IL	1	Missing	0	0	0	0	0	0	0	IL		0	No response		No respon	No response	No response	
IL	2	Missing	0	0	0	0	0	0	0	IL		0	No response		No respon	No response	No response	
IL	3	Missing	0	0	0	0	0	0	0	IL		0	No response		No respon	No response	No response	
IL	4	Missing	0	0	0	0	0	0	0	IL		0	No response		No respon	No response	No response	
IN	1	Highway Technician 3	761	27,300	34,333	41,366	27,300	35,208	43,116	IN	112%	3	Less than 50%		No	No	Yes	
IN	2	Highway Technician 2	238	30,030	38,402	46,774	30,030	40,131	47,311	IN	102%	3	Less than 50%		No	No	Yes	
IN	3	Highway Technician 1	432	32,760	41,496	50,232	32,760	41,496	50,232	IN	95%	3	Less than 50%		No	No	Yes	
IN	4	Highway Tech Sup 3	123	36,010	46,280	56,550	36,010	45,323	54,636	IN	83%	3	Less than 50%		No	No	Yes	
KS	1	Equipment Operator	351	26,998	31,585	36,171	26,998	28,358	36,171	KS	91%	3	Less than 50%		No	Yes	Yes	
KS	2	Equipment Operator Senior	300	29,744	34,799	39,853	29,744	34,491	39,853	KS	88%	3	Less than 50%		No	Yes	Yes	
KS	3	Equipment Operator Specialist	109	32,760	38,355	43,950	32,760	38,513	43,950	KS	89%	3	Less than 50%		No	Yes	Yes	
KS	4	Highway Maintenance Supervisor	135	36,171	42,328	48,485	36,171	42,384	48,485	KS	78%	3	Less than 50%		No	Yes	Yes	
KY	1	Highway Equipment Operator I	277	19,897			19,897	23,528	48,069	KY	75%	2	Less than 50%		No	Yes	Yes	
KY	2	Highway Equipment Operator II	289	21,886			21,886	24,615	31,687	KY	63%	2	Less than 50%		No	Yes	Yes	
KY	3	Highway Equipment Operator IV	327	26,783			26,808	32,041	52,743	KY	74%	2	Less than 50%		No	Yes	Yes	
KY	4	Highway Superintendent II	122	32,042			32,438	40,353	55,731	KY	74%	2	Less than 50%		No	Yes	Yes	
LA	1	Mobile Equipment Operator 2	195	22,069	33,603	45,136	23,373	30,186	45,136	LA	96%	2	No response		No respon	No response	No response	
LA	2	Mobile Equipment Operator 1 Heavy	378	27,019	41,163	55,307	28,370	37,130	55,307	LA	94%	2	No response		No respon	No response	No response	
LA	3	Highway Foreman 2	78	33,093	50,420	67,746	33,093	47,378	62,546	LA	109%	2	No response		No respon	No response	No response	
LA	4	Parish Highway Maintenance Superintendent	63	35,402	53,945	72,488	37,274	49,805	68,910	LA	92%	2	No response		No respon	No response	No response	
MA	1	Maintenance Equipment Operator I	229	42,891	50,856	58,820	44,025	57,986	67,310	MA	185%	1	Less than 50%		Yes	Yes	Yes	
MA	2	Maintenance Equipment Operator II	22	44,994	53,699	62,404	48,898	63,544	67,310	MA	161%	1	Less than 50%		Yes	Yes	Yes	
MA	3	Highway Maintenance Foreman III	65	52,171	59,884	67,596	50,152	64,173	75,222	MA	147%	1	Less than 50%		Yes	Yes	Yes	
MA	4	Highway Maintenance Foreman IV	18	52,659	61,756	70,853	58,848	72,719	77,971	MA	134%	1	Less than 50%		Yes	Yes	Yes	
MD	1	Facility Maint Tech I	138	24,056	30,630	37,204	24,056	28,788	36,545	MD	92%	1	Less than 50%	Yes	Yes	Yes	Yes	
MD	2	Facility Maint Tech III	589	30,472	39,091	47,710	36,333	40,192	47,710	MD	102%	1	Less than 50%	Yes	Yes	Yes	Yes	
MD	3	Facility Maint Tech IV	206	34,390	44,288	54,186	34,390	47,369	54,186	MD	109%	1	Less than 50%	Yes	Yes	Yes	Yes	
MD	4	Facility Maint Sup II	12	44,017	57,141	70,265	56,999	62,949	68,939	MD	116%	1	Less than 50%	Yes	Yes	Yes	Yes	
ME	1	Transportation Worker I	310	25,501	29,193	32,885	28,163	28,801	32,885	ME	92%	1	Less than 50%		Yes	Yes	Yes	
ME	2	Transportation Worker II	301	27,581	31,689	35,797	30,659	34,256	36,026	ME	87%	1	Less than 50%		Yes	Yes	Yes	
ME	3	Transportation Crew Leader	118	31,970	37,097	42,224	31,970	39,341	44,678	ME	90%	1	Less than 50%		Yes	Yes	Yes	
ME	4	Transportation Operation Manager	34	43,285	51,262	59,238	43,285	56,257	75,067	ME	103%	1	Less than 50%		Yes	Yes	Yes	
MI	1	Transportation Maint Worker 6	30	33,446	37,981	42,515	33,446	38,084	42,515	MI	122%	3	Greater than 50%		No	No	Yes	
MI	2	Transportation Main Worker 7/E8	273	34,486	40,747	47,008	36,108	45,771	47,008	MI	116%	3	Greater than 50%		No	No	Yes	
MI	3	Trans Maintenance Worker 9	81	40,851	46,686	52,520	45,136	51,798	52,520	MI	119%	3	Greater than 50%		No	No	Yes	
MI	4	Transportation Maintenance Supervisor 11 & 13	36	46,238	62,389	78,540	54,475	64,511	78,540	MI	119%	3	Greater than 50%		No	No	Yes	
MN	1	Transportation Associate	61	37,187	37,782	38,377	37,187	37,480	38,377	MN	120%	3	Less than 50%		No	No	Yes	
MN	2	Transportation Generalist	1193	39,818	44,934	50,049	39,818	47,523	54,058	MN	121%	3	Less than 50%		No	No	Yes	
MN	3	Transportation Generalist Sr	428	42,929	49,277	55,624	42,929	54,392	59,550	MN	125%	3	Less than 50%		No	No	Yes	
MN	4	Transportation Ops Supervisor 3	22	55,416	69,353	83,290	62,014	78,342	83,290	MN	144%	3	Less than 50%		No	No	Yes	
MO	1	Maintenance Worker	546	29,160	34,200	39,240	29,640	29,683	35,928	MO	95%	3	Less than 50%		No	Yes	Yes	
MO	2	Intermediate Maintenance Worker	338	30,720	36,072	41,424	30,720	31,830	35,928	MO	81%	3	Less than 50%		No	Yes	Yes	
MO	3	Maintenance Crew Leader	415	36,576	43,188	49,800	36,576	39,347	49,800	MO	90%	3	Less than 50%		No	Yes	Yes	
MO	4	Maintenance Superintendent	42	50,748	60,240	69,732	50,748	54,226	61,128	MO	100%	3	Less than 50%		No	Yes	Yes	
MS	1	DOT Maintenance Technician 1	347	19,112	26,280	33,447	19,112	19,420	27,793	MS	62%	2	Less than 50%		No	Yes	Yes	
MS	2	DOT Maintenance Tech 2	215	21,748	29,904	38,060	21,748	22,736	30,890	MS	58%	2	Less than 50%		No	Yes	Yes	
MS	3	DOT Maintenance Technician 4	72	25,264	34,738	44,212	25,264	27,558	33,978	MS	63%	2	Less than 50%		No	Yes	Yes	
MS	4	DOT Maintenance Superintendent II	120	33,115	45,533	57,951	33,115	36,463	43,356	MS	67%	2	Less than 50%		No	Yes	Yes	
MT	1	Maintenance Technician II	78	42,086	42,086	42,086	42,086	42,086	42,086	MT	134%	4	Less than 50%		Yes	No	Yes	
MT	2	Maintenance Technician III	70	43,047	43,047	43,047	43,047	43,047	43,047	MT	109%	4	Less than 50%		Yes	No	Yes	
MT	3	Maintenance Crew Leader	20	45,930	45,930	45,930	45,930	45,930	45,930	MT	106%	4	Less than 50%		Yes	No	Yes	
MT	4	Maintenance Section Person C	15	59,316	59,316	59,316	59,316	59,316	59,316	MT	109%	4	Less than 50%		Yes	No	Yes	
NC	1	Transportation Worker—Level 1	714	23,332	38,614	53,896	24,649	28,437	46,540	NC	91%	2	Less than 50%		No	Yes	Yes	
NC	2	Transportation Worker—Level 3	55	23,332	38,614	53,896	30,205	34,353	43,709	NC	87%	2	Less than 50%		No	Yes	Yes	
NC	3	Transportation Supervisor—Contributing	467	34,591	51,518	68,444	35,222	41,822	47,804	NC	96%	2	Less than 50%		No	Yes	Yes	
NC	4	Transportation Supervisor—Advanced	229	34,591	51,518	68,444	44,448	54,960	63,770	NC	101%	2	Less than 50%		No	Yes	Yes	

Sources: Laffey, Nancy; Zimmerman, Kathryn A. Training and Certification of Highway Maintenance Workers. NCHRP Synthesis of Highway Practice, Issue 483, 2015, 152p
2016 AASHTO Salary Survey.

ATTACHMENT C: HME STATE TRAINING SCAN

State	Highway Maintenance Level	Match Title	# Incumbents	Minimum Annual Pay Range	Midpoint Annual Pay Range	Maximum Annual Pay Range	Actual Low, Annual Salary	Actual Average, Annual Salary	Actual High, Annual Salary	State	%	Region	Percentage maintenance work performed by contract?	General Maintenance training provided by Community Colleges?	Is certification in general maintenance skills offered?	Does your organization align its training programs offeringswith maintenance worker performance requirements?	Is the promotion of a frontline maintenance worker dependent on the completion of certain training requirements?	Notes
ND	1	Transportation Technician I	15	26,784	35,712	44,640	33,504	35,935	39,960	ND	115%	4	Less than 50%	Yes	No	Yes	Yes	
ND	2	Transportation Technician II	203	31,908	42,540	53,172	37,140	46,902	52,680	ND	119%	4	Less than 50%	Yes	No	Yes	Yes	
ND	3	Transportation Technician III	50	35,124	46,836	58,548	51,048	54,901	57,972	ND	126%	4	Less than 50%	Yes	No	Yes	Yes	
ND	4	Transportation Services Supervisor II	77	51,120	68,160	85,200	56,496	66,506	72,624	ND	122%	4	Less than 50%	Yes	No	Yes	Yes	
NE	1	Highway Maintenance Worker		27,204	32,457	37,710				NE		4	No response		No respor	No response	No response	
NE	2	Highway Maintenance Worker, Senior	578	31,279	37,430	43,580	31,279	33,760	46,850	NE	86%	4	No response		No respor	No response	No response	
NE	3	Highway Maintenance Crew Chief	119	28,731	37,791	46,850	32,843	39,587	49,194	NE	91%	4	No response		No respor	No response	No response	
NE	4	Highway Maintenance Supervisor	93	38,861	48,577	58,292	40,803	47,478	61,208	NE	87%	4	No response		No respor	No response	No response	
NH	1	Highway Maintainer I	31	25,438	29,265	33,092	25,438	25,784	26,332	NH	82%	1	Less than 50%		Yes	No	Yes	
NH	2	Highway Maintainer II	247	27,394	31,533	35,672	27,394	32,321	35,672	NH	82%	1	Less than 50%		Yes	No	Yes	
NH	3	Highway Maintainer III	141	30,659	35,464	40,268	30,659	35,048	40,268	NH	81%	1	Less than 50%		Yes	No	Yes	
NH	4	Highway Patrol Foreman	94	37,797	43,588	49,379	37,797	44,616	49,379	NH	82%	1	Less than 50%		Yes	No	Yes	
NJ	1	Highway Ops Technician Trainee	87	32,742	33,496	34,250	32,742	33,548	34,250	NJ	107%	1	Less than 50%		No	Yes	Yes	
NJ	2	Highway Operations Technician 1	269	32,806	39,294	45,781	32,806	42,565	45,781	NJ	108%	1	Less than 50%		No	Yes	Yes	
NJ	3	Highway Operations Technician 2	142	35,761	42,924	50,087	45,311	48,899	50,087	NJ	112%	1	Less than 50%		No	Yes	Yes	
NJ	4	Heavy Equipment Operator	11	40,776	49,071	57,366	48,150	54,182	57,366	NJ	100%	1	Less than 50%		No	Yes	Yes	
NM	1	Highway Maintenance Worker—Basic	58	21,195	29,037	36,878	26,225	29,577	36,811	NM	94%	4	Less than 50%		Yes	No	Yes	
NM	2	Highway Maintenance Worker—Operational	407	23,525	32,220	40,914	28,595	32,743	41,682	NM	83%	4	Less than 50%		Yes	No	Yes	
NM	3	Highway Maintenance Worker—Advanced	253	26,229	35,943	45,656	32,844	36,764	46,891	NM	84%	4	Less than 50%		Yes	No	Yes	
NM	4	Highway Maintenance Worker—Supervisor	95	28,766	39,406	50,045	37,190	41,772	52,479	NM	77%	4	Less than 50%		Yes	No	Yes	
NV	1	Highway Maintenance Worker I	77	28,731	35,027	41,322	25,202	28,720	36,247	NV	92%	4	Less than 50%	Yes	No	Yes	Yes	
NV	2	Highway Maintenance Worker III	200	36,540	44,986	53,432	32,343	40,725	53,432	NV	103%	4	Less than 50%	Yes	No	Yes	Yes	
NV	3	Highway Maintenance Worker IV	74	39,672	47,753	55,833	37,836	48,791	55,833	NV	112%	4	Less than 50%	Yes	No	Yes	Yes	
NV	4	Highway Maintenance Supervisor II	18	46,938	58,328	69,718	48,984	60,025	69,718	NV	110%	4	Less than 50%	Yes	No	Yes	Yes	
NY	1	Missing	0	0	0	0	0	0	0	NY			Less than 50%	Yes	No	Yes	Yes	
NY	2	Missing	0	0	0	0	0	0	0	NY			Less than 50%	Yes	No	Yes	Yes	
NY	3	Missing	0	0	0	0	0	0	0	NY			Less than 50%	Yes	No	Yes	Yes	
NY	4	Missing	0	0	0	0	0	0	0	NY			Less than 50%	Yes	No	Yes	Yes	
OH	1	Highway Technician 1	721	33,675	35,443	37,211	32,864	35,676	42,390	OH	114%	3	Less than 50%		No	No	Yes	
OH	2	Highway Technician 2	873	35,152	37,638	40,123	35,152	39,298	40,123	OH	100%	3	Less than 50%		No	No	Yes	
OH	3	Highway Technician 3	195	36,670	40,061	43,451	40,123	41,412	43,451	OH	95%	3	Less than 50%		No	No	Yes	
OH	4	Transportation Manager 1	81	41,933	46,925	51,917	41,933	49,581	51,917	OH	91%	3	Less than 50%		No	No	Yes	
OK	1	Transportation Equipment Operator I	87	20,160	26,562	32,963	23,982	25,162	27,699	OK	80%	4	Less than 50%		No	No	Yes	
OK	2	Transportation Equipment Operator II	145	20,160	28,210	36,259	27,582	31,060	31,857	OK	79%	4	Less than 50%		No	No	Yes	
OK	3	Transportation Equipment Op IV	92	23,931	33,903	43,874	38,155	41,887	43,874	OK	96%	4	Less than 50%		No	No	Yes	
OK	4	Transportation Superintendent II	101	31,848	45,118	58,388	49,328	51,770	51,794	OK	95%	4	Less than 50%		No	No	Yes	
OR	1	Transportation Maintenance Specialist 1	22	30,912	37,416	43,920	32,100	39,132	43,920	OR	125%	4	No response		No respor	No response	No response	
OR	2	Transportation Maintenance Specialist 2	702	33,564	40,980	48,396	34,992	45,291	55,644	OR	115%	4	No response		No respor	No response	No response	
OR	3	Transportation Maintenance Coordinator 2	37	38,220	49,251	60,281	42,012	53,695	55,644	OR	123%	4	No response		No respor	No response	No response	
OR	4	Principal Executive/Manager C	64	52,824	65,376	77,928	55,440	72,933	77,928	OR	134%	4	No response		No respor	No response	No response	
PA	1	Transportation Equipment Operator A	1845	27,834	34,367	40,900	27,286	31,928	40,977	PA	102%	1	Less than 50%		No	No	Yes	
PA	2	Transportation Equipment Operator B	2017	31,335	39,042	46,748	31,335	41,256	49,865	PA	105%	1	Less than 50%		No	No	Yes	
PA	3	Highway Foreman 3	102	40,039	50,445	60,851	40,039	53,838	64,908	PA	124%	1	Less than 50%		No	No	Yes	
PA	4	Highway Maintenance Manager	37	58,719	73,966	89,213	58,719	73,135	89,213	PA	134%	1	Less than 50%		No	No	Yes	
RI	1	Highway Maintenance Operator I	73	37,273	38,116	38,958	37,273	38,628	38,958	RI	123%	3	Greater than 50%		No	No	Yes	
RI	2	Highway Maintenance Operator II	22	39,769	40,809	41,849	39,769	41,473	41,849	RI	105%	1	Greater than 50%		No	No	Yes	
RI	3	Road Maintenance Supervisor	24	37,791	40,002	42,212	37,791	41,614	42,212	RI	96%	1	Greater than 50%		No	No	Yes	
RI	4	Highway Maintenance Superintendent	9	45,357	48,988	52,618	47,104	50,780	52,618	RI	93%	1	Greater than 50%		No	No	Yes	
SC	1	Trades Specialist II	603	18,229	25,979	33,728	24,175	25,533	33,728	SC	81%	2	Less than 50%		No	No	Yes	
SC	2	Trades Specialist III	625	22,182	31,614	41,046	27,986	31,904	41,046	SC	81%	2	Less than 50%		No	No	Yes	
SC	3	Trades Specialist IV	361	26,988	38,460	49,932	33,448	39,181	49,932	SC	90%	2	Less than 50%		No	No	Yes	
SC	4	Trades Specialist V; Engineer/Associate Engineer I (Resident Maintenance Foreman)	37	32,838	46,799	60,760	40,668	51,280	60,760	SC	94%	2	Less than 50%		No	No	Yes	
SD	1	Highway Maintenance Worker	252	28,271	37,699	47,126	29,378	33,837	38,231	SD	108%	4	Less than 50%		No	No	Yes	
SD	2	N/A								SD		4	Less than 50%		No	No	Yes	
SD	3	Lead Highway Maintenance Worker	82	33,659	45,686	57,712	34,494	40,071	47,732	SD	92%	4	Less than 50%		No	No	Yes	
SD	4	Highway Maintenance Supervisor	25	39,964	55,249	70,533	49,694	55,840	58,777	SD	103%	4	Less than 50%		No	No	Yes	
TN	1	Operations Technician 1	460	19,440	25,260	31,080	20,268	21,443	31,212	TN	68%	2	Less than 50%		No	Yes	Yes	
TN	2	N/A								TN		2	Less than 50%		No	Yes	Yes	
TN	3	Operations Technician 2	360	26,028	33,840	41,652	27,132	29,066	41,508	TN	67%	2	Less than 50%		No	Yes	Yes	
TN	4	Operations Technician 3	89	33,228	43,200	53,172	34,644	37,945	49,176	TN	70%	2	Less than 50%		No	Yes	Yes	
TX	1	General Transportation Tech I	314	23,781	29,320	34,859	24,375	30,683	34,858	TX	98%	4	Greater than 50%		Yes	Yes	Yes	
TX	2	General Transportation Tech III	1226	29,439	37,914	46,388	30,175	38,505	46,388	TX	98%	4	Greater than 50%		Yes	Yes	Yes	
TX	3	General Transp Spec I	609	32,976	42,511	52,045	33,540	43,508	52,045	TX	100%	4	Greater than 50%		Yes	Yes	Yes	
TX	4	Maint Section Supvr III	59	48,278	63,616	78,953	53,706	66,561	78,953	TX	122%	4	Greater than 50%		Yes	Yes	Yes	
UT	1	Transportation Technician I	139	25,557	33,053	40,549	30,172	31,808	49,381	UT	102%	4	Less than 50%		Yes	Yes	Yes	
UT	2	Transportation Technician II	157	28,501	36,843	45,184	35,580	39,889	53,202	UT	101%	4	Less than 50%		Yes	Yes	Yes	
UT	3	Transportation Technician III	161	32,656	42,209	51,762	40,257	45,607	56,146	UT	105%	4	Less than 50%		Yes	Yes	Yes	
UT	4	Roadway Operations Manager I	89	37,354	49,966	62,577	44,161	54,876	67,902	UT	101%	4	Less than 50%		Yes	Yes	Yes	
VA	1	Transportation Operator II (Trainee)	18	20,894	35,132	49,370	24,288	26,102	29,000	VA	83%	2	Greater than 50%		No	No	Yes	
VA	2	Transportation Operator II	1845	20,894	35,132	49,370	26,146	36,413	48,920	VA	93%	2	Greater than 50%		No	No	Yes	
VA	3	Transportation Operator III	148	24,969	41,558	58,146	31,506	41,649	51,366	VA	96%	2	Greater than 50%		No	No	Yes	
VA	4	Transportation Ops Manager III	87	42,614	69,374	96,134	55,421	66,859	82,613	VA	123%	2	Greater than 50%		No	No	Yes	
VT	1	Missing								VT			No response		No respor	No response	No response	
VT	2	Missing								VT			No response		No respor	No response	No response	
VT	3	Missing								VT			No response		No respor	No response	No response	
VT	4	Missing								VT			No response		No respor	No response	No response	
WA	1	Maintenance Technician 1	48	33,504	36,966	40,428	33,504	36,607	39,444	WA	117%	4	Less than 50%		Yes	Yes	Yes	
WA	2	Maintenance Technician 2	504	36,744	40,698	44,652	36,744	42,697	44,652	WA	108%	4	Less than 50%		Yes	Yes	Yes	
WA	3	Maintenance Technician 3	97	40,428	44,868	49,308	42,492	47,795	49,308	WA	110%	4	Less than 50%		Yes	Yes	Yes	
WA	4	Maintenance Supervisor	74	46,884	54,960	63,036	50,496	61,842	63,036	WA	114%	4	Less than 50%		Yes	Yes	Yes	
WI	1	N/A								WI		3	100%		NA	NA	Yes	
WI	2	N/A								WI		3	100%		NA	NA	Yes	
WI	3	N/A								WI		3	100%		NA	NA	Yes	
WI	4	N/A								WI		3	100%		NA	NA	Yes	
WV	1	Trans Worker 2 Equipment Operator	1430	21,944	30,410	38,875	22,464	29,106	36,317	WV	93%	2	Less than 50%		No respor	No response	No response	
WV	2	Transportation Worker 3 Equipment Operator	368	23,732	32,780	41,828	30,326	37,482	41,371	WV	95%	2	Less than 50%		No respor	No response	No response	
WV	3	Transportation Worker 3 Crew Chief	266	27,732	39,522	51,312	41,829	41,861	47,008	WV	96%	2	Less than 50%		No respor	No response	No response	
WV	4	Highway Administrator 2	52	35,028	49,920	64,812	35,028	45,417	59,196	WV	83%	2	Less than 50%		No respor	No response	No response	
WY	1	???								WY		4	Less than 50%		No	Yes	Yes	
WY	2	Highway Maintenance Tech	364	32,364	40,452	48,540	33,984	37,117	42,512	WY	94%	4	Less than 50%		No	Yes	Yes	
WY	3	Highway Maintenance Spec II	70	41,448	51,816	62,184	46,908	48,438	51,495	WY	111%	4	Less than 50%		No	Yes	Yes	
WY	4	Highway Maintenance Supv II	19	59,172	73,968	88,764	67,563	68,792	69,887	WY	126%	4	Less than 50%		No	Yes	Yes	

Sources: Laffey, Nancy; Zimmerman, Kathryn A. Training and Certification of Highway Maintenance Workers. NCHRP Synthesis of Highway Practice, Issue 483, 2015, 152p
2016 AASHTO Salary Survey.

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Survey Summary:
Expected Impact of Transformational Technologies on the Future Transportation Safety Workforce

A Qualtrics survey was distributed in December 2017 via safety-related Transportation Research Board (TRB) committee chairs. Targeted TRB committees included: Standing Committee on Accessible Transportation and Mobility, Standing Committee on Roadside Safety Design, Standing Committee on Highway/Rail Grade Crossings, Standing Committee on Tort Liability and Risk Management, Safety and Systems Users Group, Standing Committee on Transportation Safety Management, Standing Committee on Safety Data, Analysis and Evaluation, Standing Committee on Highway Safety Workforce Development, Standing Committee on Highway Safety Performance, Standing Committee on Operator Education and Regulation, Standing Committee on Traffic Law Enforcement, Standing Committee on Occupant Protection, Standing Committee on Alcohol, Other Drugs, and Transportation, Standing Committee on Safe Mobility of Older Persons, Standing Committee on Truck and Bus Safety, Standing Committee on Roundabouts, Standing Committee on Vehicle User Characteristics, Standing Committee on User Information Systems, Standing Committee on Simulation and Measurement of Vehicle and Operator Performance, Standing Committee on Visibility, Standing Committee on Pedestrians, Standing Committee on Bicycle Transportation, Standing Committee on Motorcycles and Mopeds, and Commercial Truck and Bus Safety Synthesis Program. The survey link was additionally distributed through the National Center for Rural Road Safety's email contact list. The purpose of the survey was to query road safety professionals on which emerging technologies were expected to make the greatest impact on transportation safety practice and how those technologies are expected to change competencies that will be needed for the future safety workforce.

After removing incomplete or unusable survey responses, a total of ninety-five survey respondents answered at least a few questions. However, nine of the ninety-seven survey respondents did not fully answer the survey. The following sections discuss the findings based on the feedback received.

TRANSFORMATIONAL TECHNOLOGIES & FUTURE SKILLSETS

Survey respondents were asked, "What transformational technologies will most shape the future skillsets and/or competencies required of transportation safety professionals? (check all that apply)" Survey respondents were provided with 15 potential answers: 1) vehicle-to-vehicle communications, 2) vehicle-to-infrastructure communications, 3) in-vehicle technologies (e.g. collision avoidance), 4) roadside technologies (e.g. smart signs), 5) automated data collection systems, 6) GPS: global positioning systems, 7) GIS: geographic information systems, 8) data security/cybersecurity, 9) machine learning/artificial intelligence, 10) mobile applications, 11) drones, 12) autonomous vehicles, 13) smart personal protection equipment, 14) virtual reality, and 15) robotics.

All 95 survey respondents provided a response to this question. The top two transformational technologies which were selected were: 1) vehicle-to-infrastructure and 2) autonomous vehicles. The following table provides the number of survey respondents that selected each technology and the percentage that it represents.

Transformative Technology	Number	Percentage	Rank
V2V	65	68.4	3
V2I	75	78.9	1

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In-vehicle	58	61.1	4
Roadside technologies	52	54.7	5
Automated data collection	52	54.7	5
GPS	34	35.8	11
GIS	35	36.8	10
Data security	44	46.3	7
Machine learning	43	45.3	8
Mobile applications	37	38.9	9
Drones	30	31.6	12
Autonomous vehicles	68	71.6	2
Smart personal protection equipment	14	14.7	13
Virtual reality	11	11.6	15
Robotics	14	14.7	13

FUTURE TRANSFORMATIONAL TECHNOLOIGIES TO MAKE AN IMPACT

Survey respondents were asked in a follow-up question to Question 1, "What additional transformational technologies (not listed above) are impacting safety professionals now or are expected to impact them within the next 5 to 10 years?

Twenty-two (23.2%) survey respondents provided some additional recommendations. Big data, distractions while driving, and education silos were mentioned by at least two or more survey respondents, particularly big data. Exact responses are listed below:

1) Big data analysis
2) Data analysis, Data QC/QA
3) Mobility Management for At-Risk Populations
4) Unknown
5) I checked off those items that distract drivers.
6) Temporary traffic control through construction work zones
7) Human factors
8) Increased computer processing/small size
9) Big data
10) Can't think of any others beyond this list.
11) Big data analytics methods
12) The shift from a workforce of "Civil" Engineers to a more diversified force made up of Programmers, Electrical Engineers, System Analyst and Public Affair in addition to the standard Roadway Engineers
13) Safe Systems Analysis
14) ER response and communication
15) Mobile device usage specifically by vulnerable road users (i.e. distracted walking/cycling/skateboarding/etc.)
16) In-vehicle distractions e.g. the use of mobile devices, driver navigation, and various communications/entertainment devices that may affect the driver. Also 3D/graphical visualization of roadway designs.

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17) Crowd sourced real-time information real-time data analysis personalized to vehicle location/trip
18) Many basic human factors or safety and operations are not being taught in many of our engineering schools "today"
19) Smart cities
20) Programming, blockchain technology, internet of things
21) The gaps created by technology will be even more pressing in the future. Not just the "rural" or "frontier" divide from technology access, but right smack in the middle of urban cores. Building shadows, dark zones, electronic messaging interference/congestion, and more will create vast swaths of land not covered by technology and small little islands that will be void of service.
22) More and more Americans are purchasing items online instead of in a box store, including groceries (Wal-Mart, for instance). This will change the dynamics of motorists from citizens running errands, instead to delivery vehicles delivering to them, and more of them.

ADDITIONAL KNOWLEDGE OR SKILLSETS NEEDED

Survey respondents were asked, "What types of additional knowledge and/or skillsets will be needed by safety professionals to work with the emerging technologies that are impacting or are expected to impact transportation safety and safety-related decision-making? (check all that apply). Nine possible answers were presented to survey respondents: 1) algorithm development, 2) software development/programming, 3) predictive analytics, 4) human-machine and human-computer interaction, 5) data security/cybersecurity, 6) wireless systems, 7) spatial data visualization, 8) electrical/electronics, and 9) analysis techniques for large datasets.

Eight (8.4%) survey respondents did not provide a response to this question. The top three ranked knowledge/skills are: 1) analysis techniques for large datasets, 2) predictive analytics, and 3) human-machine and human-computer intersection. The following table presents the number of survey respondents that selected each knowledge/skillset, percentage of respondents making this selection, and its overall rank in importance.

Knowledge/skills	Number	Percentage (of 87)	Rank
Algorithm development	42	48.3	5
Software development/programming	44	50.6	4
Predictive analytics	57	65.5	2
Human-machine/human-computer interaction	52	59.8	3
Data security/cybersecurity	34	39.1	7
Wireless systems	35	40.2	6
Spatial data visualization	34	39.1	7
Electrical/electronics	17	19.5	9
Analysis techniques for large datasets	58	66.7	1

NEEDED KNOWLEDGE OR SKILLSETS

Survey respondents were asked, "What additional knowledge and/or skillsets (not listed above) will be needed by safety professionals to work with the emerging technologies that impact transportation safety and safety-related decision making?

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Sixteen survey respondents provided ideas regarding additional knowledge and/or skillsets needed. The following are their recommendations:

1) Creative thinking, systems thinking, design thinking
2) Unknown
3) Psychology, big time in 3 aspects: 1) how do people learn – multiple instruction techniques are needed for different sets of learners; 2) how do people focus – what displays and interactions support focus or distract?; 3) how do people make do (when the technology is turned off by hackers or technological failures)? How will people maintain alertness and remember unused skills in a pinch?
4) Trust in system; reliance on symptom
5) Change management for people to adopt new systems
6) Communication skills (soft skills)
7) In-depth knowledge of GIS for data analysis
8) Machine Learning/Deep Learning
9) Systems engineering to understand how these pieces fit together and what aspects impact others, human interface with machines
10) Ability to see things from the perspective of a wide variety of road users in a wide variety of operating conditions. Ability to predict and problem solve at a conceptual level – before technologies even make it to widespread market implementation/use.
11) Greater understanding of human factors and how people's attention is affected by various stimuli both inside and outside the vehicle.
12) Advanced understanding in mechanical engineering and telecommunications to predict and mitigate impacts of connected and autonomous vehicles.
13) Risk analysis of contributing components such as DSRCs, sensors, RSEs, etc.
14) Traffic signal systems
15) Unknown
16) Communication with those in the technical areas

SOURCES OF SKILLSETS

Survey respondents were asked, "What are the primary source(s) currently for gaining the needed skillsets you indicated above? (check all that apply) Five potential answers were provided: 1) elective professional development, continuing education, 2) on-the-job training, 3) university coursework, 4) technical/community college coursework, and 5) other (please specify).

Eighty-six survey respondents provided input on this question. Although the question asked respondents to "check all that apply," a survey glitch was discovered early on that restricted responses to only one selection. As a result, half of the responses were limited to only one response, and half were able to "check all that apply" after the glitch was fixed. Therefore, two analyses were conducted: 1) when survey respondents were only allowed to choose one response and 2) when survey respondents could choose as many responses as they wanted.

For survey responses that were restricted to one selection, elective professional development/continuing education was the preferred training source. On-the-job-training and

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university coursework were ranked equally. Only one respondent selected technical/community college coursework.

In the unrestricted survey group, the majority of survey respondents selected elective professional development/continuing education. For this group, on-the-job training was preferred over university coursework. Technical/community college was still selected significantly less frequently than the other categories.

Responses to selections of “other” included:

- On-the-job training and utilizing programmers, computer engineers from outside the transportation industry
- Internet, self guided courses
- LTAP
- Professional conferences, professional magazines, webinars, short briefs
- Might not yet exist!!
- On-line courses (non-traditional and traditional college)
- Transitioning applications from personal to professional use
- The challenges with college education are reduced credit hours and minimum fulfillment of other requirements.
- Critically timed internships
- Inefficient to rely on schooling. Educating practicing engineers is the difficult aspect but required.
- Some are interdisciplinary and researchers gained through involvement of researchers from different departments and in some cases schools.
- Webinars, seminars, conferences
- Third party educational vendors

DIFFICULT SKILLS

Survey respondents were asked, “What emerging skills related to transformational technologies are currently the most difficult for transportation professionals to develop?”

Fifty-three survey respondents provided the following input.

1. Creative thinking
2. Big data analysis
3. Human-machine and human-computer interaction
4. Critical thinking and decision-making
5. Maybe understanding how different humans interface with machines…differences in groups (ages, education levels, sex, etc.)
6. Predictive analytics/algorithm development
7. Sophisticated analyses; writing skills
8. Software programmer
9. Skills that cross a variety of platforms
10. Management technology for headway-based transit services, to maintain intervals between buses and avoid gaps or bunching

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11. Software programming
12. Knowledge of how real drivers respond and how research actually applies to real life driving
13. Not so much as emerging skills, rather than practical skills that is not being taught at the university/technical school level. As someone who is teaching at a local university, a growing concern for basic communication and presentation skills are lacking, both verbally and written. We expect students to comprehend these emerging skills without providing them the basic ABC's.
14. Convincing management in state agencies to engage in planning/implementing new technologies
15. The ones related to construction work zones since work zones are quite variable in how they are "set" up, who sets them up, and the time of day they are set-up.
16. Understanding that higher speeds do not work with human operators
17. Advancing autonomous vehicle recognition of traffic control devices and how to react to them.
18. I don't think the huge paradigm shift has happened yet, so the old paradigm still rules. But when driver-less technology becomes a reality, then safety will need to switch from a more human error based approach to a software/hardware detection and algorithm approach. In other words the causes of accidents will shift drastically, creating the need for a whole different approach. I really have not seen anything changes towards this new approach.
19. All – technology is new and moving very "rapidly"
20. Data handling and ensuring quality of data.
21. Algorithm/software development related to autonomous/connected vehicles.
22. Algorithms, large dataset analysis, new data collection methods
23. Understanding human-to-machine interaction
24. Computer science, data analysis, big data, machine learning
25. Connected vehicle
26. All
27. Computer programming and similar skill sets are unfamiliar to those who have traditional Civil Engineering backgrounds and expertise with the current empirical/low data techniques for planning/engineering.
28. Smart signs, other vehicle to infrastructure interfaces which will require technical knowledge of road workers beyond what is currently available, will their skill sets keep up with technology changes
29. Automated vehicles technology and implementation
30. The impacts/accommodation of Autonomous Vehicles
31. Vehicle based technologies…we can handle infrastructure based, but don't have the experience or access to vehicle systems. Also, social psychology to change culture.
32. Gaining familiarity and an understanding of the capabilities of new technologies PRIOR to road safety problems identifying themselves. We are always behind the curve it seems, playing catch-up & reacting.
33. Human interface with in-vehicle and external communications (screens, signs, alerts, etc)
34. Data governance (even recognition of the value of data), data analysis tools and techniques
35. Adaptive learning to emerging technology. Standard coursework/continuing education doesn't move fast enough to keep up with emerging technologies. By the time it is in the hands of

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professionals (and clearly by DOT IT offices) society is way ahead and perhaps already moved on to the next thing.

36. Utilizing newer technologies that hasn't been used creates liabilities for transportation agencies because of unknown reliability of the technology.
37. Transforming to C/V and A/V technology.
38. It is difficult to keep up with all the sudden changes that happen quickly.
39. Understanding big data sets.
40. Computer science related
41. Ethics for automated vehicles
42. Since most of us came in to the field through transportation and traffic operations, probably the electronics/communications aspect of it
43. Understanding telecommunications, electrical engineering, and mechanical engineering impacts of advanced vehicle technologies and how to integrate those concepts within traditional civil engineering aspects of traffic engineering and geometric design.
44. Programming
45. Knowledge required by autonomous vehicles and to some "extend" connected vehicles
46. Comprehension of challenges ahead
47. Algorithms, AI, machine learning
48. Technology and programming. Things are evolving so quickly that it is difficult to keep up with the technology.
49. Data analytics/analysis
50. Traffic safety study or audit
51. Technical understanding (not being technically challenged), and data crunching/analysis
52. Adapting to Information Technology and associated skill sets and relating them into transportation projects.
53. Understanding the current capabilities and limitations in an ever-changing environment.

REASONS FOR NOT GETTING DIFFICULT SKILLS

Survey respondents were asked, "What are the primary reason(s) for this difficulty? (check all that apply.) Five possible responses were provided in the survey, and seventy-nine respondents provided input on this question. The top reason indicated (by 65% of respondents) was that new technologies are being deployed too rapidly for safety professionals to keep their skills up-to-date. Fifty-seven percent of respondents selected: transportation agencies/organizations are slow to adopt new technologies or adapt to change, on-the-job-training opportunities therefore remain sparse. Fifty-four percent selected: at the college/university level, coursework is siloed by discipline and students do not receive adequate coverage of cross-disciplinary training needed to work with new technologies. Forty-two percent indicated that lack of knowledgeable training professionals capable of training others in emerging technologies/skillsets was a primary reason. Sixteen percent entered "Other," and clarified the selection with the following comments:

1. Making the right choices for investments and technical direction are difficult, due to the pace of technical developments and broad range of developing technologies.

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2. Such technology requires segregating bus location and Waze-type data by corridor, separate analysis, and targeted communication. Gets more complicated as routes serving part or all of a headway-based corridor may originate or end in different coordinates.
3. Most professional staff have limited **time** to do training as tasks of today take a considerable amount of time and leave little left for professional development even for those that are actively seeking to advance skills.
4. Constantly changing regulatory and industry standards landscape
5. Knowledge needs an application and safety professionals don't know their role.
6. Ignorance of and/or lack of **time** to investigate potential impacts of new technologies.
7. We simply don't know how this will all unfold.
8. I wouldn't say siloing: rather there's just not an opportunity to develop those skills in 4 or even 6 years of BS/MS coursework
9. All of the above, plus lack of engineers that pursue cross-disciplinary education and have sufficient capability to understand and combine the many aspects to implement and advance technology.
10. Based on my experiences, transportation safety professionals are not yet very knowledgeable and involved in the safety aspects of emerging tech
11. Time. Employees new to the organization consider a "career" to be 3-5 years. In many cases the highway safety profession isn't something you master in the first year or two. So just at the time an employee would be in a comfort zone to start to stretch beyond the basics, they are gone.
12. Lack of adequate funding, education, and red tape within Government Entities.

TRANSPORTATION SECTOR

Survey respondents were asked, "In which transportation sector do you currently work?" Survey respondents were provided with six potential answers: 1) construction, 2) maintenance, 3) engineering, 4) planning, 5) research/education, and 6) other (please specify).

Twelve survey respondents did not provide an answer to this question, leaving eighty-three survey respondents who provided information. Of these eighty-three, thirteen chose other. The following shows the representation of the remaining seventy survey respondents.

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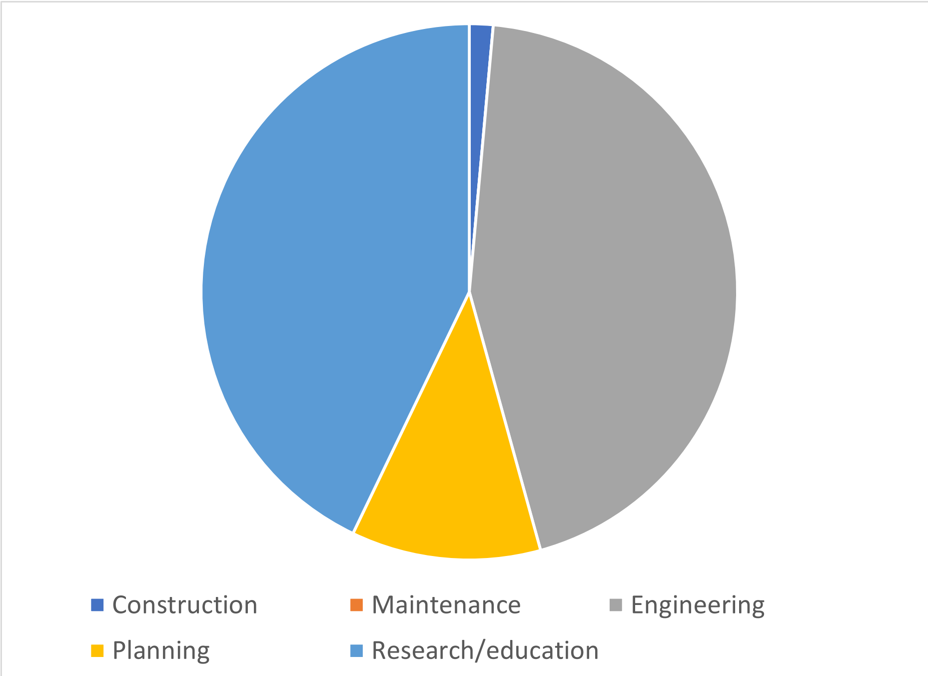

The results show that engineering and research and education dominate. There were no maintenance survey respondents.

The following information was provided for other:

1) All of it
2) Behavior
3) Safety
4) Law
5) Public transit & paratransit
6) Engineering, maintenance and planning are split about equally in my current position
7) Industry association
8) Traffic safety/data analysis
9) Traffic operations/engineering
10) State highway "safety" office
11) Safety
12) Operations management

IN-DEMAND CREDENTIALS

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Survey respondents were asked, "What are the most in-demand credentials (specific certifications, academic degrees, etc.) in your field? Survey respondents were provided with an open-ended box to provide a response.

A total of 58 people provided information. The responses are as follows:

1) PE, PMP
2) PhD
3) Business degree
4) MSc or PhD
5) Community planning grant/financial management
6) Professional engineering certification
7) Not sure
8) Not sure
9) PhD
10) Masters in safety
11) Juris doctor
12) I look for Masters Degrees in transportation planning or related field and prefer a PMP or AICP certification depending on the position. We need more professional project managers.
13) PhD
14) PhD in experimental psychology or transportation engineering
15) Academic degrees, professional licenses/certifications, and specific certifications
16) Professional engineer license, advanced degrees, experience
17) Experience
18) Graduate degree; statistics; epidemiology-study design
19) Professional license and the Project Management Professional (PMP)
20) PE
21) Electrical engineering and mechanical engineering
22) A PE
23) PE; I am not confident additional credentials mean much except college degree with a PE. Plenty of folks can pass tests but does not mean they can perform the tasks. I suggest focusing on training for transportation professionals and less on credentials. Also do not lose sight of communication skills. Does not matter how much one knows or how many credentials they have if they cannot communicate in/or of their organization, to elected leaders, etc.
24) Professional Engineers license
25) On-the-job expertise in design and safety
26) PE, PTOE
27) Computer science, electrical engineering
28) PhD, PE, degree in Transportation, Data Science, Computer Science, Systems Engineering
29) GIS/spatial visualization
30) Data analytics and integration, data interpretation
31) PTOE, PTP, PE
32) Engineering
33) BSCE
34) PE, PTOE