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MINETA TRANSPORTATION INSTITUTE

Trade and Transportation Talent Pipeline Blueprints: Building University-Industry Talent Pipelines in Colleges of Continuing and Professional Education

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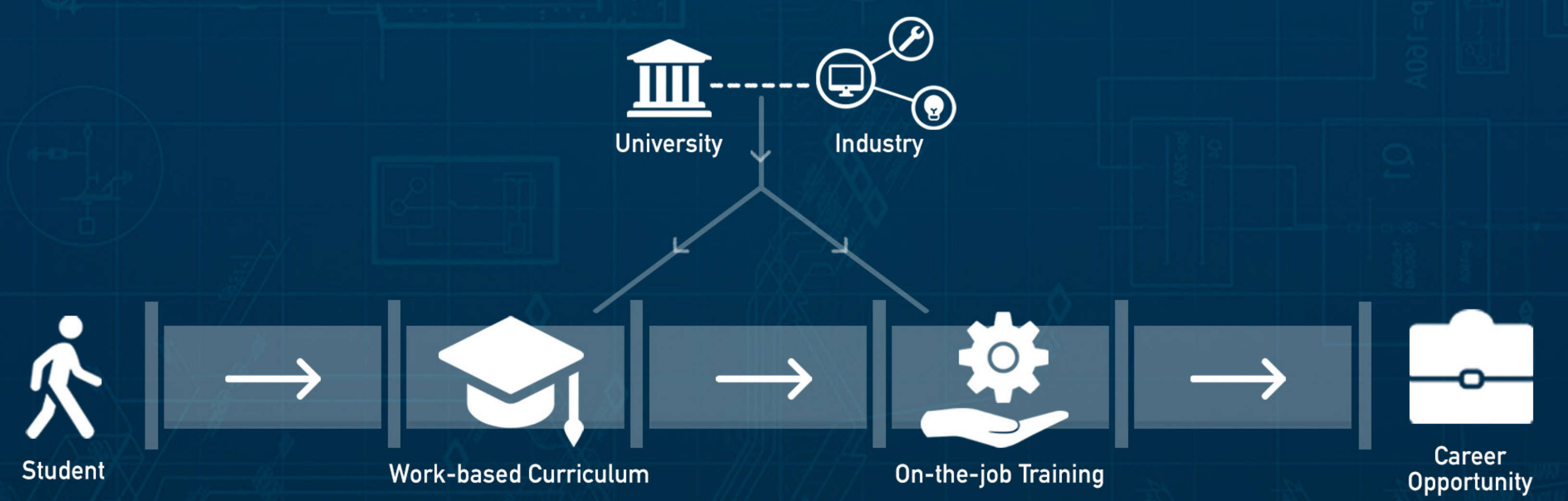

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16. Abstract
The rapid adoption of transformational technologies along with other economic and cultural shifts, have created a gap between workers and the skills and knowledge necessary for in-demand occupations. Trade and Transportation Talent Pipeline Blueprints: Building University-Industry Talent Pipelines in Colleges of Continuing and Professional Education identifies the steps required to build talent pipelines that target in-demand trade and transportation occupations requiring specific degrees, certificates, and non-credit professional development. This report provides a literature review and labor market data analysis. It also includes documentation of methodology in planning a pilot program for Colleges of Professional and Continuing Education housed within each of the 23 California State University campuses. The recommendations guide the colleges to develop talent pipelines to empower trade and transportation employers to play a more central role in addressing skills gaps and other critical workforce development needs in working partnerships with postsecondary education and training providers. The report concludes with a recommended university-industry Intelligent Transportation Systems (ITS) Talent Pipeline pilot program.

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Executive Summary

From Middle Skills to Transformational Skills

The adoption of transformational technologies in trade and transportation infrastructure and systems is creating a wide range of skills gaps and related workforce development challenges. These skills gaps are not only affecting trade and transportation sectors but also the overall health of the national economy.

The impacts of transformational technologies on current and future trade and transportation professionals are akin to "elements of the Fourth Industrial Revolution (Fourth IR), a technological revolution characterized by a fusion of the digital, physical, and biological spheres, and characteristic of its unprecedented velocity."[1] In the trade and transportation industry the Fourth IR "specifically refers to the use of robotics, artificial intelligence, automation, and digitalization in work processes."[2]

These transformational technologies, along with economic and cultural shifts, are occurring at such a rate that educational institutions are struggling to provide the relevant training and education for in-demand occupations. This "mismatch" between workers and the necessary knowledge, skills, and abilities (KSAs) has made it difficult for employers to hire qualified professionals, causing what many have come to identify as a "middle-skills gap." However, a term such ass "middle-skills gap" fails to accurately document ways that occupational definitions and expectations are changing across the trade and transportation sector and the economy at large. Equally important are ways that relevant education and training required for today's in-demand occupations challenge previous assumptions about the qualifications of a "middle-skill" job.

The reality is that most middle-skill jobs—jobs that require more than a high school diploma and less than a four-year college degree—now require continual upskilling and training for incumbent workers and industry-led training for entrants. Furthermore, numerous "middle-skill" jobs that, for previous generations, did not require bachelor's degrees are now requiring them, or even more advanced degrees. The educational and training qualifications for "middle-skill" jobs are no longer finite, which is rendering the term obsolete.

In this report, Center for International Trade and Transportation (CITT) authors replace the term "middle-skills gap" with a more relevant term: "transformational-skills gap." This redefinition, of course, raises the question, what are transformational skills? The big picture answer to that question is that they are a set of skills that prepare professionals for an unknown future with new disruptive technologies. In a more detailed sense, the transformational skills required to design, develop, operate, and maintain the mobility systems of the future will address:

- zero-emission technologies powered by battery-electric and fuel-cell drivetrains;
- vehicle-to-infrastructure and vehicle-to-vehicle "intelligent" mobility systems;
- connected and "smart" communities; and

a range of other data-privacy, digital rights, and cybersecurity issues in an era where data plays a ubiquitous and profound new role in the ways mobility systems are operated, evaluated, and optimized.

Within this transformational context, this report builds on current research regarding "middle-skills gaps" to present the necessary steps required for building talent pipelines that target the most in-demand trade and transportation occupations requiring specific degrees, certificates, and non-credit professional development. The report concludes with a recommended university-industry Intelligent Transportation Systems (ITS) Talent Pipeline pilot program deployment at CSULB in partnership with its Colleges of Engineering, Business, and Continuing and Professional Education.

Given the need for responsive and flexible programmatic and curricular support, this report makes specific recommendations for Colleges of Professional and Continuing Education (CPaCEs) housed within each of the 23 California State University (CSU) campuses to develop talent pipelines. In this way, the content of this report serves as a resource for the CSU Commission on Continuing and Professional Education as members guide and inform the larger vision for present and future CPaCE programming.

1. Introduction

In 2012, a broad coalition of industry, government, and educational stakeholders gathered in Washington, D.C. for a transportation workforce summit entitled "Strengthening Skills Training and Career Pathways Across the Transportation Industry."[3] The summit was a watershed moment for transportation workforce development because it convened the above-mentioned coalition with leadership from the U.S. departments of Transportation, Labor, and Education to address:

- Demographic changes in the future workforce;
- Lack of career awareness and competencies needed in the field;
- Skills gaps created by transformational technologies; and
- Increasing and changing demands on local, state, and federal transportation agencies.

The summit identified mission-critical workforce challenges not only for the transportation sector but also for communities and local economies across the nation. Put another way, if the mobility systems that move people and goods across the nation falter due to an insufficient workforce, so too will safety standards, rates of commerce, and social and economic mobility.

Ten years later, in 2022, the challenges identified during that 2012 workforce summit are more formidable than ever. Baby Boomer retirements continue to increase while public- and private-sector transportation employers are finding it increasingly difficult to hire skilled professionals from younger generations to assume those essential occupations. At the same time, the integration of new transformational technologies into mobility systems, affecting every transportation mode, continues to create skills gaps and occupational shortages.

The transformational skills gaps presciently identified during the 2012 transportation workforce summit align with core priorities outlined in long-range strategic plans produced by public- and private-sector institutions in the months leading up to 2020 and the dawning of a new decade. With those long-range planning priorities in mind, California State University, Long Beach (CSULB) convened "BEACH 2030," a campus-wide planning effort that brought together staff, faculty, students, community members, and industry stakeholders. BEACH 2030 compelled participants to consider transdisciplinary concepts such as the future of work, the future of higher education, the future of medical research, and the future of digitized and connected communities, among many other innovative and forward-thinking focuses. An output of the BEACH 2030 effort was the development of seven university-level action plans:

1. Build an Equitable and Empowering Culture,
2. Be a Student-Ready University,

3. Reimagine Faculty,
4. Reimagine Staff,
5. Build a Growth Strategy,
6. Advance Partnerships for the Public Good, and

Be a Future-Ready University

Each of the seven action plans underscore the value of building university-industry talent pipelines at CSULB in partnership with other public- and private-sector partners. This report identifies how talent pipelines can help build a more *equitable and empowering culture* of skills-based learning for students that leads to meaningful careers and related social and economic mobility. Talent pipeline initiatives provide common calls to action to *reimagine* the roles that faculty and staff play in making CSU campuses more *student-ready* by connecting "learning to the future of work through agile curricula, flexible degree paths, technology readiness, and high-impact practices for the modern workforce." Finally, talent pipelines hold great promise for CSU leaders seeking to *build growth strategies* by developing ethical university-industry partnerships that serve the *public good* by establishing new on-campus research and development capacity for faculty and students to tackle real-world problems—ultimately leading to graduates who are equipped with transformational skillsets that jobs of the future require.

Beyond long-range plans and institutional priorities, several socioeconomic megatrends are providing new levels of strategic urgency for CSU leaders to implement talent pipeline initiatives. By 2030, new approaches to financing student education must be established. The robust debate surrounding the Biden Administration's recent student loan reforms and forgiveness measures have highlighted the national crisis surrounding student debt.[4] In the years ahead, incoming generations of students will be wary of incurring debt, and financial institutions will avoid issuing loans with low probabilities of repayment. This reality paired with the likely continual decline in state funding will require new models for financing student education. Talent pipelines formed through industry-university partnerships make it possible for employers to invest more directly in the education and training of the talented students they seek to hire upon graduation.

Talent acquisition, recruitment, and retention are proving increasingly difficult and expensive for U.S. employers. A 2019 IBM study found that "the average time employers spend up-skilling or re-skilling employees has jumped from 3 days to a whopping 36 days in just the past five years."[5] As the adoption of transformational technologies in the design, development, operation, and maintenance of trade and transportation system increases, so too will the need for specialized training for emerging and incumbent professionals.

Employers facing ongoing shortages of qualified candidates for critical occupations are often left with the choice between bidding wars between employers to "poach" talented professionals from each other or hiring expensive staffing firms to secure talent. Fortunately, university-industry led talent pipelines provide a more sustainable and beneficial option for trade and transportation employers. By partnering with education and training organizations to form talent pipelines, employers can build systems that address current and future skills gaps in their workforces.

Talent pipelines have traditionally been categorized as workforce development systems used by leaders at community colleges, workforce development boards, and other career and technical education schools to prepare workers for targeted jobs in the trades. Later, many of the occupations associated with talent pipelines were rebranded as middle-skill jobs, which require more than a high school diploma and less than a four-year college degree. However, rapid adoption rates of transformational technologies in fields such as the trade and transportation sector are now increasingly requiring continual upskilling and training for incumbent workers and industry-led training for entrants. At the same time, employers hiring for numerous "middle-skill" jobs that did not require bachelor's degrees for previous generations are now requiring them or even more advanced degrees. Herein lies the opportunity for CSU campuses to work with industry leaders to establish talent pipelines beyond previous notions associated with the middle skills paradigm to instead address the new transformational skills paradigm.[6]

The educational and training qualifications for "middle-skill" jobs are no longer finite, which is rendering the term obsolete. These transformational technologies, along with economic and cultural shifts, are occurring at such a rate that educational institutions are struggling to provide the relevant training and education for in-demand occupations. This "mismatch" between workers and the necessary knowledge, skills and abilities (KSAs) have made it difficult for employers to hire qualified professionals, causing what many have come to identify as a "middle-skills gap." However, a term such as "middle-skills gap" fails to accurately characterize ways that occupational definitions and expectations are changing across trade and transportation sectors and the economy at large. Equally important are ways that relevant education and training required for today's in-demand occupations challenge previous assumptions about a "middle-skill" job's qualifications It is also worth noting that a focus on transformational skills eliminates class-based associations and glass-ceiling implications linked with "middle skills" branding. Alternatively, empowering emerging and incumbent professionals to adopt transformational skills conveys preparedness for changing times without limits on career trajectory.

In this report, Center for International Trade and Transportation (CITT) authors replace the term "middle-skills gap" with a more relevant term: "transformational-skills gap." This redefinition, of course, raises the question, what are transformational skills? The big picture answer to that question is that they are a set of skills that prepare professionals for an unknown future with new disruptive technologies. In a more detailed sense, the transformational skills required to design, develop, operate, and maintain the mobility systems of the future will address:

- zero-emission technologies powered by battery-electric and fuel-cell drivetrains;
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- connected and "smart" communities; and

a range of other data-privacy, digital rights, and cybersecurity issues in an era where data plays a ubiquitous and profound new role in the ways mobility systems are operated, evaluated, and optimized.

1.1 What is a Talent Pipeline?

The term *talent pipeline*, much like *talent pool*, has existed within the U.S. business vernacular for decades. Those early workforce metaphors preceded more formal notions of *talent pipeline management*, an approach that has become increasingly popular over the last two decades as public- and private-sector organizations seek to "position the right people with the right skills in the right jobs."[7]

Although the focus of this report is the trade and transportation sector, it is important to acknowledge that the most substantial and foundational talent pipeline innovations in the U.S. have occurred in the healthcare sector, particularly with nursing programs. Consider the three most basic ingredients for ongoing talent pipeline management success:

1. A pool of talented applicants who are committed to pursuing a specific career;
2. A focused education and training program with leaders who work with employers to ensure that graduating students have learned the required knowledge, skills, and abilities (KSAs); and
3. One or more employers who are committed to working with leaders in targeted education and training programs to ensure that the graduating students they hire have the skills they need to succeed.

In terms of nursing talent pipelines, consider the above three points. (1) Successful talent pipelines address in-demand jobs that pay a living wage. Decade after decade, students choose to enroll in nursing programs because qualified gradates can always find jobs and pursue meaningful careers. (2) Successful talent pipeline programs require leaders in education and training who work with employers to build the most critical KSAs into the curriculum. And (3) employers determine the success of talent pipeline efforts through direct and ongoing participation that shapes the KSA-based training and related educational activities featured in the talent pipeline program.

In many respects, nursing talent pipeline programs are bellwethers for the talent pipeline management programs required to address the transformational skills gaps in the transportation and trade sector. The healthcare industry is in a constant state of change due to ongoing enhancements to the state of practice from new technologies and research breakthroughs. To respond to these changes, nurses and other healthcare practitioners are required to complete a detailed practicum to confirm they have the required KSAs. After securing jobs, healthcare professionals are required, by certifying boards and their employers, to earn continuing education credits throughout their careers. Such an approach is warranted in a field where one mistake could mean life or death. Similarly, mistakes made in the design, development, operation, and maintenance of roads, bridges, traffic, freight, and other new data-driven trade and transportation systems could lead to a cybersecurity breach, or even lead to life-or-death consequences. This rationale means trade and transportation professionals must meet the highest standards for safety and competence to ensure safety and the preservation of national security.

Talent pipeline management systems provide a way for university-industry partners to address transformational skills gaps in the trade and transportation workforce. Students graduating from four-year and graduate programs have always had anxiety about whether they have the skills and abilities—to accompany the theoretical knowledge they acquired in college—to secure meaningful and gainful employment. In the talent acquisition and human resources fields, the KSA acronym has become synonymous with what constitutes a qualified candidate. This report focuses on talent-pipeline management strategies to ensure that emerging and incumbent professionals have access to the targeted education and training programs they need to succeed. Put another way, this report presents strategies that put the *S* and *A* back in KSA through CSU-led university-industry talent pipelines.

The talent pipeline models proposed in this report are not intended to compete with the exemplary programs already established by community college and workforce development board leaders across the country. Rather, these pipeline models seek to learn from, and give credit to, successful programs designed and managed by community college and other workforce development leaders to inform the implementation of university-industry talent pipelines within CPaCE units across the CSU system. It is equally important to note that these models are not presented as a means to restructure traditional four-year and graduate-degree programs offered by other CSU colleges. Rather, they seek to cultivate campus-wide increases in traditional and non-traditional student enrollment, and additional research and teaching opportunities for faculty in every college.

1.2 Why are CPaCE Units Ideal Hosts for Talent Pipelines?

In 2014, the U.S. Chamber of Commerce Foundation (USCCF) published *Managing the Talent Pipeline: A New Approach to Closing the Skills Gap*, which leverages successful innovations in supply chain management to outline a talent-supply-management system that situates employers in a "new and expanded leadership role" in education and workforce partnerships.[8] Beyond connecting trade and transportation innovations directly to talent-pipeline management approaches, the USCCF report makes a case for the U.S. business community to embrace strategies that move beyond traditional hiring models where employers were active in recruitment and hiring, while passive in talent cultivation. That traditional model has ultimately led to ineffective hiring because employers and educational providers have not been working together to train workers in the face of shifting in-demand skills and abilities.

Instead of relying on an open-until-filled recruitment strategy and relying on rare and outstanding candidates to walk through their doors, talent-pipeline strategies empower employers to foster their talent from the ground up. Figure 1 illustrates the traditional hiring model where there is no formal collaboration between university and industry partners and students have no assurances that what they are learning in their degree program is what potential employers seek. It is important to acknowledge that the traditional hiring model has and will continue to serve as a successful way for people to first acquire education and then pursue employment. However, in periods of unprecedented technological change, skills gaps increase, and the demand for skilled professionals also grows. During such periods, public- and private-sector employers struggle to recruit enough qualified professionals, and talent pipeline models provide a viable way for employers to proactively work with university partners to address workforce gaps. Figure 2 reflects how a university-industry talent pipeline:

- empowers students to pursue targeted career opportunities; and
- convenes university and industry partners to work together to develop and provide skills-based curriculum, on-the-job-training, work-based support, resource, and training so that a student/worker is prepared with the relevant KSAs to enter the workforce.

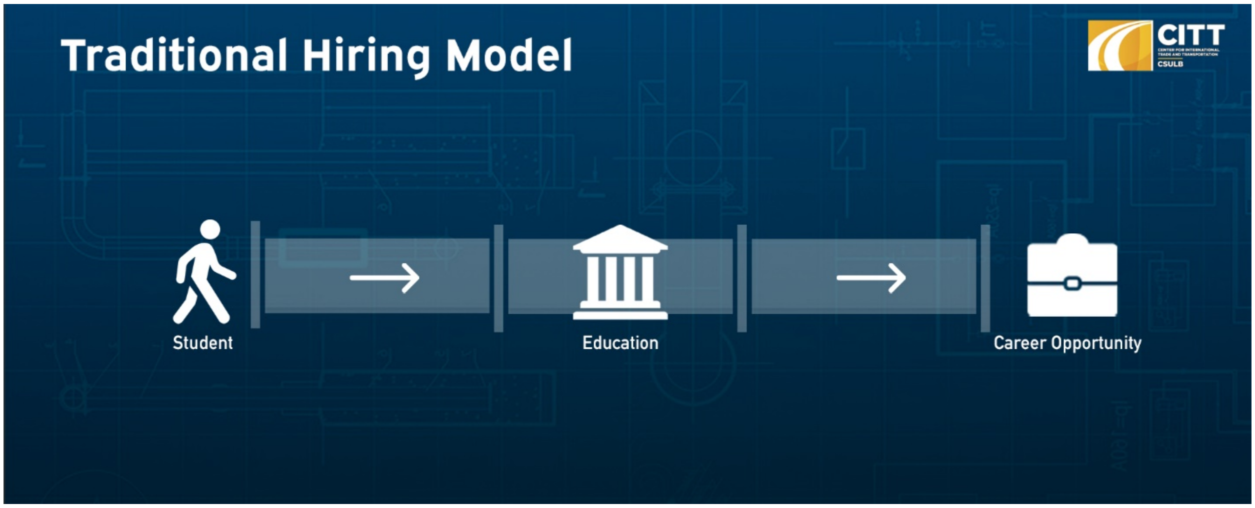

Figure 1. (© CITT 2022)

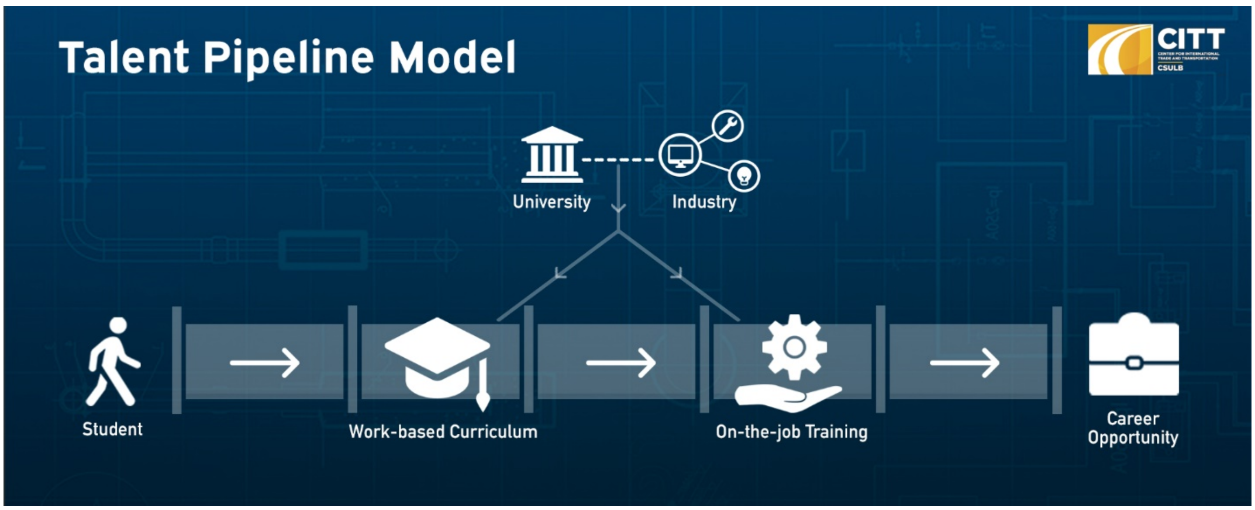

Figure 2. (© CITT 2022)

Talent-pipeline strategies are unique because there is built-in accountability and flexibility that allows for rapid responses when transformational shifts occur in required KSAs for critical occupations. Traditional four-year and graduate degree programs offered throughout the CSU system were not designed to provide rapid responses to skills gaps—particularly at the exponential rate that transformational technologies are being adopted throughout the trade and transportation sector.

Fortunately, the Colleges of Professional and Continuing Education (CPaCEs) housed within each of the 23 CSU campuses across California are in a unique position to create and facilitate talent-pipeline strategies by convening key personnel in government, industry, and education to advance common workforce development priorities.

In 2021, the CSU Chancellor's Office summary report of CPaCE programs showed a fund balance of $318.5 million to support Special Sessions degree, certificate, and credential programs; Open University; contract and extension credit; non-credit certificates, courses, and programs; and awarding of continuing education units across campuses.[9] These funds can be strategically used to initiate transformational skills-building programs that specifically target transformational skills gaps in the trade and transportation sector and beyond. This report outlines methods and suggestions for the CPaCEs within the CSU system to build a network of industry stakeholders, bring employer-driven values and insights into the classroom, and implement talent-pipeline programs for numerous in-demand occupations.

CPaCEs are the ideal college within each CSU campus to design and implement talent pipelines because they have the capacity to convene partners and to create industry-driven and not-for-credit training programs in a timely and efficient manner to meet demand. Effective talent-pipeline development and management require educational partners with the capacity to offer specific degrees, certificates, and non-credit professional development. And while the CPaCEs within each CSU campus are uniquely structured to play a foundational role in the convening, implementation, and programmatic evaluation of talent-pipeline initiatives, it is also true that no single partner can shoulder the burden of planning and implementing a successful and sustainable talent pipeline. Successful talent pipeline implementation requires what the Stanford Social Innovation Review (SSIR) defines as the five conditions of collective impact: a common agenda, shared measurement, mutually reinforced activities, continuous communication, and backbone support.[10]

The Five Conditions of Collective Impact	
Common Agenda	All participants have a shared vision for change including a common understanding of the problem and a joint approach to solving it through agreed upon actions.
Shared Measurement	Collecting data and measuring results consistently across all participants ensures efforts remain aligned and participants hold each other accountable.
Mutually Reinforcing Activities	Participant activities must be differentiated while still being coordinated through a mutually reinforcing plan of action.
Continuous Communication	Consistent and open communication is needed across the many players to build trust, assure mutual objectives, and create common motivation.
Backbone Support	Creating and managing collective impact requires a separate organization(s) with staff and a specific set of skills to serve as the backbone for the entire initiative and coordinate participating organizations and agencies.

Figure 3. [11] The Five Conditions of Collective Impact (Channeling Change: Making Collective Impact Work)

The Five Conditions of Collective Impact depicted in Figure 3 are informed by a systems-driven approach that steers clear of attempts to solve complex social problems through isolated efforts.[12] CPaCE leaders can provide that critical "backbone support" by convening and implementing talent-pipeline initiatives in partnership with industry partners that are willing to invest time and resources into developing skilled and prepared professionals who are ready to design, develop, operate, and maintain the mobility systems that move people and goods in the future. In this way, the SSIR framework for collective impact can be used as a barometer for assessing the localized effort of numerous organizations working together to solve complex problems such as the transformational skills gap in the trade and transportation sector.

The contents of this report serve as a resource for the Commission on Continuing and Professional Education as members guide and inform the larger vision for present and future CPaCE programming. The talent-pipeline management best practices and University-Industry Project (UIP) Gateway pilot program recommended in this report are informed by the notion that organizational partnerships in business and developmental evaluation begin with basic networking and increase in levels of commitment and complexity (as presented in Figure 4)

.

Figure 4. Patton, M. (2011). Developmental evaluation: Applying complexity concepts to enhance innovation and use. New York: Guilford Press.

2. Building Talent Pipelines in an Era of Transformational Change

The impact of transformational technologies can be characterized as "elements of the Fourth Industrial Revolution (Fourth IR), a technical revolution characterized by a fusion of the digital, physical, and biological spheres, and characteristic of its unprecedented velocity."[13] In the trade and transportation industry, the Fourth IR "specifically refers to the use of robotics, artificial intelligence, automation, and digitalization in work processes."[14] The COVID-19 pandemic caused the supply chain and logistics sectors to pivot quickly when shelter-in-place mandates were set, causing a "multi-year process to gather business intelligence and digitize processes" to be condensed into a matter of months and weeks.[15] These transformational technologies are rapidly changing workplace demands for trade and transportation workers, creating a need for new digital skills and competencies.

Beyond all of the technological concerns, the biggest challenges raised by transportation leaders deals with human rather than technological systems. Increasingly a "company's highest cost when adopting technology is not the initial investment of software but rather training of staff to effectively deploy the technology." There are currently "very few training and education programs [that] are aligned with these newer 'hybrid' jobs that require both sector-specific and digital skills, especially since "digital skillsets constantly change, so talent must be malleable to embrace dynamic work environments."[16]

One key takeaway from the emergence of hybrid jobs and new multidisciplinary skillsets is that "competency-based, short-term programming using industry-driven curricula will likely be the model for workforce development going forward."[17] Using Lightcast™ to conduct real-time, labor market analysis, this report analyzed a list of the top 50 in-demand trade and transportation occupations in California (See Appendix D). That analysis revealed key labor market insights regarding the current quality of those jobs and the ways in which CPaCEs can service short-term programming to produce pipelines to these jobs. To begin with, all 50 occupations are critical occupations that address crucial needs in the trade and transportation sector. Some require foundational hard skills, such as commercial pilots and diesel engine specialists, while others demand a range of transferable skills, which give current employees and entrants a means of job mobility within the industry. Much of the training, education, and certification that people need for these occupations can be addressed with two-year degrees through community colleges or other technical schools, but there is also an emerging trend in this dataset that suggests ways that universities offering four-year and graduate degrees can address critical needs in training and workforce preparedness.

A close review of the top 50 in-demand trade and transportation occupations—derived from labor market data available from June 2021–May 2022—reveals a discrepancy between the "education level of employed individuals" and "education level based on posting requirements." The percentage of job postings that now require a bachelor's degree far exceed the percentage of job holders with bachelor's degrees or higher, which suggests that employers are actively seeking certain KSAs acquired in a university environment. This raises the question, what kind of training and professional development is the university uniquely qualified to provide? Another way of framing the question is, what kind of training and professional development is needed in addition to the hard skills that are acquired through a two-year certification program? One broad answer to these questions is that there is a level of knowledgeability—perhaps critical thinking such as strategic analysis and problem-solving and/or professional soft skills—that a student or current professional can develop and improve upon in a university environment in order to meet the challenges of an ever-changing workplace landscape. Identifying the university's unique resources and capacity for developing the desired professional competencies will be the critical first step in determining effective talent-pipeline strategies.

One area of targeted skills-building will likely be hybridized digital skills. As discussed throughout this report, transformational technologies are changing the nature of work in the trade and transportation industry, so employers now require professionals who understand the traditional process of the occupation and how digital tools can be used to enhance the work. First-Line Supervisor positions, reflected in Figure 5 across sales, administration, repairs, and other areas, will require workers to implement software and use data analysis in order to improve production and day-to-day management.

#	SOC Code (ONET-6)	Occupation Tittle	Number of Job Postings	Risk of Automation	Number Employed 2020	% Change in Employment, 2019-2020	Change in Employment 2018-2028
1	11-3071	Transportation, Storage, and Distribution Managers	1,702	Medium Risk	19,080	-2%	14.1%
2	49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	1,565	Medium Risk	21,180	-5%	7.7%
3	43-5011	Cargo and Freight Agents	1,396	High Risk	13,100	-4%	15.1%
4	13-1081	Logisticians	1,355	Low Risk	24,420	6%	9.4%
5	41-1011	First-Line Supervisors of Retail Sales Workers	1,217	Low Risk	105,060	-10%	-0.4%
6	53-1021	First-Line Supervisors of Helpers, Laborers, and Material Movers, Hand*	1,167	Low Risk	28,030	5%	16.7%
7	43-1011	First-Line Supervisors of Office and Administrative Support Workers	815	Low Risk	161,550	-3%	1.7%
8	49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	637	Low Risk	40,820	1%	4.8%
9	53-1031	First-Line Supervisor of Transportation and Material-Moving Machine and Vehicle Operators*	501	Low Risk	24,710	5%	16.7%
10	43-9199	Office and Administrative Support Workers, All Other	496	Medium Risk	38,680	-13%	8.6%
11	35-1012	First-Line Supervisors of Food Preparation and Serving Workers	328	Medium Risk	80,880	-15%	16.0%

Figure 5. Emsi Burning Glass (now Lightcast) (2022) "top 50 in-demand trade and transportation occupations in California" *(See Appendix D)*

CPaCEs throughout the CSU system have the ability to design and implement talent-pipeline programs linked to targeted degree, certificate, and non-credit professional development to provide workforce development solutions that empower:

1. Emerging professionals pursuing undergraduate and graduate degrees, and
2. Incumbent and displaced professionals, who are returning to the CSUs to participate in talent-pipeline programs for necessary upskilling and retraining.

Through serving this range of emerging, incumbent, and displaced professionals, CSU leaders will establish new educational marketplaces to drive student enrolment. It is important here to note that talent-pipelines are flexible: they can be designed to provide an additional workforce development layer that students seeking degrees can optionally participate in to enhance their ability to compete for in-demand occupations.In any discussion of labor market conditions and gauging the affects of transformational technology, an important caveat must be acknowledged: no labor market data is perfect. Historical labor market data from the Bureau of Labor Statistics (BLS) and real-time datasets aggregating findings from current job listings cannot predict every new skills gap and labor market disruption. That reality was demonstrated worldwide during the COVID-19 pandemic. Fortunately, talent-pipeline programs provide CSU leaders a viable way to address transformational workforce trends even in cases where the BLS data and the related Standard Occupational Codes (SOCs) for new job titles does not yet exist. Said another way, if employers invest time and resources to support university-industry talent pipelines, they have validated the need by virtue of their participation. The pilot program recommended at the end of this report provides an example of a large employer validating the need for a CSU talent pipeline addressing a specific workforce need.

A few other critical trends to consider alongside technological changes are major infrastructure bills. Recently, the U.S. Department of Transportation announced the award of $2.2 billion in grants for the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program. In California, eight projects will receive grants totalling $120 million.[18] The projects focus on a variety of improvements, which will inevitably create new jobs and a need to equip current and emerging professionals with the KSAs required to not only meet the traditional expectations of transportation infrastructure—roads, railways, bridges, and supply chain systems—but also the transformational requirements called for in an Internet of Things future.

2.1 Talent Pipeline Management Strategies for the Trade and Transportation Sector

CPaCE units are uniquely positioned to address the need for emergent skills and abilities related to trade and transportation occupations requiring bachelors and graduate degrees as well as retraining and upskilling mid-career professionals. By conducting careful labor market analysis, CPaCE leaders can differentiate talent-pipeline efforts from the foundational learning that community colleges and workforce development boards offer for a range of occupations requiring short-term and two-year degree focuses. Conducting thoughtful labor market analysis and coordinating with community college and workforce development leaders throughout California are important steps that CPaCE leaders can make to ensure that they develop talent pipeline initiatives that address unmet workforce challenges and do not duplicate efforts already addressed by other education and training partners in the post-secondary continuum.

Using historical and real-time labor-market analysis tools, CPaCE teams can identify specific skills gaps and in-demand occupations in the trade and transportation sector. Conducting labor market analysis is the first step in identifying in-demand occupations and skills gaps created by the adoption of transformational technologies in the trade and transportation sector. CPaCE leaders can then follow three basic steps to establish talent pipelines that unite industry leaders and university subject matter experts from across the colleges in their respective campuses to address transformational skills for both new entrants and incumbent workers. Those steps are:

1. Convene industry partners to validate skills gaps and occupational gaps associated with the implementation of transformational technologies;

2. After identifying common workforce development pain points associated with skills gaps and talent acquisition challenges, CPaCE leaders work with industry stakeholders to develop a talent pipeline solution that leverages existing CSU subject matter experts (on a home campus or via partnerships with other CSUs); and

3. CPaCE leadership works with industry stakeholders to establish a formal collaboration that, in accordance with the partnership continuum presented earlier in Figure 3, includes the development of an agreement that moves beyond *networking, cooperating, and coordinating* partnerships to work in *collaborating* or *full partnership* capacities. This distinction is important because it formalizes a university-industry commitment to shared goals as well as a commitment to invest organizational funding and staff resources.

Organizational commitments to assign funding and staff support for a shared talent pipeline goal are often anecdotally referred to as “skin in the game,” which the U.S. Chamber of Commerce Foundation defines as an essential prerequisite for successful and sustainable industry engagement.[19] Such commitments form the foundation of successful talent pipeline initiatives and are consistent with a range of talent pipeline and talent management strategies.

Ultimately, a university-industry talent pipeline team amounts to a network of partners who are committed to a set schedule of meetings and activities that will lead to a sustainable and ready-to-hire talent pool and a robust workforce. Talent pipelines can be developed in single-employer formats and in consortium models as presented later in this report. Formats aside, the first and last priority for any talent pipeline should be the effectiveness and efficiency of the student learning experience and the ultimate placement rate. The simple pipeline depicted in Figure 6 conveys the notion that the student pipeline experience provides a direct connection to a meaningful career opportunity. The student experience is focused and efficient, and the frenetic coordination between university and industry partners is largely invisible to them.

Figure 6. (© CITT 2022)

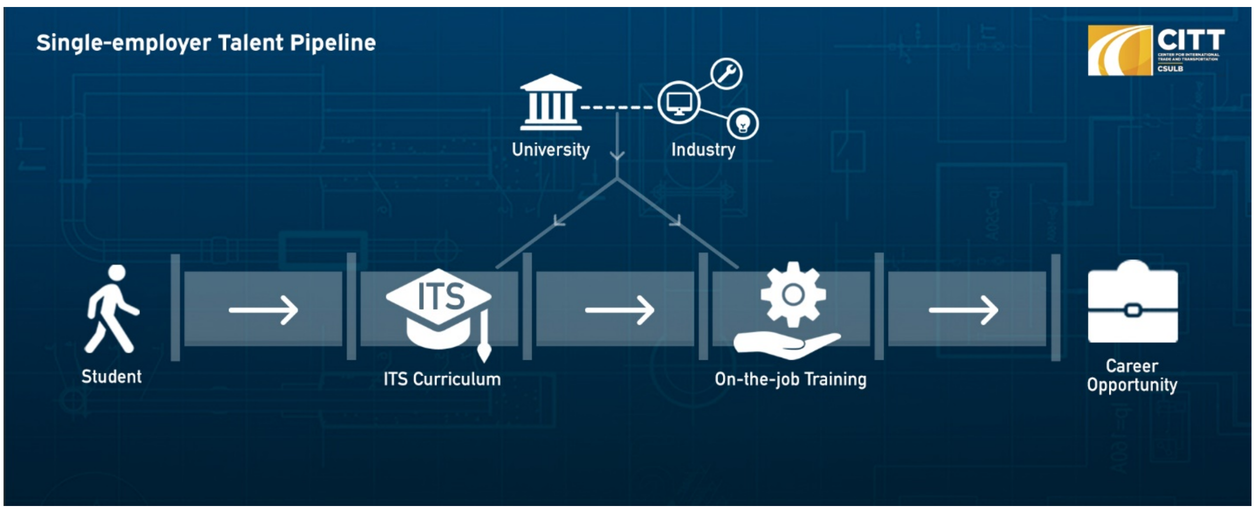

Figure 7. (© CITT 2022)

With effective university-industry coordination, as depicted in the Intelligent Transportation Systems (ITS) visualization in Figure 7, students can benefit from curriculum that helps cultivate skills and abilities related to new transformational technologies such as ITS. Equally important is that university and industry partners collaborate to facilitate enriching on-the-job-training for pipeline participants to learn by doing. The concluding section of this report will present an ITS Engineering Talent-Pipeline pilot program that CITT will launch in 2023 in partnership with Gannett Fleming, an engineering and consulting firm with a national portfolio of ITS and other transportation infrastructure projects.

From a practical standpoint, the talent-pipeline model in Figure 7 addresses a critical industry engagement requirement called for by the Accreditation Board for Engineering and Technology (ABET). In this way, university-industry talent pipelines provide focused ways for

CSU leaders to demonstrate to accrediting boards and the communities they serve that they are delivering skills-based curriculum that reflects expertise from not only subject matter experts on campus but also from working practitioners and industry leaders who are facing technological and workforce challenges in real time.

In each instance, the key to convening industry partners launching and managing effective and talent-pipeline programs requires meeting the five conditions of collective impact. The following table reflects how CSUs and local industry partners can work together to have a collective impact on skills gaps in the trade and transportation industry.

Table 1. Collaboration between CSUs and Local Industry Partners

Common Agenda:	Strategic networks of CPaCEs on CSU campuses, industry partners, and government agencies establish common agendas to implement talent-pipeline strategies in the form of short-term programming, certification programs, etc. as a solution for targeting transformational skills building in the face of a rapidly changing work landscape.
Shared Measurement:	All partners involved agree to collect data and share results across all stages of talent-pipeline planning and implementation to assess the effectiveness of the programming and each partners' involvement.
Mutually Reinforcing Activities:	All partners agree to play a distinct role in talent-pipeline planning. CSU partners agree to be the backbone support and facilitate educational/training programs; industry partners agree to provide experts and consultants who can lead the conversation on in-demand KSAs, cast the vision for the selected programming/work of the talent pipelines, and refer instructors for the CSUs; government agencies can provide economic support and resources.
Continuous Communication:	All partners agree to scheduled meetings and a schedule of events/actions/etc. that are required for successful cross-sector collaboration and planned execution.
Backbone Support:	CSU partners will serve as the facilitators and managers of this collective impact and will primarily be responsible for convening partners to initiate and coordinate participation from all other partners.

One common insight found in various talent pipeline models is that the final step in successful implementation and management is, surprisingly, not employment for the pipeline participants but rather a post-assessment and evaluation phase. While employment is the abiding reason for the talent pipeline, there is general consensus across talent pipeline and talent management strategies that assessment and evaluation activities should constitute the final step in a talent pipeline implementation. By conducting evaluations and assessments at the conclusion of a talent pipeline effort, university-industry teams can evaluate the success of the collective initiative, consider modifications, and revisit new labor market analysis. Adopting this step-by-step iterative process of deployment, assessment, revision, and redeployment empowers university-industry teams to avoid zero-sum game implementations and instead lead pipeline efforts as informed continuums dedicated to promoting cultures of continuous improvement as depicted in the talent management model in Figure 8 (below).

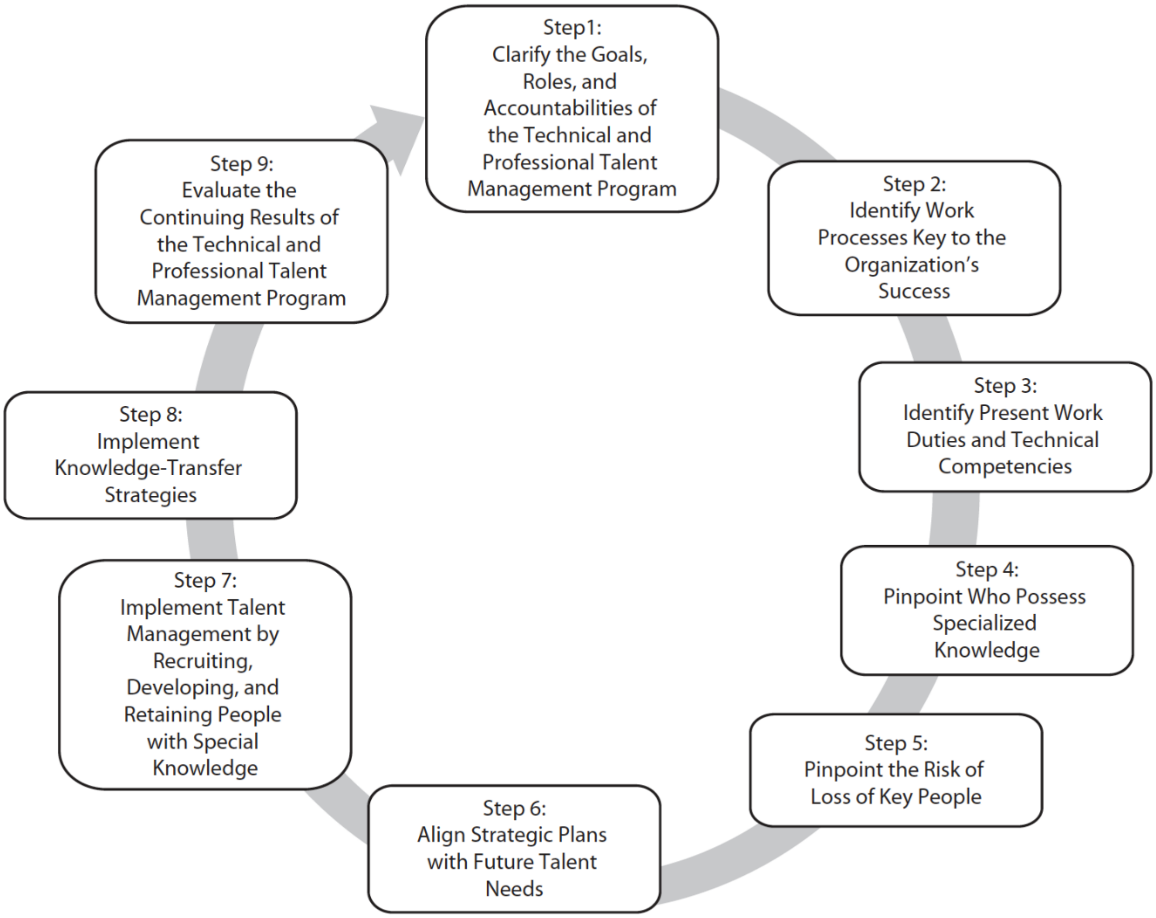

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Figure 8. Strategic Model for Technical Talent Management

CSUs throughout California have a strong record of accomplishment cultivating talent in the trade and transportation sector, as well as in many other industries. In continuing and professional education, CSUs offer a number of industry-specific certification programs that target skills-based upskilling and professionalization. There are a range of trade and transportation degree and certificate programs offered at CSUs located throughout California, as documented in Appendix A. This broad range of programmatic offerings represents an opportunity: CSU leaders can assess the champion instructors and subject matter experts working on their various campuses and establish a talent-pipeline infrastructure that can produce nimble responses to skills gaps created by rapid rates of technological and socioeconomic change.

The CSUs are, in many ways, already operating as "backbone support" in their respective local regions, working to establish training and educational programs with an eye toward current needs in workforce development. Establishing talent-pipeline infrastructure would provide a way for

CSUs to work with industry leaders to address skills gaps created by transformational trends while connecting students with in-demand career opportunities. It is also important to note that talent pipelines offered at CSUs could provide a valuable career bridge for students pursuing four-year and graduate degrees (as the ITS Talent Pipeline Pilot in the conclusion of this report will demonstrate) but also for incumbent professionals who are returning to CSUs for upskilling and retraining. Serving incumbent professionals through CSU-based talent pipelines would also serve as a way to increase enrollment of nontraditional student populations.

Another highly valuable benefit associated with talent-pipeline management is the ability to offer continual professionalization and training through ongoing partnerships and discussions with industry partners. Talent-pipeline strategies, if structured correctly, leave room for accountability and flexibility so that industry partners offer the necessary feedback and instruction for in-demand training. Those university-industry partnerships can form single-employer pipelines or coalition-supported models as depicted in Figure 9.

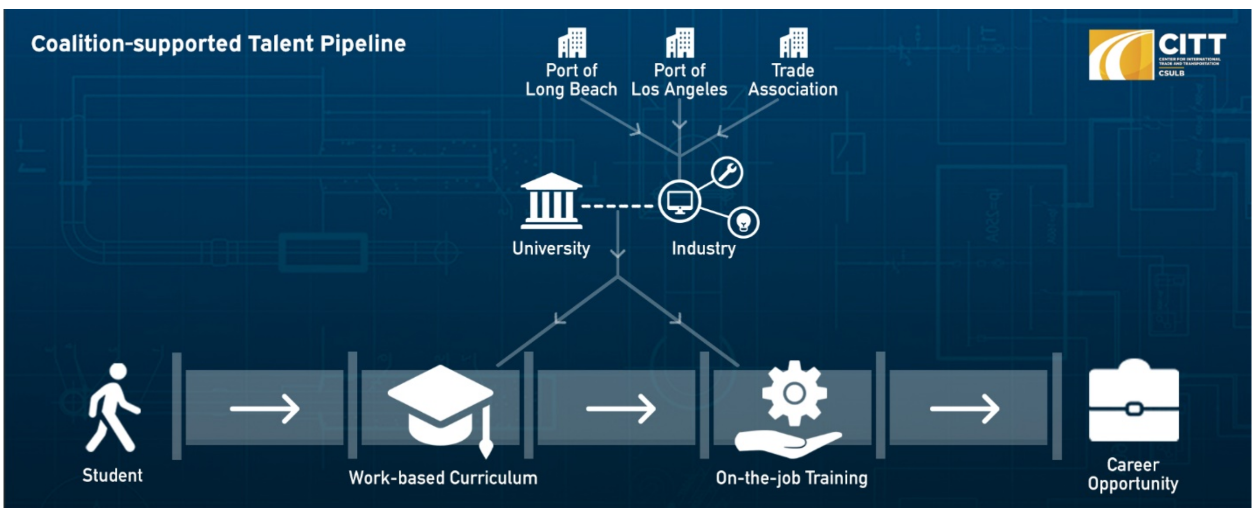

Figure 9. (© CITT 2022)

The coalition talent-pipeline model visualizes ways that members of the Southern California supply-chain community could work together to support a talent-pipeline program addressing training for in-demand occupations. In California, transformational technologies and environmental mandates are two catalysts for seemingly continual change in the trade and transportation sectors. Building university-industry led talent pipelines provides a viable collaborative system for educators and trade and transportation employers to address workforce challenges.

CPaCEs across CSUs have an opportunity to collaborate with key cross-sector stakeholders to ensure that incumbent and incoming workers are empowered and prepared in the face of continual shifts. When all cross-sector partners are committed to playing their part in the talent pipeline framework, talent-pipeline management is a proven solution for cultivating relevant KSAs and ensuring employees' success in the midst of industry changes.

CSUs can provide backbone support for talent-pipeline coalitions throughout California. This approach mirrors the same basic steps required for a single-employer talent pipeline. The big difference is the increased level of coordination among stakeholders. In this way, it is good to consider selecting a respected lead organization that can transparently and equitably convey the needs and priorities of the consortium members. In the supply-chain pipeline depicted in Figure 8, the Port of Long Beach, the Port of Los Angeles, and a trade organization work with a lead industry organization that coordinates with the university partner. The coalition talent-pipeline model requires:

- Convening industry leaders and government agencies to assess the shifting regulatory, financial, and workforce landscape for in-demand occupations in the trade and transportation industry;
- Working with employers to develop curriculum and training programs and to find well-equipped and knowledgeable instructors;
- Administering and facilitating programs for both incumbent and incoming workers; and
- Establishing a regular schedule for persistent assessment of the talent pipeline so that programming remains relevant.

Successful talent-pipeline programs are a result of collective impact involving leaders in education, state government, workforce development, and industry. CPaCE units within each CSU campus are uniquely structured to support talent-pipelines requiring a range of custom degree, certification, not-for-credit, workshop, and open-university modes of training and curricular development.

The traditional hiring model will continue to serve as a viable option for many job seekers and employers. However, in cases where shortages of skilled professionals impact the efficiency and profitability of transportation and trade operations, then talent pipelines become an appealing and viable option. CPaCEs units can provide backbone support for talent-pipeline programs to address critical trade and transportation workforce challenges throughout California. Those backbone support activities include:

- Identifying critical occupations that require rapid-response training;

- Organizing the conversations and planning between industry, education, and other partners; and

- Facilitating the agreed upon programs supported by the university-industry partnership. Here again the priorities outlined in Appendix B provide a comprehensive framework for talent pipeline priorities.

Talent pipelines can also be structured to accelerate the time it takes for cohorts to earn certificates and secure employment. Such fast-track talent pipeline/certificate programs are ideal options for displaced/dislocated workers and other adult learners seeking alternatives to traditional program delivery methods. The talent pipeline model below, in Figure 10 and in Appendix C, presents a successful Accelerated Diesel Mechanic program operated by Los Angeles Trade Technical College (LATTC). That pipeline effort compressed what would normally be a two-year program into a 10-month timeframe. The LATTC talent-pipeline program gave students access to case managers and support services throughout the program and a job placement component at the end. Out of the 32 students in that LATTC program, 30 had jobs secured by the end of the program.

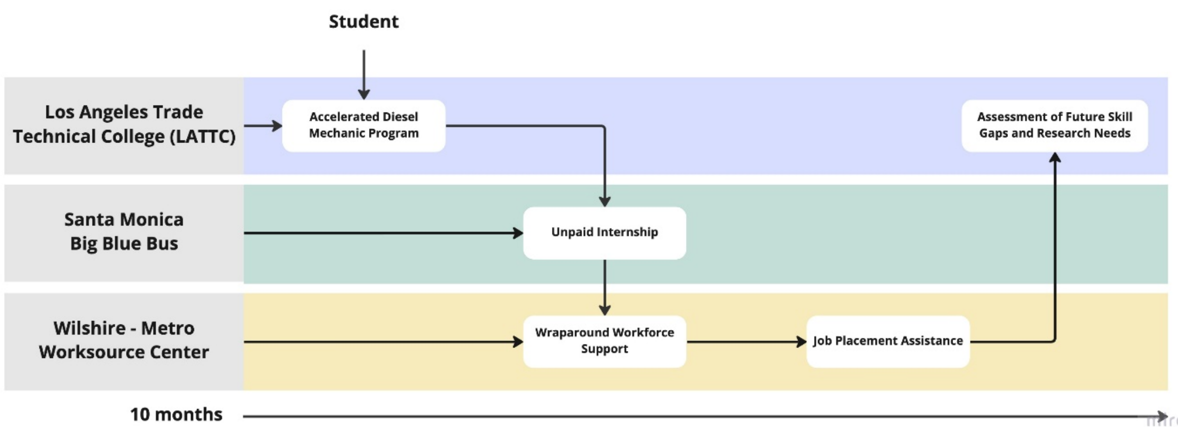

Figure 10. (© CITT 2022)

Table 2. Accelerated vs. Traditional Diesel Mechanic Program

Accelerated	Traditional
Cohort-based; enrollment restricted to initial cohort	Course enrollment open each term; non-cohort based
10-month Program	2+ Year Program
Integrated soft skills and workplace success workshops and class assignments	Minimal integration of soft skills
One tenured faculty member assigned to all courses in program	Instructor changes each term depending on course; com-bination adjunct and tenured
90% Student Certificate Completion Rate within the 10- month program	29% Student Certificate Completion Rate within two years (Appendix C)

The LATTC model serves as an exemplar for accelerated talent-pipeline deployment. The model—with its cohort-based instruction, dedicated faculty member for all classes, workplace success workshops, among other innovative approaches—took place at a community college, but CSU CPaCE units in partnership with industry partners could design and deploy equally innovative approaches to address in-demand occupations and critical skills gaps.

It is important to note that all of the talent-pipeline models presented in this report are compatible with an additional layer of support from governmental, nonprofit, and philanthropic entities. This additional support can provide a sustainable source of funding for critical talent-pipeline efforts. One factor that should always be considered in the launch of any university-industry talent pipeline is that private-sector employers may need to shift company resources and focuses as market forces shift. This reality underscores the value of transitioning university-industry talent pipelines into civic-market partnerships. Expanding industry-university alliances to include governmental/non-profit/philanthropic strategic partners creates civic-market triangulations to leverage the strengths of all three partners to ensure that talent-pipelines are not only innovative but also sustainable.

3. Summary & Conclusions

Civic-market partnerships have brought about some of the most leveraged and innovative industry, research and development (R&D), and government implementations in not only the U.S. but also global socioeconomic history. Consider transformational technologies such as the cell phone, satellite, global positioning system (GPS), and digital television technologies to name just a few examples. In each case, a shared problem or challenge is identified and then addressed through a series of coordinated efforts:

1. A big problem or challenge is identified, and subsequent targeted research problem statements are developed;

2. In response to those research problem statements, leaders from industry, R&D, and government work together to deploy pilot projects that address both human and machine-system enhancements and innovations to address those stated challenges;

3. Those initial projects inform efforts to scale and implement pilot efforts more broadly with shared contributions from the civic market partners; and

4. Over time, civic market partners conduct assessments and evaluations to consider ways to revise and build upon previous efforts.

As with the implementation of the cell phone, it takes an extraordinary amount of financial and human capital to cultivate a fledgling technology into one that transforms the world. When Motorola Engineer Martin Cooper invented the first functional cell phone prototype in 1973, "transformational" would not be the associated operative word for decades. The device weighed more than two pounds and a network of satellites, towers, and repeaters did not exist to support widespread use.[20] But, over time, using the highest standards of scientific method, governmental support, and free-enterprise innovation, the cell phone changed the world.

If a reflection on the design and implementation of cell phone technology seems far afield in a report on talent pipelines, one need only consider ways that university-industry talent pipelines can transform the way that emerging and incumbent professionals can ensure that they have the *S (skills)* and *A (abilities)* to accompany the *K (knowledge)* in KSA. If champion industry employers partner with CSU CPaCE units to form talent pipelines, all boats—to use an apt colloquialism for the trade and transportation sector—will rise together. Emerging professionals working through bachelors and graduate degree programs, who are uneasy about their post-graduation prospects, will find talent pipelines that empower them to focus and refine their KSAs to pursue and secure in-demand occupations. CSU campuses will increase enrollment among students who value clear linkages between the KSAs they acquire and their career prospects. And, equally important, champion employers will find proactive ways to help emerging and incumbent professionals bridge the skills gaps created by transformational technologies. Ultimately, the formation of targeted talent-pipeline programs will provide a common call to action for university and industry leaders to design and implement knowledge management innovations.

In "From Body of Knowledge to Base-Map: Managing Domain Knowledge through Collaboration and Computation," Sean C. Ahearn and André Skupin, note that "cutting-edge research is often slow to transition into professional practice, while educational activities and materials often do not represent the current state of research and practice."[21] They note that "scientific research, academic education, technical training, and professional practice are driven by seemingly disparate concerns, and there tends to be little interaction between these sub-communities."[22] Although it was not the explicit intention of their research, Ahearn and Skupin identify a significant opportunity for CSU leaders to use industry-university talent-pipeline programs to address long-range educational priorities such as the future of workplace learning, the future of apprenticeships, and the future of lifelong learning, through the lens of knowledge management concepts.

To get a better sense of how knowledge management could position CPaCE units throughout the CSU system as leaders in workplace learning, apprenticeships, and talent-pipeline formation, consider the following questions from Ahearn and Skupin:

- What if undergraduate curricula and textbooks co-existed in the same knowledge ecosystem with research publications, software documentation, job advertisements, and grant proposals?

- What if students learning an analytical software tool would have ready access to a set of research studies in which similar tools were recently used?

- What if students were also shown a list of current job openings requiring mastery of associated skills, reinforcing the real-world relevance of curricular content?

- What if those same students could then compare their skill levels in different areas of the knowledge domain with those required by the jobs of interest to them to see how well they matched the various positions available?

- And, finally, what if that knowledge ecosystem was organically changing as the field evolved?

If, over the next seven years, CPaCE units throughout the CSU system work together to build university-industry talent-pipeline programs, the bold goals outlined in the BEACH 2030 long-range plan referenced at the beginning of this report are within reach. University-industry talent pipelines hold significant potential in establishing the "body of knowledge system" innovations that Ahearn and Skupin envision.[23] Such industry-university innovations would position CPaCE units throughout the CSUs as indispensable resources for public- and private-sector employers to equip emerging and incumbent professionals with the KSAs that are most relevant to their needs. CPaCEs would also possess a trove of valuable labor market data to use for the development of targeted curriculum and education and training programs that meet the needs of the current workforce. CPaCE leaders could also use that labor market data to develop reports to forecast in-demand skills and occupations.

Ultimately, talent-pipeline initiatives would not only empower CSU students, but also—through the assessment and evaluation phases in each deployment—enhance the ability of CPaCE units to forecast KSAs of future occupations and anticipate "gaps," instead of playing catch up when they occur. To build this talent-pipeline infrastructure, CSU leadership will need to conduct labor market, programmatic, and curricular analysis to facilitate long-term planning efforts in concert with industry partners. This continuity in labor market, programmatic, and curricular analysis paired with ongoing industry engagement will provide more nimble and informed talent-pipeline responses about how industry landscapes change.

In the near term, leaders at CPaCEs throughout all 23 CSUs face the same challenges identifying champion industry partners. Certainly, establishing industry-university partnerships that turn in-house CSU expertise into community-serving efforts that provide internships or service-learning for students is not a new idea. The challenge is creating sustainable and efficient ways to recruit and connect industry leaders—representing small, medium, and large businesses—with the campus leaders who are best suited to respond to their workforce and research and development needs. Said another way, before industry leaders can commit to long-term industry-university talent-pipeline efforts, they first need to be assured that CSU leaders can address their most critical workforce and research development needs in a short-term testable capacity. Herein lies the value of talent-pipeline pilot programs to demonstrate "proof of concept" to generate campus and industry support.

3.1 Proof of Concept: Launching a Scalable Talent-Pipeline Pilot

Peter Drucker, a foundational thinker in modern management strategies, once famously said "Plans are just good intentions unless they immediately degenerate into hard work."[24] Drucker's words ring true when considering the prospects of implementing talent-pipelines within CPaCE units throughout the CSU system. In order to move the talent pipeline models and approaches presented in this report from the idea phase into applied in real-world contexts, this report's authors recommend deploying targeted pilot programs to demonstrate "proof of concept."

To demonstrate the viability and scalability of talent pipelines in the CSU system, this report concludes with recommendations to pilot a talent-pipeline program at CSULB within its College of Continuing and Professional Education. In that spirit, it is valuable to consider Drucker's view that private- and public-sector organizations should be defined as social institutions. Viewed through this lens, viable university-industry talent pipelines will require key criteria outlined in this report:

1. The development of Full Partnerships called for in the developmental evaluation context (presented in Figure D). Criteria for Full Partnership includes shared goals, shared decisions, and shared resources within a single talent-pipeline initiative; and

2. The Five Conditions of Collective Impact—Common Agenda, Shared Measurement, Mutually Reinforcing Activities, Continuum Communication, and Backbone Support (presented in Table 1).

To that end, on September 18, 2022, leadership from the Center for International Trade and Transportation (CITT) met with leadership from Gannett Fleming during the ITS World Congress in Los Angeles to discuss workforce development challenges. During the meeting, leadership from CITT and Gannett Fleming agreed on the value of developing an Intelligent Transportation Systems (ITS) Engineering Talent-Pipeline program. In the following weeks, leadership from CITT and Gannett Fleming finalized an agreement to launch a pilot program at CSULB to demonstrate the viability of the ITS Talent Pipeline. To validate the pipeline initiative, Gannett Fleming, an engineering and consulting firm with a national portfolio of ITS and other transportation infrastructure projects, committed to providing paid summer internships for CSULB engineering students who complete the talent-pipeline pilot program.

To formally design and implement the pilot program, CITT and Gannett Fleming jointly conducted outreach with CSULB deans from the university's colleges of Engineering, Business, and Continuing and Professional Education to confirm and validate support for the pilot initiative slated for an early 2023 launch date. Upon completion of the talent-pipeline pilot program and the subsequent paid summer internship, CITT and Gannett Fleming will present a final report to CSU leadership to recommend ways to enhance and scale the proof-of-concept pipeline model to other CSU campuses to address ITS and other mission-critical trade and transportation skills gaps and in-demand occupations.

CITT and Gannett Fleming are collaborating, as depicted in Figure 11, to launch a talent pipeline that brings relevant ITS Curriculum, paired with enriching on-the-job-training, to pipeline participants to "learn by doing." As a nationally recognized center of excellence housed within CSULB's CPaCE unit, CITT is an ideal university representative to instantiate the value of the talent-pipeline's approaches for CPaCE units throughout the CSU system. Equally important, CITT has developed a wide range of ITS Professional Capacity Building (PCB) curriculum for the U.S. Department of Transportation Volpe Center. In support of this effort, the Volpe Center has agreed to support the beta testing of ITS PCB curriculum in collaboration with CSULB College of Engineering faculty who have agreed to embed the curriculum within their Spring 2023 courses.

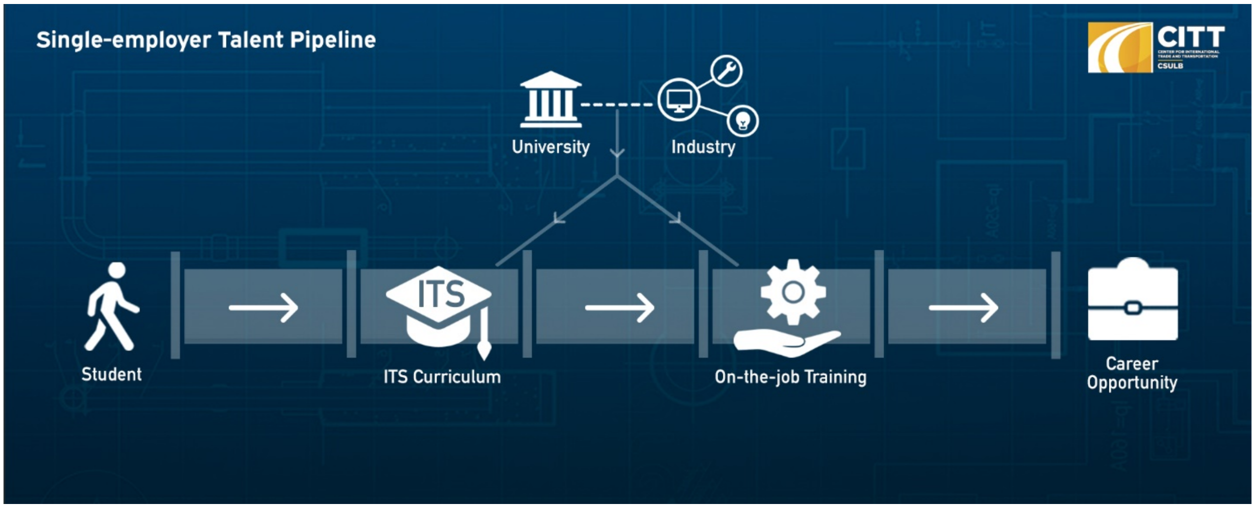

Figure 11. (for reference only; identical to Figure 7)

The ITS Engineering Talent Pipeline pilot will initially focus on CSU students enrolled in traditional engineering degree programs. However, future iterations of the pipeline could be modified to serve cohorts of incumbent professionals who are returning to CSUs for upskilling and retraining. Serving incumbent professionals through CSU-based talent pipelines would also provide a way to increase enrollment of nontraditional student populations. Additionally, in support of this effort, the National Operations Center of Excellence will connect students to a wide range of ITS career opportunities and trainings, which will assist CSU campuses in expanding the single-employer talent pipeline pilot into a coalition-led model. This transition from single-employer to coalition-led talent pipelines could be applied to other transportation modes, and other disciplines entirely.

After CSULB students successfully complete the ITS Engineering Talent Pipeline and the subsequent paid summer internship, CITT and Gannett Fleming will complete the final assessment and evaluation phase to determine how to improve and scale the program. The CITT-Gannett Fleming team will also share insights from the pilot to assist CSU partners at other campuses seeking to launch talent pipeline programs of their own. Such collaboration across the CSU system will prove essential in launching talent pipeline programs. Convening industry partners to join CSU leaders to design, develop, implement, assess, and revise talent pipelines to address skills and occupational gaps in the trade and transportation sector—created by the most rapid rates of technological transformation ever in human history—is no easy task. Doing so requires vision and a clear understanding of the labor market demands that employers and educators will face in the years ahead. One of the best ways to convey this shared vision to prospective university and industry partners is to consider long-term challenges that underscore the value of talent-pipeline solutions.

3.2 Talent Pipelines and the Future of Higher Education

Student populations at CSU campuses consist largely of people who work while taking college courses. Those who purely attend school without working comprise a small pool of scholarship students or are from wealthy families. This necessity to work while pursuing a degree has created an environment where students are very open to workplace learning, apprentice, and on-the-job-training opportunities. New generations of students are wise to question the value—or return on investment—of the education and training for which they will commit their time and money.

Just as students will increasingly challenge assumptions about education and the role it plays in their career section and development, so too should leaders in academia. In the years ahead, traditional metrics such as credit per hour/per course will be one of several currencies that CSU campuses will use to measure value and to certify the obtainment of targeted KSAs. In this future landscape, industry and governmental certifications, non-degree professional training, and apprenticeships will be part of the modern education portfolio offered by both public and private educational institutions.

At the same time, jobs in the trade and transportation sector are increasingly requiring proficiency working with robotics, artificial intelligence, automation, zero-emission, predictive analytics, and other transformational technologies. These new work processes are triggering technological disruption and compelling industry leaders to find human-driven solutions to technology problems.

CPaCE units throughout the CSU system have an opportunity to establish university-industry talent pipelines that deliver competency-based, short-term programming for students and incumbent workers who are interested in transformational skills building. To implement such innovative talent-pipeline initiatives, CSU leaders will need to thoughtfully challenge existing assumptions about education and training to consider new innovative learning and workforce development tools to address institutional barriers. In a recent whitepaper, *Ideas for Designing an Affordable New Educational Institution,* five Massachusetts Institute of Technology (MIT) professors stated that conventional models of higher education were "facing growing skepticism." The five co-authors each represented a different disciplinary focus—spanning Literature, Computer Science, Physics and History of Science, Accounting and Finance, and Mechanical Engineering—and stated that "rising tuition costs, ballooning debt, and concerns about preparedness for the work force" were raising doubts about "the value of higher education" and causing alternative credentialing and online models to gain in "currency."[25]

The views expressed in the MIT whitepaper reflect a growing consensus of leaders in academia who are challenging assumptions about the way that education is packaged and delivered to students and incumbent professionals seeking to invest time and money into enhancing their KSAs in response to rapidly changing technologies and related workplace realities. In the spirit of the MIT motto "*mens et manus*," Latin for "mind and hand," the authors called for:[26]

- introducing micro-credential models that enable students to acquire a series of stackable units that result in not only the obtainment of a degree but also validate the recipient's attainment of competencies along the way;
- innovative project-based learning;
- integration with Undergraduate Research Opportunities Programs (UROPs); and

new methods for delivering curriculum such as massive open online courses (MOOCs) and "online courses licensed from other institutions in the form of 'small private online courses (SPOCS) and the wholesale adoption of the flipped classroom model."[27]

All of the abovementioned educational tools and methods are elements that CSU leaders could incorporate into future university-industry talent-pipeline programs. Such efforts would provide new ways for students to earn degrees in conjunction with workplace learning opportunities and skills and competency-based curriculum. As previously stated, to assess the best curriculum and related delivery formats, CPaCE leaders should start with pilot programs that can be evaluated and revised on an iterative basis. Each semester and academic year then become an opportunity for CPaCEs to review and improve programming to keep up with the changing KSAs of in-demand occupations and emerging skillsets. In this capacity, talent-pipeline programs provide a means of convening CSU subject matter experts and industry partners to offer the "back bone support" or continuity in management to regularly identify and forecast the most necessary and in-demand KSAs.

3.3 A Baseball Coda for Leaders in Talent-Pipeline Implementation

The prospect of implementing talent-pipeline pilot programs that address transformational technologies first at CSULB and then across the CSU system is not an easy undertaking. It will require a broad range of industry and academic leaders to work together in new ways that will require challenging assumptions and implementing innovative approaches to overcome institutional challenges. Here it is useful to call upon the legacy of a historical figure who has not traditionally been associated with talent-pipelines: Branch Rickey.

Although he is most famous for signing Jackie Robinson and later Roberto Clemente to Major League Baseball (MLB) [https://bleacherreport.com/articles/160190], Rickey's contribution of the modern farm team system in the early 1920s provides inspiration for CSU leaders seeking to implement university-industry talent pipelines 100 years later.

In an interview with the *Sporting News*, Rickey described his farm team contribution to baseball not as any form of "inventive genius" but rather as "the result of stark necessity." Explaining further, he said: "We did it to meet a question of supply and demand of young ballplayers."[28] What started as a pilot effort during his time with the St. Louis Cardinals is now common practice throughout the MLB. Rickey would go on to join the Brooklyn Dodgers and dispute assumptions and push against institutional challenges that would not only redefine what racial equality meant with professional baseball but also as it related to an entire country. As if that were not enough, during his time with the Pittsburgh Pirates, Rickey also led an initiative to make baseball safer through the introduction of the batting helmet. Here again, Rickey piloted the effort first with his own team, and the effort was eventually adopted by other teams.[29]

Reflecting Rickey's trailblazing legacy makes introducing talent pipelines to the CSU system eminently more feasible. In that spirit, it is incumbent upon CSU leaders to launch talent pipelines, not due to inventive genius but out of stark necessity, to address mission-critical skills gaps and in-demand occupations. Such efforts will require CSU leaders to find new forums and research gateways to actively recruit and cultivate university-industry partnerships that will lead to projects and talent pipelines, which will generate increased research and career opportunities for faculty and students.

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Appendix A

CSU Dominguez Hills:

Bachelor of Science	Global Logistics, B.S. (Global supply Chain Management)	https://www.csudh.edu/future-students/explore/majors-and-programs/cbapp
	International Business, B.S.	https://www.csudh.edu/future-students/explore/majors-and-programs/cbapp
	Special Major: Product and Inventory Control, B.A.	https://www.csudh.edu/ceie/programs-schedules/degree-programs-bachelors/production-inventory-control-ba/
Certificate Programs – College of Extended and International Education (CEIE)	Global Logistics	https://www.csudh.edu/ceie/global-logistics/
	Supply Chain Management (formerly Production and Inventory Control)	https://www.csudh.edu/ceie/supply-chain-management/
	Purchasing (…)	https://www.csudh.edu/ceie/purchasing/

CSU Los Angeles:

Bachelor of Science Option	Operations and Supply Chain Management	https://www.calstatela.edu/business/center-logistics-and-supply-chain-management
	International Business	https://www.calstatela.edu/business/mkt/undergraduate-programs-and-minors
Certificate Programs – the Management Department and Continuing Education	Operations and Supply Chain Management	https://ecatalog.calstatela.edu/preview_program.php?catoid=66&poid=30080
	International Business	https://www.calstatela.edu/business/mkt/certificate-programs
	Transportation and Logistics	https://www.calstatela.edu/business/mkt/certificate-programs

Cal Poly Pomona:

Bachelor of Science Option	Supply Chain Management	https://www.cpp.edu/cba/technology-and-operations-management/tom-curriculum/index.shtml
	Operations Management (…)	https://www.cpp.edu/cba/technology-and-operations-management/tom-curriculum/index.shtml
	E-Business Supply Chain Management	https://www.cpp.edu/cba/technology-and-operations-management/ebz-curriculum/index.shtml
	International Business	https://www.cpp.edu/cba/international-business-marketing/curriculum/index.shtml
Certificate Programs/Career Training Programs – College of The Extended University (CEU)	Certified Green Supply Chain Professional	https://careertraining.ed2go.com/ceuctp/training-programs/green-supply-chain/?Category=business
	Certified Global Business Professional	https://careertraining.ed2go.com/ceuctp/training-programs/certified-business-professional/?Category=business
	Freight Broker/Agent Training	https://careertraining.ed2go.com/ceuctp/training-programs/freight-broker-training/?Category=business
	Senior Certified Sustainability Professional	https://careertraining.ed2go.com/ceuctp/training-programs/sustainability-professional/?Category=business
	Procurement and Purchasing Management	https://careertraining.ed2go.com/ceuctp/training-programs/procurement-purchasing-management/?Category=business-operations
	Commercial Driver Training	https://careertraining.ed2go.com/ceuctp/training-programs/commercial-driver-training/
Interpersonal and Professional Skills Classes (CEU)	Supply Chain Management Fundamentals	https://www.ed2go.com/ceu/online-courses/supply-chain-management-fundamentals/
	Distribution and Logistics Management	https://www.ed2go.com/ceu/online-courses/distribution-and-logistics-management/
	Purchasing Fundamentals	https://www.ed2go.com/ceu/online-courses/purchasing-fundamentals/

CSULB:

Bachelor of Science	International Business, B.S.	https://www.csulb.edu/college-of-business/international-business http://www.careers.csulb.edu/career_profiles/cob_international.htm
	Management, B.S.	https://www.csulb.edu/college-of-business/management http://www.careers.csulb.edu/career_profiles/cob_management.htm
	Operations Supply Chain Management, B.S.	https://www.csulb.edu/college-of-business/management http://www.careers.csulb.edu/career_profiles/cob_operations_supply.htm
Certificate Programs (CPaCE)	Marine Terminal Operations (Professional Designation Program)	https://www.cpie.csulb.edu/courses/certificate-programs/marine-terminal-operations-professional
	Global Logistics for International Students (Professional Designation Program)	https://www.cpie.csulb.edu/courses/certificate-programs/global-logistics-for-international-students CSULB's Center for International Trade and Transportation (CITT) offers the Global Logistics Professional (GLP) program for international students.
	Global Logistics Professional (GLP) (Professional Designation Program)	https://www.cpie.csulb.edu/courses/certificate-programs/global-logisitcs-professional

CSU Northridge:

Bachelor of Science Option	Global Supply Chain and Management	https://catalog.csun.edu/academics/som/programs/bs-business-administration-ii/global-supply-chain-management/
	Systems and Operations Management	https://catalog.csun.edu/academics/som/programs/bs-business-administration-v/systems-and-operations-management/

Cal Maritime:

Bachelor of Arts	Global Studies and Maritime Affairs	https://www.csum.edu/global-studies/index.html
Bachelor of Science	Business Administration/International Business and Logistics	https://www.csum.edu/business/index.html
	Marine Transportation	https://www.csum.edu/marine-transportation/index.html
	Oceanography	https://www.csum.edu/academics/majors.html
	Mechanical Engineering	https://www.csum.edu/mechanical-engineering/index.html
Master of Science	Transportation and Engineering Management	https://www.csum.edu/industry/graduate-studies/

San Jose State University:

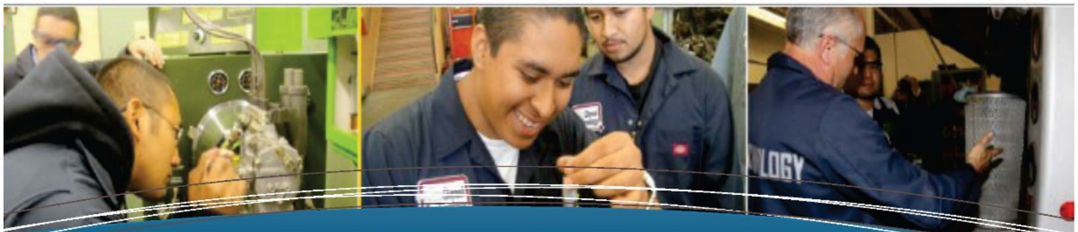
Bachelor of Science	Business Administration (Operations and Supply Chain Management Concentration)	https://catalog.sjsu.edu/preview_program.php?catoid=13&poid=7616&returnto=4973
Master of Science	Transportation Management	https://catalog.sjsu.edu/preview_program.php?catoid=13&poid=7854&returnto=4973

Appendix B

TABLE 1 EMERGING THEMES BY CATEGORY

CATEGORIES BY EMPLOYEE LIFE CYCLE (STEPS)	MAIN THEMES	DETAILED TASKS
1. Get commitment 2. Formulate a strategy	Establishing governance for technical talent management	Dedicate specific job roles or teams to oversee technical talent management Select individuals with technical skills to lead technical talent management initiatives Use workforce planning to link the technical strategy with the business strategy Include workforce diversity in the technical talent management strategy
3. Recruit technical talent	Recruiting technical talent	Craft and communicate an employment brand that appeals to technical workers Develop campus recruiting relationships and internship programs to recruit technical talent Use technology to recruit technical talent Encourage students to pursue technical careers
4. Clarify the work/people competency model 5. Evaluate performance 6. Clarify future competency and career path 7. Identify potential 8. Build on strengths and close gaps	Managing technical talent performance	Use competency models to guide and assess technical worker performance Ground performance conversations with technical employees in fact and data
	Managing technical careers	Offer flexible career paths, including dual-career ladders Provide self-service and/or technology-based tools to assist technical workers in planning for a career at the organization
	Developing technical talent	Leverage a succession-planning process to identify, develop, and promote high-potential technical talent Use on-the-job training as the primary mechanism for developing technical talent
9. Reward and retain technical talent	Rewarding and retaining technical talent	Recognize high-performing technical employees in public ways Offer development and advancement opportunities to retain technical employees Use work/life balance and flexible work options to retain technical talent
10. Transfer knowledge	Transferring technical knowledge	Offer technical workers multiple ways to exchange expertise
11. Evaluate the program	Evaluating the technical talent management program	Make fact-based decisions regarding how to improve technical talent management

Appendix C



Accelerated Diesel Mechanic Program

Results in Significantly Greater Completion Rates

ADVANCED TRANSPORTAION AND MANUFACTURING PATHWAY

The downward economy has fueled the need to develop accelerated programs to assist people to quickly learn new skills and start earning a living wage quicker than the historical duration of certificate and degree programs. Los Angeles Trade Technical College sought to address this need by developing and implementing a ten month, Accelerated Diesel Mechanic Program. The program was designed to provide students for entry-level diesel mechanic employment in automotive, trucking, and transit organizations. The specific competencies covered in the training ranged from fundamentals of diesel engine repair to complex remedial and preventative maintenance on various heavy duty equipment systems including alternative (green/clean) fuels and transportation technologies. Program completers attained a fully accredited, postsecondary Diesel Technology Certificate of Achievement as well as two California Air Resources Board industry-recognized certifications. During the program, top students were placed in unpaid internships with Santa Monica Big Blue Bus transit maintenance facility. At the completion of the program participates also received job placement assistance from a Work-Source Center partner. On the next page are specific student success strategies that were incorporated in the design/implementation of the accelerated program. Below is a comparison between the "accelerated" and "traditional" program.

Accelerated	***Traditional***
Cohort-based; enrollment restricted to initial cohort	Course enrollment open each term; non-cohort based
10-month Program	2+ Year Program
Integrated soft skills and workplace success workshops and class assignments	Minimal integration of soft-skills
One tenured faculty member assigned to all courses in program	Instructor changes each term depending on course; combination adjunct and tenured
90% Student Certificate Completion Rate within the 10-month program	29% Student Certificate Completion Rate within two years

WHAT DOES "ACCELERATION" MEAN?

For this program "acceleration" was defined as "***<u>completion</u>*** *of a sequence of courses that lead to one or more of the following:*

1. *degree;*
2. *certificate;*
3. *industry credential; and/or*
4. *transfer*

in a ***<u>shorter period of time</u>****, while* ***<u>achieving equal or better results</u>*** *than when offered in a traditional format."*

LATTC

STUDENT SUCCESS STRATEGIES ◂◂◂

Instructional/Curricular Strategies	Student Support Strategies
Modularized Curriculum – 7 modules	Online Instructional Materials Supplement In-Class Activities
Cohort Based—One Instructor and/or Instructional Team Teaches	Mandatory Orientation
Soft Skills, Workplace Competencies, and Basic Math/English Skills Integrated in Class Assignments (e.g., contextualized)	Workplace Success Workshops
Program Scheduled Full-Time and Consecutively over 10 Months (no breaks during winter and summer)	Supportive Services/Resources (e.g., transportation, textbooks, class supplies expenses covered)
GED Prep Provided to Students with No HS Diploma	Uninterrupted Unemployment Benefits (for those who qualified)
Non-Credit ESL Instruction Provided to ESL Students	Internships
Students Assigned to Study Groups/Teams	Job Placement Assistance
Bi-Weekly Student Assessments and Program Adjustments Made to Ensure Student Success	

STUDENT OUTCOMES ◂◂◂

Accelerated Program		Traditional Program		Difference
Normal Time to Completion Diesel Technology Certificate of Achievement*	10 Months	Normal Time to Completion Diesel Technology Certificate of Achievement*	18-24 Months	8+ months
Percentage of Completers within Normal Time to Completion	90%	Percentage of Completers within Normal Time to Completion	29%	61%
Percentage of Program Completers Obtaining Diesel Exhaust After-Treatment and Maintenance (DEAM) CARB* Certification	80%	Percentage of Program Completers Obtaining Diesel Exhaust After-Treatment and Maintenance (DEAM) CARB* Certification	53%	27%
Percentage of Program Completers Obtaining Periodic Smoke Inspection Program CARB* Certification	90%	Percentage of Program Completers Obtaining Periodic Smoke Inspection Program CARB* Certification	53%	38%

*For students attending full-time.

PROGRAM OUTCOMES ◂◂◂

In addition, these key strategies have now been permanently adopted in the Diesel Technology Program: (1) The use of Learning Management System (Moodle) is mandatory in all classes, (2) Online instructional materials supplement in-class activities, (3) Students are assigned writing and math assignments that help strengthen their core skills, and (4) Mahara e-Portfolio assignments are now required in every class.

CONCLUSION ◂◂◂

The "accelerated" approach implemented here provides a new learning model. It is an effective, fast track certificate program for new or displaced/dislocated workers and other adult learners who need alternatives to traditional program delivery methods.

FOR MORE INFORMATION ◂◂◂

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Los Angeles Trade-Technical College
W 400 Washington Blvd.,
Los Angeles CA 90015
http://www.lattc.edu/academics/pathways/atm

Appendix D

Source: Labor Insight (Burning Glass Technologies)
Summary Demand and Requirements Table by Occupation
Note: BLS data is only available for state, MSA, and nationwide selections. Based on your location selections the result is Statewide data.

This report provides information on both the preferred and minimum/required education levels for job postings. For this reason, a job posting may be counted in more than one of the educational categories shown in the table below. Please also note that Bureau of Labor Statistics (BLS) data is only available at the 6-digit SOC code level.

Jun. 01, 2021 - May. 31, 2022
There are 169,949 postings available with the current filters applied.
There are 0 unspecified postings.
Included Postings
New postings
Active Selections
Last 12 months (Jun. 1, 2021 - May. 31, 2022) AND (State : CA) AND ((Education : Less than a bachelor's degree (inferred)) OR (Program of study : Post-Secondary Diploma or Certificate - Agricultural Business and Management, General (inferred))) AND (Industry Sector : Transportation and Warehousing) AND (Included Postings : All New Jobs)

CATEGORY:		DEMAND AND EMPLOYMENT					SALARY		EDUCATION LEVEL BASED ON POSTING REQUIREMENTS (*EXCLUDING NA)						EDUCATION LEVEL OF EMPLOYED INDIVIDUALS		
Source:		Burning Glass		BLS/OES, 2020			Burning Glass	BLS/OES, 2020	Burning Glass						ACS, 2019		
SOC Code (ONET-6)	Occupation Title	Number of Job Postings	Risk of Automation	Number Employed 2020	% Change in Employment, 2019-2020	Projected Statewide Change in Employment, 2018-2028	Mean Market Salary, last 12 months	Mean Salary, 2020	% Requiring High School	% Requiring Post-Secondary or Associate's Degree	% Requiring Bachelor's Degree	% Requiring Master's Degree	% Requiring Doctoral Degree	% With Unspecified Education	% With a High School Diploma or Less	% With Some College or An Associate's	% With a Bachelor's or Higher
53-3032	Heavy and Tractor-Trailer Truck Drivers	67,233	Medium Risk	143,150	-2%	15.2%	$71,384	$51,400	100%	0%	0%	0%	0%	94%	87%	6%	7%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	21,580	Medium Risk	379,690	-3%	15.9%	$28,531	$35,980	95%	17%	4%	0%	0%	72%	87%	6%	7%
53-3031	Driver/Sales Workers	5,417	High Risk	41,910	-5%	6.2%	$34,224	$38,140	100%	0%	0%	0%	0%	66%	87%	6%	7%
53-3033	Light Truck or Delivery Services Drivers	4,622	Medium Risk	111,530	1%	16.4%	$36,295	$45,960	100%	0%	0%	0%	0%	76%	87%	6%	7%
43-4051	Customer Service Representatives	4,588	Medium Risk	200,920	-4%	-0.9%	$32,097	$43,710	88%	8%	16%	1%	0%	39%	62%	12%	26%
43-5061	Production, Planning, and Expediting Clerks	3,528	High Risk	50,920	-3%	8.6%	$40,383	$55,530	61%	19%	42%	2%	1%	42%	54%	12%	34%
43-5081	Stock Clerks and Order Fillers*	3,328	Medium Risk	266,620	1%	6.5%	$30,751	$34,450	91%	11%	9%	1%	1%	67%	81%	8%	11%
43-5051	Postal Service Clerks	2,738	High Risk	9,120	23%	-11.0%	$38,013	$51,330	100%	0%	0%	0%	0%	84%	72%	12%	15%
53-7051	Industrial Truck and Tractor Operators	2,195	High Risk	72,810	12%	20.4%	$29,533	$40,590	96%	11%	5%	2%	0%	70%	92%	5%	3%
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	2,055	High Risk	201,780	-11%	-7.0%	$35,665	$46,380	72%	16%	35%	1%	1%	55%	62%	14%	23%
41-2031	Retail Salespersons	1,823	High Risk	331,020	-21%	-2.0%	$31,511	$35,370	96%	2%	10%	0%	0%	40%	65%	10%	25%
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	1,776	Medium Risk	137,910	-6%	4.3%	$57,484	$76,530	28%	5%	84%	4%	1%	34%	44%	9%	48%
11-3071	Transportation, Storage, and Distribution Managers	1,702	Medium Risk	19,080	-2%	14.1%	$57,221	$111,560	49%	21%	62%	4%	3%	30%	62%	9%	29%
43-5021	Couriers and Messengers	1,657	High Risk	9,740	4%	13.1%	$32,088	$38,640	100%	0%	0%	0%	0%	19%	74%	10%	16%
13-1071	Human Resources Specialists	1,655	Low Risk	75,340	6%	10.4%	$51,865	$79,590	33%	15%	76%	4%	1%	31%	30%	8%	61%
43-9051	Mail Clerks and Mail Machine Operators, Except Postal Service	1,610	High Risk	4,710	-22%	-3.1%	$33,741	$37,460	97%	5%	4%	1%	0%	82%	78%	10%	13%
43-5071	Shipping, Receiving, and Traffic Clerks	1,577	High Risk	84,420	-5%	5.9%	$33,024	$38,870	93%	10%	7%	0%	0%	59%	82%	8%	10%
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	1,566	Medium Risk	21,180	-5%	7.7%	$45,234	$60,730	99%	2%	0%	0%	0%	38%	84%	13%	4%
53-3021	Bus Drivers, Transit and Intercity*	1,553	Medium Risk	25,020	-19%	6.0%	$36,479	$54,560	100%	0%	0%	0%	0%	59%	80%	9%	11%
49-3023	Automotive Service Technicians and Mechanics	1,544	Medium Risk	59,380	-10%	-0.9%	$41,053	$54,540	99%	4%	0%	0%	0%	63%	84%	12%	4%
53-3041	Taxi Drivers and Chauffeurs*	1,399	High Risk	25,870	-9%	23.8%	$35,797	$38,450	100%	0%	0%	0%	0%	66%	72%	8%	20%
43-5011	Cargo and Freight Agents	1,396	High Risk	13,100	-4%	15.1%	$38,954	$49,780	61%	15%	42%	1%	0%	52%	66%	11%	23%
13-1081	Logisticians	1,355	Low Risk	24,420	6%	9.4%	$52,566	$89,690	49%	10%	56%	8%	4%	32%	43%	13%	44%
43-5032	Dispatchers, Except Police, Fire, and Ambulance	1,354	High Risk	19,800	-5%	5.0%	$37,901	$47,590	93%	10%	15%	1%	0%	45%	74%	10%	16%
41-1011	First-Line Supervisors of Retail Sales Workers	1,217	Low Risk	105,060	-10%	-0.4%	$43,194	$48,400	80%	21%	44%	3%	0%	30%	64%	10%	26%
43-3031	Bookkeeping, Accounting, and	1,173	High Risk	168,720	-6%	-2.6%	$37,204	$50,160	54%	20%	49%	0%	1%	33%	69%	11%	20%

	Auditing Clerks																
53-1021	First-Line Supervisors of Helpers, Laborers, and Material Movers, Hand*	1,167	Low Risk	28,030	5%	16.7%	$41,671	$60,060	67%	11%	39%	0%	0%	62%	72%	10%	18%
43-9061	Office Clerks, General	1,110	High Risk	312,220	-7%	-1.9%	$31,685	$42,100	90%	18%	12%	1%	1%	51%	65%	13%	23%
43-5052	Postal Service Mail Carriers	1,089	Medium Risk	33,370	-1%	-10.8%	$46,419	$54,690	100%	0%	1%	0%	0%	92%	73%	12%	15%
51-9199	Production Workers, All Other	884	High Risk	25,780	-7%	8.0%	$30,893	$40,880	97%	15%	5%	1%	0%	73%	85%	7%	7%
43-1011	First-Line Supervisors of Office and Administrative Support Workers	815	Low Risk	161,550	-3%	1.7%	$53,428	$65,700	47%	8%	59%	4%	0%	37%	53%	12%	35%
49-9071	Maintenance and Repair Workers, General	814	Medium Risk	131,010	-3%	8.8%	$40,641	$49,110	94%	19%	0%	0%	0%	55%	81%	11%	8%
53-2012	Commercial Pilots	724	Medium Risk	4,060	1%	2.3%	$71,919	$137,180	61%	22%	42%	5%	0%	89%	19%	7%	74%
53-3022	Bus Drivers, School or Special Client*	719	High Risk	25,100	-9%	7.4%	$36,663	$38,450	100%	0%	0%	0%	0%	81%	80%	9%	11%
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	637	Low Risk	40,820	1%	4.8%	$57,478	$84,720	74%	21%	35%	4%	0%	32%	73%	13%	14%
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	605	Medium Risk	217,770	-7%	9.6%	$28,676	$37,520	100%	0%	0%	0%	0%	66%	88%	6%	6%
15-1151	Computer User Support Specialists*	584	Medium Risk	75,950	-7%	14.1%	$49,795	$70,510	43%	22%	56%	6%	0%	49%	36%	16%	48%
43-6011	Executive Secretaries and Executive Administrative Assistants	542	High Risk	61,110	-7%	-17.8%	$57,603	$76,050	24%	8%	82%	3%	0%	39%	52%	16%	33%
53-7064	Packers and Packagers, Hand	540	Low Risk	82,230	-16%	4.5%	$26,173	$31,530	88%	4%	14%	0%	0%	81%	90%	5%	6%
17-3026	Industrial Engineering Technicians	514	Low Risk	4,260	-7%	6.0%	$43,992	$66,750	94%	43%	5%	2%	0%	39%	59%	20%	21%
53-1031	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators*	501	Low Risk	24,710	5%	16.7%	$46,034	$60,060	61%	22%	60%	2%	0%	39%	72%	10%	18%
43-9199	Office and Administrative Support Workers, All Other	496	Medium Risk	38,680	-13%	8.6%	$37,780	$43,160	95%	26%	12%	0%	0%	79%	49%	13%	38%
29-2041	Emergency Medical Technicians and Paramedics*	478	Low Risk	22,690	3%	10.7%	$32,555	$48,280	100%	20%	0%	0%	0%	20%	57%	22%	21%
43-4181	Reservation and Transportation Ticket Agents and Travel Clerks	445	Medium Risk	13,950	-13%	-4.3%	$29,177	$45,430	97%	3%	23%	6%	0%	67%	60%	12%	28%
33-9032	Security Guards	443	Medium Risk	158,150	-3%	6.6%	$34,639	$36,040	93%	3%	8%	1%	0%	30%	73%	11%	16%
51-2099	Assemblers and Fabricators, All Other*	418	High Risk	20,310	-6%	-11.4%	$37,905	$37,680	100%	0%	0%	0%	0%	97%	87%	7%	6%
13-1121	Meeting, Convention, and Event Planners	402	Low Risk	15,880	-7%	10.6%	$47,897	$61,950	23%	6%	82%	5%	0%	29%	30%	8%	62%
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	362	High Risk	9,790	-11%	12.8%	$38,690	$37,740	67%	10%	36%	4%	0%	37%	75%	9%	15%
43-9021	Data Entry Keyers	356	High Risk	17,320	-5%	-21.1%	$30,379	$38,100	92%	15%	14%	1%	1%	53%	63%	14%	24%
35-1012	First-Line Supervisors of Food Preparation and Serving Workers	328	Medium Risk	80,880	-15%	16.0%	$41,119	$42,910	85%	4%	29%	13%	0%	49%	76%	10%	15%
11-3011	Administrative Services Managers*	324	Medium Risk	41,730	0%	9.3%	$50,918	$115,960	40%	12%	64%	2%	1%	25%	46%	12%	43%
43-4081	Hotel, Motel, and Resort Desk Clerks	301	High Risk	22,350	-16%	-4.5%	$29,504	$33,400	90%	10%	24%	0%	0%	21%	69%	12%	19%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	301	High Risk	56,130	-4%	-14.2%	$34,572	$46,750	76%	28%	23%	1%	1%	48%	73%	10%	17%
53-7061	Cleaners of Vehicles and Equipment	294	Low Risk	48,620	-18%	5.1%	$28,709	$32,880	99%	5%	1%	0%	0%	58%	91%	4%	5%
13-1151	Training and Development Specialists	286	Low Risk	30,070	2%	15.4%	$52,512	$77,840	47%	8%	65%	2%	1%	23%	36%	10%	54%
27-1026	Merchandise Displayers and Window Trimmers	269	Low Risk	15,430	-18%	5.8%	$42,115	$39,910	58%	15%	48%	6%	0%	37%	53%	10%	37%

Appendix E. Intelligent Transportation Systems Professional Capacity Building Curriculum Examples

This Appendix contains excerpts from the CITT's work on behalf of the U.S. Department of Transportation's Volpe Center. These curriculum examples are viable pilots for the sort of talent pipeline this paper has advocated in the main body of its text.

Appendix F. Instructor's Manual: Travel Time Performance Based Measures

Instructor's Manual

September 2022

Developed by the ITS Joint Program Office's

ITS Professional Capacity Building Program &

The National Network for the Transportation Workforce

Using This Manual

This manual is intended to provide the instructor with all the information needed to present this case study, including how to adapt the content to your locality, student demographic, and existing course. In this manual you will find:

- **Case Study Brief** – Describes the concept, learning objectives, student demographics, instructional hours, instructional components, and recommendations on how best to integrate this lesson into your existing course.

- **Instructional Prep** – Includes options for modifying content to fit time constraints, an instructor preparation checklist, suggestions for how to localize content, suggestions for how to adapt content to multiple grade levels and/or disciplines, student assessment sample questions, a feedback form, and additional resources.

- **Glossary File** – Presents a glossary of terms relevant to this case study, a list of acronyms, and a list of useful external references.

Instructor Notes

For each slide in Modules 1, 2, and 4, notes are provided for instructor reference. These can be supplemented and enhanced with instructor experience and localized content. The notes typically include the following (where applicable):

- **Purpose of Slide** – A brief explanation of the purpose of the slide.

- **Key Message** – Key points to be made regarding the slide content.

- **Time on Chart** – A suggestion for how much time to spend on the slide.
- **Suggested Comments** – Verbal comments to expand upon the slide's message.
- **Potential Answers** – In Module 4, potential answers to Critical Thinking Questions from the Study Exercise to aid class discussion and student assignment grading.
- **Transition** – Verbal comments to support transitioning to the next slide.
- **Interactivity** – Discussion questions (and potential answers) and activities to engage students.
- **References** – Reference to accompany the information provided.

Case Study Brief

This case study is intended to provide students with an in-depth look at the Concept of Operations as part of a systems engineering process through a series of individual or group-based activities.

Concept

Travel Time Performance Measures have an important role in maintaining efficiency of transportation systems. Travel time PMs are calculated using data gathered on vehicle count, speed, collision information along roads in a system. They are important when considering where to invest funding to improve system efficiency in a city, state, or county. outline the overall vision for proposed systems through a user-centered document. The Travel Time Case Study provides students with a better understanding of the significance of travel time performance measures, how they are calculated, how they are used by decision-makers, and practice in applying and comparing performance measures for a hypothetical applied scenario. The case study exercise can be tailored to different disciplinary applications or to the learning objectives of a particular course.

Learning Objectives

There are 4 learning objectives for the Travel Time Case Study. They include:

1. Apply the concepts discussed in the technical lesson.
2. Conduct further research into the topics discussed.
3. Define and calculate important transportation performance measures
4. Develop a brief narrative justifying where to allocate funding for congestion relief in a hypothetical town based on calculated performance measures

Target Audience/Student Demographic

This case study was designed for integration into planning courses as well as multiple engineering-based curricula including civil, industrial, systems, electrical, mechanical, and computer and information technology. The primary target audience is undergraduate students. However, options are provided in this manual for adapting this case study for middle school, high school, and graduate students.

Instructional Hours

All four case study modules can be accomplished within a 3-hour in-class period or broken into several one-hour class periods, with a take home assignment in both cases. Additional options and details can be found in the instructor manual.

Instructional Components

The complete case study instructional package includes the following files:

- **Module 1: Introduction to ITS.** An in-class, presentation-driven lecture.
- **Module 2: Technical Lesson.** An in-class, presentation-driven lecture.
- **Module 3: Student Exercise.** An unsupervised student assignment, which can be adapted to instructor needs and target audience and completed as an in-class or take-home individual or group assignment.
- **Module 4: Debrief.** A facilitated review of the study exercise that is completed as an in-class, presentation-driven lecture.
- **Instructor Manual:** A collection of case study components with deployment information on course integration, exercise options, and resources.
- **Sample Student Assessment Questions:** Questions that can be deployed for post case study student assessment or to support discussion during the exercise debrief.

Steps to Curricular Integration

This case study can be integrated into multidisciplinary coursework in a variety of ways. At the secondary level, it can enhance STEAM courses. At the undergraduate and graduate levels, it can be used in an intelligent transportation system (ITS) or transportation planning course.

Instructional Prep

This section covers options for modifying content to fit time constraints, an instructor preparation checklist, suggestions for how to localize content, suggestions for how to adapt content to multiple grade levels and/or disciplines, student assessment sample questions, a feedback form, and additional resources.

Case Study Use

This case study can be used in whole or in part to supplement ITS content within a variety of engineering, planning, technology, or other related courses. The following is an estimate of the amount of time required for each of the activities contained within this case study.

Module 1: Introduction to ITS (30 to 35 minutes)

An overview of Intelligent Transportation Systems, impacts, and career pathways. An in-class presentation-driven lecture with video profile.

Module 2: Technical Lesson (30 to 60 minutes)

Presents background on Travel Time and introduces the student exercise. An in-class presentation-driven lecture, its class time will depend on the number of interactivity questions used and the time spent discussing those answers.

Module 3: Student Exercise (1 class or multi-day, at home assignment)

An unsupervised student assignment that can be adapted to instructor needs and target audience. Designed to be modular, you can choose the best option to fit your class. Students can complete Module 3 as written, completing outside of class. Providing one to two weeks to complete all tasks would likely provide the best results. These could be completed individually or as a group project. Alternatively, students could be given in-class time to work on the assignments in groups. In either case, the Module 4 debrief allows students to share their work and ideas with the class.

Module 4: Debrief (60 minutes)

A facilitated review of the study exercise that is completed as an in-class, presentation-driven lecture. Execution time will depend on the time spent discussing the work the students did in the Module 3 assignment. The debrief time could be shortened by selecting a subset of the assignment in Module 3 to discuss.

Preparation Checklist

The estimated instructor prep time for this case study is 4 hours.

- ☐ Review each case study module. Ensure that you add/revise speaking notes to make the modules suit your presentation style and your course.
- ☐ Add local examples to help students better understand the concept (see Suggestions on Localizing Content below).
- ☐ Determine the Module 3 delivery option (see Module 3: Student Exercise options above) and due date.
- ☐ Determine the case study integration method (see Steps to Curriculum Integration).
- ☐ Review Module 2 presentation notes for answers to Lesson Interactivity Questions.
- ☐ Review Module 3 & 4 presentation notes for student exercise answers. These notes will help you grade the assignment.
- ☐ Review the student assessment sample questions and determine which option to implement (see Student Assessment Sample Questions). Consider an online questionnaire.
- ☐ Gather instructional supplies:
  - PowerPoint files for lectures (Modules 1, 2, & 4).
  - Projector and screen for displaying PowerPoint presentations, if necessary.
  - Whiteboard, physical or online, for documenting student responses in Modules 2 & 4.
  - Online link or paper questionnaire for student assessment.
  - Print documents, if necessary:
  - Instructor Manual, one copy as needed.
  - Module 3: Student Exercise, one copy per student.
  - Student Assessment questions, one copy per student.

After case study completion, please complete and submit the user feedback form online: https://www.pcb.its.dot.gov/casestudies/default.aspx.

Suggestions for Localizing Content

Instructors might consider utilizing a local example to help students better engage with this case study. Module 2, the technical lesson, could use data examples from the local state or county. Module 3 could use real-world local traffic examples in place of hypothetical Traffic Town.

Steps to Curricular Integration

The case study can be integrated into multidisciplinary coursework in a variety of ways. At the secondary level, it can be used to enhance STEAM courses. At the undergraduate and graduate levels, it can be integrated into courses to demonstrate real world applications and problem solving in courses that cover topics related transportation planning, operations, congestion management, systems engineering and integration, communication systems and technologies, and design courses.

Secondary Level Adaption

For secondary level students, the case study could focus on just high-level concepts and be used in conjunction with one or more of the ITS Lesson Plans for Middle and High School, found at: https://www.pcb.its.dot.gov/ITSlessonPlans.aspx.

Graduate Level Adaption

To adapt this case study for graduate students, three options are recommended:

- **Option 1** – Remove map in Module 3 so that graduate students will need to draw their own map based on written information provided for the student exercise example. They will need to make some assumptions and not everyone's map and solutions will look identical.

- **Option 2** – Have students use the scenario description provided in Module 3 to create a Travel Time document in a format similar to that required in the National Operations Center of Excellence Transportation Technology Tournament (https://transportationops.org/transportation-technology-tournament). This option will require students to make additional assumptions and will expose students to several examples of a Travel Time document, which have been provided by Tournament participants. It will additionally task students with creating a cost breakdown and timeline for a proposed system. The Travel Time document should include the following sections:

    - ☐ Overview
    - ☐ Problem Statement
    - ☐ Study Corridor

- ☐ Existing Scenario
- ☐ Concepts for the Proposed System
- ☐ Stakeholders
- ☐ Cost Breakdown and Timeline
- ☐ Anticipated Benefits
- ☐ Summary

- **Option 3** – Have students create their own scenario, based on the example provided in Module 3. They can then complete the assignment based on their own scenario. This may lead to more local examples to use in future classes.

Multidisciplinary Adaption

As written, this case study is most suitable for integration into a transportation course focused on planning, operations, ITS, or congestion management. These are typically part of civil engineering or planning programs. However, the Travel Time case study is also highly relevant to other multidisciplinary coursework focused on systems design, engineering, and planning. Instructors in Computer Engineering and Information Technology, Electrical Engineering, Industrial and Systems Engineering, and Mechanical Engineering programs could easily integrate the Travel Time case study into courses focused on systems design, systems engineering, and systems planning.

In addition to this case study, students can get a better understanding of travel time performance measures applied to systems engineering processes through field trips to a Transportation Management Center or ITS field devices, or instructors could consider inviting a local or state DOT official who plans, designs, or operates ITS systems to come in to share their experience and expertise.

Student Assessment Sample Questions (20 minutes)

As part of this case study package, sample questions are provided for directly assessing student knowledge related to Travel Time. This will allow you to evaluate:

- ☐ Whether or not students achieved the intended learning outcomes.
- ☐ Whether this activity increased their knowledge and interest in ITS.

These questions can be provided to students as individual assessments or may be used to stimulate class discussion. They can also be used as a pre- and post-test to assess knowledge growth based on case study exposure. For this usage, conduct the pre-survey prior to Module 1 and the post-survey after the completion of Module 4. If you prefer to discuss the survey results with students, the post-survey can be conducted on the due date for Module 3, prior to the in-class Module 4 debrief.

To help ease comparative analysis, consider deploying these evaluations via an online survey tool like Qualtrics or Survey Monkey.

Feedback Form (10 minutes)

A feedback form link is provided on the ITS PCB website (https://www.pcb.its.dot.gov/casestudies/default.aspx) to elicit instructor feedback. Your feedback is very important to continuing to refine case studies and provide additional ITS-related resources for instructors.

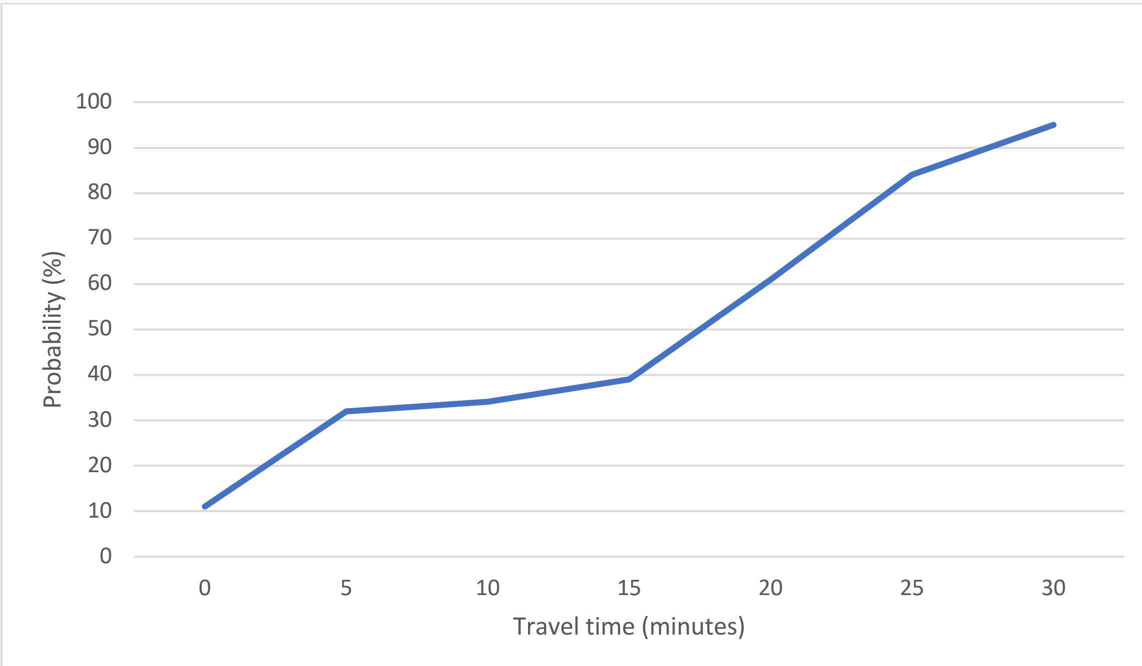
Glossary of Terms

A glossary of commonly used acronyms in the technical module and student exercise are provided separately on the next page. Instructors may want to print off the list and provide it to students as a reference prior to beginning the Module 2: Technical Lesson.

Appendix G. Student Exercise Answer Key

Identifying CDF/PDF

1. What kind of graph is this? (Multiple choice, select one)



   a. Cumulative distribution function

   b. Probability density function

Performance measure definition recall

1. Which of these are performance measures? (Multiple choice, select all that apply)

   a. Internet speed

   b. Type of vehicle

   c. Planning time index

   d. Brand of television

TTI concept

2. What is the calculation for travel time index (TTI)? (Short answer)

   a. Answer: Measured travel time divided by free flow travel time

3. What percentile is used to determine free flow travel time? (Short answer)
    a. Answer: 50%

TTI calculation

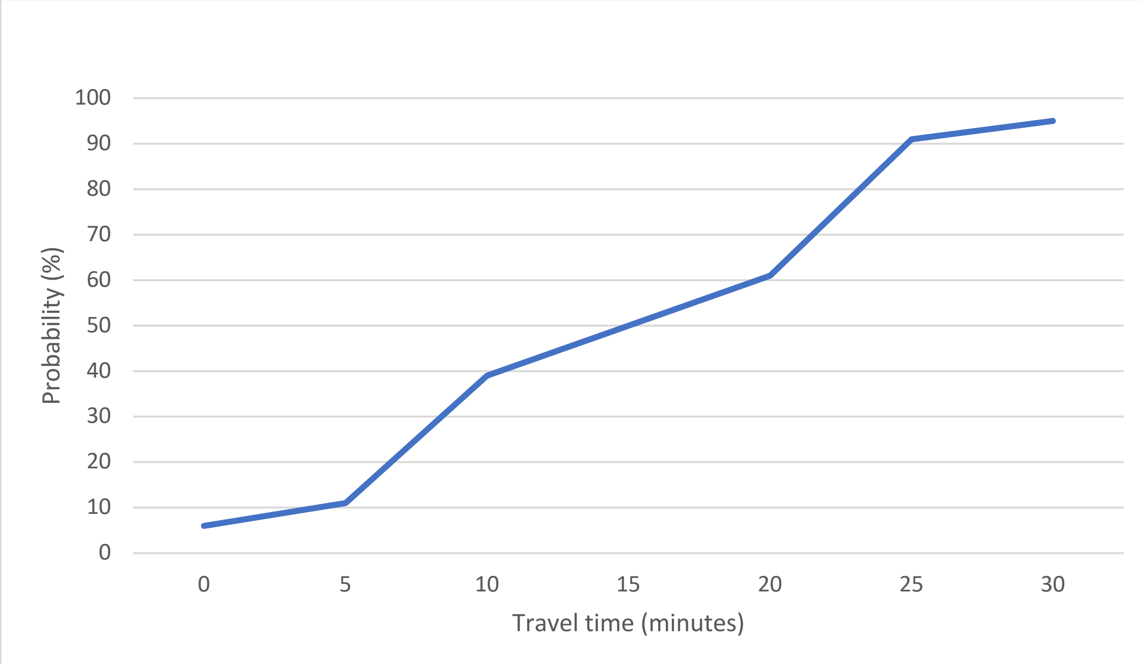
4. What is the travel time index (TTI) if the free flow travel time for the trip is 30 minutes and it took 50 minutes? (Short answer)
    a. Answer: TTI = 1.67
5. How long was the trip if the travel time index (TTI) is 2 and the free flow travel time is 20 minutes? (Short answer)
    a. Answer: Trip was 40 minutes

PTI concept

6. If you want to know a trip's non-recurrent congestion, would you look at its travel time index (TTI) or (PTI)? (Short answer)
    a. Answer: Planning time index (PTI)
7. What percentile is used to calculate planning time index (PTI)? (Short answer)
    a. Answer: 95%

PTI calculation

8. What is the PTI based on this graph? (Short answer)



a. Answer: PTI = 30min/15min = 2

Non-recurrent congestion concept

9. Which are examples of non-recurrent congestion? (Multiple choice, select all that apply)

a. Snow

b. Collision

c. Rush hour traffic

d. Utility pole repair detour

Real-world examples recall

10 What type of organization typically collects transportation performance measures? (Multiple choice, select one)

a. Departments of transportation

b. Real estate agencies

c. Third-party vendor companies

a. Transit providers

10. What type of organization most typically uses and applies transportation performance measures? (Multiple choice, select one)

a. Departments of transportation

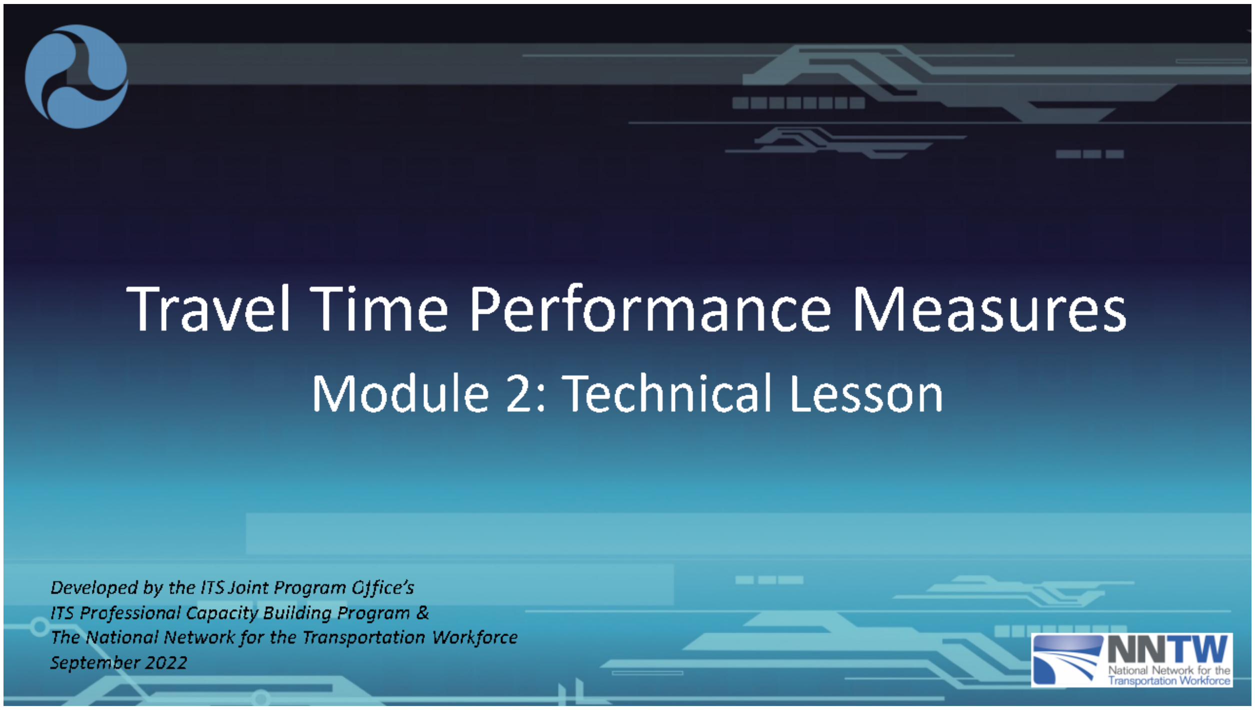
b. Real estate agencies

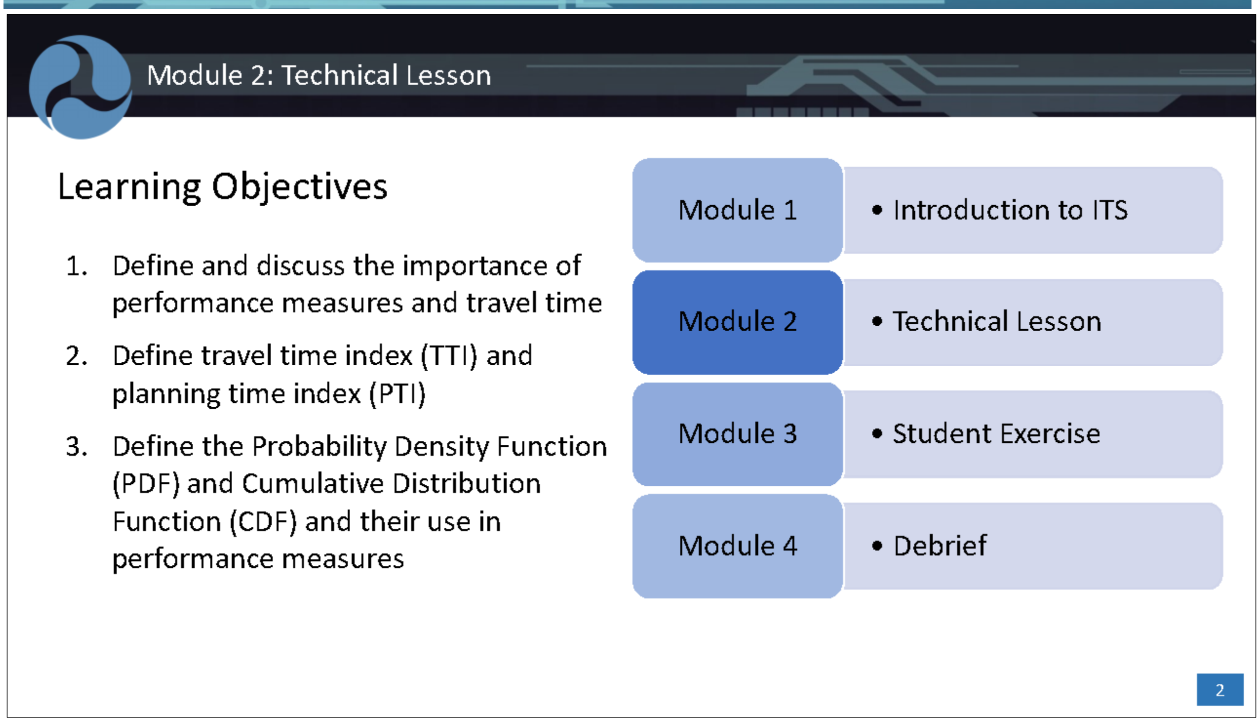
c. Third-party vendor companies

d. Financial banks

Appendix H. Travel Time Performance Measures

Module 2: Technical Lesson





Module 2: Technical Lesson

Learning Objectives, cont.

4. Calculate TTI and PTI using formulas and CDFs
5. Discuss how performance measures are used by decision-makers in government

Module 1	• Introduction to ITS
Module 2	• Technical Lesson
Module 3	• Student Exercise
Module 4	• Debrief

3

Module 2: Technical Lesson Outline

1. Defining performance measures
2. Calculating certain performance measures
3. Statistical concepts in performance measures
4. Example performance measure visualizations

4

Module 2: Technical Lesson

Performance Measures

- Defined as statistically based evidence used to track the progress towards preset objects
- Used in a variety of disciplines: health, business, etc.
  - Transportation
- **Name some non-transportation performance measures**
- **Name some transportation performance measures**

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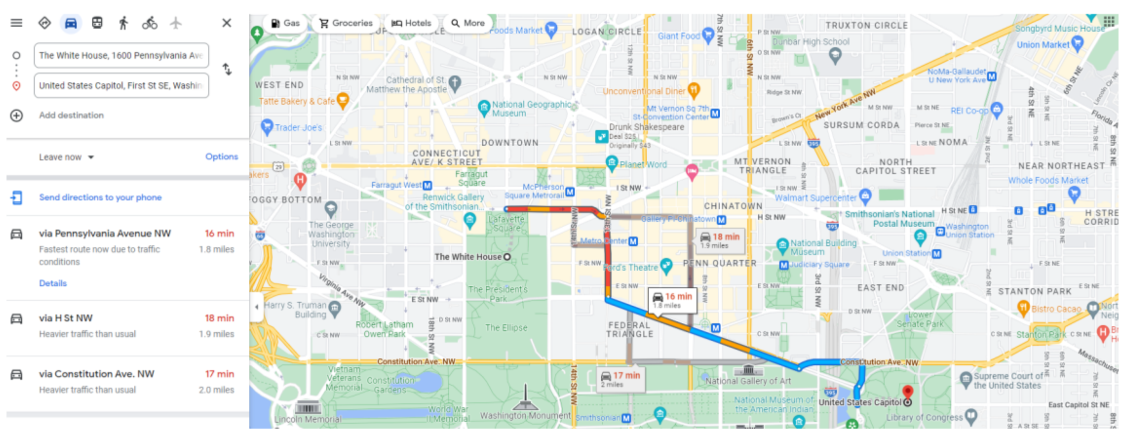
Module 2: Technical Lesson

Transportation Performance Measures



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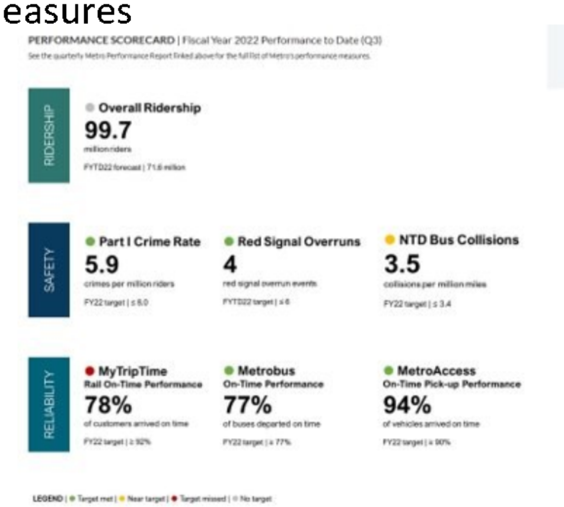
Module 2: Technical Lesson

Transportation Performance Measures

- Transportation systems have a set of performance measures to keep track of how well facilities operate.

WMATA.com (6/24/2022)



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Module 2: Technical Lesson

Significance of transportation performance measures

- Federal legislation establishes five categories of transportation performance measures
- Moving Ahead for Progress in the 21st Century Act (MAP-21), July 2012
  - Purpose: Build needed roads, bridges, and transit systems; improve safety across all forms of transportation; make progress on transportation alternatives
- Fixing America's Surface Transportation (FAST) Act, December 2015
  - Purpose: Provide long-term funding for surface transportation so states and local governments can progress with critical transportation projects
- Surface Transportation Reauthorization Act, 2021
  - Purpose: Makes provisions for performance monitoring as an essential part of modern American transportation system

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Module 2: Technical Lesson

Significance of transportation performance measures

- Transportation performance measure categories
  - Under the Federal Highway Administration (FHWA)
    - Safety
    - Bridges & Pavement
    - System Performance
  - Under the Federal Transit Administration (FTA)
    - Transportation Asset Management (TAM)
    - Transit Safety
- State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) are required to set and meet targets for these measures

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Module 2: Technical Lesson

What is Travel Time and Travel Time Reliability?

- **Travel time** is how long it takes to get from point A to point B
- **Travel time reliability** is how the time it takes to get from point A to point B can vary
  - Important when considering congestion
- Two types of congestion
  - **Recurrent congestion** is caused by commuter traffic, shopping traffic, etc.
  - **Non-recurrent congestion** is caused by unanticipated events such as crashes, special events, weather and construction

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Module 2: Technical Lesson

Why are Travel Time and Travel Time Reliability important?

- These two measures are extremely important to travelers and shippers
  - *Will you/your goods arrive on time?*
- Transportation costs are influenced by the values of travel time and travel time reliability

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Module 2: Technical Lesson

Travel Time Index

- Travel time by itself cannot quantify recurrent congestion since it is dependent on a facility’s length
- Travel Time Index (TTI) is often used instead
- TTI represents the order of magnitude the free flow travel time increases during the period the travel times were collected (usually during peak congestion, i.e. rush hour)
  - Free flow travel time: the travel time with no traffic (think: open roads at 2am)

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Module 2: Technical Lesson

Calculating Travel Time Index

- TTI = actual (measured) travel time divided by free flow travel time

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Module 2: Technical Lesson

TTI Questions

- **The less a roadway's TTI is, the __(more/less)___ the road suffers from recurrent congestion**
- **If the free flow travel time on your commute to work is 15 minutes and the rush hour TTI is 1.33, how long does it take you on average to get to work during rush hour?**

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Planning Time Index

- Planning Time Index (PTI) is a travel time reliability performance measure
- PTI is a multiplier that can be applied to the free flow travel time to get the travel time needed to be on time 95% of the time
- PTI compares how bad roads' worst travel times are and how much roads suffer from non-recurrent congestion
- To find PTI, divide the travel time at the 95% percentile by the free flow travel time

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Calculating Planning Time Index

- To find PTI, divide the travel time at the 95^{th} percentile by the free flow travel time
  - We'll take a look at how to find the 95^{th} percentile in a few slides

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PTI Questions

- **The greater a roadway's PTI is, the ____(more/less)___ reliable a roadway is**
- **Can a roadway have a relatively high PTI and low TTI?**

Now let's look at some statistical concepts

Module 2: Technical Lesson

Terminology – Statistics

- Probability Density Function (PDF) – describes the likelihood that a variable will assume a given value.
  - *What is the chance of getting x?*

- Cumulative Distribution function (CDF) – the probability that a variable with a given distribution will assume a value *less than or equal to* a given value.
  - *What is the chance of getting x or less?*

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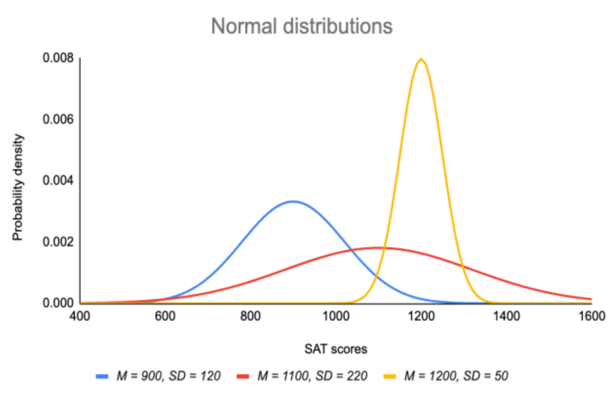
Module 2: Technical Lesson

Probability density function (PDF)

Probability Density Function (PDF): Describes the likelihood that a variable will assume a given value.
What is the chance of getting x?

In transportation: *How often will my travel time be x?*

Vertical y-axis is always “probability”



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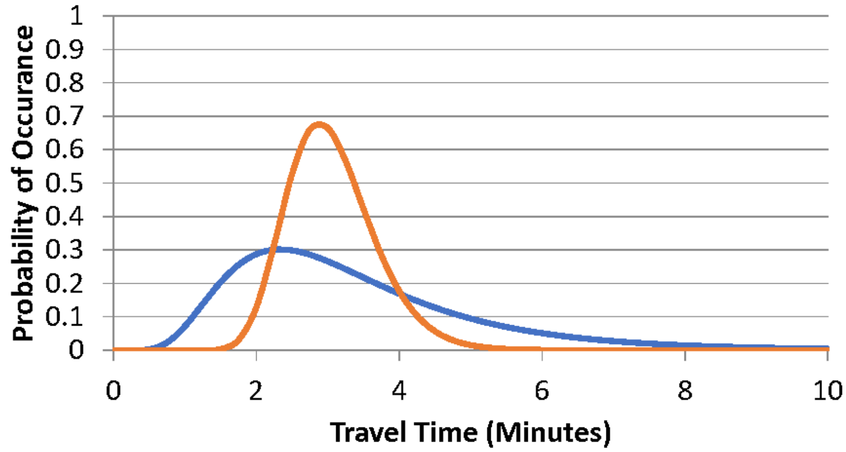
Module 2: Technical Lesson

Probability density function (PDF)



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Module 2: Technical Lesson

Cumulative Distribution Function (CDF)

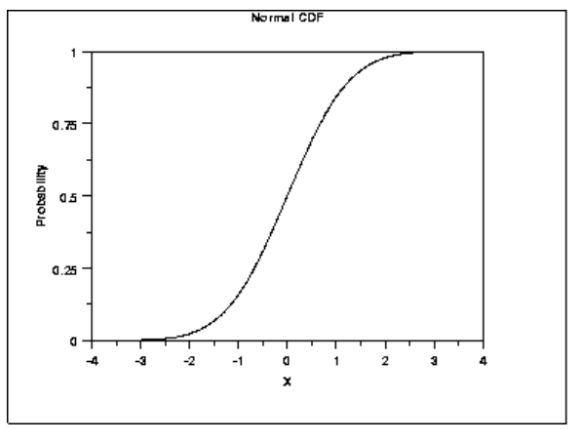
Cumulative Distribution Function (CDF): the probability that a variable with a given distribution will assume a value _less than or equal to_ a given value.

What is the chance of getting at most x?

Will I regularly be on time if I leave with x minutes to travel?

These curves indicate the probability that the travel time will be _less than or equal to_ the value on the X axis.

The line is always increasing



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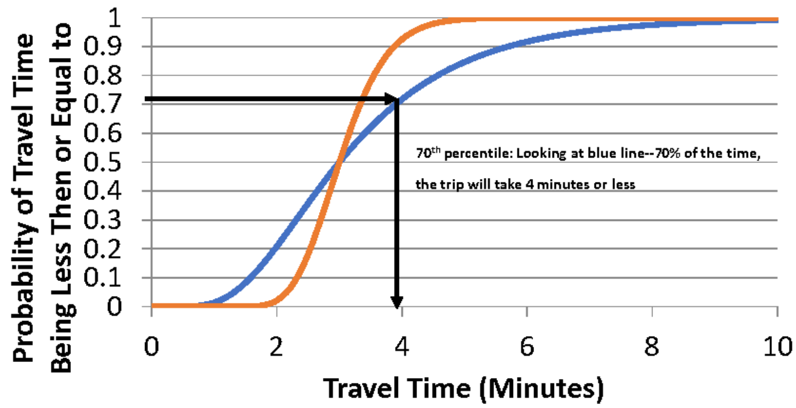
Module 2: Technical Lesson

Cumulative Distribution Function (CDF)



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In transportation, CDFs are generally more useful than PDFs

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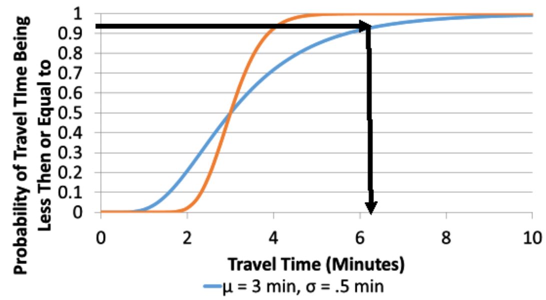
Module 2: Technical Lesson

CDFs are more useful in transportation

- Generally, it's more useful to know that a trip will take *at most* a certain amount of time rather than *exactly* a certain amount of time
  - i.e. you're still on time if you're 5 minutes early
- Percentiles from the CDF along with free flow travel time are used to calculate some performance measures



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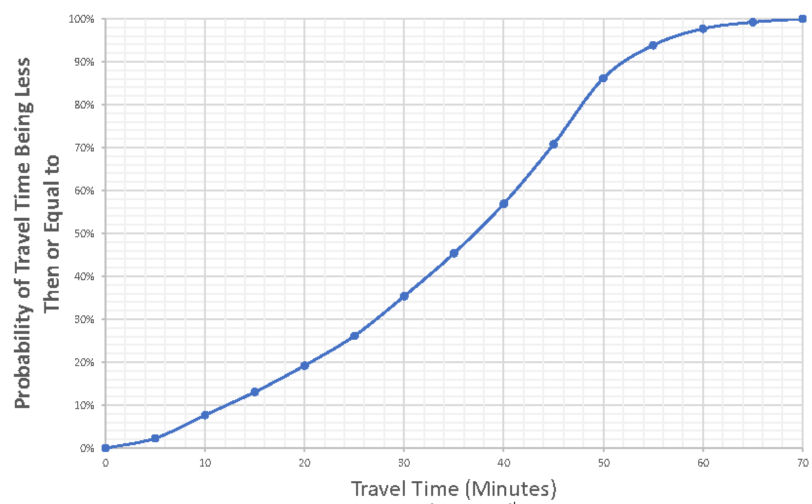
Module 2: Technical Lesson

Calculate the PTI and TTI* if the free flow travel time is the 15th percenti

CDF



* Use 50th percentile travel time for calculating TTI

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Module 2: Technical Lesson

Using Performance Measures

- General Awareness
  - *What is congestion like along this stretch of roadway?*
- Investment Prioritization
  - *What stretch of roadway in this network has low travel time reliability and needs to be improved?*
- Investment Justification
  - *Did the investment into the roadway to improve congestion prove effective?*

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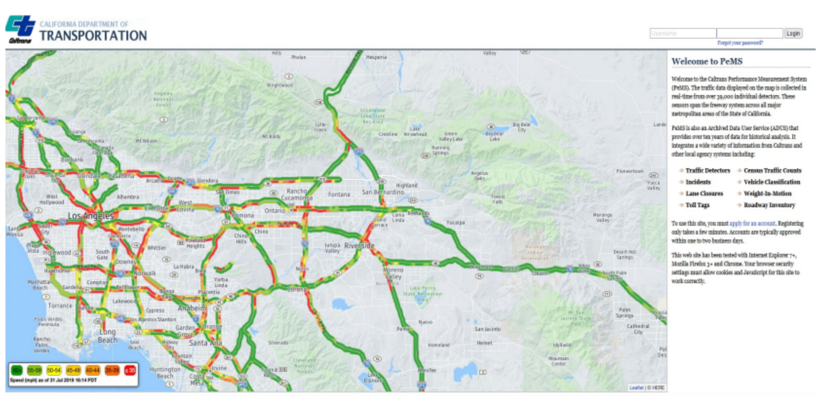
Module 2: Technical Lesson

Performance Measure Application Example (General Awareness)



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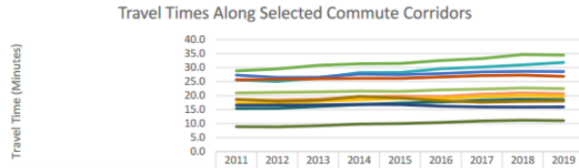
Module 2: Technical Lesson

Performance Measure Application Example (Investment Prioritization)

- Rankings of the worst segments in an area help decision makers focus on key areas
- Engineering judgment, politics, and policy also play a role



	2011	2012	2013	2014	2015	2016	2017	2018	2019
I-10 to Loop 202 (Red Mountain): Eastbound - AM I-10 at 83rd Ave to Loop 202 (Red Mountain) at Loop 101 (Price)	25.6	25.0	26.3	28.2	28.2	29.6	30.2	31.0	31.8
I-10 to Loop 202 (Red Mountain): Eastbound - PM I-10 at 83rd Ave to Loop 202 (Red Mountain) at Loop 101 (Price)	20.9	21.1	21.3	21.6	21.5	22.0	22.3	22.7	22.5
SR 143 to I-10 to US 60: Eastbound - PM SR 143 at Sky Harbor Blvd to US 60 at Val Vista Dr	18.5	18.4	18.7	19.5	19.8	19.7	20.5	21.0	20.7
I-10 to US 60: Eastbound - PM I-10 at 7th St to US 60 at Loop 101 (Price)	17.3	17.3	17.9	18.5	19.0	19.1	19.7	20.0	19.8

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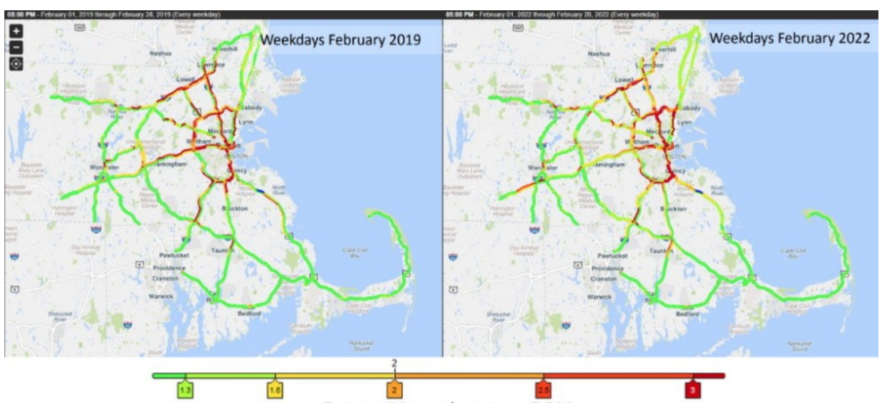
Module 2: Technical Lesson

Performance Measure Application Example (Investment Justification)



Eastern Massachusetts – 5 PM

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Module 2: Technical Lesson

Where do government agencies get travel time data?

- Travel time data can come from a variety of sources from devices along roadways to cell phone/GPS data collected by third party vendors (vehicle probe data)
  - DOTs and other government agencies purchase data from these vendors
- The I-95 Corridor Coalition allows states to purchase third party travel time with a set a tools used to use the travel time data
  - This initiative is called the Vehicle Probe Project

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Module 2: Technical Lesson

Publicly available data

- Transportation - California Open Data
  - Bottlenecks - Datasets - California Open Data
- Travel data | WSDOT (wa.gov)
- Travel Time Index | Bureau of Transportation Statistics (bts.gov)

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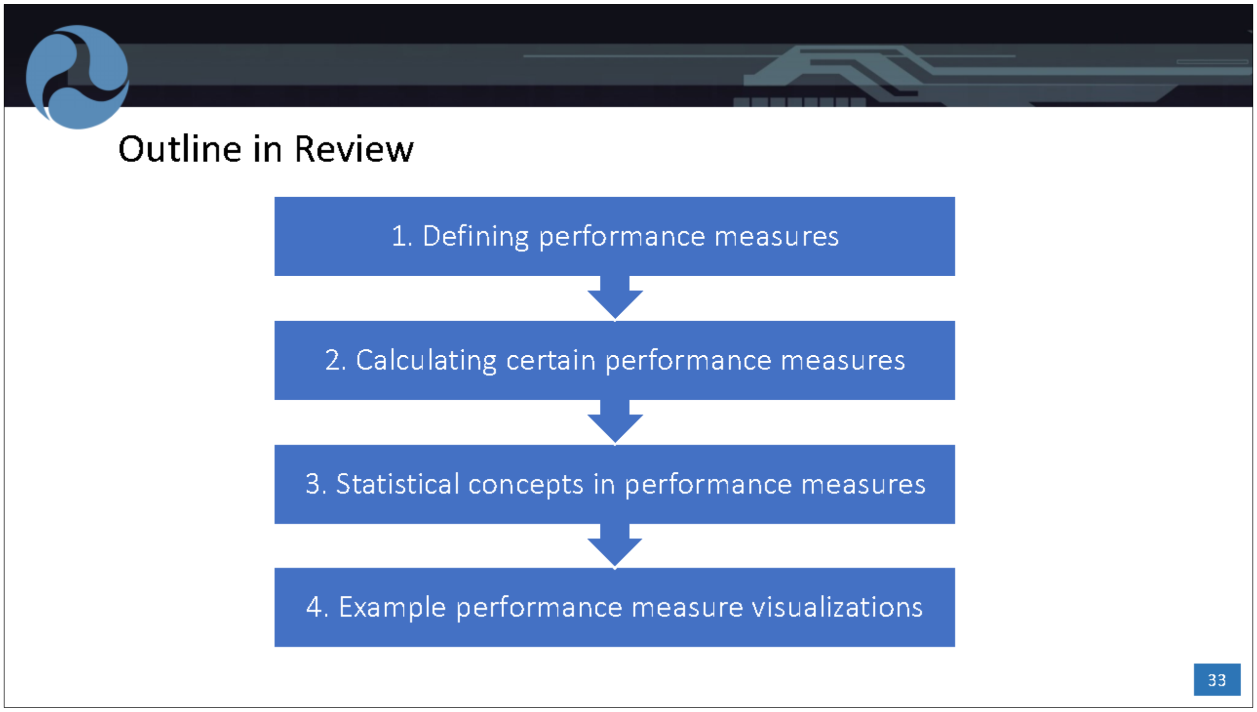
Outline in Review
1. Defining performance measures
2. Calculating certain performance measures
3. Statistical concepts in performance measures
4. Example performance measure visualizations
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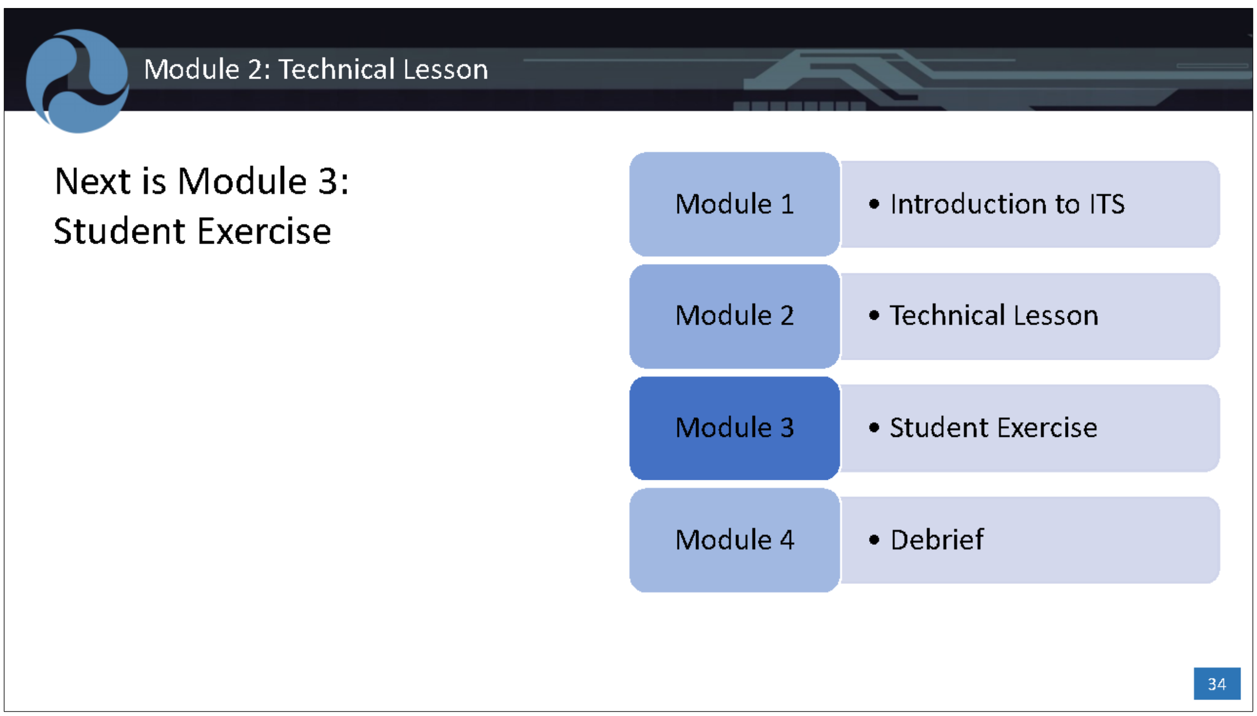
Module 2: Technical Lesson
Next is Module 3:
Student Exercise
Module 1
• Introduction to ITS
Module 2
• Technical Lesson
Module 3
• Student Exercise
Module 4
• Debrief
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Module 2: Technical Lesson

Student Exercise Introduction

- Presents a hypothetical city, Traffic Town, with congestion problems
- The city is looking to identify the commonly-traveled route that will most benefit from redevelopment to mitigate congestion
- Data has been acquired from a vendor
- Students must compare routes based on travel time performance measures they calculate
- Explore and connect to real world transportation developments

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Module 2: Technical Lesson

Student Exercise Learning Objectives

- Apply the concepts and formulas discussed in the technical lesson to the given scenario.
- Calculate travel time-based performance measures in a hypothetical applied context
- Connect discussion of the hypothetical context to real-world congestion and traffic relief projects

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Module 2: Technical Lesson

Student Exercise Tasks

Task 1: Calculate TTI and PTI

↓

Task 2: Consider real-world congestion relief projects

↓

Task 3: Recommend a route to invest in development

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Module 2: Technical Lesson

Student Exercise Expectations

- Individual or group exercise
- 1 day (1-2 hours)
- 1 document to turn in
- Module 4: Class Debrief

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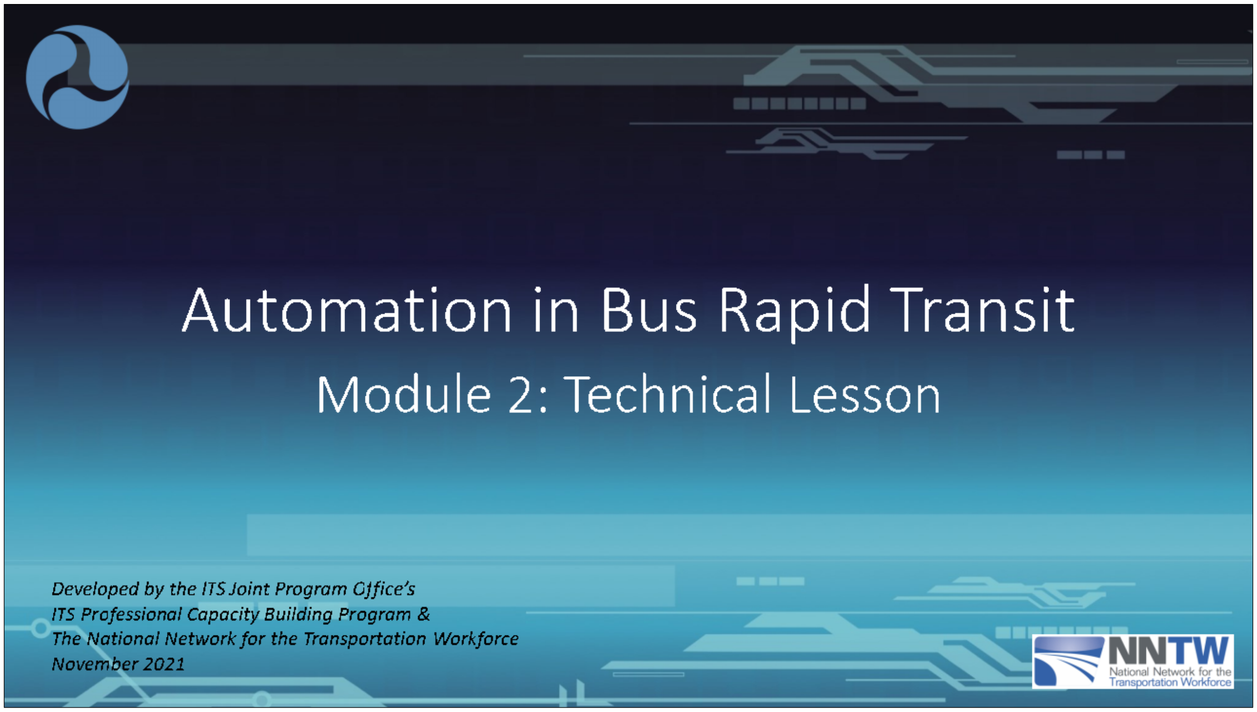
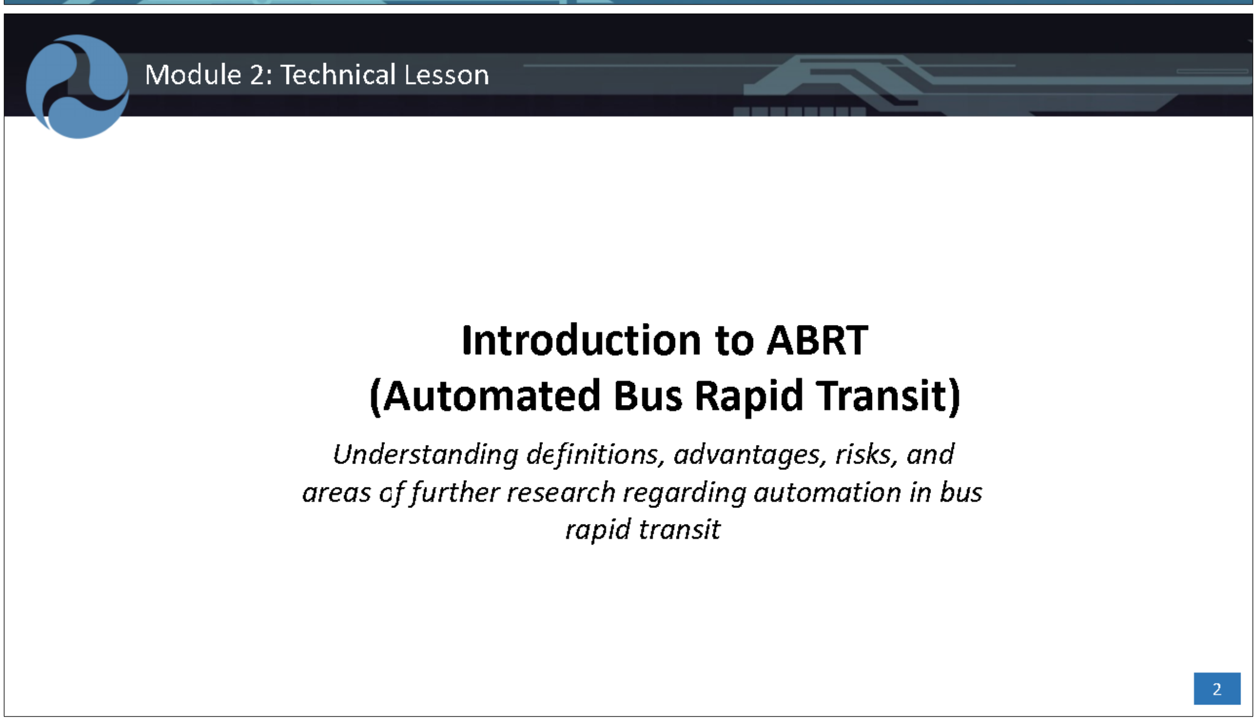
Appendix I. Automation in Bus Rapid Transit

Module 2: Technical Lesson





Module 2: Technical Lesson

Technical Lesson Introduction

- BRT stands for Bus Rapid Transit, an approach to public transit that is faster and more efficient than traditional busses and is competitive with similarly-minded Light Rail Transit (LRT) projects.
- ABRT is an acronym that stands for automated bus rapid transit systems. Simply put, the concept of ABRT revolves around introducing automated driving technologies to bus rapid transit (BRT) systems. There are several kinds of automated technologies that can be used, and are already in use, that can make BRT safer and more efficient. In this technical lesson, we will explore the levels of automation and existing automation technologies, current BRT systems, and the current state of research and practice of ABRT systems.

3

Module 2: Technical Lesson

Learning Objectives

1. Understand automation within larger field of ITS
2. Become familiar with history of BRT technology
3. Identify key advantages and areas of concern regarding automation / automated technologies in and outside of BRT
4. Noting areas of further discovery for this topic
5. Apply concepts discussed throughout the modules in a cumulative exercise scenario

Module 1	• Introduction to ITS
Module 2	• Technical Lesson
Module 3	• Student Exercise
Module 4	• Debrief

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Module 2: Technical Lesson

Introduction to Automation

- ***Automation*** refers to a rendering part of a process such that it is performed with either limited manual intervention or none at all.
- ***Autonomous*** generally refers to processes or systems with a high-level of automation, such that routine operations do not require *any* manual intervention
- Some automation technologies are already common among various modes of transportation, such as cruise control
- The Stanford Cart is an example of an early experimental autonomous vehicle.

The Stanford Cart

Graphic courtesy of Stanford University Archives

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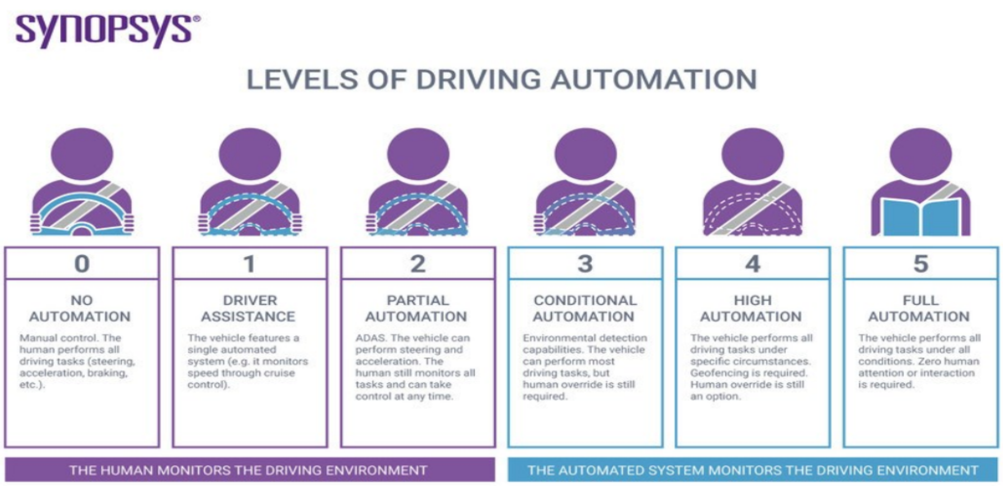
Module 2: Technical Lesson

Levels of Automation (Driving)



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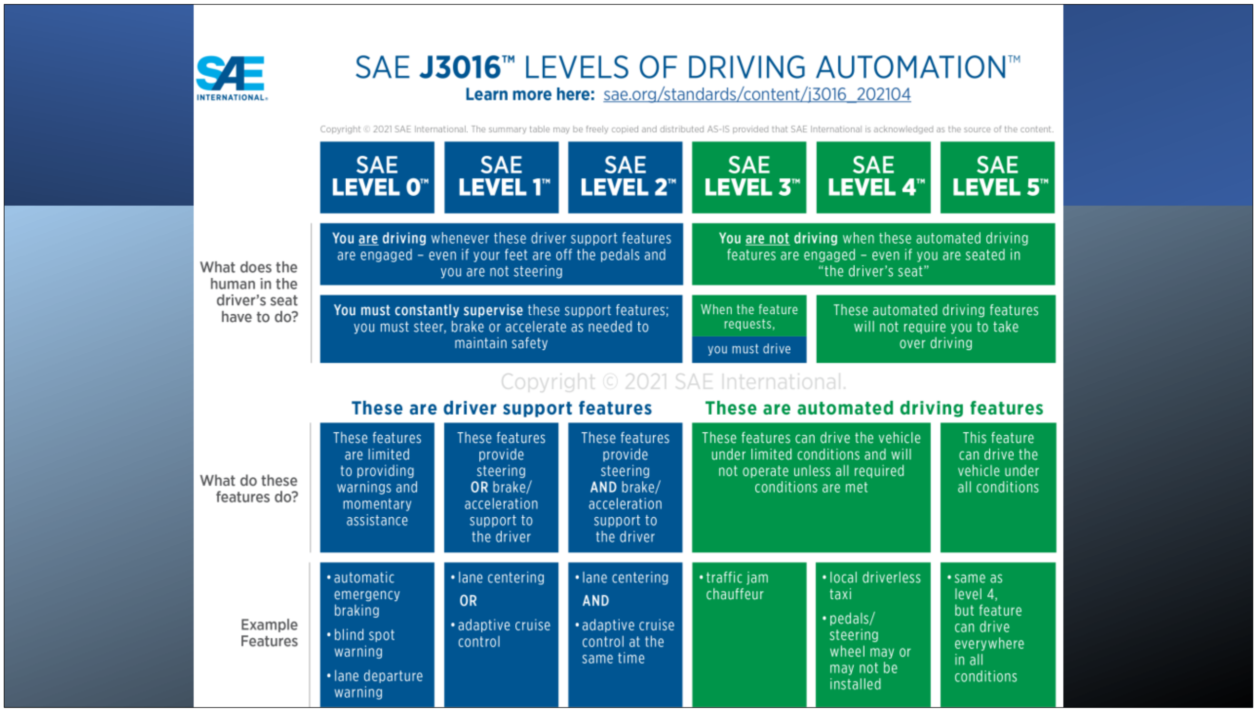
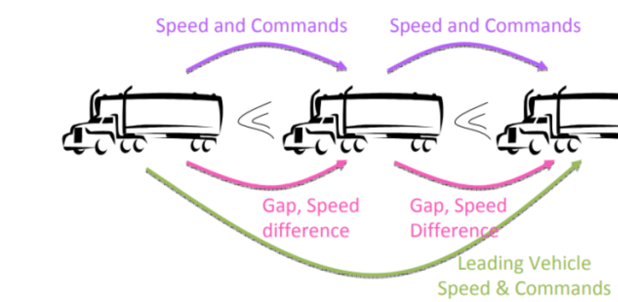


Module 2: Technical Lesson

Understanding automation within larger context of ITS

- Cooperative Adaptative Cruise Control (CACC) system
- Truck Platooning and Partially Automated Truck Platooning
- National Automated Highway Systems Consortium
- "Interaction and Communication Between Pedestrians and Autonomous Vehicles", funded by Berkeley Deep Drive.
- Connected and Automated Vehicles (CAV)



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Module 2: Technical Lesson

Automation? Autonomous? Automated driving?

- When a process is performed without any direct manual intervention, that process is ***automated***.
- A system could feature several automated technologies, without itself being considered automated.
- When a transit vehicle is ***autonomous***, it is self-operating – it does not require a human driver. It literally drives itself – ***automated driving.***
- Most current ABRT projects are aspirational. ABRT is in its *nascent stages*.

Graphic courtesy of Navya

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Module 2: Technical Lesson

What is BRT? Why BRT?

- BRT stands for **B**us **R**apid **T**ransit
  - A "best-of-both-worlds" approach that synthesizes the advantages of Light Rail Transit (LRT) and traditional bus transit.
  - **One fourth** of the cost of LRT
  - **One third** of the time to implement LRT

Graphic: Bay Area Transit News

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Module 2: Technical Lesson

What is BRT? Why BRT?

- Operates at least 50 percent of the service on fixed guideway.
- Defined passenger stations
- Traffic signal priority or preemption
- Short headway bidirectional services for a substantial part of weekdays and weekend days

Graphic Source: https://upload.wikimedia.org/wikipedia/commons/2/24/Metro_Liner_from_the_Surfliner.jpg

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"But… What is Light Rail Transit (LRT)?"

- electric-powered single cars or short trains on fixed rails.
- Similar in concept to the traditional streetcar systems of yesteryear, but runs faster and carries more passengers.
- Faster and higher capacity than BRT
- Smaller investment than highways, heavy rail, and commuter rail.
- Dallas Area Rapid Transit (DART)

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Module 2: Technical Lesson

Advantages of BRT

Level Boarding or **Near Level Boarding** makes BRT more accessible to wheelchair users and non-wheelchair users alike.

Off-board fares reduce time spent at stops

Dedicated lanes – especially physically separated lanes – increase speed of bus.

Stations are designed such that **they do not disrupt the flow of traffic**.

BRT systems can **spur economic development**, *like* LRT and *unlike* traditional busses.

Sometimes allow for conversion to **more walkable, open areas** rather than congested thoroughfares.

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Module 2: Technical Lesson

Examples of BRT Systems

- San Francisco's Van Ness Corridor
- Indianapolis's IndyGo Red Line
- Curitiba, Brazil's Rede Integrada de Transporte
- Hartford, Connecticut's CTfastrak
- Los Angeles's Metro G Line (Orange)

IndyGo Red Line Graphic courtesy of Shrewsberry & Associates LLC

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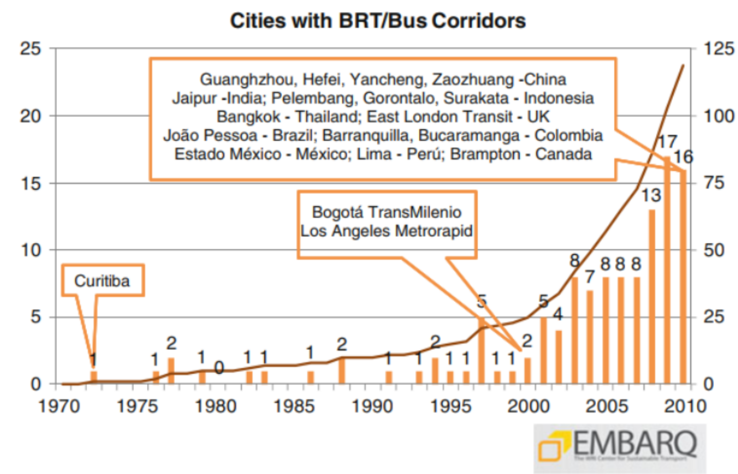
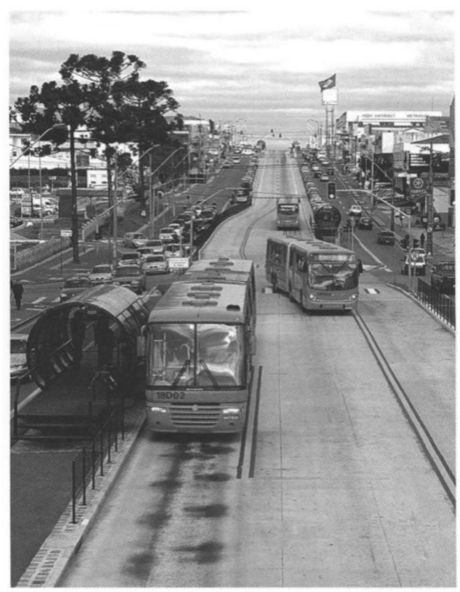


Bus Rapid Transit: Worldwide History of Development, Key Systems and Policy Issues. Figure. 3
Cities with BRT/bus corridors 1970–2010 (Source: EMBARQ BRT/Bus Corridors Database [6])

A Very Brief History of BRT

- BRT systems are theorized beginning around 1937 in Chicago.
- By 1963, J.L. Crain presented the first full BRT concept, incorporating many of the features of today's cutting-edge systems.
- However, BRT does not become as popular as light-rail projects, and few BRT developments survived. Cities in the U.S. invest more into LRT.
- Curitiba, Brazil's transit system begins to adopt features of BRT in the 1970s and becomes first full BRT system in the world in the 1980s.



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A Very Brief History of BRT

- The success in Curitiba spurs interest elsewhere, including the U.S.
- The Federal Transit Administration (FTA) takes note in the late 1990s and encourages interest in developing BRT systems in multiple U.S. cities.
- By 2018, the *6th National Bus Rapid Transit Conference* declares that BRT is no longer an emerging mode of transportation, but an established one.

Graphic courtesy of the *Indy Star*

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Curitiba, Brazil

and

Latin America

- Curitiba is "the cradle of modern BRT."
- 1982: First full BRT system in the world
- 2009: Operation of 100% bio-diesel articulated buses on the new Green Line.
- Over the past decade, Curitiba has reached performance levels that are comparable to metro transit.
- The value of land and property around the BRT corridors has increased substantially.
- BRT has been most successfully adopted in Latin America, and especially in Brazil.

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BRT returns to the United States

- In 1977, Pittsburgh, PA debuts the South Busway
- In 1983, the city also debuts the East Busway and the South Busway follows in 2000.
- Integrated with the city's LRT system
- Spurs USDOT interest in researching possible BRT developments elsewhere in the United States.

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Module 2: Technical Lesson

What is *A*BRT?

Automated **B**us **R**apid **T**ransit is a result of "combining a variety of technical and service innovations"

- Advanced Public Transportation Systems (APTS)
- Automated Guideway Transit (AGT)
- High-Occupancy Vehicle (HOV) lane operations
- Light-Rail Transit (LRT)
- Bus Rapid Transit (BRT)

A video of ABRT testing in action can be found here.

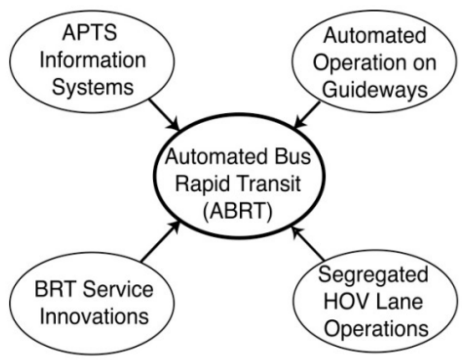

Figure 1 – Automated Bus Rapid Transit (ABRT) System Elements

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Graphic courtesy of: Shladover, Steven E. "Bus Rapid Transit and Automation: Opportunities for Synergy." Proceedings Of The 7th World Congress On Intelligent Systems, National Academies of Sciences, Engineering, and Medicine Transportation Research Board (TRB), 2000, https://onlinepubs.trb.org/onlinepubs/archive/conferences/VHA-BRT/Bus_Rapid_Transit_and_Automation--Opportunities_for_Synergy.pdf

Module 2: Technical Lesson

ABRT *maximizes* potential of existing BRT systems by…

- Permitting operations on narrower rights-of-way, thereby saving on land and physical infrastructure costs;
- Permitting precision docking at bus stops, so that physically-impaired passengers can more easily gain access to and from the buses and speeding up the loading and unloading processes for all passengers;
- Facilitating maintenance operations and saving labor ordinarily used to move buses through routine overnight maintenance and cleaning processes;
- Smoother and safer travel for passengers, increasing passenger riding comfort and reducing crash costs for operators;
- Significantly higher vehicle and passenger capacity per lane, by enabling buses to operate at shorter headway than under manual driver control;
- Reduced fuel consumption and emissions for buses that can operate in automated platoons with small enough separations (half vehicle length or less) that aerodynamic drag can be reduced significantly;
- Potentially reduced driver labor costs for the portion of the bus trip that operates on the automated lane.
- Makes dedicated lanes easier to implement and maximizes benefit: "When such a lane is made available, it becomes possible to implement automatic steering control safely, permitting use of a narrower lane and relieving the driver of the steering responsibility."

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The Value of Automated Bus Rapid Transit

Automated Collision Avoidance and Emergency Braking
- Saves lives
- Fewer collisions
- Fewer injuries
- Reduce insurance claims
- Reduce collision damage repairs
- Reduce spare bus ratios

Automated Lane-Keeping
- Narrower busways
- Support turning lanes
- Fewer sideswipe collisions
- Fewer mirror replacements
- Less Right of Way acquisition and infrastructure cost
- Use of shoulder for busses

Automated Bus Platooning and Automated Leader-Follower Capability
- Increased passenger capacity on high volume routes
- Increased flexibility to adjust passenger capacity by time of day
- Increased passenger spacing with social distancing
- Improve passenger to driver ratio

The Value of Automated Bus Rapid Transit

Automated Precision Docking

- Level boarding at all doors
- ADA-compliant access for mobility impaired users
- Improved service to disabled community at lower cost to agency
- Fewer boarding and alighting accidents
- Reduce damage to buses and platforms from manual docking

Automated Smooth Acceleration, Deceleration and Speed Control

- Better ride quality
- Greater comfort for passengers
- Fewer slip and fall incidents
- Increased fuel savings

Module 2: Technical Lesson

Currently, Most BRT Systems Implement *Some* Automation

- Implementing higher levels of automation into BRT is still in its nascent stages, but there are some automated technologies that have already become common in BRT systems.
- As of 2013, 50% of BRT lines utilized Automatic vehicle location (AVL) and 41.9% utilized automated passenger counters (APC).
- **But** – *these features are not obviously tied to the operation of the bus itself.*

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Level 1 and 2 Automation – Kansas City’s RideKC MAX

- Began testing precision guiding sensors in 2020 with grant provided by US DOT Federal Transit Authority’s Accelerating Innovative Mobility (AIM) initiative.
- Allows operator to align very closely with the BRT platform – and do so quickly.
- Reduces dwell time between stops.
- Enhances mobility in line with Americans with Disabilities Act (ADA).
- An automated process assists the driver, but the bus is still manually operated.

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Level 4 Automation – CT*fastrak*

- three 40-foot automated, electric New Flyer Xcelsior CHARGE™ heavy-duty transit buses on an existing BRT corridor.
- Project Goals:
  - ***Improve*** Americans with Disabilities Act (ADA) accessibility at platforms through precision docking to eliminate driver error that results in unsafe situations for passengers
  - ***Increase*** vehicle efficiency and capacity on the CTfastrak guideway through bus platooning
  - ***Reduce*** the number of incidents resulting in injury or vehicle damage at two intersections along CTfastrak due to cross traffic not stopping at red lights

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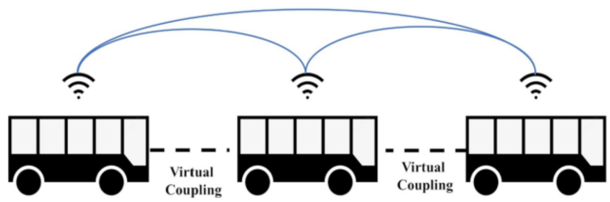
Level 4 Automation – Ct*fastrak* Bus Platooning

- Automated Bus Platooning links a fleet of busses together like a series of rail cars.
- Solensky and Calcaterra found that:
  - Peak period ridership demands larger buses (60ft articulated)
  - Off peak ridership makes large buses look wasteful to taxpayers
  - Platoon smaller (40ft) buses during peak, break platoon off-peak
  - Allows for better service, improved headways, increased capacity



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Module 2: Technical Lesson

ABRT Benefits

- Partial Automation has a Proven Track Record
- Facilitates Workforce Development
- Increased Safety by Reducing Driver Error and Driver Workload

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ABRT Risks

- Automating transit is complicated
- Full or Nearly Full Automation is not yet feasible
- Technological Errors and Safety Concerns
- Exogeneous obstacles
- Endogenous obstacles
- Automation Surprise
- Mode Error
- **Unforeseen Situations***

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Level of Automation	*Pro*	*Con*
0 - No Automation	Current status quo, no new training required	Missed opportunities for safety improvements and driver quality of life improvements
1 - Driver Assistance	Improved safety and quality of life for drivers, similar to features in passenger vehicles	Misinterpretations of system capabilities
2 - Partial Automation	Improved workload reduction for things such as cruising and lane centering	Limited use in complex urban environments
3 - Conditional Automation	Increased physical workload reduction for drivers	Increased cognitive load from vehicle monitoring New crashes caused by autonomy-operator interaction
4 - High Automation	Drivers reduce much of their active driving time and efficiency and safety may increase	Operator skill atrophy Driver intervenes during hard situations requiring more readiness (e.g., training, practice).

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Module 2: Technical Lesson

ABRT Summary

- ABRT introduces established and advanced ITS technologies into BRT.
- ABRT ***maximizes*** the potential of BRT systems
- Yet, ABRT still requires **less infrastructure investment** and necessitates a **fraction of the construction time of a comparable LRT system.**
- ABRT can be implemented into existing BRT systems in stages, and so the cost can be spread out and obstacles can be managed incrementally.
- ABRT allows for **precision docking**, **bus platooning**, and other features that render the functionality and ride experience of BRT even more similar to LRT
- Even low-risk automation projects like Bus Yard Automation can make bus transit cheaper and more efficient.
- ***Simplification Before Automation***

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Stakeholders in ABRT

- Stakeholders are involved in assessing factors for operation, maintenance, and implementation of ABRT include:
  - Municipal transit authorities
  - Workforce development agencies
  - Environmental regulatory agencies
  - State and municipal policy makers and legislators
  - Federal agencies that issue grants to fund projects, such as the U.S. Department of Transportation

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Why does ABRT matter to ITS?

- Research institutions that focus on ITS have begun to look towards BRT systems as an optimal candidate for implementing advanced ITS technologies (such as higher levels of automation).
- California PATH tested a self-steering BRT bus in Eugene, Oregon in 2013, and is now hoping to test ABRT on I-10 and I-15
- California PATH reports that "Busways are attractive early deployment environments for the higher levels of automation because they provide some segregation from other road users, simplifying the driving environment for the automation technology."
- Because BRT systems already feature designated lanes, they provide an ideal environment for testing higher levels of automation.
    - Concentrates connected vehicles together – test how they work together!
    - Segregates connected vehicles from the traffic slow – safety!

CALIFORNIA PATH

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Module 2: Technical Lesson

Introduction to the Student Exercise

Understanding the homework assignment and how to complete it.

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Module 2: Technical Lesson

Student Exercise Introduction

- "BRT to ABRT": Introducing automation to the Van Ness BRT system
- This exercise will help students:
  - show understanding of relevant concepts in Module 2
  - apply the information
  - conduct additional research*
  - The student learning outcomes are as follows:
    - Apply certain concepts discussed in the technical lesson to the given scenario
    - Conduct further research into the topics discussed
    - Explore and show understanding of key factors and ideas related to ABRT

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Module 2: Technical Lesson

Student Exercise Scenario

Goal: Introducing Automation to Van Ness BRT system

Resources:

- Slides 6-8, 21-22 in Module 2;
- https://www.sfmta.com/projects/van-ness-improvement-project;
- https://www.youtube.com/watch?v=ZkMorBpN5c8;
- https://www.youtube.com/watch?v=Op3h3Fm5N6k;

Student Exercise Tasks

1. Observe Qualities of Van Ness BRT system
2. Choose 3 automated technologies to introduce to the Van Ness BRT system
3. Explain the choices and determine the new level of automation
4. Fill out handout and prepare to discuss during debrief

Photo courtesy of Neil Hetherington, WTI

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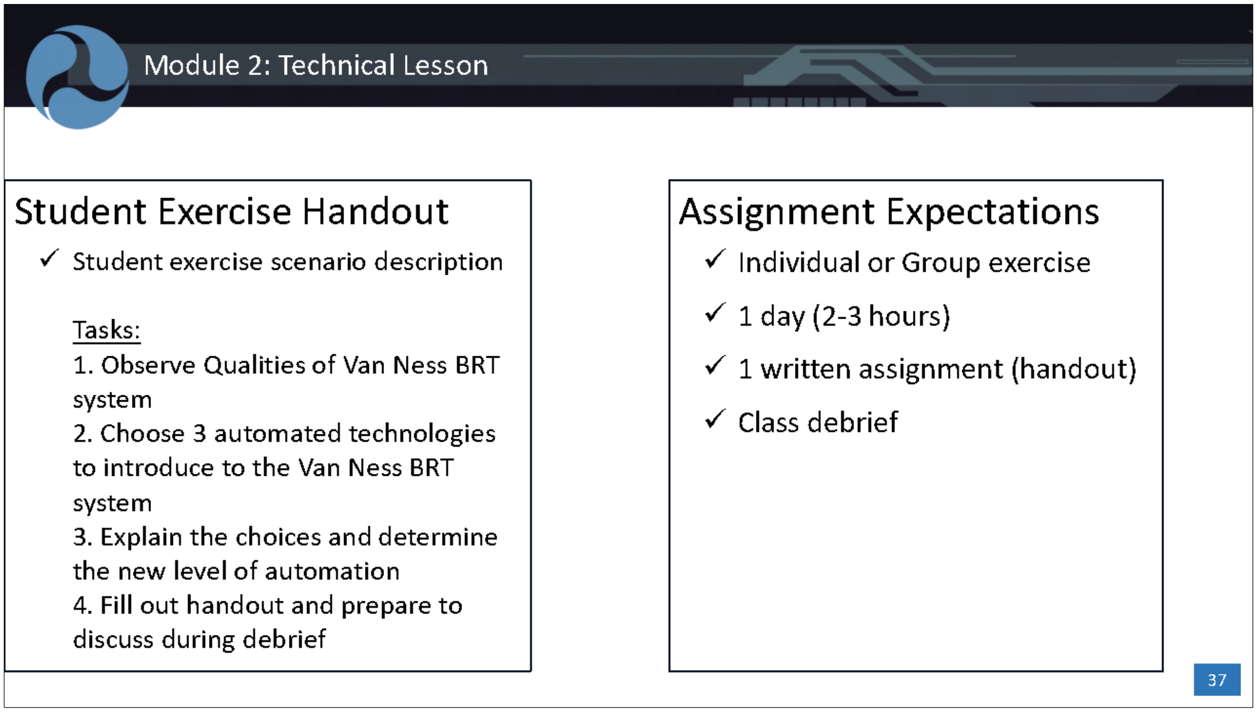
Module 2: Technical Lesson
Student Exercise Handout
✓ Student exercise scenario description
Tasks:
1. Observe Qualities of Van Ness BRT system
2. Choose 3 automated technologies to introduce to the Van Ness BRT system
3. Explain the choices and determine the new level of automation
4. Fill out handout and prepare to discuss during debrief
Assignment Expectations
✓ Individual or Group exercise
✓ 1 day (2-3 hours)
✓ 1 written assignment (handout)
✓ Class debrief
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List of Acronyms

CDF	Cumulative Distribution Function
DOT	Department of Transportation
FAST	Fixing America’s Surface Transportation (Act)
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
ITS	Intelligent Transportation Systems
MAP	Moving Ahead for Progress (in the 21st Century Act)
MPO	Metropolitan Planning Organization
PDF	Probability Density Function
PTI	Planning Time Index
TIP	Transportation Improvement Program
TTI	Travel Time Index

References

Technical Lesson References

Performance Scorecard: Washington Metropolitan Area Transit Authority Scorecard | WMATA

Moving Ahead for Progress in the 21st Century Act (MAP-21) | US Department of Transportation

The Fixing America's Surface Transportation Act or "FAST Act" | US Department of Transportation

S.1931 - 117th Congress (2021-2022): Surface Transportation Reauthorization Act of 2021 | Congress.gov | Library of Congress

Normal Distribution | Examples, Formulas, & Uses (scribbr.com)

1.3.6.2. Related Distributions (nist.gov)

Traffic is back, but the patterns have changed | WBUR News

Maricopa Association of Governance System Performance Report 2021 FY 2021 Annual Report (azmag.gov)

California State Performance Monitoring System 2022 Caltrans PeMS

Example Congestion Projects

Traffic Congestion Relief Program (TCRP) | CTC (ca.gov)

Congestion Relief Program | Infrastructure Resources Posts | Congressman Jim Himes (house.gov)

Performance Measures at State/Local Agencies

Congestion Measures | KYTC

Transportation Performance Measures | CRCOG

Wisconsin Department of Transportation Federal Transportation Performance Measures (wisconsindot.gov)

MDOT CMAQ TPM Presentation (michigan.gov)

Federal Use of Performance Measures

FHWA Proposes New Performance Measures to Reduce Congestion on the Nation's Highways | US Department of Transportation

Transportation Control Measures | US EPA

Transportation Performance Management

Reporting - Transportation Performance Management - Federal Highway Administration (dot.gov)

Transportation Performance Management (tn.gov)

About the Authors

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Dr. Reeb serves as Director of Research and Workforce Development at the Center for International Trade and Transportation at California State University, Long Beach. He oversees a multimillion-dollar portfolio of sponsored research that addresses rural, tribal, Intelligent Transportation Systems (ITS), supply-chain and logistics, zero-emission technologies, automation, data privacy, community engagement, and a range of workforce development issues. He is the principal author and editor of the book *Empowering the New Mobility Workforce (*Elsevier 2019), which was endorsed by the late Norman Mineta. He is a member of a Transportation Research Board (TRB) Rural Transportation Issues Coordinating Council (A0040C) and two TRB standing committees focused on Native American mobility issues (AME30) and workforce development and organizational excellence (AJE15). His research-driven reports, publications, and workforce development programs promote innovation and civic partnerships between leaders in business, government, and education. "Transportation in GIS," a pilot class Tyler developed in partnership with Los Angeles Trade Technical College, won the American Planning Association Award of Excellence for Opportunity and Empowerment. Tyler is currently pilot testing an ITS Engineering Talent Pipeline program at CSULB in partnership with Gannett Fleming.

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