

# Workforce Challenges in Implementing Transportation System Management and Operations within Caltrans

A Research Perspective from the University of California Institute of Transportation

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<b>16. Abstract</b> Caltrans has traditionally focused on designing, building, and maintaining California's large freeway network. Lately, a stronger focus is being placed on real time transportation network operation, which requires the use of real time data and decision support software tools. This transition represents a cultural shift for Caltrans, and its organizational structures and staffing processes are not yet in place to support the effort. This report explores major impediments to hiring data analysts and software engineers, including lack of understanding among current management personnel in regard to the need for data analysts and software engineers, barriers for Caltrans Operations to directly hire IT/software personnel, lack of interest among Caltrans engineering unions to include software engineers as members, a general belief that software engineers are not "real" engineers, and concern that the state will not be able to hire software engineers due to high salary demands. Opportunities for addressing barriers include developing appropriate recruitment strategies for software related positions, educating agency personnel on the need for data analysis and software skills, changing the requirements for positions in Caltrans traffic operations, and establishing a management team to coordinate and support these efforts.			
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# Workforce Challenges in Implementing Transportation System Management and Operations within Caltrans

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UNIVERSITY OF CALIFORNIA INSTITUTE OF TRANSPORTATION STUDIES

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## Executive Summary

Caltrans has traditionally focused on designing, building, and maintaining California's large freeway network. Lately, a stronger focus is being placed on real time transportation network operation. This is referred to as Transportation System Management and Operations (TSMO). Implementation of TSMO requires the use of real time data and decision support software tools. This move from building roadways to real time operational management is a cultural shift for Caltrans, and its organizational structures and staffing processes are not yet in place to support the effort.

The challenges of moving to a data driven organization are not unique to Caltrans and are occurring in other state government agencies in California and across the nation. One of the challenges is difficulty hiring data analysts and information technology personnel (principally software engineers). This document explores the reasons and remedies for this challenge.

The major impediments we found to hiring data analysts and software engineers are:

- 1) There is an overall lack of understanding of the need for data analysts and software engineers. Current management personnel, who have been in the workforce for many years, are unfamiliar with data analysis and software, and thus unaware of its importance in traffic management.
- 2) Within Caltrans, there is an unwritten agreement that Caltrans Operations will not hire IT/software personnel. This will be done by the IT department, which has little direct interaction with Caltrans Operations.
- 3) The Caltrans engineering union, Professional Engineers in California Government (PECG), does not appear to be interested in including software engineers as members in its union.
- 4) There is a belief that software engineers are not "real" engineers.
- 5) We were not able to speak with the Service Employees International Union (SEIU), which represents Information Technology personnel. However, SEIU is a large union and is not highly focused on software engineers. Fortunately, an update to the Information Technology Job Classifications, adopted in 2018, now includes software engineering as a desired skill and educational background. However, all relevant positions are named Information Technology specialists and not software engineers.
- 6) There is concern that software engineers are expensive and thus not able to be hired by the state. The maximum salary for the information technology job classifications appears to be around \$120,000 a year.
- 7) Prior to July 2018, there were no appropriate job descriptions for data analysts.
- 8) Caltrans is part of a large state bureaucracy whose processes are not set up to adequately engage and support the unions, the personnel board, and agency management to work together to address issues.

The above barriers are quite significant. What can be done to overcome them?

- 1) Develop appropriate salaries and/or recruitment strategies for software related positions.
- 2) Educate agency personnel on the need for data analysis and software skills.
- 3) Change the requirements for positions in Caltrans traffic operations.
- 4) Establish a management team to coordinate and support these efforts.

But there are challenges to each of these recommendations:

- 1) Education is a multiyear process and will need to involve the entire transportation ecosystem.
- 2) Modifying salaries takes years and requires management and union approval.
- 3) Management teams themselves must understand the need for these types of positions.

Of the three challenges listed above, education is the most important and can lead to resolution of the other issues. We recommend setting up a high-level team composed of Caltrans and the University of California (UC) civil, electrical, data science and computer science departments to develop a plan for how to update university transportation programs and Caltrans' work force development programs to better reflect evolving workforce needs.



# 1. Introduction and Current State of Affairs

The California Department of Transportation (Caltrans) "...manages more than 50,000 miles of California's highway and freeway lanes, provides inter-city rail services, permits more than 400 public-use airports and special-use hospital heliports, and works with local agencies. Caltrans carries out its mission of providing a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability, with six primary programs: Aeronautics, Highway Transportation, Mass Transportation, Transportation Planning, Administration and the Equipment Service Center."<sup>1</sup>

Caltrans is working to implement a culture of Transportation System Management and Operations (TSMO). TSMO as defined by the Federal Highway Administration (FHWA) is ... "a set of strategies that focus on operational improvements that can maintain and even restore the performance of the existing transportation system before extra capacity is needed. The goal here is to get the most performance out of the transportation facilities we already have. This requires knowledge, skills, and techniques to administer comprehensive solutions that can be quickly implemented at relatively low cost. This may enable transportation agencies to "stretch" their funding to benefit more areas and customers. TSMO also helps agencies balance supply and demand and provide flexible solutions to match changing conditions."<sup>2</sup>

One of the best examples of TSMO in action is the practice of Integrated Corridor Management (ICM). The United States Department of Transportation (US DOT) states that the vision of ICM is "...that transportation networks will realize significant improvements in the efficient movement of people and goods through institutional collaboration and aggressive, proactive integration of existing infrastructure along major corridors. Through an ICM approach, transportation professionals manage the corridor as a multimodal system and make operational decisions for the benefit of the corridor as a whole."<sup>3</sup>

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<sup>1</sup> <http://www.dot.ca.gov/aboutcaltrans.htm>

<sup>2</sup> <https://ops.fhwa.dot.gov/tsmo/index.htm>

<sup>3</sup> [https://www.its.dot.gov/research\\_archives/icms/index.htm](https://www.its.dot.gov/research_archives/icms/index.htm)

A TSMO approach normally includes interagency agreements leading to real time determination of responses to incidents and heavy traffic. The real time responses are generally recommended by a Decision Support System (DSS) and implemented by software connected to Intelligent Transportation System (ITS) devices.

In 2011, Caltrans contracted with the UC Berkeley PATH program to assist with the planning, development, and implementation of an ICM system for Interstate 210 in the Los Angeles area, which is referred to as the Connected Corridors program.<sup>4</sup>

Concurrently, the consulting organization System Metrics Group (SMG) was hired by Caltrans to assist with defining a new organizational structure for corridor management. As part of PATH's contract with Caltrans, a document was produced outlining the requirements for implementing the Connected Corridors program. Importantly, this included human requirements.<sup>5</sup> Several skill gaps were identified. These gaps were principally in the areas of data analysis and software engineering. Once Caltrans was made aware of these skill gaps, efforts were made to fill these gaps. However, challenges remain, which are further explored in this paper.



*Figure 1 I-210 Freeway and Metro Light Rail in Los Angeles County*

## 2. Challenges with Addressing TSMO-Related Skill Gaps at Caltrans

To gain a better understanding of the challenges associated with addressing skill gaps related to TSMO implementation, PATH researchers interviewed or held discussions with individuals from the following organizations:

- The American Association of State Highway and Transportation Officials (AASHTO) Center of Excellence
- Unions that represent Caltrans employees
  - PEEG
  - California Association of Professional Scientists (CAPS)
- The State Personnel Board
- Transportation industry consultants
- University personnel
- Caltrans personnel

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<sup>4</sup> <https://connected-corridors.berkeley.edu/>

<sup>5</sup> The I-210 Pilot System Requirements Job Descriptions and Duties/Tasks Document was published in December 2016 and is available on the Connected Corridors website: [https://connected-corridors.berkeley.edu/sites/default/files/job\\_descriptions\\_and\\_duties\\_pdf1.pdf](https://connected-corridors.berkeley.edu/sites/default/files/job_descriptions_and_duties_pdf1.pdf).

PATH's engagement with these organizations is summarized below.

## Perspective from the AASHTO National Operations Center of Excellence

“The National Operations Center of Excellence (NOCoe) is conducting an active collaborative program with key agency, industry, and educational partners to improve and enhance the Transportation System and Operations (TSMO) workforce. Efforts are being applied across the educational, public agency, and industry environments and activities include: raising TSMO awareness, professional capacity building, and addressing related management and administration issues.”<sup>6</sup>

As a part NOCoE's workforce enhancement study, an Educational Forum was held on November 9, 2017 with a focus on pre-employment education aimed at producing both TSMO generalists and specialists with key support capabilities. Forum participants included a range of educators (both community college and universities), NOCoE Board members, staff, and consultants. A key objective of the Forum was to enhance mutual understanding between educators and practitioners regarding the state-of-the-practice and the challenges faced in improving TSMO education and training. PATH's presentation at this event (i.e., Workforce Development for the Digital Age presentation<sup>7</sup> and the final Educational Forum Proceedings report)<sup>8</sup> can be found on PATH's Connected Corridors website: <https://connected-corridors.berkeley.edu/resources/presentations/conference-presentations/nocoe-academic-forum>.

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<sup>6</sup> <https://connected-corridors.berkeley.edu/resources/presentations/conference-presentations/nocoe-academic-forum>

<sup>7</sup> [https://connected-corridors.berkeley.edu/sites/default/files/aashto\\_workforce\\_final-1.pdf](https://connected-corridors.berkeley.edu/sites/default/files/aashto_workforce_final-1.pdf)

<sup>8</sup> [https://connected-corridors.berkeley.edu/sites/default/files/nocoe\\_-\\_academic\\_forum\\_proceedings-final-1.pdf](https://connected-corridors.berkeley.edu/sites/default/files/nocoe_-_academic_forum_proceedings-final-1.pdf)



*Figure 2 Data Science Class at UC Berkeley*

Likely the most interesting and perceptive comment in the Educational Forum was made by Professor Robert Bertini, who previously served as the Deputy Administrator of the Research and Innovative Technology Administration (RITA). He noted in his early 50's that "our transportation organizations are being run by old, white male civil and electrical engineers, and I am too young to be in that club."

That comment led to a discussion of the need for an infusion of younger blood into the workforce. As part of this discussion, it was realized that university transportation programs are having many of the same

challenges experienced by government transportation organizations. Faculty are not knowledgeable in software and data analytics, so they are unable, and sometimes uninterested, in training new transportation students in these skills. However, this is changing at universities. New programs are being introduced at universities around the country focused on filling this need. As such, one of the overall recommendations presented at the Educational Forum was for transportation agencies to work more closely with their local universities to ensure students are receiving the training they need, especially in the realm of software development and data analytics. Caltrans has supported this approach by working with UC Berkeley on the Connected Corridors program. However, more needs to be done in growing the partnership at higher levels in both Caltrans and the University of California, as well as with the California State University system and California Community Colleges.

## The Union Perspective

### **Professional Engineers in California Government (PECG)**

PECG was founded in 1962, and "represents 13,000 state-employed engineers and related professionals responsible for designing and inspecting California's infrastructure, improving air and water quality, and developing clean energy and green technology."<sup>9</sup> PECG leadership was friendly and open to the discussion on skills gaps Caltrans faces related to data analytics and software engineers. However, PECG had little exposure to these professions. PECG did not express an interest in expanding its membership to include software engineers and expressed

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<sup>9</sup> <http://pecg.org/>

concern about salary ranges for these positions. In general, PECG confirmed that adding new job classifications to its union is very rare.

### **California Association of Professional Scientists (CAPS)**

CAPS “is the exclusive representative of nearly 3,000 scientists working for the State of California.”<sup>10</sup> CAPS does not think data analysts or software engineers would properly fit into its organization. However, CAPS was interested in the topic and provided a referral to the State Personnel Board (see below for summary of the conversation with the State Personnel Board).

### **Service Employees International Union (SEIU)**

Despite repeated attempts, SEIU union management did not respond to any of our requests for comment or communication. The SEIU represents information technology personnel. This representation is somewhat at odds with the rest of the job classifications that SEIU represents. When the information technology classifications were first created, they generally represented low paid key punch operators. Several people mentioned that SEIU was not the best union to represent software engineers.

The California Department of Human Resources (CalHR) website does discuss changes to the Information Technology class stating that “...class consolidation is the largest piece of Governor Edmund G. Brown Jr.’s Civil Service Improvement initiative to be undertaken to date. It impacts 10,000 civil service positions, which is roughly 5 percent of the state’s workforce. The State Personnel Board approved IT consolidation at its January 11, 2018 meeting. The driving force behind the plan is to update outdated IT class descriptions that were put in place, in some cases, more than 40 years ago. The modernized system will dramatically improve civil service IT positions – both for the people in the jobs and for the State of California, which will be better able to attract, and keep, employees with vital technical skills.”<sup>11</sup> Detailed information on this class consolidation and renewal, including information related to exact job descriptions and salaries, can be accessed at: <http://www.calhr.ca.gov/employees/Pages/Information-Technology-Class-Consolidation.aspx>

In summary, PECG and CAPS agreed that the need for new skills in the realm of data analytics and software engineering is very real, but their unions are not the right place to pursue this. They felt the bureaucratic processes required to define new positions and choose appropriate salaries could take many years and may not lead to a useful result. They hoped for improved collaboration and collegial interactions with the management of state organizations, and earlier involvement of their unions in workforce renewal issues. PECG and CAPS defined the workflow for creating new positions within the state as follows:

Caltrans → CalHR → Time → State Personnel Board → Unions

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<sup>10</sup> <http://capsscientists.org/>

<sup>11</sup> <http://www.calhr.ca.gov/employees/Pages/Information-Technology-Class-Consolidation.aspx>

Both unions stressed that the hiring organization starts the process for defining new positions and the unions are involved at the end.

## Perspective from the State Personnel Board

“Established by the State Constitution, the State Personnel Board (SPB) is charged with overseeing the merit-based, job-related recruitment and selection process for the hiring of state employees who provide critical services to the citizens of California. SPB provides direction to departments through simplifying civil service laws, rules, and policy. In addition, SPB audits departments for merit system compliance...”<sup>12</sup>

We met with the Executive Officer of SPB. The discussion revolved around the complex and lengthy processes required to define new job categories and update existing ones. The SPB has also recognized the need for data analysts and updated IT skill classifications. A new job classification of Research Data Analyst was approved in July 2018. We, as well as selected members of Caltrans, reviewed the job classification document and provided comments to SPB. Comments were based on the Connected Corridors program needs and general experience in the field.

The job classification for Research Data Analyst is currently defined as: “This series specification describes professional research data classifications responsible for planning, organizing, and conducting studies in a variety of areas, which affect programs or systems development within the state. Incumbents in these classifications perform quantitative and qualitative data driven research and statistical analysis.”

The creation of this job classification resolves one of the major challenges previously encountered when trying to hire a data analyst. The lack of a job classification.

## Perspective from Transportation Industry Consultants

Consultants interviewed as part of this effort confirmed the need for data analysts and software engineers. They discussed the difficulty of educating transportation engineers, including management and engineers in their own organizations, in regard to the need for these personnel. They believe that a joint venture with universities to help train government and industry would be productive.

They also expressed concerns about the career paths for software engineers within the Caltrans operations group. They were not sure how software engineers would advance. This is similar to the limited career paths of planners, or others without a civil or electrical engineering degree, within the Caltrans operations organization. Some consultants thought that it might be possible to hire specially trained electrical engineers as software engineers. We do not agree with this opinion.

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<sup>12</sup> <http://www.spb.ca.gov/>

## Perspective from Caltrans Personnel

Caltrans personnel, including human resources personnel, expressed widely different opinions on the topic, which are summarized as follows:

- Not sure we need these new skills.
- We absolutely need these new skills.
- We should hire outside consultants for this.
- I don't understand why we need these skills.
- IT should do this, but we are worried about working with IT.
- Can't we design solutions that don't need these skills.
- This effort will fail anyway because Caltrans is not capable of changing its culture.
- This effort must succeed as it is central to Caltrans' success.
- We can't afford to hire them, they would never work for us.

We believe there are many motivations for these answers. Caltrans is a diverse organization with many older employees focused on retirement and not motivated to look at new ways of doing business. Younger employees tended to be more positive in their responses, more likely to perceive a need for organizational and skill renewal, and more hopeful for the future of Caltrans.

Overall, Caltrans personnel do not understand what data analysts or software engineers do, and often try to define them in terms of what they know. This is completely understandable, but not accurate and can be detrimental to success. There were exceptions to this, but rare.

Caltrans normally looks to consultants to provide software services with the deliverables being viewed in terms of inputs and outputs, without knowledge of the internal workings or development processes associated with these services. This approach has had challenges in the past and will likely not work in the future as systems become more complex and critical.

## Perspective from University Personnel

University personnel were divided by their opinions into three general groupings:

- 1) Definitively understood the need for new skills in transportation and were trying to do something about it,
- 2) Those who were not interested in the problem, and
- 3) Those who lacked the exposure to understand the need for software and data analytics.

As mentioned in the ASSHTO Center of Excellence section, many universities are working to create new programs that respond to the increasing need for transportation professionals to understand and work with data and software. However, more work is needed. There is a lack of real communication between the Data Science, the Computer Science, and the Civil Engineering

faculty. Transportation studies are traditionally managed by the Civil Engineering department. Within a university, it can be difficult to establish cross departmental cooperation.

Ultimately, the professors themselves began as students. If as students, faculty are not taught the importance of data and software in transportation management, then it is difficult to see how they could teach it.

### 3. Conclusion and Next Steps

The Internet, cellular communication, miniaturization of devices, and unlimited computer resources are providing organizations the capability to gather data, make decisions, and implement those decisions in real time. The management of the transportation system is no different. These technologies are essential components in real time traffic management.

However, utilization of these new technologies requires commensurate job skills. The State of California, the US Department of Transportation, transportation consultants, and universities are all working to support the adoption of these technologies and train and hire the personnel with the appropriate skills. However, barriers remain as follows:

- 1) There is an overall lack of understanding of the need for data analysts and software engineers. Current management personnel, who have been in the workforce for many years, are unaware of data analysis and software and in turn, do not know how these professions fit into the evolving field of transportation. Some are not interested, at this stage of their career, in learning more about new job classifications and working on the necessary organizational changes to facilitate filling these important skill gaps.
- 2) Within Caltrans, there is an unwritten agreement that Caltrans Operations will not hire IT/software personnel. Operations and IT in Caltrans have had a tense relationship and thus, even personnel with Caltrans Operations who would like to hire the appropriate personnel are not able to. This may be related to career tracks and promotion possibilities.
- 3) PEEG, which is the Caltrans engineering union, does not appear to be interested in including software engineers in their union.
- 4) There is a belief among civil and electrical engineers that software engineers are not real engineers. This is similar to the way software engineers were not at first accepted into the industry in the 1970's and 1980's. Additional education about the need for data analysts and software engineers within transportation agencies (and Caltrans specifically) and the unique skills these professions offer will help address this issue.
- 5) We were not able to speak with the SEIU union, which represents information technology personnel. However, SEIU is a large union and is not focused on software engineers. Fortunately, an update to the Information Technology Job Classifications, adopted in 2018, now includes software engineering as a desired skill and educational background. However, all relevant positions are named Information Technology specialists and not software engineers.



- 6) There is concern that hiring software engineers will be expensive and thus, prohibitive to hire as a state employee. The maximum salary for the information technology job classification appears to be around \$120,000 a year. We believe that while this is a concern, it can be managed. The benefits in both retirement and current lifestyle can be attractive to software engineers in much the same way they are to electrical and civil engineers.
- 7) Prior to July 2018, there were no appropriate job descriptions for data analysts. We reviewed and made suggestions to the California State Personnel Board on these new job descriptions. Many of these suggestions were accepted.
- 8) Caltrans is part of a large state bureaucracy whose processes prevent the unions, the personnel board, and agency management from working together to address issues.

The above barriers are quite significant, but the following recommended actions can help overcome them:

- 1) Develop appropriate salaries and/or recruitment strategies for software related positions.
- 2) Educate current personnel on the need for data analysis and software skills.
- 3) Change the requirements for positions in Caltrans Traffic Operations to include software engineers, and not just civil and electrical engineers.
- 4) Establish a management team to assist in implementing the above items.

There are challenges to each of the above recommended actions:

- 1) Education is a multiyear process and will need to involve the entire ecosystem. Universities themselves suffer from some of the same challenges.
- 2) Modifying salaries/recruitment approaches can take years. Changing the salary for a job involves management and union approval.
- 3) Management teams must understand the need for data analyst and software positions.

Of the three, education is the most important and can lead to resolution of the other issues. Along with education, there must be management agreement to allow software and data personnel to work with civil and electrical engineers. Without this, the skillset of software and data personnel will not be utilized, nor sought after. Several interviewees noted that the current wave of government retirements provides a unique opportunity for cultural and knowledge renewal.

We recommend setting up a high-level team composed of Caltrans and the University of California (UC) civil, electrical, data science and computer science departments to address these issues. As the unions stated, they only respond to requests from management. Thus the effort needs to start with Caltrans management and UC personnel who understand the importance of data analysis and software engineering. A good starting point would be the Connected Corridors program personnel at UC Berkeley and Caltrans. However, this would need to grow into a team with senior management from both the University and Caltrans.

The overall team would:

- 1) Determine the best path for on the job education for Caltrans employees regarding data analytics and software.
- 2) Work at a high level on determining where these skills would be best used in the Caltrans organization.
- 3) In order to facilitate knowledge transfer, improve the quality of software systems within Caltrans and ultimately reduce costs, assign software engineers within Caltrans to work with software contractors.
- 4) Work with UC Berkeley initially, and then other educational institutions, on obtaining funding for the development of new courseware for teaching civil engineering undergraduate and graduate students in data analytics and software.
- 5) Engage the unions early on in these discussions.