



PI-0326: Resource Management Maturity and Best Practices at Government Agencies

Requested by

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The Caltrans Division of Research, Innovation and System Information (DRISI) receives and evaluates numerous research problem statements for funding every year. DRISI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field. The contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the California Department of Transportation, the State of California, or the Federal Highway Administration. This document does not constitute a standard, specification, or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor, or consultant. Any trade names or photos of commercial products appearing in this publication are for clarity only.

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Executive Summary

Background

The California Department of Transportation (Caltrans) Office of Program Management (OPM) uses the Resource Target Plan (RTP) to determine the workload in its annual capital and non-capital programs and to allocate the resources required to support these programs. Program workload is managed and costs are assigned in the RTP in terms of hours, not dollars. Hours are estimated in person years for in-house staff and person year equivalents for consultant-provided services. One person year equals 1,758 hours.

OPM would like to apply performance measures to this resourcing methodology to assess the efficacy of the resource allocation. To assist Caltrans with this effort, CTC & Associates conducted a survey of state departments of transportation (DOTs) to inquire about best practices for agency management of staffing-related resources. Results of a literature search supplemented survey findings.

Summary of Findings

Survey of Practice

A survey of a select group of state DOTs gathered information about agency resource management practices, including staffing allocation practices and the application of performance measures or indicators to assess those allocations.

The survey received 11 responses from 10 state transportation agencies. (North Carolina DOT provided separate responses to the survey for preconstruction and construction services.) Survey respondents from nine DOTs—all except Illinois DOT—reported that their agencies have developed a methodology to allocate the staffing resources needed to deliver engineering-related services included in their agencies' annual capital and non-capital programs.

Survey findings from the nine transportation agencies are highlighted below in three topic areas:

- Primary mechanism for allocating staff.
- Accuracy of staffing allocations.
- Tracking performance.

Following these findings is a discussion of the agencies' assessment of using performance measures in staffing allocation processes and recommendations for implementing these measures.

Primary Mechanism for Allocating Staff

Arizona, Arkansas, Michigan, Minnesota and Ohio DOTs use person years or another staffing-related factor for allocating staff to the engineering-related services included in their agencies' annual capital and non-capital programs. The Arkansas DOT respondent added that a research project underway with the University of Arkansas will develop a new workforce forecasting system to replace the agency's outdated resource estimating program, which can no longer be used with larger projects, contractor quality control/quality assurance and contractor staking.

The remaining four agencies use other factors to allocate staff:

- *Missouri DOT* delivers its capital program with in-house resources and uses consultant resources as needed.
- *North Carolina DOT/Preconstruction* considers geography, internal versus external production, workload and expertise.
- *North Carolina DOT/Construction* uses a personnel projection that proposes the number of staff needed based on project size and complexity.
- *Oregon DOT* uses a combination of factors, including one similar to Caltrans' person year factor. Staffing levels are used as a factor to assess the amount of work that can be delivered in-house compared to the amount that will need to be contracted out. For very high level resource planning, the agency has developed a tool that shows the optimum level of outsourcing and staffing based on available resources.
- *Texas DOT* allocates staffing based on skill.

Accuracy of Staffing Allocations

Arizona and Texas DOT respondents noted that allocations are very close to what is actually required ($\pm 5\%$). Respondents from Minnesota, Missouri, North Carolina/Preconstruction and Ohio DOTs reported that their agencies usually make minor adjustments ($\pm 10\%$) to the proposed staffing allocation during the year. North Carolina DOT/Construction always requires minor adjustment during the year.

Michigan DOT adjusts staffing as needed, although the agency's scheduling software (Planisware) provides "fairly accurate staffing allocation." Arkansas and Oregon DOTs were unable to rate the accuracy of staffing allocations because of outdated forecasting systems (*Arkansas DOT*) and a lack of control over regional allocations (*Oregon DOT*).

Tracking Performance

Arizona, Michigan, Minnesota, North Carolina (Preconstruction and Construction), Ohio and Texas DOTs use allocated staffing resources to track subdivision or functional unit performance. Five performance measures were considered in the survey:

- Adherence to project schedules.
- Adherence to project- or program-level budgets.
- Quality of work performed.
- Efficiency and effectiveness of work performed.
- Type of task performed.

Adherence to Project Schedules

Task progress is monitored using performance metrics (*North Carolina DOT/Construction*), scheduling software (*Michigan DOT*) and a project's critical path method (CPM) (*Minnesota DOT*). A Microsoft Power BI balanced letting dashboard supports Minnesota DOT's application of CPM.

Ohio DOT measures projects completed within a time frame, and Texas DOT team leads meet weekly to ensure that projects are progressing and that target dates will be met. North Carolina DOT/Preconstruction does not assess in-house staff but does evaluate contractors.

Adherence to Project- or Program-Level Budgets

Four agencies assess the adherence to project schedules when monitoring staff allocations. Among the common practices are dashboards (*Arizona DOT*), CPM (*Minnesota DOT*) and performance metrics (*North Carolina DOT/Construction*). Michigan DOT assesses different phases of a project, and North Carolina DOT/Preconstruction assesses contractors.

Quality of Work Performed

Texas DOT evaluates performance for every team member and project. Quality of work is also assessed based on experience (*Michigan DOT*), inspection and project oversight (*North Carolina DOT/Construction*) and the number of reviews needed before bid advertisement (*Arizona DOT*). North Carolina DOT/Preconstruction considers quality of work to be a “major evaluation factor” for contractors, and Ohio DOT considers this assessment to be subjective.

Efficiency and Effectiveness of Work Performed

Michigan DOT considers experience and quality of work when assessing efficiency and effectiveness of work performed by both internal staff and consultants. Texas DOT measures efficiency during weekly meetings based on staff’s ability to meet target dates with the resources allocated.

Minnesota and North Carolina DOTs don’t have formal performance metrics for assessing efficiency and effectiveness. Instead, these agencies rely on individual performance management and project schedule tracking (*Minnesota DOT*) or guidance and tools for project delivery (*North Carolina DOT*).

Type of Task Performed

In Arizona, project manager performance is assessed annually based on project quantity and complexity. In other agencies, task hours are assigned by Planisware (*Michigan DOT*) and CPM (*Minnesota DOT*). North Carolina DOT/Preconstruction and Texas DOT match expertise with a specific task. North Carolina DOT/Construction evaluates contractors based on management, documentation and inspection.

Applying Performance Measures

Only one agency—Arizona DOT—applies a single set of performance measures to select subdivisions or functional units. Four agencies—Michigan, Minnesota, North Carolina/Preconstruction and Texas DOTs—apply the same performance measures across all subdivisions or functional units. North Carolina/Construction and Ohio DOTs have developed different performance measures for different units based on function.

Assessment

North Carolina DOT/Construction reports that using performance measures allows for more consistent staffing allocations across the agency and better planning with contractors. Performance measures at Texas DOT have highlighted the value of mentorship programs for knowledge transfer.

Several survey respondents discussed practices other than performance measures for managing staffing allocation, which include using scheduling software (*Michigan DOT*) and managing by individual office or unit (*Minnesota DOT*). Arizona DOT uses an 80% consultant/20% in-house delivery method, and North Carolina DOT/Preconstruction bases staffing allocations on a variety of factors, including geography and workload.

Recommendations

Below are recommended practices for implementing staffing allocation processes or performance measures:

- Standardize allocation procedures for future workloads. (*North Carolina DOT/Construction*)
- Tie payroll codes to CPM activity codes. (*Minnesota DOT*)
- Pay attention to the quality of the data produced, and be “confident in what the data is telling you.” (*Michigan DOT*)
- Emphasize knowledge transfer and allow for cross-functional teams to handle different aspects of projects at the same time. (*Texas DOT*)
- Use consultants during peak loads. (*Arizona DOT*)
- Don’t let the development of an evaluation process influence the core business function by creating gaps, redundancy or inefficiency. (*North Carolina DOT/Preconstruction*)

Related Research and Resources

A literature search of publicly available domestic in-progress and published research identified a limited sampling of national and state publications and other resources.

Although somewhat dated, a National Cooperative Highway Research Program (NCHRP) synthesis forecasts the staffing requirements for highway construction projects. The report notes the difficulty of estimating construction staffing requirements, in large part due to the variable nature of these projects.

State research includes two research projects underway: a comprehensive update of Arkansas DOT’s staffing estimating system and Kentucky Transportation Cabinet’s examination of state DOT practices for estimating staffing requirements in highway construction projects. The Arkansas DOT project is expected to develop a software tool potentially integrating artificial intelligence for estimating staffing needs.

Software tools that can be used to determine staffing are presented in other citations, including a case study of a tool used by the Construction Management Division of the Port of Long Beach and a spreadsheet tool developed by NCHRP to estimate staffing and consultant needs for highway construction projects.

A Texas DOT study assessed staffing needs for construction plans in advance so that information is readily available when construction projects are funded. Methods to identify staffing needs for design-build and alternative delivery programs are presented in a synthesis of practices from several state DOTs and in a Washington State DOT conference paper.

Gaps in Findings

Although the information gathered from the state transportation agency survey was diverse and informative, relatively few agencies responded to the survey. Caltrans could potentially uncover useful information by directly contacting agencies that didn’t participate in the survey. Additionally, recent published research on this topic is limited, and a number of the resources identified in the literature search were older.

Next Steps

Moving forward, Caltrans could consider:

- Examining the tools provided by survey participants, specifically:
 - Minnesota DOT's balanced letting dashboard.
 - Oregon DOT's tool for very high level resource planning, which shows the optimum level of outsourcing and staffing based on available resources.
- Following the status of the research projects underway at Arkansas DOT and Kentucky Transportation Cabinet for information relevant to Caltrans' needs.
- Contacting selected survey participants for additional information about their agencies' use of performance metrics in resource allocations.
- Reaching out to agencies not participating in the survey to determine if these agencies apply performance measures to assess the efficacy of staffing resource allocation.

Detailed Findings

Background

The California Department of Transportation (Caltrans) Office of Program Management (OPM) is responsible for developing the annual capital and non-capital programs workload and allocating the resources required to support these programs through the Resource Target Plan (RTP). The RTP allows OPM to ensure that each functional unit within the Division of Engineering Services (DES) has the staffing needed to deliver on its commitments, and DES executives and portfolio managers have the information needed to monitor project status and resources.

The RTP consists of multiple workload and allocation reports that are updated annually and as needed. Program workload is managed and costs are assigned in the RTP in terms of hours, not dollars. Hours are estimated in person years for in-house staff and person year equivalents for consultant-provided services. One person year equals 1,758 hours.

OPM would like to enhance its current resourcing methodology by applying performance measures that can assess the efficacy of the resource allocation. To inform this effort, this Preliminary Investigation gathered literature and reporting from state departments of transportation (DOTs) about best practices for agency management of staffing-related resources.

Survey Findings

An online survey was distributed to members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Performance-Based Management. This committee is national in scope, with representatives from DOTs in all 50 states and the District of Columbia. Survey questions, which are provided in [Appendix A](#), inquired about agency resource management practices, including staffing allocation practices and the application of performance measures or indicators to assess those allocations. The full text of survey responses is presented in a supplement to this report.

Summary of Survey Results

The initial request to participate in the survey received a limited response. To generate additional participation, customized emails announcing the survey were sent to a select group of committee representatives. This combined approach produced responses from 10 state transportation agencies:

- Arizona.
- Arkansas.
- Illinois.
- Michigan.
- Minnesota.
- Missouri.
- North Carolina (two responses).
- Ohio.
- Oregon.
- Texas.

Survey respondents from nine DOTs—all except Illinois DOT—reported that their agencies have developed a methodology to allocate the staffing resources needed to deliver engineering-related services included in their agencies' annual capital and non-capital programs.

Note: The North Carolina DOT respondent completed two surveys: one describing allocation practices for preconstruction and a second survey describing allocation practices for construction and engineering inspection (referred to as construction in the report).

Also, the respondent from Texas DOT reported that the agency has not developed a staffing methodology, however, the respondent described agency practices in the remainder of the survey. Information provided by the Texas DOT respondent is included along with the information provided by respondents who reported that their agencies have developed a staffing methodology.

Below are survey results from the nine state transportation agencies that have developed a staffing resources methodology for delivering engineering-related services. Information is presented in the following categories:

- Primary mechanism for allocating staff.
- Accuracy of staffing allocations.
- Tracking performance.
- Assessment.

Primary Mechanism for Allocating Staff

Five of the nine agencies—Arizona, Arkansas, Michigan, Minnesota and Ohio—use person years or another staffing-related factor for allocating staff to the engineering-related services included in their agencies' annual capital and non-capital programs. The respondent from Arkansas DOT provided additional detail about agency practices:

- For the last two to three years, Arkansas DOT has used experienced former Resident Engineers to estimate the inspection staff required for projects based on project size, type of work and project duration. The agency is currently developing a new staffing allocation program (see **Accuracy of Staffing Allocations**) and is hopeful that the new system will provide better accuracy and simpler processing based on current and anticipated workload in its 31 Resident Engineer offices.

Four agencies—Missouri, North Carolina, Oregon and Texas—use other factors, described below:

- *Missouri DOT* has a limited number of Plans Production staff devoted to delivering the annual construction program. Tasks are estimated based on the number of hours required to complete the task. If internal staff is unable to deliver work, it is sent to consultants.

The respondent added that because of retirements and resignations within the agency, its Plans Production staff is relatively inexperienced but the agency does what it can to deliver the capital program with in-house resources. Staff typically meets quarterly to see what consultant resources are needed.

- *North Carolina DOT:*
 - In *Preconstruction*, other factors include geography, internal versus external production, workload and expertise. See *Related Resource* below for guidance about workload needs.
 - In *Construction*, the agency uses a personnel projection that proposes the number of staff needed based on project size and complexity.

- *Oregon DOT* uses a combination of factors, including one similar to Caltrans' person year factor. The agency calculates staffing and outsourcing needed in relation to its overall expected program size. Staffing levels are used as a factor to assess the amount of work that can be delivered in-house compared to the amount that will need to be contracted out.

For very high level resource planning, the survey respondent has developed an Excel-based tool that shows the optimum level of outsourcing and staffing based on available resources. The tool uses an Excel add-in for linear, nonlinear and integer modeling and optimization to determine in-house and outsourced needs.

Note: The Oregon DOT tool has been provided to Caltrans as a supplement to this report.

- *Texas DOT* allocates staffing based on skill, using cross-functional teams with team leads to coordinate activities.

Table 1 summarizes survey responses.

Table 1. Primary Mechanism for Allocating Staff

State	Person Years/ Staffing Factor	Other Factors	Comments
Arizona	X		
Arkansas	X		
Michigan	X		
Minnesota	X		
Missouri		X	<ul style="list-style-type: none"> • Limited number of Plans Production staff to deliver annual construction program. • Tasks estimated based on number of hours required to complete task. • Excess work sent to consultants.
North Carolina/ Preconstruction		X	<ul style="list-style-type: none"> • Geography. • Internal versus external production. • Workload. • Expertise.
North Carolina/ Construction		X	Personnel projection based on project size and complexity
Ohio	X		
Oregon		X	Combination of factors, including one similar to Caltrans' person years: <ul style="list-style-type: none"> • Calculate staffing and outsourcing needed in relation to overall expected program size. • Use staffing levels to determine in-house workload and contracting workload.
Texas		X	<ul style="list-style-type: none"> • Skill-based allocation. • Activities coordinated by team leads from cross-functional teams.
Total	5	5	

Related Resource:

Construction Engineering and Inspection: Contract Administration Guidelines, Construction Unit, North Carolina Department of Transportation, October 2023.
<https://connect.ncdot.gov/projects/construction/Construction%20Policy%20Memos/Construction%20Engineering%20and%20Inspection%20Guidelines.pdf>

A discussion of workload needs assessment and documentation begins on page v of the document (page 10 of the PDF).

Accuracy of Staffing Allocations

The accuracy of proposed staffing allocations varies among survey respondents. Respondents from two agencies—Arizona and Texas—noted that allocations are very close to what is actually required ($\pm 5\%$). Four agencies—Minnesota, Missouri, North Carolina/Preconstruction and Ohio—usually make minor adjustments ($\pm 10\%$) to the proposed staffing allocation during the year. North Carolina/Construction always requires minor adjustment during the year. The respondent noted that projections are estimates only, and staff adjusts actual needs as work progresses. None of the agencies reported requiring significant adjustments ($\pm 20\%$) during the year.

While Michigan DOT adjusts staffing as needed, the survey respondent noted that Planisware, its scheduling software (see *Related Resource* below), provides “fairly accurate staffing allocation.”

The respondents from Arkansas and Oregon DOTs were unable to rate the accuracy of staffing allocations based on the following contributing factors:

- *Outdated forecasting systems.* Arkansas DOT’s current staffing allocation program was last updated in the late 1980s and is no longer accurate for the agency’s larger projects or for contractor quality control/quality assurance and contractor staking. The agency has contracted with the University of Arkansas to develop a new manpower forecasting system. (See **Related Research and Resources**, page 17, for information about this research project.)
- *Lack of control over regional allocations.* The Oregon DOT respondent noted that the accuracy of the agency’s proposed staffing allocations is “unknown” because region staff allocate resources and outsource as needed. The state forecasts are used to help region offices plan but are not used in performance measurement.

Table 2 summarizes survey responses.

Table 2. Accuracy of Proposed Staffing Allocations

State	Very Close ($\pm 5\%$)	Usually Minor Adjustment ($\pm 10\%$)	Always Minor Adjustment	Other	Comments
Arizona	X				
Arkansas				X	Currently developing a new manpower forecasting system
Michigan				X	Fairly accurate staffing with Planisware scheduling software

State	Very Close (±5%)	Usually Minor Adjustment (±10%)	Always Minor Adjustment	Other	Comments
Minnesota		X			
Missouri		X			
North Carolina/ Preconstruction		X			
North Carolina/ Construction			X		Staff adjusts actual needs as work progresses.
Ohio		X			
Oregon				X	Unknown. Region staff allocates resources and outsources projects as needed.
Texas	X				
Total	2	4	1	3	

Related Resource:

Transform How You Plan Your Projects, Planisware, undated.

<https://planisware.com/>

From the website: Planisware is a leading business-to-business (“B2B”) provider of [s]oftware-as-a-[s]ervice (“SaaS”) in the rapidly growing [p]roject [e]conomy. Planisware’s mission is to provide solutions that help organizations transform how they strategize, plan and deliver their projects, project portfolios, programs and products.

Tracking Performance

Six agencies—Arizona, Michigan, Minnesota, North Carolina (Preconstruction and Construction), Ohio and Texas—track the performance of subdivisions or functional units based on the use of allocated staffing resources. Performance measures or indicators considered in the survey were:

- Adherence to project schedules.
- Adherence to project- or program-level budgets.
- Quality of work performed.
- Efficiency and effectiveness of work performed.
- Type of task performed.

Table 3 summarizes survey responses (when available). Following the table are additional details from agency respondents.

Table 3. Staffing Allocation Performance Measures

State	Adherence to Project Schedule	Adherence to Project/ Program Budget	Quality of Work	Efficiency/ Effectiveness	Type of Task
Arizona		X	X		X

State	Adherence to Project Schedule	Adherence to Project/ Program Budget	Quality of Work	Efficiency/ Effectiveness	Type of Task
Michigan	X	X	X	X	X
Minnesota	X	X		X	X
North Carolina/ Preconstruction	X	X	X		X
North Carolina/ Construction	X	X	X		X
Ohio	X		X		
Texas	X		X	X	X
Total	6	5	6	3	6

Adherence to Project Schedules

Michigan DOT uses Planisware scheduling software to monitor staffing allocation to tasks within the schedule. The agency does not formally measure staff performance, but does track task completion tied to specific resources.

Minnesota DOT monitors progress against a project's CPM P6 schedule. (CPM, or critical path method, calculates the dates and activities in a schedule. P6 calculates the critical path in two passes: a forward pass of early start dates and a backward pass of latest dates.) The agency reports and measures progress on a negative float (the time that must be saved to complete a project on time). (**Note:** A sample balanced letting dashboard with data tables and P6 criteria has been provided to Caltrans separately.)

North Carolina DOT/Preconstruction does not assess internal staff because a variety of factors are at play. External partners, however, are assessed as adherence to schedules is a major evaluation factor. Evaluations are completed after each assignment and affect future assignments.

North Carolina DOT/Construction staff has performance metrics related to project delivery schedules, including projects staffed with consultants.

Ohio DOT measures projects completed within a time frame, projects completed on time and projects completed late.

Texas DOT team leads monitor progress to meet assigned target dates. At weekly meetings, the team leads discuss progress to address the potential for missed targets early on.

Adherence to Project- or Program-Level Budgets

Arizona DOT uses dashboards to assess adherence to project- or program-level budgets.

Michigan DOT considers different phases of a project (for example, preliminary engineering and right of way) when assessing performance.

Minnesota DOT assesses CPM schedules and sets the construction budget on projects.

North Carolina DOT/Preconstruction does not assess internal staff because a variety of factors are at play. External partners, however, are assessed as adherence to budgets is a major evaluation factor. Evaluations are completed after each assignment and affect future assignments.

North Carolina DOT/Construction staff has performance metrics related to project delivery schedules, including projects staffed with consultants.

Quality of Work Performed

Arizona DOT considers the number of reviews needed before bid advertisement.

Michigan DOT considers experience and quality of work, which can sometimes impact project assignments. The agency considers team experience and quality with consulting contract teams.

North Carolina DOT/Preconstruction does not assess internal staff because a variety of factors are at play. Quality of work in external partners, however, is a major evaluation factor. Evaluations are completed after each assignment and affect future assignments.

North Carolina DOT/Construction evaluates quality of work based on the quality of the inspection and project oversight as work is completed.

Ohio DOT considers this assessment to be subjective.

Texas DOT evaluates performance for every team member and project.

Efficiency and Effectiveness of Work Performed

Michigan DOT considers experience and quality of work when assessing efficiency and effectiveness of work performed by internal staff and consultants.

Minnesota DOT does not have formal measures for monitoring efficiency and effectiveness. Instead, the agency relies on individual performance management and project schedule tracking.

North Carolina DOT does not assess efficiency and effectiveness. In terms of efficiency, the survey respondent noted that the agency has “extensive guidance and [has] developed a variety of tools [that] are strongly encouraged if not required for project delivery, so there is no real metric.” Effectiveness is evaluated with the quality metric completed for external partners by discipline after every assignment.

Texas DOT measures efficiency during weekly meetings by meeting target dates with the resources allocated. Team members are aware of the need to be efficient.

Type of Task Performed

Arizona DOT project managers' performance is assessed annually based on the number of projects delivered and the complexity of those projects.

Michigan DOT uses Planisware to assign the hours needed to complete a task to the appropriate staff groups.

Minnesota DOT uses CPM.

North Carolina DOT/Preconstruction assesses type of task based on the expertise of internal staff or support from external partners.

North Carolina DOT/Construction evaluates firms based on management, documentation and overall inspection (construction administration).

Texas DOT matches expertise with a specific task.

Applying Performance Measures

Arizona DOT is the only agency that applies a single set of performance measures or indicators to select subdivisions or functional units. Michigan, Minnesota, North Carolina/Preconstruction and Texas DOTs apply the same performance measures or indicators across all subdivisions or functional units. North Carolina/Construction and Ohio DOTs have developed different performance measures or indicators for different subdivisions or functional units. The North Carolina/Construction respondent added that "other units within the agency utilize private firms in different capacities, therefore, alternative evaluations are performed."

Assessment

Impact of Using Performance Measures in Staffing Allocation Processes

Several survey respondents briefly assessed the impact of using performance measures or indicators with staffing allocation processes:

Arizona DOT is flexible and has an approximate 80% consultant and 20% in-house delivery method, which allows adequate staffing.

Michigan DOT monitors and tracks availability within its scheduling software and tries to balance work across units and teams as best as possible. The respondent noted that if results indicate a team is consistently overloaded, that information could be "a catalyst" for the agency to consider changes within the team.

Minnesota DOT manages staffing allocation by individual offices and functional units. It is based on previous workload and experience, and is used to plan and schedule future work.

North Carolina DOT/Preconstruction bases staffing allocations on a variety of factors, depending on the technical unit. Generally these factors are related to legislation, geography and workload. Key performance indicators don't drive staffing allocations.

North Carolina DOT/Construction notes that the use of performance measures or indicators has resulted in more consistent staffing allocations across 14 divisions and has allowed industry partners to better plan for future staffing needs as forecasts are developed.

Texas DOT reports that performance measures or indicators have helped the agency recognize the importance of mentorship programs, pairing junior staff with senior staff, to develop knowledge transfer. Performance measures indicate where the agency needs to improve on an individual basis, which helps the entire team.

Recommendations

Several survey respondents recommended practices for other agencies preparing to implement staffing allocation processes or performance measures:

- Use consultants for peak loads. (*Arizona DOT*)
- Pay attention to the quality of the data produced, and be “confident in what the data is telling you.” (*Michigan DOT*)
- Tie payroll codes to CPM activity codes. (*Minnesota DOT*) The agency previously implemented more in-depth future resourcing planning based on CPM schedules and resource loading, but this process has slowed down as a result of a change in the payroll system software.
- Be careful not to let the development of an evaluation process influence the core business function by creating gaps, redundancy or inefficiency. (*North Carolina DOT/Preconstruction*)
- Standardize allocation procedures so that future workloads can be assessed and shared. Agency policy should include evaluations of work performed by the firms. (*North Carolina DOT/Construction*)
- Emphasize knowledge transfer and allow for cross-functional teams to handle different aspects of projects at the same time. (*Texas DOT*)

Related Research and Resources

A literature search of in-progress and published research produced limited resources related to this topic. Results of the literature search are presented below in the following categories:

- National research.
- State research.

National Research

The 2020 National Cooperative Highway Research Program (NCHRP) report cited below, along with its related resources, provides “staffing-level recommendations based on project type, work type risk projections” and “methods for planning project staffing allocation at the project, district or agency level.” The project’s spreadsheet tool can be used to estimate staffing and consultant needs for highway construction projects. The final citation in this section, although published more than 10 years ago, presents forecasting models to estimate staffing needs for highway construction projects.

NCHRP Research Report 923: Workforce Optimization Workbook for Transportation Construction Projects, Timothy Taylor, Roy Sturgill, Steve Waddle, Ying Li, Paul Goodrum, Keith Molenaar and Sara Al-Haddad, 2020.

Publication available at <https://nap.nationalacademies.org/catalog/25720/workforce-optimization-workbook-for-transportation-construction-projects>

From the foreword: NCHRP Research Report 923 provides state transportation agencies with guidance to identify their construction staffing needs and how to best allocate their state or consultant engineering and inspection staff and consultant resources to highway construction projects. The guidance provides 35 specific staffing strategies that may help alleviate construction staff challenges. These strategies are linked by work type and staffing function to assist agency personnel with selection of specific strategies. The electronic version of the Work[force] Optimization Workbook (e-WOW) allows users to input project information and automatically calculate staffing needs as well as highlight strategies to alleviate staffing challenges.

....

Under NCHRP Project 20-107, the University of Kentucky was asked to develop guidance to aid state transportation agencies in adequately staffing their transportation construction projects. ... Among the results of the research are (1) staffing-level recommendations based on project type, work type risk projections, and use of consultant engineering and inspection staff; (2) methods for planning project staffing allocation at the project, district or agency level; (3) current contracting methods and associated staffing used by transportation agencies; and (4) required knowledge, skills and abilities for construction administration, engineering, inspection and human resources.

Related Resources:

Electronic Workforce Optimization Workbook (e-WOW), Roy Sturgill, NCHRP Project 20-107, 2020.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rr_923Spreadsheet.xlsm

From the spreadsheet:

The Electronic Workforce Optimization Workbook (e-WOW) is a decision support tool designed to walk a user through the process of allocating construction staff, identifying shortages and selecting strategies to mitigate those shortages. There are three e-WOW

modules to conduct the previously mentioned tasks. [T]hese may be used independently or in combination.

The modules are:

- Module 1: Project Level Full-Time-Equivalent (FTE) Calculator.
- Module 2: Program Level Staff Allocation Tool.
- Module 3: Construction Administration Staffing Strategies.

Effective Construction Project Staffing Strategies for Transportation Agencies: Electronic Workforce Optimization Workbook (e-WOW) User Guide, Timothy Taylor, Roy Sturgill, Steve Waddle, Ying Li, Paul Goodrum, Keith Molenaar and Sara Al-Haddad, NCHRP Project 20-107, 2020.

https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rr_923UserGuide.pdf

A companion to the e-WOW spreadsheet tool, the user guide provides “additional guidance ... for describing the potential use of this tool and how it can be useful in estimating staffing needs and approaches.”

NCHRP Synthesis 450: Forecasting Highway Construction Staffing Requirements, Timothy R. B. Taylor and William F. Maloney, 2013.

Publication available at <https://www.trb.org/Publications/Blurbs/169458.aspx>

From the abstract: Adequate construction staffing is critical for performance of highway construction projects. The variable nature of these projects, however, can make it difficult to estimate construction staff requirements for both the short and long term. This study gathered information on the methods being used at highway transportation agencies to forecast staffing requirements. These methods are diverse and range from simple heuristics based on generic project types to multi-variate regression models developed from historical project data.

State Research

The citations in this section include two research projects currently underway that are examining workforce forecasting practices. Arkansas DOT is conducting a comprehensive update of its staffing estimating system. The update will include a software tool that potentially integrates artificial intelligence and can be adapted by other construction offices. Results are expected in early 2025. To keep pace with changing workforce and infrastructure demands, Kentucky Transportation Cabinet is evaluating practices used by other state transportation agencies to estimate staffing requirements for highway construction projects.

A case study describes a tool used by the Construction Management Division of the Port of Long Beach that will allow for communication with management well in advance when staffing limitations require consultant support. A Texas DOT study assessed staffing needs for construction plans in advance so that information is readily available when construction projects are funded. Methods to identify staffing needs for design-build and alternative delivery programs are presented in a synthesis of practices from several state DOTs and in a Washington State DOT conference paper.

Arkansas

Research in Progress: TRC2101—Update of the ARDOT Workforce Forecasting System, Arkansas Department of Transportation, start date: January 2021; expected completion date: June 2023. (**Note:** In a follow-up email, the Arkansas DOT survey respondent noted that this

project is still active. The anticipated project end date is December 2024. The final report is expected to be completed and publicly available through the agency's website in early 2025.) Project description at <https://rip.trb.org/View/1765890>

From the project description: The software used to predict the manpower needed in the Resident Engineer [o]ffices to inspect and administer construction projects is no longer supported; is needing an upgrade due to its age; and is no longer applicable to the current workforce and types of projects being let. The objectives are to develop an annual forecasting model, a long-range forecasting model and a construction workforce forecasting software tool. The equations used to create the models will be updated by regression modeling, econometric modeling and artificial neural networks.

Related Resources:

Research in Progress: TRC2101—Update of the ARDOT Workforce Forecasting System, FY18 Projects, Transportation Research Committee, Arkansas Department of Transportation, 2024.

<https://www.ardot.gov/divisions/system-information-research/research/all-reports/trc-projects/> (Scroll down the page to find this project description.)

From the project description: To replace the current outdated system, TRC2101—Update of ARDOT Workforce Forecasting System will re-estimate and expand the capabilities of the workforce prediction model and software. The project will develop new equations for the Construction Division's Workforce Forecasting System and find or write new software with the possibility of integrating artificial intelligence in a future interface. The project will also explore the possibility of using this workforce forecasting system for more than [c]onstruction office crews.

TRC0705: Updating the AHTD Manpower Forecasting Program, Paul D. Mixon, Transportation Research Committee, Arkansas State Highway and Transportation Department, 2008.

https://www.ardot.gov/wp-content/uploads/2020/11/TRC0705_Updating_the_AHTD_Manpower_Forecasting_Program.pdf

Arkansas DOT has used this forecasting program to “estimate the manpower inspection needs for the Resident Engineer offices throughout the State of Arkansas. ... [T]he forecasting program estimates the labor required to inspect projects as they are constructed, determines when and where this labor is needed, and generates various reports on this information. Both man-hour prediction and job length prediction equations have been updated by performing linear regression analysis on AHTD [Arkansas State Highway and Transportation Department] completed job data.”

California

“Simplified Planning Tool to Determine Staffing and Consultants’ Needs,” Lincoln Lo and Ramanjit Brar, *Proceedings of the 15th Triennial International Conference*, September 2019.

Citation at <https://ascelibrary.org/doi/10.1061/9780784482629.040>

From the abstract: Effective staffing and consultant planning is key to the successful implementation of any capital improvement program. With project schedules frequently changing, a dynamic tool that can be easily developed, maintained and updated will benefit owner agencies in determining and communicating needs to governing boards for decision-making in the allocation of resources. This topic of discussion demonstrates how one owner agency faced with a common staffing planning problem, resulted in the development of a tool to make timely and effective staffing decisions. The tool incorporates standard scheduling

practices into a software platform that is practically available in all organizations without additional technology investments. The discussion includes a case study on the utilization of the tool that allows the Construction Management Division of the Port of Long Beach to forecast and strategically assign staffing, and determine when peak staffing needs would require the additional support of consultants. The tool provides forecasts that allow consultant procurements to begin well in advance of the need. Lastly, the tool also provides reporting that addresses the need to effectively communicate staffing requirements to a governing Board of Harbor Commissioners. This tool can be easily adapted by other agencies or private organizations facing similar challenges.

Georgia

Synthesis of the Project Leadership Staffing Needs for Successful Development of Alternative Delivery Programs, Baabak Ashuri and Shiva Bahrami, Georgia Department of Transportation, August 2017.

http://q92018.eos-intl.net/eLibSQL14_G92018_Documents/16-17.pdf

From the abstract: This research provides a synthesis of practices in organizational structuring and professional staffing of the innovative delivery units in several state departments of transportation (DOTs) across the nation that are actively utilizing alternative project delivery. Several major challenges and barriers faced by innovative project delivery units to fulfill project leadership staffing needs are identified. Various approaches that state DOTs have utilized to respond to their staffing and organizational needs are identified. Differences in organizational structuring and professional staffing for innovative project delivery programs are described in: (1) [m]odels of office of innovative delivery; (2) [m]ain roles and responsibilities of the headquarters office of innovative delivery; (3) [i]nvolvement of district offices in delivery of design–build projects; (4) [t]raining and staffing strategies and preferred skill sets; and (5) [u]tilizing consulting firms to assist the owner.

Kansas

“Approach for Estimating Inspection Staffing Needs for Highway Construction Projects,” Mamdouh Mohamed and Dai Q. Tran, *Transportation Research Record* 2677, Issue 6, pages 697-707, June 2023.

Citation at <https://trid.trb.org/view/2111881>

From the abstract: This study proposes an approach for estimating inspection staffing needs for highway construction projects. Data from 157 construction projects completed between 2017 and 2021 were used to evaluate project inspection staff size based on the project type, cost and duration. A total of 35 core inspection items were identified by carrying out a content analysis of construction inspection documents. Then, a focus group of 18 experts from the Kansas DOT was conducted to verify the list of 35 cost inspection items and evaluate the number and experience of inspectors required for each item. The four project types included in the analysis are as follows: grading/surfacing; sealing; surface recycling and overlay; and bridge repair. The analysis showed that the inspection staffing needs depend on project type, duration and size. The grading/surfacing and bridge repair projects require more inspection staff than the sealing, and surface recycling and overlay projects. The result of a Spearman’s correlation analysis indicated that there is a significant association between the risk level of an inspection item and the number and experience of inspectors required for that item. The findings from this study may help state DOTs identify their needs for inspection staff and improve the quality of highway construction projects.

Kentucky

Research in Progress: SPR 23-640: Balancing Workforce Needs and Infrastructure Demands, Kentucky Transportation Cabinet, start date: July 2022; expected completion date: June 2025.

Problem statement at <https://scholars.uky.edu/en/projects/spr-23-640-balancing-workforce-needs-and-infrastructure-demands>

From the problem statement: Transportation systems will undergo a significant transformation over the next 10 [to] 15 years as electric vehicles and connected and automated vehicles become increasingly common. In response, KYTC must identify pragmatic strategies to balance a shrinking workforce, supply shortages and increased materials prices against growing project demands. KYTC's 50 percent decline in staff over the past 40 years has coincided with industry partners negotiating their own unique workforce changes and issues related to materials supply and costs. These issues can often result in price adjustments via change orders after projects have been awarded. KYTC must understand the implications of workforce availability as well as materials constraints and pricing to mitigate potential issues.

OBJECTIVES

- Investigate and evaluate approaches used by other state transportation agencies (STAs) to establish appropriate personnel levels and manage supply chain issues.
- Develop analytical strategies KYTC can use to evaluate how staffing requirements and issues related to materials supply and pricing influence delivery of the Six-Year Highway Plan.
- Identify best practices and insights for proactively addressing future issues.

“Modeling Long-Term Highway Staffing Requirements for State Transportation Agencies,” Ying Li, Timothy R. B. Taylor, Gabriel B. Dadi and Roy E. Sturgill, *Transportation Research Record* 2612, Issue 1, pages 76-84, 2017.

Citation at <https://trid.trb.org/View/1438704>

From the abstract: This paper seeks to develop a dynamic model that captures the feedback mechanisms within the system that determines highway staffing requirements. The system dynamics modeling method was used to build the forecasting model. The formal model was based on dynamic hypotheses derived from a literature review and interviews with transportation experts. Qualitative and quantitative data from literature and federal and state databases were used to support the values and equations in the model. The model integrates STAs' strategic plans, funding situations and staffing strategies, and determines future staffing levels and will hopefully fill the absence of long-term forecasting tools at STAs. Standard system dynamics validation procedures were used to test the model, after which input data specific to the Kentucky Transportation Cabinet were used to calibrate the model and to simulate an expected retirement wave and search for solutions to address temporary staffing shortages.

Texas

“Assessment of Staffing Needs for Construction Inspection,” Dae Young Kim, Khali R. Persad, Nabeel A. Khwaja and Seokho Chi, *KSCE Journal of Civil Engineering*, Vol. 20, pages 2598-2603, 2016.

Citation at <https://doi.org/10.1007/s12205-016-0817-6>

From the abstract: The primary purpose of this study is to investigate CE [construction engineering] staff needs for TxDOT [Texas DOT] construction projects. To accomplish this, projects constructed during the 10-year period of 2001 [to] 2011 were analyzed. The results

indicated that large and metro projects tend to require more CE staff hours compared to smaller and/or rural projects. In particular, capacity-adding projects such as interchanges and widening projects require up to 4.45 times the CE hours needed for pavement projects. This study's findings provide a basis for estimating TxDOT's CE staffing, and ultimately contribute to efficiency improvements by providing an appropriate level of CE staff based on project type, size and location.

Assessment of TxDOT Staffing for Project Development and Construction, and Project Backlog Analysis, Khali Persad, Rob Harrison, Nabeel Khwaja, Lisa Loftus-Otway and Dae Young Kim, Texas Department of Transportation, May 2013.

<https://library.ctr.utexas.edu/ctr-publications/0-6581-ct-5.pdf>

From the abstract: The objective of the work documented in this report was to examine full-time-equivalent (FTE) staffing needs for TxDOT [Texas DOT] project development and construction, and analyze needs for backlogging projects, i.e., preparing construction plans in advance and keeping them at the ready for possible construction funding in the future. As TxDOT developed its long-term project development plans (PDP-2012 and PDP-2013), the research team provided support to the respective TxDOT task forces. In fiscal year (FY) 2011, the research team examined FTE needs for TxDOT project development and construction, and began to analyze needs for backlogging projects. In FY 2012 this work was continued to complete analyses requested by TxDOT as a result of additional complexities identified during development of PDP-2012 and to address changes in funding enacted by the 82nd Texas Legislature.

Washington

“Staffing Practices for Design–Build Projects: Lessons Learned from Washington State DOT,” Dan Tran and Sidney Scott III, *Proceedings of the Transportation Research Board 97th Annual Meeting*, Paper #18-06477, 2018.

Citation at <https://trid.trb.org/View/1497286>

From the abstract: This paper explores and documents the process and existing practices of staffing needs for implementing the D-B [design-build] program in Washington State DOT (WSDOT). Data were collected from a literature review, in-depth interviews and case studies. A total of 18 interviews (three interviews with WSDOT Deputy State Construction Engineer, Assistant State Construction Engineer and State Design-Build Engineer and 15 interviews with industry representatives who have performed work for WSDOT) were conducted to explore the staffing practices for D-B. Six case studies that are representative of a cross-section of WSDOT D-B experience were conducted. These case studies were selected based on project size (small, medium and large), project type (roadway, interchange and bridge), geographical locations (urban and rural), and other criteria (funding sources or types of program). In addition to reviewing the available project data and documentation, the research team conducted in-depth interviews with the project managers for each of these case studies. The results showed that the critical staffing issue involves the learning curve of inexperienced staff being challenged by the differing roles and responsibilities on a D-B project. The effective staffing practices for D-B should consider implementing the following areas: (1) internal staffing and organization; (2) staffing experience and expertise; (3) continuity of project teams; (4) training and staff development; and (5) appropriate use of consultants.

Contacts

CTC contacted the people below to gather information for this investigation.

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Appendix A: Survey Questions

The following survey was distributed to members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Performance-Based Management.

Survey on Allocating Staff and Measuring Performance

Note: The response to the question below determined how a respondent was directed through the survey.

The Caltrans Division of Engineering Services (DES) is gathering information about effective practices to allocate the resources needed to complete the work associated with annual capital and non-capital programs and the performance measures used to assess those allocations. For Caltrans, DES allocations are made using estimates of the person years, or PYs (one PY equals 1,758 hours), needed to manage workload in each of the functional units within DES.

(Required) Has your agency developed a methodology to allocate the staffing resources needed to deliver engineering-related services included in your agency's annual capital and non-capital programs? (These programs may also be referred to as project direct and non-project direct programs.)

- Yes (Directed the respondent to the **Staffing Allocation Practices** section of the survey.)
- No (Directed the respondent to the **Wrap-Up** section of the survey.)

Staffing Allocation Practices

1. What is the primary mechanism for allocating staff to the engineering-related services included in your agency's annual capital and non-capital programs?
 - Person years or other staffing-related factor
 - Other factor (Please describe this factor.)
2. Generally, how accurate are your agency's proposed staffing allocations?
 - Very close to what is actually required ($\pm 5\%$)
 - Usually requires minor adjustment during the year ($\pm 10\%$ for minor adjustment)
 - Always requires minor adjustment during the year
 - Usually requires significant adjustment during the year ($\pm 20\%$ for significant adjustment)
 - Always requires significant adjustment during the year
 - Other (Please describe.)
3. (Required) Does your agency track the performance of subdivisions or functional units based on the use of allocated staffing resources?
 - Yes (Directed the respondent to **Staffing Allocation Performance Measures** and the remaining sections of the survey.)
 - No (Directed the respondent to **Wrap-Up**.)

Staffing Allocation Performance Measures

1. Does your agency assess **adherence to project schedules** when monitoring staffing allocations?
 - No
 - Yes (Please describe your agency's assessment practices, including any performance measures or indicators.)
2. Does your agency assess **adherence to project- or program-level budgets** when monitoring staffing allocations?
 - No
 - Yes (Please describe your agency's assessment practices, including any performance measures or indicators.)
3. Does your agency assess the **quality of work performed** when monitoring staffing allocations?
 - No
 - Yes (Please describe your agency's assessment practices, including any performance measures or indicators.)
4. Does your agency assess the **efficiency and effectiveness** of the work performed when monitoring staffing allocations?
 - No
 - Yes (Please describe your agency's assessment practices, including any performance measures or indicators.)
5. Does your agency evaluate staffing allocations based on the **type of task** staff members are performing?
 - No
 - Yes (Please describe this evaluation.)
6. How does your agency apply performance measures or indicators across multiple subdivisions or functional units?
 - The same performance measures or indicators apply across all subdivisions or functional units.
 - Our agency has developed different performance measures or indicators for different subdivisions or functional units.
 - A single set of performance measures or indicators applies to only select subdivisions or functional units.
 - Other (Please describe.)

Assessment

1. How has the use of performance measures or indicators impacted your agency's staffing allocation processes?
2. What recommendations do you have for another agency preparing to implement such processes or measures?
3. Please provide links to documents associated with your agency's staffing allocation processes and the application of performance measures or indicators. Send any files not available online to chris.kline@ctcandassociates.com.

Wrap-Up

Please use the space below to provide any comments or additional information about your previous responses.