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## Analyzing State Highway Agencies' Project Management Organizational Structures

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Project management organizational structure plays an important role in state highway agencies as part of a network of complex relations that links a project management unit (PMU) and subject matter experts (SMEs) to tasks and resources for project development and aligns the functions for project management strategy. However, there is a lack of studies that studied the project management organizational structure of state DOTs in terms of the relative position of the dedicated PMU with other functional offices and the authority level of project managers (PMs). Thus, the primary objective of this paper is to analyze the state DOTs' project management organizational structures and recommended practices of organizational structures for project management. This paper conducted, a survey, an extensive content analysis, and interviews with PMs and SMEs in state DOTs. The primary contribution of this study to the overall body of knowledge is the insights of state DOTs' organizational structures by conceptualizing the relationships among the PMU and functional offices within the organization and identifying the state of practices in project management organizational structures.

**Key Words:** Matrix Structures, Organizational Structure, Project Management

### Introduction

The organizational structure of a state department of transportation (DOT) significantly impacts the overall performance of planning, environment, design, right of way, maintenance, and various administrative functions on achieving agency goals. The allocation of resources and distribution of authority between a single central office and multi regions or districts varies with the dimensions of organizational structure (e.g., centralized and decentralized organizations, matrix structures, and use of outsourcing and privatization) (Secrest et al. 2012). Besides, a well-designed organizational structure of project management enables state DOTs to smoothly execute construction projects with the

improvement of the efficient communication and coordination between the project stakeholders and team members (Cheng et al. 2003).

The project management organizational structure of the state DOT refers to a network through which roles and responsibilities of project management are transferred within the hierarchy of the organization based on the authorities and capabilities of the staff (Lockwood et al. 2011). The organizational structure of project management can be classified into three major forms, functional form, project form, and matrix form. The existence of a project management unit (PMU) in an organization is a critical component in differentiating between functional and project forms. First, in the functional form, there is no PMU in a project management organizational structure. Within the functional form, a project engineer from one of the key functional offices (e.g., utilities, design, and environmental offices) is designated as head of a task force and required to coordinate the activities of the various functional offices. Second, in the project form, there is a PMU in the organizational structure with complete autonomy. In this form, the project manager (PM) has complete authority and control over all project concerns such as schedule, cost, and quality. Lastly, the matrix form is a combined form of the purely functional and the pure project organizational structures with their advantages. In the matrix authority structure, the organizational power of project management is shared between functional and project authority (Thomas et al. 1983).

Based on the authority and role of the PM and functional offices, the matrix form is further divided into three categories: weak matrix, balanced matrix, and strong matrix, based on the relationship, authority, and arrangement of the functional offices and project management office (PMO). The strength of the matrix organization is determined by the influence of the PM over the performance of the projects. In this structure, one functional area plays a dominant role in project development. In the weak matrix (or functional matrix), projects rely on functional engineers (FEs) with a clear division of tasks for the delivery of activities. Managerial incentives or reprimands related to project performance must be handled by FEs (Shirazi et al. 1996). Next, a balanced matrix structure allows state DOTs to balance the strength of both the FE and the PM either by requiring them to share control over certain reliabilities or by delegating areas of influence (e.g., placing FEs over the technical content of project activities and PMs over the selection and assessment of project team members) (Feger & Thomas 2012). Lastly, a strong matrix structure is oriented around the project as the core product and activity of the state DOT. In a strong matrix structure, the project is at the center of the organization, where the PM is responsible for the successful completion of the project, rather than just overseeing the project as in a weak matrix organization (Larson & Gobeli 1987).

Different organizational structures provide varying levels of authority to the PM for effective project management. For instance, McKenna (2000) indicated that the responsibility allocated at the individual level can be counterbalanced by assigning appropriate authority for efficient and effective project management. Moreover, state DOTs must establish clear authority and definition of roles and responsibilities for all participants within the project management structure (McMinimee et al. 2009). Over the past few years, it has become evident that PMs cannot deliver successful projects based solely on their technical skills. PMs working in a matrix organization structure face a severe communication paradigm, which makes interpersonal or soft skills a key factor for the project's success. To successfully deliver projects, PMs should utilize the tools and practices that support project management throughout the project development process according to their project management organizational structures. Baek et al. (2016) indicated that PMs can benefit from effective tools and strategies for project management that are identified from state DOTs in the United States. According to Ashuri et al. (2020), a rigorous process to select the project management method can greatly benefit the transportation agency in dealing with complexity in the execution of projects.

As the level of project complexity, environmental regulations, and intense public interest and involvement increases, a PMU becomes critical for project success. However, there is a lack of studies on state DOTs' organizational structures for project management. Thus, to have a better understanding of the state of the practice in organizational structures that are currently used by state DOTs in managing their highway programs, the following critical elements are needed to explore: organizational forms (project form or functional form) of state DOTs for project management; matrix structures (strong, balanced, and weak matrices) of state DOTs' PMUs in developing projects; the relative position of a PMU concerning other preconstruction units; and practices for state DOTs' organizational structures for project management that enhance the efficiency in delivering highway projects.

### Research Methodology

The primary objective of this study is to classify and analyze project management organizational structures of state DOTs in the United States. This study conducted an extensive literature review, survey, content analysis, and interviews. A survey was distributed to 50 state DOTs in the U.S. to identify their organizational structures and the authority level of PMs. Follow-up interviews with subject matter experts (SMEs) in state DOTs, where have the higher authority level of (PMs) with a PMU, were conducted to validate the survey results and collect additional information about their organizational structures and practice of project management organizational structures. Last, extensive literature reviews of state DOTs' organizational charts, project management/project development manuals were conducted to formulate the organizational structure models of the state DOTs and summarize the recommended practices of project management organizational structure. The research methodology consists of the following major steps: (1) conducting a nationwide survey with SMEs (i.e., chief engineers, program manager, and PMs) in the state highway agencies; (2) reviewing the academic/professional literature on organizational structure for highway project delivery and analyzing the project management organizational structures in the state DOTs; (3) conducting follow-up interviews with the selected SMEs to identify the organizational structures and the state of practice for project management organizational structure; and (4) summarizing the findings from all the information collected through the survey, content analysis, and structured interviews.

### Results & Discussions

The survey was sent to all 50 state DOTs to understand the project management organizational structure of state DOTs. Among 50 states, 23 responded to the survey. The summary of the state DOTs organizational structures of project management is presented in Table 1.

Table 1

*Summary of State DOTs' Organizational Structures*

Organizational Form	PMU Structure	State DOTs	Percentage
Project Form	Centralized	Arizona, Maine, Nevada, Vermont, Louisiana, New Jersey, Georgia, Washington State, California,	31%
	Decentralized	Missouri, Utah, Michigan, Minnesota, Idaho, Texas, Virginia, Florida, Iowa, North Carolina	52%

<b>Functional Form</b>	Centralized	Arkansas, Kansas, Delaware	13%
	Decentralized	Connecticut	4%

In a centralized organization form, the project management tasks for preconstruction services are led and conducted by the PMO, located at the central (headquarters) office. On the other hand, with a decentralized organization form, the project management tasks for preconstruction services are led and conducted by the PMO in district (regional) offices throughout the state. Moreover, in a functional form, the project management tasks for preconstruction services are led and conducted by FEs either in the central office or the district offices.

The results showed that seven state DOTs (e.g., Arizona, Maine, and Nevada) have centralized PMUs in their organizations, while twelve state DOTs (e.g., Washington State, California, and Missouri) have decentralized PMUs in their organizations. Moreover, although three state DOTs, Arkansas, Kansas, and Delaware DOTs, do not have a PMU in their organizations, project management for the projects is implemented in the central offices. One state DOT (i.e., Connecticut DOT) does not have a PMU, and project management for Connecticut DOT's projects is conducted in the decentralized offices. Thus, 83% of the responded state DOTs have PMUs in their organizations.

Besides, the organizational structures of several state DOTs were analyzed to review their similarities and differences and develop organizational structure models used by the DOTs for project management. The State DOTs' organization structures were further classified into three matrix forms based on the level of project management authority of project managers/engineers. Several factors were considered in classifying different state DOTs' organizational structure models with similar characteristics, for instance, the relative position of the dedicated PMU concerning other preconstruction units, such as the design, environmental, and right of way (ROW) offices, and the relative role of district offices in handling various aspects of project delivery. The summary of the matrix types of project management organizational structure is presented in Table 2.

Table 2

*Summary of Matrix Types of Project Management Organizational Structure*

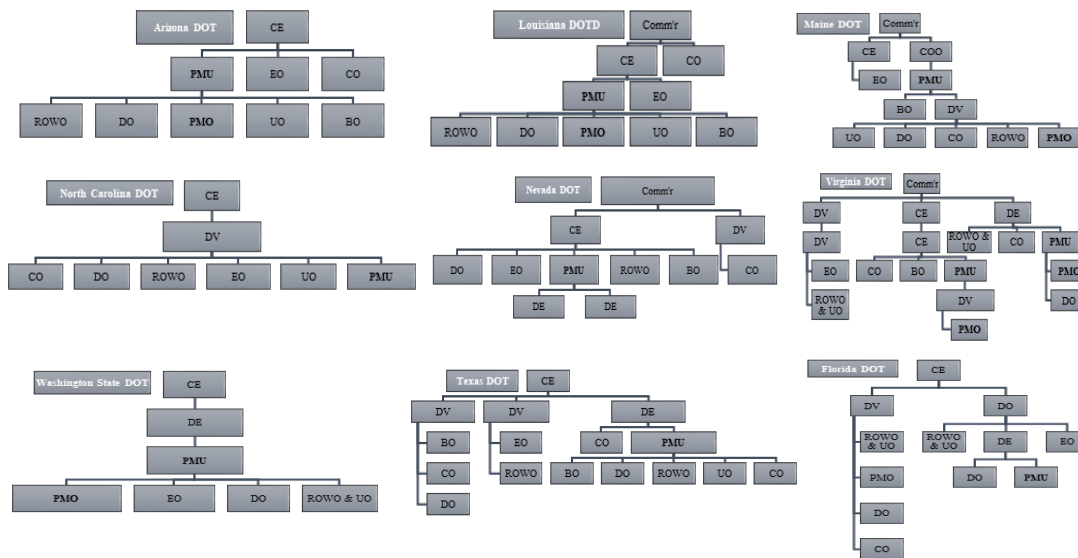
<b>Matrix Structures</b>	<b>State DOTs</b>	<b>Percentage</b>
<b>Weak</b>	Vermont, New Jersey, Georgia, California, Missouri, Utah, Michigan, Minnesota, Idaho, Iowa, Delaware, Arkansas, Connecticut, Kansas	61%
<b>Balanced</b>	Texas, Virginia, Nevada	13%
<b>Strong</b>	Arizona, Maine, Louisiana, Washington State, Florida, North Carolina	26%

Fourteen state DOTs such as Vermont, New Jersey, and Idaho DOTs, have weak matrix structures, where the PM has less influence over the performance of the project. For example, Iowa DOT is a weak matrix structure where the project engineer from the functional office contains more authority to project management and performance measurement for a project. Three state DOTs, including Texas, Virginia, and Nevada DOTs, have the balanced matrix of a project management organizational structure. For example, Virginia DOT's projects are managed either by the central office or district offices (Nine districts). And, PMs in the central office or district office are responsible for developing a project and are required to collaborate with functional offices. And, the PMs and FEs in Virginia DOT share control/authority for project management. Lastly, six state DOTs, including Arizona, Maine, Louisiana,

Washington State, Florida, and North Carolina DOTs, have a strong matrix structure. For example, Florida DOT has a strong matrix structure for project management, where PMs contain strong authority/control for project management. Florida DOT uses PMs as the single focal point for the project, which leads the project development and management of projects. 61% of the responded state DOTs have a low level of the PM's authority in developing and managing their projects and share the authority for project management with functional offices in the organizations.

*Analysis of State DOTs' Project Management Organizational Structures*

In-depth interviews were conducted with the SMEs in nine state DOTs, where have balanced and strong matrix forms for their PMUs. This study depicted different state DOTs' organizational structure models in Figure 1. Considering the relative position of the dedicated PMU for other preconstruction units (e.g., the design, environmental, and ROW office) and the relative role of district offices in handling various aspects of project delivery, this study analyzed the project management organizational structures of nine state DOTs.



Note: Comm'r is a Commissioner; CE is a Chief Engineer; COO is a Chief Operating Officer; DV is a Division; DO is a Design Office; BO is a Bridge Office; ROWO is a Right of Way Office; UO is a Utility Office; EO is an Environmental Office; CO is a Construction Office; PMO is a Project Management Office; DE is a District Engineer; DO is a District Office.

Figure 1. Project Management Organizational Structures of Nine Responded State DOTs

Arizona DOT (ADOT), Louisiana DOTD (LADOTD), and Maine DOT (MDOT) use a similar project management organizational structure, where there is a PMU over the Offices of ROW, Design, Project Management, Utilities, and Bridge. The PMU is located parallel to the other functional offices. And, the Environmental Office is located at the same level as the PMU. But, ADOT and LADOTD Construction Offices are not located under the PMU, while MDOT Construction Office is located under the PMU. Under this organizational model, the head of the PMO appoints the PM to the project. FEs are assigned to the project by the heads of the related functional offices. PMs hold responsibility for leading the projects and reporting the project progress to the PMU. North Carolina DOT (NCDOT) and Nevada DOT (NDOT) also have the structure of a centralized organization for project management, where the PMU is located parallel to other functional offices. Under this organizational model, the head

of the PMU assigns the PM to the project. FEs are assigned to the project by the head of the related functional offices in consultation with the PM.

Virginia DOT (VDOT) is a decentralized organization, where the PMU (i.e., Project Development Office) is located at the district level. Within the PMU (i.e., Project Development Office at the district level, the Project Management and Design Offices are located. The offices in the HQ are responsible for developing and managing large projects, while the district offices are responsible for managing the smaller projects. In the district office, the PMU is responsible for developing and managing the highway projects for the district. All the functional offices are located parallel to the PMU. PMs collaborate with the PMU (i.e., State Location and Design Division) and functional Offices to define the required resources for a project. Washington State DOT (WSDOT) is also a decentralized organization, where the PMU (i.e. Program Management Office) is established at the district level to develop and manage WSDOT's Highway Program. The PMU is responsible for project management on the projects in the region and is led by the engineering manager located in the district office. The PMU houses all the functional offices in the region and is responsible for all the projects in the region except the mega projects, which are handled by the HQ. PMs in the district office are responsible for developing and managing the projects and reporting the project progress to the PMU.

Texas DOT (TxDOT) is a decentralized organization, where the PMU (i.e., Transportation Planning and Development) is located at the district level. Within the PMU, other functional offices are located. Headquarters offices are responsible for providing support and assistance to the district offices, except for the Environmental Office that is responsible for preparing and developing the environmental plans and policies for all the projects across the entire state. Engineers from the functional offices at the district office act as PMs on the project during different phases of the project. Under this organizational model, the head of the functional office appoints the PM for the phase of the projects. FEs are assigned to the project by the head of the related functional offices at both headquarters and district levels. Florida DOT (FDOT) also is the structure of a decentralized organization, where the PMU (i.e., Consultant Project Management) is at the district level. The offices in the headquarters are responsible for providing support and assistance to the district offices. The PMU in the districts is responsible for managing the projects at the district level. At the district level, the PMU is parallel to other functional offices, but the ROW and the Planning and Environmental Offices are at higher levels relative to the position of the PMU. Under this organizational model, the head of the PMU appoints the PM. FEs are assigned to the project by the head of the related functional offices at both HQ and district levels. The PMs in the district office collaborate with the functional offices for project development tasks, resource allocation, and required permits for a project.

Through the analysis of project management organizational structures of nine state DOTs, it showed that the existence of the PMU provides significant opportunities to streamline collaboration among project team members during the preconstruction phase of the project. First, a PMO is typically located parallel to function offices in developing a project. A parallel structure between a PMO and other functional offices within the PMU allows the project management team to make great efforts to ensure that the focus of the organization stays on the project during the project development. The parallel structure enables the project management team to resolve the issues between the different functional offices at the lowest possible level and as quickly as possible to avoid adverse effects of issues on the project. In-depth interviews with SMEs revealed that PMs within a PMU have a high level of authority in controlling projects, assigning resources, and resolving the issues.

### *Recommended Practices of Project Management Organizational Structure*

PMs in transportation agencies operate in a dynamic organizational structure and are under constant pressure to deliver their projects successfully on time and within schedule. The state of practices in project management organizations that can enhance the efficiency in managing highway projects was identified through the survey, content analysis, and in-depth interviews with SMEs in other state DOTs. This paper presented two important practices regarding a project management organizational structure and resource allocation for project management, including establishing a project delivery bureau and using a blended approach to assign a PM to a Project

Establishing a Project Delivery Bureau (i.e., PMU) puts the project at the center of all agency activities and helps to improve coordination and collaboration during the different phases of the project. The Project Delivery Bureau helps the agency to focus more on the project goals and objectives, rather than focusing on individual concerns of different functional units in the agency. ADOT, LADOTD, and MDOT implement the concept of the Project Delivery Bureau to improve their project management capabilities. ADOT developed a Project Management Group (PMG). ADOT's highway program is managed at the headquarters. The PMG, located under the Infrastructure Delivery and Operations Division, manages all highway projects. The transportation manager oversees the senior PM and PM in the management group. Furthermore, LADOTD established the Project Development Division (PDD) to implement the concept of a project delivery bureau. The PDD was established with the primary aim of accomplishing the agency's mission through effective communication and leadership of the project and assigning adequate resources of the FEs and PMs to the projects. MDOT has developed a Bureau of Project Development in its organization to enable better coordination and collaboration during the project development phase of the project. The Bureau of Project Development takes charge of project development and construction of the Maine DOT's projects (MaineDOT 2018).

A blended approach to assigning a PM to a project is a dynamic organizational structure model for project management, which helps state DOTs effectively assign PMs to the projects and efficiently utilize the resources of the PMs. Besides, the dynamic model helps state DOTs develop project-specific training programs, which enable the PM to better handle a specific category of projects. The decision depends on the skillset of the PMs and major project characteristics (i.e., type, size, and complexity). State DOTs including Caltrans and NDOT have adopted a more blended approach for the assignment of PMs for their projects. For instance, Caltrans uses the approach of one-hat and two-hat PMs for managing and delivering its projects. Under this approach, Caltrans assigns the PMs to projects following the complexity of the project (e.g., project size and functional requirements) (Caltrans 2007). Figure 2 shows the organizational structure of the one-hat and two-hat approaches and their coordination with the functional offices. A one-hat PM is a single entity that is assigned to the sole role of managing, while a two-hat PM is a single entity that is assigned generally from a functional office and plays the role of managing the project and making sure that the project is completed within the established baseline. The approach of one-hat and two-hat PMs for managing and delivering its projects allows the agency to efficiently utilize the resources of the PMs.

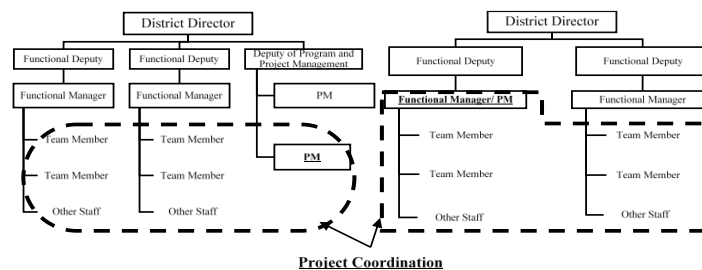


Figure 2. One-Hat and Two-Hat PM Approaches of Caltrans (Caltrans 2007)

NDOT also uses the blended approach for assigning PMs to a project. NDOT assigns PMs based on the size of the projects. For large projects (i.e., >\$100 million or politically complex projects), PMs from the PMU are assigned for the project. For small projects (i.e., <\$100 million), engineers from the Roadway Design Division are assigned to act as PMs. The engineers are responsible for developing small projects and collaborating with the other functional units located in the district office. Furthermore, VDOT uses Project Categorizations for assigning PMs based on required certificates, presented in Table 3. For determining participation in the project management development program, the individual PM's role in the organization and project, project complexities, priorities, and business needs are considered. Large and complex projects require PMs to have a master's certificate while small and less complex projects require PMs to have an associate's certificate (VDOT 2007).

Table 3

*Project Categories with Project Types and Required Certificates at VDOT*

<b>Categories</b>	<b>Certificates</b>	<b>Descriptions</b>
<b>Category I</b>	<b>Associate's Certificate</b>	<u>No plan projects</u> or projects: small/short-duration projects
<b>Category II</b>	<b>Associate's Certificate</b>	<u>Minimum plan projects</u> : simple, single-season construction projects
<b>Category III</b>	<b>Associate's Certificate</b>	<u>Full construction projects</u> , multi-season projects of medium complexity
<b>Category IV</b>	<b>Master's Certificate</b>	<u>Very large, complex construction plan projects</u> : multi-season projects of large complexity
<b>Category V</b>	<b>Master's Certificate</b>	<u>Major, multi-contract projects</u> : requiring seamless interaction among contractors

Thus, the blended approach for project management enables state DOTs to improve their capability in utilizing staff resources for project management. For instance, the assignment of PMs based on the size, complexity, and risks of the project enables the department to efficiently utilize the knowledge and experience of PMs. Besides, since the state DOTs face continuous changes caused by technological inventions, environmental and economic pressures, and public interest, the PM's training helps create a common knowledge base for PMs and project teams and improve PMs' work performance and project management practices in an organization.

## Conclusions

The organizational structure of project management has a critical impact on achieving the transportation agency's goals and objectives. Through surveys and interviews with the SMEs and content analysis on documents from other state DOTs, this study analyzed nine state DOTs' organizational structures (balanced and strong matrix forms for their PMUs), based upon the existence of a PMU in an organization and the authority level of project managers/engineers. The analysis of nine state DOTs' organizational structures suggested that the existence of the PMU provides significant opportunities to streamline collaboration among project team members during the preconstruction phase of the project. This study also identified two important practices of project management organizational structures, including establishing a Project Delivery Bureau and using a blended approach to assign PMs to a project, which enable the department to efficiently utilize the knowledge and experience of PMs.

The primary contribution of this study to the overall body of knowledge is the insights of state DOTs' organizational structures by conceptualizing the relationships among the functional offices and PMU



within the organization and identifying the state of practices in project management organizational structures that can enhance PMs' ability in delivering high-quality projects and improving coordination between PMs and project SMEs.

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