



## EXPLORING CURRENT SCOPING PRACTICES USED IN THE DEVELOPMENT OF TRANSPORTATION INFRASTRUCTURE PROJECTS

Kermanshachi, Sharareh<sup>1,7</sup>, Safapour, Elnaz<sup>2</sup>, Anderson, Stuart<sup>3</sup>, Goodrum, Paul<sup>4</sup>, Taylor, Timothy R.B.<sup>5</sup>, Sadatsafavi, Hessam<sup>6</sup>

<sup>1,2</sup> University of Texas at Arlington, USA

<sup>3</sup> Texas A&M University, USA

<sup>4</sup> University of Colorado at Boulder, USA

<sup>5</sup> University of Kentucky, USA

<sup>6</sup> Cornell University, USA

<sup>7</sup> [Sharareh.kermanshachi@uta.edu](mailto:Sharareh.kermanshachi@uta.edu)

**Abstract:** Scoping studies has become an increasing popular approach to define a project and prepare it for execution. It assists to make a decision on how to efficiently proceed with the project. It is widely accepted that an inefficient scoping process is one of the major causes of project failure, cost overruns, and schedule delays in infrastructure projects. Therefore, the goal of the present study is to provide an overview of the scope definition, and also timing, tools, and resources used through scoping process by different State Transportation Agencies (STAs). The major challenges that each STA faces during the stated process in infrastructure projects are also presented. To fulfill the objectives of this study, several in-depth structured interviews with Subject Matter of Experts (SMEs) who worked in six transportation agencies were conducted and analyzed. The selected STAs for interviews were Minnesota Department of Transportation (MnDOT), Utah Department of Transportation (UDOT), Washington Department of Transportation (WSDOT), Kentucky Transportation Cabinet, Michigan Department of Transportation (MDOT), and Louisiana Department of Transportation Development (DOTD). After qualitative data analysis, the results revealed that due to different scoping definitions from agency to agency, the time frame and project scoping activities also vary. The results of scoping time demonstrated that project scoping generally starts with the identification of needs, and continues with the development of design alternatives, preliminary estimation of project costs, and identification of important milestones. It was concluded that the environmental personnel, design professionals, and maintenance personnel are more involved among construction personnel. Furthermore, the lack of time and qualified personnel to address the demand for feasibility analyses is determined as the major challenge to the scoping process. The findings of this research will assist owner entities and policy makers to structure the scoping process more appropriately in infrastructure projects.

### 1 INTRODUCTION

Most infrastructure projects change in scope, from identification to utilization and evaluation, through the project cycle. The changes and modifications regularly occur due to various reasons during the scoping process, from developing an idea into a detailed scoping considering all the technical and financial aspects of the project. State Transportation Agencies (STAs) have experienced substantial problems with cost increases and schedule delays after a project is funded. Because transportation funding is constrained, cost overruns on one project can mean that funding for other projects is reduced or even eliminated. Changing or modification of scope to enhance a project's performance can be a common source of cost increases and schedule delays (Habibi et al., 2018). Transportation projects that are

programmed before they are sufficiently defined have a greater risk of increased project cost and/or schedule delays. While evaluating and accommodating risk are essential and ongoing activities throughout the project development process, the negative impacts that scope growth and related problems can have on an infrastructure project's cost and schedule can be minimized if these problems are identified and mitigated early in project development (Habibi, 2018).

A number of state transportation agencies have modified their scoping processes with varying degrees of success. A few STAs recognized that to improve project performance, implementation of an effective scoping process is needed. In this respect, development of an effective scoping process needs detailed timing, resources, and tools. In addition, having a structured plan to predict and address the corresponding challenges aids to prevent scope changes. Therefore, the goal of this study is to identify the definition, timing, resources, and tools of scoping through its process used by six STAs. Moreover, this study provides a list of major challenges that each STA faces during the stated process. The outcomes of this study help owner stakeholders of STAs and policy makers to gain knowledge about scoping process and challenges to improve it to achieve on-time and on-budget delivery of infrastructure projects.

## 2 LITERATURE REVIEW

Implementation of an effective scoping process is important to achieve success of a construction project. An organized scoping process is required to meet the objectives of a project. The Project Management Institute (PMI) defined that scope definition is one of the major parts of scope management (PMI, 1996). Several researchers have recognized that poor scope definition is considered as one of the major root causes of project cost overruns and delays leading to failure (Kermanshachi, 2016). In addition, Cho and Gibson (2001) stated that lack of scope definition leads to cost overruns and schedule delays. It has been found out that if the scope of project is increased later in the project, it would have a more severe impact on the execution performance rather than early implementation of the changes (Kermanshachi et al, 2017). In this respect, there are various definitions of "project scoping." O'Connor et al. (1986) explained that the terminology of scoping in construction industry was developed by different research teams supported by Construction Industry Institute (CII). The researchers mentioned that CII initiated the importance of project scoping through mid-1980s. That effort described the incredible importance of accurate "project scope definition" in order to set accurate construction cost estimates. In one of its first industry implementation resources, CII defined "project scope definition" as *"the key technical and physical attributes of the project, including general quality requirements and budget or commercial issues that would affect design planning and decision making"* (CII, 1995). A number of researchers continue to examine the significance of project scope definition, which summarized much of the CII research related to front end planning and project scoping. They found that several terms such as "front end planning" and "project definition" were often used interchangeably in the related literature. Kermanshachi et al. (2017) defined the project scoping as *"a series of project focused activities that develop key design parameters and other project requirements to a sufficient level of definition such that scope discovery is complete and a budget and letting date can be firmly established prior to programming the project in the state transportation improvement progress to minimize the risk of change and project overruns during detailed design"*. In this regard, CII has introduced several Best Practices (BPs) which could potentially reduce the unintended impact of late scope changes in a project (Safapour et al., 2017). Safapour et al. (2018) also concluded that allocation of more human, material, and financial resources in form of various Best Practices can alleviate the negative impact of scope changes in complex construction projects.

The information extracted from existing literature suggests to programing the project scoping time after the first round of project selection. This information states that a project is commonly selected on the basis of the identified requirements in the strategic plan. Some STAs have been using formal documents that serve as an output from the first round of project selection as the input into the scoping phase (Anderson et al., 2015). For instance, California Department of Transportation (Caltrans, 2009) uses the project selection document to define project deficiencies and issues, while Massachusetts utilized the project requirements form (MassDOT, 2006).

A number of tools used by different STAs for project scoping were identified through literature review (Caltrans, 2009). As an example, the California Department of Transportation (Caltrans, 2009) has several tools to aid programmers in decision making, including the Life-Cycle/Benefit-Cost Analysis Model and the California Transportation Investment System. CommunityViz and Spatial Growth Model (SGM) has been used in the Montana Department of Transportation (MDT) to evaluate alternative land use scenarios (Hart et al., 2012). Another screening tool called Mosaic was developed by the Oregon Department of Transportation (ODOT, 2013) to effectively evaluate the impact of the social, environmental, and financial costs and benefits of transportation options. It is a web-based resource tool that guides communities through a process with its needs and resources for alternative transportation solutions. Another example of an STA tool to document its level of project scope definition is the Texas Department of Transportation's (TxDOT's) Advance Planning Risk Analysis (APRA) for Transportation Projects tool. APRA consists of three sections, including Basis of Project Decision, Basis of Design, and Execution Approach (Caldas et al., 2007). A similar tool was developed by CII (1999), the Project Definition Rating Index (PDRI), to facilitate project scope definition. This tool measures the level of scope definition, identifies gaps, and decreases risk through project scoping process.

The challenge is that each transportation agency appeared to have developed its own unique timing, resources, and tools for scoping process with unique stages in the project delivery process, and no two are exactly the same. Moreover, each STA involves unique challenges through scoping process for infrastructure projects. Therefore, a comprehensive study to achieve information about project scoping will assist project programmers to provide a proactive plan to overcome issues and challenges during the scoping process.

### 3 RESEARCH METHODOLOGY

To achieve the objectives of the present study, the following five-step methodology was developed and implemented. Figure 1 illustrates these steps.

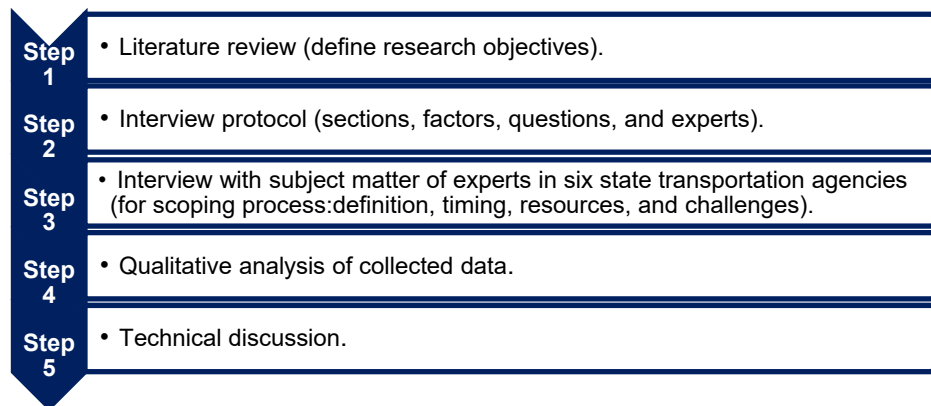


Figure 1: Research methodology.

Initially, the comprehensive literature review was conducted to find the definition, timing, resources, and challenges associated with infrastructure projects. These factors are very important for the scoping process. According to the findings of the literature review, the research team developed and provided an interview protocol. The interview protocol consisted of defining state transportation agents, factors, questions, and experts. To collect data from STAs, the research team made a plan to conduct interview with experts who worked in STAs. The research team focused to gain information corresponding to definition, timing, resources, and tools of scoping. In addition, the authors collected data related to major challenges that STAs face through scoping process. When the data collection process was completed, the research team performed qualitative analysis. In the last step, the results were discussed technically and interpreted.

## 4 DATA COLLECTION

To collect the data, the research team developed a structured interview with practitioner experts worked in six state transportation agencies (Minnesota Department of Transportation, Utah Department of Transportation, Washington Department of Transportation, Kentucky Transportation Cabinet, Michigan Department of Transportation, and Louisiana Department of Transportation and Development). The research team made a plan to find the definition and timing of the scoping process. In addition, the tools/resources, and challenges of project scope process were investigated through several interviews. The interviewees had more than a hundred years of accumulated job experience in infrastructure projects.

## 5 RESEARCH RESULTS

### 5.1 Definition/Scalability

Minnesota Department of Transportation (MnDOT) does not have a formal documented definition of the project scoping process. As shown in Table 1, the definition of scoping process in MnDOT is as “what is in the project and what is not in the project.” When the project scoping process starts is the only difference based on different project types. The same is considered true for large versus small projects. This concept is illustrated in the MnDOT scoping process narrative (Figure 2). Projects start and end at different points in the project development process. The different project categories are covered in the scoping process narrative. The scoping process is intended to be standardized across all MnDOT districts.

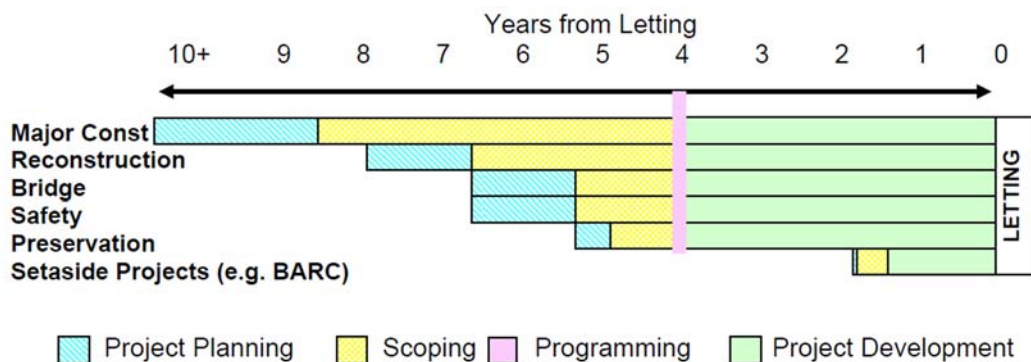


Figure 2: Timeline of project planning and scoping for different classifications of projects.

Utah Department of Transportation (UDOT) is one agency that indicated it does not having a formally documented project scoping process. While this is a fair description and was confirmed by the interviewee, the lack of a documented process should not be indicative of having no activity when it comes to project scoping. Utah appears to be on the cusp of having one of the more advanced project scoping processes in the United States due to its extensive efforts to develop a highly integrated GIS. Utah's system, named UPLAN, integrates GIS across different state agencies in Utah as well as different GIS outside Utah, for example, the National Weather Service. Utah has focused its efforts on the development of UPLAN in order to better identify and use information from a broad spectrum of agencies to aid in decisions during project planning and scoping. Utah is already using UPLAN in its project scoping efforts and anticipates developing an enterprise approach for how this information will be used uniformly across all agencies' project scoping efforts. Their anticipated enterprise approach would represent a significant advancement in formal documentation.

Washington State Department of Transportation (WSDOT) has a formal “scoping phase” definition as “The first phase of project development for a specific project, the scoping phase follows identification of the need for a project and precedes detailed project design. It is the process of identifying the work to be done and developing a cost estimate for completing the design and construction. The Project Summary, engineering and construction estimates, and possibly several technical reports (geotechnical, surfacing, bridge condition, and so on) are developed during this phase.” (WSDOT Design Manual M 22.01.08 July 2011). All federally funded projects are required to have a project summary document which consists of the Design Decisions (DD), Environmental Review Summary (ERS), and Project Definition (PD). There may be differences in the level of effort and information. This is mostly tied to size and type of project. Large and/or complex projects may require more effort during the scoping phase. The threshold for large projects depends on the region. The manual also defines the various categories of projects.

As indicated in Table 1, in Kentucky Transportation Cabinet two forms are used as part of the scoping process: the Project Information Form (PIF) and the Data Needs Analysis (DNA). The interviewees provided the forms and completed examples to the research team. An interviewee indicated that PIFs are completed at the beginning of the project scoping process, and DNAs are usually completed near the end of the planning phase. The PIF contains a basic description of the issue (i.e., increased traffic, obscured sightlines, and increased accident rate) but typically does not include design alternatives. The DNA includes design alternatives to address the issue as well as cost estimates. The interviewees provided the Kentucky Transportation Cabinet Project Delivery Core Processes, which describes the project development process within the cabinet.

In Michigan Department of Transportation, as shown in Table 1, the scoping manual says that “the scoping process begins with an identified need, and ends with a selected project supported by a complete scoping package.” This definition is consistent with the Michigan Department of Transportation’s (MDOT’s) responses to the survey where scoping takes place mainly in the planning phase. In addition, the interviewees pointed out that they perform scope verification at the beginning of preliminary design to make sure that the projects still fit in their strategic plan and goals. In MDOT’s project development process, there is a distinctive phase called early preliminary engineering, which has a separate budget.

During the meeting, the Louisiana Department of Transportation and Development (DOTD) informally defined the scoping process as the process to evaluate the feasibility of a project, look at red flags, and conduct a high-level project analysis. The high-level analysis includes a project cost estimate, a preliminary analysis of alternatives, traffic analysis, and funding source identification. This scoping process is referred to as Stage 0 at DOTD and is documented in the Stage 0 Preliminary Scope and Budget Checklist. The DOTD *Project Delivery Manual* indicates that the project scope must include all of the constraints and requirements that the project must meet, that is, special conditions imposed on the project by external or internal entities due to specific issues. DOTD uses standard preliminary scope and budget checklists to assist in the scoping process. DOTD uses the standard forms for every project it funds (except pavement preservation and Local Public Agency projects).

Table 1: Definition/scalability of scoping in several transportation state agencies

Transportation State Agent	Definition/Scalability of Scoping
Minnesota (MnDOT)	What is the project and what is not in the project
Utah (UDOT)	It does not having a formally documented project scoping process
Washington (WSDOT)	It is the process of identifying the work to be done and developing a cost estimate for completing the design and construction
Kentucky	Two forms are used as part of the scoping process: the Project Information Form (PIF) and Data Needs Analysis (DNA)
Michigan (MDOT)	Scoping process begins with an identified need, and ends with a selected project supported by a complete scoping package
Louisiana (DOTD)	Process to evaluate the feasibility of a project, look at red flags, and conduct a high-level project analysis

## 5.2 Start and End of Scoping Process

In MnDOT, project scoping starts early in the preliminary design phase, as indicated in Table 2, and ends at the end of the preliminary design phase or early in the detailed design phase. Project definition completeness is likely somewhere between 10 percent to 30 percent project maturities when the project is programmed into the Statewide Transportation Improvement Program (STIP). This percent depends on the type and size of projects.

Regardless of a lack of an enterprise approach, the interviewee worked in UDOT was able to describe some general approaches to developing a project scope. In general, project scoping within UDOT begins at the end of project planning and ends by the early stages of detailed design (Table 2). The peak of activity occurs while decisions are being made related to environmental activities.

In WSDOT, as shown in Table 2, Alternative Analysis and Preliminary Plans are typically selected before the right-of-way map development process takes place. With some exceptions, the environmental process and right-of-way map development process do not happen during the preliminary design phase. The design and PS&E assembly process typically starts in the preliminary design phase and not in the detailed design phase. Projects at WSDOT are typically funded with preliminary scope of work completed. Final scoping is not completed until the preliminary scoped project is funded. For large projects that are partially funded, the scoping process can linger on as well, which creates a shelf life. The Project Summary Document is the final item that should be completed before detailed design. This was the main reason why the respondents' answers for scoping starting and ending points varied across the provided information.

At the Kentucky Transportation Cabinet, as can be seen in Table 2, project scoping starts early in the planning phase, usually with communicating with state or county officials about project needs. Districts maintain an Unscheduled Need List and identify project needs throughout the year. PIFs are usually completed around the middle of the planning phase, and DNAs are usually completed late in the planning phase or early in the preliminary design phase. Scoping process performance is not formally measured at the Kentucky Transportation Cabinet. Project data can be accessed when necessary. Change orders are tracked on all projects, but currently no analyses are performed on the change order data in order to measure scoping effectiveness.

At MDOT, most of the road design and project scoping are performed on the regional level with input from Transportation Service Centers (TSCs). MDOT has a formal call-for-projects process that starts with the central office making strategic goals for five to six years into the future. A Road Quality Forecasting System is used to assess the performance of roads, and the general goal at MDOT is to have 90 percent good or fair roads. The regional offices then select projects that fit into the strategic plan. MDOT has a scoping manual that describes the time frame and tasks to be performed during project scoping. At the end of the scoping manual, there are detailed checklists designed for different project types, which serve as the documentation of the scoping process. MDOT tracks the engineer's estimates versus contractor's bid amount to measure the effectiveness of the scoping process. In addition, MDOT also uses a scorecard to benchmark letting dates. As required by state law, MDOT performs life-cycle cost analysis for any projects with pavement budgets over \$1 million. As far as the project delivery method goes, MDOT usually assumes a typical design-bid-build delivery system. However, there is an innovative contracting committee in place to identify those projects that may be appropriate for alternative delivery methods such as design-build and construction manager/general contractor (aka construction manager-at-risk). Estimating is performed in TSCs with the help of the estimator's checklist when necessary.

In Louisiana Department of transportation and Development, the scoping process starts early in the planning phase, and ends late in the planning phase (Table 2). Scoping is generally a planning function referred to as Stage 0 and ends when the project receives a project number and is programmed before the beginning of environmental and preliminary design activities. At this point, the project is included in the STIP. Low priority projects are not included in the STIP.

Table 2: Start and end of project scoping in several transportation agencies

Transportation State Agent	Start of Scoping Project	End of Scoping Project
Minnesota (MnDOT)	Early in the preliminary design phase	End of the preliminary design phase
Utah (UDOT)	End of project planning	Early stages of detailed design
Washington (WSDOT)	Exact time is not mentioned	Before preliminary design phase
Kentucky	Early in the planning phase	Early in the preliminary design phase
Michigan (MDOT)	Based on the scoping manual	Based on the scoping manual
Louisiana (DOTD)	Early in the planning phase	Late in the planning phase

### 5.3 Tools and Resources

The project scoping process is described by a flowchart and a narrative in MnDOT (Table 3). The key scoping tool is the scoping worksheets. These worksheets cover the different functional groups that may be involved in a project. The worksheets further describe items that generally reflect the possible scope for each of the functional groups with boxes to check for whether or not the item is needed for the specific project under consideration. Some explanation or qualification can be provided in a comment field. A second important document is the project scoping report. The report contains a description of the project scope, a cost estimate, and a schedule for letting the project. The Approved Project Scoping Report becomes the baseline from which the scope, cost, and time are managed during the detailed design phase. In terms of environmental, right-of-way, design, and construction activities/decisions, there was general agreement that almost all the activities/decisions listed were part of the scoping process. However, the level of priority of the activities/decisions was different from the MnDOT perspective when compared to survey aggregate responses. Word processor, server-based database, and web-based viewer were the most highly used technologies to support the scoping process. GIS mapping is being used to aid in the scoping process. In terms of people resources, the heavy-use staff included the design engineer, environmental coordinator, traffic engineer, bridge engineer, pavement engineer, construction engineer, maintenance supervisor and engineer, and city and county officials.

As shown in Table 3, the interviewee worked in UDOT indicated that Utah does not involve construction during the project scoping process. Based on the interviewee's previous comment that most of the project scoping activities coincide with environmental decisions, it may be assumed that Utah's project scoping process focuses on environmental issues. Outside of environmental personnel, the interviewee indicated that most of the other individuals are from design. When asked about who else the interviewee would like to see involved in the project scoping process, he indicated stakeholders from the business community, such as large corporations in and around Utah, especially in the Salt Lake City area. Some regions had dedicated scoping staff, while others did not. There was no management-level dedicated estimator at WSDOT. Maintenance engineer and maintenance supervisor input was noted as very important but typically with lesser involvement during the scoping process. WSDOT conducted risk workshops and constructability reviews to assist project scoping at the agency. WSDOT indicated the Deliverables Expectation Matrix and Scoping Checklist are tools used to support the project scoping process. WSDOT also had a dedicated Access database that was customized for assessing project risks.

The interviewee who was worked in Kentucky Transportation Cabinet addressed that server-based databases are used heavily during scoping (Table 3). The Kentucky Transportation Cabinet uses the Highway Information System to maintain information about its system. In addition, the interviewee mentioned that Oracle is used for project funding. The interviewees identified the Internal Project Development Academy as a best practice. It is an eight-day course offered over the course of two weeks. It demonstrates an overall view of how a project is developed within the cabinet. It is provided to all cabinet personnel, not just engineers. The interviewees also mentioned that maintenance personnel are more involved than construction personnel in the scoping process because maintenance personnel are consulted when assessing the performance of a road or bridge to determine project needs. The interviewees indicated that at the Kentucky Transportation Cabinet, public stakeholders are heavily involved in the scoping process. The Kentucky Transportation Cabinet holds two meetings with the public

stakeholders during project development. The first meeting is to discuss project needs and get feedback from the public, and the second is a follow-up meeting. The interviewees also mentioned that maintenance personnel are more involved than construction personnel in the scoping process. The interviewee suggested that planning engineers and urban planning personnel should be more involved in project scoping to provide input to help identify transportation needs.

A few technology platforms are being used or are going to be used in the near future at MDOT. Project documents are electronically stored in a system called ProjectWise. Environmental documents are generated from the Environmental Sensor Station and submitted into ProjectWise. MDOT is piloting E-Construction, which means all documents for construction administration go through ProjectWise and are shared externally. The new technologies are improving the scoping process at MDOT by adding consistency among projects and speeding up approval processes. In addition, the interviewees helped verify that design personnel are most involved in project scoping, followed by construction and maintenance, and that public stakeholders are hardly involved.

As shown in Table 3, Excel and Word are the main tools in DOTD. DOTD also uses a variety of databases (both desktop and server based, e.g., for crash data) to assist in the scoping process. DOTD also uses CAD during this phase. DOTD uses Bentley’s MicroStation and other products, e.g., Descartes, to manage and use imagery. DOTD uses a variety of tools for special analysis. For example, it uses Vissum and Synchro for traffic analysis. It also uses ArcGIS and TransCAD. The interviewees also mentioned that DOTD has a public involvement policy. DOTD conducts outreach activities during scoping on a project-by-project basis. Outreach includes the public and resource agencies. In some cases there may be meetings with the public and other stakeholders. However, resource agencies usually do not attend these events. DOTD also uses Planning and Environmental Linkages (PEL) checklists modified from the Federal Highway Administration (FHWA) PEL checklist.

Table 3: Major tools/resources in scoping process utilized by different transportation state agencies

Transportation State Agent	Major Tools/Resources
Minnesota (MnDOT)	Flowchart and narrative
Utah (UDOT)	Environmental personnel, design personnel, and business community stakeholders
Washington (WSDOT)	Maintenance engineer and maintenance supervisor
Kentucky	Server-based databases, and maintenance personnel
Michigan (MDOT)	ProjectWise, design personnel, and public stakeholders
Louisiana (DOTD)	Excel and Word, and a variety of databases, CAD, and Bentley’s MicroStation

#### 5.4 Major Challenges

The most significant challenge through project scoping in MnDOT is the time to prepare project scopes, as shown in Table 4. This effort often does not receive the time needed to adequately define the project scope. Moderate challenges include having qualified personnel to prepare project scopes and communicating project scoping issues or decisions to stakeholders. Determining the right level of detail for projects two to four years from letting would lead to an improved scoping process. Also, properly incorporating risks into the scoping process would likely improve outcomes. Encouraging broader involvement of stakeholders would help. Finally, using the change management process to control the scope during design and defining a change order threshold could lead to improvements in the scoping process. When it came to describing Utah’s most significant barrier to developing a project scoping process, the interviewee described the barriers of sharing information across different departments within UDOT and other Utah state agencies (Table 4). UPLAN appears to be directly targeting this barrier. As indicated in Table 4, political involvement during the scoping process was noted as a major challenge in WSDOT. This would at times results in selecting projects that were not the most critical.



Table 4: Significant challenges in different state agencies through scoping process

Transportation State Agent	Major Challenges
Minnesota (MnDOT)	Time to prepare project scope
Utah (UDOT)	Sharing information across different departments
Washington (WSDOT)	Political involvement
Kentucky	Finding time and qualified personnel to prepare project scope
Michigan (MDOT)	Time required to prepare scoping documents
Louisiana (DOTD)	Lack of resources to address the demand for feasibility analyses

Finding time and qualified personnel to prepare project scopes is the major challenge to scoping in the Kentucky Transportation Cabinet (Table 4). Each district in Kentucky has its own criteria when performing cost estimates. Regarding project delivery methods, the Kentucky Transportation Cabinet exclusively uses the traditional design-bid-build delivery method. However, recent legislation allows up to five design-build projects per year. Interviewees worked in MDOT pointed out that the most significant challenge associated with scoping is the time required to prepare scoping documents (Table 4). MDOT has not experienced an issue that constantly causes budget overruns, but the interviewees identified right-of-way as the most common reason for schedule delays. In DOTD, a challenge in the past was lack of resources to address the demand for feasibility analyses. DOTD overcame this challenge by using consultants. Overall, the department has been satisfied with the products it gets from them, although there was a learning curve while the consultants learned DOTD's procedures and requirements.

## 6 DISCUSSION

The interviews showed that because the definitions of project scoping differ from agency to agency, the time frame and project scoping activities also vary. For example, project scoping within UDOT begins at the end of project planning and ends by the early stages of detailed design, while in WSDOT and the Kentucky Transportation Cabinet the scoping process starts early in the planning phase and ends near the end of the planning phase or early in the preliminary design phase. Project scoping generally starts with the identification of needs, and continues with the development of design alternatives, preliminary estimation of project costs, and identification of important milestones. Generally, project scoping activities are performed on the regional level with input from the central office. The level of effort and information required for performing scoping activities are usually different depending on the size and type of the project, with large and complex projects requiring more effort during the scoping phase. State transportation agencies normally do not have a formal and standard practice for effectiveness of scoping activities, although they might keep track of items listed in the survey, specifically change orders. Noteworthy is the fact that individual project managers may measure the effectiveness of projects for which they may be responsible.

As for tools and techniques used in scoping activities, transportation agencies interviewed use a variety of desktop and server-based databases to aid in decisions during project planning and scoping. For example, Utah has made extensive efforts to develop an integrated GIS for identifying and using information from a broad spectrum of agencies. Document management systems are the most commonly used tools for organizing documents and reports created during the scoping process. These new technologies can improve the scoping process by adding consistency among projects and speeding up approval processes.

As for personnel involved in scoping activities, interviewees indicated that environmental personnel, design professionals, and maintenance personnel are more involved than construction personnel in the scoping process. Environmental personnel are involved because the scoping process tends to focus on environmental issues. Maintenance personnel are involved because they are consulted for assessing the performance of a road or bridge to determine project needs. Transportation agencies have mechanisms in place, mostly through meetings during the project development phase, to involve public stakeholders in the scoping process. Interviewees indicated that lack of time and qualified personnel to address the

demand for feasibility analyses is the major challenge to scoping, and in some cases, they overcame this challenge by hiring consultants.

## 7 CONCLUSION

The intent of this study was to provide an overview of scope definition, and also timing, resources, and tools utilized through the scoping process in various state transportation agencies. In addition, the major challenges during implementation of scoping process in infrastructure projects were presented. Multiple in-depth interviews with expert practitioners who worked in six STAs were conducted to collect the corresponding information. It was concluded that the timing and activities in scoping process vary due to different scoping definitions. Furthermore, project scoping commonly starts with the identification of requirements, and proceeds with the development of design alternatives, and preliminary cost estimation. The results demonstrated that design, maintenance, and environmental personnel are more involved among construction personnel in scoping process. Finally, the lack of qualified personnel and sufficient time are two major challenges that STAs face during scoping process. It is anticipated that the outcomes of this study will aid owners and policy makers to structure scoping process more effectively in infrastructure projects.

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