SPR 753: SCDOT SCOPE OF SERVICES TEMPLATE RESEARCH

FINAL REPORT

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FHWA – SC - 23 - 01

01.10.2023

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Technical Report Documentation Page

1. Report No FHWA-SC-23-01	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle SCDOT Scope of Services Template Research		5. Report Date January 2023 6. Performing Organization Code
7. Author/s Dennis Bausman, Ehsan Mousavi, Ajay Jadhav, David Taylor, Brett Harrelson		8. Performing Organization Report No.
9. Performing Organization Name and Address Clemson University 300 Bracket Hall, Box 345702 Clemson, SC 29634		10. Work Unit No. (TRAIS) 11. Contract or Grant No. SPR No. 753
12. Sponsoring Organization Name and Address South Carolina Department of Transportation Office of Materials and Research 1406 Shop Road Columbia, SC 29201		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

In the United States, federal, state, and local governments are responsible for addressing their residents' transportation infrastructure needs. Similar to most State Departments of Transportation (State DOTs), the South Carolina Department of Transportation (SCDOT) is responsible for owning, operating, and maintaining a large transportation system for the state. SCDOT is under growing pressure for efficient and effective transportation project delivery to address the need and continued expansion. The pressure is due to high demand, limited funding sources, stakeholders' concerns, federal and state policies, and intense public involvement. Due to increasing demand and pressure to meet its key strategic goals, SCDOT is taking initiatives to deliver projects as efficiently and expeditiously as possible. One of the efforts undertaken by SCDOT is streamlining its Scope of Services (SOS). An Exploratory Sequential Design is used to meet the research goals. Preliminary semi-structured interviews are conducted with SCDOT to identify the agency's current SOS practices and suggestions for improvement. An administrative questionnaire is utilized to obtain input from SCDOT's delivery partners to gain insight regarding SOS best practices. Follow-up interviews are conducted with the delivery partners. Structured interviews with comparable state DOTs are conducted to probe SOS concepts, gain an in-depth understanding of SOS practices, and identify SOS best practices. The identified SOS Best Practices are assembled based on the data, analysis, and findings supported by four different data sources. The analysis of all data sources is used to assemble ten (10) SOS Best Practices, that are organized into four categories. Based on the findings from all the sources, a streamlined and updated comprehensive SOS is developed with Decision Tree (DT) Variables.

17. Key Words Scope of Services, State DOT, SOS, Decision Tree Variables, Consultants, DT	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.		
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. Of Pages	22. Price

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ACKNOWLEDGMENTS

The research team would like to acknowledge the South Carolina Department of Transportation and the Federal Highway Administration as the sponsors of this study. Their continuing support has been instrumental in the project's success. We would also like to express our sincere appreciation for the guidance, commitment, insight, and involvement of SCDOT's Steering Committee: Jennifer Necker, Chair and Committee Members: Jeremy Harmon, Michael Hood, Lyle Lee, Josh Meetze, Tyke Redfearn, Freedom Spradley, Randy King, and Terry Swygert. The foundation for the success of this research project was the Steering Committee's genuine enthusiasm and continuing support. Additionally, we would like to acknowledge the extensive support, insight, and knowledge provided by over forty SCDOT and other State DOT agency managers from each discipline involved in the agency's Standard Scope of Services Template Development Process.

EXECUTIVE SUMMARY

The South Carolina Department of Transportation's (SCDOT) Scope of Services (SOS) serves as the agency's standard template to develop scope of services for the procurement of professional services consultants. SCDOT procures consultants to deliver projects that require engineering design and special services. The agency had been using project scopes retrieved from previously completed projects as their baseline to develop the scope and negotiate with the consultant. Of course, two SCDOT divisions, namely Environmental Services and the Preconstruction Surveys Office, had developed standard SOS templates. Seeing the impact of these templates on the streamlined negotiation process and reduced time required for procurement has encouraged the SCDOT to develop a standard scope of services template for other activities as well. The SCDOT has commissioned Clemson University to accomplish three primary research Goals:

Goal I: Update and streamline the agency's current Scope of Services Process

Goal II: Develop a comprehensive Scope of Services Template for Engineering Design Services

Goal III: Identify various project variables that affect the project scope

To support these Research Goals, the following research objectives were established:

a) Engage with SCDOT staff to identify and understand the tasks commonly included in an SOS for various projects developed by SCDOT and obtain their suggestions for enhancement of the process.
b) Strategically engage other state DOTs to identify enhancements to standard SOS templates, efficient ways to access templates, and effective policies to keep templates current.
c) Identify best practices to streamline the consultant scoping process.
d) Develop an executive level summary of recommendations for enhancing the SOS process.
e) Develop streamlined and updated Scope of Services template for procurement of various consultant services required by SCDOT.

The research methodology to achieve the research goals and supporting objectives was developed and executed in three (3) phases comprising nine (9) tasks. These three phases are: a) Investigate studies, publications, and SCDOT's current SOS, b) Collect state DOT's process data and practices, c) Identify and develop SOS Best Practices and Recommendations and Prepare/finalize deliverables. The research phase(s) and methodology to support the findings for each research goal are as follows:

Goal I: Update and streamline the agency's current Scope of Services Process

Phase 1: During this phase, secondary data from state DOTs, past studies, and scholarly publications were collected to evaluate the current state of practice in developing SOS. Interviews were conducted with SCDOT's Subject Matter Experts (SME) from each department and

functional unit involved in SOS and input from SCDOT's Professional Services Consultants was solicited. Information received from the SMEs and Steering Committee (STC) was incorporated into the baseline template examples provided by the SCDOT. The updating of SOS included streamlining the scope language for consistency, eliminating redundancy of scope items, and developing a comprehensive SOS to cater project needs.

Goal II: Identify state DOT Project Development Process Best Practices

Phase 2: This Phase involved collecting data from State DOT concerning their SOS process and professional services procurement. An online survey was conducted with the American Council of Engineering Companies – South Carolina (ACEC-SC) members. After completion of the survey, interviews with a group of consultants (8) were conducted based upon suggestions from the SCDOT. A pool of comparable state DOTs was identified with similar characteristics to the SCDOT. Structured interviews were conducted with seven (7) such State DOTs. Each of the 7 State DOTs was investigated to identify states with a comprehensive and current SOS.

Phase 3: During this Phase the research team summarized the data and findings of the preceding Phases to support development of the SOS Best Practices, The SOS Best Practices were assembled based on the data, analysis, and findings supported by the four different data sources: a) structured interviews of twenty-eight SCDOT SMEs, b) ACEC-SC consultant survey, that have, or currently are, providing professional services to SCDOT, c) Consultant interviews, and d) input received during structured interviews with seven State DOTs (VDOT, GDOT, FDOT, KYTC, CDOT, NCDOT, and TXDOT.

Goal III: Identify various project variables that affect the project scope

Upon development of a streamlined scope of services (SOS) template, the research team identified a number of project attributes that affect the scope. These 47 decision tree (DT) variables determine which tasks, clauses, or deliverables are suitable for inclusion in the project scope. The decision on each of the DT variables (include vs. exclude) determines whether the associate section of the comprehensive SOS template must be kept or removed. To aid the user, an online interface was developed that takes inputs and returns a customized, editable SOS document, as a starting point for negotiations.

In addition, the following SCDOT's Steering Committee were involved for a part or entirety of the research project: Jennifer Necker, Chair and Committee Members: Jeremy Harmon, Michael Hood, Lyle Lee, Josh Meetze, Tyke Redfearn, Freedom Spradley, Randy King, and Terry Swygert.

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ABBREVIATION	EXPLANATION
AASHTO	American Association of State Highway and Transportation Officials
AHP	Analytical Hierarchy Process
ARTBA	American Road & Transportation Builders Association
ASCE	American Society of Civil Engineers
CE	Categorical Exclusion
CSS/CSD	Context-Sensitive Solution/Design
DOT	Department of Transportation
DT	Decision Tree
EA	Environmental Assessment
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
LPA	Local Public Agency
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
PDDM	Project Development and Design Manual
PDP	Project Development Process
PS&E	Plans, Specifications, and Estimate
PSP	Project Scoping Process
ROW	Right-of-Way
SCDOT	South Carolina Department of Transportation
SME	Subject Matter Experts
SOS	Scope of Services
STA	State Transportation Agencies
STIP	Statewide Transportation Improvement Program
TRB	Transportation Research Board

CHAPTER 1: INTRODUCTION

1.1. Research Scope

The federal, state, and local governments are responsible for addressing the issues related to infrastructure needs of the citizens in the United States. (Haidary, et. al., 2022). The state and local governments utilize the aid provided by the federal government in upgrading transportation infrastructure such as highways, bridges, roadways, etc. The total investment accounts for about 60% of all capital expenditures on infrastructure and 90% of the operational cost to maintain roadways (Bausman et al., 2014; Haidary et. al., 2022).

Transportation planning and engineering have been a cost-conscious, flexible, forward-thinking, and innovative discipline that has led the state transportation agencies (STAs) to the construction of robust transportation systems (Hillis, Jones & Erken, 2016). Due to these criteria and the need for a broad spectrum of stakeholders, the state departments of transportation (DOTs) have relied on well-defined guidelines, standards, and engineering processes for planning, developing, designing, constructing, and managing the highway systems to shape the roadway geometrics and design details (Hillis, Jones & Erken, 2016). Although transportation agencies have significantly improved some aspects of project delivery, the challenges related to cost increase and time delays tend to continue occurring after a project is programmed and funded (Anderson et al., 2016). These challenges have put the DOTs under increasing pressure to deliver projects on time, on budget, and improve the performance of their programs and projects to meet the need of the constituents (The Luois Berger Group Inc. 2005; McMinimee et. al., 2009).

The pressure is due to high-demand environment, funding and revenue sources, stakeholders' concerns, federal and state policies, and intense public interest and involvement (McMinimee et al., 2009). The planning, design, environmental stewardship, and construction of highway projects are complicated, complex, and contingent on uncertainties that result in accurately predicting project performance, including schedule and budget (Wood et al., 2014). These uncertainties stem from a lack of information in developing project scope and estimates, unidentified risks that arise as the project develops, and the need for a broad spectrum of stakeholders concerned with community, environmental, historic, scenic, aesthetic, and social values (Wood et al., 2014; Crossett & Oldham, 2005).

In recent years, the transportation industry has witnessed a dramatic increase in the use of professional services consultants for engineering and design professional services to meet the rising demand. This increased demand has elevated both the number of projects for states' Department of Transportation (DOT) and the need for on-time delivery to meet the increased demand for transportation projects (Gen & Kingsley, 2007). Compounding the challenge is that DOTs are facing shortage of skilled and seasoned employees to keep up with the increasing

demands as thousands of workers are expected to retire over the next 5 to 10 years (Nambisan, Hallmark, & Albrecht, ; Vandervalk, Cronin, & Thompson, 2020).

1.2. Problem Statement

According to the American Road & Transportation Builders Association's (ARTBA) seventh annual analysis of the latest U.S. DOT's National Bridge Inventory (NBI) database, more than one-third, or 220,000, of the nation's 618,000 bridges need structural repair, rehabilitation work or replacement (TOP 10 takeaways.2017). The USDOT categorizes the condition of bridges as good, fair, and poor (structurally deficient). Of the total bridges that need structural repair, rehabilitation work or replacement, 45,000 of them are classified as structurally deficient. The key takeaways in the report are that although the number of structurally deficient bridges has been on the decline over the last five years, the conditions of bridges have continued to deteriorate from good to fair over the same period. At the current pace, it would take nearly forty (40) years to repair the rising backlog of structurally deficient bridges, according to the report (TOP 10 takeaways.2017).

Moreover, many transportation projects have experienced significant delays in schedules over the last three years (Quattlebaum & Dee, 2019). The majority of the delays were caused by deficiencies related to projects' scopes of work (SOW). The common factor that affected many projects was the absence of a consistent and effective process for developing project scope. In order for the DOTs to successfully deliver future transportation projects, a well-defined scoping process is essential (Quattlebaum & Dee, 2019).

To address the increasing burden of transportation projects aggravated by the lack of seasoned employees, the DOTs have increased the rate of procurement for engineering and design professional services. In order to avoid procurement delays, particularly related to insufficient project details associated with inadequate project scopes, a comprehensive and well-developed project scope is essential.

Considering the rising need for the DOTs to have an effective and efficient SOS, this research study scope is to:

a) Identify a state transportation agency's (i.e., SCDOT) current practice(s),
b) Collect input and suggestions from the agency's internal Subject Matter Experts (SMEs),
c) Obtain feedback and suggestions for improvement from external delivery partners,
d) Collect input from other state DOTs to identify effective and efficient practices,
e) Compare best practices to a state transportation agency's current practice and develop recommendations for improving their SOS,
f) Develop a streamlined and updated Scope of Services Template enabled with a list of project variables (i.e., Decision Tree variables).

The State DOT examined in this study is South Carolina Department of Transportation (SCDOT). However, the methodology utilized could be applicable to other State DOTs that desire to evaluate and improve their SOS.

1.3. Purpose

For SCDOT projects that require consultant procurement, one of the initial steps is the preparation of a draft of the Scope of Services (SOS). According to the SCDOT's Professional Services Contracting Office, procuring a consultant takes between 4 and 12 months, depending on the type of contract being executed. This timeline is impeding SCDOT's ability to meet one of the agency's Strategic Plan objectives to "increase SCDOT's reliability of delivering projects on-time and on-budget" for projects requiring consultant services. Based on data from SCDOT's Professional Services Contracting Office the preparation of the SOS has the greatest inefficiency in the consultant procurement process, averaging 47 to 84 days. However, the data also reveals the average procurement time is significantly reduced when the scoping phase is less than 50 days. Delays in the scoping phase are largely due to the lack of a standardized SOS template that all PMs could use as a starting point to develop the initial draft of the SOS. Currently the PM uses a similar SOS from an executed contract as the starting point to develop the draft SOS. Preparation of a draft SOS in this manner is inefficient and typically yields an SOS draft that is flawed and/or incomplete. As a result, when the draft SOS is reviewed with the consultant, instead of refining the SOS tasks, large portions of the SOS have to be rewritten, causing delay in the procurement process.

Two SCDOT divisions, Environmental Services, and the Preconstruction Surveys Office, have developed standard SOS templates. With the use of these templates, the negotiation process is streamlined, and the time required for procurement has been greatly reduced. Preparing a well written draft SOS is the starting point for successful project delivery. Standardized SOS templates for all tasks will reduce the time required for consultant procurement and increase the agency's ability to deliver projects on-time and on-budget.

1.4. Background and Significance of Work

The South Carolina Department of Transportation is responsible for owning, operating, and maintaining the 4th largest highway system in the United States and SC's transportation system needs have continued to expand. In response to the state's transportation demands, SCDOT's operating budget has increased by more than 10% per year and by 2018, reached approximately 1.4 billion to fund the transportation programs and associated administrative responsibilities. Compounding this continuing level of expansion in coming years will be the 'Roads Bill' passed by the SC General Assembly. The Roads Bill has been in effect since July 1, 2017, and will increase gas tax revenue each year over the next 6 years. By 2024 the gas tax will generate an additional $800 million per year for transportation funding. This continued expansion of SCDOT's

transportation program places increasing pressure on SCDOT personnel responsible for efficient and effective delivery of transportation projects.

SCDOT's Strategic Plan 2018-2020 was developed "to reflect the Department's current priorities, align the entire organization towards these priorities and instill accountability on achieving mission-critical goals". A key strategy identified in the plan to meet the agency's strategic goals included 'increasing SCDOT's reliability of delivering projects on-time and on-budget'. This strategic objective is challenging considering the DOT's expanding transportation program and the anticipated loss of SCDOT workforce experience and expertise due to retirements.

SCDOT regularly utilizes professional services consultants to meet the agency's needs and with the state's expanding transportation program the use of consultants will most likely increase in coming years. When a consultant is involved, procurement is generally initiated at the start of the project. As a result, an expeditious procurement process is critical because the time required for consultant selection, scope negotiation, and contracting impacts the project completion timeline. Furthermore, a streamlined process will aid SCDOT with another strategy to "enhance the network of small businesses that are ready, willing and able to assist the Agency in meeting its infrastructure goal".

Considering SCDOT's expanding transportation program and the agency's strategic objective it is essential that the agency ensure that its procurement process for professional services consultants is current, effective, and efficient. With increasing demands placed on agency personnel it is essential that the procurement process reflects best practices that enhance the effectiveness and efficiency of the process to support SCDOT's strategic objective.

1.5. Benefits

This research will help streamline the scoping phase of the consultant procurement process and increase the efficiency of the first step in the Project Development Process for projects that require consultants. The development of standard SOS templates will help clearly define project requirements and consultant services, resulting in faster project delivery, improved project understanding, and reduced contract modifications. As the Department's workload continues to increase in accordance with the 10-year Program Delivery Plan, procuring consultants more efficiently will aid the agency in achieving Strategic Plan Goal 3: "Improve SCDOT program delivery to increase the efficiency and reliability of our road and bridge network". Following are some of the additional benefits that this research study is expected to provide:

- Develop a streamlined SOS template with standard scope language confirming consistency and efficiency in procurement of Professional Services Consultants (PSC) on DOT projects
- Performance measurement of the PSC procurement process.
- Customizable SOS creation based on dependent and independent project variables, also called Decision Tree variables.

- Provide an objective and methodic approach to defining project scope and consultant SOS, predicated upon project attributes (i.e., decision tree variables).
- Ability to integrate the SOS template with the agency's Fee Negotiation database.
- Long-term tracking of project's performance in terms of cost and timeframe.

1.6. Research Objectives and Questions

The research objectives for this study are as follows:

1. Engage with SCDOT staff to identify and understand the tasks commonly included in an SOS for the various projects developed by SCDOT and obtain their suggestions for enhancement of the process.
2. Strategically engage other state DOTs and FHWA to identify enhancements to standard SOS templates, efficient ways to access templates, and effective policies to keep templates current.
3. Identify best practices to streamline the consultant scoping process.
4. Develop streamlined and updated SOS templates for procurement of various consultant services required by SCDOT.
5. Identify a baseline of decision variables based on which the scope of a project can be outlined.

1.7. Primary Research Goals

As mentioned in the previous section, this research aims to provide SCDOT, and other state DOTs, the methodology and needed insight regarding best practices to help the agency streamline and update their SOS leading to an increase in efficiency of critical task initiation, execution, and coordination. Thus, this research study and the methodology discussed later will answer the following primary research goals.

1. Goal 1: Update and streamline the agency's current SOS Process
2. Goal 2: Develop a comprehensive SOS Template for Engineering Design Services
3. Goal 3: Identify various project variables (i.e., Decision Tree variables) that affect the project scope

The abovementioned primary research goals are a refined form of management question or problem statement discussed earlier in this chapter. The primary questions have led the researcher to develop the secondary research questions, which will be discussed later in Literature Review. The primary research goals with the comprehensive literature review on SOS have also led the researcher to develop investigative and objective questions for data gathering purposes, which will be discussed later.

CHAPTER 2: LITERATURE REVIEW

2.1. Literature Review Map

The literature review map of this study is shown in Figure 1 below. The literature review map illustrates the methodology of a comprehensive review of federal policies, regulations, acts, state DOTs scoping process, peer-reviewed journal articles, studies, and reports from FHWA, NHCRP, TRB, AASHTO, ASCE, and other databases. This comprehensive literature review led the researcher to identify SOS issues, knowledge gaps, current SOS practices in the industry and DOTs, the philosophy of Context-Sensitive Design (CSD or CSS). The literature review also helped the researcher identify specific research questions that will be used to develop survey and interview questions to collect information from industry consultants and state DOTs as a part of the research design of this study. This will be discussed later in detail.

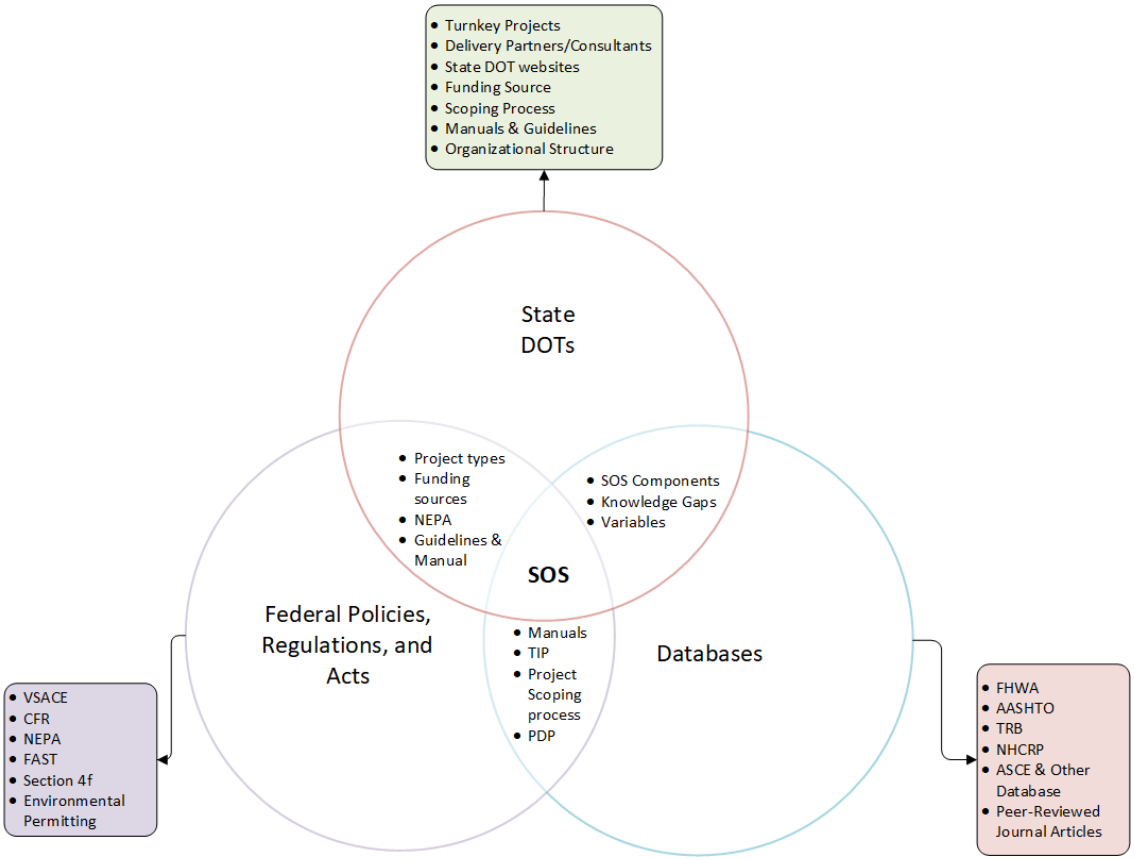

Figure 1. Literature Review Map and Bodies of Knowledge

2.2. SOS and PSP Stages

The success of long-range transportation planning depends on the accuracy of project SOS, cost estimates, and schedules. Achieving this accuracy can be difficult, especially during the project-planning stages, where information availability is limited. While developing the preliminary scope

of project, cost, and schedule, there are numerous uncertainties that need to be considered. These include future market prices, user needs, supply chains, weather conditions, design details, and unexpected site characteristics, among others. These complex factors may have greater potential effects on project proposals if not considered properly (Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M., 2017).

Nonetheless, planners are called upon to make reasonably reliable and accurate predictions and provide contingencies in order to cover alternative designs. The goal of the scoping process is to define the project alternatives accurately enough to make fair comparisons among other alternatives being considered. To tackle the risks involved in the selection of alternative designs, planners have to carefully identify potential issues that may potentially hinder the implementation of the project (Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M., 2017).

The timeframe for Project Scoping should begin early in the initial planning phase of project development, and it should continue the process of refinement through the preliminary engineering or preliminary design phase of the project. The scoping process is often divided into multiple stages, with broad evaluations made during initial planning and further refined as the work proceeds in the preliminary design phase. Figure 2 below shows the timeframe of scoping within the project development process (SOS).

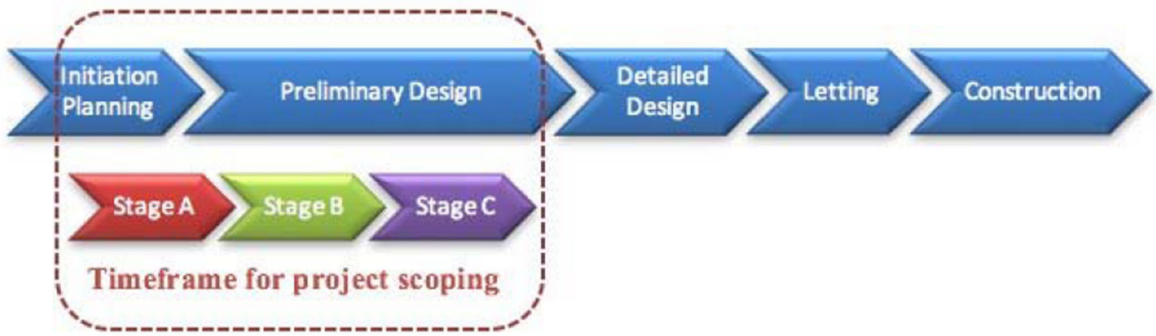

Figure 2. Timeframe of scoping within SOS

The scoping process is largely divided into three stages: Stage A – identification of project needs, Stage B – preliminary project scoping study, and Stage C – finalized project scoping study. In Stage A, the planners focus on defining the project and its needs, and compile them in the project scoping document, a well-developed report that states the purpose and needs of the project. The minimum needs-identification report includes a purpose statement; proposed project characteristics (e.g., number of lanes involved, types of proposed improvements, and major structures); the current conditions of the infrastructure; traffic projections; utility and right-of-way, environmental, and legal considerations; identification of stakeholders; initial cost and time estimates; and identification of concerns which need further investigation (Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M., 2017).

Stage B of the scoping process deals with defining the project elements in more detail. Preliminary design is under process at this stage of development, and simultaneous studies take place to collect additional information related to the environmental impacts, drainage issues, right-of-way, and utility conflict. At this stage the cost and time estimates are more detailed as the project elements are more precise in nature. Environmental clearance may be obtained during this stage of development along with supporting documents such as right-of-way maps and property descriptions. Public involvement is also performed in this stage in order to solicit feedback form affected stakeholders. Also, alternative design solutions are also taken into consideration at this stage (Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M., 2017).

Stage C is considered as the last stage of the scoping process where the project scope, budget, and schedule are finalized. This stage coincides with the preliminary design phase completion. At this stage, enough design details are established, and detailed design can be initiated. To begin, these designs are passed along to designers or professional services consultants as guidelines for their work. At a minimum, the final scoping report includes cost estimates, project development timelines, environmental classification and certification, right-of-way, and utility maps ready for acquisition and relocation, preliminary design schematics at 30% of completion, and public hearing meetings (Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M., 2017).

2.3. SOS Tasks/Activities

2.3.1. Surveying and Mapping

Surveying and mapping are fundamental to all civil engineering and roadway design work. It is a vital function linking the interdisciplinary elements of a project from planning through design, right-of-way acquisition and construction, to final asset management. (PDDM, 2018)

2.3.2. Environmental Permitting

Environmental Permitting is a task that requires acquisition of various permits required on a transportation project. These permits include Individual 404/401 Permit, United States Corps of Engineers (USACE) General Permit, Critical Area Permits, Navigational Permits, and Nationwide Permits, among others.

2.3.3. Preliminary Design

Preliminary design is also known as preliminary engineering or 30% design completion. In this task, preliminary designs such as typical sections, horizontal and vertical alignments, pavement structures, and design speeds are designed to analyze and evaluate different design alternatives. (Wood et al., 2011).

2.3.4. Final Design

According to 23 CFR 636.130, the final design is the next step that uses preliminary designs and includes the preparation of final construction plans and detailed specifications for the execution of construction work. It is considered a 95% design completion stage that includes all design plans, complete set of SCRs, and a CPM schedule (Wood et al., 2011).

2.3.5. Right-Of-Way (ROW)

Right-of-Way task is required to identify necessary acquisitions for the construction of the project. This includes railroad impacts caused due to highway projects requiring railroad impact coordination. In this task, a ROW specialist obtains and examines the ROW plans, documents, and permits, to coordinate with parties to negotiate and develop acquisition agreements. (Wood et al., 2011).

2.3.6. Utility and Railroad Coordination

Utility coordination and relocation/adjustment task is necessary to identify and coordinate utility conflicts with highway projects right-of-way such as overhead and underground power, communications, fuel, and water lines, irrigation ditches and canals, with private and government entities (Wood et al., 2011, PDDM 2018).

Railroad coordination is necessary on the projects that cross or may affect land owned by a railroad require early action to start the process required to coordinate development of necessary agreements. These agreements are made between the railroad, the cooperating agency, and Federal Lands Highway (FLH).

2.4. Federal Policies, Regulations, and Acts

2.4.1. National Environmental Policy Act (NEPA)

The National Environment Policy Act (NEPA), signed into law on January 1, 1970, establishes a national environmental policy and provides a framework for environmental planning and decision-making by federal agencies. NEPA requires Federal agencies to conduct environmental reviews when planning projects, issuing permits, and considering environmental impacts. NEPA also requires federal agencies to make environmental consequences public for comments before implementation. The Council on Environmental Quality (CEQ) is responsible for addressing the NEPA regulations and laws as a form of guidance (FHWA NEPA Toolkit).

The range of actions covered under NEPA is broad and includes but is not limited to the following:

- making decisions on permit applications,
- adopting federal land management actions, and

- constructing highways and other publicly owned facilities.

NEPA requires federal agencies to document the process as it supports and encourages public involvement and interagency coordination. The NEPA provides complete disclosure to the public and allows it to comment and propose alternatives and appropriate information regarding the impacts of the design alternatives. The documentation is classified into three basic categories. These categories of actions are Environmental Impact Assessment (EIS), Environmental Assessment (EA), and Categorical Exclusion (CE), explained further in detail.

2.4.1.1.Environmental Impact Assessment (EIS)

Depending on the environmental studies performed on transportation projects, if the project is considered to have a significant impact on the environment, NEPA requires federal agencies to prepare an EIS. An EIS document includes the purpose and need of the project, alternative studies analysis, environmental significances, and record of decision.

According to the FHWA NEPA Toolkit (2020), an EIS is a full disclosure document that describes the following in detail.

- The development process for an EIS transportation project
- Development of the range of reasonable alternatives for a transportation project
- Analysis of potential impacts of the alternatives for a project
- Compliance with other environmental regulations, laws, and orders

2.4.1.2.Environmental Assessment (EA)

A transportation project qualifies for only an Environmental Assessment (EA) when the state DOT have sufficient evidence and analysis to prepare an EA that supports a Finding of No Significant Impact (FONSI). A FONSI is a conclusion of the EA process, which presents the reasons why an action will not have a significant effect on the human environment. The FONSI document is the EA modified to reflect all applicable comments and responses. In addition, an EA document assists state DOTs when a project's environmental impact is uncertain. The FHWA must approve an EA document before it is made available to the public.

2.4.1.3.Categorical Exclusion (CE)

Transportation projects that do not require either environmental assessment (EA) or environmental impact statement (EIS) are considered for Categorical Exclusion (CE). CE is defined as the "Category of actions that do not individually or cumulatively have a significant effect on the human environment and for which, therefore, neither an environmental assessment nor an environmental impact statement is required" (40 CFR 1508.4).

2.4.2. SOS and Current Practices identified by other studies

This section discussed the state SOS and current practices identified by other studies. This will help build the knowledge and identify the gaps, areas for improvement, and recommendations for the development of streamlined and updated SOS.

2.4.2.1. Performance Management

The SCDOT has developed a risk-based Transportation Asset Management Plan (TAMP) to guide highway transportation investment decision-making. This TAMP guide was implemented based on the provisions laid down in the United States 2012 and 2015 surface transportation bills – Moving Ahead for Progress in the 21st Century Act (MAP-21) and Fixing America's Surface Transport (FAST) Act, respectively (SCDOT STIP DDR, 2021).

FAST Act was signed into law in 2015, which funded surface transportation programs, including, but not limited to, Federal-aid highways, for a timeframe of four years starting from 2016 through 2020. It was the first long-term bill that provided certainty in terms of funding for surface transportation (SCDOT STIP DDR, 2021).

Similarly, the MAP-21, enacted in 2012, included provisions to make the Federal surface transportation more streamlined, performance-based, and multimodal and address challenges facing the U.S. transportation system. This act created 7 goal areas and 17 performance measures associated with improving safety, maintaining infrastructure condition, reducing traffic congestion, improving the efficiency of the system and freight movement, protecting the environment, and reducing delays in the project delivery (SCDOT STIP DDR, 2021).

In relation to Performance Measure 1 (PM-1), the SCDOT has taken positive steps by implementing the strategic priorities in the TAMP in order to align SCDOT's internal and external efforts towards achievable results, safety projects, and operational improvement, such as Intelligent Traffic Systems (ITS), incident management, or traffic signal system projects (SCDOT STIP DDR, 2021).

In relation to Performance Measure 2 (PM-2), the SCDOT aims to make positive progress by implementing strategic priorities in the TAMP that are linked with widening projects for Interstates I-85,/385, I-26/526, I-26/I-26/I-20, and rural sections of I-95 and I-26. In addition to widening projects, there are other projects, such as preservation and rehabilitation projects that will be under construction to make progress towards achieving targets for pavements and bridges for all NHS, FA Secondary and Non-FA Secondary. The SCDOT develops an annual plan to address pavement on these roadways. The SCDOT Maintenance Office awards contracts for paving based on this plan (SCDOT STIP DDR, 2021).

Similar to the pavement plans, the SCDOT Bridge Maintenance Office keeps a running list of bridges that need addressing. These bridges are divided between the SCDOT District Engineering

offices and Preconstruction to address as necessary. Bridge replacement projects on I-20 over Wateree Swamp, Wateree River, and South Edisto, I-95 over Bagshaw Swamp and US 1 over I-20 are some of the significant projects to be completed in the near future (SCDOT STIP DDR, 2021).

Finally, in relation to Performance Measure 3 (PM-3), the SCDOT understands that reliable transportation with less congestion is the backbone of a robust and thriving economy. Therefore, Interstate capacity widening projects on I-85, I-26, and I-20 are currently under construction on top priority of the state (SCDOT STIP DDR, 2021).

The Texas Department of Transportation uses Advance Planning Risk Analysis (APRA), which is the only available tool to measure the completeness of the Project Scoping Process (PSP). Although the STAs keep track of scope items, specifically change orders, they lack formal and standard practices to measure the effectiveness of scoping activities. Less than 20 per of STAs have some techniques to measure the effectiveness of project scoping (Anderson et al., 2016).

2.4.2.2. SCDOT Professional Services Consultants – Procurement (Pre-Award)

Based on a survey conducted on the procurement of professional services consultants by Bausman et al. 2021, about 52% of the consultant firms indicated that the practice was inconsistent with the advertisement of RFPs. Similarly, only slightly over half of the responding firms thought that project scope and objectives were clearly defined prior to award. However, a large number of respondents indicated that the project scope and objective were only sometimes well defined (42% and 36%, respectively). A similar trend was observed for project deliverables; about 42% of respondents indicated that project deliverables were consistent, whereas the remaining believed there were inconsistencies.

Furthermore, the survey also measured the frequency response for the timeliness of contract negotiations. Almost two-thirds (68%) of the respondents thought that contract negotiations were seldom or almost never completed timely. In conclusion, the professional services consultants participating in the survey strongly believed that bundling design RFPs would promote procurement efficiency. Based on the indications by the professional services consultants regarding the procurement process, the consulting firms firmly believed that the current practices were inefficient and inconsistent. Furthermore, the consulting firms thought that necessary steps should be taken by the SCDOT to improve the consistency in defining and developing project scope and enhance the overall procurement process for Professional Services Consultants.

2.4.2.3. Project Scoping

The project scoping process is defined 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 STIP to minimize the risk of change and project overruns during detailed design

(Kermanshachi, Anderson, Goodrum, & Taylor, 2017). (Kermanshachi, Anderson, Goodrum, & Taylor, 2017) discusses the project scoping process (PSP) improvements to achieve on-time and on-budget project delivery of highway projects. The delay in schedule and increase in costs of highway projects are due to an increase or change in scope (Bejleri, Roaza, Thomas, Turton, & Zwick, 2003).

The proposed framework in a study by Kermanshachi and colleagues presents practices that help DOTs improve the scoping process (Kermanshachi, Anderson, Goodrum, & Taylor, 2017). They argue that the lack of adequate scope definition in DOTs causes delays and cost overruns once the project is programmed in TIP or STIP. Mismatches between projected and actual funding cause delays, increase cost, and may not be addressed due to lack of funding (Redd & McDowell, 2013). The challenges identified in this study in developing scope are the time to project scopes, cost or funding for project scoping activities, training on project scoping process, communication of project scoping issues, clarity of expected outcomes of the project scoping, framing or understanding the project itself, qualified personnel to prepare project scopes, formal documented scoping process (Kermanshachi, Anderson, Goodrum, & Taylor, 2017). The research team recommends the following practices to develop the project scope

- Project purpose and needs
- Improvement and requirement studies
- Right-of-way considerations
- Proposed project limits and rough schematics
- Project benefit-to-cost and feasibility studies
- Environmental issues
- Public involvement and participation plan and
- Integrity conditions (i.e., quality and serviceability of the physical transportation infrastructure)

In their evaluation of the current practices of PSP in the highway industry, Kermanshachi et al. developed a multi-level project scoping model for transportation projects. Specifically, they used resources from the literature to assess current industry practices for the development of alternative scoping processes. They then used the integrated definition modeling technique to develop these scoping processes. Their proposed scoping model consisted of four levels, composed of 20 activities and 84 sub-activities. Indeed, the development of such a comprehensive and detailed project scoping process model led to the adoption of appropriate best practices and strategies, which reduced costly scope changes and prevented unnecessary project delays (Kermanshachi et al., 2019).

2.4.2.4. Decision Tree (DT) Variables

The Decision Tree (DT) Variables, also referred to as DT items, is a comprehensive list of factors that affect the decision-making process during the development of SOS on a project-specific level. These DT variables are both dependent and independent and will serve as a checklist for the users to customize the SOS as per project needs.

The aim of these DT items is to provide the DOT with a comprehensive list of services enabling them to make decisions on certain tasks, subtasks, or deliverables to be requested from the consultant on a particular project. For examples, if the DOT performs Field Survey in-house, the DT variable 'Field Survey' will eliminate the appropriate scope language from the rest of the SOS. The ability of using this logical decision making process in the development of standard and customizable SOS is pivotal to the success of the overall procurement of the Professional Services Consultants on DOT projects.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1. General Research Strategy

The purpose of this research study is to streamline and update the South Carolina Department of Transportation's (SCDOT) Scope of Services (SOS) and enhance and improve the existing professional consultant services procurement and negotiation process. According to the SCDOT's Professional Services Contracting Office, the average preparation of the SOS is 47 to 84 days, which increases the procurement time drastically. However, the data also reveals that if the scoping phase is kept at less than 50 days, it significantly reduces procurement time. To address these overarching issues, this research study aims at streamlining and updating the SOS for consultant procurement and that could be used by other state DOTs. This research study is categorized as explanatory because the researcher seeks to explain the relationship between SOS and its effects on the consultant procurement process. The main purpose is to identify current SOS practices, identify the challenges and understand whether these practices affect and influence the consultant procurement process by reducing scope negotiations and overall timeframe on DOT projects.

3.2. Specific Research Questions

Developing specific research questions requires a comprehensive literature review in order to understand and identify specific problems, issues, current practices, and research gaps. Therefore, the researcher performed detailed review of the related literatures and publications to identify the gaps in the existing studies. This identification of gap helped the researcher develop a specific research design based on the information to gather data by developing survey questionnaire and interview questions. The final step was to validate the association between SOS practices and consultant procurement performance from the studies.

The primary research questions for this study are as follows:

1. What are the key components of the consultant SOS?
2. What practices of the comparable State Transportation Agencies (STAs) will help streamline the South Carolina Department of Transportation's SOS Development Process?
3. How do the comparable STA practices influence or affect the Professional Services Consultant (PSC) Procurement Performance (in terms of time and cost) in successful delivery of the project?
4. How could Decision Tree (DT) variables affect the current SOS development and aid in more efficient and effective procurement of Professional Services Consultants?

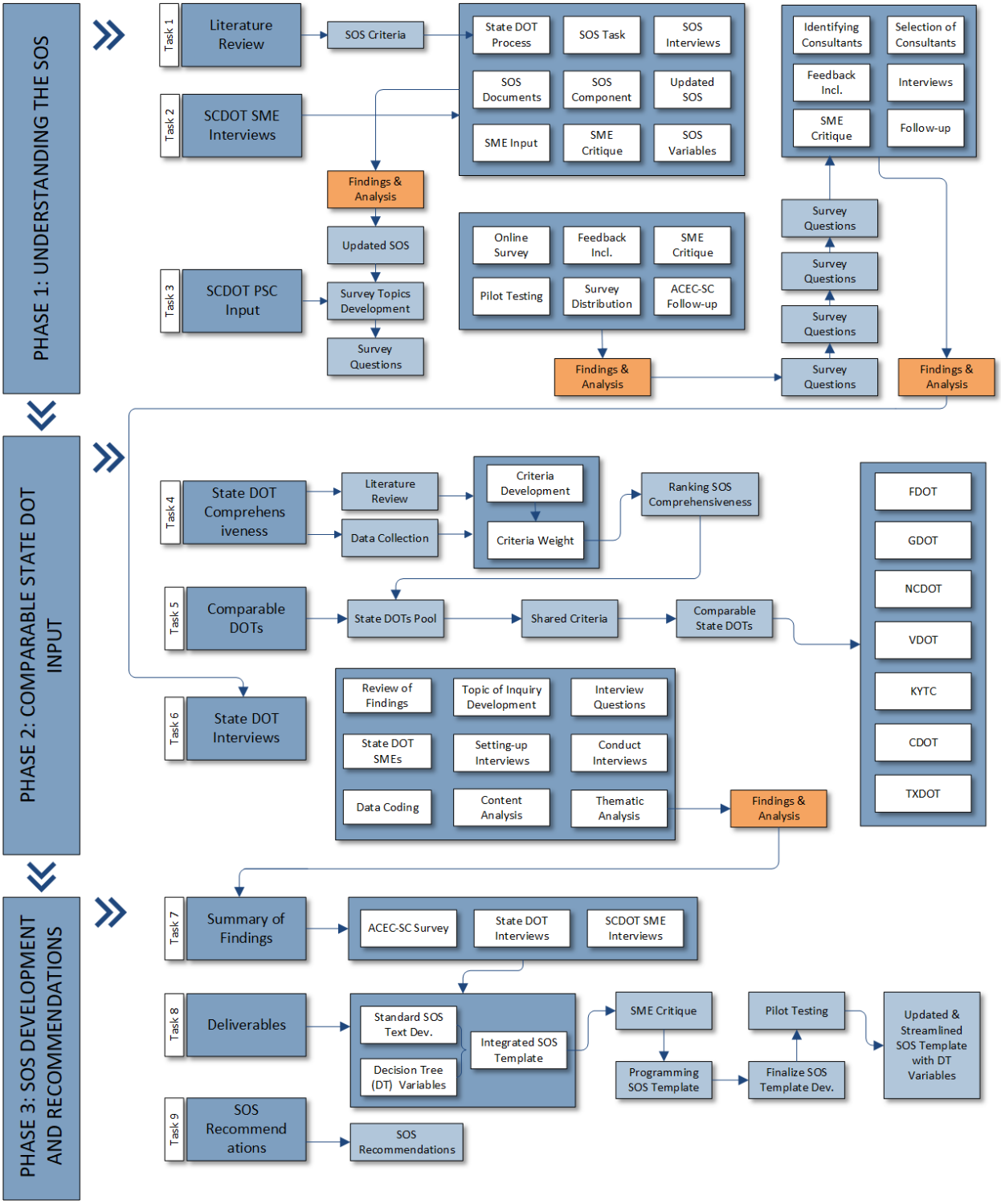

Figure 3. Research Methodology Map

3.3. Specific Research Design

The research design proposed for this study is based on the nature of data collection. The researcher will conduct computer-aided surveys and interviews with various subject matter experts. The data obtained from these research methods are expected to be explanatory in nature. Therefore, the researcher has selected an Exploratory Sequential Design (Mixed method Research Design) for this study as this design uses qualitative strand to explain quantitative results. Secondary data of state DOTs and studies and publications by reputable organizations in transportation is collected to evaluate the current state of practice in SOS and identify updated practices. Preliminary semi-structured interviews were conducted online with SCDOT's subject matter experts (SME) of each department and/or functional unit involved in SOS to identify the current SOS and of the organization as well as its issues. A computer-assisted self-administered questionnaire is selected by the researcher to identify SOS practices and its relation to procurement of professional consultant services on state DOT projects. Online Structured interviews with comparable state DOTs of SCDOT are conducted by the researcher to probe deeper in identifying and explaining the relationship between SOS development and performance of procurement of professional consultant services on the projects. The mixed method research design for this study is discussed in detail in the following sections which represent the whole research design layout or map (see Figure 3). The proposed methodology for this research study will be completed in three phases comprising a total of nine (9) tasks.

3.3.1. Phase 1: Investigation of SCDOT Scope of Services

The research methodology is shown in Figure 4. In Phase 1 of the SCDOT SOS, there are three tasks: literature review, SCDOT preliminary interviews, and gathering input from SCDOT's professional services consultant (PSC) concerning the agency's current SOS process.

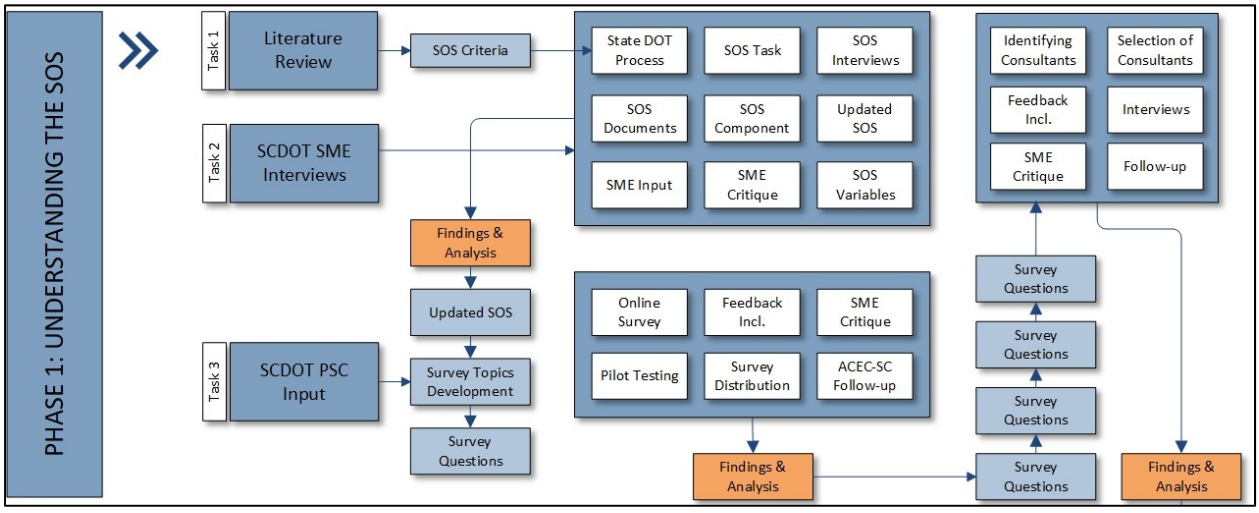

Figure 4. Research Methodology Phase 1: Understanding the SCDOT SOS

Task 1: Literature Review

The literature review is summarized in detail in the literature review section. The purpose of the literature review in SOS is to help the researcher identify related gaps and understand the problems, issues, research questions, and current practices for the objective of this study. Another purpose was to develop a specific research design based on the information collected to develop a survey questionnaire and interview questions for the state DOTs to gather data.

The literature review also provides theories and concepts related to SOS and its stages and components. These concepts are used to explore the knowledge gap related to SOS and aid in streamlining and updating the current SOS practices for SCDOT and other state DOTs. Finally, the literature review also provides SOS criteria to determine the state DOTs' SOS comprehensiveness.

Task 2: SCDOT SME Preliminary Exploratory Semi-Structured Interviews

Preliminary exploratory semi-structured interviews were conducted online with the SCDOT's subject matter experts (SME). These SMEs selected for interviews were from each department and/or functional unit involved in SOS. The primary focus of these interviews was to identify current SOS practices, problems, issues, and challenges the organization faces. To begin with, the SCDOT provided documentation regarding SOS including previously executed contract scopes. Although the scope documents were inconsistent, they provided the researcher with a baseline to explore various activities and departments involved in a project. Sixteen subject matter experts from 18 different departments and/ or functional units were interviewed. These departments and/ or functional units are Project Management, Field Surveys, Environmental, Permitting and Compliance, Public Involvement, Traffic, Utility, Railroad, Right-of-Way, Design, Construction Phase Services, and Professional Services. Besides, the SCDOT steering committee members and regional production group (RPG) leaders also participated consistently during the interview process. The interviews were semi-structured in nature with open-ended questions. The interview questions template is attached in Appendix A. The purpose of the preliminary interview with the SCDOT SMEs was to:

- Identify and document SCDOT current SOS
- Document current SOS tasks and subtasks
- Identify roles and responsibilities of each department and/or functional unit
- Identify activities in SOS associated with each department and/or functional unit
- Accessing, collecting, and examining SCDOT's SOS practices, policies, reports, studies, and other relevant material
- Identifying SCDOT SOS based on project type, program type, and funding source
- Identifying SOS tasks and subtasks that need to be revisited under negotiation process

- Identifying primary factors influencing the variance between estimated and actual performance related to professional services consultants' procurement process
- Identifying performance measurement and areas for improvement

Detailed analysis of the interviews and methodology will be discussed in the final dissertation paper. The SMEs validated the findings based on the preliminary interviews, transcripts, and summaries. In addition, the preliminary interviews also helped identify the driving factors, termed as Decision Tree variables, which were crucial in the development and updating of the current SOS.

Task 3a: Professional Services Consultants Assessment of SCDOT SOS

After receiving and analyzing the information and input from the SCDOT SMEs from various department and/or functional units, the researcher devised a survey questionnaire aimed at gathering insights from the professional services consultants. The goal was to obtain feedback regarding the SCDOT's SOS from consultants that have, or currently are, providing services on SCDOT Turnkey Projects. It was essential to aid improvement and promote consistency of SCDOT's SOS for procurement of professional services.

The unit of analysis for this survey is based on the organization level, which is SCDOT professional services partner firms. The target population is SCDOTs professional services that have or are in the process of development of SOS or specific component of it. For example, a geotechnical consulting firm has or is in the process of developing SOS on SCDOT projects. The sampling frame for this survey is a list of all professional services companies provided by American Council of Engineering Companies – South Carolina (ACEC-SC) currently providing their services to SCDOT. The survey design for SCDOT professional services input is cross-sectional, meaning the data on the sample of respondents will be gathered at one point in time.

To effectively distribute and receive feedback from the respondents, and reduce resources (time and cost), the researcher opted for computer-aided self-administered surveys. The questionnaire was developed, and pilot tested with the SCDOT SMEs prior to the distribution to the survey sample population. These responses from the SCDOT SMEs were eliminated from the final responses. The researcher also provided a brief introduction about the purpose of this survey to all the participants taking this survey. Follow-ups were sent to the participants four weeks after the survey distribution.

The survey questionnaire covered topics that include company information, SCDOT SOS negotiation process, SCDOT contract fee negotiation process, and procurement duration.

Task 3b: Consultant Interviews

Although the survey topics covered range of questions that helped gather vital information about SCDOT's SOS and Procurement Process, it was essential to investigate deeper on these topics and gather more information. Therefore, the researcher proposed to conduct interviews with select consulting firms with expertise in different areas. These professional services consultants had expertise in NEPA and Permitting, SUE and Utility Coordination, Geotechnical Investigations, Environmental, Right-of-Way, and Field Surveys. The identification and selection of eight such professional consulting firms were made with the guidance of SCDOT.

The purpose of these interviews was to:

- Gain insights on special consultant services
- Understand current SCDOT practices for scope development and fee negotiations on bridge and corridor improvement projects
- Provide project variables and/or services that are often a challenge to define/resolve the SOS
- Seek recommendations and areas of improvement
- Understand SOS practices followed by other state DOTs

In addition, the consultants participating in these interviews were also provided with the SOS updated in Task 2. They were asked to provide input and feedback related to their area of expertise. Follow-ups were sent to the consultants three week later to the day when the interviews were conducted. These interviews were semi-structured in nature. The data was collected and analyzed by the researcher and will be discussed in the final dissertation paper. The data was also validated by the SCDOT SMEs, and it was used to further streamline and update the SOS.

3.3.2. Phase 2: Comparable State DOTs' current practices

After the successful completion of Phase 1, the researcher identified the necessary components of SOS and updated the current SOS with the help of SCDOT SMEs and Professional Services Consultants' input. In both Phase 1 and 2, the researcher developed a methodology to investigate and evaluate the development of Professional Services Consultant SOS by comparable DOTs. Figure 5 shows three tasks in Phase 2, including state DOTs comprehensiveness, identification of comparable DOTs, and state DOT interviews.

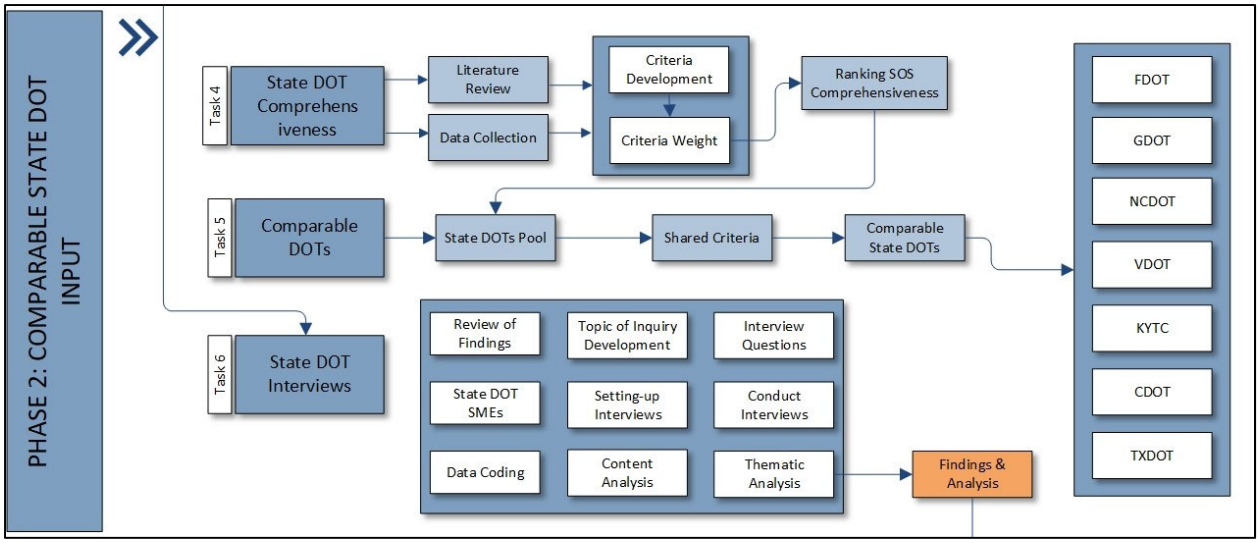

Figure 5. Research Methodology Phase 2: Comparable State DOT Input

A two-tiered systematic approach to identify comparable state DOTs to SCDOT is proposed: 'Evaluation of State DOTs SOS Comprehensiveness' and 'Identification of Comparable State DOTs.' What follows is a brief description of this two-tiered systematic approach (task 4 and task 5, see figure 5) with their steps. This evaluation process resulted in selecting seven state DOTs that have: 1) a defined scope of services process and 2) an organizational structure, approach, and transportation responsibilities comparable to SCDOT. Detailed identification of comparable state DOTs and findings and analysis of the interviews of comparable state DOTs are discussed in Chapter 4.

3.3.3. Phase 3: SOS Development and Recommendations

In Phase 3, the researcher developed a summary of findings and analysis based on previous phases of research. This data was used in the identification of Decision Tree (DT) variables, development of streamlined and updated SOS, and preparing deliverables.

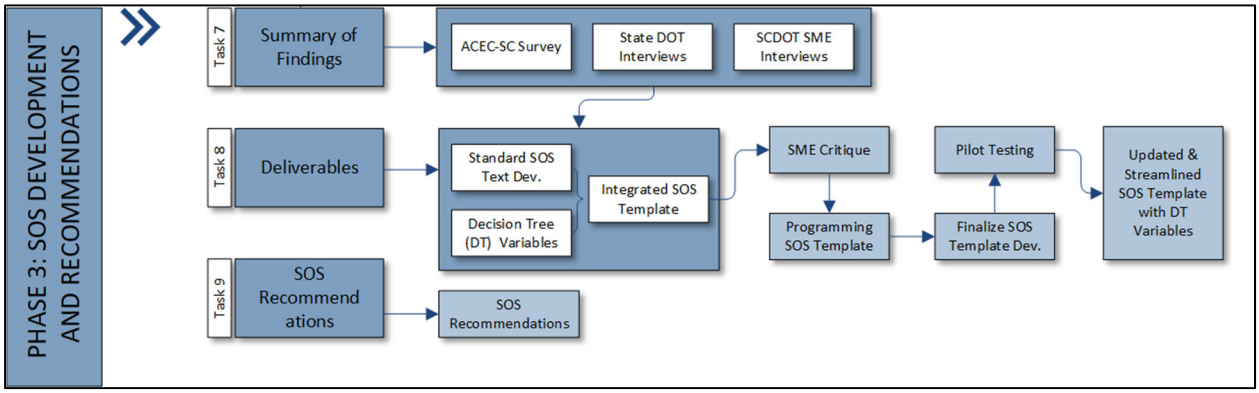

Figure 6. Research Methodology Phase 3: SOS Development and Recommendations

Data Analysis

To analyze the interview data, the research team performed content analysis and thematic analysis. Through content analysis, the qualitative data will be systematically transformed into a concise and organized summary. In addition, the data were divided into codes, labels, categories, and themes. The data from the interview transcripts were used to find association between topics and their descriptions. The data analysis report presented in the next chapter has a quantitative section followed by a qualitative section that will provide a clear understanding of the significance of the relationship between the variables of the study.

The data analyzed was then used to streamline and update SCDOT's SOS. In this process, the researcher identified the Decision Tree (DT) variables of bridge and corridor improvement projects. To aid this effort, the researcher used the feedback received from the SCDOT SMEs, professional services consultants, and comparable state DOTs to develop a list of DT variables. The list of DT variables was validated with the SCDOT SMEs for its effects on specific SOS tasks and subtasks.

The research team incorporated all the input and feedback received in Phase 1 and 2 to develop a standard scope language. The SOS language was validated and approved SCDOT SMEs. Similarly, once the DT variables were identified and validated, the researchers linked these DT variables with the SOS tasks and subtasks. After the linkage of DT variables, the team performed an internal pilot test to measure the effect of the DT variables on the scope language, its accuracy in eliminating customizing the SOS, and replacing the eliminated portion with an alternative text to identify the changes made in the process. The pilot test (both internally and by SCDOT) was performed using a web-based checklist containing all the identified DT variables. This checklist was linked with a python-based program responsible for performing changes based on the input provided by the researcher. This combined effort will assist the SCDOT Project Managers and SMEs in developing a tailor-fit SOS based on project requirements.

Recommendations

This section presents the SOS best practices based on expected findings and proposed analysis, which will be discussed in Chapter 5.

3.4. Summary of Design and Methodology

This chapter discussed the methodology of the research study (Research Design) and how it is conducted. This research study is categorized as exploratory because it seeks to identify SOS best practices to streamline a State DOT's SOS to improve overall professional services consultants' procurement process. Figure 3 shows the Research Design and Methodology Map for this research study, discussed in detail in this chapter. The proposed methodology (Figure 3) for this research study is completed in three phases comprising eight tasks.

CHAPTER 4: RESEARCH FINDINGS AND ANALYSIS

This chapter discusses, describes, and presents the findings and analysis of four research phases described in Chapter 3. These phases are: a) Phase 1, Investigate and update the South Carolina Department of Transportation's Scope of Services (SCDOT SOS) Process, Current Best Practices, including SCDOT preliminary exploratory interviews and obtaining input from SCDOT's professional services delivery partners concerning the agency's current SOS, b) Phase 2, the Comparable States' Department of Transportation input concerning SOS Process, and c) Phase 3, States' Department of Transportation Scope of Services Best Practices. What follows is a description of these phases' findings and analysis.

4.1. Findings and Analysis: Phase 1 – Investigate SCDOT SOS and Consultants' Input

Preliminary Exploratory Interviews with SCDOT SMEs were conducted to: 1) investigate, understand, and map SCDOT's preconstruction activities and development sequence to document current SOS practices, and 2) during SME mapping of current practices, identify areas for improvement. This exercise provided guidance to determine key SOS tasks, sub-tasks, and activity sequences for the agency's various program/project types, funding source(s), and environmental impacts. Ultimately, the goal of the preliminary interviews with SCDOT SMEs was to:

a. Understand, identify, and document the current SCDOT SOS tasks and subtasks, and practices.
b. Seek the SME's constructive critique of the overall procurement process and solicit suggestions to streamline the procurement and consultant scoping process.
c. Seek additional insight from the industry Consultants regarding SCDOT's procurement and SOS process and obtain suggestions for improvement.
d. Identify SOS areas for improvement to pave the way for improving and streamlining SCDOT's SOS, which is the ultimate goal of this research study.

A five-step methodology was developed to guide the mapping process of SOS, shown in Figure 7. The initial step was a thorough review of state DOTs' SOS and related literature. The next step involved developing topics of inquiry for the key components/tasks in SOS. These inquiry topics were then used to guide interviews with the SMEs from departments and functional units of the SCDOT, serving as the focus of this study. Data were collected, coded to gather necessary information, and analyzed to prepare SOS flowcharts for the agency. These flowchart tasks were then validated through a two-day focus group with a SCDOT leadership team. After incorporating the workshop's input, the researcher mapped SOS flowcharts for the SCDOT based on program/project type, funding source, and environmental requirements.

The first step for this Phase was to complete a thorough review of publications, research papers, and studies concerning the SOS for transportation projects to gain a comprehensive understanding of the SOS. Special emphasis was placed on studies and publications from state DOTs and related industry and professional organizations, including FHWA, AASHTO, TRB, and the NCHRP. The research team also examined state DOTs' websites to obtain relevant information on the agency's project development process, organization, training, and execution.

Online data relating to the SOS from twenty-six (26) state DOTs were collected and reviewed to identify SOS components, tasks, and sub-tasks. The remaining twenty-four (24) states did not have substantive information relating to their SOS available online. The researcher also explored the extent of the state's system, and the agency's organizational structure, gained insight into the impact that the funding source had on the state DOT's process, and sought to identify any pending modifications to SCDOT's SOS.

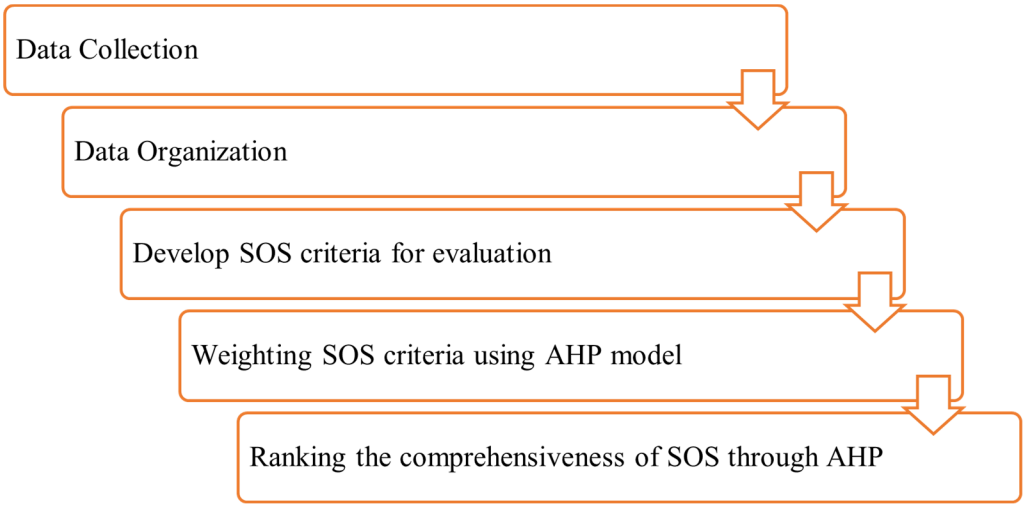

Figure 7. SCDOT SOS Mapping Process Methodology

The identification of current SOS practices utilized by the SCDOT for this study entailed two sequential activities: a) review of the SCDOT's SOS documented processes and practices, and b) gain insight from the SMEs of each functional unit regarding their role in the SOS and the unit's relationship with other functional units and departments. An overview of the investigative process for each activity is as follows:

Subsequent to the literature search, the next step in the research process was to investigate the state agency's development process that serves as the 'case study' – hereafter referred to as the 'SCDOT.' The research team collected and examined SCDOT's SOS documentation regarding practices, policies, reports, studies, and other relevant material for each program and project type of project development. Information and documentation regarding the SCDOT organization structure, personnel responsibilities, critical tasks, control activities, communication/coordination, and reporting was examined. SCDOT's approach and scheduling software utilized for SOS

planning and management were identified and investigated. SCDOT's organizational structure and functional departments were identified in preparation for the next step of the investigative process.

This step involved developing a detailed listing of topics for the inquiry to understand the activities and process flow of the SCDOT. The topics were developed after studying SOS components, tasks, and activities of SCDOT and other state DOTs and identifying important components relevant to this study. Subsequent to the identification of the major SOS components, a list of questions was prepared for each functional unit regarding: a) their role and activities in the SOS, b) the unit's interaction with other functional units, c) the timing and sequence of their SOS activities, d) steps taken to monitor and track their performance, and e) the impact that various projects and program type and funding source had on the SOS activities. The topics of inquiry alongside the SCDOT SME interview questions are attached in Appendix A.

The team then met with SCDOT's leadership team to review the agency's organizational structure and functional departments to identify the most appropriate SMEs to provide the department's SOS activities, roles, responsibilities, and suggestions for improving the process. Twenty-eight (28) SMEs from twenty-two (22) functional units were identified as candidates for the interview process.

Over the course of approximately two months, semi-structured interviews were conducted with the twenty-eight (28) SMEs (Table 1). Prior to each session with the SME(s), an interview outline was developed that was tailored to the interviewee's functional unit, as previously noted. However, consistent general themes addressed during all the interviews included:

- Introduction and review of the purpose of the SOS research and the interviews to gain their understanding and support.
- SOS role(s), responsibilities, and execution timing.
- Functional department organization and involvement in the SOS.
- Interaction with other functional departments during the SOS.
- How their role(s) was impacted by project type, program type, and funding source.
- Performance metrics tracked.
- Suggestions for improvement of the SOS.
- Collection of any additional process documentation.

Each interview lasted approximately 1½ to 2 hours. With the interviewee's permission (s), each session was recorded to ensure comprehensive capture of their input and efficiently utilize the interviewee's time (s). Additional SOS documentation was identified and noted for collection after the interview process. Following each interview, a complete transcript was developed that was subsequently analyzed and summarized by theme/category using Content and Thematic forms of Analysis. The content and thematic analysis led the researcher to organize and map the SME input

by flowchart task to supplement and clarify the SOS information previously assembled during an examination of the agency's SOS documentation.

4.1.1. Develop Initial Baseline Scope of Services (SOS)

Once the SCDOT process documentation and SMEs input were summarized, analyzed, organized, and evaluated, the researcher then developed a 'baseline' SOS (See Appendix B). At the beginning, 15 different scopes of services from previously contracted SCDOT projects were reviewed and evaluated for their consistent scope tasks and sub-tasks on similar projects. Followed by the review of these documents, a list of tasks and subtasks were compared for Bridge Replacement and Corridor Improvement Projects. The tasks, subtasks, and deliverables of these scope of services were then compared with the help of SCDOT SMEs during the interview process and through further consultations and inputs. This effort was spearheaded by the research team along with a consultant firm on the project and the SCDOT Steering Committee. A total of 28 SMEs were involved in the development and finalization of the SOS template. Initially, the SMEs had differences in terms of perceiving the final SOS template, but those differences were resolved after conducting a series of interviews which helped understand the purpose of developing the SOS template.

Table 1 SCDOT Interviewed Subject Matter Experts

Department/Functional Unit	Number of SME(s)	Title
Project Organization and Management	3	Program Manager
Field Surveys	1	Manager
Environmental Documentation	2	Director
Environmental Permitting	2	Manager
Environmental Compliance	2	Manager
Public Involvement	1	Coordinator
Subsurface Utility Engineering (SUE)	1	Manager
Bridge/Structural Design	2	Engineer
Bridge Load Ratings	1	Engineer
Roadway Design	4	Engineer
Traffic Analysis & Design	1	Engineer
Hydrology & Hydraulic Design	1	Engineer
Geotechnical Engineering	2	Engineer
Utility Coordination	1	Manager
Railroad Coordination	1	Manager
Construction Phase Services	1	Engineer
Right of Way Services	1	Manager
Professional Services	1	Manager
Total Interviewed	**28**	

4.1.2. Finalize Initial SOS Template

After completion of the interviews with the SCDOT SMEs, feedback on the initial SOS draft template was collected. Follow-up interviews were conducted to precisely understand the issues pertaining to the tasks and their interdependencies on other tasks and departments. Once the data collection was complete, the research team then categorically defined these issues and called them Decision Tree Variables, as these variables had varying degrees of effects on the overall SOS.

4.1.3. SCDOT Professional Services Consultants Input

Professional Services Consultants (PSCs) are significant and vital to the SOS of most state DOTs (Bausman et al., 2014). The use of consultants in the SOS in state DOTs is increasing due to several factors, including increased funding and corresponding state DOT workload, insufficient in-house resources or technical ability, and project complexity. PSCs are the state DOT's delivery partners, and their input is essential to help evaluate current practices and identify change(s) that could drive improvement in the development process.

In this task, input from SCDOT delivery partners (PSCs) involved in the SOS was solicited to identify strengths and weaknesses in the current SOS and obtain suggestions for improvement via a computer-assisted self-administered questionnaire. The questionnaire focused on the effectiveness and efficiency of SCDOT's SOS related to the PSC's interaction and execution. Consultants were asked to provide suggestions for improvement of the SOS. What follows is the input from SCDOT's delivery partners along with its findings and analysis.

Gathering input was an essential step (see Figure 8) in this research effort to gain feedback on the SCDOT's process from professional services consultants providing engineering and consultant services to the agency during project development. The objective of this task of research was to seek the input of SCDOT's delivery partners, the professional services consultants, to help the agency improve and streamline its SOS. The PSC survey's primary topics of interest were to gain insight regarding the agency's: a) project scoping process, and b) negotiations of SOS and procurement of professional service consultants.

The unit of analysis for this consultant survey was "organizations" that were professional services consultants. The target population was professional service consultants that have been, or currently are, providing consultant services for SCDOT's project scoping process. The sampling frame for this survey was professional service planners and project developers that are members of the American Council of Engineering Companies of South Carolina (ACEC-SC). The survey design for SCDOT professional services input was cross-sectional.

Nationally, ACEC represents engineers, architects, land surveyors, and other specialists. This national organization has state chapters across the U.S. To gain membership in the ACEC-SC, firms must be certified by the SC State Board of Registration for Professional Engineers and Surveyors. Firms in ACEC-SC are classified into two different categories: Member firms and Affiliate Members. At the time of this survey, there were 82 Member firms and 17 Affiliate Members. It was anticipated that many of the firms in the selected population have multiple engineers from the company that have provided services or who are currently engaged to provide SOS services to the agency. Therefore, SC-ACEC member firms were asked to: a) limit their survey response to one per firm and b) provide a survey response that was representative of the collective experience and insight of the firm.

Data collection for this task was obtained from a computer-assisted self-administered online survey. A detailed questionnaire containing forty-four (44) questions was developed for the survey. The questionnaire was subdivided into seven primary topics. The first section involved general questions addressing services the firm provides SCDOT, the firm's primary area(s) of operation, number of full-time professional employees, percentage of the firm's annual volume in transportation services (federal/state/local), and the percentage of their transportation services for SCDOT. The remaining three sections of the questionnaire addressed: a) the state DOT's SOS negotiation process, b) the state DOT's contract fee negotiation process, and c) the state DOT's procurement process duration. PSCs were also asked for suggestions for improvement concerning both sections. The professional services consultant's questionnaire is shown in Table 2. The development of the individual questions was an eight-step process. Similar to the national state DOT survey, it was developed subsequent to a comprehensive literature review and the SCDOT Exploratory Interviews with twenty-eight (28) SMEs from eighteen (18) different functional units within the SCDOT (Table 1).

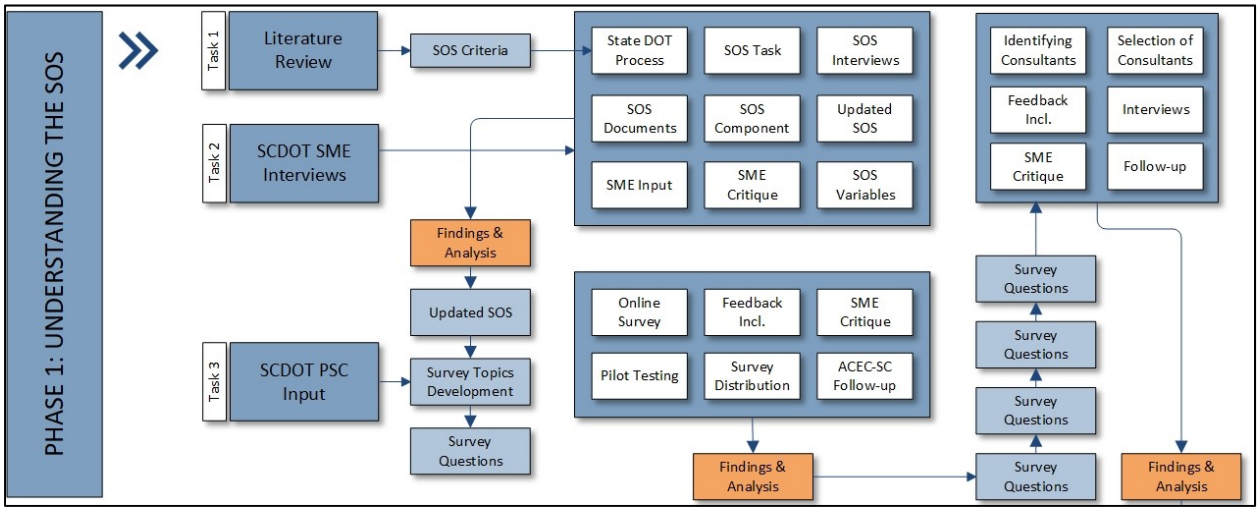

Figure 8. Research Methodology Phase 1: Professional Services Consultants Input

Once the preceding data was collected, organized, and analyzed, the survey topics and individual questions were developed. This first draft of the questionnaire developed was then subjected to three rounds of critique by subject matter experts from academic, consulting, and practicing transportation professionals. Comments and suggested edits received during each pass were addressed and incorporated as necessary before each succeeding review. The final draft of the questionnaire was then formatted on an online survey site, and pilot tested. A group of academic professionals, SMEs from the industry, and SCDOT department/functional leaders pilot tested the online survey, and their feedback was addressed before finalizing the online survey.

A request to distribute the survey was sent to the state chapter of the ACEC by SCDOT's preconstruction department head. The email solicitation provided a brief overview of the survey, the primary topics of interest, the approximate time to complete, and the survey link. The initial request, subsequent distribution, and follow-up by ACEC to their membership was in March, April, and early May 2021.

Table 2 ACEC-SC Consultant Survey Questions and Responses Coding for Analysis

Questions	Code	Response Code				
Company Information		**(Note: Exclude Design-Build and CE&I Projects in your response)**				
Type of Services Provided for SCDOT	Q1	Engineering Design (1)	Specialty Services (2)	Other (3)		
Type of Role served on SCDOT turnkey projects	Q2	Prime (1)	Sub (2)			
Primary Area of Operation	Q3	South Carolina (1)	Regional (2)	National (3)		
Annual Volume in Transportation	Q4	Percentage (%)				
SCDOT Scope of Service Negotiation Process		**Likert Scale: Level of Frequency (Almost Never-Almost Always)**				
The negotiation process for scope of services is consistent from Program Manager to Program Manager.	Q5.1	1	2	3	4	5
The SCDOT Scope of Services Negotiation Process is handled consistently by each RPG within the Agency.	Q5.2	1	2	3	4	5
The SCDOT Scope of Services Negotiation Process is handled consistently by each Department (Traffic, Survey, Utility Coordination, etc.) within the Agency.	Q5.3	1	2	3	4	5
Consultants typically assume that the initial scope of services provided by SCDOT is accurate and necessary for the project.	Q5.4	1	2	3	4	5
SCDOT's review(s) and feedback to consultants during the negotiation process for the scope of services is prompt.	Q5.5	1	2	3	4	5
SCDOT provides adequate training on the agency's procurement process for professional services consultants.	Q5.6	1	2	3	4	5
Overall, the negotiation process for the scope of services is typically efficient and effective.	Q5.7	1	2	3	4	5
The initial scope of services provided by the SCDOT is consistent with the services identified in the RFP.	Q5.8	1	2	3	4	5
Meeting, face-to-face or virtually, during the negotiation process to discuss & resolve scope of services issues is more efficient than trading comments/edits via email.	Q5.9	1	2	3	4	5
SCDOT Project 'background' information and key project decisions are shared with the Consultant.	Q5.10	1	2	3	4	5
Consultants typically have a sufficient understanding of the scope at the onset of negotiations.	Q5.11	1	2	3	4	5
SCDOT Program Managers typically have sufficient understanding of the scope at the onset of negotiations.	Q5.12	1	2	3	4	5

SCDOT Technical Staff (Design Disciplines, Traffic, Survey, etc.) typically have a sufficient understanding of the scope at the onset of the negotiations.	Q5.13	1	2	3	4	5
SCDOT scope documents are consistent for similar project types.	Q5.14	1	2	3	4	5
Consultants are encouraged to suggest changes to the project scope based on their knowledge/experience with the project type.	Q5.15	1	2	3	4	5
Overall, the negotiation process for scope of services is completed in a timely fashion.	Q5.16	1	2	3	4	5
SCDOT Contract Fee Negotiation Process		**Likert Scale: Level of Agreement/Disagreement (Strongly Disagree–Strongly Agree)**				
Negotiation of the estimated cost for the professional services is completed in a timely fashion.	Q7.1	1	2	3	4	5
Reaching agreement on the cost of services is an efficient process.	Q7.2	1	2	3	4	5
The fee negotiation process results in a fair and reasonable fee for the project.	Q7.3	1	2	3	4	5
SCDOT's negotiation process is consistently administered/managed from RPG to RPG.	Q7.4	1	2	3	4	5
Once negotiation of consultant fee(s) is finalized, the contract & NTP are issued in a timely fashion.	Q7.5	1	2	3	4	5
During fee negotiations the scope of services is revisited multiple times.	Q7.6	1	2	3	4	5
SCDOT Procurement Process – Duration(s)		**(Enter in whole months the typical duration & duration range on SCDOT projects for the following)**				
		Typical (mos.)		Lowest		Highest
Consultant selection after submission of proposals.	Q9.1					
Scope of Services negotiation.	Q9.2					
Estimation and negotiation of the cost of services.	Q9.3					
Receipt of a NTP once contract negotiations are completed.	Q9.4					
The overall duration from proposal submission to an NTP.	Q9.5					

Most of the survey questions were structured with Likert scale response options to provide interval data for testing. Statistical tests incorporated a confidence level of 95% and ANOVA tests with an $\alpha = 0.05$, assuming unequal variances were conducted between respondent groupings when appropriate. Table 2 shows the survey questions and responses coding that is used for the analysis. Ninety (90) firms responded to the survey. Ten participants provided input for only the 'general' section of the survey. From the remaining eighty (80) firms, thirty-three (33) firms sporadically completed the questionnaire and provided input regarding the procurement and execution of professional services consultants yielding a (47/90) 42.22% [complete] response rate for questions structured to permit statistical testing.

Thirty-seven percent (37%) of the responding firms indicated that they operated nationally, 42% were Southeast regional firms, and 21% limited their area of operation to the SC (Figure 9). Sixty-one percent (61%) of the engineering design services firms indicated that their operation area was regional and state bound. In comparison, thirty-seven percent (37%) of the engineering design services firms provided services across the nation. Combined, 66% of the total respondents performed engineering design services. Twenty-five percent (25%) of the firms providing engineering services also provided 'specialty' services to support design. Approximately half (50.7%) of the total responding firms operating at national, regional, and state levels combined have more than 50% of their company's annual volume in transportation, whereas the majority (64.3%) of the regional firms have more than 50% of their annual company volume in transportation.

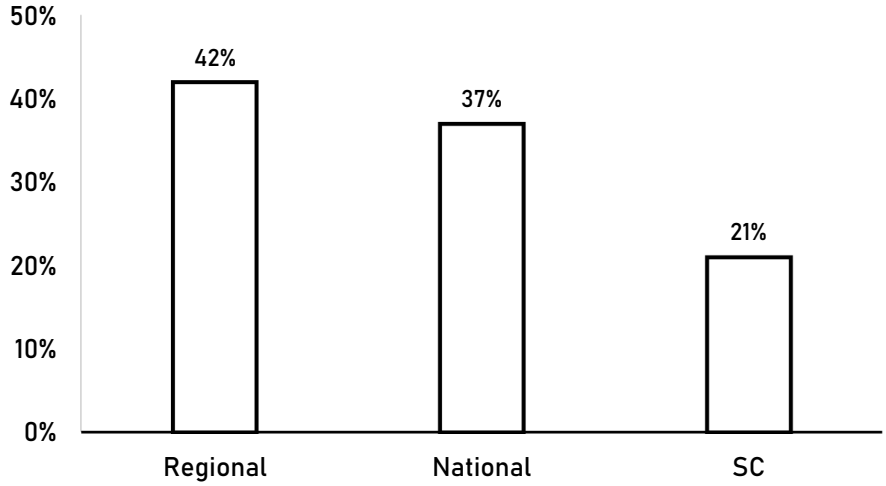

Figure 9. PSCs Area of Operation (%)

Respondents were asked to provide the approximate percentage of the firm's annual volume for transportation services on federal, state, or local projects. Respondents were asked to provide the percentage of their transportation work with SCDOT, and the percentage of their annual volume.

Over half (50.7%) of the total responding firms operating at national, regional, and state levels combined have more than 50% of their company's annual volume in transportation, whereas the majority (64.3%) of the regional firms have more than 50% of their annual company volume in transportation. Survey participants were then asked a series of questions concerning both the SCDOT's SOS negotiation process for the procurement of professional services and the agency's contract fee negotiation process pre-award. The survey respondents were also asked to indicate the typical, lowest, and highest durations in months, required to complete the negotiation process. The findings are addressed as follows:

4.1.4. Professional Services Consultants – SOS Negotiation Process

The questionnaire asked a series of questions (sixteen) that focused on the SOS negotiation process for the professional services consultants' procurement. The investigation topics ranged from the advertisement of services in the RFP, consistent scope negotiation process adherence among the program manager and by the RPGs within the agency, understanding of the scope at the onset of negotiations, and the timeliness in completion of the scope negotiation process. More than two-third (69.8%) of the respondents agreed or strongly agreed that the initial SOS provided by the SCDOT is consistent with services identified in the RFP. However, in contradiction, more than half (56.6%) of the respondents also indicated that the SOS negotiation process was not efficient and effective.

A similar trend was found where 56.6% of the respondents agreed or strongly agreed that the SCDOT's review(s) and feedback to consultants during the negotiation process for the SOS is prompt. But two-thirds (67.9%) of respondents *disagreed* or *strongly disagreed* that the overall negotiation process for the SOS is completed in a timely manner.

An overwhelming majority (98.1%) of the respondents indicated that meeting, face-to-face or virtually, during the negotiation process to discuss and resolve SOS issues is more efficient than trading comments/edits via emails. Similarly, 77.4% of the respondents indicated that the SCDOT program managers typically have a sufficient understanding of the scope at the onset of negotiations.

The results of this section is particularly interesting in that respondents, on average, perceived that the SOS negotiation process is not effective and takes longer than needed, yet they generally thought of their colleagues at SCDOT to be punctual, accurate, and responsive. This implies, though tacitly, that the root of the problem must be sought in the mechanics of the utilized procedures. For example, retrieving scope text from a previous project could result in unwanted 'residues' in the contract and delay the negotiation process.

4.1.5. Professional Services Consultants – SOS Contract Fee Negotiation Process

In this series of questions, the respondents were asked to provide their feedback on SCDOT's contract fee negotiation process. The questions were focused on topics including consistency and effectiveness of the fee negotiation process, and timely issuance of the contract and notice to process (NTP).

Similar to the negotiation of scope of services, two-thirds (69.4%) of the respondents disagreed or strongly disagreed that once the negotiation of consultant fee(s) is finalized, the contract and NTP are issued in a timely fashion. About 61.3% of the respondents showed dissatisfaction that reaching an agreement on the cost of services is not an efficient process. However, 59.2% of them also agreed that the fee negotiation process results in a fair and reasonable fee for the project. When asked about revisiting SOS during the fee negotiation process, more than two-third (72.9%) of the respondents agreed that it is revisited multiple times during fee negotiation process.

4.1.6. Professional Services Consultants – SCDOT Procurement Process (Duration)

In this topic, the questions were focused on the typical duration and duration range of SCDOT projects for consultant selection, SOS negotiation, fee negotiation, receipt of an NTP, and the overall duration from proposal submission to NTP.

Forty-three percent (43%) of the participating consultant firm respondents to these questions. Out of them, 73.2% of the responding firms indicated that it typically took 2-3 months for consultant selection after submission of proposals. About two-thirds (65%) of them felt that it typically took 2-3 months for SOS negotiation. When asked about the estimation and cost negotiations, 70% of the respondents mentioned that it typically took between 1-3 months. Similarly, 87.5% of them suggested that typically it took between 1-3 months to receive NTP once contract negotiations are complete.

There was a variation in responses on the overall duration from proposal submission to NTP. Less than a quarter (20.5%) of respondents felt that it took 6 months, and 17.9% of respondents indicated that it took 9 months and 12 months from proposal submission to NTP. Besides, the average lowest and highest durations were noted between 5 and 12 months.

4.1.7. Statistical Analysis

For all the variables (questions) in the PSCs questionnaire, a t-test was conducted to determine if there is a significant difference between the means of National operating and Regional/Local operating consultants. For many variables, the t-test for two samples assuming unequal variances resulted in no significant difference between the means of National and Regional/Local PSCs (not enough evidence to reject the null hypothesis). However, Table 3 presents the variables that the ANOVA-test resulted in determining a significant difference between the two groups means.

Approximately half (48%) of the consultant firms responding to the survey indicated that project RFPs were often or almost always well-advertised. However, greater than half (52%) of the firms indicated that practice was not consistent. They felt that RFPs were well advertised only sometimes, seldom, or almost never. Consultant opinions regarding proposal requirements (level of effort) were divided into three camps. About a third (35%) felt that the required level of effort for proposal response was often or almost always reasonable. Another third of the respondents thought that requirements were reasonable only sometimes. The remaining third (32%) felt that the required level of effort for a response was seldom or almost never reasonable.

The ranked ANOVA test concluded a significant difference among concerning questions (variables) Q5, Q7, and Q9 related to the SCDOT SOS negotiation process, contract fee negotiation process, and consultant procurement duration. The interpretation of the statistical tests are provided in the Tables 4 and 6 below.

Table 3 ANOVA Test: SCDOT SOS Negotiation Process vs. Procurement Duration

Q5.5 & Q9.1.1		Q5.6 & Q9.3.3		Q5.7 & 9.3.3	
Count	41	Count	37	Count	37
p-value	0.0256	p-value	0.00867	p-value	0.00317
Effect size (Cohen's f)	0.643	Effect size (Cohen's f)	0.454	Effect size (Cohen's f)	0.615
Confidence	0.95	Confidence	0.95	Confidence	0.95

Q5.10 & Q9.3.3		Q5.15 & Q9.1.1		Q5.16 & Q9.3.3	
Count	37	Count	41	Count	37
p-value	0.00518	p-value	0.00761	p-value	0.00526
Effect size (Cohen's f)	0.563	Effect size (Cohen's f)	0.619	Effect size (Cohen's f)	0.646
Confidence	0.95	Confidence	0.95	Confidence	0.95

Table 4 Interpretation of SOS Negotiation Process vs. Procurement Duration

Questions/Code	Response	Response Rate (%)	Interpretation
Q5.5 & Q9.1.1	Agree	56.09%	The SCDOT's review and feedback to consultants is prompt during the scope negotiation process.
Q5.6 & Q9.3.3	Disagree	59.46%	The SCDOT lacks adequate training on the agency's procurement process for professional services consultants.
Q5.7 & Q9.3.3	Disagree	62.16%	Overall, the negotiation process for the scope of services lacks efficiency and effectiveness.
Q5.10 & Q9.3.3	Agree	59.46%	The project background information and key project decisions are shared with the Consultants.
Q5.15 & Q9.1.1	Agree	80.48%	The Consultants are encouraged to suggest changes to the project scope based on their knowledge/experience with the project type.
Q5.16 & Q9.3.3	Disagree	67.56%	The negotiation process for scope of services is not completed in timely fashion.

Table 5 ANOVA Test: SCDOT Contract Fee Negotiation vs. Procurement Duration

Q7.2 & Q9.5.1		Q7.2 & Q9.5.3		Q7.4 & 9.5.3	
Count	39	Count	39	Count	39
p-value	0.0250	p-value	0.0389	p-value	0.0258
Effect size (Cohen's f)	0.650	Effect size (Cohen's f)	0.655	Effect size (Cohen's f)	0.625
Confidence	0.95	Confidence	0.95	Confidence	0.95

Q7.6 & Q9.5.3		Q7.2 & Q9.4.3		Q7.2 & Q9.3.1	
Count	39	Count	37	Count	37
p-value	0.0264	p-value	0.0132	p-value	0.0177
Effect size (Cohen's f)	0.410	Effect size (Cohen's f)	0.621	Effect size (Cohen's f)	0.629
Confidence	0.95	Confidence	0.95	Confidence	0.95

Table 6 Interpretation of Contract Fee Negotiation vs. Procurement Duration

Questions/Code	Response	Response Rate (%)	Interpretation
Q7.2 & Q9.5.1	Disagree	64.10%	Reaching an agreement on the cost of services is inefficient as the Consultant is not selected on timely manner upon submission of proposals.
Q7.2 & Q9.5.3	Disagree	66.66%	The overall duration from proposal submission to a NTP is very high and therefore not efficient.
Q7.4 & Q9.5.3	Disagree	69.23%	SCDOT's negotiation process is not consistently administered/managed from RPG to RPG.
Q7.6 & Q9.5.3	Agree	74.36%%	During fee negotiations the scope of services is revisited multiple times resulting in delays in receipt of an NTP.
Q7.2 & Q9.4.3	Disagree	64.86%	Receipt of a NTP is not timely once contract negotiations are completed.
Q7.2 & Q9.3.1	Disagree	62.16%	Reaching an agreement on the cost of services lacks efficiency in terms of time.

4.2. Findings and Analysis: Phase 2 – Comparable state DOTs Current Practices

Subsequent to the SCDOT SMEs and Professional Services input, Phase 2 of this research study aimed to obtain input from the comparable or peer state DOTs to SCDOT to identify SOS best practices by further probing and gathering in-depth information on SOS explored in previous phases of this research. Besides, gathering in-depth input from comparable state DOTs helped establish support for SOS best practices and findings explored through the professional services consultants. Phase 2 of the research study includes three main interrelated tasks (Figure 10): evaluation of state DOTs SOS comprehensiveness, identification of comparable state DOTs based on SOS comprehensiveness, and finally, obtaining input from identified comparable state DOTs via structured interviews concerning transportation SOS and best practices.

After the successful completion of Phase 1, the research team identified the necessary components of SOS and updated the current SOS with the help of SCDOT SMEs and Professional Services Consultants' input. In both Phase 1 and 2, the researcher developed a methodology to investigate and evaluate the development of Professional Services Consultant SOS by comparable DOTs.

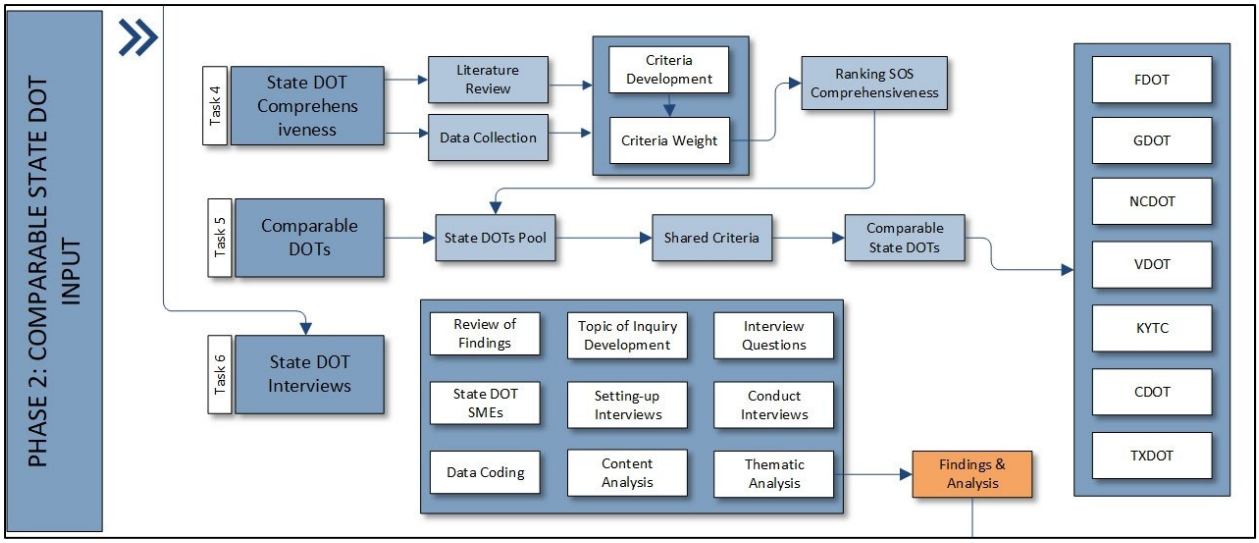

Figure 10. Research Methodology Phase 2: Comparable State DOT Input

4.2.1. Task 4: Evaluation of State DOTs SOS Comprehensiveness

Task 5 discussed the evaluation of state DOTs SOS comprehensiveness in five steps. This evaluation is used to identify comparable state DOTs to SCDOT to gather data related to practices followed by these state DOTs via structured online interviews.

Step 1: Data Collection

The first step in the research methodology was to collect data that was relevant to the SOS for professional services consultants. To initiate this step, the authors further divided this step into three sub-steps.

Conduct a literature review – Scientific databases such as Google Scholar, Transportation Research Board (TRB) database, FHWA, and other scholarly publications that include American Society of Civil Engineers' (ASCE) Construction Research Congress (CRC), and SAGE Publications were searched to retrieve relevant literature data. A total of 37 publications based on various topics including PSP and related studies were retrieved from these sources.

Investigate each of the 50 state DOT websites for relevant data – Figure 11 shows the availability of SOS documents publicized on state DOT websites across 50 state agencies. Twenty-six (26) states had a variety of documents related to professional SOS ranging from templates, requests of proposal (RFP), and contracts with actual project scopes. These documents were available in the public domain. Published documents were not available on the DOT's website for the remaining 24 states. Some of these remaining states did have a consultants' page on their respective agency websites, but the documents were not publicly accessible. In addition to the website search, the authors also reached out to industry consultants for SOS documents.

Collection of data from secondary sources – including the industry consultants' websites.

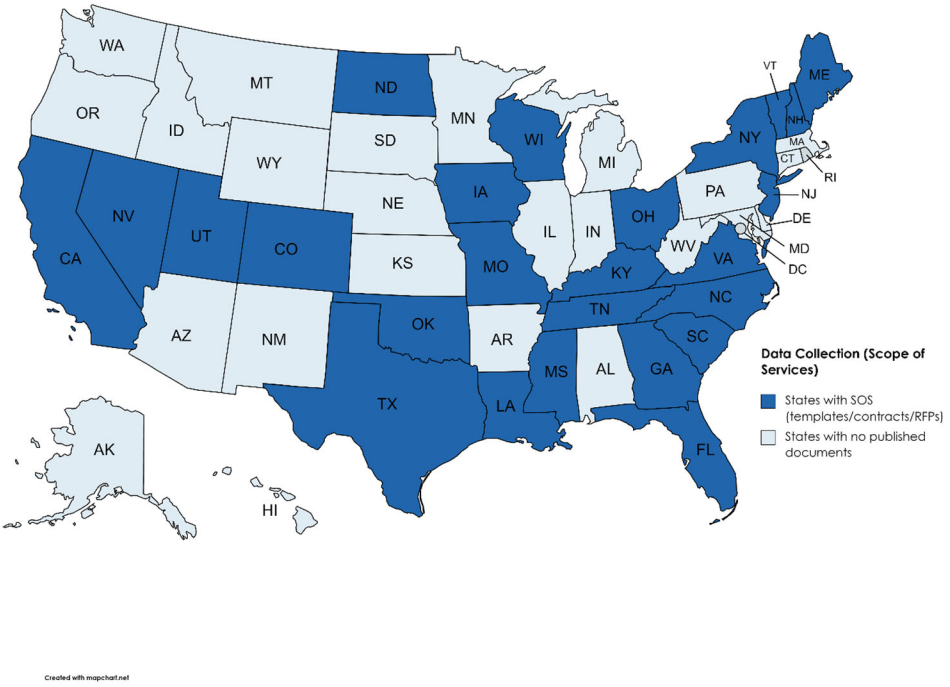

Figure 11. State DOTs having Scope of Services (SOS)

Step 2: Data Organization

Based on the website search of state agencies, the authors identified 155 documents relevant to the study. These documents include templates, contracts, and RFPs. The documents were studied for their content and organized according to the services provided. The organization of these documents was done in the following manner:

State-wise listing of documents – The documents collected were arranged according to the states. For example, Florida DOT (FDOT) documents were listed under FDOT column. This step was followed to include all the states with available online data.

Organize the documents – After listing, the documents across states were re-arranged based on the document name/title, meaning the documents with similar title were grouped together.

Categorize the documents – Once the documents were organized, they were placed into their appropriate group or "service categories". This task aimed to process the raw data into a more meaningful form for detailed study within the defined service categories. Each service category represented the type of service the documents provided. This process was repeated until all 155 available documents were grouped into their most suitable categories.

Step 3: Develop SOS Criteria for Evaluation

Considering the influence that engineering design elements have on the scoping process (Burati, Farrington, & Ledbetter, 1992; Kirby, Furry, & Hicks, 1988) the focus of the research effort was

strictly limited to the category of 'engineering design/design' SOS only . This resulted in reduction of the candidate state DOTs from twenty-six (26) down to eight (8) as the other state DOTs lacked published SOS documents related to engineering design. Among these eight (8) states DOTs, a total of forty-nine (49) design SOS documents were available for evaluation. In Step 3, the elements of design SOS were compared to develop criteria for evaluation. Each SOS had two (2) elements – task, and subtask. The documents with a similar type of SOS were compared to identify common tasks and subtasks between them. Similar tasks and subtasks were then grouped into the most suitable criteria. For example, Engineering Design & Analysis criterion had all design-related activities from various SOS documents. This comparison was made across all eight states to determine the criteria.

The eight (8) essential criteria identified included:

- Project Organization & Management
- Engineering Design & Analysis
- Survey & Mapping
- Plans, Specifications, and Estimates (PS&E)
- Right-of-Way (ROW)
- Utilities & Railroad Coordination
- Environmental Studies/Documentation/Permits
- Public Involvement

In addition to the SOS tasks and subtasks, there are additional criteria that are relevant to evaluate the comprehensiveness of a state DOT's SOS development process (Jin, Haidary, Bausman, & Chowdhury, 2021). They included the following:

SOS Document Year – To evaluate the comprehensiveness of the SOS, it was essential to determine the year when the documents were published by the DOTs. Having a recent SOS is a key indicator factor that the document is the latest and most appropriate for agency use.

Other Improvements - Value engineering (VE) means adding value to the project in various possible ways including but not limited to reducing overall project cost, improving the design delivery process, make construction simpler, reduce the project duration, improve safety and quality, and consider environmental goals (Jin, Haidary, Bausman, & Chowdhury, 2021). According to Tiendung Le et al., Risk Management (RM) and scope definition are crucial elements of the project development process (SOS) as it allows to identify the risks at their sources (Jin, 2021; Le et al., 2009). SOS consists of various components and PSP is one of the important components of it. Incorporating risk management criteria built into the SOS allows the DOTs and the consultants to identify, analyze, and mitigate the risks during the design phase.

Step 4: Weighting SOS Criteria using AHP Model

After identifying the criteria for evaluation, the next step was to weigh the criteria. To address this step, the authors adopted AHP as the most appropriate method to weigh the criteria (Jin, Haidary, Bausman, & Chowdhury, 2021). AHP allows judgment in assigning weights to criteria that are incommensurable.

The goal was to assign an importance score to each SOS criterion. The authors deemed the steps utilized by Weimin et al. to determine SOS comprehensiveness suitable for use in this study (Jin, Haidary, Bausman, & Chowdhury, 2021). This study's problem was divided into main criteria: SOS components, SOS document year, and other improvements. The SOS components were divided into sub-criteria: project organization & management, engineering design & analysis, survey & mapping, PS&E, ROW, utilities & railroad coordination, environmental studies/documentation/permits, and public involvement, shown in Figure 12.

Once the hierarchical structure was developed, the authors performed a pairwise comparison which involved comparison of each criterion with the remaining criteria to calculate the weight with respect to one another. The weights were assigned to each criterion with respect to another using the AHP rating scale. For example, the team conducted a pair-wise comparison between Engineering Design and Analysis and Survey and Mapping, where an importance rank of 9 (i.e., extreme importance) was assigned to Engineering Design and Analysis versus 3 (moderate importance) for Survey and Mapping. Note that these scores are assigned to these two categories when compared with each other, not in an absolute fashion. Therefore, a score of 9/3 is marked in row 2, column 3, and the inverse of this score (i.e., 3/9) is marked in row 3, column 2. By definition, the comparison matrix has two distinct properties: (1) it is a symmetrical matrix, and (2) all the diagonal elements are one, as the relative importance of a criterion with respect to itself is one.

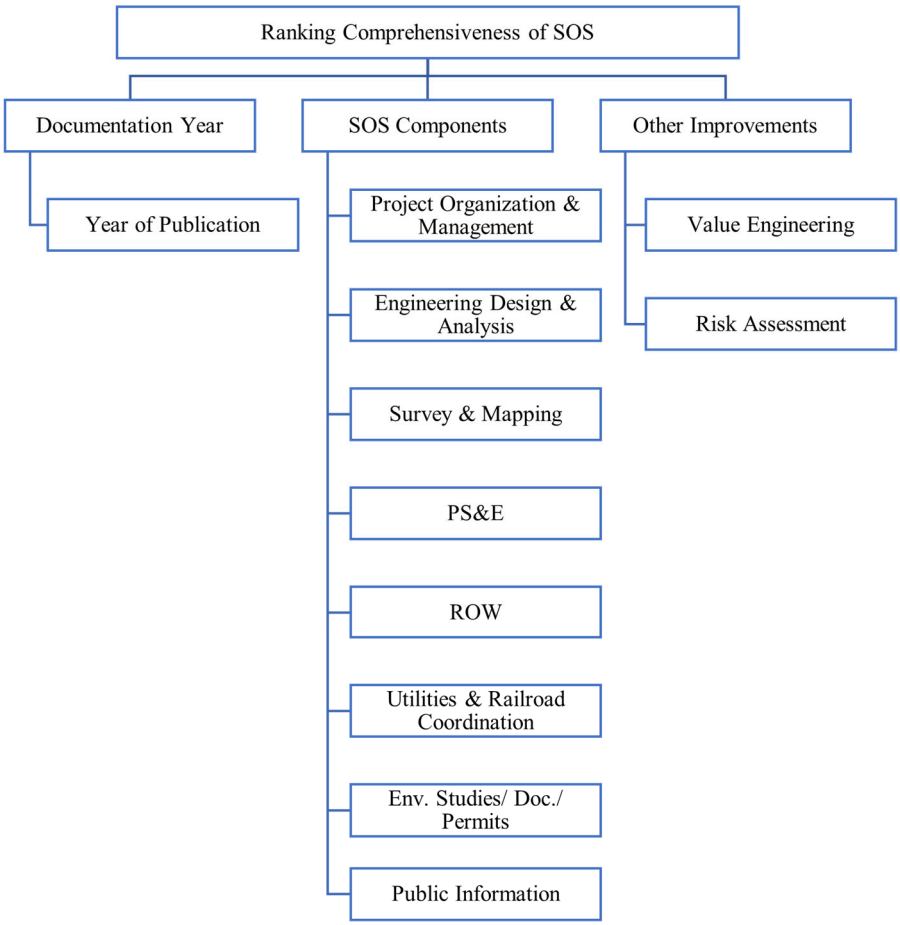

Figure 12. Hierarchical Structure for Ranking Design SOS

The weighting of criteria consisted of various steps including: (1). assigning weights to each criterion with respect to another to develop a pairwise comparison matrix; as explained above; (2). normalizing the comparison matrix; and (3). calculating the weights of each criterion by averaging the normalized values in each row.

To validate the accuracy of the criteria weights, consistency index (C.I.) and consistency ratio (C.R.) were calculated.

C.I. = $(\lambda_{max} - n) / (n - 1)$.

and C.R. = C.I. / R.I.

where, λ_{max} is calculated by dividing all the elements of the weighted sum matrices by each criterion weight, n is the total number of criteria, and RI is the C.I. for a randomly generated matrix.

Assigning the pair-wise scores was a subject task that incorporated the perception and understanding of subject matter experts (SMEs) in design and construction management. The

final outcome of this step was a series of importance levels (γ) for each criterion. Specific (γ) values for each criterion are presented and discussed in the Results and Findings section.

Step 5: Ranking the Comprehensiveness of SOS

The final step in the development of evaluation method was to measure the comprehensiveness (ε) of the SOS documents. While there could be several numerical and categorical approaches to do this, one convenient metric is the number of pages with each document that is allocated to each criterion. To that end, each SOS document was closely observed, and the number of pages allotted to each criterion was calculated. It must be noted that the absolute number of pages is misleading. For example, a criterion could be 9 pages in 200 page document vs. in a 20 page document. To resolve this matter, the team defined two distinct approaches to measure (ε) by: (1). Calculating internal comprehensiveness (ε_i) by normalizing the criterion's number of pages by the total number of pages in the document, and (2). Calculating external comprehensiveness (ε_e) by the criterion's number of pages by the total number of pages of the same criterion across all the SOS documents.

With the above definitions, one can estimate the comprehensiveness score for each document using the below mathematical formulations:

$$Internal\ Comprehensiveness\ Score: CC_i = \sum_{j\ over\ criteria} \gamma_j \times (\varepsilon_i)_j$$

$$External\ Comprehensiveness\ Score: CC_e = \sum_{j\ over\ criteria} \gamma_j \times (\varepsilon_e)_j$$

Table 7 Basic Criteria of Engineering and Design Scope of Services (SOS) (n = 49)

Criteria		Min.	Mean	Max.	SD
Documentation year of SOS document		2008	2018	2021	
SOS Components	Total number of document pages	3	56.7	312	67
	The number of tasks in the SOS	1	15.7	39	15.1
	The number of pages of project organization & management	0	6.3	33	8.5
	The number of pages of engineering design & analysis	0	18.5	101	23.9
	The number of pages of survey and mapping	0	3.4	14	4.9
	The number of pages of PS&E	0	2.7	12	3.5
	The number of pages of ROW	0	0.5	4	0.8
	The number of pages of utilities & railroad coordination	0	2.7	19	3.4
	The number of pages of environmental studies/documentation/permits	0	4.1	48	7.3
	The number of pages of public information	0	1.3	10	2.2
Other Improvements	Value engineering	0	0.2	1	0.4
	Risk management	0	0.2	1	0.4

Based on the data collected, the authors conducted data analysis to investigate SOS criteria and their occurrence in the documents collected from various states. A total of 49 SOS documents from eight (8) states were studied. The authors conducted a basic statistic to inspect the standard

deviation (SD) with respect to the mean values of the components of SOS criteria. The authors found that the criteria range was wide, and the standard deviation was moderately larger than the mean calculated for the criteria. This indicated that the variation in the comprehensiveness of the criteria among the states was high. The basic criterion of design SOS is explained in Table 7. As shown in Table 7, the combined mean of document pages and number of SOS tasks were 56.7 and 15.7 respectively, whereas the state with the highest number was Florida with a mean of 106 pages and 33 tasks. This proves that there was a significant variation between the states.

Based on AHP, the weights of criteria were calculated to evaluate the comprehensiveness of design SOS. The criteria weights were then used to rank the comprehensiveness of each SOS document. To validate the accuracy of criteria weights, the authors measured the consistency index (C.I.) and consistency ratio (C.R.). Upon calculation, the authors concluded that (C.R. = 0.07568 < 0.10) the matrix was reasonable consistent. Table 2 shows the weights of each criterion and sub-criterion.

Table 8 Weight of Each Criterion

Criterion	Weight	Sub-criterion	Weight
Documentation Year	8.33%	Year of publication	8.33%
SOS Components	72.35%	Project organization & management	2.79%
		Engineering design & analysis	14.82%
		Survey & mapping	6.99%
		Plans, Specifications, & Estimates (PS&E)	10.64%
		Right-of-Way (ROW)	7.82%
		Utilities & railroad coordination	4.42%
		Environmental studies/ documentation/ permits	19.14%
		Public information	5.72%
Other Improvements	19.32%	Value engineering	9.66%
		Risk assessment	9.66%
Sum	**100%**		**100%**

It was found that SOS components were the most important criteria (72.35%) when compared with other improvements (19.32%) and documentation year (8.33%). Among the sub-criterion of SOS components, environmental studies/ documentation/ permits, engineering design & analysis, and PS&E ranked higher in terms of their weights with 19.14%, 14.82%, and 10.64% respectively. This indicates that the sub-criteria had a high level of importance in terms of tasks and subtasks in the SOS. After establishing weights for each criterion and sub-criterion, the internal and external comprehensiveness score (i.e., CC_i and CC_e) SOS documents across the states were completed.

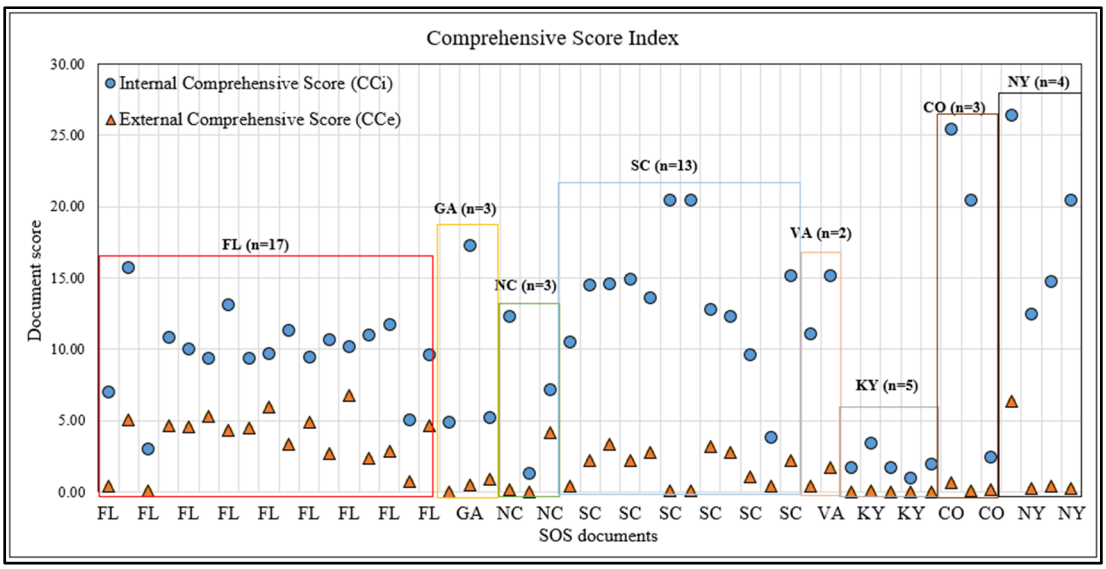

Figure 13. Comprehensive Score Indices of state DOTs

Figure 13 shows the comprehensive score indices for internal and external comparison of the SOS documents. The (CC_i) is the product of weighted average of level of comprehensiveness and the level of importance within each document, and the (CC_e) is the product of level of comprehensiveness and the level of importance across all the documents. Based on Figure 13, the authors found the following:

- The comprehensive scores indices are highly variable for both internal (CC_i) and (CC_e).
- The highlighted boxes in Figure 13 show the number of documents from respective states. The FDOT documents in Figure 13 have a significantly consistent comprehensive score index when compared to the rest of the documents. Further, the overall score index for FDOT is the highest among others. This indicates that the FDOT document range in Figure 13 has both consistency and comprehensiveness.
- Again, FDOT ranked first in terms of the average number of SOS tasks with 32.76 (~33) tasks per document.

To meet the ever increasing demand of infrastructure projects across the U.S., the state transportation agencies need to avoid procurement delays and issues related to insufficient scope development. In order to address the issues related to lack of detailed scope, it is necessary that the state DOTs develop a comprehensive design SOS which can be modified according to the project's need. However, it can only be possible through a detailed evaluation of design SOS components. Therefore, this task is aimed at evaluating the engineering and design SOS and measuring the comprehensiveness of the identified criteria. Based on the comprehensive score indices for internal and external SOS documents, it was found that FDOT had both consistency in their SOS documents as well as comprehensiveness when compared with the other seven (7) state DOTs. The key takeaways from this study are:

- Out of the 26 state DOTs that have SOS documents published on their websites, only 8 state DOTs have SOS documents related to engineering design.
- The state DOTs should focus on developing a standard scope language for environmental studies, engineering design & analysis, and PS&E as they contribute 61.64% of the total SOS components.
- Also, a very few state DOTs had documented value engineering and risk assessment in the SOS documents.

4.2.2. Task 5: Identification of Comparable State DOTs

This task discusses an approach to identify the comparable state DOTs to the SCDOT among eight candidate DOTs that were screened in the evaluation process in Task 5. The researcher used the collected data related to SOS on each state's DOT organization type and highway statistics. According to Haidary et.al, 2021 by comparing these key statistics of these candidate DOTs with SCDOT, the researcher identified and determined the comparable DOTs of SCDOT. Scope Development is an integral part of SOS, and the key statistics of comparable state DOTs were related to the components involved in the development of SOS. Highway statistics include total mileage, mileage of state-maintained highway systems, mileage of National Highway System (NHS), and mileage of county/town/municipal-maintained highway systems. Highway system mileage information was obtained from Highway Statistics 2017 provided by FHWA (Alaska DOT, 2018). The state DOTs that were identified for the interview process were Florida, Georgia, North Carolina, Virginia, Kentucky, Colorado, and Texas.

4.2.3. Task 6: Comparable State DOTs Interviews

The interviews were semi-structured and were conducted online to identify SOS effective practices in state DOTs. The purpose of these interviews was to understand the practices followed by the comparable state DOTs to SCDOT and also seek feedback on SCDOT's current practices related to SCDOT, and obtain suggestions, recommendations, and areas of improvement. The state DOTs were sent a brief introduction about the research study along with interview questions via email. The interviews were primarily focused on the comparable state DOT's processes and approaches related to the procurement of professional services consultants on the agency's projects. The state DOTs were also be provided the updated SCDOT SOS for additional feedback with the aim to streamline it. Follow-ups were sent two weeks after the interview concluded.

The initial step was a thorough review of the findings of previous phases of this research to help develop topics of inquiry for the interviews (see Appendix C). After the development of the inquiry topics, the interview questionnaire was developed. The inquiry topics explored general information of the DOT and their approach, current professional services consultant procurement process, SOS development and contract fee negotiation. The next step was to identify appropriate SMEs for the

interviews from the comparable state DOTs. The SMEs list was provided by the SCDOT, and requests were sent to the identified comparable states for the interviews.

Due to the research's scope, the SMEs were advised that two or more SMEs from their state DOTs may be necessary to conduct the investigative interview. Over the course of approximately four months, semi-structured interviews were conducted with ten (10) SMEs from comparable state DOTs. The SMEs represented a range of functional units and departments. Each interview lasted approximately 1½ to 2 hours. With the interviewee's permission(s), each session was recorded to ensure comprehensive capture of their input and efficiently utilize the interviewee's time. Additional SOS documentation was identified and noted for collection after the interview process. Following each interview, a complete transcript was developed that was subsequently analyzed and summarized by theme/category using Content and Thematic forms of Analysis.

Subsequent to the transcription of the data collected from the comparable state DOTs interviews, the data was analyzed using content analysis and thematic analysis. Through content analysis, the qualitative data is systematically transformed into a concise and organized summary. Besides, the data is coded, organized by category, and analyzed to identify central themes using MAXQDA software. Via thematic analysis, by moving the data back and forward, the association's patterns and descriptions are searched and explored across the interview transcripts. Table 9 presents the interview analysis codes used during content and thematic analysis. The codes are categorized into six major categories (themes): state DOT Organization, Project Delivery Approach, Scope of Services Development process, Scope of Services template, Professional Services Consultants Procurement process, and Contract Fee Negotiation process. Each code category has its subcategories, which helped identify and organize the data by different themes and sub-themes. These codes also helped ease the comparative analysis of data across the comparable state DOTs by their themes.

Following are the summarized versions of the findings from the state DOT interviews:

1. Virginia Department of Transportation (VDOT) – The project delivery approach used by VDOT is mostly phased manner. They conduct preliminary studies and contract out smaller work orders not exceeding $750,000 in value. They perform fixed contracts on their projects but most of the contracting that is done are on-call contracts. VDOT has generic scope of work developed for design activities, geotechnical studies, traffic and utilities. The department uses expertise of their in-house SMEs from bridge, materials, traffic, and other departments based on the project requirements to develop detailed work scope which is then used during procurement and negotiations with the consultant. They have manuals for road design, hydraulic design, drainage and flood studies, and also a project management guideline, on which they rely and work through to develop project-specific scope of services. The RFPs are well-developed and contains project information necessary

for the consultants to develop detailed SOS in collaboration with the VDOT's project manager assigned on that particular project. In addition, the department's SMEs are also consulted during the SOS development process.

2. Georgia Department of Transportation (GDOT) – GDOT has a centralized organizational structure and operates from the central office. In terms of delivering projects, GDOT does multi-phased projects, meaning the work is contracted out in a phased manner. GDOT has developed and updated various design manuals periodically, including road design, hydraulic and hydrology, traffic design, ROW, utilities, and others. Besides, they also have boilerplate templates for project-specific contracts and Indefinite Delivery Indefinite Quantity (IDIQ) contracts. Since the manuals are updated on a timely basis, the scope is done at a high level and referenced to the manuals for finer details. Moreover, the scope is mainly edited for quantities and special items that include assumptions and deliverables pertaining to that project. One of the most significant challenges GDOT faced was related to the NEPA and FHWA requirements on federal- and state-funded projects. These projects often take 3-5 years from conception to final design development. Therefore, GDOT utilizes the funds as per availability and contracts projects in a phasewise manner.

3. Florida Department of Transportation (FDOT) – FDOT has a decentralized organizational structure and operates at district levels. The project managers and the SMEs work in collaboration in defining project scopes, and it is done using a tool called 'Scope Development Tool.' The tool is used to generate project-specific SOS for both project design and environment (PD&E) and design phase. It is governed by a checklist consisting of questions related to project information and details, which populates SOS in PDF format after filling it. They also have a word document version as an output file, but it is only provided to the local cities, counties, and municipalities which rely on FDOT's system. Due to the scope development tool, the procurement time is greatly reduced to an average of 4-6 months. FDOT has a robust team dedicated to the maintenance and updating of the SOS templates, which is done biannually. The scope language is reviewed and updated once in a year. To support these functions, FDOT has a team of a programmer and 3 application administrators. Besides, there is no formal training provided to the consultants and FDOT staff. However, it is provided on demand with an additional guideline for training.

4. Kentucky Transportation Cabinet (KYTC) – KYTC has a decentralized organizational structure and operates through its district offices and a central procurement division. KYTC does not have SOS templates but has a broad scope of work boilerplate template. The boilerplate template is flexible in nature, meaning it can be edited by the project managers and SMEs before and during contract and scope negotiations. One of the challenges

identified during the interview was that the templates are modified by different personnel across the agency, causing a lack of standardization in scope language. Another challenge KDOT faced was with respect to the availability of federal funds causing delays in the procurement of consultants and forcing the agency to contract out projects in definite parts.

5. Colorado Department of Transporation (CDOT) – CDOT has a decentralized organizational structure and operates through its five regions. They have developed an 80-page comprehensive generic SOS template in recent years, and it is available on the agency website. Although it is not used consistently across the agency, the agency is trying to make it mandatory to use generic scope of work for the development of project-specific SOS. The generic scope is updated in a timely manner and the road design team is a part of this effort. The biggest challenge for CDOT is that its funds are in constant flux. This has caused stop-and-go situations in most of their projects, and therefore the procurement of consultants is done only when the funds are available. Fee negotiation with the consultant is done through their evaluation form specific to the Phoenix association. The evaluation form consists of six criteria which are weighted. The only challenge with the fee matrix is that it is comprehensive and not easy to use.

6. North Carolina Department of Transportation (NCDOT) – NCDOT has a hybrid organizational structure. Each business unit within the agency procures its won contracts, meaning the procurement is not centralized. Earlier, the organization faced issues due to siloed departments, resulting in reforms in the organizational structure which now is more of a matrix form of organization. NCDOT has a standard contract document for on-call contracts where 99% of the scope remains unchanged. Besides that, the agency does not have a standardized SOS template. However, they have standard templates for task orders. The business units take ownership of developing and modifying project-specific task orders. One of the biggest challenges NCDOT is facing is the lack of staff due to retirements in recent years. Therefore, NCDOT has increased the amount of contracting out design-related works to the consultants. Like GDOT, NCDOT also issues contracts in a phased manner and calls it limited services which is spread across 2-4 or sometimes more than 4 phases, depending on the project's complexity. Since the procurement of consultants takes longer duration and the DOT is facing issues with funding, they have moved towards bundling of services on their limited services projects.

7. Texas Department of Transportation (TXDOT) – TXDOT also has a hybrid organizational structure similar to NCDOT. They have a well-developed generic scope template which is used consistently in the development of project-specific SOS. The scope template is used mainly to edit quantities, and 90-95% of the time, the scope language remains unchanged. TXDOT provides periodic training on scope development to the consultants and their staff.

One of the biggest problems faced by the agency is the lack of project fund availability. This has caused delays in advancements on the project and the procurement of consultants. Scope and fee negotiation is done through various channels that include trading of emails, face-to-face review meetings, and even through video conferencing to improve effectiveness. The scope development is more of a collaborative effort that involves 25 districts, the agency's SMEs, and consultants throughout the scope development process.

The qualitative analysis of the comparable state DOTs interviews using content and thematic forms of analysis (Table 9) provided a wealth of information concerning various SOS concepts and best practices. The data analysis helped clarify the SOS concepts and best practices explored from the previous phases of this research. The comparable state DOTs interview data were also compared to explore means and practices to streamline a state DOTs SOS and identify best practices. The identified SOS best practices from comparable state DOTs and the brief comparative summary of findings are presented in Table 9.

As shown in Table 9, seven comparable state DOTs (VDOT, GDOT, FDOT, KYTC, CDOT, NCDOT, and TXDOT) shared meaningful data that is organized by the code system using MAXQDA software. The findings of the comparable state DOTs interviews have helped develop SOS best practices and recommendations to streamline a state DOT SOS discussed in the next chapter. During the interviews, the SMEs also provided secondary documentation to support the interview data. The secondary documentation concerning SOS provided by the SMEs during the interviews was also used and analyzed to evaluate and establish support on how the identified SOS best practices are utilized in the comparable state DOTs. In addition, the secondary documentation clarified the SOS concepts and best practices explored from the interviews. The list and detailed description of the SOS best practices are discussed in Chapter 5.

Table 9 Comparable State DOTs Interviews Summary of Findings, Analysis, and Coding

Code	Theme/Sub-Themes	VDOT	GDOT	FDOT	KYTC	CDOT	NCDOT	TXDOT
1	State DOT Organization	Hybrid	Centralized	Decentralized	Decentralized	Decentralized	Hybrid	Hybrid
1.1	Organization Chart	✓	✓	✓	X	✓	✓	✓
2	Project Scoping	✓	✓	✓	✓	✓	✓	✓
3	PSCs	✓	✓	✓	✓	✓	✓	✓
3.1	Consultants Procurement Organization	Central Office	Central Office	Districts	Central Office	Central Office	Central Office	Central Office
3.2	Consultant Use	55%, LPA: 100%	83%	90%	80%	Less than 50%	75%	80%
3.3	Consultant Procurement Process	Prequalification RFP – NTP	Prequalification RFP – NTP	Prequalification RFP – NTP	Prequalification RFP – NTP	RFP – NTP	Prequalification RFP – NTP	Prequalification RFP – NTP

3.4	Consultant Procurement Time	6-9 months	9-12 months	4-6 months	100 days	6-12 months	6 months	6 months
3.5	Contracting Method	Limited Lump-Sum	Limited Lump-Sum, Project Bundling	Lump-Sum,	Lump-Sum	Lump-Sum	Limited Services Contract, Lump-Sum	Lump-Sum
4	Standard Scope of Services	✓	✓	✓	X	X	✓	✓
5	Prequalification Manual PSCs	✓	✓	✓	✓	✓	✓	✓
6	Procurement Manual	✓	✓	✓	✓	X	✓	✓

4.3. Findings and Analysis: Phase 3 – SOS Development and Recommendations

The Phase 3 of this research study focused on summarization of the findings from the efforts put in the previous two phases, developing the standard SOS template, identification of DT variables, and recommending SOS best practices.

The main goal of this phase was to develop a comprehensive SOS template and integrate it with the DT variables identified with the input of the SMEs from the SCDOT, consultants, and other state DOTs. Figure 14 shows the step-by-step process used in the development of the SOS, DT variables and their integration:

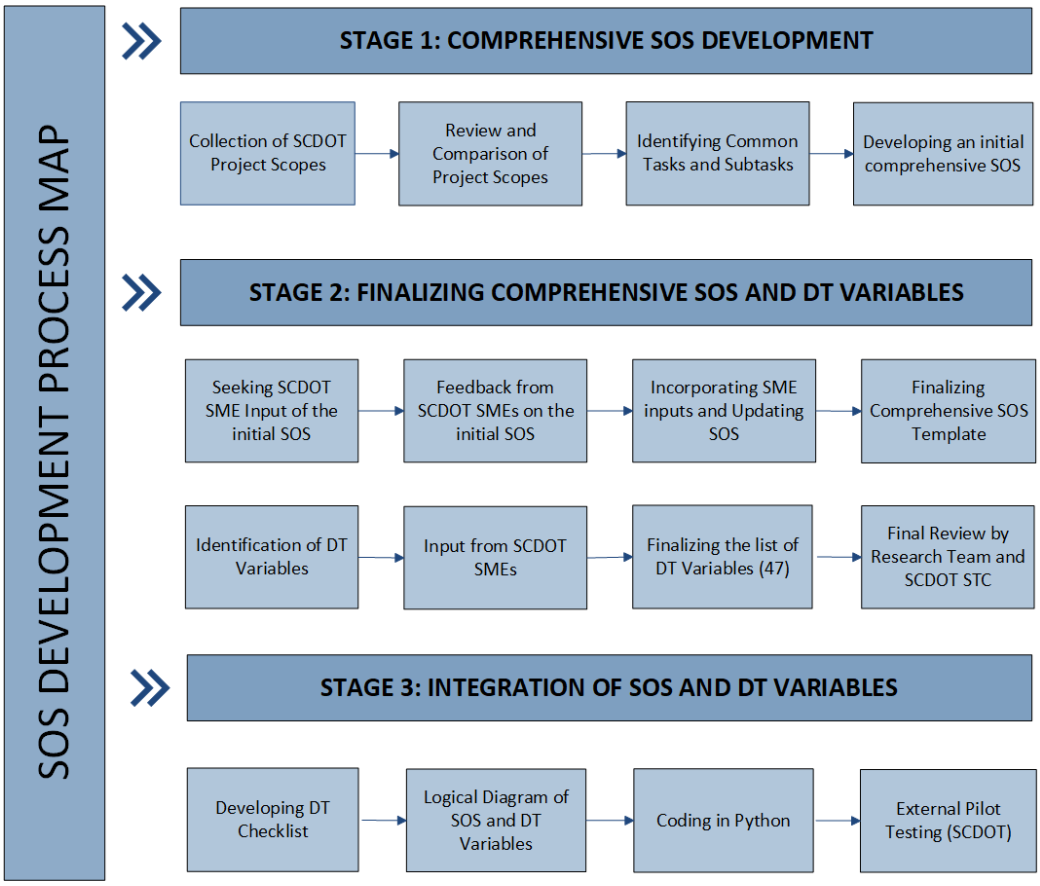

Figure 14. SOS Development Map

In Stage 1, the research team collected project scopes from the SCDOT's completed projects in the recent past. The objective behind this step was to understand the SOS developed and used by the SCDOT, and to guide the process of developing the standard SOS. The collected scopes were then reviewed and compared with one another. There were 17 SOS project scopes consisting of bridge replacement, corridor improvement, geotechnical exploration, tidal, and bridge loadings. The research team compared the SOS for tasks, subtasks, detailed description of tasks, and scope language. Based on the review of these project scopes, the research team categorized them into two major SOS templates: Bridge Replacement, and Corridor Improvement. Furthermore, the research team compared these two templates and combined them to create a comprehensive SOS template. The comprehensive SOS template was sent to the SCDOT SMEs for review. The review process was performed both at an individual level and at a departmental level by the SMEs. The feedback was provided by the SMEs on their respective scope element. After gathering feedback from all the SMEs, the research team then incorporated all the feedback received to update the SOS template.

4.3.1. Decision Tree and the Web-Based Application

In Stage 2 and once the SOS template was finalized for its scope items and language, the next task was to identify DT variables. This process was initiated by revisiting the qualitative interviews with the SMEs, other State DOTs, and the consultants, particularly looking for the project attributes that dictate certain contractual requirements. Next, the research team conducted several brainstorming sessions to identify, refine, and generalize (to the possible extent) the project variables. The list of project variables, also termed 'DT variables' were sent to the SCDOT SMEs for review. Upon receiving inputs from the SMEs, a list of 47 DT variables was finalized. These identified DT variables were predominantly based on the tasks (16 variables) and subtasks (31 variables) of the SOS. A final review was conducted by the research team and then by the SCDOT SMEs and the Steering Committee (STC) before finalizing the list of DT variables. These were all binary variables that could only take yes/no values. Since the SOS template is a comprehensive document, the SOS document for any given project will be a subset of the comprehensive text. Hence, each (yes/no) decision dictates which paragraph from the comprehensive SOS template gets to 'stay in' or 'leave' the final document. Moreover, the impact of a decision is fully exhaustive, meaning that if yes means to remove a section, no means to keep it. For example, if public involvement is not required for a project (i.e., Decision='no'), then Paragraphs 10, 41, and 279-285 of the comprehensive text should be deleted.

Task Number	*Task/Subtask Title*	*Decision*	*Action*	*Scope Revisions*
1	**Project Organization and Management**	No Decision Tree Items Associated with this Task		
2	**Field Surveys**	no	Remove	Remove para 9, 39, 123-158
	Geotechnical Bore Holes	no	Remove	Remove para 145
3	**Environmental Documentation (NEPA)**	no	Remove	Remove para 10, 40, 43, 160-277, 339-341
	Waters of the US	no	Remove	Remove para 142, 156, 173, 175, 276, 277
	CFR Part 772 - Noise Analysis	no	Remove	Remove para 190-214
	EA	no	Remove	Remove para 180, 226-229, 231-238, 250-254, 260, 262, 285
3a	**Public Involvement**	no	Remove	Remove para 10, 41, 279-285
4	**Environmental Permitting**	no	Remove	Remove para 21, 42, 43, 241, 287-337, 339-341
	Part of NEPA Document	yes	Remove	Remove para 290, 292, 305, 307, 313, 314
	404/401 Permit	no	Remove	Remove para 294, 296, 298, 301, 315, 316, 318-320
	Critical Area Permit	no	Remove	Remove para 294, 296, 298, 301, 315, 316, 318-320
	Coastal County (CZC Certification)	no	Remove	Remove para 311, 321
	Navigational Permit	no	Remove	Remove para 303, 309, 317
	Individual Permit (IP)	no	Remove	Remove para 309
	Mitigation Bank Available	yes	Remove	Remove para 323-337

Figure 15. Example of actions for each yes/no decision on the DT variables

The goal of Stage 3 was to integrate the SOS language and DT variables using the above logical network diagram. The logic was based on "If…then" conditions with the support of the SCDOT STC. In the case of a conflicting decision, keeping the content would take precedence. A HyperText Markup Language (HTML) user interface was designed to obtain input regarding the DT variables and develop a code to integrate the comprehensive SOS template with the DT variables. The coding was developed in a free source programming language called Python. Upon completion of the coding task, debugging and random pilot testing were conducted by the research

team to verify the accuracy of the program. Once accomplished, the checklist was then sent to the SCDOT SMEs for pilot testing. Both internal and external pilot tests reported satisfactory performance. The interface can be temporarily found at (http://scdotclemson.herokuapp.com/). A copy of the DT variables, as well as the user interface appearance, is presented in Appendix D. By clicking the submit button, the user will receive a customized contract.

CHAPTER 5: STREAMLINED AND UPDATED SOS PRACTICES AND RECOMMENDATIONS

This chapter discusses, describes, and presents the research methodology utilized for Phase 3. It presents the States' Department of Transportation Scope of Services Process Best Practices identified from the data analysis and findings of the previous phases of this study. Phase 3 of the research methodology includes three tasks, review and summarization of findings and data analysis from previous research phases, development, and detailed description of SOS best practices from the findings and analysis and establishing recommendations concerning SOS for SCDOT (Figure 3).

As shown in Figure 3, data analysis occurred at several points in this study: 1) analyzing the qualitative data collected from semi-structured SCDOT SMEs, 2) analyzing quantitative data collected from professional services consultants via a structured survey, 3) analyzing the qualitative data collected via semi-structured interviews from professional services consultants, and 4) analyzing the qualitative data collected via structured interviews and secondary data from comparable state DOTs. To summarize, these findings and analysis are used to identify and establish correlational support for the development of SOS best practices.

For the quantitative analysis, a statistical significance test is conducted to determine the significance of the explored concepts related to SOS best practices and project development performance from the data collected via surveys. The survey instrumentation's measurement scale was mainly nominal and interval data; thus, both parametric and nonparametric tests are conducted. The statistical test results are presented by probability values (p-value). Data collected from interviews are analyzed by content analysis and thematic analysis for the qualitative analysis. Through content analysis, the qualitative data is systematically transformed into a concise and organized summary. Besides, the data is coded, organized by category, and analyzed to identify central themes. Via thematic analysis, by going through the data back and forward, the association's patterns and descriptions are searched and explored across the interview transcripts. The final analysis presented a clear understanding of the relationships between the study variables and provided support for the SOS best practices discussed in the next section.

The Scope of Services (SOS) Best Practices are identified based on the findings and analysis from the previous phases of this research. This chapter outlines the ten SOS Best Practices, their categories, and the key findings from the research study's data sources that support each Best Practice. The SOS Best Practices were assembled based on the data, analysis, and findings supported by four different data sources as follows:

1. Structured interviews of twenty-eight Subject Matter Experts (SMEs) with SCDOT. The interviews examined each component of the SOS and collected agency data on process, performance, and SME suggestions for improvement.

2. A survey of The American Council of Engineering Companies of South Carolina (ACEC-SC) that have, or currently are, providing professional services to SCDOT. Forty-three (43) firms out of 82 member affiliates participated in the survey study.

3. Semi-Structured interviews of 8 professional services consultants. The topics of inquiry were focused on the development of SOS, negotiation process, and contract fee negotiation process.

4. Input was received during structured interviews with seven state DOTs (FDOT, GDOT, NCDOT, VDOT, KYTC, CDOT, and TXDOT). Comparable states were identified based on their transportation program's similarity and the comprehensiveness of their project development process utilizing an Analytical Hierarchy Process (AHP) to weigh the criteria. Also, the results from the previous research project on the development of Project Development Process for SCDOT were used as guiding tool.

The analysis of all data sources was used to assemble SOS Best Practices, which are numbered and categorized into four categories: Scope of Services Template Development and Implementation, Integration and Programming of SOS Template with DT Variables, Consultant Procurement and Management, Hosting, Maintaining and Updating of Scope of Services Template. A detailed description of the SOS Best Practices, recommendations, and associated source material for each are as follows.

5.1. Category A – Scope of Services Template Development and Implementation

5.1.1. **Best Practice #1:** Development of a comprehensive baseline SOS template for process standardization and to aid the procurement of professional services consultants.

Key Findings:

- Out of the 26 state DOTs that had documents related to the SOS, RFPs, and contracts, only Florida, Texas, and Colorado have developed a fairly well-developed SOS template that can be used on their projects. Other DOTs have developed generic contracts which have project scopes on a broad level and aim to have generic scopes of services encompassing all the scope items.
- Among the comparable state DOTs, Florida has developed a comprehensive SOS with standard scope language that can be used to create project-specific SOS.

- Many survey responding consultant firms indicated that the SCDOT should put an effort towards developing a standard SOS to avoid delays in negotiation and frequent contract modifications once the project is contracted out.

Recommendations for SCDOT:

- None. SCDOT has developed SOS templates for the field survey and environmental and permitting tasks and is currently taking steps with the research team to develop a comprehensive and standard SOS for projects requiring professional consultants.

5.1.2. **Best Practice #2:** Identifying a list of major project variables that affect the overall SOS and project deliverables.

Key Findings:

- Florida is the only state DOT that has identified 38 major project variables that are linked with the scope language in their Scope Development Tool. These project variables can be answered yes/no in order to remove sections of the scope that do not apply to a particular project.

- Similarly, the deliverables are also linked with the project variables to create project-specific list of deliverables.

Recommendations for SCDOT:

- None. SCDOT has currently engaged in the process of identification of major project variables.

5.1.3. **Best Practice #3:** Use of comprehensive SOS as a starting point for scope negotiation and the initial development of contract fee.

Key Findings:

- Among comparable DOTs, Florida, Colorado, and Texas use their generic scope as a starting point for scope negotiation.

- However, only Florida DOT uses the generated template for advertisements of RFPs, LOIs, scope negotiations, and the initial development of the contract fee. The DOT fills out an estimate form and the consultant fills a similar one. Once the forms are filled with estimates, both estimates are traded, and the differences are then negotiated.

- Besides, Florida DOT is in the process of developing a negotiating tool similar to the Scope Development Tool, which can reduce the timeframe for negotiation in the future.

- North Carolina DOT is taking a necessary step to complete scope, fee estimates, and negotiations of the task orders with the consultants within 30 days for their on-call contracts.

Recommendations for SCDOT:

- SCDOT has recently pilot-tested a project using the comprehensive SOS as a starting point for scope negotiation. By extending the aims and goals of the existing project, SCDOT can further such efforts, combining the comprehensive SOS document with AI-supported decision mechanisms and historical data to improve the time and efficiency of consultant services contracts.

5.2. Category B – Integration and Programming of SOS Template with DT Variables

5.2.1. **Best Practice #4:** Integrating the Decision Tree Variables with the comprehensive SOS and developing a program to help generate project-specific SOS.

Key Findings:

- Florida DOT has identified and linked the major project variables to the SOS items based on yes/no selection choices. These selection choices use a logic/program to either keep or remove certain sections of the scope which is not applicable to the project. Similarly, deliverables are also linked with the project variables to create project-specific list of deliverables.

- Florida DOT has developed a web-based tool called "Scope Development Tool" which uses these major project variables to eliminate portions of the scope to generate a tailored SOS in a PDF form.

Recommendations for SCDOT:

- SCDOT has currently engaged in the process of associating project variables to the scope language and also developing a program that generates project-specific SOS. It is recommended to take the existing effort to the next level, which is a user-friendly, and easy-to-host, easy-to-maintain software application for the agency's project managers.

5.3. Category C – Consultant Procurement and Management

5.3.1. **Best Practice #5:** Developing a standard fee estimate tool and integration with the SOS for efficient and effective negotiation process.

Key Findings:

- Among comparable DOTs, Florida, North Carolina, and Colorado have an excel-based fee estimate which is first filled in by the DOT, and then it is compared with the fee estimates filled by the consultants. However, none of the DOTs have a standard fee estimate tool that is integrated with their SOS. Florida DOT is moving ahead in that direction, and it may likely take a few years to have a fully functional package.

- Based on the consultant survey data analysis, 67.31% of the firms indicated that the SOS negotiation process is not completed in a timely manner. Many firms also noted that the SCDOT staff for procurement is overwhelmed which leads to longer review periods resulting in delays in the overall procurement process.

Recommendations for SCDOT:

- The research team recommends that the SCDOT should develop a standard fee estimating template similar to the SOS template and integrate them in such a way that the estimates and auto-filled into the generated project-specific SOS.

5.3.2. **Best Practice #6:** Creating a database for negotiated SOS and contract fee for better budget controls and tracking.

Key Findings:

- Among comparable DOTs, none of them mentioned the creation and management of scope negotiation and fee negotiation databases for budget control and using them for future projects as a reference point. However, project details could be available with the Florida DOT on their intranet portal.

Recommendations for SCDOT:

- The research team recommends that SCDOT create an integrated dashboard that keeps track of previously completed projects and the data on negotiated scope items and fees.

5.3.3. **Best Practice #7:** Increase the frequency of face-to-face/virtual meetings during negotiation process to discuss and resolve SOS issues.

Key Findings:

- Based on data analysis of the survey collected from the professional services consultants, all firms agreed that, face-to-face or virtually, meetings during the negotiation process to discuss & resolve SOS issues are more efficient than trading comments/edits via email.

- Among comparable DOTs, frequent scope meetings are held by FDOT, KYTC, and GDOT for scope negotiations and the consultants are also encouraged to provide suggestions for improvement.

Recommendations for SCDOT:

- The research team recommends that SCDOT take advantage of the technology to conduct more frequent and timely meetings with the consultants during the SOS negotiation process to discuss/resolve related issues.

5.3.4. **Best Practice #8:** Provide adequate training to the DOT personnel and professional services consultants on using the SOS template.

Key Findings:

- Among comparable DOTs, only Texas DOT has indicated that they provided periodic training to the professional services consultants on their SOS template. However, Florida does not have formal training, but it can be provided on demand. Florida DOT has developed guidelines on how to use the SOS template which is also available on their agency website.

Recommendations for SCDOT:

- The research team recommends that SCDOT provide necessary and regular training to their staff and professional services consultants on the use of the SOS template.

5.4. Category D – Hosting, Maintaining, and Updating of Scope of Services Template

5.4.1. **Best Practice #9:** Hosting the integrated SOS checklist and program on the SCDOT intranet.

Key Findings:

- It was found that Florida DOT has a well-established page dedicated to the SOS for professional services consultants. Besides, they host a variety of guidelines and forms pertaining to the SOS development and usage. However, based on the interview discussions, it was found that Florida DOT has an intranet portal called "Scope Development Tool" which is restricted to the DOT officials. This is a web-based tool that can be used by the DOT officials to generate project-specific SOS.

Recommendations for SCDOT:

- The research team recommends that SCDOT devise a strategy to host the program on their intranet to develop initial scopes for negotiations with the professional services consultants. Alternatively, SCDOT might want to consider outsourcing this effort to a third party web-development company to minimize future hassles regarding updating and maintaining the program internally.

5.4.2. **Best Practice #10:** Identifying a team of experts (Champions) for the regular maintenance and updating of the scope of services.

Key Findings:

- Among comparable DOTs, Florida, Colorado, and Texas have set up a team to manage and update their SOS templates.

- Florida has a team of one main programmer along with 3 application admins who are dedicated to the maintenance and updating of their SOS template. The suggestions are brought up by the PMs and SMEs from the districts and then reviewed before sending them to the team to update. The updates are made biannually whereas the language revisions are made at least once a year.

- Texas uses more of a collaborative approach where the SMEs available in the central division work with the districts to maintain and update the SOS.

Recommendations for SCDOT:

- The research team recommends that SCDOT set up a dedicated team of professionals including an I.T. person to regularly seek feedback on the template language and scope to keep the SOS template maintained and updated.

CHAPTER 6: CONCLUSIONS AND DISCUSSIONS

The purpose of this research study was to identify Scope of Services (SOS) Best Practices to enhance, streamline, and improve procurement of Professional Services Consultants (PSCs) on transportation projects. This research provided SCDOT and other state DOTs the methodology and needed insight regarding best practices to help the agency streamline and update their SOS leading to an increase in efficiency of SOS development, SOS negotiations and procurement of PSCs.

Most state DOTs face increasing transportation needs, scarcity of funding, growing pressure to reduce the time of project development, and an increasing need to enhance the effectiveness and efficiency of their SOS. Identification, development, and implementation of best practices will help state DOTs develop and deliver projects faster by improving project procurement effectiveness and efficiency. This study also provided a 'Model,' the methodology, for state DOTs to systematically assess their current practices and obtain input/suggestions for process improvement from the agency's own SMEs, other comparable state DOTs, and the external development and delivery partners providing professional services.

This research study utilized an Exploratory Sequential Design, as shown in Figure 3.1 (Mixed Method Research Design). It is categorized as exploratory because it seeks to identify and SOS best practices to streamline a State DOT's SOS to improve scope development and procurement of PSCs on their projects. This design was selected to facilitate a qualitative analysis to aid and enhance the quantitative findings. The proposed methodology for this research study is completed in three phases comprising nine tasks. What follows is a brief description of conclusions supported by each phase of this research.

6.1. Conclusions: Phase 1 – Investigate SCDOT SOS and Consultants' Input

The knowledge gained and the lessons learned by the Steering Committee and the research team during the execution of this phase of research methodology were extensive. This review of the study methodology (steps) and the lessons learned should be valuable to any state DOT planning to evaluate its approach to project development. The lessons learned include the following:

- Inter-departmental coordination and leadership are essential in project scope development: Cross-functional coordination within an agency is always a challenging task when it comes to interdependencies and how they impact project delivery. Active involvement of RPGs, SMEs, and project managers in the SOS development process is critical to the project's successful delivery. It was found that a lack of coordination between the DOT personnel may result in inadequate project information in the advertisements, burdening the consultant firms as they prepare to bid. Again, poorly developed SOS is prone to frequent scope and fee modifications impacting the overall project performance.
- Clearly defining the project deliverables and assumptions in the SOS: Defining the project deliverables, design exceptions, and assumptions is a critical part of the strongly developed

SOS. These elements together provide a better understanding to the DOT and the consultants in terms of what is expected on a particular project. Currently, the absence of such details in the SOS has resulted in duality in conceiving the project. The consultants then develop their man-hours and fee estimates different from those developed by the DOT. Having the deliverables defined clearly, along with necessary assumptions, will reduce the gap in understanding and aid better scope and fee negotiations between the parties.

- Need for standardization of SOS development: As stated, the SOS development process is complex and spans multiple agency functional departments. In addition, during the scope development process, the SMEs and the PMs often refer to the SOS of similar projects that were delivered in the recent past. Although this practice seems to save time in developing SOS from the beginning, it comes with many variables based on the project's needs. There is little control over a non-standardized scope. Therefore, it is necessary to develop a comprehensive SOS that encompasses standard scope language, list of deliverables, and project assumptions. This, of course, will help streamline the scope development and negotiation process with the consultants.
- Identification of Project Variables: All projects come up with a range of uncertainties and variables, including source of funding, type of project (EA/CE), geography, soil data, which need to be dealt with differently. Therefore, identifying these project variables (i.e., Decision Tree Variables) by the research team is key to developing SOS that fulfills project-specific needs.

Conclusions supported by the survey data received from Professional Services Consultant firms for both negotiations of scope and contract fee in the procurement of PSCs include the following:

6.1.1. Procurement of Professional Services Consultants (PSC)

Professional Services Consulting firms thought the SOS mentioned in the agency's Requests for Proposal (RFP) was consistent. However, they also mentioned that SOS did not mention project information with the necessary details. Besides, the majority of consultants believed that the project scope and goals were well-defined. However, they considered project deliverables to be inconsistent from project to project. In addition, one of the strongest assertions shared by consulting firms was that the procurement timeframe was too long. More than two-thirds (69.4%) of the respondents believed that once consultant fee(s) negotiations are finalized, it takes unnecessarily long to issue the contract and NTP. Similarly, 56.6% of the respondents thought the SCDOT SOS negotiation was ineffective and inefficient.

There was strong support from PSCs for developing a standard SOS template to aid an efficient and effective consultant procurement process. Also, most consulting firms suggested that adding assumptions and deliverables would be beneficial to reduce the timeframe of the SOS negotiation

process. An overwhelming consultant support was seen for face-to-face or virtual scope meetings rather than trading emails to resolve scope-related issues.

6.2. Conclusions: Phase 2 – Comparable State DOTs Input

The literature related to SOS was reviewed, and SOS documents of different state DOTs were analyzed to identify eight criteria and collected information for each criterion from 26 state DOTs. Results showed the comprehensiveness of each criterion varied from state to state. Thirty percent (30%) of the states (8 states out of 26 states) had SOS documents related to engineering design. The SOS criteria were weighted and scored using AHP and inputs from the data analysis, and SOS components were the most important criterion (importance weight=72.35%). Among the sub-criteria of SOS Components, Environmental studies/Documentation/Permitting had the highest importance weights.

Finally, the SOS's comprehensiveness was evaluated, and a list of the rankings of the state DOT's SOS was generated through the AHP. Comparable state DOTs were identified based on state DOT's shared criteria, characteristics, and statistics, and structured interviews were conducted. The structured interviews with comparable state DOT SMEs resulted in identifying all the objectives noted in this chapter.

To conclude, Phase 2 of this research helped identify SOS best practices by further probing and gathering in-depth information on SOS concepts explored in previous phases of this research. Besides, gathering in-depth input from comparable state DOTs helped establish support for SOS best practices and findings explored through the national state DOTs interviews discussed in chapter 4. A detailed description of the identified SOS Best Practices is discussed in Chapter 5.

6.3. Conclusions: Phase 3 – SOS Development and Recommendations

This research phase presented the research methodology, Phase 3, Streamlined and Updated SOS practices identified from the data analysis and findings of the previous phases of this study discussed in the previous chapters. It discussed three tasks, review and summarization of findings and data analysis from previous research phases, development, and detailed description of SOS best practices from the findings and analysis and establishing recommendations concerning SOS for SCDOT (Figure 3).

The identified SOS best practices were assembled based on the data, analysis, and findings supported by four different data sources, SCDOT SME Interviews, ACEC-SC consultant survey, interviews with the PSCs, and interviews with the comparable DOTs. The analysis of all data sources was used to assemble ten (10) SOS Best Practices, which are numbered and categorized into four categories as follows:

- SOS Template Development and Implementation

- Integration and Programming of SOS Template with DT Variables
- Consultant Procurement and Management, and
- Hosting, Maintaining and Updating of Scope of Services Template

The ten SOS best practices identified, developed, and listed in this phase are compared to SCDOT's current SOS development process to generate a list of recommendations to enhance and streamline SCDOT's SOS. These SOS best practices are focused on project and program-specific needs and aid the development and implementation of a streamlined and updated SOS permitting SCDOT and any other state DOT to manage the SOS development process more effectively and efficiently. This research phase also focused on the development of a comprehensive SOS template and integration of the SOS with DT variables. The DT variables were linked with specific project scope items to customize the SOS document per the project needs.

6.4. Limitations and Future Directions

With any scientific research comes a number of limitations. As stated in the report, the overarching mixed methods design for this work comprised qualitative and quantitative phases. Perhaps a major limitation was the number of participants in our survey. While valuable information was retrieved from the survey data, the number of respondents was insufficient to generalize our findings to the entire engineering design population. This limitation was minimized by combining the quantitative findings with the qualitative data. Interview and panel participants found the goals of this research meaningful and practical, which helped the team recruit knowledgeable experts with diverse work backgrounds and experience.

Almost unanimously, and throughout every task and phase of this current work, we came across a dire need for a standardized, centralized SOS development process tied to fee estimates. That is, a system that could refine and scope a new project based on its basic characteristics (i.e., DT variables). As part of the current project, the research team identified these characteristics and how the input to the DT variables should impact the SOS document. Also, a web-based platform was designed to operationalize this effort. With the proof-of-concept handy, a number of critical research questions listed below must be addressed in the future.

I. To what extent can the streamlined SOS process help reduce the procurement duration, if adopted?
II. How often should the comprehensive SOS template and the website be updated? Who should be responsible for maintaining the system and ensuring its proper performance?
III. Can the existing system be tied to estimating fee calculations, and as a result, a unified, centralized system be designed such that the user(s) access a single hub to draft, share and negotiate a consultant contract?
IV. How can the existing and past efforts at the SCDOT be utilized to make smart and efficient decisions for future projects?

This research project has opened new windows to more meaningful and practical ideas as to how SCDOT can improve procurement and contract-management processes by using the invaluable knowledge already embedded within the expert individuals and the agency as a whole.

References

1. Haidary, T. A., Bausman, D. C., Jadhav, A. S., & Chowdhury, M. (2022). Mapping the Preconstruction Project Development Process for Transportation Projects. In *Construction Research Congress 2022* (pp. 706-714).
2. Bausman, D., Chowdhury, M., & Tupper, L. (2014). Best practices for procurement and management of professional services contracts. *Journal of Professional Issues in Engineering Education and Practice*, *140*(3), 04013019.
3. Hillis, D., Jones, J., & Ekern, D. (2016). Executive Strategies to Deliver Practical Design (No. NCHRP Project 20-24, Task 102).
4. Anderson, S., Quiroga, C., Overman, J., Choi, K., Sahu, J., Kermanshacki, S., . . . Li, Y. (2016a). Effective project scoping practices to improve on-time and on-budget delivery of highway projects Transportation Research Board. doi:10.17226/23398
5. Berger, L. and I. Associates, Design-Build Environmental Compliance Process and Level 31 of Detail: Eight Case Studies, 2005.
6. McMinimee, J. C., Schaftlein, S., Warne, T. R., Detmer, S. S., Lester, M. C., Mroczka, G. F., ... & Yew, C. (2009). Best practices in project delivery management (No. NCHRP Project 20-68A)
7. Wood, H. P., Kassoff, H., McGrath, T., Malley, W. G., Rose, D. C., & Skinner, N. (2014). Guidance for Managing NEPA-Related and Other Risks in Project Delivery, Volume 2: Expediting NEPA Decisions and Other Practitioner Strategies for Addressing High Risk Issues in Project Delivery (No. NCHRP Project 20-24, Task 71)
8. Crossett, J., & Oldham, S. (2005). Framework for measuring state transportation agency performance in context-sensitive solutions. Transportation research record, 1904(1), 84-92
9. Gen S, Kingsley G. Effects of Contracting Out Engineering Services Over Time in a State Department of Transportation. Public works management & policy 2007 Jul;12(1):331-343.
10. Nambisan S, Hallmark S, Albrecht C. PREPARING TOMORROW'S TRANSPORTATION WORKFORCE: A MIDWEST SUMMIT.
11. Vandervalk A, Cronin B, Thompson C. PROJECT FINAL REPORT ACKNOWLEDGMENT OF SPONSORSHIP. 2020 -03.
12. TOP 10 takeaways. Sun (London, England : 1964) 2017 Aug 06,:29.
13. Quattlebaum L, Dee PEP. Reducing Scoping Deficiencies to Improve the Delivery of Transportation Projects 1. Problem Statement. 2019 -02-20.
14. FDOT. https://www.fdot.gov/environment/pubs/scope/sos.shtm June 21, 2022

15. Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M. (2017). Project scoping guidebook for metropolitan planning organization transportation projects product 0-6929-P1 cooperative research program in cooperation with the federal highway administration and the Texas department of transportation
16. Project Development and Design Manual | FHWA. 2018 https://highways.dot.gov/federal-lands/pddm
17. Wood, H. P., Kassoff, H., McGrath, T., Malley, W. G., Rose, D. C., & Skinner, N. (2011). Guidance for managing NEPA-related and other risks in project delivery, Volume 1: Guide for managing NEPA-related and other risks in project delivery (No. NCHRP Project 20-24)
18. NEPA: Environmental Review Toolkit. (n.d.). Retrieved January 6, 2021, from https://www.environment.fhwa.dot.gov/nepa/nepa_projDev.aspx.
19. Statewide Transportation Improvement Program – STIP. https://www.scdot.org/inside/planning-stip.aspx 2021
20. Bausman, D., Haidary, T., Chowdhury, M., & Lifsey, M. (2021). *SCDOT Project Development Process: Update and Best Practices* (No. FHWA-SC-21-03). South Carolina. Dept. of Transportation. Office of Materials and Research.
21. Kermanshachi, S., Anderson, S. D., Goodrum, P., & Taylor, T. R. (2017). Project scoping process model development to achieve on-time and on-budget delivery of highway projects. Transportation Research Record, 2630(1), 147-155
22. Bejleri, I., Roaza, R., Thomas, A., Turton, T., & Zwick, P. (2003). Florida's efficient transportation decision-making process: Laying the Technology Foundation. Transportation research record, 1859(1), 19-28
23. Redd, L., & McDowell, T. (2013). Minimizing the Impacts of Cost and Revenue Uncertainties on Transportation Project Delivery. Transportation research record, 2346(1), 56-62.
24. Kermanshachi, S., Safapour, E., Anderson, S., Goodrum, P., Taylor, T., & Sadatsafavi, H. (2019). Development of multi-level scoping process framework for transportation infrastructure projects using IDEF modeling technique. In Proceedings of Transportation Research Board 98th Annual Conference.
25. TransTech Management, Inc. (2004). Performance Measures for Context Sensitive Solutions: A Guidebook for State DOTs. Transportation Research Board.
26. Paiewonsky, L., DiPaolo, T. A., Bonsignore, R., Larkin, B., & Conklin, C. (2007). Mainstreaming context-sensitive design in Massachusetts: deployment of the new project development and design guide. Transportation research record, 2025(1), 98-107.
27. Neuman, T. R., Schwartz, M., Clark, L., Bednar, J., Forbes, D., Vomacka, D., ... & Abere, D. (2002). A Guide to Best Practices for Achieving Context Sensitive Solutions (CD-ROM) (No. CRP-CD-23).

28. Craigie EK, Gransberg DD, Jeong HD. Cost and Scope Breakdown Structure for Functional Level Estimating of Consultant Fees. Transportation Research Record 2016 - 01;2573(1):157.
29. Kirby JG, Furry DA, Hicks DK. Improvements in Design Review Management. Journal of construction engineering and management 1988 Mar;114(1):69-82.
30. Burati JL, Farrington JJ, Ledbetter WB. Causes of Quality Deviations in Design and Construction. Journal of construction engineering and management 1992 Mar;118(1):34-49.
31. Jin W, Haidary TA, Bausman DC, Chowdhury M. Evaluation of Project Development Process at State Transportation Agencies. Transportation research record 2021 Mar;2675(3):326-337.
32. Le T, Asce SM, Caldas CH, Asce AM, Gibson ;GE, PE, et al. Assessing Scope and Managing Risk in the Highway Project Development Process.

Appendices

SCOPE OF SERVICES INTERVIEW TOPICS/QUESTIONS

CURRENT SOS DEVELOPMENT PROCESS

Department/SME Involvement

- Review/explain the current process for development of SOS task(s)
- What are the 'challenges' for SOS Development? Your view as to best practices?
- What is the Department's involvement/responsibilities? What should it be?
    - Responsibility for SOS development/creation for each project? (create, review/critique?)
- Is there a defined process used to determine what scope items to include/exclude?
    - How much detail about the project is available?
        - Is the info available consistent from project to project?
    - How much input/authority does a PM typically have in making final determination of scope items related to their project?
- Would it be useful to develop such a process, given the variations in project type and PM's level of involvement?
- Is there a different methodology/process for different project types and/or RPG/PM? Your thoughts for developing consistency?
- What is the 'normal' amount of time required for SOS development for a PSC contract? Recommendations (and implementation suggestions) to shorten the timeframe?
- What changes or improvements, if any, would you suggest for SCDOT's current scoping process?
- What steps can consultants take to improve the process? Have you noticed any best practices by consultants?

TEMPLATE/STANDARD SCOPE OF SERVICES (SOS)

Template/SOS Development

- What scopes of work have a 'Standard' Template(s)?
- If there is currently no 'baseline' template(s), can you recommend example(s) of what you consider to be a well-developed SOS?
- Characteristics of a SOS that you deem to be well-developed?
- We are evaluating 'Bridge' and 'Highway' SOS for template development – are there others you would see as critical?

Template/SOS Changes & Alterations

- What scope tasks often need to be revisited when negotiating the man-hours? Does this normally result in a renegotiation of scope?
- What templates (or SOS) never (or seldom) change?
- How does the Template change, if needed, to address each project variable?
- Which scope items are often the most difficult to finalize?

SCOPE OF SERVICES INTERVIEW TOPICS/QUESTIONS

Template/SOS 'Components' (Use Department's SOS or an SCDOT 'Baseline')

- Do you prefer a prescriptive (detailed) SOS or one that is performance based (general)?
- In general, are current SOS's prescriptive (detailed) or performance based?
- Should/could some SOS language be addressed by referencing Federal, State/SCDOT, or Local regulation, manual or process? i.e. Should/could federal, state, or local requirements, manual, process just be referenced? Do you have examples from previous SOS's?

- Of the following list, which do you consider to be the primary project variables that drive template (SOS) change(s)?
    - Project type? (which ones)
    - Project location, seismic, traffic volume or loading, over water/hwy/land, ROW needs, foundation system added/replaced, funding source,…?
    - Types of bridge(s) – standard, more complex, or major cable-stayed or suspension?
    - RPG/SCDOT Management Preference
    - Funding source (local, state, federal)?
    - Level of environmental document? CE vs EA/FONSI

    Other scope issues, such as:
    - Level of public engagement anticipated (mailings and flyers, web interaction, public information meeting(s), formal public hearing(s), or major community engagement program)?
    - Maintenance of traffic scheme during construction? (construct in same footprint under road closure, construct on new alignment, construct on new alignment parallel to the existing, construct in the same footprint while maintaining traffic - staged construction)
    - Bridges crossing (1) a creek, (2) a major river, (3) a coastal inlet, or (4) a railroad?
    - Aerial mapping required, or is it small enough to be limited to ground surveys?
    - Is coastal storm surge or wave impact analysis required?
    - Will the project involve adding or modifying an interchange on an interstate system?
    - HazMat sites within the project footprint?
    - Wetland or stream impacts? Mitigation credits available?
    - Accommodations for pedestrians or bicycles?

    Considering the number of 'possibilities' the variables addressed by the template(s) will likely need to be limited.

- Difference(s) of a stand-alone vs a task in a 'comprehensive' project Design template/SOS?

CONSULTANT PROCUREMENT AND SCOPE OF SERVICES SURVEY

Survey Objective

.

SCDOT has commissioned Clemson University to assist the agency's development of Standard Scope of Services templates for procurement of Professional Services Consultants. The following survey has been developed to obtain feedback regarding the agency's Scope of Services from consultants that have, or currently are, providing professional services on SCDOT Turn-Key Projects. Your feedback is essential to aid improvement and promote consistency of SCDOT's Scope of Services for procurement of professional services.

The survey should take you only 10-15 minutes to complete. Please be assured that your responses will remain confidential. If you have any questions/concerns regarding this survey, or require additional accommodations, please contact dennisb@clemson.edu. Thank you for your participation!

Company Information (Exclude Design-Build and CE&I Projects in your response)

Q1.

Which of the following services does your firm typically provide on SCDOT Turnkey projects? (Select all that apply)

☐ Engineering Design ☐ Speciality Services to Support Design ☐ Other

Q2. What role does your firm most commonly serve on SCDOT Turnkey contracts?

○ Prime ○ Sub

Q3. Which of the following best describes your organization's primary *area of operation*?

○ South Carolina ○ Regional ○ National

Q4.

Approximate percentage of your company's annual volume that is in *transportation* (fed/state/local):

○ 0-10% ○ 11-25% ○ 26-50% ○ 51-75% ○ 76-100%

SCDOT Scope of Services Negotiation Process

Q5.

Please indicate your agreement or disagreement with the following statements: (select one)

	Strongly Disagree	**Disagree**	**Agree**	**Strongly Agree**	Don't Know
The negotiation process for scope of services is consistent from Program Manager to Program Manager.	○	○	○	○	○
The SCDOT Scope of Services Negotiation Process is handled consistently by each RPG within the Agency.	○	○	○	○	○
The SCDOT Scope of Services Negotiation Process is handled consistently by each Department (Traffic, Survey, Utility Coordination, etc.) within the Agency.	○	○	○	○	○
Consultants typically assume that the initial scope of services provided by SCDOT is accurate and necessary for the project.	○	○	○	○	○
SCDOT's review(s) and feedback to consultants during the negotiation process for the scope of services is prompt.	○	○	○	○	○
SCDOT provides adequate training on the agency's procurement process for professional services consultants.	○	○	○	○	○

	Strongly Disagree	**Disagree**	**Agree**	**Strongly Agree**	Don't Know
Overall, the negotiation process for the scope of services is typically efficient and effective.	○	○	○	○	○
The initial scope of services provided by the SCDOT is consistent with the services identified in the RFP.	○	○	○	○	○
Meeting, face-to-face or virtually, during the negotiation process to discuss & resolve scope of services issues is more efficient than trading comments/edits via email.	○	○	○	○	○
SCDOT Project 'background' information and key project decisions are shared with the Consultant.	○	○	○	○	○
Consultants typically have a sufficient understanding of the scope at the onset of negotiations.	○	○	○	○	○

	Strongly Disagree	Disagree	Agree	Strongly Agree	Don't Know
SCDOT Program Managers typically have sufficient understanding of the scope at the onset of negotiations.	○	○	○	○	○

	Strongly Disagree	Disagree	Agree	Strongly Agree	Don't Know
SCDOT Technical Staff (Design Disciplines, Traffic, Survey, etc.) typically have a sufficient understanding of the scope at the onset of the negotiations.	○	○	○	○	○
SCDOT scope documents are consistent for similar project types.	○	○	○	○	○
Consultants are encouraged to suggest changes to the project scope based on their knowledge/experience with the project type.	○	○	○	○	○
Overall, the negotiation process for scope of services is completed in a timely fashion.	○	○	○	○	○

Q6.

Suggestions for improvement of the Scope of Services Negotiation Process:

SCDOT Contract Fee Negotiation Process

Q7.

Please indicate your agreement or disagreement with the following statements: (select one)

	Strongly Disagree	Disagree	Agree	Strongly Agree	Don't Know
Negotiation of the estimated cost for the professional services is completed in a timely fashion.	○	○	○	○	○
Reaching agreement on the cost of services is an efficient process.	○	○	○	○	○
The fee negotiation process results in a fair and reasonable fee for the project.	○	○	○	○	○
SCDOT’s negotiation process is consistently administered/managed from RPG to RPG.	○	○	○	○	○

	Strongly Disagree	Disagree	Agree	Strongly Agree	Don't Know
Once negotiation of consultant fee(s) is finalized, the contract & NTP are issued in a timely fashion.	○	○	○	○	○
During fee negotiations the scope of services is revisited multiple times.	○	○	○	○	○

Q8.

Suggestions for improvement of the Fee Negotiation Process:

SCDOT Procurement Process - Duration(s)

Q9. **What is the typical duration & duration range on SCDOT projects for:**

(Note: Please enter numeric values in whole months)

	Typical (mos.)	Lowest	Highest
Consultant selection after submission of proposals			
Scope of Services negotiation			
Estimation and negotiation of the cost of services			
Receipt of a NTP once contract negotiations are completed			
The overall duration from proposal submission to a NTP			

Additional Comments/Suggestions

Q10. Any additional comments or suggestions?

. Again, thank you for your participation! If you would like a summary of the findings of this study please provide your e-mail address (or if you would like to maintain anonymity, please send your e-mail address and request directly to **dennisb@clemson.edu**)

PSC Procurement and Scope of Services Development Research

South Carolina Research Project

Research Interest/Focus and South Carolina DOT Approach:

A large portion of SCDOT's bridge and corridor improvement projects are contracted to design consultants via a comprehensive, all-inclusive design package with the consultant. With these contracts the design consultant is also responsible to procure and manage any specialty firms and supporting consultants they may need to complete the project. Typically, these design contracts are awarded prior to the start of any conceptual design. Then, subsequent to award, the agency's project team (project manager and SMEs) develops & negotiates a comprehensive, project specific scope of services with the design consultant. This method of contracting has some advantages and several challenges, including the development of a comprehensive project design package when some (possibly many) of the design and development variables are not well known at the time of contract.

Some state DOTs utilize a similar approach while others may use some variation of phased procurement, a more extensive use of on-call, expanded use of design-build, and/or another approach for design procurement and scope development. To gain insight into these procurement and scope development alternatives, SCDOT has commissioned Clemson to investigate how other DOTs procure design services and develop the corresponding scope of services.

We are not looking to 'drill down' into task specifics, but rather focus on agency process(es) and approach. To aid our effort we have developed a summary listing of questions/topics we would like to probe with each state DOT as noted below. In addition to providing insight regarding our inquiry, it should help identify who within your agency is best suited to address these topics.

We look forward to gaining insight into your agency's approach. Thanks for your support of this effort.

State DOT Interview Topics/Questions

PSC Procurement & Scope Development

Professional Services Consultant (PSC) Procurement Process

PSC Use

- Use of PSC for project design and project /program types

Contracting Approach for PSC (extent of use, where/when used)

- Turn-key: full responsibility for engineering/design procured at project start
- Phased: engineering/design procurement in multiple phases (& # of phases)
- On-call: a) portions of the project, b) turn-key, and/or c) phased
- Pros/Cons with each approach?
- Who makes the decision regarding project approach/contracting method?
- What impact, if any, has the state's legal environment had on your procurement method(s)?
- Trends regarding the agency's use of certain procurement method(s)?

Procurement Process

- Does the agency have a procurement flowchart(s) reflecting the (each) process?
- Does the agency track performance (time) of the procurement process?
- What process milestones are used to monitor/measure performance?
- Any trends regarding the agency's use or monitoring of procurement performance?

PSC Procurement and Scope of Services Development Research

South Carolina Research Project

Process effectiveness

- What elements of the agency's procurement process are effective? Why?
- What is ineffective – needs improvement? Why?
- Recent changes and/or improvements that the agency has taken to enhance the process?
- Changes or improvements you would suggest for the current procurement process?

PCS Procurement: Scope of Services (SOS) Development

Scope of Services Development

- Who has responsibility for scope development (personnel and/or department)?
- Level of functional department involvement in scope development:
- How does it differ with each Contracting Method?

Scoping Templates

- Template Development (& access to templates)
- Scoping Template Use
- Projects, Programs, and/or Procurement Methods difficult to establish the correct scope?
- SOSs Development Effectiveness
- Scoping process improvements that are planned, or you recommend the agency consider?

Fee Negotiation

- Negotiation process. Who is responsible? Who is involved?
    - Use of the following contracting fee (payment) method? Cost-Plus, Lump Sum, Other
- Changes or improvements you would suggest for the current negotiation process?

Scope of Services for Consulting Projects

Project ID 1111

Project Title My New Project

Uncheck the box if not applicable:

- [x] **Field Surveys**
- [x] Geotechnical Bore Holes
- [x] **Environmental Documentation (NEPA)**
- [x] Waters of the US
- [x] CFR Part 772 - Noise Analysis
- [x] EA
- [x] **Public Involvement**
- [x] **Environmental Permitting**
- [x] Part of NEPA Document
- [x] 404/401 Permit
- [x] Critical Area Permit
- [x] Coastal County (CZC Certification)
- [x] Navigational Permit
- [x] Individual Permit (IP)
- [x] Mitigation Bank Available
- [x] **Traffic Analysis & Design**
- [x] Lane Closure(s)
- [x] Roadway Widening
- [x] Intersection Improvement
- [x] New or Existing Traffic Signal(s)
- [x] Low Volume Bridge
- [x] Roadway Lighting
- [x] **Subsurface Utility Engineering (SUE)**
- [x] Quality Level A (Location)
- [x] Quality Level B (Designating)
- [x] Quality Level C (Surface Survey)
- [x] Quality Level D (Existing Records)
- [x] Gravity Sewer Manholes
- [x] Aerial Poles
- [x] **Bridge Project**
- [x] Tidally Influenced Hydrology
- [x] Bridge Alternate Study
- [x] Conceptual Bridge Plans
- [x] SDC A
- [x] **Bridge Load Ratings** (Required for Bridge OR Bridge Size Culvert)
- [x] **Roadway Structure(s)**
- [x] Earth Retaining Structure(s)
- [x] Sound Barrier Design
- [x] Culvert(s)
- [x] **Roadway Design**
- [x] Alternative Roadway Design
- [x] **Hydrology & Hydraulic Design**
- [x] FEMA Floodplain
- [x] **Geotechnical Investigation & Engineering**
- [x] Preliminary Subsurface Investigation
- [x] Preliminary Exploration
- [x] **Utility Coordination**
- [x] **Railroad**
- [x] **Right of Way Services**
- [x] **Pipe & Culvert Inspections**

Submit

Evaluation of the Engineering and Design Scope of Services for State DOT Infrastructure Projects

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Transportation agencies across the United States (U.S.) are under increasing pressure to deliver the project more efficiently and effectively. To meet expectations, the agencies are increasing the rate of procurement of professional consultant services as they are facing various challenges in project scoping process (PSP). Since the scope of services (SOS) and PSP are related to each other, this study is focused on evaluation of the available data addressing the comprehensiveness of the SOS across different states. The authors focused on the design SOS and evaluated 49 documents from 8 state departments of transportation (DOTs). The authors then developed a series of criteria for assessing the comprehensiveness of these selected DOTs. Data analysis indicated significant variations across the states in terms of the criteria. Further, weights were assigned to the identified criteria and sub-criteria using the analytic hierarchy process (AHP) and the SOS documents were ranked for their comprehensiveness. Comprehensive score indices (CC_i and CC_e) were calculated using the level of comprehensiveness and the level of importance derived from actual SOS document pages and AHP respectively.

Keywords: Scope of Services (SOS), Project Scoping Process (PSP), Analytic Hierarchy Process (AHP), Department of Transportation (DOT).

Introduction

In recent years, the transportation industry has witnessed an increase in the use of professional services consultants for engineering and design professional services to meet rising demand. This increased demand has elevated both the number of projects for states' Department of Transportation (DOT) and the need for on-time delivery to meet the increased need for transportation projects (Gen & Kingsley, 2007). Compounding the challenge is that DOTs are facing shortage of skilled and seasoned employees to keep up with the increasing demands as thousands of workers are expected to retire over the next 5 to 10 years (Nambisan, Hallmark, & Albrecht, ; Vandervalk, Cronin, & Thompson, 2020).

According to the American Road & Transportation Builders Association's (ARTBA) seventh annual analysis of the latest U.S. DOT's National Bridge Inventory (NBI) database, more than one-third, or 220,000, of the nation's 618,000 bridges need structural repair, rehabilitation work or replacement

(TOP 10 takeaways, 2017). The USDOT categorizes the condition of bridges as good, fair, and poor (structurally deficient). Of the total bridges that need structural repair, rehabilitation work or replacement, 45,000 of them are classified as structurally deficient. At the current pace, it would take nearly forty (40) years to repair the rising backlog of structurally deficient bridges, according to the report (TOP 10 takeaways, 2017). Moreover, many transportation projects have experienced significant delays in schedules over the last three years (Quattlebaum & Dee, 2019). The majority of the delays were caused by deficiencies related to projects' scopes of work (SOW).

To address the increasing burden of transportation projects aggravated by the lack of seasoned employees, the DOTs have increased the rate of procurement for engineering and design professional services. In order to avoid procurement delays, particularly related to insufficient project details associated with inadequate project scopes, a comprehensive and well-developed project scope is essential. The objective of this study is to evaluate the components of professional consultant scope of services (SOS) for state DOT projects. This paper elucidates essential engineering and design SOS criteria identified from relevant SOS documents collected from different state DOTs.

Literature Review

A well-defined project scoping process (PSP) is essential for a state Department of Transportation (DOT) to effectively meet the infrastructure needs of their state. The lack of consistent project scoping definition makes the pre-contract scoping processes challenging for the state transportation agencies (STAs). According to a study conducted on pre-contract PSP by Hamed Zamenian et al., the Indiana DOT had to face problems due to inconsistency in the scoping process across different units within the agency. This problem was also associated with lack of resources for coordination and long-term planning (Zamenian & Abraham, 2016). The authors could not identify a pattern for such inconsistencies in the scoping practices, but support was identified to link it to the absence of formal policy to assess the quality and effectiveness of their scoping procedures (Zamenian & Abraham, 2016).

In developing the PSP framework, Kermashachi et al., highlighted that the lack of scope definition and lack of details associated with project scoping often resulted in cost and time overruns. The authors also indicated that transportation projects are often programmed before defining the scope sufficiently which resulted in delays and increased costs (Kermanshachi, Anderson, Goodrum, & Taylor, 2017). Moreover, inaccurate estimates result in changes associated with project budgeting and schedule causing the DOTs to adjust in the scope definition of transportation projectss (Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M., 2017). The level of scope definition has considerable influence on the cost and schedule of a project and can hinder the ability to control project change orders (Kermanshachi, Safapour, Anderson, Goodrum, & Taylor, 2020; Le et al., 2009).

Kermanshachi et al. also developed a multi-level project scoping model for transportation projects. The authors used the integrated definition modeling technique to develop the scoping process. The development of this technique led to the adoption of appropriate best practices and strategies which reduced scope changes and prevented unnecessary delays for infrastructure projects (Kermanshachi et al., 2019). The authors also identified major activities associate with the PSP which were classified into four categories: environmental, right-of-way (ROW)/utilities, design, and construction. The study of these categories indicated that collectively all four categories are critical dimensions of an effective PSP (Kermanshachi et al., 2020).

An internal report on reducing scoping deficiencies to improve the delivery of transportation projects for the South Carolina Department of Transportation (SCDOT), identified eight major obstacles that delayed projects from advancing to the construction phase of work (Quattlebaum & Dee, 2019). The analysis showed 495 events of delays in different phases of work across a span of over three years. The delays that were evaluated ranged from 90 days to over 1700 days. Among the eight obstacles identified, scoping deficiencies attributed to 45% of the delays. These deficiencies included any modifications to the original design criteria established to meet the purpose of the project (Quattlebaum & Dee, 2019).

At present, few, if any, detailed investigations have been undertaken to evaluate the comprehensiveness of scope of services (SOS) related to development of engineering and design elements. This study is intended to bridge this gap and assist state DOTs in the development of the tasks and subtasks necessary to identify the SOS criteria which is important to achieve a comprehensive SOS.

Research Methodology

A five-step research method was used to investigate and evaluate development of consultant scope of services (SOS).

Step 1: Data Collection

The first step in the research methodology was to collect data that was relevant to the scope of services (SOS) for professional services consultants. To initiate this step, the authors further divided this step into three sub-steps.

Conduct a literature review – Scientific databases such as Google Scholar, Transportation Research Board (TRB) database, FHWA, and other scholarly publications that include American Society of Civil Engineers' (ASCE) Construction Research Congress (CRC), and SAGE Publications were searched to retrieve relevant literature data. A total of 37 publications based on various topics including PSP and related studies were retrieved from these sources.

Investigate each of the 50 state DOT websites for relevant data –Twenty-six (26) states had a variety of documents related to professional SOS ranging from templates, requests of proposal (RFP), and contracts with actual project scopes. These documents were available in the public domain. Published documents were not available on the DOT's website for the remaining 24 states. Some of these remaining states did have a consultants' page on their respective agency websites but the documents were not publicly accessible. The 26 states that had information available are California, Nevada, Utah, Colorado, Texas, Oklahoma, North Dakota, Wisconsin, Iowa, Missouri, Louisiana, Mississippi, Tennessee, Kentucky, Ohio, Florida, Georgia, South Carolina, North Carolina, Virginia, New York, North Hampshire, Maine, New Jersey, Vermont, and Minnesota.

Collection of data from secondary sources – This includes the data collected from the industry consultants' websites.

Step 2: Data Organization

Based on the website search of state agencies, the authors identified 155 documents relevant to the study. These documents included templates, contracts, and RFPs. The documents were studied for

their content and organized according to the services provided. The organization of these documents was done in the following manner:

State-wise listing of documents – The documents collected were arranged according to the state.

Organize the documents – After development of a comprehensive listing, the documents across states were re-arranged based on the document name/title. Documents with similar titles were grouped together.

Categorize the documents – Once the documents were organized, they were placed into their appropriate group or "service categories". This task aimed to process the raw data into a more meaningful form for detailed study within the defined service categories. Each service category represented the type of service the documents provided. This process was repeated until all 155 available documents were grouped into their most suitable categories.

Step 3: Develop SOS criteria for evaluation

Considering the influence that engineering design elements have on the scoping process (Burati, Farrington, & Ledbetter, 1992; Kirby, Furry, & Hicks, 1988) the focus of the research effort was strictly limited to the category of 'engineering design/design' SOS only . This resulted in reduction of the candidate state DOTs from twenty-six (26) down to eight (8) as the other state DOTs lacked published SOS documents related to engineering design. Among these eight (8) states DOTs, a total of forty-nine (49) design SOS documents were available for evaluation. In Step 3, the elements of design SOS were compared to develop criteria for evaluation. Each SOS had two (2) elements – task, and subtask. The documents with a similar type of SOS were compared to identify common tasks and subtasks between them. Similar tasks and subtasks were then grouped into the most suitable criteria. For example, Engineering Design & Analysis criterion had all design-related activities from various SOS documents. This comparison was made across all eight states to determine the criteria.

The eight (8) essential criteria identified were:

- Project Organization & Management
- Engineering Design & Analysis
- Survey & Mapping
- Plans, Specifications, and Estimates (PS&E)
- Right-of-Way (ROW)
- Utilities & Railroad Coordination
- Environmental Studies/Documentation/Permits
- Public Information

In addition to the SOS tasks and subtasks, there are additional criteria that are relevant to evaluate the comprehensiveness of a state DOT's SOS development process (Jin, Haidary, Bausman, & Chowdhury, 2021). They included the following:

SOS Document Year – To evaluate the comprehensiveness of the SOS, it was essential to determine the year when the documents were published by the DOTs. Having a recent SOS is a key indicator that the document identifies current DOT policies and processes for the agency.

Improvements - Value engineering (VE) means adding value to the project in various possible ways including but not limited to reducing overall project cost, improving the design delivery process, make construction simpler, reduce the project duration, improve safety and quality, and consider

environmental goals (Jin, Haidary, Bausman, & Chowdhury, 2021). According to Tiendung Le et al., Risk Management (RM) and scope definition are crucial elements of the project development process (PDP) as it allows to identify the risks at their sources (Jin, 2021; Le et al., 2009). PDP consists of various components and PSP is one of the important components of it. Incorporating risk management criteria built into the SOS allows the DOTs and the consultants to identify, analyze, and mitigate the risks during the design phase.

Step 4: Weighting SOS criteria using AHP model.

After identifying the criteria for evaluation, the next step was to weight the criteria. To address this step, the authors adopted AHP as the most appropriate method to weight the criteria (Jin, Haidary, Bausman, & Chowdhury, 2021). AHP allows judgment in assigning weights to criteria that are incommensurable. The goal was to assign an importance score to each of SOS criteria. The steps utilized to determining the comprehensiveness of PDP were consistent with a prior study (Jin, Haidary, Bausman, & Chowdhury, 2021). For this study, the problem was divided into main criteria: SOS components, SOS document year, and other improvements as shown in both Tables 1 and 2.

Once the hierarchical structure was developed, the authors performed a pairwise comparison which involved comparison of each criterion with the remaining criteria to calculate the weight with respect to one another. Table 1 shows the process of assigning weights to each criterion relative to other criteria using pairwise comparison matrix. The weights were assigned to each criterion with respect to another using the AHP rating scale. By definition, the comparison matrix has two distinct properties: (1). it is a symmetrical matrix, and (2). all the diagonal elements are one, as the relative importance of a criterion with respect to itself is one.

Table 1

Pairwise Comparison Matrix for assigning criteria weights

		Criterion Number							
Criterion	**#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Project Organization & Management	**1**	1	2/9	3/9	3/9	3/9	4/9	2/9	5/9
Engineering Design & Analysis	**2**	9/2	1	6/2	9/9	8/4	4/1	9/9	9/3
Survey & Mapping	**3**	9/3	2/6	1	1/3	5/5	4/2	1/5	6/2
PS&E	**4**	9/3	9/9	3/1	1	6/3	6/2	1/3	1/2
ROW	**5**	9/3	4/8	5/5	3/6	1	4/2	1/3	6/2
Utilities & railroad Coordination	**6**	9/4	1/4	2/4	2/6	2/4	1	1/3	4/4
Environmental Studies/ Documentation/ Permits	**7**	9/2	9/9	5/1	3/1	3/1	3/1	1	8/2
Public Involvement	**8**	9/5	3/9	2/6	2/1	2/6	4/4	2/8	1

The weighting of criteria consisted of: (1). assigning weights to each criterion with respect to another to develop a pairwise comparison matrix; as explained above; (2). normalizing the comparison matrix; and (3). calculating the weights of each criterion by averaging the normalized values in each row. To validate the accuracy of the criteria weights, consistency index (C.I.) and consistency ratio (C.R.) were calculated.

$$C.I. = (\lambda_{max} - n) / (n - 1), \text{ and } C.R. = C.I. / R.I.$$

where, λ_{max} is calculated by dividing all the elements of the weighted sum matrices by each criterion weight, n is the total number of criteria, and RI is the C.I. for a randomly generated matrix.

Assigning the pair-wise scores was a subject task that incorporated the perception and understanding of subject matter experts (SMEs) in design and construction management. The final outcome of this step was a series of importance levels (γ) for each criterion. Specific (γ) values for each criterion are presented and discussed in the Results and Findings section.

Step 5: Ranking the comprehensiveness of SOS.

The final step in the development of evaluation method was to measure the comprehensiveness (ε) of the SOS documents. While there could be several numerical and categorical approaches to do this, one convenient metric is the number of pages with each document that is allocated to each criterion. To that end, each SOS document was closely observed, and the number of pages allotted to each criterion was calculated. It must be noted that the absolute number of pages is misleading. For example, a criterion could be 9 pages in 200 page document vs. in a 20 page document. To resolve this matter, the team defined two distinct approaches to measure (ε) by: (1). Calculating internal comprehensiveness (ε_i) by normalizing the criterion's number of pages by the total number of pages in the document, and (2). Calculating external comprehensiveness (ε_e) by the criterion's number of pages by the total number of pages of the same criterion across all the SOS documents.

Data Analysis

Based on the data collected, the authors conducted data analysis to investigate SOS criteria and their occurrence in the documents collected from various states. A total of 49 SOS documents from eight (8) states were studied. The findings are presented in Table 2.

Table 2

Basic Criteria of Engineering and Design Scope of Services (SOS) (n = 49)

Criteria		**Min.**	**Mean**	**Max.**	**SD**
Documentation year of SOS document		2008	2018	2021	3.5
SOS Components	Total number of document pages	3	56.7	312	67
	The number of tasks in the SOS	1	15.7	39	15.1
	The number of pages of project organization & management	0	6.3	33	8.5
	The number of pages of engineering design & analysis	0	18.5	101	23.9
	The number of pages of survey and mapping	0	3.4	14	4.9
	The number of pages of PS&E	0	2.7	12	3.5
	The number of pages of ROW	0	0.5	4	0.8
	The number of pages of utilities & railroad coordination	0	2.7	19	3.4
	The number of pages of environmental studies/documentation/permits	0	4.1	48	7.3
	The number of pages of public information	0	1.3	10	2.2
Other Improvements	Value engineering	0	0.2	1	0.4
	Risk management	0	0.2	1	0.4

As shown in Table 2, the combined mean of document pages and number of SOS tasks were 56.7 and 15.7 respectively, whereas the state with the highest number was Florida with a mean of 106 pages and 33 tasks. This proves that there was a significant variation between the states.

Results And Findings

Based on AHP, the weights of criteria were calculated to evaluate the comprehensiveness of design SOS. The criteria weights were then used to rank the comprehensiveness of each SOS document. To validate the accuracy of criteria weights, the authors measured the consistency index (C.I.) and consistency ratio (C.R.). Upon calculation, the authors concluded that (C.R. = 0.07568 < 0.10) the matrix was reasonable consistent. Table 3 shows the weights of each criterion and sub-criterion. It was found that SOS components were the most important criteria (72.35%) when compared with other improvements (19.32%) and documentation year (8.33%). Among the sub-criterion of SOS components, environmental studies/ documentation/ permits, engineering design & analysis, and PS&E ranked higher in terms of their weights with 19.14%, 14.82%, and 10.64% respectively. This indicates that the sub-criteria had a high level of importance in terms of tasks and subtasks in the SOS. After establishing weights for each criterion and sub-criterion, the internal and external comprehensiveness score (i.e., CC_i and CC_e) SOS documents across the states were completed.

Table 3

Weight of each criterion

Criterion	**Weight**	**Sub-criterion**	**Weight**
Documentation Year	8.33%	Year of publication	8.33%
SOS Components	72.35%	Project organization & management	2.79%
		Engineering design & analysis	14.82%
		Survey & mapping	6.99%
		Plans, Specifications, & Estimates (PS&E)	10.64%
		Right-of-Way (ROW)	7.82%
		Utilities & railroad coordination	4.42%
		Environmental studies/ documentation/ permits	19.14%
		Public information	5.72%
Other Improvements	19.32%	Value engineering	9.66%
		Risk assessment	9.66%
Sum	100%		100%

Figure 1 shows the comprehensive score indices for internal and external comparison of the SOS documents. The (CC_i) is the product of weighted average of level of comprehensiveness and the level of importance within each document, and the (CC_e) is the product of level of comprehensiveness and the level of importance across all the documents. Based on Figure 1, the authors found the following:

- The comprehensive scores indices are highly variable for both internal (CC_i) and (CC_e).
- The highlighted boxes in Figure 1 show the number of documents from respective states. The FDOT documents in Figure 1 have a significantly consistent comprehensive score index when compared to the rest of the documents. Further, the overall score index for FDOT is the highest among others. This indicates that the FDOT document range in Figure 1 has both consistency and comprehensiveness.
- Again, FDOT ranked first in terms of the average number of SOS tasks with 32.76 (~33) tasks per document.

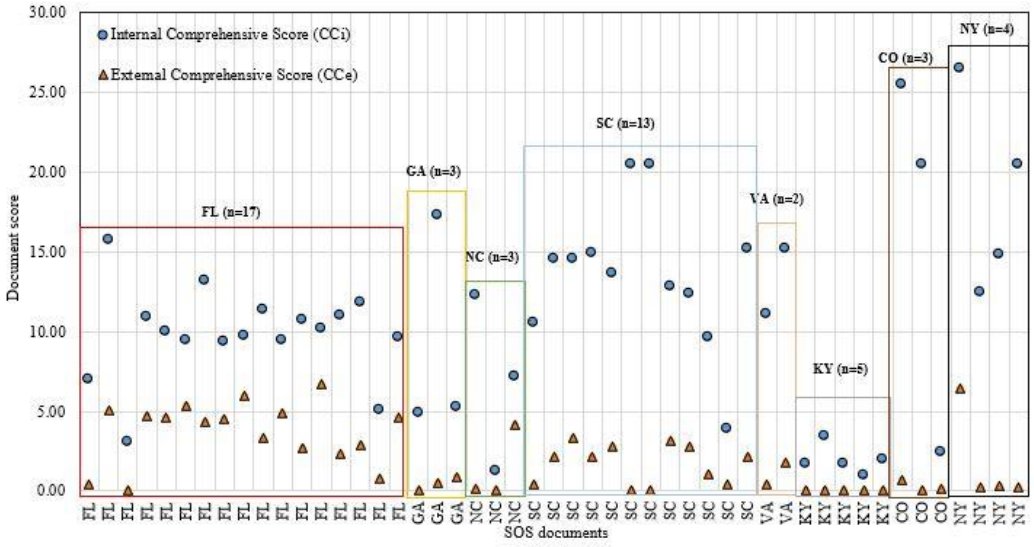

Figure 1. Comprehensive Score Index

Conclusion

To meet the ever increasing demand of infrastructure projects across the U.S., the state transportation agencies need to avoid procurement delays and issues related to insufficient scope development. In order to address the issues related to lack of detailed scope, it is necessary that the state DOTs develop a comprehensive design SOS which can be modified according to the project's need. However, it can only be possible through a detailed evaluation of design SOS components. Therefore, this research paper is aimed at evaluating the engineering and design SOS and measuring the comprehensiveness of the identified criteria. Based on the comprehensive score indices for internal and external SOS documents, it was found that FDOT had both consistency in their SOS documents as well as comprehensiveness when compared with the other seven (7) state DOTs. The key takeaways from this study are:

- Out of the 26 state DOTs that have SOS documents published on their websites, only 8 state DOTs have SOS documents related to engineering design.
- The state DOTs should focus on developing a standard scope language for environmental studies, engineering design & analysis, and PS&E as they contribute 61.64% of the total SOS components.
- Also, a very few state DOTs had documented value engineering and risk assessment in the SOS documents.

Future Research

Based on the evaluation of design SOS, the authors aim to develop a baseline template for design SOS that can be used by all DOTs in procuring consultants. To achieve this goal, the authors will conduct a series of interviews with the industry consultants and candidate states identified in this study.

References

Burati, J. L., Farrington, J. J., & Ledbetter, W. B. (1992). Causes of quality deviations in design and construction. *Journal of Construction Engineering and Management, 118*(1), 34-49. doi:10.1061/(ASCE)0733-9364(1992)118:1(34)

Gen, S., & Kingsley, G. (2007). Effects of contracting out engineering services over time in a state department of transportation. *Public Works Management & Policy, 12*(1), 331-343. doi:10.1177/1087724X07302585

Hessami, A. R., Sun, D., Odreman, G. J., Nejat, A., & Saeedi, M. (2017). Project Scoping Guidebook for Metropolitan Planning Organization Transportation Projects (No. 0-6929-P1). Texas A & M University.TOP 10 takeaways. (2017, Aug 06,). Sun (London, England : 1964) Retrieved from https://search.proquest.com/docview/1926307708

Jin, W., Haidary, T. A., Bausman, D. C., & Chowdhury, M. (2021). Evaluation of project development process at state transportation agencies. *Transportation Research Record, 2675*(3), 326-337. doi:10.1177/0361198120971260

Kermanshachi, S., Anderson, S. D., Goodrum, P., & Taylor, T. R. B. (2017). *Project scoping process model development to achieve on-time and on-budget delivery of highway projects* SAGE Publications. doi:10.3141/2630-18

Kermanshachi, S., Safapour, E., Anderson, S. D., Goodrum, P., & Taylor, T. R. B. (2020). *Establishment of effective project scoping process for highway and bridge construction projects* American Society of Civil Engineers (ASCE). doi:10.1061/(asce)sc.1943-5576.0000427

Kermanshachi, S., Safapour, E., Anderson, S., Goodrum, P., Taylor, T., & Sadatsafavi, H. (2019). Development of multi-level scoping process framework for transportation infrastructure projects using IDEF modeling technique. In Proceedings of Transportation Research Board 98th Annual Conference.

Kirby, J. G., Furry, D. A., & Hicks, D. K. (1988). Improvements in design review management. *Journal of Construction Engineering and Management, 114*(1), 69-82. doi:10.1061/(ASCE)0733-9364(1988)114:1(69)

Le, T., Caldas, C. H., Gibson Jr, G. E., & Thole, M. (2009). Assessing scope and managing risk in the highway project development process. Journal of Construction Engineering and Management, 135(9), 900-910.

Nambisan, S., Hallmark, S., & Albrecht, C.*Preparing tomorrow's transportation workforce: A midwest summit*

Vandervalk, A., Cronin, B., & Thompson, C. (2020). *Project final report acknowledgment of sponsorship*

Zamenian, H., & Abraham, D. M. (2016). *Pre-contract project scoping processes: Synthesis of practices* Purdue University. doi:10.5703/1288284316192