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ABSTRACT

Estimating the cost of preconstruction services during the early phases of highway project development is an important task requiring an increased level of attention. Research has found a link between early investment in preconstruction planning and design services and final project costs. The purpose of this paper is to assess current estimating practices and propose a Cost and Scope Breakdown Structure (CSBS) framework to structure functional level estimation of consultant fees. Such a framework is promoted to reduce the chance that under-funded preconstruction services may degrade post-award construction contract cost certainty. This study found that preconstruction services are generally viewed as a minor component of a project's budget and as such are sometimes estimated without subsequent preconstruction cost control or accountability. Current practices for consultant fee estimating by state Departments of Transportation (DOT) documented in this study show little standardization in estimating practices across and within transportation agencies. As a consequence many individuals are creating their own tools to develop preconstruction service cost estimates. The result is that national and regional consultants that work in more than a single state are forced to expend additional effort to maintain agency-specific work task databases; the cost of which no doubt is passed back to the agency in increased overhead costs. This study found that application of a CSBS to classify specific work tasks and utilizing a database of previous project cost information promotes consistency and aids contract negotiations with consultants.

BACKGROUND

A change in attitude towards preconstruction service (PCS) cost estimating is needed as increasing evidence in the literature shows that underestimation of PCS costs can impact the overall financial success of a project and the efficient use of an agency's fiscal year construction budget. Investment in PCS services has a strong influence on construction cost growth and hence the total project cost (*1*). Research by Kirby et al. (*2*) and Morgen (*3*) found that 56% of construction contract modifications resulted from the need to correct design deficiencies during construction. The relationship between design quality and subsequent construction contract modifications was also identified by Burati et al. (*4*), who found that on average 9.5% of total project cost growth was caused by deviations in construction required to correct design errors. A study of the Oklahoma Turnpike Authority reinforced this concept. Analysis of $90 million worth of projects found a direct relationship between amount spent on design and the construction cost growth of both bridge and roadway projects (*1*). The underlying theme of this previous research is summarized in Figure 1. If adequate resources are not assigned to allow designers and planners enough time and funding solve technical, environmental, and constructability problems during the preconstruction phase then the quality of construction documents produced is compromised, this in turn creates additional (cost incurring) work during construction.

FIGURE 1 Relationship Between PCS Investment and Construction Cost Growth.

Because state DOTs must work in an environment of increased funding uncertainty and shrinking budgets, it has become important to ensure proper allocation of funds across all phases of the highway project development life cycle. Poor estimation of preconstruction services across multiple projects can lead to a misallocation of available capital funding in the preconstruction phase. Later, a need to redistribute funding late in an agency's fiscal year may arise to cover overages and to expend underruns before the authorization of fiscal year funding expires (*5*).

Consistency is an important quality of successful cost estimating. As such, providing a framework or process to facilitate a uniform approach to estimating is highly beneficial. Larson and Gray (*6*) state "when people are guided by a core set of principles, they are naturally more predictable because their actions are consistent with these principles". The North American vertical construction industry have acknowledged the importance of core principles, implementing an information classification system called OmniClass to organize information about a project from its conception to demolition (*7*). OmniClass consists of 15 tables, each representing a different facet of construction information (*8*). These tables classify engineering tasks along with structural components of a project. A universal classification system for highway preconstruction services does not currently exist, making estimating practices between DOTs highly variable.

There are a number of approaches to estimating PCS costs, this paper focuses on functional level estimating which is a bottom-up approach used to assign resources within the preconstruction phase. Functional level estimating is a particularly important part of PCS

estimating as this approach is used to form estimates that are used to negotiate PCS contracts with external consultants – commonly referred to as outsourcing.

The amount of PCS work that is outsourced varies from state to state. Some DOTs have sufficient staff capacity and expertise to complete the majority of work internally, while other agencies, such as Florida Department of Transportation (FDOT) employ consultants more frequently. Table 1 indicates the levels of PCS work outsourced from the responses of 17 DOTs surveyed at the AASHTO Subcommittee on Design conference in Montana, June 2013. It is clear from this survey that outsourcing work to consultants is a task that affects the majority of states in some capacity; a total of 16 out of the 17 states surveyed seek external resources for PCS. The use of consultants to assist state DOTs with preconstruction services (PCS) has increased over the past 20 years (*9*). Interviews with various DOTs suggest that this trend will continue to grow.

TABLE 1 Percentage of PCS Work Outsourced to Consultants by State

Percentage Outsourced	State DOT
0%	WY
1-30%	CA, GA, KS, NC, WI
31-60%	AK, AL, AZ, ME, MD, MN, MS, NE, WV,
61-90%	SD, WA

External consultants are typically employed in the following scenarios (*10;11;12*):

1. *when an agency cannot complete the work within the desired time with its available resources, or*
2. *the work entails specialized professional or technical skills not readily available within the DOT.*

This paper documents current practices used by DOTs for estimating PCS costs to benchmark approaches for determining the level of investment required for PCS services. Data has been collected from a national survey and nine case studies.

Defining Preconstruction Services

Preconstruction services covers a broad spectrum of project services and includes all work completed on the project from project conception through to the contract award. For the purposes of this paper, preconstruction services (PCS) are defined as all of the work completed on a project commencing at the allocation of a project identification number (PIN), and ceasing at construction contract award. Figure 2 displays the activities included within the preconstruction phase of a project timeline. It should be noted that with this definition all activities that occur prior to the PCS phase; initial startup, scoping and budget, corridor planning and conceptual design, are considered sunk costs and are encompassed in the departmental overhead rate assigned to all projects.

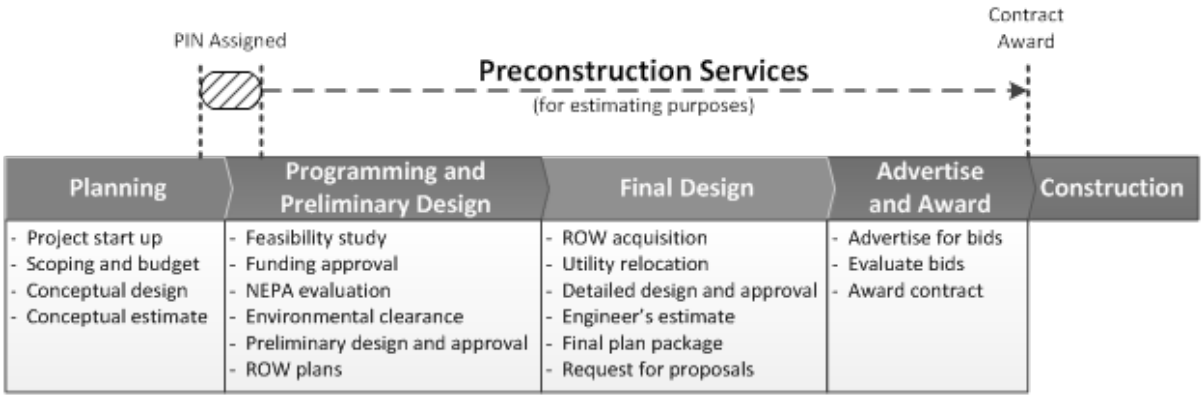

FIGURE 2 Preconstruction Services Timeline (adapted from Anderson et al. (*13*))

Cost Estimating Approaches

There are two different approaches to cost estimating, 'top-down' and 'bottom-up'. 'Top-down' is a high-level approach used to form an order of magnitude estimate when there is limited knowledge and information about the project (*6*). A 'bottom-up' approach is more rigorous. It involves estimating specific work tasks and then combining them to form a total estimate for a specific service. A 'bottom-up' estimate is typically estimated by a person who is involved in monitoring all preconstruction stages of the project, such as a senior designer who will manage their team to complete the work (*6*).

Functional Level Estimating

The preconstruction phase includes the delivery of many intermediate products and services such as environmental investigations, geotechnical studies, public involvement and permitting. The level of effort required to complete these tasks is project specific and influenced by location, resources impacted and regulations governing the project, rather than one specific project characteristic such as lane-miles or bridge length (*14*). As a result, the best way to quantify these services is to develop a scope of work for the effort required to complete each task.

Functional level cost estimation is a form of 'bottom-up' estimating. The scope of work is distributed to the different functions, or engineering offices, that will be involved with the project. Each function is then responsible for identifying all the tasks they will need to complete and estimating the hours/costs required for those. Finally each functions estimate is aggregated to form a total PCS cost estimate for the project.

Use of Functional Level PCS Cost Estimating

A functional level estimate can be used to quantify the number of work hours that will be required by a design team to complete a given work package. This can aid management's decision on whether to perform the work with in-house resources or outsource particular tasks. Figure 3 indicates the processes involved in the functional estimate and point at which the in-house or outsource decision should be made.

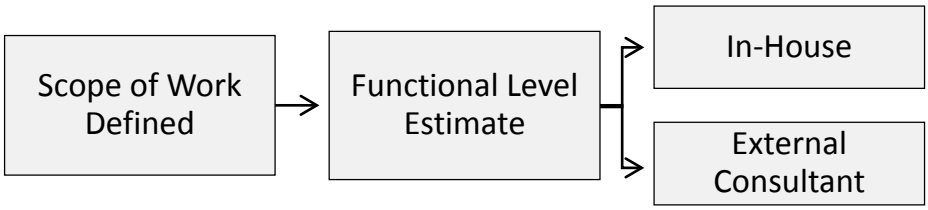

FIGURE 3 Functional Estimate Sequence.

In-House Design

If the estimated work effort does not require specialized services and can be accommodated into the departments schedule then a decision to do the work in-house can be made. The estimate can assist the resource management of the PCS team through distribution and monitoring of forward work load to available team members.

External Consultant Design

If the work package cannot be completed in-house, the functional level estimate is still useful. It can be used during negotiation with a consultant who will complete the work for the DOT. With an ever increasing number of external consultants being contracted for PCS services, there has been an implementation of various state policies and consultant services manuals across the nation. Within these documents DOT engineers are often required to perform detailed in-house cost estimates or independent cost estimates (*15*) for the work to be contracted out. The Federal Transit Administration (*16*) has highlighted the importance of a well prepared in-house cost estimate (work estimate) "in order to meaningfully evaluate and negotiate [a consulting] firm's cost proposal".

The Brooks Act, introduced in 1972, requires that all applicable architectural and engineering service contracts be awarded in accordance to an open negotiation process on the basis of demonstrated competence and qualifications (*17*). Federal regulation stipulates a "detailed cost estimate, except for contracts awarded under small purchase procedures, with an appropriate breakdown of specific types of labor required, work hours, and an estimate of the consultant's fixed fee…for use during negotiations" (*18*).

The purpose of an independent in-house cost estimate is to provide a DOT with a comprehensive understanding of the scope of work and the effort required to complete the preconstruction services for a given project. This estimate can then be used as a guide to determine fair and reasonable compensation for services rendered. The independent cost estimate is "an important baseline for negotiations with the Consultant" (*15*). With such a strong emphasis on forming a high quality estimate, this paper investigates how DOTs are developing their preconstruction service estimates across the nation.

METHODOLOGY

To gain insight into how DOTs deal with PCS cost estimates on a daily basis, two data gathering techniques were employed. A digital survey was distributed to the AASHTO Subcommittee on Design and case studies were conducted. These studies provided a wealth of knowledge regarding the differing agency views related to PCS costs and the details of their PCS approach.

Survey

A survey was distributed to the AASHTO Subcommittee on Design (SCOD) titled "Estimating Consultant/Design Effort Hours for Preconstruction Service Contracts". A total of 47 responses were received yielding a response rate of 44% from the full committee. They came from the 29 different state DOTs shown in Figure 3.

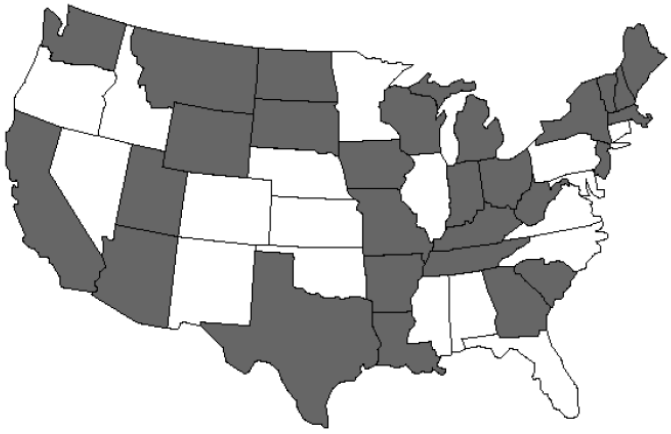

FIGURE 3 Geographic distribution of survey respondents.

Case Studies

Case Study Protocol

The case study research was initiated by issuing a separate screening survey to participants at the AASHTO SCOD conference in Bozeman, Montana June 2 – 6, 2013. Of the 35 states represented at the conference the researchers received 18 responses, a 51% response rate. The survey was designed to understand the preconstruction services facilitated by an agency and to identify what methods were currently being used to estimate preconstruction services costs. The survey also aimed to recognize what PCS data an agency had available and whether the agency would be willing to share the data for research purposes. From the results, several project-level case studies were identified.

While the screening survey provided some useful insights into the overall state-of-the-practice, case studies were the primary source of data for the PCS cost estimating techniques. Though research technique and protocol preferences vary for given scenarios, case study research has been shown to be an effective research tool for evaluating and analyzing emerging business practices such as PCS estimating approaches (*19*). Case studies can be useful in answering questions about the details of how things are done, particularly when investigating a number of different cases (*20*). A perceived weakness of using case studies is lack of statistical rigor. To overcome this, a defensible and repeatable method to form the case study process was established using widely accepted case study protocol authored by Yin (*20*).

Case Study Process

A pilot case study was conducted to assess effectiveness of the protocol and allow modifications to be made to the process before conducting multiple case studies. The case study protocol specified interactions and communication with project participants in a sequential order. Interviews were conducted on site at agency headquarters to ensure availability of appropriate staff to answer the questions provided. Questions were provided two weeks in advance of the interview.

Case Study Selection

Various case study options were considered based upon factors such as land area and budget. From an original shortlist of 16 proposed states, nine DOTs were selected. Data was collected on the agencies PCS cost estimating procedures and some project case study projects were

obtained. The list of the nine participating agencies is displayed in Table 2 along with the states population, land area, yearly construction budget and lane miles. The table demonstrates that difference in funding per lane mile for each state. A state with a large land area and relatively small population, for example Montana, has a significantly low dollar ($) per lane mile budget. This differs greatly from smaller states with denser populations, for instance Maryland, that have far higher dollar per lane mile budgets.

TABLE 2 Population, Land Area and Highway Information (*21*)

Agency	Population (million)	Land area (square miles)	Budget ($ Million)	Lane-Miles	$/Lane-Mile
California	38.3	155,779	$13,000 - $15,000	171,874	$81,455
Colorado	5.27	103,642	$500 – $700	88,278	$6,797
Iowa	3.09	55,857	$400	114,347	$3,498
Maryland	5.93	9,707	$600 – $800	31,461	$22,250
Montana	1.02	145,546	$385	73,627	$5,229
New York	19.7	47,126	$1000	114,546	$8,730
Oklahoma	3.85	68,595	$632 – $790	115,851	$6,137
Rhode Island	1.05	1,034	$300	6,400	$46,875
Utah	2.90	82,170	$1,100	44,877	$24,511

CURRENT FUNCTIONAL LEVEL ESTIMATING PRACTICES

Interviews with case study DOTs and survey responses indicate that not all DOTs create an independent estimate to negotiate with. In the cases where an independent estimate is not created a department may review a submitted consultant proposal with professional judgement and anecdotal experience on how long their in-house team would typically take to complete the same task.

Reasons for not completing an independent cost estimate included having limited time and resources. Another challenge that can hinder estimate development is definition of the project scope – this may be a task that the consultant is expected to render as part of their services, or a task may be so unique it is difficult to define. It is important for an engineering department to develop a scope of work that is sufficiently detailed so that cost estimates based on the specific tasks can be performed. AASHTO (*22*) specifies that “an effective scope of services is written in clear, unambiguous, and precise language. It contains provisions for determining the quality of services or products rendered”.

Estimating Tools

There is significant variation in the current practices for functional level PCS estimating across the nation for those DOTs who do create an independent estimate. Results from the survey of AASHTO SCOD show that only 35% of respondents that perform a functional level estimate for consultant negotiation have a formalized tool provided by their agency to assist them. An estimating tool is defined as any procedure that assists forming an estimate, the most basic example being an excel spreadsheet. The survey found that individuals have created their own tools to help with preparing estimates in 53% of cases reported due to the lack of a standardized tool. The remaining 13% of those surveyed commented that no estimating tool was used at all.

This result reflects a lack of estimating standardization within agencies. While it is excellent to acknowledge that individuals are furnishing their own techniques for developing estimates to better perform their duties, utilizing independent approaches does not provide a

consistent product across an agency. For those agencies without any means or methods, estimating tasks will be limited to those with extensive personal experience in PCS cost estimating. It is very difficult for in-experienced engineers to develop estimates without guidance. Survey respondents were asked what type of tools they used for developing functional level estimates. The tools from the survey responses have been categorized into four different methods as detailed in Table 3.

TABLE 3 Functional Level Estimating Methods

Method	Description
First Principles	Utilize metrics such as man-days per mile, or other 'rules of thumb'.
Work Breakdown Structure (WBS)	Use a specific list of PCS tasks to assign work hours and calculate costs.
Historical Database	Utilize cost/hour data collected from previous projects.
Software	Sophisticated software that incorporates historical data with a WBS, for example ePM.
Experience	Base estimates on professional judgement acquired from experience.

Table 3 summarizes a broad spectrum of estimating methods, however from this list, only three of the methods can be deemed scientific; able to be repeated consistently by a variety of people and more easily transferrable to less-experienced engineers. Both utilizing a historical database and a work breakdown structure provide guidance within the estimating procedure to make it serviceable to a range of staff. Within the vertical construction industry, "Table 34 – Services" of the OmniClass classification system defines specific activities and processes provided by project participants in the design phase (*7*). As the highway preconstruction phase does not currently have a similar system, using a database and WBS are identified as the first steps in moving towards a standardized classification. Using a software package such as ePM (electronic project management), encompasses both these approaches. Experience and First Principle driven approaches require a level of professional experience and this can vary greatly between staff members.

Cost and Scope Breakdown Structure

Accurately understanding and defining the scope of a project is a fundamental step within a project. This research found that 78% of survey respondents that create functional level estimates for negotiation utilize a work breakdown structure (WBS) to organize the scope of work for estimating. For purposes of this report and to eliminate potential confusion with the classic WBS used during construction phases, the term Cost and Scope Breakdown Structure (CSBS) is coined to represent the practice when applied to the preconstruction portion of project delivery.

To create a CSBS the activities that occur during preconstruction can be organized into a hierarchy, as displayed in Figure 4. It provides an orderly classification of work tasks and indicates when they should occur during the preconstruction phase. A CSBS is typically set up as a spreadsheet, listing preconstruction tasks specific to different departments and then assigning effort hours to them. Breaking each functional level into specific tasks allows work to be clearly identified, managed and controlled (*23*).

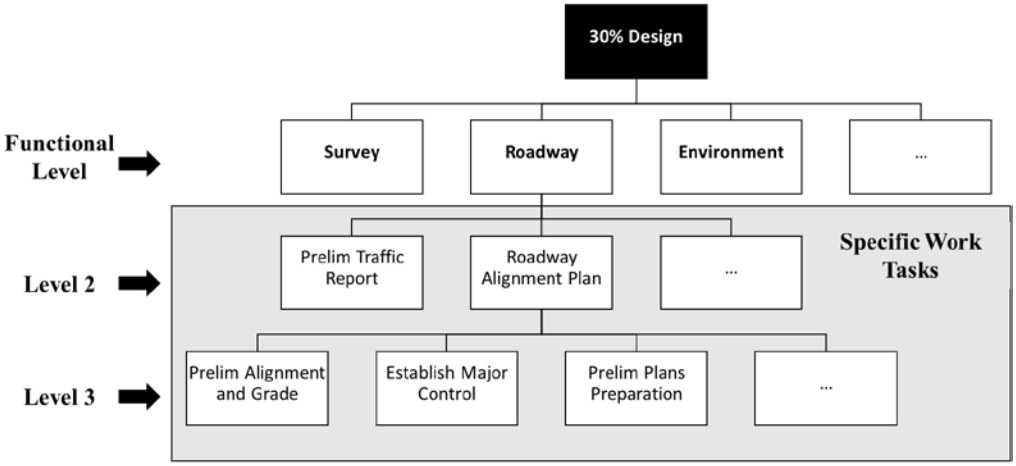

FIGURE 4 Example of a CSBS.

Across state DOTs the level of detail and sequence of tasks varies greatly, however the benefits to using a CSBS for the PCS phase are universally recognized. Formal classification of specific work tasks:

- Provides a template that can be reused to quickly identify tasks required for future projects.
- Allows the collection of work effort hours and costs to aid future estimates.
- Ensures that all appropriate tasks are included within an estimate – no portions are omitted.

Another application of a CSBS is to provide it as the template for consultants submitting a cost proposal. In Florida the estimates developed by both the DOT and the consultant are made in the same format, for "ease of reconciliation" (*24*). Standard Staff Hour Estimation forms are provided in Excel format for project development & environmental tasks, highway and bridge/structural design projects on the Department's Project Management/Production Support Office website.

Utilizing Historic Data

From the interviews within the case studies, it was possible to gain insight into how DOTs currently value PCS and whether they take any steps to estimate the cost of this phase within the project lifecycle. Some of the information gained from these interviews is summarized in Table 4. Six of the nine DOTs calculate PCS cost, and while they also keep a record of PCS cost, only three of those DOTs go on to use that recorded data for future estimates. Colorado, Iowa and Oklahoma do not estimate PCS costs at all.

TABLE 4 Case Study Results

Agency	Calculate PCS Costs	Collect PSC Costs	Use Historical PCS Costs for New Estimates
California	Yes	Yes	Yes
Colorado	No	No	No
Iowa	No	Yes	No
Maryland	Yes	Yes	No
Montana	Yes	Yes	No
New York	Yes	Yes	Yes
Oklahoma	No	No	No
Rhode Island	Yes	Yes	No
Utah	Yes	Yes	Yes

The separate survey from the Subcommittee on Design identified 74% of respondents do not use organized historical data to aid the development of estimates, however a large portion (68%) recognized they "may look" at previous projects to assist their decision making. While this practice is a good sense check, without an organized database of historical projects to reference, experience is required to recall similar projects and relate differences in the expected scope-of-works. Many opportunities are lost when useful data is not recognized and applied. Within the construction industry, it is commonly accepted that collecting and archiving data on past project estimates and actual costs is a successful way to improve future estimates. This same principle applies for functional level PCS cost estimating, despite it not currently being widely recognized by DOTs.

It is interesting to observe in Table 4 that of the nine case studies, seven currently collect PCS cost data, but only three utilize this information. While the survey did not specifically ask what the purpose of the data collection is for, it is likely that many of these DOTs that collect the data do not formally use it for anything other than record keeping. Information from previous projects can be collected in the form of accounting systems and timesheet records provided that there is a standardized WBS in-place at the DOT to classify tasks.

New York State DOT has developed a commercial spreadsheet / database program that aids design hour estimates for its highway projects. The model utilizes 12 "key" project characteristics to search for similar completed projects or generate an estimate of total design hours expected for a new project (*25*). The hours are calculated from a regression model. As more project data is made available the model is expected to become more accurate.

Utilizing information about specific tasks and corresponding work hours from previous consultant contracts and in-house projects creates a knowledge base that is valuable in developing more accurate future estimates. It also provides a formal resource to aid the professional judgement of less-experienced engineers when they are charged with developing PCS cost estimates of their own.

DISSCUSSION

This research has documented current practices for functional level estimating of PCS costs. The results of the case studies and survey identified that of the DOTs that currently create a functional level estimate for negotiation, many use informal tools or independent tools. Several barriers to forming functional level estimates were identified during this investigation:

1. Limited time and resources.
2. Project scope not yet defined – sometimes this will be included in the PCS contract with the consultant.
3. Some tasks within scope are very unique and complex making it hard to define tasks.
4. Little importance placed on accurate estimating, no tracking to check performance
5. No formal tools or processes in place to aid estimating PCS costs.

Of the formalized and independent estimating tools used by DOTs to aid functional level estimates the CSBS and historical database methods are the most effective. This is because these methods are highly structured and do not rely primarily on personal judgement. The tools go hand-in-hand with the structure of a CSBS allowing accurate collection of data, such as the work effort hours for specific work tasks.

Implementing a CSBS could greatly reduce the amount of time needing to be invested into each PCS cost estimate, for both DOTs and consultants. As Florida DOT has already recognized, there is value in using the ‘same standard format’ for agency estimates and consultant cost proposals. It allows for easy comparison between parties estimates, streamlining the negotiation process. In addition to improving the negotiation itself, a standardized CSBS could have an influence on reducing overhead costs passed on to a DOT from a consultant. For the purposes of this paper standardization is defined as “the extensive use of (a process), in which there is regularity, repetition and a record of successful practice” (*26*). National and regional consultants that work in more than a single state must currently maintain a different database of work descriptions in each state they offer services. If PCS cost proposals had a standardized CSBS, less effort would need to be expended on maintaining multiple cost proposal formats and historic project cost information would be more easily comparable for proposal development. A reduction in administration efforts should translate to smaller overhead costs passed onto DOTs.

There are a number of issues that can make implementing a CSBS difficult. For example, if the scope of the work has not yet been defined and its definition is an activity to be included within a consulting contract then it can be hard to identify specific tasks to estimate. Also, if tasks are very unique and complex it is unlikely there is any historic data that can be used as a reference for estimating. In both of these situations a wide estimate range should be used to reflect the high uncertainty. As more information comes to light, the estimate can be refined until an acceptable level of confidence is achieved.

The fact that many DOTs do not have an organized database of completed project information, yet still recognize the need to evaluate previous projects when forming a new estimate, highlights the value of utilizing historical data for estimating purposes. Keeping a record of each project, its work tasks and final effort hours provides useful information to base new estimates on. In order to successfully learn from previous projects a DOT needs to store this information in an accessible and easy to use system. A database of historical project information, whether just a simple spreadsheet or something more robust, is a valuable asset. The low percentage of surveyed staff that have organized databases to draw estimating information from infer that agencies do not yet understand the true value of this resource.

CONCLUSION

Current practices indicate that most DOTs form functional level estimates of PCS costs for either consultant negotiation or to allocate resources internally, however the approaches used to do so vary widely. Of the five different methodologies identified from survey respondents, only two were defined as effective practices. The use of a CSBS and a historical database complement one another well for developing functional level estimates. The CSBS provides a task classification system that data can be associated to. Both these methods create a standardized approach that are not dependent on personal judgement. An additional benefit of a CSBS is that, if standardized across the nation, it could simplify fee proposal efforts for consultants, reducing overhead fees, which are no doubt passed back to DOTs.

Ensuring the correct investment in PCS is very important to control construction cost growth. DOTs need to invest in tools that ensure PCS are consistently estimated across an agency. Providing a formalized estimation tool for all employees is a way to achieve this. Currently only a third of the DOTs surveyed have this resource. DOTs should recognize the importance of creating a standard classification for work tasks and the benefits of well-organized historical data for developing estimates.

Future research needs to address the barriers to utilizing organized historical data in an effort to aid PCS estimates. The construction industry has benefited from added estimate accuracy established with historical data. There is no reason the preconstruction phase could not also benefit from adopting some of these practices if a correct implementation framework was developed.

REFERENCES

1. Gransberg, D.D., C. Lopez del Puerto, and D. Humphrey. Relating Cost Growth from the Initial Estimate Versus Design Fee for Transportation Projects. *Journal of Construction Engineering and Management*, ASCE, Vol. 133(6), 2007, pp. 404-408.
2. Kirby, J.G., D.A. Furry, and D.K. Hiks. Improvements in Design Review Management. *Journal of Construction Engineering and Management*, ASCE, Vol. 114(1), 1988, pp. 69-82.
3. Morgen, E.T. *Claims by the Federal Government Against Its A/E – Guidelines for Improving Practice*. Office for Professional Liability Research, Victor O. Schinner and Co., Washington, D.C.. 1986.
4. Burati, J.L., J.J. Farrington, and W.B. Ledbetter. Causes of quality deviations in design and construction. *Journal of Construction Engineering and Management*, ASCE, Vol. 118(1), 1992, pp. 34-36.
5. Hollar, D. *Predicting Preliminary Engineering Costs for Highway Projects.* North Carolina State University, Raleigh, NC, 2011.
6. Larson, E.W., and C.F. Gray. *Project Management the Managerial Process*, 5th Ed. McGraw Hill, New York, 2011.
7. OmniClass Construction Classification System. *A Strategy for Classifying the Built Environment.* http://www.omniclass.org. Accessed Jul. 15, 2015.
8. Cheng, C. P., G. T. Lau, K. H. Law, J. Pan, and A. Jones. Improving access to and understanding of regulations through taxonomies. *Government Information Quarterly* 26, No. 2, 2009, pp. 238-245.
9. Wilmot, C. G., D. R. Deis, H. Schneider and C. H. Coats Jr. In-House Versus Consultant Design Costs in State Departments of Transportation. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1654*, Transport Research Board of the National Academies, Washington, D.C., 1999, pp. 153-160.
10. Colorado Department of Transportation. *Project Development Manual*. Denver, 2013.

11. Montana Department of Transport. *Consultant Services Manual*. Helena, 2010.
12. Iowa Department of Transportation. *Negotiated Contracts for Architectural, Engineering, and Related Professional and Technical Services*. Policy No. 300.12, Policies and Procedures Manual. Ames, 2007.
13. Anderson, S., K. Molenaar, and C. Schexnayder. *NCHRP Report 574: Guidance for Cost Estimation and Management for Highway Projects during Planning, Programming, and Preconstruction*. Transportation Research Board of the National Academies, Washington, D. C., 2007.
14. American Association of State Highway and Transportation Officials. *AASHTO Guide to Estimating Environmental Costs*. American Association of State Highway and Transportation Officials. Washington, D.C., 2008.
15. Utah Department of Transportation. *Consultant Services Manual of Instruction*. Salt Lake City, 2013.
16. Federal Transit Administration (FTA). *Procurement Object Types*. Federal Transportation Administration, Washington, D.C. http://www.fta.dot.gov/12831_6189.html#BM6_4. Accessed Nov. 13, 2014.
17. Public Law 92-582, 40 U.S.C. 541 et seq.
18. General Services Administration, *Code of Federal Regulations,* Part 172- Administration of Engineering and Design Related Service Contracts. 23 CFR Section 172.7.
19. Eisenhardt, K. M. Better Stories and Better Constructs: The Case for Rigor and Comparative Logic. *Academy of Management Review*, Vol. 16(3), 1991, pp. 620-627.
20. Yin, R. K. *Case Study Research: Design and Methods*. Sage Publications, New York, 2008.
21. United States Census Bureau. *State and Country Quick Facts* http://quickfacts.census.gov/qfd/index.html. Accessed Jan. 2014.
22. American Association of State Highway and Transportation Officials. *AASHTO Guide for Contracting, Selecting and Managing Consultants in Preconstruction Engineering.* American Association of State Highway and Transportation Officials. Washington, D.C., 1996.
23. Association for the Advancement of Cost Engineering (AACE) International. *Skills and Knowledge of Cost Engineering, 5th Ed*. AACE International, Morgantown, WV, 2012.
24. Florida Department of Transportation. *Negotiation Handbook, Professional Services Contracts.* Tallahasse, 2015.
25. Williams, T. P., N. Parker, and J. Klotz. Development of an Estimating Tool for Transportation Project Design Effort. Presented at 92nd Annual meeting of the Transportation Research Board, Washington, D.C., 2013.
26. Gibb, A.G.F., and F. Isack. Client drivers for construction projects: implications for standardization. *Engineering Construction and Architectural Management*, Vol 8(1), 2001, pp. 46-58.