Pooled Fund Project Statement of Work

for

MULTI-STATE ABC DECISION TOOL AND ECONOMIC MODELING

Submitted by

Dr. Toni Doolen

Oregon State University
Mechanical, Industrial & Manufacturing Engineering
410 Rogers Hall
Corvallis, OR 97331

for

Oregon Department of Transportation
355 Capitol St. N.E.
Salem, OR 97301-3871

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1.0 Identification

1.1 Organizations Sponsoring Research

Oregon Department of Transportation (ODOT) (Lead State)
355 Capitol St. N.E.
Salem, OR 97301-3871

Utah Department of Transportation (UDOT)
4501 South 2700 West
Mail Stop 141200
Salt Lake City, UT 84114-1200

Washington Department of Transportation (WSDOT)
310 Maple Park Avenue SE
PO Box 47300
Olympia WA 98504-7300

Federal Highway Administration (FHWA)
Washington, D.C. 20590

1.2 Principal Investigator

Dr. Toni Doolen
Oregon State University
Mechanical, Industrial & Manufacturing Engineering
410 Rogers Hall
Corvallis, OR 97331
Phone: 541-737-5641
E-mail: toni.doolen@oregonstate.edu

1.3 Technical Advisory Committee (TAC) Members

Ben Tang (ODOT)
Holly Winston (ODOT)
Daniel Hsiao (UDOT)
Bijan Khaleghi (WSDOT)
Paul Chung (Caltrans)
Nat Coley (FHWA)
Mary Huie (FHWA)
Others -TBD

1.4 Project Coordinator

Steven Soltesz (ODOT) Phone: 503-986-2851
E-mail: steven.m.soltesz@odot.state.or.us

2.0 Problem Statement

Accelerated Bridge Construction (ABC) is recognized as an important method to design and rehabilitate highway structures (U.S. DOT Strategic plan 2006-2011). ABC uses both new technology and innovative project management techniques to reduce the impact of bridge construction projects on the public and to reduce bridge construction costs. In particular, ABC can lead to substantially lower user delay costs and significantly lower traffic control costs. AASHTO and FHWA have encouraged the use of ABC technologies as a mechanism for reducing traffic congestion, increasing work zone safety, and for providing longer-lasting and more durable bridges (Fowler, 2006). Various DOTs have supported the use of ABC when there has been a perceived agency benefit (e.g., Johnson, 2008).

New technology and accelerated construction techniques can introduce risk and uncertainties into a project. Within this context, decision-makers need to assess whether elements of ABC are "achievable and effective for a specific bridge location" (FHWA, Dec. 2005, p 4). While the potential advantages of ABC are recognized, transportation personnel do not have an established protocol to quantify the risks and economic benefit of using ABC over traditional construction for specific bridge replacement or rehabilitation projects. This research effort will develop a project-level tool for engineers and decision-makers to quantitatively assess the utility of using ABC.

2.1 Background and Significance of Work

It is estimated that in a one-year time frame, congestion caused users to waste 4.2 billion hours and 2.9 billion gallons of gas for an economic impact of $78 billion (Schrank and Lomax, 2007). The cost of congestion is real and has been increasing on an annual basis in urban areas across the U.S. since 1982. While construction and maintenance projects are needed to mitigate congestion, these projects also add to the congestion problem. Twenty-five percent of the publicly-owned bridges in the U.S. are structurally deficient or functionally obsolete (Federal Highway Administration, 2007). This translates to approximately 150,000 bridges. Whether these bridges are rehabilitated or new bridges providing additional capacity are built, these projects will add to congestion and will result in additional costs to users. In addition to exacerbating congestion, these projects are also associated with safety issues and often limit road access. It is challenging to find economical ways to reconstruct deteriorating bridges in urban areas while keeping roadways as safe as possible and while minimizing disruption to individuals and businesses in the surrounding community. There is strong evidence, at least on a case-by-case basis, that ABC can lead to reduced traffic disruption, reduced environmental impact, reduced economic impact, improved safety, improved constructability, improved quality, as well as lower total costs (Ralls, 2008).

ABC requires both new technology and innovative project management techniques. New technology, such as pre-fabricated bridge elements and systems (PBES) provides designers and contractors with an opportunity to reduce construction times, reduce congestion, increase jobsite safety, minimize the environmental impact, and decrease construction costs (Fowler, 2006). By reducing construction times, the negative impact on the public is reduced. Transportation corridor improvements through bridge replacement and rehabilitation have direct impact during and after construction on surrounding communities and on the potential for community development. ABC can also minimize the environmental foot print and be beneficial when there is a limited construction window due to environmental constraints. As a result, this research project is in direct support of the USDOT's priorities of Safety, Mobility, Environmental Stewardship, and Congestion.

PBES is advocated as one mechanism in the design, construction, and rehabilitation of highway infrastructure that provide longer and more reliable performance. This is consistent with priorities specified in the U. S. DOT Strategic plan (2006-2011). Successful applications of PBES have been summarized at http://www.fhwa.dot.gov/bridge/prefab/projects.cfm. Pre-fabricated bridge elements, e.g. decks, superstructures, bent caps, columns, or substructures and innovative construction systems, e.g. self-propelled modular transporters have all been used in bridge replacement and rehabilitation projects across the U.S. A summary of 54 completed ABC projects using various types of PBES is available on FHWA's website (http://www.fhwa.dot.gov/bridge/prefab/all.cfm). For each of these projects, the rationale for using a chosen technology is identified. Reduced traffic disruption, improved construction zone safety, minimized environmental disruption, and improved constructability are just some of the benefits cited. Details are summarized at both http://www.fhwa.dot.gov/bridge/prefab/pubs.cfm and http://www.fhwa.dot.gov/bridge/prefab/research.cfm.

The development of decision-making tools to enable both economic evaluations and tradeoff analyses has been identified within the DOT strategic plan as a key area of need (U. S. DOT Strategic Plan, 2006-2011). Use of decision-making tools in early stages of planning is advocated as a mechanism for helping decision makers to assess alternatives with more confidence and for preventing investment in alternatives that are more costly. Data-driven decision making tools are also consistent with recommendations by the Government Accountability Office (GAO, January 2009) and the National Highway Research and Technology Partnership's report, *Highway Research and Technology: the Need for Greater Investment*. Effective investment decisions are a critical component in the management and funding of improvements to U.S. surface transportation. Decision-making tools, in particular, have been identified as drivers for cost reductions, improved public service, and increased public confidence in the nation's surface transportation (http://www.gao.gov/new.items/d09271.pdf). Ultimately, the nation's economic vitality and its citizen's quality of life depend on the efficiency of its transportation infrastructure.

Completed studies related to ABC have focused on the technological aspects, specifically PBES, and to some extent, the economic benefits of using ABC. In 2004, for example, a scanning study of prefabricated bridge elements and systems was conducted in four European countries and in Japan (FHWA, 2005). As a result of this study, 10 bridge technologies were identified and recommended for possible use in the U.S. Similarly, Mistry and Mangus (2006) summarized the use of different ABC solutions by seven different State DOTs. The authors' summary of "successes" demonstrates the advantages of ABC, overall, but with a primary focus on PBES.

Recent studies have also begun to address the management and economic components of ABC. Bai and Burkett (2006) studied accelerated bridge replacement processes and techniques in emergency situations. This study provided evidence that effective bridge repair, particularly in critical situations, is affected by factors unrelated to the technology including contracting strategies, the availability of historical records, and local expertise. In another study, Ralls (2008) itemized on a project by project basis the benefits of 17 different ABC projects completed in 13 different states. Various contracting strategies, innovative project management strategies, as well as PBES were used in these projects. In addition, both construction and user costs (where available) were summarized to help demonstrate the need for economic assessments that look beyond the costs incurred by the bridge owner to the larger set of costs associated with the overall system.

The decision to use ABC must be made on a project by project basis. Towards this end, the FHWA (Dec. 2005) has developed a qualitative decision-making framework to determine whether or not a prefabricated bridge should be considered for a given project. Decision-makers respond to 21 questions about specific project characteristics. This framework includes questions related to the appropriateness of rapid, onsite construction, safety, environmental issues, standardization, construction site issues, traffic management costs, contracting costs, owner costs, and service life. This framework provides an excellent starting point for the proposed work. However, the tool does not help decision-makers estimate the economic impact of selecting various elements of ABC over traditional methods.

3.0 Objectives of the Study

The objective of the study is to develop a set of tools for transportation specialists and decision-makers to determine whether or not ABC is more economically effective than traditional construction for a given bridge replacement or rehabilitation project. The tools, using a spreadsheet format, will be designed to take the specific characteristics of a proposed bridge replacement or rehabilitation project, such as project size (e.g. bridge length), complexity, road user characteristics, environmental requirements, and construction site attributes into account. The tools will be user-friendly, flexible to accommodate a range of construction situations, transparent as to the method of calculation, and customizable to maintain future relevance.

3.1 Benefits

Given the significant number of bridge replacement and rehabilitation projects that must be undertaken to revamp the aging system of bridges in the U.S., it is clear that an aggressive approach is needed. The widespread application of ABC has the potential to provide significant advantage over traditional construction methods and to help address this need.

The majority of ABC projects completed and proven successful to date have been industry driven to fulfill requirements set by owners' mandated schedules and/or short closure restrictions. Owners often employ incentives/disincentives contracting initiatives to reward contractors for rapidly delivering these projects. These contracting initiatives are typically based on cost estimates which lump user delay costs with other variables, making it difficult to identify total system costs and/or savings. This study will enable owners to identify and quantify the values of an entire range of costs and savings. Users will be able to compare costs under different scenarios, e.g. traditional construction, using prefabricated elements, and/or accelerated management techniques.

The final tools set will allow the user to specify key project characteristics (e.g. bridge length, complexity, road user characteristics, environmental requirements, traffic levels, existing levels of congestion, and construction site attributes) and to evaluate the economic impact of applying various ABC technologies and management approaches such as rapid, onsite construction, standardization, or PBES to a particular project. This tool will incorporate not only construction costs (including traffic control costs) but also include estimates of soft costs including user delays resulting from congestion, rerouting, and/or closures associated with the project. To enable broader usage and accessibility, a web-based tool and on-line documentation will be developed.

4.0 Implementation

The spreadsheet application will be accessible via the Web and will have a comprehensive user's manual and on-line help functionality. To support the dissemination of the tool, a PowerPoint presentation will also be developed to use in conference and workshop settings. The focus of this presentation will be to provide a variety of potential users with an overview of the tool, including the purpose of the tool, built in assumptions, as well as illustrative examples for how the tool could be used as part of a decision-making process.

In addition to the final report, the project investigator will conduct workshops, submit journal publications, and make conference presentations.

5.0 Research Tasks

This research project will be conducted in collaboration with DOT transportation and bridge specialists who have experience in both bridge construction and ABC techniques. Through this collaboration the researchers will identify and model major characteristics of bridge replacement/rehabilitation projects that must be considered to complete an overall economic evaluation and cost analysis. Existing qualitative and quantitative approaches and models will be integrated into a single set of tools, with a specific focus on bridge replacement and rehabilitation projects. For example, the Schrank and Lomax (2007) cost assessment model for congestion (not specific to bridge projects) could be incorporated into the PBES Decision-Making Framework (FHWA, Dec. 2005) to estimate congestion costs under different conditions.

Task 1: Conduct literature review
A literature review will be completed with a focus on published reports and presentations that identify the processes used by various state DOTs and other local agencies to implement ABC. In addition studies that incorporate economic models and/or defined evaluation processes for estimating both the hard and soft costs associated with general construction projects will also be included. Reports summarizing best practices associated with successful ABC projects will also be reviewed, as well as studies and recommendations from organizations such as AASHTO, NCHRP, RBG, and FHWA. The first goal of Task 1 is to identify existing economic models and analysis tools that could be leveraged into the project. The second goal of Task 1 is to create a list of relevant project characteristics and project costs to include in the decision tree and economic models.

Time Frame: 3 months
Responsible Party: Dr. Doolen, OSU
Deliverable: A concise report that: identifies models and analysis methods that can be incorporated into Tasks 2 and 3, lists bridge project characteristics and costs to be considered in Tasks 2 and 3, and provides references accessed.
TAC Decision/Action: Review report and meet with project investigator to provide feedback.

Task 2: Document current use of ABC
The current use of ABC will be studied. Analyses, similar to that summarized by Ralls (2008) will be completed using data from 8 ABC projects, completed under the Highway for LIFE program. Project characteristics, cost data, as well as the specific elements of ABC that were applied will be summarized on a project by project basis. A portion of this data will be obtained from archival records and reports, and if needed, stakeholders from these projects will be interviewed. The effort will include: developing a database template, obtaining ABC archival data and construction reports from participating DOTs, conducting interviews with ABC project stakeholders, and completing the database entries.

This task will serve two important purposes. First this analysis will document the existing processes used to make a decision to use ABC. Second, this analysis will provide details needed to allow these specific cases to be used in validating the tools developed in the third phase.

Time Frame: 6 months
Responsible Party: Dr. Doolen, OSU
Deliverable: Summary report of Task 2 and database of ABC history
TAC Decision/Action: Review summary report, meet with PI, and provide feedback.

Task 3: Develop models
A decision tree and economic models will be developed based on the findings of Tasks 1 and 2. The decision tree and models will leverage existing tools and will be designed to be applied to a specific project. The tools will be tested and validated using data from a subset of completed ABC projects where sufficient data are available. The initial tool development will be completed in MS Excel. The ease of creating visual user interfaces, along with existing Excel analysis functions makes MS Excel an ideal environment for prototyping the analysis tool. The effort will include: developing the MS Excel application, validating the models, creating the user's guide and training materials, testing and revising application to improve the usability, and finalizing the application and report. Documentation will clearly explain the basis for the spreadsheet application output and how to revise the model that drives the application to accommodate future updates.

Time Frame: 6 months
Responsible Party: Dr. Doolen, OSU
Deliverable: Spreadsheet application with user's manual and help files. Final report.
TAC Decision/Action: Review report, user's manual, and documentation and provide feedback. Provide input during the spreadsheet application development. Assist in finding users to test the application and provide feedback.

Task 4: Implementation and dissemination
The decision trees and economic models will be available for download through the Web. It is anticipated that journal articles will be submitted, workshop sessions will be delivered, and conference presentations will be given pertaining to the work from this study.

Time Frame: 3 months
Responsible Party: Dr. Doolen, OSU
Deliverable: Article submissions, workshop sessions, and conference presentations.
TAC Decision/Action: Assist where possible in implementation and dissemination such as coordinating workshop and conference presentations.

Task Summary and Schedule

Effort	Duration	Product
Task 1 (1/2010 – 3/2010)		
Literature review Review BCA.Net tool structure and capabilities	1/2010 - 2/2010	• List of existing tools and framework • List of project characteristics and cost categories
	3/2010	• TAC Face-to-Face meeting • Task 1 summary report
Task 2 (4/2010 – 9/2010)		
Develop data collection template	4/2010 – 5/2010	• ABC Project Template
Lead the collection of summary archival data and reports from participating DOTs ABC projects	5/2010 – 8/2010	• PI to travel to DOTs, as needed to collect data
Conduct interviews	5/2010 – 8/2010	

with ABC project stakeholders, as needed		
Complete template for each ABC project. Evaluate integration of model with BCA.Net	5/2010 – 8/2010	• Completed templates for each ABC project
	9/2010	• TAC Face-to-Face meeting • Task 2 summary report
Task 3 (10/2010 – 3/2011)		
Develop tool integrating identified framework and models from Tasks 1 and 2	10/2010 – 11/2010	• Functioning Excel tool, including decision trees and economic analysis
Develop preliminary user guide and other training materials Develop plan for integration with existing tools, e.g. BCA.Net	11/2010 – 12/2010	• User guide • Overview presentation to use in conferences and workshops
Coordinate identification of end users for tool testing	12/2010 – 1/2011	• List of usability issues and preliminary documentation
Validate models	12/2010 – 2/2011	• TAC Face-to-Face meeting
	3/2011	• Final report
Task 4 (4/2011 – 6/2011)		
Dissemination	4/2011 – 6/2011	• Workshops • Technical reports • Journal publications

All reports will be produced in the standard ODOT Research Group report format unless some other format is deemed to be more appropriate as a supplement to the ODOT format.

6.0 Budget Estimate

Project Cost

Oregon State University contract amount:	$91,053
Travel costs for TAC members:	$15,200
(Lodging, airfare, mileage, parking, per diem)	
Report publication and project incidentals:	$5,000
Total project cost:	**$111,253**

Funding Sources

FHWA	$50K confirmed	Mary Huie -9/11/09
ODOT Bridge	$15K confirmed	Ben Tang
ODOT Local Agency	$15K confirmed	Holly Winston -10/5/09
WSDOT	$10K confirmed	Bijan Khaleghi 10/8/09
UT DOT	$10K confirmed	Daniel Hsiao 10/13/09
ODOT Research 2010	Balance pending selection of proposal to be submitted	Proposal to be submitted Nov 2009
Caltrans	Pending request	Paul Chung
AK DOT	Pending request	Rick Pratt

Budget Summary for OSU Contract

	TOTAL
Personnel	
Toni L. Doolen, PhD (1.3 mo)	$ 13,844
Hourly Grad (1 term)	$ 3,574
GRA (@ 0.49 FTE 2 terms)	$ 11,684
Hourly Grad (summer)	$ 13,746
Total Salaries	$ 42,848
Fringe Benefits	
Toni L. Doolen (47% OPE)	$ 6,507
Graduate student (hourly)	$ 1,386
GRA	$ 2,828
Total Fringe Benefits	$ 10,720
Travel (PI/GRA)	$ 7,400

Services and Supplies	$ 1,000
Total Direct Costs	$ 61,968
Total Indirect Costs ($30,000 at 26% and remainder @ 46.2%)	$ 22,569
Tuition	
2 terms	$ 6,516
Total Tuition	$ 6,516
Total OSU Costs	**$ 91,053**

7.0 Qualifications of PI

Dr. Toni L. Doolen will be the PI for the project. She will be responsible for directing the development of the decision tree and economic models and supervise a graduate student through all three phases of the project. She has extensive background in applying statistical techniques to problems where a mix of quantitative and qualitative data must be used. She is currently working with ODOT on a project entitled, “State vs. County Delivery Bridge Replacement Analysis.” In this project, data from 194 bridge replacement projects have been analyzed in an effort to identify the most important sources of variation in determining project costs and duration. Mathematical models for project cost and duration have been developed. Standard engineering economic principles have been applied to enable evaluation from a multi-year time frame. The proposed work is consistent with her overall research expertise in using both quantitative and qualitative methodologies to study the impact of improvement methodologies and innovation on system performance. She also has 12 years of experience at Hewlett-Packard as an engineer, engineering manager, and project manager. She has published in various journals including *Computers & Industrial Engineering*, *IEEE Transactions on Engineering Management*, *International Journal of Production Economics*, *Journal of Manufacturing Systems*, *International*, *International Journal of Productivity & Performance Management*, and the *Journal of Manufacturing Technology Management*. She has received funding for her research from a wide variety of organizations, including the National Science Foundation (NSF), Northwest Academic Computing Consortium, the Oregon Department of Transportation, and the William and Flora Hewlett Foundation.

8.0 References

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Schrank, D., and Lomax, T., "The 2007 Urban Mobility Report", Texas Transportation Institute and the Texas A&M University System, September 2007.
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