White Paper on Solving Cost Engineering Issues

Introduction

Cost engineering for construction is a major challenge to Department of Defense agencies including the U.S. Air Force Civil Engineer Center (AFEC), the Navy Facilities Engineering Command (NAVFAC) and the U.S. Army Corps of Engineers (USACE). Independent cost estimates, acceptable construction pricing, and the authorized amount for projects often vary to such an extent that projects are not awardable without significant delay or re-work, and these delays or cancellation of projects put our Nation at risk.

In late March, the Tulsa Post of the Society of American Military Engineers (SAME) held a workshop on cost engineering, primarily for military construction projects. This SAME post-level workshop brought together private sector members from the architecture-engineering and construction industries, and government members from USACE and AFCEC to collaborate and resolve issues at the grass roots level. The intent is to implement solutions locally, and to identify additional solutions that require higher level action.

The workshop included a thorough presentation of the issues by Amber Lanphere, Cost Engineer Team Leader at USACE Tulsa District and two moderated panels looking at the issue of cost engineering from a government and a private sector perspective. The government panel included Tom Hodges, Design and Construction Branch Chief, Facilities Engineering Directorate for AFEC, as well as the chiefs of Tulsa District military programs branch and engineering. The private sector panel included two members representing two separate construction firms, two members from two separate AE firms, and two members from cost engineering firms. Both panels presented their challenges and potential solutions for accurate cost engineering.

Cost Engineering Issues Overview

The two primary estimates used by the government are the budget estimate and the current working estimate (CWE). The budget estimate is developed at the installation level three to four years prior to construction using parametric estimating. This estimate is documented in a Department of Defense (DD) 1391 military construction project data form and used to justify a Congressional appropriation for military construction. Once appropriated, the budget becomes the programmed amount (PA). Once design begins, the DD 1391 form is finalized using a conceptual design and any changes to the PA need formal approval up to Congress.

The CWE development begins with design initiation and is required to ensure that the design cost estimate is within the PA as documented in the DD 1391. If the CWE exceeds the PA, the design team must halt design and seek further guidance, and then develop options for the scope of work and redesign and/or seek reprogramming through Congress. The CWE eventually becomes the Independent Government Estimate (IGE) just prior to receiving contractor proposals for either the design-build or design-bid-build project.
With PAs based on DD 1391s, developed as much as four years prior using parametric cost estimating and verified with only a 15% conceptual design, CWEs often exceed the PA. Note that the American Association of Cost Engineers (AACE) International lists a Class 3 estimate as a project defined to only 10% to 40%, used for budget authorization, and this estimate has a -30% to +50% expected accuracy range. Because reprogramming can be very difficult and risk a project that exceeds the PA risks being cancelled, there is pressure to minimize the costs the go into the CWE to ensure it is within the PA. This leads to inaccurate CWEs and the inability to ultimately award construction contracts.

In preparing for the workshop, Amber Lanphere conducted an analysis of Tulsa District projects costs in fiscal year (FY) 2016 and FY 2017. This analysis included comparing the IGE versus award, PA versus award, IGE versus low/med/high bidder and range of bids versus IGE versus award. The overall result for all 64 projects is shown in the chart below:

<table>
<thead>
<tr>
<th>Project Type</th>
<th>No. of Projects</th>
<th>% of Total Projects</th>
<th>Difference Between IGE Total and Awarded Contract Total</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100.00%</td>
<td>Award Total &lt;- 25% of IGE</td>
<td>Award Total &gt;25% of IGE &amp; &lt;- 15% of IGE</td>
</tr>
<tr>
<td>All Projects</td>
<td>64</td>
<td>100.00%</td>
<td>21.88%</td>
<td>7.81%</td>
</tr>
</tbody>
</table>

Overall, these results are not too bad, as 84.38% of the awards were either within 15% of the IGE or significantly less than the IGE. However, 15.63% of projects had award totals over 15% greater than the IGE and required redesign and/or reprogramming. Additionally, even those within 15% over IGE are not awardable (10% is the maximum an award can exceed PA without Congressional approval). In her analysis, Ms. Lanphere identified the following potential root causes (bold indicates most important causes):

- **Within Government Control:**
  - Estimate developed from a poorly written scope of work (SOW)
  - Lack of time to develop a detailed CWE/IGE
  - Estimates prepared by personnel lacking appropriate training and certifications
  - Lack of adequate site visits by the cost engineer
  - Lack of technical mentorship for cost engineers
  - **Cost engineer not involved early enough in the project delivery process**
  - Lack of pertinent information from members of the project delivery team (PDT) (amendments not sent to cost engineer; scope changes without cost engineer’s knowledge.
  - Lack of peer reviews, quality control and other best practices
  - **Lack of proper market research**
Estimating to the PA and not the SOW

Outside Government Control:
- Bidding climate (supply/demand) and range of bids
- Lack of subcontractor competition
- Market conditions (such as natural disasters that compete for construction resources)
- Programmed Amounts and other historical programming documents are inaccurate
  - Contractor risk (contractors must interpret the risk and be willing to accept the risk)
  - Procurement method
  - Cost Engineer experience level (retention) – note this is an issue for both the Government and AE firms.
  - Base, facility and installation access that is restrictive and drives up contractor bids
  - Pool of qualified subcontractors (some specifications require highly specialized qualifications)
  - Cost book latency (currently utilizing 2016 cost book)
  - Equipment library latency (utilized 2014 throughout FY17)

Through her extensive analysis of Tulsa District’s 64 projects awarded in FY 16 and FY 17, Ms. Lanphere developed some conclusions and recommendations. Foremost was the need for the District cost engineers to be involved early in the DD 1391 development process in order to influence the PA. Other high priority recommendations included:

- Changing the culture for in-house and A-E cost estimators to estimate to the SOW versus the PA.
- Using an independent A-E for cost estimating services versus the design engineer – note that this is an issue for both the Government and AE firms.

Additional recommendations included:

- Involving District cost engineers in developing Area Cost Factors
- Robust cost estimate quality control
- Having the cost engineers participate in site visits and design review meetings
- Having cost engineers participate in proposal evaluations, discussions and negotiations
- Documenting lessons learned, best practices and processes and policies
- Regularly tracking market conditions; this could involve partnering meetings w/industry or having proper resources
- Implementing a cost schedule risk analysis (CSRA) process for MILCON projects
- Developing cost metrics to determine areas of improvement

To further examine cost engineering challenges on Department of Defense construction projects, the cost engineering workshop next conducted two panels, one government-focused and one private industry-focused.
Cost Engineering Issues – Government Perspectives

The government panel included: Tom Hodges – Air Force Civil Engineer Center (AFCEC) Design & Construction Branch Chief; Patrick Beard – Tulsa District (SWT) Chief of Military & IIS Programs; and Shawn Painter – SWT, Chief of Engineering Branch.

Tom Hodges discussed military project cost challenges from the perspective of the Air Force organization responsible for integrating and optimizing civil engineering at Air Force installations to include design and construction. He identified two major challenges. The first was increased construction costs nationwide generally and specifically in regional hot markets. An additional challenge was the requirement to execute high visibility and often short fused projects. This lack of time to properly support a variety of new initiatives led to hasty programming, in some cases having as little as one week to draft project DD 1391s.

Air Force bases develop initial cost estimates for projects using the Air Force’s parametric cost estimating tool, PACES (Parametric Cost Engineering System). PACES is based on models of typical facility types, however supporting facilities costs are estimated based on a percentage of primary facility costs until site investigations are completed. For approved future year defense program (FYDP) projects, cost and scope validation is conducted three years out (in FY 19 validating FY 22 projects). Cost and scope validation is conducted on site with a planning charrette involving users and installation organizations utilizing the cost estimating tool – Micro-Computer Aided Cost Estimating System (MCACES II Generation). Many projects are inserted late into the program two years out (FY 21 projects added in FY 19). These finalized cost estimates are used to adjust and finalize the draft DD 1391s. This becomes the Programmed Amount (PA).

During design, AEs perform cost estimates at every design stage prior to construction award utilizing the MCACES II tool with actual quantity take-offs from design documents. Consideration of local conditions, economy and market conditions are factored into the cost estimates, but after PA cost has been established. Design Agents review, revise and approve all design estimates including final construction bid estimate. It should be noted that local market conditions and availability of materials and sub-contractor workforces can have a significant impact on bids.

Because many factors that can have a significant influence on project cost are not considered until after PA cost is established, the Air Force is faced with the following challenges:

- Increasing number of high bids driving Congressional reprogramming
- Reprogramming, when approved by Congress, do not come with additional funding
- Increased reprogramming with no additional funding results in reduced funding availability for other projects.
- Lengthy reprogramming timelines – minimum of six months – drive bid extensions.
For these reasons, AFCEC seeks to improve cost estimates to reflect current market conditions. This will lead to more contract awards within approved funding and reduce the number of bid busts and reprogramming.

Patrick Beard, SWT Chief of Military & IIS Programs examined the 15-year construction cost index from 2005 to 2020. This index showed a 25% to 35% increase going back 12 years and forecasts a 20% increase over the next three years. The driving factor for these projected increases is labor cost.

Mr. Beard also presented feedback received from contractors bidding and working on SWT projects. Contractors see Federal firm fixed priced contracts as high risk, due to a culture within Government contracting where the Government's first move is to show it's the contractor's fault or respond to questions with "just follow the contract." This is particularly problematic since the vast majority of SWT construction contracts are firm fixed priced. Other contractor feedback included:

- The 10% hub-zone requirement is often difficult for large business to compete with.
- Small business requirements on large contractors are limiting competition and driving up risks due to lack of sub-contractors. This may lead to lack of submitting a proposal or increasing costs.
- Profit margins on commercial vs. Government contracts are close to the same, however Government contracts usually have 20% or more contingencies built in due to issues with Governments effort to fault the contractor.
- Contractors actually prefer design-bid-build. If they use design-build, the Government needs to allow more flexibility or make trade-offs on design.
- Communication – or lack of – during the solicitation process increases risk, which drives up cost. Contractors suggest a more open dialogue during bidding/proposal prep. USACE is concerned that open dialogue results in unequally shared information and potential protests.
- Sub-contractors are not committing to projects until after contract award, which is causing the contractors to take large risks on sub-contractor bids.
- Contract site access with background checks is limiting sub-contractor/labor pool.
- Steel suppliers were only holding prices for one week due to current market conditions.
- Even when a contractor wins a bid, they only celebrate for about a minute, then they worry if they can complete the job successfully. Winning a large government contract is scary.
- Time to actually award the contract causes reluctance to bid jobs (delay in funding to award or our solicitation timelines). This ties up contractor bonding capacity and forces the contractor to take risks on future commitments.

For these reasons, SWT is focusing on reducing the perceived contractor risk. Some recommendations include increasing the number of contractors participating in the regional discussions regarding process improvements and improving methods of communication during the pre-procurement and procurement phase of the contract without violating the integrity of the process. Additionally, SWT is working to adjust costing information to more rapidly match current market conditions and looking to further develop partnering opportunities to reduce the “contractor is at fault” vs. “team” approach.
The final Government panel member was Shawn Painter, SWT Chief of Engineering Branch. After an overview of SWT’s military construction mission and MILCON programming, Mr. Painter focused on two key programmatic discussion areas: incorporating risk when developing DD 1391s and understanding the limitations of program estimates.

Project cost risk includes:

- Price of working inside the fence vs. outside. This is in addition to whether or not the Area Cost Factors are accurate.
- Price of government process and controls vs. those of private industry. Government processes/controls are more extensive and expensive.
- Market conditions, worker availability, material cost fluctuations; how do you forecast contractor risk?
- Acquisition approach – design-build or design-bid-build; cost plus or firm fixed price.
- Unforeseen conditions
- Scope Reductions/User Requested Changes

Understanding Program Estimate Limitations ($/SF)

- Cost is not definitized by actual scope and design of the specific project at the programmatic estimate.
- Standard designs can help, but there are local conditions that may not be included (safe rooms, standing seam metal roofs, foundations in expansive soils, sustainability measures, etc.).
- Unique facilities that don’t fit in the typical $/SF.
- Economy of scale impacts.
- Material selection.
- Type of building construction.
- Utility requirements.

Mr. Painter also discussed cost estimating during the design stage and specific cost concerns for MILCON projects. As the design progresses, the cost estimate and risk identification improve. MILCON specific concerns involve not pushing design problems into construction, and identifying and acting on any potential design issues immediately. Some recommendations included:

- During the Programming Phase:
  - Develop risk matrix during preliminary design review (Government & Contractor Risks)
  - Cost-Schedule-Risk-Analysis (CSRA) approach during DD1391 development
  - Independent development of DD1391 Costs with Peer Review/validation
  - Inclusion of Lessons Learned during design review (Correct People on the Bus)
  - Program to minimum facility requirement AND add 5-10% in user options
  - Installation/owning agency consider what is minimally acceptable
- Installations consider SRM funded investigations/survey/site assessment prior to preliminary design review
- DoD consider funding design during construction (DDC) Via discretionary pot vs. project funds (DDC is deducted from contingency)

- **Design Pre-Award Phase**
  - Design to 95% of construction cost limitation (CCL)
  - Enforce IGE with Peer Review/validation
  - Ensure proper design quality management
  - Upward report cost concerns during design immediately
  - Incorporate contractor risk reduction measures
  - Contractor involvement in common construction problems
  - Value Engineering
  - Partner on cost concerns
  - Contractors provide cost reduction recommendations during bidder inquiry
  - Contractors provide feedback to contracting officer after pre-bid site visits

At the end of the Government panel, Wade Anderson, SWT Chief of Engineering and Construction summarized issues with DoD cost estimating as falling into four categories: 1) programming, 2) risk management, 3) communication and coordination, and 4) market conditions

**Cost Engineering Issues – Industry Perspectives**

Although Patrick Beard discussed contractor feedback during the Government panel, a second, industry perspectives panel fully examined cost engineering issues from both the design consultant and construction contractor viewpoints. This panel included: Jeff Harper, Owner, Harper Construction; Kyle Duininck, Owner Duininck Brothers Construction; Jason Kling, Burns & MacDonnell; Mike Runde, Mead & Hunt; Rich Trotter, Crawford Consulting; and Mark Childs, Michael Baker international.

Jeff Harper from Harper Construction led the panel by discussing his preference for **design-build contracts with performance-based requirements**. These allow the builder to innovate and find cost savings while meeting Government requirements. He is also a strong proponent of partnering with the Government and working through contract modifications by face-to-face meetings to discuss scope with the Government. He gave a comparison of USACE and NAVFAC and endorsed NAVFAC’s focus on design-build with performance-based requirements and base bid with options. He also recommended that for any modification of less than $250,000, the Government not complete an IGE but rely on the contractor’s estimate.

Jason Kling from Burns & MacDonnell discussed **proactive project cost control during design**. This starts at the charrette and establishes design targets of:

- 80% of construction cost limit
- 75% of square footage
- Meet minimum mission requirements
• Options to full scope

This approach provides a much needed “cushion” to ensure that the project can be awarded within the estimated construction contract price (IGE). This approach does require support from both USACE, Air Force or Army Installation Command and the installation.

Mike Runde from Mead & Hunt discussed value engineering during design with specific examples of two airfield projects recently completed for SWT. Material requirements, project schedule (accelerated or mission-limited), base access, construction phasing all effect costs. These need to be clearly detailed during the charrette and considered when developing the IGE. These items/conditions can then be reconsidered during value engineering at the 65 percent design point in order to reduce the IGE within the PA.

Rich Trotter for Crawford Consultants, a cost-estimating consultant specializing in MCACES MII cost estimates discussed the problem inherent in developing an accurate cost estimate. These include: locality issues related to availability of materials and labor, conceptual estimates with essential inaccuracies (see discussion of AAAE Class 3 estimate accuracy above), owner feedback or lack of feedback after completion, and other unknowns. The opportunities for providing more accurate cost estimates are primarily in sharing real cost data. Even with this, there needs to be some owner acceptance of market volatility.

Mark Childs of Michael Baker International discussed the AACE Cost Estimating Classifications and characteristics of a credible cost estimate. He also identified common problem with developing a credible cost estimate including:

• Insufficient time
• Erroneous or optimistic assumptions
• Inexperienced cost estimators
• Failure to consider key factors
• Failure to understand scope and specifications
• Failure to recognize local practices and cost impacts
• Inaccurate cost basis for labor, material, and equipment
• Lack of review cycle
• Poor quality control
• Misapplication of markups
• Quantity or pricing errors

The industry panel included a question and answer session. Items discussed included the “Corps factor.” Basically, this is a contingency mark-up in cost to protect the contractor. All panel participants agree it does exist. In discussing labor and materials costs, Jeff Harper from Harper Construction stated that in remote locations they self-perform to overcome labor shortages. Kyle Duininck stated that they can usually lock in material pricing for 18 months. Jeff Harper affirmed that they buy key material ahead of time. Shawn Painter discussed including cost, schedule risk analysis in the charrette phase.
Following the second panel discussion, BG (Ret) Schroedel, SAME Executive Director, asked all workshop participants, “If you could change one thing - what would you do?” Answers included:

- Shorten procurement timeline
- Empower people at lower levels
- Learn lessons from other agencies - block grants
- Watch what Air Force is going to do at Tyndall AFB, FL.

Conclusions and Recommendations

The workshop identified issues with cost engineering in four main areas: 1) programming, 2) risk management, 3) communication and coordination, and 4) market conditions. Some of these such as risk management and communication/coordination have local solutions. Others, such as programming may need engagement by higher headquarters at USACE and service installation command. Market conditions cannot really be changed. However, they can be better understood and adapted to. The workshop therefore identified potential solutions at several levels including the local level and at levels requiring higher headquarters and Congressional support.

Local solutions fell into three main categories: 1) solutions that SWT can implement, 2) solutions that SWT-supported clients (military installations) can implement, and 3) best practices that AEs and construction firms should implement.

Recommendations for SWT to Implement:

- Work with your supported Army and Air Force installations to be involved early in the DD 1391 process in order to influence PA’s.
- Develop risk matrix during preliminary design review
- Engage in the development of Area Cost Factors
- Ensure robust quality control of cost estimates
- Implement proactive project cost control during design (see discussion above)
- Use value engineering to drive IGE below the PA.
- Require participation by cost engineers in site visits and design review meetings
- Document lessons learned, best practices and processes and policies
- Share real construction cost data with the design agent and AE cost engineers to ensure more accurate future cost estimates
- Regularly track market conditions by conducting partnering meetings w/industry
- Implement a cost schedule risk analysis (CSRA) process for MILCON projects
- Develop cost metrics to determine areas of improvement
- Use an independent A-E for cost estimating services vs. the design agent.
Recommendations for SWT-Supported Installations to Implement:

- Work with Tulsa District; involve them early in the DD 1391 process to influence PA’s.
- Engage in the development of Area Cost Factors
- Help document lessons learned, best practices and processes and policies
- Help tracking market conditions
- Support proactive project cost control during design (see discussion above)
- Support value engineering to drive IGE below the PA.

Best Practices for AEs and Construction Contractors:

- Implement proactive project cost control during design; establish design targets of 80% of construction cost limit, 75% of square footage, meeting minimum mission requirements, and identifying options to full scope.
- Use value engineering to drive IGE below the PA.
- Develop risk matrix during preliminary design review.
- Ensure robust quality control of cost estimates.
- Have cost engineers participate in site visits and design review meetings.
- Document lessons learned, best practices and processes and policies.
- Support partnering meetings with industry to regularly track market conditions.
- Self-perform construction to overcome labor shortages.
- Lock in material pricing as much as possible to minimize market volatility.

Additional actions fall outside the authority of either SWT or SWT-supported military installations. These will require action by Higher Headquarters or Congress.

HQ USACE Recommended Actions:

The workshop recommended that HQ USACE partner with SAME to conduct a National roundtable on the topic, bringing together the leadership of AFCEC, NAVFAC, USACE and private sector design and construction firms. Other recommendations for HQ USACE included:

- Work with Districts to shorten procurement timelines.
- Empower people at lower levels.
- Edit USACE guidance to recommend involving the contractor early in the design and cost estimating process.
- Edit USACE guidance to recommend shifting some risk from contractors to the Government to bring it more in line with private industry practice.
- Work with the service installation commands to devote more resources/design efforts to develop accurate DD 1391s.
- Work with service installation commands to mandate and fund a more thorough validation of DD 1391s at the beginning of the design phase.
- Consider updating the Cost Book (HAG/HII Database) with as-constructed costs, rather than relying exclusively on awarded bid costs.
- Update the cost book more frequently (every six months).
Coordinate with the American Council of Engineer Companies (ACEC) to Engage Congress:

- Recommend Congress shorten procurement timelines. For approved future year defense program (FYDP) projects, cost and scope validation is conducted three years out (in FY 19 validating FY 22 projects), and these finalized cost estimates are used to adjust and finalize the draft DD 1391s. This becomes the Programmed Amount (PA) that Congress authorizes for the project. A lot can change in three years and the workshop recommended shortening this three-year timeline.
- Allow for more liberal reprogramming rules that recognize market changes.
- Consider learned lessons from other agencies and consider the use of block grants for MILCON.
- Require more resources/design effort in developing accurate DD 1391s to include mandating a more thorough validation of DD 1391s at the beginning of the design phase.

About the Authors

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Miro Kurka, PE, PMP, COL USA (Ret), spent 30 years as an Army engineer. Miro has commanded two United States Army Corps of Engineers (USACE) Districts and was the Deputy Commander of the USACE Northwestern Division from 2008 to 2010. Miro has managed large USACE civil works studies and construction and maintenance projects worldwide. He has also worked with federal and state regulatory and environmental agencies to solve major water resource regulatory and policy issues.

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Ms. Amber Lanphere began her Federal civil service career in 2004 at the Redstone Technical Test Center (RTTC) in Huntsville, Alabama. Prior to her Federal civil service career, she graduated from the University of Memphis with a Bachelor of Science in Electrical Engineering in December 2003. While working at RTTC from 2004 – 2014, Ms. Lanphere held many positions including an Electronics Test Engineer within the modeling & simulation team. Ms. Lanphere accepted a position at USACE Tulsa District in May 2014 as a Technical Manager for the Military Design Section. In March 2015, Ms. Lanphere was selected for a promotion to the Cost Engineering Team Lead with the mission to stand up the Cost Engineering Team. Since March 2015, Ms. Lanphere has continued to serve as the Tulsa District Cost Engineering Team Lead while supporting civil works programs, military programs and hydropower programs. Ms. Lanphere earned a Master of Science in Construction Management in July 2019 and is currently in the USACE Leadership Development Program Level 3.

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