

Delivering to cost in an EPC world

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Abstract

With inflationary pressures such as increases in materials costs on EPC projects, the need to develop processes and tools to deliver to cost has never been greater. This presentation will focus on the key issues to be considered when delivering to cost and suggest general ways and means to approach design to cost. Although the planning and engineering constitute a small percentage of the total project cost, they have a huge influence on the final cost. This presentation will review such practices as integrating the engineering, procurement and construction team, tracking materials quantities, spending more on engineering to save much more on construction, and continuously looking for ways to build faster, better, and more cost effectively. Daily interaction between construction and design personnel early in the design process helps identify issues early, before design re-work or before construction are underway. Packaging the design in the sequence to support the construction effort is key. Examples from project experience will be included. This presentation will be of interest to all those managing EPC projects as well as those participating in EPC projects.

Introduction

With inflationary pressures such as increases in materials costs on engineering, procurement and construction (EPC) projects, the need to develop processes and tools to deliver to cost has never been greater. Although the planning and engineering constitute a small percentage of the total project cost, they have a huge influence on the eventual construction and life cycle costs. Daily interaction between design, procurement, and construction personnel early in the design process brings issues to the surface early, before design re-work or before construction are underway. Packaging design in the most efficient sequence to support the construction effort is a key success factor.

For the purposes of this paper, delivering to cost is defined as a systematic approach to managing cost throughout the project life cycle to deliver the entire project below the cost target. The project cost is monitored throughout the design and compared to the baseline to help the Project Manager (PM) identify overruns and mitigate them. Above all, deliver to cost must become a pervasive attitude among all members of the project team. While the owner's senior management staff are concerned with project cost and schedule, the owner's operations and engineering divisions are primarily concerned with function. EPC firms cannot assume that the owner will be fully aware of the cost impact that their decisions and selections will have. Thus, it is the EPC firm's responsibility to track the cost impact of functional changes, not the owner's responsibility.

The EPC project manager (PM) must be cognizant of two agreements that are equally important. One agreement is with the owner and is codified in a formal legal contract. The other agreement is with the leadership and stockholders of the EPC firm. This second agreement is rarely written down in detail, yet is equally important. The EPC project manager typically makes a promise to:

- Control engineering and construction labor and expense costs (managing change)

- Control equipment, materials quantities (e.g., concrete, steel and process equipment)
- Minimize the constructed or installed cost, including engineering. For pure EPC or design-build (DB) projects, this is the key objective, and for design-build-operate (DBO) projects in particular, it is critical to address the entire life cycle cost by also including the operation and maintenance costs.

This paper assumes that the project manager has prepared a project execution plan that has been endorsed by the client and the project team. For the purposes of this paper, the project execution plan includes the following key elements:

- | | |
|----------------------------|---|
| • Project scope | • Quality |
| • Major deliverables | • Safety |
| • Work Breakdown Structure | • Client Service including communications |
| • Schedule | • Document Management |
| • Budgets | • Change Management |
| • Resources | • Project closeout |

Building Blocks

Minimizing total project cost may mean spending more at the beginning of the project to properly baseline the quantities and level of effort expected and develop processes and tools to track progress. Adequate planning of the engineering, estimating, and procurement efforts will reap rewards later. For example, co-location of the entire team promotes integration and collaboration that will cost more up front but save money in the long run.

Integration

The total project is often delivered by a team that includes:

- Designers
- Constructors
- Procurement staff
- Estimators
- Project controls specialists

One of the primary building blocks of a deliver-to-cost system is the integration of these key functions. Integration is the result of having a combination of the right people supported by appropriate processes and tools. Of the three, having the right people is the most important. It is important that the key team members have EPC project experience. It is not necessary for all project team members to have EPC experience, but key project positions should be populated with people that do.

As mentioned, it is best to co-locate key personnel to promote daily interaction. Weekly communication is not enough. Co-location of team members offers enormous benefits. These include the ability to avoid or rapidly solve cross-functional problems, identify innovative means to reduce costs and to enhance communication, understanding and collaboration. In addition, integration must be encouraged and enhanced by appropriate processes and tools. The processes and tools should be carefully developed to allow for rapid (and informed!) decision making. This process and tool topic will be further developed later in this paper. The key here is to be sure the project is set up for success at the outset.

It is important that the entire team be integrated as much as possible and all members focused on the total project cost. It is possible and even likely that if each project function were to focus solely on minimizing its individual costs, without considering the impacts on the overall project, the project would still go over budget. Similarly, if each function were to optimize with disregard for the total project cost, the total project would be sub-optimized.

Coordination takes careful planning and investment. Spending a little more on planning and design can have a 10-fold payback during construction. Designers need to continually seek input

from construction, procurement and estimating experts on the team.. On a recent project for the City of San Diego, collaboration between designers and constructors turned up dozens of ideas that saved construction cost and schedule while adding value to the project. In one case the engineer laid out the project site to minimize the overall facility footprint. On review of the layout the constructor asked whether one of the buildings could be moved to create some separation from another facility. The engineering team did not immediately see an advantage and asked for an explanation. The constructor pointed out that digging the foundation for the second building would undermine the foundation of the first unless sheet piles were installed. Installing sheet piles would have added to the construction cost and the schedule. Once the engineering team understood the construction realities, they revised the layout allowing construction to stay on schedule.

People – Be Selective and Invest

The people must have the right attitude! Teamwork is a critical success factor. Engineers, constructors, procurement specialists, estimators, and project controls personnel must all work together towards a common goal. The separation of engineers and constructors that prevails in the design-bid-build delivery approach commonly employed in the U. S. and Canada often fosters some distrust and animosity. Integrated EPC teams must actively work to overcome this history of separation and the lack of mutual understanding and appreciation it has built.

Charter the Team to a Common Project Vision and Mission

Chartering is a structured process used to build high levels of clarity, agreement and motivation among key contributors at the beginning of a project. It can greatly increase the probability that the team will experience high levels of performance resulting in a successful project outcome.

Chartering is undertaken to:

- Establish team goals that support the overall project objectives
- Define roles and relationships needed to achieve the goals
- Clarify members' expectations of their own and others' work
- Build alignment within the team and with external stakeholders
- Establish operating guidelines that will support collaborative effort
- Make better use of the collective resources and knowledge

Chartering is different from a conventional project “kickoff,” in that kickoffs tend to focus on one-way communication of the “what's,” such as milestones, deliverables, schedules, payments, etc., whereas chartering uses two-way communication to engage team members and other contributors in the crafting of effective goals, roles and procedures to help fulfill the project mission. One tangible product of this process is a written charter document. A good charter provides all contributors with a clear and simple sense of the overall purpose of the project, the respective parts they are to play, guidelines for communication, decision-making, conflict resolution and other key team processes, and expected behaviors.

During the chartering effort, care should be taken to define quality for each project. Quality is situational. For example quality to a client in a market of rapid technological change, facing immense time-to-market pressures, with a tight budget and needing a simple facility to last five years is different than the quality to the client wanting an iconic structure built for the ages. We have all experienced occasions in our own lives when low price or convenience were more important to us than durability or aesthetics. Sometimes we are interested in a fast cup of coffee and other times we want to linger for a while a read the paper. Neither approach is always right or always wrong, and it is the same for quality. Sometimes a client will place a premium on speed and low cost; other times, that same client will place a premium on high tech or perhaps durability. In all cases, quality is not superficial gold plating. For project teams, total project quality means that individually and as a team, they capture the client's expectations and control risk by meeting the scope, schedule, budget, and applicable codes. Finding the right mix of delivery

speed, durability, and cost takes time and requires a good understanding of client's needs, drivers and concerns. Discerning these needs, drivers, and concerns takes some time, but it is well worth the effort.

Gaining team commitment to change management is critical. Change always costs more than originally envisioned, especially in a multidiscipline design with issues that ripple through a design. For example, our client asked us to change a design to accommodate a larger flow. The project manager did some due diligence and was convinced that the increased flow could easily be accommodated by increasing the motor size and requesting some minor alterations to the pump. The cost impacts of these changes were documented and submitted to the client as a change order request. The client was surprised that the change would have any cost impact at all and asked that we revisit the cost impact. It seemed like a small change but the client finally agreed to a reduced amount. During the next few weeks, the project team realized that the power supply to the pump station was barely adequate after the motor size was increased. In addition, the HVAC system would be undersized for prolonged operation during warm weather and the ancillary equipment in the same room was very sensitive to temperature. The impact of the simple request to pump more water rippled through the design in unexpected ways and had significant cost impacts. All team members must be coached to recognize the importance of change management and avoid the tendency to underestimate the ripple effects of a change.

Communicate, Communicate, and Communicate!

Communication is key to the success of any team endeavor. Its importance cannot be underestimated. A 2003 study of the factors influencing project performance found that the frequency of team meetings correlated with project success more than project organization, level of project management training or the frequency of status reporting (Kuprenas, 2003). Project managers must take time at the beginning of a project to set up key communication channels and establish the frequency and attendance of project team meetings. It is critical to get key team members together on a frequent basis to assure that all team members:

- Are aware of budgets and expectations -designers need to know baseline assumptions
- Discuss unexpected challenges (change)
- Identify upcoming deadlines
- Pass on input from the client
- Reinforce a common understanding of the vision for the project and the mission of the team

We recommend one meeting a month as a minimum. On a fast-paced EPC project, it is prudent to meet more frequently. These meetings provide an opportunity to coordinate team members' activities and instill an "EPC mindset":

- Time is money
- Total project cost is key
- Optimize for the total project and not just your particular function; aggressively seek to provide value to other functions

Processes and Tools Facilitate Integration

Exhibit 1 is a schematic showing the various activities that occur on an EPC project along with the flow of information between key project steps. The orange bars show the flow of information needed to "Deliver to Cost". This is an iterative, "looping" process and the general cost trending touch points are shown. Major points of Exhibit 1 are listed below:

- The process starts with baseline information (labor fee, construction cost, basis of estimate) that goes from project acquisition to project planning and setup and also project controls to establish a datum for change management.
- The design team must endorse the basis of estimate. If this has not occurred during project acquisition, then it must occur very early in the design phase and before the chartering effort is completed.

- The baseline information is developed into an integrated project controls plan.
- As the design progresses, construction and design must collaborate in an iterative process. Estimating and procurement must be involved to help make informed decisions about alternative selections and project cost
- As construction starts, the designers need to maintain involvement to clarify the intent and help the constructor manage change and remain true to the design intent.
- Procurement and construction need to coordinate and collaborate to assure that equipment and supplies are purchased for reasonable prices and are available on site when and where they are needed.
- Project controls is the glue that holds all these pieces together.

Each step involves a flow of information that can be facilitated by a process or an electronic tool. Several tools are available, and this paper will not address which of these electronic tools is best suited for EPC projects. Often, electronic tool selection is based on personal preferences, company convention, or owner preference.

Exhibit 1

Delivering-to-Cost Information Flow

Major Considerations in the Deliver-to-Cost Process

Integration of engineering, construction, procurement, and estimating can be facilitated by four actionable steps. These steps can be altered or added to depending on project need but serve as a starting point for project managers.

1. Share Baseline As-Bid Estimate and the Basis of Estimate with the Design and the Procurement Team

The designers should pay particular attention to the quantities of materials used to prepare the initial construction cost estimate. It is advisable for the design team to validate the basis of the estimate and the quantities of materials (see Exhibit 2). Ideally, validation should occur before the bid is submitted, but often there is not enough time in the schedule. Should a mistake be noticed after the estimate is agreed to with the owner, then the design team must collaborate with procurement, estimating and construction to identify other potential areas of saving. Some of the key attributes of value engineering can be used to determine how best to decrease cost while balancing other project goals including durability. The true value of this approach might be best highlighted by envisioning what would happen if the information is not shared. In one classic case, the project manager asked the structural engineer to quickly design a foundation slab so construction could start. No information was shared and the loads had not yet been determined, but the project manager was determined to get started. The structural engineer dutifully, and quickly, pulled together a slab of the appropriate dimensions and drew it up on the site plan and sent it off to the construction team. In the absence of having loads and geotechnical recommendations, the structural provided enough conservatism for almost any load or soil type that could reasonably be expected in this location. After two weeks time, the structural engineer heard from the project manager that “the design is screwed up!” There was twice as much concrete in the foundation as was in the original bid estimate. The lesson learned was that the information developed and the as-bid estimate needed to be shared with the project team so they do not operate in a vacuum.

Exhibit 2

Validation of Estimates and Quantities of Materials

2. Promote Daily Interaction

Engineers, estimators, constructors, and procurement specialists should be interacting on a daily basis during design development. All of these functions view projects differently and add value in different ways. Leveraging these unique insights in a synergistic manner has the opportunity to add even greater value. For example, on a large water treatment plant design, close collaboration between the engineer and estimator revealed several design decisions involving the thickness of a floor slab that had the potential for huge cost impacts with little impact on overall functionality or quality.

3. Trend Material Quantities and the Estimated Construction Cost through the Design

The materials quantities to be tracked will vary depending on the project type. For example, if the project requires large quantities of concrete and steel, then these two material quantities will be tracked and compared to the quantities used in the baseline estimate. Trending materials quantities and key equipment costs can force collaboration between engineers, procurement, and estimators: Engineers communicate material quantities in their designs to estimators, and procurement communicates key cost categories (e.g., key equipment and craft labor) to estimators who report out a comparison between the as-bid estimate and actual. When this information is reported to the project manager on a monthly basis, the project manager can share it with the team to proactively address overruns and take advantage of under-runs.

The project manager should work with the estimator to determine which quantities should be tracked and develop a plan to do so during the design. Exhibit 3, Estimating Information Flow Chart shows a simple process designed to capture key information on quantities from the leads and generate reports to the team to provide feedback. The design leads estimate the key quantities included in the design and provide the information to estimating staff. The estimator generates reports for the project team that compare these key quantities in the design to the baseline. Procurement personnel can easily be added to the information flow if major equipment is also to be tracked.

Electronic tools are becoming more commonplace in engineering and construction and can be very useful in tracking quantities. Computer-aided design tools that are used to develop 3-dimensional models can often generate quantities of the key materials. When the design information in these models is shared directly with estimating tools (as shown in Exhibit 4), the tracking of quantities and trending of construction cost can be performed very rapidly. In fact, a fully developed model will generate materials take-offs in a matter of seconds.

Exhibit 3

Estimating Information Flow Chart

Design leads should be encouraged to review the information to identify quantities that deviate significantly from the baseline bid, and the designs should be reviewed to determine why the deviation has occurred. Here are some common reasons for deviations:

- The scope has changed, either by conscious decision or in error.
- There is a mistake in the model.
- The initial base estimate was in error.

Exhibit 4

Integrating Estimating into Automated Design

Once the reason for the deviation is determined, the appropriate technical discipline lead can take appropriate action.

4. Practice Proactive Value Engineering

In almost every case, a small multi-discipline team focused on proactively and aggressively identifying money-saving ideas will reap rewards. As shown in Exhibit 5, the benefits from

brainstorming, developing and implementing cost savings ideas are much greater early in a project's life cycle. In one case, a small team was reviewing the layout of the site. The constructor asked two simple questions that initially baffled the designers: Can we move the buildings a little closer together and can we make all the buildings be multiples of 4 feet? He went on to explain that if we moved the buildings closer together, he could put the crane in the center of the site and not have to move it. In addition, his standard forms were 4 feet in length, and avoiding the need to construct standard forms would decrease the project schedule and cost. The owner was delighted to have the buildings all a little larger.

Exhibit 5

Ability to Influence Project Cost Over Time

Change Management

Change is an inevitable part of projects; therefore change management is an essential part of project management. Planning for change by developing appropriate guidelines and processes is crucial to the successful execution of a project. The project manager must develop, implant, and use a robust change management process.

Change management includes managing scope creep as well as any internal or external influence that changes the project from the negotiated scope. Change can be initiated by the project team; by the client or by third-party stakeholders, availability for resources, changing construction and procurement costs or other factors. The effect of change may be positive, providing opportunities to enhance value or save money, or they may be negative, threatening to increase project cost without adding value. Whether the effect is positive or negative, managing change during the execution phase of a project is an important factor in project success. For this reason, change management is an essential component to delivering to cost.

Managing change requires planning, discipline, and communication among team members and client representatives. Change does not cause projects to go over budget. It is the lack of clear, consistent direction and leadership when confronted with the challenges of change that cause delivery costs to exceed budget. The types and sources of change are too numerous to mention in this paper but are detailed in many books on project management including CH2M HILL Project Delivery System (CH2M HILL, 2001).

Five elements should be included in the change management plan:

- Identify the change. – Change identification is often accomplished by routine assessments such as scheduled project reviews. Once identified, the change should be logged in a project change notice.
- Analyze the effects of the change. – The impact of a change on a project's schedule and budget should be assessed and documented.
- Develop a response strategy. – Once the source and effects of the change are determined, a specific response strategy should be developed. It is important to determine who will assume responsibility for the cost of the change before the work is undertaken. The project manager should settle change management issues promptly.
- Communicate the strategy and gain endorsement – The change management plan should include a process for communicating change to the client, the firm's management, and other key parties. This is often done during regularly scheduled meetings. The PM should maintain a log of client requested changes and their impact to the project. Occasionally, this log should be reviewed with the client to make sure they are aware of the changes they have requested and the updated project costs.

Risk Management

A large part of change management is identifying risks associated with the project. Each project has its own risk elements but some common examples include: technically complex project, difficulty accessing needed resources, changing regulations/code, and heavy stakeholder involvement. Identifying risks ahead of time and developing a strategy for mitigation will reap rewards. Many sophisticated tools such as Monte Carlo Analysis are available to evaluate the potential cost impacts of risk. The simplest tool is a spreadsheet that lists each identified risk along with the potential cost impact, the mitigation strategy, and a trigger point to identify that the risk has been mitigated and can be removed from the list. Likewise, new risks should be added as they are identified. The exact tool to be used is less important than the process of identifying risks and associated mitigation strategies.

Final Tips

Here are some basic tips to follow in delivering a project to cost:

- When choosing between complex concepts and simple ones, lean heavily towards the simple. Constantly look for easier ways to accomplish an objective.
- Know and follow your company's established delivery processes. Communicate these processes to the project team so that everyone supports and follows the same processes.
- Co-locate team members when possible. In very large EPC projects, it may be feasible to establish a project office and include all staff including designers, constructors, estimators, project controls, and procurement personnel. In cases where team members are spread among several offices, consider how to best promote daily, real time interaction.
- Communication is critical and a project newsletter or website can be a great way to communicate progress and maintain a sense of connection with the team.
- Constantly monitor and control. Manage change aggressively! Change will occur on almost any project and the PM must be proactive and persistent in discussing change issues with the client and the team.
- ALWAYS keep the total project cost in mind when decisions are made. It is the total project cost that counts!

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