NAC Executive Insights

Minimizing Engineering Cost Overruns

Key Points

- Cost and schedule overruns plague the engineering and construction industry.
- Factors contributing to engineering cost overruns have been grouped by three areas:
  - Foundational weaknesses, where the seeds of engineering cost overruns are sown.
  - The "flow" of the project, where many overruns begin to emerge.
  - Stakeholders, particularly those outside the project team, who may impact engineering cost performance.

Minimizing Engineering Cost Overruns

Cost and schedule overruns plague the engineering and construction industry. This Executive Insight looks solely at cost overruns in engineering projects. In design/build and EPC projects where engineering and construction are tightly integrated, engineering performance is a leading indicator of later challenges faced as construction begins and progresses.

There are many contributors to engineering cost overruns and the factors detailed in this Executive Insight are not comprehensive. Other solutions exist and the coverage is not intended to be exhaustive.

Factors Contributing to Engineering Cost Overruns

The factors laid out in this section are further explored in subsequent sections. This listing of factors has been grouped by three areas where we see repeated failings in large complex projects, but the considerations apply through the full range of project sizes.

1. Weak Foundations

Weak foundations might best be described as "bad start; bad finish."

> **Said another way, "Go slow to go fast."**

Specific foundational weaknesses represent where the seeds of engineering cost overruns are sown and can be found in:

- Client/market selection
- Project selection/decision to bid
- Sponsorship
- Inadequate/inappropriate leadership
- Underestimate of complexity
- Incomplete scope
- Estimate basis and foundations
- Management of contingency and risk
- Granularity of deliverables
- Unrequired deliverables

2. Inadequate Attention to Flows

Our project execution methodologies implement traditional project management theory, which decomposes major tasks into smaller and smaller more manageable tasks. We display this decomposed project execution approach as up to 100,000 activities or more on a large complex project and then connect those discrete tasks with a plethora of "arrows" that we tend to treat as dimensionless. They are not. The arrows represent the "flow" of the project and it is here where many overruns begin to emerge. Some factors contributing to engineering overruns can be found in:

- Owner readiness/unresolved policy issues
- Alignment
- Inadequate project start up
- Lack of short-term execution planning
- Value of time
- Team structure
- Human factors
- Scope control
- Communication breakdown
- Delays and disruptions
- Lack of contingency planning
- Inadequate project review

3. Stakeholder Effects

In this context, stakeholders are used to describe those external to the project team proper. They can include elements of the owner's organization; external parties potentially impacted by the project; regulators and political bodies; broader market conditions, including competitor actions; and even the engineering organization in which the project team resides.

The balance of this Executive Insight explores many of these contributors to engineering project overruns.

Weak Foundations

Strengthening weak foundations represents our single best opportunity to minimize the risk of engineering cost overruns.

Client/Market Selection

"They are a major client." "We have always worked for them." These are all too familiar responses regarding the rationale for working for a specific client or in a specific country, state, or city.

- Have you ever made a profit?
- Will you ever make a profit?
- Does it give you some special capability which allows you to make profits (and enough of them) elsewhere?
- If not, why are you there?

All too often, engineering cost overruns begin by choosing to work for a client where you will never make a profit. Prioritize your management focus where there is at least the potential to make a profit. Sometimes you have to fire a client.

Project Selection/Decision to Bid

The go/no-go process is essential to business survival. The design, construction, and engineering industries are littered with CEOs who sought growth at any cost, but worse, the ones who overrode proven, strong go/no-go processes in their pursuit of growth.

The decision to bid represents not only a decision to expend the always scarce overhead/business development (BD) dollars but also a statement that you can deliver targeted returns or better if successful.

Ask the following questions:

- Do we have the capability and capacity to successfully deliver this project or a strategy to get them firmly in place?
- Do we understand how we are different than our competitors?
- Is that differentiation valued by our client and will it result in a reasonable probability of selection (40 percent or better)?
- Are the risks within our risk profile manageable and do they provide the risk-weighted returns we desire?

There are other questions, but these get you thinking about whether taking on the project, all things

considered, is even a solid business proposition.

Sponsorship

Is there a strongly committed and, importantly, engaged executive sponsor? The executive sponsor is a link from the project team back into the broader resources of the organization, but also a primary source of challenge and oversight. Sponsorship is something beyond a "resume adder." It is a significant value adder and part of that first line of defense against engineering cost overruns.

All engineering projects require sponsorship, even if it is the departmental manager. Projects are the only source of revenue for an engineering company.

Inadequate/Inappropriate Leadership

This Executive Insight assumes the engineering team is adequately qualified and resourced. If it is not, the decision to bid needs a closer look, both with respect to the team's adequacy and rigorous use. Are "waivers" to corporate risk profiles and policies being handed out like candy?

The project manager's job is a tough one. Their performance will greatly influence the trajectory of the job's performance if it is on solid foundations. Here are a few key points about leadership factors contributing to engineering cost overruns:

- Is the "best" PM the "best available" PM; an "available" PM; or the "best engineer" in the project's principle discipline? Project management is a discipline unto itself. That does not mean an engineer cannot become an outstanding project manager; many have made the change. But it does not happen by osmosis. Training (deputy roles; formal training) and mentoring are essential.
- Are the PM's skills commensurate with the complexity of the project at hand? How do you know? Score the complexity of projects and the capabilities of your project managers to deal with complexity. Uncertainties, potential overruns, and worse, "black swans" (big risks) lie in the "white space" of complexity. (*White space* risks are those that fall in between well-defined organizational, policy, process, and scope elements (discrete projects or tasks, for example), and are not otherwise reflected in risk assessment and management activities.)
- No PM is an island. It may not take a village, but it does take a team "working together." Think about skills related to project control, contract management, and project administration.

Underestimate of Complexity

This is touched on above, but complexity relates to:

- Significantly more "arrows" than tasks.
- Large number of conditions precedent.

- Lack of clarity on objectives, the decision-making process, and authorities.
- How the project team interprets the world around it.
    - Delusions of success
        - Seeing patterns and meaning in random data.
        - Drawing unsupported conclusions from incomplete/inconclusive data.
        - Seeing what the team expects to see when the data is actually ambiguous/inconsistent.
    - Seeing what we want to see.
    - Failing to listen.
    - Resisting learning and advice.

Incomplete Scope

You cannot have a good estimate (or schedule) without a complete scope. Of all the project baselines, scope holds primacy. (NAC Executive Insight*,* "Know What You Are Trying to Accomplish: The Primacy of the Scope Baseline"*)*

Estimate Basis and Foundations

As design progresses, in most instances there will be growing attention given to constructability and operations and maintenance (O&M) considerations. These will take the form of constructability reviews, operability reviews, and maintainability reviews. No matter how effective these reviews are, they are too late.

Incorporation of the most significant of these considerations begins at the basis of design stage, which in turn informs scope and the basis of estimate. An expanded basis of design (NAC Executive Insight, "Business Basis of Design") helps minimize the disruptive impacts of later stage review comments as well as reducing RFIs (Requests for Information).

In addition to an expanded and thorough estimate basis, the quality of the cost baseline is influenced by the quality of the estimating data used in building up the estimate. Estimating databases that include libraries showing standard hours by design configuration, factors to be considered in adjusting for

project specifics, and actual performance on historical projects act to reduce the risks of a bad estimate. Reference class estimates built off these libraries provide an initial check on the estimate baseline. It is important for estimating and actual cost data to be broadly shared across an engineering organization.

Equally important is considering the following questions:

- Who is involved in the development of project estimates?
- What are the drivers for optimistic project estimates?
- How do project sponsors and other key project players interact in developing estimates?

- What role should senior management play?
- How are optimistic project estimates and cost overruns related?
- Why are underestimated projects allowed to continue?

Management of Contingency and Risk

Contingency and risk are different. Contingency deals with quantitative uncertainties while risk more appropriately deals with event uncertainties or unknowns. As important as it is in formally establishing each of these pools, it is even more important to control their release to the project team. If not controlled, they will have evaporated before they are truly needed. (NAC Executive Insight, "Managing Risk in Large Complex Programs")

Granularity of Deliverables

There is a real world example from a design-build project that can make this point best. On the specific project, there were five utilities that had to undertake utility relocations. The 50,000-activity schedule showed one activity for each, with a start and end date. The problem was there was a total of 600 individual relocations (each a mini-project for engineering) that were required in a defined sequence and schedule to support construction. The result: 600 deliverables had to be tracked and sequenced to support construction. In addition, manpower loading had to be done, which in turn meant providing for unplanned overtime. (NAC Executive Insight, "Management of Engineering in Design/Build")

Unrequired Deliverables

Relook at what are the "minimum deliverables." As we move more consistently today to building information management (BIM), can some traditional deliverables be replaced with data and models? What does "fit for purpose" truly look like? Can some of the detailing be left up to the contractor, thus limiting your role to "review and accept"?

Does shifting the mix of home office and field engineering allow certain design details to be completed in the field, typically a lower total cost for engineering?

Inadequate Attention to Flows

Engineering cost overruns may result from poor productivity on a task. If you peel back the analysis further, however, you will likely find one or more flows where the dependent task did not contribute what was required when required and of the right quality. Some of the flow-impacting factors contributing to engineering cost overruns are:

Owner Readiness/Unresolved Policy Issues

Insufficient readiness on the owner's part results in inefficiencies in engineering execution. (NAC Executive Insight, "Owner Readiness") This can take forms ranging from incomplete information to extended decisions times to changes of direction or scope. The engineer has an obligation to communicate these factors and concerns to the owner and respect the letter of the contract. Notice

should be provided as required in the contract and appropriate approvals and relief sought.

Inadequate prime contract management by the engineer is a significant contributor to engineering cost overruns. (Executive Insight, “Prime Contract Management”)

Alignment

The importance of alignment of project teams is well recognized. The need for alignment extends to alignment with the client (strategic business objectives, processes, and procedures) as well as with subcontractors. Alignment within joint ventures can present special challenges.

Inadequate Project Start-Up

Efficient execution reduces exposure to engineering cost overruns. Effective execution begins with an efficient, well-planned, and comprehensive start-up. Dedicated start-up professionals free engineers to do what they do best and eliminate rework that results from processes being put in place late in the project.

Lack of Short-Term Execution Planning

While overall project execution plans are essential, planning for short-term execution is necessary to keep cost and schedule under control. In construction, workface planning provides a framework for short-term execution planning. Short-term execution planning and measurement of performance and productivity provide early controls and alerts concerning negative engineering cost performance.

Short-term execution planning (sometimes called two-week look ahead or pull planning and scheduling) also highlights (1) immediate information and (2) approval needs aiding in their expediting, which are two of the largest productivity-impacting factors.

Value of Time

Time is money. Any stretch out of schedules adds to engineering costs, especially to associated indirect labor. Accelerating project schedules is an effective strategy for engineering cost control.

Effective, timely close-out of projects also reduces costs associated with engineering related activities. Planning for project completion should begin shortly after project mobilization.

Team Structure

Integrated, not discipline-based, project teams promote project communication and overall team execution cycle acceleration. Identification of “white space” issues and opportunities are also improved.

Human Factors

Projects are composed of people and their performance is affected by a full range of human factors:

- Poor morale
- Poor motivation

- Poor human relations
- Poor productivity
- No employee commitment
- No functional commitment
- Delays in problem solving
- Too many unresolved policy issues
- Conflicting priorities between executives, line managers, and project managers

Scope Control

Complete scope at the project foundations stage is essential, but so is scope control when moving through project execution. Prime contract management and administration are essential for the engineer to assure work performed is required and will be compensated. Scope control is facilitated by a strong scope baseline addressing both scope of services as well as scope of facilities to be designed.

Communication Breakdown

Much has been written on communication techniques, strategies, and tools. A project requires timely, effective, and complete communications if it is to avoid an engineering cost overrun. There can never be too much communication.

In a project setting there are some key questions that must be considered to support effective engineering cost control:

- Who needs to be informed (and of what)?
  - Project team members, executives, stakeholders or clients?
- What kind of communication will be required?
  - Team and management meetings, project updates? Match communication to project and team needs. Avoid unnecessary, large meetings with no clear agenda or action-oriented outcomes.
- How frequently will communication be needed?
- What details must be communicated?
  - Meeting notes, progress, problems, successes?
- Who needs to know what?
  - For example, does the CEO need to know about a delivery hitch? Who needs to know about budget overages?
- What is the role of the project sponsor in communications?

Delays and Disruptions

Delays and disruptions of any kind have a negative multiplier effect on engineering cost performance. They “mess with the arrows.” In the middle phases of a project, the effects of disruption on the totality of the project can easily be three times or more or whatever direct cost we may ascribe.

Lack of Contingency Planning

Stuff happens. Planned sequences of tasks and activities are interrupted and engineering labor can go into essentially a standby mode. Effective project managers will have identified work that can progress as resources become available, thus continuing execution of work on a contingent basis.

Routine contingency planning together with short-term execution planning act to support engineering productivity levels.

Inadequate Project Review

This has been covered in NAC Executive Insight, "Effective Project Review Meetings." Project review meetings are a key factor in achieving consistently good performance. Effective project reviews are challenging and comprehensive when the right people are involved, both from the project team and the management review team.

Stakeholder Effects

Stakeholders represent the unbounded nature of projects, which is not adequately reflected in classical project management theory. NAC Executive Insight, "Stakeholder Management in Large Complex Programs" discusses the importance of "influencing flows" arising from stakeholders and the cascading impacts on the project.

The range of stakeholders and how they may impact engineering cost performance include:

- **Owner's Organization**
  - Late information to all parties
  - Scope-impacting changes
  - Delayed decision-making
  - Lack of timely response to notices
- **External Parties Potentially Impacted by the Project**
  - Influence project scope without adequate recognition by owner
    - Mitigation measure more extensive than initially envisioned
  - Delayed project approvals
  - Extended consultation periods
- **Regulators and Political Bodies**
  - Change the rules requiring rework or extending project performance periods
- **Broader Market Conditions**
  - Escalation rates
  - Labor shortages
  - Competitor actions
- **Engineering Organization in which the Project Team Resides**
  - Changes in risk profile
  - Changes in cost structure

- Shortage of project personnel
- Shortage of engineering personnel or disciplines
- Inadequate IT capacity
- Access to working capital and insurance

Summary

Engineering cost overruns impact the overall financial performance of the engineering industry and are a leading indicator of construction challenges related to productivity and schedule in design/build projects. Lost profit has an impact not only on shareholders but also employee compensation and investments in advancing the state of the profession and the tools we deploy to execute projects.

Engineering cost overruns can add to owner's costs both directly and indirectly and tie up valuable and limited resources due to rework and productivity shortfalls.

Minimizing engineering cost overruns begins with ensuring the project is well founded, adequate attention is paid to project flows, not just tasks, and the impacts of influences external to the project team are appreciated and recognized.

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.