NAC Executive Insights

Pitfalls of Mega/Giga Projects

Key Points

- Very large and complex projects are fragile for many reasons.
- They are overly sensitive to many issues that smaller projects do not face or that typically are re-solved more easily.
- Execution plans must not only focus on doing the right things, but must also address the key vulnerabilities these type projects face.
- Each pitfall described in this Insight is a Key Point. The top three pitfall key points are:
    - It is extremely important to complete a robust level of FEED (front-end engineering design) to obtain a quality cost estimate to create the best chance for project success.
    - Continuity of project leadership from beginning to end is critical.
    - Multi-dimensional communication paths must be developed to support synchronization efforts on such large projects.

Introduction

The history of large complex projects is strewn with significant cost overruns and schedule delays. Using basic cost and schedule criteria, benchmark data indicate nominally two-thirds of such projects significantly fail. In short, they fail at a much higher rate than normal sized large projects. For those who wish to undertake such behemoth efforts, these realities are discomforting. Published best practices and guidelines attempt to point toward the most effective methods to address these heavyweight challenges. This Insight does not intend to duplicate these best practice publications. It does intend, however, to focus on the reasons why these type projects are fragile and are more vulnerable to risks, i.e., their “pitfalls.”

Table 1 lists the pitfalls to which such projects are susceptible. This Insight addresses each one. These pitfalls often are the hidden dangers lurking to unsuspecting mega or giga project leadership.

Table 1 The List of Mega/Giga Project Pitfalls
1. Failing to Do the Basics Well:
a. Unstable objectives
b. Unqualified team members
c. Unproven technology
d. Incomplete front-end loading
e. Gate reviews that cannot close gates
f. Constrained funding
g. Late changes
2. A Project Ahead of the "Deal"
3. Expecting Precision Predictability: Cost and Schedule
4. Becoming Schedule Driven
5. Ignoring Known Risks
6. Arms-Length Sponsors, Proponents, and Stakeholders
7. Constrained Resources
8. Late Staffing of the Startup/Operations Team
9. Prioritization
10. Contracting that Does Not Fit the Market
11. Ignoring the "Soft Stuff"
12. Team Member Turnover
13. Under Sizing Contingency Funds
14. Timid Interventions
15. Ignoring Interface Management
16. Ignoring Black Swan Inevitabilities
17. Ignoring the "Supply of Everything" Problem
18. Failure to Communicate, Communicate, Communicate
19. Failure to Learn and Leverage
20. Failure to Provide Transition Leadership
21. Failure to Add New Capabilities

1. Failure to Do the Basics Well

In the last 30 years the industry has attempted numerous times to define the best practices associated with developing and executing large projects. These industry best practices are not hard to find and are readily available to any organization desiring to train and develop its members. History has demonstrated, however, that establishing these best practices so they become integral into a project organization's culture and daily behavior is both time consuming and difficult. As a result, projects are still routinely developed and executed without teams deploying all of these best practices. Ensuring that all project team members are well versed in these best practices and synchronized on terminology and methodology is paramount when executing a large complex project. It is not the intent of this Insight to describe all of these best practices. Instead, the intent is to address some best practices to which large complex projects are particularly vulnerable when not performed exceptionally well.

a. Unstable objectives

All projects start with an intended objective, sometimes referred to as its mission or desired outcome. All projects suffer negative impacts if this objective is not fixed and stable throughout the project. The end-point that defines success for a project must remain the same throughout its journey. If not, it will suffer rework, delays, added costs, and schedule extensions. When these occur to a very large and complex project, the negative impacts are equally large and complex.

b. Unqualified team members

The engineering and construction industry identifies and executes projects. The industry is volatile. Peak to valley workload levels can easily range from five to one. While many reasons exist for this, the resulting impact on the personnel who staff this industry is immutable. Staffing may be growing and hiring, often acquiring inexperienced personnel, or the current staff is moving on due to insufficient future work, perhaps seeking work in other industries. Another concurrent reality of the engineering and construction industry is the large majority of people who have relevant experience with projects are already working on a project. Thus, when it comes time to staff that next project, organizations begin to ask that inevitable question, "Who is available?" Answering that question most often does not place the most qualified personnel in each role on any given project. The result is often inexperienced, or insufficiently experienced, personnel assigned to key roles on large projects. These two concurrent realities alone perhaps explain why the industry struggles with consistently deploying its best practices.

c. Unproven technology

Credible benchmark data show projects attempting to deploy a new primary technology face higher levels of challenges and thus perform less well than projects deploying mature and proven technologies. Deploying new technologies is a welcomed initiative. It is one reason the engineering and construction industry can become more productive and produce better and higher quality products. Some best practices specifically relate to the unique challenges of executing new technology. Deploying new technologies within the scope of a very large and complex project, however, simply increases the risks that unexpected discoveries will occur and will create late changes. Large complex projects are best suited for mature technological scopes. If new technology elements are inevitable, then learning and deploying the best practices for managing this discovery-prone scope is very worthwhile.

d. Incomplete front-end loading

"Fix the scope before starting the project." This old adage has matured significantly in construction. Today, the contents and level of detail in front-end engineering design (FEED) packages are precise. These FEED activities, sometimes referred to as front-end loading, are critical to the success of projects. Complete, robust execution of these activities is a prerequisite to project success. Funding, however, is required to perform this early work. Large complex projects require large amounts of early funding for robust FEED. An unfortunate propensity, regardless of the owner or type of project, is to underfund this early work when the project scale is very large. Obtaining large amounts of funds for a big project not sufficiently defined to obtain quality estimates or bids is understandably difficult. If sufficient funds are not obtained, however, and the resulting FEED is not performed well on a large complex project, the consequences will be dire.

e. Gate reviews that cannot close gates

Project histories and case studies have documented that the best systems for developing and executing projects have integrated "gates" into their work processes. These gates are similar to the hold-points in a rocket launch countdown. The hold-points verify all parties to the launch have checked their work and their indicators to ensure everything is safe and ready to proceed with the countdown. Similarly, a gate in a project process allows all stakeholders to verify that all expected and required work is complete so the project can proceed. Unfortunately, even many of the best project processes do not have the tenacity to hold a project's progress when a gate review indicates inadequate prior work. Therefore, gates that cannot close will inevitably allow projects, knowingly not prepared, to proceed. Such gate closing decisions are difficult when the stakeholders do not want the project delayed. Very large projects are complex. More moving parts. More people working to deliver more work products. Thus, they are more vulnerable to some key deliverable not making it to a gate review in good fashion. Allowing a large complex project to proceed when knowingly unprepared will have grim consequences.

f. Constrained funding

Large complex projects often have very large budgets and can experience cash flows greater than $300MM per month. These size numbers make everyone nervous. Often this manifests in attempts to constrain the spending to reasonable levels. In short, you can't put gorillas on diets. Attempts to constrain funding often start ahead of full authorization (the typical full funding point) during the formative period for the project. Nothing can be more damaging than to prevent a very large project from doing the work that it needs to do. Yet those who attempt to limit the funding often feel they have a duty to keep project leaders from spending funds too freely. Nothing could be further from the truth. If the nominal project capital cost is, say, $10B, then it may well take $750MM to complete FEED and obtain a quality cost estimate to take to the funding committees. And yes, someone has to put up that initial $750MM before full funding can be achieved. Not a comfortable journey for the faint-of-heart.

g. Late changes

Changes in project objectives, product slate, and technologies can have negative impacts on cost and schedule, especially changes that occur after full sanction. Large complex projects always take longer than typical large projects. This lengthened schedule gives greater opportunity for change mechanisms to occur. Change forces can come from changes in management, market conditions, the local community, environmental regulations, labor supply, and numerous other areas. Due to their greater scope and longer schedules, large complex projects attract greater than average change forces. Early stakeholder alignment and planning to combat these forces are all there is to minimize this reality.

2. A Project Ahead of the Deal

Multiple entities often sponsor large complex projects. These can be joint venture partners, multiple municipalities, and/or government entities. The result is that none of these organizations is on their own turf, using their typical processes for project development. Therefore, they are typically working for the first time with a project's specific set of stakeholders and using unfamiliar processes to build alignment on what they want to achieve and how they want to achieve it. Often these stakeholders, however, are aware that a large project's schedule for development and execution will take many years. This realization then builds consensus that the project effort should begin, even though the details of what is to be built may still be ambiguous. Starting a large complex project under these circumstances is very

risky. Getting the cart before the horse is exactly what is happening. Better to first have all the sponsoring stakeholders resolve the ambiguities and demonstrate full alignment on what is to be built. Once stakeholders agree and are aligned, celebrate the milestone and then start the project.

3. Expecting Precision Predictability: Cost and Schedule

Large projects are notoriously unpredictable by most people's gut-check standards. If +/- three sigma defines a normally distributed system and with one sigma equal to nine percent as the cost variation versus an authorization estimate, then +/- 27 percent defines the "normal" cost variation in this system. Consider that a one sigma of nine percent represents some of the best project systems in the world. Schedule variability is equally large. Bring to this environment executive leaders or public servants, all with an expectation that annual budgets will stay within a range of a few percent, and the components for significant non-alignment and conflict potential begin to appear. Careers have ended due to this disconnect of understanding. This is why sponsoring organizations should place their most experienced project leaders in the oversight roles of large projects. When this issue is scaled to the size of a typical mega/giga project, the potential for substantial tension and discord is real. Given sufficient discord, the message will get to the project team. The result: large amounts of hidden contingency funds placed within the line items of the estimates and equal amounts of float within schedule activities. Beginning with hidden contingency and float is not a good start to a large complex project.

4. Becoming Schedule Driven

Typical large projects take years to develop, execute, and complete. As one scales to mega/giga size, the better part of a decade can result. Sponsors are rarely mum regarding these long schedules. They often admonish project leaders: "Speed things up." Large complex projects have an enormous amount of momentum (mass times velocity), but most of that momentum is in the mass, not the velocity. There are some project execution best practices on how to speed up much smaller projects, but combining a schedule driven mindset with a large complex project will inevitably result in frustration and wasted effort (money and schedule). That is not to say they should be executed slowly; that too can be costly. It is best to have each sub-project's schedule be a reasonable industry average, and then on top of this recognize that virtually all large projects, and the very large as well, will slip their schedules somewhat.

5. Ignoring Known Risks

"Let's focus on what we *can* control!" Not bad advice in the right setting. This thinking, however, can cause sponsors as well as project leaders to dismiss risks they recognize as completely out of their control and influence. Because this mantra is so prevalent within operating organizations, it can leak into the culture of a project leadership team and cause it inadvertently to fail to place these type risks within the contingency and schedule analysis efforts, or within the risk management structure, or to underestimate their potential impacts. Just because one cannot influence a risk does not mean simply to ignore its power to create a negative result. Closely monitor its developments.

6. Arms-Length Sponsors, Proponents, and Stakeholders

Many project leaders prefer to keep their management and/or other stakeholders away from their project, allowing them to believe everything is running smoothly all the time. They like to be the swan

gliding over the water: no one can see all the paddling going on beneath them. They believe it keeps the less experienced away from things they do not understand, keeps them from creating waves and non-value-added debates. This desire to remain separated from the project also can come from sponsors, proponents, and stakeholders themselves, not wanting to get too close so their lack of project experience is exposed. Regardless of the reason, this is simply bad stakeholder management from either side. Transparency is your friend when it comes to the direct funding sponsors of a large project. Sharing risk management "heat maps" and the stories behind them is good practice regardless of the experience level of those in the room. Inviting in fresh-eye reviews and sharing the results help this transparency. It allows those sponsors to join in the project's journey, gain an invaluable education, and be up to speed when Plan A needs to change to Plan B. Keeping these folks at arms-length simply creates a future date when the big surprise walks into the room and permanent distrust is immediate, pervasive, and permanent.

7. Constrained Resources

Constraining the funds needed to develop and execute a large complex project can be devastating. Other types of constrained resources can have an equally harmful effect. The most prominent is a constraint on personnel: the type of personnel who have the experience to staff and lead the project teams supporting a major complex program. Large complex projects need plenty of human resources in all the roles, both for the owner's team(s) as well as the contractor teams. Naïve views persist that large scale projects can benefit from "economies of scale'" and thus require less people per unit of work. In fact, the reverse is true. Large complex projects come with unique challenges that require human resources dedicated to managing them. Other examples of constrained resourcing faced by large complex projects are: slow decision making, slow permitting, slow procurement processes, and elevated auditing practices that burden team members with unplanned work, to mention only a few. Large complex projects cannot suffer from either artificial or real-world constraints. Otherwise equally large unanticipated consequences are certain.

8. Late Staffing of the Startup/Operations Team

"Proponents" is a great descriptor for the people and organizations who will inherent the built project to operate it on a daily basis into the future. Regardless of the type of project, proponents will inherit the results. In many project systems, the proponents do not arrive on the scene until the project is close to turnover. And when this occurs, inevitably the proponent points out elements within the project that either will not work properly or that they simply do not like, thus perpetuating debates late in the project. Avoid this. Place representatives of this future proponent organization on the project teams from the beginning. Not only is this good practice on all projects, it is a special need on large complex projects since, due to its nature, that future proponent organization also will be large and complex. Their integration and alignment along the project journey create a much smoother transition from turnover through startup.

9. Prioritization

Prioritization and Pareto charts are the purview of operating organizations. They are at liberty to decide the most important work for today and what is to be done tomorrow or next year. It permeates a project's culture and project teams' mindsets. And when used in the right settings and in the right way,

prioritization is both reasonable and prudent. When used within a project's culture, however, it can be disastrous. It focuses our attention on what is "most important" and similarly draws attention away from what is "not so important." In this way, some things are delegated to someone else later. Many seemingly unimportant things are not worked on because they were down a bit on the Pareto chart. Projects, and especially the large complex projects, cannot suffer from this type of culture. Everything on a Pareto chart or on a checklist must be performed as scheduled, with the needed quality, every day, by every team member. A gate review meeting (or startup) is not the place to discover a piece of important work simply was not important enough to get done on time.

10. Contracting that Does Not Fit the Market

Different parts of the globe have different preferential and customary contracting practices for executing large projects. For example, large lump-sum contracts are customary within Asia Pacific countries, but not so within North America or Northern Europe. Trying to implement contracting styles from one's home-base viewpoint in a region that considers those styles to be foreign is often disastrous. Yet home-base contracting styles frequently seem to be hard-wired into our brains as the "right way" to get things done. Some Asia Pacific companies have attempted to execute large lump-sum contracts in the U.S., and vice-versa, North American companies attempting to execute mixed-contracting styles in Asia Pacific. Neither ever go well. A certainty in this industry: construction is always local. (Yes, a few modular projects have worked when the circumstances required it.) Get familiar with the contracting practices wherever they may be before assuming the home-base style can fit in anywhere.

11. Ignoring the "Soft Stuff'

Engineers and the technical staff making up most of the engineering and construction industry have advanced to where they are because of their technical prowess. They are inexorably smart people, at least smart in the STEM (Science, Technology, Engineering, and Mathematics) sort of way. And the industry needs that prowess. The progress and safety of societies depend upon their smarts. But stand-alone smart people tend to not get much done. It takes *teamwork* to get big projects developed, designed, and built. And teams are needed to make teamwork happen. For teams to work well together many interpersonal skills are needed that are not on the curriculum of university STEM degrees. These "soft skills" might be known as emotional intelligence. They are the oil in the machinery when it comes to professional teams working well together. When the soft stuff is ignored, the result is not pretty: a workplace full of distrust, backstabbing, meeting refusals, non-committal attitudes, and worse. On the other hand, team members who trust one another, who see the value in each one's contributions, and who remain aligned on their objectives and methods, can achieve amazing things. The hard stuff is easy, but the "soft stuff" is hard. And when it's a large complex project, it needs mega-doses of the soft stuff. The good news is abundant best practice information is available about team building and alignment, and this information can help to accelerate the building of a first-class team.

12. Team Member Turnover

Turnover among project team members has negative impacts. The more senior the leader is in the turnover, the more adverse the result of the transition is on the team. Large complex projects are particularly vulnerable to team member turnover primarily due to the extended length of their schedules. The longer the schedule, the more turnover will occur. Some try to mitigate this risk by

dividing the project into stages, with new teams coming onboard at each stage. This does not work. Why? It institutionalizes the turnover and related disruptions. All projects, and especially large complex ones, need continuity of leadership from beginning to end. That continuity is highly valuable. The reverse is highly value-destroying. Large complex projects, therefore, need extraordinary efforts to recruit and retain its key team members.

13. Under-Sizing Contingency Funds

Contingency, when properly sized, attempts to address the size of risks faced by a project, though the sources of risks may not all be known. While the specific risks eventually experienced may not be recognized when the authorization estimate is formed, quantitative methods can be used to both describe the project's risk environment and the amount of single-line-item contingency needed within the estimate. When large complex projects begin their estimating journey, however, the numbers get quite large quickly. While all projects seem to face the "That's just too much money" speech, the large complex projects will get this speech in huge quantities, especially the contingency amount. Lightning is drawn to this single line item in the estimate. Even when prudent methods are used, contingencies on these very large projects become very large numbers. Then the questioning begins, "What is that for?" "What are you going to buy with all that money?" "Is it a slush fund for someone's pet project?" And so on. Full debates will begin about the size of funds needed for the contingency within the estimate. Be ready for it. There will be those who will want it to stay out of the official estimate, and they will claim to keep it in their pocket whenever it is needed. Do not fall for this; it means a lower-than-needed estimate is being authorized. If anything, contingencies on large complex projects need to be larger (as a percentage) than on normal large projects due to the Black Swans (discussed later in this Insight).

14. Timid Interventions

Plan A does not always work. This is true with personnel selected for a particular role on a project, or a contractor selected for a specific scope of work. All the right things are done to pre-screen these individuals and companies, but sometimes Plan A is not working out as imagined. Everyone's attention then is drawn to the situation. Options are pondered. Coaching, mentoring, training, and coercion are tried. "Everything will work out." There is a chance they might. The waiting and hoping begin. Such is the DNA of timidity. There is no formula as to how much time should be used to correct a situation that needs correcting. Most people will take too long. It is human nature to hope, taking deep breaths. Seasoned leaders in this industry, however, tend to make their interventions sooner than they did earlier in their careers and are more direct with less ambiguity as their careers progress. Large complex projects cannot suffer through timid interventions.

15. Ignoring Interface Management

Large complex projects invariably, and appropriately, are divided into smaller component project scopes. When performed correctly, this is a very helpful tool. By dividing a large project into smaller more manageable projects, however, the need to ensure the interfaces between the sub-projects are well synchronized becomes an important coordination effort. To be sure, it is not a trivial effort; it comes with being large and complex. Often, project leaders simply want to delegate this effort down to the component contractors. This invariably does not go well. Each contractor is reasonably looking out for their own interests, and this does not bode well for interfaces needing to synchronize on a large

number of dimensions. It is one thing to have roadways match up at interfaces and piping connections that match in specifications, sizing, and flange ratings, but interface management does not stop there. It includes wiring, control logic, and fluid flow rates and pressure, both in equilibrium as well as transient conditions. Interface management is something the owner wants to keep close and monitor its progress diligently.

16. Ignoring Black Swan Inevitabilities

In his book, *The Black Swan*, Nassim Nicholas Taleb describes very disruptive impacts derived from highly improbable events: Black Swans. Large complex projects do face these Black Swan risks that truly are *very* unlikely. Events like compressors falling overboard from a ship, a fire raging through all the labor camp housing, a global pandemic unleashed mid-construction. All are improbable, yet all can have highly disruptive impacts. It is rare to see these types of risks quantified into contingency estimates or plans early in a project's development. Perhaps this is reasonable for typical large projects as these risks are so small at that scale. When the scale is multiplied upwards, however, these very small probability risks also get scaled up. Within the context of executing large complex projects, this is what is called a Black Swan. When the project is very large, by its nature its size will attract typically low probability risks, and at giga scale become almost certain. Similar to all early identified risks, however, no one can know exactly how they will manifest. The only known is they will manifest when a project is hyper-large. So how do we respond? First, contingency modeling (and schedule float modeling) should account for at least one Black Swan event—try to size it and estimate an impact. Ignoring it will not make it go away. Second, brainstorm low probability project impacts and pre-plan a response to each. This exercise will sensitize the project team to the potential risks and help them learn how to keep their eyes and ears out in front of the project. Whatever is done, do not pretend it is not going to happen.

17. Ignoring the "Supply of Everything" Problem

Large complex projects at their heart are a supply problem. The rate at which these type projects consume resources is unequaled. Their appetites can be likened to tsunami waves. It is impossible to understand the resources they will consume in a set amount of time. Suddenly, one stands face to face with a peak demand that is unprecedented for the newcomers to this type projects. The demand for *everything* a typical project needs increases: people, experts, buyers, engineers, designers, materials, specialized equipment, construction inspectors, decision making by decision makers, cash flow, space. Name it, mega and giga projects need it in quantities that will tax most global supply chains. As a minimum, analyze the size of purchases and the potential impact they will have on suppliers. Assess the capabilities and bench strength of the organizations being drawn upon. Sometimes it may be desirable to standardize on a particular supplier or equipment type, only to find out they do not have the capacity to meet the need at the scheduled time. Assess vulnerability to these types of supply chain constraints early, and then assemble mitigation plans. Failure to do so is like racing in a fog.

18. Failure to Communicate, Communicate, Communicate

On a typical large project, a leader can send out an email, then follow up at the weekly team meeting to ensure everyone got and understood the message. Scale this up to mega or giga and many project teams are now involved, located in different contractor offices, all wanting to be left alone to execute

their project, and yet they need to remain synchronized on a large number of topics. There are interfaces, equipment and design specifications, schedules, contract terms and interpretations, learnings from other teams; the list goes on. What works for effective communications on a single large project is simply inadequate when things scale up to a large complex endeavor. Multi-dimensional communication paths must be developed to support this massive synchronization effort. Without this, disintegration and confusion will naturally develop.

19. Failure to Learn and Leverage

As mentioned earlier, large complex projects typically are divided into smaller, more manageable project scopes that must then be interfaced and synchronized for the duration of the project. When all the schedules are assembled and integrated into a single master schedule, it is inevitable that one or a few of these sub-projects must start earlier and lead the effort in their FEED work, contracting, design, and construction activities. Invariably, these early sub-projects experience some type of learnings that will need to be understood, digested, and leveraged to other project teams, and perhaps functional support will be required for corrective actions. These learnings could be as simple as mistakes found in specifications, errors in safety procedures, or more material such as contract language not as clear as it could be. In order to capture these learnings, take appropriate actions, and then leverage out these learnings across all the sub-projects, there has to be a learning and leveraging process that is owned and operated by someone in leadership who will ensure these learnings are genuinely deployed. Not planning to learn in this fashion will sentence the overarching project to repeat its mistakes, again and again.

20. Failure to Provide Transition Leadership

Projects are composed of a number of serial phases or stages. An inherent sequence is found in all project work. Early formations of objective ideas give birth to site and technology decisions that are defined in more detail via FEED work and deliverables. After FEED, design work follows and is integrated with procurement and delivered to the site for construction activities. Those activities are followed in a structured sequence by turnover and startup efforts. Such work processes have natural transition points in them, e.g., FEED to design. Each of these transition points is typically surrounded by each team member's assumptions about what will happen next and how. Of course, these assumptions are built on each individual's past experiences, which may or may not be similar. Transitions like this have a way of exposing each team member's differing views as to how each transition will transpire. When transitions are scaled up to a large complex project, chaos often ensues, even when each team has achieved alignment internally. It is doubtful such alignment will naturally occur across all the sub-project teams. To tackle this challenge requires the use of "transition leadership teams." Such teams are composed of the natural leaders from among all the sub-project teams, who then poll all members about their needs and expectations for each transition. Then everyone knows about deliverables, action items, and alignment efforts. They will also know how it will happen and how each action will affect them. Transition leadership teams are an effective tool for handling the rough-water rapids of project transitions.

21. Failure to Add New Capabilities

Many of the pitfalls discussed in this Insight require new activities, ones that are not typically needed on a single large project. When the scale of a project has grown to mega and especially giga size, these new activities and actions clearly are necessary. Things like interface management, Black Swan response planning, institutionalized learning, 3D communications, and transition leadership must be coordinated —often by a leader with a team. These new capabilities do not always require adding new people to the team, but frequently it becomes necessary. To assume all these new requirements can simply be added to the roles of traditional project team members is dangerous thinking. Each new requirement needs an execution plan that is sound and well thought out, and if needed, staffed by a capable leader. Do not ignore or treat lightly the need for additional new capabilities.

Summary

Large complex projects, often referred to as mega or giga projects, are prone to above-average failure rates due to their many additional vulnerabilities when compared to smaller projects. This Insight has explored some pitfalls to which these large projects are especially susceptible. When planning for such a project, specific plans and resources are required to help protect against these pitfalls.

Finally, and equally important, while these pitfalls may be more impactful on mega/giga projects, they are also relevant on any size project.

About the Author

Joseph Brewer was elected to the National Academy of Construction in 2016. He is a senior executive with more than 40 years of experience executing and overseeing large projects in the petrochemical industry. He is often invited to speak or consult on giga-project execution due to his experience leading the successful Sadara Project in Saudi Arabia, which he documented in his book, *When Mega Goes GIGA (ISBN 978-0-359-61893-4)*.