

INDUSTRIAL MEGAPROJECTS

CHAPTER 11

CONTRACTING

If I had to select a few terms to describe megaproject directors and managers, *practical*, *hardheaded*, and *not given to magical thinking* would come to mind—except in one area: contracting. Contracting for the services needed to engineer, procure materials, and construct megaprojects is an area of intense disagreement and almost religious-like fervor among project professionals.* Individual experiences with single projects, good or bad, come to shape views for a career. Every approach to contracting appears to have both ardent adherents and steadfast opponents. I do not expect the following discussion to change either of those groups, but I hope some facts will aid those still searching for what to do.

Contractors tend to do good projects well and bad projects poorly. By that I mean that contractors almost always succeed when the project has a strong business case, fully aligned stakeholders, bought-in sponsors, an integrated owner team, and best practical front-end loading (FEL). Conversely, when the sponsors are fighting among themselves, other stakeholders are sniping, the business case is marginal, the owner team is missing key functions, and the FEL is mediocre, the contractors always look moronic. We tend to exaggerate the importance of contracting approach to project success or failure. No contracting approach guarantees success; most contracting approaches can succeed. Contracting is a second-order concern.

That being said, some contracting approaches are fraught with more dangers. Some are unsuitable for certain situations. Some strategies work for some owner organizations but fail miserably for others

*The reader who is unfamiliar with the many special terms used in contracting in industrial projects should refer to the Glossary before reading this section.

because the strategy depends on owner strength. Some strategies help a well-developed project deliver on its promise while failing on a project that is less well prepared. Every contracting approach brings with it uncertainty and possibility. Contracting is difficult, and it is situational. Perhaps that is why so many owner project and business professionals want to believe they have found *the* answer. But in reality, *the* answer probably does not exist. There is, however, one rule that always seems to apply: if sponsors decide to engage in contracting games, by which I mean trying to get the better of contractors, they will always lose. Contractors always have been and always will be better at contracting games than owners. Their lives depend on it.

Before moving into alternative approaches, I need to address who should be involved in contracting decisions. The basic contracting strategy must be addressed as part of the project shaping phase. Disagreements among partners on this issue can be so violent that the project can come apart. The business leaders who will be fighting out any issues must be informed by their project management teams, and the view of the project director should weigh very heavily in the discussions. After all, it will be the project director who must ultimately make the strategy work.

When it comes to the actual selection of contractors, that decision should absolutely be made by the project director and the team. Any involvement by business leadership in the selection of individual contractors is inappropriate and could be viewed as a breach of trust by partners. Any involvement of the lead sponsor's purchasing (procurement or sourcing) organization in the selection of contractors is likely to be catastrophic. The selection of the right contractor often comes down to the selection of the right contractor team. That needs to be a team that the sponsor team can work with creatively. Purchasing does not have to live with the selection made and only rarely has the expertise required to even assist.

CONTRACTING APPROACHES

There are four basic types of contracts for megaprojects with endless variations. I define each in this chapter and then show the relationships between success and the use of the different approaches. In addition, I

discuss some fundamentals of successful contracting for large complex projects.

EPC Lump-Sum (Fixed-Price) Contracting

EPC lump-sum contracts are the most common form of megaproject contracts and involve a single contractor being responsible for engineering, procurement, and construction for the whole project or for some portion of the whole project under a single contract. This basic form has a number of variations.

1. All parts of the project are under the single EPC contract, including installation for offshore projects. If commissioning and startup are included, the contractual form is generally considered "turnkey," which is to say that an operating facility is turned over to the owner/sponsors. The contractor will often subcontract for fabrication/construction and for various other activities. This single prime contractor form is unusual for large megaprojects because single contractors rarely have enough people and the full range of skills to devote to a very large EPC lump-sum contract without creating lumpiness* problems in their project portfolio. In some cases, contractors have formed joint venture consortia that offer a single EPC lump-sum contract for a large megaproject. These consortia often focus on a single technology package.
2. A second form of EPC lump-sum contracting involves multiple prime contractors reporting to the owner/sponsors. Multiprime arrangements are common on very large megaprojects where a single prime contractor would be reluctant to take the risks associated with the entire project. Multiprime arrangements require a good deal of owner/sponsor competence to manage the interfaces between the contractors.
3. "Conversion" to lump-sum contracts is a strategy that starts the project with reimbursable engineering and procurement and

*In this context the term *lumpiness* refers to an unbalancing of desired portfolio risk due to a single element in the portfolio being unduly large.

then provides an option for the sponsor and engineering and procurement contractor to convert to a whole project lump-sum contract at some point during engineering.

4. Occasionally, there will be some portions of the project done on a reimbursable basis. If most of the total cost is in an EPC lump-sum contract, I classify the project in that category, although I discuss some ingenious mixing of lump-sum and reimbursable contracts later.

Reimbursable EPC and EPCm

Under this form, a single contractor is responsible for all (or the great majority) of the project under a contract that reimburses the contractor based on the quantity of services and materials provided. The details of how the contractor is reimbursed are very important. Alternatives include a percentage fee, fixed fee, fixed fee and fixed overhead, and various incentive forms.

The key attribute of reimbursable EPC is that the engineering and procurement contractor controls the construction/fabrication as well. That provides both opportunity and lots of problems for the owner/sponsors. The precise manner in which the contractor is reimbursed interacts with the control of the field to determine the incentive structure under which the contractor actually is operating, which may be quite different from the incentive structure under which the sponsors think they are operating. We return to this subject later in this chapter. The fee structure for reimbursable contracts is very important and the subject of a great deal of misinformation.

Reimbursable EPC can also be operated with a multiprime arrangement, much like multiprime EPC lump-sum contracts. Lump-sum and reimbursable EPC contracts can be run on the same project and are sometimes even run on the same site, but with generally very poor results. The poor results are driven by the fact that the contractors with reimbursable contracts are able to take resources away from the lump-sum contractors, resulting in (quite justifiable) large claims by the lump-sum contractors. In one case, a contractor with a lump-sum contract actually quit a major project under these circumstances, resulting in a complete disaster.

A hybrid of this model is EPCm—engineering, procurement, and construction management. In this case, the engineering and procurement contractors hire the constructors/fabricators and manage their work. They may hire the constructors on any form of contract—reimbursable, unit rates, lump-sum, or whatever—but the full costs of construction are passed directly to the owners/sponsors without risk to the EPCm contractor(s). I group EPCm with EPC reimbursable contracts for a very simple reason: they behave the same way. The key characteristic is that the engineering contractors control the construction activities.

Alliance Contracts

[MULTI-PARTY]

Alliance contracting is a particular form of reimbursable incentivized contracting that was pioneered in the petroleum industry in the UK North Sea in the 1990s. It is not to be confused with long-term multiproject relationships between an owner and a contractor, which are sometimes also called frame agreements. My use of the term *alliance* here refers to a grouping of all (or almost all) of the contractors working on a megaproject under a single compensation scheme. The grouping of contractors takes place for the particular project; this form is not to be confused with a contractor consortium or contractor joint venture. The primary goal of the alliance contracting approach is to align the goals of the contractors with those of the owner/sponsors through a “shared destiny” approach. The schemes involve some form of bonuses or gainshare (usually in the form of splitting under-runs among the owner/sponsors and contractors) in the event that the project performs better than targets, usually on cost. In the event of an overrun, some alliance schemes have the contractors share some portion of that overrun up to some cap.

Mixed Contracts

Mixed contracting is a strategy that involves reimbursable engineering and procurement, including, in some cases, the procurement of some lump-sum package items, followed by lump-sum contracts for construction or fabrication by constructors or fabricators that are independent of the engineering and procurement firm(s). The construction lump-sum contracts can be a single lump-sum contract to a

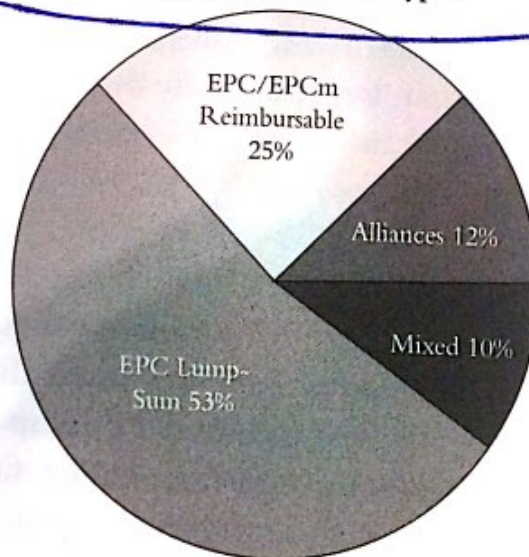
construction management organization or a series of lump-sum contracts by craft discipline. However, the strategy does not apply in cases in which the engineering firms procure the construction or fabrication work. That strategy would be an EPCm arrangement. The key characteristic here is that the constructors and fabricators are independent of the engineering contractor(s), which is to say they are prime contractors to the sponsors.

Frequency of Use on Megaprojects

One of these four basic contract types, with variations, of course, was followed by all of the megaprojects in our database. Figure 11.1 provides the breakdown of the contract types in our sample. Lump-sum contracting in a number of variations is by far the most common approach to contracting large projects. Although EPC lump-sum contracts predominate, they are actually less common than they were in the 1990s. Some parts of the world, notably Canada and Australia, moved away from lump-sum contracting as their project markets heated up in the past decade because EPC lump-sum arrangements

Figure 11.1
EPC Lump-Sum Contracting Predominates

Megaprojects Contract Types



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tend to become less cost-effective for owners/sponsors, or even altogether unobtainable, when the market for EPC services is overheated.

There is little or no pattern by industrial sector. No chemicals sector projects were executed with an alliance-type contract, but every contract type was found in all industrial sectors. Contract type is, however, clearly influenced by geography. EPC lump-sum contracts dominated the megaproject contracts in the Middle East, South America, Asia, and Africa. This is largely an artifact of the involvement by government-owned companies as sponsors or cosponsors of projects in these areas. Governments tend to prefer whole project lump-sum contracting the world over; more than 80 percent of the projects in which the lead sponsor was a nationally owned company used an EPC lump-sum contracting strategy, versus about 45 percent of other megaprojects. We return to the subject of government involvement in the contracting process, which we argue is rarely helpful, later in this chapter. Alliances were used predominantly in OECD countries, except in Japan. The other contract forms were used in every region.

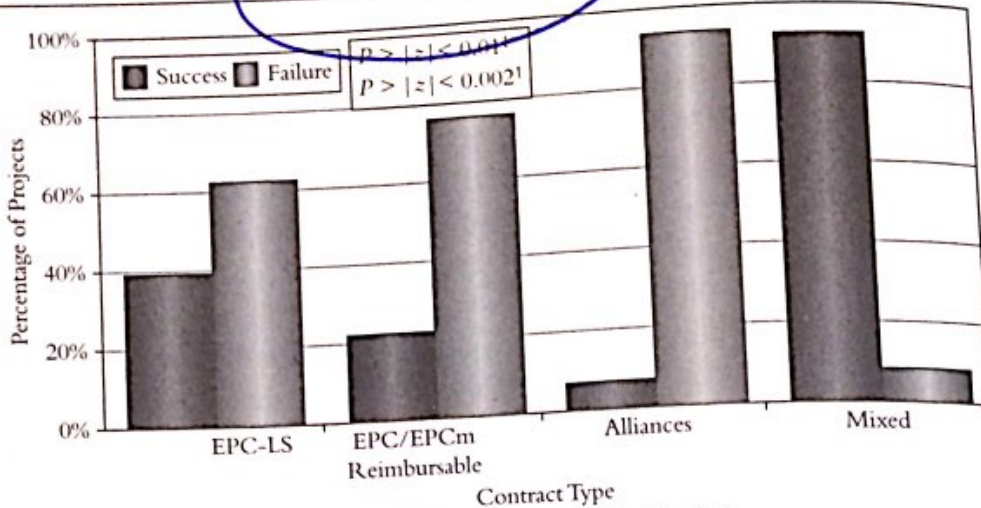
There is no pattern between estimated project cost (inflation adjusted) and type of contract. Every type of contract had some "elephant" projects in their set. The alliances ended up larger, but that is due to overruns, not intent.

CONTRACTS AND PROJECT OUTCOMES

Figure 11.2 shows the success and failure rates for our four basic contract types. The results will not be particularly surprising to anyone who has followed our research on contracting for industrial projects over the past 10 years. The EPC lump-sum projects had a success rate that was about average for the megaprojects overall. Given that they constitute more than half the sample, that result is surely to be expected. The reimbursable projects fared a little worse than the lump-sums. However, if we control for other factors that affect project outcomes, the reimbursable projects are not statistically different than the EPC lump-sum in terms of results. Reimbursable contracting is by far the most flexible approach for owners/sponsors. The owners/sponsors have complete control over schedule and quality. The greater control also, of course, implies a very hands-on approach to the project.

Figure 11.2

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Alliance Contracting Hurts Performance; Mixed Contracting Helps



¹After Controlling for Team Integration and Front-End Loading

Two contract types clearly influence project results, albeit in opposite ways. The alliance arrangements were in almost every case disastrous. The mixed strategy projects were disproportionately successful. To test whether contract type has an independent effect on project results, I first controlled for team integration and the completeness of FEL because they are major drivers of success and failure and are far more important to explaining variation in success than contract type. Projects using alliance contracts and those using mixed contracts are both statistically significantly different than the average in terms of success rate.*

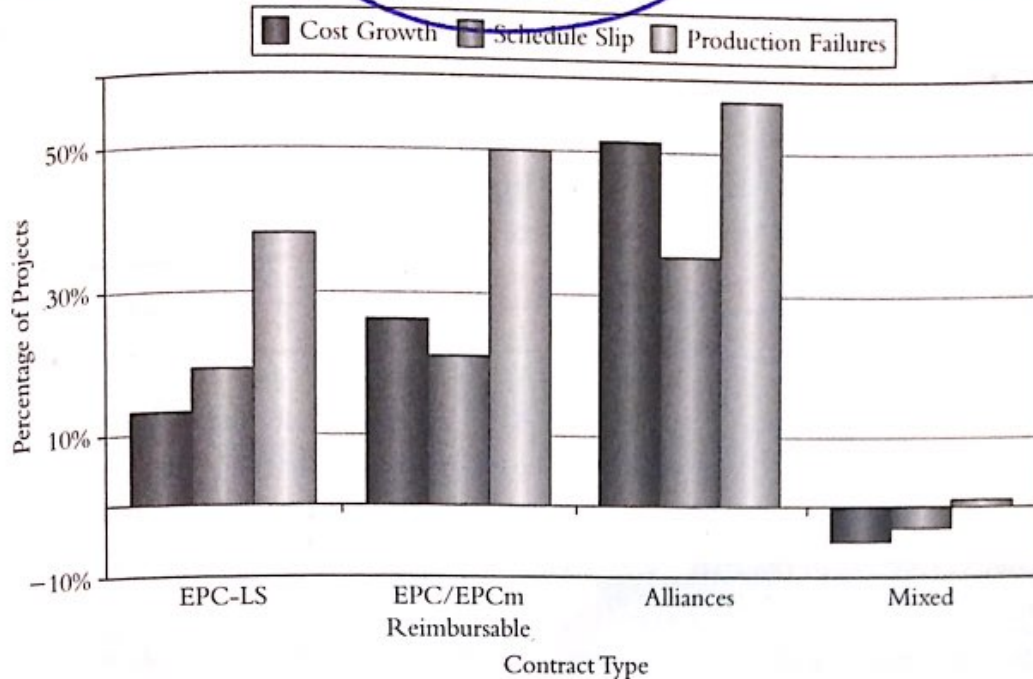
The patterns of outcomes are different for different contract types. Figure 11.3 provides some greater granularity around the outcomes of projects by contract type. The projects using EPC lump-sum contracts averaged only modest overruns of about 13 percent, but they suffered an unacceptably high rate of failure in production attainment. The danger of this trade-off is inherent in lump-sum contracting. If the contractor is not in a loss position, quality will be reasonably

*Results are based on logit regression z coefficient probabilities.

CONTRACTING

Figure 11.3
Patterns of Outcomes Vary by Type of Contract

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good if owner/sponsor controls are good. If the contractor is in a large loss position, quality will be poor. The high incidence of production attainment failure in the EPC reimbursable class was mainly driven by a higher incidence of the use of new technology and the higher use of reimbursable forms in highly remote locations. Those two factors together account for most of the differential production attainment failure rate. Highly remote locations are more likely to end up with reimbursable contract forms because obtaining cost-effective EPC lump-sum bids is difficult when the uncertainties around logistics are high. The production attainment result is not a reflection on the use of reimbursable contracting; the reimbursable contracts were selected in part based on the uncertainty associated with the technology and location. The result does remind us about the importance of solid Basic Data.

The results of the alliance projects are dismal with respect to every outcome, but cost overruns and production shortfalls are particularly so. The average alliance-contract project experienced more than 50 percent cost growth, and nearly 60 percent of the projects were

production attainment failures. Only a few alliance-contract projects were successful. Our results regarding alliance contracting flatly contradict the views of a number of published articles on the subject. Miller and Lessard, for example, believe that "Substantial gains in costs, schedules, and project delivery . . . can be made by the adoption of generative owner-contractor relationships," that is, alliance-type arrangements.¹ As I discuss later, however, these arrangements actually increase instability in project execution. I would like to be able to report that this contracting strategy is dead, but that is not the case. It continues to be used, often by companies using it for the first time.

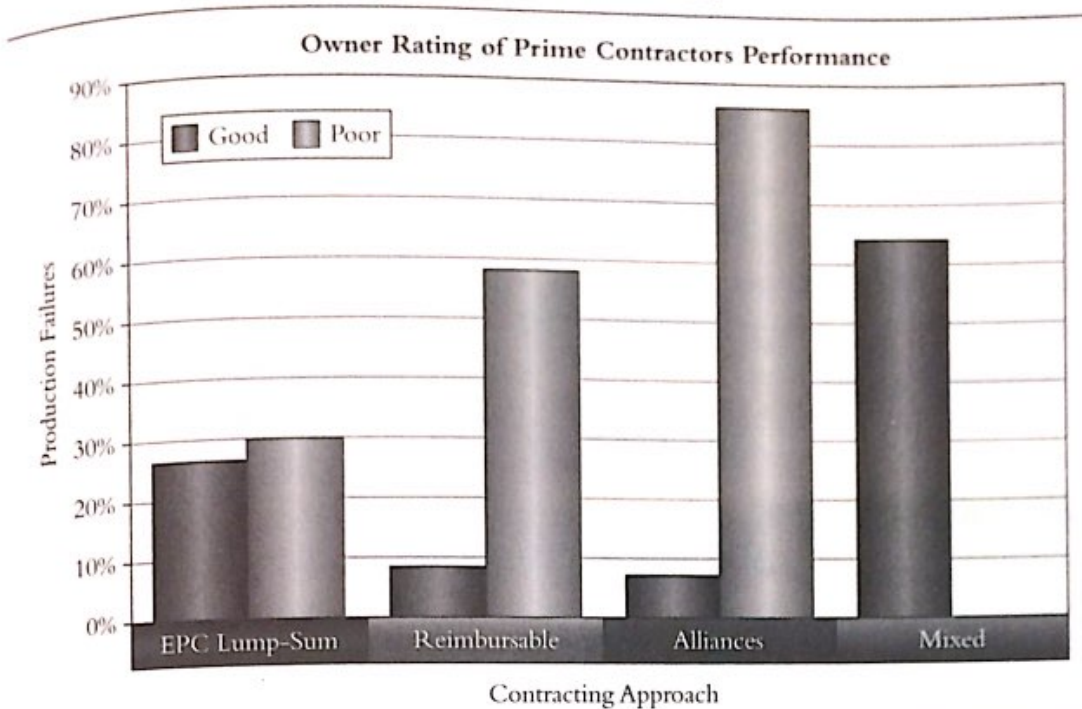
The projects using a mixed strategy fared by far the best of any contractual approach. One reason for this was that, for whatever reason, the projects using mixed contracting were the best front-end loaded of any group; they averaged a "best practical" FEL index. However, excellent FEL was not the only reason for their success. Even after I control for FEL and team integration, the mixed-strategy projects fared significantly better. I discuss the reasons for their success later in this chapter.

Not surprisingly, how sponsors rated the performance of their prime contractors correlates very strongly with how the projects came out. The differences by contract type are shown in Figure 11.4. We asked the owner's team to rate the overall performance of the prime contractors on the project on the simple three-point scale: good, about average, and poor. The contractors with EPC lump-sum contracts were the only normally distributed group; a little more than a quarter were rated "good" and "poor," with the majority in the "about average" category. The ratings of the contractors who had lump-sum contracts were reflective of the quality of the facilities more than any other outcome. Neither cost growth nor schedule slippage was important, but quality associated with facility performance accounted for nearly half of the total variation in the contractor ratings.

For the reimbursable contracts, what the ratings are picking up most strongly is slippage in the execution schedule. Although many of the facilities had operability problems, the sponsor teams are not blaming that outcome on the contractors.

For those who had alliance and mixed strategy contracts, there is so little variation in the ratings that it is impossible to quantitatively link

Figure 11.4
Sponsors View Contractor Performance Negatively in Alliance and Reimbursable Contracts



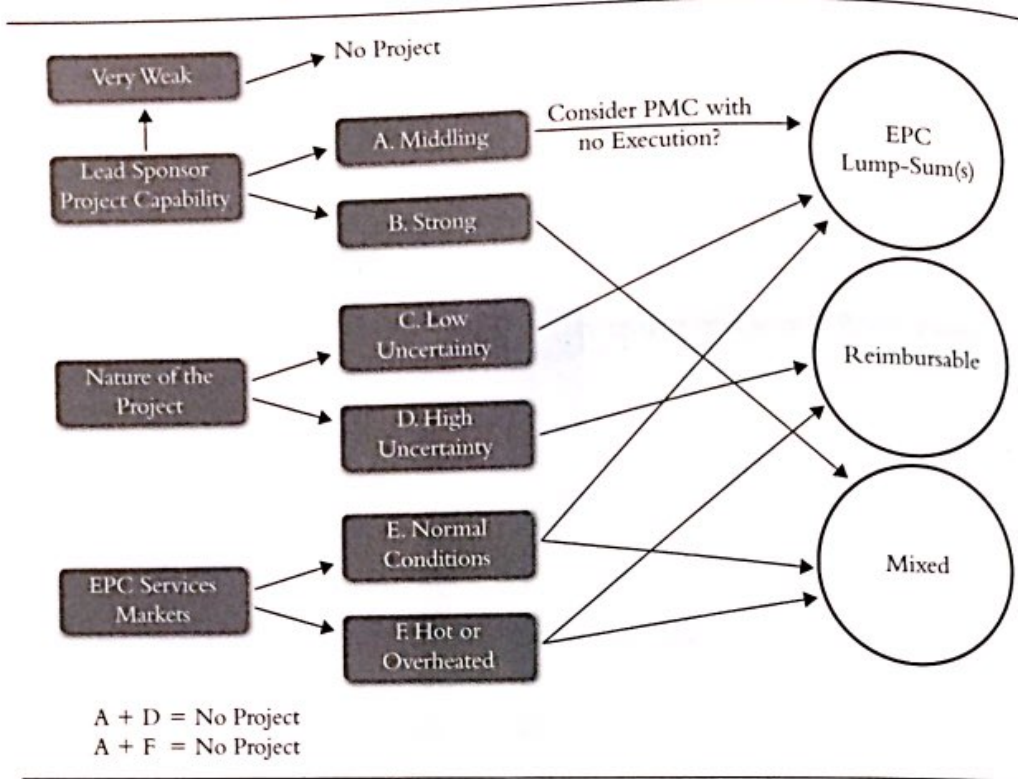
the teams' unhappiness and happiness, respectively, to any particular outcome. We know from the case studies that the sponsor teams were genuinely outraged at the attitude and performance of their contractors on the alliance-contract projects. As I show later in this chapter, I think they really have mostly themselves to blame.

Having now described the relationship between contractual approaches and project results, I want to explore the strengths and weaknesses of each approach suggesting what promotes success with each strategy.

THE CENTRAL ISSUES IN CONTRACTING STRATEGY

As we discuss contracting strategy in this section, there are three important considerations that need to be kept clearly in mind: the capabilities of the sponsors, the nature of the project, and the state of the EPC services markets. All three must be carefully and honestly

Figure 11.5
Contract Selection Decision Making



assessed if a reasonable approach is going to result. The way these issues should push the contracting decisions is shown in Figure 11.5.

Sponsor Capabilities Influence Contract Approach

The following questions need to be addressed:

- Has the lead sponsor undertaken large projects before?
- Does the lead sponsor's business leadership understand the owner's role in project management?
- Does the lead sponsor have a mature project work process? By *mature*, I mean a work process that has been used many times before by the sponsor project organization, with proper training of its people on the use of the work process.
- Can the lead sponsor (with assistance from partners if they are willing) staff FEL with all of the needed functional leads?

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- Can the lead sponsor develop a detailed estimate and schedule for a megaproject?
- Does the lead sponsor have a procurement organization that can order long-lead equipment during FEL prior to authorization?
- Can the sponsor field a strong controls organization that can fully monitor and control engineering and construction?

If the answer to most of the questions above is "no," the company is not ready to take on a leadership role for any megaproject. If the answers are mixed and "sort of," this should push the company toward an EPC lump-sum contracting strategy, perhaps with independent contractor support for certain missing skills sets. The focus will be on the preparation of a strong invitation to bid (ITB) package followed by strong quality assurance/quality control (QA/QC) in execution. These middling answers also make the use of a project managing contractor (PMC) more attractive, but as I discuss later, projects with PMCs did not fare well. Sponsors that can answer all of the questions with an unqualified "yes" can use whatever strategy they prefer.

The Nature of the Project

Some projects must carry more uncertainty into execution than others. New technology is one main source of uncertainty. Highly remote areas are another. Such projects are inherently more difficult. Greater difficulty translates into a higher incidence of late changes, especially during engineering. The probability of late changes influences the relative merits of different contracting strategies.

If change during execution is highly probable, even with excellent FEL, the contracting strategy is pushed away from EPC lump-sum contracting and toward a strategy with reimbursable engineering. This is because changes rapidly undermine the cost-effectiveness of EPC lump-sum strategies. It does not follow, however, that construction or fabrication work must be reimbursable.

The State of the EPC Services Market

When the markets for engineering services, vendor-fabricated equipment, and craft labor are overheated, the chances of obtaining a

cost-effective EPC lump-sum bid are reduced. The contractors view the circumstances as risky for them, and given the state of the market, they can afford to bid conservatively. If a lump-sum strategy is going to be pursued in a hot market, the sponsors need to remove as many of the risk elements from the contractor as possible. For example, prices can be indexed, currency risks hedged or otherwise reserved to the owners, and equipment ordered during FEL on owners' novation.

Nonetheless, if the markets are hot enough, it may become simply impossible to obtain EPC lump-sum bids or the bids may be high enough to render the project uneconomic. If the sponsor group cannot manage a reimbursable format, at least for engineering, the appropriate action may be to cancel the project.

During the long period of oversupply of EPC contractors up to 2003, weaker owners were able to have some successful megaprojects because the contractors could in effect bail them out of trouble and, given the lack of alternatives, were highly motivated to do so. EPC lump-sum contracts were more common in that period and more likely to be successful than they are now.

THE ROLE OF EXTERNAL FINANCING ON CONTRACT APPROACH

When banks finance projects, they routinely require that the project be contracted via EPC lump-sum contracting and often even require that a single lead contractor be responsible for the entire project. These requirements, as well as the behavior of government entities, are the primary reasons that EPC lump-sum contracting predominates in megaprojects.

20175 It is regrettable that banks insist on lump-sum contracting for two reasons. First, lump-sum contracting of very large projects is expensive, and the larger the project, the larger the penalty, especially when market conditions are tight. Second, EPC lump-sum contracting has absolutely no bearing on the risk profile of the project. Bankers, like some sponsor businesspeople and lawyers, fail to understand that lump-sum contracts are not a ceiling on the cost of the project. Indeed, they are a floor on the cost because surely no less than the contract price will be paid. Furthermore, although cost performance

is important, it is not nearly as important as operability, and when lump-sum contractors start to bump up against that contract "ceiling," the first thing to suffer is operability of the facilities. Given that banks are repaid via the cash flow from production, it behooves them to start understanding project risk at a first principles level.

WHAT DRIVES SUCCESS AND FAILURE IN EPC LUMP-SUM CONTRACTING?

EPC lump-sum contracting is a perfectly acceptable way to contract for megaproject execution. Many successful projects have been completed using some form of this basic contract vehicle. There are some important pitfalls to be avoided, and there are some erroneous beliefs about lump-sum contracting among many sponsors that tend to push us into making disastrous mistakes. It is these pitfalls and mistakes we need to review, as well as some creative uses of this vehicle. EPC lump-sum contracting is a risk-averse approach to contracting from the owners' perspective. Ironically, it is an approach that tends to work well only when inherent risk in the project is low anyway.

Some Key Pitfalls In EPC Lump-Sum Contracting

Much of the benefit of EPC lump-sum contracting derives from competitively bidding the work. The process of preparing the ITB, prequalifying a set of contractors that will be invited to bid, and then evaluating the bids themselves provides the sponsors with a great deal of information that can be used to help guide the project to success. The key to success lies as much in the process of competitive bidding as the results in terms of low bid value. The competitive bidding process provides the sponsors with excellent information about how much the project should cost if (and only if) they interpret the bid responses correctly. What this means is that there is very little value to sponsors in sole-source EPC lump-sum contracting. Our research shows what others have shown as well: sole-source lump-sum contracting is an expensive option.²

Sole-source EPC lump-sum contracts sometimes are used because a technology license that the sponsor wants comes bundled with an

EPC contractor. That arrangement is enormously bad for sponsors' wallets. Such tied-sale contracting arrangements clearly are a restraint of trade, even if they are not universally illegal.

Other situations that generate sole-source lump-sum contracts can be at least as bad. The worst case is when the primary FEED contractor is going to be allowed to bid the project in a lump-sum competition. This often has the effect of discouraging other qualified firms from bidding, resulting in the FEED contractor receiving the project by default. Let me provide an egregious example.

The project was in a remote area that suffered serious security concerns. The FEED contractor, who was experienced in the area while the lead sponsor was not, carefully built the hourly labor rate. The labor would be sourced from an expensive area and the labor would have to be flown in and out of the sites daily. The security costs would add greatly to the rate, and so on. The final expected hourly cost was well north of \$100 U.S. per hour. The FEED contractor, as he had fervently hoped, was the only bidder; no one else was interested, primarily because the FEED contractor was being allowed to bid. The contractor then took home almost \$100 on every hour as a low-cost source of labor was "discovered" and the local army was suddenly willing to provide security (for a small consideration), all of which resulted in an extra \$500 million in profit to the contractor.

Still another route to the sole-source EPC lump-sum contract is the "convertible" lump-sum contract. This form starts as a reimbursable engineering and procurement contract with an option to convert to a lump-sum contract at some point during engineering. In principle, there is nothing wrong with this approach and a lot to like. In principle, it means that almost all of the potential cost growth and schedule slippage will have been discovered by mid-engineering and there will be very little remaining risk to the engineering and procurement contractor in taking the project on as a lump-sum contract with a minimal premium.

In practice, convertibles usually turn out very differently. Because the owner expects the contractor to choose to convert, the owner is not prepared for any other outcome. The field controls organization needed to continue the project on a reimbursable basis is not there, nor has the sponsor done the things needed to bid the construction to a set of prequalified construction management organizations. The

engineering and procurement contractor, who is expecting to do construction on whichever basis he or she believes will be more lucrative, would not cooperate with another construction management organization anyway. If the contractor believes more money can be earned through lump-sum contracting, he or she goes with lump-sum; otherwise, the contractor stays with reimbursable. It is one more contracting game sponsors can't win.

Schedule Incentives and Liquidated Damages

EPC lump-sum contracts always include powerful incentives to minimize cost. Any money saved is profit earned for the contractor. However, the same structure creates incentives to float the schedule to whatever duration will assist in minimizing cost. Fortunately, good cost performance on EPC lump-sum contracts correlates very strongly with good schedule performance ($P |r| < .02$) and limited schedule slippage (.01). The addition of incentives to achieve schedule has no relationship with better schedule performance. Directionally, the statistics point in the opposite direction! When schedule incentives were included in lump-sum contracts, they were associated with an increase in the frequency of production attainment failures ($P |\chi^2| < .03$) in all industrial sectors. What is going on is quite apparent: at the end of the project, when the contractor company could see the possibility of gaining the schedule incentives by acceleration, it cut corners on quality so substantially that operability was damaged well into the second year after startup. Any time they actually saved toward the end of the project was minimal, but the damage to the project's value was huge. Schedule incentives should not be used.

Sometimes schedule incentives have the effect of reducing schedule slippage but do so simply by lengthening the forecast schedules. The most extreme form of this game involves the FEED contractor insisting on a percentage of any sales of product that can be made due to early completion of the project. Being the FEED contractor, he or she is in a position to manipulate the schedule promised and then profit handsomely from this pessimism.

Liquidated damages are a contract provision that imposes a penalty from the contractor if a project is late. In some cases the penalties are

quite substantial. Liquidated damages generally are not applied until a project is several months beyond the expected target completion date. Of course, liquidated damages cannot be applied if the sponsors were responsible for the delay or if force majeure can be claimed successfully. Liquidated damages appear to have only a negligible effect on the low bids for projects, although they are so intensely disliked that some contractors may choose not to bid. In some cases, liquidated damages are essential because there are very large downside consequences to the sponsors of the project being late. These circumstances include cases in which the production has been forward sold with penalties for nondelivery and cases in which a large value stream is dependent on the completion of the project, such as a petroleum field's production depending on the completion of a gas plant. Unlike schedule incentives, liquidated damages appear to work. The average schedule slippage on lump-sum projects with liquidated damages was only 6 percent. However, when I control for FEL, the relationship between liquidated damages and schedule slippage disappears.

Sponsors must understand that the schedule is the most common source of contractor claims. In some cases these claims are entirely justified. But schedule claims are a major source of abuse by contractors as well. There are so many forms of claims games relating to schedule, I cannot hope to cover them all. Fortunately, that has already been done.³

Taking the Very Low Bid

We have already discussed at several prior points what happens when a significantly low bid is accepted. (We defined a significantly low bid as one that is \$100 million [in 2009 terms] less than the next lowest bid.) Acceptance of such a bid guarantees that the bidder does not fully understand the project or has made a disastrous bidding error. Either way, the sponsor will lose. Occasionally sponsor greed drives acceptance of such a low bid. More often, however, the involvement of a government-related partner requires that any low bid will win.

All of the EPC lump-sum contracts that were won on significantly low bids—that is, \$100 million or more lower than the next closest bidder—failed. When the “winning” contractors realized the magnitude

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of their low bids, they immediately started to try to recover their losses. They floated the schedules longer to minimize costs believing (correctly in most cases) that they could avoid liquidated damages. Even if the liquidated damages would be triggered, the amount of money contractors paid in liquidated damages would be relatively unimportant in the bigger scheme of things. The most damaging aspect of their behavior, however, was to cut quality corners at every opportunity. The sobering aspect of this is that the strength of the sponsors' controls organization for the project had no mitigating effect on the ability of the contractors to cut corners on quality when they were facing cost overruns on lump-sum contracts. The operability results were simply unaffected by controls for the lump-sum projects. (For non-lump-sum projects, however, higher quality controls in execution were clearly associated with fewer operability problems.) There is also no reliable relationship between turnkey provisions in the lump-sum contracts with regard to operability. The contractors on turnkey projects appear to be increasing their bids enough—about 5 percent—to absorb any losses associated with performance guarantees.

When EPC lump-sum contractors are facing a significant loss on a project, they routinely take several actions that further damage the project. They start squeezing their subcontractors and suppliers and slowing down payment. That causes the subcontractors to go into defensive mode, looking for claims opportunities. The losing contractor will also start thinning out his or her management people on the project in an attempt to save money. This often extends right down to the general foreman level for fabrication or construction. The staffing levels need to be articulated down to the general foreman level in the bids, and then the sponsors need to try to hold the contractors to those levels as the project proceeds. I say "try" because it will be very difficult to do.

Acceptance of significantly low bids is so strongly associated with bad results that I believe that the procedure for handling them needs to be addressed between partners as a shaping issue. If addressed as a shaping issue that requires a full investigation of a seriously low bid, there will be at least some possibility of getting the bid rejected or allowing the contractor to amend. One might imagine that given the overheated state of the megaproject market since 2003, no one will

have to worry about very low bids. This is not so; serious bidding errors were made right through the boom market.

When Governments Control Contracting

In many countries in the world and for almost all nationally owned companies, the government controls the contracting process. In almost all cases, the government rules require competitive bidding of essentially all contracts. Often, as mentioned before, the rules will require that the contracts be lump-sum, fixed-price arrangements. In some cases, the rules do not actually stipulate that fixed-price contracts be let. However, they require specific government approval for all transactions over a certain amount. In one important case, the amount is \$10,000. What this means is that the project would have to return to the government to secure approval every time it spent much of anything, which would be not only impracticable but wide open to abuse. The solution is to make a single expenditure for the entire project amount.

Governments almost always require that low bids be accepted. Acceptance of significantly low bids almost always triggers project failure. This means that prequalification of bidders is the most important single step in the contracting process. Not only must the prequalification process be thorough, but it must be done with an eye on the possibility that the government will seek to add bidders that, for whatever reason, it wants to win the competition. Remember, this is not just a Third World phenomenon. It happens everywhere.

The most important single change that could be made in the usual low-bid acceptance procedure is a provision for an investigation of any low bid that is substantially separated from other bids. The definition of *substantial* can be either a dollar amount (I would suggest \$100 million) or a percentage amount (I would suggest 10 percent). Ideally, the investigation would enable the low bid to be rejected in the event that it is based on a misunderstanding of the requirements or an estimating error.

One common government provision that causes misunderstandings with bidders are rules forbidding anything but written communication between bidders and the project in the period between the issuance of

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the ITB and the award of the work. Although this may seem reasonable to ensure a level playing field, it greatly hinders effective communication. Very early in project development, discussions need to start to amend these rules to allow a series of face-to-face (or telephone conference) meetings between the evaluation team and all of the bidders during the bid preparation. These occasions would allow the bidders to ask any questions in the presence of everyone.

There also needs to be allowance for the team to verify a bidder's representation of qualifications when questions arise during the bid evaluation process. One of our megaprojects failed because one of the bidding companies exaggerated its experience with the 3D computer-aided design (CAD) system. (They owned the system but had never actually used it!) When their bid was evaluated, some members of the evaluation team raised questions about whether the bidder really understood the CAD system, but they were precluded from verifying the bidder's qualifications at this point. The result was that a critical part of the design was six months late, equipment was late being ordered, and materials were incorrect. The project spiraled out of control.

Some government rules concerning secrecy of company cost estimates have the ability to cause a significant amount of trouble. The government concern is that information about the estimate will be brokered to contractors and provide an unfair advantage. But in some cases the secrecy provisions become absurd. For example, one national company keeps the sanction estimate secret from the project teams! The effect is that they have no idea of the relationship between what they are scoping and what things cost.

The usual assumption is that government rules are immutable and must be accepted. That is, of course, usually true. However, we did have a few projects that successfully argued with the governments for rule changes that would allow more flexibility. The project directors started discussions with the government about the contracting rules very early, sometimes more than two years before the ITBs were sent out. They made their successful arguments for greater flexibility by explicitly linking contract flexibility to more effective local content. In particular, what they sought was permission to contract directly for local content using whatever contracting vehicle would give the local provider the best chances to actually succeed in developing their skills,

rather than just dumping money into the local economy. The persistence of these project directors achieved two excellent benefits: they received high quality and inexpensive local content, and they eliminated very large risk premiums by taking the local content requirements out of the ITBs for the international contractors. The lesson is do not automatically assume that the government agencies will not consider strong arguments for added flexibility, especially when those arguments are couched in terms of their goals.

Creative Use of EPC Lump-Sum Contracts

When EPC lump-sum contracts are used, sponsors often think that they have very limited control over the execution process. This view is reinforced by corporate legal staff who worry that any sponsor intervention in an EPC lump-sum situation will make it impossible to hold the contractor liable for poor results. (These folks believe in the myth of risk wholesale transfer, which I discuss shortly.)

In fact, some of the most successful EPC lump-sum projects involved owners being hands-on during every facet of execution. The best EPC lump-sum projects were usually multiprime arrangements. This involved careful carving out of pieces of the project that could be executed almost as a parallel stand-alone project. Where I am from in the United States, we have an expression, "Good fences make good neighbors." This expression certainly applies to how the pieces of multiprime EPC lump-sum projects are defined. Parts of a project that are too intimately linked from either a design or construction perspective must be included within the same contract. Pieces that can be designed based on a requirements and specification statement without reference to the details of the design of other bits can be contracted separately. For example, onshore portions of offshore petroleum production projects are usually contracted with separate EPC lump-sum contracts. As long as the oil and gas composition data were correct from the reservoir appraisal, this arrangement works well.

A Good Example

One of the more ingenious uses of EPC lump-sum contracting occurred in a chemical complex built in a developing country environment.

The primary units consisted of an olefins cracker, a large power plant, and a number of olefins derivatives units. The cracker and the power plant were tightly coupled, feeding streams to and from each other, so they were grouped in a single contract. Each of the derivatives units were contracted separately, each with a different EPC lump-sum tender. The result was five prime contracts.

The contracting strategy was developed during FEL-2 as the scope was being developed. Knowing that the site offered some real challenges in access and logistics, they laid the units out so that separate access was available to each portion of the complex as they intended to contract it. The first task after site preparation was literally the construction of those "good fences." With five prime contractors and complex lay-down and site logistics problems, most owners in this situation would have hired a PMC to keep track of everything and manage the interfaces. A PMC was considered but ultimately rejected because the PMC candidates wanted part of the execution. The owners decided to hire a sixth contractor on a reimbursable basis with very clear rules about behavior—the reimbursable contractor was barred from hiring anyone who had ever worked for one of the lump-sum contractors on the project. The reimbursable contractor was assigned any tasks that "fell between the fences," such as logistics, canteen, safe and timely movement of construction workers to and from the site, and so on. The reimbursable contractor also served another purpose: if one of the lump-sum contractors submitted a change order that the sponsor team thought was significantly overpriced, they refused the change, saying that they would have the reimbursable contractor do the work when the lump-sum contractor was out of the area. This had the beneficial effect of significantly moderating the prices on change orders from all five lump-sum contractors. The result was a highly successful project that could easily have become a nightmare.

The best EPC lump-sum projects had the characteristic of a hands-on sponsor team that would not let the contractors fail. In all of the lump-sum megaprojects, I cannot find a single instance in which the basis of a contractor claim was that the owner interfered when the contractor got into trouble on the job. There were cases of claims based on owner interference, but they were around issues such as the owner taking responsibility for managing the lay-down

yard, not intervention. Interference between contractors is one of the major sources of contractor claims.⁴ Strong interface management, like that described in the preceding example, is what prevents those claims from materializing.

Interface management is one of the most critical jobs on any complex megaproject. The interface management effort needs to start as part of FEL-2 and continue through the execution of the project. As discussed in Chapter 9, interface management is not a job for junior engineers; it is central to the success of the endeavor. One of the key mistakes made in EPC lump-sum projects is to imagine that because the contractors "are responsible for the execution of the project," the owner team size can be small. Owner team size on successful megaprojects is quite insensitive to contracting approach. What varies with the contracting approach is the content of what the team is doing, not the numbers of people required.

The Illusion of Wholesale Risk Transfer on EPC Lump-Sum Contracts

Most adherents of EPC lump-sum contracting for megaprojects argue that the contracting strategy effectuates significant transfer of risk and responsibility from the sponsors to the EPC lump-sum contractor. The facts, however, suggest that this really is not the case. Some lump-sum prime contractors did indeed lose significant amounts of money on megaprojects in our set. However, those losses for the contractors did not translate into gains for the sponsors. Instead, those losses translated into facilities with an endless stream of operating problems.

Significant risk transfer from sponsors to contractors is structurally impossible. Contractors, including the very large contractors that take leading roles in megaprojects, are too thinly capitalized to survive wholesale risk transfer on large projects. During the period of overcapacity of EPC services between the mid-1980s and the early years of the twenty-first century, the contractors that had to take on significant EPC lump-sum projects to have enough work mostly failed to survive. Many of those that survived were badly wounded, and all learned an indelible lesson: The failure to be carefully risk averse will

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surely result in bankruptcy. The only cases in which major losses were sustained and high-quality projects resulted for owners involved large Japanese contractors. Those contractors were supported by large commercial banks that were part of their business consortia. They were in effect losing other people's money.

Risk transfer is possible on smaller projects because the contractor in a loss position can afford to complete the project with reasonably good performance without destroying its business. The value of preserving its reputation and the hope of future business make that calculation reasonable. On a megaproject, however, the losses are too large. Furthermore, because there are very few contractors that are capable of taking on megaproject leadership, industrial sponsors have very few choices. Every project, in effect, becomes a "one-night stand" because the downside consequences for the contractors are minimal. If industrial companies banned forever using contractors that have performed very poorly on megaprojects, they would quickly find themselves without contractors to hire. Even when contractors have behaved in utterly unethical ways toward an owner on a large project, they can be quite sure that more business will be forthcoming anyway. I can think of only a couple of cases in 30 years in which a major contractor has been effectively banned by an owner for poor performance. Those were by large national oil companies.

The simple fact that major risk transfer cannot take place on megaprojects should not lead sponsors to automatically abandon EPC lump-sum contracting. EPC lump-sum arrangements have some important advantages in terms of project organization. EPC lump-sum contracts reduce the number of interfaces that the lead sponsor has to manage. Often, the lead contractor in an EPC lump-sum strategy has developed working relationships with the organizations that will act as subcontractors for the project. The major contractors are often highly proficient at procurement and can orchestrate getting all of the various pieces of the project fitted together. EPC lump-sum contracting may be the only realistic way in which sponsors with weak project organizations can have any hope of executing a megaproject successfully.

However, our findings have some important implications for how EPC lump-sum arrangements should be approached by sponsors. If

a sponsor is hoping for a bargain-basement price by using a lump-sum strategy, that hope will lead to trouble. Even when all works well, EPC lump-sum contracts do and should cost more than other contracting approaches. This is simply because the lead contractor is being asked to take on more work than in other forms. Also, there is some chance that an EPC lump-sum contract will result in a substantial loss to the contractor. (Remember, that does not necessarily mean a gain to the sponsors!) From the contractor's viewpoint, taking on a large EPC lump-sum contract is a bit like playing Russian roulette. Usually, there is no bullet in the chamber, even if the project seriously overruns, because most significant overruns on lump-sum projects are accompanied by lots of changes that largely render the lump-sum nature of the contract moot. Once in a while, however, there is an unlucky spin and the contractor might get stuck with a catastrophic loss. The contractor wants, reasonably enough, to do everything possible to insure against such a loss.

As a result, large EPC lump-sum bids will carry a risk premium over and above normal contractor contingency, except when the market for their services is in a prolonged slump and they face the prospect of extinction without winning the project. Some owner companies, especially national companies in the Middle East, take a very hard "no change orders accepted" approach on their EPC lump-sum contracts, even when they, as the owner, have clearly made changes that should normally cause an increase in the contract price. Often, the courts of jurisdiction in any disputes are the home country courts and hence viewed as a home playing field advantage. In those cases, the companies are paying risk premiums of 25 to 40 percent over a "fair" contract price to the low bidders on the projects. Some of our "failure" projects in the Middle East came in on budget, on schedule, and started up appropriately but paid 40 percent more for the project than they should have.

Often, the underlying purpose of using an EPC lump-sum approach to contracting for megaprojects is not risk transfer but *blame* transfer. Under an EPC lump-sum arrangement, especially with a single contractor taking the responsibility, that contractor can become the designated scapegoat when problems arise. Government preferences for lump-sum contracts are rational when one considers

the traditional weaknesses of government project organizations. Competitively bid EPC lump-sum contracts are also perceived to be less subject to corrupt practices than are other contractual forms (although for practical purposes, I find it difficult to see any advantage in that regard). Many companies, especially in the Middle East, cling to EPC lump-sum approaches because of very unhappy experiences with reimbursable contracts in the past. A good many of the megaprojects built in the Middle East in the 1970s by Western contractors on reimbursable contracts overran hugely without any ability of the host governments to control. It soured the countries and their national companies on reimbursable contracting for a generation.

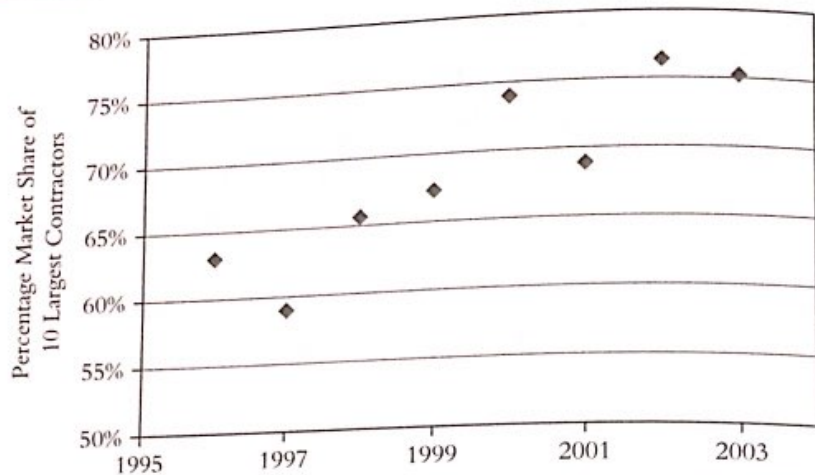
The Pricing of Risk in EPC Lump-Sum Contracts

The period of oversupply in EPC services for the global industrial megaprojects market came to an abrupt end in early 2004. The period of oversupply had extended over the prior 20 years, and that 20-year period significantly upset the power balance in contracting, with a strong tilt toward the buyers. The effect of the imbalance was that owners could get almost any terms they wanted from contractors, many of which were struggling to survive. Many, of course, did not. As shown in Figure 11.6, this period saw a substantial concentration of the market for large industrial projects. By 2003, the top 10 international contractors controlled about 75 percent of the major projects market, up from roughly 50 percent a decade earlier.

During the long period of oversupply, contractors were forced away from pricing risk as they bid on EPC lump-sum contracts and accepted more and more onerous terms for all types of contracts. During this period, it was common for contractors to have to finance substantial portions of the project because the terms allowed owners to withhold payments for relatively trivial reasons. Liability clauses were rewritten to make contractors liable for almost all mishaps, often even including cases in which the owner was found to be primarily responsible or even negligent!

When the market turned in 2004, contractors had accumulated 20 years of grievances. Those that survived had become very adept at avoiding potentially catastrophic risks. And as soon as market

Figure 11.6
Concentration of EPC Market Has Increased



Market share of the industrial/petroleum sector that the top 10 international design firms hold

Source: Engineering News Record, The Top International Design Firms, July issues, 1996–2004

balance was restored, the major contractors started pricing risk back into their bids.

By examining the bids against the situation of the projects, we have isolated seven risk areas that contractors started to price in 2004. As the decade progressed, the risk premiums for these areas rose and peaked in 2008. They have subsided some, but still are priced and will likely be priced more aggressively once again as the megaproject market is slated to accelerate in the first half of this second decade. I will define each area and the rough amounts that have been added to base bids to account for the perceived risks associated.

Onerous Local Content Requirements As discussed in prior chapters, local content requirements are nearly universal, even in areas that pride themselves as fully world open market. As I have also mentioned, getting local content into projects is simply business smart. Local content is associated with building local support for projects and with fewer hassles from opportunistic politicians. Local content is often considerably less expensive than alternative supply.

The problem with local content surfaces when there is a requirement that appears difficult or impossible to fulfill. In places without an industrial supply infrastructure, such as structural steel, pipe manufacture, high-quality equipment vendors, and engineering firms, relatively few inputs into industrial megaprojects can actually be supplied. The inputs tend to be restricted to nonengineered bulk materials and construction labor. Often, the local labor is not qualified for many of the key crafts, such as alloy welding. For example, we had one megaproject in Central Asia that stipulated an astonishing 80 percent local content requirement for a petroleum development project and pipeline. There is not even a basic line pipe manufacture in the country!

Often, the host governments are trying to push the limits of feasible local content, which is understandable, but they have trouble figuring out where that feasibility point becomes very expensive in terms of risk pricing. Not surprisingly, international company complaints are viewed as whining. In these situations, the local content requirements should be understood by the sponsors as a perceived major risk to lump-sum bidders. When local content is viewed as difficult to meet, contractors have added a premium of 30 to 40 percent above the base bid for onshore projects. This added premium has been so large that it has pushed many sponsors away from EPC lump-sum contracting. For offshore petroleum development projects, the added premium has been around 15 percent.

Civil Unrest in the Immediate Area For some obscure reason, contractors believe it is difficult to build a megaproject and dodge bullets at the same time. When there is shooting in the neighborhood, contractors are adding an average of 25 to 30 percent to their bids.

Harsh Physical Environment or Climate Contractors are perceiving projects in difficult climates as posing unknown risks that need some degree of cushion in their bids. Projects in remote desert areas, very mountainous areas, arctic areas, and tropical jungle areas are carrying risk premiums of 20 to 25 percent. What the contractors are in effect saying is that there are so many unknowns in these areas that rather than trying to build the problems into the base estimates, they will simply put an added premium on top. This is reasonable when one

considers that developing a solid bid for a megaproject is an expensive proposition for contractors. In a period when they are receiving a substantial number of ITBs, the added time needed to explore all of the logistical challenges of harsh climates doesn't make economic sense. The failure rates in our data in very remote locations suggests that the added premiums are founded in sound logic.

Political Instability Political instability translates into logistical nightmares for contractors. They find that goods cannot be moved across ports. Visas are not being processed. Staff are being arrested by local authorities. Some nationals are now persona non grata. These sorts of hassles make getting a project completed in a timely way very difficult. Although they may be the source of legitimate claims, this is not a welcome route for the contractor because the claims process is also risky. Areas of political instability are adding 15 to 20 percent to bids.

An Unstable Regulatory Regime Politically unstable areas also have unstable regulatory regimes, but I counted them under the prior category. Many quite stable political areas have regulatory problems. As discussed back in Chapter 4, regulatory problems may be symptomatic of a weak institutional environment. In such environments, permits are highly political acts. But many areas with stable institutional environments have problematic regulatory regimes. In some cases, the regulators find themselves simply overwhelmed with the workload and cannot get permits issued in a timely or predictable way. In some areas, there are so many interveners allowed in the regulatory process that the timing of permits is utterly unpredictable. When contractors under EPC lump-sum contracts are tasked with permitting, they look at this area as a source of delay and therefore risk and are adding 15 to 20 percent to the bids to cover.

High Potential for Craft Labor Shortages During the middle of the last decade, craft labor shortages sprang up in a number of areas, including some that had never before seen them. Western Canada, West Australia and then all of Australia, the Middle East, Central Asia, the U.S. Gulf Coast, and selected parts of Asia all found themselves unable

to find enough qualified labor to complete large projects on time. Labor shortages are a real and present danger to projects. Contractors were adding about 15 percent to bids in areas of labor shortage, which was probably not enough. In some of these areas, the contractors stopped bidding on EPC lump-sum contracts altogether.

Currency Exchange Risk Essentially every industrial megaproject spends money in a number of different currencies. Many contractors found themselves seriously hurt by currency exchange rate fluctuations in the 1990s as financial crises caused very sudden changes. Therefore, when risk pricing again became possible, the contractors attached a premium to accepting the currency risks associated with their lump-sum projects. The size of the premium averaged about 8 to 13 percent.

I find two things astounding about this. First, the premium bid is far more than the amounts actually needed to go into currency markets and forward buy the currencies in question and thereby fix their values. And second, why in the world are industrial companies passing currency risks to their contractors? The kinds of companies sponsoring these projects are sophisticated financially, certainly more so than many of the contractors. They should either accept the risk themselves or hedge the risks themselves rather than attempting to pass the burden along and get charged a hefty premium.

Other Areas of Priced Risk Transfer

The seven risk areas just cited are not the risks that contractors evaluate. There are a host of contractual provisions that carry perceived risks for contractors that are routinely priced into their bids. Among others, these include:

- Uncapped liability provisions
- Responsibility for consequential damages
- Payment provisions (and especially provisions that make delay or withholding of payments easy)
- Provisions for processing change and schedule extensions, and
- Broad definitions of gross negligence

These provisions are contained in the terms and conditions in the contracts and apply to all contract types. Although we have not measured the bid premiums from such onerous provisions, contractors do factor them into their bid decisions. In some respects, harsh terms and conditions are insidious; one common reaction of contractors to such provisions is to decline to bid without explanation. Harsh terms and conditions also start the contractors out in a defensive mode, which is not conducive to successful projects.

The Myth of the "A Team"

I was once having a conversation with the chief executive officer (CEO) of one of the top international contractors and the subject of incentive contracts came up. He asked me why so many owners seem to prefer them. I answered, "Because they believe they will get the 'A team,' that is, the best people the contractor has to offer."

He laughed and said, "If they can figure out what the 'A Team' is, they are welcome to them. But they have to tell me because I have been trying to find them for years!"

I asked another contractor executive if he could name the "A Team" in his organization, and he said, "Sure, they retired two years ago."

There is an almost magical belief within the owner community that there are a set of much stronger project teams among the major contractors, which if they can be secured, will guarantee success. Although there is, of course, variability in the competence of contractor teams, just as there is for sponsor teams, the A Team is a myth. As a sponsor you are much more likely to find yourself with an A Team if your FEL has been excellent and all the owner functions were present and accounted for during FEL.

There are some attributes of contractor teams that do make a difference. First, all of the contractor lead participants should have worked for the contractor on at least one prior major project. If they have not, it is likely that they cannot actually operate the contractor systems because they are not sufficiently familiar with them. One of the most common shortfalls of contractors is not that their systems are poor; it is that the people on the project don't actually know how to run those systems. Second, you would greatly prefer a group from

your leading contractors that have worked together before as a team. The contractor project manager, lead engineer, disciplinary leads, lead cost estimator, lead planner/scheduler, and construction/fabrication manager, if they will be responsible for construction, should have experience together. The search for the mythical A Team is a distraction from asking the right questions as you qualify the contractors. The issues are whether a potential contractor can and will field the right team for this particular project and whether the contractor will give reasonable assurances that the team selected will stay in place.

REIMBURSABLE CONTRACTS ARE FOR HIGHER-RISK PROJECTS

Reimbursable EPC and EPCm contracts were used for a quarter of the projects in our sample. This contract form was used by every industrial sector and in every region in the world. Reimbursable approaches are most appropriate, and may even be essential, when a project is subject to significant uncertainties that will carry well into execution. For example, reimbursable contracts were twice as likely to be used in highly remote locations. Reimbursable contracts were associated with greater use of innovative technology, and reimbursable forms were a little more common when projects were schedule driven. Reimbursable contracts were much more common when local project markets were overheated. For that reason, reimbursable forms have been the predominant megaproject contract type in Australia, Canada, and Central Asia during the first decade of this century. Projects with inherent risks are tilted toward reimbursable forms because sponsors and contractors are much less likely to be able to agree on a lump-sum price when execution is uncertain. Because of the economic inefficiency associated with risk transfer, real or imagined, from owners to contractors, the risk premiums contractors want for lump-sum contracts are too large for owners to swallow.

Straight reimbursable EPC contracts are difficult for most sponsor teams to control. Very few owners have the strong skills needed to prevent the reimbursable contract from becoming an open wallet that enables the contractors to charge many more than the budgeted hours for engineering and construction/fabrication. Most owners do not

know, for example, what is an appropriate number of hours for various parts of the design. Most owners lack even basic understanding of megaproject construction management that would enable them to know if the field is being properly managed or not.

The Use of Incentive Schemes

This lack of expertise has led many owners to attempt to mitigate the open-ended nature of reimbursable contracts through the introduction of incentive schemes. These schemes involve extra profits to contractors if the project underruns its budget, schedule, or other objectives as desired. Sometimes the schemes involve extra payments for meeting the sanctioned objectives. Sometimes, they involve some form of penalties for disappointment such as "fee at risk" or "pain-sharing" approaches. The incentive schemes almost always applied to the prime contractors, which were the engineering and procurement organizations, and not specifically to the subcontractors who were used for construction.

None of the incentive schemes associated with reimbursable EPC contracts had any detectable effects on project success. They are a complete random walk. The success rate with incentives is actually lower than that without, but not statistically significant. The only relationship that I am able to detect is that cost target incentives were associated with *greater* schedule slippages, and that finding is statistically marginal. Our findings flatly contradict case study findings by researchers such as Berends.⁵ To be sure there are some successful incentivized megaprojects. There just are not very many of them.

The incentive schemes suffer a number of defects. Most of these schemes were put in place with contractors that had also executed the FEED on the projects and had therefore had a primary role in the development of the sanction estimate. Knowing (or at least hoping) that the execution contract will contain incentives for underruns, these estimates characteristically overstate the bulk material quantities that will be needed to construct the facilities. Even slight padding of the bulk material quantities translates into a significant "cushion" in the estimate because the bulk material quantities are the primary drivers of engineering hours and construction hours. If all goes well,

which is actually determined by fundamental things, the project then underruns, the contractor has "earned" a sizeable bonus, and the sponsors are pleased because they believe they have gotten a bargain. This leads some researchers and project directors to believe the incentive scheme has worked as well, when, in fact, the result was created via creative estimating and the project is actually a bit more expensive than it needed to be.

Those are the good incentivized outcomes. In the much more typical case (about four times as likely), the project runs into difficulties. Those difficulties were usually due to the project fundamentals not being good. Then, instead of generating better outcomes, the incentives get in the way. Imagine yourself as the prime contractor expecting to make profits largely by earning incentives. You are now three months into execution, and it is clear that the project is headed for an overrun. You see this simply by observing the number of changes coming through the system. Now you are looking at three years more of an unprofitable project. How do you respond? You may demand that the incentives be rebaselined. But if the sponsor agrees to that, the entire premise of incentives is undermined. More likely, you view the best route to profits to be cranking in as many hours and as many change orders as you possibly can. You will try to make profits on field hours via hidden profit there. You are feeling ill-used and abused and therefore entirely justified in finding profit opportunities wherever they crop up. The relationship between owner and contractor sours, and the project becomes harder due to the contract provisions, not easier.

Incentive schemes suffer an inherent logical problem: they implicitly assume that there is a great deal of money to be saved below the owner estimate during the execution of the project. But unless the estimate was padded, that just isn't true. Unusually efficient execution can save a bit if all goes well. But the idea that efficient execution can normally produce savings large enough to compensate contractors fairly is absurd. Execution is all about trying to hang on to the value that has been created. It is not about generating new value.*

*Those familiar with the project management literature will be reminded of the "influence curve," which dates at least back to the 1950s, despite those claiming more recent paternity. The influence curve shows that the ability to shape the value of a project is high only when the rate of expenditure is low.

I also have a nagging philosophical problem with the use of incentives in contracts, which goes beyond the simple fact that they don't work. I believe the offering and taking of incentives fundamentally disrespects the professionalism of contractors. What incentives are really saying is, "Because you, the contractor, won't do a good, honest job just for your fee, I need to bribe you with some contingent money based on whether you actually show up for this job." Incentive schemes may reflect the broken state of relationships between sponsors and contractors in the process industries, but because they do not work and have so much potential for abuse, they have made and will continue to make the relationships worse rather than better. The perceived need for incentive schemes was created by sponsors squeezing contractor fees during the 1990s down to a point where many of the contractors were no longer viable. Realizing that contractors with no hope of making a profit were without much incentive to do a good job, owners started to incentivize the contracts. The more appropriate course in a professional relationship would have been to simply restore a reasonable fee.

Controlling Contractor Hours and Fees on Reimbursable Contracts

Contractor hours can be effectively controlled by means other than lump-sum contracts or incentives. The most effective is the systematic reduction and then elimination of all profit potential as hours become excessive. The approach works in the following way:

1. Negotiate target hours for the major work tasks: detailed engineering, project management (if any), field engineering support, and commissioning and startup (if any). This will be a difficult negotiation, and the sponsor needs to bring as much data from prior projects to the process as possible.
2. The target hours, plus approved change orders (with hours, of course), will earn full overhead contribution and fees. Fees will stop when the target hours are reached in any category. Alternatively, fees will stop when the total ceiling is reached, unless that ceiling is raised by sponsor-generated change orders.

3. Another increment above the target, say 10 percent, will earn full overhead.
4. Above 110 percent, no overheads whatsoever will be paid. The contractor will be paid only for out-of-pocket costs.

This provides the contractor with:

- A guaranteed fee
- A cushion above the target on which no loss is taken
- An incentive to never go more than 10 percent above the target because at this point he or she is foregoing other opportunities in order to complete your project

This approach provides fair and balanced protection to both parties. On reimbursable EPC and EPCm arrangements, the owner should want the contractor's profit to be made only in the contractor's fee. Unfortunately, that is often not the case, and unless the owners are careful, the fee may be but a small portion of the contractor's profit. Allow me to share a blatant example.

The project was a large onshore petroleum development project in a remote area. The project was technically straightforward. The big issue was going to be logistics and labor supply. Virtually all labor was going to have to be imported. The EPC contractor, as is often the case, executed FEED on the project. The project was estimated at \$1.2 billion. When IPA evaluated the project prior to sanction, two problems were identified. First, there was very poor granularity in the estimate, so it was difficult to conduct a sensible evaluation of the cost competitiveness of the project. Second, the EPCm contractor was asking for only a \$10 million fixed fee. That was less than 1 percent of the total project! It was particularly surprising to us because the contractor is well known throughout the industry for demanding high fees, so we were perplexed at the low fee and told the owner something was amiss. We were told, with a pat on the head, not to worry. Indeed, they were quite proud that they had managed to secure such a low fee.

The project was completed on time and on budget and had a smooth startup. It was apparently a very successful project. When we conducted the closeout evaluation, however, nobody could produce a coherent breakdown of the total cost of the project. The first

breakdown made no sense at all; five iterations later and it still made no sense. The lead sponsor had hired a third-party controls firm to keep track of the costs but had failed to ensure that the key people would remain with the project through closeout. We strongly recommended a complete audit of the EPCm's costs. And here is another problem: The sponsors had standard audit clauses in their contract with the EPCm for reimbursable contracts, but they had not actually used those audit rights throughout the project. When confronted with the demand for an audit, the EPCm contractor said, "Well, you can try, but because you didn't exercise any of the audit rights throughout the project, we didn't really keep a lot of the 'stuff.'" The attempt to audit the project was utterly hopeless.

That would have been the end of the story except that about a year later, I ran into the EPCm contractor's chief estimator and controller on the project, who was now working for an owner client of ours. I asked him how much the contractor cleared on the project over and above that \$10 million fee. He chuckled and said, "Just over \$250 million free and clear." They had made money on just about everything. Materials were marked up and every field hour generated a "fee" from the construction organization to the EPCm.

I would like to say that this story is genuinely exceptional, but I strongly suspect that it is not. If a sponsor is not in a position to carefully audit expenditures on a reimbursable contract, then sometimes money will disappear without a trace. Unexercised rights are lost no matter what the language of the contract says. Finally, third-party controls organizations can be very good, but they provide no benefit if they leave the project before the cost closeout reports are completed and all the loose ends cleaned up. Pay the contractors a good fee; audit to ensure that is all you pay!

WHY MEGAPROJECT ALLIANCES FAIL

There are a number of features of alliance contracting that are quite problematic for industrial megaprojects. Industrial megaprojects are quite complex from a technology perspective. This means that they are necessarily engineering-intensive—much more so than, for example, most infrastructure projects. Many of the projects examined in

this book are also inherently risky vis-à-vis operational safety. A majority of the projects involve huge hydrocarbon inventories that pose inherent safety risks.

This technical complexity means that quality in engineering, materials procurement, and construction is essential. However, quality in industrial megaprojects is often difficult to gauge in real-time without an extensive effort on the part of the sponsors. Engineering errors can render a plant unsafe or inoperable while being completely invisible to the naked eye. Equipment fabrication errors and incorrect or fraudulent metallurgy can do the same. To the extent sponsors believe that alliancing enables them to withdraw from very close and active supervision of quality, alliancing is very problematic.

If multiprime EPC lump-sum contracting thrives on the notion that "Good fences make good neighbors," alliance contracting believes in no fences at all. Alliance contracts are an extreme form of incentivized reimbursable schemes. The basic form is EPC reimbursable, so the same set of contractors stay on the job throughout. The twist is that all of the contractors share in the incentive scheme, usually proportionately to their slice of the entire project's estimated cost. The underlying rationale for this approach is actually rather elegant. Most megaprojects necessarily involve a large number of contractors, subcontractors, specialty contractors, and vendors. As I mentioned earlier, negotiating all of the interfaces among so many players is a major headache for sponsors in reimbursable formats and is even a major problem in multiprime EPC lump-sum arrangements. So, if we put everybody into a "shared destiny" pool, surely they will cooperate and manage the interfaces themselves. Even the sponsors will share in this pool. We are all in this together!

Unlike the rationale, the real world of megaprojects turns out to be quite messy. I have spoken to a great many contractors involved in alliance arrangements, and they have one thing in common: they privately but passionately despise the form. They believe that it completely breaks the relationship between what they do and what they get paid, rather than the opposite. Their point is simple: I may do everything right but end up with nothing because some idiot somewhere else on the project made a mistake! Some specialty contractors, such as heavy lift and installation, will categorically refuse to participate in

these schemes. It is the norm rather than the exception that the agreement on the incentive scheme in alliances was not finalized until well after the start of execution and sometimes long after the start of execution.

The designers of alliances also thought that they would get the best features of EPC lump-sum contract with none of the drawbacks. The advantages of lump-sum contracting are that (1) the contractors manage their own interfaces, (2) the contractors will put that legendary A Team on the project because it is their own money, and (3) the sponsors don't have to field as large of a controls staff as on reimbursable projects because the contractors have no incentive to crank hours. The downsides of lump-sum contracting are that (1) quality is always a problem, (2) we have to pay a premium for risk transfer that we usually never manage to actually effectuate, and (3) the contractors rather than the sponsor get to keep any savings. With an alliance contract, the reasoning goes, (1) we will get the A Team because the contractors have the possibility of making a lot of money, (2) the contractors will manage their own interfaces—just like lump-sum contracting—but we will get to share underruns, (3) we don't have to pay a risk premium because the basic form is reimbursable, and (4) quality will not be a problem. (I have never actually heard the exact rationale of this last bit on quality.)

So what do we actually get with alliance contracts? We actually end up with some of the worst features of lump-sum contracts combined with the worst features of reimbursable contracts:

- There is no evidence whatsoever that contractors assign more highly skilled and experienced people to alliance contracts than to other reimbursable contracts.
- We have, in fact, created exactly the same incentive structure to skimp on quality that exists in lump-sum contracts, which is evidenced by the fact that alliance-contract projects suffered the worst record of operability failures.*

*The early burst of enthusiasm for alliance contracting ensued before the operability problems of many of the alliance projects were understood. Operability data are almost never made public voluntarily, especially when they are poor.

- The interface management hypothesis is debunked by the fact that the contractors are actually *more* prone to fight among themselves, not less.
- As the data make very clear, there are rarely any underruns to divvy up. There were no underruns to share in more than 85 percent of the alliance projects!

The role of contracts is to:

- Define who is responsible and accountable for what. Good contracts define responsibilities very clearly. By defining responsibilities clearly, good contracts facilitate interface management, which is one of the most difficult areas of project management on megaprojects.
- Establish a useful mechanism for conflict resolution if difficulties arise.
- Provide a way that all parties working on a project can be *fairly and transparently* compensated for their work.

In a perfect world, having agreed on the contract, the document can be put in a drawer and never seen again. As we have seen, however, in industrial megaprojects, things rarely go entirely according to plan. When problems occur and it becomes necessary to pull the contract out of that drawer, the contract should help resolve the difficulties.

Alliance contracts tend to do none of the bulleted items listed above. Responsibilities and accountabilities are shared among all participants. But in practice this means that no one is actually responsible. The contractual approach was supposed to “dissolve the interfaces.” But the interfaces between contractors, and between contractors and sponsors, cannot be eliminated and when poorly defined become entirely unmanageable.

The worst feature of the alliance contract form is that it actually makes it more difficult, rather than less so, to resolve problems when they occur. Megaprojects are messy. There will be problems, even if everything possible has been done to prepare the project. When a problem occurs, the contract should be pulled out of the drawer, dusted off, and read for assistance in resolving the problems. Alliance contracts, because we are “all in this together,” do nothing to help us understand who is responsible and needs to step up and who is

not. Alliance contracts are the epitome of "shared risk." *Shared risk* is shorthand for "it's nobody's responsibility." The typical alliance contract is so complex that it cannot be used to help settle disputes.

The alliance-contract projects were understaffed by owners; in nearly two-thirds of the alliances, the project director described the project as insufficiently staffed. The alliances also had another feature characteristic of failure: "stretch" targets. More aggressive cost and schedule targets were set for the alliance projects than any other contract type. Part of the ethos of *alliancing* was that great things could be done via this new contract form.

The alliancing approach is becoming more popular for commercial buildings, especially health care facilities, and public sector contracting of infrastructure projects in the United States and Australia respectively.* This contracting approach results in "multiparty" agreements executed by the owner, architect, general contractor, consulting engineers, and specialty trade contractors. There have only been a handful of projects executed on this basis in the United States and the verdict is out as to its overall effectiveness. If enough money is stuffed into the estimates the projects can appear successful because very few alliance projects outside the process industries are benchmarked for cost. Likewise, for buildings and transportation infrastructure quality problems are not nearly as obvious as they are for industrial projects that fail to start up.

It may be that the use of alliancing in other industry sectors is less problematic than alliancing on industrial facilities. Nonindustrial projects are not only less technically complex, but the lead construction contractor self-performs very little and the lead designers are not part of the construction contractor's organization. However, given the sorry track record of alliances for megaprojects and for process facilities in general, I have to wonder if the successes of alliances in other areas are not more apparent than real.

*See Department of Treasury and Finance, Victoria, Australia, *In Pursuit of Additional Value: A Benchmarking Study in Alliancing in the Australian Public Sector*, October 2009. The approach is sometimes called "Integrated Project Delivery" in the U.S. context and "alliancing" in the Australian context.

WHY MIXED CONTRACTING SUCCEEDS

The orphan child of megaproject contracting is the mixed form, sometimes also called the hybrid approach. It involves separate contracting of engineering and procurement services on a reimbursable basis followed by lump-sum construction or fabrication with a construction organization. This approach was least used, but it was used at least once by every sector and in every part of the world. It was employed most frequently in petroleum development and in chemicals. As discussed previously, projects using this approach to contracting were much more successful than the average megaproject.

To discover that the mixed form was more successful was hardly a surprise. Prior research involving more than 2,800 processing facilities and petroleum developments around the world had established that the form was, by a substantial margin, the most cost-effective approach to contracting. Why does it work?

I believe there are several compelling reasons why the mixed contracting strategy is more successful than other forms. The mixed form breaks the contractual links between project engineering and construction or in the engineering and procurement world between engineering and fabrication, installation, and hookup and commissioning. Severing this link has a number of advantages. It reduces the engineering contractor's span of control, making the project more manageable. The focus is on engineering and engineering alone. It also prevents the engineering contractor from devising his or her project strategy so as to make extra profits from nonengineering activities.

The mixed form removes any incentive of the FEED contractor, who is usually the engineering contractor on non-EPC lump-sum projects, to pad the estimate or otherwise manipulate the incentive scheme. That frees up the use of incentives, if the owner so chooses, to be used for instrumental goals, such as low engineering error rates and appropriate sequencing of design. It also frees up the use of instrumental incentives for the construction firm as well around issues such as quality and proper sequencing of construction completion so as to facilitate turnover and commissioning.

The mixed strategy improves the quality of the construction management because construction management must stand alone and not be subsumed by the engineering contract. It forces owners to know something about construction management because they are going to be selecting the constructor/fabricator rather than relying on the engineering contractor to either provide that skill set in-house or contract it with minimal owner input. Many of the world EPC firms are much better at engineering and procurement than they are at construction or construction management. Most of the EPC contractors are engineering-centric organizations that have relegated construction to second-class status. Projects, however, are done better when engineering is construction driven. The mixed form does not ensure that will occur, but it does prevent engineering from simply dictating how the project will be executed.

A mixed strategy makes it much more likely that construction or fabrication will not start until the engineering and procurement effort has progressed far enough and well enough that construction will not be slowed by late, inaccurate, and out-of-sequence design and late and out-of-sequence materials. I return to this important subject in Chapter 12.

Finally, a mixed strategy is associated with much better front-end planning. The FEL index for the mixed projects was far better than any other contract form ($P |t| < .001$). In particular, both engineering and execution planning elements were far superior when the mixed strategy was going to be used. The reason for this link is simple: the mixed strategy must be planned early. The construction or fabrication contractors have to be prequalified, which forces the sponsor team to know (or learn) something about construction management.

Mixed Contracting and Understanding Construction Management

EPC contracting, both lump-sum and reimbursable, has one very dubious virtue for sponsors: It enables them to contract their megaprojects while being almost entirely ignorant of what constitutes effective construction management. When contracting EPC, sponsors usually get whatever constructors their engineering firm wants or can

manage to get. Often, the construction arm of that engineering firm we really wanted is far from first rate.

This book is not the place to discuss the intricacies of excellent construction management. But sponsors must realize that excellent construction management may be the difference between success and failure, and in regions with labor shortages, it is the difference between success and utter disaster. If a sponsor is going to be capable of using the mixed contracting strategy, the ability to select effective construction managers is essential.

I consider the following areas of knowledge to be the backbone of effective construction management.

- **A modern safety system**

Ideally, the construction management on a megaproject will employ a modern, positive-reinforcement-based safety program and will work with the sponsor team to ensure worker safety. What we are actually seeing on too many sites, especially in low-wage regions, are systems designed to minimize accident reporting.

- **Sequencing of design and materials delivery**

The excellent construction management organization can examine a project and explain in detail the sequences that must be followed in the delivery of design and the ordering and delivery of equipment and materials to the construction site. Proper sequencing will drive field labor productivity more than any other single item. The quickest way to depress field productivity is for workers to have nothing to do.

- **Materials management**

Megaprojects usually involve billions of dollars' worth of equipment and materials. One of the most common problems on megaprojects is not being able to locate materials when they are needed for construction. Many projects end up ordering items more than once because they can't be located, only to end up with millions of dollars' worth of surplus material at the end of the project. At some sites, material walks off the site at the end of every shift because the lay-down yards are not secure.

Materials management and all of the logistics that go with it are very complex systems for megaprojects. They may require

modern technology such as radio frequency identification (RFID) and global positioning system (GPS) location finders. Whether low tech or high tech, a great deal of skill and experience is essential.

- **Hiring of craft**

The construction management organization on a megaproject absolutely must know how to acquire craft for the particular site. They must know the local norms. They must know what kinds of craft can be brought into a country or an area and which cannot. They must know where to source first-line supervisors. Conflicts between local labor and imported first-line supervision can shut sites down. In one of our projects, the animosity actually led to murder of first-line supervisors.

- **Productivity measurement and problem identification**

The effective construction management organization must know how to monitor productivity down to the gang level. Their systems must enable rapid aggregation of productivity so that the construction management organization itself at a minimum knows what productivity looks like on a weekly basis. The effective construction management organization has a system that signals immediately, not months down the road, when an area is falling behind and identifies the problem as materials availability, changes, or craft skill immediately.

- **Construction management staffing**

The construction management staff above general foremen should be at least 50 percent from the permanent staff of the construction management organization. If more than half of the construction management organization has been recruited from the street, you are not hiring a competent construction management, just a collection of people.

- **Construction management systems**

The sponsor needs to understand what systems will monitor and report progress; how system completion and turnover will be ensured; how materials management will be done; how tools quality, appropriateness, and availability will be ensured; and how work package planning will be done, including safety planning and backup task planning.

THE USE OF A PROJECT MANAGING CONTRACTOR (PMC)

The PMC arrangement involves hiring a contractor that will act for the owner team or augment the owner team in managing the execution of a project. PMCs were employed by 15 percent of the projects in our sample and were used with every contract type, in every region of the world, and in every industrial sector. Projects with PMCs were not substantially different than other projects. They were a little more likely to be onshore projects, but a good many of the PMCs were in petroleum development.

The projects that used PMCs were considerably more likely to fail than those that did not ($P > |\chi^2| < .03$). Their schedule performance and production attainment success were average, but their cost and cost growth performance was terrible. Projects using PMCs averaged a 40 percent real overrun and were highly uncompetitive in capital cost (+38 percent). They were a little poorer in FEL completeness at authorization, but that can account for only a small portion of the very high costs.

They were especially expensive when the execution contracts were EPC lump-sum and when alliances were used. I believe the reasons for these results are similar. The use of a PMC arrangement is met with great skepticism by the other contractors working on the project. The PMC is in a very powerful position to shape the destinies of the other contractors. If you believe that contractors don't trust owners, you are right. But they *really* don't trust other contractors! And if the PMC was also given part of the execution work on the project, as they were in a majority of cases, the distrust among the other contractors goes off-scale.* They believe the PMC will use its close ties to the owner and its position at the top of the project to make the execution of the project easier (and more profitable) for the PMC and harder (and less profitable) for everyone else. As a result, on EPC lump-sum projects, the lump-sum contractors are bidding higher than you would otherwise expect.

*There were even cases in which the PMC was contracted on a reimbursable basis for PMC work while executing work on an EPC lump-sum basis on the same project at the same site! This, of course, violates the first rule of sensible contracting.

Is this distrust justified? At least some of the time, the answer appears to be "yes." On some projects, the PMCs routinely disparaged the work of the other contractors to the owners. There were a number of complaints from other contractors about control of the lay-down areas for construction. And in some cases, the PMC was quick to encourage the owner to replace execution contractors who were struggling . . . with themselves!

I am not sure that PMC arrangements can ever be used cost-effectively on large projects. I realize that this creates a real problem for some owners who simply do not have sufficient personnel to staff their megaprojects. If you have to use a PMC, I would make the following suggestions:

- Never allow the PMC to take any portion of the execution and make it clear to every other contractor that under no circumstances will the PMC be allowed to take on their work.
- Call the PMC something else, owner support services, for example.
- If at all possible, seek to blend the PMC into the owner team, with the owner team taking the key lead positions, such as sub-project managers.
- Rather than using a tier 1 international contractor for this role, seek out second-tier contractors or large contractors that do not take on EPC lump-sum international work. What is needed is a source of skills to support the understaffed owner team, not an organization that will take over the project.

OWNERS AND CONTRACTORS LIVE IN DIFFERENT WORLDS

Despite the fact that many owners and contractors spend large portions of their careers seated right next to one another, I am convinced that most owners and contractors fundamentally do not actually understand one another. In particular, I think owners imagine that contractors are like owners. I suspect most contractors think that owners are from another planet.

This was brought home to me a few years ago during a conversation I was having with the director of capital projects for one of

the major international oil companies. This was no newbie; he had 30 years of project experience in petroleum development projects all over the world and a well-earned reputation for being deeply cynical. He said to me, "I just don't understand why these darned contractors won't take on any risk, and when they do, they can't manage it. It really irritates me!" I was so amazed at his naïveté that I was struck dumb. Those who know me will testify that doesn't happen often.

When it comes to perceptions of risk, owners and contractors live in completely separate worlds. As the expression goes, where you stand depends on where you sit. Owners complain that contractors don't want to take on any risk, which they equate to responsibility, and that when contractors do, they want inordinately high prices for taking the risks on. Contractors believe that owners are pushing them to bet their business on every project and would push them into bankruptcy without a second thought.

The different views spring directly from the differences between industrial companies and contractors as economic entities. Owner/sponsors look at the world from the viewpoint of assets. Each project involves the creation of a new asset or the expansion and enhancement of an existing asset. How much cash flow the asset can generate relative to its cost determines the value of the project. Owner companies are judged in the marketplace by that calculus overall. Their balance sheets are "asset heavy."

By contrast, contractors are at the other end of the spectrum. They are almost devoid of physical assets. Their balance sheets are asset light and are asset light by design. Very few major contractors even own their headquarter buildings. Contractors earn primarily by the sale of services. They are judged in the marketplace by how well they avoid taking large equity risks as they earn fees from their services.

The difference between contractors and owners with respect to risk taking can be illustrated with a simple mental experiment. Let's take as an example the average failed megaproject in our database. The project was estimated to cost about \$3.1 billion (in 2009 U.S. terms). That average failure suffered a 33 percent overrun, roughly \$1 billion. Now let's suppose that one of the world's major contractors took the entire project on as an EPC lump-sum contract. If successful, it might have hoped to earn about \$100 million from the project, but it wasn't

successful and they suffered a \$1 billion overrun. If the sponsors were careful, the contractor's hope of recovering the losses via claims will be dim. Where does the \$1 billion come from? It is deducted straight from the company's balance sheet. What would the effect be on a very strong contractor such as KBR, JGC, or Aker? It would remove every bit of cash from their balance sheets and more!⁶ The loss would exceed the net operating cash flow of Fluor or Technip for 2009. It would do the same to most other major contractors around the world. They would find themselves scrambling to find credit to avoid insolvency.

Now, let's suppose that the owners had to "eat" that \$1 billion overrun. What results? The return on that asset would decline from about 15 percent to about 5 percent. That is a very disappointing result for the investment, but not catastrophic, unless it was a very small owner. The \$1 billion overrun, however, would be *added* to its balance sheet as an asset.

The economic differences between owners and contractors generate fundamental disagreements about how project risks should be priced by contractors. But in this regard, the contractors surely have the better of the argument. The first principle of risk pricing is that the price attached to a risk will be a function of the bettor's wealth vis-à-vis the size of the bet. In these bets, the contractor is almost always the poorer of the two parties to the contract and therefore *should* attach a significantly higher price to the risks that it takes on. Moreover, when taking on risks, it is economically rational for the contractor to seek to find ways of mitigating those risks.

Contractors equally do not understand owner's needs around creating operating assets. In my experience, contractors focus too narrowly on meeting targets on cost and schedule and attach little value to turnover sequencing and successful turnover of the asset to operations. These shortcomings should be expected given their orientation. Interestingly, construction organizations often appear more sensitive to the needs of turnover and commissioning than the engineering contractors.

Some "new and improved" approaches to contracting are based on the premise that with the proper contractual structures, the differences between owners and contractors can be bridged and goals aligned. I believe, and the data strongly support, that the differences cannot

be bridged. The contractual platforms such as alliancing are actually highly unstable because they cannot actually ensure that contractors will be fairly and routinely compensated for their work. Similarly, most incentive schemes are transparently easy for contractors to game or again end up failing to compensate contractors for their work.

Both owner personnel and contractor personnel come to work each expecting to do their best on their project. Both need to be compensated for what they do. At the end of the day, it is not at all clear that we should want contractors to "think like owners" or owners to "think like contractors." Owners need to focus their attention on asset health and quality. Contractors need to focus their attention on execution excellence. Owners and contractors are different. Understanding, appreciating, and supporting those differences are essential for successful projects.