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After the Dust Settles – Exploring Common Causes and Cures of Mega-project Failures

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ABSTRACT— Far too many mega-projects have failed because of recurring root causes. These causes include: (1) First of a kind (FOAK) projects, either in terms of new technologies or scale; (2) Insufficient information to develop effective project controls and schedules; (3) Design schedules, scope and schedule creep; and (4) cultural differences, whether inside the organization or outside. When one or more of these conditions exist, careful planning at the earliest stages; contract drafting at the risk allocation stage; implementation of certain project management techniques; and early intervention with a variety of dispute resolution techniques can avoid or mitigate costly litigation or arbitration – even before the dust finally settles.

A panel of arbitrators with professional lifetimes of experience dealing with global mega-projects will: (a) explore common root causes of project failures; (b) suggest what changes could have been made at the project planning stage to avoid failure; (b) explain various contracting options to avoid or mitigate risks; (c) discuss practical options during the project to correct or mitigate impending failure; (d) identify various options short of litigation and arbitration to resolve project disputes.

Common Causes and Cures – Planning Stage

Distinctive Aspects of Mega-projects

Mega-projects are generally defined within the industry as very large-capital investment projects that attract a high level of public attention or political interest because of substantial direct and indirect impacts on the community, environment, and companies that undertake such projects.[1] The projects are typically so large that not one company can provide sufficient resources and personnel for all aspects of the project. Nor can a single company afford to finance or absorb all the risks associated with a project of such large magnitude over an extended period of time – a period in which most of the original project team may not even be around to see the ribbon cut at final completion. Typical attributes of a megaproject include:

- Cost above $1 billion USD
- An extended project schedule (greater than four years measured from initial concept development to final completion)
- Multiple and multi-national involvement of designers, engineers, contractors, equipment suppliers and specialty material vendors

- Multiple specialty trade contractors and specialty trade workforces numbering in the thousands of individuals
- Execution of an engineered facility, structure or asset which is technically complex or unusual
- Consortium financing and/or ownership, with multiple, multi-national project stakeholders and investors
- Government involvement with enhanced political dimensions and risks, and
- Cultural and social differences and risks.

As each mega-project features its own complexities and the environment in which it is executed there is often a lack of suitable benchmark projects. It is well known that no two megaprojects are alike, and therefore, such projects cannot be compared. Nevertheless, there are common denominators with respect to cost development and typical underestimation of costs during project appraisal.

Cost overruns occur on almost every mega-project. Without doubt, it can be said that the main cause of cost overruns is the lack of realism in initial cost estimates. Generally, initial cost estimates do not account for changes in project specifications, changes in design, delays and cost of delays, as well as changes in exchange rates among currencies, financing arrangements and safety and environmental demands. Cost underestimation and overruns cannot just be explained by clerical errors and seem to be best explained by strategic over-optimism and misinterpretation of the need, scope and cost of the projects. The usual focus is to get the project underway, then deal with problems as they progress.

At one point in time it was believed that projects executed in the public sector were more prone to cost overruns; but with privately owned, privately financed, and privately-operated projects, the phenomenon of cost underestimation and overruns would disappear — for example, by inducing more discipline and accountability in the planning and execution stages. However, the data indicate, whether the project is managed and executed within the public or private sector or as a public-private partnership, the dual phenomena of cost underestimation and resulting overruns still occur.

While there is some commonality, the challenges faced on a typical construction project are several orders of magnitude less challenging that those faced on a megaproject. The technological complexities, in and of themselves, mean that each mega-project presents unique challenges, any one of which may have a direct bearing on the context within which the management of a project should be examined and judged.

Management of Mega-projects

The management of a mega-project is more challenging than the management of a typical construction project. For example, in a megaproject there is simply not a “one-size-fits-all” or “best” methodology for sub-contracting for the numerous different sub-scopes of work required in a mega-project. The sheer size and complexity of most mega-projects generally results in an execution methodology that involves multiple delivery methodologies and contracting approaches. For example, the specialty trade elements of a process or power generation mega-project may cost more and take longer than the average construction project, requiring the use of multiple specialty trade contractors, each working on an element of the whole and each under a different tailored contractual agreement. A typical construction project may hire one specialty trade contractor to execute the entire scope of that specialty work. But, on a mega-project, management will have to work with multiple contractors to gain sufficient resources to execute that trade specialty scope of work.

Mega-projects are primarily delivered using methods known as Design Build (DB), Engineer-Procure-Construct (EPC), construction manager at risk (CMAR) or construction manager/general contractor (CMGC). Often these approaches are referred to as alternative delivery methods as opposed to the more traditional approach of Design-Bid-Build (DBB). In each case the designer and builder have a relationship that allows for substantial collaboration and interaction, as opposed to the relationships that are formed under DBB where the owner develops the design without substantial input from the contractor who will build the facility.

And, there is the time factor. It is a given in life that the further one attempts to see into the future the less reliable one's predictions of future conditions will be. The same given applies to mega-projects. The only thing anyone really knows for certain about the future, insofar as a mega-project is concerned, is that there will be changes which will impact the planned execution of that mega-project, and these changes must be managed.

The two primary factors in successfully planning and executing a mega-project are (1) how well the megaproject is managed; and (2) establishing and maintaining control during planning and execution. Management and control are two different, yet interrelated, factors on which the ultimate success of the megaproject rests:[2]

Management is best defined within the Project Management Institute's (PMI) Body of Knowledge: Project Management is application of knowledge, skills, tools and techniques to project activities to meet project requirements. PMI then identifies 42 "logically grouped project management processes"[3] that form the application platform from which project management activities and actions are taken. (PMI 2008) Essentially, project management is a process (or set of processes) employed to guide and focus work towards achievement of goals which have been set for the project.

Control however is not so easily defined. According to *to exercise restraining or directing influence over; Black's Law Dictionary* control would be "*To direct or indirect power to govern* …" the planning and execution of a megaproject.[4] In more common usage, control means to "*to exercise restraining or directing influence over;*[5] Within megaprojects, and all construction projects, control means primarily to *hold in check*, to prevent such things as cost overruns and schedule delays or to maintain minimum required quality.

Why is this distinction important? Simply because one can *manage* a mega-project well, using all of the best available tools and processes, and yet still fail to exercise *control* over the mega-project during planning and execution. Such failure almost always results in the mega-project failing to meet its scope, cost, schedule and quality goals. Inattention to either management or control at any point in the project execution can have devastating impacts on the success of the megaproject as a whole.

First of a Kind (FOAK) Mega-projects

One often recurring cause of project failures are first-of-a-kind (FOAK) elements via technology, equipment and/or various components. Mega-projects that are one-of-a-kind, by definition, do not have typical historical cost records and data from which to develop a basis for estimates or projections so as to understand whether the technology, the design, the equipment or the components will actually perform to the "theoretical" calculations that formed the basis of the prototypical engineering concepts.

There are good examples and good reasons for wanting to proceed with FOAK projects. For example, in the early

2000s', the United States Government believed that with its rich and extensive reserves of coal deposits, proceeding with technologies that allowed integrated gasification, combined with combined cycle power plant technology (IGCC), would allow utilities to utilize coal deposits while producing power with significantly less harmful air emissions. But, even though small pilot projects, such as the TECO-IGCC project in Florida, produced economic power at 250 MW, when scaled up to over 600 MW, the impact of that scale up had an unforeseeable and negative impact on the estimated price and schedule. The result was an operating plant, but late on the schedule and with cost overruns of over $1 billion.

Another example was a different IGCC technology, which again based its technology on successful small-scale pilot plants. Yet, the scale up when combined with the unknowns of interconnecting pieces of equipment finally resulted in billions of dollars of cost overruns, coupled with shareholders having to absorb those cost overruns. The end result was a decision to abandon the integrated gasification portion of the plant using only the combined cycle portion of the project to generate electricity.

The question who bears the liability and cost of FOAK impacts becomes even more complicated when there are several parties involved in the engineering planning, typically involving the Employer, the manufacturer of equipment, the designer of the technology and the constructor, all or some of whom may typically be in consortium with the designer who is constructing the FOAK project.

The most effective way to achieve a successful FOAK or complex design that meets the Employer's requirements and is constructible is to involve both the Employer and the constructor in the design process from the beginning, so as to better understand expected scope, responsibilities and allocations of risk. Attempting to reduce the cost of a mega-project by reducing engineering staff too quickly, or to a level that cannot efficiently and effectively support construction, can cost more than it can save the mega-project.

Project Change and Evolution

The typical construction project is developed in several discrete stages, the most common of which are Initial Project Planning, Engineering/Design, Procurement, Construction, and Commissioning. There may be additional stages, such as testing and start-up of process systems, but almost every construction project includes these basic stages. Within the construction industry there are two methods by which one can stage the execution of a project:

(1) One can move sequentially through those stages generally in the order in which we have listed them, or

(2) One can overlap those stages, initiating each subsequent stage as the preceding stage reaches a point at which it can maintain a lead over the subsequent stage — which is generally referred to in the construction industry as a "fast-track" project schedule.

In a typical construction project, the Employer and constructor have some flexibility as to which sequencing method they will follow over the execution of the project. Mega-projects, from a practical perspective, do not have the same choice for project sequencing. Virtually, all mega-projects are executed on a fast-track schedule, simply due to the fact that sequential staging adds a tremendous amount of time to the already lengthy duration to complete a mega-project. As noted above, the more time it takes to execute a mega-project the less reliable the future project condition predictions. And, the less reliable the future project condition predications, the higher the probability that those conditions will change.

Managing Scope Creep[6]

When design is not well managed and design changes ensue, scope creep is introduced. Not surprisingly, the impacts that can occur on a mega-project is significant. Everyone involved with construction projects generally understands the phenomenon of "ripple effect". For example: the delay to the delivery of a needed commodity will "ripple" through a particular string of schedule activities necessary to complete a specific element of the full scope of work. Ripple effects are likewise common within mega-projects, but which exhibit another effect which we call the "*ricochet effect.*" In fact, it is almost impossible to introduce a significant change into one element of work in a mega-project which does not have some *unexpected and unintended impact* on some other element(s) of work in the mega-project. While ripple effects are generally isolated to a particular string of logically related activities within a scope of work, a ricochet effect can bounce through non-logically linked activity strings in unexpected and unpredictable ways all of which can result in unintended impact consequences for those other activities and often the entire project.

Change management cannot remain a more or less *ad hoc* activity during which only involve those directly responsible for planning and managing the activity. When a change in any work activity string is contemplated, then it is wise to designate "change representatives" from each of the primary participatory stakeholders who can be actively involved in examining the change. Their particular responsibility will be to determine if there are any ricochet effects which would impact other activity strings thought to be outside of the impact zone of the change.[7] If any such ricochet effects are identified then the cost and schedule estimates for that change, and the planning to execute the change, need to reflect the ricochet effects.

Controlling cost on mega-projects requires that project management transition from a *reactive based* cost management to a *predictive based* cost management. There are three "givens" when it comes to controlling cost on mega-projects.

- First: cost on a megaproject cannot be definitively estimated – for the very simple fact that no one can foresee economic conditions 4 to 7 years (or further) into the future. In the last ten years it has become abundantly clear that the typical historical factors (*i.e.,* average escalation over the previous five years in the construction industry) are not reliable indicators of future economic conditions.
- Second: "the economy" is no longer confined or defined by local, national or even regional location; what happens in one region of the globe can (and does) impact the economy in every region of the globe.
- Third: there is nothing that anyone can do to control the first and second "givens", including mega-project estimators and project managers. However, participatory stakeholders can stop making the situation worse by overoptimistically "assuming the best possible outcome" at the start of every mega-project.

The hard reality is that there is no basis in fact for a "*promised cost*" to the participatory stakeholders. No matter how often the term "estimate" is used on a mega-project, the only two realistic data points that can be relied on by non-participatory stakeholders are the original total cost, handed out in the promotional materials, and the actual final cost at the end of the project. Hence, the very first action to take in controlling "cost" is to do a better job of setting non-participatory stakeholders cost expectations. Never give "a number" from which a single promised cost is assumed. Risk models should provide the participatory stakeholder with a probabilistic range of cost results depending upon certain assumptions. Planners should simply provide the range, together with the primary factors which *explain the range* from best case to at least the most probable case. Then describe how project management intends to exercise control over that which it has control.

Cost control is not the same thing as cost accounting. Cost accounting tells project management where it's been by reporting where money was expended and compares the costs to date against the control budget. However, once an expenditure has been made and is accounted for, it is history, and even the best project management team cannot control what has already happened. Unlike cost accounting, cost control is focused on *where the megaproject cost is at a specific point in time and forecasts where it will be at given points in time in the future based on current conditions, evolving expectations, and cost performance on the megaproject to date*. Project computerized cost control tools are amazingly powerful and sophisticated and if properly populated and used can provide project management with cost data in almost real time. Such tools can also perform any number of "what if" forecast scenarios from which project management can chart a cost course through the megaproject.

Managing Schedule Creep

Unlike cost management and control – two distinct elements, schedule management and control are encompassed in one master document which reports where the mega-project has been, where it is headed, and the plan for completion of the Project. From that perspective schedule data is more easily captured, recorded and distributed than cost data. However, the fact that the data is encompassed in a single schedule may also be one of the significant weaknesses when attempting to exercise control over "the schedule." This is because of the nature of scheduling and preconceptions relative to CPM scheduling which have been set over years of experience with CPM scheduling on "typical" construction projects. For example, unlike a typical construction schedule:

- the megaproject schedule will encompass a much longer total duration than the typical project
- the mega-project schedule will cover a broader, more complex scope of work
- the megaproject schedule will most likely involve initial input and updating from a higher number of participatory stakeholders
- the megaproject master schedule is not easily converted into a document which can be used by separate participatory stakeholders to actually plan, manage, and control their own individual scopes of work.

The first schedule control point is to recognize that developing a schedule for a mega-project is an iterative process which necessarily involves input and by-in by participatory stakeholders, all or some of whom may not be known until planning is underway or complete. Consequently, mega-project management is often forced into the position of prematurely trying to forecast a completion date, without having the details which would confirm the reasonableness of the completion date, which, of course sets the stage for stakeholder frustration.

The second schedule control fact is that optimistic bias is actually built into the schedule in the form of the critical path, which assumes no float in that critical path schedule. However, as much as cost is impacted by events and issues completely outside of management's control, schedule is even more vulnerable to such impacts as they can flow from something as catastrophic as an earthquake or as seemingly benign as having to move a heavy haul crane more times than expected.

The third schedule control fact is that schedule is much more sensitive to both ripple effects and ricochet effects than cost, which makes both identification, trending and forecasting more complicated as those effects may pass through hundreds of different and even seemingly unrelated activities on a given megaproject.

Fortunately, some of the most powerful planning and control tools available to project management are specifically designed to address planning, managing and controlling schedule on what is essentially a real time basis. Those sophisticated schedule and control tools, operated by enough properly trained and experienced schedule control staff, provide project management with both a sound trend and forecasting capability. Most often, however, the problematic issues are not in the tools, but failing to use the tools effectively.

Managing Cultural Differences

Although effective schedule and cost control are crucial to the success of the mega-project, effective management also requires knowledge about dealing with people, organizational options, and communications. Cultural factors may differ significantly in the diverse cultures which exist around the world. For example, an examination of cultural perspectives of engineers and constructors from Japan reveals that the Japanese consulting engineers have traditionally designed and constructed projects in a different manner than that of their counterparts in the United States and Europe (collectively the “Western Nations”). These differences are typically reflected in management and operation methods and have primarily been based upon Asian values, which from a cultural perspective are quite in contrast with the values perceived to be important in the Western Nations.

One of the most significant cultural differences, for example, resides in the difference in perspective between the Japanese contract management basis of “mutual trust” versus the Western Nations contract management basis of “mutual mistrust”. This dichotomy is a major contributor in Japanese consulting engineers having difficulties managing multi-national mega-projects with a high level of Western Nation stakeholder participation. Simplistically, “mutual trust” assumes that regardless of what a contract document might state, the parties will ultimately resolve issues “fairly” once the mega-project has been completed. “Mutual trust” leads the Japanese consulting engineer to resist preparing formal written notices of impacts, regardless of what the contract document may require. The assumption by the Japanese consulting engineer is that everyone is fully aware of the impact issue, and that the Employer will, in fairness, adjust the cost and/or schedule requirements contained in the contract in recognition of those known impacts. To submit a formal notice is seen as an insult, implying, for example, that the Employer will not act “fairly” or honorably.

While our example was based on one country, Japan, and one region, the Western Nations, such differences in cultural perspectives exist around the world, and among all countries. Mega-projects by their very nature are seldom owned, financed, planned, executed, and operated by stakeholders residing in a single country. Mega-project management structures by their very size, breadth and complexity involve stakeholders from different countries, each with a different cultural perspective which influences how that stakeholder executes their role within that particular management structure. Success of multi-national mega-projects demands that those stakeholders recognize, and proactively work through, those cultural differences. In particular, project management should ensure that it has sensitized the control staff to the possibility of cultural differences and established processes and systems which address the areas where such differences are most likely to arise:

- *Miscommunication across cultural lines* is usually a primary cause of cross-cultural problems. Miscommunication can have several sources, including differences in body language or gestures, different meanings for the same word and different assumptions made in the same situation.[8] Different languages also contribute to the problem, and frequently, the language barriers seem to be ignored, creating confusion and a sense of mistrust among the parties.

- *Differing approaches to problem solving* is another source of cross-cultural problems. The approaches used by engineers and project managers of different cultural backgrounds to tackle the same technical problem are likely to differ widely. The type of approach used to solve engineering problems is often a reflection of what is emphasized in educational curricula leading to engineering degrees in various countries.
- *Differences within organizational cultures* can also be problematic. Large companies operate quite differently from small companies, and the same occurs as between government entities and private ones. Some of the most noticeable differences include: the way information is shared and distributed, the hierarchy of departments, approval and decision-making processes. Large firms, as well as government agencies have the tendency to be more bureaucratic.

In order to overcome cross-cultural differences, all stakeholders need to be aware of these differences from the onset of the mega-project. Successful communication is essential, including clarification to ensure that the team players understand everything that needs to be done, as well as getting into the details to avoid the temptation of agreements based on general principles that can create major problems in the long run. At a minimum, training is required with respect to doing business in a given country, as well as doing business with people with different cultural backgrounds. Selection of the right people and with the right attitude towards international and multinational assignments should be a top priority of the executive team. Executives, senior management and management teams should include at least one person originally from the location where the project is to be executed and staff which have experience working with the other cultures represented within the participatory stakeholders on the megaproject.

Common Causes and Cures – Contracting Stage

It is not prudent to discuss legal considerations regarding mega-projects in a vacuum. Strategic objectives and risk tolerance must shape the legal considerations at each stage of the life cycle of the project. Construction lawyers work with all disciplines, including operations, engineering, procurement, finance, project controls and risk assessment. Construction lawyers also work in several roles: to assist with the planning and development of the project, to refine the scope of Work, to select the appropriate project delivery system, to negotiate the relevant contracts, to document the transactions, to provide advice and claims avoidance strategies during the execution of the contract, and, finally, to assist with project closeout and resolution of disputes, if any.

While axiomatic, contract negotiations are, at their core, the negotiation of the risk matrix for the project. Assumption of additional risk in exchange for the payment of additional money or risk premium does occur, and, most efficiently, each risk should be borne by the party best able to manage that particular risk. It is very difficult to allocate risk and establish a risk matrix for the project unless the foreseeable risks are identified pre-contract and expressly allocated to one party or the other during the contract negotiation process.

Project Delivery System

The importance of selecting the appropriate mega-project delivery system cannot be overstated. There are a variety of project delivery methods on mega-projects,[9] including the one-stop EPC or “turn-key” model, the multiple Contractor model, the Employer’s performance of all or some of the engineering or procurement functions, or the Employer’s responsibility for the engineering, procurement, and construction functions through a cost-reimbursable model. Each approach presents certain advantages and disadvantages, particularly with respect to financial risk, project management responsibilities, and cost control. It is fair to say that the contracting relationships, and the resulting allocation of risks, are defined by the project delivery system.[10] Consequently, the project delivery model must be carefully considered and evaluated to ensure that a proper project delivery method is selected for this particular project, this owner, these financing parties and stakeholders. The failure to select an appropriate project delivery system can be the death knell to a mega-project and can have disastrous financial consequences to all involved.

EPC Consortiums

Given the size, complexity, and duration of mega-projects, EPC consortiums have become the preferred and most common method used for projects of that scale.[11] Using the EPC consortium arrangement, the Employer contracts with a consortium on an EPC basis, while the consortium participants internally allocate responsibility for development and execution of the project among themselves. The consortium participants are generally jointly and severally liable to the Employer or Owner, with allocation of responsibility for schedule, costs, and performance for consortium partners addressed in the consortium agreements. A typical collection of participants forming an EPC consortium could include one or more major equipment suppliers, an international engineering firm, and multi-national contractors, and local market contractors.[12]

The EPC consortium allows each of the consortium partners to pool their resources and knowledge in an effort to effectively complete the project, but requires a heightened level of communication and coordination among the consortium members. This method contemplates a single line of communication between a designated representative of the consortium and the Owner, and a separate and distinct internal line of communication between the designated representative of the consortium and the designated representative of each participating members of the consortium and potentially their subcontractors and suppliers.

There are a number of risks and challenges associated with an EPC consortium, each of which must be identified and addressed in order to achieve a successful project. Two of the primary challenges facing consortiums are differences in culture among its members and differences in approach to a project.

EPC Consortiums – Cultural Differences

EPC consortiums are typically composed of members that are based in different countries and which come from different legal traditions.[13] The presence of these fundamental legal and cultural differences can present increased difficulty with communication and in achieving consensus and agreement regarding the development and execution of the project. Aside from the potential communication-language barrier, varying business practices and approaches stemming from each members' culture can present significant obstacles if not dealt with directly and affirmatively. For example, on a large fossil fuel power plant, the design and major equipment for the boiler works may come from Japan, while pipe and structural steel for the boiler works are supplied to the boiler OEM from China and eastern Europe. The design and major equipment for the air quality control system may come from France, the design and major equipment for the turbines and related scope of supply may come from Germany, and the balance of plant design and civil design is subcontracted to a local engineer, while structural steel, miscellaneous metals, and other supplies come from China, Asia, or other regions of the world. The Contractor, and its project execution, project management, contract management, and project scheduling and controls teams may come from the United States. Under this scenario, the consortium must clearly define the responsibilities and potential liabilities of each participant, and must ensure that each participant understands the unique nature of constructing a megaproject in the local region. Each country or region has many unique features that must be clearly understood, anticipated, and managed if a project is to be successful. Labor unions rules and the price of labor, for example, may be a significantly larger cost in the United States and Canada than it may be in Japan, China, Latin America, or other areas of the world. Consortium participants that typically work in parts of the world with low labor costs may not commonly face the same demand for labor efficiency and competition for skilled resources that is present in the U.S. Many of the mega-projects, in particular, power projects, that have been built in the U.S. and Canada in the recent past have experienced enormous overruns in labor hours and labor costs. Typically, these cost overruns resulted from schedule delays as a result of late or incomplete engineering or late, incomplete, or out of sequence equipment supply, all of which resulted in a shorter duration for construction. Constructors added crews and worked overtime, often on an extended basis, and also added second or third shifts, leading to significantly higher labor costs than originally anticipated. Because the number of the craft labors significantly increased (doubling or more in some cases), extended travel and lodging were required on most of these projects, further adding to the cost of labor and stressing the capacity and quality of labor pool.

Similar issues have existed with large multi-national contractors performing work in regions remote to their base of operations. A number of contractors have encountered significant issues with the quality of foreign labor contracted to the project. To offset issues with foreign labor, contractors may significantly increase the number of expatriates dedicated to the project, causing an increase in overall labor and staffing costs. Other issues, such as fundamental differences in project scheduling and project controls, can create significant difficulties among consortium members from different cultures and backgrounds.

EPC Consortiums – Differences in Experience and Approach

EPC consortiums often include a collection of participants that have had significant successes on EPC projects and have developed certain approaches and methods that have proved to be “the right way to do it” through their respective experiences. This blending of knowledge and experience is one of the benefits of the consortium, but it also presents practical difficulties in executing the project because there is normally not necessarily a singular entity guiding the project. The consortium partners must identify and discuss their respective experiences and approaches prior to consortium formation, and they must establish communication and chain of command processes so that the consortium can decide which approaches are best suited for the successful completion of the particular project. The consortium must designate a Project Representative who shall have the singular responsibility of interfacing with the Employer on behalf of the consortium. Selecting a qualified and experienced Project Representative to interface with the Employer, while at the same time effectively communicating within the consortium, is critical to the success of the mega-project.

Another example of differing experiences has to do with the approach to project controls, project scheduling, and cost management. Different organizations may have different approaches to project controls, scheduling, and cost reporting. In addition to the tracking that is performed at the member level, the consortium must have a unified approach to project controls, scheduling, and cost management. This requires a team that is employed by the consortium to monitor and report on behalf of the consortium. Independence from the individual participants is highly desirable, and transparency with the Employer and the EPC participants yield the highest likelihood for a successful project.

It is particularly important to fully consider all aspects of project controls prior to negotiation of the Contract. The Employer must fully develop its own internal controls and reporting requirements, as well as the reporting requirements of the financing parties and the “independent engineer.” The Contract must consider and integrate these project controls and project reporting requirements with the information being provided to the Employer by the Contractor. This integration is typically handled through detailed appendices to the Contract which provide specific requirements for schedule, cost, quantities, progress, and other performance metrics. The appendices also typically address the requirements for demonstrating entitlement to any extension of contract time and/or contract price, including the requirements of any schedule analysis or time impact analysis. In many cases, the appendices will incorporate recommended standards, protocols, and practices, such as those of the AACE International (AACEI) or the Society of Construction Law (SCL).[14]

Proactively identifying cost and schedule issues and trends allows the parties to evaluate mitigation options and other strategies to minimizes schedule and cost risk on large capital projects. It is worthy of note that some of the information that the Employer requires to proactively manage the project execution is exclusively developed by the Contractor.[15] The process of integrating the information and submittal requirements of the Contract with the Employer’s project controls process and project reporting obligations are critical functions that are sometimes overlooked during the contract drafting process. The requirements of the Contract should be designed to require the Contractor to provide to the Employer any information needed so as to meet the Employer’s internal and external reporting requirements, and to fully assess mitigation strategies when adverse schedule or costs trends arise on the project.

Project controls should allow the early identification of performance, budget, and schedule risks, and allow prudent decisions to be made in light of the issues identified. While the level of detail and definition of the project controls system and staff will vary, based on the size, location, complexity, contract type and risk profile of the project, the Employer typically should perform the following functions during the Execution Phase of the project:

- Report costs to date and forecast costs to complete
- Monitor, verify, and document project status against various metrics, including budget, schedule, and payments
- Verify schedule status, including schedule status of major engineering, procurement, and construction activities
- Monitor status of major scopes of supply
- Change management, including design maturation, and
- Internal and external reporting of project data.

Contractors are typically required to submit to the Employer the following types of information on a monthly basis as a precondition to invoice approval and payment:

- contract and payment status
- schedule status
- schedule progress
- quantities installed and stored
- work-in-process
- total project costs
- project progress and other project metrics

- submittal logs
- drawing logs
- status of pending change requests
- status of requests for information
- safety and quality data
- manpower and equipment utilization, and
- a myriad of other project information.

This information is typically provided through a detailed monthly progress report. The key from the Employer's perspective is to ensure that the Contract requires the Contractor to submit the quantity and quality of information needed in the form most useful. At a minimum, the information must meet the tracking and reporting needs of the Employer and must be sufficient to allow verification of the validity of the construction and schedule progress and all other relevant aspects of the Work.

Addressing Risk Allocation in the EPC Contract

Perhaps the most important task faced by the project participants is the clear allocation of responsibility and risk in the Contract. Identification and acceptance of defined risks by each participant at the outset of the project is crucial, as is trying to ensure that all potential risks are allocated to at least one of the parties and, to the extent possible and financially prudent, mitigated by insurance or other financial instruments. The parties must work diligently at the outset of the project to identity and address all foreseeable risk contingencies. In the context of the EPC Contract, it is generally the Employer's goal to shift as much risk as possible to the Contractor. Nevertheless, in a general sense, the Employer provides the performance criteria for the project, the site for the project, and access to the work areas as needed to complete the Contract. The Contractor in a general sense agrees to construct the project to meet the agreed criteria within the agreed schedule and in compliance with all applicable laws.

Risks Typically Retained by the Owner/Employer

Although one of the primary benefits to an Employer in utilizing an EPC project delivery system is reduction of risk (and presumably the payment of a risk premium to the Contractor), there are still certain elements of risk that an Owner or Employer typically retains. Examples of the general responsibilities and risks often retained by the Employer include:

- Payment – Securing project financing and being able to pay pursuant to the terms of the Contract
- Environmental Permits and Permissions – Because the Employer assumes the risk of hazardous substances on the site, typically the Employer will obtain the necessary environmental and other permits required to allow for the performance of the work on the project site
- Site Availability and Access – Providing the site for the project, along with the logistics related to accessing the site and often retaining responsibility for materially differing subsurface conditions at the site;
- Site Power – Providing permanent power interconnection to the facility
- Owner's Representative – Providing an Owner's Representative with authority to make decisions for the Owner in a timely basis
- Owner Non-performance – The Owner must fully and timely perform its obligations under the Contract
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The right to direct variations and changes in the scope of the Work, with a concurrent obligation to assume the impacts on cost and schedule

- Owner's Suspension of the Work – While retaining the right to suspend all or part of the work, the Owner will typically bear responsibility for any suspension of the work that it initiates
- Force Majeure and Changes in Law – Force majeure events and changes in law during the execution of the work are typically Owner risks, but are sometimes allocated to and assumed by the Contractor in an EPC Contract
- Performance Guarantees and Performance Testing – Providing achievable performance criteria and evaluation prior to the execution of the Contract.[16]

In addition to these responsibilities and risks expressly retained by the Employer under the Contract, there may be certain implied obligations that may be imposed upon an Employer under the federal, state, or local laws of the United States.[17] These implied obligations may include the following:

- The duty to disclose material information to prospective bidders
- Implied warranty of the adequacy of any plans and specifications provided
- The duty to provide accurate performance specifications, and to provide performance criteria that are achievable
- The duty to provide accurate site information, including information concerning known subsurface conditions
- The duty to obtain necessary regulatory approvals, permits, and easements to allow, at a minimum, access to the project site of the purpose of completing the contractual works
- The duty to provide access to the work site, and
- Duties relating to owner-furnished products, materials or equipment.

Risks Typically Allocated to the Contractor in an EPC Contract

The following are items for which the Contractor typically assumes responsibility and risk under an EPC project delivery method:[18]

- Site Safety – Ensuring that the labor force is utilizing construction practices and procedures that minimize the potential for incidents and injuries and comply with all applicable health and safety regulations, norms, and standards
- Price – Committing to complete the project at an agreed price
- Labor Risk – Labor risks, including risks relating to labor productivity and labor quality, and labor availability
- Schedule – Managing and implementing an overall project schedule in order to achieve the contractual completion dates, including coordination with all designers, suppliers and subcontractors to ensure compliance with overall schedule and deliverable obligations
- Management of Subsurface Conditions – Constructing the project without disruption or delay due to subsurface conditions that were identified and disclosed by the Owner
- Performance Guarantees – Committing to provide a facility that functions within the specifications and performance criteria agreed in the Contract
- Environmental Compliance – Committing to provide a facility that operates in compliance with environmental rules and regulations required by the government or the underlying environmental permits and environmental laws
- Compliance with Applicable Laws – Committing to comply with all applicable laws, permits, and regulations governing the performance of the works
- Quality Assurance/Quality Control – Developing an appropriate Quality Assurance/Quality Control Plan to

ensure that the project complies with the specifications and satisfies the warranty obligations of the Contractor, and

- Craft Support of Commissioning – Providing and managing the craft labor necessary in order to support the start-up and commissioning of the facility.

Ideally, the EPC delivery system should attempt to assign the risks to the party that can best manage and minimize the that particular risk. The failure to properly identify, allocate and manage project risk can be devastating to the overall project, causing severe to catastrophic financial implications to each of the project participants.

Common Causes and Cures – Execution Stage

We have addressed disputes in our last section, below, but it is extremely important to try to resolve individual disputes on the project during execution and as they arise. For example, notice letters are often written during the execution or performance stage of projects, identifying disputes, putting a party on notice, or otherwise "preserving" a position on an issue. Often, these letters become change requests, including a request for additional costs and a request for an extension of time supported by a time impact analysis. Rather than attempt to resolve the issue at that point, project participants often wait until the project is nearing completion, or until consideration is given to assessing liquidated damages for failing to achieve an interim milestone, or, in a worst case scenario, until notice is sent and a default termination is threatened. By that point, the losses have grown, the claims have morphed, positions have polarized, and amicable resolution of the underlying dispute(s) becomes a difficult possibility. Proactive leadership between the project participants is imperative if the project is to be successful. If left unresolved, small, manageable disputes tend to tend destroy cooperative working relationships among project participants, give rise to major claims with significant cost and schedule impacts.

It is often the case that communication issues are at the root of these problems. The personality, background, culture, or perspective of the designated representatives clash, impeding the ability of their respective organizations to communicate with one another to resolve a discrete and manageable issue. If this pattern develops, it can become difficult to control unless addressed promptly by strong management action.[19] Similarly, due to the duration and physical location of mega-projects, there tends to be turnover of the senior site management personnel, and often of the executive management personnel. This can present a number of issues, including the loss of institutional knowledge of both sides. Unless the situation is managed properly, issues that were resolved at an earlier time are questioned, and relationships among project personnel that once existed are lost. Project Examples and Solutions

In dealing with performance problems on mega-projects, identification of "root causes" is critical. We have identified the most common recurring problem scenarios. Now, we shall take several project examples and illustrate how first of a kind" (FOAK) projects can present challenges if not anticipated in contracting and project controls , including schedule preparation. Also, the absence of good communication and accountability for change management and early identification of risks can result in "scope creep." This increase in work which normally results in major claims occurs particularly when project personnel approach a project from the perspective of a "cost reimbursable" culture as opposed to the contract is "lump sum" or GMP. These cultural differences can also manifest on budget-controlled cost reimbursable projects in substantial overruns and schedule delay. After we examine several projects and illuminate the "root causes of failure or challenge," we shall suggest a remedy that can minimize risk, identify and resolve issues early, and help record cost and time for later resolution.

Offshore Wind Farm, Europe

An EPC company undertook a windfarm project in conditions that were FOAK – at the time the largest — at least in terms of number of actual wind turbine generators (WTGs) sitting in nacelles supported by masts set into transition pieces which were on top of monopiles driven deep into the seabed. Installation of the WTGs required specialized vessels and were only allowed to work (and in certain cases, only available) in certain months of the year. Further, the conditions at the wind farm were windy — good for electric generation — and stormy. The surrounding seabed was 1,000 feet plus deep, with the sandbar where the WTGs were installed only 35 feet deep in places. The depth differential, plus the wind, resulted in occasional 60-foot high waves, all of which necessitated a careful design, timing, and installation of each unit. The approach taken by the project controls team was challenging – to try to measure wave height, wind speed (and hence a force majeure event for cost, time, or both); it was also extensive, complicated, and required constant record keeping, regardless of season, to record non-work days and adjust schedule activities.

These unique conditions for work under unique circumstances, with a defined force majeure, resulted in substantial additional cost and over a year's delay of the project to completion. Further, the unique conditions made the inter array cables — which linked with ocean substations for collection and transmittal by massive cables to onshore transmission facilities — were particularly challenging, especially in an area of shipwrecks and unexploded WWII ordinance. The failure by the owner and EPC contractor to contemplate risks of such a FOAK project manifested in prodigious cost and schedule growth.

Processing Facility, Western Hemisphere

A reimbursable EPCM services contract for a FOAK processing facility was designed and built for an owner based on the owner's proprietary process technology. The owner had previously designed a pilot plant (1:200 scale). After trial runs on the pilot plant, the owner then procured front-end engineering design (FEED) work for a full-scale facility. The owner then procured on a fast-track basis an EPCM services contract from a different firm to perform detailed design, procurement and construction management where all trade contractors reported to the owner (i.e., a multi-prime arrangement).

The FEED work-product, which was given to the EPCM contractor upon award, turned out to be poor and incomplete. Not only was the "scale up" of the owner's proprietary process inaccurate, but the FEED missed or under-designed usual and customary utilities support (boilers, chilled water systems, building HVAC, etc.). The EPC was challenged to exercise project controls in terms of cost and schedule in an environment where the engineering was being determined as field work progressed. The resulting difficulties included a plethora of design and long-lead procurement problems that ultimately cascaded through all execution aspects, given the fast-tract nature of the project. The problems in construction were exacerbated by the multi-prime approach and the owner's communications to the multiple prime contractors on how to complete the project.

Lump Sum Turnkey Contract (LSTK) Gas Turbine Power Plant

As a result of a truncated bid exercise, an EPC contractor familiar with the client-Employer was short-listed on a lump sum turnkey gas turbine power plant with a compressed schedule. The Employer maintained responsibility for procurement and delivery of key equipment, including a gas turbine and heat recovery steam generator

(HRSG), but elected to use the EPC Contractor as "agent" for final erection and completion. The project controls team could not develop a detailed schedule or cost itemization without delivery information that was slow to materialize; in fact, delivery was incomplete to project controls even after site construction commenced. The culture that evolved over time between the Employer and EPC Contractor was akin to a "cost-reimbursable" relationship, meaning that the EPC's activities as "agent" included, at the request of the owner, certain installation and erection duties normally undertaken by the suppliers. In addition, the "lay down" area should have been smaller to accommodate parking on the congested site. This fact necessitated "double handling" of materials from a rented yard to the (now) smaller laydown area at the site. The materials handling (and productivity and safety issues) were not improved by placing the laydown yard between the parking area and the actual construction site.

While this particular project had no aspect of new or novel design or construction, insufficient information on deliveries and problems with material and equipment handling exacerbated productivity problems because trades were required to walk some distance, even in bad weather to get to their work stations. The scope of work on scheduled activities was extended as additional tasks were undertaken by the EPC at the owner's request or default in failing to assign matters to suppliers. Thus, project controls were challenged to keep budgets even close to plan, and the change management was not consistent with a lump sum turnkey project. As a result of the tight time lines and mixed relationships of the parties, the culture of the project evolved into a "get 'er done" mentality, without careful contemplation or recording of impacts to schedule or cost. The inevitable result was substantial delay, increase in cost of many activities without relief from supplier's costs, plus redesign costs because of moved valves and instrumentation. Ultimately, liquidated damages were assessed and project overruns became a significant percentage above the contract value.

Hydrocarbon Facility, Europe

In this example of an EPC/LSTK hydrocarbon facility for an international oil company on a brownfield, congested site, the Employer's contract documents included both site specific and company-wide requirements. The Employer's team consisted of two disparate stakeholders with two different internal philosophies and cultures – the projects group (with a company-wide purview) and the local site team (whose interests stopped at the site boundary). The requirements from each Employer group were often in conflict; and, to solve its own internal culture conflict, the Employer adopted a "most stringent" approach to interpreting Contract documents.

Added to this unhappy scene, the execution plan called for diverse design resources by the EPC contractor in India and in the Far East. This, in turn, compounded the issues by not alerting project management to potential conflicting directions and led to increased scope growth from each Employer faction. The divided design resources were not sensitive to the need for close coordination, because they were accustomed to pleasing their own clients on cost-reimbursable jobs, coupled with the cultural circumstance that it could be viewed as offensive to correct the Employer on conflicting directions.

These challenging conditions ultimately manifested into cost growth and substantial schedule slippage. Compounding the problems were that the site was highly congested and required significant off-site modularization. Modular-intense projects are particularly impacted by late design and logistical/procurement decisions.

Suggested Execution Stage Solutions

The common causes of mega-project failures we have outlined above, including FOAK technologies, ineffective management and control teams, and cultural differences during execution of major projects can be dealt with to the benefit the Employer and design and contracting disciplines. We now suggest a possible solution by augmenting the project team with an individual filling a key position whose task it will be to early identify and resolve developing problems on mega-projects – before the problem threatens the success of the project. We believe that this measure will be cost-effective, minimize risk, while not displacing or threatening the normal project management team with a “police informant.”)

The “Early Action” Coordinator

The key objective in avoiding or minimizing threats to the success of a mega-project is to first identify and then timely respond to developing issues. Many large EPC and EPCM organizations, including joint ventures, have tried a project counsel;