

INNOVATIVE CONTRACTOR PROCUREMENT METHODS FOR SPECIALTY GEOTECHNICAL CONSTRUCTION PROJECTS

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ABSTRACT

Methods used to procure contractors for specialty geotechnical construction projects have evolved over the years. Given the increasingly difficult technical challenges posed to the industry, and the deep resources of equipment, experience and expertise contained within the better specialty contractors, the traditional “low bid” selection basis is no longer adequate for contractor procurement and does a disservice to the project. This paper reviews the more traditional methods before examining the newer innovative methods, such as Alliancing and Early Contractor Involvement. The overlying tenets of superior communication and collaborative environments are exemplified in the overarching process of Partnering.

1. HISTORICAL PERSPECTIVE

One of the fundamental precepts of the much adored and much lamented philosophy of Total Quality Management (TQM) was that “you cannot inspect quality into the finished article”. Indeed, its proponent and chronicler Philip B. Crosby reiterated in the dedication of his universally adopted 1979 book “Quality is Free”, the opinion “Quality is not only right, it is free. And it is not only free, it is the most profitable product line we have.”* It is widely accepted (even in certain stone age circles) that we must apply the *appropriate* levels of quality control and assurance to each and every successive production process: manage the process, ensure the result.

An early but vital process in any construction project is the method by which the “right” contractor is selected, and the terms under which he then builds the project in concert with the other stakeholders. It may surprise some engineers that the word “contract” derives from the Latin verb “contrahere” meaning “to draw together”.

The concept of selecting a contractor based on his ability (or misfortune) to calculate a price lower than any of his competitors, dates from a time when the construction world was simpler, but undeniably more corrupt. Public openings of bids was a logical and transparent process adopted to negate the opportunity for less than honest officials in the public and private sectors to influence bid awards through bribery and corruption. The puritanical spirit of this concept even went so far as to invalidate bids from contractors who had the common sense (and temerity) to take exception to certain terms and conditions in the Contract Documents or, heaven forbid, to offer an alternative solution (even if it were better for the project). The apogee of this process occurred within the last 50 years in large federally-sponsored dam

*For those interested in the development of TQM, beginning with Stewart in 1931, and accelerated by Deming and Juran from the late 1940's, the textbook “Total Quality Management for Engineers” by Mohamed Zairi (1991) is highly recommended. He quotes Juran (1988) on the need for long term planning using the example of a manager surrounded by alligators: “He undertakes to slay alligators, one by one – a reptilian version of project by project improvement. But there will never be an end to it, because more and more alligators keep emerging from the swamp. The ultimate answer is to drain the swamp.” Sounds familiar?

grouting projects, where the successful (i.e., low) bidder became, in effect, merely a purveyor of labor, equipment and materials, subject to intimate technical direction by the Owner's inspectors. It is now generally recognized that the stagnation in dam grouting practices in the U.S. between the 1920's and the 1980's was directly due to this suppression of inventiveness (Weaver and Bruce, 2007).

Significant changes have occurred in the construction industry over the last few decades which have forced procurement practices to be re-evaluated in certain fields. Strong and far reaching attempts have been made to stamp out unlawful practices in contractor procurement and payment processes although there are still isolated cases of "kickbacks" and so on being reported, especially on non-Federal public sector projects across the nation. More significant from the viewpoint of the vast majority of owners, engineers and contractors alike is the fact that the technical demands placed on the construction industry have changed. Industry no longer focuses on building highways in greenfield sites *between* centers of population: it is now building arteries *through* and under such cities. New dams on "good" geology are now few and far between in terms of numbers under construction: the remediation of existing structures on problematic geologies is now the focus. Urban developments and redevelopments require specialty construction techniques to control soil movement and water ingress. There is not the option of a "walk-away" solution since sewer and transportation tunnels must be built under heavily populated and trafficked conurbations.

Response by "contracts and procurement specialists" over the last few decades has been varied. On the one hand, many continue to favor the low bid system which is not unreasonable or inappropriate for works of a relatively simple nature, mainly above-ground, and therefore visible and inspectable at every phase of construction. However, many have chosen or have been forced by the nature and complexity of the project, to adopt other bases for contractor selection. The onus, with such works, is on "best value", as opposed to "low bid" although many times the two can become one and the same. Thus, various flexibilities such as Pre-bid or Post-Bid Alternates and Value Engineering were introduced and indeed, despite their various well-known deficiencies, are still in vogue. Partnering has become an excellent addition in the last 30 years or so, although it must be recalled that Partnering is a post-award, non-legal process. However, when properly and universally implemented it provides a robust platform for creating "best for project" principles of decision-making on a project.

In the 1980's, some large Federal agencies introduced for especially challenging dam remediation projects a "two-step" process. In this, the provisionally successful bidder is identified on the basis of a detailed Technical Proposal (quantitatively analyzed and graded). Provided he is within the project's pre-established "responsive price range", then he is invited for contract award negotiations. A slight variation on this theme is where the bidders submit separate Technical and Price proposals for the same project. Each proposal has a certain numerical "weighting", e.g., 70% Technical and 30% Price, and each proposal is evaluated by a separate panel of specialists. The bidder with the highest aggregate score is then invited for final negotiations, or indeed may be awarded the project outright on the basis of these quantitative analyses.

In the private sector, it is increasingly common, given the growing sophistication and engineering capabilities of the better specialty contractors, to find "Design-Build" vehicles. These are described clearly (as "Contractor Controlled" projects) in the Micropile Implementation Manual (2000).

Despite all these good ideas and noble intentions, the North American construction industry remains a highly litigious and adversarial environment, even though the capacity of its participants to collaborate to find technical solutions continues to astonish observers, both at home and overseas. When faced with challenges, technical and contractual, of enormous complexity, the North Sea oil and gas industry responded by creating the "Project Alliance" concept. Following its initial success in the late 1990's at assuring project delivery on schedule and under budget, it has spread to other major infrastructure

industries in Europe and Australasia, with similar success. Variants of this concept have been creeping into U.S. practice in recent years, but it is by no means common at this time.

Closer to home, the concept of “Early Contractor Involvement” (ECI) has been more widely employed to the advantage of all shareholders on a number of high profile and complex projects. The concept is self-explanatory: a contractor is selected to work *beside* the Engineer-of-Record to help develop the plans and specifications which he will be governed by during the subsequent construction phase. This approach ensures project quality while at the same time allowing project costs to be closely managed.

In the subsequent sections of this paper, each of these procurement methods – ranging from traditional “low bid” to ECI – is expanded upon, with reference to particularly illustrative publications and case histories. Each method has its own merits and place, but the underlying question should be – “How does each approach best serve the needs of a very complex and challenging project requiring the engagement of the “right” contractor?”

2. MORE ON “TRADITIONAL” METHODS

Labeling something “traditional” is not necessarily an indictment: songs sung and music played at religious ceremonies are happily “traditional”. However, as the face of our construction industry continues to change and always challenges, we cannot resist the need to challenge the paradigms of the traditionalists. To do this, though, we have to establish what “traditional” actually means in industry, and how the pros and cons of the inherent conservatism really impact us.

Nicholson (1990) wrote a very interesting paper describing contracting practices for building Earth Retaining Structures (ERS). Although it was written by a motivated specialty contractor for a narrow field of application, the paper did provide a valuable review of the different practices in play in the late 1980’s. Stripping out the polemic aspects of the paper relating to comparisons with European and Japanese practices, the dearth of research and development funding, and the threats from foreign competition in the U.S. market, the paper contained many useful historical perspectives:

- In 1989, the Department of the Navy’s NAVFAC reported an increase of more than 100% in its docket of litigation over a 5 year period.
- “The contracting practice most unique to U.S. construction is the competitive bid.” This was first adopted in the mid-1800’s in an attempt to prevent corruption by government officials and to obtain the lowest possible prices. Due to quality-related project failures, modifiers such as “lowest responsible bidder”, and “if determined to be in the public interest” were added to existing laws on competitive bidding. “Sealed” bidding was also common (an “imperfect” development according to Nicholson).
- “Low Bid” contracting leads to low contractor margins, which in turn creates several major drawbacks, such as:
 - The potential for collusion (limiting competition).
 - Inevitable claims, and resulting litigation (even for “reputable contractors”).
 - Little reward for quality.
 - Suppression of innovation and the widespread use of very “Prescriptive” specifications.
 - No advantage or benefit for contractors with superior qualifications and experiences.
- Prequalification has improved the situation somewhat in that only Owner-approved specialty contractors should be considered by the General Contractors, who therefore are relieved of the decision regarding “price versus quality”. However, this is often circumvented by last minute hustles from previously non-qualified subcontractors, and further, excludes the specialists from contributing during the project’s developmental phases, especially with respect to potential economies of design.

- Described under “Recent U.S. Improvements – Design/Build Concept”, Nicholson listed several alternatives to the sealed bid system, namely:
 - Value Engineering Cost Proposals: long established in U.S. practice, but used very infrequently for ERS projects. This is due, not to the reality of sharing the cost savings with the Owner, but because at bid time the General Contractor is unable to properly assess several risks. These include potential disruption to other phases of his work, the possibility that the Owner may not accept the proposal, and potentially insufficient time for the approval process.
 - Post-Bid Design: especially popular for temporary works, where the specialty contractor acts as designer and builder, but is gaining popularity for permanent works also (where the Owner must provide design guidelines and liability coverage). One drawback, however, is that after the contract is awarded, the subcontractor’s price is fixed and so disputes may arise between him (designing to minimum standards) and the Owner (who may “over-specify” the design parameters to assure the safety of the re-design).
 - Pre-Bid Design: intended to eliminate the drawbacks of the post-bid process, and by 1990 was becoming popular for anchored retaining wall projects. Once the Owner and the specialty contractor have agreed on the design criteria and methodology, the latter “is not under any financial pressure to dispute the Owner’s viewpoint” especially on quality standards. Each competitive design is regarded as “proprietary” to the originator, who can then only bid his own design, the implication being that the successful bidder will be chosen on price and schedule since other criteria will have already been agreed as acceptable.
 - Comments were also made on an idealized “Team Approach” was in many ways presaged the Alliance and ECI concepts described below.
 - Negotiated Bids: becoming more popular at the time in Federal Agencies, and involves the submittal and appraisal of separate Technical and Cost Proposals. This was claimed to favor the Owner and the specialty contractor equally.
- Nicholson concluded by stating that “U.S. contracting practice is slowly improving”, while opining that “Instead of focusing on the transfer of technology from overseas we should be looking for ways to import commercial practices that foster technology from within”. Borderline xenophobic or brilliantly prescient?

3. MORE ON PARTNERING

The post-tensioned anchoring of Boonton Dam, NJ was the subject of a paper illustrating the benefits of “Partnering in a conventional bid climate”, by Snider and Bruce in 1994. The actual contractor procurement method was conventional, the plans and specifications prepared by the Engineer-of-Record on behalf of the Owner, and the project built by the low-bid anchor contractor. The latter, however, because of the partnering environment encouraged on the project, was able to offer redesigns of certain elements, to the benefit of all stakeholders. In addition to providing a solid case history of a challenging dam anchoring project, the paper provides interesting contemporary commentary on “The Role of Partnering”. The relevant section of the original draft is reproduced as follows:

“In specialty geotechnical works of this type, it is inevitable that changes from the foreseen plan will have to be made. This can occur for a variety of reasons, but the most common cause relates to the subsurface conditions actually encountered once the work commences. The manner in which the risk can be managed by each of the contracted parties is reflected in the type of procurement process. The owner and/or engineer primarily carry the risk for jobs secured under a prescriptive specification, provided the contractor has performed in a manner consistent with the job specifications. With performance

specifications, and contracts won with a turnkey approach, then the contractor may bear a larger share of the risk.

In all cases, however, change brings the potential for conflict, and the threat of legal action. From the description of the work conducted at Boonton Dam, it is clear that several changes were necessitated, involving substantial sums of money. However, the fact that these modifications typically brought little more than healthy debate followed by pragmatic consensus speaks volumes for the attitudes of the parties in general, and the successful application of the principles of partnering in particular.

As described by Nicholson and Bruce (1992), the concept of partnering is not new – it has always been the fair basis of doing business between honest and responsible parties. In recent years, however, the formal process of partnering has attracted much favorable attention as an aid to avoiding conflict between the contracted parties. Significantly, the initiative has now been fully endorsed by the Association of General Contractors, who have not always been so supportive for innovations in contracting, or procurement procedures in the past. In September, 1991, they issued a booklet entitled “Partnering – A Concept for Success” which describes in detail the respective benefits to each party, potential limitations, and the basic mechanism of the process.

It must be realized that partnering “is not a contract, but a recognition that every contract includes an implied covenant of good faith. While the contract establishes the legal relationships, the Partnering process attempts to establish working relationships among the parties (stakeholders) through a mutually-developed, formal strategy of commitment and communication. It attempts to create environment where trust and teamwork prevent disputes, foster a cooperative bond to everyone’s benefit, and facilitate the completion of a successful project” (AGC, 1991).

Recurrent themes in the respective benefits to each partner included reduced exposure to litigation, lower risk of cost overruns or project delays, enhanced quality and safety, and an “increased opportunity for innovation through open communication and element of trust, especially in the development of value engineering changes and constructability improvements”. It is intended to be an opportunity in public sector contracting, where the open competitive-bid process keeps the parties at arm’s length prior to award, to achieve some of the benefits of closer personal contact which are possible in negotiated, or design-build, contracts.

Regarding potential problems, it is fundamental that all parties (and their staff) fully commit to the concept. This may prove very difficult for those conditioned in an adversarial environment, or those who regard it as just another “fad”. The four key elements of partnering, in addition to commitment, are communication, conflict resolution, trust and continuous evaluation.

At Boonton, each of these key elements was in evidence during the work and during the solution of problems arising from the changes. This atmosphere encouraged the parties to devote their own specific resources to obtain the best practical result. The owner provided financial resources, the engineer technical expertise, and the contractor specific human and mechanical resources. The alternative would have been the scenario all too common on complex evolving jobs of the type: an outraged owner, a disillusioned engineer, an impoverished contractor, and a wealthy attorney.

Common sense, strong personal and professional relationships, and the application of the principles of Partnering together helped ensure that this project was regarded as a success by all its stakeholders.”

Almost three decades later, this description of “Partnering at work” withstands critical scrutiny. In fact, similar papers written since then have highlighted the same benefits, and endorsed the same processes i.e., the four key elements of Partnering. Personal experiences gained on several large and very complex dam

remediation projects undertaken since Boonton fully support the beneficial power of the Partnering elements, and confirm that it was just not another “fad”, but is here to stay.

Partnering was once described (not only by me) as “Applied Commonsense”. How can this not be a force of good in our works? Viva!

4. THE CONCEPT OF “ALLIANCING”

As introduced in Section 1, above, the concept of “Alliance contracting” grew out of necessity in the very challenging constructional and contractual environments of the North Sea oil and gas production industries in the late 1990’s. The concept has now spread to civil and geotechnical projects in Europe and Australasia, the classic example being the remediation of Arapuni Dam, New Zealand (Bruce and Gillon, 2003). This is a concept that has not yet per se become widespread in the U.S. although many of the elements are now being integrated within more traditional procurement methods. However, it has the potential to offer real benefit to the specialty construction industry, especially when and where engaged in particularly large, complex, and technically challenging projects, and which would otherwise carry exceptionally high risks of all types. Carter and Bruce (2005) described the concept in detail, a summary of which follows. This account also owes much to the work of Andrew Hutchinson and John Gallagher “Project Alliances – An Overview” first presented at the Centre of Advanced Engineering Seminars, Auckland and Christchurch, New Zealand, March 2003.

Project Alliances have traditionally used terms such as “outstanding” or “breakthrough” to describe objectives, results, and performances of high performance teams. The term “gamebreaking” is used below to mean similar step changes in outcomes, but with an emphasis on the sense of a sporting context where a team is looking for opportunities to break traditional approaches to a game to gain ***significant and unprecedented advantage***.

There are, obviously, many cases of outstanding success under conventional bidding processes, but these can most often be attributed to the chemistry of the individuals from the respective teams. One of the key drivers for adopting an Alliance approach is not leaving to chance whether or not the team will click. Rather, the Owner is being intentional in having the parties build the right chemistry and work as a team to proactively pursue gamebreaking performance by selecting the team based on chemistry, experience and track record (and not price) and then establishing a commercial framework where the only way to increase profit margins is through delivering outstanding results.

Simply, a Project Alliance is a project delivery strategy where Owner and commercial participants align their objectives to:

- maximize performance;
- proactively manage risk;
- reduce cost; and
- achieve outstanding results in specific key project objectives.

More specifically, a Project Alliance can be defined as: *an integrated high performance team selected on a best person for the job basis; sharing all project risks with incentives to achieve gamebreaking performance in pre-aligned project objectives; within a framework of no fault, no blame and no dispute; characterized by uncompromising commitments to trust, collaboration, innovation and mutual support; all in order to achieve outstanding results.* (The reader is encouraged to reread this definition: it does contain several radical concepts!).

The unique feature of a Project Alliance is the synergy created between the selection of the commercial participants, the core alliance principles, the clarity and alignment of project objectives and the commercial framework, which all drive the pursuit and delivery of outstanding results. Key elements are:

- participants are selected on capability, approaches and systems skills (as in traditional evaluation processes) and more subjective assessments, such as enthusiasm, commitment, chemistry with ownership and likelihood of the combined team delivering outstanding results. Price is not typically a part of the selection process;
- a commercial framework is created that drives **best for project** decisions that are consistent with, and create an environment of, gamebreaking performance and outstanding rewards for all participants;
- the participants intentionally seek to align Owner's and Contractor's objectives and to cascade this alignment down through alignment between individuals, procedures, culture, and behaviors;
- there is a single integrated high performance project team selected on a "best person for the job" basis;
- all risks are shared and all participants are jointly responsible to deliver every aspect of the Alliance;
- there is no fault, no blame, and no dispute amongst participants; all decisions are made unanimously.

Not all projects are suited to an Alliance approach. Projects particularly suitable have many of the following features:

- elements of the unknown, particularly in terms of the technology, processes and methodologies to achieve defined objectives;
- a high degree of complexity in design, construction, technology, development, or in the number of interfaces with other parties and which cannot be satisfactorily or sufficiently scoped and specified at the commencement of the project;
- radical or rapidly developing or expanding technology which may influence time, cost or performance objectives;
- overly aggressive, if not impossible, project schedules which require flexibility in innovation and approach as external influences, including economic, political or stakeholder considerations, dictate timeframes that do not permit the project to be sufficiently scoped or specified prior to the commencement of the project;
- a desire to efficiently engineer value by incorporating delivery innovations, constructability and operability into the earliest possible stages of the definition, design, development or documentation. To this extent it is generally the case that up to 65% of the cost of the project is determined during the definition and initiation phases of a project when less than 5% of the project cost is expended;
- the necessity for innovation and step-change developments in design, technologies and construction methodologies to reduce the capital cost of a project to enable a product, commodity or service to be delivered at an economical cost, or within budget, to enable a project to be viable;
- stakeholder or external project interests or influences that have the capacity to broadly impact the project objectives, but where if addressed and concentrated on in a cooperative team approach can lead to gamebreaking outcomes; and
- where the experience and expertise needed to deliver a project are spread either throughout an Owner's or Contractor's organizations, or across the world, and there is a need to harness that expertise into one team throughout the project.

Project objectives can be distinguished in two categories:

- minimum conditions of satisfaction (i.e., "business as usual").

- gamebreaking (i.e., containing real business objectives for the Owner and Contractor that are not at the project outset predictable).

This is illustrated in the following table:

KEY RESULT AREA	MINIMUM CONDITIONS	GAMEBREAKING PERFORMANCE OBJECTIVES
Cost	Deliver project within budget.	Deliver the project for 20% under budget.
Schedule	Deliver the project on time.	Deliver the project six months early.
Quality	Deliver the project to agreed specifications (workmanship and design).	Deliver the project to agreed benchmarks of outstanding workmanship. Design the project to agreed benchmarks of high levels of integration with existing and adjoining assets.
Community	The project is not delayed by community or stakeholder opposition to the project.	There is widespread community advocacy and support for the project.
Operability	Operators and end users are generally satisfied with the delivered asset.	There is widespread support and high levels of satisfaction with the delivered asset.

One key quality of gamebreaking is that it is implicitly creative and participants must not fall into the trap of regarding project Alliances in a process driven or “tool-kit” way. Although some processes, workshops and features are broadly similar and should be adhered to from project to project, it is critical that each Alliance freshly designs its project Alliance approach, objectives and processes to meet its specific and unique characteristic. Apart from being more likely to deliver the desired results, such freshness will also ensure more genuine ownership by the members of the team.

The few Alliances that have failed are typically the second Alliance that a group of companies undertake together. The fault arises when the individual team members who were on the first Alliance insist on using the same practices, wanting to repeat them since they worked on the previous Alliance even though they may not be appropriate for the second Alliance. The new team members do not necessarily understand why they are being used and will not feel any sense of ownership of what is being imposed on them. The team members from the first Alliance are not being creative, and the new team members feel no commitment to what is being asked of them. That is not a project Alliance.

Carter and Bruce (2005) identified six core features of an Alliance:

- (i) Principles: a clear set of desired outcomes, behaviors, values and culture. These become a contractual requirement. High amongst these is the requirement to make “best for project” decisions, as opposed to self-serving or CYA decisions.
- (ii) Team and Leadership Structure: a single integrated project team with the members selected on the basis of being the “best available athlete” for each position. There is therefore one team, one schedule, one cost control team, one design team and one set of constructors. The key to making this happen is the leadership structure, shown in [Figure 1](#).

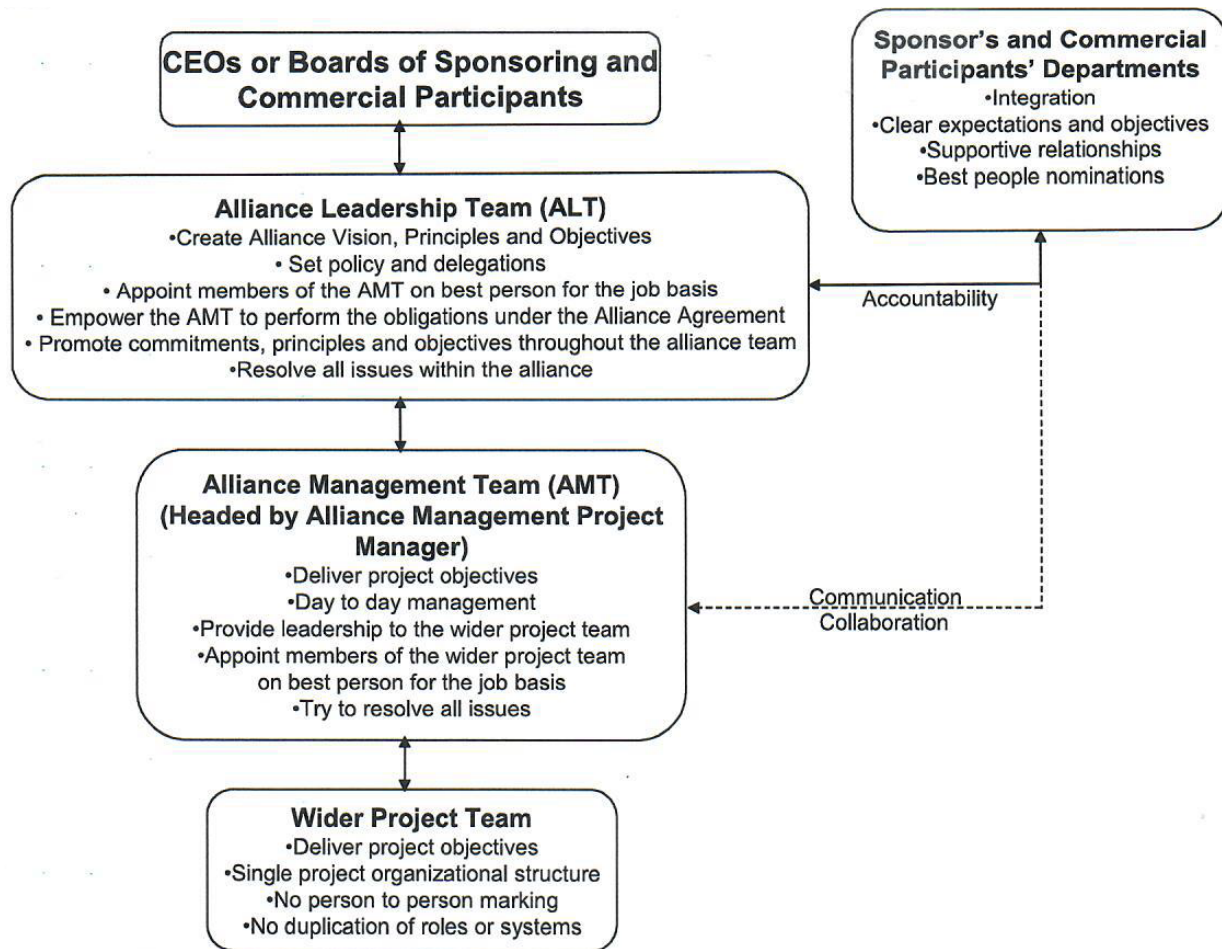


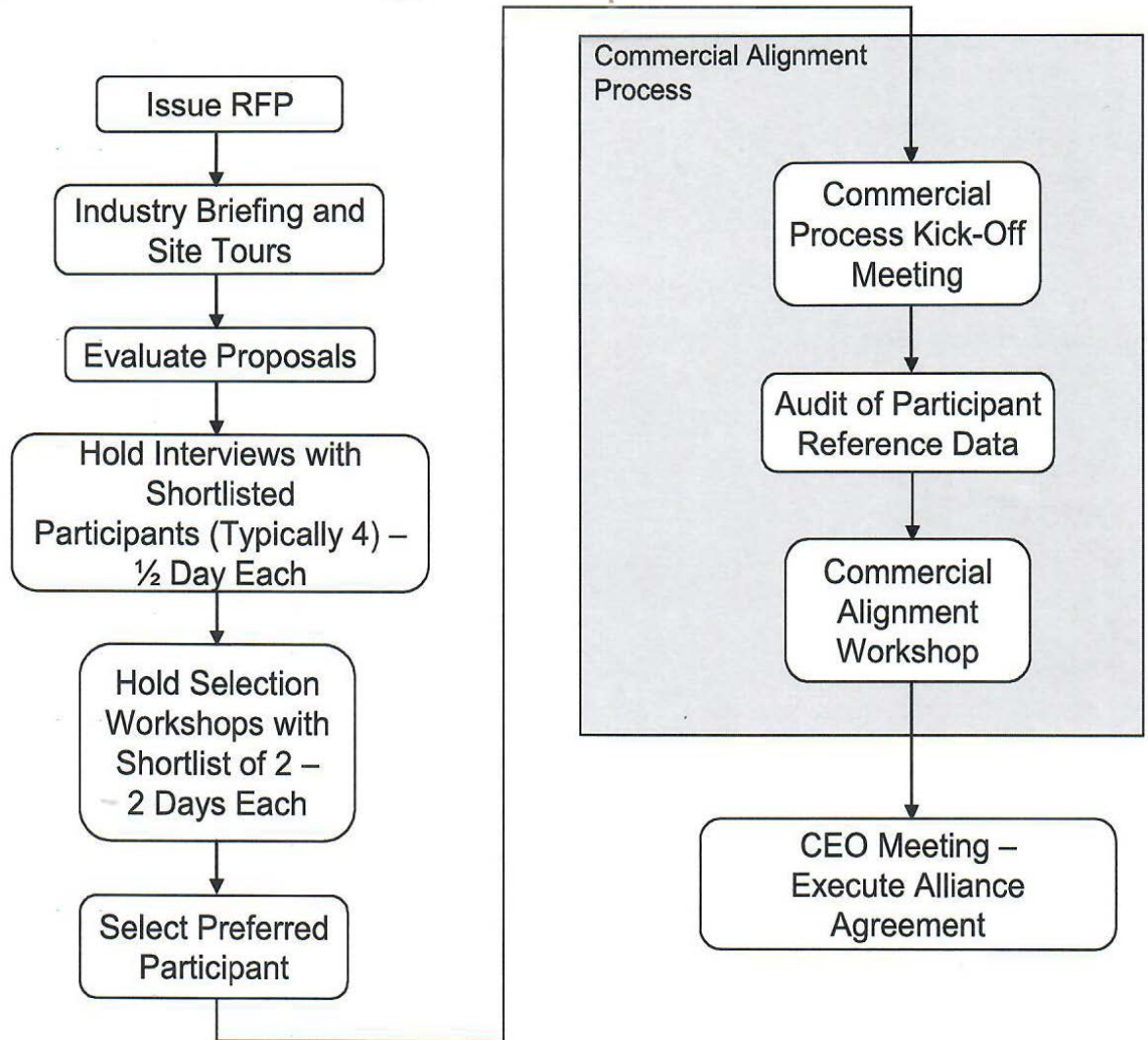
Figure 1. Alliance leadership structure

- (iii) Alliance Agreement: describes the alignment and commitment of the members to their behaviors, and relationships, and to the project and its risks. Specific features include collective and unanimous decision making; no fault/no blame or dispute; logical, consistent and incentivized commercial framework; and financial transparency.
- (iv) Commercial Framework: this is fundamentally different from other procurement approaches. The key components are “if one participant wins, all win; or if one loses, all lose”, and the critical impact of gamebreaking performance. Otherwise, normal performance will deliver “normal” results, and poor performance will deliver poor returns for all parties.
- (v) Target Outturn Cost: In a traditional lump sum contract there is only one certainty regarding the contract lump sum: the starting price. It has little connection with the actual final cost to the Owner for delivering the project. In a traditional contract a contractor has three main ways to maximize his profits:
 - to drive his own costs down, typically through quality or scope reduction;
 - to increase his revenues through scope changes and variations and therefore push up the Owner’s costs, particularly if the Contractor is not able to reduce his costs;
 - to find ways to increase efficiency – if at all feasible within the confines of the project.

The Alliance Agreement does not contain a contract sum. It has a target outturn cost that is agreed jointly by all Alliance participants over the first few months of the project. A key

point of difference in developing the target outturn cost is the level of communication and shared understanding and depth of joint risk and contingency analysis. As opposed to an *over the wall* separate office approach in traditional projects, in a project Alliance, the team works together in the same office developing a single estimate jointly and collaboratively.

- (vi) Participant Selection: vital to obtaining many outcomes such as increasing the momentum of the project as soon as possible, developing personal and professional relationships, encouraging original thought, and meeting the highest standards of probity and bidding requirements. This process is illustrated in [Figure 2](#).



[Figure 2](#). Steps in selecting the commercial participant

It is common that when the project Alliance encounters a major breakdown or challenge, participants comment that it was the relationships, shared understanding and depth of alignment developed during the selection process that provided the basis for them breaking through the challenge.

Given how radical the Alliance concept is, it is normal that organizations participating in their first Alliance feel they are stepping into the unknown. However, once in an Alliance, the participants begin to

genuinely appreciate the possibilities and opportunities that are created. The most difficult part is the first step – taking that leap of faith.

5. EARLY CONTRACTOR INVOLVEMENT (ECI)

For those for whom the Alliance “leap of faith” is indeed a leap too far, the concept of Early Contractor Involvement (ECI) can provide an attractive option. As in demonstrated in the following discussion, in many ways, ECI is in effect “Alliancing Light”, as many of its principles coincide with those of full-strength Alliancing.

One of the highest profile ECI projects of the past 15 years was the levee reconstruction adjacent to the Bayou Sauvage National Wildlife Refuge in East New Orleans, and known as the Lake Pontchartrain Hurricane Protection System and Vicinity Contract 111 (LPV-111). This project has been the subject of numerous technical papers, mostly dealing with the major component associated with the Deep Mixing Method (DMM) used to buttress the very soft deltaic soils to provide slope stability for the higher rebuilt levee, and to virtually eliminate consolidation settlement. The project overview provided by Cali et al. (2012) provided the following introduction to the ECI method used for contract acquisition, which was introduced as a “radical change from the conventional Design-Bid-Build” process commonly used by the U.S. Army Corps of Engineers, the sponsors of the project.

“ECI permitted design innovation during construction and was a key element in the project’s success. With ECI, prospective contractors bid on the project based on 10% design completion. The contract was awarded to the bidder offering the lowest projected cost and best plan for on-time completion. After a contractor was selected, the designer, owner, and contractor co-located as a team and pooled their experience and expertise to optimize the design. ECI not only allowed for contractor input on constructability, including review of plans and specifications, it also enhanced communication amongst all parties and it enabled the contractor to obtain a thorough understanding of the design intent and to work directly towards achieving the design intent, with consequential benefits on construction quality and reduced potential for disputes. Once the design was completed and 100% construction plans and specifications were approved, the contractor submitted a Firm Fixed Price to complete the construction on schedule.

Significant ECI design innovations that were developed included:

- Use of Recycled Embankment Material as levee fill.
- Configuration of the DMM column diameter and panel spacing to match the contractor’s equipment.
- Development of appropriate design details to protect against differential settlement.
- Accommodation of construction logistics in the design itself.
- Reduction of specified column strength and refinement of other details of the DMM acceptance criteria based on Quality Control and Quality Assurance observations and statistical analyses of the data.
- Increase of the maximum allowable moisture content for compaction of clay material.
- Reduction in the thickness of the clay cover on the protected side slope.

With construction scheduled for completion by June 2011, the ECI design and construction period was compressed to only 23 months after contract award in July 2009. While the design was being refined, notice to proceed for construction could not be issued until September 2009, leaving only 20 months to achieve 100-year flood protection. However, construction was allowed to begin using separate work packages, mini-contracts of a sort, for mobilization and staging area preparation, construction of access roads, and other construction features that would not be impacted by design changes. Additional

subsurface investigation was performed to better define peat thickness, delineate the Pleistocene horizon, and obtain samples for bench-scale testing. Bench-scale testing was begun as soon as samples were obtained, and design mixes were optimized almost continuously throughout the project.”

The LPV-111 project remains the largest DMM contract executed in North America, and one of the largest in the world outside Japan. The project was successful for all the stakeholders, and was unique in terms of size, contracting method and schedule. Cali et al. (2012) described several important “lessons learned” during the course of the work, including:

- “• In Design-Bid-Build contracts, the Designer of Record (DOR) performs engineering during construction to ensure that construction is executed in accordance with the design, while in ECI the Designer is embedded with the Contractor and Owner during all phases of construction. Therefore, the DOR must be engaged throughout the construction process to reap full benefits of the Design-during-Construction approach. This is more effort than afforded a typical Engineer during the Engineering-during-Construction approach since the design evolves throughout construction.
- Co-location of the Owner, Designer, and Contractor is critical to establish the teamwork and trust necessary to successfully execute an ECI project. Important benefits are that the Designer fully understands the needs of construction, and the Contractor fully understands the design intent. The outcome is that the Designer’s plans and specifications are consistent with construction means and methods, and the Contractor is engaged from the beginning in producing a facility that meets the Owner’s needs.
- As long as the end product meets the design requirements, design should be modified to best facilitate construction. This requires three things on the part of the Owner and Designer: (1) flexibility to consider Contractor suggestions, (2) careful review to verify that the design intent is still being met, and (3) an appropriate design budget to permit such review. On the Contractor’s part, this requires the ability to rapidly adapt to design changes.
- Accurate As-Built drawings and records are particularly important for ECI construction.”

In support of these conclusions, a companion paper largely authored by the Designer (Cooling et al., 2012) stated “Based on direction from the ECI contractor (Archer-Western-Alberici, and mixing contractor TreviIcos), the deep mixing design assumed the tooling would include dual-auger mixing tool rigs with 1.6-m (5.25-ft) diameter augers. Also, based on the ECI contractor’s suggestion, a wide working bench at El. 3.7 m (12 ft) was incorporated in the design to allow construction of full-length DMM panels at a constant elevation. This simplified construction by allowing uninterrupted installation of each panel, which would not have been possible from two different bench elevations as originally planned.”

Bringing the evolution of ECI up to date, an excellently structured and informative paper by Rounds et al. (2022) described ECI in the Lake Vermilion Dam Gate Replacement Project, in Illinois. Readers are encouraged to study the paper especially where it describes:

- Why was ECI used?
- What is ECI?
- ECI contractor selection process.
- ECI initiation and process.

In particular, the benefits realized by using ECI on this technically challenging project were listed as:

- “• Eliminated common adversarial owner-contractor relationship by creating a team having open communication and transparency, building a high level of trust.

- Increased team's knowledge base during design by including historical and operational knowledge of the owner, the design expertise of the engineers, and the knowledge and experience of construction means and methods of the contractor.
- Allowed for preliminary testing and inspection during design often left for contractor verification, reducing unknowns and ultimately project risk.
- Addressed construction risk in a way that allowed for a redistribution of risk that ultimately reduced contractor contingencies, potential conflict from change orders in the field, and cost overruns.
- Assured constructability and construction efficiency by including contractor means and methods into design and creating detailed construction level schedules that include preliminary work planning.
- Increased understanding of aspects of construction and design allowing for "value added" ideas."

The authors also listed several key lessons learned that "owners could apply in future endeavors":

Establish a format for transparent construction cost estimates detailed enough to justify costs, yet concise and clear enough for all parties to understand. The ECI contractor developed two cost estimate types: a detailed, itemized estimate showing labor hours, equipment rates, and overhead posts for each work activity, and a separate cost summary with 14 work items, and a brief narrative of critical assumptions. The contractor updated the estimates throughout the process to understand the cost implication of changes. For example, the contractor could explain how the removal of a work item may not eliminate 100% of the cost of a particular line item if that activity also included indirect costs. Or, the added cost of a new work item may not be as high when utilizing resources already assigned to the project.

Assign cost contingencies as risks become clearer. Identifying general and specific risks such as weather delays, material pricing, union labor jurisdictional disputes, late deliveries, and additional concrete and crack repairs can prevent issues that cause delays. Understanding identified risks and implementing risk matrices can allow for mitigation strategies and redistribution of risk. For example, the owner chose to procure the gates rather than have the contractor place the order.

Verify costs with multiple quotes. Lack of competition is a common concern with having a single ECI contractor. Providing substantiating documentation for costs and supplying multiple subcontractors, equipment, material, or insurance quotes for cost drives can alleviate these concerns. The owner can also maintain the ability to bid the project to other contractors if desired at the end of the design phase."

In summary, the authors provided their main conclusions, which are, in my opinion, common to all ECI projects:

"The Early Contractor Involvement process provided numerous benefits for this project. All parties had a voice in the design process, leading to a tailored design. Owners and engineers also had insight into the construction process, allowing for adjustments to streamline construction. Other key takeaways about ECI include:

- Maintaining the owner's ability to select another contractor for construction or bid the project was effective in addressing the owner's concerns about being "locked in" to a single ECI contractor and loss of cost competitiveness.
- Many benefits of using ECI are only realized if the personnel involved in design are also engaged in construction. Identify these people before contractor selection.
- ECI allowed real-time feedback from the contractor during design on constructability, cost, and schedule impacts. This can be especially desirable on projects with ambitious schedules and complex constructability challenges.

- Cost estimates should have an agreed-upon format, level of detail, and identification of contingencies for items not yet designed. These items should be clearly defined at the outset to ensure all parties agree with the conveyance of information.
- ECI allowed design of performance-based, delegated design components for long lead time items to commence during overall project design.
- Maintaining relationships with local subcontractors who can provide additional support to address unforeseen conditions is essential to avoid project delays.” Res ipsa loquitor, as the attorneys say (and rightly so!)

6. CLOSURE

Methods to procure contractors – and especially specialty contractors usually acting as subcontractors – have evolved over the years. This evolution has had several drivers many of which have had primarily commercial and contractual roots. However – and again in the specialty construction arena – projects have become more technically challenging at the same time that the variety of means and methods has greatly expanded as the result of domestic ingenuity and foreign developments (Bruce, 2013). The goals of all project stakeholders should be common, and must be aligned to ensure a mutually successful outcome. This harmony is typically not fostered by the low bid method wherein the combined skills and experiences of the stakeholders are little shared, and usually not at all in the preconstruction stages. This paper describes several ways in which mutual success can be achieved, ranging from a “two step” process involving separate technical and financial contractor proposals, through Alliancing to ECI. Every project does not warrant the sophistication of these newer innovative concepts, and indeed many projects continue to be successfully built under the conventional Design-Bid-Build format by prequalified contractors and under Partnering arrangements. However, innovation is frequently the key to overcoming particularly severe technical, logical and scheduling project challenges, such as are typically found in the remediation of existing dams and levees. Since technical innovation is most typically driven by the specialty contractors, it is logical to involve them in the development and design of a project, at the earliest practical stage. The ingredients of the newer contracting methods are described herein, from which Owners and their Designers can select for the benefit of all stakeholders in future projects.

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