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Review and Analysis of the Project Management Process at the Engineer Research and Development Center

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By

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Increasing economic pressure forces personnel within the construction industry to be more prudent and thorough with their decision-making processes. To this end, the possibilities of pursuing incorrect courses of actions must be minimized in order to increase the chances of a successful project culmination. The research contained herewith shall investigate the usage of a review process that if utilized properly, can reduce conflicts, oversights, cost over-runs, and other deleterious actions that can inversely affect the successful outcome of a project. Through the use of the Biddability, Constructability, Operability and Environmental (BCOE) process, construction industry personnel can ensure and effectively manage projects to a desirable end state.

DEDICATION

I dedicate this thesis to my loving wife, Kelly, for her unwavering support.

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Without the guidance and direction from Dr. Islam El-adaway; I would not have been able to derive this thesis. Thank you, Dr. El-adaway for your patience and tolerance on this project. Thanks is also extended to my friends and co-workers that have helped me persevere through this journey. And last but not least, thanks is given to God for the gift I have been given to be able to complete such a challenging task.

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CHAPTER I

INTRODUCTION

1.1 BCOE Necessity

The United States Army Corps of Engineers (USACE) created a checklist in order to ensure all proposed government projects meet a minimum set of guidelines. They coined the checklist BCOE: Biddability, Constructability, Operability and Environmental. This project review process incorporates a plethora of constantly changing input from all USACE employees from around the globe. The most current construction practices, the newest building configurations, the most recent ingenious method to perform an old task are all captured by the USACE database. However, during the BCOE review of a project anywhere in the world, the review engineers are challenged with access to the most up to date practices. If accurately instated, this capability could provide valuable knowledge to project review officials and allows those individuals to revise the drawings and plans well before they are finalized and solicited for bid. By utilizing tried and true knowledge confirmed at other project sites, minor changes can be made in advance of beginning construction that may otherwise be costly when encountered later. The sharing of construction discoveries and the implementation of those discoveries into new projects through the BCOE process enables for efficient use of materials, labor, and funding and decreases the likelihood of construction errors or conflicts due to inadequate drawings or plans. By reviewing the project documents with many sets of eyes, the probability of erroneous drawings actually being distributed decreases significantly. In retrospect, it is the responsibility of the project-level personnel to populate the BCOE database in hopes that others within USACE may learn from their triumphs and their shortfalls.

1.2 BCOE Process

Currently, the BCOE process is mainly concerned with tangible construction items, such as the clarity and consistency of the drawings to ensure accurate bids are received during the solicitation process. The process also strives to ensure the proposed project can feasibly be constructed utilizing standard construction materials without exuberant cost due to extravagant building proposals. Additionally, the project must be functional and have the capability to be easily maintained for the lifespan of the completed project. In actuality, the more constant preventive maintenance that is performed, the longer the lifespan of the projects extends. Environmental compliance must be met as well. The initial disturbance of the construction site is a small portion of the overall environmental impact a large facility can influence over a fifty year timeframe. If environmental considerations are addressed and adhered to in the design phase of the project, then the completed facility will be more “green” with respect to current regulations and requirements. Therefore, consideration for future enhancement of the facility must be incorporated into the BCOE review early on so the entire project is “expandable” in years to come without having excessive rework due to improper planning.

1.3 BCOE Implementation

Implementation of the BCOE process is a challenge throughout USACE. Standardized requirements mandated by official memorandums and regulatory documents are utilized to ensure the BCOE is performed for each construction project. However, the guidance provided only steers the reviews towards an end result that must be provided. The sequential steps, systematic procedures, or a uniformed checklist is non-existent. Thus, each review is performed differently and is unique to each individual project. The desired end result is the same, but the path utilized to reach the mean to an end can vary significantly.

With broad overarching guidance comes a window of interpretation. The regulations provided establish a milestone that must be met. The implied concept of the guidance is each independent district shall deduce, generate, distribute and enforce a feasible course of action that can be followed regardless of the project that may be undertaken. This action delegates the responsibility of BCOE utilization and enforcement to the individual districts within the Corps of Engineers. Consequently, freedom to implement pertinent courses of action that are applicable to the local geographic region are appreciated by the district in that particular region.

1.4 BCOE Standardization

With diverse expertise exhibited by numerous districts throughout the globe, a uniform or standardized all inclusive BCOE check list would be difficult to generate, disseminate, and enforce for implementation. That's not to say the task is impossible, but an extensive compilation of attempted trial and error events, and a summarization of lessons learned from numerous after action reviews would be required to establish a datum line. The diversity of the USACE districts is a similar to AE firms. Some firms concentrate on geotechnical, where others expertise lie in hydraulics; such is the configuration of the districts. A mutually advantageous median must be found, mandating minimum requirements that would be applicable to all entities.

As with any tasks it is more feasible to ensure adequate completion of said tasks if it is split into smaller sub-tasks and itemized. An all inclusive list of BCOE items to complete that would apply worldwide to any potential project would be so extensive that no one would attempt to begin for fear of inevitable failure. Thus, that alternative is invalid. On the contrary, grouping of BCOE items into more inclusive topics may be an alternative if the topics do not become too broad or generalized. Perhaps the generation of a BCOE checklist should be generated based on commonly encountered discrepancies or conflicts from past projects. It goes without saying that districts internally will share lessons learned in order to prevent the same conflicts on the next project. However, districts are prohibitive on sharing their failures publicly though out USACE. Hence, the imperative importance of communication becomes evident.

1.5 Problem Statement

A more specific course of action and additional guidance is required regarding how to attain the mandated BCOE Review milestones. Due to the numerous independent paths that may be followed, it is easy to see that countless courses of action can be utilized to reach the desired objective. Some plans are probably patterned from previous paths and some are self generated with little or no outside input. Neither option ensures that the followed course of action is valid or the sequential and interdependent logic is viable.

1.6 Goals and Objectives

Using case studies of projects performed at the Engineer Research and Development Center (ERDC), this thesis investigates how proper utilization of USACE's BCOE project management process can reduce conflicts, oversights, cost over-runs, and other deleterious actions that can inversely affect the successful outcome of project. Thus, construction industry personnel can ensure and effectively manage projects to a desirable end state.

CHAPTER II

LITERATURE REVIEW

2.1 Biddability

The BCOE process was initiated by the Corps of Engineers to ensure a "sanity check" was performed on proposed construction projects prior to allocation of funds and initiation of work. Biddability is synonymous with the ease in which the contract documents can be understood, bid, administered, and executed (ER 415-1-11). Several items within a packet of construction documents affect the biddability of any project. The requirement for accurate drawings that definitely depict the proposed construction is a must. Gao et al. (2006) expresses that the issue of poor-quality drawings and ineffective specifications often result in less than optimal project cost, quality, and schedules. Comprehensive specifications that are all inclusive must be provided in order to solidify accurate cost estimates. Project specifications, guidelines, and manuals are often inconsistent in their context because of different technical guidelines imposed by multiple project disciplines (Ryoo et al. 2010). For that reason, engineers waste time and effort on checking specifications, guidelines, and manuals for their appropriateness and applicability to the project. Therefore, the specifications must be comprehensive yet written in a way that includes and allots for any type of new or "out of the box" approach at providing the required items. Ingenuity at delivering a quality product faster and cheaper than one's competition is the key to capitalism and competitive bidding. Ioannou and Leu (1993) contest that the competitive bidding process for awarding construction contracts in the U.S. is typically on the low-bid method and is probably as close to pure competition as possible. However, adequate guidance in the form of all inclusive, yet somewhat vague guidelines must be present to ensure uniformity of the presented construction courses of action. Thus, proper legal documents that shall bind the construction parties must be properly oriented to match the actual construction documents. It is imperative that an attorney or contracting official familiar with construction and construction practices "draws up" the binding documents. Attorneys, as with any professional field, have concentrations of areas of expertise. Attorneys that possess specific knowledge of the standard operating procedure and "norms" of that particular area should be utilized to reduce potential differing opinions due to locale variations.

2.1.1 Comprehensive Bid Documents

The bid documents must also indicate any special conditions that may be organic to the project. Often, it is common to reuse previous project specifications from similar projects to avoid using conflicting information by various parties (Ioannou and Leu 1993). The challenge is ensuring that the reused specifications are still applicable to the newly designed project. Standard specifications will ensure the building is constructed in a sound manner with normal everyday finishing and accessories. Special condition specifications provide requirements to items that enhance the particular project only such as a doctor's office that may require a special lead lined door utilized to seclude an X-ray facility. Special condition specifications require thorough review and input from the end-user to guarantee acceptable delivery of required items. Mandatory meetings are another item that should be identified during the biddability review. Pre-bid conferences and pre-construction meetings are a must in order to ensure accurate dissemination of the intent of the designer and end-user. Williams and Haston (1983) believe that attendance and participation in pre-bid conferences, as a resource to the prime professionals, can contribute to the prospective bidders' understanding of material related requirements. Hence, both mandatory meetings will enable the designer, contractor, and end-user to generate requests for information (RFI's) to clarify and solidify the end product. Implementation of a RFI process is an integral part of successful project management for construction projects which improves communication between the construction, design, and project management teams (Hanna et al. 2012). Many times the RFI's are incorporated into the special condition specifications to ensure their inclusion and delivery within the project scope of work. A specific scope of work identifies the desires of the end-user. Dumont et al. (1997) indicates that it is widely accepted that poor scope definition is one of the leading causes of project failure in the U.S. construction industry. A thorough and well devised scope provides a brief view into the day to day operations that will be performed in the completed facility and thus, why such a facility is required. A mandatory portion of the scope of work should be a narrative describing and/or justifying the usage of the facility to explain to known users exactly what is expected to occur once the facility is complete.

2.1.2 Pre-bid Site Assessment

Similarly, impacts to adjacent areas around the new facility must be investigated during the design of the project and incorporated into the construction documents. Significant cost overruns can occur due to failure to disclose constraints caused by existing conditions. Cost overruns in construction contracts include change orders and claims (Jahren and Ashe 1990). Change orders and claims originate from inaccurate drawings or unforeseen conditions. Overhead power lines, for instance, are a big constraint that typically affects accessibility of excavation and building placement equipment. Likewise, contractor lay down areas often impact parking lots and traffic flow to existing buildings next door.

2.1.3 Required Project Documentation

In-progress reviews, weekly meetings, construction huddles and various other names have been coined to indicate communication requirements. Often the meetings include the owner, designer and contractor, when others isolate any two out of the three. Regardless of communication between all parties, the maximum frequency of occurred and accurate documentation of that communication should be specifically designated in the construction documents. Additionally, a definitive list of required project close-out items is a must. In order for a project to approach the close-out sequence, the contractor must be substantially complete. This milestone is important because it means that the contractor is entitled to the release of retainage, less deductions for uncompleted work (Thomas et al. 1995). Warranties, operating manuals, subcontractor pay vouchers and material disposal certificates are just a few of the many items that should be denoted in the construction documents during the close-out portion of the project. Scheduling is probably the most important requirement that must be definitively established within the contract documents. Time is relative to every second of a construction project. If an agreed upon time is not met, then the second function is delayed. Nepal et al. (2006) ensures that site managers often schedule activities aggressively to maintain the project on schedule or to recover from a lapsed schedule. This type of maneuver is risky if too many tasks are not completed on time and begin to pile up and thus move into the critical path of the project.

2.2 Constructability

Constructability is the ease with which a project can be built (ER 445-1-11). Numerous factors can contribute to the level of difficulty a project can exhibit. The key is utilizing constraints as a positive influence on the construction process. The coordination between multiple disciplines is a must.

Constructability includes consideration to provide an adequate laydown area in order to properly stage, assemble, or store required materials. By the generation of a definitive site laydown map, and the placement of a corresponding field lay out, all applicable contractor allotted areas would be confirmed and attested by all parties concerned. Usually the contractor that arrives on the project earlier than others claims the areas that they desire. This is true with material placement within the project itself and within the laydown area. Sprawl and excessive claim to valuable storage area tends to increase as the project proceeds. Enforcement of allotted laydown areas ensures latter material arrivals have adequate areas to be delivered; thus eliminating excessive material reconfiguration and possible material damage.

2.2.1 Accuracy of Construction Documents

The most prevalent example of construction conflicts is created by lighting and ventilation layouts. Overlays of lighting and vent locations must physically be reviewed to minimize these potential conflicts. The next most recurring issue is probably piping conflicts either internal to the building or external within site improvements. Goodrum et al. (2008) introduces that utility conflicts are one of the most significant and frequent sources of construction delays. Thus, it becomes increasingly important that utility conflicts and minimum separation distances must be reviewed and coordinated well in advance of instructing ground breaking activities. If discovered at an early stage rerouting of utilities and storm drainage piping is not difficult during the initial design phase.

An accurate geotechnical report is a must to confirm a course of action to be followed when proceeding with foundation design. Townsend (2005) contests undoubtedly, geotechnical engineering deals with the most challenging civil engineering material, as opposed to water, steel, or concrete. With numerous soil types and varying strata and geological shifts prevalent to any site location, geotechnical engineering must be precise to the maximum extent possible. The proposed foundations must coincide with the soil type indicative to the site or must be conducive to function properly upon cut or fill of the in-situ soil conditions.

Similarly, an accurate and field-validated survey is a must. At a minimum a boundary survey with control markers, a topographic survey with vertical datum, and a surface feature survey must be incorporated into the design effort. Ground penetrating, radar surveys, tree surveys, and hydrological surveys assist in design accuracy and often identify otherwise unforeseen conditions, but are expensive to procure and often require extended length of time to complete. It is not uncommon to discover rifts in the soil that were not known to be present. Halligan et al. (1987) found that contractors routinely encounter unexpected geologic and structural conditions during the course of construction.

2.2.2 Due Diligence

Unforeseen conditions are always a concern for all owners and are always an item of insecurity for contractors. Some unforeseen conditions will arise regardless of the effort to prevent them from showing themselves. That is simply the law of averages. However, in similar fashion to requesting a certified due diligence checklist, an assessment and generated list of possible and probable concealed or unforeseen circumstances or conditions can be provided prior to initiation of work. This assessment would include an agreement for a predetermined monetary amount between the owner and contractor should the encounter of the unforeseen conditions actually arise. Thus a seamless transition from planned work to required work could occur with minimal delay, dispute, coordination, or stress. This agreement could also include a predetermined responsive cause of action on behalf of the contractor so if unforeseen conditions are encountered during the completion of one task, the contractor could redirect his forces to work on another task that may not be on the critical path but could require the same work force or similar equipment.

2.2.3 Compliance

Other influences such as fire codes must be reviewed prior to site layout and building configuration. Often maximum travel distance and hydrant accessibility mandate the designer’s planning agenda. Likewise, handicap accessibility requirements drive grading designs, parking configurations and interior restroom orientation and frequency. Jensen and Varano (2011) researched that due diligence in relation to buildings can be seen as a particular type of condition assessment. The typical use of condition assessments of buildings is as a basis for maintenance planning. From this, proper due diligence with a composite checklist is often the saving grace to a designer. Taking into account material availability and maintainability of those materials are key constraints that must be considered. Often this topic affects architectural designs more than others since original configurations utilizing non-standard materials is indicative of architectural practices. On occasion, site material availability will require minor redesign to avoid potential conflicts due to lack of availability of the initial product. For instance, the requirement of a shallow utility made of steel that is unavailable must be buried deeper or possibly concrete encased if a weaker EPA material is utilized.

The BCOE process also incorporates permitting requirements for the project. The environmental portion of the review investigates all pertinent local, state and federal code compliance issues. All reviewing disciplines are required to address permitting from their perspective viewpoint and even include other possible conditions that may require permitting from another perspective. For instance, a structural engineer may review the foundation design and determine that undercut may be required in an environmental sensitive area, thus coordination with the civil engineer or geological discipline may be required. The inclusion for the requirement of a signed and sealed certificate of due diligence would eliminate the possibility of unforeseen permits or approvals from authorities having jurisdiction. The completion of the BCOE process generates a comprehensive and properly completed due diligence checklist prior to the initiation of work.

As mentioned in many contracts the contractor is not responsible for the contract document's compliance with all authorities having jurisdiction. However, the contractor is required to disclose any discrepancies or non-conformities discovered on the project site. Thus, a weekly verification of the sub-clause by the engineer or architect will decrease any legitimate opportunity for the contractor to withhold any inconsistencies. If open communication is maintained, and the contractor is required repetitively to confirm that no errors or stray items are present, then the chances of surprise unforeseen conditions and/or the collection of held knowledge being disclosed all at once are very slim.

2.2.4 Accounting for Natural Phenomena

Often construction projects are planned with no consideration of potential seasonal impacts. The seasons change near the same time each year, but designers and end-users rarely incorporate their schedules with respect to seasonal variations. It is not until the contractor and material suppliers become involved in the process that scheduling issues are incorporated. Alternate building materials can be proposed to work in unison with colder environments, just as with hotter environments. Sequencing of construction tasks can be proposed if the proposed start date of construction is relayed early in the design process. From time to time projects are significantly delayed due to adverse weather conditions that could have been avoided if planned properly. The critical path of a project can be altered by substitution of readily available building materials. In the past, crises were handled in a haphazard and random manner by trying to isolate them from the rest of the organization (Sriraj and Khisty 1999). Now it is understood that all aspects of a possible delay or acceleration of a task must be incorporated into the overall composite schedule to verify the long reaches that task may affect.

Storm water impacts to site development go hand in hand with seasonal project coordination and overall site orientation. Improper site layout often impedes the opportunity to properly install and maintain erosion control best management practices. Guo and Cheng (2008) express that it is imperative that the on-site hydrologic methods be revised or newly developed to use the incremental imperviousness as the key factor. In other words, a comprehensive overview of all proposed stormwater impacts must be incorporated into the initial design to account for future changes and improvements. Additionally, knowledge management practices should be implemented to educate the site workers of the possible impending violations from not following the approved site regulatory plans. Kale and Karaman (2011) practice that evaluating knowledge management practices is considered one of the most important challenges facing firms in today's business environment. Keeping employees at all levels abreast of the most current standards is practiced concerning safety and hazard material regulations, but stormwater issues are often overlooked. Lack of enforced guidance and unrealistic construction practices paired with disregard for seasonal weather fluctuations make the efficient constructability of a site nearly impossible.

2.3 Operability

Operability refers to the ease with which a project can be operated and maintained (ER 415-1-11). It is often referred to as maintainability. Operability must be incorporated into the design process from the very beginning of the project. Access to hidden areas via a chase is something that must be on the plans and allotted for early on.

Adequate working space around pieces of equipment is often a challenge for maintenance personnel. Minimum clear distances around a piece of equipment often reference the necessity to ensure proper operation and cooling of the equipment but are actually established to ensure mechanic access to repair or service the item itself. Additionally, many current equipment designs are becoming more compact and more economically efficient and hence, require a smaller "carbon" footprint.

2.3.1 Equipment & Utility Efficiency

Conversely, demands are increasing to maintain desirable inhabitable conditions as a more powerful piece of equipment is required to satisfy the demand. Growing awareness of the impact of emissions on climate change, caused by the exacerbation of the earth's greenhouse effect, has brought critical attention towards developing strategies to identify sources, and estimate and reduce their magnitude (Melanta et al. 2012). To this affect, the resultant change in the overall size of the equipment may be negligible or may even increase slightly. The increase in size reduces the available access space surrounding the equipment. The need for forward thinking and long term vision is more important than ever. Access to sanitary lines is provided by strategically located clean outs. Many plumbing vents are designed with this available to receive a plumbing snake as an alternative to a non-successful clean out attempt.

Isolation values on water mains and sanitary force mains are often omitted by designers that possess no field experience. In water distribution systems, valves play a crucial role in system reliability and security by providing a shutoff function when it is necessary to isolate subsystems (Jun et al. 2007). For example, an isolation shut-off valve on a force main on both sides of a creek crossing will decrease extensive paperwork and environmental impacts should a line rupture occur. The presence of the valves on either side of the creek alone indicates to reviewing officials a diligent design was performed prior to initiating construction. East et al. (1995) writes that the objective of a review is to increase the cost-effectiveness, timeliness, and overall quality of the completed construction project. All three items listed in the statement are true for BCOE reviewers where regulatory reviewers would be more concerned with the quality of the installed materials and compliance with mandated regulations.

2.3.2 Planning for Growth

The expansion of existing facilities should always be a concern for designer and end-user when planning a facility. The use of a half-bay rigid frame structure on the ends of a proposed metal building limits the expansion of that facility. To expand the building length the end wall must remain, or the entire half-bay frame must be replaced with a full frame like the existing interior frame of the building. The only cost swings initially appreciated is on the steel beam thickness and weight. Similarly, main utility trunk lines within the building can be sized to extend the entire length of the building with smaller branch laterals sized to efficiently service the existing facility, but the capacity for expansion is available from the trunk line. This concept is extensively utilized in city and subdivision and campus planning. Daily and/or periodic servicing of operating parts should be included in the operability review. Grease fitting locations, or equipment, must be utilized extensively. Coordination with the equipment manufacturer, orientation of the equipment once installed, and loss of access to the equipment can all be synchronized well in advance of actual manufacturing and delivery of the equipment. Logical and beneficial installation of access hatches and portals is paramount in some applications.

Natural wear and tear and degradation of materials warrants replacement from time to time. An access hatch that is improperly located or too small is useless in this situation. However, the installer probably received credit for providing the access hatch without thought of functionality at a later date. "It's not my problem, I don't have to maintain it," is a common thought process in the construction industry which makes the need for an operability review even more justifiable. Safety concerns related to unfeasible maintenance requirements must be considered. Permanently fixed windows that have no consideration of the roof to attach a window dolly are not a good practice when tilt-in windows are available to facilitate exterior cleaning. Many times preliminary design drawings should be consulted by experienced construction personnel. A designer can draw the end result to any proposed project, but reaching the end is more times than not the larger challenge. Cross referencing the designer's intent with the contractor's course of action often yields many constraints that affect the overall schedule and timelines of project completion.

2.4 Environmental

The Environmental Review refers to the protection of air, water, land, animals, plants and other natural resources from the affects of construction and operation of the project. Most construction projects have an Environmental Assessment (EA) conducted prior to initiation of work. Eagan and Ventura (1993) relay that local, state, and federal agencies as well as consultants, researchers, and the public are interested in current, reliable, accessible, and understandable data concerning environmental issues. Soil erosion and the prevention of sediment leaving the construction site is one of the major items when speaking about environmental concerns. Endangered species used to be the main topic and is still the most discussed, but in recent years the Clean Water Act passed by the federal and state governments has turned much focus to soil erosion issues and the impacts to the receiving waters downstream. Phelan and Phelan (2007) reported that federal agencies must analyze, to the fullest extent possible, the potential environmental impact of those "major federal actions significantly affecting the quality of the human environment" (NEPA 1969). From this intent, some states concentrate their detention efforts on the soil particles and particulates themselves and forego trying to reduce the storm water runoff. One of the key factors in urban hydrology is the area's imperviousness percentage that serves as an indicator to reflect the development density (Guo and Cheng 2008). Some states focus on the silt fences, storm water sediment ponds with filtration weirs, and similar best management practices. Other states believe dilution is the solution. They detain or retain storm water runoff and allow the suspended particulates to settle out of the water over a period of time. Simultaneously, the stored runoff also percolates into the ground, which provides cleansing functions. The latter method depletes the volume of water received downstream. Both methods provide a treatment and cleansing action to satisfy the federal mandates. It is imperative that the designer have knowledge of which treatment system must be followed and the associated storage volume or outlet stabilization efforts that accompany either option.

2.4.1 Site Analysis

Various other concerns must also be addressed in the planning and design phase of the project. The presence of wetlands or the loss of utility availability due to forces out of ones control are difficult to plan for even the most seasoned designer. Impact mitigation due to environmental issue or other acts can be planned for preliminarily, but not totally accounted for. Infrastructure loss in disasters can cause substantial societal dislocation (Chang 2003). Reclamation or corrective action must be incorporated into the design matrix along with the associated time allocations. A suitable site layout that minimizes possible wetland or potential utility impacts is the most desirable approach. The presence of contaminated soil is sometimes not discovered until earth moving operations have begun. However, contingencies in the specifications for contaminated soil should be included if required. Similar to a rock clause, contaminated soil is usually dealt with on a unit cost basis. Trial and error insertion of contaminated soil discovery into the schedule yields possible alternate critical path methods that may be followed should contaminated soil actually be encountered.

Usually inclusive with an Environmental Assessment is an archeological assessment. Thus, most of the time the designer knows in advance which areas need to be avoided at all expenses. If these areas must be disturbed a relocation and reclamation plan is usually performed in advance of the actual field work. Again trial and error dry runs prove effective in preparation for actual unanticipated discoveries. Tree surveys and tree preservation requires advanced planning usually from someone other than the site designers. Any designer can isolate and protect a tree to keep it for use when the project is complete, but the likelihood that tree will coincide with the proposed of the landscape architecture or end user's intent is very slim. Coordination, with definitive conclusions, are required if tree salvage credits are counted up front against other mitigation taxes such as wetland disturbances. Additionally, many municipalities require a 2:1 replacement policy for hardwood or significantly listed trees that are removed.

2.4.2 Site Considerations

Burning of cleared debris is usually not approved by most municipalities, but most contractors will quote the true clearing and grubbing including burning the debris onsite. Other contractors may propose an onsite borrow pit utilized to accumulate required fill volumes elsewhere on the site. Usually the creation of a storm water retention pond yields itself as a borrow pit. Occasionally the pond is over excavated to provide more fill material and the cut tree debris is placed in the pit/pond and capped to create the bottom. As long as the side slopes of the pond are adequately designed and a stabilized and the pit/pond are reclaimed, that practice is usually accepted. Guo and Cheng (2008) continue with stormwater control facilities designed by the imperviousness-based stormwater approach are often subject to continuous improvements as the watershed is always developed through multiple stages. From this, operability of the stormwater retention facility must be considered during the BCOE review.

Direct construction related environmental concerns are usually limited to miner fuel or hydraulic fluid spills. These are unforeseen in the design process, but procedures on how to correct the actions and treat the spill must be included in the specifications and contract documents. A rather insignificant, four gallon fluid spill can create huge delays if not properly treated.

2.4.3 Green Building

Recycling has become a large part of all construction planning. In recent years, an emphasis toward implementing recycling programs has developed. The motivation behind this development stems from both practical and environmental issues (Jacobs and Everett 1992). In addition, recycling is an environmentally sound method for the efficient utilization of natural resources. The re-utilization of construction materials for purposes other than mutually planned brings big credit when applying for a LEED certification on a project. Many think that recycling is utilizing crushed concrete for a driveway, but the use of any material more than once for two functions can constitute recycling. The designer, contractor and end user should establish goals and a brainstorming session to facilitate a unified recycling effort. The Corps of Engineers has been mandated to pursue and obtain a net-zero rating on new and renovated construction projects. Bayraktar and Owens (2010) list that Leadership in Energy and Environmental Design (LEED) is a certification program developed by the U.S. Green Building Council (USGBC) for designing, constructing, and certifying green buildings. The use of LEED friendly designs includes the installation of cool roof materials, thicker and more efficient insulation, more efficient windows and doors, and an overall tighter building envelope. The concept that a building can be too air tight and thus dry rot is no longer valid. The reason for the dry rot was due to portions of the building being water tight, yet other areas had water infiltration or excessive moisture barriers that could not "breathe". Today's building materials are designed and manufactured to meet the intent of the Green Building Council. Wu and Low (2010) confirm that the concept of green building is now widespread in the construction industry due to the rising awareness of sustainability.

2.5 Project Generation

Compatibility of the BCOE process with standardized construction practices is a challenge that must be overcome in order to make the BCOE review effective and properly integrated into the overall construction process. Research indicates that five areas within the construction environment have been studied and reviewed for their importance in project generation. Planning, project delivery methods, construction feasibility, construction efficiency, and accuracy of contract documents are five topics of discussion that shall follow.

2.5.1 Planning

The planning portion of a construction project includes several topics or tasks that arise during different phases of the construction process. Initial planning efforts must include the actual design of the project that must in turn take into account the productivity of the design firm itself. Liao et al. (2011) stated that engineering performance has a major impact on subsequent project phases, such as procurement and construction, and thus has the potential to affect the overall project outcome. Proper allotment of engineer assets ensures an efficient, accurate, and timely design. Further into the construction timeline, work plan scheduling is conducted by the contractor himself. This type of planning is based on past experiences encountered on previous projects. Wambeke et al. (2011) indicated that two main types of variations ultimately affects the project outcome and duration. Task starting times and task duration variation are the two most influential factors in project completion. The likelihood of both of these possible variations affecting project efficiency can be significantly decreased by thorough and comprehensive planning efforts. These efforts would be best suited in advance of starting project construction. Conversely, a field expedient work plan must be implemented and/or revised when planned operations do not proceed as predicted. Indicators can give wind to upcoming conflicts much like darkening clouds and the smell of ozone can foresee a thunderstorm. The factors that are considered in analyzing technical solutions and the task used to obtain technical solutions have changed for construction engineers over the past thirty years (McTavish and Stallard) 2011. McTavish and Stallard continue by explaining that an efficient project begins with the definition of the operations or activities that require a work plan and the end product is a document that provides all the information necessary to perform the operation, including expectations and metrics. Thus, brainstorming and generation of a complete list of possible conflicts or showstoppers early in the project phasing can enhance the work plan efficiency, or even prevent possible conflicts from occurring by adequate planning input during the design and BCOE review process. Once a conflict has been discovered and sequential work or installations have already occurred, most of the time rework of the area in concern must be performed. Obviously, the required amount of non-value added work will try to be minimized, but a certain amount of demolition or reconstruction will be required. The inclusion of an experienced field engineer or seasoned construction personnel can influence minimal corrections to an already undesirable situation. Han et al. (2012) definitely writes in a design and construction project non-value adding effort (NVAE) is wasted effort that could have been avoided if the project had been more carefully planned, executed, monitored, and controlled. The imperative need to keep all parties abreast of current work conditions and the requirement to enforce sufficient communication between all pertinent entities is prevalent. Communication is no more imperative than when determining the project delivery method between the end user and the contractor.

2.5.2 Delivery Methods

Culp (2011) limits the construction process to four options. Design-bid-build is the traditional delivery method which incorporates the construction triangle of the end user, the designer, and the contractor in its fullest usage of the word. Design-build, design-build-operate, and design-build-finance-operate are the more recent and liberal alternative delivery methods. As listed, the delivery methods increase the amount of time in which the end user and contractor are joined in the construction effort well into the usage and operation phases. On the contrary the indecision of the designer is decreased. Delivery and complete turn over times increase as forced interaction increases. Deshpande et al. (2011) utilizes a differing view by writing the successful execution of the design phase in fast track projects is especially challenging because of the concurrent execution of design and construction interferes with the inherently iterative nature of the design process. In other words, while the designer and end user are still tweaking the final touches of the product, the contractor is already installing prerequisite items that may affect any items that are being tweaked. This process minimizes the amount of time the end user and contractor must interact, but extensive communication and daily status updates must be present to ensure accuracy of construction. Fast tracking projects is a risky venture but necessary in certain instances when time constraints cannot be avoided. Often the entire manpower required to continually "micromanage" the product on all parties' sides offsets any cost saving that may be possible due to a shortened project duration period.

A slowed design phase may not necessarily be the proper course of action either. Sullivan and Michael (2011) found that over fifty percent of design efforts finish behind or significantly behind schedule. Furthermore, it found that seventy percent of clients have seen the quality of design documents decrease over the past ten years. This reinforces the adage that the more time one has to complete a task, the more time they require. When delivery methods slow, due to controlled or uncontrolled parameters, tasks tend to be dropped or forgotten and errors or omissions tend to creep into the project. Personnel become immune to the repeated exposure to a project, design, or construction, that has not changed the last several times it has been viewed. For this reason a fresh set of eyes, or several sets, should review the documents during the design and work plan generation phase of the project.

2.5.3 Construction Feasibility

Following completion of the initial design effort and buy-in from the end user and contractor, if applicable, the feasibility of actually constructing the project begins to become paramount. If early contractor involvement (ECI) is a part of the project, then construction considerations have already been analyzed and discussed in a fair amount of certainty. Concurrent with these efforts, site and building simulators are being generated which will further clarify unknowns or confirm disputed decision points that affect pending courses of action. The use of computer simulators is increasingly common and AbouRizk (2011) notes that simulation is defined as the science of modeling a construction production system and experimenting with the resulting model on a computer. The use of three dimensional graphics to view a product and the ability to vary the viewing point from any perspective is an extremely powerful tool. Any discrepancies or omitted design or layout characteristics will be captured. However, one down fall of computer modeling is most programs will extrapolate unknown values until convergence with another known datum. Essentially if two walls of a structure and the roof of that structure do not all intersect at the building corner as they should, the program will extend the planes until an intersection is created. Thus the original two dimensional drawing from which the three dimensional model was generated was actually drawn incorrectly. A thorough review of the original layout will verify any false findings that the computer program corrected unknowingly.

2.5.3.1 Physical Models

That said, the need for physical models is still applicable. As designers have done for numerous years, the generation of a physical model will absolutely confirm that all required components of a project accurately assemble. Although time consuming and costly, the assurance received by complete assembly of an accurate model is unequalled. Notwithstanding the recognized capabilities of digital models, mockups are still needed for capturing and eliciting the tacit knowledge that characterizes many construction operations and which cannot be visualized fully by the digital world (Pietroforte et al. 2011).

2.5.3.2 Digital Models

An extremely effective use of digital modeling is in the field of Building Information Modeling (BIM). Randall (2011) reported that significant industry transformations in the use of building information modeling present extraordinary opportunities for AEC professionals. BIM assets do not just include the structure walls, roof and larger furniture as the earlier programs used to employ. Today BIM programs assist in quantity takeoffs; utility networking and distribution layouts; pressure, voltage and bandwidth loss calculations; thermal barrier and inductive heat transfer calculations; and overall building envelope summations. Combined with validated model analysis of proposed structures, estimates generated utilizing BIM output are more accurate monetarily than standard estimates. Synchronization of scheduling and subtasks durations with quantity based cost estimates remains a challenge.

2.5.3.3 Compartmentalized Construction

One major factor that affects project duration is the utilization of prefabricated items in lieu of constructed in-place. The BCOE process during the design phase seldom encounters exact data pertaining to prefabrication of essential building components. The means and methods in which a contractor proposes to assemble a concrete building are usually not specified during the design process. The requirement for a ten inch thick concrete building wall is established, but the construction of the wall can be cast in-place, cast on site tilt-up panels or manufactured prefabrication. As long as the explicit specifications are met and the intent of the wall is satisfied, each bidding contractor can propose their own construction course of action. The BCOE process in this situation is limited to review the variables that have been assigned known values. The review of the means and methods that are submitted later becomes the responsibility of the project manager and project engineer. During this time, prefabrication is often encouraged due to potential cost savings and possible acceleration of schedule. Khalili (2012) recommends that a developed configuration of groupings of precast elements to minimize the total number of components so as to reduce the production, transportation and installation costs. Preliminary designs and standard re-usable designs are often steered toward constraints that are conducive to the utilization of prefabricated construction components.

2.5.4 Construction Efficiency

According to Jarkas (2011), labor cost constitutes from thirty percent (30%) to fifty percent (50%) of the overall project cost. By default, labor costs must be the single most influential variable that affects the overall project. From this one can deduce that the most beneficial and efficient use of labor would equate to a more efficient project. Efficient projects are on time and within budget. Utilizing this deductive reasoning it can be said that from the BCOE viewpoint, constructability is the most influential variable that directly affects labor and the ability to perform tasks at an efficient rate. Jarkas (2012) suggests that a buildable design leads to a higher labor productivity and lower construction cost. Opposing that concept is a poor constructability which would encourage lower productivity and thus a higher construction cost. When observed from this angle, a thorough BCOE review becomes imperative and one can argue that the constructability portion of the review directly correlates to labor efficiency and overall project cost. One can also deduce that the importance of effective communication is a must if any indication of a complex construction process may be present. The more complicated the construction becomes, the more possibility for variation of construction means and methods. The same ingenuity that allows one contractor to devise a more efficient and expedient course of action can just as easily allow the same contractor to veer off course unknowingly. Hence, the importance of open and thorough communication is exhibited once again.

2.5.4.1 Teamwork

Hartmann (2011) studied that a decision support system can support the communication during the project by distributing information to specific member of the project team. The proposed matrix focuses on the project delivery team level of construction. Some of the assumptions made incorporate a buy-in from all personnel that participate in the construction process or are a part of the project team. If all parties are actively engaged, then the system should be beneficial, but a chain is only as strong as its weakest link. None-the-less, the justification exists that comprehensive communication among constituents is a must.

Cerato (2012) confirms that teamwork is an essential part of engineering practice and continues that the ability to effectively communicate is one of the most important screening criteria for new employees. Inability to properly relay critical information is one of the most recurring faults encountered on construction projects. Misinterpretation from second or third order conversations is common on all projects. One item that needs to be stressed, construction drawings are a form of communication that are often overlooked during verbal iterations in field and office environments.

2.5.4.2 Team Leaders

The innate ability for designers to be flexible, objective and open to unique proposals allows them to converse well with the end user. Most influential designers that have a favorable customer base are also extremely good listeners. This allows the designer to absorb all of the pertinent and constructive requests and also receive the more challenging or unusual suggestions as well. The out of the ordinary requests are usually sprinkled back in to the project with the mandatory request in an attempt by the designer to appease the end user. From this capacity of the designer there needs to grow an ability to perform a similar function on the construction side of the project. Accordingly, the American Society of Civil Engineers (ASCE) claims that a new education paradigm in construction needs to be pursued so civil engineers can become “multifaceted, multidisciplined, and holistic” (ASCE 2008) (Grau 2012). Civil engineers are the logical choice for such a venture when considering the educational requirements mandated by universities that teach civil engineering. As pertaining to building construction, civil engineers are required to possess knowledge in fluid dynamics which can be applied to heating and ventilation design. Similarly, materials analysis and system distribution knowledge can be utilized as a basis for electrical layout. Additionally, soil mechanics and associated retaining and headwall designs for stormwater usage are an excellent building block for increase structural analysis courses. Consequently, civil engineering site design and layout incorporate all of the previously mentioned disciplines at this time.

With the BCOE review process being such an influential factor in proper project procurement, vetted and seasoned individuals should be utilized to head the review process. However, due to their more pressing requirements because of seniority, capable and motivated subordinate or junior level engineers could be placed in the reviewing process to gain knowledge and experience. Kirschenman (2011) indicates to function as master-builder, the future engineer will need to have an understanding of and some competence in the many aspects of the processes involved in bringing projects from an idea to a complete project. Thus, a one year internship within the US Army Corps of Engineers (USACE) while partnering with a university would be a beneficial course of action to implement. Similarly, construction firms could partner as an improved and mandatory type of coop following more stringent regulations to assist in establishing a “master-builder” as a construction field. Regardless of how the semantics work out, more experienced entry level engineers and designers that are cognizant of field operations makes for less errors and discrepancies that may be discovered during a BCOE review. ASCE's Vision 2025 indicates that civil engineers will function as master-builders (Shen and Jensen 2011). This could possibly enable USACE to pursue a course of action to implement a new field position within the Corps ranks as a "BCOE Specialist".

2.5.5 Accuracy of Contract Documents

The BCOE review serves to reduce costly, time-consuming modifications to the construction contract by eliminating design problems before construction begins (CEHNC 1180-3-1). The BCOE process is important to the construction industry because it ensures the accuracy of the desired work to be performed. Additionally, the BCOE requires that sufficient due diligence and planning effort was conducted in advance of the project. Discussion shall focus on the deliverance of accurate contract documents and then shift into the planning process.

2.5.5.1 Accountability

The ultimate responsibility of any design professional is to protect and serve the health, safety and welfare of the general public. The BCOE review process enforces the concept by requiring a minimal number of reviews by constituents. The proper designing of foundations and structural beams is directly related to the safety of the individuals occupying the facility. Similarly, the proper amount and sufficient location of fire exits ensures adequate egress for building occupants. This again is a safety concern. Both items should be reviewed, coordinated and conformed to be in compliance with standard emergency practices during the BCOE review process. Kerrigan and Law (2003) suggested that environmental regulations are complex and voluminous, which can be disproportionately burdensome on small businesses. In the concern of the business entrepreneur, blatant non-compliance with regulatory requirements should not be present if competent designers are assigned to the project. However, minor oversights, or errors and omissions, may blend into the drawings because of repeated exposure on the designer's behalf should be captured by a fresh and neutral set of eyes. Lopez et al. (2010) mandated that it is clear that design errors continue to be a major contributor to building and engineering infrastructure as well as project time and cost overruns. For this reason, many companies enforce policies that no sets of plans are released for construction until at least two or three sets of eyes have reviewed the documents. This is not referred to as a BCOE review but it is the same concept.

Validating the accuracy of the drawings also ensures basic public facilities are provided. With any construction project, inevitably public personnel, whether invited or not, will frequent the facility. Numerous personnel reviewing the same set of plans will foster questions that must be addressed. Handicap accessibility, public drinking fountains, and dedicated vehicle areas are constant reminders of overlooked items that end up being mandatory before the project can be completed.

2.5.5.2 Shared Responsibility

During the conceptual design phase, the designer envisions a concept of how the end result will appear. The designer's attempt to relay this vision is what generates the drawings submitted to the end user for approval. Many times by this stage only a few sets of eyes have actually seen any of this work and probably are unaware all together that a new project is growing. Thus, the BCOE review is extremely effective to identify the vision the designer possesses is actually very obtuse and does not particularly synch with the surrounding motif of the area. The importance of “borrowing” ideas and concepts off fellow workers is never more prevalent until you realize you are that designer.

The more accurate and synchronized a set of plans and construction documents are, the less potential for internal conflict. Often differing disciplines design their portion of the facility within their own vacuum and at an accelerated rate. It is not until the review that it is discovered that the same “mechanical” room houses three different disciplines equipment, or the vertical chase between floors contains more piping and ductworks than can possibly fit in the confined space. Thus, the benefit gained from shortening design completion time may be outweighed by the additional effort required for redesign (Hossain et al. 2012). Redesign by any of the disciplines is not desired, resulting in not just internal building construction, but design personnel conflicts and additional cost incurred by the end user.

Most engineers, architects, and designers process construction activities in sequential order. Some may deduce the required tasks in order of priority, but priority and sequence of construction are not necessarily the same. Either way, during the BCOE review “process”, the reviewers will “process” the items required to complete the project. The key is allowing and/or mandating the reviewer to drill down into some of the more mundane tasks, but not drilling down too far to micromanage or become overly inundated to the point their eyes glaze over and they lose interest. Often time during this procedure, small or intrinsic tasks will be identified. These findings may affect the facility design as well as scheduling and costs.

2.5.5.3 Accountability of Responsibility

During the review, documentation should be provided for what functions were conducted, and what items were analyzed, or which systems were calculated. This documentation ensures accountability on behalf of the reviewer. It is very easy and convenient to provide a cursory once-over of a colleague's design, but when one is required to document and sign-off on the design all things change. Cavill and Sohail (2005) reported that greater accountability will then promote improved capacity and ability of local government to meet the challenges of urban service provision. Enforcement of the BCOE review process ensures a valid effort by competent personnel to further guarantee that over-arching local, state and federal regulations are met.

Ensuring the accuracy of the contract documents reduces the chance of change orders. Poor and inaccurate designs create problems and allow conflicts to arise. These problems very often result in cost escalation and time delays and are legally corrected by change orders and modifications to the contract (CEHNC 1180-3-1). Not to mention excessive rework may be required by multiple disciplines that failed to coordinate and synchronize their individual efforts. A minimum of two reviews should be conducted on each construction project.

2.6 Advanced Planning

In order for a project to be successful, advanced planning must be initiated well in advance of actual generation of contract documents. Advanced planning is not an easy task to perform and is often tines extremely difficult to solicit participation. Information suggests that only about half of the accredited urban planning programs offer infrastructure engineering and planning in their curricula (Nelson 1987). Hence, individuals do not typically desire to participate in functions that they are not well versed. So many end users focus on the short term solution or the here and now approach and conduct very little input for any subsequent requirements in future years. During conducting a BCOE review numerous questions should arise that will steer the reviewer one direction or the other. It should be the responsibility of an accountable reviewer to verify with the end user or designer which desired path they want to follow. This will require additional review time on behalf of the reviewer, but will yield more comprehensive results. Verifying these questions or assumptions ensures the end user and the facility master planner share the same vision and desire the same end result.

2.6.1 Stakeholder Participation

Advanced planning requires more participation on behalf of all entities and parties that may be associated with the project. That said, many participants shy away from taking an active role in the planning process either because they are too busy at the time, they have no interest in the result so why should they provide any input, they don't fully understand the planning process and its importance on subsequent projects, or they are simply too lazy or disinterested. As previously stated, note the importance of a documented accountability system. For those that actively participate in the planning process, expansion of existing infrastructure systems are guaranteed. Planning anticipates the expected growth of the facility or the cluster of buildings and allocates sufficient capacity with the construction of the first facility.

During the planning process the review of the project is extended. During this extended time frame is when errors and design omission tend to surface. The quick, down and dirty, get it out the door procedure has been slowed and allowed initially suppressed (or overlooked) items thought to be inadvertent have had time to resurface in the designer's thoughts. As we all know, the ability to walk away from a project and then return to it with a refreshed mind tends to yield previously unforeseen items. Also, during this slowed time, design personnel are able to dedicate their time and even additional subordinate resources to the project to further ensure complete recovery of the contract documents.

2.6.2 Third Party Participation

The inclusion of other entities into the review process is not a new concept for internal personnel coordination within the design disciplines. Saram et al. (2003) expresses the opinion that construction coordination is a "service process" whereby the project manager and the team of coordinators provide a service to the "production personnel" building the facility being constructed. However, inclusion of construction oriented personnel is not a widespread concept. Usually construction project manager type personnel are not interested in reviewing contract documents until they are 100% complete and have been solicited, bid, and awarded. With more current times, project managers and contractors are invited or requested to participate in the review process to ensure the feasibility of construction. This is not the same as a design bid concept unless an engineer or architect designs the facility on behalf of the contractor. Early Contractor Involvement solicits the contractors to "review" the existing contract documents and comment on potential improvements or revisions in order to make the overall project more conducive for construction. Song et al. (2008) teaches that failure of design professionals to consider how a contractor will implement the design can result in scheduling problems, delays, and disputes during the construction process. Often times the same contractor may be utilized to construct the project, but it is usually an agreed upon commitment entering into the “review” phase.

One of the unexpected benefits of input from a non-designer is the ability of how to make expedient field revisions, which are engineering sound, to a construction process that must be changed if influenced by forces beyond our control. For instance, the concrete within the precast tilt-up panels was diluted during casting due to rain, but the reduced compressive strength was sufficient to act as a precast box culvert that was originally designed as a double-barrel round culvert. This was after the fact, but the concept is instilled in contractors for extraction during their early involvement.

2.7 Reduction of Change Orders

In today’s economy, time is money. Everything has to happen at an accelerated rate and if it doesn’t then individuals get impatient. It seems that most people always have somewhere else to be or have something else to do regardless of where they are located or what tasks they are performing. This is not a bad concept necessarily to ensure productivity and timeliness completion of tasks. However, this accelerated rate of lifestyle lends itself to a high degree of errors and omissions because no one spends the time to double check their work or even confirm that the work they performed was submitted properly or successfully received. These errors and omissions ultimately result in change orders if not properly and quickly revised prior to implementation of construction. Lopez et al. (2010) evaluated that design errors have been the root cause of numerous catastrophic accidents that have resulted in death and injury of workers and members of the public. So the fact that a close eye is kept on potential design discrepancies should not be a new concept to the any personnel within the construction triangle. Additionally, change orders have long been identified to have a negative impact on construction productivity, leading to a decline in labor efficiency and, in some cases, sizeable loss of man hours (Moselhi et al. 2005). The BCOE review directly affects the costs of each project by reducing the number and monetary amount of change orders and by ensuring efficient operation of the facility once the project is complete.

2.7.1 Review Time

The standard amount of time allotted to perform a BCOE review is thirty days, unless all reviewers agree to another schedule (USACE-COS-09). As previously mentioned, initially suppressed or overlooked inadvertent items should resurface during a thirty day review period. Thirty days is allotted to ensure that all reviewers have no excuses to perform their required tasks. By completing their tasks, a comprehensive and accurate set of construction documents should be produced which will yield a thorough project with little or no change orders, most of the time. Change orders do not benefit the end user or the designer. Sometimes, change orders inversely affect the contractor even though the change order was initiated by them. Thus, most projects operate better overall when it experiences less change orders.

2.7.2 Cash Flow

By executing a project with little or no change orders, the end users and contractors cash flow is uninterrupted. Navon (1996) reported that cash is the most important of the construction company's resources, because more construction companies fail due to lack of liquidity for supporting their day-to-day activities than because of inadequate management of other resources. Adequate cash flow maintains paying the bills, making payroll, and some sort of continuity in the funding planning cycle. Additionally, material suppliers can be promptly reimbursed for good delivered to the project site without worry of interest accrued or late fees. By promptly paying pending debts to suppliers contractors gain credibility that may be useful in the future when funds may not be as readily available.

2.7.3 Time Management

To minimize delays in a project a contractor utilizes a well thought out and comprehensive sequential schedule of events that must occur, without waiver. Kraiem and Diekmann (1987) indicate that with a critical path network, it is impossible to determine compensation in time, and to some degree in cost, for delays arising from an eventuality. Thus, if the schedule is successful, then the project is successful and the contractor enjoys the profits of a well devised plan. It is doubtful that a contractor actually incorporates a change order into their schedule. Thus, the lack of a change order is beneficial to the contractor and a thorough BCOE can greatly reduce the likelihood that a change order will arise. The faster and less impacted project a contractor can complete, the better it is for all parties concerned.

2.7.4 Improved Working Environment

With less change orders also comes less argumentative correspondence. Minor variations or omissions that almost always surface on any given project can usually be traded out for any excess somewhere else in the project. The less inclusion of legal counsel within a project the better it is. It is always a better alternative to negotiate the issue at the grass roots level rather than elevate it to include other parties. Neither the end user nor the contractor wants their money in the pocket of the litigator if it can be avoided.

The lack of change orders creates a much more pleasant working environment. As all know, a more pleasant working environment is a more productive working environment. Less stress and less dissention between workers of multiple disciplines creates camaraderie among the workers where they will lend a hand to help one another. Leading by example and exhibiting a respectful and fair working environment between the end user and the contractor will be noticed by laborers and general construction personnel.

2.7.5 Reduction of Rework

Ultimately, lack of change orders decreases the amount of rework required to get the project back to where it should have been when the change order was initiated. There is usually a delay for all the manufacturers, suppliers, subcontractors, and project management personnel to halt their efforts. Rework is one of the most common cost escalators. Hwang et al. (2009) confirms that construction projects often experience cost and schedule overruns and rework is a significant factor that directly contributes to these overruns. Even with extensive supervision, the work performed to date is subject to require removal of alterations should a change order be executed. Change orders and associated rework should be held to a minimum with a proper BCOE review process.

2.7.6 Preventive Execution

One of the main purposes for the generation of the BCOE process is to decrease unjustifiable cost to the government. One of the most important and most simple ways to achieve this task is to eliminate possible delays due to discrepancies with the contract documents or erroneous drawings. The most prudent way to prevent delays from occurring on a project is to eliminate the catalysts that initiate the delay to form in the first place. Much like ear plugs prevent damage from excessively loud noises, confirmation of vague or questionable statements within a contract prevent the opportunity for discrepancy at a later date. Failure to insert the ear plugs does not eliminate the excessive noise, but buffers the noise from entering the ear and causing hearing loss. Inserting the ear plugs after the noise has damaged the ears does nothing to restore the loss already incurred. Such is the way claims by a contractor operate when obtuse definitions, erroneous drawings or unclear language leaves open voids of opinion. Thus a successfully implemented BCOE review process anticipates and identifies these possible voids and enables USACE to correct these deficiencies before increased cost impacts.

2.8 Efficient Operation

The most efficient operation of a facility is scheduled and governed by the plant engineer or facility manager. Therefore, it is imperative that during the planning and design phase of the project the engineer or manager is intricately involved with the BCOE review process. Who better than the facility operator would know more about operability? The challenge is persuading the end user to include his engineer in extensive meetings thus lowering their existing productivity. So it boils down to a matter of pay now or pay later.

2.8.1 Quality Assurance of Construction Documents

With a complete BCOE, the end user will have less call backs of the subcontractors tweaking their installation and balancing units and adjust variable flow dampers and similar items. Often the plans conflict among the main subcontractors. Plumbing, mechanical, and electrical plans usually share the same space; above the suspended ceiling or under the floor. Either way the confined space is limited on how many items can fit. Unfortunately, it usually ends up being whoever installs their materials first gets to claim the easier and more direct route with little or no thought of how the follow-on trades will install their materials. Thus makes for a poor working condition and one that is subject to rework and dissention. In this case the last trade to install is pretty much forced to work with what available space remains. This yields improperly installed materials, fittings, and sizes that may not properly align or have excessive bends in order to negotiate around other existing materials. The efficiency of the system that was so diligently designed to comply with LEED requirements is now nowhere near the initial design parameters. The degree to which the design of a building embraces maintenance considerations has a major impact on its performance (Arditi and Nawakorawit 1999).

If the various trades are approached about the conflicting installation, in the absence of a certified BCOE reviewer by accountable individuals, the end user will be lucky to get any changes made at most by the subcontractors. Thus a change order must be initiated simply to get what was thought to be delivered in the first place. The end user does have recourse against the subcontractor if a performance specification was written and upon commissioning or testing of the system the specified efficiency or delivery values are not met. However, this tactic still ultimately delays the overall project but most of the rework cost will not be absorbed by the end user but rather by the negligent subcontractor. Elzarka (2009) employs that the objective of commissioning is to increase the likelihood that a newly constructed building will meet the expectations of the owner, occupants, and operators.

2.8.2 Maintaining Flexibility

With sufficient impact from the end user, flexible office or manufacturing space can be programmed into the design documents. The cost of including allocations for future flexible conversion of space is greater than standard construction, but is significantly less than a non-planned retrofit sometime in the future. Duffy (1995) believes that dissolving of the bond between the individual and the fixed workplace, so long overdue, brings space use and organizational performance much closer. The benefit of flexible space is smaller or modular conversions can be made as the need for conversion arises in lieu of a full blown office shut-down for several months to perform an overall renovation. Planning of this type must be initiated early on in the discussion process with the end user because numerous renditions of possible unforeseen future growth will be realized.

Expanding on the concept of flex space, the designer should steer the end users towards the overall goals of the facility. If the end user is knowledgeable of the operation that has been in use for decades, then the end user has seen the progression of equipment over the years and with reasonable surety be able to estimate what may happen in the future. The designer should allocate adequate space at this time for possible equipment upgrades in the future. The designer could also allot for the building to be expanded as a future construction phase. If the machinery increases in height, it is doubtful the roof will be raised to accommodate. Exterior considerations must be incorporated into the initial design and the BCOE review due to increased vehicular sizes through the decades.

2.8.3 Environmental Efficiency

LEED requirements are currently fairly strict and are becoming more mandated. It would stand to reason that more strict requirements shall be forthcoming in future years. Likewise it is reasonable to expect new inventions or discoveries will generate new applications or building systems that must be utilized in order to meet minimal regulated levels. An example of this is the conversion of FREON R-113 to FREON R-22 on most residential cooling systems. The existing R-113 compressors must be replaced to operate on the R-22 compressor level. The distribution of R-113 shall be banned forcing the use of R-22 and the purchase of the associated compressors. Potentially costly LEED compliance issues such as these shall continue to increase as green building becomes more prevalent. Wu and Low (2010) indicate that green building is a way of enhancing the environment, which benefits human well being, community, environmental health, and life-cycle costs.

2.9 Differing Perspectives

There is always a challenge dealing with conflict in the construction industry. Differing points of view and trying to relay that point of view into someone else's perspective is a constant struggle for all parties. Many say that the only thing constant is change. This is no more true than in the construction industry.

2.9.1 Designers Chair

Most of the time one will find that designers are more concerned with safety and compliance issues on construction projects. Profit is absolutely involved in their perspective, but ensuring accuracy of construction to guarantee occupant safety and installation of mandated measures to meet compliance requirements is paramount. If the latter conditions are met, then profit will follow. Contractors, on the other hand, are concerned most solely with profit. Quality assurance is a large consideration, but often addressed similar to speeding on the highway. Burgess (1988) implied that design assurance is “those planned and systematic actions taken to provide confidence that the completed design will satisfy the requirements of its intended use.”

2.9.2 Contractors Viewpoint

Contractors will often attempt shortcuts by substituting less quality materials or lower quality workmanship. Lower quality workmanship usually equates to performing a specific task in a faster time which results in oversights or inadequate checks and balances. Less time and less quality material means a larger profit margin for the contractor. Often the concept of contractors is that designers overdesign their projects for two large a factor of safety. This may be true, but in which item in the project sequence is overdesigned is not for the contractor to determine, or even question. Conversely, designers tend to overdesign some aspects of the project due to lack of experience, confidence, or lack of accurate field data, resulting in over exuberant design parameters.

2.9.3 Multiple Disciplines

The BCOE process cross references utility and layouts, and building finishing within the project. Conflicts are analyzed and some utilities are rerouted to avoid cluttered areas while building amenities are adjusted to coincide with other mandated requirements. For instance, some waste water piping must be located in certain places to facilitate restrooms. That piping cannot be relocated or rerouted if the restroom is to remain in the same location. However, the ductwork for the restroom can be rerouted to avoid the plumbing pipe. The differing views come into play again when the mechanical and plumbing entities each think their respective amenity governs over the other. Constantly, subcontractors bicker over who should have the right of way. As mentioned previously, the first installer on the project usually establishes the most convenient route for themselves with little to no consideration for follow on trades.

2.9.4 Change of Heart

Over arching and long term expansion plans are often not disclosed to the contractor during the original construction of the facility. Some consideration for possible expansion is incorporated in the design, but that intent may not be relayed to the contractor. Resources and end users limit the available knowledge disclosed to the contractor to eliminate the potential for cost overruns that may occur when the contractor realizes more potential work may be available. The end user may not want the same contractor or may have different founding partners that govern construction operations. The point being, that some apparent end work that should support half a bay, may in fact be scheduled to support a full bay sometime in the future. If the contractor does not know this, the foundation may be undersized in an attempt to cut cost and boost the contractor's profit margin. In this case, the contractor does not have adequate knowledge to warrant the importance of a fully constructed and compliant foundation.

2.9.5 Subversive Tactics

Often time contractors will review construction documents with the intent to discover discrepancies, omissions, or loop holes in the construction process. Dershimer (1993 defines that successful resolution of conflict requires a whole complex of interpersonal skills, including our abilities to listen, gather information, deal with feelings, negotiate, problem-solve, confront, and give feedback. Conflicts or discrepancies should be brought to the attention of the designer with the intent to rectify the issue amicably. This is not always the case. If a coordination error or critical sequential omission is discovered the contractor may not mention the issue in order to keep the item in reserve for discovery at some later date. This tactic is utilized by the contractor to ensure a change order or bargaining chip that the BCOE process is specifically tasked to eliminate.

2.10 Differing Communication Efforts

The construction triangle consists of the designer, the contractor, and the end user. As with any triangle, one vertex has access to the other two corners, but can never join the two corners together to reach them both simultaneously. In order to reach either corner the effort at the vertex must be split to proceed in two directions. Such is the situation when coordinating with two of the three project entities. The only way to bridge the gap and ease accessibility to both parties is through effective communication. One of the most important procedures to be initiated when starting construction is to establish the contract communication rules (Folland 1983). As stated previously, "Communication is the key to the construction triangle."

2.10.1 Chess Match

The contractor often views the designer as an obstacle in his course of action to achieve profit. Many contractors are also engineers or architects and are extremely knowledgeable in the various means and methods utilized in the construction industry. Thus, they often have a preconceived plan of how they will achieve the desired end state even before the final plans are provided by the designer. This concept returns to the previous comment that the contractor does not fully understand the importance of some of the various requirements mandated by the designer. Similarly, the contractor often envisions the designer as an inspections or quality assurance entity that has a sole purpose to find fault with what has been contracted. Very often, the only time a contractor sees a designer on the project site is when there is a complaint by the end user. This makes for a non-conducive work environment that creates dissention. Dissention is also present between educated graduates that possess very little field experience and project site workers that have extensive construction knowledge due to longevity in the construction industry. Open communication between the entities and consultation at times other than when problems are present are beneficial to all parties and stimulate growth of knowledge by sharing of ideas.

2.10.2 Acquisition of Allies

The contractor often tries to influence the end user in a direction other than the designer is trying to pursue. Input from the contractor is valued if constructive and shared by all parties concerned. It is when the contractor attempts to solicit the end user to compromise the designer's documents in an effort to save money that cause for concern should arise. Efficient and sound alternatives to a designer's plan should be coordinated and discussed among all parties, but from time to time substandard construction is installed at the end user's knowledge in order to save money. Achieving end-user satisfaction and optimizing the total value of a project design is a major goal of facility owners and developers (Cariaga et al. 2007). A properly coordinated charrette enforcing influential participation and communication by all could find an approved alternate design that would benefit all.

Similarly, the end user does not always know what the overall end result of the project should be. The designer may not be able to effectively convey their ideas in such a way that the end user can grasp, nor can the designer extract the end user's intent in order to produce acceptable documents. In this situation the designer should have enough forethought and humbleness to see advice or input from the contractor or more experienced personnel. Again, communication and the ability to properly convey desired end states can alleviate a potential situation before it can escalate. The BCOE process is entwined with communication among reviewers, designers, and contractors alike.

2.10.3 Shared Objective

Effective communication does not just pertain to verbal conversation. A proper set of plans, specifications, and construction documents should tell a story. Construction documents are the designer's way of communicating their thoughts onto paper which can then be constructed by the contractor. The construction industry is adopting the latest communications and information technologies available in order to improve collaboration, coordination, and information exchange among organizations that work on a construction project (Caldas et al. 2002). The written word is extremely powerful and longer lasting than the spoken word. Thus, proper documentation of the entire scoping, programming, design, solicitation, contracting, construction, warranty, and close-out of a project is paramount. Each and every task should be thoroughly documented from birth to death. Lack of documentation can create significant conflicts later in the construction process when memories start to fade. Disregard to generate proper close-out documents is a major concern for many project managers and designers. Failure to respect proper permitting authorities and provide sufficient certifications and commissioning documentation often delays project completion. The contractor and owner are more concerned with occupancy and utilization rather than completing tedious paperwork in which the designer is usually held accountable. Biddability reviews should include proper tasking of whom is responsible for close-out documentation and explicit actions or penalties that should be enforced upon failure of compliance by any party.

2.11 BCOE Procedure

In order for any review process to be uniform and have identical characteristics throughout the extent of its use, several basic principles must be established. The BCOE process is no different. Currently, the Corps of Engineers does not implement a definitive procedure that must be followed worldwide. Due to the diverse specialties that are performed by the Corps, each district is authorized the freedom to establish their own system in which to utilize the BCOE process. Various climatic regions along with numerous soil types joined with countless construction practices organic to the location all factor into the proper procedure to follow and to conduct an adequate BCOE review.

The challenge is to locate and extract the applicable practices, and compile those that will hold true and effective regardless of locale on the globe.

2.11.1 Checklists

Wuellner (1990) defines that a checklist is designed with four main characteristics or goals: comprehensiveness; simplicity; usefulness; adaptability. A comprehensive checklist for any project is a must. Many don't travel without consulting their own personal checklist. The same should apply to a procedure as important as a BCOE review. It is much more convenient and thorough to consult a list and mark an item "not applicable" than it is to not have the item listed in the first place. A checklist ensures uniformity among all that use it. A checklist is a working document that can grow and expand its coverage, as others encounter atypical situations. A checklist can be forwarded to the designer, contractor, and end user in advance to indicate exactly what the BCOE personnel will be looking for during their review. Inclusion of the checklist alone in the design process will lessen potential design commissions and construction conflicts even without a BCOE review.

2.11.2 Information Sharing

BCOE reviewers currently have access to a limited availability database. The database contains lessons learned and specific alternative design and construction procedures that have been encountered during other construction projects. The database is usually organic to the district in which the project was constructed. Sharing of information between districts is limited due to the non-presence of a centralized and shared database, and due to the lack of manpower required to maintain such a database.

Internal to each district sharing is not uncommon, however, outside the district errors, omissions, and challenges encountered within a project are kept silent for fear of the district appearing inept or subsequent to other districts that appear not to have any challenges of their own.

2.11.3 Meeting of the Minds

Often times the BCOE reviewer must make assumptions during the review process as to the contractor's sequential order of construction for example. Assumptions should be made by the designer but should not be made during the review period. Validation of these previously made assumptions should be made during the BCOE review. Hence, synchronization of the contractor's proposed construction course of action with the BCOE review is a must. Echeverry et al. (1991) provides that a vital part of construction planning is the appropriate scheduling of different activities necessary to deliver the constructed facility. Often construction sequencing shall require a portion of a site to be cleared for improvements which is actually being utilized as a lay down area. This causes delays after the fact that could have possibly been avoided had the BCOE reviewers been able to communicate with the contractor. This further enforces the requirement that all parties that may be affected by the project should be included in the design phase and pre-construction timeframe of the project. It is inefficient and costly for one property owner to install a driveway when the neighbor is planning an adjacent driveway project during the same timeframe. Again, communication amongst constituents and a composite checklist would capture that potential conflict.

2.12 Long Range Planning

The BCOE process is mandated by the Corps of Engineers. By default, the completion of the BCOE process constitutes "checking a box" of completion. The process is often considered just another task that must be completed prior to the issuance of a contract for construction. That concept reduces the effectiveness and lowers the potential in which a properly conducted BCOE can influence a project. The process becomes just another check mark or another larger overall list of tasks. A comprehensive BCOE review will require a sufficient amount of time to conduct. Therefore, sufficient planning must be performed at the on-set of the project well in advance of the design phase, to allot well needed time to conduct a review. Planning is a time-consuming, instance-related, and communication-intensive process. It is expensive, and it is easily affected by disturbances (Jagbeck 1994). Planning for time allotment is not all that is required. Micro-planning in a vacuum without consideration of macro-planning delivers little results that are essentially un-vetted due to exterior coordination. This is evident when two driveways are constructed side by side as mentioned previously. Macro-planning without input from developers, realtors, designers, and similar professionals is useless as well. Grandiose elaborate subdivision plans are ineffective when discovered the neighboring property is proposed as an industrial facility with heavy truck traffic. Operability of the proposed subdivision project fell off the chart.

2.12.1 Joint Venture

This leads into lack of coordination with the local municipalities and their proposed Capital Improvement Plan (CIP). Garvin et al. (2000) reviewed that public owners are challenged by limited and constrained capital resources for acquiring and sustaining infrastructure facilities. The Corps of Engineers is a steward of federal land and shall develop that land with the best interest of the local community in mind. It is stressed over and over again that the Corps of Engineers, at all locations, and at all project sites shall be good regulators and strive to comply with local norms of the community. Failure of a BCOE review to reference the local CIP or design standards manual is a show-stopper before the process even begins. Input from the local community is welcomed and fully expected during all project initiation phases not just the BCOE review. If two heads are better than one, then numerous heads with independent thinking and crisp perspectives have to be better.

2.12.2 Archives

One caveat to long range planning is that all planning must be well documented and disseminated. Failure to properly vet decisions, or follow up with tabled discussions, or revise altered site plans results in planning that is useless in years to come. If the completed and properly executed and approved documents are not recorded and archived then when referenced in the future they might as well not even exist. The same holds true to the BCOE review documents that should thoroughly reference the planning documents for future projects and as lessons learned to prevent futile repetitive procedures. Dissemination of all documents to levels above and below the BCOE ledge must occur and be documented as well. Communication is the key.

2.13 Reinforce the Triangle

The construction triangle (Appendix B) consists of the designer, contractor, and the end user. It is a critical member in the proper execution of any project. The geometric shape of a triangle makes it strongest and most stable configuration that can be utilized in structural design. However, the triangle is unyielding just as well so care must be taken when utilization of the shape is initially contemplated. Such is the same with the construction triangle. If properly connected communicated, and synchronized, the triangle is extremely resilient and uniform and status quo is achieved. But, the same three legs of the triangle that tie the figure together can just as easily hold the vertices apart.

2.13.1 Getting Started

The designer and the end user must conduct extensive coordination during the initial consultation period. Similar to the concept of finding lost people, within the first forty-eight hours of vanishing, the designer should solicit, extract, and pry all available information they can at the beginning of the process. Due diligence must be performed and document and internal programming requirements must be captured early in the process when the end user's mind is fresh and their original desires and thoughts have not been tarnished by the cloud of inability. Cho and Campbell (1997) agree that the engineers involved on a site investigation must understand the necessity of a thorough investigation and the means to complete this. In unison with performing due diligence functions extensive Front End Planning (FEP) must be utilized so the end users end state can be approximated with all available accuracy while still fresh in their mind. George et al. (2008) reports that the Construction Industry Institute (CII) defines front-end planning as the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project (CII 1995). Hence, the closer and more accurate the design is to the initial thoughts envisioned in the end user's head, the more pleased the end user will be at the time of project delivery.

2.13.2 All Aboard

Likewise, the designer must communicate with potential contractors at an early stage in the design and programming process. Input from experienced contractors is invaluable to opening up doors of possibility that may not have otherwise been breached. Early Contractor Involvement (ECI) is an extremely useful tool to validate beneficial design parameters, delete excessive or unlikely design constraints, and alter ineffective, inflexible, and costly proposals. Even if a contractor has not been selected to perform the work at this stage in the construction process, contractor consultation in the design process is worth the expenditure.

2.13.3 Leaving the Station

The end user and the contractor must also interact early in the project phasing. Ghavamifar and Touran (2008) describe that a project delivery system (method) is a term used to refer to all the contractual relations, roles, and responsibilities of the entities involved in a project. Project Delivery Methods (PDM) should be discussed and reviewed for feasibility on a project by project basis. The end user and contractor have both consulted with the designer at this stage so all three entities should have a general consensus of the way forward. Some projects yield themselves to Design-Bid-Build (DBB), while others are conducive to Design-Build (DB). If Design-Bid-Build is the chosen path, contractor consultation in this aspect is again worth the expenditure for the information gained from their perspective.

Frequent and well structured meetings among all three entities make the triangle stronger. Documentation of all meetings and decisive course corrections is the most effective communication tool. A well balanced and reinforced construction triangle represents that all three parties are comrades in lieu of competitors.

CHAPTER III

METHODOLOGY

3.1 Project Level Reviews

The methodology utilized in this study encompassed three independent steps consisting of: (1) collection of data for five projects that were performed at ERDC, (2) analyze the efficiency and effectiveness of the BCOE process, (3) collect and assimilate project data for an additional fifteen ERDC projects in order to conduct a more in-depth analysis of the BCOE process.

Often, adequate time is not available to perform the proper checks and balances during a project origination. Steps in the due diligence check list are omitted due to pressure from supervisors or the end user to begin the project at a specific time. The designer usually is aware of the fact that all steps in the construction process have not been fully followed, but the designer is willing to accept risk that any oversights will not adversely affect the project outcome. This is poor practice and should not be tolerated and avoided if at all possible. A diligent designer makes time to conduct a thorough analysis and generates a course of action for the proceedings of the project. The failure of proper due diligence references lack of accountability on the designer when derogatory actions be encountered during the construction process. It is often said that there is little time to perform a task right the first time, but there is always time to do it again.

There are numerous examples of projects that exhibit challenges. The following projects will be reviewed: (A) water main improvements project, (B) office and room additions project, (C) gate improvements project, (D) facility roofing project, and (E) shelter relocation project.

3.2 (A) Water Main Improvements Project

The ERDC installation is currently supplied domestic water via seven meters located around the perimeter of the property. As the installation has grown in size and density over the years, additional water taps and meters have been provided by the local municipality. With the improvements to several facilities and the proposal to construct numerous new ones, it became apparent that a comprehensive water distribution plan was required. Thus a new supply point was established in association with a main trunk line that would traverse the installation and cross connect two municipality water mains. The proposed main would provide redundancy to the municipality and boost pressures for local neighborhoods. Similarly, ERDC would enjoy a new enlarged double fed supply line that could be connected to the existing aged and undersized distribution system. The initial supply point would include a backflow device and meter since the main trunk would be a dead-end line. Due to funding constraints, the entire length of pipe could not be purchased, nor installed. It was proposed that Phase II of the project would complete the main trunk and then provide the cross connect desired by all.

Due to time constraints and insufficient validation of material requirements, a portion of the proposed main trunk pipe was purchased and delivered. The pipe was delivered and stored for a duration in expectation of installing the pipe once inclement weather had passed. It was later discovered that the delivered pipe was actually steel casing. Unlined steel pipe is not an approved building material by the local municipality. The sizing of the pipe is not conducive to match existing precast fittings, valves, taps, and repair appurtenances. Similarly, the supply point provided by the local municipality consisted of ductile iron pipe in anticipation of connection to a new backflow and meter device, which was not included in the original steel pipe purchase. Lack of coordination with the local municipality, failure to properly sequence the construction process, and absence of review by constituents contributed to the unsuccessful attempt. After more than twelve months trying to exchange the inadequate pipe and attempts to purchase required appurtenances with insufficient funds, the project remains at a stalemate. The second and third order effects felt by subsequent projects continue to hinder the overall planning effort for the numerous other projects.

3.3 (B) Office and Room Additions Project

On occasion, entities within ERDC will solicit construction services from maintenance personnel whose primary function is to repair and maintain the installation. There is a significant difference between new construction practices and performing isolated repairs or maintenance to a facility. The average end user does not differentiate the various skill sets required by each. Thus, some office personnel requests "repairs" that stretch the imagination and may exceed the definition of conducting routine repairs. Similarly, the maintenance personnel are competent in their field and welcome the challenges presented to them.

One such project was submitted and initially included installation of a "couple" of offices within a warehouse. There were existing offices in the building, but the new offices would be free-standing and bear on the open concrete slab of the warehouse floor.

Prior to the work beginning, a sketch indicating ten offices in a linear configuration was provided to further solidify the required scope of work. However, just prior to purchase of materials, an alternate layout was issued consisting of five large and oversized storage rooms, each one approximately forty feet square. From this information, forty feet long glue laminated joists were purchased in order to provide a clear footprint on the interior of the room. Upon arrival, the twelve inch deep joist were found to be inadequate to span such an unsupported distance under their own weight, much less provide any support to attach a ceiling or roof cover. The maintenance personnel consulted the engineering section at this time, yet failed to inform the end user of any issues or potential show-stoppers. Upon analysis, a centrally located steel beam with one middle column support was devised to minimize clear floor impact. Unfortunately, the revised plans were never issued to all of the maintenance personnel so minor dimension variations required to accommodate the insertion of the steel beam were not captured when the walls were laid out. It was also discovered that three of the rooms required air conditioning, HVAC units, and ductwork that would be installed on the roof cover. Fortunately, the calculated live load was sufficient to support the mechanical equipment, but personnel access and storage on the roof must be prohibited. That makes it very challenging for the HVAC technician to service their roof mounted equipment when personnel access on the roof is prohibited.

Operability of the system in this case was not considered. Even if the inclusion of the HVAC units came late in the process, the locations of the equipment could have been as such to provide access, in lieu of being placed at the back of the room near the warehouse exterior wall, thus limiting lifting equipment access. Failure to include the minor dimension variations compounded as the five rooms progressed in succession. Upon reaching the final room, the steel beam was too short and the already constructed wall had to be moved to allow the beam adequate bearing length. This would raise the question that the encapsulated steel beam in room four may not be sufficiently installed.

Failure to consult with licensed and accredited design personnel, lack of attention to detail, failure to properly sequence the project through completion, and overall lack of communication resulted in the project being significantly behind schedule. The end user has expressed displeasure with the completed project when they attempted to piece-mill the acquisition of materials and labor. Constant observation of the rooms and specifically the roof shall be required to prohibit the migration of storage on the roof over an extended duration.

3.4 (C) Gate Improvements

As with any large corporation, many subordinate sections within the company may possess, maintain, and expend their own budget. This is not a bad thing as long as the lines of communication remain open between the various sections. When one section fails to coordinate or include their adjacent sections is when conflicts arise and surprises crop up. Accountability for ones' actions and the impacts it creates upon others should be expected and enforced in such a situation. The potential usage of the expended effort to overcome the lack of a unified front should be considered as well. Lost opportunity to exert effort elsewhere due to lack of coordination cannot be recaptured.

Such is the case with the gate improvements project that was not fully vetted and incorporated into the overall master plan for the installation. Guidance was issued that an alternate and less conspicuous access point was required in order to separate larger and commercial vehicles from everyday smaller privately operated automobiles. This guidance was disseminated and various sections began to perform their required interior functions. However, one section evidently pursued a course of action a little too aggressively and failed to include others of their intentions. An existing, obsolete, and undesirable gate that has been inoperable for many years was suddenly the target of improvements. Associated with the gate was a post World War II building that was listed on the potential demolition list, but had not been implemented due to the presence of asbestos in several of the building materials. When deconstruction of the facility began, it was thought it was in an effort to comply with demolition requirements, not in preparation to clear an interior area just inside the obsolete gate. It was determined the area was required to facilitate a staging area for trucks waiting to enter the gate. The issue with utilizing the old gate was the physical width of the gate itself, the width of the exterior roadway, sight distances upon exiting the gate, and lack of turning lanes on the city roadway outside the gate.

Unfortunately, with most of the focus being exerted on the trafficability issues associated with utilizing the old gate, little effort was exerted to properly implement an approved asbestos abatement program for the building that was being demolished. The workers in the structure were properly protected, but it is suspect if adequate collection and disposal of asbestos containing materials (ACM) was performed in compliance with regulations. Lack of disposal certificates from accredited reclamation landfills yields suspicion. Not to say the project was not performed in an acceptable manner, but prior planning and adequate due diligence would ensure compliance.

A resultant of the gate being utilized forces installation employees to accept the gate as being the preferred location for the alternate access point. Nothing could be further from the truth with respect to traffic flow within the installation. Traffic congestion, intersection impacts, force protection concerns, and roadway alignment are all items that require analysis. Unsafe sight distances and vehicle collision concerns due to turning vehicles yielding to oncoming traffic are two major concerns for the local municipality. Most of these issues could have been avoided had the alternate access been located elsewhere as was being planned in the master planning proposal.

Failure to participate in the master plan process and failure to disseminate information and share intent, lack of proper environmental mitigation efforts, and disregard for municipality compliance all contribute to an undesirable end result. The gate must be utilized until another alternate access can be constructed at additional costs sometime in the future. The gate must also be decommissioned at that time and placed back into an inactive status which will include final site reclamation to include vegetative cover.

3.5 (D) Facility Roofing Project

Once the lines of communication are established, it takes little effort to keep them open. A reoccurring “touch” on either parties’ behalf ensures the recipient that they are still in good graces and confirms the initiator that they still have a point of contact should it be required. It is when these entities join together that a proposed project is successful. Not only are they cognizant of the others views and opinions, but all parties feel free to verbally speak their mind and release their true opinions and recommendations. That in itself is good communication practices, all because of extending a “touch” once in a while.

From this a new roofing project derived that pertained to an older solidly constructed building with little maintenance items and a constantly leaking roof. The roof had been patched, caulked, taped, and sealed several different times but to no avail. The situation was not pleasant but due to a confiding ability through open communication, the end user openly, yet respectfully, shared their desire to totally and finally repair the leaking roof, once and for all. By sharing the fact that numerous meetings and extensive input from the end users would be required, the designer oriented himself for a successful compilation of building intricacies and normalities. It was not an easy task to dwell up years of unsatisfactory roof repairs and the resulting leaks that migrated throughout the building. However, from this painstaking and unappreciated effort, an analysis was generated that yielded several possible water intrusion points. It was discovered that the rain water was actually coming in through the roof mounted HVAC system and migrating through the building along the supply and return ducts. Hence, water leaks inside would appear dozens of feet away from where the water intrusion actually occurred. Similarly, it was established that the masonry joints in the parapet wall cap were allowing intrusion.

With this information, compiled from comprehensive due diligence, a corrective course of action was derived for presentation to the end user. Once accepted and approved as a viable remediation effort, early contractor involvement (ECI) was immediately implemented. With the realization that numerous specialty contractors would be required to complete their specific portion of the overall scope of work, the task became that sub-projects must be implemented. However, contractual regulations require that one prime contractor receive the project and they can utilize selected sub-contractors at their discretion. A conglomerate of contractors, suppliers, engineers, and end users was compiled and assembled in one mass conference room. From this the project was designed and specified with construction drawings and specifications being generated as a resultant. Prior to final issuance of the bid package all entities received a review and input packet so any minor oversights or misconstrued information could be corrected. The design portion of the project ended up being fairly lengthy, but it ultimately confirmed that one either pays now or pays later. The extensive hours applied up front yielded a successful roofing project that was on schedule and within budget. The end user finally received what they had wanted.

By performing extensive due diligence, enforcing various entities to conduct technical reviews of proposed building systems, and coordinating a "readable" set of plans and specifications, the project resulted in success. Perseverance pays off. The relentless pursuit of end user input and review of previous as-builts enabled the designer to piece together the clues of the leaking roof. Likewise, by ensuring compatible building components were utilized, the construction of the roof became a "system" that was fully integrated and dependent upon one another. The various specialty contractors and trades actually embraced the fact that their actions affected subsequent operations. From this it was feasible to request one final review from all of the entities prior to placing the project out to bid. Due to their participation during the due diligence and design portion of the project, many of the contractors were the successful low bidders. The higher bidders did not fully understand the water intrusion and migration so they bid the project as unknown and increased their costs to cover unforeseen conditions.

3.6 (E) Shelter Relocation Project

It is not uncommon for larger, more complicated projects to inadvertently affect adjacent areas. Often the "spread" of the project has further reach effects than what is initially anticipated. A proper due diligence and BCOE will uncover most, if not all, of these matters. There is always one item that seems to slip through the cracks or fly under the radar. In this particular situation, an extensive metal hangar renovation, to include perimeter site work, was being programmed and designed.

The initial meetings and site assessments determined that an existing metal shelter, located within the affective site of the hangar, would remain and the site would be renovated accordingly. The rigid frame structure was in good condition and included a significant concrete foundation and slab on grade. Thus, the site design proceeded with the shelter as a focal point that all renovations must adhere. Upon additional communication with the end user it was determined that the hangar and surrounding area had been previously occupied by another entity and all of the area had been transferred to the current end user. Unfortunately it was unknown by the applicable construction triangle participants that the shelter had been allocated to a third entity prior to being transferred to the current end user. Before proper coordination and synchronization could occur the shelter was disassembled in order to be relocated elsewhere on the installation. From this, a viable and useful asset that had been incorporated into the renovation efforts was now lost. Additionally, the foundations and slab that remained were now considered a liability, obtrusive, and undesirable. The intent had changed overnight to remove the slab which directly affected numerous allotments that had been designed to accommodate and bypass the structure.

In addition to the removal of the shelter, the subordinate entity that disassembled and acquired the structure now needed a new foundation and site plan in order to reconstruct the shelter within their allotted property. The shelter had been utilized for storage of weather sensitive equipment so the facility needed to the re-erected immediately. The unfortunate news was that no coordination, nor site due diligence, nor master planning efforts had been initiated. This is a process that takes from two to three months to complete. Not to mention, a soil analysis, environmental assessment, nor construction plans had been initiated for the proposed wooded site.

In lieu of pushing an accelerated schedule and attempting to bypass or receive a waiver in the planning board process, a temporary storage area within yet another entity's facility was "leased" to house the sensitive equipment. This enabled the proper protocol to be followed and relieved undue stress created by lack of communication. Once an organized and structured corrective course of action was implemented for the reassembly of the shelter, it enabled adequate time to revise and finalize the original hangar plans and scope of work to reflect the removal of the shelter. Meanwhile, proper site exploration, due diligence and generation of construction plans was performed on the new shelter location. Both projects proceeded ahead successfully according to anticipated time lines once open communication and periodic review meetings were implemented. Once again, communication is the key.

3.7 Summary

After review of the five projects, it can be determine that three of the BCOE efforts failed to be conducted and thus the three projects suffered numerous challenges. One of the projects reviewed performed satisfactorily, and the last project was recovered from failure and resulted in an acceptable outcome. An overarching theme became evident for each project that acted as a catalyst to set a specific sequence of events into motion that ultimately influenced the projects outcome. For each action there is an equal and opposite reaction.

The water main improvements project is simply an example of wasted assets. The materials that were delivered cannot be utilized for the intent in which they were purchased. Thus, the funds that were expended are essentially lost. The received steel pipe can be utilized for some type of function, like casing pipe for shallow utility placement. Repurchase of acceptable pipe had to be performed, which resulted in delays to the project. The window of opportunity to install the pipe was passed over resulting in rescheduling not only of the pipe itself, but also affecting the next sequential project that may or may not be adequately prepared.

The office and rooms addition project resulted in an extended number of compounded delays. Dissention between numerous key players within the project resulted in simple hand-off tasks being dropped and left uncompleted. These actions then resulted in unprepared conditions conducive to accept subsequent work efforts; which furthermore caused scheduling windows for individual teams to be revised. The unsuccessful completion of minute subtasks propagated into significant delays resulting in far reaching impacts to other projects. One could argue that once dissention was present that malicious intent by supervised personnel governed unsuccessful tasks completion.

The gate improvements project is an example of pending rework efforts. The current gate configuration is conducive for the actions for which the improvements were intended. However, that effort, and funding, could have been better utilized elsewhere. The gate was required to satisfy imposed regulations, but minimal exertion of effort to properly coordinate would have resulted in fruitful returns. Current efforts are in progress to identify, validate, and receive approval on alternate gate locations that will be better adapted for the intended gate functions. Closure of the existing gate and transfer of the personnel, materials, and equipment to the newly proposed location is a significant drain of design man hours and budget. Un-doing of what has already been done is always a requirement of rework efforts.

The facility roofing project is one of the more successful efforts. The contractor portion of the work proceeded with minimal conflicts at a cost of extensive and lengthy due diligence and design times. The pay me now or pay me later adage definitely applies to this example. This is not to say that proper due diligence and design coordination should not be performed on each project, but the extended amount of man hours and effort put into this project nearly broke the budget. This raises the concern that the allotment currently utilized for design services needs to be reconsidered on future projects.

The shelter relocation project was initially headed towards failure but due to a timely and extensive effort from the project manager the shelter proceeded without impact. The lack of communication and coordination exhibited at the beginning of the project had to be arrested and corrected in order to turn the process around. Unfortunately the personnel responsible for setting the project on a course of destruction are independent of the project manager that was required to rectify the undesirable situation. Enforcement of standard construction operating and planning procedures must be exercised to eliminate this occurrence from arising in the future.

CHAPTER IV

ANALYSIS AND RESULTS

4.1 BCOE Phases

The BCOE process is currently utilized by an independent type of management system. That is to say that the various districts most likely conduct BCOE reviews for their individual projects, but the process and system of checks and balances utilized varies as much as the location of the districts themselves. As with any other type of "compliance" oriented tools, there are a minimum amount of functions that must be performed in order for the tool to be effective. The BCOE must include a review process by independent third party personnel. A knowledgeable and seasoned professional that is not intricately involved with the design of the project can yield an uninfluenced objectionable opinion. The BCOE must include a system to compile, cross reference, and track the review comments and input received from the third party personnel. Confirmation that the comments have been addressed or that recommendations have not been implemented into the project, must be noted and disseminated to applicable people associated with the project. Ultimately, the inclusion of review comments and recommended revisions into the design documents or specifications falls under the responsibility of the project engineer and/or the project manager. One can lead a horse to water, but one cannot force him to drink. An inclusive and final document containing all correspondence should be distributed to all associates. Again, the possibility of a BCOE specialist position becoming an integral part of the design team or management team becomes feasible. Depending on the influence and guidance exhibited by the individual district chiefs will determine the emphasis placed on the need for an efficient and comprehensive BCOE.

It was discussed previously that the construction triangle consists of the designer, contractor, and end user. These all inclusive terms could be considered to contain other influential players in the construction process. To this effect the designer designation would include architects, engineers, project managers, and other A&E personnel. The contractor circle would apply to tradesmen, suppliers, inspectors, quality assurance, and personnel associated with the permitting, compliance, and authorities having jurisdiction. The end user would consist of the owner, developer, operator, and general public patrons.

Once the BCOE process was considered from these varying view points and at different phases during the total construction process it became evident that multiple "BCOE" review processes occur over the life of the project. From this it was derived that four major phases arise, and must be considered and completed, in order for any project to be implemented and completed. A Conceptual Phase must be grasped in which the initial requirement or demand for the project is conceived and begins to flourish a plethora of ideas and potential outcomes. Next a Design Phase follows in which a series of trial and error proposals is volleyed back and forth between interested parties. At which the Preconstruction Phase overtakes and the design documents are bid and the project is prepared to be constructed. And lastly, the Construction Phase kicks off and all the previously involved personnel actually get to see a tangible item evolve out of their efforts.

During each of these phases a "BCOE" should be conducted. To a certain degree the review items are considered by default out of general necessity in order to generate a viable product. However, the actual compilation of a composite and comprehensive checklist of all this data is extremely difficult to regulate. The timing of the BCOE varies from phase to phase as well. During the Conceptual Phase the BCOE must be performed at the beginning, vetted, confirmed and then performed once more as a complete review. The Design Phase BCOE is performed at the end once the documents and specifications are complete. Similar to the first phase, the Preconstruction Phase must perform in initial BCOE, then prepare a bid, propose a course of action, and then perform a total and final BCOE just prior to submitting the bid for consideration. The Construction Phase BCOE must be performed prior to actually beginning work on the project. It does little good to perform an initial BCOE after a significant portion of the project has been completed.

The Table 4.1 visualizes the participants that should be involved during the previously discussed four phases:

Table 4.1 BCOE Participants by Phases

PHASE	**PARTICIPANTS**			
Conceptual Phase BCOE	Owner	End-User	Developer	Investors
Design Phase BCOE	End-User	Designer	Engineer	AHJ*
Pre-Construction Phase BCOE	Designer	Contractor	PM*	
Construction Phase BCOE	Contractor	PM*	Owner	

*Note: PM = Project Manager; AHJ = Authority Having Jurisdiction

4.2 Successful Project & Unsuccessful BCOE

After the compilation and review of the case study projects, several topics of discussion came to light. If a project is successful, then by default a thorough BCOE must have been performed. This is a logical statement, but not always true. If a high level of perseverance is maintained throughout the course of the project then that effort could correct a questionable BCOE review process. In order to consider a project a success it was deduced that the project completion was on-time and within budget. Additionally, the project was actually completed to the initial conceptual phase expectations, and the end user and contractor were satisfied. It must be noted that it was also concluded that as the project duration extends the level of “success” diminishes. Which means the participants will waive 100% satisfaction in order to receive closure of a particular portion of the project and be able to move on to another milestone in hopes of completing the project once and for all. An extreme case could result in the “waiting game” where the individuals hold out as long they can until one gives in so progress can continue. This usually results in the end user submitting to less than desirable conditions.

4.3 Successful BCOE & Unsuccessful Project

Conversely to this initial situation, if a comprehensive and successful BCOE is conducted it is usually unfeasible to result in an unsuccessful project. Time and unforeseen conditions were concluded to be two factors that could affect the project results. If a rush project with a shortened design time was implemented, a thorough Design Phase BCOE review could still not discover intrinsic assumptions made on behalf of the designers. Similarly, a shortened period of performance could adversely impact scheduling assumptions made on behalf of the contractor, yet remain undetermined during the Preconstruction Phase BCOE review. Even with a thorough BCOE performed at each of the phase lines, unforeseen conditions can cause a project to be unsuccessful. The difference in the latter case is usually no one is specifically held accountable for the results. From this it can be concluded that a BCOE review process is a function of time; and time and BCOE efficiency have a direct correlation (or are proportional).

Other factors that affect project outcomes include end user input during the construction phase of the project. As indicated in the chart above, the end user's requirements and input are during the initial two phases of the project. Excessive end user participation during the construction phase leads to change orders, which manifests delays and cost overruns, two things that have been determined to make a project unsuccessful.

End user input at the inappropriate time is not the only issue. All participants must adhere to providing their review, input, and documented correspondence during the proper sequencing of the project. Review comments from permitting officials always seem to directly conflict with assumptions and bidding materials utilized by contractors. This occurs when the preconstruction phase starts prior to significant completion of the design phase.

4.4 Requirements of a Successful BCOE

In order to manage input from various entities and ensure that input is received at the proper time and not past due, professionals during each phase of the project must persevere. They must maintain a high level of attention to detail throughout the entire process. Not start out strong and energetic, and then become complacent over the life of the project. Performing at the expected job performance level of a professional should ensure that proper due diligence and attention to detail are delivered. A second set of eyes is desirable to discover minor oversights and provide a differing perspective, not to provide a total revamp of the project, and perform the duties of the initial individual.

4.5 Enforcement of a Successful BCOE

This leads to the requirement and enforcement of the BCOE in the first place. Is the BCOE performed to ensure a complete project that will meet the requirements of the end user, or is the BCOE performed to identify incomplete efforts on behalf of the designers, estimators, and project managers? Obviously, the initial intent was to provide a complete project, but the process has been forced into the latter. Lackadaisical designers, cost estimators, project managers, contractors, and suppliers constantly depend on another set of eyes to identify their shortfalls. It stands to reason that all people make mistakes and can omit or transpose items, but when the expected task is performed counting on a BCOE to catch one's omissions, that approach is unacceptable. Failure to hold individuals accountable for their actions, or lack there-of, is one resultant of the catalyst created by the utilization of the BCOE process. There are so many reviews the buck can be passed several stages in either direction.

Aside from the previous discussion, the BCOE process is advantageous when utilized properly. Due to the fact that contractors, owners, and end users consider litigation to be one of their tools to keep in their toolbox, the BCOE process is a good combatant to decrease that likelihood. Additionally, the BCOE can retard the usage of substandard materials and installation when performed by professional knowledge with intricate field operations. By ensuring proper terminology and reference specifications are provided the chance of inappropriate construction reduces significantly. Again, the need to ensure proper implementation and documentation of a BCOE review process becomes paramount.

4.6 Case Study Analysis

When comparing the five case studies, several common themes were detected. Out of the five studies, three were failures, one was a success, and one began as a failure but resulted as a success. Common among the failures was a lack of communication. Dissemination of information, documentation, confirmation of expected end results, and even generation of completed as-builts were absent from these projects. A lack of attention to detail was also present in the failed projects. Numerous smaller oversights that made significant impacts later in the project were identified. Proper supervision and quality control could have decreased the impacts caused by complacency. Disregard for authority was present in the unsuccessful projects. Failure to hold personnel accountable for their actions lead to total disrespect and total lack of effort to comply with known regulations and generally accepted standards of construction. The disregard for authority probably stems back to the need for a culture shift within the workplace. "This is the way it's always been done", attitude doesn't make it an acceptable course of action. It could have been done incorrectly for all this time. Additionally, control issues exhibited by numerous personnel yielded the attitude that "I know what I'm doing and you can't tell me how to do my job any better". Constructive orientation and constructive criticism was met with total defiance. From comparing all five studies it is concluded that effective communication is directly related to the success or failure of the projects. Communication is the key to the construction triangle.

4.7 Project Comparison

Due to trending similarities in the initial 5 case studies, 15 additional projects were compiled and compared. The Table 4.2 lists the total 20 projects:

Table 4.2 Project Compilation & Comparison

PROJECT	FLOAT	PM ACCOUNT ABILITY	DILIGENT & COMPETENT CONTRACTOR	DESIGN BCOE CONDUCTED	OVERALL PROJECT RATING	CAUSE & AFFECTS
Water Vault	Yes	No	No	No	Low	Purchase of Wasted Assets (Non-Due Diligence)
EL Boat Shed	Yes	No	No	No	Low/High	Successful PM Efforts (AHJ & Permitting)
B1008 Rooms	No	No	No	No	Low	Delays Lack Coordination (Dissention & Uncertainty)
Gate 3 Access	Yes	No	No	No	Low	Rework & Wasted Effort (Lack of Coordination)
B1004 Renovation	No	No	No	No	Low/High	Successful PM Efforts (Extensive Coordination)
B3100 Demo	No	Yes	Yes	Yes	Low/High	Enforcement of Contract (AHJ & Permitting)
B5104 Roof	Yes	Yes	Yes	Yes	High	Lengthy Design Time (Extensive Due Diligence)
B3100 Fiber Optic	No	Yes	Yes	Yes	Low/High	Successful PM Efforts (Unforeseen Conditions)
B2026 Break Rm	Yes	No	No	No	Low	Delays Lack Coordination (Enforcement of AHJ)
Frag Sim Lab	Yes	Yes	Yes	Yes	High	Lengthy Charrette & BCOE (Extensive Due Diligence)
B3278 Fiber Optic	No	Yes	Yes	Yes	Low/High	Successful PM Efforts (Extensive Coordination)
Roadway Paving	Yes	Yes	Yes	Yes	High	Lengthy Design Time (Extensive Due Diligence)
B3296 Tornado	No	Yes	Yes	No	Low	Enforcement of Contract (Lack of Coordination)
B6001 Renovation	No	No	Yes	No	Low/High	Successful PM Efforts (Distribution of Tasks)
B3203 Demo	No	Yes	Yes	No	Low	Lack Enforce Contract (Incomplete Project)
B8000 Drainage	No	No	No	No	Low	Rework – No QA/QC (Non-Due Diligence)
B3396 Windows	Yes	No	Yes	No	Low/High	Successful Contractor Effort (Lack of Due Diligence)
B6008 Roof	Yes	Yes	Yes	Yes	High	Successful PM Efforts (Construction Diligence)
B3046 Renovation	Yes	Yes	Yes	Yes	High	Successful PM Efforts (Construction Diligence)
B6000 Roof	No	No	Yes	No	Low/High	Successful Contractor Effort (Rework & Wasted Assets)

The column headings in the table above indicate key catalysts and/or factors that affect the outcome of any project. “Float” represents if the project was rushed or accelerated in order to meet time constraints or was there ample time to perform the mandatory steps required to ensure successful completion of the project. “PM Accountability” indicates if a designated and dedicated individual was assigned to the project and thus was held accountable for the success or failure of the project. “Diligent & Competent Contractor” equates to an objective view if the personnel tasked to complete the construction of the project or perform the indicated improvements were adequately manned, equipped, and organized to carry-out the assignment. “Design BCOE Conducted” lists the projects that received a review, not necessarily a formal and documented review, but an effort was conducted and appropriate meetings were held. “Overall Project Rating” summarizes the resultant state of the project and the overall consensus of applicable personnel if the project was a success or did the project have its challenges and /or shortcomings. “Low/High” informs the reader that the project may have begun with less than desirable results, but due to a catalyst the project course was altered and expectations improved. The “Cause & Affects” column captures the positive or negative influences that may have been inflicted upon the project and the counterpoint that resulted from the impact.

4.8 Summary

There are five projects that resulted with a high overall project rating. All five projects possessed adequate time, an accountable project manager, a competent contractor, and performed a BCOE review. Furthermore, all five projects cite that due diligence was performed in support of acquiring a successful project outcome. It should be noted that the due diligence was performed by varying personnel contained within the construction triangle. In other words, if due diligence was performed, then the project was deemed as being successful. Similarly, if a BCOE was conducted on a project, it resulted in an overall high rating of a successful project. Not all of the projects that conducted a BCOE may have started out as a successful project, but ultimately ended up as one. From this, it can be deduced that the BCOE was performed at a later stage in the construction process as in the "Pre-Construction" or "Construction" phase of the project. As well, it can be concluded that the BCOE corrected the failing course of action and righted the construction process in order to guarantee a successful project. Cost overruns are usually a by-product of such extreme remediation if time constraints must be met. Most of the projects indicated above with no available float time, experienced cost increases when alternate work plans were implemented in an attempt to redirect the course of the project towards a successful completion.

Failure to perform a BCOE review on a project pointed to a low or low/high overall rating. The projects that were able to be corrected were dependent on a competent contractor to pull the project across the finish line. As one would expect, the contractor does not desire to fail when performing his tasks in an attempt to successfully complete the project. However, failure on behalf of the designer or project manager to perform their tasks properly and then transferring that lack of effort on to the contractor is not the proper way to conduct business. Prevention of setting the contractor up for failure should be a consideration that is forefront in the minds of all designers and project managers in lieu of performing the bare minimum and passing the buck.

Adequate project float time does not appear to inversely affect the overall project rating. All high ratings possessed ample float time but the projects that started low and were corrected to a successful project either had an accountable project manager or competent contractor to push the project through to success. As one may anticipate, when an accountable project manager or competent contractor discovers their project is not performing properly, corrective actions are implemented to align the course of the project towards success. The question and concern still exists as to how did the project get behind schedule or oriented improperly to begin with if competent and diligent personnel were assigned to the project from the initiation.

Without any question or dispute, if a BCOE review was conducted, then the project did not receive a low overall rating.

CHAPTER V

CONCLUSION

5.1 BCOE Review

The BCOE review process is definitely beneficial to ensuring the successful completion of a project when properly executed. Results previously discussed are conclusive that implementation of a BCOE review at sometime during the construction process significantly increases the likelihood of a complete and adequately constructed project. Results are inconclusive with respect to project outcome for failure to implement a BCOE. Other contributing factors, such as extensive project management or excessive project delivery times, may affect the overall results of a project all ready in execution that is in need of a BCOE review.

5.2 Construction Projects Topics of Concern

Countless reviews and numerous informal questionnaire processes yielded seven common items that repeatedly surfaced concerning the construction process. Regardless from which viewpoint the individual occupied, be it the end-user, the contractor, the designer, or a non-interested passer-by; seven topics continued to be the center of concern. The following Table 5.1 lists the topics in no particular order.

Table 5.1 Construction Projects Topics of Concern

	TOPIC
1	Time Frame / Schedule
2	Licenses / Permits / Codes / Safety / Compliance
3	Completed Project & Ready to Use
4	Budget / Profit / Finances
5	Names & Contact Information (Supplier, Owner, Contractor, Designer)
6	Minimize Conflicts / Enjoy Construction Process / Low Stress
7	Contracts / Drawings / Specifications

Further research and analysis is recommended on the potential impacts the Topics of Concern may influence on construction projects and the management of the same.

5.3 Advantages & Disadvantages of Conducting a BCOE Review

Table 5.2 lists the advantages and disadvantages of performing a BCOE review during the design/construction process. The tabulated items were not differentiated as to when the BCOE was performed, at the "Conceptual Phase" or the "Construction Phase", but simply the process of conducting a BCOE was performed.

Table 5.2 Advantages & Disadvantages of Conducting a BCOE Review

Benefits of Performing a BCOE Review	Negative Impacts of Failure to Perform a BCOE Review
More Cost Efficient Project	Increased Cost Over-runs
Schedule Maintained	Delays / Extended Project Duration
Less Unforeseen Conditions / Conflicts	More Unforeseen Encounters / Conflicts
Increased Stakeholder Input	Uninformed End-User
Improved Communication	Lack of Communication
Better Work Environment	Stressful Work Conditions
Satisfied End-User	Non-compliance with Regulations
Completed Project	Undesired Final Product

5.3.1 Communication

The most important benefit of conducting a BCOE is the capability to gain improved communication. Effective communication remains to be the most powerful tool to ensure the successful delivery and completion of a project. The benefits of improved communication vastly outweigh the ramifications of lack of communication. Dissemination of information to all interested parties, and even some parties that are not, decreases the possibility of conflicts and omissions. Effective communication ensures a more informed end user. The lack of simply knowing the status of a project is enough to agitate many owners to the level of disappointment with the designer or contractor. Informing any of construction triangle trio of good or bad news is better than holding the disclosure for sometime in the future. Another advantage of sharing information is the early detection of possible conflict. Many times one person's generic brief of repetitive occurrences will trigger a flag in someone else's course of action. Unknowingly, one individual sheds light on a potential conflict that now can be avoided by another individual simply by non-bias, non-premeditated, sharing of otherwise everyday information.

5.3.2 Checklist

From the findings of the research, the utilization of a BCOE review is an effective tool to ensure a successful project. With that function, a comprehensive checklist must be generated and disbursed for use throughout the USACE community. As mentioned, numerous districts utilize their own checklists to ensure project completeness, but a uniformed checklist would ensure regardless of where the project is located the BCOE review process is in effect. In synchronization with a checklist, the BCOE must be performed by a non-bias third party. The individuals must be professional and well versed in construction in order for the BCOE to be effective. The personnel conducting the review must not be inherently involved with the initial design or due diligence so as to cast a fresh set of eager eyes and inquisitive mind on the plans and specifications upon which they are about to review. It is often the most mundane and innate billboard that is the most overlooked each morning on the same drive to work. But that same billboard is the topic of conversation when a new attendee is included in the daily commute. Such is the requirement for a BCOE review.

5.3.3 Mandate

In order for the BCOE process to fully exhibit the power and potential that it possesses, each project, regardless of size, must be mandated to perform a BCOE. An individual at each district or installation assigned as a BCOE Specialist, or QA/QC Reviewer, would track each project from conception to completion and log the BCOE dates and attendees. The benefits from the BCOE process could then be distributed at a USACE-wide level to encourage others to request and enforce the requirement for a BCOE review. A culture change must occur where individuals realize this entire effort to conduct a BCOE upfront pays dividends against potential delays and overruns, and conflicts further down the road. Higher level emphasis can continue to "suggest" the implementation of a BCOE review process, but until a checks and balances system and disbursement of success stories becomes widespread, the BCOE potential will never be fully realized.

5.4 Final Word

Regardless of how the BCOE system advances, the need for effective communication and dissemination of information will always be the single most important factor in a construction project. The potential exists for the BCOE Review process to be implemented into the BIM software system, which is currently utilized in several USACE districts throughout the world. This could be a powerful tool to begin the process of an interconnected worldwide database that is easily accessible and subject to be frequently utilized. Without communications the world is at a stand-still, much less a construction project. Disruption of communications is one of the first tasks that any force tries to impress upon its enemies. Thus, by default, the need for unobstructed and continuous communication becomes paramount in any operation or construction project. As a final caveat to this concept, communication is, and shall always be, the key to the construction triangle.

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