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Essence Applicability Matrices for the Reduction of Project Cycle Time

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Abstract

Global competition and reduced project life cycle ultimately puts greater performance requirements on the capital project delivery systems used to maintain competitiveness. Despite continuing improvements in delivery cycle time, business owners of facilities continue to demand greater improvements in project delivery cycle time. Therefore, it is very important to investigate the various techniques and methods leading to reduction in project cycle time and also identify the applicability of identified techniques and methods. This paper introduces reduction techniques identified through literature review (i.e, Schedule Reduction Techniques (SRTs), Management Techniques (MTs), and Construction Institute Industry (CII) Best Practices (BPs). In order to collect applicability of these techniques under different project phases (Pre-project planning (PPP), Design (D), Material Management (MM), Construction (C), and Start-up (SU)), the Essence Applicability Matrices (EAM) is used.

Keywords: Project Management, Reduction Techniques, Construction Scheduling, Project Cycle Time

1. INTRODUCTION

From the automotive industry to process industries and from information technology to e-commerce, today's business relies on just-in-time capacity enhancements and first-to-market product strategies to gain competitive advantage and increase profit margins. This has created an increased demand for a high performance project delivery system that can achieve a dramatic reduction in project delivery time. Despite continuing improvements in delivery cycle time, business owners of facilities continue to demand greater improvements in project delivery cycle time. However, very few decision tools and guidelines exist to assist owners and contractors in choosing delivery systems to reduce the cycle time from the pre-planning stage through start up.

Increasing complexity of not only the facility technology, but also the regulatory environment increases the obstacles to significant progress. The competitive nature of business requires that owners make scope changes at the last moment even in the face of shortened cycle times. And yet very few decision tools and guidelines exist to assist owners and contractors in helping undertake assessment of project strategies with an aim to reducing capital facility planning and construction time.

Therefore, it is very important to investigate the various techniques and methods leading to reduction in project cycle time and also identify the applicability of identified techniques and methods.

Various reduction techniques identified through literature review are introduced in this paper. Essence Applicability Matrices (EAM) are used to identify the applicability of identified various reduction techniques and methods under different project phases (Pre-project planning (PPP), Design (D), Material Management (MM), Construction (C), and Start-up (SU)). The different project phases are discussed in the first of part of this paper.

The literature review helped in identifying the various Schedule Reduction Techniques (SRTs) as well as CII Best Practices (BPs) currently used in the construction industry. The literature reviews also helped in identifying the reduction techniques that are applied in other industries such as manufacturing, processing, and automotive, and have been categorized as Management Techniques (MTs). Out of MTs, the ones which had more relevance to civil engineering and the construction industry were studies in detail. These techniques are discussed in the following section of this paper. Each of these techniques suggests various ways and means (essence) to reduce cycle time and achieve reduction. These ways and means (essence) have been captured under 'EAM', details of which are included in the following section of this paper.

2. ENGINEERING PROCUREMENT CONSTRUCTION (EPC) MACRO MODEL

The EPC process is represented as a set of interrelated activities that spans from the owner's earliest involvement with pre-project planning to the completion of plant start-up (Back et al. 1998). Activities included in the model may be performed by owners, contractors, sub-contractors, suppliers, and others. There is no differentiation of responsibility or reference to organizational structure. The EPC Macro Model consists of a comprehensive list of activities commonly executed in an EPC Project. There are three levels of detail incorporated. Level one consists of five primary phases of project execution in an EPC process:

- Pre-Project Planning (PPP)
- Design (D)
- Material Management (MM)
- Construction (C)
- Start-Up (SU)

Level two of the activity list defines broad subdivisions or categories of the work performed in each of the five primary phases (refer to Figure 1). Level three is a further refinement of the hierarchical activity listing and defines specific project activities which commonly occur in an EPC project execution strategy.

There are 164 level three activities. In this paper, only the first two levels are required and hence, information about level three has not been mentioned here.

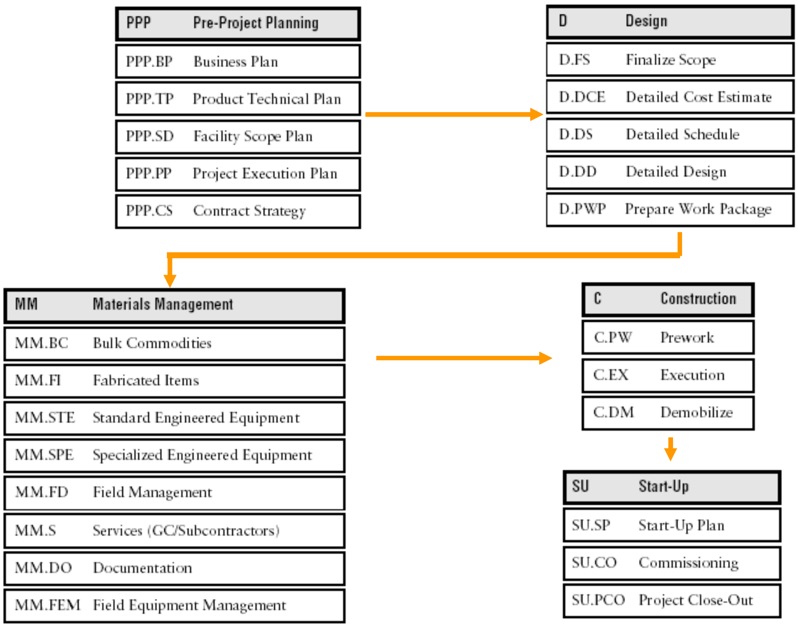


Figure 1. EPC Macro Model (Source: Back et al. 1998)

(1) Pre-Project Planning Phase

Pre-project planning includes those activities required to develop sufficient strategic information with which owners can address risk, decide to commit resources, and maximize the chance for a successful project. This phase provides a comprehensive framework for detailed project planning (Gibson et al. 1993). It includes the development of a business plan, that is, a strategic plan involving the goals and objectives of a business entity (Gibson et al. 1993).

(2) Design Phase

Design, as it pertains to the second phase of the activity list, includes all activities required for an overall engineering function, including numerical engineering analysis required to produce design documents as a final product (Choi and Ibbs 1989). This phase includes the design organization's review of any designs or information initiated and provided by the owner to enable the finalization of the scope.

(3) Material Management

Material management consists of those activities necessary to insure that the correct quality and quantity of materials and installed equipment are appropriately specified in a timely manner, are obtained at a reasonable cost, and are available in the field when needed (Back and Bell 1995). More specifically, the activities from specification to shipment have been separately identified for four classifications of materials and equipment. These are bulk commodities, fabricated items, standard engineered equipment, and specialized engineered equipment. After the materials or equipment reach the site, activities involving the items are consolidated under field management.

(4) Construction

The construction phase covers the field operations of the project. This phase includes all pre-work activities to prepare the site for construction, from site mobilization to the installation of communication systems. It also includes all concluding field activities required to demobilize the site. The physical construction of the facility is only one of several activities included under construction execution. All of the activities required to maintain the budget and schedule, and to manage changes while the physical construction progresses, are also included in the Construction phase.

(5) Start-Up

Start-up is composed of all requirements, procedures, and tests necessary for initial facility or system component production (Mathews and Ashley 1986). It includes activities necessary to start-up a project activity after the construction has been deemed complete and in accordance with the plans and specifications. Specifically, activities have been categorized under the headings of Start-Up Plan, Commissioning, and Project Close-out. Also included on the activity list, with each activity, is an associated activity code. The coding system reflects both phase and level. For example, the Pre-Project Planning Phase has been denoted by the cod 'PPP' preceding the phase title. All level two activities in Pre-Project Planning have 'PPP' as the first code element. All subsequent code elements are separated by a period. Similarly, level two activities, Business Plan, have been denoted by the code 'PPP.BP' preceding the activity title (refer to Figure 1).

3. CII BEST PRACTICES

A CII Best Practice is a process or method, that when executed effectively, leads to enhanced project performance.

(1) Pre-Project Planning

CII defines pre-project 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 (Pre-Project Planning Research Team 1994).

Pre-project planning has many aliases such as front-end loading, front-end planning, feasibility analysis, programming, conceptual planning, and others.

(2) Alignment

In the context of capital projects, alignment is defined more specifically as "The condition where appropriate project participants are working within acceptable tolerance to develop and meet a uniformly defined and understood set of project objectives" (Front End Planning Research Team 1997).

(3) Constructability

Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives (Construction Implementation Task Force 1993). Maximum benefits occur when people with construction knowledge and experience become involved at the very beginning of a project.

(4) Design Effectiveness

"Design effectiveness is an all encompassing term to measure the results of the design effort, including input variables and design execution, against the specified expectations of the owner; the owner's expectations include such criteria as cost, schedule, quality, and others either explicit or implicit in the project objectives" (Design Task Force 1986). Design is a complex and creative process in which the interplay of numerous factors, including physical, financial, and environmental constraints and technical and managerial knowledge, harmonize and result in plans, specifications, and models that are aimed at satisfying the owner's project needs.

(5) Material Management

Material management can best be defined as "the planning and controlling of all necessary efforts to insure that the correct quality and quantity of materials and equipment are appropriately specified in a timely manner, are obtained at a reasonable cost, and are available when needed" (Material Management Task Force 1986). Implementation of materials management assures quality materials are on hand when and where required and also how to obtain the best value for purchased materials.

(6) Team Building

The team building process is a project focused process that brings together key stakeholders in the project outcome, usually representatives of the project owner, designer and/or contractor. It seeks to resolve differences, remove roadblocks, and build and develop trust and commitment, a common mission statement, shared goals, interdependence, accountability among team members and problem solving skills (Project Team Building Task Force 1993).

(7) Partnering

Partnering is a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources (Partnering II Research Team 1996). This requires changing traditional relationships to a shared culture without regard to organizational boundaries. The relationship is based on trust, dedication to common goals and an understanding of each other's individual expectations and values.

(8) Quality Management

Quality management means meeting the requirements of all customers. This involves being proactive in helping customers articulate their requirements so that their expectations are met (Cause and Effects of Fieldwork Research Team 2001, Quality Management Task Force 1990).

(9) Change Management

Changes like additions, deletions, or other revisions within the general scope of a contract cause an adjustment to the contract price or contract time. This may present a variety of challenges for every party to a construction project. To overcome the problems associated with changes to a project, project teams must be able to effectively manage changes (Project Change Management Research Team 1994).

(10) Disputes Resolution

Identify causes of disputes and resolve them using Alternative Dispute Resolution (ADR) techniques. These serve as a valuable way to reduce the cost of construction. Three main, underlying causes of construction disputes are: (i) project uncertainty, (ii) process problems, and (iii) people issues (Disputes Prevention and Resolution Team 1995).

(11) Zero Accidents Techniques

Zero Accident Techniques are high-impact zero injury safety techniques that are applicable to small as well as large owners and contractors (Zero Accidents Task Force 1993). The Zero Accidents Task Force research has identified five "High-Impact Zero Injury Safety Techniques" that are being used by owners and contractors who achieve "Zero Injury". Both small and large owners and contractors can benefit by including the five techniques in a strong, basic safety program. The following are the five high-impact zero injury techniques:

- Pre-Project/Pre-Task Planning for Safety
- Safety Orientation and Training
- Written Safety Incentive Program
- Alcohol and Substance Abuse Program
- Accident/Incident Investigations

4. SCHEDULE REDUCTION TECHNIQUES

Forty-six Schedule Reduction Techniques have been identified from previous CII literature.

(1) Advanced Construction Equipment

This Schedule Reduction Technique suggests utilizing erection equipment best suited for fast, safety erection of components. For example, helicopters can be used for positioning items in hard-to-reach and high positions; pedestal cranes properly positioned early in a project can serve a large area; scissor lifts can be used in lieu of scaffolding; and concrete pumps and concrete conveyors can simplify concrete placement (Cost/Schedules Control Task Force 1988).

(2) Alternative Construction Methods

This technique implies that to achieve faster construction, alternative construction methods, use of which might result in reduction of time, should be analyzed and considered (Songer and Diekmann 2000).

(3) Avoidance of Interruption

Any interruption of worker concentration will reduce productivity. Typical interruptions are employees stopping to visit with other employees, giving of revised or additional instructions, delivery of supplies, or noisy activity in adjacent areas. Meticulously plan work so that all instructions, for example supply deliveries, occur before work begins, and organize to avoid other distractions. In the field, training of apprentices is a continuing requirement, but must be accomplished in a manner that minimizes the effects of interruptions (Cost/Schedules Control Task Force 1988).

(4) Craftsmen

A variety of incentives for craft workers can be included in a project which will encourage better schedule performance. For example, awards for attendance should reduce productivity and time losses associated with absenteeism. Similarly awards related to zero defects can reduce delays associated with rework due to construction error. Bonuses or prizes may be used to reward productivity improvements noted during work sampling (Cost/Schedules Control Task Force 1988).

(5) Crew

Training before the start of the project and during the project can really help boost productivity. Prior to assigning crews to new tasks, the crews are briefed on the new procedures through the use of models, audiovisuals, and demonstrations. Crew input is solicited as to best methods for accomplishing the tasks. This technique reduces rework and contributes to quality. Actual time required for accomplishing a task can be reduced if the crew is provided formal training and rehearses actual work using mockups or other training devices (Cost/Schedules Control Task Force 1988).

(6) Critical Equipment Contingency Planning

This technique lays stress on planning for equipments which are most essential for the progress of the project so that in the case of breakdown of such equipment the work doesn’t stop and the schedule not hampered. Typical items are high-capacity cranes, concrete pumps, and batch plants. On large projects, the establishment of an onsite maintenance shop may be practical (Cost/Schedules Control Task Force 1988).

(7) Concurrent Engineering

Concurrent engineering (CE) is a systematic approach to include all entities affecting or affected by the project in the planning, engineering, and design of the project. It is a means of simultaneously identifying all requirements and expectations, and obtaining design approvals at the earliest possible time, instead of following the traditional serial project delivery process (Eldin 1996).

(8) Constructability Analysis during Construction

It is defined as the optimum use of construction knowledge through the planning, design, procurement, and field operation phases of a project (Eldin 1996).Constructability studies should be continued during the construction phase for both time and cost reduction (Cost/Schedules Control Task Force 1988).

(9) Construction Driven Schedule

This technique proposes that scheduling software should be used to prepare and track an integrated engineering/construction schedule. This shall help by putting into focus the construction progress in light of the base schedule (Songer and Diekmann 2000).

(10) Dual Purpose Design

Designs can be selected that allow components to serve both as construction function and a function in the completed structure. Such designs are dual purpose designs. For example, steel may be used as both a form and structural component on some concrete structures (pipe columns, piers formed with sheet-piling) (Cost/Schedules Control Task Force 1988).

(11) Efficient Packaging for Transportation

This technique involves considerations of dimensional limitation of common transportation modes (length, width, height, volume, weight) when designing and specifying components so as to minimize the need for special transportation and handling. The handling of oversize components can be expected to add to both cost and delivery time (Cost/Schedules Control Task Force 1988).

(12) Empowerment

Owner's Project Manager (PM) must be a team leader with authority to make decisions and be supported by upper management. Moreover the delegation of authority to the field personnel of the contractor is also helpful in getting prompt decisions (Eldin 1996, Songer and Diekmann 2000).

(13) Expedite Payment

It has been proven by research that expedited payments in form of rewards to contractor can expedite the execution phase (Songer and Diekmann 2000).

(14) Fast Track Scheduling

The overlapping of engineering, procurement, construction, and start-up will shorten total project time (Cost/Schedules Control Task Force 1988).

(15) Field Rework Index Implementation

Field rework is defined as "activities in the field that have to be done more than once in the field or activities which remove work previously installed as part of the project." The rework manifests itself in the field during construction; its roots actually begin in the design and project definition phases (Causes and Effects of Field Rework Research Team 2001).

(16) Frequent Inspection

This technique suggests increased testing of the construction materials and also check on the construction process so that time lost in rework can be saved (Songer and Diekmann 2000).

(17) Freezing Project Scope

Early freezing of scope as a schedule reduction technique is defined as a systematic approach to early identification of major decisions/requirements that may affect the project delivery time. It also focuses attention on scope issues and details that are often omitted, forgotten, or left to be addressed at a later date. Identification and scoping of such issues can impact the project delivery time significantly (Eldin 1996).

(18) Incentives

"Incentive" means incentives in form of awards and bonuses to the team member. A variety of incentives can be incorporated into a total project. Some incentives are targeted on the individual employees and run the gamut from token awards, such as certificates or belt buckles, to bonuses determined through a point or report card system. Experience has shown that the most successful incentive programs are those that ultimately benefit the individual employee (Cost/Schedules Control Task Force 1988, Songer and Diekmann 2000).

(19) Job Site Preassembly

Reinforcing bar cages, structural assemblies, ducts, piping spools, wooden concrete forms and other components can be preassembled in controlled shop areas where jigs and assembly lines can be setup. This work can be accomplished in parallel with other work and, when done in a weather-protected area, can continue during inclement weather. Such work is more productive, usually permits better quality control, and reduces time needed for final in-place assembly (Cost/Schedules Control Task Force 1988, Songer and Diekmann 2000).

(20) Just-In-Time Material Deliveries

This technique encourages delivery of materials to the workplace as they are needed without intermediate onsite storage. It eliminates the time normally allowed for onsite storage. However, successful execution of just-in-time deliveries requires extreme planning, coordinating, and expediting action since any failure in the process can produce delays throughout the system (Cost/Schedules Control Task Force 1988, Songer and Diekmann 2000).

(21) Lay down Area Assignment

This method promotes development of a laydown area plan to best support the construction. It suggests that each subcontractor or craft superintendent be provided with their own laydown area as close as possible to the areas where work will be performed. This provides single point accountability and control and thus minimizes potential for delays caused by material misappropriation, damage, or loss when materials are accessible to multiple parties. Material delivery travel time also may be reduced (Cost/Schedules Control Task Force 1988).

(22) Lump Sum Contract

With lump-sum contracts, the contractor is interested in getting on and off the job as soon as possible since there is no incentive to keep the clock running on indirect costs. Thus, this contract form can in some cases speed contract execution. Since this method depends on the availability of design documentation of a quality to permit fixed-price bidding, the engineer's production of that documentation must be carefully planned and scheduled (Cost/Schedules Control Task Force 1988, Songer and Diekmann 2000).

(23) Material Coordinator

This technique suggests establishing a staff position whose primary, if not only, function is to be totally aware of the material situation at all times. This individual will maintain material status, reports, serve as a link between the field construction personnel and procurement personnel, be a key advisor during weekly look-ahead planning meetings, coordinate temporary diversions of materials to meet emergency demands, and otherwise assure the availability of materials when needed (Cost/Schedules Control Task Force 1988).

(24) Material Identification on Purchase Documentation

The technique promotes a universal company-wide coding system for the material appearing on the purchase order. It suggests including on purchase orders a coding for each item which identifies the item itself plus working package for which the item is intended, further specifying all tags, stencils, or other identification placed on the item by the supplier. This will facilitate routing of incoming items to laydown areas and minimize potential for misplacement and loss. This technique is practical only for engineered or tagged items. It is not suitable for bulk items or those warehoused on a stock-level basis (Cost/Schedules Control Task Force 1988).

(25) Minimize Owner's Involvement

The owner should restrict involvement in contractor work to that absolutely essential to protect owner interests. It suggests that we avoid unnecessary holds for inspection, review, and approval of subcontracts, which can delay work. Utilize joint owner/contractor in-process reviews as compared to separate after-action reviews and inspections. (Eldin 1996, Songer and Diekmann 2000).

(26) Non-Traditional Drawing Release

Traditionally, drawings are released for construction as completed drawings in packages. Non-traditional release allows a partially completed drawing that contains a complete and approved detail to be released for purposes of expediting procurement, construction planning, and execution for the completed portion of the drawing. Release for "procurement" (Cost/Schedules Control Task Force 1988).

(27) Pareto's Law of Management

The main objective of this technique is to concentrate management attention on those activities that have the greatest potential to adversely affect project schedule, cost and quality. The famous 80:20 law of management states, "The 80/20 Rule means that in anything a few (20 percent) are vital and many (80 percent) are trivial." Concentrate management attention on those activities which have the greatest potential to adversely affect project schedule, cost, and quality (Cost/Schedules Control Task Force 1988).

(28) Participative Management

This technique involves obtaining worker/employee ideas for reducing inefficiencies and increasing production. Participative Management is a process of involving those who are influenced by decisions, in making decisions, where everyone makes certain that everyone gets their needs met. This can be achieved by utilizing techniques such as delay surveys, quality circles, problem solving teams, suggestion programs, and worker discussions to obtain employee/worker ideas for reducing inefficiencies and increasing production (Eldin 1996).

(29) PEpC (Procurement Engineering, Procurement & Construction Implementation)

It is an innovative project delivery system which makes it possible to utilize key supplier expertise in all phases of project life cycle by developing an advance procurement strategy and by actually reaching full commercial and contractual agreement with the suppliers of strategic procurement items and /or prior to the principal project engineering activities (Vorster et al. 1998).

(30) Prioritize Procurement of Material

This technique proposes that the prime contractor should consider purchase of material for subcontractor. It also suggests priorities be established for materials acquisition consistent with project needs and supplier capabilities and ensure that these priorities are communicated to purchasing and expediting personnel so that they will concentrate their efforts on the right items (Cost/Schedules Control Task Force 1988).

(31) Productive Working Environment

Personnel in an engineering office will be more efficient and productive if the working environment is pleasant and well laid out. Effective lighting, comfortable furnishings, positioning of work units to facilitate coordination, use of dividers or other techniques to reduce potential for employees to disturb each other, use of sound barriers to isolate copy machines or other distracting activity, and use of background music or other "white" noise to facilitate concentration are among the suggested techniques (Cost/Schedules Control Task Force 1988, Songer and Diekmann 2000, Eldin 1996).

(32) Realistic Scheduling

This technique involves regular review and updates of schedules to reflect the realities of the situation. It involves the use of a summary level schedule for overall control, reserving detailed schedules for short-range planning, regularly reviewing and updating these schedules to reflect the realities of the situation (Cost/Schedules Control Task Force 1988).

(33) Repetitive Task Scheduling

The same type of work in sequence so that the same crew on regular shifts can be used to take the advantage of the learning curve and shorter time requirements are associated with experienced members (Cost/Schedules Control Task Force 1988).

(34) Single Engineering Procurement and Construction (EPC) Contractor

It is always more viable for single EPC contractor to carryout a project because there is always a time loss for aligning the processes of two organizations in case of a joint venture (Cost/Schedules Control Task Force 1988).

(35) Staged Pre-Positioning

This involves carrying out rough positioning as soon as the space and workability constraints are removed in parallel. This will save considerable effort and final positioning can be completed at a later time. This work is most effective if accomplished off-shift from the structural work since this eliminates the potential for interferences and reduces accident exposure of other crews (Cost/Schedules Control Task Force 1988).

(36) Standard off the Shelf Design

These are design having pre-designed modules for the facility to be constructed which if utilized helps reduce potential for design errors and omissions, reduces design time and cost. Suppliers often have standard designs available that can be incorporated into a project's design. Their use helps reduce potential for design errors and omissions, reduces design time, and reduces costs. Also, a design organization may have designs on the shelf from previous projects which are usable on the new project. Their use also reduces design time and cost (Cost/Schedules Control Task Force 1988).

(37) Start up Driven Scheduling

On an EPC project, this technique proposes to develop the schedule based on the logic that the owner's need date governs start-up activity, start-up activities establish the dates for construction and construction establishes the need dates for procurement and engineering (Cost/Schedules Control Task Force 1988).

(38) Temporary Start up System

Eliminate or reduce need for temporary systems for start-up by scheduling completion of permanent systems in time to support start-up activity (Cost/Schedules Control Task Force 1988).

(39) Use of Electronic Media

Use of electronic media in project management as a schedule reduction technique (SRT) is defined as the use of computer related technology to improve information management and communication in order to achieve higher productivity in developing project documents (i.e., drawings, specifications, procurement documents, instructions, change orders, procedures) and supporting field operations (Eldin 1996, Songer and Diekmann 2000).

(40) Use of Float Flexibilities

This technique considers putting non-critical activities within available float to release resource for concentration on critical activities (Cost/Schedules Control Task Force 1988).

(41) Vendor Submittal Control

This technique involves making sure that the vendor makes the delivery on time. This involves various steps such as, developing a strict compliance policy in terms of "no-later-than dates" for vendors, suppliers, owner representatives, and engineers covering submittal and approval of documents, shop drawings, and samples. The policy should be incorporated into each vendor and supplier contract (Cost/Schedules Control Task Force 1988).

(42) Well- Defined Organizational Structure

A well-defined organizational structure is one which maintains an organizational structure that clearly establishes all reporting and control lines, also maintains narrative position descriptions which delineate the authority, responsibility and accountability of each position. This will reduce the potential for delays caused by lack of understanding of who is responsible for what (Cost/Schedules Control Task Force 1988, Eldin 1996, Songer and Diekmann 2000).

In addition, four additional schedule reduction techniques were identified as follows:

- Continuity of Work Responsibility
- Effective Administration of Construction Site
- Reduction of Task Scope
- Vendor/Engineering Early Information Exchange

SRTs of CII Best Practices / 32 Activities (CII 125-11)	Pre-Project Planning	Alignment	Construct ability	Design Effectiveness	Materials Mgmt.	Team Building	Partnering	Change Mgmt.	Quality Mgmt.	Disputes Resolution	Zero Accidents Techniques
Pre Project Planning											
Business plan											
Product technical Plan											
Facility scope plan											
Project execution plan											
Contract strategy											
Design											
Finalize scope											
Detailed cost estimate											
Detailed Schedule											
Detailed Design											
Prepare Work Package											
Material Mgmt.											
Bulk Commodities											
Fabricated Items											
Standard Engineered Equip.											
Specialized Engineered Equip.											
Field Mgmt.											
Services (GC/Subcontractors)											
Documentation											
Field Equip. Mgmt.											
Construction											
Prework											
Execution											
Demobilize											
Start-up											
Start-up Plan											
Commissioning											
Project Close-out											

Figure 2. Essence Applicability Matrix-1: CII Best Practices

5. MANAGEMENT TECHNIQUES

Around 21 management techniques were outlined to be studied, out of which some have not been included because of their obvious inapplicability to the construction industry. In selecting management techniques applicable to the construction industry, the research team conducted several workshops and Tele-conference with the CII member companies. The following are the management techniques used in the EAM. For detail information regarding MTs, please refer to Hastak et al. (2004).

- Inventory Reduction

- Elimination of Unneeded Items
- Employee Involvement
- Increase Output
- Improve Quality
- Reducing Cycle Time
- Safety in Workplace
- Space Reduction
- Reliability
- Continuous Improvement
- Prevent Mistake
- Minimal Resources
- Reducing Delivery Lead Times

6. ESSENCE APPLICABILITY MATRICES

Before developing the EAM, Research team has held several workshops and meetings with all research team members for this research, which called PT 193, in finalizing techniques among the identified various CII BPs, SRPs, and MTs explained in the above. In addition, research team has taken an interview with the CII member companies in order to confirm whether or not these techniques can be applied to the construction industry.

In order to collect responses on the applicability of reduction techniques identified through literature review (CII BPs, SRTs, and MTs) under different project phases (EPC Macro model illustrated in Figure 1), the EAM was sent out to two groups of people, one being the research team members and the other being the respondents of the member companies who participated in the case studies. 11 responses were received from the research team members and 15 from respondents participating in the case study. The reason that the EAM has sent out to two groups of people is to do a comparative analysis of the responses obtained from the research team members, who were involved in finalizing the various techniques used in the EAM, and the responses obtained from CII company members, who had a lot of practical experience. For detailed information about how to calculate results of questionnaire survey, please refer to Hastak et al. (2004) due to editorial constraints.

The EAM has essentially been divided in three matrices (i.e., CII BPs, SRTs, and MTs). Figure 2 shows the EAM related to the CII BPs among the three matrices. For each matrix, the total responses to each of the five macro activities viz., Pre-project planning (PPP), Design (D), Material Management (MM), Construction (C) and Start-up (SU) have been computed. Also, scores have been computed for all reduction techniques as per the five macro phases (refer to Figure 1). The higher the score of a reduction technique, the better suited it is for achieving radical reduction in project cycle time. The results of these responses have been tabulated under the following different sections.

(1) EAM – Research Team Responses

The EAM has been developed by compiling all the responses from the research team members. Figures 3, 4, and 5 show the top 10 BPs, SRTs, and MTs.

As shown in Figure 3, Constructability has been rated as the top CII BPs that should be implemented to achieve reduction in project cycle time. Alignment and Material Management are the other two important CII BPs.

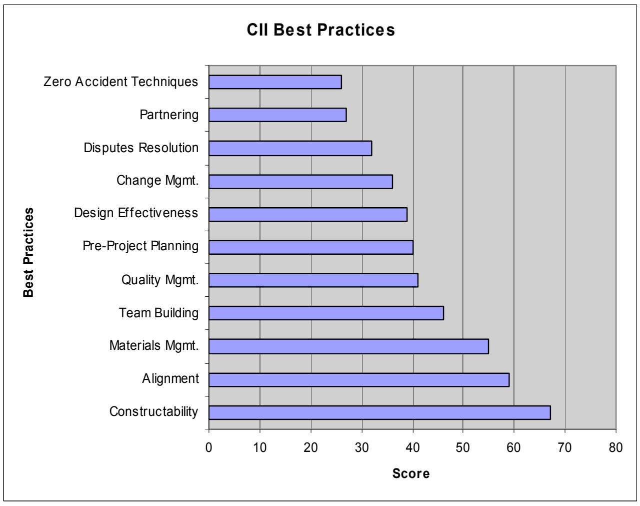


Figure 3 Top 10 CII Best Practices – Research Team Responses

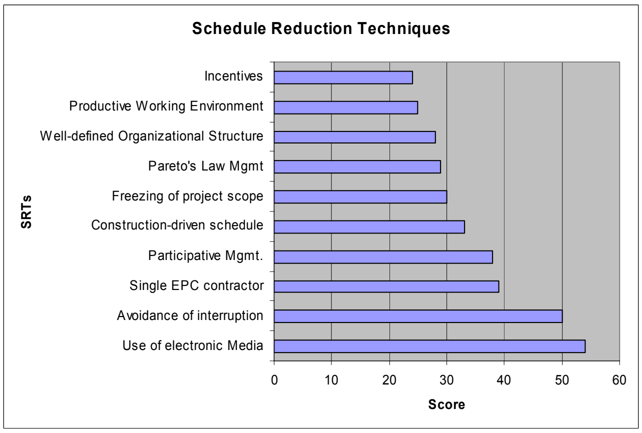


Figure 4 Top 10 Schedule Reduction Techniques – Research Team Responses

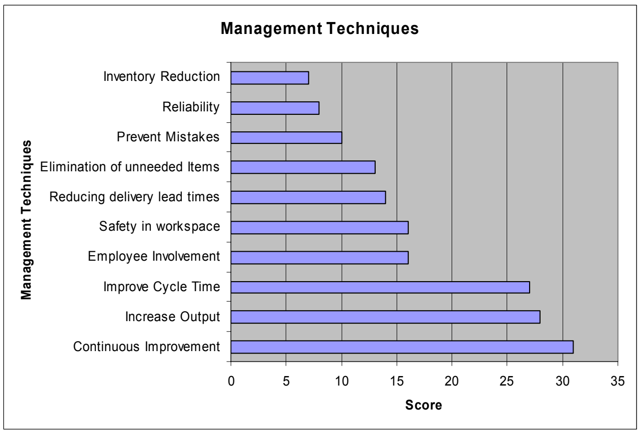


Figure 5 Top 10 Management Techniques – Research Team Responses

In Figure 4, Electronic Media, Avoidance of Interruption, Single EPC Contractor and Participative Management have been considered as important SRTs. In Figure 5, Continuous Improvement, Increase in Output and Improving Cycle Time have been identified as some of the important MTs.

Table 1 shows the scores received by the macro phases in descending order for CII BPs, SRTs, and MTs. It tells us briefly that when considering the CII BPs and SRTs, Material Management, Pre-Project Planning, Design, Construction and Start-Up are the macro phases in order of importance. When looking at the MTs, Design, Pre-Project Planning, Materials Management, Construction, and Start Up were the important macro activities

Table 1. Macro Phase Comparison – Research Team Response

CII Best Practices		Schedule Reduction Techniques		Management Techniques	
Macro Activities	Score	Macro Activities	Score	Macro Activities	Score
Material Mgmt.	150	Material Mgmt.	229	Design	51
Pre Project Planning	118	Pre Project Planning	176	Pre Project Planning	41
Design	96	Design	173	Material Mgmt.	39
Construction	66	Construction	164	Construction	32
Start-up	38	Start-up	60	Start-up	26

(2) EAM – Case Study Responses

The EAM has been compiled using data obtained from 15 respondents of the seven case studies identified (i.e., Project Manager, Construction Manager, Design Manager, Program Manager, PM/Resident Engineer, Site Manager, Project Coordinator, and Senior Construction Superintendent).

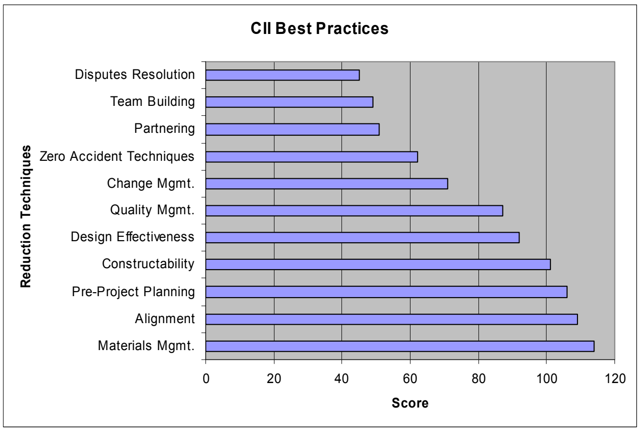


Figure 6. Top 10 CII Best Practices – Case Study Responses

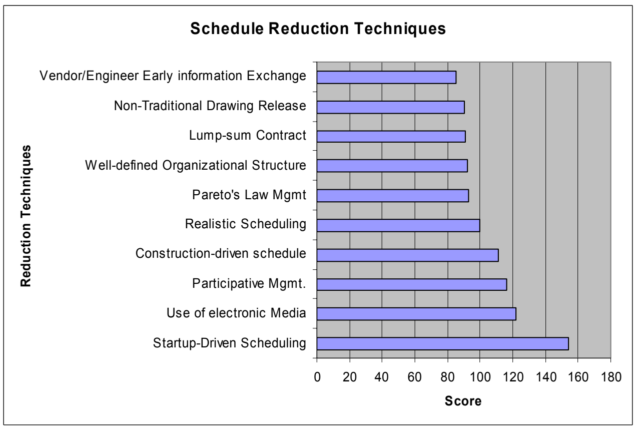


Figure 7. Top 10 Scheduel Reduction Techniques – Case Study Responses

Figures 6, 7, and 8 show the top 10 BPs, SRTs, and MTs. Material Management, Alignment, Pre-Project Planning and Constructability have been ranked as the top CII BPs (refer to Figure 6). Start-up-Driven Scheduling has been ranked as the most important SRTs followed by Use of Electronic Media and Participative Management (refer to Figure 7). Employee Involvement, Continuous Improvement, Safety in Workspace, and Reliability are the important MTs (refer to Figure 8). Table 2 has been also compiled showing the scores received by the macro phases in descending order for CII BPs, SRTs and MTs. It tells us briefly that when considering the CII BPs and SRTs, Material Management, Design, Pre-Project Planning, Construction, and Start-up are the macro phases in order of importance. When considering the MTs, Design, Material Management, Pre-Project Planning, Construction, and Start Up were the important macro activities. This order is slightly different from that obtained by EAM – Research Team responses

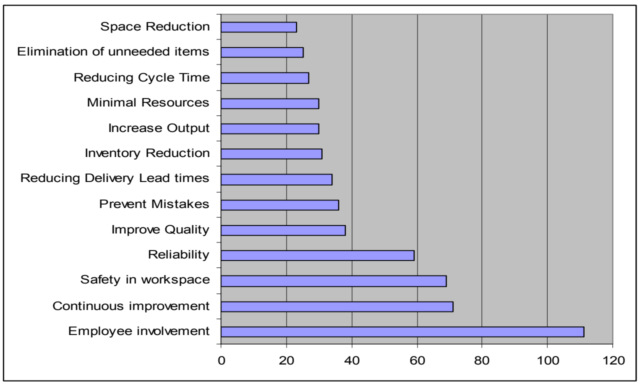


Figure 8. Top 10 Management Techniques – Case Study Responses

Table 2. Macro Phase Comparison

CII Best Practices		Schedule Reduction Techniques		Management Techniques	
Macro Activities	Score	Macro Activities	Score	Macro Activities	Score
Material Mgmt.	282	Material Mgmt.	912	Design	211
Design	185	Design	615	Material Mgmt.	114
Pre Project Planning	172	Pre Project Planning	547	Pre Project Planning	114
Construction	144	Construction	445	Construction	89
Start-up	104	Start-up	289	Start-up	56

(3) EAM – Combined

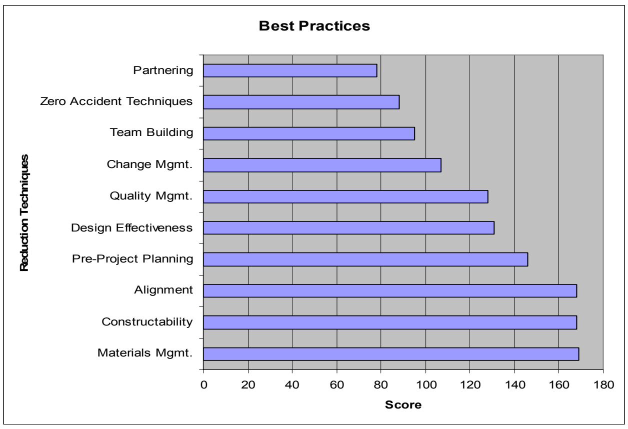


Figure 9 . Top 10 CII Best Practices – Combined

The three matrices for EAM – Research Team Responses and EAM – of Case Study Responses were merged together to form three sets of matrices which have been called EAM – Combined. Figures 9, 10, and 11show the top 10 BPs, SRTs, and MTs. Material Management, Constructability, and Alignment have been ranked as the top CII BPs (refer to Figure 9). In case of SRTs, Use of Electronic Media, Start-up-Driven Scheduling and Participative Management are the top techniques (refer to Figure 10). Employee Involvement has been ranked as the most important MTs for reducing in project cycle time. Continuous improvement and Safety in Workspace are the two other important techniques (refer to Figure 11). An overall comparison of the macro phases tells us that Material Management is a very important phase for implementing CII BPs as well as SRTs, while Design is the most important phase while implementing MTs (refer to Table 3)

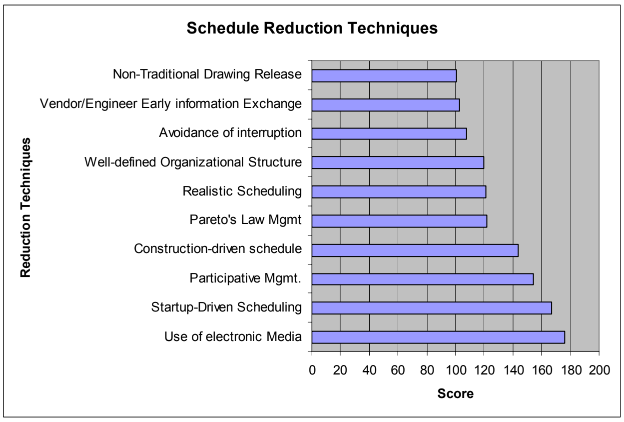


Figure 10. Top 10 Schedule Reduction Techniques – Combined

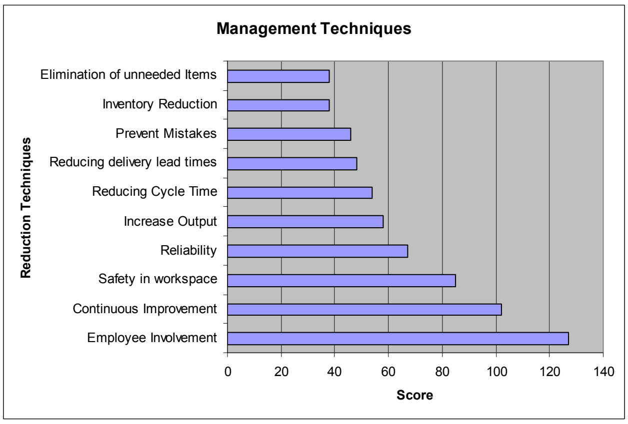


Figure 11. Top 10 Management Techniques – Combined

Table 3. Macro Phase Comparison – Combined

CII Best Practices		Schedule reduction Techniques		Management Techniques	
Macro Activities	Score	Macro Activities	Score	Macro Activities	Score
Material Mgmt.	432	Material Mgmt.	1141	Design	262
Pre Project Planning	290	Design	788	Pre Project Planning	155
Design	281	Pre Project Planning	723	Material Mgmt.	153
Construction	210	Construction	609	Construction	121
Start-up	142	Start-up	349	Start-up	82

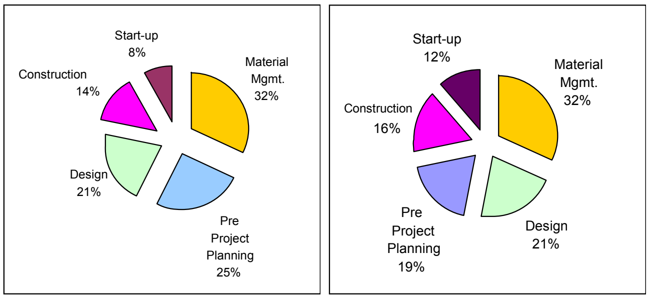
7. ESSENCE APPLICABILITY MATRICES – A COMPARISON

This section evaluates the results of both the EAM complied from the research team responses and the case study responses and analyzes various aspect of them

(1) Project Phase Comparison

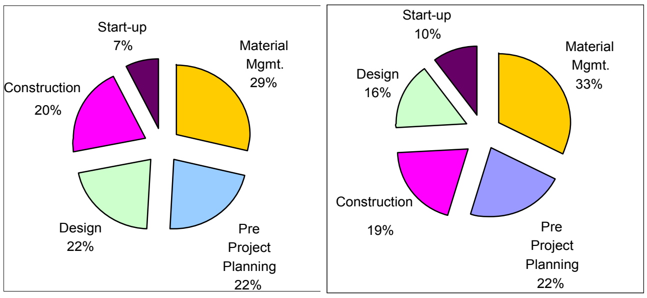
Results obtained from the research team responses and the case study responses have been compared, considering the five macro phases. In this comparison, the scores obtained were converted to a percent score for evaluation. This comparison gives the variation in results obtained using these Essence Applicability Matrices.

Figure 12 shows a side by side comparison of the importance (in terms of percentage) of implementing CII BPs in a particular project phase. It can be seen that Material Management ranks very high at 32% as per the research team responses and also the case study responses. Pre-Project Planning and Design rank second and third respectively according to team responses, while in the case of case study a response, Design is ranked higher than Pre-Project Plan.



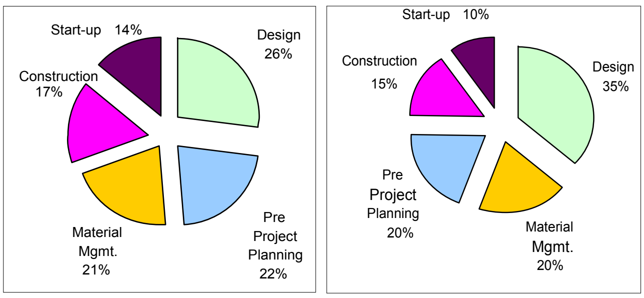
(a) Research Team Responses (b) Case Study Responses

Figure 12. CII Best Practices – Comparison



(a) Research Team Responses (b) Case Study Responses

Figure 13. Schedule Reduction Techniques – Comparison



(a) Research Team Responses (b) Case Study Responses

Figure 14. Management Techniques – Comparison

Figure 13 shows a comparison of the project phases while implementing SRTs and it is observed that Material Management and Pre-Project Planning are important project phases as ranked by the research team as well as the case study respondents. In comparing project phases while implementing MTs (refer to Figure 14), Design and Pre-Project Planning are the important project phases.

(2) Comparison by Rank

In this section, the top macro activities from the three Essence Applicability Matrices have been compiled from team responses and case study responses and analyzed in terms of percentages.

Table 4. CII Best Practices Rank wise comparison

TEAM RESPONSE			CASE STUDY	
Activities	Score (%)		Activities	Score (%)
Constructability	14		Materials Mgmt.	13
Alignment	13		Alignment	12
Materials Mgmt.	12		Pre-Project Planning	12
Team Building	10		Constructability	11
Quality Mgmt.	9		Design Effectiveness	10
Pre-Project Planning	9		Quality Mgmt.	10
Design Effectiveness	8		Change Mgmt.	8
Change Mgmt.	8		Zero Accidents Techniques	7
Disputes Resolution	7		Partnering	6
Partnering	6		Team Building	6
Zero Accidents Techniques	6		Disputes Resolution	5
	100			100

Table 5. Schedule Reduction Techniques Rank wise comparison

TEAM RESPONSE			CASE STUDY	
Techniques	Score (%)		Techniques	Score (%)
Use of electronic Media	7		Use of electronic Media	4
Avoidance of interruption	7		Participative Mgmt.	4
Single EPC contractor	5		Construction-Driven Schedule	4
Participative Mgmt.	5		Realistic Scheduling	4
Construction-driven schedule	5		Pareto's Law Mgmt	3
Freezing of project scope	4		Well-defined Organizational Structure	3
Pareto's Law Mgmt	4		Lump-sum Contract	3
Well-defined Organizational Structure	4		Non-Traditional Drawing Release	3
Productive Working Environment	3		Vendor/Engineer Early information Exchange	3
Incentives	3		Empower-ment	3
Standard or on-the-shelf design	3		Prioritize Procurement of material	3
Job Site Preassembly	3		Material Id. on Purchase Documentation	2
Realistic Scheduling	3		Productive Working Environment	2
Just-in-time Material Deliveries	3		Standard or on-the-shelf design	2
Effective administration of construction site	3		Minimize Owner Involvement	2

Table 6. Management Techniques Rank wise comparison

TEAM RESPONSE			CASE STUDY	
Techniques	Score (%)		Techniques	Score (%)
Continuous Improvement	16		Employee Involvement	19
Increase Output	15		Continuous Improvement	12
Reducing Cycle Time	14		Safety in workspace	12
Safety in workspace	8		Reliability	10
Employee Involvement	8		Improve Quality	7
Reducing delivery lead times	7		Prevent Mistakes	6
Elimination of unneeded Items	7		Reducing delivery lead times	6
Improve Quality	6		Inventory Reduction	5
Prevent Mistakes	5		Increase Output	5
Reliability	4		Minimal resources	5
Inventory Reduction	4		Reducing Cycle Time	5
Space Reduction	3		Elimination of unneeded Items	4
Minimal resources	2		Space Reduction	4

Table 4 shows all the best practices arranged in descending order of percentage scores obtained from research team respondents as well as case study respondents. There is not much variation in data obtained from the team as well as case studies. The top Best Practices were identified as Constructability, Alignment, and Materials Management.

Table 5 shows the top 15 SRTs ranked in descending order of importance as per research team responses and case study responses. The techniques that are highlighted were ranked in the top 15 by the research team respondents as well as case study respondents. This also shows that some techniques like Avoidance of Interruption and Single EPC Contractor were considered as important reduction techniques by the team, but apparently the case study respondents did not rank these in the top 15, similarly for Freezing of Project Scope. Also, Lump sum Contract and Non-traditional Drawing Release were considered significantly important by the case study respondents, but not by the research team member.

A comparison between all thirteen MTs is shown in Table 6. It can be seen that Increase Output has been ranked second by the research team, whereas it ranks ninth as per the case study respondents. Also, Reducing Cycle Time which is ranked third by the team stands at the 11 place when ranked by the case study respondents. Similarly Reliability was given a low ranking by the team, but a very high ranking by the case study respondents.

(3) Top Reduction Techniques Identified

Table 7 shows the top reduction techniques over the project cycle as per research team responses and case study responses. As in the previous section, highlighted activities indicate that they are common to both set of the responses. The 'reference' column indicates whether that particular reduction technique is a CII BPs, SRTs, or MTs. Start-up-Driven Scheduling, which has been ranked as the most important reduction technique (rank one) by the case study respondents fails to appear in the top 15 list of the research team responses. Also, Avoidance of Interruption and Team Building which have been considered as important by the research team respondents fails to find a place in the top ranked activities as per the case studies. Similarly Employee Involvement has been considered as an important reduction techniques by the case study respondents, but not by the research team respondents

8. CONCLUSION AND SUMMARY

The major objective of this research was to find methods of achieving reduction techniques in project cycle time. To achieve this objective, various literature reviews were conducted. The comprehensive literature reviews assisted the research team in identifying a set of criteria that were important to establish the state-of-practice and evaluation of project cycle time reduction techniques. Schedule Reduction Techniques (SRTs), CII Best Practices (BPs) currently used in the construction industry and Management Techniques (MTs) applied in other industries such as manufacturing, processing, and automotive were studied.

Essence Applicability Matrices (EAM) was sent out to two groups of people – (i) research team members and (ii) member companies who participated in the case studies – in order to identify the applicability of reduction techniques identified through literature review under different project phases (i.e., PPP, D, MM, C, and SU). Based on each analysis of the responses from the research team members and case studies, the top 10 BPs, SRTs, and MTs were identified.

Also, the results obtained from the research team responses and case study responses were evaluated and analyzed in terms of two different ways: (i) Project Phase Comparison and (ii) Comparison by Rank. Finally, the top 15 reduction techniques in project cycle time were identified in this paper.

The results of this research benefit both owners as well as contractors in the industrial, power manufacturing, petroleum, telecom, environmental, building, transportation, and infrastructure sectors. Potential benefits to the contractor could include earlier income from the job due to the shorter overall duration, earlier deployment of resources to other jobs, ability to tackle more jobs with the same level of resources, possible opportunity to earn incentives, possible opportunity for long term relationship with client through an alliance, and enhanced reputation leading to opportunity with other clients.

Table 7. Top 15 Reduction Techniques in Project Cycle Time

TEAM RESPONSE			CASE STUDY		
Ref.	Techniques	Score (%)	Ref.	Techniques	Score (%)
BP	Constructability	9	SRT	Startup-Driven Scheduling	8
BP	Alignment	8	SRT	Use of electronic Media	7
BP	Materials Mgmt.	7	SRT	Participative Mgmt.	6
SRT	Use of electronic Media	7	BP	Materials Mgmt.	6
SRT	Avoidance of interruption	7	SRT	Construction-driven Schedule	6
BP	Team Building	6	MT	Employee Involvement	6
BP	Quality Mgmt.	5	BP	Alignment	6
BP	Pre-Project Planning	5	BP	Pre-Project Planning	6
BP	Design Effectiveness	5	BP	Constructability	5
SRT	Single EPC contractor	5	SRT	Realistic Scheduling	5
SRT	Participative Mgmt.	5	SRT	Pareto's Law Mgmt	5
BP	Change Mgmt.	5	BP	Design Effectiveness	5
SRT	Construction-driven Schedule	4	SRT	Well-defined Organizational Structure	5
BP	Disputes Resolution	4	SRT	Lump-sum Contract	5
MT	Continuous Improvement	4	SRT	Non-Traditional Drawing Release	5
SRT	Freezing of project scope	4	BP	Quality Mgmt.	5
SRT	Pareto's Law Mgmt	4	SRT	Vendor/Engineer Early information Exchange	5
SRT	Well-defined Organizational Structure	4	SRT	Empower-ment	5

* BP - Best Practices; SRT - Schedule Reduction Techniques; MT - Management Techniques

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